The Key Elements of Ecosystem-based Management:

Theory vs. Fishermen's Priorities

By

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ABSTRACT

The large number and variation of principles that define EBM has created confusion, impeding its application. A frequency analysis of EBM principles was conducted from a variety of published sources, across various disciplines and application mediums to identify the Key Elements that currently define EBM.

This slow onset of EBM may be a result of the lack of fishermen support at the ground level. Face to Face surveys were conducted with twenty-three local fishermen in the soft-shell clam, lobster and groundfish fisheries in southwest Nova Scotia and southwest New Brunswick in the Bay of Fundy, to assess whether industry priorities within EBM principles are aligned with those published in theoretical literature and to identify what issues are standing in the way of EBM application. Connections were made between the key issues that are driving these priorities to provide insight on how EBM can be more readily applied on the ground.

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TABLE OF CONTENTS

LIST OF CHAPTER 1 FIGURES

LIST OF CHAPTER 1 TABLES

LIST OF CHAPTER 2 FIGURES

LIST OF CHAPTER 2 TABLES

INTRODUCTION

Ecosystem-based Management

Traditional management practices have proven to be ineffective and unable to protect marine systems from human pressures (Crain *et al.* 2009) and fishery stock collapses (Pikitch *et al.* 2004). This has sparked the need for change in current management practices, making room for alternative approaches such as Ecosystem-Based Management (EBM). EBM is a more holistic approach, moving beyond the single species or sector focus of traditional management, in its most inclusive form it acknowledges ecological, social and governance objectives (Bianchi 2008). With its rise in popularity over the past two decades EBM has been a hot topic in natural resource management literature and has been defined by many academic, government, non government and international organizations. This has left EBM with many different definitions or defining principles as well as similar or synonymous terms such as the Ecosystem Approach and sector specific approaches such as the Ecosystem Approach to Fisheries (Short *et al.* 2008). A typical inclusive definition of EBM is:

"an integrated approach to management that considers the entire ecosystem, including humans. The goal of EBM is to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need. EBM differs from current approaches that usually focus on a single species, sector or activity or concern; it considers the cumulative impacts of different sectors" (COMPASS 2005)

The multitude of definitions and principles used to describe EBM, have resulted in many different ways in which EBM can be applied, with no universal application framework (Bianchi 2008). This creates a great deal of confusion when it comes to the implementation of EBM, creating a gap between theory and practice, slowing down the

application process. A clear set of EBM principles is needed in order to achieve the widespread application of EBM throughout marine systems.

Ecosystem-based Management in Canada

Although Canada is considered to be one of the leaders of EBM in fisheries (Pitcher *et al.* 2009), much needs to be accomplished before an inclusive EBM approach is widely applied to all Canadian fisheries. Canada has made efforts to implement EBM in marine systems with legislation such as the Oceans Act (Government of Canada. 1996), EBM pilot projects in large ocean management areas such as Eastern Scotian Shelf Integrated Management initiatives (O'Boyle and Worcester 2009) and the development of the Ecosystem Approach to Fisheries (Fisheries and Oceans Canada 2010), solely focusing on ecological objectives. To move towards an approach that includes a broader range of social and governance issues, there needs to be better understanding of how EBM functions on the ground. Further research of EBM at a smaller scale, will allow for local issues to be recognized and encourage stakeholder support of EBM initiatives which is vital for successful management initiatives (Mackinson *et al.* 2011).

Research Objectives

The overall goal of this paper is to work towards closing the gap between EBM theory and practice that in turn will help to achieve a more widespread application of EBM in Canada. In Chapter 1 a frequency analysis of EBM principles derived from theoretical literature was conducted to compile a list of the Key Elements of EBM needed for successful application. The evolution of these EBM principles in theoretical literature was tracked to identify changes over time and potential future Key Elements. To gain perspective of these EBM principles in a practical context, face-to-face surveys were

conducted with fishermen in the lobster, soft shell clam and groundfish fisheries in southwest Nova Scotia and southwest New Brunswick to identify their priorities within EBM principles. In Chapter 2 the fishermen's priorities were compared with the concluded list of Key Elements in Chapter 1 to identify the gaps between theory and practice. Connections were made between the management issues raised by the fishermen during the face-to-face surveys and their priorities within the EBM principles, to gain an understanding of what is driving these priorities.

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Chapter 1: The Key Elements of Ecosystem-based Management: Tracking the Evolution of Ecosystem-based Management principles to provide insight for the Future of Marine Governance

INTRODUCTION

There is no debate surrounding the intrinsic value of global marine ecosystems (Costanza *et al.* 1997) or the immense pressures which humans have inflicted on them (Brander *et al.* 2010). With rapid population growth and densely inhabited coastal areas, our dependence on future marine resources is greater than ever (Crain *et al.* 2009). The overuse and mismanagement of ecosystem services have placed great pressure on marine systems such as overexploitation, habitat loss, pollution and disease (Crain *et al.* 2009). This threatens the future of these marine ecosystems and therefore the services they provide (Crain *et al.* 2009). The traditional silo-structured management focusing on a single species or sector has proven to be insufficient (Pikitch *et al.* 2004). It has failed to protect marine systems from these human pressures (Crain *et al.* 2009) or fishery stock collapses (Costello *et al.* 2008), which has not only had a devastating effect on the marine ecosystems themselves but has also deeply impacted the humans that depend on these resources (Millennium Ecosystem Assessment 2005). The consequences of the inefficiencies in traditional management systems, along with the desire to restore and maintain ecosystem health, have induced a desire for change.

The Changing Face of Management

The single species focus of traditional management does not take into account the importance of marine biodiversity which has the ability to enhance ecosystem processes, stability and resilience, with species rich systems showing lower collapse rates (Worm *et*

al. 2006). Biodiversity not only influences ecological health but the people that depend on these ecosystem services (Millennium Ecosystem Assessment 2005). The extensive research carried out by the Millennium Ecosystem Assessment has identified the need to draw connections between the ecological impacts of biodiversity, and ecosystem services, and in turn human well being (Carpenter *et al.* 2006). A more interdisciplinary analysis allows for a better understanding of these social-ecological systems and the drivers and consequences of biodiversity loss (Carpenter *et al.* 2006). Further research in this area at both local and global scales is essential in identifying what is needed to maintain and restore ecosystem functions and build resilient social-ecological systems in the future (Carpenter *et al.* 2009). Inclusive management strategies, such as community-based co-management, have proven to better recognize local social-ecological needs, instilling a sense of ownership and therefore encouraging local stewardship (Gutierrez *et al.* 2011). Gutierrez *et al.* (2011) found that community-based co-management is most successful in cohesive communities with strong leaders and in the presence of marine protected areas and rights-based management. Rights-based approaches alone do not always provide incentives for habitat preservation or the conservation of non-target species (Beddington *et al.* 2007). The implementation of fishery certification programs or 'eco-labels' encourage consumers to purchase environmentally friendly seafood products and provides market incentives for fishermen to further embrace sustainable fishing practices. The United Nations Food and Agriculture Organization has developed international eco-labelling guidelines (FAO 2009) which are followed by certification organizations such as the Marine Stewardship Council (MSC) (MSC 2005) yet despite these guidelines the overall effectiveness of eco-labels is highly debated amongst the academic community.

For example, although MSC complies to FAO guidelines, some researchers feel that the program's overall objectives are being comprised by the loose standards for certification of fisheries with declining populations (Jacquet and Pauly 2010), while others recognize the progress in fisheries such as the New Zealand hoki which has benefited from the MSC certification program (Hilborn and Cowan Jr 2010). Although there is not always agreement on the direction which management should take, there is a general consensus on the need for change in current management practices this has made room for new alternative management approaches. Traditional management systems have generally failed to include issues such as biodiversity, social-ecological systems, stakeholder participation or the use of incentives, all of which have been recognized as key components of the more holistic approach known as Ecosystem-Based Management (EBM).

What is Ecosystem-based Management?

Providing a definition for EBM is not a simple straightforward task, as the term holds many definitions. A typical definition of EBM acknowledges the complexity and interspecies relationship within ecological systems and has evolved into an approach that also accounts for social and governance objectives. This has allowed for a large spectrum of definitions ranging from those with a narrow set of objectives to those which are much broader. For example the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) have a narrow set of ecological objectives and describe the ecosystem approach as a management that:

"*takes into account all the delicate and complex relationships between organisms (of all sizes) and physical processes (such as currents and sea temperature) that constitute the Antarctic marine ecosystem*" (CCAMLR 2001).

While United Nations Convention on Biological Diversity focuses on ecological, social and governance objectives and describe the ecosystem approach as

"*a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way*". (UNCBD 2011)

The Communications Partnership for Science and the Sea's (COMPASS) developed a more in depth, inclusive definition of EBM for the oceans which is described as:

"*an integrated approach to management that considers the entire ecosystem, including humans. The goal of EBM is to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need. EBM differs from current approaches that usually focus on a single species, sector or activity or concern; it considers the cumulative impacts of different sectors*" (COMPASS 2005).

Despite the variety of EBM definitions, it should not be interpreted as a strategy that manages the ecosystems themselves, but rather one that manages the human activities that have an impact on ecosystems, and taking these effects into account when making management decisions (Gavaris 2009).

Multiple Perspectives of Ecosystem-based Management

EBM has gained the attention of ecologists over the last two decades. It has recently gained momentum in marine management initiatives (UNEP 2011) and increasing attention in the fisheries sector in classic works such as Sinclair and Valdimarsoon's (2003) *Responsible Fisheries in the Marine Ecosystem* and more recent literature such as Christensen and Maclean's (2011) *Ecosystem Approaches to Fisheries: A Global Perspective* and Link's (2010) *Ecosystem-Based Fisheries Management: Confronting Tradeoffs.* When EBM began to rise in popularity so did similar or synonymous terms such as the Ecosystem Approach and sector specific varieties such as Ecosystem to Approach to Fisheries (See Figure 1). Each of these terms has differing definitions and

underlying principles, and some provide frameworks for their implementation, yet none of these approaches currently dominate the field of natural resource management (Bianchi 2008). These terms have been defined by many academic, government and NGOs institutions in a variety of contexts including general, terrestrial, and marine applications as well as sector specific use such as in the forestry and fishing industry. The variations in the definitions of EBM, together with the versatility of the environments or sector in which it can be applied, leaves EBM without a universal application framework (Bianchi 2008). As a result EBM can be applied in many different forms with various combinations of principles. Depending on the EBM principles utilized, the degree to which each are applied, as well as the overarching objectives of the organization implementing EBM, will determine how it is applied (Morishita 2008) and the amount of emphasis placed on ecological, social, and governance factors (Bianchi 2008). For example while the FAO has developed an ecosystem approach to fisheries management that focuses on balancing ecological, governance and socio-economic factors (Bianchi 2008), this differs from some environmental organizations such as Greenpeace's Ecosystem Approach (Greenpeace 2007) or governmental approaches such as Canada's Department of Fisheries and Oceans Ecosystem Approach to Fisheries which solely focuses on ecological objectives (Fisheries and Oceans Canada 2010) (See Figure 2).

A Brief History of Ecosystem-Based Management Principles

Despite EBM's more recent popularity, the philosophies behind it are far from new and have been practiced by First Nations people for over ten thousand years (Coastal First Nations Turning Point Initiative 2009). Although not widely recognized, one of the first major initiatives to include overall ecosystem health in natural resource management

principles was in the 1970s (Forst 2009), during a set of workshops on the wildlife management attended by professionals across North America from a wide range of disciplines and organizations (Holt and Talbot 1978). A list of four management principles were developed at the workshop, entitled *New Principles for the Conservation of Wild Living Resources,* to my knowledge the term EBM had not yet been coined. These principles went on to gain international recognition in 1978 when they were utilized at the United Nations Conference on the Law of the Sea (UNCLOS) and therefore contributed to a major stepping stone in marine policy (Forst 2009). These principles focused on ecological objectives, as at this time "resource conservation was regarded primarily as a biological problem" (Mangel *et al.* 1996), nonetheless they provided the foundation for contemporary EBM approaches which also acknowledges social and governance objectives. In 1996 Mangel *et al.* decided it was time to update these principles and take into account some of these more contemporary management issues and applications that were arising. This revision consisted of a series of meetings with scientists and managers across the globe between 1992 and 1994 wrapping up with a final workshop to incorporate international perspectives on the seven management principles that were developed and later published as the *Principles for the Conservation of Wild Living Resources*. Although the principles described by both Holt and Talbot (1978) and Mangel *et al.* (1996) are not labelled as EBM, they both exhibit innovative EBM philosophies for their time, and mark the beginning of clear principles to describe this holistic management process.

Gaps between EBM Theory and Practice

Although the principles that make up EBM are not a new development, there is still a lot to be learned before EBM is widely implemented in marine systems. The overwhelming number of terms, definitions and principles that are synonymous with EBM, create a great deal of confusion and multiple perspectives of EBM and how it should be implemented according to the key players in marine management. This also makes it difficult to begin the EBM process and choose an application which is most appropriate for a given area or environment. The lack of a clear concise list of EBM principles does not provide the user with the tools to practically apply EBM or recognize when and where it is currently being implemented on the ground. This lack of consensus creates a gap between EBM theory and practice, impeding its successful application.

Objectives

With the goal of helping to clear up the confusion surrounding the definition of EBM, in this chapter a systematic analysis of contemporary EBM theoretical literature will be used to develop a list of the minimum 'Key Elements' required to successfully implement EBM. The evolution of EBM principles will be analyzed to identify which principles are no longer recognized as defining characteristics in more recent publications, as well as to predict which more contemporary principles exhibit potential of becoming Key Elements in the future. The historical principles put forth by Holt and Talbot (1978) and Mangel *et al.* (1996) will be used to look back at principles that were developed before the confusion surrounding the term EBM. Although these principles did not receive a lot of recognition they will provide a historical reference point and allow EBM principles that have been lost or left behind to be identified. The objective of this chapter is to provide a

clear and up to date list of the Key Elements of EBM derived from contemporary publications and provide implications for the future of EBM. It is hoped that this will provide a better link between theory and practice allowing EBM to be more readily applied in a marine environment.

METHODOLOGY:

The Key Elements of EBM

i) Selection of EBM literature

An extensive literature search of theoretical EBM publications was conducted. Literature was reviewed from a variety of academic, government and NGO sources covering a wide range of EBM applications; these included a general implementation, as well as applications in a terrestrial environment, a marine setting, and sector specific approaches such as fisheries, forestry and agriculture. A subset of these EBM sources published prior to spring of 2010 was selected for further analysis using selection criteria that consisted of two requirements. First and foremost each article must define EBM with a clear list of EBM principles. Second the articles must undertake a contemporary perspective of EBM that acknowledges the interconnections between the ecological, social and governance systems. Upon satisfying these criteria, each source was investigated to ensure that each publication and/or author was widely accepted as a leader in the field and/or with experience practically applying EBM. This was explored by researching the background of each author, looking at the number of articles published in the field, the frequency of citations received by the article as well as whether a successful case study was utilized. A set of thirteen publications was selected for further analysis, as they satisfied the selection criteria. The selected publications consisted of primary literature, technical

reports and guidelines from academia, government, international organizations, and NGO institutions. The selected articles varied in EBM application; including those geared towards general implementation, those focusing on terrestrial or marine environments, as well as sector specific approaches for the forestry and fishing industries, however no publications that fit these criteria were found in the agriculture sector. Organized by application type, the criteria satisfaction of each of the selected articles is discussed below.

a) General Application

The United Nations Convention on Biological Diversity developed 12 Principles of the Ecosystem Approach (Vierros 2008) which cater to a variety of disciplines around the world (Pirot *et al.* 2000) and are widely cited and utilized in EBM literature (Ruckelshaus *et al.* 2008). EBM Tools (2010) is an alliance made up of a long list of users, providers and researchers promoting the implementation of EBM in aquatic, marine and terrestrial environments. Their website and *Road Map of the Core Elements of EBM*, gives a theoretical perspective of EBM provided by those who practically apply it.

