Integrating stakeholder values and science in marine management

M. J. Espinosa-Romero[1], K. Chan[1], T. McDaniels[1], and D. M. Dalmer[2]

Abstract

Ecosystem-based management (EBM) has been widely recognized as the new paradigm for marine resource management. This approach considers all the elements of the ecosystem including humans. Even though, EBM has been well defined in theory, its implementation has been challenging worldwide. The few successful initiatives at implementing EBM have suggested that stakeholder involvement is a key element. For marine management, as for other common resources, discussion on management alternatives often depend on technical and complex concepts from diverse fields. Without the discussions of stakeholder values, many people and their values are often excluded from or play a minor participation in the decision making process. In addition, stakeholders might not trust the process and reject the implementation of a decision/management alternative. To implement EBM, managers require a decision-making framework in which the values of the constituents are identified since the beginning of the process, and objectives and performance measures for EBM are consistent with these values. Structured decision-making (SDM) is a systematic approach that can bring together stakeholders, scientists and managers to build a framework for EBM that reflects what matters to people and the scientific aspects of the ecosystem and EBM. I present as a case study, the use of SDM for the on-going EBM process on the west coast of Vancouver Island (WCVI), British Columbia, Canada.

Keywords: *structured decision-making, ecosystem-based management, adaptive management, indicators.*

1. INTRODUCTION

Ecosystem-based management (EBM) has been called, by national and international institutions, the new approach to managing the human activities that affect marine ecosystems (Leslie and Kinzig 2009). This approach goes beyond traditional management based on single species and single sectors (Leslie and McLeod 2007) and recognizes deep connectivity amongst all elements of the ecosystem—including humans (McLeod et al. 2005)—and the underlying processes of producing the services people need and want (Arkema, Abramson, and Dewsbury 2006; Guerry 2005). It is place-based and requires a coordinated effort to sustainably manage the human activities that impact ecosystems (Lubchenco and Sutley 2010; Guerry 2005; Leslie and McLeod 2007). This approach represents an opportunity to manage marine ecosystems, where overexploitation, pollution and social conflicts are often presented.

[1] Institute of Resource, Environment and Sustainability, University of British Columbia, 2202 Main Mall, Vancouver, British Columbia, Canada, V6T1Z4
[2] West Coast Aquatic, 3-4310 10th Avenue, Port Alberni, BC, V9Y4X4

Although there have been various efforts to define the key aspects, principles and guidelines (McLeod et al. 2005; Leslie and McLeod 2007; Lester et al. 2010) of what ecosystem based management (EBM) is and requires, there is still a gap between theory and practice (Arkema, Abramson, and Dewsbury 2006; Lester et al. 2010; Ruckelshaus et al. 2008). Managers face political, legal, social and scientific difficulties in implementing the complex concepts of EBM, which has come to be seen as daunting and expensive (Arkema, Abramson, and Dewsbury 2006; Tallis et al. 2010; Lester et al. 2010).

More science will not necessarily lead to the implementation of EBM (Lester et al. 2010). This is reflected in research studies, which argue that the main challenges for the implementation of EBM include building a collective vision and objectives for EBM, designing metrics to evaluate the accomplishment of the objectives and creating ocean governance frameworks (Leslie and McLeod 2007), as well as bridging the gap between scientific concepts and operational goals (Arkema et al. 2006). Successful initiatives aimed at implementing EBM (e.g,, Great Barrier Reef in Australia, Puget Sound in United States, and Raja Ampat in Indonesia) show that meaningful involvement of stakeholders in the definition of objectives and in monitoring processes have been key elements for success (Arkema, Abramson, and Dewsbury 2006; Tallis et al. 2010). Put differently, environmental management is never an exclusively science-based undertaking. Human values, articulated and pursued within appropriate governance processes, are at the heart of why EBM is important and they define what EBM should achieve (Gregory et al. 2006).

Because management is the process of making decisions (Walters and Martell 2004), the implementation of EBM requires a participatory and systematic framework to identify the values of the constituents with respect to EBM and to make decisions that best satisfy those values. This framework would help managers anticipate and address the concerns of stakeholders and make more informed decisions about the use of natural resources (Gregory, McDaniels, and Fields 2001). In addition, if stakeholders see their values reflected they are more likely to trust the process and/or support its implementation (Gregory, McDaniels, and Fields 2001).

