

Towards Ecosystem-Based Management of Shellfish Aquaculture in British Columbia, Canada:
An Industry Perspective

by

Melanie Paula Mamoser
BSc., Mount Allison University, 2005

A Thesis Submitted in Partial Fulfillment of the
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Supervisory Committee

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Supervisory Committee

Dr. Rosaline Canessa, (Department of Geography)
Supervisor

Dr. Stephen Cross, (Department of Geography)
Departmental Member

Dr. Jutta Gutberlet, (Department of Geography)
Departmental Member

Abstract

Supervisory Committee

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Supervisor

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Departmental Member

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Departmental Member

With declining wild fisheries and increasing seafood demand from a growing population, attention has turned to aquaculture in general, and shellfish aquaculture in particular, to meet this demand. Aquaculture has grown dramatically in the last twenty years through intensification of operations and the expansion of the industry into new areas. This growth has been associated with environmental degradation and social conflict leading some to question its sustainability. However, those studying the problem point to significant opportunities for sustainable forms of aquaculture by focusing on the cultivation of species such as shellfish and the adoption of ecosystem-based management (EBM).

Shellfish aquaculture has a long history in British Columbia (B.C.), Canada with an abundance of coastline and suitable water conditions. There is significant development potential for shellfish aquaculture in B.C., which creates an opportunity to ensure this development occurs in an ecologically sound way through the use of governance approaches like ecosystem-based management. Transitioning from conventional approaches to resource management to an ecosystem-based approach presents several challenges particularly for the management of one sector.

This study highlights how an understanding of the industry and the existing governance context can inform the implementation of EBM. The specific research objectives include: (1) to understand the governance system for shellfish aquaculture in B.C.; (2) to understand the shellfish aquaculture industry within the context of EBM; and (3) to explore EBM as an approach to governance in the shellfish aquaculture industry in B.C. The main method of inquiry is a questionnaire survey (October 2006 to February 2008) of the shellfish aquaculture industry. Supporting methods include an analysis of

industry data, an in-depth analysis of government documents, policies and regulations, and targeted interviews with federal and provincial government regulators. The empirical knowledge gained through the main research instrument was combined with the contextual knowledge gained through the supporting methods to achieve a more holistic understanding of the case study.

The results show that the governance setting for the shellfish aquaculture industry is multi-lateral and the lack of comprehensive and targeted legal instruments, and the ill-use of marine spatial planning and conflicts with other coastal users have together contributed to an inefficient and costly site application process. EBM has the potential to address some of these challenges with the current governance process by making some decisions on an ecosystem-scale as opposed to an application-by-application basis, such as assessing the presence of fish habitat and consulting with stakeholders.

The results of the survey of the shellfish aquaculture industry show that the industry is geographically diverse, and understands and values the connection between their business and the large ecosystem. This suggests that the industry may be supportive of EBM. However, the industry faces many economic challenges that may influence their capacity to participate, as such regulators should look towards the use of economic incentives to achieve policy objectives.

Although this research provided several recommendations for management and the industry in moving forward with this new approach to governance, three fundamental elements are needed:

- marine spatial planning that is integrated within the governance framework;
- the integration science and management through adaptive management including an ongoing monitoring framework that informs governance strategies; and,
- engaging the industry as active partners in this governance approach through co-management.

This research makes significant contribution to understanding the shellfish aquaculture industry in B.C. Prior to this study there was little information available characterizing the structure and socio-economic make-up of the industry. The results of the survey and the in-depth analysis of the governance context for the shellfish aquaculture industry provide a previously unavailable base of information from which to build future studies. In addition this research

contributes to the growing body of literature on EBM assessing the potential challenges and opportunities for moving the theoretical concept into practice.

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Dedication

I would like to dedicate this thesis to the shellfish farmers in B.C.

Chapter One: Introduction

1.0 Introduction

Consumer demand for seafood has grown dramatically over the last thirty years as the population of the world increases and as more people choose seafood as a source of protein (United Nations Food and Agriculture Organization [FAO], 2010). Until recently, the majority of seafood production came from the capture of wild fish, a practice akin to hunting the sea. Today half of the commercial fish stocks are considered fully exploited and a quarter over fished or collapsed resulting in a virtual stagnation of wild captured fisheries production (FAO, 2010). This has had a dramatic effect on the population of many fish species and, consequently, the biodiversity, health and resilience of the oceans (Pauly *et al.*, 2005; Worm *et al.*, 2006). Aquaculture is increasingly promoted by governments as a desirable way of changing the way we exploit our oceans to meet growing demand for seafood, providing economic development in rural communities traditionally dependent on wild fisheries and preventing the overexploitation of wild fisheries (e.g., Canada and New Zealand). However, others warn that aquaculture could become a contributing factor to the collapse of fisheries stocks through the reliance of wild fish for feed and the modification of habitat (Naylor *et al.*, 2000).

Aquaculture refers to the farming of aquatic organisms including fish, shellfish and seaweed. Farming implies some form of intervention in the rearing process to enhance production and individual or corporate ownership of the stock being cultivated. Over the course of history, human societies have adopted various forms of farming, including that of aquatic organisms, in order to increase the production of food and stabilize supply (Pillay, 1990). Today, aquaculture provides almost half the world's total food fish supply, and it is the fastest growing food production industry in the world (FAO, 2010). Therefore, it seems aquaculture is here to stay. The question is then how do we turn to aquaculture to meet the demand for seafood without doing further damage to the ocean?

The dramatic growth in aquaculture has been described as a “blue revolution” similar to the green revolution in agriculture that dramatically increased production of land-based food through the expansion and intensification of production made possible by technological innovation (Brush, 1992). Like the green revolution, the blue revolution in aquaculture implies

the intensification of production and the expansion of cultivated areas made possible by technological innovations and research (Soto *et al.*, 2008). However, the reliance on technology in agriculture disconnected the system of production from the ecosystem allowing levels of production that surpassed the natural carrying capacity and introduced new synthetic products in the form of chemical fertilizers, herbicides and pesticides not naturally found in the system. This results in the degradation of ecosystems through the overexploitation of soils, the contamination and overuse of water, the eutrophication of the water bodies, and decreasing biodiversity (Pimental *et al.*, 1995; Matson *et al.*, 1997; Robertson, 2000).

Like the green revolution, the expansion and intensification of aquaculture has been associated with environmental degradation and social conflict leading some to question its sustainability (Naylor & Burke, 2005). Those studying the problem point to significant opportunities to improve the sustainability of aquaculture by focusing on the cultivation of lower trophic species such as shellfish and seaweed, and by adopting more ecologically sound practices and resource management, such as ecosystem-based management (Naylor *et al.*, 2000; Gibbs, 2004; Neori *et al.*, 2004; McLeod *et al.*, 2005). This thesis will explore the challenges and opportunities to transition towards a more ecologically sound resource management approach, ecosystem-based management, through a case study of the shellfish aquaculture industry in British Columbia, Canada.

1.1 Ecosystem-based Management

Ecosystem-based management is an approach to natural resource and environmental management aimed at maintaining or restoring the productive capacity of ecosystems. The approach developed from a growing awareness of the fundamental role ecosystems play in sustaining natural resources and the increasing impact human activities are having on ecosystems (Grumbine, 1994; United Nations Millennium Ecosystem Assessment [MEA], 2005). When applied to resource management, EBM means that development must be practiced within the limits of the ecosystem. Advocates of this approach argue that the growing crisis in marine ecosystems is in large part due to a failure of governance (Crowder *et al.*, 2006). Conventional approaches to natural resource management developed prior to an understanding of the connection between resources being exploited and the ecosystem sustaining their production are

designed around individual sectors. This presents two major challenges for connecting governance with ecosystems. First, the boundaries of management are not aligned with the ecosystem (Cumming *et al.*, 2006; Crowder *et al.*, 2006). Second, sectoral management fragments management actions within a given ecosystem making it difficult to account for the cumulative effects of activities on that ecosystem (Crowder *et al.*, 2006). Fundamentally, EBM aligns natural resource management with ecosystems by integrating management of all activities in one place (Crowder Norse, 2008).

The ecosystem as a scientific concept is relatively new, first conceptualized in 1935 by Arthur Tansley; however, the concept has been prevalent in many indigenous cultures (Berkes *et al.*, 1998). A number of definitions of an ecosystem exist in literature, the following is the one adopted by the Convention on Biological Diversity: “a dynamic complex of plant, animal and micro-organisms communities and their nonliving environment interacting as a functional unit” (United Nations Convention on Biological Diversity, 1992, p.3). This definition highlights three important characteristics of ecosystems. First, ecosystems are places with unique structures, processes and challenges. Second, ecosystems are complex and dynamic. And third, ecosystems are fundamentally about connections.

Shifting the focus of natural resource management from resources to ecosystems creates several challenges for the structure and process of government institutions. First, resource management must become more place-based to capture the connection between resource use and the ecosystem (Grumbine, 1997). Second, managers will have to be flexible to adapt to the dynamic characteristics of ecosystems (Grumbine, 1997). Finally, the challenges facing ecosystems cannot be addressed by government alone; they will require the engagement of stakeholders with an interest in maintaining healthy ecosystems (Yaffee, 1999).

The theoretical literature on EBM is filled with thoughts on how to implement this complex concept into practice. The applied literature makes clear that there is no single way of implementing EBM because it depends on the ecological, social, economic and institutional context. The majority of the applied literature looks at the implementation of EBM across a defined geographic area or focuses on the governance challenges of implementation. There is little research, however, looking at the implementation at the scale of an individual industry in the absence of a larger EBM plan nor the role an industry can play within a governance framework. This research addresses this gap in the current literature by exploring the

governance of shellfish aquaculture in British Columbia (B.C.) Canada within the context of EBM. The following section will describe the shellfish aquaculture industry in B.C. and the current approach to management.

1.2 Shellfish Aquaculture in British Columbia

British Columbia (B.C.) is ideally suited for shellfish aquaculture. There are approximately 25,725 kilometres of heavily indented coastline providing many sheltered bays and inlets (Sebert & Munro, 1972). The coastal waters are temperate, productive and free of pollution outside more developed areas on the southern part of the province (Quayle, 1998). In fact, B.C. has a long cultural history of aquaculture. The first shellfish aquaculture operations were established at the turn of the 20th century. In addition, recent research shows that First Nations traditionally enhanced the production of clams by manipulating beaches (Williams, 2006).

The shellfish aquaculture industry in B.C. is a \$16.3 million dollar industry producing 7,300 tonnes of mostly oysters (*Crassostrea gigas*) and clams (*Venerupis philippinarum*) in 2009 (Fisheries and Oceans Canada [DFO], 2010). A study of the industry's potential commissioned by the provincial government in 1998 concluded that the industry could generate \$100 million (Coopers & Lybrand Consulting, 1998). The significant growth potential creates an opportunity to ensure the growth is managed in an ecologically sound way.

The management of shellfish aquaculture is predominantly undertaken on an application-by-application basis, which limits the potential for assessing potential ecosystem effects such as cumulative effects and carrying capacity. In addition, the application process is cited as one of the major challenges to the growth of the shellfish aquaculture industry (Howlett & Rayner, 2004). These problems are even recognized by the government: "Access to sites has also been made difficult because of the limitations of the current federal-provincial siting process, which is based on an application-by-application approach and not long-term, proactive plan" (DFO, 2002, p.21). One way of increasing the efficiency of the current process is to depart from a case-by-case model to an ecosystem approach under EBM.

1.3 Towards EBM of Shellfish Aquaculture

The foundation is already set for the introduction of an ecosystem-based management approach to shellfish aquaculture in British Columbia. The provincial government has undertaken various coastal and land-use planning initiatives to support the development of shellfish aquaculture as part of an ongoing process to support local economies in coastal communities. In addition, the province is taking an ecosystem-based management approach to land-use planning in the Central and North Coast of B.C. (Ministry of Agriculture and Lands [MAL], 2009). The federal government through their responsibilities under the *Oceans Act* (1996) initiated an ecosystem-based and integrated management plan called the Pacific North Coast Integrated Management Area, which covers much of the marine environment adjacent to provincial planning area.

More specific to aquaculture, Fisheries and Oceans Canada adopted a policy framework committed to supporting aquaculture development in a manner consistent with its commitments to ecosystem-based and integrated management (DFO, 2002):

“Within the context of ecosystem-based and integrated management, DFO will encourage provincial and territorial government, the aquaculture industry, communities and other stakeholders to begin working together to identify regional aquaculture growth objectives and to select biophysically and socially suitable areas for aquaculture development” (p.21)

This policy commits to expanding the management of shellfish aquaculture from a site-by-site approach to a more regional approach. Although almost a decade old, no new policy has been released. In addition, the policy is a reflection of a legislative mandate for ecosystem-based and integrated management under the *Oceans Act* (1996) and therefore is still relevant.

The management framework for shellfish aquaculture recently changed. In February 2009 the B.C. Supreme Court upheld a lower court decision which argued that the provincial government’s regulatory powers over aquaculture are unconstitutional because aquaculture is a fishery and therefore falls under the legislative authority of the federal government and that a Memorandum of Understanding (MOU) between the two levels of government, which gave administrative authority over the industry to the provincial government, is an unconstitutional

delegation of power (Morton v. British Columbia (Agriculture and Lands), 2009). As a result, the federal government took over regulatory power for shellfish aquaculture in December 2010. It is an opportune time to be looking at how to implement the federal policy of aquaculture development within an EBM context.

1.4 Research Goal, Objectives and Questions

Given the context outlined above, there is significant development potential for the shellfish aquaculture industry in coastal British Columbia. In recognition of this development potential and more broadly the need to adopt more ecologically sound approaches to the management of Canada's oceans, the federal government has adopted EBM into law and policy. Transitioning from conventional approaches to resource management to an ecosystem-based approach presents several challenges particularly for the management of one sector. Through a case study of the shellfish aquaculture industry in B.C., this study highlights how an understanding of the industry and its governance can inform the implementation of EBM.

The specific objectives and questions that this study addresses are:

1. To understand the governance system for shellfish aquaculture in B.C..
 - a. What are the laws that establish the framework for management?
 - b. What are the provincial and federal government policies that define the course of action?
 - c. How are the laws and policies applied in the evaluation of new shellfish aquaculture applications?
 - d. What are the challenges with the current governance system from the perspective of government regulators?
2. To understand the shellfish aquaculture industry within the context of EBM.
 - a. What are the characteristics of the industry with respect to employment, operations and goals?
 - b. Do shellfish farmers value the ecosystem?
 - c. What are the trends in the industry?
 - d. What are the shellfish farmers' barriers to development?

3. To explore EBM as an approach to governance in the shellfish aquaculture industry in B.C.
 - a. What are the challenges to EBM of the industry?
 - b. What are the opportunities to EBM of the industry?
 - c. What are the implications of EBM for the industry?

1.5 Research Contributions

This research contributes to the body of literature exploring the implementation of EBM. The theoretical literature on EBM emphasizes the importance of social sciences in developing and implementing EBM; however, there are few examples of social data being collected for this purpose. This study addresses this gap in the literature by using an understanding of the industry and its governance to inform the implementation of a new approach within governance, EBM.

This research also addresses a second gap in the literature. There are few studies of the shellfish aquaculture industry in B.C. In her doctoral dissertation on the political ecology of shellfish aquaculture expansion on the west coast of Vancouver Island, Jennifer Silver suggests that her understanding of the shellfish aquaculture industry is limited by a lack of quantitative characterization of the structure and socio-economic makeup of the shellfish aquaculture industry is available (e.g., size of firms, ownership, changes over time) and that further research to characterize aquaculture entrepreneurs would be informative (Silver, 2010). This research partially addresses these two research gaps.

It is an opportune time to examine EBM of shellfish aquaculture in light of the recent BC Supreme Court decision that transfers regulatory authority for shellfish aquaculture from the provincial government to the federal government. The federal government has a policy to “support aquaculture development in a manner consistent with its commitments to ecosystem-based and integrated management.” (DFO, 2002). The research will conclude with a series of recommendations for government to facilitate the implementation of this policy.

1.6 The Geographic Focus of this Thesis

This thesis has been written in partial fulfilment of the requirements for a Masters of Arts degree in the field of geography; as such, it is important to recognize the relationship between this thesis and the discipline. The discipline of geography is characterized by a great deal of diversity. In studying geography, several different approaches exist often divided into physical and human, with much diversity within and overlap between (Small & Witherick, 1989; Norton, 2007). As such, the study of geography lies at the interface of the natural and social sciences.

This research draws upon aspects of human geography, which can be defined as “the spatial differentiation and organization of human activity and its interrelationships with the physical environment” (Johnston *et al.*, 2000, p.353). However, as it is also concerned with how such information can inform resource management, this research also falls under the category of applied geography. Applied geography can be defined as “the application of geographic knowledge and skills to the resolution of social, economic and environmental problems” (Pacione, 1999, p.XXVI). This approach to the study of geography is interested in the relationship between theory and practice and it is generally focused on key challenges facing society, in this case the implementation of a more ecologically sound approach to resource management, EBM.

EBM is a place-based approach to resource management as opposed to the conventional sectoral approach. The literature on ecosystem-based management is heavily oriented towards an ecological understanding. However, it is recognized that implementation of this paradigm in resource management requires a spatial and social understanding of the actors and institutional context (Endter-Wada *et al.*, 1998). Geography is well suited for developing such an understanding. Consequently, this study makes a contribution to the literature on ecosystem-based management through the application of social sciences information to identify challenges and opportunities for implementation.

1.7 Dissertation Organization

The dissertation is organized according to the research objectives. Chapter Two sets the literature context for the research by reviewing the relevant literature on the theoretical and practical application of EBM, exploring the relationship between shellfish aquaculture and the ecosystem, and reviewing the management approaches in different jurisdictions. Chapter Three presents the methodological context for this research by reviewing the development and current state of the shellfish aquaculture industry in B.C. and the methodological framework undertaken to address the research questions. Chapter Four addresses the first research objective by investigating the governance framework. Chapter Five addresses the second research objective by presenting the results of the industry survey. Chapter Six addresses the third research objective by using the understanding developed in the fourth and fifth chapter to identify the opportunities and challenges of the industry and its governance framework with respect to the dominant themes of EBM and assess the implications for applying EBM to an individual sector. Chapter Seven concludes the dissertation.

Chapter Two: Literature Review

2.0 Introduction

This thesis examines the shellfish aquaculture industry in British Columbia, Canada, within the context of ecosystem-based management (EBM). The objective of the research is to use an understanding of the industry and its governance framework to assess the opportunities and challenges for EBM. This chapter will examine theoretical and empirical research relating to ecosystem-based management, the relationship between shellfish aquaculture and the ecosystem and describe the management regimes in France and New Zealand to highlight best practices and lessons learned in those locations.

2.1 Ecosystem-based Management

Ecosystem-based management (EBM) is an approach to managing human activities focused on conserving ecosystems. An ecosystem (or ecological system) is a self-supporting system composed of the living biological organisms (e.g., plants, animals and microorganisms) interacting with each other and the physical environment (e.g., rocks, water and soil). Those interactions drive numerous ongoing processes as a result the function of the whole system is greater than the sum of its parts. The Millennium Ecosystem Assessment estimates that 60% of the world's ecosystems are degraded and that the severity and scale of impacts to ecosystems resulting from human activities is increasing affecting not only the species that are part of those systems but those that depends on them as well, including humans (MEA, 2005). Emerging research such as this is increasing calls for EBM.

The most widely accepted definition of EBM was compiled in a consensus statement prepared by scientists and policy experts published by the Communication Partnership for Science and the Sea (McLeod *et al.*, 2005):

“Ecosystem-based management is an integrated approach to management that considers the entire ecosystem, including humans. The goal of ecosystem-based management is to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need. Ecosystem-

based management differs from current approaches that usually focus on a single species, sector, activity or concern; it considers the cumulative impacts of different sectors”

Three key elements of EBM emerge from this definition. First, the goal of EBM is to maintain ecosystems. Second, EBM takes an anthropocentric approach to achieving this goal as reflected in its inclusion of humans in ecosystems and its focus on the services ecosystems provide to humans. Although controversial, it is argued that this is appropriate because EBM ultimately focused on managing human behaviour (de la Mare, 2005; McLeod & Leslie, 2009). Third, EBM contains many elements found in other approaches to resource management, like integrated management, such as managing multiple objectives and spatial planning, but ultimately differs because of the goal. The goal of integrated management is largely to create a governance system capable of managing multiple uses in an efficient way, not explicitly to maintain ecosystems (Ehler, 2003).

Although some human activities have direct affects on the health of an entire ecosystem, such as industrial fisheries (Worm *et al.*, 2006), many threats to ecosystem health result from the impacts of multiple activities working in concert. Conventional resource management is characterized by a sector-by-sector approach, where each human activity, such as fisheries, coastal development, agriculture or aquaculture, is managed separately (Kessler *et al.*, 1992). The result is a spatial mismatch between the scale of the governance system designed to manage human activities and the scale of the ecosystems that support those activities (Brown, 2003; Crowder *et al.*, 2006; Folke *et al.*, 2007). Resolving this mismatch will require mechanisms for integrating management activities at an ecologically relevant scale and developing closer ties between science, management and stakeholders (Agardy, 2005).

Changing the goal and scale of management will inevitably impact the structure and function of the organizations responsible for resource management because there is a link between what managers do and how they do it (Grumbine, 1997). Although the concept of EBM has been widely adopted by academics and governments worldwide, little agreement exists on how to move forward with implementation (Crowder *et al.*, 2008). One reason for this is the transdisciplinary nature of the concept, where knowledge is derived from many disciplines such as ecology, conservation biology, geography and resource management (e.g., Christensen *et al.*, 1996, Grumbine, 1994, Slocombe, 1998, and Agee & Johnson, 1988). Each author brings his or

her own set of underlying values, knowledge, and methods to the concept (Yaffee, 1999). In addition, the concept is continually evolving as scientific understanding of the ecosystems and experience with implementing the EBM grows.

Many different organizations have suggested approaches to EBM including the United Nations Convention on Biological Diversity (1992), the World Conservation Union (Pirot *et al.*, 2000), the World Wildlife Fund (Ward *et al.*, 2002), the PEW Ocean Commission (Palumbi, 2002), and the Food and Agricultural Organization (Soto *et al.*, 2008). In addition, several academics have made attempts at summarizing the work done to date, including Grumbine (1994, 1997) and more recently Arkema *et al.* (2006) and Curtin & Prellezo (2010).

Through a review of the empirical research on EBM, it became clear that there is no one prescribed way of approaching EBM. Instead EBM relies on adapting a set of approach to a particular social, ecological and historical context (McLeod & Leslie, 2009). Most research identifies a consistent set of elements which characterize EBM. Many of these elements are interrelated and can be organized under broader themes to avoid redundancy and increase clarity for use in exploring the implementation of EBM. The following three themes will be used in this research: scale, linking science and management, and stakeholder engagement (Table 2-1).

Table 2.1 Example of EBM elements from the literature consolidated into three overarching themes (Christensen *et al.*, 1996; Grumbine, 1997; Slocbome, 1998; Yaffee, 1999; Pirot *et al.*, 2000; Ward *et al.*, 2002; Pikitch *et al.*, 2004; McLeod *et al.*, 2005)

Theme	Element
Scale	Context; Considering cumulative effects; Ecosystem level planning; Overarching goals to link local, regional and national priorities; Managing across spatial and temporal scales; Cross-jurisdictional goals; Decentralized management; Ecologically defined boundaries.
Linking science and management	Balance conservation and use; Manage within ecosystem limits; Consider all relevant information including scientific, indigenous and local; Acknowledging uncertainty; Precautionary approach; Research and monitoring; Systematic evaluation; Track changes in biotic, abiotic and human ecosystem components for management purposes.
Stakeholder engagement	Humans as part of ecosystems; Human well-being is important;

Co-management;
Recognize human use and value of ecosystems;
Integrate economic factors into the vision for the ecosystem;
Engage stakeholders in planning and management.

2.1.1 Scale

One of the biggest threats to ecosystems results from the cumulative effect of managed activities (Halpern *et al.*, 2008). Many government institutions responsible for managing coastal activities are focused on individual sectors or resources (e.g., fisheries, aquaculture, residential development, waste discharge and transportation). Although managers often consider the impacts of these activities on the environment, the various management institutions operated in relative isolation from one another which makes it difficult to assess the potential cumulative effect.

Examples of EBM in the literature vary in scale from Large Ocean Management Areas such as the Eastern Scotian Shelf of Canada (O’Boyle & Jamieson, 2006) and the Great Barrier Reef Marine Park in Australia (Ruckelshaus *et al.*, 2008) to small estuaries such as the Morro Bay, California, USA (Wendt *et al.*, 2009). Regardless of the scale, none of these initiatives have done away with single-sector management; instead they have created mechanisms for integrating sectoral management within a larger geographic scale. However, in all cases this required the creation of a formal or informal institution whose focus is on the ecosystem.

One way of integrating the management of a sector into a larger EBM process is by linking goals and objectives at various scales, as exemplified in the Eastern Scotian Shelf of Canada. EBM on the Eastern Scotian Shelf was a top-down initiative established as the result of a national policy directive guided by the *Oceans Act*. Therefore the approach taken was to “unpack” the overarching conceptual objectives derived from the *Oceans Act* into operational objectives and outcome indicators at various scales down to ones for individual industries.

The use of a hierarchy of goals and objectives for EBM implementation is a characteristic of many EBM initiatives worldwide (Rosenberg & Sandifer, 2009). A hierarchy of goals and objectives ensure that higher-level goals and objectives are linked to lower levels. This not only ensures consistency but also facilitates the identification and management of the cumulative effects of all activities and assists in engaging stakeholders and providing direction to on-the-ground regulators.

Several authors suggest formulating the ecosystem goals in terms of ecosystem services (de la Mare, 2005; Halpern *et al.*, 2008). This approach will be reviewed in the following subsection (2.1.2).

Another mechanism for managing across scales and integrating the management of various activities is through the use of place-based management. Many recent articles on EBM are espousing the use of marine spatial planning and ocean zoning as a mechanism for integrating the management of human activities to achieve EBM (Young *et al.*, 2007; Halpern *et al.*, 2008). An example of such an approach is in the Great Barrier Reef Marine Park (GBR) in Australia, which is arguably the largest and most sophisticated application of marine zoning in the world which includes both zones for multiple-use and protection (Ruckelshaus *et al.*, 2008). Through this approach, representative examples of each of the broad habitat types in the GBR are protected while sustainable use is still permitted. In addition, new legislation now allows the regulation of activities outside the GBR that could have an adverse impact, including land-based activities (Day, 2002). The success of the GBR's approach to integrated management is in part due to the fact that it is entirely within the jurisdiction of one authority. However, the human activities that occur within the GBR continue to be managed by many different organizations and it is recognized that the management would benefit from better coordination (Ruckelshaus *et al.*, 2008).

2.1.2 *Linking science and management*

The first step in linking ecological sciences to resource management requires the creation of a common language with which to understand the connection between ecosystems and human activities. Some authors suggest focusing on ecosystem services (de la Mare, 2005; Halpern *et al.*, 2008; MEA, 2005; McLeod & Leslie, 2009). Human activities, particularly natural resource based activities, depend on ecosystem components and processes. These components and processes can be looked at as services. The Millennium Ecosystem Assessment classifies ecosystem services into four categories (MEA, 2005). The first are provisioning services that produce resources, such as food and fresh water. The second are regulating services, such as disease control and climate regulation. The third are cultural services that provide nonmaterial benefits, such as education and recreation. And, the fourth are supporting services, such as nutrient cycling and primary production, which are necessary for the generation of all other

ecosystem services. By focusing on ecosystem services, as opposed to ill-defined concepts such as ecosystem health, integrity or function, managers can more easily address the use of the ecosystem and the impacts of that use (de la Mare, 2005). This will facilitate assessments of cumulative impacts of various activities, conflicts between activities and trade-offs between activities (Halpern *et al.*, 2008).

The complexity and uncertainty associated with ecosystem responses to human activities presents a challenge for people and institutions who demand certainty in decision-making. Conventional resource management approaches often rely on tools based on “command-and-control” which requires relative certainty that what you are “commanding” will achieve the desired outcome and that you can control ecosystem responses (Holling and Meffee, 1996). It has been questioned whether this approach is adequate in light of the complex and dynamic characteristics of ecosystems. There is wide consensus in the literature that a more appropriate management process for EBM is adaptive management (Westley, 1995; Grumbine, 1997; Pirot *et al.*, 2000; Soto *et al.*, 2008).

Adaptive management is not a new concept; it has been applied to environmental management situations for over 30 years (Holling 1978). The central tenet of adaptive management is learning from experience (Holling, 1978; Walters, 1986). It is based on an understanding that ecosystems are unpredictable and that our understanding of the ecosystem and the effects of management will be incomplete (Gunderson *et al.*, 1995). Adaptive management is a process for action despite the above.

Under an adaptive management approach research and management are not separated. The management process is designed in an iterative fashion whereby strategies are continually evaluated through monitoring and adjusted as needed; this is similar to the iterative process of hypothesis testing explicit in the scientific method of inquiry (Christensen *et al.*, 1996).

Adaptive management involves developing models to simulate key relationships in a system, using this model to test a range of policy options (or hypothesis) most likely to achieve management objectives (Christensen *et al.*, 1996). The best policy option is then selected and implemented. A monitoring and evaluation system is established so that managers can determine how actual performance compares with expected outcomes. Through this process managers can accumulate knowledge about the system more rapidly allowing them to increase the accuracy of their models and the suitability of their policies (Holling, 1978, Walters, 1986).

Adaptive management can help decision makers make informed choices under conditions where scientific experiments to increase knowledge are too costly, impractical, or too risky to carry out (McLain and Lee, 1996).

Few examples of adaptive management exist in the literature. According to Walters (1997) adaptive management has seldom moved beyond the initial states of model development. The low success rate is attributed to the high cost of designing management as an experiment and the institutional barriers to the risk and uncertainty involved. For example, although the Chesapeake Bay is cited as an example of adaptive management (Hennessey, 1994), Boesch (2006) in his review of EBM initiatives in this ecosystem states that adaptive management has been relegated to the science program and not integrated into the ecosystem restoration program itself. As such, more research is needed exploring cost effective ways of developing and integrating a continuous process of scientific exploration into the management process.

The literature on adaptive management emphasizes the importance of incorporating various forms of knowledge not just scientific. Although the EBM literature is dominated by discussion of the role of science, more recently some authors have suggested the important role for local and traditional knowledge (Kliskey *et al.*, 2009). Local and traditional knowledge can enhance scientific knowledge by providing a more holistic perspective based on long-term experience within an ecosystem. Local and traditional knowledge can also be an important component of adaptive management. There is an opportunity to engage indigenous and local communities to assist in monitoring the ecosystem, for they are often in closer proximity to the ecosystem than scientists and have more long-term connections. This also has the potential to diminish the cost of adaptive management. This brings us to the final theme, stakeholder engagement.

2.1.3 Stakeholder Engagement

Several authors have now stated that the success of EBM depends on involving stakeholders throughout the process (Hartig *et al.*, 1998; Yaffee, 1999; O'Boyle & Jamieson, 2006). EBM needs to be communicated effectively to stakeholders so that they can engage and support the process, which will reduce the need for monitoring compliance. Stakeholders are also an important source of knowledge that can contribute to adaptive management.

EBM must ultimately adapt to the context in which it is applied (McLeod & Leslie, 2009). Several researchers point to the importance of thoroughly understanding the attitudes of the people affected by EBM so that the management process is designed appropriately, the stakeholders are involved effectively, and the right decisions are made (Yaffee, 1999).

A recent trend in EBM is the recognition of the importance of incorporating the economic and social dimensions of the ecosystem into the management approach. In the past there has been an overemphasis on the ecological dimension of EBM (Grumbine, 1997). A balance needs to be found in which economic and social goals can be pursued within the limits set by the ecosystem. This can be achieved in part by communicating the importance of ecosystem protection not for moral reasons but for economic and social reasons (Curtin & Prellezo, 2010).

A good example of including stakeholders in EBM is the initiative in Morro Bay California in the United State of America where EBM was linked to economic activities (Wendt *et al.*, 2009). An important part of this initiative was to communicate the benefits of EBM to stakeholders through the use of economic indicators related to ecosystem services to create incentives to participate and gain political support. In addition, economic indicators of ecosystem health such as fish landing provided valuable information on ecosystem health and for monitoring changes in the ecosystem overtime. These indicators also helped engage the public in a scientific discussion of the links between ecosystem and people in a way that allows stakeholders to make educated decisions about potential trade-offs.

2.1.4 Challenges

Several challenges have emerged from studies of EBM in action. Arkema *et al.*, (2006) compared forty-nine management plans for eight large marine ecosystems to assess the degree to which they incorporate EBM principles. They found that EBM principles are only loosely incorporated into management plans. Conceptually, most plans paid lip service to EBM principles such as sustainability, ecological health and inclusion of humans in ecosystems, but operationally management actions were quite disconnected from EBM. Specifically, they noted a lack of monitoring procedures and the inclusion of stakeholders only in the very beginning and not throughout the process. They suggest that the concept of EBM needs to be more effectively translated into action through the use of operational tools but did not specify what operational tools could be used.

Koontz and Bodine (2008) reviewed the implementation of EBM in two public agencies in the United States with a mandate for EBM. The largest barrier to EBM identified in surveys of employees was political. Employees felt pressured to manage for one use or sector. This is in part due to legislative mandates that do not reflect ecosystem concerns or scales. They also identified a lack of resources to undertake ecosystem-scale planning and monitoring. Finally, they also cited an inability to get different interest groups to work together. Similar barriers were identified by Barnes and McFadden (2007) during their survey of employees with a marine based public agency in the United States.

Resource-based industries desire certainty from governments. Assured access to territory and/or specific amounts of resources, predictable labour supply and sustained productivity levels are pre-requisites for profitability (Boyd *et al.*, 2001; Bridge & Jonas, 2002). This is one of the fundamental challenges for the implementation of EBM for this approach is grounded in an understanding of the dynamic and complex nature of ecosystems whereby uncertainty is the rule rather than the exception.

This research looks at how an understanding of the shellfish aquaculture industry and its management can help inform the implementation of EBM. The three themes of EBM and the examples given provide a theoretical basis for exploring the role of an individual industry within an EBM framework and what is needed for implementation. This will inform the discussion of the findings in Chapter 6. The next section of the literature review will explore the relationship between shellfish aquaculture and the ecosystem.

2.2 Shellfish Aquaculture

For the purpose of this research, the term shellfish is restricted to mean species from the class *Bivalvia*. Shellfish are invertebrate aquatic animals belonging to the phylum *Mollusca* and comprise about 75000 species (McKindsey *et al.*, 2006). They are soft-bodied animals protected by two shells extending on either side of their body joined at one edge by a flexible ligament (McKindsey *et al.*, 2006). Numerous species of oysters, mussels, clams, scallops and cockles are used for aquaculture worldwide. The most prominent species globally (i.e., those with production of more than 260,000 tonnes per year) are the Pacific oyster (*Crassostrea gigas*), the Japanese carpet shell clam (*Ruditapes philippinarum*), the Yesso scallop (*Patinopecten*

yessoensis), the razor clam (*Sinonovacula constricta*), the blood cockle (*Anadara granosa*) and the Asian green mussel (*Perna viridis*). The Pacific oyster has the distinction of being the most produced aquaculture species in the world with over four million tonnes produced in 2007 (FAO, 2010).