b) Terrestrial Applications

A few of the selected publications do not specify a medium of application and resemble general applications, yet have evidence of a focus in the terrestrial environment as the article was published or frequently cited in a terrestrial journal. For example Grumbine's (1994) list of EBM principles in *What is Ecosystem Management?* is widely accepted and has been cited in over 1130 journal articles. This publication was the most dated publication selected, evidence of a terrestrial focus include Grumbine's use of EBM

definitions from the forestry sector to determine his list of fundamental components. Christensen *et al.*'s (1996) list of principles in *Ecological Applications* has also been widely cited in over 870 related articles, again this article did not specify a medium of application yet during my literature review it dominated the definitions and applications of EBM in the terrestrial field (Kimmins 2002). Lackey's (1998) *Seven Pillars of Ecosystem Management*, has been cited in approximately 140 publications, despite his general focus this article is published in the journal of *Landscape and Urban Planning.* Natural Resources Canada's (Harris 2011) support and use of EBM in the forestry sector is expressed in *Implementing Ecosystem-based Management Approaches in Canada's Forests: A Science Policy Dialogue.*

c) Marine Applications

Similarly, there are multiple EBM publications that discuss EBM in a marine environment but do not specify that EBM is specifically designed for marine applications yet are published in marine journals or use marine-based case studies. Similar to Grumbine, Arkema *et al.* (2006) utilize EBM definitions from various publications to develop a list of EBM core elements, yet the publications that are used to formulate this list include EBM publications geared towards both terrestrial and marine applications. This article is widely used and has been cited in 75 publications. Boesch (2006) provides an analysis of the application of the key EBM principles in the restoration of Chesapeake Bay and Coastal Louisiana, and once again the principles are not specific to a marine environment. In Forst's (2009) contemporary themes of EBM were utilized and an analysis of the convergence of integrated coastal zone management implied a marine

focus in its analysis and in its study of the Great Barrier Reef Marine Park and Belize Marine Protected Area Program. His thorough and insightful description of EBM, along with his employment with the New Jersey Division of Fish and Wildlife has ensured his credibility. As a result of NOAA's (Murawski 2007) great contributions to ocean science and management their ecosystem approach has been selected for further analysis. McLeod and Leslie's (2009) book *Ecosystem-based Management for the Oceans* offers an excellent explanation of EBM in a marine setting, touching on theory, practical application and a variety of successful case studies. McLeod's involvement in Communication Partnership for Science and the Sea (COMPASS) which has contributed to EBM Tools (http://www.ebmtools.org/) and West Coast EBM Network (http://www.westcoastebm.org/Home.html) as well as Leslie's EBM research at Brown University are a few examples of their immense experience with EBM research and successful implementation. The United Nations Food and Agriculture Organization's Ecosystem Approach to Fisheries (Bianchi 2008) is widely used and respected around the world in the academic field as well as within NGOs. World Wildlife Fund's (WWF) publication *Policy proposals and operational guidance for ecosystem-based management of marine capture fisheries* (Ward *et al.* 2002) states their version of the defining elements of EBM in the fisheries sector which has been utilized in the academic evaluation of the global implementation of EBM in fisheries (Pitcher *et al.* 2009).

ii) Defining EBM principles

The EBM principles along with their respective definitions were extracted from each publication and compiled into a list. Similar to EBM, there are many different synonymous terms for each principle and various accepted definitions for each. To avoid

repetition or overlapping terms during the analysis, similar principles along with their definitions were grouped together. An appropriate 'EBM principle name' was assigned to each group of similar terms. Each 'EBM principle' was defined by consolidating the various definitions derived from each affiliated source to ensure that the allotted definition satisfied all the interpretations of the term. Twenty-six EBM principles along with their definitions were extracted from the selected publications. A master list of all the published EBM principles and definitions was then created (See Figure 3).

iii) Identification of the Key Elements of EBM

Due to the variation in the number of EBM principles and the detail with which they are described within each publication, the description of each EBM principle was carefully re-examined to ensure the occurrences of EBM principles were properly represented in each of the selected publications. The EBM principles were then organized into one of three categories according their overall objective whether it be ecological - to conserve the natural environment, social - to tend to the needs of humans that utilize it, or governance - the processes used to manage these environmental and social goals and benchmarks. An exception was the EBM principle of *Sustainability,* this satisfies all three category objectives and was put into a category of its own. The number of EBM principles that appeared in each of the selected publications was recorded. A frequency analysis was conducted to allow for a clear look at the variation of the overall frequency of EBM principles published within the selected articles. The EBM principles present in more than half the selected publications, were deemed as the Key Elements of EBM necessary for its successful application due to their support in the majority of the selected publications.

Evolution of EBM principles

i) Evolution of EBM principles within the selected publications

The selected publications were organized chronologically, displaying how the frequency of each EBM principle changed over time. The date of the first and last publication in which infrequent EBM principles, those that were not concluded as Key Elements, were documented to further investigate if these infrequent principles have become redundant or are potential future Key Elements. EBM principles that were present in earlier publications but absent from more recent publications, could indicate they are no longer associated with or used to define EBM. EBM principles that first appeared only in more recent publications, and potentially infrequent because they are newly associated with EBM, may indicate future Key Elements. The selected publications were then grouped according to their application types, or specific environment or sector for which they were developed. EBM principles that had a low overall frequency may have a high frequency within a single environment or sector and be of great importance to that particular application type.

ii) Contemporary EBM Principles vs. Historical Principles

The frequency of the EBM principles from the selected publications within the historical principles published by Holt and Talbot (1978) and Mangel *et al.* (1996) were recorded and the principles that were not present in the contemporary list of EBM principles were documented. The presence of EBM principles and Key Elements derived from the selected publications were contrasted with those present in the principles put forth in the publications by Holt and Talbot (1978) and Mangel *et al.* (1996).

RESULTS

The Key Elements of EBM

The Key Elements were highlighted according to their category, green, purple and blue representing ecological, social and governance-based elements respectively. *Sustainability* is a member of all three categories and highlighted in a beige colour. A bar graph was developed to visually express the frequency of each EBM Principle organized into ecological, social and governance categories (See Figure 4).

EBM principles present in 50% or more of the selected publications, having a frequency of 7 or greater, were considered to be the Key Elements of EBM and fundamental for its successful application due to their wide recognition in creditable and contemporary EBM publications. There was a natural break in the frequencies of the EBM principles, as there were no frequencies of 6 or 7. This made it very clear which EBM principles were widely accepted, and all principles considered as the Key Elements of EBM have a frequency of 8 and over, making a total of 15 Key Elements which are discussed below:

i) Ecological Key Elements

There are 4 fundamental Key Elements with an ecological focus, the two most frequently acknowledged were *Ecosystem Connections* and *Appropriate Spatial & Temporal Scales*, which are present in 11 of the 12 selected publications. The other two are *Dynamic Nature of Ecosystems* and maintenance of *Ecological Integrity & Biodiversity,* both have a frequency of 8.

ii) Social Key Elements

There are also 2 Key Elements in the social category, *Coupled Social-Ecological Systems* and *Decisions reflecting Societal Choice*, each have a frequency of 8.

iii) Governance Key Elements

The governance category is the largest of the 3, with 9 Key Elements. *Adaptive Management* with a frequency of 11, *Use of Scientific Knowledge* with a frequency of 10, and both *Stakeholder Involvement* and *Integrated Management* with a frequency of 9. The remaining 5 elements – *Distinct Boundaries, Interdisciplinary, Adaptive Management, Monitoring,* and *Acknowledge Uncertainty* - each have a frequency of 8.

iv) Sustainability

Sustainability is a category on its own as it corresponds with ecological, social and governance objectives and was present in 8 of the selected publications.

Evolution of EBM principles

i) Evolution of EBM principles within the selected publications

The Key Elements of EBM were for the most part present consistently across the selected EBM publications from 1994 – 2010, and all appeared in one of the selected publications by 2000 (See Table 1). Ten of the Key Elements were present in the earliest selected publication in 1994, Grumbine's *What is Ecosystem Management?: Ecosystem Connections, Appropriate Spatial & Temporal Scales, Coupled Social-Ecological systems, Decisions reflect Societal Choice, Adaptive Management, Use of Scientific Knowledge, Integrated Management, Distinct Boundaries, Monitoring, Acknowledge Uncertainty.* While *Sustainability* and *Stakeholder Involvement* were first seen in 1996 in Christensen's article published in Ecological Applications. The Key Elements *Ecological Integrity & Biodiversity* and *Interdisciplinary* first appeared in 1998 in Lackey's *Seven Pillars of Ecosystem Management* and 2000 in the UN CBD's Ecosystem Approach respectively.

There were three EBM principles that appeared predominantly in more recent publications, most of which were developed for marine application. *Cumulative Impacts* is only present in 3 of the selected articles all of which were published after 2007 (See Table 1), two of these publications have a marine focus and one is a general application (See Table 2). *Precautionary Approach* first appeared in the literature in 2001 (See Table 1) and all 4 publications that have included this principle have a marine-focus (See Table 2). Explicit *Trade Offs* was present in 3 of the selected publications after 2008 (See Table 1) covering general, marine and terrestrial applications (See Table 2).

While both *Ecosystem Resilience* and *Economic Context* have been evenly represented throughout the timeframe of the publications in all three application types, they only had a frequency of 5 and 4 respectively and were not concluded as Key Elements (See Table 2). *Long Term Objectives* and *Principles of Equity* were only present in 2 of the publications before 2000 and 2001 respectively (See Table 1), and *Use of Incentives* and *All forms of knowledge* were only acknowledged in a single publication in 2000 and 2001 respectively (See Table 1), none of these principles were concluded as Key Elements.

ii) Contemporary EBM Principles vs. Historical Principles

From Holt & Talbot's (1978) list of four principles there were nine Key Elements present: *Sustainability, Ecosystem Connections, Appropriate Spatial & Temporal Scales, Dynamic Nature of Ecosystems, Ecological Integrity & Biodiversity, Adaptive Management, Use of Scientific Knowledge, Monitoring* and *Acknowledge Uncertainty* (See Table 3). The EBM principles *Ecosystem Resilience, Economic context* and *Precautionary Approach* were also recognized along with two principles not found in the selected literature *Conservation of all Resources* and *Critical Public Review of Results*. There were 10 Key

Elements within Mangel *et al's (1996)* list of seven principles: *Sustainability, Ecosystem Connection, Dynamic Nature of Ecosystems, Ecological Integrity & Biodiversity, Coupled Social-Ecological systems, Decisions reflect Societal Choice, Use of Scientific Knowledge, Stakeholder Involvement, Interdisciplinary and Monitoring* (See Table 3). Mangel *et al. (1996)* also recognized 2 EBM principles *Use of all Forms of Knowledge* and *Economic Context* as well as an additional principle *Communication* which was not present in the selected publications.

DISCUSSION

The Key Elements of EBM

Each of the selected publications has a different way of expressing principles and each varies in the number of principles listed and the detail with which they are described. The components of EBM that were derived from the selected publications represent the components that the authors feel define or are the key themes of EBM. If an author did not include a principle in their list of defining features of EBM it does not mean the author is necessarily stating that this principle is unimportant in natural resource management but simply that it is not a defining characteristic of EBM at the point in time the article was written. None of the publications contained a complete list of the fifteen Key Elements concluded in this Chapter. Arkema *et al.*'s (2006) list of principles contained fourteen of the fifteen Key Elements, only missing the *Dynamic Nature of Ecosystems*. The completeness of Arkema *et al.*'s list with respect to the Key Elements, may be as a result of their methodology. Arkema *et al.* completed a frequency analysis of keywords used in the definition of EBM, but not specific to publications using EBM principles, published within eighteen peer reviewed academic journals. Their use of

keywords from a wide range of publications provided a solid foundation to develop their list of up-to-date principles. Boesch's (2006) list included all but two Key Elements: *Decisions reflect Societal Choice* and *Distinct Boundaries*. EBM Tools (2010) and UN CBD's Ecosystem Approach (2000) contained twelve of the fifteen Key Elements. EBM Tools (2010) did not include *Ecological Integrity & Biodiversity, Stakeholder Involvement* and *Acknowledge Uncertainty*, while the UN CBD's Ecosystem Approach was without the *Coupled Social-Ecological Systems, Distinct Boundaries* and *Monitoring.*

Evolution of EBM principles

It is clear that EBM is an evolving concept and the Key Elements developed in this Chapter represent a snapshot of EBM in time. As current management practices are analyzed and further research progresses, EBM will continue to evolve. Analyzing the change which EBM principles have already undergone helps pinpoint those EBM principles that are outdated or have been lost as well as which principles are up and coming and can be used to make predictions about the future direction of EBM.

i) Evolution of EBM principles within the selected publications

The dates of the selected publications ranged from 1994 – 2010, the insight and expertise within the field of EBM in this sixteen year period has therefore been used to develop this list of the fifteen Key Elements. These fifteen Key Elements were consistently seen over these sixteen years, indicating their strong presence in the definition of EBM throughout this time period. Since most of the Key Elements were present in one of the two earliest publications in 1994 and 1996, this indicates that there is a good chance these Key Elements were associated with EBM prior to 1994. Further, looking at how these principles have evolved over those sixteen years allows us to track when each principle

surfaced and if and when it is no longer used to define EBM, which will help to predict the direction EBM may take in the future.

Examining the lower frequency EBM principles that are present in the more recent selected publications indicate which principles are newer to the field of EBM and could potentially be considered as a Key Element of EBM in the future. For example *Cumulative Impacts* is only present in three of the selected articles all of which were published after 2007. Two of these publications have a marine focus and one is a general application (See Table 2). While it is too early to draw conclusions from this, it could potentially mean that *Cumulative Impacts* is more prominent or applicable in a marine environment. Similarly the *Precautionary Approach* first appeared in the literature in 2001 (See Table 1) and all four publications that have included this principle have a marine focus, which indicates that the implementation of the *Precautionary Approach* may be included as a Key Element mainly in marine applications in the future (See Table 2). Explicit *Trade-offs* was also present in three of the selected publications after 2008 covering general, marine and terrestrial applications indicating that *Trade-offs* may potentially be an important element of EBM in any application (See Table 1).

Both *Ecosystem Resilience* and *Economic Context* have been evenly represented throughout the timeframe of the publications in the three application types, yet only had a frequency of five and four respectively and were not concluded as Key Elements, indicating potential for their presence in future EBM publications. There are multiple EBM principles that had extremely low frequencies in the early selected literature that did not resurface in more recent publications and potentially have lost their association or place within EBM. For example the EBM principle *Long Term Objectives* and *Principles*

of Equity were only present in two of the publications before 2000 and 2001 respectively. Similarly *Use of Incentives* and *Use of all Forms of Knowledge* were only acknowledged in a single publication in 2000 and 2001 respectively. Each of these low frequency EBM principles was published in United Nation's Food and Agriculture Organization's Ecosystem Approach to Fisheries and/or United Nations Convention on Biological Diversity's Ecosystem Approach which are both widely accepted applications. One explanation for their exclusion from more recent selected publications is that these EBM principles may be intended for developing nations or small scale applications widely studied by the United Nations. It should also be recognized that although these EBM principles are not highly recognized in EBM theoretical literature, it does not mean they are not widely recognized as important in the scope of marine management.

Future Implications from Historical EBM Principles

A long list of professionals participated in the development of the principles in both the Holt and Talbot (1978) and Mangel *et al.* (1996) publications. These participants had affiliations with a wide range of academic, government and NGO organizations with a wide range of expertise in various disciplines and applications such as terrestrial, marine and sectors such as forestry and fisheries. Although both sets of principles were published decades ago, the expertise in both the field of EBM and the participation of individuals such as Brian J. Rothschild (Holt and Talbot 1978) who has made a great contribution to fisheries science and management throughout his long career, has the potential to offer great perspective to current EBM Key Elements and provide insights into the future of EBM.

Holt and Talbot's (1978) Principles vs. the Key Elements of EBM

From the four principles and their descriptions presented in Holt and Talbot (1978), it was clear that ecological objectives dominated management goals in this publication as none of the social EBM principles or Key Elements are present, although *Sustainability* is acknowledged. Their principles thoroughly covered the ecological EBM themes in contemporary literature with all of the ecological Key Elements present, and in addition they acknowledged the importance of *Ecosystem Resilience*. Holt and Talbot (1978) also offered some very insightful governance principles, presenting four of the seven Key Elements along with *Economic Context* and the *Precautionary Approach*. The inclusion of the *Precautionary Approach* at this time was very innovative and insightful. Holt and Talbot (1978) also put forth two interesting principles that are very relevant to current management problems that were not present in the contemporary list of EBM principles from the selected literature. One falls in the ecological category, the *Conservation of all Resources* which touched upon the importance of not wasting resources, such as bycatch, capital, labour and fuel, while trying to extract the commercial/desired resource. This issue is particularly relevant to the fishing industry where large-scale fisheries are dominating and overtaking small scale fishing operations despite the fact that large-scale fisheries tend to decrease the number of fishers employed and increase fuel consumption (Pauly 2006). The re-examination of this principle within the field of EBM or particularly in the sector specific approaches in the fishing industry may help EBM tailor to specific fishery management issues. Holt and Talbot also touched upon the importance of *Critical Public Review of Results* which highlights the importance of accountability in natural resource management. Open lines of communication and transparency regarding

management actions and initiatives are currently recognized as crucial for achieving sustainable fisheries management (Shelton and Sinclair 2008; Stringer *et al.* 2009). Although *Critical Public Review of Results* is categorized as a governance objective it provides the medium for the public to be aware of management actions and is a stepping stone to further explore social objectives. The re-evaluation of this principle as part of EBM may be worthwhile as it could serve as a solution to many current management problems, such as the misunderstanding and lack of trust, between the different players with conflicting interests involved in the management process.