1.1 The need to improve decision-making processes

We suggest using structured decision-making (SDM) as it provides a systematic process that can help stakeholders and managers construct this framework based on the values of the participants, which can be used to create, evaluate and select between alternatives (McDaniels 2000). Since it is a well-explored field for multiple stakeholder planning processes, it provides methodologies and approaches for each stage of the process.

We summarize the SDM process below and present the case study of West Coast Aquatic (WCA)—a multiple-stakeholder regional management board that is using the SDM approach to implement EBM on the west coast of Vancouver Island (WCVI), British Columbia, Canada. Specifically, we give insights on how to define operational

objectives that reflect the values of the constituents and how to derive indicators based on those objectives so as to facilitate the process of decision-making within an EBM context.

1.2 The SDM process

The first step is to define the decision to be made (McDaniels 2000). For this context, the decision represents the design of a decision-making framework for EBM. The second step is to identify what matters to stakeholders in the EBM context, as well as the objectives that need to be achieved (see McDaniels 2000; Keeney 1996d). Generally, a list of wants, desires, and concerns that reflect stakeholder values and their collective vision on a particular issue is derived at this stage. This list needs to be categorized to identify the collective objectives (McDaniels 2000).

Subsequently, objectives are separated into fundamental and means objectives. Fundamental or end objectives are those that are important because they directly reflect the values of the participants, while means objectives are those that are important because they contribute to the achievement of fundamental objectives (Clemen and Reilly 2001). Fundamental objectives should be identified to guide decision-making (Keeney 1996b). When means objectives are mistaken for end objectives, the risks are that management may achieve means objectives in a manner that fails to achieve the end objectives.

The next step is to define the attributes for each fundamental objective. The attributes represent the meanings or the context in which the fundamental objectives are perceived (Failing and Gregory 2003). Achieving a collective and clear articulation of attributes is essential to define appropriate indicators for the fundamental objectives (Failing and Gregory 2003).

Subsequently, performance measures or indicators are defined. The importance of measuring the achievement of EBM objectives through the use of indicators has been widely recognized (Guerry 2005; Tallis et al. 2010) and great efforts have been made to define multiple indicators for ecosystem conservation, not all of which are useful for decision makers, and which collectively may not reflect stakeholder values (Failing and Gregory 2003). In a SDM approach, the only indicators that are selected are those based on the attributes of fundamental objectives. In the case of EBM, communication between stakeholders and scientists is essential to identify indicators that reflect what matters and also how the ecosystems work.

Once indicators are defined, the following step is to create alternatives based on fundamental objectives and then evaluate the performance of alternatives based on the selected indicators. The identification of fundamental objectives and attributes often spurs participants to create more innovative alternatives that better satisfy the full range of objectives (Gregory, McDaniels, and Fields 2001).

Choosing between alternatives involves tradeoffs. A key strength of SDM is that such tradeoffs are made explicit and stakeholders are able to understand what tradeoffs each

alternative entails. Stakeholders often end up choosing amongst only a small set of alternatives, as those that poorly satisfy the objectives are quickly eliminated. When there is disagreement on a group's preferred alternative, stakeholders could be asked to choose their preferred alternative, and then present the reasons for choosing it, as well as the expected winners, losers, pros and cons (Gregory, McDaniels, and Fields 2001). After this, stakeholders will likely be more amenable to agree on a preferred alternative. If they do not, the whole SDM process can nonetheless provide managers with good insights about the advantages and disadvantages of each alternative (Gregory, McDaniels, and Fields 2001).

SDM can also help managers address situations as they come and identify decision opportunities to better satisfy the objectives (Keeney 1996c).

1.3 Considerations for the implementation of SDM for EBM

When organizations or multiple stakeholder groups have already defined their initial set of objectives to achieve EBM, these objectives should be revised to ensure that they reflect the values of the participants and that they are clearly articulated to guide decision-making. It will be also essential to verify with stakeholders the attributes of each fundamental objective to define appropriate indicators for the objectives. If objectives are not appropriate, well-defined, and well thought out, decisions may not satisfy the fundamental objectives regardless of the rest of the process (Keeney 1996a).

1.4 Case study: The EBM initiative on the WCVI

The WCVI is a large and diverse area that supports multiple human activities such as commercial, recreational and subsistence fisheries, aquaculture, tourism and transportation (Gislason 2007). Therefore, diverse and conflicting objectives characterize the use of the natural resources in the area.

