

Underwater community gardens?
Exploring community-based marine aquaculture as a coastal
resource management strategy in Nova Scotia, Canada

By

Jessica Isabel Bradford

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ABSTRACT

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Aquaculture is one of the world's fastest growing food production sectors and presents an opportunity for rural, coastal community development that can support 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 presents a possible option to advance an EAA in this way; however, context-specific research is needed to understand its potential application and suitability. This research explores community-based marine aquaculture (CBMA) in Nova Scotia (NS), Canada, on provincial and local-scales, using a mixed methods approach, which includes stakeholder interviews, geographic information system (GIS) analysis, and surveys, to examine its suitability as a coastal resource management strategy. Findings suggest that CBMA is a feasible approach to future aquaculture development in NS and its possible implementation is conceptualized. This research also initiates pilot methods that can be used to determine suitability of coastal communities, which factor the importance of community perceptions into the planning and operationalization process. Although this research was undertaken in the context of NS, it has implications that can help to further opportunities for CBMA in other regions of the world, supporting the advancement of the EAA.

Keywords: community-based management, marine, aquaculture, ecosystem approach, rural development, coastal communities, planning, Nova Scotia

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LIST OF ABBREVIATIONS

AANS	Aquaculture Association of Nova Scotia
BC	British Columbia
CBMA	Community-based marine aquaculture
CEDIF	Community Economic Development Investment Funds
CIC	Community Interest Company
CICA	Community Interest Companies Act
COI	Communities of Interest
CSSP	Canadian Shellfish Sanitation Program
DFO	Department of Fisheries and Oceans Canada
EAA	Ecosystem approach to aquaculture
EBSA	Ecologically and Biologically Significant Area
FAO	Food and Agricultural Organization of the United Nations
GIS	Geographic information system
HRM	Halifax Regional Municipality
MPA	Marine protected area
NGO	Non-governmental organization
NS	Nova Scotia
PEI	Prince Edward Island

Underwater community gardens? Exploring community-based marine aquaculture as a coastal resource management strategy in Nova Scotia, Canada

1 INTRODUCTION

1.1 MANAGEMENT PROBLEM & OPPORTUNITY

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; Neori et al., 2007; Ponte et al., 2014). Marine aquaculture, which refers to the cultivation of aquatic plants and animals in the ocean, contributes to approximately one-third of total world fisheries and aquaculture production (FAO, 2016) and takes place mainly in coastal areas (Le Gouvello et al., 2017; Trujillo et al., 2012). On a local scale, this presents socio-economic development opportunities for resource dependant rural coastal communities that can support livelihoods (Bailey, 2008; Burns et al., 2014; Pelletier et al., 2016). However, because marine aquaculture sites are located in shared ocean spaces (referred to hereafter as the *coastal commons*), there are many users and potentially conflicting opinions on how to manage the resource (Aarset, 2002; Armitage et al., 2017; Ertör & Ortega-Cerdà, 2015; Murray & D’Anna, 2015a). Furthermore, aquaculture development has not always been done sustainably in the past and, in some cases, has resulted in environmental degradation (Belton, 2016; Ertör & Ortega-Cerdà, 2015; Zheng et al., 2009). 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 goods and services provided by marine ecosystems (Soto et al, 2008).

Increasingly, the “ecosystem approach” to resource management, which acknowledges the important linkages between people and the environment, has been encouraged and utilized for more integrated and equitable oversight of natural resources (Millennium Ecosystem Assessment, 2003). The Food and Agricultural Organization (FAO) of the United Nations has followed suit, recommending the ecosystem approach to aquaculture (EAA) to help facilitate sustainable aquaculture development worldwide (FAO, 2010; Soto et al., 2008). It is defined as “a strategy for the integration of the activity within the wider ecosystem such that it promotes sustainable development, equity and resilience of interlinked social-ecological systems” (Soto et al., 2008). It is guided by three key principles, suggesting that aquaculture development should: 1) not threaten ecosystem function and service, 2) support human well-being and equity, and 3) be developed through a multi-sectoral or integrated approach (FAO, 2010). The FAO suggests that the EAA may improve social acceptability of aquaculture and reduce user conflict (FAO, 2010). Participation of stakeholders is intended to be a critical component of the strategy, which must include a “participatory process for planning and management with local communities and other stakeholders” (FAO, 2010). The operationalization of the EAA has proven to be a challenge, with much of the focus on addressing the technical and biological aspects of aquaculture development, as opposed to inclusion of relevant stakeholders and social concerns (Costa-Pierce, 2010; Krause et al., 2015). 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 aquaculture operations (Gonzalez, 2008; Krause et al., 2015). Community-based management could, therefore, emerge as a possible coastal resource management strategy that supports an EAA.

Community-based management, which has been applied worldwide in many sectors (e.g. forestry, fisheries, agriculture, protected areas) (Armitage, 2005; Castro & Nielsen, 2001; del Mar Delgado-Serrano et al., 2017; Fernandez-Gimenez, 2008; Gruber, 2011; Hackel, 1999), is thought to improve the resource management process in terms of equity, inclusivity and sustainability (Blythe et al., 2017; Govan, 2009; Jupiter et al., 2014). Although the definition of community-based management varies, it typically involves a decentralized and participatory management regime in which communities are engaged in planning and decision-making for shared, or “*common pool*,¹” resources (Armitage, 2005; Castro & Nielsen, 2001; Fernandez-Gimenez, 2008; Gruber, 2011; Hackel, 1999; Newkirk, 1996). In some cases, it may even include a complete devolution of ownership and management from government to local communities (Galappaththi & Berkes, 2014; Phillips, 1998), which is often referred to as “community-based cooperative management” or, more simply, “co-management” (Castro & Nielsen, 2001; Wiber et al., 2010). There are many commonly endorsed potential benefits and outcomes of community-based management arrangements, for example, reduced user conflict, increased resource access, and improved environmental stewardship (Armitage, 2005; Fernandez-Gimenez, 2008; Galappaththi & Berkes, 2014; Pretty & Ward, 2001). Additionally, it can support rural livelihoods and well-being through not only economic development opportunities, but, also, improved food security and/or sovereignty, education, and reduced vulnerability (Ateweberhan et al., 2014; Galappaththi & Berkes, 2014; Pelletier et al., 2016; Serrat, 2006; Todinanahary et al., 2017). This helps to build the case that community-based

¹ *Common pool resources*, or common property resources, are resources for which the exclusion of users is difficult (excludability) and usage of the resource by one user decreases benefits for others (subtractability) (Ostrom et al., 1994).

marine aquaculture (CBMA) could be a more socially acceptable approach to aquaculture development in the coastal commons, thus supporting the advancement of the EAA.

For illustrative purposes, the basic idea of “underwater community gardens” demonstrates the possibility of community members working together to sustainably grow seafood in the marine environment through CBMA. This notion also aligns with current trends in terrestrial community gardening, which have been said to provide numerous health and well-being benefits, as well as connect people to their food and the environment (Datta & English, 2016; Jermé & Wakefield, 2013; Kingsley et al., 2009; Litt et al., 2011). 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 & Dearden, 2014; Deur et al., 2015; Groesbeck et al., 2014; Neudorf et al., 2017; The Clam Garden Network, n.d.). There are also current examples of community-based freshwater and marine aquaculture activities taking place throughout the world that can be drawn upon to help understand opportunities and suitability in other regions (Ateweberhan et al., 2014; Blue Ventures Conservation, 2015; Galappaththi & Berkes, 2014; Rougier, Ateweberhan, & Harris, 2013; Saphakdy, Phomsouvanh, Davy, Nguyen, & De Silva, 2009; SEAFDEC, 2007; Todinanahary et al., 2017).

The inherent challenges involved with CBMA must also be acknowledged, since coastal resource management is complex and ‘local communities’ are not the homogenous and egalitarian entities they can oftentimes be depicted as (Billé, 2008; Madden & McQuinn, 2015; Weinstein et al., 2007). Additionally, decentralized management, as manifested through

community-based management, is often difficult, where genuine transfer of political, financial, and human capital may not occur (Ribot et al., 2006). Therefore, it cannot be assumed that community-based management is applicable in all scenarios. Context-specific research is often required to determine suitability and understand public perceptions to achieve long-term effectiveness (Armitage, 2005; Bennett, 2016; Beyerl, Putz, & Breckwoldt, 2016; Diana et al., 2013; Hackel, 1999; Hauzer et al., 2013; Jefferson et al., 2015; Krause et al., 2015; Rhoads et al., 1999). Although CBMA may have potential to advance the EAA by facilitating increased aquaculture development in a socially sustainable way, there remains a need for better understanding its applicability for different locations and contexts.

1.2 RESEARCH OBJECTIVE & FOCUS

The continuous upward trend in global aquaculture production necessitates proactive strategies such as CBMA that could support sustainable aquaculture development and enhance livelihoods for people in coastal communities. Nova Scotia (NS), a province on the Atlantic coast of Canada, has potential for increased marine aquaculture, a populated coastline with many small coastal communities, and a need for rural economic development (Ivany et al., 2014; NS Department of Fisheries & Aquaculture, 2016; Province of Nova Scotia, 2009a), which makes it an appropriate pilot study area for CBMA. Two different spatial scales (provincial and local) will both be examined to capture a range of factors that may influence suitability of CBMA. The overarching objectives of this research are to:

- 1) Explore CBMA as a potentially suitable coastal resource management strategy in the context of future aquaculture development in NS, Canada.

- 2) Develop pilot methods to examine the suitability of coastal communities for CBMA development.

These objectives were achieved by researching the following questions:

- 1) How is CBMA conceptualized as a resource management strategy by various stakeholders in NS?
- 2) To what extent is CBMA ecologically and socially suitable for development in rural NS?
- 3) How can community perceptions be analyzed to help determine suitability and acceptability of CBMA?

2 MATERIALS AND METHODS

A mixed qualitative and quantitative methods approach was used to explore CBMA in NS on provincial and local scales, which included: 1) stakeholder interviews, 2) GIS analysis, and 2) surveys (Figure 1). This allowed for “triangulation” to occur between the three methods, which can validate findings and improve credibility (Belton, 2016; Njokweni, 2015).

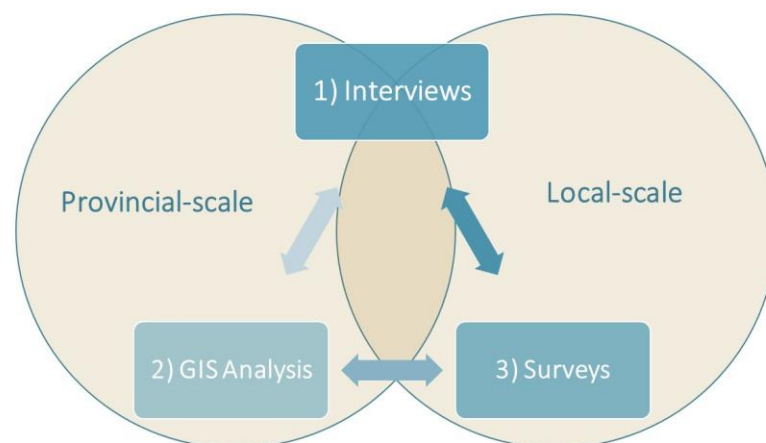


Figure 1. Schematic of mixed methods approach used on two different spatial scales.

This type of approach is increasingly used in social science research because it facilitates greater understanding of complex phenomena and can overcome shortcomings associated with using only one approach (Belton, 2016; Jones et al., 2007; Kanbur & Shaffer, 2007; Murray et al., 2016; Shaffer, 2013; Valente, 2011). The methods section is organized by spatial scale, with the provincial-scale background and methods described first, followed by the local-scale.

2.1 PROVINCIAL-SCALE

2.1.1 Study area: Nova Scotia (NS), Canada

Located in the Northwest Atlantic Ocean, NS has 7579 km of coastline with a variety of oceanographic and climatic conditions suitable for a diverse aquaculture sector in seven different regions (Figure 2; Manning & Hubley, 2015; Sebert & Munro, 1972; Stantec, 2009).

