



## Key principles of ecosystem-based management: the fishermen's perspective

Rachel D Long<sup>1</sup>, Anthony Charles<sup>1</sup> & Robert L Stephenson<sup>2,3</sup>

<sup>1</sup>School of the Environment and School of Business, Saint Mary's University, 923 Robie Street, Halifax, Nova Scotia, Canada B3H 3C3; <sup>2</sup>Department of Fisheries and Oceans, St. Andrews Biological Station, 531 Brandy Cove Road, St. Andrews, New Brunswick, Canada E5B 2L9; <sup>3</sup>Canadian Fisheries Research Network, Department of Biology, University of New Brunswick, P.O. Box 4400, Fredericton, New Brunswick, Canada E3B 5A3

### Abstract

Despite the growing popularity of ecosystem-based management (EBM) in national legislation and in research and institutional literature, there is often an implementation gap 'on the ground', impeding widespread adoption in fisheries. This gap reflects in part the differing understandings of EBM held by fishermen and by management institutions. To explore and seek to close this gap, the underlying principles of EBM considered priorities by fishermen were systematically compared with the priorities identified in the published literature. The fishermen's priorities were determined by asking Atlantic Canadian fishermen to identify the EBM principles they consider most important. Four priority principles were identified: *Sustainability*, *Stakeholder Involvement*, *Develop Long-Term Objectives* and *Use of All Forms of Knowledge*. The latter two were not frequently noted as priorities in the literature, while some literature priorities were less commonly chosen by fishermen, indicating a significant difference in perspectives on EBM. The rationale for fishermen's choice of priorities was explored by analysing the fishery management issues they raised – many directly connected to the above four priorities. In addition, another principle, *Commit to Principles of Equity*, often arose as an implicit priority among fishermen. We suggest that success in implementation of EBM may depend on reconciling differing priorities among its underlying principles, and combining knowledge and expertise from fishermen with research and institutional sources. The comparative methodology used here, which could be replicated elsewhere, should lead to better recognition of local challenges in EBM implementation and encourage support for EBM, to further its contribution to sustainable fisheries.

### Correspondence:

Rachel Long, School of the Environment, Saint Mary's University, 923 Robie Street, Halifax, Nova Scotia, Canada B3H 3C3  
Tel.: (902) 420-5732  
Fax: (902) 496-8101  
E-mail: long.rachel@me.com

Received 2 Mar 2016

Accepted 11 Jul 2016

**Keywords** EBM principles, ecosystem approach to fisheries, ecosystem-based fisheries management, ecosystem-based management, fishermen, stakeholders

<b>Introduction</b>	<b>245</b>
<b>Methodology</b>	<b>246</b>
Assessing conceptual/theoretical/institutional priorities among EBM principles	246
Assessing fishermen's preferences among EBM principles and priorities for EBM	246
<b>Results and discussion</b>	<b>247</b>
Conceptual/theoretical/institutional priorities among EBM principles	247

Fishermen's priorities among EBM principles	247
A comparison of priorities among EBM principles	248
Issues driving fishermen's EBM priorities	248
<i>Sustainability</i>	249
<i>Develop long-term objectives</i>	249
<i>Stakeholder involvement</i>	250
<i>Use of all forms of knowledge</i>	250
<i>Commit to principles of equity</i>	250
<b>Conclusion</b>	<b>251</b>
<b>Acknowledgements</b>	<b>252</b>
<b>References</b>	<b>252</b>
<b>Appendix 1: Survey methodology</b>	<b>253</b>

## Introduction

The development and growing acceptance of ecosystem-based management (EBM, also known as the ecosystem approach) for fisheries and aquatic environments can be attributed in part to global concern over resource productivity and ecosystem health in the world's oceans (FAO 2008), and specifically to a recognition that marine ecosystems can support little if any further increase in fishing pressure (FAO 2012). EBM is driven by a recognition of the failure of conventional management to protect marine ecosystems from over-exploitation (Crain *et al.* 2009), and of the need for change in fishery management to recognize (i) important interspecies relationships within an ecosystem (Pikitch *et al.* 2004), (ii) the key underlying human dimensions in marine and fishery systems (De Young *et al.* 2008; Charles 2014) and (iii) the intricate connections between the social and ecological components of these systems (Ward *et al.* 2002; Garcia and Cochrane 2009). Thus, EBM, as an approach to managing fisheries, is seen as a means to incorporate the ecological, social, economic and governance needs of the fishery system.