Mangel *et al.* (1996) Principles vs. the Key Elements of EBM

Mangel *et al.* (1996) included seven principles to update those published by Holt and Talbot (1978) and include social objectives to acknowledge contemporary management issues. It is evident that including social factors was a primary objective in revising Holt and Talbot's principles, both the social Key Elements were present along with the use of *All forms of knowledge* in management. This emphasis on social objectives shifted the focus and some of the ecological and governance principles that were supported by Holt and Talbot were not present. Although Mangel *et al.* (1996) did include three of the four ecological Key Elements, they failed to mention the importance of *Appropriate Spatial & Temporal Scale* or focus on the principle of *Ecosystem Resilience*. With respect to the contemporary Key Elements of EBM, along with Holt and Talbot (1978), Mangel *et al.* (1996) are lacking in governance objectives. Although both recognized the importance of Use of *Scientific Knowledge* and *Monitoring*, Mangel *et al.* (1996) did not continue to include important Key Elements such as *Adaptive Management* and *Acknowledge Uncertainty* as well as potential future EBM Key Elements important to marine

applications such as *Precautionary Approach.* Yet Mangel *et al.* (1996) did advance towards a contemporary approach by acknowledging that EBM management practices should have an *Interdisciplinary* focus, and introduced the principle of *Communication* which much like Holt and Talbot's *Critical Public Review of Results* will help to enhance transparency between management parties which has been greatly supported in the literature. By comparing the Key Elements to those put forth by Holt and Talbot (1978) and Mangel *et al.* (1996) it confirms that EBM has been constantly evolving, these principles have provided a benchmark to assess how far EBM has come as well as a reference point to look back on and ensure that key concepts have not been lost.

CONCLUSION

The concept of EBM has been a hot topic of discussion in the management field for decades, yet the lack of consensus on what defines EBM, impedes the application process. The constant reinvention of EBM and its replacement with similar and synonymous terms has not advanced EBM, its implementation or provided solutions to some of the major challenges associated with its application in a marine setting. This Chapter attempted to break that cycle by developing a clear concise list of the Key Elements necessary for the successful application of EBM.

While tracking the changes in EBM principles over time has shown that EBM is an ever evolving concept, this should not be used as an excuse to delay its application or its potential will be foregone. This list of the Key Elements of EBM can now be readily incorporated into existing EBM frameworks, such as Fletcher *et al.*'s (2010) Ecosystem-based Fisheries Management Process, where specific objectives for each Key Element

can be developed and tailored to the needs of a given area or community. It is hoped that this Chapter will also spark future research initiatives in the field of EBM to further investigate potential emerging principles such as *Cumulative Impacts* and the *Precautionary Approach* and their ability to contribute to EBM and its successful application in the world`s oceans.

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Figure 1. The various terms synonymous to EBM and their corresponding definitions derived from Short *et al.* (2008).

Ecosystem-based management-- management of the uses and values of ecosystems in conjunction with *stakeholders* to ensure *ecological integrity* is maintained, and recognizing that ecosystems are dynamic and inherently uncertain (Ward et al 2002)

Ecosystem management-- a synonym for EBM; often interpreted incorrectly to imply management of ecosystems, but more correctly interpreted to mean management of human activities that affect ecosystems, often detrimentally (Ward et al 2002)

Ecosystem-based fisheries management--a new direction for fishery management, essentially reversing the order of management priorities to start with the ecosystem rather than the target species (Pikitch et al 2004)

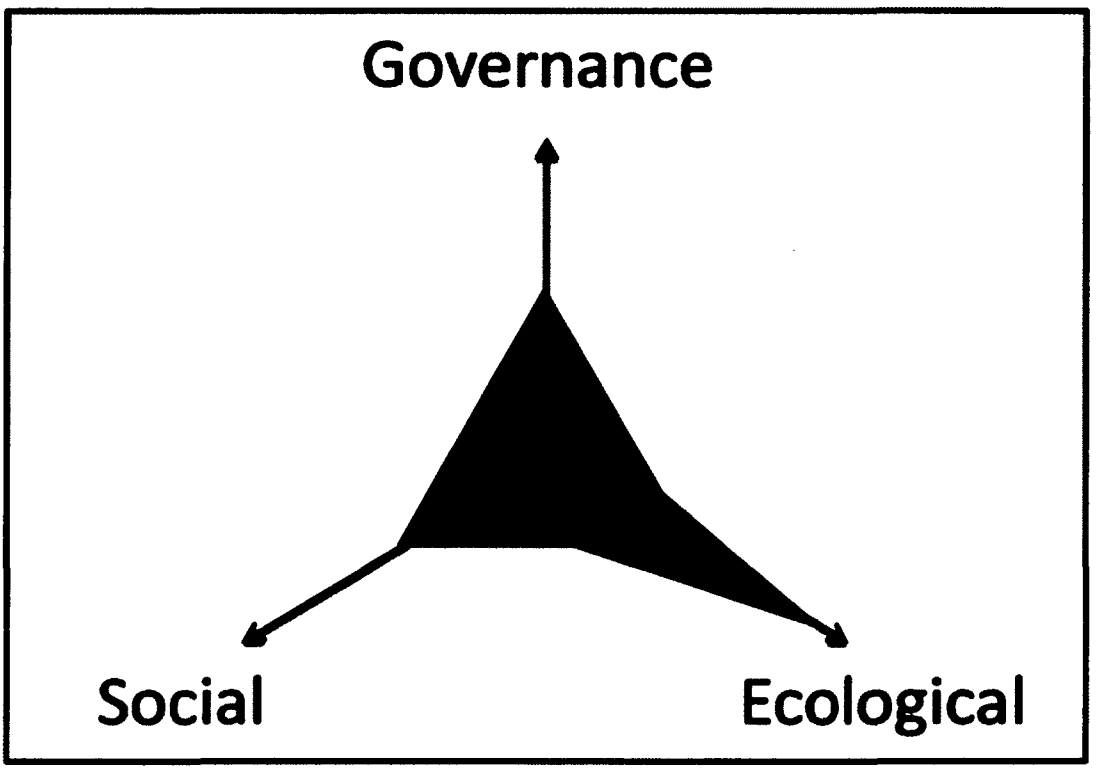
Ecosystem approach to management--an *ecosystem* is a *geographically specified* system of organisms (including humans), the environment and the processes that control its dynamics. Characteristics of EAM are: adaptive; incremental; takes account of ecosystem knowledge and uncertainties; considers multiple external influences; strives to balance diverse social objectives and geographically specified (NOAA working definition in Murawski 2005)

Ecosystem approach to fisheries- -strives to balance diverse societal objectives, by taking into account of the knowledge and uncertainties of biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries (FAO 2002)

Marine ecosystem-based management-- EBM is an integrated approach to management that considers the entire ecosystem, *including humans*. The goal of EBM is to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need. EBM differs from current approaches that usually focus on a single species, sector and activity or concern; it considers the cumulative impacts of different sectors. (Compass Consensus Statement, 2005. http://www.compassonline.org/pdf_files/EBM_ Consensus_ Statement_v12.pdf)

(Short *et al.*2008)

Figure 2. Simplified representation of different emphasis given by various Ecosystem-based Management approaches along the three main dimensions of a fishery system



EAF defined by UN FAO

EBM defined by environmental NGOs

Adapted from (Bianchi 2008)

Figure 3. A consolidated list of all the key elements and their respective definitions extracted from the selected EBM theory publications utilized in the frequency analysis to determine the fundamental components of EBM.

Ecosystem Connections: ensure that the structure of ecosystems and the interrelationships between species and their environment are maintained.

Appropriate Temporal Scales: ensure that the time and length of the fishing season is appropriate for the given ecosystem.

Dynamic Nature of Ecosystems: acknowledge that ecosystems are not static but constantly changing.

Ecological Integrity & Biodiversity: ensure that ecosystem health is maintained by preserving the number and variety of species within it.

Ecosystem Resilience: acknowledge how well and to what extent the ecosystem can withstand disturbances and still maintain its natural structure and function.

Effects on Adjacent Ecosystems: consider the effects of fishing on neighbouring ecosystems.

Sustainability: find a balance between conservation and use to ensure the needs of future generations.

Coupled Social-ecological systems: acknowledge the linkages between humans and their environment, treating humans as a part of the ecosystem.

Decisions reflect Societal Choice: ensure that decisions are made according to community values.

Principles of Equity: balance social objectives and rights between various sectors of society.

Use all Forms of Knowledge: consider all forms of knowledge relevant information, including scientific, indigenous and local knowledge.

Adaptive Management: revise decisions/policies as the ecosystems changes and/or when new information or scientific knowledge becomes available.

Stakeholder Involvement: allow stakeholders to actively contribute to the decision making process.

Integrated Management: collaboratively make decisions with coexisting sectors/ ecosystem services.

Use of Scientific Knowledge: make decisions based on scientific evidence.

Distinct Boundaries: have distinct geographic boundaries defined using ecological factors and not be constrained by political boundaries.

Interdisciplinary: acknowledge ecological, economic and social needs when making decisions.

Monitoring: monitor biological and physical factors to track management progress.

Uncertainty: acknowledge that ecosystems are complex and will never be fully understood.

Economic Context: consider Economic factors when making management decisions.

Precautionary Approach: use precautionary measures to account for the lack of full understanding of ecosystems and unforeseen environmental changes.

Cumulative Impacts: acknowledge the overall impacts of all the ecosystem services/ sectors in a given ecosystem.

Organizational Change: make structural changes to incorporate the elements of EBM.

Trade-offs: explicitly acknowledge compromises when making management decisions.

Long Term Objectives: not focus on short term gains but on future benefits.

Use of incentives: provide incentives in order to encourage sustainable resource use.

Figure 4: A Frequency Analysis of the EBM principles (from selected publications with various applications) to isolate the Key Elements of EBM that are mandatory for successful application. The Key Elements are shaded and organized according to ecological (green), social (purple) and governance (blue) foci, with *Sustainability* falling into all three categories (beige).

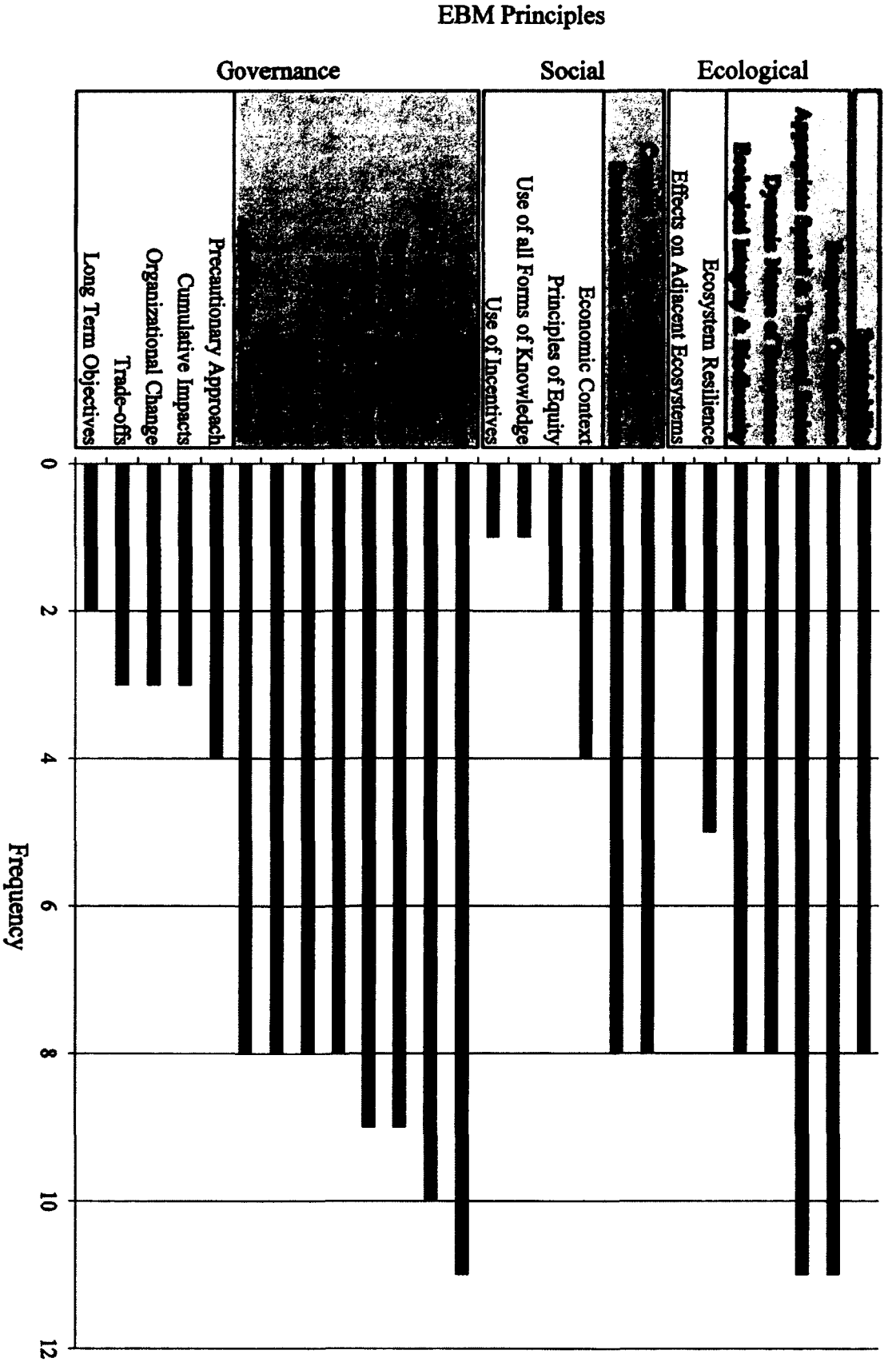

EBM Principles
Governance
Social
Ecological
Long Term Objectives
Trade-offs
Organizational Change
Cumulative Impacts
Precautionary Approach
Use of Incentives
Use of all Forms of Knowledge
Principles of Equity
Economic Context
Effects on Adjacent Ecosystems
Ecosystem Resilience
Frequency
0
2
4
6
8
10
12

Table 1: A Frequency Analysis of EBM Principles extracted from the selected literature to track their evolution over time. The Key Elements are shaded and organized according to ecological (green), social (purple) and governance (blue) foci, with *Sustainability* falling into all three categories (beige).

Publication: / EBM Principles / Year:	Grumbine 1994	Christensen 1996	Lackey 1998	CBD 2000	FAO 2001	WWF 2002	Arkema 2006	Boesch 2006	NOAA 2007	NRC 2008	Forst 2009	McLeod 2009	EBM Tools 2010	Total
[redacted]														8
Ecosystem Connections	1	1	1	1	1	1	1	1	1			1	1	11
Appropriate Spatial & Temporal Scales	1	1		1	1		1	1	1	1	1	1	1	11
Dynamic Nature of Ecosystems		1	1	1	1	1		1	1				1	8
Ecological Integrity & Biodiversity			1	1	1	1	1	1	1		1			8
Ecosystem Resilience		1	1	1				1				1		5
Effects on Adjacent Ecosystems				1					1					2
Coupled Social-Ecological systems	1	1	1				1	1		1		1	1	8
Decisions reflect Societal Choice	1		1	1		1	1		1			1	1	8
Economic content				1			1			1			1	4
Principles of Equity				1	1									2
All Forms of Knowledge				1										1
Use of Incentives					1									1
Adaptive Management	1	1		1	1	1	1	1	1		1	1	1	11
Use of Scientific Knowledge	1	1	1	1	1	1	1	1			1		1	10
Stakeholder Involvement		1		1	1	1	1	1	1	1	1			9
Integrated Management	1			1	1		1	1	1	1		1	1	9
Distinct Boundaries	1		1				1		1	1	1	1	1	8
Interdisciplinary				1			1	1	1	1	1	1	1	8
Monitoring	1	1				1	1	1			1	1	1	8
Acknowledge Uncertainty	1	1		1	1		1	1	1		1			8
Precautionary Approach					1		1	1			1			4
Cumulative Impacts									1			1	1	3
Organizational Change	1							1		1				3
Trade-offs										1		1	1	3
Long Term Objectives		1		1										2
Total Number of EBM Principles	11	12	9	18	13	8	16	16	13	9	10	13	15	

Table 2: A Frequency Analysis of the EBM Principles within the different environmental or sector specializations derived from the selected publications. The Key Elements are shaded and organized according to ecological (green), social (purple) and governance (blue) foci, with *Sustainability* falling into all three categories (beige).