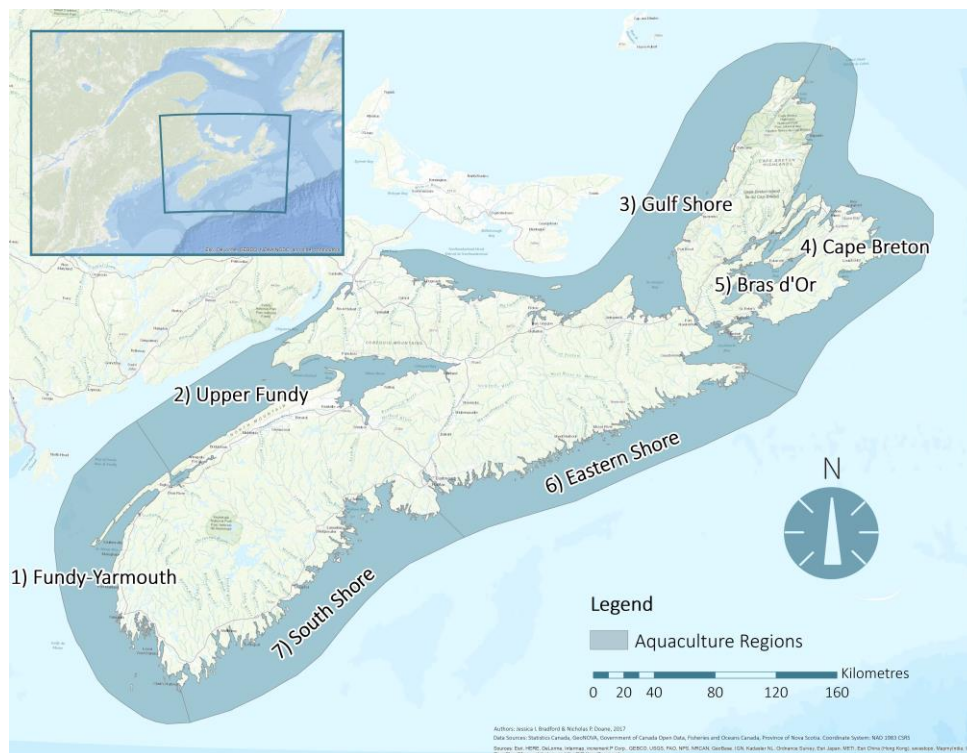


Figure 2. Map of provincial-scale study area, NS, Canada, including seven aquaculture regions: 1) Fundy-Yarmouth, 2) Upper Fundy, 3) Gulf Shore, 4) Cape Breton, 5) Bras d'Or, 6) Eastern Shore, and 7) South Shore (Stantec, 2009).

The aquaculture regions are broadly based on the biophysical suitability for commercial cultivation of a number of 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 determined to be ready for more widespread commercial cultivation (Chopin, 2015, 2017; Ross, 2017). Dulse (*Palmaria palmata*), though most often considered to be a wild harvest species, is another potential commercial species that could be cultivated in NS and research is underway to increase its readiness for commercial cultivation (Chopin, 2017; Ross, 2017). The opportunities for small-scale CBMA of commercial shellfish and/or seaweed species in NS are of specific focus for this research. This is because it is assumed that CBMA operations would need to start as “small-scale,” that is, they would generally involve low input and output systems (Harrison, 1997) to ensure efficient use of financial and human resources, especially in the proof-of-concept phase. As compared to finfish aquaculture, the cultivation methods for shellfish and seaweeds require little to no input of feed, fertilizer or medicine (Eklöf et al. 2006) and use more simplistic gear (e.g. lines, buoys, rafts, and rope) (Kim et al., 2017; Roesijadi et al., 2008; Titlyanov and Titlyanova, 2010), and, therefore, would be less risky and easier to start-up.

Several socio-economic indicators suggest increasing trends in poverty, food insecurity, and rural decline in the province and demonstrate a need for more rural development opportunities. Nova Scotia 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 (Canadian Rural Revitalization Foundation, 2015; Statistics Canada, 2011). 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 (Canadian Rural Revitalization Foundation, 2015; Ivany et al., 2014).

Aquaculture is being promoted as one way to support rural economic development (NS Department of Fisheries & Aquaculture, 2016; Province of Nova Scotia, 2012) and recommendations have been made to see fisheries and aquaculture exports double (Ivany et al., 2014). Compared to other resource sectors, aquaculture is a relatively young industry in NS (Province of Nova Scotia, 2012; Stantec, 2009). It currently contributes \$60 million to the province's economy, directly employs approximately 600 people, and takes place mainly in rural areas (Ivany et al., 2014; NS Department of Fisheries & Aquaculture, 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, 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, May 1, 2017).

The governance structure and regulatory framework for aquaculture in NS includes mainly federal and provincial levels of government, with some support from municipal and non-

governmental bodies (Figure 3). A memorandum of understanding between the federal (Fisheries and Oceans Canada [DFO]) and provincial government (NS Department of Fisheries and Aquaculture) has established the province as the principal regulator responsible for aquaculture licensing, lease management, site inspection and compliance, but both levels of government share responsibility for environmental management and monitoring (Manning & Hubley, 2015).

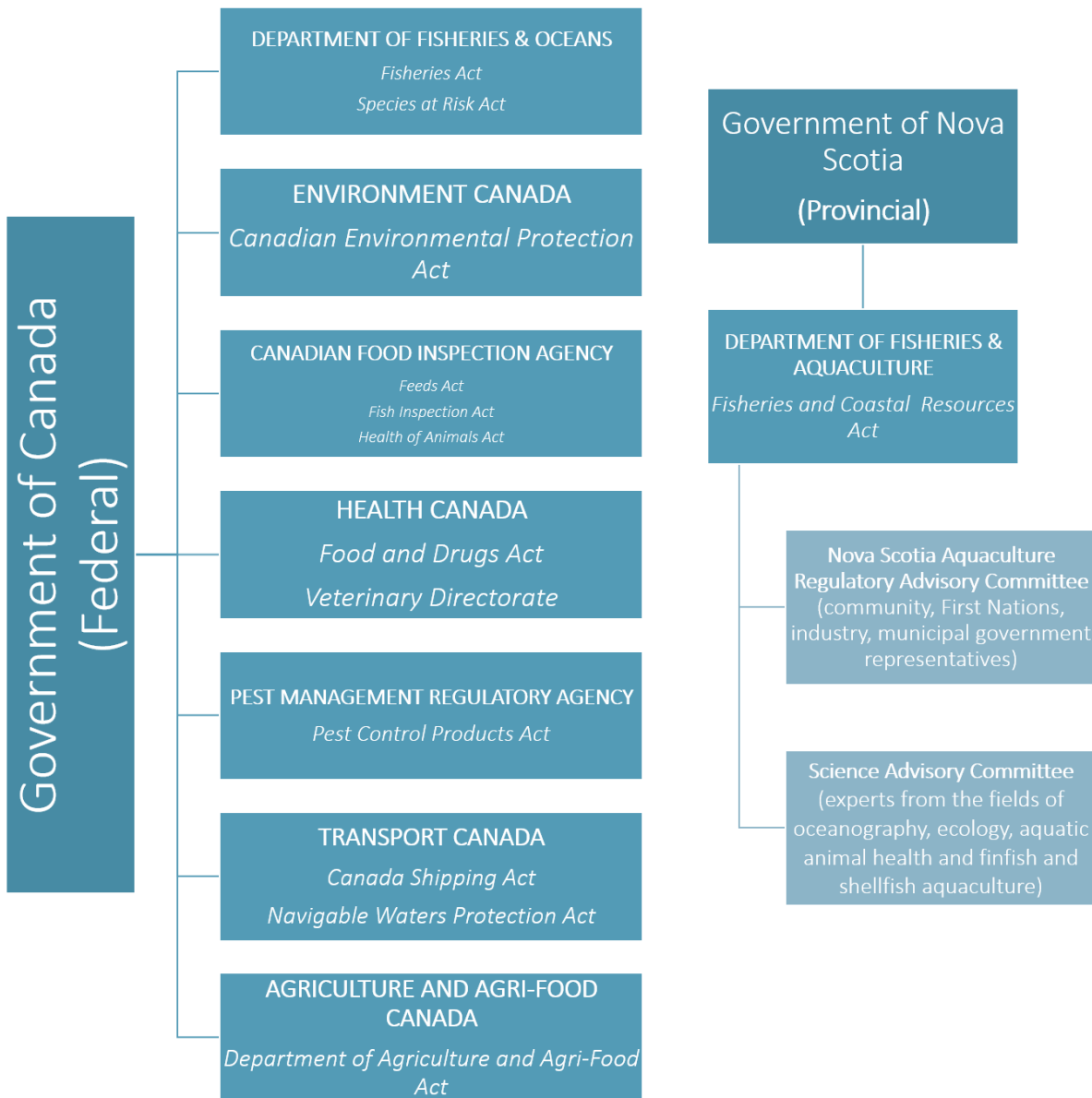


Figure 3. Federal and provincial regulatory framework for aquaculture in Canada/NS (DFO, 2016; Government of Nova Scotia, n.d.; Manning & Hubley, 2015).

2.1.2 Stakeholder interviews

From June to September 2017, a series of targeted semi-structured interviews 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. Although no one declined interviews, there were several who did not respond.
- 2) **Local government representatives (n=6):** Councillors and community/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/lease holders), industry employees, associations, and/or non-governmental 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 & aquaculture, marine ecology, and oceanography.

Interviews were conducted in person to help conceptualize opportunities for CBMA in NS by gathering information on the following: 1) the potential for aquaculture expansion in NS, 2) understanding of community-based management, 3) benefits and challenges, 4) suitable areas and communities, and 5) operationalization strategies. Information was recorded via handwritten notes, as well as audio recording device to refer to for clarification, as needed. While the interviews were primarily intended to explore the potential for CBMA more broadly on a provincial-scale, they also helped to inform local-scale examination. The full list of interview questions can be found in Appendix 1.

2.1.3 GIS analysis

To identify areas in NS that are potentially suitable for CBMA, which are referred to hereafter as Communities of Interest (COIs), GIS analysis was conducted using ArcGIS software. Social-ecological data layers were compiled (Appendix 2) and used to identify COIs according to the following nested filtering process:

- 1) **Biophysical and regulatory suitability:** The successful cultivation of plants and animals in the marine environment relies on certain biophysical conditions (e.g. temperature, salinity, currents, dissolved oxygen levels, pollution and bacterial contamination levels) (Stantec, 2009). Biophysical suitability is also closely tied to regulatory suitability because sanitary and water quality parameters can inform regulation such as the “Shellfish Growing Area Classification in Canada” under the Canadian Shellfish Sanitation Program (CSSP) (Government of Canada, 2015). These data layers were filtered to display only “approved” shellfish growing areas in NS, thereby eliminating areas with growing and harvesting restrictions to ensure

biophysical and regulatory suitability for communities². All other data layers, as described below, were queried to be within a certain proximity to this layer.

- 2) **Community integration:** Whereas CBMA is not exclusively an economic activity and should provide for broader goals to improve human and environmental well-being (Galappaththi & Berkes, 2014), opportunities for community integration should be considered. This aspect is also well-aligned with social sustainability goals of the EAA (Soto et al., 2008). A layer of all public schools in NS was used as an indicator of community capital to identify opportunities for integration of aquaculture with potential livelihood and well-being benefits such as educational opportunities, food, and supplemental income for families³. The selection of this layer as an indicator of opportunities for community integration is supported by the example of community-based sea cucumber aquaculture in Madagascar in which the involvement of a local school in farming activities has provided significant operational and social benefits (Rougier et al., 2013). The public school layer was queried to be within 10 km of approved shellfish growing areas.
- 3) **Accessibility:** Access to required infrastructure (e.g. wharves, roads) is important for any aquaculture development (Stantec, 2009). Due to the need for efficient use of financial resources and to maximize involvement from community members, accessibility to infrastructure becomes an even more important aspect for CBMA.

² Shellfish Growing Area Classification in Canada can change at anytime by regulatory orders from DFO (e.g. areas being placed in a restricted or prohibited status due to sewage outflows or elevated biotoxin levels) and, therefore, regular updating of this layer is required (Government of Canada, 2015). While some general conclusions can be drawn with the data used to help determine biophysical and regulatory suitability for COIs in this study, more site-specific research would be required to determine final site selection.

³ While, for the scope this research, a layer of all public schools in NS was used to demonstrate one opportunity for community integration with CBMA activities, it does not represent the only way for CBMA to be integrated with wider community benefits. Further research could examine other potential opportunities for integration and additional data layers for this category.

Therefore, two data layers were used to indicate accessibility to infrastructure. The first was the “Small Craft Harbours” layer, which was filtered to display “Core Fishing Harbours” only, as they are managed publicly by Harbour Authorities (not privately) to ensure accessibility to public wharves and cost efficiency for communities (Fisheries and Oceans Canada, 2016). The second was the “Nova Scotia Topographic Database - Roads, Trails and Rails” layer, which was filtered to remove any dry weather roads, trails and rails to ensure easier year-round access. These layers were queried to be within 5 km and .5 km of the approved shellfish growing areas, respectively.

- 4) **Potential social-ecological conflict:** Marine aquaculture activities take place in the coastal zone where 70% of Nova Scotians live (Province of Nova Scotia, 2009a) and, therefore, the potential for conflict with other resource users is present (Le Tissier, Hills, McGregor, & Ireland, 2004; Sanchez-Jerez et al., 2016). Aquaculture development also introduces structural materials and increased biomass of cultivated species to the marine environment, which modifies the area both aesthetically and ecologically (Weitzman et al., in press). Accordingly, data layers with locations of provincial parks, national parks, historic sites, and military reserves were compiled to identify land-use areas of concern that could conflict with aquaculture⁴. A data layer of the “Ecologically and Biologically Significant Areas (EBSAs) in the Atlantic Coastal Region of NS” was also gathered. EBSAs are used for determining marine conservation priorities (e.g. potential future marine protected areas [MPAs]), thus representing marine areas of concern. Not all EBSAs are created equal, therefore, the

⁴ This layer was developed using open data from the Nova Scotia Geographic Data Directory. There are likely coastal stakeholder groups with similar or higher potential for conflict (e.g. commercial and/or recreational fishermen, private business, tourism, etc.); however, this information was not as readily available publicly and, therefore, was not included in the scope of this research.