Over the last two decades, as EBM has become prominent and has been incorporated into international agreements and the legislation of many nations, an extensive literature base has emerged on conceptual, theoretical and institutional aspects of EBM, covering terrestrial, marine and sector-specific applications including fisheries. Remarkably, however, there is a lack of consensus in published literature on the definition of EBM, and on the specific components comprising this

approach (Morishita 2008). Instead, EBM is defined using varying combinations of underlying principles. The many variations in the sets of underlying principles, and accordingly in the definitions of EBM, have prevented the development of a single broadly accepted framework. As a result, EBM continues to mean different things to different people (Grumbine 1994), with the resulting lack of clarity creating confusion among management players (Stephenson 2012), impeding its broader and more widespread implementation. Also problematic has been a lack of knowledge of how EBM principles are viewed 'on the ground', within fisheries themselves.

This article addresses these challenges by comparing the principles of EBM considered as priorities by fishermen, with those resulting from analysis of a set of published conceptual, theoretical and institutional EBM frameworks (from Long *et al.* 2015; referred to as 'the literature' for the remainder of the paper), now being applied to the fishery sector by governments and major institutions. Applying a broad view of EBM that acknowledges a range of ecological, social and governance objectives (Bianchi 2008), the article contrasts fishermen's perspectives of EBM principles (based on a survey conducted in Atlantic Canada) with those offered in the literature. This analysis aims to close the gap between EBM theory and practice, with a better 'fit' expected to produce greater stakeholder support, a vital component of successful management initiatives (Mackinson *et al.* 2011), and lead to more effective application of EBM within fisheries. By focusing on the fishermen's perspective, we are also able to connect fishery management issues explicitly identified by the

fishermen with EBM principles that can be used to address them. To our knowledge, this is the first systematic comparison between the fishermen's perspective on key principles of EBM and that of the conceptual, theoretical and institutional literature.

## Methodology

### Assessing conceptual/theoretical/institutional priorities among EBM principles

Conceptual, theoretical and institutional perceptions of EBM were obtained by first carrying out a comprehensive compilation and analysis of EBM publications covering academic, government and NGO sources across a wide range of applications. That component of the research involved selecting specific publications that (i) define EBM through a clear list of principles, (ii) take an inclusive perspective of EBM, acknowledging interconnections among ecological, social and governance systems, and (iii) are seen to have a high level of credibility, based on citations and related factors (Long *et al.* 2015).

Using these criteria, 13 publications were chosen for further analysis. These were based on a variety of EBM applications and included those oriented towards general implementation, those focusing specifically on terrestrial or on marine environments, and those taking a sector-specific approach (forestry and fisheries). The EBM principles from each publication were extracted, compiled and synthesized into a comprehensive list of 26 EBM principles. Finally, principles were deemed to be 'key principles' of EBM if they appeared in the majority of the selected publications. This synthesis produced a set of 15 key principles of EBM that, from a conceptual/theoretical/institutional perspective, are considered as necessary for successful implementation. The identification of these key principles enabled the development of an inclusive definition of EBM (Long *et al.* 2015):

*'Ecosystem-based management is an interdisciplinary approach that balances ecological, social and governance principles at appropriate temporal and spatial scales in a distinct geographical area to achieve sustainable resource use. Scientific knowledge and effective monitoring are used to acknowledge the connections, integrity and biodiversity within an ecosystem along with its dynamic nature and associated uncertainties. EBM recognises coupled social–*

*ecological systems with stakeholders involved in an integrated and adaptive management process where decisions reflect societal choice'.*

Further details regarding the methods and analysis are provided in Long *et al.* (2015).

### Assessing fishermen's preferences among EBM principles and priorities for EBM

The second data set focuses on how fishermen set priorities among the EBM principles found in the literature. This was determined through a face-to-face survey in the Bay of Fundy region of Canada's Atlantic coast, a region in which coastal communities depend heavily on fisheries, have a long history of fishing and have a strong connection with their local environment.

To provide a diversity of fishery and ecosystem situations, fishermen were interviewed from six different fishery units, comprising three types of fisheries – the soft shell clam (*Mya arenaria*, Myidae), Atlantic lobster (*Homarus americanus*, Nephropidae) and groundfish fisheries – in two geographical areas, on each side of the Bay of Fundy (i.e. south-west Nova Scotia and south-west New Brunswick). While these six fishery units are all subject to the management system of the Canadian government, which has committed to following EBM (Stephenson 2012), they differ ecologically, in their harvesting methods and management structure and in the status of the fishery (abundance and economic importance). Therefore, the results obtained here reflect a range of fishery realities, albeit within a specific geographical region.