Application Type: / Sector Specific Application Type:	General		Terrestrial				Marine							
						Forestry						Fisheries		
Publication: / EBM Principles Year:	CBD 2000	EBM Tools 2010	Grumbine 1994	Christensen 1996	Lackey 1998	NRC 2008	Arkema 2006	Boesch 2006	Forst 2009	NOAA 2007	McLeod 2009	FAO 2001	WWF 2002	Total
Ecosystem Connections	1	1	1	1	1		1	1		1	1	1	1	11
Appropriate Spatial & Temporal Scales	1	1	1	1		1	1	1	1	1	1	1		11
Dynamic Nature of Ecosystems	1	1		1	1			1		1		1	1	8
Ecological Integrity & Biodiversity	1				1		1	1	1	1		1	1	8
Ecosystem Resilience	1			1	1			1			1			5
Effects on Adjacent Ecosystems	1									1				2
Coupled Social-Ecological systems		1	1	1	1	1	1	1			1			8
Decisions reflect Societal Choice	1	1	1		1		1			1	1		1	8
Economic context	1	1				1	1							4
Principles of Equity	1											1		2
All Forms of Knowledge	1													1
Use of Incentives												1		1
Adaptive Management	1	1	1	1			1	1	1	1	1	1	1	11
Use of Scientific Knowledge	1	1	1	1	1		1	1	1			1	1	10
Stakeholder Involvement	1			1		1	1	1	1	1		1	1	9
Integrated Management	1	1	1			1	1	1		1	1	1		9
Distinct Boundaries		1	1		1	1	1		1	1	1			6
Interdisciplinary	1	1				1	1	1	1	1	1			8
Monitoring		1	1	1			1	1	1		1		1	8
Acknowledge Uncertainty	1		1	1			1	1	1	1		1		8
Precautionary Approach							1	1	1			1		4
Cumulative Impacts		1								1	1			3
Organizational Change			1			1		1						3
Trade-offs		1				1					1			3
Long Term Objectives	1			1										2
Total Number of EBM Principles	18	15	11	12	9	9	16	16	10	13	13	13	8	

Table 3: A Frequency Analysis of EBM Principles extracted from the Historical Principles in Holt and Talbot (1978) and Mangel *et al.* (1996) to track the evolution of the Key Elements of EBM over time. The Key Elements are shaded and organized according to ecological (green), social (purple) and governance (blue) foci, with *Sustainability* falling into all three categories (beige) and the red text identifies EBM principles exclusive to historical literature.

Publication: / EBM Principles — Year:	Holt & Talbot 1978	Mangel *et al.* 1996
Ecosystem Connections	1	1
Appropriate Spatial & Temporal Scales	1	
Dynamic Nature of Ecosystems	1	1
Ecological Integrity & Biodiversity	1	1
Ecosystem Resilience	1	
Effects on Adjacent Ecosystems		
Conservation of all resources	1	
Coupled Social-Ecological systems		1
Decisions reflect Societal Choice		1
Economic context	1	1
Principles of Equity		
All Forms of Knowledge		1
Use of Incentives		
Adaptive Management	1	
Use of Scientific Knowledge	1	1
Stakeholder Involvement		1
Integrated Management		
Distinct Boundaries		
Interdisciplinary		1
Monitoring	1	1
Acknowledge Uncertainty	1	
Precautionary Approach	1	
Cumulative Impacts		
Organizational Change		
Trade-offs		
Long Term Objectives		
Communication		1
Critical Public Review of Results	1	
Total Number of EBM Principles	14	13

Chapter 2: The Key Elements of Ecosystem-based Management: Theory vs. Industry Priorities in three Fisheries in the Bay of Fundy, Canada.

INTRODUCTION

In recent years the productivity of marine systems and overall ecosystem health of the world's oceans have become global concerns (FAO 2008). According to the United Nations Food and Agricultural Organization's (FAO) most recent report on the State of the World Fisheries (FAO 2010), the catch from global fisheries and aquaculture reached a high of 145 million tonnes in 2009. High exploitation rates have left 32% of global fish stocks overharvested and 53% fully exploited and therefore marine ecosystems have reached a level where they will not be able to support a further increase in fishing pressures (FAO 2010). Traditional management systems have failed to protect marine ecosystems from human pressures such as overexploitation (Crain *et al.* 2009) and fish stock collapses, which indicates that there is a need for change in current fishery management systems (Pikitch *et al.* 2004). Traditional management systems have historically been geared towards maximum sustainable yields, focusing on a single fish stock and its ability to regenerate from year to year (Garcia and Cochrane 2009). This system fails to recognise the important interspecies relationships within an ecosystem, as well as the intricate connections between social and ecological systems (Ward *et al.* 2002). The importance of these factors when making fishery management decisions, along with the emerging societal interest in conservation, has led to the evolution and the slow growing acceptance of alternative management practices such as Ecosystem-Based Management (EBM).

Ecosystem-based Management

Over the last two decades EBM has been a hot topic in the field of natural resource management in terrestrial, marine and sector specific applications such as fisheries. EBM offers a more holistic alternative to traditional approaches, acknowledging objectives in each of the three aspects of fishery management: ecological, social and governance (Bianchi 2008). The popularity and promise of EBM have resulted in much discussion surrounding EBM theory and has led to the development of many different definitions associated with the term (Grumbine 1994). Although EBM means many different things to different people, a typical inclusive definition describes EBM as:

"*an integrated approach to management that considers the entire ecosystem, including humans. The goal of EBM is to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need*" (COMPASS 2005)

Despite the various definitions of EBM, there are many publications that fail to clearly define EBM or provide a list of the components that make up this holistic approach (Morishita 2008). This lack of clarity surrounding EBM has created multiple perspectives on the term and confusion amongst management players, which has impeded its application. To overcome these obstacles in Chapter 1 I identified a list of 15 of the Key Elements of EBM mandatory for successful implementation. This list was developed using a frequency analysis of EBM principles from selected credible sources. These Key Elements consist of: *Sustainability, Ecosystem Connections, Appropriate Spatial & Temporal Scales, Dynamic Nature of Ecosystems, Ecological Integrity & Biodiversity, Coupled Social-Ecological systems, Decisions reflect Societal Choice, Adaptive Management, Integrated Management, Stakeholder Involvement, Use of*

Scientific Knowledge, Distinct Boundaries, Interdisciplinary and Monitoring (See Figure 1).

EBM and Canadian Fisheries

Policy and Legislation

Canada has put a great deal of effort into the development of national policy and legislation as well as signing on to international agreements that support a number of the Key Elements listed above, creating a platform to allow the implementation of EBM in Canada. For example on the international front Canada was the first developed country to sign onto the UN Convention on Biological Diversity in 1992 (United Nations 1992). A few years later, in 1995 Canada signed onto the UN Fish Stock Agreement which is legally binding and commits to the conservation and sustainable harvest of migratory species (United Nations 1995). Also in 1995 Canada supported the UN Code of Conduct for Responsible Fisheries which is a non-binding commitment that advocates sustainable fisheries while protecting the environment (FAO 1995). National legislation such as the Fisheries Act, expresses Canada's efforts in fisheries regulation and habitat conservation (Government of Canada 1985). Also the Canadian Environmental Assessment Act was developed in 1992 to preserve the quality of our national soil and waters (Government of Canada 1992). These two prominent acts coupled with the Species at Risk Act in 2003 (Government of Canada 2002), advocate sustainable marine systems and allow the government to regulate human services to protect wildlife against extinction. The Ocean Act (Government of Canada. 1996) in 1996 further advanced marine management and embraces the principles of EBM by further supporting sustainable development and management strategies such as the precautionary approach and integrated management

(Fisheries and Oceans Canada 2002). The Ocean Strategy in 2002 created momentum on the ground and put the Ocean Act into action as well as encouraging stakeholder participation through a bottom up management approach (Fisheries and Oceans Canada 2002).

DFO's Ecosystem Approach to Management

Although Canada is considered to be one of the leading advocates of EBM in fisheries (Pitcher *et al.* 2009) it still has to make great strides before Canadian fisheries are managed under an inclusive EBM framework, the current approach merely acknowledges ecological objectives. Canadian marine fisheries are under federal jurisdiction and managed by the Department of Fisheries and Oceans (DFO), with the Minister of Fisheries and Oceans having ultimate decision-making power (Government of Canada 1985). DFO Science in the Maritimes Region has embraced an EBM framework that acknowledges ecological objectives which address productivity, biodiversity and habitat of a given fishery as well as the cumulative impacts of overlapping fisheries in a given area (Fisheries and Oceans Canada 2010). However this framework does not include social and governance objectives which fall under the jurisdiction of DFO management. This has created a considerable gap between science and management which does not allow for effective trade-offs to be made with respect to overall ecological, social and governance objectives, therefore Canada has yet to embrace EBM in its contemporary form. Canada's first and best known example of EBM in a marine environment is the pilot project known as the Eastern Scotian Shelf Integrated Management (ESSIM) area that was established in 1998 (O'Boyle and Worcester 2009). Although ESSIM is labelled as in integrated management initiative, its objective was to explore both EBM and

integrated management requirements and was selected as a practical example of EBM in McLeod and Leslie's book *EBM for the Oceans* (O'Boyle and Worcester 2009). ESSIM covers a large marine region stretching from12 nautical miles off the coast of Nova Scotia to the 200 nautical mile limit, known as the Exclusive Economic Zone. This project is therefore a large scale, offshore initiative, and does not have the proximity and physical connection with coastal communities that are present in most of the fisheries in the maritime region. ESSIM has a Pacific counterpart known as the Pacific North Coast Integrated Management Area (PNCIMA). PNCIMA, like ESSIM is a large ocean management area, that began the planning phase in 2009 with plans to reach full implementation by early 2013 (PNCIMA Initiative 2012). While, through these initiatives Canada is currently implementing a couple of EBM pilot projects, to move closer to a more inclusive EBM framework more research needs to be done surrounding EBM at a smaller scale to better recognize local perspectives on management issues (Charles 2009).

Gaps between EBM Theory and Practice

Despite the extensive research that has been conducted surrounding EBM theory along with Canada's efforts to embrace it through DFO's EBM framework and pilot projects in large ocean management areas, improvement is needed in order to advance to a more inclusive, widespread application of EBM in Canadian fisheries. In order to broaden Canada's current EBM framework to include a wider range of social and governance objectives, there needs to be a better understanding of how EBM functions at smaller scale, investigating its ability to recognize local issues and gain stakeholder support which is a vital component of successful management initiatives (Mackinson *et al.* 2011). Greater knowledge of EBM at the ground level will help to close the gap between EBM

theory and practice, encouraging EBM to be implemented more readily throughout the fishery sector in Canada.

Objectives

The goal of this chapter is to provide insight into how EBM can be more readily applied within the Canadian fishing industry. The results of face-to-face surveys conducted with local fishermen are used to identify fishermen's priorities among EBM principles and to analyse the importance of each. Fishermen's priorities are compared and contrasted with those published in theoretical literature to identify gaps between theory and practice. Management issues identified by the fishermen are analyzed, to contextualize their priorities, to identify the major problems that are driving the issues, and to understand how EBM principles can be used to address them. Canada's Bay of Fundy region was chosen as the case study area and fishermen were interviewed from the soft shell clam, Atlantic lobster and groundfish fisheries in both Southwest Nova Scotia and Southwest New Brunswick.

METHODOLOGY

Fisheries in the Bay of Fundy

The Bay of Fundy is a large body of water on the east coast of Canada, bounded by New Brunswick and Nova Scotia. It is known for its extreme tides which drive high levels of productivity in the Bay and in turn provide a feeding ground for many marine species (Percy 1996). The Bay has 1300 km (Percy 1996) of coastline, houses 65 communities on its shores (Bull *et al.* 2000) and is of great ecological, economical and cultural importance (Graham *et al.* 2002). The Bay of Fundy communities depend heavily on fisheries for their livelihood, and with a long history of fishing have a strong connection

with their local environment, making the Bay of Fundy an ideal area to study local fishery management practices. Many of the fishermen in this area partake in multiple fisheries, optimizing the number of fishing days and allowing for a viable income. The decline or closure of many traditional inshore fisheries such as herring, groundfish and Atlantic salmon has forced communities to be greatly dependent on the lobster fishery and has created a niche or need for new industries such as aquaculture. Given the large number of communities that are situated along the coastlines of the Bay of Fundy, southwest New Brunswick and southwest Nova Scotia were selected as study sites to narrow the scope of the research along. The geographic area of study within southwest Nova Scotia and southwest New Brunswick was determined by the communities which the local fishing organizations represent. The study site in southwest Nova Scotia includes Digby, Annapolis, Kings, Haunts, Colchester and Cumberland counties while in southwest New Brunswick it stretches from St. Martins to St. Stephen, including Deer Island, Grand Manan and Campobello Island. These two study sites are both situated at the mouth of the Bay of Fundy and contain overlapping fisheries. This allowed for three fisheries to be investigated, across two provinces, in order to gain a wide range of perspectives to determine if local fishermen have similar priorities within EBM principles. Further variability was provided by choosing three very diverse fisheries for study, the soft shell clam, lobster and groundfish fisheries differ ecologically, in their harvesting methods and management structure, as well as the status of each fishery (abundance and economic importance) within Canada (See Table 1).

Participant Criteria and Selection

Local fishing organizations across the Maritimes provide a voice for fishermen and participate in the fishery management process. Both clam harvesters and lobster fishermen are not required to buy a membership with a local fishing organization, yet it is mandatory in the groundfish fishery due to the allocation of community quotas to these local organizations. Many lobster fishermen also hold groundfish licences, as these fisheries have opposite seasons, to maximize annual days of fishing and income. The local fishing organizations represent multiple fisheries such as the lobster and groundfish fishery, to accommodate fishermen with multiple licences. The local fishing organizations that represent the soft clam, lobster and groundfish fisheries in Southwest Nova Scotia and Southwest New Brunswick are listed in the table below. There is one organization for the Soft Shell Clam fishery in each Province and two organizations representing both the lobster and groundfish fisheries in each Province (See Table 2).

The local fishing organizations listed in Table 2, as well as Eastern Charlotte Waterways Inc in New Brunswick (a local environmental agency that is active in the management of soft shell clams), were asked to recommend fishermen who were knowledgeable and/or active in local management, who would be willing to participate in a face-to-face survey. Each fisherman was asked to discuss the management of one of the selected fisheries, regardless of whether they participate in multiple fisheries selected for the study. This focused the responses on a single fishery and allowed for a more in depth interview. Although selecting fishermen participants through organizations may have created a bias by not representing all local fishermen, this ensured that the selected individuals were knowledgeable or active in the local management of the fishery at hand, and were willing

and able to answer questions regarding how ecological, social and governance factors influence decision making. Also choosing to do individual surveys rather than group discussions means that the conclusions drawn from this chapter represent individual opinions and are not necessarily representative of all fishermen in these local areas or the fishing industry.

Apart from the diversity of perspective provided by studying of three different fisheries in two provinces the interviews provided a further broadening of perspective. Fishermen were interviewed from six different fishing organizations covering a variety of communities within the areas each organization represents. Participants were also from various age groups and with varying length of time in the fishing industry.

Face-to-Face Survey Development

A face-to-face survey was used as the method of obtaining information from fishermen regarding their perspective on EBM application and priorities among EBM principles proposed in the literature. The face-to-face survey had two distinct parts and was conducted in a time frame of approximately one hour (See Appendix C). In Part One EBM was not mentioned to the fishermen to avoid either negative or positive associations with the term that could potentially influence their responses and in turn skew the data. The fishermen representatives were asked two questions for each of the EBM Key Elements concluded in Chapter 1: first, how each Key Element is currently implemented in their area, and second what are their personal recommendations or ideas on how each element can be better represented. This provided a platform for the fishermen to naturally discuss their thoughts on each Key Element with respect to their fishery and express strong feelings and issues surrounding the implementation of each Key Element. In

order to remain within the allotted timeframe the fishermen were not questioned regarding the Key Element *Distinct Boundaries,* as strict fishing areas are designated by DFO and this information is are available online. The Key Element *Appropriate Spatial & Temporal Scales* was broken into two distinct questions to gain valuable information on the appropriateness of both spatial and temporal management scales at the local level. These responses were then further explored to get a sense of what aspects of fisheries management are impeding the application of each Key Element and in turn affecting EBM application as a whole.

In Part Two of the face-to-face survey each fisherman was asked to rank the importance of each of the EBM principles using a score from 0-4, ranging from not important to extremely important respectively. Each principle was described one at a time, without mentioning the name of the EBM principle, and the participants did not have the opportunity to read the list as a whole – this therefore provided an evaluation of the importance of each principle on a standalone basis. After each EBM principle was ranked, a list of all the EBM principles and their definitions was handed to the participant and they were asked to identify five EBM principles that they felt were the most important. The ranking for each EBM principle from the previous question was not given back to the fisherman. This step provided information on the importance of each element with respect to one another.

Before conducting face-to-face surveys with the selected fishermen participants, a test survey was conducted with a fisherman from outside the study area. After he responded to each question, the vocabulary used and content of each question along with the overall

intended delivery was discussed to ensure that the information was effectively relayed in a clear and concise manner.

Ethics approval was received from the Saint Mary's University ethics board prior to commencing the interview process and all fishermen participants completed a consent form. Upon conducting the first couple face-to-face surveys some changes or adjustments to the original questions were made and the survey in Appendix C has been updated. These changes included the removal of the likert scale in Part one of the survey that measured the degree in which management acknowledges each Key Element when making decisions. This question was removed because it was difficult for the participants to rate management as a whole and responses would not distinguish between the different scales of management. In the first few interviews there were a few instances when a term was not understood when participants were asked to rate the overall importance of each EBM principle in question 16. This term was then skipped over and its definition was adjusted for a more clear delivery of its meaning in upcoming interviews and this was acknowledged in the analysis. In question 18 participants were finding it difficult to select their top 5 EBM principles and as a result participants were then ask to select the 5 EBM principles they felt were the most important and not asked to put them in order of importance. Due to time constraints when conducting a face-to-face survey with a clam harvester in Nova Scotia , eight questions in Part One were not answered in order to have time to complete the quantitative questions in Part Two.