EBSA layer was filtered to display only EBSAs deemed to meet all established conservation design criterion (e.g. uniqueness, aggregation, fitness consequences, resilience, and naturalness), as they considered to be of greater conservation value (DFO, 2014). These data layers (land-use areas of concern and EBSAs) were queried under the following two potential planning approaches: 1) a “cautious approach” that removed any approved shellfish growing areas within 1 km of these terrestrial and marine areas of concern and 2) a “comprehensive approach” that does not factor these areas into the analysis and, instead, displays approved shellfish growing areas within 1 km of them.

- 5) **Community boundaries:** Once these areas were identified, the next step was to use the “NS Civic Address File - Community Boundaries” layer to identify community boundaries within 10 km of suitable shellfish growing areas for the final mapping output, thus identifying COIs for CBMA in NS based on the two different planning approaches, as described above.

2.2 LOCAL-SCALE

2.2.1 Study area: Seaforth, Halifax Regional Municipality, NS

The study area selected for local-scale examination was the community of Seaforth (Figure 4), which was identified as a COI through GIS analysis, as described in section 2.1.3. The selection of which was also supported by information gathered in the interview component (see section 3.3).

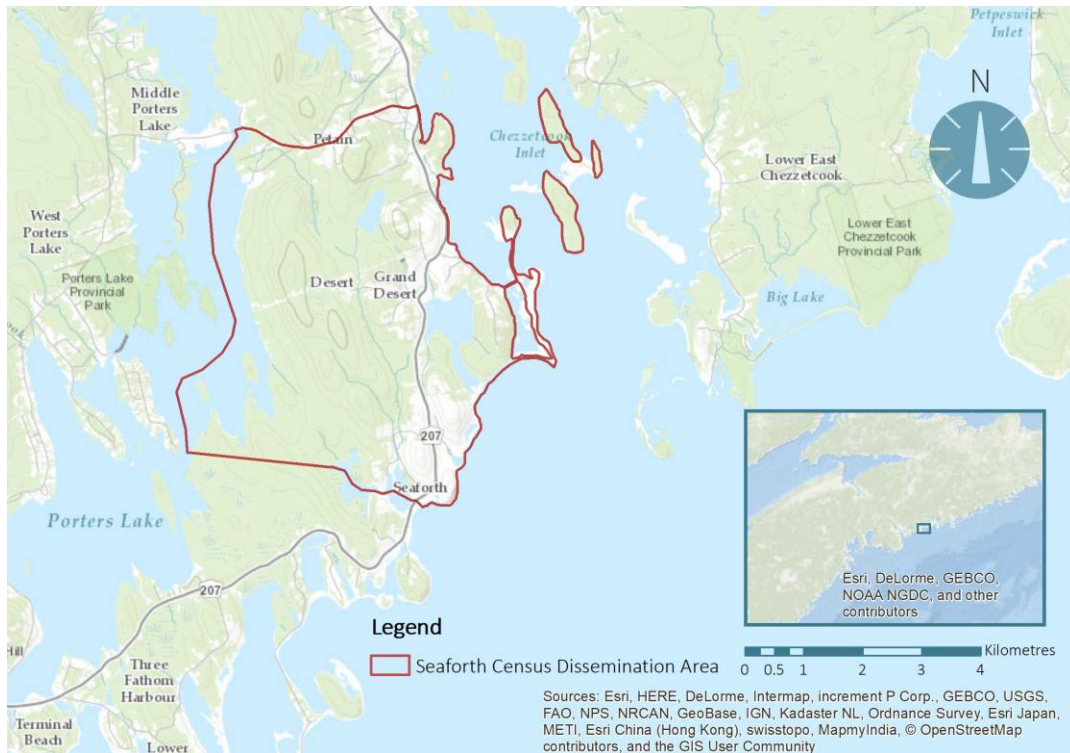


Figure 4. Map of local-scale study area, Seaforth, HRM, NS, Canada.

This community falls within the political boundary of District 2 (Preston-Chezzetcook-Eastern Shore) in the Halifax Regional Municipality (HRM), the capital region of NS, which is a geographically large district made up of approximately 80 communities and is predominantly rural (HRM, 2017). It is also located within the Eastern Shore aquaculture region, which has been characterized as having generally pristine and undeveloped coastlines. The extent of development, potential for contamination, and subsequent closures of shellfish growing and harvesting areas increases toward the more populated areas of the HRM (Stantec, 2009). Currently, there is no aquaculture activity taking place near Seaforth, with the closest lease sites being in Ship Harbour nearly 50 km east (Province of Nova Scotia, 2016b).

2.2.2 Surveys

Surveys were conducted in Seaforth (under Dalhousie ethics #2017-4160) to get an understanding of community perceptions to help determine suitability of CBMA in this area. Over 30 days from September to October 2017, the survey was administered through Opinio—a secure online survey tool housed on Dalhousie University servers. The sample population was determined to be the 2016 census dissemination area boundary (DAUID #12090944) that encompasses Seaforth and Grand Desert (Figure 4). The total population is 658 residents—an increase from 444 in 2011 (Statistics Canada, 2017). Respondents were required to be over the age of 18 to participate and, therefore, the population under the age of 18 ($n = 155$) was removed from the total size to establish a population of 503 people (Statistics Canada, 2017). Respondents were also required to identify as a member of the Seaforth community before they could continue with the survey. To achieve an industry standard of a 95% confidence level and 5% margin of error, a sample size of 219 respondents would be required. Survey recruitment occurred in the following ways: 1) email contact to local businesses and community groups, 2) posts on public Facebook community pages, 3) in person administered by tablet over two days (September 16 and October 14, 2017) at the Seaforth Market located in the Seaforth Community Hall, and 4) in print in the HRM District 2 news bulletin, which included a short description of the research and link to survey. The total number of survey respondents recruited was 47.

The survey format was adapted from D'Anna & Murray (2015), which employed a mixed methods approach that included interviews and surveys to determine community perception of shellfish aquaculture impacts on well-being in Baynes Sound, British Columbia (BC). The survey (Appendix 3) included a series of socio-demographic questions to examine factors that might affect perceptions (age, sex, income). Then, respondents were asked to rate a series of 10

statements related to the following themes: 1) coastal connection, 2) sense of community, 3) knowledge of aquaculture, 4) uses and benefits, and 5) CBMA. The statements were rated on a 5-point Likert-type scale where 1 = strongly disagree, 2 = disagree, 3 = unsure, 4 = agree, and 5 = strongly agree.

3 RESULTS & DISCUSSION

This section provides an exploration of CBMA as a coastal resource management strategy for aquaculture development in NS and pilots a method for examining the suitability of coastal communities based on social and ecological data. Stakeholder interviews first help to conceptualize the potential application of CBMA in the province. Next, GIS analysis reveals potentially suitable areas for CBMA development (or COIs) throughout NS. Finally, surveys employed on a local-scale provide insight into how community perceptions can be factored into the planning process. Although the results are focused on the context of NS, the integrated format broadens the perspective by discussing results in the context of relevant literature.

3.1 CONCEPTUALIZATION OF CBMA IN NS: STAKEHOLDER INTERVIEWS

The information from the stakeholder interviews was organized around five topics that aimed to understand the general opportunities for CBMA in NS, determine feasibility, and, ultimately, explore ways for the management strategy to be operationalized.

3.1.1 Aquaculture expansion

Before delving into the topic of CBMA, it was important to understand interview participant perceptions on the general suitability of NS for increased aquaculture development. Nearly all the sixteen interview participants (n = 14), across all stakeholder groups, agreed that it

was a suitable place for development. Although the reasons for suitability differed between participants, two indicators related to environmental conditions were consistently cited throughout all stakeholder groups: 1) size of coastline and 2) their perception of good water quality. The size (7,579 km) likely makes NS a suitable place due to the perceived amount of space for development, as well as provides a variety of environmental conditions that create opportunities for a diverse industry (Manning & Hubley, 2015; Sebert & Munro, 1972; Stantec, 2009). 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 category/participant #Dq-40). The perception of good coastal water quality, described by participants as “pristine,” “clean,” and “healthy,” 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 to densely populated industrialized countries or regions, but there is no clear depiction of the state of coastal water quality for NS and there are indications of pollution and contamination in certain urban and rural areas alike (Province of Nova Scotia, 2009b). Although there is good potential for aquaculture development, 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 to the smaller neighbouring Maritime province of

Prince Edward Island (PEI), stating “in the Northumberland Strait, our 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 category/participant #Dq-40). To provide more perspective on this, PEI has 1,260 km of coastline, yet it is the largest producer of blue mussels in Canada and second largest producer of American oysters behind BC (25,725 km of coastline) (Manning & Hubley, 2015; Sebert & Munro, 1972). This example illustrates the potential for increased shellfish production in NS.

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 that may stand to 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. Nevertheless, 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 category/participant #wv-31). This response is related to previous controversies around aquaculture in the province, namely social and environmental issues with finfish aquaculture (see Doelle & Lahey, 2014; Grant, Filgueira, & Barrell, 2016; Loucks, Smith, & Fisher, 2014, 2016). In the advent of increased development, there was a need identified for adequate conflict management between user groups and sustainable development. 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 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 category/participant # ag-75). Both the EAA and community-based management arrangements are intended to address social and ecological issues related to natural resource usage (Armitage, 2005; Fernandez-Gimenez, 2008; Galappaththi & Berkes, 2014; Pretty & Ward, 2001; Soto et al., 2008). Therefore, together, these two approaches may help to alleviate some of the concerns around future aquaculture development.

3.1.2 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 highly dependent on local context and perceptions and, therefore, its definitions can vary (Armitage, 2005; Beyerl et al., 2016; Castro & Nielsen, 2001; Gruber, 2010; Pretty & Ward, 2001). 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 category/participant #fJ-10). The idea that there is no singular formula for community-based management further touches on the understanding that such initiatives are context-specific, depending on the local needs and goals.

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 category/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 addresses critical issues related to resource access, enhances participation and local decision-making processes, and offers the ability for community members to obtain benefits (financial or otherwise) from resource management (Armitage, 2005; Fernandez-Gimenez, 2008). 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). In particular, integration is a critical component of the EAA and was expressed multiple times in the interviews (n = 5) to ensure that aquaculture expansion does not occur in isolation and instead works with other sectors to provide wider benefits to society. An example of CBMA operating in Madagascar emphasizes how aquaculture is integrated within broader community development efforts, including community and reproductive health programs, protected area development initiatives, and education at primary, secondary and university levels (Blue Ventures Conservation, n.d.; Slayer, 2012). The different ways for aquaculture to be incorporated into community development will differ case-by-case, depending on what the goals, wants, and/or needs are for the community.

For a Nova Scotian context, some generalizations for specific CBMA goals can be made based on interview responses, which are summarized under the umbrella goal of sustainability, including social, economic, and environmental sustainability⁵ (Table 1).

⁵ These three aspects of sustainability (social, economic, and environmental) have been identified as broad goals for aquaculture strategies in other regions of the world such as the European Union (Costa-Pierce, 2008) and, therefore, provide an appropriate categorization scheme for the goals identified by interview participants.

Table 1. Summary of CBMA goals based on interviews with multiple stakeholders in NS, Canada.

Social sustainability	Economic sustainability	Environmental sustainability
<ul style="list-style-type: none"> - Production of good quality and healthy food - Maintaining and increasing population - Supporting children and families - Resource-sharing and access - Cooperation and social inclusion - Meaningful skill-building activities - Training and education 	<p>Community-level:</p> <ul style="list-style-type: none"> - Keeping money in the community - Redistribution of wealth - Creating jobs - Increasing tax base - Spin-off benefits to other local business, ecotourism, etc. <p>Operational-level:</p> <ul style="list-style-type: none"> - Ensuring profitability and sustained financial stability - Establishing markets for products and/or services 	<ul style="list-style-type: none"> - Good resource stewardship - Increased connection to the marine environment - Establishing the appropriate scale for development

3.1.3 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: 1) governance, 2) economic, 3) social, and 4) environmental (Table 2). Many of the benefits are related to the interview participants’ understanding of CBMA, as well as possible goals outlined in Table 1.

Table 2. Summary of potential benefits and challenges of CBMA based on interviews with multiple stakeholders in NS, Canada.

Benefits	Challenges
<p>Governance</p> <ul style="list-style-type: none"> - Local empowerment and decision-making - Increased transparency - Resource access 	<p>Governance</p> <ul style="list-style-type: none"> - Navigation of regulatory process - Bureaucracy (“red tape”) - Adaptive capacity (quick decision-making)
<p>Economic</p> <ul style="list-style-type: none"> - 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 	<p>Economic</p> <ul style="list-style-type: none"> - Start-up costs and funding - Processing - Market access for product - Risk for investors - Labour market - Seed supply/hatchery - Potential displacement of commercial wild harvesters
<p>Social</p> <ul style="list-style-type: none"> - Education - Local food security/sovereignty - Eco/experiential tourism opportunities - Social interactions - Meaningful activity 	<p>Social</p> <ul style="list-style-type: none"> - Teamwork/consensus-building - Conflict - Capacity/knowledge
<p>Environmental</p> <ul style="list-style-type: none"> - Stewardship - Sustainable development 	<p>Environmental</p> <ul style="list-style-type: none"> - Climate change - Invasive species/species migration - Disease

The identified benefits further reiterate the 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 category/participant #ag-75). As for challenges, in addition to what was described as the “normal challenges for any business and starting up an aquaculture

farm” (industry stakeholder category/participant #RU-72), challenges around teamwork and conflict were also identified. These types of challenges are commonly referenced for community-based resource management initiatives, which highlights the importance of having conflict resolution mechanisms in place (Castro & Nielsen, 2001; Lane & 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 category/participant #RU-72). This is reinforced by the example of the involvement of a local school in CBMA 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). Opportunities for increased social learning and innovation has also been identified as a potential beneficial outcome of the diversity of perspectives, approaches, and sources of information and knowledge involved with collaborative resource management (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.