Interviews were conducted with 23 fishermen recommended by local fishing organizations as knowledgeable and/or active in local fisheries management initiatives. Further details on the methodology for this survey process are provided in Appendix 1. Fishermen were first asked a series of questions about the fisheries that broadly relate to the EBM principles identified in the literature, but these questions were posed without mentioning the term EBM, to avoid bias. From the responses, a list was compiled of management-related issues raised by the fishermen. Following this, fishermen were asked to express their priorities among the list of EBM principles derived from the literature (as discussed above) by (i) rating the importance of each of those EBM principles on a

scale of 0–4 (ranging from not important to extremely important) and (ii) listing the five EBM principles they consider most important. The list of management issues derived from the first portion of the interview was subsequently correlated with the fishermen's priorities identified in the latter part of the interview to provide context surrounding what was driving the fishermen to select their priorities among the EBM principles. Therefore, in the following section, the fishermen's priorities will be discussed first followed by the fishery management issues connected to each of the priorities.

## Results and discussion

### Conceptual/theoretical/institutional priorities among EBM principles

The analysis of key literature on EBM, discussed above and reported more fully in Long *et al.* (2015), resulted in a set of 15 key principles (Fig. 1) – those principles appearing most frequently in that literature. The most important, based on the frequency of occurrence, were *Ecosystem Connections*, *Appropriate Spatial & Temporal Scales*, *Adaptive Management*, *Use of Scientific Knowledge*, *Stakeholder Involvement* and *Integrated Management*.

Most of the key principles of EBM identified were present consistently across the selected EBM publications and over time. Indeed, ten of the 15 key principles were present in the earliest selected

publication (Grumbine 1994). A comparison of the key principles with those listed in early works on EBM indicates similarly that most of the principles were in fact considered from the beginning in the EBM literature. On the other hand, some principles that were not among the most frequently chosen are in fact being selected increasingly over time – these include *Consider Cumulative Impacts*, *Apply the Precautionary Approach* and *Explicitly Acknowledge Trade-Offs* which accordingly may emerge as key principles in the future.

### Fishermen's priorities among EBM principles

For each EBM principle identified from the literature (Long *et al.* 2015), Table 1 shows the mean and standard deviation of its relative importance (on a scale from 0 to 4), as seen by fishermen. No principles were rated particularly low. With all average ratings of importance lying between 2.5 and 4, even the lowest lies in a range of medium-to-high importance. This indicates that either (i) the fishermen felt that all of the EBM principles derived from the literature, when rated individually, were reasonably important or (ii) alternatively, they were unwilling to state that any principle was considerably less important than others.

The second request to the fishermen, to list their five most important among the EBM principles derived from the literature, provided greater differentiation among the principles, in terms of their perceived importance. Accordingly, those principles most frequently selected in this second process were deemed to be the fishermen's priorities. These priorities are clear (Table 1), as there is a strong dividing line between those principles most frequently selected and the others. The four EBM principles that can be considered the fishermen's priorities, based on this process, are (listed in descending order of frequency): *Sustainability*, *Develop Long-Term Objectives*, *Stakeholder Involvement* and *Use of All Forms of Knowledge*.

These priorities are reflected fairly well across all three types of fisheries (with a slightly greater weight from the lobster fishermen being due to a higher proportion of that group having been interviewed). Note that although the definition of each principle was provided, the fishermen would have, in any case, recognized and related to the widely publicized term *Sustainability*, more so than some of the other EBM principles; this may in part



**Figure 1** The key principles of EBM as derived from the theoretical/conceptual/institutional EBM literature. (Long *et al.* 2015).

**Table 1** For each EBM principle, the frequency with which fishermen in the Bay of Fundy, Canada, considered that principle as being among the five most important EBM principles, together with the average rating of importance of the EBM principle (averaged across all fishermen).

EBM principles	Fishermen	
	Frequency	Average rate of importance $\pm$ SD
<b>Sustainability</b>	19	3.7 $\pm$ 0.5
<b>Develop Long-Term Objectives</b>	17	3.7 $\pm$ 0.5
<b>Stakeholder Involvement</b>	11	3.7 $\pm$ 0.5
<b>Use of All Forms of Knowledge</b>	9	3.7 $\pm$ 0.6
Use of Incentives	5	2.8 $\pm$ 1.3
Consider Economic Context	4	2.7 $\pm$ 1.2
Acknowledge Uncertainty	4	3.2 $\pm$ 0.8
Appropriate Monitoring	4	3.0 $\pm$ 0.8
Use of Scientific Knowledge	4	3.4 $\pm$ 0.7
Ecological Integrity & Biodiversity	4	3.4 $\pm$ 1.0
Apply the Precautionary Approach	3	3.4 $\pm$ 0.7
Adaptive Management	3	3.5 $\pm$ 0.6
Recognise Coupled Social–Ecological systems	3	3.7 $\pm$ 0.5
Consider Effects on Adjacent Ecosystems	3	2.7 $\pm$ 1.0
Acknowledge Ecosystem Resilience	3	3.2 $\pm$ 0.9
Consider Ecosystem Connections	3	3.4 $\pm$ 0.7
Organizational Change	2	3.2 $\pm$ 1.1
Decisions reflect Societal Choice	2	3.5 $\pm$ 0.8
Appropriate Spatial & Temporal Scales	2	3.1 $\pm$ 1.2
Explicitly Acknowledge Trade-Offs	1	3.3 $\pm$ 0.7
Interdisciplinarity	1	3.5 $\pm$ 0.5
Integrated Management	1	3.1 $\pm$ 0.9
Commit to Principles of Equity	1	3.4 $\pm$ 0.6
Account for Dynamic Nature of Ecosystems	1	3.2 $\pm$ 0.9
Consider Cumulative Impacts	0	3.3 $\pm$ 0.7
Distinct Boundaries	0	3.0 $\pm$ 0.6