WCA is a forum for coastal communities and those affected by marine management decisions to participate in the decision-making process for managing the area (WCA 2001). Members of the WCA include Federal, Provincial, Local and First Nations governments, representatives of commercial and recreational fisheries, the aquaculture and tourism industries, and conservation organizations, among others (WCA 2006). The ethical principles under which WCA operates include an ecosystem-based approach to management, conservation, precaution, adaptivity, sustainability, shared responsibility, inclusivity, benefits, and flexibility (WCA 2009).

WCA has initiated a marine planning process with an EBM approach. WCA has already defined eight objectives that reflect both "what matters" and "what EBM entails" to the stakeholders as well as the goals and sub-goals required to achieve the eight main objectives.

The eight objectives are as follows: (1) integration and collaboration; (2) sustainable economic benefits; (3) healthy ecosystems; (4) healthy, prosperous and safe communities and waterways; (5) First Nations, reconciliation and relationships-

strengthening; (6) collection of knowledge, information and technology; (7) capacity building; and (8) good governance (WCA 2009).

2. METHODS

We applied SDM to WCA marine planning process to help them design a decision-making framework for EBM. The original set of objectives defined by WCA (Table 1) involved important aspects for EBM; however, they were stated in a complex way, making their use for decision-making very difficult. We therefore review them and suggest how to re-structure them in an operational way without losing or distorting their intended meanings.

We separated fundamental from means objectives, using the "why each objective is important" test defined by Clemen and Reily (2001). When an objective was important because it contributed to the achievement of another objective, we defined that objective as a means objective. When an objective was important because it represented WCA values we defined it as a fundamental objective.

We looked at the goals and sub-goals documents (see WCA 2009) to identify the intended attributes of each of the eight objectives. Attributes usually appeared in more than one objective or were stated as fundamental objectives, this often occurs because stakeholders strive to elevate particular interests as much as possible in the objectives. The result is that operationalizing the objectives is very difficult. Therefore, we combined any attributes with the same meaning, and moved any attributes that better fit with other fundamental objectives to those respective objectives. For objectives that were broadly described, we suggested attributes based on a literature review and other case studies that expressed similar objectives.

We suggested indicators for the attributes of fundamental objectives. For attributes that were not informative for measures, such as 'vibrancy' of communities, we reviewed the indicators used in other case studies to measure those attributes.

One of us (DMD) is the Executive Director of WCA and was involved in the process of defining the initial set of objectives. This helped to ensure that the new structure reflected WCA original values, and that indicators were appropriate and meaningful to them.

3. RESULTS

From the list of eight main objectives defined by WCA for their marine planning process, four were considered fundamental objectives: (a) foster economic benefits; (b) foster healthy ecosystems; (c) foster healthy communities; and (d) foster good governance.

Adaptive management (AM) was included as a fifth fundamental objective. It was part of one fundamental objective ("healthy ecosystems"), but from conversations with WCA it was agreed to include it as a separate objective due to its importance for the whole

process rather than only for that particular fundamental objective, and because it represents an ethical principle for WCA.

Three of the eight original objectives—'integration and collaboration', 'knowledge, information and technology', and 'capacity building, engagement and communications'—were identified as *means* objectives, as their importance relies on their contribution to the fundamental objectives.

Three attributes of the 'integration and collaboration' objective (i.e. shared responsibilities, collaboration with other plans, and participatory management) were re-identified as falling under the fundamental objective of 'good governance'.

All attributes of the last objective 'First Nations reconciliation and relationships strengthening' proved to fit within other fundamental objectives. We thus ensured these attributes were made explicit within the other fundamental objectives. For example, 'respect aboriginal and treaty rights' was re-grouped within 'healthy communities'; and 'participation in decision-making' was grouped under 'participatory management' as part of the 'good governance' objective.

Below, we describe the new structure (Table 2) of fundamental objectives, attributes, and suggested indicators.

3.1 Framework for EBM: Fundamental objectives, attributes and indicators

3.1.1 Foster economic benefits

This objective includes generating benefits derived from the ecosystem and their fair distribution across present and future generations. Benefits can include profits and employment, but also the goods or services themselves, because trading is a traditional practice in the region. The retention of benefits by local communities, specifically First Nations, was stated twice in the original document of objectives, goals and sub-goals, and also emphasized in WCA planning process.

a) Suggested indicators

A commonly used indicator for profits is the net present value—aggregated benefits minus aggregated costs, discounted over time. Discount rates are applied to estimate the present value of future revenues or costs; and these rates can vary among individuals or social levels (Sumaila and Walters 2005). Net present value is a well-known indicator but insufficient alone, because it does not capture the distribution of benefits and costs among stakeholders (Timko and Satterfield 2008a).