2.2.1 Shellfish aquaculture and the ecosystem

Natural shellfish populations are an important component of many coastal ecosystems. They modify environmental conditions, resource availability, and species interaction through the consumption and excretion of nutrients and the habitat created by their aggregation (Bruno and Bertness, 2001; Gutierrez et al. 2003; Newell 2004; Ruesink et al. 2005). The combination of shellfishes ability to filter large volumes of water and their propensity for living in dense populations give them considerable influence on the local physical and biological processes of the ecosystem, leading them to be termed “Foundation species” or “ecosystem engineers” (Dame, 1996; Gili & Coma, 1998; Ruesink *et al.*, 2005).

Shellfish aquaculture relies to a great extent on natural ecosystem processes for production and requires few external inputs (Folke & Kautsky, 1989). Unlike some other forms of aquaculture which depend on the addition of food to the environment, shellfish continue to rely on the ecosystem for the provision of food and the assimilation of waste. This reliance on the ecosystem also means that shellfish aquaculture is sensitive to reductions in water quality. Three most common types of pollution, affecting the shellfish aquaculture industry, are industrial pollution (e.g., pulp mills, log booms, and antifouling paints), agricultural run-off, and sewage (EC, 2009). The pollution resulting from these and other coastal activities can lead to reduced growth rate, harvesting closures or increased mortality (Quayle, 1998). Shellfish aquaculture is therefore intricately and inextricably linked to the ecosystem (Cranford *et al.*, 2006).

The most significant difference between natural shellfish populations and farmed shellfish is the manipulation of the habitat to enhance production and the net removal of nutrients from the ecosystem through harvest. A variety of technologies and methods are used for cultivating shellfish which allows the industry to span a wide variety of habitats from the intertidal zone to shallow and deep coastal waters (Cranford *et al.*, 2006). Culture techniques can be organized into two general categories based on the type of habitat they occupy. The first category is bottom culture, whereby shellfish are grown in or directly on the sediment of the

intertidal zone. This form of culture is the least intensive with intervention in the rearing process often limited to excluding predators and competitors from the site and uses minimal technology (e.g., poles or cages). The second form of culture is suspended culture, whereby shellfish are grown in containers or on lines suspended in the water column in shallow or deeper coastal waters. This form of culture is more intensive, allowing for higher densities of animals per hectare than bottom culture and has a heavy reliance on technology to facilitate the culture of shellfish in habitats where they do not naturally occur (Cranford *et al.*, 2006).

Shellfish aquaculture is generally considered a more sustainable form of aquaculture than the culture of carnivorous fish (Naylor *et al.*, 2000). This is due to the fact that it is more intricately connected to the health of the ecosystem in which it is found, reliant on natural ecosystem services for food and clean water. However, as with any human activity the interaction with the environment can have both positive and negative effects and some effects can be both positive or negative depending on the perspective. In the case of shellfish aquaculture, the range of husbandry methods and the variety of habitats it can occupy complicate the assessment of those effects (Dumbauld *et al.*, 2009).

The potential positive effects of shellfish aquaculture include increased ecosystem productivity through the provision of additional habitat and nutrients in the form of feces and the shellfish themselves (Dealteris *et al.*, 2004; Powers *et al.*, 2007; Žydelis *et al.* 2008; Lin *et al.*, 2009). This has been shown to have a positive impact on species diversity and density and shorebird populations (Dealteris *et al.*, 2004; Powers *et al.*, 2007; Zydelis *et al.*, 2008; Lin *et al.*, 2009). Shellfish aquaculture can also enhance water quality by decreasing turbidity and removing excess nutrients (Lindahl *et al.*, 2005).

The potential negative effects of shellfish aquaculture include the removal of nutrients from the pelagic habitat (i.e., phytoplankton) (Grant *et al.*, 2007), eutrophication of the benthic habitat (Cranford *et al.*, 2009), increased competition with other filter-feeders (Pietros and Rice, 2003), and the disturbance or removal of habitat and source of prey for other species such as shorebirds and juvenile fish (Bendell-Young, 2006; Gibbs, 2007). Shellfish aquaculture is a high risk for the introduction of exotic species when the species under culture are not endemic because they are broadcast spawners and therefore difficult to contain (McKindsey *et al.*, 2006).

The physical characteristics of site and the level of production influence the risk of an impact, particularly with respect to eutrophication, phytoplankton depletion and habitat

degradation (Cranford *et al.*, 2003; Beadman *et al.*, 2004; Anderson *et al.*, 2006; Mallet *et al.*, 2006; Grant *et al.*, 2007; Cranford *et al.*, 2009; Dumbauld *et al.*, 2009). Although some studies have shown shellfish aquaculture to result in organic enrichment, most studies have found little or no effect. The organic enrichment observed in the study by Cranford *et al.* (2009) is attributed to large stocking densities in a shallow coastal inlet with relatively low dispersive capacity. Similarly, reductions in phytoplankton occur when the stocking density of shellfish and the currents, tides and primary production (Gibbs, 2007). In addition, if the site contains critical habitat or endangered species the impact could have significant consequences (Forrest *et al.*, 2009). Therefore, the selection of a suitable location for shellfish aquaculture and an assessment of the ecosystems ability to support the production can mitigate many of the potential negative impacts. In contrast, the role of shellfish aquaculture in the spread of exotic species is a universal risk which some researchers conclude is the most significant (Cranford, 2003; Forrest *et al.*, 2009).

Most of the research on the impact of shellfish aquaculture is focused on the ecological impact. There is considerably less information available on the social impact of the industry. Shellfish aquaculture can conflict with or displace other coastal uses such as boating, fishing and swimming, as well as causing a visual impact (Naylor *et al.* 2000). This can lead to public objections to the establishment of shellfish aquaculture operations (Vestal, 1999). Gibbs (2008) found that objection from local stakeholders was a major factor limiting the development of shellfish aquaculture. Again, the scale and location of shellfish aquaculture development can influence the degree of conflict.

There is an increasing desire from regulators and the public to ensure the sustainability of shellfish aquaculture prior to development. In response, research has turned its focus towards methods of determining the carrying capacity of ecosystems with respect to shellfish aquaculture in order to plan the level of development ahead of time. This is a method of communicating the science to managers in order to inform decision-making. The following subsection will review the most recent literature on the subject.

2.2.2 *Assessing carrying capacity*

Carrying capacity is a contentious issue in the development of shellfish aquaculture since the concept can be interpreted in different ways based on which ecosystem services are being

examined (McKindsey *et al.*, 2006). A holistic way of approaching carrying capacity is to frame the question in terms of production, ecological, economic and social factors. This concept of carrying capacity was first introduced by Inglis *et al.* (2000). More recently it has been adopted and modified by others such as McKindsey *et al.* (2006) and Gibbs (2009). The following four definitions of carrying capacity are those adopted by Gibbs (2009)

- 1) *Production carrying capacity* – the absolute maximum long-term yield that can be produced within a region.
- 2) *Ecological carrying capacity* – the yield that can be produced without leading to significant changes to ecological processes, species, populations or communities;
- 3) *Economic carrying capacity* – the biomass that investors are willing to establish and maintain.
- 4) *Social carrying capacity* – the biomass/water space of culture that the community is willing to allow.

Production carrying capacity is the most widely researched form of carrying capacity because it is the simplest to measure. The carrying capacity in this case is limited by the physical characteristics of an area and the availability of food. A wide range of modelling approaches, some using Geographic Information Systems, have been developed to determine the production carrying capacity of an ecosystem with respect to shellfish aquaculture (Dame and Prins, 1998; Congleton *et al.*, 1999; Arnold *et al.*, 2000; Nath *et al.*, 2000; Pérez *et al.*, 2002).

These modelling approaches operate within the following parameters:

- water residence times, which is influenced by tidal exchange, ocean currents, and surface water runoff from the surrounding landscape;
- food availability, which is determined by primary production and the import and export of food into the system;
- bivalve feeding and physiology, which influences the amount of food they consume; and,
- availability of capable sites, which is determined based on physical characteristics such as appropriate beach substrate and availability.

Much of the information needed to determine production carrying capacity is readily available from hydrographic charts and targeted field work (McKindsey *et al.*, 2006).

Ecological carrying capacity is more difficult to determine due to the wide range of factors that can be considered. There are currently two main classes of research to determine the ecological carrying capacity for shellfish aquaculture. The first class uses models to predict the impact of the excretion of organic materials. An example of such an approach is the use of the DEPOMOD program (Chamberlain *et al.*, 2006; Weise *et al.*, 2009). These models are based on the assumption that the ecological carrying capacity of an area for shellfish aquaculture is limited by the ability of the seabed to assimilate the waste produced by the shellfish. The second class of ecological carrying capacity models use food-web models to examine the influence of shellfish aquaculture on the trophic functioning of an ecosystem. An example of such a model is ECOPATH (Pauly *et al.*, 2000). This approach to ecological carrying capacity assumes that the availability of food to support both existing filter-feeders and introduced shellfish is the limiting factor. Gibbs and Jiang (2005) used ECOPATH to predict the production and ecological carrying capacity of an area in New Zealand. They found that the production carrying capacity was 310 tonnes per year and the ecological carrying capacity was only 65 tonnes per year. As such, production carrying capacity may overestimate the carrying capacity of an ecosystem and if used to determine the rate of development may result in unsustainable levels of production.

Economic carrying capacity, according to Gibbs (2009) is the easiest of the four types of carrying capacity to predict because it is assessed by potential applicants. However, he does not take into account the fact that economic carrying capacity may be the most variable because it depends in large part on markets, institutional arrangements and external factors such as processing plants, hatcheries, transportation networks, consumption patterns and culture.

Social carrying capacity may be the most complex model to use because it depends on tradeoffs among all potential uses of the ecosystem (McKindsey *et al.*, 2006). Decisions regarding tradeoffs are heavily influenced by the values of local stakeholders and governance. Acceptance by the local community is an important factor determining social carrying capacity (Burbridge *et al.*, 2001). Acceptance is influenced by the degree of consultation with the public during the planning stage of aquaculture development. Shellfish aquaculture is promoted by governments as a means of economic diversification for rural communities; however, some coastal areas are witnessing a wave of immigration from urban people who value the aesthetics of undeveloped coastal areas more than the economic value of activities such as shellfish aquaculture (Gurran *et al.*, 2007).

In a review of methods to assess shellfish aquaculture carrying capacity, Gibbs (2009) emphasizes that carrying capacity is not a fixed target but instead changes over time as a result of external processes impacting the assimilative or productive capacity of the ecosystem, the acquisition of new knowledge, and technological advances; therefore, it must be re-evaluated over-time.

Shellfish aquaculture is inextricably connected to the ecosystem in which it is found. Although it has the potential to result in negative impacts to the ecosystem, the industries dependence on a health and fully functioning system means that they benefit from ecosystem-based management. Carrying capacity models like the ones described above are one way of translating scientific understanding of the relationship between shellfish aquaculture and the ecosystem into informed decisions about the development of the industry. The next section will review management approaches to shellfish aquaculture in two jurisdictions: France and New Zealand.

2.3 A Global Perspective on Managing Shellfish Aquaculture

Shellfish aquaculture presents unique management challenges for governments due to the coastal location of operations, the production of food for human consumption, and the potential impacts on the environment. Resource use on land customarily includes an exclusive right to the landscape. In contrast, the marine environment is usually distinguished by common property or open access rights, because shellfish aquaculture occurs on public or Crown land, the government has a significant role in many aspects of the management of operations.

The first level of government intervention is in the allocation of seabed to a shellfish aquaculture operation. As seen in the previous section, the location of a shellfish aquaculture operation is a major factor determining the potential impact on the environment and from an industry's perspective, on the economic viability. In addition, the location of a site near potential sources of pollution will also influence the risk to human consumption. The following section will look at how three countries approach the allocation of land for shellfish aquaculture: France, New Zealand and the United States.

2.3.1 France

Shellfish aquaculture is an old industry in France dating back to the 17th century. France passed a Decree on Maritime Fisheries in 1852 that formalized the industry by allowing the leasing of public land for oyster production (Buestel *et al.*, 2009). France is the world's fifth largest of producer of cultured molluscs in the world.

Although France also produces freshwater and marine finfish, marine shellfish account for 80% of its production (FAO, 2011). In 2002, there were over 4,000 shellfish aquaculture enterprises producing 187,420 tonnes of shellfish for a value of \$371 million euros (FAO, 2010b). The production occurs on 60,000 sites over an area of 20,000 hectares. The majority of production comes from the introduced species of Pacific oysters (*Crassostrea gigas*), with smaller production of the native flat oyster (*Ostrea edulis*) and two native species of mussels (*Mytilus edulis* and *M. galloprovincialis*). Production methods vary by region and include intertidal bottom culture and deep-water suspended culture. Virtually all production (95%) is destined for a local market making shellfish aquaculture an important source of local food security (Buestel *et al.*, 2009).

France is a unitary state and leasing decisions involve both state and local authorities. However, the state plays more of a coordinating role with most decisions made at the local level with input from stakeholder groups (Dosdat & de la Pomelie, 2000; Mongruel *et al.*, 2008). The duration of the process depends on the level of stakeholder involvement varying from eleven to thirty-five months, and the permits are limited to a five to ten year period (Dosdat & de la Pomelie, 2000).

The history of shellfish aquaculture in France consists of a succession of development phases which focused on a single species, followed by a collapse in production caused by disease and/or overproduction and the reconstruction of the industry around a different species (Buestel *et al.*, 2009). The shellfish aquaculture industry in France faces several immediate challenges, many of which are interconnected, including excess production, disease, water quality concerns, conflict with other coastal users, and mismanagement (Fontenelle *et al.*, 1998; Dosdat & de la Pomelie, 2000; Gouletquer & Le Moine, 2002; Mongruel & Thébault, 2006; Mongruel *et al.*, 2008; Buestel *et al.*, 2009). Despite this, density of shellfish aquaculture operations and the environmental impacts of shellfish aquaculture are not explicitly considered in the decision-making process. Although finfish aquaculture requires an environmental impact assessment, this

is not required for shellfish aquaculture because in law it is not considered an activity that is likely to pollute (Dosdat & de la Pomelie, 2000).

France is currently exploring the use of new management approaches to address some of these problems, including co-management to address overproduction and integrated coastal zone management to address conflicts. Fontenelle *et al.* (1998) describe the use of co-management in Mont Saint-Michel to address overproduction of mussel aquaculture. The shellfish aquaculture industry in this area experienced cycles of production rises followed by collapse due to poor growing conditions and/or disease outbreak. Finally, in 1985 with the assistance of the state scientific institute and government, the shellfish aquaculture industry in the area addressed this problem by working together to limit the density of shellfish produced in the bay. The benefits of the co-management arrangements were immediately demonstrated through increase in yield per site and the cycle of growth and decline has been stabilized. In 1997 harvests reached record levels. Success in this case was attributed to the high homogeneity of the user group including a common history due to long standing ties in the area, limited controversy over the cause of the problem, agreed upon objectives, the use of sanctions for those not complying and leadership.

In contrast, Gouletquer & Le Moined (2002) describes a failed effort at integrated coastal zone management in Mareenes-Oléron Bay and Charentais Sounds, the largest production areas for shellfish aquaculture in France. The failure is attributed to a lack of cooperation between government agents and local communities. This resulted in a plan that conflicted with established local coastal planning arrangements.

France's experience with shellfish aquaculture highlights a few important lessons. First, despite the relatively small impact associated with individual shellfish aquaculture operations, the cumulative impact can lead to overproduction and disease outbreaks. Second, shellfish aquaculture is a long-standing industry and contributes to local food production. This has given it a large social licence resulting in more lax regulations. However, as the industry expands into new areas, facilitated by the adoption of suspended culture techniques, conflicts are increasing with other coastal users and the industry is quickly losing some of that social license. France's experience with integrated management highlights the importance of shared problem definition and stakeholder engagement. Their small-scale initiatives were able to achieve both, whereas the larger-scale initiative developed at the state level without adequate local consultation failed.

2.3.2 New Zealand

New Zealand is a unitary state like France and it is the world's 11th largest producer of cultured molluscs. In 2007 the industry occupied 5,500 hectares of water space producing 102,500 tonnes of shellfish with a value of 242 million dollars (New Zealand Ministry of Fisheries and Aquaculture [NZMFA], 2010). The primary cultured species is the native mussel, *Perna canaliculus*, representing 97% of production (NZMFA, 2010). The preferred culture method is the use of the longline technique. The majority of shellfish production is destined for the export market (82%) (NZMFA, 2010). Finfish species are also cultured in New Zealand but represent a much smaller fraction of marine aquaculture production (9%) (NZMFA, 2010).

Shellfish aquaculture is a relatively new industry in New Zealand starting in the 1960s but remaining relatively small until the 1980s (FAO, 2011). During the 1990s the amount of ocean space used for shellfish aquaculture grew five fold. The rapid development of the industry created many institutional challenges and social backlash that led to legislative reform in 2004 (Tollefson & Scott, 2006; Banta and Gibbs, 2010).

During the development phase of the industry, the government approached its management in a piecemeal fashion using a combination of old and new regulations on an application-by-application basis. The first stage of the application process is to apply for a coastal permit from the local authority under the *Resource Management Act 1991* (RMA), a comprehensive legislation designed for integrated management. If a coastal permit is awarded, the second stage is to apply for a marine farming permit from the state authority under the *Fisheries Act* (1996), where the application is assessed for any "undue adverse effects" on fisheries. This dual-consent process resulted in fragmentation between coastal management, fisheries management, and aquaculture activities, resulting in a duplication of permit applications and a lack of certainty for the applicants and other coastal users (Banta & Gibbs, 2010).

As the industry expanded and began to apply for larger sites, the conflict between users of the coastal zone became more pronounced and the government was forced to make resource consent decisions with relatively sparse amount of information, especially with respect to cumulative effects (Banta & Gibbs, 2010). Furthermore, the process did not respect indigenous claims to the ocean space (Tollefson & Scott, 2006). Although the industry was managed in part under an integrated management framework, the dual-consent system and lack of information resulted in a lack of integration and a lack of adequate information to make sound decisions.

In 2004, a new regulatory regime for shellfish aquaculture was initiated creating a single process for aquaculture consent and integrated within overall coastal marine planning under the *Resource Management Act*. The new system addresses shellfish aquaculture in a proactive way by creating Aquaculture Management Areas (AMA) defined by the local government and pre-approved by the state and local resource users. In addition, the new process has resolved indigenous claims to the coastal environment through the *Maori Commercial Aquaculture Claims Settlement Act* (2004) which commits the state to provide Maori with 20 percent of the existing and future marine farming space within every region (issued on or after 2002). If space is not available, the state is responsible for financial compensation to the Maori Peoples.

This new regulatory system creates a more streamline application process. However, as of 2009 no new AMAs have been created, which has stifled development in the industry. Local governments have not taken the initiative to begin the AMA creation process due to lack of resources and political will (Banta & Gibbs, 2010). The new regulatory regime discourages the industry from applying to create new AMAs since the cost of assessment is born by the initiator but the initiator is not guaranteed access to the newly created area. As well, the process of balancing competing interests was found to be unnecessarily slow and complicated (NZ, 2011). As a result, the New Zealand government tabled a new aquaculture reform bill in 2010 aimed at reducing costs, delays and uncertainty, promoting investment in aquaculture development, and enabling integrated decision-making. Changes include: the appointment of a Minister with overall responsibility for aquaculture, the establishment of an aquaculture unit within the Ministry of Fisheries, and the development of a national aquaculture strategy and action plan. Overall the plan gives more central powers to the state with respect to aquaculture development by allowing the Minister responsible for aquaculture to amend regional coastal plans by regulation for the purpose of managing aquaculture development and allowing aquaculture development outside aquaculture management areas.

New Zealand is a good example of a rapidly growing industry without a comprehensive management plan. It also highlights the challenge of balancing state and local interests in the marine environment and determining which level of government should be responsible for development, state or local government. Unlike France, the majority of shellfish production in New Zealand is exported, which probably has a significant bearing on local opinion. The

experience in New Zealand also shows that it takes more than legislation to achieve integrated management

2.3.3 *United States*

Aquaculture has developed much less rapidly than in the United States (U.S.) than in other countries despite the fact that approximately 84% of seafood consumed in the U.S. is imported (Fridley, 1995; U.S. NOAA, 2011). The vast majority of aquaculture production in the U.S. comes from the freshwater environments (Head, 2003). However, recent data is lacking, older reports placed marine aquaculture at approximately 10% of the total production. The lack of comparable success in the marine aquaculture industry has been assigned to challenges associated the regulatory environment (DeVoe, n.a.; Sandifer, 1994; Fridley, 1995; Head, 2003).

Declining wild fisheries led the U.S. to pass the National Aquaculture Act of 1980 which declared it a national policy to encourage the development of aquaculture. Despite this, marine aquaculture has not grown significantly since its passage. One potential reason is that the Act gives principal responsibility for the development of aquaculture to the private sector, not assigning any government agency with responsibility for coordinate activities to encourage development (DeVoe, n.a.). As a federation, powers in the United States are divided between the federal, state and local governments, whereas France and New Zealand were unitary states. There are a variety of local, state, and federal regulations that apply to aquaculture but most of them were not designed with aquaculture in mind (Golburg *et al.*, 2001). The diversity of federal, state and local agencies involved in regulating aquaculture in the U.S. results in a complex, inconsistent, and overlapping policy and regulatory regimes. Because shellfish aquaculture is located in coastal waters it is primarily under state jurisdiction. Despite this, there are approximately eleven federal agencies directly involved in the regulation of marine aquaculture, despite the fact that only a few permits and licenses are required.

The literature is sparse on the management of marine aquaculture in the U.S., and shellfish aquaculture more specifically. The literature that does exist reveals several challenges. First, unlike freshwater aquaculture which has experienced significant success, marine aquaculture occurs on public land and access to coastal space is one major impediment to growth due to conflict with other established users, the high value placed on use for recreational and aesthetic purposes, and increasing pollution resulting from urbanization and industrialization

limiting potential sites (DeVoe, n.a.). The second major challenge results from a lack of government support for marine aquaculture. Despite the National Aquaculture Act little progress has been made to coordinate federal and state regulatory roles in the shellfish aquaculture industry as seen in the previous section. The third challenge is a the lack of provisions for determining the capacity of coastal environments for shellfish aquaculture (Defur & Radar, 1995). The development of shellfish aquaculture occurs on a case-by-case basis with no long-rantg or system-wide planning (DeVoe, n.a.).

Recently, the National Oceanic and Atmospheric Administration (NOAA) released a draft Aquaculture Policy (U.S. NOAA, 2011). The policy priorities include coordinating federal, state and local agencies in exercising their regulatory and management actions for marine aquaculture, using coastal and marine spatial planning to facilitate siting, reduce conflict and minimize adverse impacts. Although a step in the right direction for addressing some of the challenges facing the industry, the policy is for only one agency of over eleven involved in the management of the industry.

These three international examples to the management of shellfish aquaculture bring to light three different challenges. France is challenged by a lack of environmental regulation, which led to overproduction and a collapse of the industry but it also exhibits the greatest social support for the industry, probably due to the fact that the industry has been established for over a century and that the vast majority of production is for local markets. New Zealand exemplified the rapid growth of this industry without a comprehensive approach and the challenges balancing local and national interests and responsibilities. The United States is an example of an industry with less government support and a wide variety of overlapping regulatory instruments impeding growth.

2.4 Summary

This literature review has focused on the theory and practice of ecosystem-based management, the relationship between shellfish aquaculture and the environment and examples of management approaches in other jurisdictions. This thesis explores how an understanding of

the governance framework and the characteristics and values of individual entrepreneurs in an industry can help inform the implementation of EBM.

There is no one way of approaching EBM because it is influenced by the context in which it is applied. In addition, successful implementation depends in part on understanding and engaging the stakeholders affected by EBM. Despite understanding the theoretical research on EBM of the importance of social science, there is little literature exploring the opportunities and challenges for EBM from the perspective of the industries that are being managed. Instead the literature is focused on the institutional and environmental dimensions of EBM. It is felt that this study will help fill a gap in the literature and contribute a social science perspective to EBM.

Shellfish aquaculture is recognized as one of the most sustainable forms of aquaculture. However, like all human activities, it will have an effect on the ecosystem in which it is found. A review of the literature on the impacts of shellfish aquaculture on the ecosystem shows that it can have both positive and negative effects, the type and magnitude of which depends on the characteristics of a site and the level of production. Studies of the carrying capacity of ecosystems to shellfish aquaculture show that the ecological carrying capacity is significantly smaller than production carrying capacity and that the social carrying capacity may be the most important limiting factor for development.

A review of management approaches in France, New Zealand, and the United States aid in understanding the governance approach in Canada and underscores some of the opportunities and challenges for shellfish aquaculture such as the importance of cultural acceptance and local food production, the challenge reconciling local, regional and national interests, and the importance of government support to enable the development of the industry.

Chapter Three: Methodology

3.0 Introduction

This chapter describes the strategy used to answer the research questions outlined in Chapter One. The chapter begins with an introduction to the case study – shellfish aquaculture in British Columbia, Canada. Next, the research strategy and the rationale for its selection are discussed. This is followed by a detailed discussion of the research design. The chapter concludes by discussing the challenges and limitations of the research strategy and design.

3.1 Case Study: Shellfish Aquaculture

Ecosystem-based management emphasizes the importance of stakeholder engagement for successful implementation of the approach. Jentoft (2007, p.362) defines stakeholders simply as “those who have something to win or lose in the governing process”. Generally, stakeholders are a group of individuals with attributes in common resulting in shared interests or values (Jentoft, 2007). Although there are many potential stakeholders in the context of ecosystem-based management of shellfish aquaculture, the industry itself has arguably the largest interest in the proposed process and considerable influence towards its success.

The geography of British Columbia is well suited to shellfish aquaculture with approximately 25,725 kilometres of heavily indented coastline and the temperate coastal waters are productive and relatively free of pollution (Sebert & Munro, 1972). The coastal waters are naturally rich in shellfish with up to 180 endemic species (Broadley *et al.*, 1988). In fact, Aboriginal peoples in B.C. have traditionally enhanced the production of shellfish through intervention in coastal ecosystems (Williams, 2006). This can be considered an early form of shellfish aquaculture.

Shellfish aquaculture began commercially at the turn of the 20th century on the large tidal flats in the southern Strait of Georgia (Figure 3.1). The industry was originally developed around the native oyster (*Ostrea lurida*). However, disease outbreaks and low productivity encouraged the industry to explore alternative species. In 1925, the Pacific oyster (*Crassostrea gigas*) was introduced (Quayle, 1998). The Pacific oyster grows faster than the native oyster and

tolerates a wider range of environmental conditions thus increasing the productivity of the industry and allowing the industry to expand into new areas. Today, the native oyster is listed as a species of special concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and under the Species at Risk Act. Although the native oyster was already depleted due to over fishing and water pollution prior to the establishment of the Pacific oyster in British Columbia, the continued lack of population recovery is thought to be due to a combination of limited habitat, competition with the Pacific oyster, predation from introduced predators and industrial pollution (White *et al.*, 2009; Buhle and Ruesink, 2009, Trimble *et al.*, 2009).

In 1964, declining water quality and outbreaks of paralytic shellfish poisoning led the federal government to enact legislation to protect the public from the risk of contaminated shellfish. The primary strategy for addressing the health risk was through the implementation of closures and restrictions on harvesting. Declining public confidence in shellfish products and new government interventions into the industry, led the industry to organize for the first time with the creation of the B.C. Oyster Growers Association and the Shellfish Marketing Board (Quayle, 1998).

Shellfish aquaculture was a relatively small industry until the 1980s producing just under 3,000 tonnes in 1986 with a value of \$2.5 million (1986 was the first year statistics were kept) (DFO, 2010). The industry was composed primarily of small family operations using ranching-style of aquaculture raising shellfish collected from the wild.

Five major developments have influenced the growth of the industry between 1986 and present. The first was the signing of a Memorandum of Understanding between the provincial and federal government in 1988 placing shellfish aquaculture under the regulatory authority of the provincial government. As a result, the provincial government began to undertake activities to develop the industry such as province-wide coastal assessments of shellfish aquaculture capability and the Shellfish Aquaculture Development Initiative (Cross & Kingzett, 1992; Silver, 2010).

The second was the development of hatchery-produced juvenile shellfish (Chew, 1984). This marked a change from a ranching- to a farming-style of shellfish aquaculture. Prior to this development, the industry was dependent on wild shellfish from B.C. or the importation of wild shellfish from Japan. In theory, hatchery-produced spat has the potential to provide a more

reliable supply of shellfish for production and can potentially provide for a larger industry than the ecosystem can.

The third development was the adoption of suspended deep-water husbandry techniques. Suspended culture techniques increase the productivity of operations by enabling shellfish farmers to increase the density of shellfish on a site and reduce the grow-out time by taking full benefit for the three-dimensional nature of water bodies (Armstrong, 1986; Pillay, 1990). It also allowed shellfish farmers to expand into deeper waters thus increasing the availability of space for the industry. By 2007, 39% of shellfish aquaculture operations managed sites capable of using suspended culture techniques.

The fourth development was the introduction of Manila clam as an approved aquaculture species in B.C. Overharvesting by the capture fishery led to an alarming decline in the wild Manila clam population in the 1980s. In response, Fisheries and Oceans Canada, the federal government department responsible for ensuring the sustainability of fisheries, turned to clam culture as a viable alternative to a basically unmanageable fishery (Caine and Dickson, 1992). Up to this point, the shellfish aquaculture industry in B.C. was based entirely on Pacific oysters. The introduction of Manila clam not only provided a new market for the industry but also a higher value species. In 2009, the production value of Pacific oysters was \$1.20 per kilogram and the production value of Manila clams was \$5.67 per kilogram.

The fifth development is the expansion of the shellfish aquaculture industry into the west coast of Vancouver Island. Declining water quality in the southern Strait of Georgia and increasing conflict with water front property owners and other coastal resource users such as ecotourism industry and recreational boaters constrained the further allocation of tenures in the region in the 1990s (Silver, 2010). This spurred efforts to expand the industry into different regions and increase the overall productivity of the existing industry (Silver, 2010).

Between 1986 and 2009, the industry grew by 254% to a total production of 7,300 tonnes with a value of \$16.3 million (Figure 3.1). As described above, the growth in the industry can be attributed in part to increasing number of entrepreneurs and improvements in farm-level productivity resulting increasingly from advances in scientific research and technology. As such, the success of individual entrepreneurs began to rest increasingly in their ability to incorporate changing technologies (Silver, 2010). In fact, a growing gap between the productivity of the top

producers and that of the industry overall was first recognized in 1995 (Coopers & Lybrand Consulting, 1997).

Growth in the industry was steady through the 1980s and early 1990s (Figure 3.1). However, since then the industry has experienced fluctuating production. Production declined by 34% in 1997. According to an industry representative, this decline was caused by a lack of available seed for planting a few years prior, which influenced the amount of shellfish available to harvest in 1997 (R. Stevenson, pers.comm., 2011). Production declined by 30% between 2006 and 2008, this time it is attributed to unfavourable markets and a resulting lack of investment in the industry (R. Stevenson, pers. comm., 2011). Although production increased slightly in 2009, there was a significant decline in the number of shellfish aquaculture licenses between 2009 and 2011 (Table 3.1).

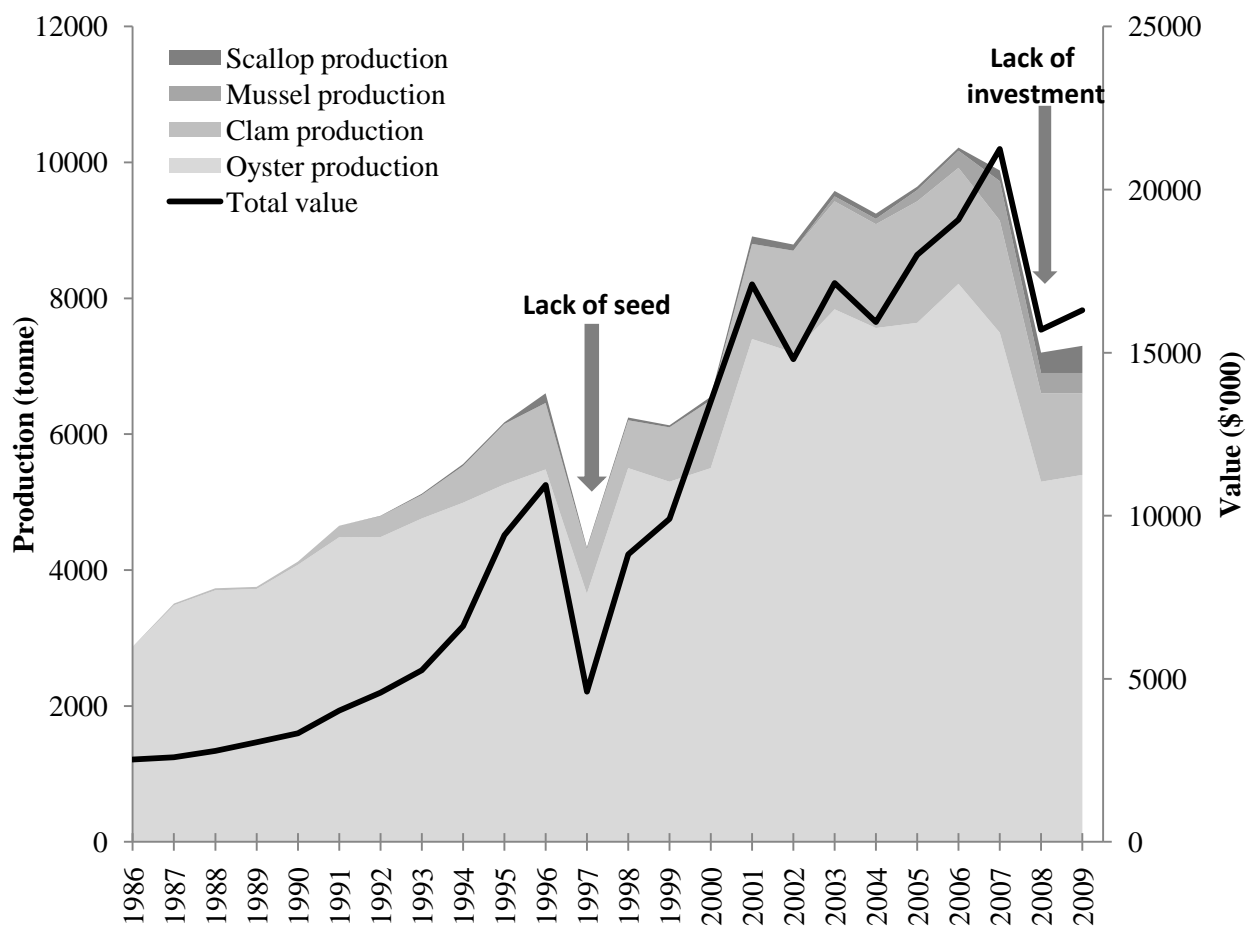


Figure 3.1 Total production by species and total value of shellfish aquaculture in B.C. from 1986 to 2009 (DFO, 2010)

Table 3.1 Summary of select B.C. shellfish aquaculture industry characteristics
(BC Ministry of Environment (2011); DFO (2010))

Year	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10
# Firms	236	283	231	278	278	302	300	304	314	321	322	322	282
# Sites	427	437	417	455	455	464	481	487	489	450	506	508	467
Size (ha)	2300	2300	2400	2700	2700	2812	2937	3019	3123	3339	3334	3535	n/a
Production ('000 t)	6.1	6.5	6.5	8.9	9.1	10.2	9.9	10.1	10.2	9.9	7.5	7.3	n/a
Value (\$ millions)	9.0	10.5	12.1	17.2	15.2	17.9	15.9	17.9	19	21.3	16.2	16.4	n/a

Since 2001, the industry has been diversifying into new species such as mussels and scallops. These species have a higher market value than Pacific oysters. For example, in 2009 oysters were valued at \$1.20 per kilogram, clams at \$5.67 per kilogram, mussels at \$4.67 per kilogram and scallops at \$4.00 per kilogram. Therefore, although Pacific oysters represent 74% of the volume of shellfish produced in aquaculture, it only represented 40% of the production value (Figure 3.2).