From the frequency analysis, the EBM principles shown in bold clearly reflect the fishermen's top priorities.

account for it being selected more often as a priority.

#### A comparison of priorities among EBM principles

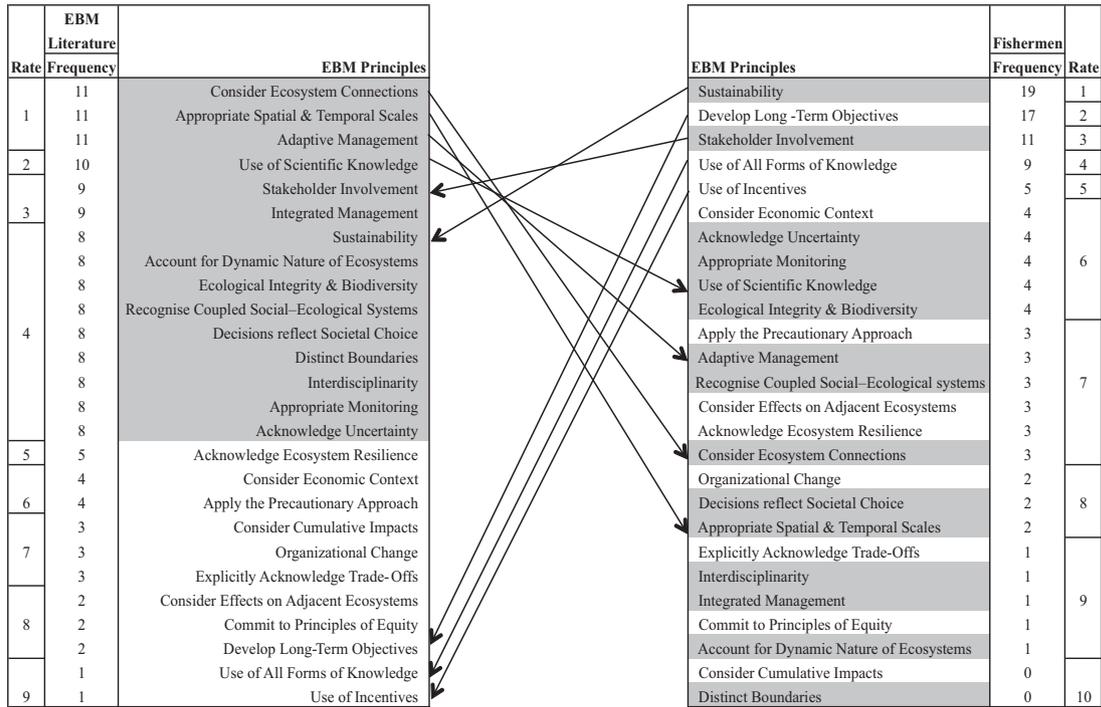
The fishermen's priorities, which they chose from among the EBM principles found in the literature,

were compared to the corresponding priorities in the literature itself (see Long *et al.* 2015). Figure 2 shows the two lists of EBM principles, from the fishermen and from the literature, with the first organized in descending frequency according to prevalence in the literature, and the second, in descending frequency based on prevalence among the fishermen's sets of the five most important EBM principles. It is clear that there is a distinct difference between the priorities among EBM principles based on the literature versus those of the fishermen.

Many of the EBM principles that rated highly in the published literature were rated much lower by the fishermen, and vice versa. Specifically, five of the principles arising with high frequency in the literature— *Consider Ecosystem Connections, Appropriate Spatial & Temporal Scales, Adaptive Management, Use of Scientific Knowledge* and *Integrated Management* – were of relatively lower priority for the fishermen. On the other hand, two principles noted above as the highest priorities for fishermen – *Develop Long-Term Objectives* and *Use of All Forms of Knowledge* – together with the fairly highly rated *Use of Incentives*, were at the very bottom of the importance ratings based on the EBM literature (albeit present in some of the selected literature). The only exceptions to the divergence of the two sets of priorities were (i) *Stakeholder Involvement*, which rated highly in both data sets, and (ii) *Sustainability*, which was top-rated by fishermen and rated fairly high in the literature as well.