RESULTS/DISCUSSSION

Face-to-Face Survey

A total of twenty-three fishermen participated in the face-to-face surveys (See Figure 2). The survey results were used to draw conclusions on which of the EBM principles are priorities according to the fishermen, followed by a comparative frequency analysis of these priorities with those found in theoretical literature. The fishermen's priorities were then contextualized by drawing connections between these priorities and the management issues raised by the fishermen.

i) Fishermen's Priorities within EBM Principles

The mean rank of importance, on a scale of 0-4 (ranging from not important to extremely important), for each EBM principle was calculated and the standard deviation was used to measure the variance of each mean. Figure 3 indicates the individual importance of each EBM principle according to the fishermen participants. In Figure 3, there are no overarching trends with all average ranks of importance lying between 2.5 and 4. The lowest average rank of importance was between 2.5 and 3, which is between medium and high importance. This indicates that the fishermen felt that all of the EBM principles were of relative importance, or they were not willing to state that any of the EBM principles were unimportant.

The frequency with which the fishermen selected each EBM principle as one of the five most important principles is displayed in a stacked bar graph (See Figure 4). It is clear which EBM principles are priorities amongst the fishermen participants, and if certain EBM principles resonate more within a given fishery. Figure 4 shows that there is a clear division of the EBM principles into those which are selected with a high frequency and

those selected with a low frequency. In descending order of frequency, which is presented in parentheses, *Sustainability* (19), *Long Term Objective* (17), *Stakeholder Involvement* (11) and *Use of all Forms of Knowledge* (9) were the four EBM principles selected with particularly high frequencies. These are therefore concluded as the priorities of fishermen within the theoretical list of EBM principles. These priorities are supported by a fairly even distribution of representation across all 3 fisheries - the slightly greater weight from the lobster fishermen is due to a higher proportion of lobster fishermen being interviewed. The priorities *Sustainability* and *Stakeholder Involvement* were supported by the literature and were concluded as Key Elements of EBM in Chapter One, while *Long Term Objectives* and *Use of all Forms of Knowledge* were present in some of the selected EBM literature but not with high enough frequencies to be selected as Key Elements. *Sustainability*, much like EBM, has become a buzz word in the field of natural resource management not only with academics and government officials but is frequently used in popular media and is widely recognized as an important concept. Although the definitions of each term was provided for the fishermen, the fishermen would have instantly recognized and would have been able to relate to the term *Sustainability* over some of the other EBM principles, which may have enticed them to select it as a priority.

ii) Theory vs. Industry Priorities among EBM Principles

The fishermen's priorities among the principles are next compared to the frequency with which the principles appear in theoretical literature, to assess the gap between theory and practice. Two lists of EBM principles were compiled, organized in descending frequency according to (i) their prevalence in the theoretical literature and (ii) their selection as a fishermen's priority. These rankings are compared in Figure 5. It is clear in Figure 5 that

there is a distinct difference between the EBM principles more heavily weighted in theory and those which represent fishermen's priorities. Many of the EBM principles ranked highly from a theoretical point of view were much lower ranked by the fishermen, and vice versa. The exceptions were *Stakeholder Involvement* which ranked highly in both the theoretical literature and according to the fishermen, and *Sustainability* which was top-ranked by fishermen and also ranked fairly high in the literature. *Long Term Objectives, Use of all Forms of Knowledge* and *Use of Incentives* were all top fishermen priorities but in theory they are the three EBM principles at the very bottom of the list. While *Ecosystem Connections, Appropriate Spatial & Temporal Scales, Adaptive Management, Use of Scientific Knowledge* and *Integrated Management* have a high frequency in EBM theoretical publications, these Key Elements are of low priority for the fishermen.

iii) Issues driving Industry Priorities

In order to isolate the major issues raised by each of the fishermen which they considered to be an impediment to the application of each Key Element, the responses to Part One of the face-to-face surveys were transcribed. The responses were organized according to Key Element and individual fishery, allowing for easy comparison across individuals for each Key Element. The survey results were reviewed, highlighting each management issue brought forward by the fishermen and providing a label for each. The frequency of each issue was determined for each individual fisherman. Each issue was counted once for each Key Element question and could be raised a maximum of 15 times per individual, as there are 15 Key Elements. Issues could be expressed by the fishermen in answer to the first question as a complaint or concern with a negative context, or in response to the second question in the form of a recommendation, or a method to address

an issue for each Key Element. For example fishermen could mention that the government does not listen to fishermen or that government need to start listening to fishermen. If an issue arises in both a negative and positive way within a Key Element question it was counted as a frequency of 1 to avoid repetition or the effect of individuals fixating on a single issue.

Each individual issue was allotted a code which consisted of the issue label, as well as the fishery, province, fishing organization, individual and Key Element (Strauss and Corbin 1990; Coffey and Atkinson 1996). This coded information allows for connections to be drawn between issues, the identification of issues in a specific province or fishery, as well as whether issues are raised multiple times by one individual or if an issue is prominent across many respondents.

The overall frequency of each issue was determined. Issues were then connected to the EBM principle, that when applied has the most potential to mitigate the issue at hand. Although these issues are complex and may have connections to multiple EBM principles, due to the large number of issues, the scope of this research did not allow minor connections between issues and EBM principles to be mapped out. Issues were organized according to their connection with EBM principles in stacked bar graphs, the issues were grouped according to their connection with an EBM principle, breaking down the frequency between fisheries across both Nova Scotia and New Brunswick (See Figures 6-8). Issues expressed by only a single individual were not included in these figures in order to focus on trends. Figures 6-8 contextualizes the fishermen's priorities by connecting them with the local issues that are driving each priority. Making these connections provides insight into how the inclusion of these priorities within EBM could

address these issues and potentially mitigate their effects in the local area. Each of the four EBM priorities selected by the fishermen was characterized below by highlighting the trends from Figures 6-8 and discussing the local impact of relevant issues.

Sustainability

Sustainability is a very broad EBM principle that has been referred to as the overall goal of natural resource management, including EBM. For this reason it has the most connection to local issues of any of the fishermen's priorities. Figure 6 highlights twenty-seven issues that drove the selection of *Sustainability,* and these issues are broken down into four categories.

Fishermen's ability to fish, or use the resource, is dependent on both the physical presence of fish as well as the ability to access them and make a profit off the catch. Although the Bay of Fundy has not seen a moratorium in the groundfish fishery (Fisheries Resource Conservation Council 2011), it has faced a serious decline and the biggest issue in connection with *Sustainability* is the lack of groundfish in the Bay of Fundy, with specific references to groundfish species such as cod and pollock. The lack of groundfish has put a lot of pressure on the lobster fishery to support community livelihoods. A fisherman from Nova Scotia stated that "it is sad to say, but all that is left in this part of the province, is the lobster fishery. There is absolutely nothing else left to keep our communities together." The lack of herring or more general lack of a food source for groundfish is also a great concern. A few individuals attributed this to the harvest of herring roe; one fisherman stated "if you are going to sell the eggs how are you going to have fish ?" The decline of the groundfish biomass in the Bay of Fundy has been expressed by both groundfish and lobster fishermen, as many groundfish fishermen fish

lobster or other species to make a living due to low quotas and large fees such as the mandatory purchase of black boxes and monitoring fees. Since there is a lack of fish in the Bay, fishermen have to travel farther than ever to catch their quota, and with the high price of gas this increases expenses to earn an already deceasing income due to the decline in quota.

Catch prices are also an issue amongst both the soft shell clam and lobster fishery. These have been very low over the last couple of years and make it difficult to make a living. Soft shell clam harvesters in both Nova Scotia and New Brunswick also suffer from access issues and discussed how viable closed beaches in their area have not been opened due to a lack of testing by the government, which on top of the low price of clams is another strain on their income.

Overfishing as well as habitat destruction conflict with the conservation efforts needed to maintain sustainability within a fishery. The most frequent issue associated with overfishing that spanned all 3 fisheries was fishing during spawning season. This issue was brought up 15 times by 12 different individuals in all 3 fisheries across both Nova Scotia and New Brunswick. Fishermen also feel that there is too much fishing in certain geographic areas and there is a need for no fish zones or rotational digging, in the case of soft shell clam fishery, to give areas time to regenerate their populations. Some soft shell clam harvesters in Nova Scotia feel that there is a lack of management system and that having a daily clam limit would help to prevent beaches from being stripped. Fishermen from both provinces expressed that illegal fishing is a problem in the soft shell clam industry and there is a need for more enforcement. In Nova Scotia a few lobster fishermen felt that fishing on Sunday was an issue as it did not give the stocks a rest.

Fishermen from both provinces discussed the problem of inconsistencies across Lobster Fishing Areas (LFAs). Conservation efforts made in one LFA allow others to reap the benefits, which provide little incentive for individual LFAs to implement their own conservation efforts. Despite the biodegradable hatches on lobster traps, which function to allow entrapped lobsters to escape from lost traps, fishermen discussed the impact of ghost fishing.

Destructive fishing methods such as fish trawlers were a major issues expressed by predominantly groundfish fishermen- this contributes to habitat loss and the capture of excessive bycatch. A few lobster fishermen also discussed destruction of lobster habitat by scallop draggers.

Long Term Objectives

Making decisions for the future rather than focussing on short term gain has proven to be very important to the local fishermen in the Bay of Fundy. One of the major issues backing up this priority is the threat that aquaculture poses to the commercial fishery, both with the use of chemicals that are harmful to lobster larvae as well of the use of mussels in integrated multi-trophic aquaculture that have the potential to smother wild soft shell clam populations. Fishermen feel that the government is focusing on the initial economic gain of the aquaculture industry rather than undertaking a proper evaluation of the associated risk it can inflict on the local area. One fisherman states, "I don't think there is enough being done as far as aquaculture effect on the lobster industry. I think there are too many chemicals being used, too freely. All they are doing in a lot of cases it seems is trying to remedy a current problem with not much sight for down the road."

Aquaculture has been widely practiced in southwest New Brunswick for the past two

decades, and therefore the lobster fishermen from New Brunswick speak from experiencing the effects of aquaculture firsthand, while in Nova Scotia the provincial government plans to expand aquaculture production in LFA 34, Canada's most lucrative LFA. In response to the potential threat of aquaculture on the lobster fishery, a fisherman expresses his concern in stating that "it seems that one industry is being saved by the cost of another. That kind of scares me."

Many of the fishermen feel that the advancement of aquaculture and other destructive coastal development projects have been approved because the public don't truly understand the future impacts or what is at stake as "the public only sees from the water level up but never see from the water line down." Some lobster fishermen as well as soft shell clam harvesters feel that the government has their own agenda regardless of the future consequences of some of these decisions on surrounding coastal communities. For instance, the soft shell clam industry was greatly affected by the installation of a new septic system which overflows onto viable beaches with heavy rain. This issue was predominantly raised by harvesters in the Digby area in southwest Nova Scotia, but a clam harvester in southwest New Brunswick also raised concern of septic system overflow in Blacks Harbour. The introduction of a tidal power generating station in Nova Scotia has also had long term impacts on sedimentation patterns and the surplus of sedimentation smothered the clam populations, decreasing the biomass which impacts the income from local harvest. The clam harvesters feel that the government was not held accountable for their lack of long term foresight and the consequences of these coastal development projects, and did not provide compensation for the continuous impact on their access to the resource and their ability to make enough money to support

themselves. The participants also had issues with fishermen that do not recognise the long term impacts of their behaviour and are stuck in their 'old ways', refusing to see the long term consequences of polluting the ocean by disposing of their garbage and old traps overboard to avoid the fees associated with proper disposal at the dump.

Stakeholder Involvement

There is undeniable connection between coastal communities and the fishing industry in the Bay of Fundy. This strong relationship along with the communities' direct and indirect dependence on fisheries for their livelihood, justifies the importance of stakeholder involvement and the ability to participate in the shaping of the future of the industry. Figure 7 shows that in the soft shell clam and lobster fisheries in Nova Scotia there is a view that government is not listening to what the fishermen have to say. Similarly participants in the groundfish fishery feel that they are consulted to create an "illusion of participation", while others feel their input is not included in the actual decision making process. The need for transparency when making management decisions was further supported locally in the goals developed for the Southwest New Brunswick Marine Resource Plan (SWNB MRP 2008). This lack of effective participation in how the fishery is managed or in having input on the future of the fishery, has sparked interest in all three fisheries in having more management control at the local level. Despite this desire to take part in management, there were many issues that prevent local stakeholder participation. These issues included the poor organization amongst lobster fishermen in Nova Scotia as well as the poor attendance of fishermen at meetings in the lobster and groundfish fisheries in both provinces.

Use of all Forms of Knowledge

Fishermen hold a great deal of knowledge regarding the local fishing environment and the species that thrive in it. Fishermen felt that this knowledge has the ability to greatly contribute to fisheries management and should be used to inform local management decisions. Figure 7 shows that participants from all three fisheries in Nova Scotia along with the New Brunswick lobster fishermen, expressed that the current use of science in fisheries management is biased and does not always reflect what fishermen are seeing on the ground. The lobster fishermen in particular felt strongly about having fishermen science brought to the table to create a more welled rounded perspective. One fisherman said that "local fishing knowledge should be number one priority when looking to change the oceans that we work on." Groundfish fishermen discussed the gap created by science when it is not appropriately tailored in a language that the fishermen can relate to or fully understand. The lobster fishermen from both Nova Scotia and New Brunswick felt that there is not enough science or funding to support new research initiatives, and that the science management decisions are based on is outdated and does not provide the confidence needed to make vital management decisions for the most lucrative fishery in Canada.

Principles of Equity

There were a number of issues that were frequently raised by the fishermen that did not directly support any of the four fishermen's priorities within EBM principles selected in the face-to-face survey. Analysis of these issues indicates that they all relate to the theme of *Principles of Equity* that was only selected explicitly as a priority by a single fisherman in the lobster fishery, but due to the high frequency of related issues brought forward by

the fishermen, it is clear that *Principles of Equity* is an indirect priority. These issues in *Principles of Equity* are rooted in the ability of large companies to dominate the fishery and management decisions, while making owner operator fishermen inferior. This has a large impact on the historical structure and cultural nature of these fisheries and the fate of the surrounding communities. One fishermen expressed his thoughts as "I think that government is run basically by big industry, [that is] what I see in my little community and I don't think that the small communities are really taken into account." One of the major trends expressed in Figure 8 is the dominance of depuration companies in the Nova Scotian soft shell clam fishery where clam harvesters working for the depuration company have access to the closed and mildly contaminated beaches that they treat, as well as access to the open beaches, allowing these company harvesters to monopolize the industry over owner-operator harvesters. This leaves soft shell clam harvesters in Nova Scotia feeling powerless against the large depuration company.

Clam harvesters in both provinces feel they are seen as a low priority with respect to more profitable fisheries such as lobster. The soft shell clam and lobster fishery have faced very low market prices in recent years and participants expressed that they feel buyers have too much control over the price paid to the fishermen, creating another power struggle in the fishery. Another major trend in the lobster fishery was the recent 'stacking of licences' or the ability to fish two licences on a single boat with only one licence holder present, which allows companies to get ahead of fishermen using a single licence, further developing inequality among fishermen within the industry. Lobster fishermen have also expressed a great fear that the lobster fishery will slowly phase out owner operator fishermen. They also felt that large fish trawlers and aquaculture companies

control decisions that have a large impact on the future of the industry, creating equity issues between fisheries. There are also issues with the overcrowding of harbours in New Brunswick leaving owner operator lobster fishermen fighting for access to local fishing grounds.

Not only is *Principles of Equity* directly connected to the local issues discussed above, it is also supported by another local research initiative in the Bay of Fundy. The *Writing the Rules (2000)* project interviewed fishermen in the Bay of Fundy to develop a set of 'Principles of Good Management' which were a set of operational principles, developed by the fishermen and therefore tailored to fisheries management needs of the local area. One of the principles is to 'Promote Owner-Operated Fisheries' which reinforces that *Principles of Equity* as a broad fishery management priority amongst local fishermen, beyond just those who participated in the face-to-face surveys. The need to acknowledge owner operator fisheries was also a recommendation in *Response of Atlantic Canada's Independent Core fleet sector organizations to "The Future of Canada's Commercial Fisheries"* (2012), indicating that the preservation of owner operator fisheries has been of upmost importance over time and not restricted to my study area, further justifying it as a priority amongst the narrower scope of EBM principles of this research.