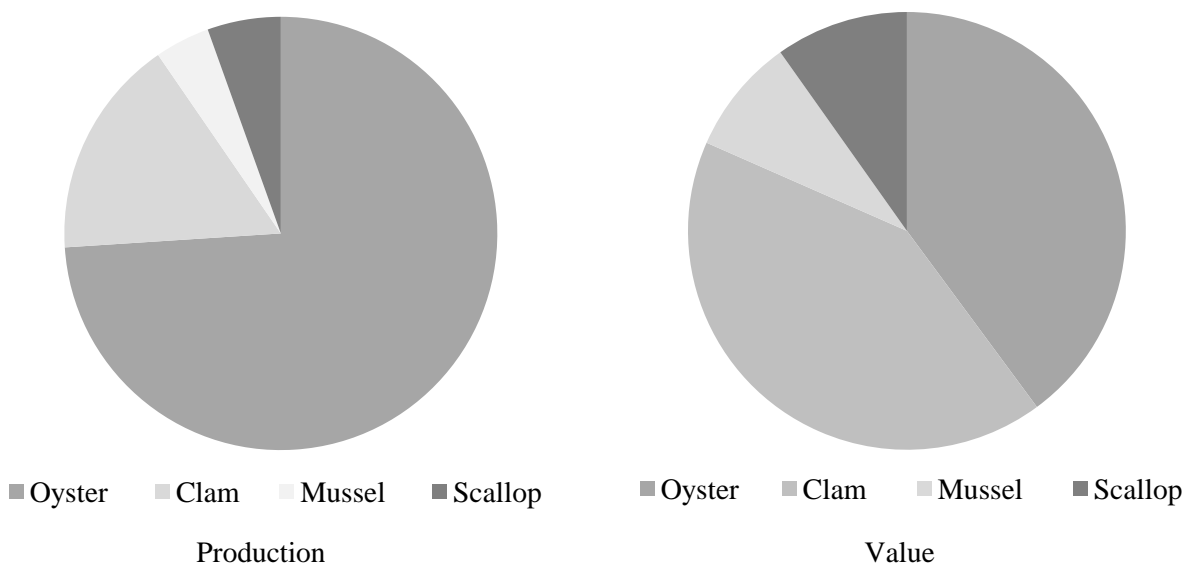


Figure 3.2 Comparison of shellfish species contribution to total shellfish aquaculture production and value in B.C. in 2009 (DFO, 2010)

Today, the industry is dominated by the production of the non-native Pacific oyster and Manila clam, although 16 other species of shellfish are being grown on a commercial basis such as species of mussels, scallops and other species of oysters and clams (Table 3.2). Of the 417

shellfish aquaculture operations in 2007, 67% were licensed for more than one species.

Technological and regulatory change has increased the practice of shellfish co-culture on tenures that extend from the intertidal to the deep-water (Silver, 2010).

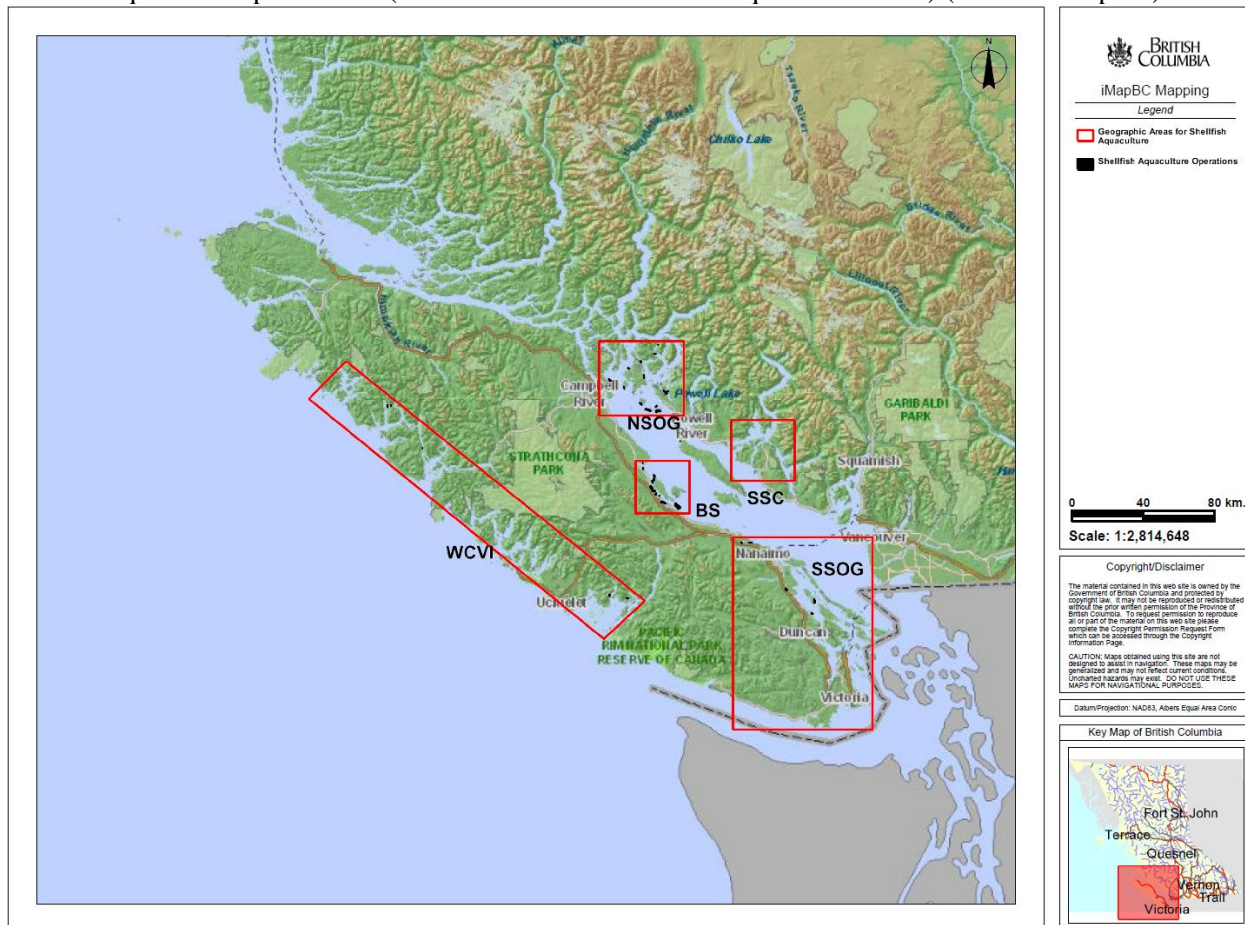
In B.C., oysters are grown both intertidally using bottom culture techniques or suspended in the nearshore or deeper coastal waters. When suspended, oysters will grow three times faster than intertidally grown oysters. However, when grown in deeper waters, shellfish farmers generally require access to an intertidal site to “harden” their oysters prior to sale because the shells are too soft when grown suspended. Clams are only grown in intertidal areas. However, they may be started suspended but must be moved to the intertidal area for the majority of their lifespan. The culture of clams requires a more intensive physical modification of the environment to optimize production and clam farmers will often cover their lease area with a mesh netting to protect the clams from predators. Scallops on the other hand are only grown suspended in coastal water. They are very sensitive to wave action and therefore must be placed in protected sites. Mussels can be grown using both intertidal systems and suspended systems. To date mussel culture in B.C. is limited to suspended culture. Like scallops, mussels grow best in sheltered areas. Scallops, clams and mussels can tolerate lower seawater temperatures than oysters (Kingzett, 2003; BCSGA, 2011; FAO, 2011).

Table 3.2 Shellfish species cultivated in B.C. in 2007 (B.C. Ministry of Agriculture and Lands, 2008)

Species			Number of Licensed Sites (n=417)
Common name	Scientific name	Native or Introduced	
Pacific Oyster	<i>Crassostrea gigas</i>	I (Japan)	381
Manila clam	<i>Tapes philippinarum</i>	I (Indo-Pacific)	261
Gallo mussel	<i>Mytilus galloprovincialis</i>	I (Mediterranean)	42
Eastern blue mussel	<i>Mytilus edulis</i>	I (East coast of Canada)	40
Varnich clam	<i>Nuttallia obscurata</i>	I (Asia)	40
Japanese scallop	<i>Patinopecten yessoensis</i>	I (Pacific Asia)	37
Geoduck	<i>Panope abrupta</i>	Native	36
Littleneck clam	<i>Protothaca staminea</i>	Native	28
European oyster	<i>Ostrea edulis</i>	I (Europe)	15
Kumamoto oyster	<i>Crassostrea sikamea</i>	I (Japan)	12
Eastern oyster	<i>Crassostrea virginica</i>	I (East coast Canada)	11
Western blue mussel	<i>Mytilus trossulus</i>	Native	11
Giant rock scallop	<i>Crassadoma gigantea</i>	Native	10
Olympia oyster	<i>Ostrea conchaphila</i>	Native	5
Nuttall's cockle	<i>Clinocardium nuttallii</i>	Native	4
Weatherwane scallop	<i>Patinopecten caurinus</i>	Native	2
Spiny scallop	<i>Chlamys hastata</i>	Native	2
Pink scallop	<i>Chlamys rubida</i>	Native	2

Shellfish aquaculture operations are primarily found in the Strait of Georgia between Vancouver Island and the mainland of British Columbia and on the south-west coast of Vancouver Island. For the purposes of this research the locations of shellfish aquaculture operations are divided into five geographic areas: Baynes Sound, the southern Strait of Georgia, the northern Strait of Georgia, the Sunshine Coast and the West Coast of Vancouver Island (Figure 3.3). The geographic areas are based on logical geographic delineations in conjunction with areas of relatively high concentrations of shellfish aquaculture and influenced by identified marine ecoregions (Powles *et al.*, 2004). In 2007, there were no shellfish aquaculture operations on the north coast of Vancouver Island and only three operations in the north central coast of B.C.

Figure 3.3 Map of Vancouver Island, British Columbia, highlighting the five main geographic areas* of shellfish aquaculture production (black dots indicate shellfish aquaculture sites) (Source: iMapBC)



* WCVI (West Coast of Vancouver Island); NSOG (Northern Strait of Georgia); BS (Baynes Sound); SSC (Sunshine Coast); SSOG (Southern Strait of Georgia)

Baynes Sound is the longstanding geographical and production core of the shellfish aquaculture industry with 31% of licensed shellfish aquaculture operations located there in 2006. This geographic area is found within the Regional District of Comox Valley and within the Municipality of Courtenay. Part of this area is also under the jurisdiction of the Islands Trust adding an additional level of government to the management of the industry. The population of Courtenay is 64,642 and grew by 37% between 1996 and 2010 (BCStats, 2010). This area has experienced conflict between the community and the shellfish aquaculture industry (Hamouda *et al.*, 2004). In response, in 2001 the provincial government undertook a planning process to address this conflict (BC, 2002).

The southern Strait of Georgia contains some of the oldest shellfish aquaculture operations in the province and contains 16% of the licensed shellfish aquaculture operations in 2006. This area spans the three most populated Regional Districts on Vancouver Island (Nanaimo 149, 686; Cowichan 82,871; and Capital 372,339) and several Municipalities (e.g., Nanaimo, Ladysmith, Duncan and Sooke). The Islands Trust also covers parts of this geographic area. The population grew on average by 14% between 1996 and 2010 (BCStats, 2010).

The northern Strait of Georgia contains 27% of licensed shellfish aquaculture operations in 2006. Sites here are found around islands within the Strait of Georgia such as Cortes. The largest urban centre in the vicinity of these sites is Campbell River, which is accessed by ferry or boat. The other region is in the Malaspina inlet. The distance to market increases the cost of producing shellfish in this region. The population of Campbell River is 44,386 and has grown by 5% between 1996 and 2010 (BCStats, 2010). The population of Powell River has slightly declined between 1996 and 2006 (BCStats, 2010).

The Sunshine Coast contains the fewest shellfish aquaculture operations of the geographic areas represented (7%). The population of the sunshine coast is approximately 29,984 and it has grown by 16% between 1996 and 2010 (BCStats, 2010). Access to Vancouver Island or Vancouver is by ferry.

The west coast of Vancouver Island is the most remote of the geographic areas represented both in terms of distance to urban centres and population density. It contains 18% of licensed shellfish aquaculture operations in 2006. It covers two Regional Districts (Alberni-Clayoquot and Strathcona). The population in the towns on the West Coast of Vancouver Island are generally decreasing. For example, the populations of Tahsis and Zeballos on the northern

end of the area decreased by 61% and 31% respectively between 1996 and 2006; whereas the population of Tofino on the southern part of the area increased by 55%.

The Central Coast is the northern most range of shellfish aquaculture in B.C. Although the first license was authorized in the 1990s, the industry has not substantially grown since. One reason is a lack of water quality monitoring in this region (Kingzett and Norgard, 2003). This area encompasses two ambitious ecosystem-based management planning initiatives: the federal Pacific North Coast Integrated Management Area and the provincial Ecosystem-Based Management approach to the North and Central Coast.

The characteristics of the shellfish aquaculture industry vary between geographic area (Table 3.3). In Baynes Sound and the southern Strait of Georgia, the majority of the shellfish aquaculture operations use bottom culture, whereas in the west coast of Vancouver Island, the Sunshine Coast and the Central Coast shellfish aquaculture operations are primarily suspended. In the northern Strait of Georgia there is an even split between bottom and suspended operations. The average size of operations is larger in Baynes Sound than the other geographic areas. Operations in the northern Strait of Georgia are the smallest. Finally, almost half of all operations in Baynes Sound are subject to some form of harvesting restrictions. A large number of operations on the west coast of Vancouver Island and the southern Strait of Georgia are also subject to harvesting restrictions, whereas only a small number of operations in the northern Strait of Georgia are subject to restrictions. The diversity of characteristics between geographic areas may be influenced by the ecosystem context in which they are found.

Table 3.3 Comparison of the characteristics shellfish aquaculture operations by geographic areas (n=414) (B.C. Ministry of Agriculture and Lands, 2010)

Geographic Area	Sites (n)	Husbandry			Size		Harvesting Restrictions (%)
		Bottom (%)	Off-bottom (%)	Both (%)	Total (ha)	Average (ha)	
Baynes Sound	129	84	11	5	1076	9	46
Northern Strait of Georgia	110	53	25	20	366	4	8
West Coast Vancouver Island	76	30	49	17	463	6	29
Southern Strait of Georgia	67	85	12	3	416	7	36
Sunshine Coast	29	7	62	31	167	5	17
North Coast	3	0	33	67	16	5	33
Total	69	60	26	13	378	7	29

Shellfish are grown largely for export markets to the United States and increasingly to Asian countries such as Japan, Hong Kong and China. Accessing international markets is done through local processors and/or distributors. Therefore, the shellfish growers are generally not involved in the marketing, sales and distribution decisions. Eleven processors were advertised on the B.C. Shellfish Growers Association website in 2011, five are located in Baynes Sound, three are located in the southern Strait of Georgia, two are located in Vancouver, and one is located in the northern Strait of Georgia.

Attributes of the B.C. shellfish aquaculture industry are compared to that of the Canadian province of Prince Edward Island and the country of New Zealand (Table 3.4). Despite having the longest coastline, the size of the shellfish aquaculture industry is relatively small compared to the other jurisdictions. In addition the value of the product is lower in B.C. An estimate of the average production value per site in each jurisdiction shows an average of \$370,000 per site per year in New Zealand, compared to \$143,000 per site per year in PEI and \$39,000 per site per year in B.C.

Three factors emerge when comparing these three jurisdictions. The first is species. Both New Zealand and PEI grow mussels, a higher value species than the Pacific oyster produced in B.C. The value of the product is highest in New Zealand at \$3,300 per tonne, compared to \$1,900 per tonne in B.C. and \$1,500 per tonne in PEI. The second is the size of operations. In PEI, the average size of a shellfish aquaculture operation is 35 hectares, much larger than the average of 5 hectares in New Zealand and 7 hectares in B.C. The third factor is density. The average density of sites in New Zealand is 18 tonnes per hectare, much larger than the average of 4 tonnes per hectare in B.C. and just under 3 tonnes per hectare in PEI.

Table 3.4 Comparison of the shellfish aquaculture industries in British Columbia (B.C.) Canada, Prince Edward Island (PEI) Canada, and New Zealand in 2006 (DFO, 2010; BC Ministry of Environment, 2010; PEI, 2010; NZ, 2010; FAO, 2010b; Atlas of Canada; CIA World Factbook Coastline).

	BC	PEI	New Zealand
Coastline (km)	25 725	1 260	15 134
Area (ha) under production	2512	7377	5497
Production (Tonnes)	10,217	20,117	99,800
Value ('000,000)	19.1	30.6	325
# Sites	489	213	875
Main Specie	Pacific oyster	Blue mussel	New Zealand mussel

The shellfish aquaculture industry in B.C. is characterized as comprised of small- and medium-size enterprises (SMEs) (Howlett & Rayner, 2006). The comparison presented above of the B.C. industry with that of PEI and New Zealand highlight this point. SMEs pose significantly challenge for empirical research. Because they are under-resourced, SMEs are generally unable to participate in research (Gunningham, 2002). The following sections will review the research strategy designed to understand the shellfish aquaculture industry in the context of EBM.

3.2 Research Strategy

This study explores the challenges and opportunities to implementing of ecosystem-based management through a case study of the shellfish aquaculture industry in British Columbia, Canada. Case studies often use multiple sources of information to understand the phenomenon within its context (Yin, 1992). In this case, the empirical knowledge gained through the main research method is combined with contextual knowledge gained through the supporting methods.

The main method used is a questionnaire survey of shellfish farmers. The supporting methods were a statistical analysis of industry data, an in-depth analysis of government documents, policies and regulations, and targeted interviews with federal and provincial government regulators.

Gathering information about the shellfish aquaculture industry may be done using a variety of survey methods including interviews and various types of questionnaires (e.g., mail, telephone, internet, face-to-face). Though a mail-out questionnaire survey method was chosen for this project, other methods were considered. The following paragraphs will present the advantages and disadvantages of the other methods considered. Factors that affected this choice include the human and financial resources allotted to the project, the comprehensiveness of the approach, and the time allotted for data collection.

Face-to-face survey methods, either by interview or questionnaire, are a more personal form of research. Through this interaction, the researcher can convey the importance of participation, ensure all questions are answered and understood, and pose follow-up questions to clarify responses. Face-to-face survey methods also can provide a higher response rate due to this interaction between the researcher and the respondents. The drawbacks of face-to-face

survey methods are the time it takes to administer and the cost of traveling to meet the sample population. In addition, it is prone to measurement error because of the surveyors may influence responses through their own projected biases (Salant & Dillman, 1994). Because the population of shellfish growers in B.C. is spread out around the coast of Vancouver Island, it was thought impractical both in terms of financial resources and time, to use this survey approach.

Telephone survey methods, either by interview or questionnaire, is another survey method considered. The benefits include the ability to produce results quickly and the ability to enhance respondents' understanding of the question. One weakness of the telephone survey method is sensitivity to measurement error. As with a face-to-face survey method, surveyor's biases could influence results (Salant & Dillman, 1994). In addition, certain styles of questions, such as likert that ask respondents to rank a series of items, are difficult to communicate over the phone.

A more recent method developed to conduct a questionnaire survey is online. This was not feasible for this research because a list of the population's email addresses was not available. Though respondents could have been initially contacted by mail and directed to fill-out the survey online, it was not known whether respondents would have access to the internet.

For this study, the researcher chose a mail questionnaire survey. The main benefit of this research approach is that it requires the least amount of human resources to conduct and allows a larger sample-size, thereby reducing sample error (Salant & Dillman, 1994). This was an important reason for selecting this research method because the researcher wanted to reach as many shellfish growers as possible within the resource and time constraints. Mail questionnaire surveys also provide a standardized set of responses that facilitates analysis. In addition, this approach provides a sense of privacy and anonymity. By not interacting with a researcher directly, respondents are more likely to respond to sensitive questions such as political attitudes (Salant & Dillman, 1994). A final strength of this method is that it is less sensitive to biases introduced by in-person interviewers.

The greatest weakness of a mail questionnaire survey is the potential for large non-response error; depending on the topic of the survey, some respondents may choose not to complete the survey. Also, the type of person not responding might be different than the type who does respond, thereby affecting survey results. Another drawback includes a lack of control over whether the questionnaire is filled out completely and whether the questions are understood.

Several strategies were employed to facilitate response. According to Fowler (1993) almost anything that makes a mail questionnaire look more professional, more personalized, or more attractive will have some positive effect on response rates. To look more professional, the survey included the University of Victoria logo. To be more personalized and motivate respondents, the survey included a map of the shellfish aquaculture sites in the province and the cover letter made reference to the reasons why the research is pertinent to them, the importance of their participation and demonstrated an understanding of the industry and the challenges they may face. It also included an endorsement from the industry association and included paid-postage. Ethical protocol was established by the Human Research Ethics Committee at the University of Victoria before the survey was administered (see Appendix A).

3.3 Research Design

Four methods were used to gain an understanding of the shellfish aquaculture industry in B.C and its governance. The main data collection instrument was a survey questionnaire addressed to individual farmers within the industry. Three supporting methods were used to provide triangulation: statistical analysis of industry data; an in-depth analysis of government documents, policies and regulations; and targeted interviews with provincial and federal government regulators. The first subsection describes the design of the questionnaire survey of the industry and the final subsection describes the design of supporting methods.

3.3.1 Industry questionnaire

Design

The main data collection instrument was an eight page questionnaire addressed to shellfish growers in B.C. (see Appendix B). The questionnaire was designed to collect information about the respondents' characteristics and values to understand the barriers and opportunities they present for EBM and the implications of EBM for the industry.

The questionnaire consisted of thirty-two open- and close-ended questions. The format of the questionnaire was designed to make it fast and easy to complete. The close-ended questions included pre-coded Likert-style response categories where the respondents were

requested to circle the most appropriate answer. Partially closed questions were employed when answers apart from those provided by the fixed response categories were possible (Salant & Dillman, 1994). This option allowed respondents to write their own response in an “other” category. Only a few select open-ended questions were inserted to gather data in specific cases where the range of responses was uncertain or potentially very broad. An open-ended question was also included to give respondents an opportunity to provide any additional comments that they may find pertinent. Prior to distribution, the questionnaire was reviewed by two industry representatives to ensure clarity and accuracy.

The questionnaire was divided into four sections. A detailed description and rationale for each section of the questionnaire follows in the appropriate sections below.

Section 1: Contact information. The first section gathered contact information. This information was used to compare to government data to expand on the available information about the industry and permitted the tracking of questionnaires to ensure duplicate responses did not occur.

Section 2: Business information. The second section collected business information. This section of the questionnaire sought general information about the characteristics of the respondents’ shellfish aquaculture operation, the respondents’ values and assesses potential trends in industry development. The answers to these questions were also used to assess nonresponse error by comparing the results with government data about the population. The characteristics identified include:

- The length of time the respondent has been in the industry (P2Q1);
- Employment status (i.e., part-time or full-time) (P2Q3);
- Connection to place (P2Q4);
- The number of operations, their total size and the proportion under production (P2Q5);
- The species of shellfish farmed and factors influencing that decision (P2Q8/9); and,
- Membership to an industry association and factors influencing that decision (P2Q10/11).

This section also explored potential trends in industry development through a series of questions that first asked how long respondents plan on staying in the industry (P2Q2), whether they plan on increasing production in the future (P2Q6) and what species of shellfish they plan on growing in the future (P2Q8). In addition, one question presented a list of potential means of increasing production and asked respondents to circle all the means they plan on using including an option to specify “other” means (P2Q7).

Section 3: Site Selection Process. The third section of the questionnaire explored the process for selecting and approving a site. The location of shellfish aquaculture operations is a major determinant of the potential impacts on the environment, and, from the industry’s perspective, on the economic viability. For this reason, the initial site selection process for shellfish aquaculture is important for both government and industry. Government involvement in the industry occurs primarily at this stage of development.

This was the longest section consisting of 12 questions. The questions were formulated to assess respondents’ values with respect to siting, their experience with the site approval process and their attitudes and preferences for governance.

The first question asked respondents to rank the importance of a set of goals for selecting a site to assess respondents’ values (P3Q1). This section also asked respondents about the type of information they may value such as: knowledge of the environment surrounding their site (P3Q8) and local or traditional knowledge (P3Q9). The next set of questions explored their experience with the governance including the agencies involved (P3Q2), if an environmental assessment was performed and the time and cost involved (P3Q4) and if they ever had any applications turned down and why (P3Q5). This was followed by a series of questions to assess respondents’ perception of governance by asking them to rank the utility of involving the public in the decision-making process (P3Q10) and to rank their level of agreement with a series of questions about the effectiveness and efficiency of the governance more generally (P3Q11). The final question was an open-ended question asking respondents to provide recommendations for governance (P3Q12).

Section 4: Long-term Management. The fourth section of the questionnaire explored the ongoing management of operations. The first three questions asked respondents about their

experience with government, which includes the government agencies they interact with (P4Q1), the type of information they are required to provide to government (P4Q2) and the frequency to which they provide it (P4Q3). The fourth question explored the perceived impact of a series of activities that can take place around an operation (P4Q4). The next set of questions asked respondents about environmental monitoring, whether they would support a more active role in environmental monitoring (P4Q5) and whether they would benefit from access to monitoring information (P4Q6). The final question was an open ended question asking respondents what they consider the most significant barriers to the growth of their business (P4Q8). The survey ended by providing space for the respondents to provide any additional information about the governance of the industry.

The final section explored the respondents' experience, values and concerns with respect to the on-going management of the industry. The barriers to growth provided by the respondents helps tie the rest of the responses together by summarizing the aspects of the industry most in need of attention. By not confining responses to a pre-determined set of challenges, this question allows the researcher to explore a broader range of issues not previously considered.

Sampling Strategy

The questionnaire surveys were administered by mail and telephone. Initially, the study was designed to rely solely on the responses to the mail-out campaign but the response rate was too small to generate meaningful conclusions. Therefore, a subsequent telephone campaign was undertaken to increase the response rate. Shellfish growers were recruited using publicly available contact information acquired from the B.C. Ministry of Agriculture and Lands.

A total of 308 survey packages were sent out to shellfish growers' in October 2006. The surveys were administered during the winter to avoid shellfish growers busy summer season and therefore increase the response rate. The package contained the questionnaire, a brief description of the project and the rationale, two consent forms and a stamped return envelope.

In order to increase response rate, two additional steps were taken. The first step was participation in the Annual General Meeting of the BCSGA on October 20th, 2006 to solicit additional responses. Attention was paid to the bias that could result from an over representation of members of the industry association. Asking respondents in the questionnaire whether they were a member of an industry association assisted in assessing this bias. The second step was to

send another round of questionnaires in April 2007, identical to the first except for an updated introduction. As a result of both mail campaigns, the response rate to the questionnaire was 16% ($n = 50$).

In January 2008, a telephone campaign to administer the questionnaire was undertaken to increase response rate. A list of shellfish growers' contact information, including phone numbers, was provided by the B.C. Ministry of Agriculture and Lands. The list was cross-referenced with the original list to ensure the same population was contacted. The researcher used systematic sampling to randomly sample the population. Statistics books warn against systematic samples if a list is ordered by some characteristics. In this case the list was ordered alphabetically and therefore the systematic samples did not differentially affect the sample. The researcher wanted to generate the maximum number of additional responses to the survey within a given time constraint. Therefore, the researcher randomly selected a starting point in the list and called every 10th individual/company to solicit responses. The questionnaire was administered verbatim over the phone and no additional information was provided so that consistency in the administration of the questionnaire was maintained. The final response rate to the questionnaire was 22% ($n = 69$).

Analysis

The results of the questionnaires were first edited to check to find obvious erroneous responses and to identify consistency in the information provided by respondents (Salant and Dillman, 1994). Then the results of the questionnaire were coded, computerized and analyzed using SPSS 8.0. Qualitative responses to open ended survey questions regarding recommendations for improving governance, barriers to growth and additional comments were content-analyzed, categorized and entered into SPSS 8.0 for analysis. The small response rates meant that only descriptive statistics could be performed on the data. Univariate analysis of distribution, central tendency and dispersion were performed for each variable. Some variables were cross-tabulated to explore potential correlations, although no statistical correlation tests were employed. The results are released as an aggregate to ensure the confidentiality of respondents is maintained. They are presented numerically and as tables and graphs in Chapter 6. The results from the open-ended questions were also used for indirect and direct quotes. The raw data is included in tables in Appendix D.

3.3.2 Supporting methods

Industry Statistics

The provincial and federal governments distribute a limited amount of information on the shellfish aquaculture industry in B.C.. This includes the number of leases, total production and the total value of production. In order to create a more complete picture of the population, the researcher accessed two additional sources of industry data. The first source was iMapBC, a self-serve web-based mapping tool, providing public access to provincial natural resource datasets hosted by the BC government (<http://webmaps.gov.bc.ca/imfx/imf.jsp?site=imapbc>). The second source of information was a publicly available spreadsheet of the licensed shellfish aquaculture sites in the province. It was accessed through the Ministry of Agriculture and Lands website at the following address:

http://www.agf.gov.bc.ca/fisheries/licences/SF_Sites_Current.htm. The two datasets were aggregated and contained the following information about individual operations:

1. Size (ha);
2. Species cultured;
3. Culture Type (e.g., bottom, off-bottom, etc.);
4. Tenure type (e.g., lease or licence);
5. Species approval date;
6. Tenure issue date;
7. License expiry date;
8. Fisheries and Oceans Canada Fisheries Management Area; and,
9. Special harvest restrictions.

This data was analyzed using descriptive statistics and is presented at the beginning of this chapter to describe the case study. The information was also used to determine nonresponse error of the survey questionnaire of the industry (see Section 3.6).

Government Documents, Policy and Regulation

A number of government documents, policies and regulations were referred to and referenced through the course of the research (Table 3.5). Every attempt was made to understand the nature and context of these documents in order to avoid misrepresenting or

misinterpreting government institutions and policy-makers. Guided by examples from previous studies (VanderZwaag *et al.*, 2002; Howlett & Rayner, 2004), these documents were examined with a mind to objectively report their policy implications and disseminate the facts, not opinions, regarding policy and legislation. The documents were accessed electronically through public government websites.

Table 3.5 Provincial and federal government documents, regulations and policies reviewed during this research

	Documents	Policies	Regulations
Federal	Auditor General of Canada report on Canada's Ocean Management Strategy (2005);	CEAA Operational Policy Statement on Addressing Cumulative Environment Effects (2007)	Fisheries Act (R.S. 1985, c. F-14)
	Standing Senate Committee on Fisheries report on Aquaculture in Canada's Atlantic and Pacific Regions (2001)	DFO Aquaculture Policy Framework (2002)	Canadian Environment Assessment Act (1992, c.37)
	DFO Ecosystem Science Framework (2007)	Canadian Action Plan for Aquaculture including interim guides for applying regulatory responsibilities.	Navigable Water Protection Act (R.S. 1985, c. N-22)
	Standing Committee on Fisheries and Oceans report on The Federal Role in Aquaculture in Canada (2003)	Canadian Shellfish Sanitation Program	Species at Risk Act (2002, c. 29)
	Office of the Commissioner for Aquaculture Development Legislative and Regulatory Review of Aquaculture in Canada (2001)	Canadian Wildlife Services Guidelines	Oceans Act (1996, c.31)
	Canadian Science Advisory Secretariat research documents	Policy for the Management of Fish Habitat (1986)	Constitution Act, 1867 to 1982 (R.S., 1867, c. C-0)
	DFO Pacific Region Shellfish Aquaculture Operational Statements (2006)		Migratory Birds Convention Act
	Environment Canada Guidelines for Environmental Assessment of Shellfish Aquaculture Projects (2001)		Pest Control Products Act
	Proponent Environmental Assessment Guide (2006)		
Provincial	Coastal Land-Use Plans	Land-Use Operational Policy for Aquaculture (2004)	Land Act (Ch. 245, R.S.B.C., 1996)
	BC Shellfish Aquaculture Code of Practice (2002)		Fisheries Act (Ch. 149, R.S.B.C. 1996)
	Shellfish Aquaculture Application Package (2005)		

Government Interviews

In an effort to understand the government policy, documents and regulations reviewed and provide additional context, government regulators in the provincial and federal government directly responsible for the shellfish aquaculture industry were interviewed. The interviews were open-ended and semi-structured to increase flexibility in both the questions posed and the responses. The open-ended nature of the questions reduced the possibility of restrictions being placed on the responses and allowed ideas to be more freely expressed. A semi-structured question guide was used to tailor questions to a specific interviewee's area of expertise and it gave the interviewee the freedom to elaborate on issues s/he deemed relevant (see Appendix C). A conversational interview style was used to place interview subjects at ease and to facilitate the exploration of issues raised during the course of the interview. Interviews were conducted with regulators in the following agencies:

1. Fisheries and Oceans Canada (n = 6)
 - Oceans, Habitat and Enhancement (n = 2)
 - Habitat Protection and Sustainable Management (n = 1)
 - Fisheries and Aquaculture Management Branch (n = 3)
2. Transport Canada (n = 5);
 - Environmental Services (n=3)
 - Marine Safety (n = 2)
3. Environment Canada (n = 2);
 - Environmental Stewardship Branch (n = 2)
4. B.C. Ministry of Agriculture and Lands (n = 6);
 - Aquaculture and Commercial Fisheries Branch
5. B.C. Integrated Land Management Bureau (n = 1).
 - Crown Lands and Resources (n = 1)

The majority of the interviews were conducted in-person and a few interviews were conducted over the telephone, all interview were recorded using an audio recording device with the consent of the interviewee for transcription purposes. No perceived bias was noted between the in-person and telephone interviews; however, the telephone interviews were with regulators with a smaller role in the management of the industry and therefore the conversations tended to be shorter.

The interviews were transcribed verbatim into a Microsoft Word document. A total of 19 interviews were conducted during the course of this research. All information generated is

referred to as personal communication in order to maintain the anonymity of the individuals who participated. This allowed the interviewee's opinions to be clearly and openly stated without causing them discomfort. In some cases, interviewees' were subsequently contacted for clarification and updates.

3.4 Challenges and Limitations

3.4.1 *Nonresponse error*

Due to the chosen method of research, mail survey, the researcher is concerned with the impact of nonresponse error on the survey results. The effect of nonresponse depends on the response rate and the extent to which those not responding are biased or in other words how different they are from the population as a whole. Because the response rate is low, it is important to understand if the nonrespondents are representative of the population. Knowing that mail surveys have an increased risk of nonresponse error, the research incorporated questions in the survey for which population data was available. The following subsections will compare the survey respondents to the population to assess if the nonrespondents may bias the results.