#### Issues driving fishermen's EBM priorities

To further explore the factors influencing fishermen's priorities among the EBM principles, each of the priorities identified by fishermen was linked to the fishery management issues they raised earlier in interviews. This provides real-world context concerning the fishermen's choice of priorities among the EBM principles derived from the literature, by determining the driving issues underlying the choices, and indicating which EBM principles may have the greatest potential to address management issues of concern to the fishermen. The focus here is on the four highest priority EBM principles, as seen by the fishermen, as well as one other (*Commit to Principles of Equity*) that can be inferred to be important from its prevalence in their responses. The fishery management issues



**Figure 2** A cross comparison of the importance of EBM principles according to (1) the frequency of publication in the theoretical/conceptual/institutional EBM literature and (2) those chosen by fishermen as being among the five most important EBM principles. The shaded EBM principles represent the key principles of EBM, as derived from the literature, in Long et al. (2015).

connected to these EBM principles, and their context in the Bay of Fundy, are discussed below.

*Sustainability*

This broad EBM principle was most connected to local issues, of all the fishermen’s priority principles, with several management issues closely linked with *Sustainability*. In particular, resource abundance was a frequently raised management issue by fishermen in connection with *Sustainability*, with a majority (52%) of fishermen specifically referencing the lack of groundfish species such as cod and pollock, which have faced a serious decline in abundance and landings in Atlantic Canada (Fisheries Resource Conservation Council 2011). Fishermen described needing to travel farther than previously to catch their groundfish quota, which increases expenses at the same time as declines in quotas reduce revenues. Concerns about overfishing spanned all fisheries, with fishermen often feeling (26%) that certain geographical areas are being overfished. Most lobster fishermen (60%) were concerned about a lack of incentives for local areas to implement their own

conservation initiatives, when such efforts made in a given area allow others to reap the benefits. The use of destructive fishing methods, such as fish trawlers, was a major issue expressed by 30% of individuals, predominantly groundfish fishermen, as they feel this contributes to habitat loss and the capture of excessive by-catch. In terms of economic sustainability, low catch price was discussed by 39% of the fishermen as an issue in both the soft shell clam and lobster fishery, with soft shell clam harvesters also suffering from access issues, as raised by 86% of individuals.

*Develop Long-Term Objectives*

Making decisions for the future rather than focussing on short-term gain is considered a strong priority among the fishermen. A very clear illustration of this arose in relation to concerns expressed by 61% of the fishermen about aquaculture (salmon farming, in this case) threatening the commercial fishery through impacts on wild populations. Fishermen felt that the government focuses on the initial economic gain of the aquaculture industry rather than undertaking a proper

evaluation of long-term impacts, and expressed concerns about poor understanding on the part of the public and of some other fishermen. They felt that aquaculture and other coastal development projects have been approved because the public does not 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 individuals (22%), including lobster fishermen as well as soft shell clam harvesters, felt that the government was ignoring the future consequences of some decisions on surrounding coastal communities. This emphasis on long-term sustainability is consistent with, for example, the development by industry of a voluntary Canadian Code of Conduct for Responsible Fishing Operations (ref [http://www.dfo-mpo.gc.ca/international/media/bk\\_fao-eng.htm](http://www.dfo-mpo.gc.ca/international/media/bk_fao-eng.htm)).

#### *Stakeholder Involvement*

Fishermen often noted concerns with lack of effective participation in decision-making. The local importance of fishery livelihoods justifies *Stakeholder Involvement* as a key principle, in providing the ability to participate in shaping of the future of the fisheries (e.g. Kearney *et al.* 2007; Pinkerton 2009). Individuals (39%) across the soft shell clam, lobster and groundfish fisheries felt that the government is not listening to fishermen, and similarly, 67% of groundfish fishermen suggested that consultations with fishermen create an 'illusion of participation' and that their input was not included in the actual decision-making process. The lack of effective participation in fisheries management or in forging the future of the fishery has sparked interest in all the fisheries in having more management control at the local level. Despite this desire to take part in management, there were many factors noted that prevent local stakeholder participation, including poor organization among lobster fishermen and poor attendance of fishermen at meetings in the lobster and groundfish fisheries.