Income per capita has been also used to represent benefits (McDaniels, Longstaff, and Dowlatabadi 2006; Hobbs and Horn 1997). For the case of employment, we suggest accounting for the number of skilled, unskilled, temporary and permanent jobs derived from each alternative (Timko and Satterfield 2008a; Timko and Satterfield 2008b). For the case of the goods, WCA can consider the weight in pounds or kilograms.

The proportion of these benefits and losses (in terms of net revenues, income per capita, employment, and the goods themselves) retained by each stakeholder group (adapted from Philcox 2007) over time (Timko and Satterfield 2008a; Timko and Satterfield 2008b) can help measure the distribution of benefits and losses. WCA could also measure the proportion of benefits and loss retained among local communities to evaluate if the most vulnerable groups are retaining benefits (e.g., McDaniels, Longstaff, and Dowlatabadi 2006).

3.1.2 Foster healthy ecosystems

For this objective, WCA will focus on minimize the adverse effects of human activities on the integrity of ecosystems. Based on the approach used by the Department of Fisheries and Oceans Canada (DFO) in the Eastern Scotian Shelf (DFO 2007), WCA has defined three main aspects of integrity: diversity, productivity and environmental quality. Diversity includes species, populations and communities; productivity refers to primary and secondary productivity, as well as trophic and population productivity; and marine environmental quality involves physical, chemical and habitat quality (Okey 2009 ; DFO 2007).

a) Suggested indicators

- Diversity: species, populations and communities

Species richness—number of species—within defined boundaries such as communities or habitats (Gray 1997) and evenness—distribution of species biomass—have been suggested to measure diversity. However, the composition of biological communities is also important: while species richness may show a high number of species in the region, this number may also include introduced species, which are not members of the native community and can cause negative impacts to native species and ecosystems.

Because it is very difficult to focus on all species in the community or habitat, it is necessary to select species or groups whose characteristics represent attributes of other species, the ecosystem and environmental conditions (Lindenmayer, Margules, and Botkin 2000); or groups that play an important ecologically or culturally role such as endemic species, species at risk, etc.

Endemic species for example are important because they only occur in specific places and their populations are usually small and vulnerable to extinction (Lamoreux et al. 2006). Some studies demonstrate that the conservation of sites with high levels of endemism can capture large proportions of all identified species of a region (Lamoreux et al. 2006). Species at risk, can also be useful in the sense that it highlights biodiversity components that might be lost, but this measure can also be limited because of the political process of listing, and because simple species counts are far removed from ecological integrity.

It is advisable to look at species richness and abundance across the selected groups, as well as the historical trends to evaluate if their populations are increasing, stable or declining (Tallis et al. 2010).

The mean trophic level (TL) (Pauly et al. 1998; Pauly and Watson 2005) is a well-known indicator that can be also used as a proxy for the community composition. It is calculated by assigning species to trophic levels and using information on species' catch and diet composition. The TL has been often used to indicate the impacts of fisheries (Pauly et al. 1998; Pauly and Watson 2005); however, it can be also used to analyze the trophic structure of an ecosystem by including non-target species' abundance and diet composition.
In terms of diversity, it has also been suggested to pay attention to community and habitat diversity (DFO 2007) because their conservation can ensure the conservation of species (Gray 1997).

- Productivity: primary, secondary, trophic level and population productivity.

Abundance per trophic level can be used as an indicator of the productivity at trophic level (Jamieson et al. 2001; O'Neill, Bravo, and Collier 2008) as well as for primary and secondary production. Historical catch and biomass of target species can also be used to measure productivity of species and populations (DFO 2007) and provide insights on the status (declining, stable, or decreasing) of those species.

- Marine environmental quality: physical, chemical and habitat quality

This can be accounted by evaluating the concentration of toxics in the water, sediments (DFO 2007; O'Neill, Bravo, and Collier 2008) and species (e.g., harbour seals, pelagic and benthic fish, clams, mussels and juvenile salmon) (PSP 2009) as well as the generation of noise and atmospheric pollution (DFO 2007) derived from each of the alternatives.