Industry association. In an effort to increase response rate, the research solicited the support of the largest industry association, the B.C. Shellfish Growers' Association (BCSGA) and participated in this industry association's Annual General Meeting. The researcher was concerned that this may bias responses towards those who are members of the BCSGA. At the time of the survey, the BCSGA had a membership of 170 shellfish growers or 55% of the population (McCallum, D., personal communication, November 10th, 2006). The results of the survey show that 57% of respondents are a member of the BCSGA. Therefore, the survey design did not result in an overrepresentation of the BCSGA.

Location. The researcher divided the coast of B.C. into seven geographic areas to compare the spatial distribution of the population to that of the sample (Figure 3.4: **page 47**). The respondents' operations were distributed across most of the geographic areas in which the population is found with the exception of the north coast of B.C. (Table 3.6). A comparison of

the frequency distribution of operations shows a slightly smaller proportion of shellfish growers from the northern Strait of Georgia and a slightly larger proportion of shellfish growers from the west coast of Vancouver Island responded to the questionnaire survey. The researcher would be concerned if there was a major aggregation of responses in either remote or more urban areas but based on the results this is not a concern.

Table 3.6 Distribution of population (n = 417*) and sample (n = 92*) by geographic area

Geographic Area	Population (%)	Sample (%)
Baynes Sound	31	36
Northern Strait of Georgia	27	17
Sunshine Coast	7	3
Southern Strait of Georgia	16	19
West Coast Vancouver Island	18	25
North Coast Vancouver Island	0	0
North Coast BC	1	0

*these numbers represent the total number of operations and therefore is larger than the number of shellfish farmers: there are 259 shellfish farmers in the population managing 417 operations and there are 69 shellfish farmers in the sample managing 92 operations.

Number of Tenures. The researcher compared the frequency distribution of the population and the sample with respect to the number of tenures managed by each company. The sample has a larger proportion of companies with more than two tenures (Table 3.7). Mail surveys will attract people who have a particular interest in the subject matter and/or the resources (e.g., time or staff) to fill it out. It is therefore not surprising that a larger percentage of the population with more than two tenures would respond to the survey. These companies may have more resources and a larger relative stake in the future of the industry.

Table 3.7 Distribution of population (n=259) and sample (n=69) by number of tenures managed per enterprise

Number of Tenures	Population (%)	Sample (%)
1	76	61
2 or more	24	39

Size of operations. The average size of operations in the population is 6 hectares whereas the average size in the sample is 9 hectares. The median size of operations in the population and the sample is 3 hectares. The average size of operations in the sample is skewed by the presence of one farm of 375 hectares. This is the largest farm in B.C. by a large margin with the second largest farm at 50 hectares.

Culture technique. The final point of comparison is the culture technique. Two general categories of shellfish culture techniques are used in the industry in B.C. These are bottom culture and suspended culture. In B.C. some operations include both bottom and suspended culture. The researcher compared the frequency of each culture method for the population and the sample. There are more shellfish farmers with the ability to use both culture techniques in the sample than in the population and less that use solely bottom culture techniques (Table 3.8).

Table 3.8 Distribution of population (n=417) and sample (n=54) by culture technique.

Culture technique	Population (%)	Sample (%)
Bottom	60	50
Off-bottom	26	24
Both	13	26

Based on the comparison between the population and the sample, it can be concluded that the respondents are generally representative of the population. No large deviations between the characteristics of the population and the sample were evident. As such, bias resulting from nonresponse error is not a concern in this study.

3.4.2 Response rate

The major challenge and limitation resulting from the survey design and sampling strategy is the low response rate. Every effort was made to collect as many surveys as possible which resulted in a return of 69 questionnaires amounting to a 22% response rate. A comparison of the population and the sample show a modest difference between the two based on a select number of parameters. Nevertheless, the low response rate limits the researcher's ability to reach conclusions that extend beyond the immediate data. As such the analysis of the results will be descriptive and exploratory and not explanatory.

Although the response rate could be considered low, due to the nature of the shellfish aquaculture industry in B.C. composed of small- and medium-sized enterprises (SMEs) this is not surprising. Gunningham (2002) states that SMEs present a particular challenge for empirical researchers due to lack of resources. In this context, the researcher is satisfied with the level of participation in this study. The use of a multi-method approach triangulating different sources of evidence will strengthen the researcher's ability to construct an explanation of the results.

Chapter Four: Governance Context for Shellfish Aquaculture in B.C.

4.0 Introduction

The goal of this chapter is to build an understanding of the governance context in which ecosystem-based management will be developed thus addressing the first research objective. Governance is different than government. The Institute on Governance defines governance as “a process whereby societies or organizations make decisions, determine whom is involved in the process and how they render account” (Graham *et al.*, 2003: 1). As such governance includes the laws, process, and policies that define who has authority over what, how decisions are taken, and how decisions are made accountable. Although government has a large influence over governance, it is but one social institution within governance. Governance is broader and more inclusive of other social organizations than government; however, government institutions are generally at the centre of a governance because they have the most power.

Ecosystem-based management (EBM) is an approach within governance not just government. Maintaining healthy, productive and resilient ecosystems is an objective that cannot be accomplished by government alone. It requires the engagement and participation of stakeholders with an interest in the ecosystem and the cooperation and coordination of various levels of government around a common objective. EBM is being adopted within existing governance contexts which will in part define the challenges and opportunities to adoption. It is for this reason, the following chapter will explore the governance context for shellfish aquaculture in B.C. as it existed until December 2010.

The chapter is divided into three sections. The first section presents the governance policy for shellfish aquaculture. The second section presents the regulatory framework on which the governance approach is founded. Once the legal context is understood, the decision-making procedures are assessed in the following two subsections.

4.1 Governance Policy

Canada is a federation where power to govern is divided between a central federal government, regional provincial governments and local or municipal governments. The *Constitution Act* of 1867 divides federal and provincial responsibilities into two mutually exclusive sets of powers that form the foundation for the division of power between the two levels of government (note: the powers of the local governments are delegated from provincial jurisdiction). In general, the federal government is responsible for “peace, order and good government of Canada” (*Constitution Act*, s.91) generally defined in areas of national concern such as military, banking and currency, and criminal law. The provincial government is responsible for “generally all matters of a merely local or private nature” (*Constitution Act*, s.92) such as the management of public lands, municipal institutions, and property and civil rights.

However, on many policy issues, such as shellfish aquaculture, the constitution is ambiguous, leaving considerable room for interpretation by the federal and provincial governments, as well as the courts. In the case of shellfish aquaculture there has been is legal ambiguity over whether aquaculture is a fishery or a form of agriculture. The Constitution gives the federal government exclusive jurisdiction over the management of fisheries, whereas agriculture falls under both federal and provincial jurisdiction. In addition, the coastal zone where shellfish aquaculture is located is under both federal and provincial jurisdiction. The federal government has jurisdiction over the water and navigation and shipping, and the province has jurisdiction over the seabed. Furthermore, the coastal zone is subject to undefined aboriginal rights and conflicting public and private rights. As a result, the shellfish aquaculture industry is situated in a complex jurisdictional context.

In the spirit of cooperation, the federal and provincial government negotiated a Memorandum of Understanding in 1988 on aquaculture management to define a separation of government management responsibilities. The MOU gave the provincial government administrative powers over aquaculture. However, the MOU does not abrogate the division of powers established by the Constitution described above. The federal government is responsible for the conservation and management of wild fish stocks, the safe access to navigable waters and the safety of shellfish exported to other provinces or other countries. The provincial government is responsible for allocating Crown land, including the seabed. Therefore in addition to the

MOU, the federal and provincial governments regulate the industry with respect to the above mentioned areas.

In February 2009, the courts ended the debate over whether aquaculture is more akin to a fishery or agriculture. The B.C. Supreme Court upheld a lower court decision that aquaculture is a fishery making the MOU between the two levels of government an unconstitutional delegation of power (*Morton v. British Columbia (Agriculture and Lands)*, 2009). The following sections describe the policy and the procedural arrangement prior to this ruling.

4.1.1 Provincial policy

Provincial policy for shellfish aquaculture emerged during a time of political and economic uncertainty resulting from the decline of traditional resource-based industries such as forestry and fisheries, un-clarified Aboriginal rights and title, and increasing social activism (Silver, 2010). In response, the province began to explore new approaches to environmental and social issues such as the introduction of more widespread public land-use planning and more inclusive decision-making. There is no clear policy for shellfish aquaculture, the following will describe provincial initiatives.

In 1998 the provincial government launched the Shellfish Development Initiative (SDI) to enable industry growth through expansion and intensification (Howlett & Rayner, 2004; Silver, 2010). This policy was informed by a province-wide coastal assessment of the capability for shellfish aquaculture in B.C. that began in the 1990s (Cross & Kingzett, 1992) and an associated economic assessment based on capable land and productivity trends that projected that the industry could grow from \$12 million wholesale to \$100 million in ten years (Coopers & Lybrand Consulting, 1997). The initiative was supported through the creation of a Shellfish Unit as a “one-window” service model for the industry to acquire both licences and tenures. It worked with the federal government to create a joint federal/provincial application package and also worked with communities, First Nations, various other government agencies and the industry to plan responsible land use and develop environmental standards and practices. Pilot projects were established at 15 sites on the North Coast and Queen Charlotte Islands in cooperation with local First Nations. In addition, the Barkley Sound and Clayoquot Sound Shellfish Aquaculture Steering Committees were created to explore the potential for developing shellfish aquaculture on the west coast of Vancouver Island (Osborne, 2000).

In support of the SDI, the province undertook biophysical, ecological and social carrying capacity studies. The biophysical carrying capacity studies were undertaken for the whole coast of B.C. whereby the biophysical attributes of the coast were assessed with respect to the requirements of shellfish aquaculture. Ecological carrying capacity was assessed in areas with relatively high levels of shellfish aquaculture such as Baynes Sound, Lemmon's Inlet on the west coast of Vancouver Island, and Gorge Harbour and Malaspina inlet in the northern Strait of Georgia. Social carrying capacity studies were undertaken in the form of marine spatial planning in areas with high levels of conflict with the local community such as Baynes Sound.

Despite these efforts, the shellfish aquaculture industry did not reach projected levels within ten years (1998-2008). According to some authors, some of the challenges the initiative faced include lack of adequate coordination between the federal, provincial and local government, inadequate consultation with local communities and First Nations, uncertainty surrounding unresolved First Nations' claims and their impact on coastal waters, and a lack of infrastructure to support expanded production (Howlett & Rayner, 2004; Silver, 2010).

The province also committed to achieving full implementation of ecosystem-based management through the Central and North Coast Land and Resource Management Plan by March 31, 2009. In this plan EBM is defined as "an adaptive, systematic approach to managing human activities, guided by the Coast Information Team EBM Handbook, that seeks to ensure the co-existence of healthy, full functioning ecosystems and human communities" (British Columbia, 2007: 1). Although this plan only covers the land base and not the marine environment, it establishes a framework for EBM by the provincial government that is relevant to this research.

A review of provincial government programs for the aquaculture industry by the federal Office of the Commissioner for Aquaculture Development in 2002 found that B.C. is the most aggressive province with respect to developing programs addressing environmental considerations, but that the province lacks support for processing and marketing. The primary provincial policy in the development of shellfish aquaculture, the Shellfish Development Initiative, focused on providing additional coastal space for aquaculture development. Although additional space will be required, other factors such as marketing and processing are required to support the growth as noted by Howlett & Rayner (2004) and Silver (2010).

4.1.2 Federal policy

The federal government's policy is to sustainably develop Canada's ocean resources. The federal government identified aquaculture as an important ocean industry for job creation in Canada (DFO, 2002). As the management of aquaculture was primarily a provincial responsibility under the Memorandum of Understanding, the federal government committed to enabling the sustainable development of the industry within its areas of jurisdiction (e.g., oceans, fisheries, navigation, water quality and significant species). The most recent federal government's policy for aquaculture was established in the 2002 *Aquaculture Policy Framework* which establishes nine policy principles to guide management:

1. ecosystem-based and integrated management;
2. science-based decision-making;
3. effective communication with Canadians;
4. contributing to Aboriginal economic development;
5. access to aquatic resources;
6. enabling legislative and regulatory frameworks;
7. support for responsible aquaculture development;
8. client centred approach; and,
9. interdepartmental and intergovernmental cooperation.

Of particular relevance to this research is the first policy principle of ecosystem-based and integrated management.

Ecosystem-based and integrated management is mandated by the Canadian *Oceans Act* and guided by *Canada's Oceans Strategy* (DFO, 2002a) and the *Policy and Operational Framework for Integrated Management in Canada's Estuarine, Coastal and Marine Environments* (DFO, 2002b). Ecosystem-based management objectives are to be established at two scales: Large Ocean Management Area (LOMA) and Coastal Management Areas (CMA). LOMAs will typically extend from the coast out to the limit of Canada's maritime jurisdiction. CMAs are nested within LOMAs and are created to address the specific challenges at the coast.

The framework for Integrated Management involves the creation of ecosystem, human-use and institutional objectives and indicators. Ecosystem objectives define the requirements of the ecosystem or a future state for the physical, chemical, and biotic environment. Human-use objectives provide goals to ensure the sustainable use of ocean resource and space. Institutional

objectives provide a governance framework or strategy by which the oceans and coastal areas can be managed. Most attention thus far has been on developing ecosystem and institutional objectives (O'Boyle *et al.*, 2005; DFO, 2002b).

There are currently five ecosystem-based and integrated management initiatives in Canada: Beaufort Sea Integrated Planning Initiative (Arctic Ocean); the Eastern Scotian Shelf Integrated Management Initiative (Atlantic Ocean); the Gulf of St. Lawrence Integrated Management Area (Gulf of St. Lawrence); the Placentia Bay and Grand Banks Integrated Management Areas (Atlantic/Grand Banks); and the Pacific North Coast Integrated Management Initiative (Pacific Ocean). These initiatives all occur in Large Ocean Management Areas.

CMAs face different governance challenges than LOMAs due to overlapping provincial and federal jurisdictions, a larger number of human uses, and the impact of land-based activities (DFO, 2002b). To date, no ecosystem-based and integrated management initiatives have been created for CMAs by the federal government. However, several provincial coastal plans could be argued to be integrated management.

Several challenges have been identified with moving towards the implementation of ecosystem-based management in Canada. These include federal-provincial coordination, particularly at the CMA-scale, interdepartmental coordination at the federal level, the lack of clear guidelines for interpretation and implementation of EBM and the fact that government accountability continues to be linked to single activities as opposed to addressing the horizontal targets of integrated management (Mageau *et al.*, 2005).

In 2009, the federal government released a discussion document on the *National Aquaculture Strategic Action Plan Initiative* as a collaborative exercise to seek stakeholder and public input into creating an action plan for implementing the policy principles. The document identifies three action areas: (1) regulatory and management regime; (2) sustainability, competitiveness, investment and innovation; and (3) social license and reporting. The document does not address the application of ecosystem-based management to the industry. It does however touch on other priorities for the industry, such as the development of alternative species, developing new approaches for the Canadian Shellfish Sanitation Program, access to wild aquatic resource for shellfish "spat" and seedstock, new technology to expand production to new areas (e.g., further off-shore to reduce conflict), access to funding, and infrastructure to support expansion into more remote areas.

With the federal government having to take responsibility for the management of the shellfish aquaculture industry in December 2010, the federal government will have more authority to apply EBM to the industry as per their policy. To date there are no public federal government policy papers describing how EBM will be incorporated into the management of the industry.

4.2 The Regulatory Framework

The previous section reviewed the provincial and federal policies for the shellfish aquaculture industry. The next section looks at the legislation that grants authority and specifies responsibility to each level of government in their areas of jurisdiction and ultimately creates the governance framework within which government policy is applied.

Provincial and federal government involvement in regulating this industry is based on three major policy areas. The first is food safety. Shellfish aquaculture produces food for human consumption and the government is responsible for protecting the public from the health risk that could occur from consuming contaminated shellfish. The second is the allocation of Crown land. Shellfish aquaculture occurs on Crown land, therefore the government must decide if it is an appropriate use of land. In addition, unresolved indigenous land claims that include wild shellfish and coastal space exist in the province and therefore the indigenous peoples must be consulted. The third is environmental protection. Shellfish aquaculture has the potential to impact the marine environment and therefore the government may intervene to mitigate those impacts. There are no laws specific to shellfish aquaculture defining the government responsibility; therefore government activity is based on established legislation covering these three areas. The following subsections will review the regulations used to manage the industry based on these areas.

4.2.1 Food safety

Shellfish aquaculture produces food for human consumption. The filter-feeding nature of shellfish renders them prone to concentrated toxins, microorganisms and viruses that may be present in the ambient environment (Quayle, 1998). Any of these can present a significant risk to public safety if the shellfish are consumed.

The safety of the shellfish produced under aquaculture conditions is the responsibility of the federal government under the Canadian Shellfish Sanitation Program (CSSP). The CSSP's objective is to protect the public from the consumption of contaminated shellfish by monitoring and intervening, when necessary, in the harvesting of shellfish in Canada. The program is designed to maintain equivalent health outcomes with food safety standards in the major export markets (e.g., United States, European Union and Japan).

The CSSP is led by the Canadian Food Inspection Agency (CFIA) in collaboration with Environment Canada (EC) and Fisheries and Oceans Canada (DFO) under the authority of two pieces of legislation: the *Fisheries Act (Management of Contaminated Fisheries Regulation)* and the *Fish Inspection Act (Fish Inspection Regulation)*. EC undertakes shellfish growing area surveys under the Marine Water Quality Monitoring Program that includes three main components: (1) the identification of pollution sources, including land-based sources; (2) meteorological and hydrographic studies to determine the influence of physical factors on the sanitary quality; and (3) bacteriological studies monitoring the levels of fecal contamination in shellfish growing areas. Based on the results of the survey, a classification level is assigned (Approved, conditionally approved, restricted, conditionally restricted or prohibited). The classification level is re-evaluated at least once every three years. EC does not undertake chemical testing under CSSP, but will advise the CSSP partners of any concerns resulting from the survey. DFO enforces the opening and closure of shellfish growing areas based on recommendations from EC and CFIA. Shellfish closure orders are made under the *Management of Contaminated Fisheries Regulation* pursuant to the *Fisheries Act*.

Bacteria are not the only concern, shellfish can also concentrate naturally occurring marine biotoxins occurring during certain algae blooms. Three types are monitored: Paralytic Shellfish Poison, Amnesic Shellfish Poison and Diarrhetic Shellfish Poison. The CFIA monitors for these marine biotoxins by sampling shellfish at established sampling stations and at processing plants the results of the test may lead to temporary closures.

Sanitary closures have increased steadily since the 1970s when EC began to monitor the sanitary quality of shellfish growing waters in B.C.. As of 2005, there were 123,832 hectares closed to harvesting of shellfish in B.C. This is double the area covered by closures before 1976. Of the closed areas, 58% are in the Strait of Georgia.

In 2007, 29% of shellfish aquaculture operations were subject to some form of closure due to fecal contamination. This varied by region, 46% of operations in Baynes Sound were subject to closures, 36% in the southern Strait of Georgia, 29% on the west coast of Vancouver Island, 17% on the Sunshine Coast and 8% in the northern Strait of Georgia. According to EC, in 2005 59% of closures resulted from multiple sources of contamination, 13% from agricultural/urban runoff, 11% from hinterland drainage, 10% from sewage discharges and 7% from marine vessel discharges.

While the increase in the area under closure is significant, part of this increase is the result of expanded monitoring activities to areas that had not previously been tested. EC surveys the sanitary quality of approximately 750,000 hectares of coastal water in B.C. of which 2,600 hectares are utilized for shellfish aquaculture (EC, 2005). However, some areas also remain closed because of lack of monitoring test for re-opening.

EC is also responsible for s.36 of the *Fisheries Act*, which prohibits the deposit of deleterious substances into fish habitat. This section of the *Fisheries Act* gives EC the power to protect the safety of shellfish growing areas by addressing the source(s) of pollution (i.e., deleterious substance). This section of the *Fisheries Act* is being increasingly used to address pollution resulting from sewage discharges to the marine environment. However, most sources of pollution are non-point or difficult to identify. As such, the federal government relies on the closing of shellfish harvesting areas as the primary instrument in ensuring shellfish sanitation.

Lack of government fiscal resources or alternative implementation mechanisms to support the expansion of the CSSP to accommodate the expansion of shellfish aquaculture is identified as an impediment to the shellfish aquaculture sector (Office of the Commission for Aquaculture Development [OCAD], 2001). Currently, the program operates over large geographical areas and therefore may close an operation based on water quality data collected at a distance from the site and may not reflect the conditions at the site. One recommendation is that the industry be involved more in monitoring growing water sanitary levels for classification purposes (OCAD, 2004).

4.2.2 Access to space

Shellfish aquaculture operations are located directly on or suspended above the coastal shore or seabed. Provincial government jurisdiction on the coast is based on proprietary powers

over the foreshore (the area between the low water level and the natural boundary), embayed seabeds and the beds of inland seas such as the Strait of Georgia, Juan de Fuca Strait and Johnstone Strait, with the exception of federal Crown lands (e.g., harbours) and Indian Reserve land. The federal government, and not the province, has jurisdiction over these lands, the exception being coastal land covered under a treaty negotiation with a First Nation, in which case the land may be under the jurisdiction of the Nation. However, to date no coastal lands have been included in any settled treaty negotiations in B.C.

Prior to commencing operation, shellfish aquaculturists must obtain tenure to the ocean space from the provincial Integrated Land Management Bureau (ILMB) under authority of the *Land Act*. Land tenures come in two forms, a lease or a licence of occupation, not to be confused with a license of operation under the provincial *Fisheries Act*. A lease is granted for a maximum of thirty years and is issued when long-term tenure is required, substantial improvements are proposed, and/or definite boundaries are required to avoid conflicts. A license of occupation generally has a term of 20 years and are issued when minimal improvements are proposed or a short-term tenure is required to allow development to proceed while an applicant is completing survey requirements for a lease or assessing the capability of a location. In 2007, 71% of shellfish aquaculture tenures were in the form of licenses of occupation.

Regional Districts and local governments in the province have authority to influence and regulate land-use and development, including activities on Crown lands. They regulate activities using Land-Use Zoning Bylaws under the authority of *Local Government Act* and the *Islands Trust Act*. Therefore, if the site requested for shellfish aquaculture is under zoning authority and is not zoned for aquaculture, the applicant has to apply for re-zoning through the local government. This does not negate the need to apply for a tenure through the provincial government.

First Nations view coastal areas as a traditional and communal resource. Shellfish aquaculture in particular can be viewed as an infringement of aboriginal sovereignty (Joyce & Canessa, 2009). In addition, there is large aboriginal participation in commercial intertidal clam harvest. Aboriginal rights and title are recognized and affirmed in the *Constitution Act, 1982*. These rights take precedence over provincial legislation if they are proven in court or if a treaty has been signed. However, in the absence of the recognition of rights through the courts or a treaty, the province is responsible for avoiding unjustifiable infringements upon any rights or

title that may exist. The province must consult with all First Nations with any interests in a site when an application is pending. In B.C., final treaty agreements are in effect for two nations, the Nisga'a Nation and the Tsawwassen First Nation; in 2011 there were 60 First Nations participating in treaty negotiations representing approximately two thirds of all aboriginal people in B.C.. Seven First Nations have signed agreements in principle, the blueprint for a final treaty (BC Treaty Commission, 2011). It is still unclear whether coastal lands will be included in treaty agreements.

Federal government jurisdiction with respect to the location of shellfish aquaculture operations is based on its responsibility for protecting the public right to navigate under the *Navigable Waters Protection Act* (1985). The *Navigable Waters Protection Act* (NWPA) prohibits the construction or placement of a “work” in any navigable water unless approved by Transport Canada. All suspended shellfish aquaculture facilities and certain intertidal facilities are considered a “work” under the NWPA and therefore require an approval prior to construction. However, prior to 2001 shellfish aquaculture operations were exempt from such approvals. Since 2001 the location of the proposed operation is assessed by Transport Canada to evaluate the impacts of the operation on navigation safety. An approval under the NWPA then triggers a federal environmental assessment of the project and the site under the *Canadian Environmental Assessment Act*. The *Canadian Environmental Assessment Act* will be discussed in the next subsection.

4.2.3 *Environmental protection*

Environmental protection has come to be accepted as one of the fundamental values of Canadian society. Environmental issues are complex, influencing and influenced by all policy areas and therefore cannot be addressed by one level of government. Therefore, both the federal and provincial levels of government use legislative tools to address the potential environmental impacts of shellfish aquaculture. The following subsection will describe activity on this front.

Although traditionally the provincial government has taken the lead with respect to protecting the environment, in the marine environment potential environmental impacts are primarily addressed through federal legislation (Harrison, 1996). The federal government addresses potential environmental impacts of shellfish aquaculture through four existing pieces

of legislation, the federal *Fisheries Act*, the *Species at Risk Act*, the *Migratory Birds Convention Act* and the *Canadian Environmental Assessment Act*.

The constitution gives the federal government exclusive legislative power over the “sea coast and inland fisheries”. Through the *Fisheries Act* the federal government adopts measures to preserve fish and fish habitat, providing the federal government with an important opportunity to regulate impacts to marine habitat (e.g., the seabed) and water quality. Section 35 of the *Fisheries Act* prohibits the “harmful alteration, degradation and destruction (HADD) of fish habitat”, which prohibits the establishment of shellfish aquaculture operations on or over fish habitat such as eelgrass unless authorized by DFO.

Fisheries and Oceans Canada (DFO) is responsible for administering and enforcing the fish habitat protection provisions of the Act. The *Fisheries Act* provisions do not require DFO to take action to prevent a HADD. However, shellfish aquaculture applications are referred to DFO for review. If a proposed shellfish aquaculture operation will result in a HADD, DFO will either work with the proponent to mitigate a HADD or can authorize a HADD. An authorization will trigger an environmental assessment under the *Canadian Environmental Assessment Act*.

Section 43 of the *Fisheries Act* allows for the creation of regulations for the conservation and protection of fisheries resources. The shellfish aquaculture industry is in some cases reliant on the introduction of non-native species or the transfer of native species from one location to another which can create a risk to native species. As a result, the *Fisheries (General) Regulation* establishes the regime for licensing the introduction and transfer of shellfish to protect native species. Interviews with regulators responsible for this section of the Act suggest that the policy direction is to support the development of native species not any new non-native species.

The *Migratory Birds Convention Act* prohibits the harming of migratory birds and the disturbance or destruction of their nest and eggs. The *Canadian Wildlife Service of Environment Canada* administers the *Migratory Bird Convention Act*. Shellfish aquaculture has the potential to disturb migratory birds if placed within a staging area or through the use of deterrence devices to prevent predation by migratory birds. This act can be used to prevent this potential impact.

The *Species At Risk Act* contains general prohibitions that make it an offence to kill, harm, harass, capture or take a listed species at risk and damage or destroy the residence of a species at risk. In addition, the *Species At Risk Act* requires the creation of recovery strategies for species at risk including the identification of critical habitat that must be protected. For

ocean species, DFO is responsible for creating, identifying and protecting their habitat. As such, this act can help identify important habitat to ensure they are not impacted by potential development in the shellfish aquaculture industry.

All suspended shellfish aquaculture operations now undergo an environmental assessment under the *Canadian Environmental Assessment Act* (CEAA) triggered by the need for an approval under the *Navigable Waters Protection Act*. CEAA may also be triggered through an authorization to cause a harmful alteration, degradation or destruction of fish habitat under the *Fisheries Act*. Although such authorizations are rare for shellfish aquaculture, if they do occur it generally applies to the intertidal culture of shellfish because important fish habitat such as eelgrass occurs in the intertidal area of the coast. The environmental assessment is a process used to predict and mitigate the adverse environmental effects of a project before it is carried out.

The scope of the environmental assessment is the same for every project in the marine environment. It includes the following environmental components: (1) fish and fish habitat; (2) water quality; (3) accidents and malfunctions; (4) cumulative effects; and (5) the effects of the environment on the project. Although CEAA has provisions for assessing the cumulative effects of a project, in the interviews conducted for this research regulators stated that they did not have clear guidance on how to assess cumulative effects. CEAA is also focused on components of the ecosystem not the ecosystem as a whole. In addition, CEAA does not consider socio-economic effects, such as conflicts with other users. Therefore CEAA is not a comprehensive tool for assessing the effects of shellfish aquaculture.

The provincial government addresses potential environmental impacts of shellfish aquaculture through the provincial *Fisheries Act*. The *Fisheries Act* gives the provincial government the authority to license shellfish aquaculture operations. In 2002 the provincial government developed a Code of Practice for Shellfish Aquaculture as an enforceable condition of acquiring an aquaculture license. The Code of Practice for Shellfish Aquaculture is a form of regulation made by a Ministry as opposed to the Provincial Legislature or Parliament of Canada. The Code of Practice for Shellfish Aquaculture sets social and environmental objectives for 17 operational practices and includes baseline standards for achieving these objectives. For example, under the operational practice “tenure modification” the objective is “to prevent negative impacts on fish or wildlife habitat when enhancing the productive capacity of a site” and the baseline requirements are: (1) comply with their approved Shellfish Management Plan

when physically modifying their site; and, (2) receive a letter of advice or authorization from DFO before proceeding with physical modification of sites are required. As such, the Code of Practice is a more targeted regulatory tool and the only regulatory tool that directly addresses impacts specific to the shellfish aquaculture industry.

As a result of established jurisdiction for areas affected by shellfish aquaculture, the regulatory framework for the industry is composed of ten separate pieces of legislation spread across three levels of government (federal, provincial, and municipal) and under the authority of seven different government agencies (see Table 4.1). Further implications of the regulatory framework will be discussed in Chapter 6 as they pertain to the implementation of ecosystem-based management.

Table 4.1 Overview of legislation pertinent to shellfish aquaculture in B.C.

Legislation	Relevance to Shellfish Aquaculture	Responsible Agency
Provincial		
The Constitution Act (1867) establishes provincial government authority over land-use, including aquatic lands, and the business of bivalve aquaculture.		
<i>Fisheries Act</i> (Ch. 149, R.S.B.C. 1996)	Establishes the regime for the management and control of aquaculture using a licensing approach. It allows the Ministers to enact regulations for “safe and orderly aquaculture”.	Ministry of Agriculture and Lands
<i>Land Act</i> (Ch. 245, R.S.B.C. 1996)	Establishes the regime for the disposition of Crown Land for shellfish aquaculture operations.	Ministry of Agriculture and Lands
<i>Land Use Objectives Regulation</i>	Requires the provision of an appropriate balance of social, economic and environmental benefits in the creation of objectives for land use plans.	Integrated Land Management Bureau
<i>Local Government Act</i> (Ch. 323, R.S.B.C. 1996)	Gives local governments authority to create bylaws zoning land under their jurisdiction.	Integrated Land Management Bureau
<i>Farm Practices Protection (Right to Farm) Act</i> (Ch. 31, R.S.B.C. 1996)	Licensed aquaculture operations are included in the definition of “farm operations” and therefore subject to the protections under the act, including limiting the liability of aquaculturists for nuisance arising from “normal” farm operations and a complaint board to resolve conflicts.	Various local governments
Federal Government		
The Constitution Act (1867) establishes federal authority over navigation and shipping, sea coast fisheries, including the protection of their habitat, and all matters not under the exclusive jurisdiction of the province.		
<i>Fisheries Act</i> (R.S. 1985, c.F-14)	Establishes a regime for the management and control of fisheries. Aquaculture was not considered a fishery until a B.C. Supreme Court Decision in 2009 (<i>Morton v. British Columbia</i> (Agriculture and Lands)).	Fisheries and Oceans Canada
	Provides for the conservation and protection of fish and fish habitat. Shellfish aquaculture applications are assessed by DFO with respect to potential impacts on fish habitat.	
	Provides for the control and management of aquatic invasive species. Shellfish aquaculturists must get a permit from DFO to introduce or transfer certain bivalve species.	

Legislation	Relevance to Shellfish Aquaculture	Responsible Agency
<p><i>Management of Contaminated Fisheries Regulation</i> (S.O.R. 90-351)</p> <p><i>Fisheries (General) Regulation</i></p>	<p>Licences fisheries including the collection of wild spat from the environment for the purpose of aquaculture.</p> <p>Provides for the prohibition of harvesting in areas believed to be contaminated unless a decontamination plan has been approved. Provides the authority to open and close areas to shellfish harvesting under the Canadian Shellfish Sanitation Program.</p> <p>Establishes a regime for the control of bivalve transfers from one location to another in order to protect native species.</p>	<p>Fisheries and Oceans Canada</p> <p>I&T Committee of DFO</p>
<p><i>Navigable Waters Protection Act</i> (R.S. 1985, c.N-22)</p>	<p>No work shall be built or placed in, on, over, under, through or across any navigable water without the Minister's prior approval of the work, its site and the plans for it.</p> <p>Off-bottom and suspended aquaculture operations are considered "works" under this Act.</p>	<p>Transport Canada</p>
<p><i>Canadian Environmental Assessment Act</i> (R.S. 1992, c.37[c.15.2])</p>	<p>An authorization under s.5(1) of the NWPA triggers an environmental assessment under the <i>Canadian Environmental Assessment Act</i>. Establishes a regime to incorporate environmental assessments as information tools for federal decision-makers.</p> <p>Approvals under the <i>Navigable Waters Protection Act</i> and authorizations under the <i>Fisheries Act</i> trigger an environmental assessment for shellfish aquaculture.</p>	<p>Responsible Authority (TC)</p>
<p><i>Fish Inspection Act</i> (R.S., 1985, c. F-12)</p>	<p>Shellfish aquaculture generally triggers an environmental assessment under the <i>Navigable Water Protection Act</i>.</p> <p>Gives authority to inspect fish products, including shellfish, under the Canadian Shellfish Sanitation Program.</p>	<p>Canadian Food Inspection Agency</p>
<p><i>Species at Risk Act</i> (S.C. 2002, c.29)</p>	<p>Provides for the protection of species at risk. DFO is responsible for the protection of aquatic species at risk and is responsible for creating a recovery strategy for species at risk that identifies critical habitat which can impact the location of shellfish aquaculture operations.</p>	<p>Fisheries and Oceans Canada</p>
<p><i>Migratory Birds Convention Act</i> (S.C. 1994, c.22)</p> <p><i>Oceans Act</i></p>	<p>Section 79 requires the proponent of a project that could impact a listed species or critical habitat to undertake an environmental assessment and monitor and mitigate any potential effects.</p> <p>Section 6(1) prohibits the disturbances, destruction or taking of the nests or eggs of migratory birds.</p> <p>Section 32 gives the Minister authority to establish marine environmental quality guidelines, objectives and criteria for the marine environment.</p>	<p>Environment Canada</p> <p>Fisheries and Oceans Canada</p>
<p>First Nations</p> <p>The <i>Constitution Act, 1982</i> recognizes and affirms existing Aboriginal and treaty rights. However, in the absence of the recognition of rights through the courts, the government is responsible for avoiding unjustifiable infringements upon any rights or title that may exist. Therefore the government must consult with all First Nations with any interests in a site for which a shellfish aquaculture application is pending.</p>		

4.3 The Governance Process

The regulatory and policy frameworks described in the previous sections shape the governance process for proposed shellfish aquaculture operations. Governance occurs primarily during the initial site and licensing application process and during license and lease renewals. It is through this decision-making process that the federal and provincial governments determine the capability and suitability of the proposed location and dictate the terms and conditions of operation.