Should the benefits of CBMA can be maximized and the challenges overcome, all interview participants (n = 16) revealed the unanimous belief that CBMA is a feasible strategy that could be implemented to benefit rural communities in NS. 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 category/participant #ag-75).

The NS Community Economic Development Investment Funds (CEDIF) program (see CEDIF Canada, n.d.; Nova Scotia Department of Finance, 2016) was mentioned specifically as a potential way to fund CBMA development. Additionally, 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. Before funding for CBMA development is considered, there is first a need to identify suitable areas and interested communities.

3.1.4 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/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 indicators for areas included: 1) access relevant infrastructure (e.g. wharves, road access, processing facilities, etc.), 2) proximity to sheltered waterbodies, and 3) sense of community and/or tradition of resource sharing. Not all participants provided specific community names or regions, but there were two aquaculture regions that were the most commonly mentioned: Eastern Shore (n = 6) and Bras d’Or (n = 4). The Eastern Shore was thought to be suitable for CBMA because of the region’s low population density, as well as its less productive fishery, as compared to other regions such as the South

Shore or Fundy-Yarmouth. The Bras d'Or region was thought to be suitable because of its history of shellfish farming, current attempts to bring oyster farming back to the region, and the many First Nations groups within the region.

First Nations were commonly mentioned (n = 8) as a group that could be interested in CBMA development. First Nations groups are generally considered to be community-oriented because of their cultural values (Lee, 1992). Furthermore, the importance of seafood consumption to Coastal Indigenous peoples has been documented previously (Cisneros-Montemayor et al., 2016). The Mi'kmaq, a nation of 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 (McMillan & Prosper, 2016; Miller, 2004). CBMA, therefore, could present a potentially culturally-aligned development opportunity (Fleming, Petheram, & Stacey, 2015) for interested First Nations communities in the province.

Young people/families were 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 (Canadian Rural Revitalization Foundation, 2015; Harling Stalker & Phyne, 2014; Nova Scotia 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 community, with spin-off activities associated with it, allows for youth to start to envision a future for themselves within their community" (provincial stakeholder category/participant #gR-39). There is a need in the

province to attract and/or keep young people in rural communities, making CBMA a potential development opportunity to help do so.

Some participants (n = 8) thought 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 category/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 category/participant #nc-99). There was a discrepancy between interview participants on this, as there were others (n = 4) who 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 category/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 and experience with the local marine environment. In some regions of the world, aquaculture has been introduced as an alternative or supplemental livelihood strategy in response to fisheries declines (Crawford, 2002; Job, Do, Meeuwig, & Hall, 2002; Sheriff, Little, & Tantikamton, 2008; Sievanen, Crawford, Pollnac, & Lowe, 2005); 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 category/participant #zd-85). Regardless, this difference in opinion highlights the importance of consulting local fishermen as stakeholders in potential CBMA initiatives.

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 brought up the idea of using CBMA to support with 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 (Fay et al., 2012; Hamilton et al., 2005; Krasny et al., 2014; Rossi-Snook et al., 2010). 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 (Krasny et al., 2014; Rossi-Snook et al., 2010). In relation to this, 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 category/participant #ag-75). Active engagement in environmental stewardship programs can lead to behavioural changes that are favourable toward environmental activism and conservation (Jefferson et al., 2015; Ryan et al., 2001). Therefore, by engaging more people in aquaculture through CBMA, there may be improved overall stewardship for marine ecosystems in coastal communities, which supports the environmental-oriented principles of the EAA.

The concept of oyster gardening was also referenced (n = 3) when discussing opportunities for “boutique,” “hobby farm,” and/or “artisanal” aquaculture to take place in regions such as the Gulf Shore. This is a popular area for cottage owners and, therefore, much of the coastal land is under private ownership. One participant stated, “not everyone wants to see an aquaculture site when they wake up in the morning” (industry stakeholder category/participant #Pi-38), which calls into question the suitability of these types of areas to CBMA development. Perhaps with opportunities for coastal land owners to become involved with initiatives like oyster gardening, aquaculture development could become more socially acceptable in coastal areas with a lot of privately-owned land.

Other potentially interested groups described by interview participants included terrestrial farmers, local food movement supporters, academics, environmental groups, investors, entrepreneurs, seniors/retirees, and immigrants. It was also indicated multiple times (n = 5) that there would be a possibility for any person regardless of background and experience to be involved and contribute their knowledge. After all, community-based management does require a collaborative effort to make it possible.

3.1.5 Operationalization strategies

If suitable areas and interested communities are identified, the next step is determining how CBMA could be operationalized in terms of building public support, assembling the team, training, business planning, identifying governance approaches, and selecting operational models.

Whereas CBMA would be a new concept for the province, interview participants identified a need for advocacy and awareness of it and its potential benefits to build support. 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. 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 category/participant #Pi-38).

To put this in a global perspective, a handbook that was developed for the advancement of community-based freshwater aquaculture initiatives in remote rural areas of southeast Asia may prove to be a useful resource (SEAFDEC, 2007). It provides a series of training modules on a range of topics, including freshwater aquaculture techniques, participatory approaches for

community-based management of aquaculture, and business planning. Although this handbook was created specifically for a southeast Asian context, it could act as a guide for developing similar resources that can be used for CBMA in NS.

As for the governance approach, several 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 would, instead, must come from the “bottom-up.” Previous research related to coastal resource 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 approach versus “top-down” more centralized approach is commonly discussed in environmental resource management. Oftentimes, the “bottom-up” approach is advocated for in situations where the “top-down” approach has been perceived to have shortcomings or failures (Fraser et al., 2006; Lane & McDonald, 2005; Rhoads et al., 1999). Studies have cautioned against understanding these two approaches as dichotomous and, rather, they should be considered multi-scalar, ranging from decentralized (local) to centralized (federal) (Lane & McDonald, 2005). There are many ways that CBMA could be operationalized on a local-scale in NS, yet any initiatives would function within the federally and provincially regulated framework (Figure 3).

Much like how there was no singular definition given by interview participants for community-based management, there is no individual model for operationalization of CBMA. Also, there are many complexities in understanding how it could function, for example, this issue was raised when some interview participants (n = 2) brought up the significance of determining the difference between community-based versus community-owned. Arnstein's (1969) influential

“Ladder of Citizen Participation,” which is commonly invoked in literature on co-management (Berkes, 2007; Dovers et al., 2015; Sandström & Widmark, 2007), reveals that not all community-based initiatives will be created equal in terms of public control and participation. The ladder has eight levels (or rungs) of public participation, ranging from less participatory levels such as “manipulation” and “consultation” up to higher degrees of citizen power such as “partnerships,” “delegated power,” and “citizen control” (Arnstein, 1969). This model is often used to demonstrate the need to move from simply “selling people your ideas” on the lower rungs of the ladder to meaningful involvement of people in decision-making on the higher rungs (Gruber, 2010). It has been suggested that effective community-based management initiatives should work at the higher rungs of the ladder, with participation occurring at all stages of the planning and implementation process. Building off this idea, any operational models for CBMA in NS will also fall along a spectrum of public control and participation.

Interview participants identified some potential operational models that could be applied for CBMA in NS (Table 3), which included community ownership, community-based organizations, community partnerships, community-shared/-supported aquaculture, and cooperatives (co-ops) or “cluster” management.

Table 3. *Ideal type operational models for CBMA in NS based on interviews with multiple stakeholders.*

Ideal type of operational model	Description	Defining features	Examples and/or sources
Community ownership (n = 8)	Local-level government (e.g. municipality or First Nations Band Council) ownership and operation of aquaculture lease/license.	Lease/licence owned and operated by publicly elected body.	Waycobah First Nations Band Council aquaculture leases/licenses (Fisheries and Oceans Canada, 2015; Province of Nova Scotia, 2016b; The Chronicle Herald, 2013; Thompson, n.d.)
Community-based organization	Private ownership and operation of aquaculture lease/license by registered	Private ownership with	Development Isle Madame Association (Development Isle Madame Association, 2006;

Ideal type of operational model	Description	Defining features	Examples and/or sources
(n = 6)	non-profit, charity, NGO, business or social enterprise with community values, purpose, benefits, etc.	community values.	Province of Nova Scotia, 2016b), Community Interest Companies (Province of Nova Scotia, 2016a; Smith, 2016)
Community partnership (n = 2)	Partnership arrangement between multiple stakeholders, which may include the private sector (business, social enterprise, NGOs, etc.), public sector (varying levels of government), community members/groups, etc.	Multi-stakeholder type initiative.	Blue Ventures Conservation (Ateweberhan et al., 2014; Blue Ventures Conservation, 2015)
Community-shared/supported aquaculture (n = 2)	Community members purchase “shares” for goods produced by participating farms (private or community-based) and receive harvest. Opportunities for not only financial involvement from community members, but through labour as well.	Community member participation through provisioning of financing and/or labour needs.	(Campbell et al., 2014; Fieldhouse, 1996; MacMillan et al., 2012)
Cooperatives (co-ops)/ “cluster” management (n = 9)	Individual aquaculture operations (private or community-based) establish voluntary agreements/group management rules with other farms.	Individually-owned and operated aquaculture with group management regimes.	(Diana et al., 2013; Galappaththi & Berkes, 2014; Mills et al., 2011)

To clarify the defining features of the potential operational CBMA models, they have been identified as ideal types (Weber, 1978). This makes the diverse applications of the concepts consistent and helps to resolve the “conceptual chaos” involved in understanding these models, which, empirically, may not fit into clear categories (Zhang, 2016). This is because operational models could have multiple characteristics from the various ideal types identified, depending on community-context and stakeholder needs and values.

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 category/participant #zd-85).

As a step toward the potential development of this kind of CBMA initiative, one participant (local government stakeholder category/participant #aC-36) identified proactive efforts by the municipality to conduct water quality testing for establishing new shellfish aquaculture sites in their community to initiate rural economic development. The operational model for the potential development has not yet been determined, but one possible option they identified was for the municipality to start-up the operation and, then, auction it to someone within the community once the farm was well-established. Also, several interview participants (n = 4) referenced the Waycobah First Nations Band Council ownership of a rainbow trout (*Oncorhynchus mykiss*) farm in Whycocomagh Bay in the Bras d’Or Lake region (see Fisheries and Oceans Canada, 2015; The Chronicle Herald, 2013; Thompson, n.d.), as what could be considered an example of community ownership of CBMA currently operating in the province.

Interview participants (n = 6) referenced the opportunity for a community-based organization such as a non-profit, business, or social enterprise to be created, which would own

and operate the aquaculture lease and license. This model may involve the establishment of a community board of directors to oversee operations, with board meetings open to the public. A potential example of an arrangement such as this in the province that was referenced during the interviews (n = 1) was the Development Isle Madame Association (DIMA), a community-owned, non-profit limited company (see Development Isle Madame Association, 2006), which owns a six-hectare lease and licenses for aquaculture of various shellfish species, including bay quahaug, sea scallop, blue mussel, and American oyster (Province of Nova Scotia, 2016b). Although DIMA owns the leases and license, whether it is in operation is unknown.

Though it was not referenced in the interviews, it should be noted that legislation within in NS allows the opportunity for individuals and groups to establish and register social enterprises under the province's *Community Interest Companies Act (CICA)*, which could fit under the umbrella of community-based organization. According to this legislation, Community Interest Companies (CICs) are defined as a "hybrid corporate vehicle" that combines characteristics of "for-profit businesses with the social purpose nature of non-profit entities" and must have a "community purpose," which is beneficial to the "society at large" or "a segment of society that is broader than the group of persons who are related to the CIC" (see Province of Nova Scotia, 2016; Smith, 2016).

Community partnership, a multi-stakeholder type initiative, was another way in which some participants (n = 2) thought CBMA could be operationalized. This would involve the establishment of 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 Waycobah First Nations Band Council trout farm may also provide an example of community partnership. Although the Band Council owns

the leases and license for aquaculture, they partner with a private business called Coldwater Fisheries out of Ontario (Thompson, n.d.) to operate the farm. An international example of a community partnership arrangement is a CBMA project in Madagascar in which sea cucumbers (*Holothuria scabra*) and red algae (*Kappaphycus alvarezii*) are cultivated through a joint project between an international NGO called Blue Ventures Conservation and local community members referred to as the *Vezo* people. This also involves researchers and academia from a local university, as well as private business such as a seafood exporter and an aquaculture company that provides the juvenile sea cucumbers for grow-out (Astuti, 1995; Blue Ventures Conservation, n.d., 2015; Todinanahary et al., 2017).