#### *Use of All Forms of Knowledge*

Fishermen are well aware that they hold a great deal of knowledge regarding the local fishing environment and the species that thrive in it, and feel that this knowledge has the ability to greatly contribute to fisheries management and therefore should be used to inform local management decisions. Identification of this topic is consistent with

recent work on fishermen's knowledge research, participatory research and governance (Wiber *et al.* 2004; Stephenson *et al.* 2016). An issue raised by fishermen in this study (26%) is that the current use of science in fisheries management often fails to reflect what fishermen are seeing. In particular, 30% of the lobster fishermen felt strongly about having fishermen's knowledge brought to the table to create a more well-rounded perspective. One fisherman said that 'local fishing knowledge should be number one priority when looking to change the oceans that we work on'. Related to this were concerns (1) by 33% of groundfish fishermen, who noted the gap created by science when it is in a language that the fishermen cannot relate to or fully understand, and (2) by lobster fishermen, who felt that there is not enough science or funding to support new research initiatives (30%) and that the science that management decisions are based on is outdated and inadequate for this most lucrative fishery in Canada (40%).

#### *Commit to Principles of Equity*

A number of issues frequently raised by the fishermen did not relate directly to any of the above four fishermen's priorities among the EBM principles. However, there are clear connections between these issues and the less frequently noted principle *Commit to Principles of Equity*. While only a single fisherman selected this EBM principle as a priority, many management issues brought forward by the fishermen link closely to it. This included frequent concerns about the dominance of large companies both in the fishery itself and in corresponding management decisions. One fisherman said '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'. Fishermen also felt that decisions with a large impact on the future of the industry are controlled by large fish trawlers and aquaculture companies (26 and 39%, respectively), and those in the soft shell clam and lobster fisheries specifically felt that buyers had too much control over the price paid to the fishermen. Another equity issue, particularly relevant to lobster fishermen, is a concern (raised by 50% of individuals) that the long-standing focus of their fishery on owner-operator fishermen will be lost, as a result of a policy shift in that fishery leading to greater concentration of control among

fewer fishery participants. The high frequency with which these equity-related management issues were raised by fishermen, and the strength of the concerns, suggests that even though the EBM principle *Commit to Principles of Equity* was not rated highly by fishermen, it is implicitly a priority of fishermen.

## Conclusion

This article has addressed the dual problems of inconsistency among formal definitions of EBM and a lack of knowledge of how EBM principles are viewed 'on the ground' within fisheries themselves. The latter particularly concerns differences between the priorities among underlying principles of EBM, as reflected in the literature, and those favoured by fishermen. Such differences were examined through a systematic comparison of the principles underlying EBM, on the one hand as seen in the conceptual, theoretical and institutional literature, and on the other hand, based on fishermen's perspectives. The first set of principles was derived from a systematic analysis of the literature, used to deduce a set of the most widely accepted core principles. The second set of principles reflects an assessment of the fishermen's perspective of the most important among the EBM principles derived from the literature. The specific results for the latter set of EBM principles, obtained for a set of fisheries on the Atlantic coast of Canada, do not necessarily apply to other places, or to the fishing industry as a whole, but the comparative methodology used here could be applied equally well in other settings.

As a key result, while the elements of EBM from the literature were all important to fishermen, the priority EBM principles of the fishermen proved to be very different from the priorities found in the literature. Of the four EBM principles that stood out as the fishermen's priorities – *Sustainability*, *Develop Long-Term Objectives*, *Stakeholder Involvement* and *Use of All Forms of Knowledge*, two of these (*Develop Long-Term Objectives* and *Use of All Forms of Knowledge*) were overlooked in most of the literature. In contrast, some major principles in the literature did not resonate as much with the fishermen.

The article also analyses how the fishermen's major EBM principles relate to fishery management issues identified by fishermen themselves. This connection indicates that application of

suitable EBM principles may be useful in resolving the management issues raised by the fishermen. An important point arising from the analysis was the close connection of several issues raised by fishermen to the EBM principle *Commit to Principles of Equity*, despite this principle not being explicitly highlighted as a priority by the fishermen. Accordingly, we concluded that equity, as an EBM principle, was indirectly a priority of the fishermen, one needing to be better acknowledged.

Among the selected literature analysed in this research, there was only one publication – the United Nations Convention on Biological Diversity's Ecosystem Approach (Vierros 2008) – that acknowledged all five of the fishermen's (explicit and implicit) priorities. The fact that the majority of the literature examined did not connect so closely with fishermen priorities indicates significant differences between conceptual, theoretical and institutional approaches to EBM, on the one hand, and the priorities of the fishermen, on the other.