CONCLUSION

EBM is a tool that has the capacity to incorporate the ecological, social and governance needs of a given area, yet its ability to successful achieve these goals is dependent on the way in which it is practically applied. In theoretical literature EBM is defined using various combinations drawn from a long list of principles that make up this broad management regime. The variety of features defining EBM has led to many different

application methods and no universal framework. This has created confusion amongst management players and little knowledge of how these principles function on the ground. With the goal of pinpointing the gaps between EBM theory and practice, this research explores fishermen's response to theoretical EBM principles and identifies the issues surrounding their application in the soft shell clam, lobster and groundfish fisheries of southwest Nova Scotia and southwest New Brunswick. Overall the local fishermen indicated that each of the EBM principles are important, but with four EBM principles taking precedence over the others. The importance of *Sustainability, Long Term Objectives, Stakeholder Involvement* and *Use of all Forms of Knowledge* resonated with the fishermen, despite the provincial divide and the diverse nature of the three fisheries that were explored.

The priorities of the local fishermen and the dominant principles in theoretical literature proved to be very different. Notably, two of the fishermen's priorities, *Long Term Objective* and *Use of all Forms of Knowledge*, were overlooked in most of the theoretical literature, while some major principles in the literature did not resonate as much with the fishermen. The issues raised in the face-to-face surveys are directly linked to the fishermen's priorities within EBM principles and the exploration of these issues provided an indication of how they could be mitigated through the application of EBM principles. Several issues raised are connected to the EBM principle, *Principles of Equity*, indicating the need for this principle to be acknowledged locally - as a result it was concluded as an indirect priority of the fishermen.

The United Nations Convention on Biological Diversity's Ecosystem Approach (Vierros 2008) was the only publication from the selected literature used in Chapter 1 that

acknowledges all five of the Bay of Fundy fishermen's priorities. This indicates that EBM theory is not always in line with the needs of the fishermen. Fishermen's priorities must be better recognized by key management players in order for EBM implementation to be supported locally. By practically applying EBM at a smaller scale, local issues can be recognized and multiple small scale initiatives can be built upon and 'scaled up' to take on larger issues while maintaining the benefits of localized management (Charles *et al.* 2011). The lack of involvement of fishermen during the development of EBM principles or the lack of industry support of EBM at the ground level may explain the lack of success in the widespread implementation of EBM in Canadian fisheries. The implementation of EBM from the ground level up will ensure that fishermen's priorities are involved in the application process from the beginning and not an afterthought. This involvement would encourage fishermen to embrace EBM - a consensus for this among fishermen, along with their endorsement and willingness to implement EBM in a meaningful way at the ground level, will contribute to the success of EBM in the future.

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Figure 1. A list of the Key Elements of EBM concluded from a frequency analysis study of EBM principles from theoretical EBM publications for various applications. The Key Elements are organized into the three aspects of fisheries management, with *Sustainability* as a member of all three.

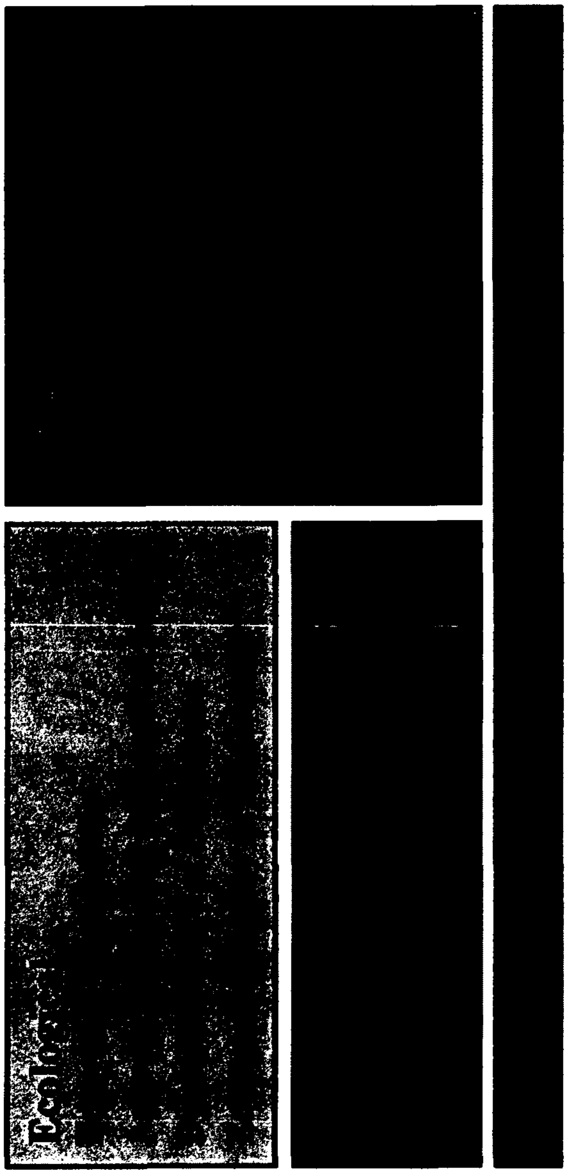

Figure 2. The Bay of Fundy communities in both Southwest Nova Scotia and Southwest New Brunswick that were used as study sites. Twenty-three fishermen participated in face-to-face surveys from the soft shell clam, lobster and groundfish fisheries. Each point on the maps indicate the communities of each fisher.

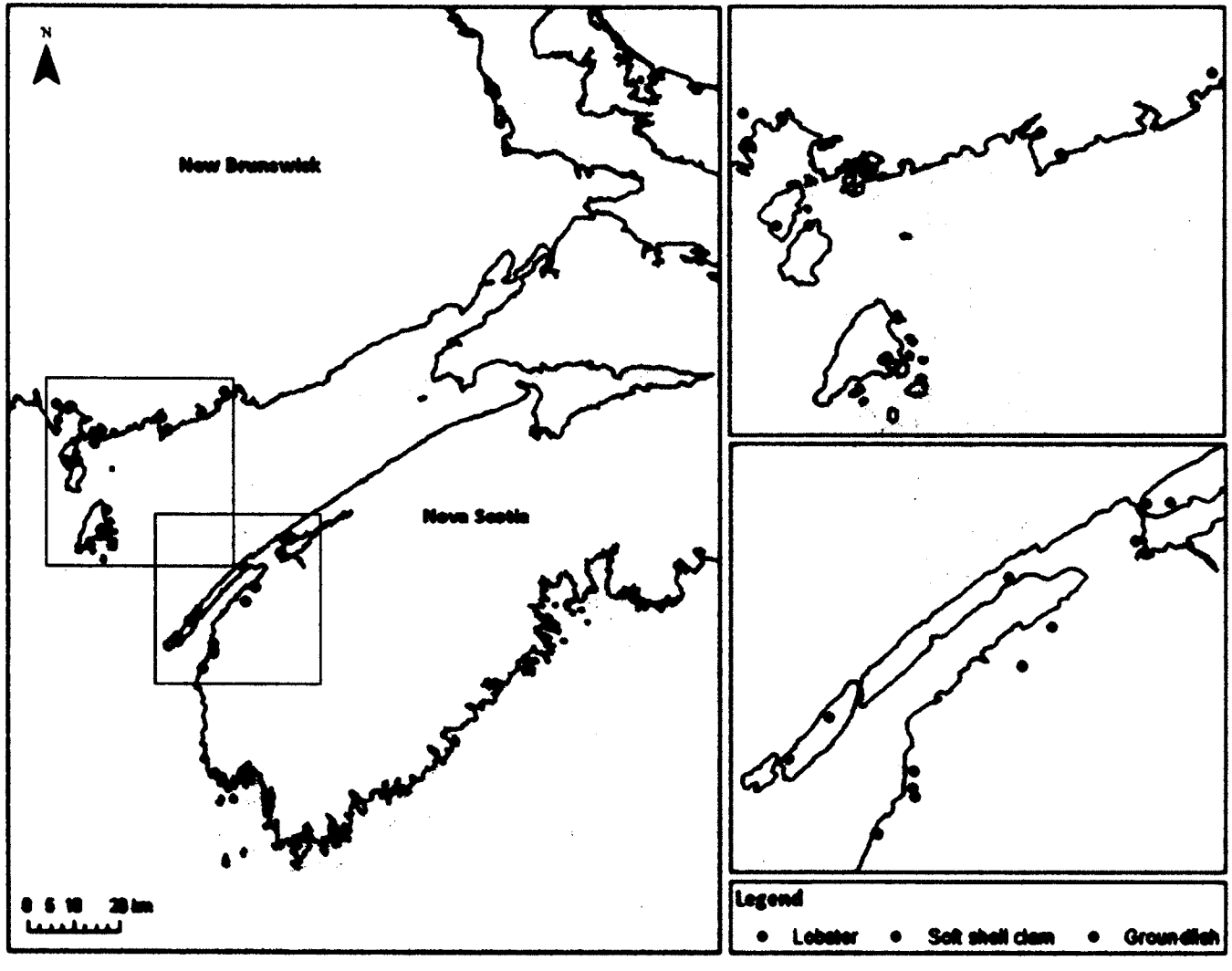
N
New Brunswick
Nova Scotia
0 5 10 20 km
Legend
Lobster
Soft shell clam
Groundfish

Figure 3. Fishermen's evaluation of the overall importance of each EBM principle in the management of the soft shell clam, lobster and groundfish fishery in Southwest Nova Scotia and New Brunswick in the Bay of Fundy, Canada. Each element was ranked from not important to extremely important with a score from 0 – 4 respectively. The Standard Error displays the variation in ranking between participants and the shaded EBM principles are the Key Elements of EBM according to the theoretical literature in Chapter One.

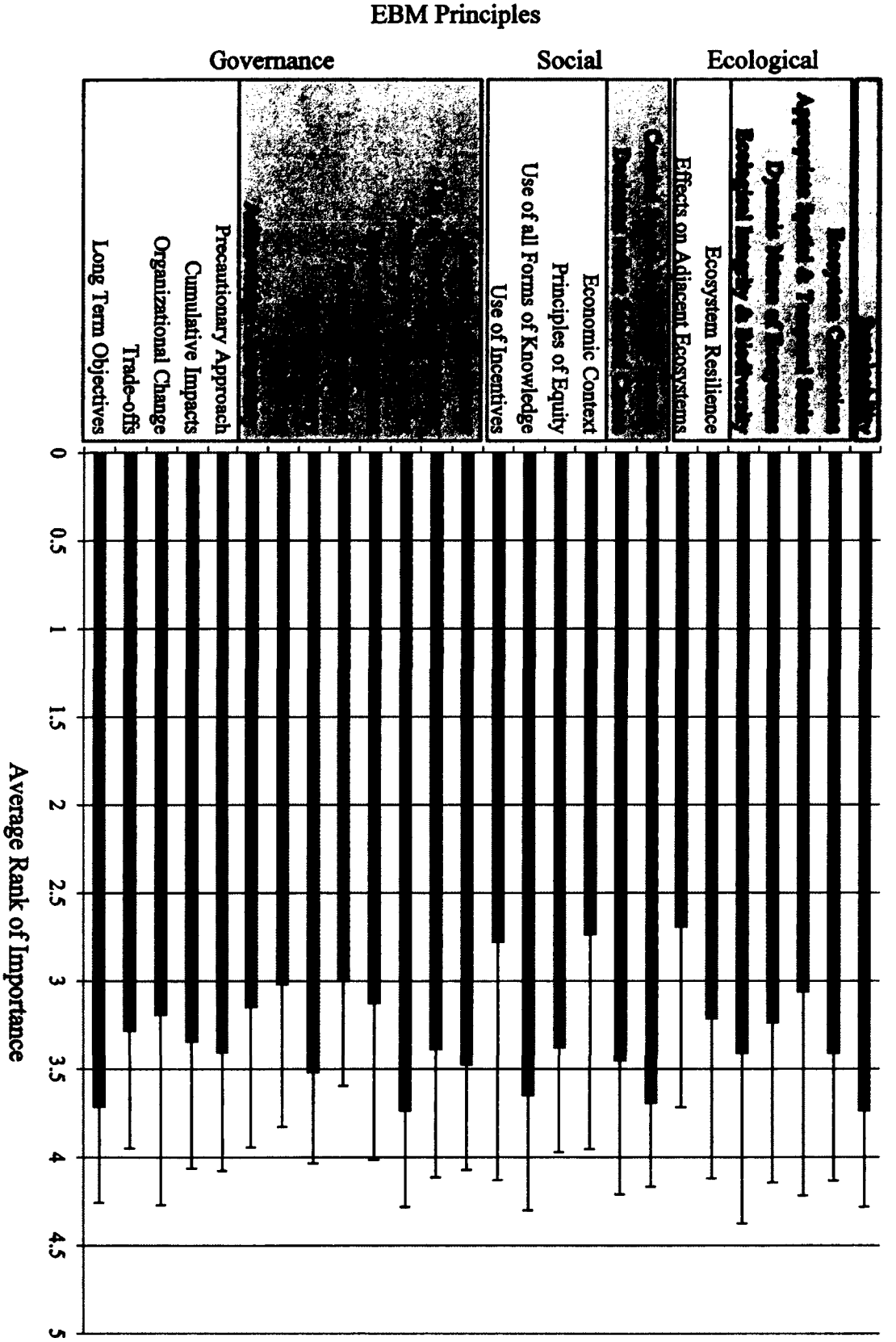
EBM Principles
Governance
Social
Ecological
Precautionary Approach
Cumulative Impacts
Organizational Change
Trade-offs
Long Term Objectives
Use of Incentives
Principles of Equity
Economic Context
Effects on Adjacent Ecosystems
Ecosystem Resilience
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Average Rank of Importance

Figure 4. A frequency analysis of the five most important EBM principles concluded from face to face surveys with fishermen regarding the management of the soft shell clam, lobster and groundfish fisheries in Southwest Nova Scotia and New Brunswick in the Bay of Fundy, Canada. The shaded EBM principles are the Key Elements of EBM according to the theoretical literature in Chapter One.

EBM Principles
Ecological
Social
Governance
Ecosystem Resilience
Effects on Adjacent Ecosystems
Economic Context
Principles of Equity
Use of all Forms of Knowledge
Use of Incentives
Precautionary Approach
Cumulative Impacts
Organizational Change
Trade-offs
Long Term Objectives
0
2
4
6
8
10
12
14
16
18
20
Frequency
Soft shell clam
Lobster
Groundfish

Figure 5. A cross comparison of the importance of EBM principles according to the frequency of publication in the selected theoretical EBM literature with those chosen as one of five most important EBM principles by fishermen participants in the soft shell clam, lobster and groundfish fisheries in Southwest Nova Scotia and New Brunswick in the Bay of Fundy, Canada.

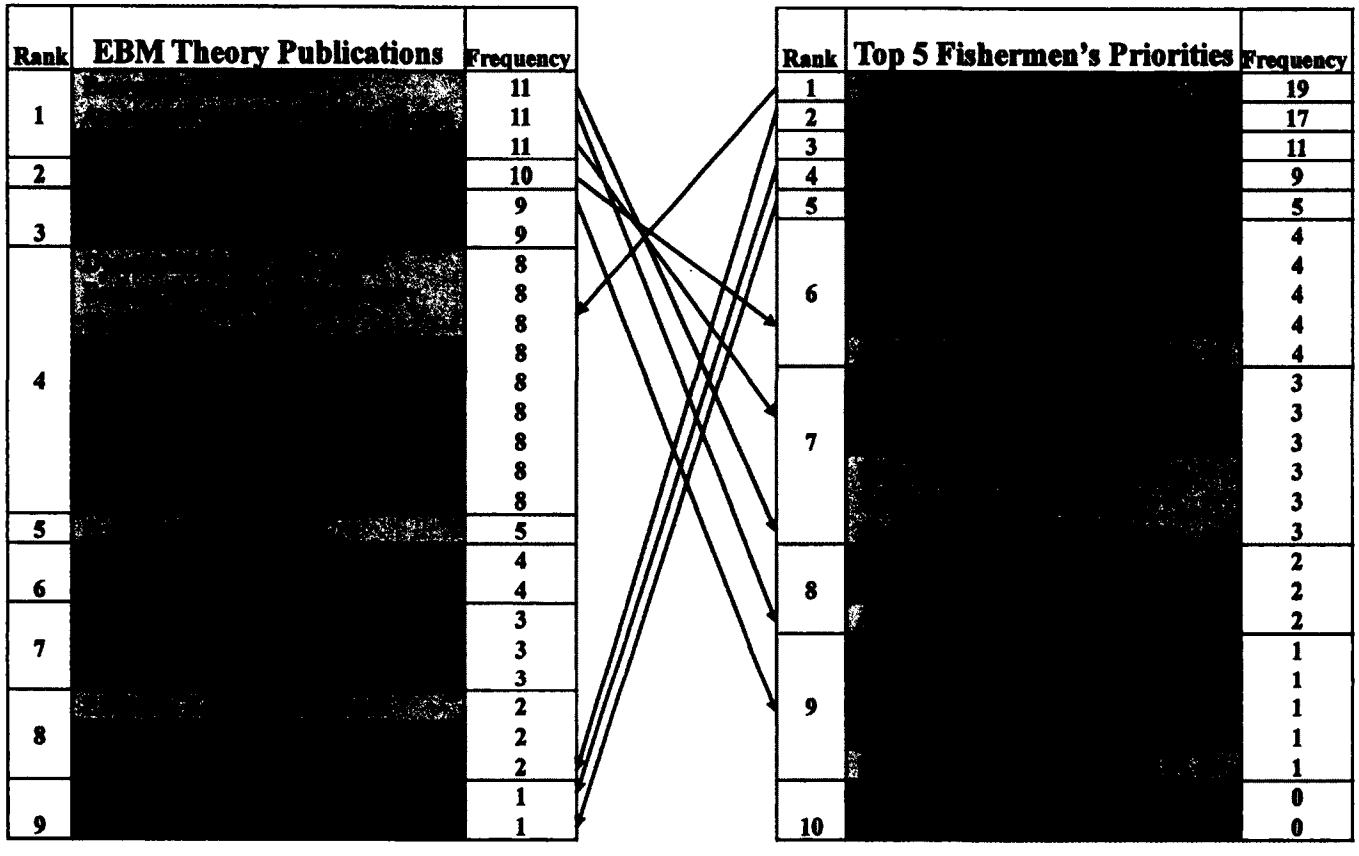
Rank
EBM Theory Publications
Frequency
1
11
11
11
2
10
3
9
9
4
8
8
8
8
8
8
8
8
8
8
5
5
6
4
4
7
3
3
3
8
2
2
2
9
1
1
Rank
Top 5 Fishermen's Priorities
Frequency
1
19
2
17
3
11
4
9
5
5
6
4
4
4
4
4
7
3
3
3
3
3
3
8
2
2
2
9
1
1
1
1
1
10
0
0

Figure 6. The frequency of issues brought forth by fishermen in the face-to-face surveys that are connected to and drive the selection of *Sustainability* as a fishermen's priority of EBM Principles within the management of the soft shell clam, lobster and groundfish fisheries in Southwest Nova Scotia and New Brunswick in the Bay of Fundy, Canada. The numbers at the end of each stacked bar represent the number of individuals that expressed each issue.