Community-shared or -supported aquaculture was another potential operational model referenced by some interview 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). In this model, 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 (Campbell et al., 2014; MacMillan Uribe et al., 2012). Community-shared agricultural (CSA) and fisheries (CSF) initiatives have been applied widely and continue to grow in popularity (Campbell et al., 2014; Fieldhouse, 1996; Kis, 2014; MacMillan Uribe et al., 2012; Sarjanović, 2013). 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 category/participant #ag-75).

If participation can only occur by buying shares, then it may not be accessible for all community members from a socio-economic standpoint.

Another way interview 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 (Diana et al., 2013; Galappaththi & Berkes, 2014; Knowler, 2008; Mills et al., 2011). 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 & Berkes, 2014). Benefits for these kinds of arrangements include: 1) easier access to certification schemes, 2) collective power in marketing to local or export markets, and 3) pooling of resources (e.g. shared access to equipment for invasive species mitigation such as high pressure water treatment machinery for invasive tunicates) (Diana et al., 2013; Fisheries and Oceans Canada, 2010; Knowler, 2008). 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.

Although the interviewed stakeholders identified a variety of ways 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 category/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 “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 (Berkes, 2004; Folke et al., 2002; Ruitenbeek & Cartier, 2001). 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 (Blythe, 2013), any evaluation methods should include both environmental and socio-economic indicators. 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.

3.2 IDENTIFICATION OF POTENTIALLY SUITABLE COMMUNITIES: GIS ANALYSIS

GIS analysis was conducted to determine potentially suitable areas for CBMA, referred to as “Communities of Interest” (COIs), based on proximity to aspects of the following parameters: 1) biophysical/regulatory suitability, 2) community integration, 3) accessibility to infrastructure, and 4) potential social-ecological conflict. This analysis was done based on two different planning approaches. Through the “cautious” approach, which avoided areas of potential social-ecological concern, there were 373 COIs identified, while the “comprehensive” approach that did not avoid these areas yielded a total of 874 COIs (Figure 5).

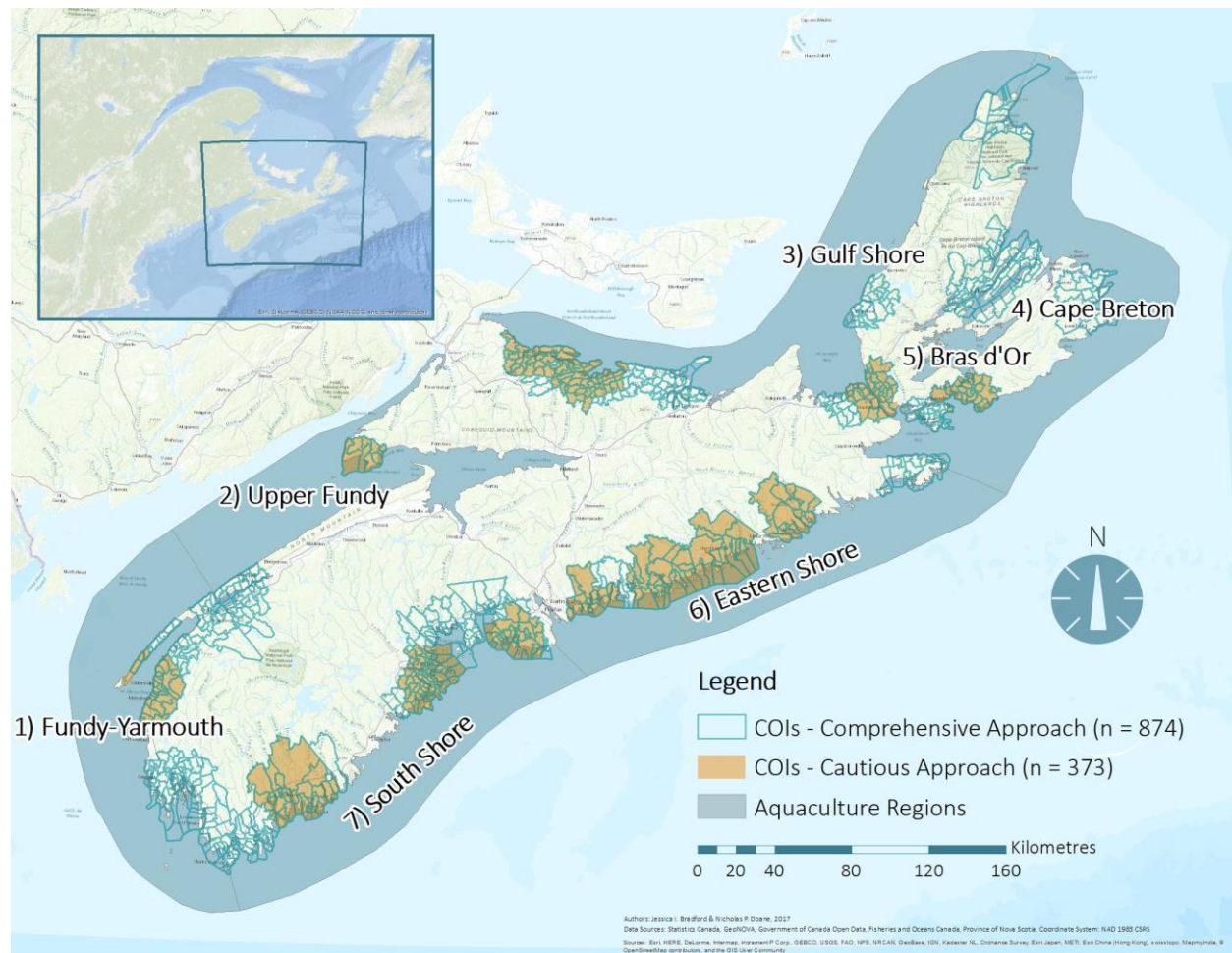


Figure 5. Map of Communities of Interest (COIs) identified through GIS analysis, using two different planning approaches.

The four parameters selected for this analysis were based on several assumptions of what the best-case scenario for the development of CBMA in NS would look like. For the first parameter, biophysical/regulatory suitability, the community would, ideally, be near or on a sheltered waterbody with good water quality, as indicated by the “approved” areas through the Shellfish Growing Area Classification in Canada. Second, for successful community integration, there should be forethought into how CBMA activities could feed back into the local community to provide livelihood and well-being benefits. This could be accomplished through, for example, involvement of local schools, providing supplemental income for families, supporting a community fund for health care initiatives or infrastructure development, and more. Third, there

should be local infrastructure that facilitates cost efficiency and ease of access to CBMA sites, which includes a publicly accessible wharf and year-round roads. Finally, any CBMA initiative must be generally accepted by the local community and, therefore, should avoid conflicting with existing uses of the shared waterbody. Instead, it should supplement and/or support already established activities and uses such as commercial fishing and ecotourism.

To avoid potential conflict with existing waterbody usage, the “cautious” approach, which eliminated any COIs within 1 km of EBSAs (marine conservation priorities), provincial and national parks, historic sites and military reserves, was applied. This reduced the number of potentially suitable areas indicated in the “comprehensive approach” (n = 874) by nearly half (42%) to 373. The reasoning for applying this approach was based on the guidelines used to establish siting criteria for marine finfish aquaculture development in BC. These guidelines require a “minimum separation distance” for aquaculture sites to be more than 1 km away from existing federal, regional and provincial parks, and/or or marine protected areas (Government of Canada, 2014; Stantec, 2009). As mentioned previously, aquaculture can be considered a conflicting use of the coastal commons because of the potential for resource user conflict and negative ecological effects (Murray & D’Anna, 2015b; Ottinger et al., 2016; Read & Fernandes, 2003), which is why there are certain planning strategies used such as the application of “minimum separation distances” in the case of BC.

Although it is important for aquaculture development planners, whether CBMA or otherwise, to factor these considerations into decision-making when determining suitability, it must also be recognized that being within 1 km of these types of areas is not a definitive factor that should halt aquaculture development. This is especially true if it is a development activity of interest to help meet community goals. Additionally, cultivation of both shellfish and seaweed

are often considered to be sustainable forms of aquaculture with potential environmental benefits and, therefore, may be more socially accepted (Eklöf et al., 2006; Phillips, 1998; Zemke-White & Smith, 1999). Furthermore, even though there are ecological effects of aquaculture, the effects are not always negative and there is potential for it to support goals beyond only economic development for coastal communities—a principle that is strongly aligned with the EAA (Soto et al., 2008).

Some examples of goals beyond economic development that aquaculture can support that are gaining traction include conservation and ecological restoration. For instance, there have been efforts to highlight the potential opportunities and synergies between aquaculture and both terrestrial and marine protected areas (Augustine & Dearden, 2014; Dempster et al., 2006; IUCN, 2017; Le Gouvello et al., 2017; Walton et al., 2015), thus demonstrating that aquaculture may not be a use of the coastal commons that has to conflict with conservation needs. After all, both aquaculture and MPAs rely on healthy marine ecosystems and good water quality (IUCN, 2017; Le Gouvello et al., 2017). Additionally, aquaculture development could provide financing opportunities for management and enforcement activities of an MPA (IUCN, 2017; Le Gouvello et al., 2017), which addresses what is often considered to be a major barrier to MPA effectiveness (Gill et al., 2017). Also, aquaculture practices such as oyster gardening, which was identified in the interviews, and seaweed farming have been used for ecological restoration purposes (Chopin, 2015; Chung et al., 2002; Fay et al., 2012; He et al., 2008; Krasny et al., 2014; Rossi-Snook et al., 2010; Xiao et al., 2017; Zhou et al., 2006). These examples of multi-purpose initiatives could be well-suited to CBMA efforts, as they can be designed to meet the needs of the communities. With communities taking control of such initiatives, it can also help to mitigate the potential for a phenomenon known as “ocean grabbing” to occur, described as the unjust

reallocation of marine resources and space (Bennett, Govan, & Satterfield, 2015). This can further support the social and environmental sustainability aspects of the EAA.

Recognizing these kinds of potential opportunities to integrate aquaculture development with other priorities such as conservation targets or ecological restoration, the “comprehensive” planning approach, featuring 874 COIs, demonstrates the great potential for CBMA throughout all regions of the province. A next potential step, beyond the scope of this research, would be to add other data layers that could represent additional opportunities for community integration beyond only the layer of public schools to further support CBMA planning. Determining opportunities for increased community integration would further solidify how CBMA could support the EAA through achieving human well-being goals, as well as ensuring that aquaculture is not developed through a single-sector approach (FAO, 2010). In the case of CBMA happening in Madagascar, it has been said that, in addition to protected area development and primary, secondary and university-level education, these initiatives are integrated with community and reproductive health programs (Blue Ventures Conservation, n.d.). Therefore, another potential data layer that could be hospitals and/or medical clinics to demonstrate opportunities to integrate CBMA programs with local health care initiatives. Other beneficial layers may include community halls or markets to identify places where the community members can gather and/or where locally-produced aquaculture products could be bought and sold. These are just a few potential examples of additional layers that could be added to identify opportunities for community integration, but there are likely many more, which would be dependent on local context and needs.

While this research component offers a pilot approach for determining areas potentially suitable to CBMA, there are limitations that must be acknowledged. The distances selected (e.g.

communities within 10 km of approved shellfish growing areas that are 10 km from public schools, 5 km from core small craft harbours, and .5 km from roads) were selected based on assumptions that they would be within an accessible range for community members. This requires further research to determine optimal distances for accessibility to CBMA sites, which would likely be community-specific. Additionally, simply because a community has been identified as a COI due to its proximity to the identified criterion, it does not mean that such an approach to aquaculture development will be desired or accepted by the community. Values and perceptions of community members are diverse, contextually-dependent and can vary at fine scales (Murray et al., 2016). Therefore, GIS analysis is a useful tool for planning and prioritization, but a complete understanding into some of the more nuanced characteristics that make certain areas more suitable than others for CBMA development is not provided and necessitates additional research to be undertaken in the communities.

3.3 EXAMINING COMMUNITY PERCEPTIONS: SURVEYS

After conceptualizing the management strategy for a Nova Scotian context and identifying potentially suitable areas in the province, the next important step is to examine possibilities for local implementation and understand how community perceptions can be factored into a socially equitable and ecologically sustainable CBMA program within the province. Perceptions have been said to affect every aspect of community-based natural resource management and are often disregarded in the planning process (Beyerl et al., 2016). Gaining an understanding of community perceptions can be genuinely integrated into CBMA development from the start, as opposed to only when issues are encountered, offers a proactive approach to planning. It can support the social sustainability aspects of the EAA by factoring human dimensions into the process (Bailey, 2008) As identified in the interviews, CBMA should be

initiated from the bottom-up and, therefore, development should not be pursued without community motivation. Additionally, there is a need to ‘ground truth’ (Steinberg & Steinberg, 2006) or verify the data that was gathered in the other research components to gauge community-level interest. These considerations provide the basis for local-scale examination and piloting a survey method to understand community perceptions in one of the identified COIs.