The key result of this article – that the most important principles of EBM, from the fishermen's perspective, can differ greatly from those in the EBM literature – has practical implications, as a better recognition by management players of fishermen's priorities, among EBM principles, may well generate greater on-the-ground support and thereby aid EBM implementation. Moreover, fishermen need to be included in the process from the beginning, by bringing their expertise and perspectives, in addition to academic and institutional analyses, to bear on the selection of appropriate EBM principles, so as to include major EBM principles from both perspectives. These vital steps in the implementation process could be accomplished, for example, by replicating the approach used here. This can form the grounding for a suitable EBM implementation framework, such as Fletcher *et al.*'s (2010) ecosystem-based fisheries management process, tailoring specific objectives for each principle to the local needs and context.

Three other points should be raised regarding implementation. First, EBM must be incorporated appropriately into governance arrangements, whether in relation to biodiversity conservation or to natural resource management (e.g. Garcia *et al.* 2014). Much has been written about the importance of shared objectives and participatory processes (e.g. Kooiman *et al.* 2005; Mahon *et al.* 2011). Second, EBM frameworks must be suitably compatible and responsive to multiple spatial and

organizational scales, while ensuring a role for fishermen across scales. Third, it is important to understand how specific fishery management issues influence or impede the application of EBM. An examination of connections between such issues and the fishermen's priorities among EBM principles, as carried out here, leads to a greater understanding of challenges that stand in the way of the successful implementation of EBM. Overall, acknowledging the EBM priorities of those 'on the ground' in a fishery system will help to bridge the gap between theory and practice and move towards the successful implementation of EBM.

### Acknowledgements

We would like to thank all the fishermen who participated in this research, as well as Fundy North Fisherman's Association, Grand Manan Fishermen's Association, Eastern Charlotte Waterways Inc., Maritime Fishermen's Union, Bay of Fundy Inshore Fishermen's Association and Digby County Clam Digger's Association. The research reported herein benefited from a series of discussions held through the Canadian Fisheries Research Network. Funding support is acknowledged from the Natural Sciences and Engineering Research Council of Canada, and the Social Sciences and Humanities Research Council of Canada.

### References

- Bianchi, G. (2008) Chapter 2: The concept of the ecosystem approach to fisheries in FAO. In: *The Ecosystem Approach to Fisheries*. (eds G. Bianchi and H.R. Skjoldal). CAB International, Oxfordshire, UK, pp. 20–38.
- Charles, A. (2014) Chapter 3: Human dimensions in marine ecosystem-based management. In: *The Sea* (Volume 16, eds Fogarty, M.J. and McCarthy, J.J.), Harvard University Press, Cambridge, USA, pp. 57–75.
- Coffey, A. and Atkinson, P. (1996) Chapter 2: Concepts and coding. *Making Sense of Qualitative Data: Complementary Research Strategies*. SAGE Publications Inc., London, UK, pp. 27–53.
- Crain, C.M., Halpern, B.S., Beck, M.W. and Kappel, C.V. (2009) Understanding and managing human threats to the coastal marine environment. *Conservation Biology* **1162**, 39–62.
- De Young, C., Charles, A. and Hjort, A. (2008) *Human Dimensions of the Ecosystem Approach to Fisheries: An Overview of Context, Concepts, Tools and Methods*. Fisheries Technical Paper No. 489.
- FAO (2008) *The State of the World Fisheries and Aquaculture*. Available at: <http://www.fao.org/docrep/011/i0250e/i0250e00.htm> (accessed 24 June 2016).
- FAO (2012) *The State of the World Fisheries and Aquaculture*. Available at: <http://www.fao.org/docrep/016/i2727e/i2727e00.htm> (accessed 24 June 2016).
- Fisheries Resource Conservation Council (2011) *Towards Recovered and Sustainable Groundfish Fisheries in Eastern Canada*. Fisheries Resource Conservation Council. Available at: <http://www.oceansadvance.net/sites/default/files/FRCC2011.pdf> (accessed 24 June 2016).
- Fletcher, W.J., Shaw, J., Metcalf, S.J. and Gaughan, D.J. (2010) An ecosystem based fisheries management framework: the efficient, regional-level planning tool for management agencies. *Marine Policy* **34**, 1226–1238.
- Garcia, S.M. and Cochrane, K.L. (2009) Chapter 17: From past management to future governance: a perspective view. In: *A Fishery Manager's Guidebook*, 2nd edn. (eds K.L. Cochrane and S.M. Garcia). Blackwell Publishing and FAO, Oxford, UK, pp. 447–472.
- Garcia, S.M., Rice, J. and Charles, A. (2014) *Governance of Marine Fisheries and Biodiversity Conservation: Interaction and Co-evolution*. Wiley-Blackwell, Oxford, UK, 552p.
- Grumbine, R.E. (1994) What is ecosystem management? *Conservation Biology* **8**, 27–38.
- Kearney, J., Berkes, F., Charles, A., Pinkerton, E. and Wiber, M. (2007) The role of participatory governance and community-based management in integrated coastal and ocean management in Canada. *Coastal Management* **35**, 79–104.
- Kooiman, J., Bavink, M., Jentoft, S. and Pullin, R. (2005) *Fish for Life: Interactive Governance for Fisheries*. MARE Publication Series No. 3. Amsterdam University Press, Amsterdam, Netherlands, 427p.
- Long, R.D., Charles, A. and Stephenson, R.L. (2015) Key principles of marine ecosystem-based management. *Marine Policy* **57**, 53–60.
- Mackinson, S., Wilson, D.C., Galiay, P. and Deas, B. (2011) Engaging stakeholders in fisheries and marine research. *Marine Policy* **35**, 18–24.
- Mahon, R., Fanning, L. and McConney, P. (2011) Chapter 2: Principled ocean governance for the wider Caribbean region. In: *Towards Marine Ecosystem-Based Management in the Wider Caribbean*. MARE Publication Series No. 6. (eds L. Fanning, R. Mahon and P. McConney). Amsterdam University Press, Amsterdam, Netherlands, pp. 13–16.
- Morishita, J. (2008) What is the ecosystem approach to fisheries management? *Marine Policy* **32**, 19–26.
- Pikitch, E.K., Santora, C., Babcock, E.A., Bakun, A. and Bonfil, R. (2004) Ecosystem-based fishery management. *Science* **305**, 346–347.
- Pinkerton, E. (2009) Coastal marine systems: conserving fish and sustaining community livelihoods with co-management. In: *Principles of Ecosystem Stewardship*