The decision-making process underwent a series of changes beginning in 2000. First, suspended shellfish aquaculture operations were deemed a threat to navigation and therefore the location of operations began to require a federal authorization under the *Navigable Waters Protection Act*. In turn, shellfish aquaculture applications needing such authorization then required an environmental assessment under the *Canadian Environmental Assessment Act*. The second change took place in 2005 when responsibility for the *Navigable Waters Protection Act* was transferred from Fisheries and Oceans Canada to Transport Canada. As a result, an additional government department became involved in the evaluation of shellfish aquaculture applications. The third change occurred in 2004 the result of a Supreme Court of Canada ruling (*Haida Nation v. British Columbia (Minister of Forests)*, 2004) that made it clear that the Government of British Columbia has an obligation to consult with First Nations when decisions related to activities on Crown land could impact on Aboriginal rights and title. As a result, the provincial government began to consult First Nations prior to making any tenure or licensing decisions, including those for renewals. The following reflects the institutional and procedural arrangements in 2006.

Proposed shellfish aquaculture operations require at least two provincial approvals, potentially two federal approvals, and consultation with First Nations, stakeholders and the public. Figure 4.1 contains a flow chart of the federal-provincial approval process for shellfish aquaculture. The following elaborates on the portions of the flowchart marked with associated numbers.

- 1) The applicant submits an application package to Front Counter BC which includes the following forms and information:

- i. Shellfish Management Plan: this containing a description of the site, operation, layout, proposed improvements, production information and waste management plans.
- ii. Application for Crown Land which requires minimal information on the proposed use.
- iii. Relevant fees (e.g., Land Tenure Purpose and Application Fees (\$1,260), Shellfish Aquaculture Licence Fee (\$50))

Front Counter BC is a service provided by the provincial government to help clients of natural resource ministries obtain all the information and authorizations they need to start a business and then refers the information to relevant agencies on behalf of the province. This service is intended to facilitate access to the provincial government.

- 2) The Shellfish Management Plan is then referred by Front Counter BC to the following four institutions for comment:
 - i. Fisheries and Oceans Canada, Regional Aquaculture Coordination Office (RACO).
 - ii. Transport Canada, Navigable Water Protection Division.
 - iii. Relevant First Nations.
 - iv. Relevant Local Government.
 - v. Provincial Biologist
- 3) The Integrated Land Management Bureau coordinates the collection of comments from the four referral bodies (see above) and the public, and passes them on to the Ministry of Agriculture and Lands - Aquaculture and Commercial Fisheries Branch and Crown Land Administration Division. Information from the public is canvassed through advertisements in local newspapers.
- 4) The Aquaculture and Commercial Fisheries Branch makes an approval decision for the aquaculture licence and sets the terms and conditions of the licence. Decisions are based on the merits of the management plan in relation to the capability of the environment and the suitability of the operation based on information from other agencies. Suitability differs from capability in that it considers socio-economic factors influencing the appropriateness of a site whereas capability only considers biophysical factors.

- 5) The Crown Land Administration Division makes an approval decision for the Crown land tenure. The Crown Land Administration Division requires written consent from upland owners for intertidal shellfish aquaculture operations. The applicant is responsible for acquiring this consent. If the application is successful, the applicant must advertise inviting comments in the local newspapers prior to final approval. The Crown Land Administration Division makes decisions based on the availability of the land and the suitability of the use based on comments received from other agencies and the public.
- 6) The Fisheries and Oceans Canada (DFO) Regional Aquaculture Coordination Office coordinates the three potential approvals from DFO. The RACO forwards the Shellfish Management Plan to the three following DFO branches and committees:
 - i. Introduction and Transfers Committee: Reviews the project if the applicant plans on introducing “seed” or spat from a hatchery. If so, the proponent will require and Introduction and Transfer Licence under the *Fisheries Act*.
 - ii. Fisheries Management Branch: Reviews the project to provide comment on any potential conflict with fisheries. If the project plans on catching wild “seed” or spat for their operation, they will require a fisheries licence under the *Fisheries Act*.
 - iii. Oceans, Habitat and Enhancement Branch: Reviews the project to assess if it has potential to result in the harmful alteration, disruption or destruction (HADD) of fish habitat. The Habitat Management Program developed Operational Statements for intertidal and deep-water bivalve aquaculture operations in 2007 that eliminate the need for a review of a project to assess a HADD if the conditions and measures in the Operational Statement are followed. If the conditions and measures in the Operational Statement cannot be followed, a full review of the proposal is conducted. The applicant is then responsible for submitting habitat information as required in DFO’s *Guide to Information Requirements for Environmental Assessment of Marine Shellfish Aquaculture*. If the proposal is found to result in a HADD, a *Fisheries Act* Authorization under section 35(2) will be required. Such an authorization will trigger an environmental assessment under the *Canadian Environmental Assessment Act*.

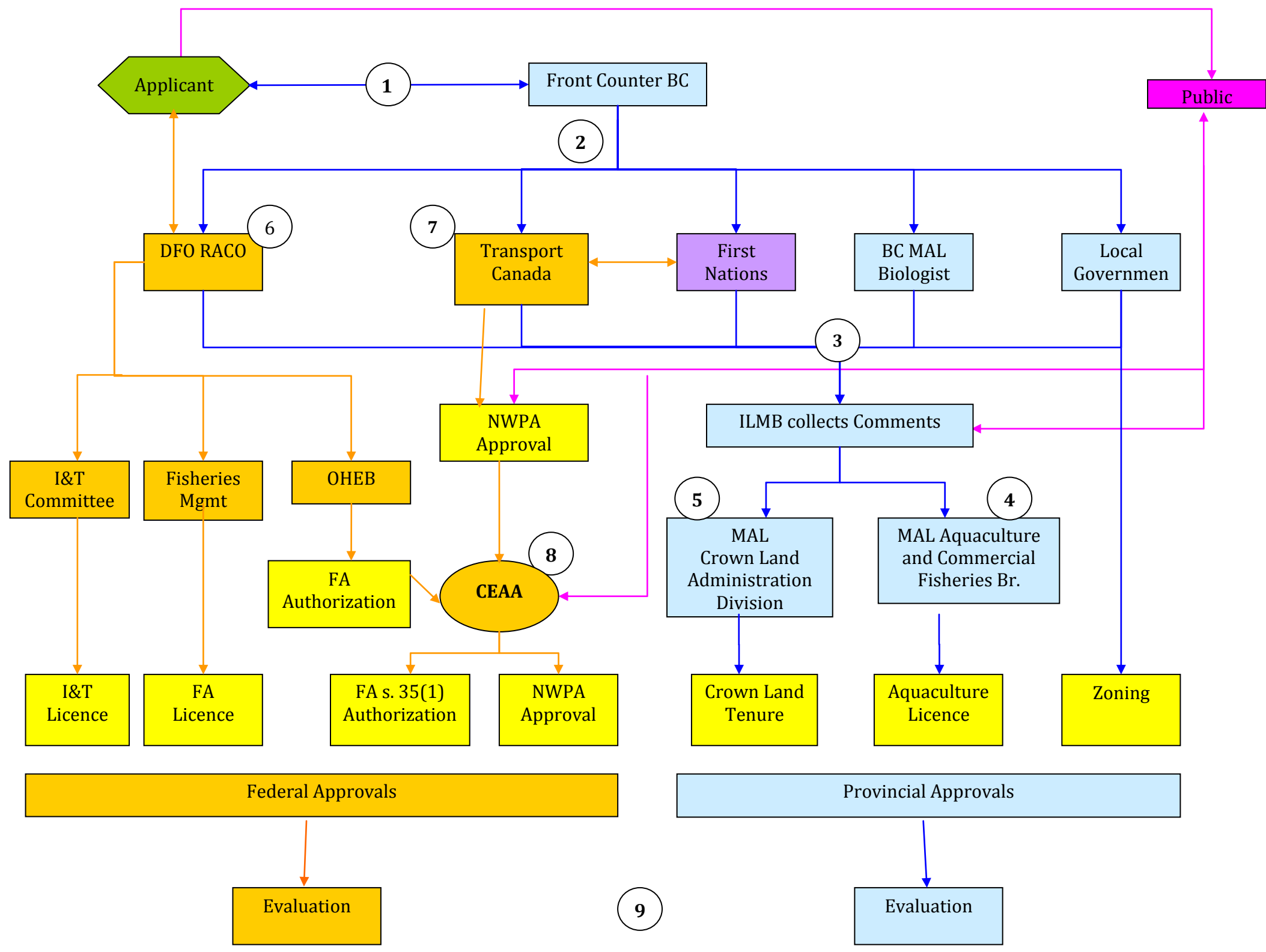
- 7) The Navigable Waters Protection Division of Transport Canada reviews applications to assess any threats or conflicts with navigation. All suspended deep-water bivalve aquaculture operations require a *Navigable Waters Protection Act* authorization. The Navigable Waters Protection Division will consult marine stakeholders and relevant First Nation governments when making a decision. Such authorizations trigger an environmental assessment under the *Canadian Environmental Assessment Act*.
- 8) Bivalve aquaculture undergoes a screening type environmental assessment (EA). During the EA, the Responsible Authority (RA) (i.e., the agency that triggered the CEAA) will consult with other expert authorities, generally Fisheries and Oceans Canada and Environment Canada. They will also consult with First Nations and provide the opportunity for public comment through the *Canadian Environmental Assessment Registry* on the Canadian Environmental Assessment Agency webpage. The RA will work directly with the applicant to collect any additional information. The scope (i.e., what is included in the project and what is included in the environmental assessment of the project) is determined by RA and includes mandatory and discretionary factors. The scoping of the assessment is critical to how the federal decision-maker makes a final decision on whether the project is likely to result in a significant environmental effect and whether that effect is justified.
- 9) Two forms of compliance monitoring are performed after a shellfish aquaculture operation is approved. The first is an evaluation of the shellfish aquaculture operation for compliance with the terms and conditions of their approval. The second is an evaluation of the decision to approve a shellfish aquaculture operation.

The provincial government evaluates compliance with the Shellfish Aquaculture Management Plan and the terms and conditions attached to the shellfish aquaculture licence including the B.C. Shellfish Aquaculture Code of Practice. Fisheries officers with the Ministry of Agriculture Lands try to visit every shellfish aquaculture site once every four years. In addition they will respond to any specific complaints with respect to an individual site. The shellfish aquaculture licence is renewed every five years, which provides an opportunity to review the suitability of an operation. The reviews do not focus on the potential impacts of an operation but instead on compliance with the

approved Shellfish Management Plan (e.g., boundaries of the site, species cultured and production levels).

The federal government does not evaluate compliance of shellfish aquaculture operations. The *Canadian Environmental Assessment Act* does not have any enforcement provisions because it is a decision-making tool and not a regulatory tool and therefore the suggested mitigation measures stemming from the environmental assessment are not enforced under the Act. If there is a concern about the potential impact of a shellfish aquaculture operation, it is up to the federal department involved to use the legislative tools at their disposal. For example, if a shellfish aquaculture operation is impacting fish habitat, Fisheries and Oceans Canada could charge the operator under the *Fisheries Act*. But because a *Fisheries Act* offence results in a criminal charge, the *Fisheries Act* is less likely to be used to ensure compliance, unless the offence is severe. The approval under the *Navigable Waters Protection Act* must be renewed every five years. The review process is not as comprehensive as for new applications and does not trigger an environmental assessment under the *Canadian Environmental Assessment Act*. Transport Canada does consult the boating community and relevant First Nations to see if any conflicts have arisen during the last five years that should be considered prior to renewing the authorization.

Figure 4.1 Federal-Provincial approval process for shellfish aquaculture



Legend

Provincial Approval Process

ILMB Integrated Land Mgmt Bureau
 MAL Ministry of Agriculture and Lands

Federal Approval Process

DFO Fisheries and Oceans Canada
 NWPA Navigable Waters Protect Act
 TC Transport Canada
 I&T Introduction and Transfers
 RACO Regional Aquaculture Coordination Office
 CEAA Canadian Environmental Assessment Act
 FA Fisheries Act
 OHEB Oceans, Habitat and Enhancement Br.

Public Input

First Nation

Shellfish Farmer

4.4 Summary and Key Issues

Based on the interviews with government regulators, four main challenges were identified with the current governance approach to shellfish aquaculture. The first is the multi-lateral government context which includes seven different government agencies across three levels of government and increasingly includes consultation with various stakeholder groups. The second challenge is a lack of comprehensive targeted regulations for the shellfish aquaculture industry. The third challenge is the ill-use of marine spatial planning initiatives, which is linked to the first challenge. The fourth challenge is unresolved First Nation land claims. Together these challenges contribute to an inefficient, unpredictable and costly site application process.

The multi-lateral government context is in part the result of the constitutional division of power between the federal and provincial government. As seen in the literature review, a similar challenge exists in the United States which also has an overly complex regulatory environment that dissuades investment in the industry. The result is multiple agencies addressing concerns in a piece-meal way resulting in overlap and gaps in regulatory coverage. For example, the potential environmental impacts of shellfish aquaculture are addressed by Environment Canada with respect to migratory birds, Fisheries and Oceans Canada with respect to fish habitat and species at risk and Transport Canada with respect to the environmental assessment. Conflicts with other coastal interests are addressed by Fisheries and Oceans Canada with respect to fisheries, local government with respect to local community concerns, Transport Canada with respect to navigation, and potential conflicts with First Nation interests is addressed by three government agencies, the provincial Ministry of Agriculture and Lands, Fisheries and Oceans Canada and Transport Canada.

In B.C., the legal instruments are adapted from existing legislation and not targeted to shellfish aquaculture. The regulatory framework is based on existing legislation that is not well suited for the nature of shellfish aquaculture. For example, the primary regulatory instrument is the provincial license under the *Fisheries Act*. The licensing provisions under this act are designed for fisheries. The main challenge with this is the lack of flexibility in the licenses; there are no provisions to allow a license to be amended over time. A seasonal fishery would not require this flexibility, but as conditions change, a shellfish farmer may want to adapt their

activities. As it stands they cannot do this without applying for a new license. Another example is the legislation used to address the environmental impacts of shellfish aquaculture. Although the current legislation addresses all potential site-specific effects of the industry, the literature on shellfish aquaculture shows that the main ecological concern is from the cumulative impacts of multiple activities. Although the environmental assessment under the *Canadian Environmental Assessment* has cumulative impact within its assessment scope, the site-by-site nature of the application process challenges regulators' ability to assess cumulative impacts in any meaningful way.

The provincial government has undertaken several marine spatial planning initiatives in areas with significant shellfish aquaculture development such as Baynes Sound, Malaspina Inlet, and Gorge Harbour. These planning initiatives could have addressed the first challenge of coordinating the federal, provincial and local governments but they were undertaken primarily by the provincial government with consultation with other levels of government but no commitment to enact or enforce the plans. As a result of these challenges, the provincial government is now stepping away from marine spatial planning.

The final challenge relates to unresolved First Nation land claims in the province. The provincial government is currently addressing this issue through a policy of consultation with First Nations prior to making any decisions that may affect areas that may be covered by land claims, this includes the seabed. This causes two challenges. First, until the treaties are negotiated, the number of consultations is large which slows down the management process for shellfish aquaculture, and other activities. The number of referrals to individual nations can be large affecting their ability to respond in a timely manner. The second challenge relates to the uncertainty as to what lands may be available in the future for shellfish aquaculture. This uncertainty affects the willingness of entrepreneurs to invest in the province. New Zealand experienced a similar challenge with the Maori. They made a priority of addressing this issue during their legislative renewal for the shellfish aquaculture industry that can be used as an example for the provincial government moving forward.

Chapter Five: The Industry's Perspective

5.0 Introduction

This chapter presents the results of the survey conducted with the shellfish aquaculture industry in British Columbia (B.C.) addressing the second objective of this thesis: to understand the shellfish aquaculture industry within the context of EBM. Due to the small response rate ($n = 69$), this study is limited to an exploration and descriptive analysis presented using frequency distributions and cross-tabulations of the results.

The survey was designed to explore the characteristics and values of individual shellfish farmers to assist in understanding the barriers and opportunities they present for EBM. This chapter is divided into four sections. The first section presents the results pertaining to the respondents' characteristics. The second section explores potential trends in industry development. The third section explores the factors that may influence industry behaviour. The final section presents the barriers to development faced by respondents and their proposed solutions.

5.1 Shellfish Farmer Characteristics

The first section of the survey asked respondents a series of general questions about their enterprises. Some of the results describe attribute of the industry not previously available through published government statistics. Throughout the analysis, relationships between various characteristics are explored.

5.1.1 Geographic distribution of sites

The geographic area where an aquaculture operation is located may influence the nature of the operations and the challenges respondents face. The geographic distribution of sites was assessed by cross-referencing the respondents contact information with government data containing the location of operations.

Respondents were spread across five geographic areas in B.C. (Map 3.1, **page 46**): Baynes Sound, the southern Strait of Georgia, the northern Strait of Georgia, the Sunshine Coast and the West Coast of Vancouver Island.

The majority of respondents are located in Baynes Sound (25%), the west coast of Vancouver Island (23%) and the northern Strait of Georgia (17%). A smaller number are located in the southern Strait of Georgia (9%) and the Sunshine Coast (4%) (Table 5.1). The distribution of respondents by geographic area creates an opportunity to explore the spatial diversity of respondents. It is noted that the small sample size for the southern Strait of Georgia and the Sunshine Coast affects the ability to draw meaningful conclusions.

Table 5.1 Frequency distribution of the location of respondents' sites by geographic area (n = 69)

Geographic Area	Frequency (n)
Baynes Sound	17
West Coast Vancouver Island	16
Northern Strait of Georgia	12
Southern Strait of Georgia	6
Sunshine Coast	3
n/a	15

5.1.2 Proximity to operations

The survey asked respondents if their shellfish aquaculture operations are located in the community where they live. The results show that a large majority of respondents live and farm in the same community (78%). However, when the responses are analyzed spatially, the results show that this is not the case on the west coast of Vancouver Island where the majority operate farms outside their communities (Table 5.2).

Table 5.2 Cross-tabulation of a frequency distribution of respondents operating farms in their community by geographic area (n=69)

Location	Farm in community		
	Yes	No	Total
Baynes Sound	15	2	17
Northern Strait of Georgia	12	0	12
West Coast Vancouver Island	7	9	16
Southern Strait of Georgia	6	0	6
Sunshine Coast	2	1	3
n/a	12	3	15
Total	54	15	69

5.1.3 Form of employment

The survey asked respondents whether they farm shellfish on a part-time or full-time basis. This question was posed to assess the form of employment respondents experience in the industry. The results showed an almost even split in the number of respondents who farmed shellfish on a full-time and part-time basis (55% and 45% respectively). This suggests either barriers to full-time employment in the shellfish aquaculture industry or that shellfish farmers chose to farm on a part-time basis.

To explore this further, the results were cross-tabulated with other attributes to assess any relationships. First the results were analyzed geographically to assess if any differences exist by geographic areas (Table 5.3). The results show that a large proportion of part-time farmers are located on the west coast of Vancouver Island and the northern Strait of Georgia. Barriers specific to these geographic areas will be explored in section 5.4.

Table 5.3 Cross-tabulation of the frequency distribution of respondents' employment status by geographic area (n=69)

Location	Employment		
	Full-time	Part-time	Total
West Coast Vancouver Island	5	11	16
Northern Strait of Georgia	6	6	12
Baynes Sound	12	5	17
Southern Strait of Georgia	4	2	6
Sunshine Coast	2	1	3
n/a	9	6	15
Total	38	31	69

The results were also cross-tabulated with the proximity to operations. Overall, a larger proportion of part-time farmers' have operations outside their communities (Table 5.4). However, this does not explain the high proportion of part-time farmers in the northern Strait of Georgia where all respondents operate farms within their communities.

Table 5.4 Cross-tabulation of the frequency distribution of respondents operating farms in their community by their employment status (n=69)

Employment status	Farm in community		
	Yes	No	Total
Full-time	33	5	38
Part-time	21	10	31
Total	54	15	69

Other reasons for the high proportion of part-time farmers may be deduced from information contained in responses to open-ended questions. One factor that emerged from these responses is the physical nature of the coastal environment. As one respondent stated *“I don’t farm in the winter due to night tides.”*. The winter months in B.C. are characterized by shorter days, stormier weather and low tides at night. The same respondent went on to say that they do odd jobs to supplement the seasonal income. As such, some farmers such as the one quoted, may limit activity to a seasonal basis. Another respondent commented that they got into the industry as a hobby and balance it with an existing full-time job. Therefore, the part-time status of employment may be a choice in these cases.

Another reason may be economic. For example one respondent stated: *“shellfish are a low value product thus cannot be farmed in some remote inlets and compete with oysters coming from areas closer to the market”*. In this comment, the respondent brings attention to the added costs of farming in a remote location where product must be shipped in refrigerated transportation to urban centres for processing. Therefore they may need to supplement their income with other employment. As stated previously, the two areas with the highest concentration of part-time farmers, the west coast of Vancouver Island and the northern Strait of Georgia, are the most remote geographic areas in this sample. In this case, economic factors may be a factor contributing to the number of part-time farmers.

5.1.4 Operations

The nature of shellfish aquaculture operations with respect to the type of husbandry method employed, species grown, and the size of operations, can influence their relationship to the ecosystems as seen in Chapter 2. In addition, the size of operations can influence a respondent’s ability to engage and be engaged by government. The following subsection looks at the type of operations represented in the sample.

The type of husbandry method was assessed by cross-referencing survey results with published government statistics. The results show that 46% of respondents have intertidal sites, 26% have deep-water sites and 28% have sites that include both intertidal and deep-water. However, the type of husbandry method employed differs among geographic areas (Table 5.5). Respondents from the west coast of Vancouver Island, the northern Strait of Georgia, and the Sunshine Coast use primarily of suspended husbandry techniques; whereas those in Baynes

Sound and the southern Strait of Georgia use predominantly bottom culture techniques. The type of husbandry method employed is influenced by a farmer's preference and the biophysical nature of the coast. For instance, the choice to use bottom culture techniques will be influenced in part by the availability of sites with the appropriate sediment and the choice to use suspended culture techniques will be influenced in part by the required financial investment for infrastructure.

Table 5.5 Cross-tabulation of the frequency distribution of culture techniques by geographic area (n = 54*)

Geographic Area	Culture Technique			Total
	Bottom	Suspended	Both	
Baynes Sound	11	0	6	17
West coast Vancouver Island	4	9	3	16
Northern Strait of Georgia	4	4	4	12
Southern Strait of Georgia	6	0	0	6
Sunshine Coast	0	1	2	3
Total	25	14	15	54

*Note information on the culture technique did not come from the survey results but from other sources. It was only possible to identify 54 of the survey respondents in order to acquire this information.

The findings were also cross-tabulated with the respondents' status of employment (table 5.6). These results show that the majority of respondents that farm on a full-time basis have sites that allow both bottom culture and suspended culture, whereas the majority of respondents that farm on a part-time employ bottom culture techniques. Sites that allow for both bottom and suspended culture would allow greater flexibility with respect to species cultured.

Table 5.6 Cross-tabulation of the frequency distribution of culture technique by employment status (n=54)

Employment Status	Culture Technique			Total
	Bottom	Suspended	Both	
Full-time	11	6	12	29
Part-time	15	7	3	25
Total	26	13	15	54

The majority of respondents (86%) grow Pacific oysters on their site. Other species grown include the Manila clam (49%), Japanese scallop (13%), and gallo mussel (13%). In addition, some respondents grow geoduck mussels, blue mussels, rock scallop, savoury clam and cockle.

The type of species grown was analyzed based on geographic area to assess any differences. The respondents from the northern Strait of Georgia farm the largest variety of

species with over six species represented. This is followed by the west coast of Vancouver Island with five species represented and the Sunshine Coast with four species represented. Baynes Sound and the southern Strait of Georgia have three species represented (Pacific oyster, Manila clam and Japanese scallops). This suggests factors encouraging the use of a wider variety of species in certain geographic areas.

The survey asked respondents the number of shellfish aquaculture tenures they manage (Table 5.7). Sixty-one percent of respondents manage a single site and 39% manage multiple sites.

Table 5.7 Frequency distribution of the number of tenures operated by respondents (n=69)

Number of Sites	Frequency
1	42
2	10
3	4
4	7
5	1
>5	5

A cross-tabulation of the distribution of single- and multiple-site operations by geographic area is presented in Table 5.8. The number of single-site operations is proportionally higher in the northern Strait of Georgia and on the Sunshine Coast. In the other three geographic areas, an almost even split exists between single-site and multi-site operations. One reason why there may be more single-site operations in the northern Strait of Georgia is due to the existence of an industry cooperative, which may assist single-site operators (i.e., smaller operators) to market their products.

Table 5.8 Cross-tabulation of the frequency distribution of the number of sites operated by respondents by geographic area (n=69)

Location	Number of Sites		
	1	>1	Total
Baynes Sound	9	8	17
Northern Strait of Georgia	9	3	12
West Coast Vancouver Island	8	8	16
Southern Strait of Georgia	3	3	6
Sunshine Coast	3	0	3
n/a	10	5	15
Total	42	27	69

5.1.5 *Industry associations*

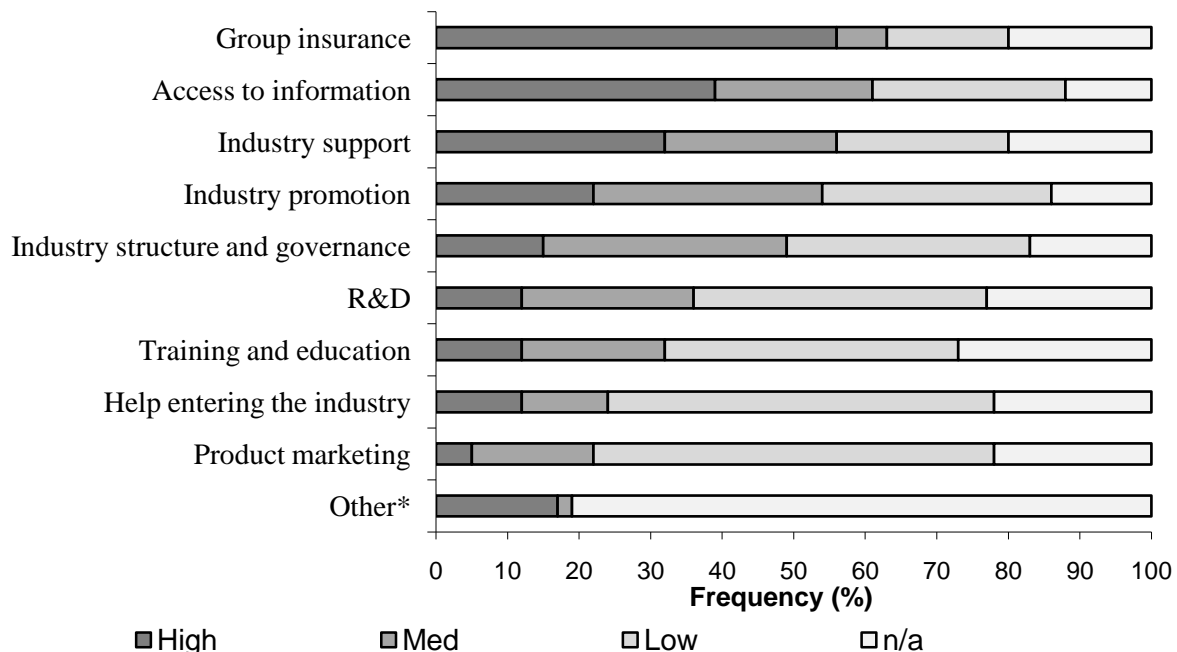
Industry associations are important tools for sharing knowledge, unifying individuals within an industry, and for developing government-industry partnerships. This is particularly important for SMEs because they face more significant capacity challenges than large enterprises (Jenkins, 2006; Murillo & Lozano, 2006).

The survey asked respondents if they were members of an industry association and 59% responded positively. The main industry association in B.C. is the B.C. Shellfish Growers Association; all but two respondents were members of the BCSGA. There are several smaller more regional industry associations in the province for which respondents were members such as the Active Malaspina Mariculture Association (n=3) and the Cortes Island Shellfish Cooperative (n=4) in the northern Strait of Georgia, and the Nuuchahnulth Shellfish Development Corp (n=1) and the Clayoquot Sound Oyster Organization (n=1) on the west coast of Vancouver Island. Most respondents that were members of smaller industry associations were also members of the BCSGA. The presence of these smaller more regional industry associations on the west coast of Vancouver Island and the northern Strait of Georgia may support the large proportion of part-time farmers in those geographic areas.

The results were also cross-tabulated with employment status. The results indicate that a larger proportion of full-time respondents (70%) are members of an industry association than part-time respondents (52%).

The results were also cross-tabulated with the length of time respondents have been in the industry to assess if there was a difference between respondents that were in the industry for less than ten years and more than ten years. No major difference was found. The geographic location of respondents' sites also did not influence membership to an industry association.

Industry associations provide benefits to attract membership. The survey asked respondents to rate the importance of a series of benefits in influencing their decision to join an industry association (Figure 5.1). This question was asked to assess factors respondents' value. Some of the benefits were taken directly from the BCSGA strategic direction: industry promotion, industry structure and governance, research and development, and training and education. The others were included based on other potential benefits: access to information, industry support, group insurance, product marketing and help entering the industry. Only respondents that are members of an industry association were asked to respond to this question.



*government lobbying, industry voice, public education and networking.

Figure 5.1 Importance placed by respondents on a set of services offered by an industry association (n = 41)

The most valued benefit of membership to an industry association was access to group insurance. All shellfish aquaculture operations in B.C. are required to provide a bond to the provincial government for their tenure, \$1000 for beach culture and \$2,000 for deep-water culture. The bond is used as insurance in case a shellfish farmer abandons a site. The provincial government has an agreement with the BCSGA allowing them to administer a blanket bond of \$15,000 to cover all their members. This benefit was particularly valued by respondents that have a single-site and/or farm on a part-time basis. This suggests that offering this benefit is an important way of attracting and including these smaller enterprises.

Access to information was the second most valued benefit of membership to an industry association. This was followed by industry support and promotion. Less than fifty percent of respondents placed a high value on an industry association's ability to provide industry structure and governance, product marketing, help entering the industry, training and education, and research and development.

Other benefits added by respondents for joining an industry association included government lobbying, providing a voice for the industry, public education and networking.

These results confirm that industry associations provide tools for sharing information, unifying industry through promotion and networking opportunities, and creating government-industry partnerships as exemplified by agreement between the BCSGA and the government for group insurance.

Two characteristics of the industry not previously understood emerged through the analysis of the results. The first is the proportion of part-time shellfish farmers (Table 5.4). The results suggest that this may be a choice influenced by the physical characteristics of the environment in B.C. (e.g., seasonal day-time low tides) and possibly influenced by the seasonal nature of wild shellfish harvesting from which some respondents may have transitioned into the industry. However, there are also indications that the low value of shellfish products may present an economic barrier to full-time employment. Interestingly, the two regions with larger proportions of part-time farmers, the west coast of Vancouver Island and the northern Strait of Georgia, are also the two geographic areas that have formed regional industry associations. This may be a mean of overcoming some challenges in those areas.

The second characteristic to emerge is the spatial diversity within the industry (Table 5.9). Certain respondent characteristics vary between geographic areas such as employment status, husbandry methods, size of operations and proximity to sites. These differences suggest that the industry should not be considered one homogenous group; instead different approaches may be required in different geographic areas.

Table 5.9 Comparison of respondents' operational characteristics by geographic areas (n=54)

Geographic Area	n	Full-time (%)	husbandry	multi-site operations (%)	Farm in community (%)
Baynes Sound	17	71	Mostly intertidal	47	88
West Coast Vancouver Island	16	31	Mostly deep water	50	44
Northern Strait of Georgia	12	50	Both intertidal and deep water	25	100
Southern Strait of Georgia	6	67	All intertidal	50	100
Sunshine Coast	3	67	Mostly deep water	0	67
Total	69	55	Mostly intertidal	39	78

5.2 Industry Development Trends

The survey asked respondents questions exploring potential trends in industry development to generate results that may help understand how certain attributes of the industry may change in the future.

5.2.1 Length of time in the industry

Respondents were asked how long they have been in the shellfish aquaculture industry (Table 5.10). The majority of respondents (68%) have been in the industry for over 10 years. When analyzed by geographic area, the results show that respondents that entered the industry in the last five years are concentrated in Baynes Sound and the west coast of Vancouver Island. This suggests that these two geographic areas are experiencing growth.

Table 5.10 Frequency distribution of the length of time respondents have been in the industry (n = 69)

Time (years)	Frequency (n)
0-2	5
3-5	6
6-10	11
>10	47

Respondents were asked how long they plan on staying in the shellfish aquaculture industry. The majority of respondents (61%) anticipate being in the industry for at least 10 years (Table 5.11). However, 26% anticipated leaving the industry within the next five years.

Table 5.11 Projected Duration in the Industry (n=69).

Time (years)	Frequency (n)
0-2	14
3-5	4
6-10	8
>10	42
n/a	1

In order to assess whether the number of respondents planning to leave the industry in the next five years is due to natural attrition or due to certain challenges, the projected duration was cross-tabulated with the length of time respondents have been in the industry (Table 5.12). Of

the 18 respondents that plan on leaving the industry in the next five years, half have been in the industry for over 10 years but three have only been in the industry for three to five years, barely enough time to complete a single harvest. This suggests that both natural attrition and challenges within the industry are factors in the number of respondents leaving the industry.

Table 5.12 Cross-tabulation of the length of time in the industry and projected duration (n=46)

Projected duration	Length of time in industry			
	0-2	3-5	6-10	>10
0-2 years	0	3	2	9
3-5 years	0	0	1	3
5-10 years	0	0	0	8
>10 years	5	3	8	26
Total	5	6	11	46

To see if the respondents leaving the industry have any specific characteristics, the results were cross-tabulated with the number of tenures operated by respondents and the employment status. 77% of the respondents who anticipate leaving the industry in the next five years operate a single-site. However, employment status did not influence the results. This may suggest particular challenges for single-site operations.

When projected duration in the industry is cross-tabulated with the geographic location of respondents' sites, the results show that more respondents from the west coast of Vancouver Island plan on leaving the industry in the next five years than any other geographic area. This may indicate particular challenges in this geographic area.