Seaforth was the community selected for local-scale examination (Figure 6). It was identified as a potentially suitable community through the GIS analysis, indicating that it met all the established COI criterion. Though it does not have CBMA suitability indicators (i.e. schools, small craft harbours or approved shellfish growing areas) within its immediate community boundary, it is centrally located between all those features and still within the specified distances. Also, Seaforth was one of the communities identified under the “cautious” approach, meaning it is at least 1 km away from any areas of potential conflict, which, in this case, would be the three provincial parks nearby.

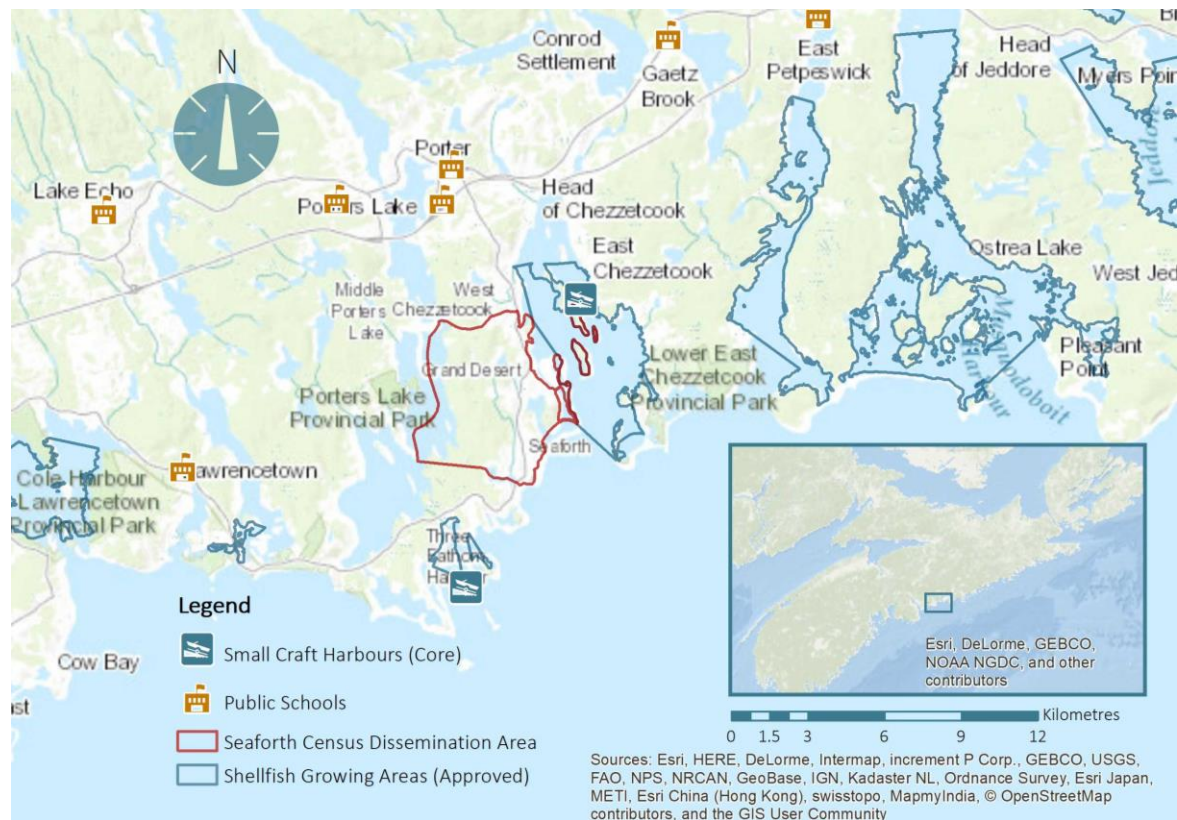


Figure 6. Map of Seaforth, local-scale study area, and surrounding communities, with CBMA suitability indicators.

Information gathered in the semi-structured interviews also helped in the selection of the study area through triangulation with the data from the GIS analysis. This further demonstrates the utility of applying a mixed methods approach for this research. Interview information first helped to narrow down the region, as the Eastern Shore aquaculture region was identified as a potentially suitable area the most number of times by participants ($n = 6$). One interview participant also indicated that there was a shellfish depuration and processing plant currently under construction in the community of Seaforth. Depuration is a purification process to hold shellfish in tanks of clean seawater under conditions that make them filter at maximum capacity and expel intestinal contents, including potential contaminants (e.g. faecal bacterial contaminants) (Lee et al., 2008). The ability to use such a facility can open access to previously

restricted or closed shellfish growing and harvesting areas. This is an important consideration for not only economic development, but also for local food security and sovereignty considerations. Also, it represents an opportunity for integration of CBMA activities with the depuration and processing plant similar to arrangements that have been established between First Nations communities and depurators in BC (Wiber et al., 2010). It is especially significant because previous experience in the Fundy-Yarmouth/Upper Fundy aquaculture regions of the province has shown that privatization of the clam fishery in the form of large aquaculture leases owned by depuration companies in closed areas has been met with community opposition and concern (Sullivan & Clean Annapolis River Project, 2007; Wiber et al., 2010). Without interviews to help inform this selection, these kinds of subtle, context-specific considerations would have been missed through GIS analysis alone.

As described in the methods (section 2.2.2), once the local-scale study area was selected, the next step was to administer the surveys to understand how community perceptions and values can be measured to help determine potential suitability and acceptability of CBMA. The survey had a total number of 47 respondents, which represents a 95% confidence level and 13.7% margin of error based on the population size of 503 people. The survey sample differed from 2016 census data by not having an even split between genders, with 61% females versus 35% males and 4% preferring not to identify (Statistics Canada, 2017). The age range was relatively even, with 47% of respondents between ages 18-44 and 52% being 45 or older; however, this differs slightly from 2016 census data where approximately 60% of the population is 45 or older (Statistics Canada, 2017). The income ranges of respondents were also divided relatively evenly, with the most respondents (27%) reporting an income range in the category of \$21,000 to

\$40,000. This is somewhat comparable to census data, which, in 2016, reported a median income of \$32,576 and an average income of \$42,221 for the sample area (Statistics Canada, 2017).

While socio-demographic questions can offer insights into factors that may influence perception (Beyerl et al., 2016; Murray et al., 2016), there are some limitations in this research because of the small sample size that does not accurately reflect the local context. For this reason, the ability for cross tabulation of data (e.g. influence of demographics on statement responses) is limited and survey data has instead been compiled and interpreted mainly in terms of single variable frequency distribution by theme to illustrate community perceptions and values. This was done based on five themes, encompassing two statements each: 1) coastal connection, 2) sense of community, 3) knowledge of aquaculture, 4) uses and benefits, and 5) CBMA.

Regarding coastal connection (Figure 7), there was a balanced response to the statement related to the ocean supporting livelihoods with answers across all levels. This signifies varying degrees of perceived reliance on and/or connection to ocean resources and services within the community. This could be attributed to the relativity of the term “livelihood,” as it could be perceived in many ways from providing food, jobs and its regulating services (e.g. air quality, climate regulation) to other services and values such as recreational, spiritual or cultural services (Millennium Ecosystem Assessment, 2003). Despite this ambiguity, most agreed (53%) that much of their time was spent near the water, indicating a strong coastal connection. This was to be expected, however, as the sample population is in an area that is no more than approximately 6 km from the ocean and, therefore, quite connected by proximity.

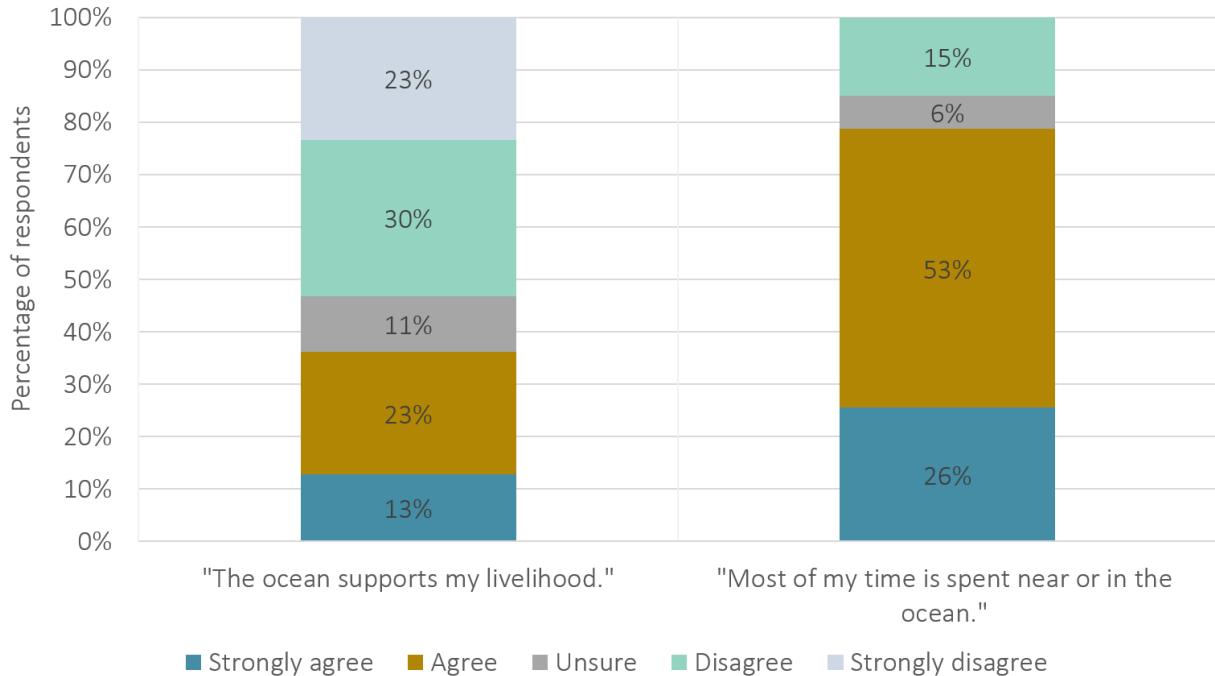


Figure 7. Summary of survey responses for theme 1 - coastal connection

For sense of community (Figure 8), respondents indicated feeling a strong sense of community where they lived with 49% of respondents agreeing and 40% strongly agreeing with the statement. Previous research has drawn parallels between sense of community and community participation, as well as identified the importance of understanding this relationship for planning and policy development (Aref, 2011; Mannarini et al., 2014; Talò et al., 2014). Therefore, the strong sense of community felt in Seaforth may indicate good potential for community participation in a CBMA endeavour. Although many (38%) agreed that the community is thriving, there was a degree of uncertainty with this statement, as 36% of respondents were unsure. This could be due to the relativity of the statement and how respondents may have conceptualized or defined “thriving.” Additionally, the relationship between CBMA suitability and whether a community is considered “thriving” or “not thriving” is unclear. If the community is thriving from an economic perspective, then perhaps it is less

suitable to CBMA initiatives, as there is not as much of a need for economic development. This notion was indicated in the interviews, as one participant had mentioned that CBMA may not be suitable for areas where traditional fisheries (e.g. the lobster fishery) is lucrative. However, if the community is thriving from a social cohesion perspective, as perhaps indicated by a strong sense of community, then it could be well-suited to CBMA. This indicates a need for further clarity on this aspect should this research method be applied again.

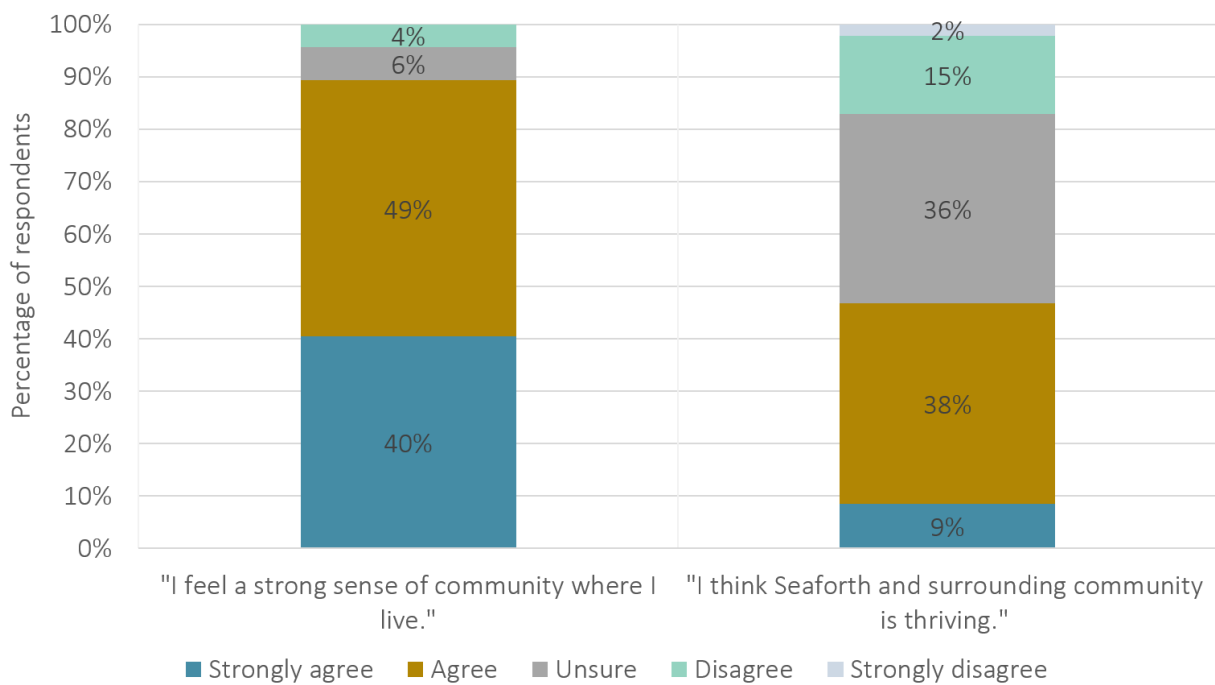


Figure 8. Summary of survey responses for theme 2 – sense of community.