- (eds C. Folke, G.P. Kofinas and F.S. Chapin). Springer, New York, NY, pp. 241–257.
- Stephenson, R.L. (2012) A perspective on advancing ecosystem research for the Gulf of Maine. In: *Advancing an Ecosystem Approach in the Gulf of Maine*. (eds R.L. Stephenson, J.H. Annala, J.A. Runge and M. Hall-Arber). American Fisheries Society, Symposium 79, Bethesda, Maryland, pp.1–pp.7.
- Stephenson, R.L., Paul, S., Pastoors, M.A. et al. (2016) Integrating fishers' knowledge research in science and management. *ICES Journal of Marine Science*. doi:10.1093/icesjms/fsw025.
- Strauss, A. and Corbin, J. (1990) Chapter 6: Techniques for enhancing theoretical sensitivity. *Basics of Qualitative Research: Grounded Theory Procedures and Techniques*. SAGE Publications Inc., London, UK, pp. 75–95.
- Vierros, M. (2008) Chapter 3: The ecosystem approach of the convention on biological diversity. In: *The Ecosystem Approach to Fisheries*. (eds Bianchi, G. and Skjoldal, H.R.). CABI, Oxfordshire, UK, pp. 39–46.
- Ward, T., Tarte, D., Hegerl, E. and Short, K. (2002) *Policy Proposals and Operational Guidance for Ecosystem-Based Management of Marine Capture Fisheries*. WWF, Sydney, Australia, 80p.
- Wiber, M., Berkes, F., Charles, A. and Kearney, J. (2004) Participatory research supporting community-based fishery management. *Marine Policy* **28**, 459–468.

## Appendix 1. Survey Methodology

For each fishery, in each area, local fishing organizations were asked to recommend fishermen who were knowledgeable and/or active in local management, to participate in a face-to-face survey. The fishermen interviewed came 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. The 23 interviews included participation from five lobster fishermen and three groundfish fishermen in each of the two study areas, as well as four soft shell clam harvesters in south-west Nova Scotia and three in south-west

New Brunswick. Each fisherman was asked to discuss the management of just one of the selected fisheries, regardless of whether the individual participates in multiple fisheries selected for the study. This focused each response on a single fishery and allowed for a more in-depth interview. Although selecting fishermen participants through organizations may have created a potential bias, as not all fishermen are members of these organizations, this approach provided greater assurance that the selected individuals were knowledgeable about fishery management considerations.

Each EBM principle was described one at a time, without stating the name of the principle, and the participants were not shown the list of principles as a whole – this therefore provided an evaluation of the importance of each principle on a standalone basis. After each EBM principle was rated, 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 (without reference to their previous one-by-one rating of the principles).

The frequency with which each management issue was raised by each individual fisherman was determined from the survey results. To set comparable limits on these frequencies, across fishermen, each issue could be counted only once for each of the 15 key principles discussed, and thus could be considered a maximum of 15 times per individual. Each individual issue was allotted a code which consisted of the issue label, as well as the fishery, province, fishing organization, individual and key principle (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 area or fishery, as well as whether issues are raised multiple times by one individual or if an issue is prominent across many respondents.