5.2.2 *Development plans*

Next respondents were asked about development plans. A large majority of respondents (76%) plan on increasing production. When asked how they would like to increase production, the majority (64%) responded that they would increase the density of shellfish on their current tenure(s) and/or increase the proportion of their tenure(s) under cultivation (56%). Only 26% of respondents considered increasing production by acquiring new sites and 13% considered increasing the size of their tenure. Other methods reported included improving technology and adding new species. These results suggest that respondents are looking to increase efficiency of their current operations rather than starting new operations to increase production. However, it is worth noting that the application process to increase the density of a site or the proportion under

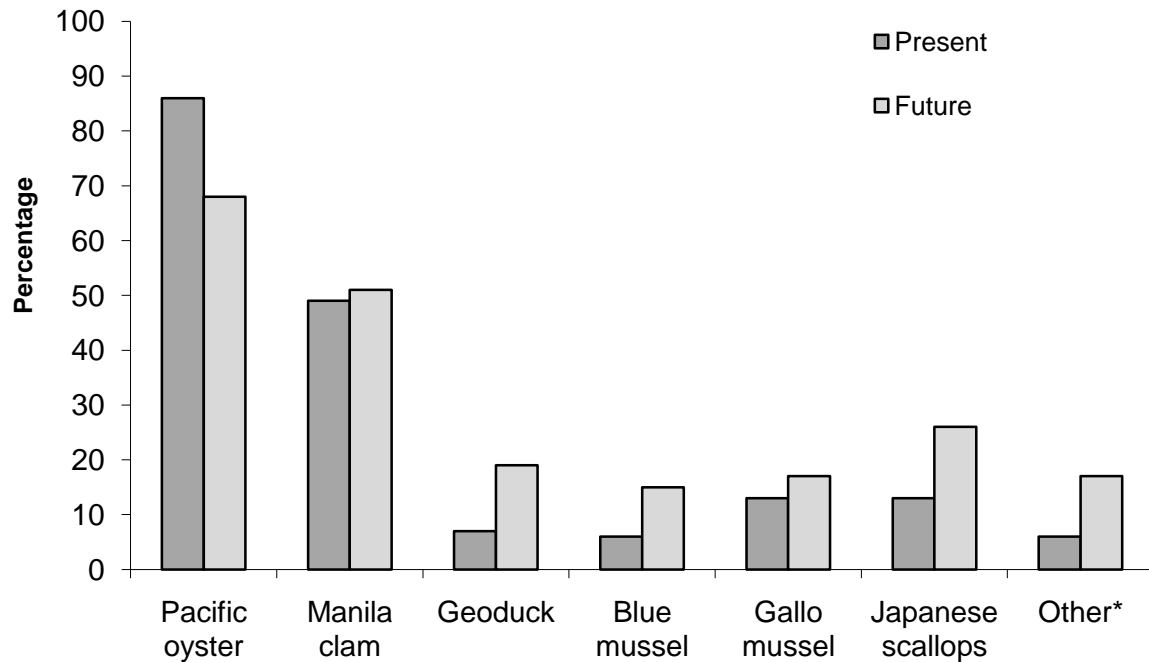
cultivation is less onerous than applying for a new site or a site expansion. Therefore, this may also influence the choice.

When the results are cross-tabulated with the geographic area of the site, the results varied. Proportionately fewer respondents from Baynes Sound, the southern Strait of Georgia and the Sunshine Coast selected increasing the number of tenures as a means of increasing production suggesting geographic area may also influence this decision.

The results were also cross-tabulated with employment status and the number of sites. A larger proportion of full-time farmers indicated that they would increase production by acquiring additional sites.

A few respondents indicated they intend to increase production through the introduction of other higher value species to their sites. Respondents were asked what species they plan on cultivating in the future (Figure 5.3). When compared to the species they currently farm, the results indicate a shift away from the cultivation of Pacific oyster towards the cultivation of other species such as Japanese scallops, blue mussels and Manila clams. These are higher value species than Pacific oyster. For example, in 2009 the production value of cultivated oysters in B.C. was \$1.20 per kilogram, \$5.67 per kilogram for clams, \$4.67 per kilogram for mussels and \$4.00 per kilogram for scallops (DFO, 2010).

Although Pacific oysters will continue to dominate the industry, the results indicate that respondents would like to diversify the species cultivated at a site. The results show that 83% of respondents plan on farming more than one species at their site in the future compared with 62% at present. It is unclear whether those wanting to farm additional species have the capacity or if this is a wish list of species they would like to farm.



* Varnich clam, Nuttall's cockle, Rock scallop and polyculture (e.g., seaweed or sea cucumber)

Figure 5.2 Comparison of respondents present and future species choice (n = 69)

In summary, the results suggest that the majority of respondents are not looking to access additional sites to increase production but instead would prefer to diversify the species they cultivate. Of those leaving the industry, some may be due to natural attrition within the industry but the results suggest that there may also be particular challenges for single-site enterprises and farmers on the west coast of Vancouver Island.

5.3 The Site Selection Process

The majority of respondents have been in the industry for over ten years and therefore may not have direct experience with the current government approach to the approval process which includes environmental assessments, First Nation and other stakeholder consultation, and the involvement of Transport Canada. Despite this, important information can be derived from their responses to the questions posed in the survey about their values, needs and perceptions of the process.

5.3.1 *Overview of respondents' experience*

The mean time it took for the approval process was 23 months but it varied with a minimum reported time of a few weeks and a maximum of 12 years. The longer approval times were attributed to approvals for new species (e.g., geoduck), local government involvement in Baynes Sound and First Nation consultation on the west coast of Vancouver Island.

Overall, only 13% of respondents used the assistance of a consultant to go through the process. However, those entering the industry in the last six years were more likely to have employed a consultant (67%) than those who had been in the industry longer. This suggests that the government approval process is becoming more onerous and expensive because applicants are turning to professionals for help completing the applications.

Respondents were asked which government agencies they worked with during the site application process. On average respondents worked with four government agencies during the process. However, the number was highly variable ranging from one to ten. The following agencies were included in the list (n=46):

- B.C. Ministry of Agriculture and Lands (93%);
- Fisheries and Oceans Canada (85%);
- Transport Canada (70%);
- B.C. Ministry of Environment (57%);
- Environment Canada (50%).

Other government agencies included are the B.C. Integrated Land Management Bureau, regional governments, local governments, Canadian Food Inspection Agency, and First Nations. The responsibilities of various government agencies have changed overtime and new agencies have been created which in part accounts for the diversity of responses. However, this does highlight the large number of agencies involved in the process.

Eleven respondents underwent an environmental assessment as part of the approval process. All but one of these respondents were applying for a deepwater site. An environmental assessment is a recent addition to the approval process introduced in 2000 for suspended shellfish aquaculture operations. Prior to this, although some applications could potentially require an environmental assessment if there was the potential to impact fish habitat this was rarely triggered. Now an environmental assessment is require for all sites located in deepwater.

The length of time for the assessment varied from several weeks to several years. The cost of the assessment also varied between respondents from no cost to five thousand dollars.

Twenty respondents had an application turned down. The reasons for denying an application are the following:

- conflicting use (e.g., navigation, fisheries, First Nation rights, protected areas) (n=10)
- competing applications (n=5)
- public opposition (n=2)
- unclear (n=2)
- operational design (n=1)

These results suggest that social considerations, rather than environmental considerations, have a larger impact on the potential success of an application.

The survey asked respondents to rate the level of agreement or disagreement with a series of statements pertaining to the government's approach to the site selection process (Figure 5.3). The statements were crafted to represent characteristics of an effective and efficient governmental process. The respondent's level of agreement or disagreement is used to understand their perception of the government's performance and understand what aspects of the process may need to be improved.

The majority of those who responded to the statement agreed that they had access to sufficient information during the application process. For all other statements, the majority of those who responded did not believe that it described their experience with the governmental process.

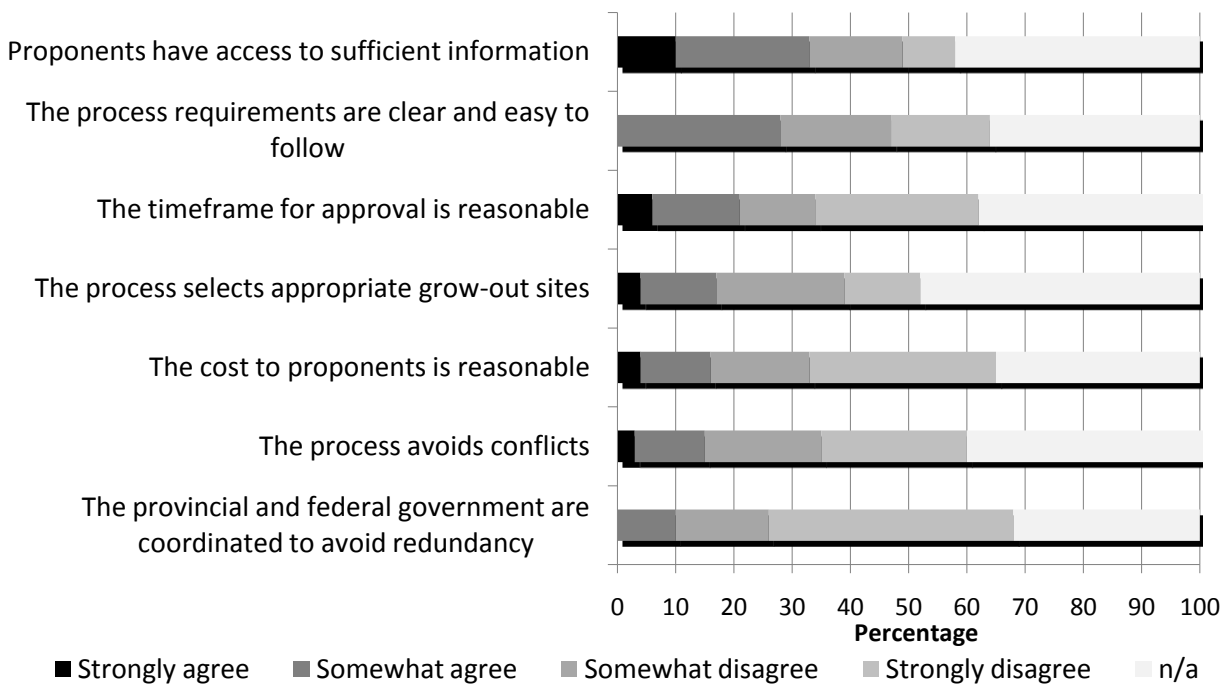


Figure 5.3 Level of agreement with statements about the site selection process (n = 69)

Although the results to this question may not reflect the current government process for approving a site because the majority of respondents have been in the industry for over ten years and the process has changed during that time, the responses highlight challenges with the current process that could be addressed through EBM, such as:

- government coordination;
- addressing conflict with other coastal users;
- the cost to the industry; and,
- the timeframe for approval.

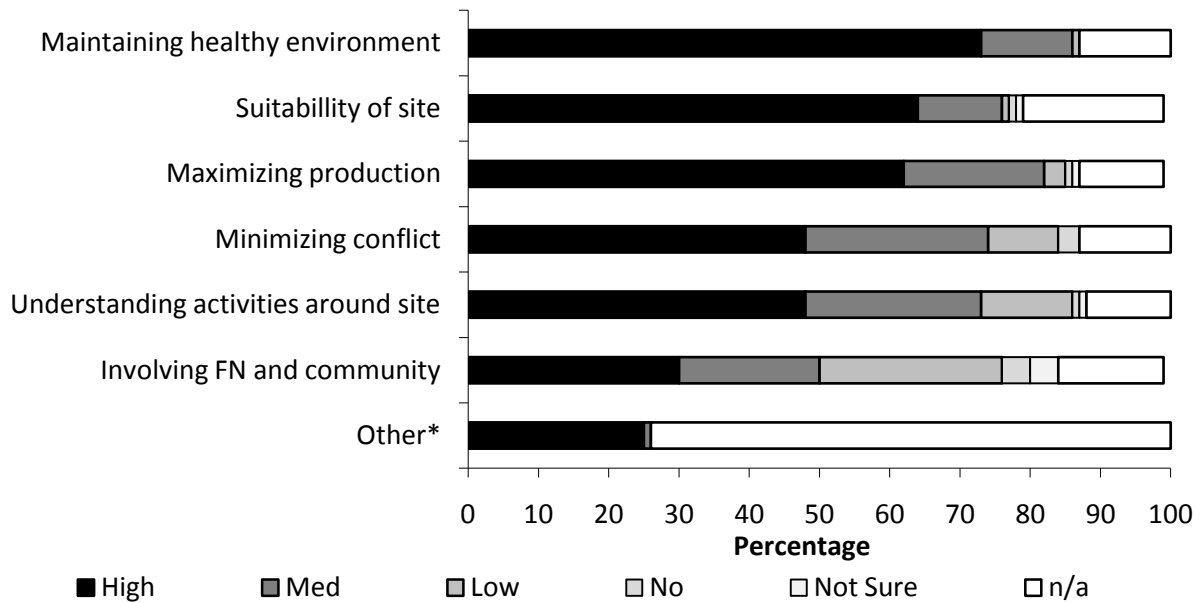
The survey asked for recommendations to improve the government site approval process. Two overarching recommendations emerged. First, respondents would like the government to approach the management of the industry with more flexibility to account for the diversity of sites and species. As one respondent stated: “There needs to be greater flexibility by government in understanding the specific needs of the applicant”. One respondent pointed specifically to the Canadian Shellfish Sanitation Program being ill-adapted for species grown on the substrate of deep waters, such as geoducks, and deeper in the water column such as scallops, where they are not affected by algae blooms. Several other respondents would like government staff to visit

prospective sites so that they understand the context of the application and to build a relationship between the applicant and the government agents.

The second recommendation is the integration of government responsibilities with respect to shellfish aquaculture. Some respondents referred to this as a “one-stop-shop” in which they interact with one government agency and address all the government requirements in one process. As described in Chapter Four, the government has moved in this direction with the Shellfish Development Initiative but the approval process still requires applicants to work with several different agencies. Some respondents suggested a joint consultation with First Nations and the local community involving the federal government, provincial government and the applicant. Others see integration occurring through a planning process in which suitable sites are identified ahead of time. The respondents believe this would not only increase the efficiency and effectiveness of siting decisions but also ensure “areas for food production are not damaged or compromised by other uses”. Although planning processes have been initiated in B.C., such as the Baynes Sound Coastal Plan for Shellfish Aquaculture, which identified potential sites for shellfish aquaculture, they have not streamlined the process because not all levels of government have signed on to enacting the plan.

5.3.2 Respondents’ values in a site

The respondents’ values in a site was assessed based on the results of a survey question asking them to indicate the level of importance (high, medium, low, not) of potential goals when selecting a location for a shellfish aquaculture operation (Figure 5.4).



*Proximity to residence, acceptance of local community, accessibility and existing healthy species base.

Figure 5.4 Importance of a series of goals to respondents when selecting a site (n = 69).

The majority of respondents placed high or medium importance on all of the goals and included some additional goals such as proximity to residence, acceptance of the local community, accessibility and existing healthy species base. The goal valued the most by respondents is to maintain a healthy environment, ensure a site is suitable for shellfish aquaculture, maximize production, minimizing conflict and understanding the activities taking place around a site. A smaller number of respondents valued involving First Nations and the local community in the decision-making process. This may in part be due to perceived conflicting interests between the shellfish aquaculture industry and local community and First Nations. For example, there is increasing conflict between the wild shellfish fishery and shellfish aquaculture as they compete for productive sites (Joyce & Canessa, 2009).

These responses were cross-tabulated with the size of operations. Respondents with a single-site were more likely to place high or medium importance on social criteria, such as minimizing conflict with other coastal users, understanding human activities around their site and involving First Nations and the local community.

The responses were also cross-tabulated with the location of operations but no noteworthy differences resulted.

5.3.3 Perception of other coastal activities

The previous section showed that a large majority of respondents value understanding the human activities occurring in the vicinity when selecting a site. As a follow-up, respondents were asked to rate the perceived impacts of a series of coastal activities on their operations (Figure 5.5).

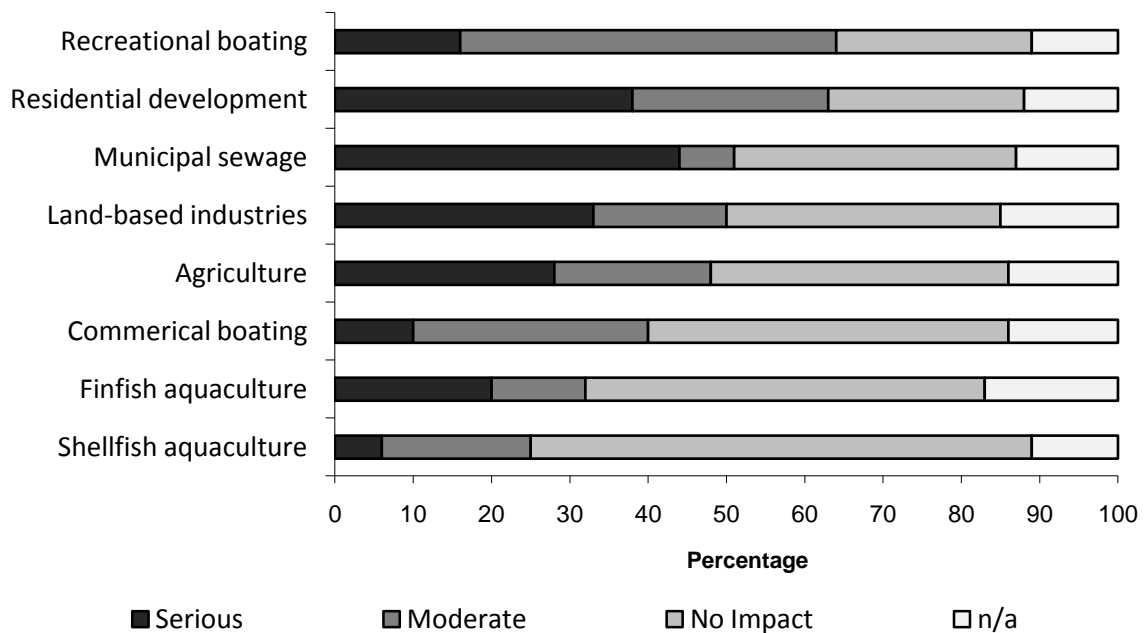


Figure 5.5 Perceived impacts of various activities on respondents' operations (n = 69).

The majority of respondents perceived recreational boating and residential development as posing a moderate to serious impact on their operations, followed by municipal sewage, land-based industries, and agriculture. Other shellfish aquaculture operations, finfish aquaculture and commercial boating were more frequently perceived as not having an impact. Interestingly, the five activities perceived by the majority of respondents as having a serious to moderate impact, four originate from land. This suggests that respondents are aware of the intimate connection between land-based activities and the health of the coastal environment. Although in Chapter Four, it was shown that the government focuses primarily on municipal sewage with respect to water quality concerns. The responses to this question show that the industry is concerned about a broader suite of human activities.

The perceived impact of coastal activities was analyzed by geographic area. The impact of other shellfish aquaculture operations were more frequently perceived as serious by

respondents in Baynes Sound: 21% of respondents from Baynes Sound perceived other shellfish aquaculture operations as having a serious impact compared to 8% of respondents in the sample. Bayne Sound is the region with the highest concentration of shellfish aquaculture operations and therefore additional development of shellfish aquaculture may be seen as a threat to existing operations.

All respondents in the southern Strait of Georgia perceived residential development and municipal sewage as having a serious impact. The southern Strait of Georgia is one of the most developed coastal areas in B.C. and most municipal sewage is discharge into the ocean. As a result, many operations in the southern Strait of Georgia are under harvesting restrictions. In contrast, respondents from the west coast of Vancouver Island were less likely to perceive residential development, municipal sewage and agricultural activities as having a serious impact. The west coast of Vancouver Island is less developed than the Strait of Georgia and therefore respondents from this area would not encounter many of the land-based activities listed in the question.

Fifteen respondents are subject to shellfish harvesting restrictions resulting in partial, seasonal or complete closure of harvesting from their operations. Forty percent of the closures are in Baynes Sound, followed by the west coast of Vancouver Island (33%) and the southern Strait of Georgia (20%). Only one closure occurs in the northern Strait of Georgia and none in the Sunshine Coast. When perceived impacts are cross-tabulated with the data on shellfish harvesting restrictions, the respondents subject to restrictions more frequently perceived the impacts of other coastal activities as serious for all but other shellfish aquaculture operations.

5.3.4 Environmental considerations

The biophysical characteristics of the ecosystem are important indicators of the potential productivity of an operation and also the potential impacts of an operation. Over three quarters of respondents do consider the regional environment when selecting a site. When those results are cross-tabulated with employment status, it shows that 97% of full-time farmers consider the regional environment.

Information about a site or regional environment can come from a variety of sources. Local and traditional knowledge is a source of information that could assist is selecting an appropriate site. For instance, aboriginal people in B.C. have traditionally used clam gardens to

enhance shellfish production and therefore may have traditional knowledge that could benefit the industry with respect to growing native shellfish species. In addition, local residents in communities may know of productive beaches where shellfish aquaculture is likely to succeed. The survey asked respondents if they benefited from local and/or traditional knowledge about the environment when selecting a site for their operation. 28% indicated they benefited from this source of information. As indicated in section 5.3.2, approximately the same percentage of respondents valued local and/or First Nation knowledge when selecting a site. This would suggest that those that chose to access information from these sources valued it. Several respondents indicated that they consider themselves a source of local knowledge. As previously noted, 78% of respondents' shellfish aquaculture operations are within their community and therefore could be considered sources of local knowledge themselves. There may be some sensitivity with respect to sharing information on productive shellfish beaches in some communities due to the existence of an important commercial shellfishery and subsistence fishery. As the industry grows there are increasing conflicts between the shellfish aquaculture industry and other coastal users (Joyce & Canessa, 2009).

Respondents were asked if they would support taking a more active role in monitoring the environment around their site. This question was posed because the federal government is challenged by a lack of resources to meet their responsibility for water quality monitoring for shellfish sanitation. A government report suggested greater industry involvement in the monitoring process to help address these resource challenges (OCAD, 2004). In addition, concerns over the potential impacts of shellfish aquaculture may lead to additional monitoring requirements in the future. Although this relates primarily to water quality monitoring, the question was expanded to include monitoring of beach debris originating from shellfish aquaculture operations, which are a concern for local communities, benthic quality, which is an indicator of organic loading from operations, and phytoplankton levels, which is an indicator of the availability of food for operations.

The majority of respondents supported a more active role in monitoring for these indicators of ecosystem impacts (Figure 5.6). However, one respondent added that they would play an active role in monitoring only if it was not economically prohibitive. In fact, many respondents (35%) are actively collecting environmental information at their site. Information collected includes temperature, salinity, water quality (e.g., bacteria and toxins), weather

patterns, the species of fouling organisms and human activities. The majority of respondents (56%) also indicated that they would benefit from access to monitoring information about the environment surrounding their site. However, only 28% of respondents thought they would benefit from the information generated from environmental assessments conducted for new applications, suggesting a disconnected between the information generated in an environmental assessment and the information valued by respondents.

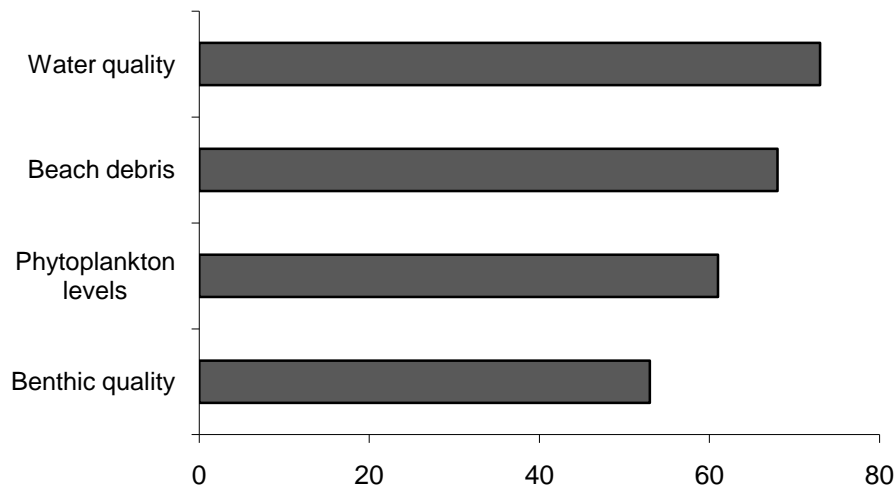


Figure 5.6 Percent of respondents that support taking a more active role in monitoring environmental parameters (n = 69)

When these results are cross-tabulated with employment status and the number of tenures managed, respondents with more than one operation and those operating on a full-time basis were more likely to oppose increased monitoring. Perhaps this is because they are already monitoring the environment.

5.4 Barriers to Growth

The last question in Part 4 of the survey asked respondents to identify the most significant barriers to growth of their business (Table 5.13). The responses to this question were diverse and therefore for ease of discussion they were organized into five categories: economic, governance, operational, social and environment. The following will discuss the results within these categories.

Table 5.13 Respondents' barriers to growth organized in categories (n=69)

Category	Example	n
Economic	<ul style="list-style-type: none"> • Diminishing return on investment • government fees; • labour cost; • access to markets; • access to loans; • cost of seed. 	41 (59%)
Governance	<ul style="list-style-type: none"> • process for ensuring shellfish sanitation; • local government opposition; • excessive interference; • lack of support; • lack of coordination between levels of government; • road block to exploring new species. • uncertainty/lack of transparency; • Accountability; • Equity; • Efficiency; • Predictability. 	37 (53%)
Operational	<ul style="list-style-type: none"> • finding labour; • distance to processing plants; • availability of seed; • access to information on how to get into new species. 	28 (41%)
Social	<ul style="list-style-type: none"> • local opposition; • conflict with other coastal users (e.g., First Nations, wild shellfishery, upland owners); • lack of public understanding of the industry; 	22 (32%)
Environmental	<ul style="list-style-type: none"> • industry reaching carrying capacity; • water quality; • storms. 	9 (13%)
n/a		4 (6%)

5.4.1 Economic

Economic barriers were the most frequent barrier to growth cited by respondents (59%). The most widely cited economic barrier is diminishing return on investment. The following response summarizes this problem: “cost of doing business (e.g., license fees, cost of seed, ferry costs, gas prices) all have increased significantly since I started 14 years ago but the price I get for my oysters has dropped”. Some respondents see this barrier as an issue of scale, affecting smaller operations more so than larger operations: “The only way to balance the books is to deal with large volumes. The smaller operations are going to be squeezed out.” However, an analysis of this barrier based on the size of operations and the employment status shows that economic concerns are not limited to smaller operations.

Diminishing returns on investment are related to the other economic barriers cited. For example, if the cost of doing business increases (e.g., labour, government fees and seed) profits will decrease unless the price of the product increases as well. In order to increase the price of the product respondents are exploring the use of new species in order to access new markets and intensifying operations to achieve economies of scale. However, doing so requires a capital investment in their operations. Several respondents cited not being able to access loans from the bank as a barrier to investing in their operations.

5.4.2 Governance

Governance barriers were cited by 53% of respondents. The most widely cited governance barriers are a lack of support, over regulation of the industry, ineffective public consultation process and unresolved First Nation claims resulting in industry insecurity. This sentiment is reflected in the following comment by one of the respondents: “For an industry with huge potential we sure don’t have a government that acts like it.” This highlights a sentiment that was expressed by many of respondents that the industry is not considered on an even footing with other coastal activities.

Other barriers included the seafood processing regulations that make it cost prohibitive for shellfish farmers to sell to their communities, the difficulty acquiring new space to farm either by expanding existing tenures or acquiring new ones, government barriers to diversifying into new species and the burden caused by the Canadian Shellfish Sanitation Program which is described as outdated, inconsistently applied and under-funded.

Some respondents were also concerned that government policy and regulations favour the development of larger operations at the expense of smaller operations. Many expressed concern for the loss of small operations that they see as having “*very little environmental or aesthetic impact, and great social benefit*”.

A lack of government understanding of the needs of the industry results in misguided policies. Provincial government policy for the industry under the *Shellfish Development Initiative (SDI)* was based on developing the industry by increasing the numbers of tenures. Although several respondents cited access to new tenures as a barrier to development, many others pointed to other barriers such as a lack of seed, assistance transitioning into new species and declining water quality. As such, the SDI’s focus on availability of new sites neglected the

other needs of the industry. One respondent addressed this in the following comment: *“BCSGA says that we need more land but leave out that its because we can’t get into higher value species.”* This statement shows that the industry would prefer to develop by farming higher valued species within the existing footprint than expanding the production of lower value species.

Lack of adequate consultation with local government and the public also affected the success of the SDI. Efforts such as the Baynes Sound Coastal Management Plan for Shellfish Aquaculture created to resolve conflict and identify suitable sites for expansion failed to adequately engage the local government and the public in the process. As a result, one respondent stated that it was useless: *“Tried to apply for an expansion after the plan went through in an area designated for shellfish aquaculture but didn’t have any government support.”*

The SDI may have resulted in increased development in more remote areas, such as the west coast of Vancouver Island. However, some respondents commented that they need additional support to overcome the challenges particular to remote areas such as access to the foreshore for shelter, availability of labour and distance to processing facilities.

Most respondents find government regulations to be a deterrent to development. They question the degree of regulation for the industry, *“Aquaculture is the most benign use of marine space, yet the one most rigorously regulated and opposed. Why?”*, the type of regulations used, *“we do not have our own set of regulations specific to farming the ocean.”*, and their suitability, *“each site presents unique biophysical conditions and challenges and broad government regulations work against this fact.”*

Several respondents brought up the strained relationship between government agencies and the industry. For example: *“The many department and levels of government that regulate the shellfish industry are far more interested in being restrictive than helpful and almost all of them are casually hostile.”*. Echoing this sentiment, one respondent stated: *“Almost every communication from the various ministries begins with an outline of penalties for non-compliance, what a hell of a way to do business.”*. This may suggest a lack of balance between regulations and incentives. Or conversely, it may suggest the need to use guidelines to complement the use of regulations and so increase their flexibility. One respondent commented

that regulations are not flexible enough to take into account the unique biophysical conditions of a site.

Many respondents would like the government to recognize and promote the sustainability of the industry. *“There is not enough recognition for the oyster farmer who took over a dead beach (booming ground for 30 years) and turned it into a very productive area.”* In addition: *“Shellfish aquaculture (...) is like the canary in the coal mine in that it requires clean water and pristine conditions to survive.”* By focusing on regulating potential impacts, the government may be missing a change to enhance the potential benefits of the industry and ensure it grows in an ecologically sound way.

5.4.3 Operational

Operational barriers were cited by 41% of respondents. The most widely cited operational barriers are problems acquiring seed, access to processing plants, finding labourers and accessing training and information for the production of new species. Historically, shellfish farmers relied on wild pacific oyster seed for their aquaculture operations. Over the last twenty years, there has been a transition towards a reliance on hatchery produced seed. For species that do not have a breeding population in B.C., such as Japanese scallops and blue mussels, shellfish growers rely exclusively on hatchery raised seed. However, even for species with breeding populations such as Japanese oysters and manila clam, access to wild seed is not guaranteed. One respondent described the situation as a “catch 22”: “we need hatchery production of seed which we cannot get because enough growers cannot get tenures. Growers cannot get tenures because there is no hatchery seed.”

Remote location was another operational challenge identified in the responses. Farming in remote areas poses unique challenges such as the ability to acquire tenure rights to the upland public land for shelter from the elements and the distance to processing facilities.

Processing plants are another challenge particularly for remote shellfish growers. Many processing plants are located close to urban centres and therefore shellfish farmers have to ship their product a great distance for processing. Consequently, in order to sell to their local community they have to ship the product back making it difficult to support local food security and enhance their social capital. One farmer provided the following comment: “There are no

processing plants on the sunshine coast. I cannot sell in my own community. It is not viable to ship to Vancouver and back for certification of shellfish.”

Finding people to work on their sites is another challenge reported by several respondents. One respondent commented that the government does not allow shellfish growers to use mechanical harvesters but they cannot find labourers to assist in harvesting.

5.4.4 Social

Social barriers were cited by 32% of respondents. A lack of public understanding of the industry and effective mechanisms to facilitate understanding and communication were cited as significant social barriers to development. Many shellfish aquaculture operations are located in relatively urban areas where residents place high value on the aesthetics of the coastal environment and shellfish aquaculture operations are seen to reduce the aesthetic quality.

At the regional level, local government land-use planning and zoning is heavily influenced by local residents. It is at this scale that the respondents expressed challenges with local residents. One responded gave the following comment. “The areas that are extremely productive such as Baynes Sound, is not able to increase the number of tenures because of local opposition.” In addition, some operations are located in areas with upland property owners in which case the shellfish farmer is required to get the upland owners consent as part of their application package giving the upland owner some power over what activities take place on the Crown land.

Another social barrier expressed by respondents is the impact of irresponsible shellfish farmers. As one respondent stated “*a few irresponsible growers can create terrible P.R. (public relations) for all growers.*”

There is also considerable uncertainty resulting from unresolved First Nation claims. As one respondent stated: “*We want to expand to increase profits but are worried about investing in the lease when it could be taken away when Native claims are resolved.*” Until the land claims are resolved the government must consult with First Nations prior to awarding and transferring tenures, a process that can take a long time and leave the farmer uncertain as to the fate of their investment.

5.4.5 *Environmental*

Finally, the environment was cited by 13% of respondents as a barrier to development. As one respondent stated: *“Our main concern is the continuance of pristine water.”* The results show that respondents in more urban areas, such as Baynes Sound and the southern Strait of Georgia, are concerned about the impacts of activities such as residential development, municipal sewage, land-based industry and agriculture on their operations. The most significant barriers were impacts of other activities and the impact of storm events on the infrastructure of operations. One respondent commented: *“The most important factor however is other uses. We must get into coastal planning so that areas for food production are not damaged or compromised by other uses e.g., floathomes, tourist lodges, logging steep slopes etc.”*. One respondent commented that the cost of depuration of product with faecal contamination is too costly for them. This would differently affect smaller operations with that do not have the economies of scale to afford to use such technologies.

Respondents were not just concerned about the impact of the environment on their operations but also on minimizing their impact on the environment. One respondent would like the government’s assistance in finding appropriate ways to dispose of waste, particularly sewage, from their operations. This is particularly a challenge in remote areas where centralized facilities are not available.

5.4.6 *Influence of geographic area*

The research analyzed the responses to explore any potential barriers to growth specific to geographic area (Table 5.7). Respondents from the west coast of Vancouver Island and the Sunshine Coast cite difficulties in operating in remote areas including a lack of infrastructure, specifically the availability of processing plants, and the added cost of shipping. Several respondents on the west coast of Vancouver Island cited a lack of access to the upland area for shelter as a barrier. These respondents travel to their site by boat and therefore would like to be able to build a shelter on the upland to shelter them from storms.

Respondents from the northern Strait of Georgia and Baynes Sound were the only ones to cite public opposition as a challenge. One respondent from the northern Strait of Georgia said his community is becoming a “playground for the rich” where urban values are replacing rural

values. In such a situation, the economic value of shellfish aquaculture is becoming less important than the scenic value of the area.

Declining water quality is a challenge cited solely by respondents from the southern Strait of Georgia. Two of the six respondents from this area have had their operations closed due to faecal coliform contamination. Respondents in other geographic areas did not express this challenge.

Concerns of over-expansion of the industry were cited by several respondents in Baynes Sound, the most concentrated area for shellfish aquaculture in B.C. They worried that additional development in the area would adversely affect their operations.

Social barriers were cited more frequently in Baynes Sound. These barriers included problems with irresponsible shellfish farmers harming the industry's reputation. One respondent stated: *"A couple of tenure holders are irresponsible (...) labelling all shellfish growers as sloppy and uncaring and polluting."* Respondents in other geographic areas did not express this challenge.