The next theme for the survey was designed to gauge the respondents’ knowledge of aquaculture and understand their perspectives on the province’s suitability for aquaculture development (Figure 9). Respondents indicated that they did not feel informed about aquaculture in NS, with 32% disagreeing that they felt informed and 28% being unsure. The need for more information on aquaculture has been documented previously, for example, a report by the Senate Committee on Fisheries and Oceans found finfish farming in NS, in particular, to be often

misunderstood by the public (Manning & Hubley, 2015). Despite generally not feeling informed about aquaculture, respondents still felt that NS is a suitable place for aquaculture development. This is demonstrated by 36% of respondents strongly agreeing, 34% agreeing, and no respondents strongly disagreeing to increased development. This kind of information can help support a case for CBMA development in this area. It indicates a need for increased education (one of the goals/benefits of CBMA, as identified in the interviews), as well as signifies potential acceptance of aquaculture development locally. The results favouring aquaculture development come as somewhat surprising, as the public perception of aquaculture in NS was considered to be mixed, mainly because of the strong opposition to the expansion of open net-pen finfish farming (Mitchell, 2015). In the Eastern Shore region specifically, a community group, called the Association for the Preservation of the Eastern Shore, which is comprised of hundreds of concerned residents and business people, formed to oppose finfish aquaculture (Mitchell, 2015; Traversy, 2015), yet there is no indication of strong opposition in the survey results for this research. The emphasis on CBMA of shellfish and/or seaweed as the focus of this research, as outlined in the survey preamble (Appendix 3), and general social acceptability of these forms of aquaculture (Doelle & Lahey, 2014; Eklöf et al., 2006; Phillips, 1998; Zemke-White & Smith, 1999) may have helped to ease any concerns around this issue, thus potentially contributing to the favourability shown for aquaculture development.

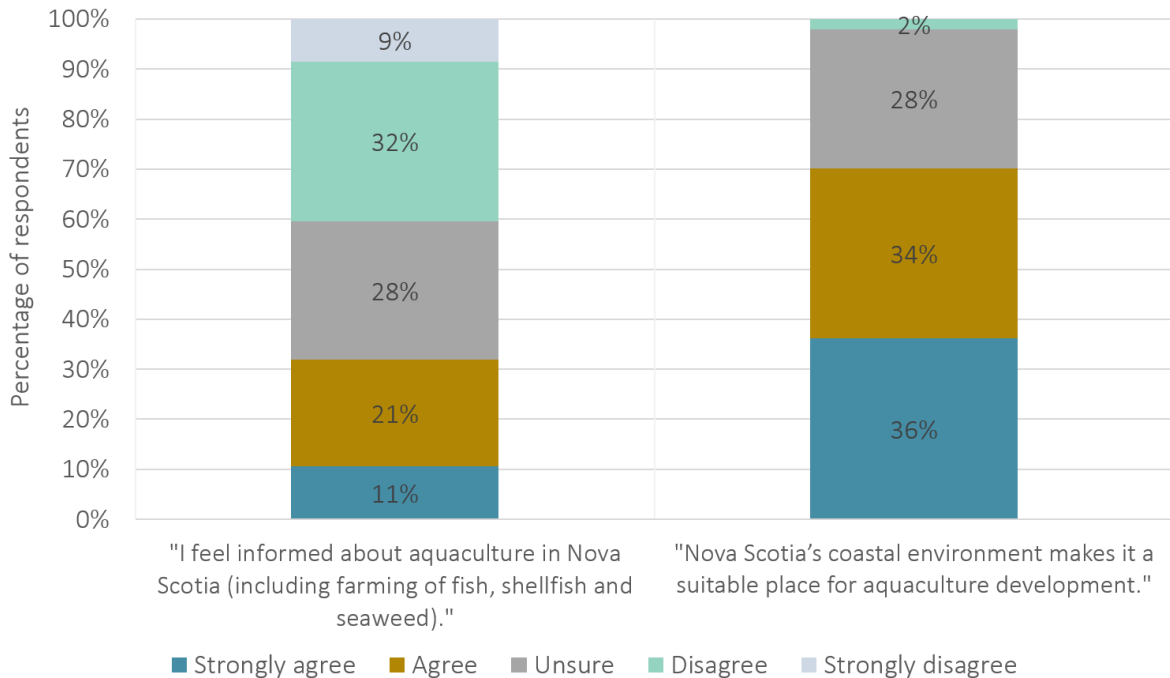


Figure 9. Summary of survey responses for theme 3 – knowledge of aquaculture.

As for potential benefits and challenges of aquaculture (Figure 10), respondents thought that aquaculture could bring benefits to rural coastal communities, with 47% strongly agreeing, 36% agreeing and no one indicating that they disagreed or strongly disagreed with the statement. Furthermore, as identified previously, one of the common challenges of aquaculture development is that it can conflict with other uses of the ocean (Ertör & Ortega-Cerdà, 2015; Ottinger et al., 2016; Read & Fernandes, 2003; Sanchez-Jerez et al., 2016); however, respondents specified that aquaculture does not have to conflict with the ways in which their community enjoys the ocean, 38% strongly agreeing and 40% agreeing. The favourability shown toward these two statements related to benefits and challenges may also highlight acceptance for aquaculture development locally, whether community-based or otherwise, as it is generally felt that it can bring benefits and can be developed in a way that does not conflict with other uses.

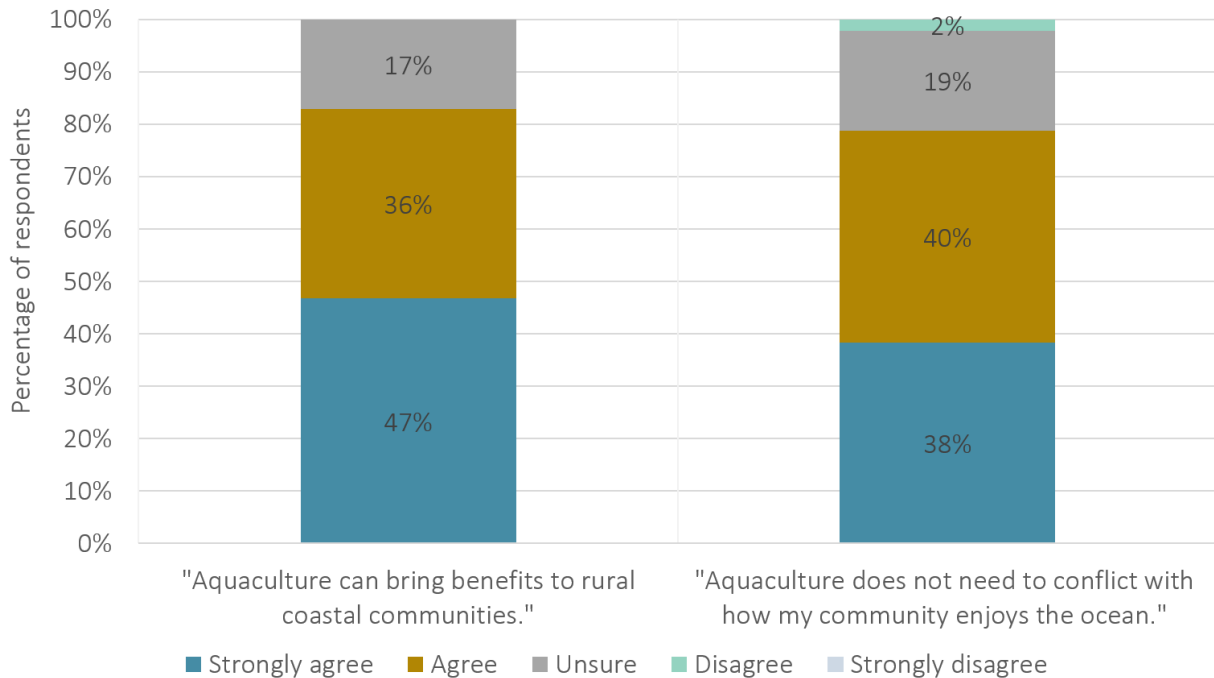


Figure 10. Summary of survey responses for theme 4 – benefits and challenges.

For the last theme, which involved statements directly related to CBMA (Figure 11), respondents demonstrated a high level of favourability toward the statement that “community members should work together to develop marine aquaculture,” as 51% strongly agreed and 36% agreed. Community-based management of natural resources necessitates a collaborative community effort toward a shared goal (Beyerl et al., 2016). Therefore, the response to this statement is particularly informative, as it indicates a preference for CBMA, which, simply put, involves community members working together on the shared goal of marine aquaculture development. However, although respondents may be in support of the idea of CBMA in principle, that does not necessarily mean they would like to be involved with it themselves. This is potentially demonstrated by the variability in responses to the other statement related to this theme in which respondents were to indicate whether they would personally like to work with community members to grow seafood. Though, still, with 38% of respondents agreeing, it

appears that there is interest in the opportunity to be involved with CBMA. The level of uncertainty indicated by 30% of respondents who were unsure may be related to the general sense that people do not feel knowledgeable about aquaculture in the province and, therefore, increased education and awareness of opportunities of CBMA may help to change this perception.

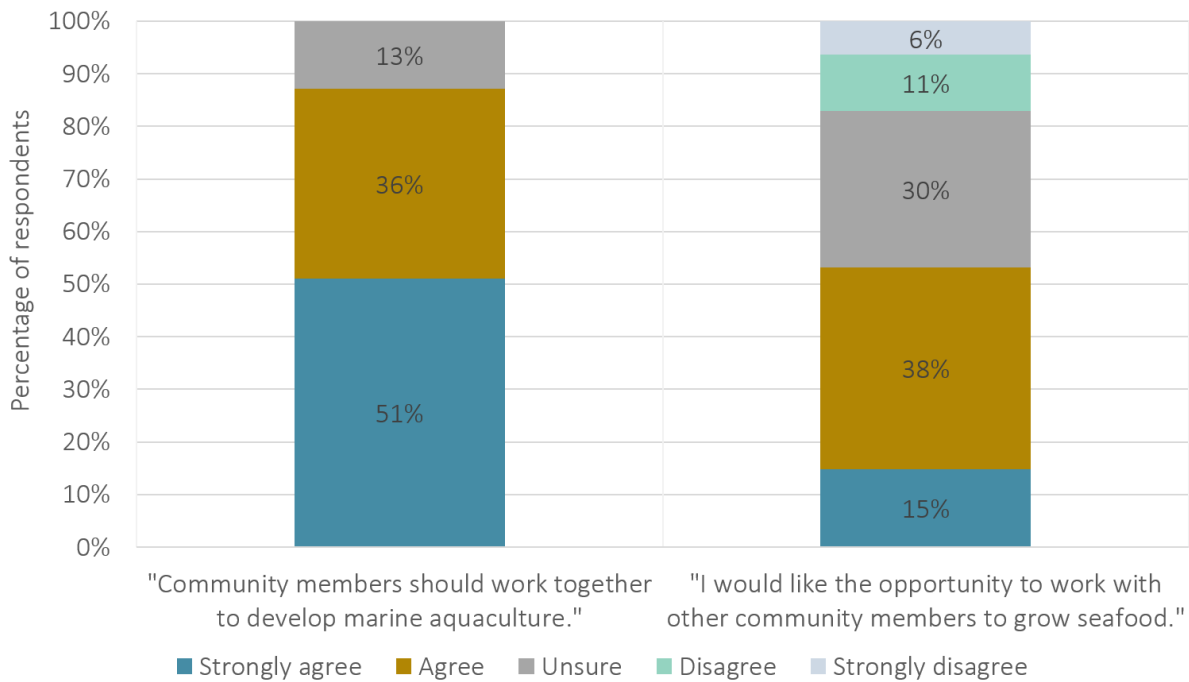


Figure 11. Summary of survey responses for theme 5 - CBMA.

Overall, the results of the survey indicate a high level of acceptance and interest in aquaculture and CBMA in Seaforth. The survey also provided the opportunity to pilot a method that can be used to examine how community perceptions can be factored into the planning process by helping to determine indicators of suitability and acceptability of CBMA. Moreover, while this was not captured in the formal survey research, anecdotally, public awareness of this project for survey recruitment purposes yielded a degree of interest in the region that is worth noting. The researcher was contacted on multiple occasions via phone, email, and social media

message from people in the Eastern Shore region interested in the concept of CBMA and its potential application in their communities.