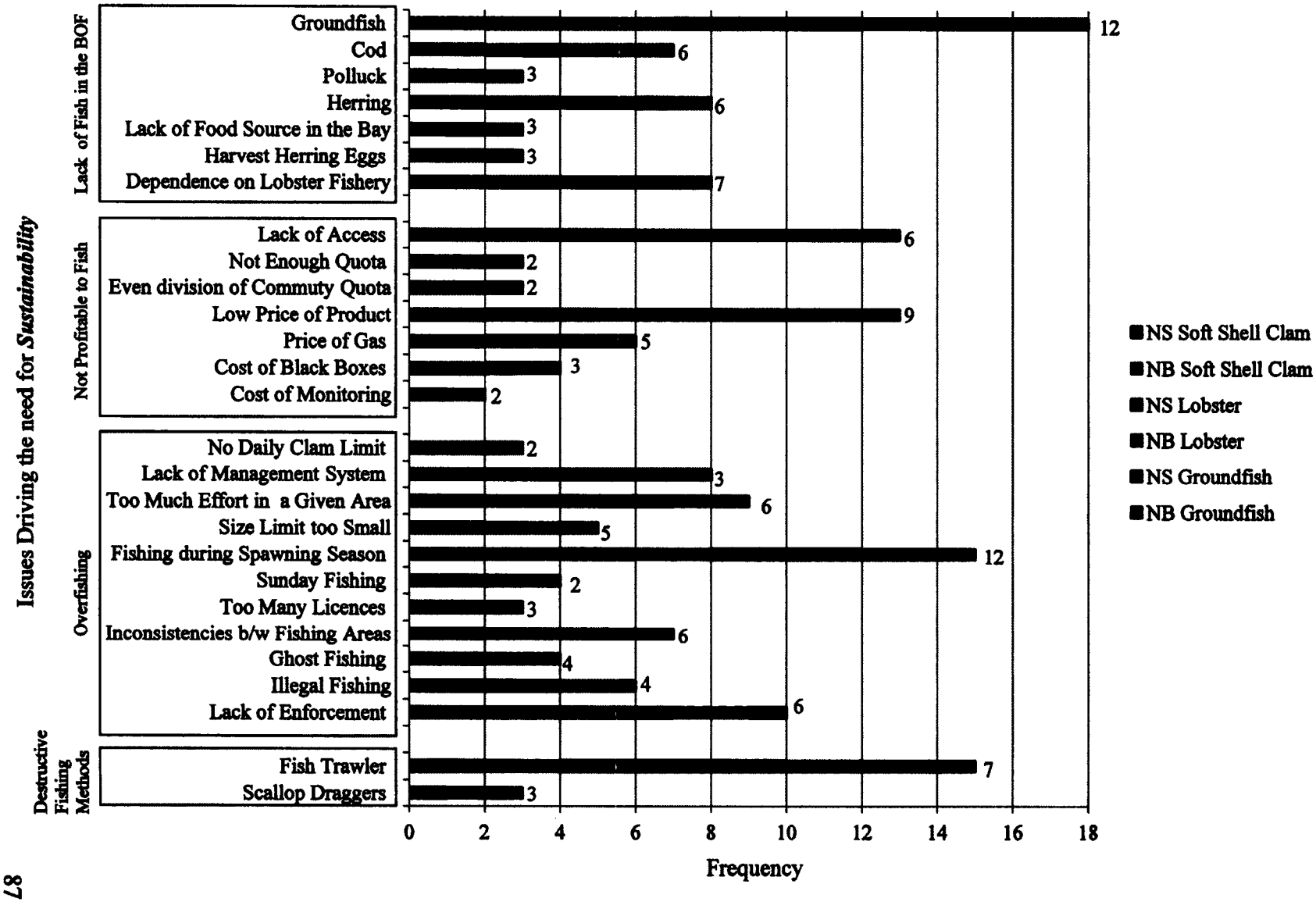
Issues Driving the need for Sustainability
Lack of Fish in the BOF
Groundfish
Cod
Polluck
Herring
Lack of Food Source in the Bay
Harvest Herring Eggs
Dependence on Lobster Fishery
Not Profitable to Fish
Lack of Access
Not Enough Quota
Even division of Commuty Quota
Low Price of Product
Price of Gas
Cost of Black Boxes
Cost of Monitoring
Overfishing
No Daily Clam Limit
Lack of Management System
Too Much Effort in a Given Area
Size Limit too Small
Fishing during Spawning Season
Sunday Fishing
Too Many Licences
Inconsistencies b/w Fishing Areas
Ghost Fishing
Illegal Fishing
Lack of Enforcement
Destructive Fishing Methods
Fish Trawler
Scallop Draggers
12
6
3
6
3
3
7
6
2
2
9
5
3
2
2
3
6
5
12
2
3
6
4
4
6
7
3
0
2
4
6
8
10
12
14
16
18
Frequency
NS Soft Shell Clam
NB Soft Shell Clam
NS Lobster
NB Lobster
NS Groundfish
NB Groundfish

Figure 7. The frequency of issues brought forth by fishermen in the face-to-face surveys that are connected to and drive the selection of *Long Term Objectives*, *Stakeholder Involvement* and *Use of all Forms of Knowledge* as the fishermen's priorities of EBM Principles within the management of the soft shell clam, lobster and groundfish fisheries in Southwest Nova Scotia and New Brunswick in the Bay of Fundy, Canada. The numbers at the end of each stacked bar represent the number of individuals that expressed each issue. For each fishermen's priority the issues are organized into two boxes, the first box are issues that fishermen have with government/ governmental management decisions and the second are issues that fishermen have with one another and their contribution to management (shaded).

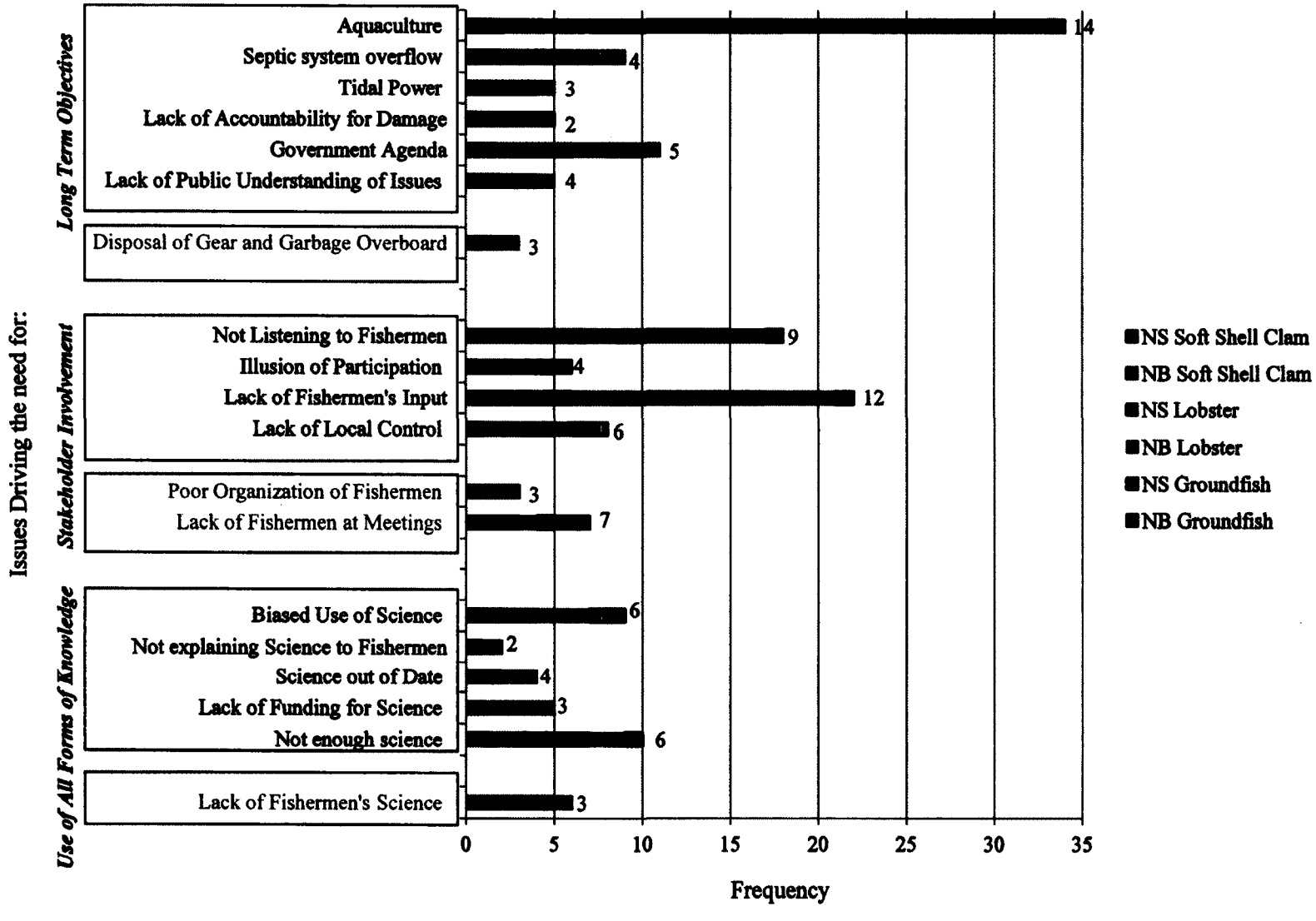
Issues Driving the need for:
Long Term Objectives
Aquaculture
Septic system overflow
Tidal Power
Lack of Accountability for Damage
Government Agenda
Lack of Public Understanding of Issues
Disposal of Gear and Garbage Overboard
Stakeholder Involvement
Not Listening to Fishermen
Illusion of Participation
Lack of Fishermen's Input
Lack of Local Control
Poor Organization of Fishermen
Lack of Fishermen at Meetings
Use of All Forms of Knowledge
Biased Use of Science
Not explaining Science to Fishermen
Science out of Date
Lack of Funding for Science
Not enough science
Lack of Fishermen's Science
14
4
3
2
5
4
3
9
4
12
6
3
7
6
2
4
3
6
3
0
5
10
15
20
25
30
35
Frequency
NS Soft Shell Clam
NB Soft Shell Clam
NS Lobster
NB Lobster
NS Groundfish
NB Groundfish

Figure 8. The frequency of issues brought forth by fishermen in the face-to-face surveys that are connected to *Principles of Equity*, an indirect priority of the fishermen within the management of the soft shell clam, lobster and groundfish fisheries in Southwest Nova Scotia and New Brunswick in the Bay of Fundy, Canada. The numbers at the end of each stacked bar represent the number of individuals that expressed each issue.

Issues Indirectly Driving the need for ***Principles of Equity***

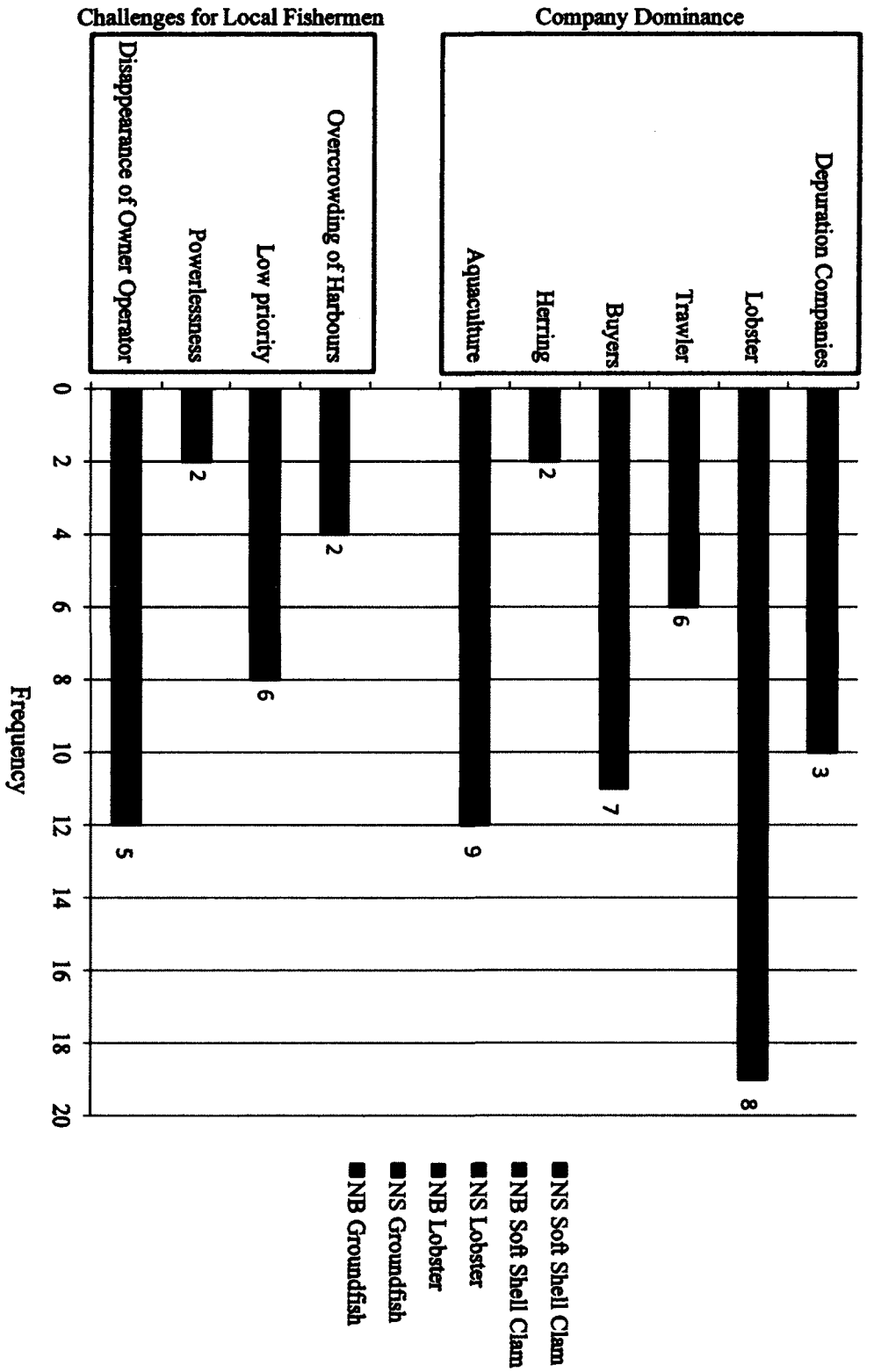

Table 1. Characterizing the Variation between the Soft Shell Clam, Lobster and Groundfish fisheries with respect to their ecology, harvest method, management and status in Canada

	Soft Shell Clam	Lobster	Groundfish	
Ecology	Bivalve Mollusc	Large Crustacean	Demersal fish	
Harvest Method	Clam Hack	Lobster Trap	**Fixed Gear**	**Mobile Gear**
			Longline/Hook & Line -Gill net	-Otter Trawl
Management	Size Limit Harvest by hand Health & Safety Standards (coliform or phycotoxin area closures) Winter Closure (SWNS)	Size Limit # of traps Biodegradable gear Size of escape vent No egg bearing or v-notched females Number of licences Length and time of fishing season	Community Quota	Individual Transferable Quotas (ITQs)
Status in Canada	Very Small Commercial Fishery	Lucrative Fishery	Declining Fishery	

Table 2. Local Fishing Organizations in Southwest Nova Scotia and New Brunswick that took part in the selection of fishermen to participate in face-to-face surveys from the soft shell clam, lobster and groundfish fisheries.