For habitat quality, WCA could select those habitats or communities that are important to conserve, and evaluate the potential impacts of alternatives on those habitats. This can be done by assessing the total area of 'selected' habitat impacted (e.g., Gregory, McDaniels, and Fields 2001) or by identifying the main threats for those habitats (e.g. trawlers) and the magnitude of the particular threat (e.g., number of trawlers).

3.1.3 Foster healthy communities

This objective refers to avoiding adverse effects on the health, safety and vibrancy of local communities.

Attributes for minimizing the adverse effects on health and safety can be related to people, private and public property (McDaniels, Gregory, and Fields 1999).

We include as attributes of vibrancy the 'respect of First Nations rights and title', which was part of the original objective 'First Nations reconciliation and relationships strengthening', and 'First Nations access to natural resources', which was an attribute of the 'economic benefits'. Other attributes of vibrancy include cultural practices (Timko and Satterfield 2008a; Timko and Satterfield 2008b) and aesthetics (adapted fromMcDaniels, Longstaff, and Dowlatabadi 2006).

a) Suggested indicators

Effects on human health and safety, specifically on people, private and public property can be measured by identifying risks, their magnitudes and probabilities, who (or what, in the case of private and public property) is exposed, and to what extent. This can be based on science and stakeholders' perceptions (Hobbs and Horn 1997). Illness and deaths that could be associated with marine resources—in this case those associated to the management alternatives—have been suggested as a health indicator (PSP 2009).

Indicators for the attributes of vibrancy can be measured qualitatively using constructed scales (e.g., 1 to 5; low, medium, high) to answer questions determined by WCA. Here, we suggest some questions helpful for scoring each attribute previously mentioned.

For the impacts on access to natural resources including land: Are the conditions of access perceived locally to be fair? If the conditions of access to locals are negatively impacted, is the compensation fair? (adapted from Timko and Satterfield 2008b).

For the impacts on First Nations rights and title: Are the First Nations rights, treaties and title respected? To what level of satisfaction according to local perception? (adapted from Timko and Satterfield 2008b).

For the impacts on the cultural practices identified as important for locals (e.g., potlatch, festivities, transmission of traditional knowledge, language): What are the impacts of different alternatives on these practices (adapted from McDaniels, Longstaff, and Dowlatabadi 2006; Philcox 2007; PSP 2009)? If a cultural form is lost or negatively impacted, for those who are affected, is the compensation fair (Timko and Satterfield 2008b)?

For impacts on aesthetics: What is the perceived magnitude of the visual, odor and water quality impacts in the region (Satterfield*, pers. comm.)*?

3.1.4 Foster good governance

For WCA this objective includes participatory management and shared responsibilities (originally in the 'integration and collaboration' objective), compatibility with other plans and social agreements (originally in the 'First Nations reconciliation and relationship' objective), implementation of the precautionary principle (originally in the 'healthy ecosystems' objective) and public accountability.

Attributes of participatory management include the followings: representativeness, fairness and competence (Renn 2004). Representativeness means that all stakeholders are represented when making decisions. Fairness refers to the equitable access to participatory processes, equal opportunities to make and reject claims during deliberation, and the consideration of different sources of information. Competence means that all participants have a sufficient level of understanding of the consequences of each alternative, including knowledge, uncertainties and ambiguities (Renn 2004).

a) Suggested indicators

The attributes of this objective can be measured qualitatively using constructed scales as suggested for the 'vibrancy' attributes.

For the participatory management: Were all stakeholders represented in the process? Were there opportunities (e.g., forums, meetings) for the public and stakeholders to participate in the process? Was there a capacity building program and training opportunities for locals and other stakeholders to improve their competence (Timko and Satterfield 2008a; Timko and Satterfield 2008b)?

For the responsibilities distribution: Do all the members agree with the distribution of tasks? Do the members have the capacity to do the work they were tasked with?

For alignment with other plans: Were synergies and new partnerships with other organizations made during the process?

For resolutions between First Nations and other governments: To what extent is there a respectful relationship and agreement between First Nations and other governments (Timko and Satterfield 2008a; Timko and Satterfield 2008b)?

For the precautionary approach: Was there a comprehensive consideration of possible negative effects of human activities, including those with considerable uncertainty? Was a monitoring plan adopted to evaluate the harm on ecosystems and human health? Do proponents of potentially actions/activities have responsibility to demonstrate small likelihood of major negative effects? Were alternatives considered and adopted to reduce harm on ecosystems and human health? If uncertainty was a reason for inaction, was a concrete plan adopted to reduce uncertainties?