Despite these indicators of community interest, there are limitations to this method that demonstrate opportunities for future research and refining of pilot methods. As identified previously, a larger survey sample size that is more reflective of the population and the ability to incorporate socio-demographics into understanding perceptions would provide a more accurate depiction of opportunities for CBMA in this community. Additionally, perceptions are formed by a variety of psychological factors (e.g. values, habits, attitudes, norms) beyond just socio-demographic background (Beyerl et al., 2016), therefore these aspects should also be considered. One other limitation was that the survey sample was limited to the census dissemination area that Seaforth was located within; however, there were many potential respondents from other areas outside of that boundary that may still identify as a member of the Seaforth community and could possibly be interested in being involved in CBMA. This touches on some of the difficulties around defining the term ‘community’ (Gurney et al., 2017; Kepe, 1999) and draws attention to the need to, perhaps, expand survey boundaries for future research. Finally, this research would further benefit from providing definitions for some of the more ambiguous terms and concepts in the surveys such as “livelihoods” to reduce variance in understanding between respondents.

Limitations aside, attempting to gauge perceptions remains an important component of community-based management research both in the planning stage and after implementation. Perceptions influence every stage of the process and an improved understanding of the dynamics between individual perceptions and group behaviours can better support longevity of initiatives (Bennett, 2016; Beyerl et al., 2016; Jefferson et al., 2015). This relates back to the need for adaptive management and design of socio-economic and environmental evaluation and

monitoring methods. Perceptions should be included in ongoing evaluation and monitoring, as it can provide a useful tool for measuring social indicators of success.

4 SYNTHESIS & CONCLUSION

As aquaculture continues to grow worldwide (FAO, 2016), there becomes even more of a need for improved participatory mechanisms that factor people into the policies and processes. Although the FAO has established the EAA to do so (FAO, 2010; Soto et al., 2008), there have been challenges in how to achieve some of its social sustainability goals (Costa-Pierce, 2008; Krause et al., 2015). This issue is heightened by the challenges faced in the coastal commons due to competing uses for space and resources, as well as the potential for negative ecological effects of aquaculture. CBMA emerges as a potential solution to better facilitate aquaculture development by supporting the human dimensions of the EAA through improved governance, participatory processes, and, perhaps, in some cases, social acceptability. It may allow for aquaculture development to better support livelihoods and well-being in rural coastal communities, while also potentially improving environmental sustainability and resource stewardship. This taps into current trends such as oyster gardening and terrestrial community gardens, encouraging more public participation in aquaculture activities to the benefit of local communities and advancing the industry. Should the concept grow and become of interest to governments, community groups, and individuals, there becomes a need for ensuring people are equipped with the resources and knowledge to initiate and sustain successful CBMA projects.

This research lays the groundwork for better understanding CBMA as a potential coastal resource management strategy in the context of future aquaculture development in NS, where it has not yet been formally applied or studied. The application of a mixed methods approach on

two different spatial scales, involving stakeholder interviews, GIS analysis and surveys, provides multi-faceted insights on CBMA and helps to synergistically validate findings. By starting with stakeholder interviews, the idea of CBMA was conceptualized. It was confirmed to be a feasible approach that could help facilitate increased marine aquaculture development, while supporting livelihoods in rural, coastal communities. Tangible planning and operationalization strategies were also identified and discussed, providing a foundation for understanding how the concept may be applied to a Nova Scotian context. The research also provides pilot methods for CBMA planning that offer a holistic understanding of suitability both spatially through GIS analysis and in terms of community perceptions through surveys.

Several limitations and challenges identified in this work highlight the need for further research to ensure interested governments and communities have adequate knowledge to possibly pursue CBMA development in an informed way. Therefore, in the case of NS, to fill data gaps and overcome potential challenges, it is recommended that future studies focus on improving planning and operationalization capabilities of CBMA. This would include: 1) refining GIS analysis to identify suitable areas based on additional environmental and socio-economic data, 2) conducting more detailed surveys in multiple COIs to capture a diverse range of factors that influence perceptions, and 3) the development of planning and operationalization guidelines such as a handbook (see SEAFDEC, 2007) that could be used by provincial and/or municipal planners to advance CBMA opportunities throughout the province in a socially and environmentally responsible manner. Additionally, this could help to establish partnerships and networks between academia, industry, NGOs, different levels of government, and communities interested in or already undertaking CBMA-related activities. By continuing this research based on these recommendations and moving toward potential CBMA development in suitable areas,

the province and local communities may have the opportunity to become leaders in industry innovation. This could support the advancement of CBMA other regions of Canada or elsewhere in the world, helping spread a concept that develops aquaculture with both people and environment in mind.

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APPENDICES

Appendix 1: Semi-structured interview questions

Participant background:

1. Can you tell me about your current occupation/role with [insert government department, business, organization, association or institution name]?
2. How long have you been in this position?
3. Can you tell me about any other related experience you may have had in other occupations?
4. How does your role support the mission and mandate of your [government department, business, organization, association or institution]?

Gauging knowledge base

5. What is your level of familiarity with community management of natural resources? And, if not natural resource management specifically, then can you tell me about any other examples of community management initiatives you're familiar with?
6. What is your level of familiarity with aquaculture?
 - a. Can you elaborate on what are you most/least familiar with?
 - b. If very familiar with aquaculture: Can you tell me about your knowledge of/or experience with marine aquaculture of shellfish and/or seaweed?

Marine aquaculture in NS

- a. Do you think Nova Scotia is a suitable place for increased marine aquaculture development? Can you elaborate on your response?
7. What are the potential benefits of increased marine aquaculture development for the province (provincial-scale)?
8. Potential challenges?
9. Can you think of any potential benefits that would be specific to the communities (local-scale)?
10. Potential challenges?
11. What do you think it means for something to be 'community-based'?
12. Do you know of existing marine aquaculture operations in NS that have any level of

community involvement?

13. If community-based management of marine aquaculture was implemented in select rural coastal communities in NS, what do you think the potential benefits would be?
14. Potential challenges?
15. Do you think community-based management of marine aquaculture in NS is feasible?
 - a. If not, why? What barriers might there be? On a provincial scale? Barriers on a local scale?
 - b. If yes, why? What makes NS a good place for this to happen?
 - c. Where do you think funding for this could come from?
16. Can you think of any particular areas in NS where community-based mariculture may be applicable?
 - a. Can you elaborate further? Why would this area be suitable? Describe the local context that makes this area suitable.
17. What types of people/groups do you think would be interested in getting involved?
 - a. Think about demographics. Can you elaborate further? Why these people or groups over others? Would they have the means to get involved? Would they get more benefit out of involvement over others?
18. What should be the goals of community-based marine aquaculture?
19. You have identified some of the desirable goals being X,Y,Z. How do you think community-based marine aquaculture could best be designed, implemented, and managed to achieve these goals?
 - a. In other words, how do you see this being operationalized?

Thank you for your time. Before we end the interview, do you have any additional comments or insights that may help to inform this research?

Appendix 2: Data layers used for GIS Analysis

Data layer	Notes	Source
Geospatial Boundaries of Shellfish Growing Area Classification in Canada	These are areas suitable for growing and harvesting shellfish. Data on sanitation and water quality is collected by Environment and Climate Change Canada to inform this data layer.	(Government of Canada, 2015)
Aquaculture regions	N/A	(Stantec, 2009)
Small Craft Harbours	The layer provides information about access to harbours that are open and in good repair that can be used by commercial fish harvesters and other harbour users.	(Fisheries and Oceans Canada, 2017)

Data layer	Notes	Source
Nova Scotia Topographic Database - Roads, Trails and Rails	N/A	(Province of Nova Scotia, 2015b)
Nova Scotia Map & Directory of Public Schools	N/A	(Province of Nova Scotia, 2017)
Nova Scotia Topographic Database - Delimiter Lines	Provincial Parks, National Parks, National Historic Sites, Military Reserves and Historic Sites selected from this layer and merged to create new layer that represents potential land-use areas of concern that could present user conflict.	(Province of Nova Scotia, 2015a)
Ecologically and Biologically Significant Areas in the Atlantic Coastal Region of Nova Scotia	N/A	(DFO, 2014)
Nova Scotia Community Boundaries	This layer was established in consultation with NS municipalities, factoring input from municipal councillors, Emergency Health Services, local fire and police departments, etc.	(Province of Nova Scotia, 2016c)
2016 Census Profiles Files - Profile of Census Disseminations Areas (Population and dwelling counts)	2016 Canadian census data with geo-spatial boundaries accessed through Computing in the Humanities and Social Sciences (CHASS) at University of Toronto.	(CHASS, 2016)

Appendix 3: Survey example

Introduction:

This survey is a part of a research project conducted by Jessica Bradford, a graduate student in the Master of Marine Management program at Dalhousie University.

Purpose: To investigate opportunities for community-based management of marine aquaculture in NS.

Terminology:

- **Marine aquaculture:** farming of aquatic plants and animals in a saltwater environment

- **Community-based aquaculture:** involving community members in the planning and operation of aquaculture development

Focus: Community-based marine aquaculture of shellfish and/or seaweed in rural coastal communities in NS.

Research process:

1) The first part of this study involved identifying potential coastal communities of interest in NS and conducting interviews with members from 4 groups: 1) provincial representatives, 2) municipal representatives, 3) industry, and 4) the research and education sector.

2) The second part of this study (that you are being asked to participate in) involves administering surveys in two coastal communities selected to get an understanding of community perceptions related to community-based aquaculture.

Who is being asked to take part in this study:

- You may participate in this survey if you identify as a member of *Seaforth and surrounding community*.
- Participants must be over the age of 18 years old.

What will be asked of participants:

Participants must review this introduction and consent to participate. Survey time should be approximately 5 minutes once you begin. The survey is available online, in person on tablet or paper, or by mail.

Additional information:

- This study is entirely voluntary and there will be no compensation provided for your involvement. However, your participation in and contribution to this research is **greatly** appreciated.
- Your participation in this survey will remain anonymous. The online survey is administered through *Opinio*, a safe and secure online survey tool housed on Dalhousie University servers.
- If you begin the survey and wish to stop participating before completion, you may quit and none of the survey responses will be collected or stored.

If you have questions:

Please contact the primary researcher (Jessica Bradford), who can answer any questions you have about the study, or your participation in it. She can be reached at your convenience at Jessica.Bradford@dal.ca or (902) 440-5503.

If you have concerns about the ethics of this study, or your potential participation in it, please feel free to contact Research Ethics, Dalhousie University, at 902-494-1462, or email at ethics@dal.ca (reference REB file #2017-4160).

Thank you in advance for your participation.

1. Having read the above:

- I agree to participate in this study under the terms and conditions outlined in the introduction.
- I confirm that I am 18 years of age or older.
- I confirm that I identify as a member of Seaforth and surrounding community in NS.

Check One:

- Yes
- No

Demographics (Check one per question):

2. How old are you?

- 18-24
- 25-34
- 35-44
- 45-64
- 65 or older

3. What is your gender?

- Male
- Female
- Prefer not to say

4. What is your annual income?

- Under \$20,000
- \$21,000 - \$40,000
- \$41,000 - \$60,000
- \$61,000 - \$80,000
- Above \$81,000

Statements (Check one answer per statement):

5. The ocean supports my livelihood.

Strongly disagree Strongly disagree Disagree Unsure Agree Strongly agree Strongly agree

Strongly disagree Strongly agree

6. Most of my time is spent near or in the ocean.

Strongly disagree Strongly disagree Disagree Unsure Agree Strongly agree Strongly agree

Strongly disagree Strongly agree

7. I feel a strong sense of community where I live.

Strongly disagree Strongly disagree Disagree Unsure Agree Strongly agree Strongly agree

Strongly disagree Strongly agree

8. I think Seaforth and surrounding community is thriving.

Strongly disagree Strongly disagree Disagree Unsure Agree Strongly agree Strongly agree

Strongly disagree Strongly agree

9. I feel informed about aquaculture in Nova Scotia (including farming of fish, shellfish and seaweed).

Strongly disagree Strongly disagree Disagree Unsure Agree Strongly agree Strongly agree

Strongly disagree Strongly agree

10. Nova Scotia's coastal environment makes it a suitable place for aquaculture development.

Strongly disagree Strongly disagree Disagree Unsure Agree Strongly agree Strongly agree

Strongly disagree Strongly agree

11. Aquaculture can bring benefits to rural coastal communities.

Strongly disagree Strongly disagree Disagree Unsure Agree Strongly agree Strongly agree

Strongly disagree Strongly agree

12. Aquaculture does not need to conflict with how my community enjoys the ocean.

Strongly disagree Strongly disagree Disagree Unsure Agree Strongly agree Strongly agree

Strongly disagree Strongly agree

13. Community members should work together to develop marine aquaculture.

Strongly disagree Strongly disagree Disagree Unsure Agree Strongly agree Strongly agree

Strongly disagree Strongly agree

14. I would like the opportunity to work with other community members to grow seafood.

Strongly disagree Strongly disagree Disagree Unsure Agree Strongly agree Strongly agree

Strongly disagree Strongly agree

Closing:

Thank you to those of you who completed the survey. Your answers are greatly appreciated and a valuable part of this research.

Should you have any questions or would like a summary of results, please feel free to contact the primary researcher, Jessica Bradford, at Jessica.Bradford@dal.ca or (902) 440-5503. The results will also become available online in January 2018 as a requirement of the researcher's graduate project for the Master of Marine Management program at Dalhousie University.