Fishery	Southwest Nova Scotia	Southwest New Brunswick
Soft Shell Clam	Area II Clam Harvesters Association	Charlotte County Clam Harvesters Cooperative
Lobster & Groundfish	Maritime Fishermen's Union Local 9 Bay of Fundy Inshore Fishermen's Association	Fundy North Fishermen's Association Grand Manan Fishermen's Association

CONCLUSION

Despite the great deal of attention EBM has received over the past two decades it has yet to be widely applied in the field of marine management. The slow onset of EBM implementation indicates a gap between theory and practice which has been attributed to both the confusion surrounding the multitude of EBM definitions and similar and synonymous terms as well as the lack of understanding of how EBM functions at the ground level. Both Chapters one and two address these issues respectively, with hopes to prevent these challenges from further impeding the practical application of EBM in the future and therefore its potential to provide a more holistic alternative to traditional management approaches in a marine environment.

Chapter one sets out to clear up this confusion and provides a list of the defining EBM principles derived from a frequency analysis of the theoretical literature. Fifteen Key Elements were concluded for the successful application of EBM and are listed in descending frequency: *Ecosystem Connections*, *Appropriate Spatial & Temporal Scales*, *Adaptive Management*, *Use of Scientific Knowledge*, *Integrated Management*, *Stakeholder Involvement*, *Dynamic Nature of Ecosystems*, *Ecological Integrity & Biodiversity*, *Sustainability*, *Coupled Social-Ecological Systems*, *Decisions reflect Societal Choice*, *Distinct Boundaries*, *Interdisciplinary*, *Monitoring* and *Acknowledge Uncertainty*. Chapter one tracked the evolution of EBM principles to gain a sense of how far EBM has come as well as made predictions on the direction in which EBM will take in the future. The change of EBM principles was documented throughout the timeframe in which the selected literature was published, along with the evolution of the EBM philosophy preceding the term with Holt and Talbot's (1978) wildlife conservation

principles and their revisions in 1996 by Mangel *et al.* From this analysis it is clear that EBM is an ever evolving concept, with the concluded list of Key Elements representing EBM at the present time which will continue to grow and change in the future. Therefore the changing nature of EBM should not be used as an excuse to delay its application as this constant growth or change is an inherent trait of EBM. To account for new EBM theoretical literature the frequency analysis used in Chapter one can be replicated to obtain an update list of the Key Elements in the future. Further research of potential up and coming Key Elements such as *Cumulative Impacts* and the *Precautionary Approach* will help shape the face of EBM and its ability to grow and accommodate the management needs of the future.

Little is known about how EBM functions on the ground which further contributes to the gap between EBM theory and practice. Chapter two attempted to close this gap by conducting face-to-face surveys with fishermen to determine their priorities within EBM principles and identify the issues surrounding their application in the soft shell clam, lobster and groundfish fisheries of southwest Nova Scotia and southwest New Brunswick. Although fishermen expressed that all of the EBM principles were of relative importance, there were 4 EBM principles that took precedence over the others despite the provincial divide and the diverse nature of the three fisheries that were explored. The 4 most prominent priorities of the fishermen in descending frequency are: *Sustainability, Long Term Objectives, Stakeholder Involvement,* and *Use of all Forms of Knowledge.* These priorities were compared with the Key Elements derived from the literature to assess their local support of EBM theory. Two of these fishermen's priorities, *Long Term Objectives* and *Use of all Forms of Knowledge,* were overlooked by most of the selected literature

and therefore were not concluded as Key Elements in Chapter one, indicating a clear gap between EBM theory and practice. This was further exemplified in the overall theoretical ranking of the EBM principles which proved to be very different from the fishermen's priorities, all of which were lower ranked in the theoretical literature with the exception of *Stakeholder Involvement* which received a ranking of three in both. Similarly EBM principles that had a high ranking within the literature were all ranked lower by the fishermen: *Ecosystem Connections*, *Appropriate Temporal & Spatial Scales*, *Adaptive Management*, *Use of Scientific Knowledge* and *Integrated Management.*

The management issues raised by the fishermen in the face-to-face surveys had a direct connection to their priorities within the EBM principles. These connections contextualized the fishermen's priorities and provided insight on what drove the fishermen to select these priorities over other EBM principles. Frequently raised issues that did not support any of their selected priorities were connected to, *Principles of Equity*, which was then concluded as an indirect priority of the fishermen, for a total of five priorities. The United Nations Convention on Biological Diversity's Ecosystem Approach (Vierros 2008) was the only theoretical publication in Chapter one that acknowledged all five of the fishermen's priorities within the EBM principles. This reaffirms that the theoretical EBM literature is not always in tune with the needs of the fishermen.

The practical application of EBM at smaller scales has the ability to recognize local needs but 'scale up' with neighbouring small scale initiatives to tackle larger issues (Charles *et al.* 2011) which has proven to be successful in a series of small interconnected EBM initiatives on the west coast of the United States (West Coast EBM Network 2010).

According to Mackinson *et al.* (2011) stakeholder support is vital for the success of management initiatives and with the recognition of fishermen's priorities this will encourage local support of EBM and contribute to its successful implementation. To ensure that local needs are recognized it is important to include fishermen in the EBM application process from the beginning and not as an afterthought. The selection of the appropriate EBM principles is a vital step in the application process and will dictate how EBM is implemented and the type of objectives that will be achieved. It is important to recognize not only the expertise in the theoretical EBM literature but also that of the local fishermen. Both the theoretical and local expertise have often been insufficiently represented in the practical application of EBM, such as DFO's Maritime Region Framework for an Ecosystem Approach to Management (Fisheries and Oceans Canada 2010), but meaningful acknowledgement can be achieved by implementing both the Key Elements concluded from the selected publications and the fishermen's priorities. These EBM principles can then be inputted in a pre-existing EBM implementation framework, such as Fletcher *et al.*'s (2010) Ecosystem-based Fisheries Management Process, and specific objectives for each Key Element can be developed to tailor to the needs of the local area or community.

The fishermen's priorities concluded in Chapter two represent the priorities of fishermen in southwest Nova Scotia and southwest New Brunswick and are not meant to be interpreted as a generalization for the fishing industry as a whole. This case study provides an example of how fishermen's priorities can differ from those expressed in the EBM literature, affirming the need to determine local fishermen's priorities in each area of implementation as these priorities will differ between individual case studies. The

methodology used in both Chapter one and Chapter two build upon one another to provide an effective method of compiling an up to date list of EBM principles from the theoretical literature which can then be used to develop a face-to-face survey to determine fishermen's priorities within EBM principles and management issues that are impeding the local application of each. The connections made between the local issues and the fishermen's priorities allow for a greater understanding of local challenges that stand in the way of the successful implementation of each of the EBM principles and the overall application of EBM. For a more well rounded perspective of the gap between theory and practice at the local scale, face-to-face surveys could be extended to other stakeholder groups such as fishermen not a member of the local fishing organizations, First Nation fishermen (commercial, food and ceremonial), buyers and processers as well as various levels of government and academics involved in local research and management. Fishermen's priorities could then be further investigated in the future by building on the face-to-face surveys and provide participants with the opportunity to recommend additional management priorities that align with EBM objectives that were not present in the EBM principles derived from the theoretical literature. These methodologies provide a template that can be applied to future case studies, utilizing the expertise from the wide range of sources which define EBM Principles to advance the application of EBM rather than slowing it down, and with the acknowledgement of fishermen's priorities within EBM this will help to bridge the gap between theory and practice and move towards the successful implementation of EBM in marine systems both in Canada and internationally.

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Case #:

Face to Face Survey

An assessment of the local fishery management practices of the soft shell clam, atlantic lobster and groundfish fisheries in the Bay of Fundy

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Name:

Specie(s) fished:

Gear Type:

Fishing Area:

Fishing Organization:

Full time or Part time:

Vessel Size:

License holder/ Captain/# of crew:

Length of time in the fishing industry:

Community:

Introduction:

In the first part of the interview I will be asking you broad questions regarding the management practices of the *xxx* fishery. Each question concerns one aspect of fisheries management and has three parts , the first inquiring if this particular management practice is occurring, the second rating its effectiveness, the third asking for an example of how it applies to the *xxx* fishery in your area. The second part will involve more detailed questions regarding a single management practice and the entire interview process should last about an hour.

Part One:

Ecosystem Connections:

1. A) In what ways do management processes consider the effects of ecosystem connections, such as relationships between *xxx* and other species and its habitat etc?

B) What do you feel should be done to better recognize these connections in management?

Spatial Scale

2. A) In what ways are local ecosystems compatible with the geographic fishing boundaries in your area?

B) How can these boundaries be designated to better consider the local ecosystem?

Temporal Scales:

3. A) How are local ecosystem considerations considered when designating the seasonal timeframes and the length of the xxx fishery in your area?

B) How should these timeframes be altered to better include local ecosystem considerations?

Dynamic Nature of Ecosystems

4. A) How do management decisions acknowledge the fact that ecosystems are constantly changing?

B) What should be done to better acknowledge ecosystem change in fishery management?

Ecological Integrity and Biodiversity

5. A) In what ways do management practices ensure that ecosystem health is maintained by protecting biodiversity or the number and variety of species within it?

B) What can be done to better achieve this?

Sustainability

6. A) In what ways do fishery management practices balance conservation and the harvest of xxx to secure the needs of future generations?

B) How can the balance between conservation and use be better accounted for in management?

Coupled Social-Ecological systems

7. A) How do current management practices consider the integral connection that communities have with the local ecosystem (for example the idea that communities are impacted by the ecosystem and the ecosystem is impacted by the community)?

B) How can the connection between communities and their local ecosystem be better acknowledged in management?

Decisions reflect Societal Choice

8. A) In what ways do fishery management decisions reflect community values or choices?

B) How should community values be better reflected in management?

Stakeholder participation

9. A) In what ways do stakeholders participate into local fisheries management?

B) How should stakeholders be better able to actively contribute to local management practices?

Adaptive Management

10. A) How are management policies able to adapt to changes within the local environment, or to incorporate new research findings?

B) How should management better adapt to these environmental changes and/or new information?

Integrated Management

11. A) In what ways do the fishing industry and neighbouring or overlapping sectors work together to manage the local environment?

B) How should these sectors better work together and participate in local management?

Use of Scientific Knowledge

12. A) How is scientific evidence utilized to make fisheries management decisions?

B) How should scientific information better be used to dictate fisheries management decisions?

Interdisciplinary

13. A) How does management use multiple disciplines such as ecological, economic and social factors to make decisions?

B) How should these disciplines be better utilized in fisheries management?

Monitoring

14. A) In what ways are physical and biological monitoring used to monitor the local ecosystem and inform fisheries management decisions?

B) How should monitoring efforts be used to be more effective in fisheries management?

Acknowledge Uncertainty

15. A) How do local fishery management practices account for a lack of full understanding of the marine environment or resource at hand?

B) How should management practices better account for this lack of full understanding

Part Two: Ecosystem-based management

16. Below is a list of some suggested components of ecosystem-based management, please rate each component as: **0** **1** **2** **3** **4**

Not important **low** **medium** **high** **extreme importance**

☐ **Ecosystem Connections**: ensure that the structure of ecosystems and the interrelationships between species and their environment are maintained.

☐ **Appropriate Temporal Scales**: ensure that the time and length of the fishing season is appropriate for the given ecosystem.

☐ **Dynamic Nature of Ecosystems**: acknowledge that ecosystems are not static but constantly changing.

☐ **Ecological Integrity and Biodiversity**: ensure that ecosystem health is maintained by preserving the number and variety of species within it.

☐ **Ecosystem Resilience:** acknowledge how well and to what extent the ecosystem can withstand disturbances and still maintain its natural structure and function.

☐ **Effects on adjacent ecosystems**: consider the effects of fishing on neighbouring ecosystems.

☐ **Sustainability**: find a balance between conservation and use to ensure the needs of future generations.

☐ **Coupled Social-Ecological systems**: acknowledge the linkages between humans and their environment, treating humans as a part of the ecosystem.

☐ **Decisions reflect Societal Choice**: ensure that decisions are made according to community values.

☐ **Stakeholder involvement**: allow stakeholders to actively contribute to the decision making process.

☐ **Principles of Equity**: balance social objectives and rights between various sectors of society.

☐ **Use all forms of knowledge**: consider all forms of knowledge relevant information, including scientific, indigenous and local knowledge.

☐ **Adaptive Management**: revise decisions/policies as the ecosystems changes and/or when new information or scientific knowledge becomes available.

☐ **Integrated Management**: collaboratively make decisions with coexisting sectors/ ecosystem services.

☐ **Use of Scientific Knowledge**: make decisions based on scientific evidence.

☐ **Distinct Boundaries**: have distinct geographic boundaries defined using ecological factors and not be constrained by political boundaries.

☐ **Interdisciplinary**: acknowledge ecological, economic and social needs when making decisions.

☐ **Monitoring**: monitor biological and physical factors to track management progress.

☐ **Uncertainty**: acknowledge that ecosystems are complex and will never be fully understood.

☐ **Economic Context**: consider Economic factors when making management decisions.

☐ **Precautionary Approach**: use precautionary measures to account for the lack of full understanding of ecosystems and unforeseen environmental changes.

☐ **Cumulative Impacts**: acknowledge the overall impacts of all the ecosystem services/ sectors in a given ecosystem.

☐ **Organizational Change**: make structural changes to incorporate the elements of EBM.

☐ **Trade-offs**: explicitly acknowledge compromises when making management decisions.

☐ **Long term objectives**: not focus on short term gains but on future benefits.

☐ **Use of incentives**: provide incentives in order to encourage sustainable resource use.

17. Here is the list of suggested components. Please select the five elements that you feel are of the greatest importance.

- ☐ **Ecosystem Connections**: ensure that the structure of ecosystems and the interrelationships between species and their environment are maintained.
- ☐ **Appropriate Temporal Scales**: ensure that the time and length of the fishing season is appropriate for the given ecosystem.
- ☐ **Dynamic Nature of Ecosystems**: acknowledge that ecosystems are not static but constantly changing.
- ☐ **Ecological Integrity and Biodiversity**: ensure that ecosystem health is maintained by preserving the number and variety of species within it.
- ☐ **Ecosystem Resilience**: acknowledge how well and to what extent the ecosystem can withstand disturbances and still maintain its natural structure and function.
- ☐ **Effects on adjacent ecosystems**: consider the effects of fishing on neighbouring ecosystems.
- ☐ **Sustainability**: find a balance between conservation and use to ensure the needs of future generations.
- ☐ **Coupled Social-Ecological systems**: acknowledge the linkages between humans and their environment, treating humans as a part of the ecosystem.
- ☐ **Decisions reflect Societal Choice**: ensure that decisions are made according to community values.
- ☐ **Stakeholder involvement**: allow stakeholders to actively contribute to the decision making process.
- ☐ **Principles of Equity**: balance social objectives and rights between various sectors of society.
- ☐ **Use all forms of knowledge**: consider all forms of knowledge relevant information, including scientific, indigenous and local knowledge.
- ☐ **Adaptive Management**: revise decisions/policies as the ecosystems changes and/or when new information or scientific knowledge becomes available.
- ☐ **Integrated Management**: collaboratively make decisions with coexisting sectors/ ecosystem services.
- ☐ **Use of Scientific Knowledge**: make decisions based on scientific evidence.
- ☐ **Distinct Boundaries**: have distinct geographic boundaries defined using ecological factors and not be constrained by political boundaries.
- ☐ **Interdisciplinary**: acknowledge ecological, economic and social needs when making decisions.
- ☐ **Monitoring**: monitor biological and physical factors to track management progress.
- ☐ **Uncertainty**: acknowledge that ecosystems are complex and will never be fully understood.
- ☐ **Economic Context**: consider Economic factors when making management decisions.
- ☐ **Precautionary Approach**: use precautionary measures to account for the lack of full understanding of ecosystems and unforeseen environmental changes.
- ☐ **Cumulative Impacts**: acknowledge the overall impacts of all the ecosystem services/ sectors in a given ecosystem.
- ☐ **Organizational Change**: make structural changes to incorporate the elements of EBM.
- ☐ **Trade-offs**: explicitly acknowledge compromises when making management decisions.
- ☐ **Long term objectives**: not focus on short term gains but on future benefits.
- ☐ **Use of incentives**: provide incentives in order to encourage sustainable resource use.

18. A) According to your understanding of fishery management practices, please describe what ecosystem-based management (EBM) or the ecosystem approach means to you.

B) How long ago did you first hear about ecosystem-based management? Where?

C) How has your definition of the term changed since then?

19. What is the status of ecosystem-based management in the *xxx* fishery in your area?

20. In your opinion which components of ecosystem-based management should be better represented in your community and how?

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