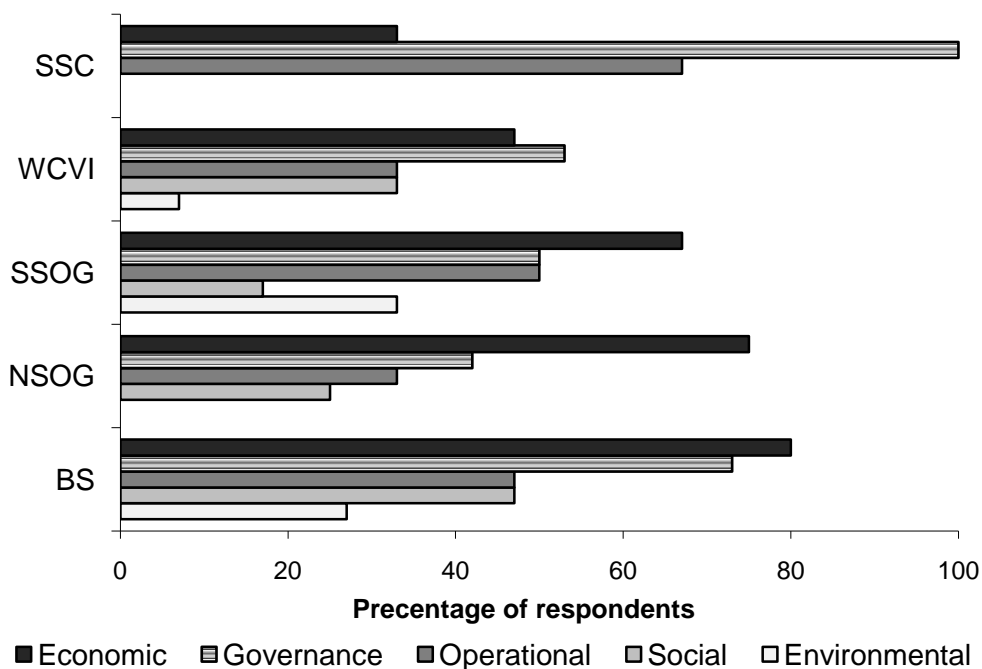


Figure 5.7. Barriers to development by geographic areas (n=54)

5.5.7 *Influence of enterprise size*

The results were analyzed based on the size of operations (single-site or multiple-site). Two differences emerged. The first involves markets. Only respondents with a single-site cited their inability to sell to the local community as one of the most significant barriers to operation growth. This suggests that smaller operations would like to access smaller markets. In contrast, one respondent with multiple-sites would like to see the industry grow in order to access larger markets such as Asian markets and large domestic chain stores.

The second difference involves the level of government intervention. Smaller operations cited not enough government support as one of the most significant barriers to growth, whereas large operations complained of too much government intervention and were less likely to cite lack of government support as a barrier. This suggests that the size of an operation may affect the operation's governance needs. As seen in section 5.2.7, smaller operations more frequently valued the support offered by membership in an industry association.

5.6 **Summary and Key Issues**

The results show several patterns in the shellfish aquaculture industry. First, respondents show a strong connection to place with 78% living in the community in which they farm. Second, a large number of respondents farm on a part-time basis (45%). This suggests the existence of barriers to full-time employment. Third, a small majority of respondents are members of an industry association (59%). Industry associations are important points of contact between the industry and government. This suggests that government may not be connecting with almost half of the industry. Fourth, there is much diversity within the industry with respect to the type of operations, the species farmed, and the size of enterprises (i.e., number of sites). Finally, the survey results suggest that the industry will look to increase the density of operations and diversify the type of species farmed in order to increase production in the future. These patterns in the industry are not universal. A cross-tabulation of these results with the location of operations suggests that different geographic areas show different patterns in the operations particularly the connection to place, the number of part-time farmers and the type of operations.

The results indicate that the respondents value environmental, social and economic factors when selecting the location of their site. They also value access to information, industry

support and industry promotion. Single-site operations have slightly different values than multiple site operations such as placing more importance on social values of a site, research and development, training and education, and marketing.

The results indicate that respondents have different experiences with the site selection process. The length of time and the number of agencies they worked with varies. This suggests that the process is inconsistent and can be resource intensive for respondents. The results also suggest that the most common reason for denying an application is for social reasons such as conflicts with other activities and public opposition and not environmental reasons.

The results show that the respondents do not think the governance process for approving a site is effective, efficient and reasonable. In addition the public participation process is not useful in avoiding conflict, a factor respondents' rate as highly important when selecting a site.

The respondents suggest that the governmental management process could be improved by establishing suitable areas for shellfish aquaculture through planning ahead of time. However, in the cases where this has been done (e.g., Baynes Sound) some respondents believe this has been ineffective. Many respondents would also prefer a more personal relationship with government so that managers are able to develop greater understanding of the particular characteristics of their site.

The main barriers for growth for the respondents include low profitability, uncertainty and lack of support. The respondents' comments suggest that many aspects of these barriers could be overcome with increased government understanding of the industry and a management approach more tailored to the specific challenges facing this industry.

Chapter Six: Discussion

6.0 Introduction

The goal of this research is to use a case study of the shellfish aquaculture industry in B.C. to highlight how an understanding of the governance framework and the characteristics of an industry can inform the implementation of ecosystem-based management (EBM).

Specifically it set out to address the following objectives:

1. To understand the governance context for shellfish aquaculture in B.C.
2. To understand the shellfish aquaculture industry within the context of EBM.
3. To explore EBM as an approach to governance in the shellfish aquaculture industry in B.C.

Chapter Four addressed the first objective through the results of an in-depth analysis of government documents, policies and regulations, and targeted interviews with government employees. Chapter Five addressed the second objective by presenting the results of a questionnaire survey of shellfish farmers in B.C. This chapter brings together the knowledge gained in these two chapters to address the third research objective of exploring EBM as an approach to governance in the shellfish aquaculture industry in B.C. This will be accomplished by exploring the challenges, opportunities and implications of EBM using the three EBM themes identified in the literature review (Chapter Two) as a guide to discussion: scale, linking science and management, and stakeholder engagement.

These three themes are umbrella concepts consistently identified in the literature. They are meant to provide a manageable and inclusive guide to exploring EBM as it applies to the shellfish aquaculture industry in B.C. The themes are interrelated and interdependent. It is acknowledged that stakeholder engagement, for instance, plays an important role in both expanding the scale of resource management and in linking science and management. In order to avoid redundancy, the following discussion will try to separate these three themes as much as possible. Broad themes were selected to allow for the exploration of their implications within the shellfish aquaculture industry but the discussion will be limited to elements within the themes that were found to be particularly applicable based on the results of the findings.

6.1 Scale

A mismatch between the scale of ecosystems and the scale of governance systems is identified in the literature as one of the biggest challenges with the conventional approach to resource management (Crowder *et al.*, 2006). Conventional resource management is characterized as a sector-by-sector approach, where each human activity is managed separately, and the ecosystem is considered in a piecemeal fashion because, when it does occur, it is from the perspective of each individual industry (Kessler *et al.*, 1992; Crowder *et al.*, 2006). As such, it is difficult to consider the cumulative impacts of all activities within a given ecosystem and assess whether the ecosystem can sustain all the activities. Addressing this challenge is one of the reasons for the implementation of EBM.

The literature suggests integrating the management of various sectors within ecologically relevant boundaries such as watersheds, sounds, bays and estuaries (Grumbine, 1997; McLeod *et al.*, 2005; Ruckelshaus *et al.*, 2008; Wendt *et al.*, 2009). One mechanism for accomplishing this goal widely suggested in the literature is the use of marine spatial planning (Young *et al.*, 2007; Halpern *et al.*, 2008; Rosenberg *et al.*, 2009). This is particularly relevant to shellfish aquaculture because it is an industry that occurs in one place and therefore would be amenable to marine spatial planning.

Shellfish aquaculture depends on the provision of a suite of ecosystem services such as access to coastal space, sufficient food for growth and the processing of waste. Because shellfish aquaculture relies to a great extent on natural ecosystems for production and requires few external inputs, it is intricately and inextricably dependent on a functioning ecosystem (Folke & Kautsky, 1989; Cranford *et al.*, 2006). This is one reason why it is considered a more sustainable form of aquaculture than salmon or shrimp (Naylor *et al.*, 2000). However as seen in Chapter Two, shellfish aquaculture does have the potential to negatively affect ecosystem productivity and the location of shellfish aquaculture operations is an important consideration for both the ecological, economic and social sustainability of the industry (Anderson, 2002; Cranford *et al.*, 2009; Gibbs, 2009).

A review of the governance context in Chapter Four reveals that the shellfish aquaculture industry in B.C. is managed within a multilateral governance context where jurisdiction over the industry is spread across three levels of government (federal, provincial and local) and under the

authority of seven different government agencies. Each agency approaches the industry from a different mandate, which can be either very specific such as protecting fish habitat or very broad such as licensing the activity, and none of which is specifically mandated to protect the ecosystem. From an ecosystem perspective, this results in a governance system with gaps and overlaps in addressing ecosystem concerns and from an industry and governance perspective, this results in an inefficient governance process.

This challenge is exacerbated by two factors. The first factor is the lack of comprehensive regulations designed to address the specific social and ecological issues associated with the shellfish aquaculture industry. And the second factor is the scale of the governance process.

Shellfish aquaculture is managed primarily at the scale of individual operations. The allocation of tenures by the provincial government is a prerequisite for aquaculture development. As such, the governance framework for the management of shellfish aquaculture has evolved around the allocation of coastal space. Since coastal space is allocated on a case-by-case basis, the process for assessing all other social and environmental considerations under the various agency mandates occur at this scale as well such as potential impacts on protected habitat and species, conflicts with other coastal users, indigenous interests and public consultation.

Delineating the governance framework around the application for access to coastal space limits the ability of government institutions to consider the ecosystem implications of an application and the cumulative impact of the industry on the ecosystem. Although certain regulations such as the *Canadian Environmental Assessment Act* include provisions to consider ecosystem impacts through assessment of cumulative impacts, regulators cited being constrained by the scale of the assessment. For instance, the environmental assessment is generally triggered as a result of the need for an approval to obstruct navigation. According to regulators, the decision to approve or reject an application is most appropriately undertaken on a case-by-case basis; however the environmental assessment triggered by such an approval is most appropriately undertaken at an ecosystem scale.

In other cases, the governance process could be improved through proactive planning. Certain decisions that occur on a case-by-case basis could be assessed proactively for a given ecosystem thus streamlining the application process and generating an understanding of the ecosystem. Examples include mapping important fish habitat under the *Fisheries Act*, habitat

occupied by species at risk under the *Species at Risk Act*, habitat occupied by migratory birds under the *Migratory Birds Convention Act*, conflicts with other coastal users, and determining the social carrying capacity for the industry as opposed to consulting the public on every application.

As Chapter Four points out, the federal government has a policy of ecosystem-based management of the shellfish aquaculture industry. This policy stems from a legislative commitment, the *Ocean's Act*, to take an ecosystem-based approach to the management of Canada's oceans and the marine activities (DFO, 2002a). This policy has been understood by the lead federal department for aquaculture, Fisheries and Oceans Canada, to mean four things: managing within ecosystem as opposed to jurisdictional boundaries, setting regional aquaculture growth objectives, addressing impacts of the industry throughout the entire ecosystem, and selecting biophysically and socially suitable areas for aquaculture development (DFO, 2002b). However, the results of the interviews with government employees showed that jurisdictional divides mandated by existing regulations hamper the ability of government employees to move forward with this policy direction.

One of the most widely cited mechanisms for implementing EBM is through marine spatial planning. Marine spatial planning is a way of coordinating government activities designed to address individual sectors within an ecosystem. Shellfish aquaculture as an industry is well suited for marine spatial planning because it is a place-based activity, meaning it exists in a specific geographic location and is influenced by activities accruing around it. In addition, the governance process would benefit from coordinating government actions with respect to the industry through a planning initiative.

Marine spatial planning initiatives have been undertaken in coastal waters of B.C. by both the provincial and federal government. These initiatives differ in goals and scales. The provincial initiatives, such as the Baynes Sound Coastal Plan for Shellfish Aquaculture, covered the most important shellfish aquaculture areas of B.C. to assess development potential and address conflicts between the industry and other coastal users. According to some members of the shellfish aquaculture industry, the plan was successful at addressing some of the water quality concerns of the industry through better coordination between the industry and the Canadian Shellfish Sanitation Program allowing areas that were previously classified as closed to be re-opened with special harvesting restrictions. The plan considered both biophysical and

social concerns and employed the expertise of marine scientists to assess the potential risk. The plan was created to provide guidance to regulatory agencies and entrepreneurs in selecting sites that avoid spatial conflict. However, these plans have not been effectively incorporated with the overall governance framework. According to the provincial government, they were unable to adequately engage the local government in the plan in agreeing to areas for potential expansion of the industry. One reason for this is that the plans were not binding as such the local government continues to oppose shellfish aquaculture proposals within identified suitable areas for development.

The federal government approach to marine spatial planning in B.C. is exemplified by the Pacific North Coast Integrated Management Area (PNCIMA). PNCIMA differs from the provincial example in the goal and the scale of coverage. PNCIMA covers a large area extending from northern portion of Vancouver Island to the Canada-United State border. This planning initiative creates operational objectives with associated performance indicators for the whole planning area based on knowledge derived from an overview of the ecosystem, the identification of ecologically significant areas, an analysis of socio-economic uses and local and traditional ecological knowledge. However, as with the provincial planning initiative there lacks a formal mechanism for integrating the plan within existing governance approaches to individual sectors. The plan suggests that it will be implemented through existing processes or will influence other levels of planning. Therefore it depends on the existence of sector-based plans to connect to. This suggests that EBM in B.C. may take the shape of large-scale ecosystem plans such as PNCIMA that will connect to more regional coastal plans such as the Baynes Sound Coastal Plan for Shellfish Aquaculture.

The results from the survey of the industry suggest that the industry would be in favour of marine spatial planning. The survey respondents recommend marine spatial planning as an improvement to the current siting process. Respondents believe that such planning could be used to coordinate the actions of the government agencies with a say in the location of shellfish aquaculture operations.

The survey results show that respondents are concerned about conflicts with other coastal activities, particularly land-based activities such as residential development, municipal sewage, industrial activities and agriculture. In addition, conflict with other coastal users is the most frequent reason for applications for new shellfish aquaculture operations being turned down.

Therefore, integrating the management of the industry within a large-scale planning process that included the planning and zoning of land-based activities would assist in addressing these concerns. The current examples of marine spatial planning, such as the Baynes Sound Coastal Plan for Shellfish Aquaculture and PNCIMA, do not integrate land-based activities within the coastal plans.

The industry is diverse, composed of numerous individual operations that vary based on the geographic locations of the sites. The results from the survey were analyzed based on geographic area and found that the attributes of the industry such as the type of husbandry techniques, the percentage of larger enterprises (i.e., two or more operations), the employment status of the respondents (i.e., full-time or part-time) and the proximity to their operations varied. For example, in Baynes Sound the majority of operations were intertidal, nearly half of the respondents' operated more than one site, almost three quarters of respondents farmed shellfish on a full-time basis and a large majority (88%) lived in the community where they farmed. Whereas on the west coast of Vancouver Island, the majority of operations were suspended, the majority of respondents farmed on a part-time basis, half of the respondents' farmed more than one site and less than half of the respondents operate farms within their community. In the northern Strait of Georgia, there was an even split between intertidal and suspended sites, half of the respondents farmed on a full-time basis, three quarters of respondents operated a single site and all respondents operated farms within their community. The geographic differences in the industry suggest that the industry would benefit from an approach to management that can adapt to the variations that occur between geographic regions. In this respect, the geographic differences suggest that the industry would benefit from a more place-based approach to management as exists under EBM.

The discussion of the challenges and opportunities of the shellfish aquaculture industry with respect to the EBM theme of scale suggest the need for new approaches to marine spatial planning within B.C. The new approach should integrate the planning for shellfish aquaculture with the planning for other potentially conflicting activities. The plans should coordinate various levels of government and government agencies activities around common ecosystem goals and should be enforceable so that they have a meaningful impact of government activities.

6.2 Linking Science and Management

Implementing an EBM approach to governance requires more than just expanding the spatial scale of governance, it also expands the scope of information required to make informed decisions about the effects of a given activity and an explicit consideration of the trade-offs between different human activities. Ecosystems are complex systems that are often not well understood and therefore their response to various human activities will be uncertain. The knowledge needed for this understanding should come from a variety of sources including the natural and social sciences and more context specific information from local and traditional sources of knowledge.

The literature on EBM overwhelmingly endorses the use of adaptive management as a process for proceeding with management despite uncertainty and creating a more flexible process that can change in response to changes in the ecosystem and as new knowledge is gained. Fundamentally, adaptive management is an iterative process where decisions are re-evaluated over-time to assess if goals are being achieved.

Maintaining a functional ecosystem is a main goal of EBM, this includes protecting the environment from environmental impacts of the industry. The governance framework for shellfish aquaculture considers the potential impacts of the industry on the ecosystem through the enforcement of existing regulations designed to protect the marine environment such as the *Fisheries Act*, the *Migratory Bird Convention Act*, the *Species at Risk Act*, and the *Canadian Environmental Protection Act*, and more generally through the assessment of the suitability of an application during the licensing approval process. Environmental effects considered include impacts on habitat, significant species, and cumulative effects. Regulators with the federal and provincial government stated that they believe shellfish aquaculture is a low risk activity and that the current regulations adequately address the potential effects of individual operations.

However, as seen in Chapter Two, the potential effects of shellfish aquaculture on the ecosystem result from the cumulative effect of all operations in a given area. And as explored in Chapter Four, these regulatory tools are applied at the scale of individual operations on a case-by-case basis during the approval of new shellfish aquaculture applications limiting their ability to truly assess the cumulative effect of multiple operations beyond the individual footprint of a site. There is therefore an opportunity to increase the effectiveness and efficiency of addressing

the potential ecosystem impacts of individual shellfish aquaculture operations within an EBM framework.

The primary tool for assessing potential ecosystem effects in the literature is the use of carrying capacity studies. This allows regulators to pre-determine the level of development that can be accommodated within a given ecosystem without affecting the productive capacity of the system. With the exception of a handful of one-off carrying capacity studies in areas such as Baynes Sound, Malaspina Inlet, Gorge Harbour and Lemmon's Inlet, the governance of shellfish aquaculture is not designed to collect ongoing information about the health of the ecosystem. As seen in Chapter Two, carrying capacity is not static; it will change over time as the ecosystem changes.

Arguably the most important element of adaptive management is evaluating the outcome of decision-making against policy goals. Evaluation depends on the existence of an established monitoring process. The provincial government has a monitoring program targeted at ensuring compliance with the Shellfish Aquaculture Management Plan. In this case compliance is based on the location of the site, the type of shellfish being grown and the production levels. The federal government does not undertake any monitoring to ensure compliance with the mitigation measures stemming from the environmental assessment.

According to the respondents, monitoring the environment is an important source of information for their day-to-day operations. Thirty-five percent of respondents are actively collecting environment information at their site. The survey results also suggest that the industry is willing to coordinate with government to monitor the environment. The majority of respondents would support a more active role in monitoring water quality, phytoplankton levels, benthic quality and beach debris.

Although the governance process for approving new shellfish aquaculture operations is subject to rigorous scrutiny from multiple agencies at both the federal and provincial level, decisions are made at the scale of individual sites and has very limited potential to assess the potential ecosystem effects of proposed development. Recognizing this challenge for the development of the industry, the provincial government has undertaken a series of ecological carrying capacity studies in areas with significant shellfish aquaculture activity or with significant growth potential. However, these studies are a snapshot in time. They could be more

useful if they were incorporated into a planning process and expanded their consideration to include the social and economic carrying capacity of an ecosystem.

The governance framework for shellfish aquaculture currently lacks the ability to implement adaptive management. Incorporating adaptive management will require the establishment of ecosystem goals, a monitoring framework to evaluate attainment of these goals, and a governance framework that can adapt strategies in light of new information. There is much potential to engage the industry as partners in evaluating the achieving of specific policy goals.

6.3 Stakeholder Engagement

As experience with the implementation of EBM grows, several authors are beginning to emphasize the importance of stakeholder engagement in the process (Hartig *et al.*, 1998; O'Boyle & Jamieson, 2006). Stakeholder engagement in the case of this research is limited to the shellfish aquaculture industry itself. This section will therefore examine the strengths and weaknesses of the industry as illuminated through the surveys, that can inform the engagement of the industry as part of the EBM process.

The biggest challenge within the shellfish aquaculture industry is engaging the industry in EBM. Two factors contribute to this challenge. The first is diversity and the second is economic. Chapter Five points out that the biggest challenge for the shellfish aquaculture industry is economic. Shellfish are a low value species and therefore shellfish aquaculture has small profit margins. Chapter Five also showed that the shellfish aquaculture industry is diverse; this creates challenge for industry unity. Both these factors affect the ability of the industry to be engaged in EBM as will be discussed below.

The diversity within the industry presents a challenge to industry cohesion. The results show that 59% of respondents are members of the B.C. Shellfish Growers' Association. According to provincial employees, the BCSGA is the main conduit that government uses to partner with the industry. However, since 41% of respondents are not members of the BCSGA, the government is not connecting with this large portion of the industry. In addition, just because a shellfish farmer is a member of the BCSGA does not mean that they are engaged. As the

survey results showed, the majority join to access group insurance not necessarily to create a partnership.

The results show that the industry differs between geographic areas. This compounds the challenge of unifying the industry. However, this does create an opportunity for managing the industry using a place-based approach such as EBM.

The second factor influencing the ability to engage the industry is economic. Shellfish are a low value product as such profits rest in the ability to produce large volumes. In addition, the price of oysters has remained relatively static over the last twenty years, but the cost of operating a shellfish farm has increased. According to Silver (2010) the success of individual entrepreneurs in the industry rests increasingly on their ability to incorporate changing technologies, which can result in the intensification of operations. The results of the survey suggest that economic challenges are influencing the type of development the industry is exploring in the future. The majority of respondents want to increase the density of shellfish farmed at their site, increase the proportion of their tenure under cultivation, and/or farm higher valued species. Although shellfish aquaculture is currently seen by the government as an environmentally sustainable industry, as seen in other jurisdictions such as France, there is the potential as production intensifies to impact the ecosystem and as a result the productivity of the industry.

The most significant barriers to growth of the industry are profitability, uncertainty and lack of support. These results show that the sustainable development of this industry rests on a broader set of factors than simply the availability of appropriate sites. However, the provincial and federal government policy has been focused on making new sites available; these results suggest that this may be misguided and that efforts should instead be focused on steering the industry towards more ecologically sound practices and diversifying into higher value native species.

As Chapter Five points out, the shellfish aquaculture industry appreciates the importance of maintaining the health of the ecosystem. The majority of respondents to the survey placed high importance on maintaining a healthy environment when selecting a location for their shellfish aquaculture operation. In addition, over three quarters of respondents consider the regional environment when selecting a site. The term regional environment was used as a proxy to assess whether respondents' considerations expand beyond the immediate location of their

operation. This existing appreciation for the ecosystem within the industry creates an opportunity for engaging the industry in efforts to maintain ecosystem health, the primary objective of EBM.

6.4 Summary

Ecosystem-based management aims to sustain resource management by maintaining healthy ecosystems. To achieve this, the management of individual sectors is integrated at the scale of the ecosystem so that the cumulative effects of human activities can be addressed. Changing the goal and the scope of resource management necessitates a change in the structure and function of government.

The current governance framework for shellfish aquaculture reflects the conventional way of managing human activities characterized by a sectoral approach. As seen in the literature this results in a mismatch between the scale of governance and the scale of the ecosystem (Crowder *et al.*, 2006). A review of the management framework shows that the shellfish aquaculture industry has many of the same challenges the literature describes with such an approach, such as fragmentation in the way the ecosystem is considered and lack of coordination between government agencies. This form of management presents challenges for protecting the ecosystem as required under EBM.

However, the review of the governance framework shows that the individual agencies are aware of these challenges and have taken steps to address them. For example, the provincial government has undertaken carrying capacity studies to assess the threat of current development of the industry on the ecosystem and spatial planning initiatives to take a broader view of industry development. The federal government is supportive of such initiatives as seen in their policy towards the development of the industry but has taken the position that such planning should be undertaken at a local scale. These planning initiatives and carrying capacity studies are a step in the right direction but need to be linked more directly with the management of the industry.

The shellfish aquaculture industry depends on a healthy environment therefore will be receptive to a management approach that aims to protect the health of the environment.

However, the industry's ability to be engaged in the process may be limited because of the economic challenges they face.

The move towards EBM could also address some of the challenges facing the industry through better planning, which can ensure greater certainty. In addition, a move towards EBM could address the challenge of intergovernmental coordination and community and First Nation consultation by addressing concerns on an ecosystem scale as opposed to a site-by-site approach.

Legislation, which provides authority to move towards EBM, is already in place (e.g., the *Oceans Act*). In addition, the current legislation addressing the environmental impacts of the industry can address the ecosystem effects of the industry if applied at the appropriate scale (e.g., the *Canadian Environmental Assessment Act*).

Some of the challenges for a move towards EBM include a lack of financial resources within the industry limiting their ability to invest in any strategic planning. In addition, the industry is not united making it difficult to engage them in a planning process. Although the provincial and federal government are working towards coordinating their activities with respect to shellfish aquaculture, this is still in its infancy and presents a challenge. Further coordination will be required to move forward. The current site-by-site process will need to be built on a strategic planning framework and supported by a monitoring framework, which will need to be developed. Halpern *et al.* (2005) suggest a monitoring framework based on the ecosystem services the industry uses. This will allow the framework to be integrated with monitoring frameworks designed for other human activities by establishing a common language based on ecosystem services.

Chapter Seven: Summary, Conclusion and Recommendations

7.0 Introduction

As the world is turning towards aquaculture to meet growing demand for seafood while preventing the overexploitation of wild fisheries, it is necessary to ensure that aquaculture does not become a contributing factor to the increasing degradation of the oceans ecosystems. There is significant opportunity for sustainable aquaculture by focusing on the cultivation of lower trophic species such as shellfish and by adopting more ecologically sound resource management practices such as ecosystem-based management. The goal of this thesis is to explore the challenges and opportunities for transitioning towards ecosystem-based management through a case study of the shellfish aquaculture industry in British Columbia, Canada.

There is significant development potential for shellfish aquaculture in British Columbia and the government of Canada has committed in policy and legislation to manage that development with an ecosystem-based approach. However, the transition from conventional resource management characterized by sectoral management to an ecosystem-based approach presents several challenges and opportunities. This thesis used an understanding of the industry and its governance context to inform the implementation of EBM. The specific objectives of this study were:

1. To understand the governance context for shellfish aquaculture in B.C.
2. To understand the shellfish aquaculture industry within the context of EBM.
3. To explore EBM as an approach to governance in the shellfish aquaculture industry in B.C.

Chapter Six presented a discussion of the results of the study using three EBM themes to guide the discussion. This chapter will present recommendations for moving forward with EBM and recommendations for future research.

7.1 Summary of Findings

7.1.1 Governance context (Chapter 4)

This chapter addressed the first research objective to understand the governance context for shellfish aquaculture in B.C. The transition to EBM will occur within a pre-existing

governance context and therefore it is important to understand this context in order to identify barrier and opportunities to implementation. Governance refers to the process of decision-making, including the policies and laws that guide governance, the process for implementing them and the actors involved in those decisions. The method used to collect data for this chapter was in-depth analysis of government documents, policies and regulations, and targeted interviews with federal and provincial government regulators.

Both the federal and provincial government have initiated EBM plans in B.C. The provincial plan covers a large portion of land in the north-central coastal area of the province and the federal plan covers a large segment of the marine environment from the northern portion of Vancouver Island to the border with the United States. Both initiatives are in the planning stages and it is not yet clear how they will be implemented within resource management agencies.

The results of this chapter found that the shellfish aquaculture industry is situated in a complex jurisdictional context due to overlapping federal and provincial government authority, undefined indigenous rights and a lack of private ownership rights. This creates challenges with respect to coordinating the activities of the various government agencies and a responsibility to consult First Nations, various interests groups and local communities prior to making decisions. In addition, in the absence of an agreed upon vision or goals for the coastal environment, the governance process is marred by conflicting interests between the various stakeholders.

The regulatory framework for shellfish aquaculture is based on three major policy areas: food safety, the allocation of Crown land, and environmental protection. There are no regulations designed to specifically address the policy issues associated with shellfish aquaculture, instead the regulatory framework is based on existing regulations. This has resulted in the use of ten separate pieces of legislation governing shellfish aquaculture activities. This creates an onerous regulatory process for both government and the industry.

Through the interviews with government regulators at the provincial and federal level, four main challenges were identified with the current governance context. The first challenge is coordinating the various stakeholders involved in the governance process. The second challenge is the lack of comprehensive targeted regulations for shellfish aquaculture to guide decisions under existing legislation. The third challenge is acquiring buy-in for marine spatial planning initiatives from all levels of government in order to help guide the governance process. And the

fourth challenge is finding efficient and effective ways of consulting with First Nation and local communities.

7.1.2 The shellfish aquaculture industry (Chapter 5)

This chapter addressed the second research objective, to understand the shellfish aquaculture industry within the context of EBM. There is significant development potential for the shellfish aquaculture industry in B.C., which creates an opportunity for ensuring that this development occurs in an ecologically sound way. The method used to collect data for this chapter was a mail-out questionnaire to individual entrepreneurs within the industry. The survey was designed to explore the characteristics and values of individual shellfish farmers within the industry to assist in understanding the barriers and opportunities they present to EBM. Due to the small response rate (n=69), this analysis was limited to a descriptive analysis of the results.

The results of the survey suggest that the characteristics of the industry vary between geographic areas with respect to connection to the local community, form of employment, and the type and size of enterprises. In addition, some of the challenges faced by the industry differ by geographic area. This geographic diversity within the industry suggests that a place-based approach to management may be more appropriate than an industry-wide approach or as currently practiced a site-by-site approach.

Industry associations have played an important role in the development of the shellfish aquaculture industry in B.C. when faced with challenges of public acceptance and new government regulations such as in the 1960s when the B.C. Oyster Growers Association (now the B.C. Shellfish Growers Association) was first formed. However, presently just over half of the industry participates in an industry association. This is despite the fact that the industry is experiencing governance, economic and social challenges.

The results show that the industry may be moving towards increased intensification of operations and the farming of new higher valued species. This is occurring as almost 40% of the current entrepreneurs are planning on leaving the industry. This suggests that the industry may be entering a phase of transition as new entrepreneurs enter the industry and the types of operations change. This creates an opportunity to ensure that this transition is done in an ecologically sound way.

The survey results show that the industry is generally dissatisfied with the governance approach citing challenges with government coordination, addressing conflict with other coastal users, and excessive cost and timeframes for approval. These are similar challenges to those cited by government regulators with the governance process.

The results indicate that the respondents value environmental, social and economic factors when selecting a location for their operations. This suggests an awareness of the interconnectedness of these three factors.

Finally, the survey results indicate that the main barriers to development faced by the industry are low profitability, uncertainty and a lack of government support.

7.1.3 Barriers and opportunities for EBM (Chapter 6)

This chapter addressed the third research objective: to explore EBM as an approach to governance in the shellfish aquaculture industry in B.C. This was accomplished by bringing together the results of Chapter Four and Chapter Five and discussing them with respect to three EBM themes identified in the literature review: scale, linking science and management, and stakeholder engagement.

The first theme considered is scale. A mismatch between the scale of governance and the scale of ecosystems is identified in the literature as one of the biggest challenges with conventional approaches to resource management (Crowder *et al.*, 2006). Literature on EBM suggests the explicit consideration of the impact of resource management decisions on the ecosystem, integrating resource management within ecologically significant boundaries and the use of marine spatial planning as ways of addressing this challenge.

The main challenge to implementing EBM from a scale perspective is the multilateral governance context, the lack of comprehensive regulations targeted at addressing issues specific to the industry and a governance process that occurs on an application-by-application basis without any meaningful proactive planning. Both the federal and provincial government have acknowledged some of these challenges and taken some steps to address them through efforts to better coordinate activities, marine spatial planning initiatives and carrying capacity studies. However, these efforts would benefit from mechanisms to formally connect planning to management. EBM provides an opportunity to formalize such initiatives which would not only

benefit the environment but could also address some of the challenges associated with the multilateral governance context.

The survey results suggest that the industry would be supportive of a formal planning framework. They are challenged by the multilateral governance framework and conflicts with other coastal users. Both these challenges could be addressed through meaningful planning as part of EBM. Place-based planning initiatives under EBM could account for the geographic diversity within the industry thus assisting in addressing some of the specific challenges within different geographic contexts.

The second theme considered was linking science and management. Addressing ecosystem concerns within governance requires more than just expanding the scale of management but also requires the expansion of the scope of information required to make informed decisions about resource use. This presents not only a challenge with respect to understanding ecosystems but ecosystems are also constantly changing. The literature on EBM overwhelmingly endorses the use of adaptive management as a process for managing within complex and changing systems. The main challenge to adaptive management found in this study is the lack of a formal framework for evaluating management decisions over time. There is an opportunity to address this challenge through partnerships with the industry to monitor ecosystem indicators and to use production information as an indicator of ecosystem health. Environment Canada considers shellfish an indicator species for ecosystem health.

The third theme is stakeholder engagement. Addressing ecosystem challenges cannot be done by government alone; it requires stakeholders to understand their roles as stewards of the environment particularly in the case of shellfish aquaculture and industry that depends on public resources. The results show that the biggest challenge to engaging the shellfish aquaculture industry is industry diversity and the economic challenges associated with small enterprises. However, the industry expressed a willingness to be engaged in monitoring the marine environment and understand the importance of a healthy environment to the success of their operations. This creates an opportunity for stakeholder engagement. The government should explore a co-management relationship with the industry to empower the industry to take a more meaningful role in the protection of the ecosystem and the governance of the industry.

7.2 Recommendations

1. The management of the shellfish aquaculture industry should be embedded within a larger place-based planning process.

The literature on EBM stresses the importance of taking a place-based approach to management in order to consider the relationship between human activities and the ecosystem. The current governmental approach is based on an application-by-application basis, which not only limits the ability to consider the cumulative effects of the industry as a whole, but in the absence of an ecosystem-scale planning and managing process it is not possible to assess the cumulative effects of all activities nor proactively identify important ecosystem components to be protected.

Several of the challenges identified with the current governance process, such as multilateralism, conflict with other users, and onerous consultation processes, could be addressed by enacting certain decision-making processes at an ecosystem-scale through a planning process as opposed to the scale of an individual site. For example, important habitat for fish, migratory birds, and species at risk could be identified proactively instead of evaluated on a site-by-site basis. Identifying important habitat on an ecosystem scale could assist in identifying areas that should be protected from development. Another example is addressing conflict with other coastal users. In the absence of an ecosystem-scale planning process, incompatible activities such as shellfish aquaculture and a sewage discharge can be placed adjacent to each other resulting in conflict. However, if an ecosystem-scale plan exists areas can be zoned for specific activities proactively addressing potential conflicts.

It is important that such planning processes are formally connected to the governance process to be successful. The provincial government has used marine spatial planning for the shellfish aquaculture industry. However, it has no influence on the actual management of the industry because it lacked a formal mechanism for integrating the plan within the governance process. This was in part due to the fact that the various levels of government did not commit to implementing the plan. It was largely driven by the provincial government with the interest of increasing the development of the industry and the local government did not share the same interest.

2. A monitoring framework needs to be developed to evaluate the effectiveness of management actions.

Monitoring is an important component of the evaluation process within an adaptive management framework. Monitoring ecosystem indicators allows managers to adjust management actions to achieve desired ecosystem goals. Without a monitoring system this is not possible. However, a monitoring system is but one component, there must be mechanisms for using the resulting information to change management practices if needed.

The current approach to managing the industry does not include an on-going monitoring system, because of this it is not possible to assess whether the industry is having a negative or a positive impact on the ecosystem. This is a major challenge for developing an adaptive management approach as called for in EBM literature.

Monitoring can be resource intensive and government regulators express being challenged by a lack of financial and personnel resources. However, there are opportunities to work with the industry to develop a more efficient monitoring system. The results show the industry is willing to take a more active role in this activity. It is suggested that government work with the industry to develop cost-efficient indicators from which to measure the health of the ecosystem. For example, shellfish farmers can assist in identifying the occurrence of invasive species and the productivity of their operations can be used as an indicator of ecosystem productivity. Shellfish farmers could also measure many physical and chemical properties of the marine water such as temperature, salinity and turbidity.

3. Consideration should be given to meaningful involvement of the industry in developing EBM practice.

The literature emphasizes the importance of involving stakeholders in developing EBM approaches because ecosystem-scale challenges cannot be addressed by government alone. A lack of industry involvement can result in failed policies such as the Shellfish Development Initiative. In the former case, the government focused on productive capacity of the environment in terms of available land to determine development potential, whereas the industry was more interested in access to higher value species and better infrastructure in the form of processing plants and hatcheries to support a growing industry. One way of involving the industry is through the industry association. However, the largest industry association represents just over

half of the shellfish farmers in the province. It is the responsibility of individual entrepreneurs interested in remaining in the industry to organize themselves whether through the large industry association or through the creation of smaller more regional associations so that their voices can be heard.

It is suggested that the government engage the industry within particular geographic areas because as the results of the thesis show the industry is diverse across geographic areas. As such, there are more similarities with respect to industry characteristics and challenges and the ecological and social context within a geographic area. This may be a more effective way of engaging the industry in sustainable development.

4. The industry should actively pursue ecologically sustainable forms of development

The shellfish aquaculture industry actively promotes itself as a “green” form of aquaculture. According to the results from the surveys, the industry plans on increasing production by intensifying operations and cultivating higher value species. This can increase the risk to the ecosystem. As operations intensify the risk of eutrophication and depletion of primary productivity increase and non-native species risk affecting natural shellfish populations. In order to keep its image as a green form of aquaculture the industry should be actively pursuing research into ecologically sustainable forms of development. This may include cooperating within a region to assess ecological carrying capacity to ensure the increased production does not negatively affect the ecosystem or other shellfish aquaculture operations and exploring the development and marketing of native species.

5. Public education is required to enhance understanding of the shellfish aquaculture industry and the role it can play in sustainable food production.

The results identified public opposition as a barrier to industry development. The literature also suggests that social carrying capacity is an important constraint on industry development and suggests the use of public education and enhance communication to increase social carrying capacity for the industry. This is an area where the industry should take the lead within their communities to communicate the benefits of the industry.

7.2 Suggestions for Future Research

Future work studying ecosystem-based management includes the creation of a framework for evaluating governance progress. This will involve a more comprehensive examination of the theory and practice of ecosystem-based management than was possible during this thesis in order to identify comprehensive principles, themes, and mechanisms for implementation. Such an evaluation framework can be used to assess federal government progress in moving forward with its policy of ecosystem-based management of shellfish aquaculture now that the federal government will be taking the lead role in managing the industry.

Future work in studying the shellfish aquaculture industry should focus on the increasing the resilience of the industry to changes, both environment and institutional. This research found that the industry is composed of small- to medium-sized enterprises, which may be particularly vulnerable to such change. The industry appears to be undergoing a transition from an industry dominated by small family owned operations to one increasingly made up of larger enterprises. It would be interesting to examine this trend further and explore what it means for resilience within the industry.

7.3 Conclusion

This thesis has taken a broad approach at understanding the shellfish aquaculture industry in B.C. and its governance context. However, the discussion of the results was focused on understanding how this information can inform developing EBM practices. The information generated in this thesis provides a previously unavailable understanding of the industry which can prove valuable to future research involving the industry. The analysis of the information within the context of EBM has primarily been framework to demonstrate the utility the social sciences in developing EBM, which has primarily been based on the ecological sciences.

This research examined the challenges and opportunities of such a transition within the shellfish aquaculture industry in B.C. Although this research provided several recommendations for management and the industry in moving forward with this new approach to governance, three fundamental elements are needed. First, marine spatial planning that is integrated within the governance framework. Second, the importance of explicit integration of various forms of knowledge about the ecosystem within management and the use of adaptive management including an ongoing monitoring framework to inform decision-making. Third, engaging the industry as active partners in this governance approach through co-management.

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Appendix A: Human Research Ethic Board Certificate of Approval



University
of Victoria

Human Research Ethics Board
Office of Research Services
University of Victoria
Technology Enterprise Facility, Room 218
Tel (250) 472-4545 Fax (250) 721-7836
Email ethics@uvic.ca Web www.research.uvic.ca

Human Research Ethics Board Certificate of Approval

<u>Principal Investigator</u> Melanie Mamoser Master's Student	<u>Department/School</u> GEOG	<u>Supervisor</u> Dr. Rosaline Canessa	
<u>Co-Investigator(s):</u> Stephen Cross, Committee Member, UVic Jutta Gutberlet, Committee Member, UVic			
<u>Project Title:</u> An Ecosystem-based Approach to the Management of Bivalve Aquaculture in Canada			
<u>Protocol No.</u> 06-219	<u>Approval Date</u> 30-Aug-06	<u>Start Date</u> 30-Aug-06	<u>End Date</u> 29-Aug-09

Certification

This certifies that the UVic Human Research Ethics Board has examined this research protocol and concludes that, in all respects, the proposed research meets appropriate standards of ethics as outlined by the University of Victoria Research Regulations Involving Human Subjects.

Dr. Richard Keeler
Associate Vice-President, Research

This Certificate of Approval is valid for the above term provided there is no change in the procedures. Extensions or minor amendments may be granted upon receipt of a "Research Status" form.

06-219
Mamoser, Melanie

Appendix B: Industry Survey Questionnaire

An Ecosystem-Based Approach to Shellfish Aquaculture Site Selection and Management in Canada



(B.C. Ministry of Agriculture and Lands, 2006)

A Survey of Shellfish Farmers in British Columbia, Autumn 2006

Research Conducted By:

Melanie P. Mamoser

Department of Geography, University of Victoria
mmamoser@uvic.ca / (250) 247 7207



University of Victoria | British Columbia
Canada



Part 1 Participant Information

First Name: _____

Last Name: _____

Company: _____

Phone: _____

Fax: _____

Email: _____

Part 2 Business Information

1. How long have you been in the shellfish aquaculture industry? (Please circle correct answer)

- A. 0-2 years B. 3-5 years C. 6-10 years D. >10 years

2. How long do you plan on staying in the shellfish aquaculture industry?

- A. < 3 years B. 3-5 years C. 6-10 years D. >10 years

3. Are you a part-time or full-time farmer?

- A. P/T B. F/T

4. Do you live in the community in which your shellfish operation is located?

- A. Yes B. No

5. How many shellfish aquaculture tenures do you own?

- 1 2 3 4 5 > 5

5a) What is the total area of your combined tenure(s)? _____

5b) Approximately what proportion of your tenure(s) area is currently being farmed?

- A. 0% B. 25% C. 50% D. 75% E. 100%

6. Do you plan on increasing your production (tonnes) in the future?

- A. Yes B. No (Go to question 8)

7. By what means do you plan on increasing production? (Please circle all that apply)

- A. Increasing the size of your current tenures
 B. Increasing the density of your current tenures
 C. Increasing the proportion of your tenure area currently being farmed

D. Other (Please specify) _____

8. The following is a list of shellfish species being farmed in B.C. In the first column, please **rank in order of importance** (tonnes produced) the type of shellfish you farm (1 being the most important, leaving blank those you do not farm). In the second column, please **rank in order of importance** (1 being the most important, leaving blank those you do not plan on farming) the type of shellfish you plan on farming in the future.

TYPE OF SHELLFISH	PRESENT FARMING	FUTURE FARMING
A. Pacific Oyster		
B. Manila clam		
C. Geoduck		
D. Blue mussel		
E. Gallo mussel		
F. Japanese scallop		
E. Other (please specify) _____		

9. What made you decide to grow those species? (circle all that apply)
- A. Market price B. Consumer demand C. Past experience D. Environmental conditions
- E. Others (please specify) _____
10. Are you a member of an industry group? (e.g. BC Shellfish Growers Association)
- A. No (Go to Part 3) B. Yes, Please specify _____
11. Membership to an industry association is seen as beneficial in a variety of ways to many shellfish growers. The following is a list of possible benefits. Please indicate how important each of the following benefits were to your decision to join an industry association.

BENEFITS	IMPORTANCE			
	HIGH	MEDIUM	LOW	NOT SURE
A. Access to information	1	2	3	4
B. Industry support	1	2	3	4
C. Group insurance	1	2	3	4
D. Product marketing	1	2	3	4
E. Help entering the industry	1	2	3	4
G. Industry promotion	1	2	3	4
H. Industry structure and governance	1	2	3	4
I. Research and Development	1	2	3	4
J. Training and education	1	2	3	4
K. Other (Please specify) _____	1	2	3	4

1. In order to properly manage the shellfish aquaculture industry, government must take into consideration the goals of the industry. Please indicate how important the following industry goals were to you in your site selection process.

GOALS	IMPORTANCE				
	NOT AT ALL	HIGH	MEDIUM	LOW	NOT SURE
A. Maximizing production	0	1	2	3	4
B. Maintaining ecosystem health and integrity	0	1	2	3	4
C. Finding an environmentally suitable site	0	1	2	3	4
D. Involving First Nations and the local community	0	1	2	3	4
E. Minimizing conflicts with other coastal resource uses	0	1	2	3	4
F. Understanding all human activities around the site	0	1	2	3	4
G. Other (Please specify) _____	0	1	2	3	4

2. What government agencies did you directly work with during your tenure application? (Please circle all that apply)
- A. B.C. Ministry of Agriculture and Lands
 - B. B.C. Ministry of Environment
 - C. Fisheries and Oceans Canada (DFO)
 - D. Transport Canada
 - E. Environment Canada
 - F. Others (please specify) _____
3. Did you get help from a consultant to complete the tenure application?
- A. Yes B. No
4. Was an environmental assessment through the Canadian Environmental Assessment Act (CEAA) triggered during your application?
- A. Yes B. No (go to question 5)
- 4a) How long did the environmental assessment take? _____
- 4b) How much did the environment assessment cost you? _____
- 4c) Why was the environmental assessment triggered? _____
- 4d) What additional information, if any, did you have to collect for the environmental assessment?

5. Did you have any tenure applications that were turned down?

A. Yes

B. No (go to question 6)

6. For those applications that were approved, how long did it take from initial investigation (e.g. talking to government officials before submitting an application) to approval? _____

7. Did you use Geographic Information Systems (GIS) or information derived from GIS when selecting your site?

A. Yes

B. No (Go to question 8)

7a) If so, please explain how?

8. Did you consider the environmental conditions beyond your immediate site when choosing a site?

A. Yes

B. No

8a) Would you have benefited from access to information stemming from past tenure applications and environmental assessments conducted in the area beyond your immediate site?

A. Yes

B. No (go to question 9)

8b) What information would have benefited you?

9. Did you benefit from local knowledge and/or First Nation Traditional Knowledge in your site selection process? If so, how?

10. Coastal communities are direct and indirect users of coastal resources and for this reason they have a stake in coastal management decisions. One way of including them in shellfish aquaculture decision making is through the public consultation process. How would you rate the public consultation processes usefulness in achieving the following:

	VERY USEFUL	SOMWHAT USEFUL	NOT SURE	SOMEWHAT USELESS	VERY USELESS
A. Enabling communication between the industry and the community	1	2	3	4	5
B. Resolving conflicts	1	2	3	4	5
C. Avoiding conflicts	1	2	3	4	5
D. Creating acceptable strategies and plans for coastal areas	1	2	3	4	5
E. Increasing community understanding of the industry	1	2	3	4	5
F. Improving site selection	1	2	3	4	5

11. Please rate your level of agreement or disagreement with the following statements pertaining to the site selection process.

STATEMENTS	STRONGY AGREE	SOMEWHAT AGREE	NOT SURE	SOMEWHAT DISAGREE	STRONGLY DISAGREE
A. The process selects appropriate grow-out sites	1	2	3	4	5
B. The timeframe for approval is reasonable	1	2	3	4	5
C. The cost to proponents is reasonable	1	2	3	4	5
D. The process avoids conflicts	1	2	3	4	5
E. The process requirements are clear and easy to follow	1	2	3	4	5
F. The provincial and federal government are coordinated to avoid redundancy	1	2	3	4	5
G. Proponents have access to sufficient information	1	2	3	4	5

12. What are your recommendations for improving the site selection process?

4. Shellfish aquaculture requires pristine waters for the long-term sustainability of operations. How would you rate the overall impacts of the following activities on your operation.

IMPACTS	NO IMPACT AT ALL	MODERATE IMPACT	SERIOUS IMPACT	NOT SURE
A. Finfish aquaculture	1	2	3	N/A
B. Other shellfish aquaculture operations	1	2	3	N/A
C. Residential development	1	2	3	N/A
D. Recreational boaters	1	2	3	N/A
E. Commercial boaters	1	2	3	N/A
F. Land-based industries (e.g. pulp mills)	1	2	3	N/A
G. Municipal sewage	1	2	3	N/A
H. Agricultural activities	1	2	3	N/A
I. Other (Please specify) _____	1	2	3	N/A

5. The provincial government is currently responsible for the monitoring of any impacts stemming from shellfish aquaculture. Please indicate your level of support or opposition to a more active role in the monitoring of the following for **your operation**:

	STRONGLY SUPPORT	SOMEWHAT SUPPORT	NOT SURE	SOMEWHAT OPPOSE	STRONGLY OPPOSE
A. Beach debris	1	2	3	4	5
B. Water quality	1	2	3	4	5
C. Benthic quality	1	2	3	4	5
D. Phytoplankton levels	1	2	3	4	5

6. Would you benefit from industry sharing of the above mentioned information about the environment surrounding your site?

A. Yes B. No

7. What do you currently do to monitor the health of the environment surrounding your shellfish operation?

8. What do you consider the most significant barriers to the growth of your business?

Appendix C: Government Interview Question Guide

Interview Questions

Part 1 – Background Information

1. Name
2. Job title and organization
3. What is your background (education and experience)?
4. How long have you worked in bivalve aquaculture?
5. What are your responsibilities in relation to bivalve aquaculture?

Part 2 – Bivalve Aquaculture General

1. What are the operational objectives for the bivalve aquaculture industry?
2. What are the positive and negative impacts of the bivalve aquaculture industry on the ecosystem?
3. How can these effects be assessed and measured?
4. What chemical, biological and physical indicators are available to measure these effects?
5. What are the thresholds to these indicators?
6. What modeling methods are there available to predict the impacts of the bivalve aquaculture industry?
7. What are the advantages and disadvantages of these modeling methods?

Part 3 – Site Selection Process

1. Briefly describe the site selection process with emphasis on your role and the role of your organization?
2. What are the goal(s) of the site approval process, both substantive and procedural?
3. How are the goal(s) currently being met?
4. How could the goal(s) be better met?
5. What criteria are most important for the decision making process?
6. Do some criteria carry more weight than others?
7. How are the boundaries of consideration established for bivalve aquaculture site selection?
8. Do you differentiate between the capability of a site and the suitability of a site?
9. What are your information needs to assess the capability of a site and how do they fit into the decision making criteria?
10. How is this information collected? By what means, at what coast and by whom?
11. What information do you require proponents to gather during the decision making process?
12. How is information generated through the site selection process stored, shared and subsequently referred to?
13. How are regional effects such as cumulative impacts and carrying capacity considering during the site selection process?
14. What are the information needs for such considerations?

15. How has public participation been integrated into the site selection process?
16. What additional information is considered during a CEEA review?
17. How are mitigation measures determined?
18. The Canadian Shellfish Sanitation Program collects baseline water quality information for bivalve growing areas. Currently the program does sanitary and bacteriological surveys. How is the information collected during the CSSP stored, shared and subsequently referred to? Is there any useful water quality information that is not collected during the CSSP? Could the CSSP be expanded to collect more regional biophysical information?
19. What are the strengths of the current site selection process?
20. What are the limitations of the current site selection process?
21. How is consistency in the site selection process ensured?
22. How is the site selection process reevaluated overtime in order to ensure your goal(s) are being met?
23. In your opinion, is the process successful in appropriately selecting bivalve aquaculture sites? Why or why not?

Part 4 – Monitoring Process

1. Briefly describe the monitoring process with emphasis on your role and the role of your organization?
2. What are the boundaries of consideration for the monitoring process?
3. What are the goal(s) of the monitoring process, both substantive and procedural?
4. How are the goal(s) currently being met?
5. How could the goal(s) be better met?
6. What decision making criteria are most important for the monitoring process?
7. Do some criteria carry more weight than others?
8. What are your information needs as part of the monitoring process and how do they fit into the decision making criteria?
9. How is this information collected? By what means, at what coast and by whom?
10. How is this information subsequently stored, shared and referred to?
11. How does the information under consideration differ from that assessed as part of the initial site selection process?
12. How has public participation been integrated into the monitoring process?
13. How are regional effects such as cumulative impacts and carrying capacity considered during the monitoring process?
14. What are the strengths of the current monitoring process?
15. What are the limitations of the current monitoring process?
16. How do you ensure consistency in the monitoring process?
17. In your opinion, is the monitoring process successful? Why or why not?

Part 4 – Ecosystem-Based Management

1. Is ecosystem-based management applied to regulation and management of bivalve aquaculture?
2. What is ecosystem-based management?

3. How does it apply to the bivalve aquaculture industry?
4. What are the boundaries to the application of ecosystem-based management to bivalve aquaculture?
5. How could these boundaries be overcome?
6. To what extent is local knowledge incorporated into bivalve aquaculture?
7. How can local knowledge be incorporated into ecosystem-based management?
8. Has traditional knowledge contributed to the data generation for ecosystem-based management?
9. What are the benefits of ecosystem-based management to communities?

Part 5 - GIS

1. Has GIS or computer decision support been used to assist in bivalve aquaculture management?
2. If yes, in what capacity and for what purpose?
3. What role, if any, do you feel GIS could play in making decisions about bivalve aquaculture siting and monitoring?
4. Have you received any formal or informal training or education in GIS?

Appendix D: Raw Survey Data

P2Q1 Length of time in the industry ($n = 69$)		
Time	Frequency (f)	Percentage (%)
0-2	5	7
3-5	6	9
6-10	11	16
>10	47	68
n/a	0	0
Total	69	100

P2Q2 Length of time respondents plan on staying in the industry ($n = 69$)		
Time	Frequency (f)	Percentage (%)
0-2	14	20
3-5	4	6
6-10	8	12
>10	42	61
n/a	1	1
Total	69	100

P2Q3 Respondents employment status ($n = 69$)		
	Frequency (f)	Percentage (%)
Part-time	31	45
Full-time	38	55
n/a	0	0
Total	69	100

P2Q4 Respondents that live in same community as their farm ($n = 69$)		
	Frequency (f)	Percentage (%)
Yes	54	78
No	15	22
n/a	0	0
Total	69	100

P2Q5 Number of tenures ($n = 69$)		
	Frequency (f)	Percentage (%)
0	1	1
1	41	59
2	10	15
3	4	6
4	7	10
5	1	1
>5	5	7
n/a	0	0
Total	69	98

P2Q5c Proportion of tenure under cultivation ($n = 69$)		
	Frequency (f)	Percentage (%)
0%	8	12
25%	16	23
50%	21	30
75%	10	15
100%	6	9
n/a	8	12
Total	69	101

P2Q6 Number of respondents that plan on increasing production ($n = 69$)		
	Frequency (f)	Percentage (%)
Yes	45	65
No	15	22
n/a	9	13
Total	69	100

P2Q7a Number of respondents that plan on increase production by increasing the number tenure(s) ($n = 45$)*		
	Frequency (f)	Percentage (%)
Yes	13	29
No	31	69
n/a	1	2
Total	45	100

* Only respondents that plan on increasing production

P2Q7b Number of respondents that plan on increase production by increasing the size of current tenure(s) ($n = 45$)*		
	Frequency (f)	Percentage (%)
Yes	6	13
No	38	84
n/a	1	2
Total	45	99

* Only respondents that plan on increasing production

P2Q7c Number of respondents that plan to increase production by increasing the density of current tenure(s) ($n = 45$)*		
	Frequency (f)	Percentage (%)
Yes	29	64
No	15	33
n/a	1	2
Total	45	99

* Only respondents that plan on increasing production

P2Q7d Number of respondents that plan to increase production by increasing the proportion of tenure(s) being farmed ($n = 45$)*

	Frequency (f)	Percentage (%)
Yes	25	56
No	19	42
n/a	1	2
Total	45	100

* Only respondents that plan on increasing production

P2Q7e Number of respondents that plan to increase production by an other method ($n = 45$)*

	Frequency (f)	Percentage (%)
Yes	13	29
No	32	71
n/a	0	0
Total	45	100

* Only respondents that plan on increasing production

P2Q8 Number of respondents that cultivate more than one species on their site ($n = 69$)

	Frequency (f)	Percentage (%)
1	26	38
2	30	44
3	4	6
4	4	6
5	2	3
n/a	3	4
Total	69	101

P2Q8 Number of respondents that cultivate more than one species on their site in the future ($n = 69$)

	Frequency (f)	Percentage (%)
1	9	13
2	19	28
3	9	13
4	9	13
5	5	7
6	2	3
n/a	16	23
Total	69	100

P2Q8a Number of respondents that currently cultivate Pacific oysters (*Cassostrea gigas*) ($n = 69$)

	Frequency (f)	Percentage (%)
Yes	59	86
No	8	12
n/a	2	3
Total	69	101

P2Q8b Number of respondents that currently cultivate Manila clam (*Tapes philippinarum*) ($n = 69$)

	Frequency (f)	Percentage (%)
Yes	34	49
No	33	48
n/a	2	3
Total	69	100

P2Q8c Number of respondents that currently cultivate Geoduck (*Panope abrupta*) ($n = 69$)

	Frequency (f)	Percentage (%)
Yes	5	7
No	62	90
n/a	2	3
Total	69	100

P2Q7d Number of respondents that currently cultivate Blue mussels (*Mytilus edulis*) ($n = 69$)

	Frequency (f)	Percentage (%)
Yes	4	6
No	863	91
n/a	2	3
Total	69	100

P2Q8e Number of respondents that currently cultivate Gallo mussels (*Mytilus galloprovincialis*) ($n = 69$)

	Frequency (f)	Percentage (%)
Yes	9	13
No	58	84
n/a	2	3
Total	69	100

P2Q8f Number of respondents that currently cultivate Japanese scallops (*Patinopecten yessoensis*) ($n = 69$)

	Frequency (f)	Percentage (%)
Yes	9	13
No	58	84
n/a	2	3
Total	69	100

P2Q8g Number of respondents that currently cultivate other species ($n = 69$)

	Frequency (f)	Percentage (%)
Yes	5	7
No	62	90
n/a	2	3
Total	69	100

P2Q8h Number of respondents that plan to cultivate Pacific oysters (<i>Cassostrea gigas</i>) ($n = 69$)			P2Q8n Number of respondents that plan to cultivate other species ($n = 69$)		
	Frequency (f)	Percentage (%)		Frequency (f)	Percentage (%)
Yes	47	68	Yes	12	17
No	7	10	No	42	61
n/a	15	22	n/a	15	22
Total	69	100	Total	69	100

P2Q8i Number of respondents that plan to cultivate Manila clam (<i>Tapes philippinarum</i>) ($n = 69$)			P2Q8 Number of respondents that plan on adding or changing species ($n = 69$)		
	Frequency (f)	Percentage (%)		Frequency (f)	Percentage (%)
Yes	35	51	Yes	24	35
No	19	28	No	29	42
n/a	15	22	n/a	16	23
Total	69	101	Total	69	100

P2Q8j Number of respondents that plan to cultivate Geoduck (<i>Panope abrupta</i>) ($n = 69$)			P2Q9a Number of respondents that used market price as a criteria for species selection ($n = 69$)		
	Frequency (f)	Percentage (%)		Frequency (f)	Percentage (%)
Yes	13	19	Yes	27	39
No	41	59	No	23	33
n/a	15	22	n/a	19	28
Total	69	100	Total	69	100

P2Q8k Number of respondents that plan to cultivate Blue mussels (<i>Mytilus edulis</i>) ($n = 69$)			P2Q9b Number of respondents that used consumer demand as a criteria for species selection ($n = 69$)		
	Frequency (f)	Percentage (%)		Frequency (f)	Percentage (%)
Yes	10	15	Yes	31	45
No	44	64	No	19	28
n/a	15	22	n/a	19	28
Total	69	101	Total	69	101

P2Q8l Number of respondents that plan to cultivate Gallo mussels (<i>Mytilus galloprovincialis</i>) ($n = 69$)			P2Q9c Number of respondents that used experience as a criteria for species selection ($n = 69$)		
	Frequency (f)	Percentage (%)		Frequency (f)	Percentage (%)
Yes	12	17	Yes	23	33
No	42	61	No	27	39
n/a	15	22	n/a	19	28
Total	69	100	Total	69	100

P2Q8m Number of respondents that plan to cultivate Japanese scallops (<i>Patinopecten yessoensis</i>) ($n = 69$)			P2Q9d Number of respondents that used environmental conditions as a criteria for species selection ($n = 69$)		
	Frequency (f)	Percentage (%)		Frequency (f)	Percentage (%)
Yes	18	26	Yes	29	42
No	36	52	No	21	30
n/a	15	22	n/a	19	28
Total	69	101	Total	69	100

P2Q9e Number of respondents that used an other criteria for species selection (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
Yes	15	22
No	35	51
n/a	19	28
Total	69	100

P2Q10 Number of respondents members of an industry association (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
Yes	26	38
No	40	58
n/a	3	4
Total	69	100

P2Q11a Benefit of membership to an industry association - Access to information (<i>n</i> = 36)*		
	Frequency (f)	Percentage (%)
High	16	44
Medium	9	25
Low	1	31
n/a	0	0
Total	36	100

*Only past and present members responded

P2Q11b Benefit of membership to an industry association - Industry support (<i>n</i> = 36)*		
	Frequency (f)	Percentage (%)
High	13	36
Medium	10	28
Low	10	28
n/a	3	8
Total	36	100

*Only past and present members responded

P2Q11c Benefit of membership to an industry association - Group insurance (<i>n</i> = 36)*		
	Frequency (f)	Percentage (%)
High	23	64
Medium	3	8
Low	7	19
n/a	3	8
Total	36	99

*Only past and present members responded

P2Q11d Benefit of membership to an industry association - Product marketing (<i>n</i> = 36)*		
	Frequency (f)	Percentage (%)
High	2	6
Medium	7	19
Low	23	64
n/a	4	11
Total	36	100

*Only past and present members responded

P2Q11e Benefit of membership to an industry association - Help entering industry (<i>n</i> = 36)*		
	Frequency (f)	Percentage (%)
High	5	14
Medium	5	14
Low	22	61
n/a	4	11
Total	36	100

*Only past and present members responded

P2Q11f Benefit of membership to an industry association - Industry promotion (<i>n</i> = 36)*		
	Frequency (f)	Percentage (%)
High	9	25
Medium	13	36
Low	13	36
n/a	1	3
Total	36	100

*Only past and present members responded

P2Q11g Benefit of membership to an industry association - Industry structure and governance (<i>n</i> = 36)*		
	Frequency (f)	Percentage (%)
High	6	17
Medium	14	39
Low	14	39
n/a	2	6
Total	36	98

*Only past and present members responded

P2Q11g Benefit of membership to an industry association - R&D (<i>n</i> = 36)*		
	Frequency (f)	Percentage (%)
High	5	14
Medium	10	28
Low	17	47
n/a	4	11
Total	36	100

*Only past and present members responded

P2Q11h Benefit of membership to an industry association - Training and education (<i>n</i> = 36)*		
	Frequency (f)	Percentage (%)
High	5	14
Medium	8	22
Low	17	47
n/a	6	17
Total	36	100

*Only past and present members responded

P2Q11i Benefit of membership to an industry association - other (<i>n</i> = 36)*		
	Frequency (f)	Percentage (%)
High	7	19
Medium	1	3
Low	0	0
n/a	28	78
Total	36	100

*Only past and present members responded

P3Q1a Importance of maximizing profits in selecting a site (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
High	43	62
Medium	14	20
Low	2	3
Not sure	1	1
n/a	9	13
Total	69	99

P3Q1b Importance of maintaining ecosystem health and integrity in selecting a site (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
High	50	73
Medium	9	13
Low	1	1
Not sure	0	0
n/a	9	13
Total	69	100

P3Q1c Importance of finding a suitable site (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
High	44	64
Medium	8	12
Low	1	1
Not sure	1	1
n/a	15	22
Total	69	100

P3Q1d Importance of involving First Nations and the local community in selecting a site (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
High	21	30
Medium	14	20
Low	18	26
Not sure	3	4
n/a	13	19
Total	69	99

P3Q1e Importance of minimizing conflicts in selecting a site (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
High	33	48
Medium	18	26
Low	7	10
Not at all	2	3
n/a	9	13
Total	69	100

P3Q1f Importance of understanding human activities around the site (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
High	33	48
Medium	17	25
Low	9	13
Not at all	1	1
n/a	9	13
Total	69	100

P3Q1g Importance of other goals in selecting a site (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
High	17	25
Medium	1	1
Low	0	0
Not at all	0	0
n/a	51	74
Total	69	100

P3Q3 Use of a consultant to complete tenure application process (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
Yes	7	10
No	46	67
n/a	16	23
Total	69	100

P3Q4 EA triggered during tenure application process (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
Yes	11	16
No	40	58
n/a	18	26
Total	69	100

P3Q5 Tenure application(s) turned down (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
Yes	20	29
No	32	46
n/a	17	25
Total	69	100

P3Q7 Use of GIS during tenure application process (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
Yes	4	6
No	44	64
n/a	21	30
Total	69	100

P3Q8a Consideration of regional environment during tenure application process (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
Yes	53	77
No	6	9
n/a	10	15
Total	69	101

P3Q8b Would you benefit from access to regional information (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
Yes	19	28
No	37	54
n/a	13	19
Total	69	101

P3Q9 Use of traditional knowledge and/or local knowledge (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
Yes	19	28
No	30	44
n/a	20	29
Total	69	101

P3Q10a Public consultation usefulness in enabling communication between the industry and the community (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
Very useful	9	13
Somewhat useful	15	22
Somewhat useless	11	16
Very useless	10	15
n/a	24	35
Total	69	101

P3Q10b Public consultation usefulness in resolving conflicts (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
Very useful	7	10
Somewhat useful	7	10
Somewhat useless	16	23
Very useless	14	20
n/a	25	36
Total	69	99

P3Q10c Public consultation usefulness in avoiding conflicts (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
Very useful	9	13
Somewhat useful	8	12
Somewhat useless	14	20
Very useless	13	19
n/a	25	36
Total	69	100

P3Q10d Public consultation usefulness in Creating strategies and plans (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
Very useful	9	13
Somewhat useful	10	15
Somewhat useless	11	16
Very useless	13	19
n/a	26	38
Total	69	101

P3Q10e Public consultation usefulness in increasing community understanding (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
Very useful	11	16
Somewhat useful	18	26
Somewhat useless	5	7
Very useless	12	17
n/a	23	33
Total	69	99

P3Q10f Public consultation usefulness in improving site selection (<i>n</i> = 69)			P3Q11e The tenure application process requirements are clear and easy to follow (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)		Frequency (f)	Percentage (%)
Very useful	5	7	Strongly agree	0	0
Somewhat useful	5	7	Somewhat agree	19	28
Somewhat useless	9	13	Somewhat disagree	13	19
Very useless	17	25	Strongly disagree	12	17
n/a	33	48	n/a	25	36
Total	69	100	Total	69	100
P3Q11a The tenure application process selects appropriate grow-out sites (<i>n</i> = 69)			P3Q11f The provincial and federal government are coordinated in the tenure application process (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)		Frequency (f)	Percentage (%)
Strongly agree	3	4	Strongly agree	0	0
Somewhat agree	9	13	Somewhat agree	7	10
Somewhat disagree	15	22	Somewhat disagree	11	16
Strongly disagree	9	13	Strongly disagree	29	42
n/a	33	48	n/a	22	32
Total	69	100	Total	69	100
P3Q11b The tenure application process approval time is reasonable (<i>n</i> = 69)			P3Q11g Proponents have access to sufficient information in the tenure application process (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)		Frequency (f)	Percentage (%)
Strongly agree	4	6	Strongly agree	7	10
Somewhat agree	10	15	Somewhat agree	16	23
Somewhat disagree	9	13	Somewhat disagree	11	16
Strongly disagree	19	28	Strongly disagree	6	9
n/a	27	39	n/a	29	42
Total	69	101	Total	69	100
P3Q11c The tenure application process cost is reasonable (<i>n</i> = 69)			P4Q2 Personal environmental monitoring (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)		Frequency (f)	Percentage (%)
Strongly agree	3	4	yes	24	35
Somewhat agree	8	12	n/a	45	65
Somewhat disagree	12	17	Total	69	100
Strongly disagree	22	32			
n/a	24	35			
Total	69	100			
P3Q11d The tenure application process avoids conflicts (<i>n</i> = 69)			P4Q4a Perceived impact of finfish aquaculture (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)		Frequency (f)	Percentage (%)
Strongly agree	2	3	No impact	35	51
Somewhat agree	8	12	Moderate impact	8	12
Somewhat disagree	14	20	Serious impact	14	20
Strongly disagree	17	25	n/a	12	17
n/a	28	41	Total	69	100
Total	69	101			

P4Q4b Perceived impact of other shellfish aquaculture operations (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
No impact	44	64
Moderate impact	13	19
Serious impact	4	6
n/a	8	11
Total	69	100

P4Q4c Perceived impact of residential development (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
No impact	17	25
Moderate impact	17	25
Serious impact	26	38
n/a	9	13
Total	69	101

P4Q4d Perceived impact of recreational boaters (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
No impact	17	25
Moderate impact	33	48
Serious impact	11	16
n/a	8	12
Total	69	101

P4Q4e Perceived impact of commercial boaters (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
No impact	32	46
Moderate impact	21	30
Serious impact	7	10
n/a	9	13
Total	69	99

P4Q4f Perceived impact of land-based industries (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
No impact	24	35
Moderate impact	12	17
Serious impact	23	33
n/a	10	15
Total	69	100

P4Q4g Perceived impact of municipal sewage (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
No impact	25	36
Moderate impact	5	7
Serious impact	30	44
n/a	9	13
Total	69	100

P4Q4h Perceived impact of agricultural activities (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
No impact	26	38
Moderate impact	14	20
Serious impact	19	28
n/a	10	15
Total	69	101

P4Q5a Active role in monitoring beach debris (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
Strongly support	30	44
Somewhat support	15	22
Somewhat oppose	4	6
Strongly oppose	4	6
n/a	16	23
Total	69	101

P4Q5b Active role in monitoring water quality (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
Strongly support	37	54
Somewhat support	13	19
Somewhat oppose	1	1
Strongly oppose	3	4
n/a	15	22
Total	69	100

P4Q5c Active role in monitoring benthic quality (<i>n</i> = 69)		
	Frequency (f)	Percentage (%)
Strongly support	24	35
Somewhat support	12	17
Somewhat oppose	3	4
Strongly oppose	2	3
n/a	28	41
Total	69	100