For public accountability: Was information on financial resources available for all members of the board? Was information—on the impacts of management alternatives in relation to the objectives—available for all members? Are there sufficient measures in place to ensure transparency?

3.1.5 Foster learning through adaptive management

Adaptive management represents the ability to learn from the process as new information arrives (McDaniels, Gregory, and Fields 1999), learn from other participants, and treating policies as experiments to explore possible outcomes (Walters 1986).

a) Suggested indicators

Most attributes of these objectives can be also qualitatively measured with constructed scales to answer questions defined by WCA. Here, we present some examples.

For learning from other participants: Did the board learn from conflict resolution (adapted from Timko and Satterfield 2008b)? Did stakeholders learn from each other during the process?

For learning from the process: Are members satisfied with the process? Was new information identified and integrated to the process? Were there opportunities to review and adjust agreements and policies (Timko and Satterfield 2008a; Timko and Satterfield 2008b)? Were there learning opportunities over time (Gregory, McDaniels, and Fields 2001)?

For learning through treating policies as experiments: Were key sources of uncertainty indentified? Were opportunities to reduce uncertainties identified? Did members consider means for applying such opportunities in policy/management alternatives? Were those means implemented?

4. DISCUSSION

The implementation of EBM is of interest of scientists, managers and stakeholders; therefore a collective vision of what is wanted from EBM to achieve is very important. Understanding and articulating in a proper way our values can help direct our decisions to what we want. We intend with this work to help WCA identify their most fundamental objectives and articulate them in an operational way to guide decision-making processes.

The process of re-structuring objectives requires the involvement of stakeholders for two main reasons. First, to ensure that stakeholder values are well understood and reflected in the new structure. And second, for stakeholder to understand the process and realize that their objectives and attributes were not changed, left out or ignored, but only re-structured to make them operational in order to guide the decision-making. If stakeholders are not involved, they may resist the changes included in the new structure. For this particular case, one of us (DMD), as representative of WCA, confirmed that WCA values were reflected in the new structure of objectives and attributes. However, for the implementation, the results will have to be consulted with all WCA members.

Little attention has been paid to the definition of indicators for EBM that reflect stakeholder values and guide decision-making. Through this work, we emphasize the importance of linking indicators to fundamental objectives as well as involving stakeholders and scientists in the definition of indicators to integrate value judgments and technical information. The proposed set of indicators may seem extensive; however, it reflects WCA fundamental objectives. It is essential that WCA explore them using particular decisions to select the most useful ones according to their goals, priorities and constraints.

As EBM involves complex decisions, conflicting objectives and massive uncertainties, a systematic framework to make decisions has significant potential as it can be repeatedly used for any decision even in the most complex situations (Keeney 1996b). Because the framework is built for multiple decisions, it needs to be flexible as particular decisions might be different from each other, and the weighting of objectives might

require re-negotiations for each decision, in part because the people strongly affected by particular decisions will differ.

SDM can make management more consistent as all the decisions are meant to achieve the same fundamental objectives; it can make the decision-making process more transparent as tradeoffs are made explicit; and it can build trust in the process as stakeholders and their values are involved since the beginning. Stakeholders might support decisions that they would not have supported otherwise, by understanding the trade-offs and the benefits of each alternative in terms of the fundamental objectives.

5. CONCLUDING REMARKS

This work provides an example of how to apply SDM for the implementation of EBM. We specifically showed how to restructure objectives to make them operational and how to integrate values, objectives and indicators in a consistent framework. Managers can repeatedly use these frameworks to create and evaluate alternatives, to make more informed and consistent decisions based on stakeholder values, as well as to identify data gaps and opportunities to reduce uncertainties (Keeney and McDaniels 2001).

For this case study, we intend to provide insights and a first step towards building the framework for the WCVI. WCA members will need to revise it and decide what is most appropriate for their values, needs and goals. Then, WCA could use it for any issue of concern—from the marine zoning initiative to the water pollution—in which multiple objectives, emotions and history are involved.

With this work we demonstrate that stakeholders-derived objectives and values can help shape a collective vision and objectives for EBM; however, a systematic process and the communication between stakeholders, managers and scientists will be required to identify fundamental objectives and indicators that are consistent with stakeholder values. Without a systematic approach, objectives will be often stated in a redundant and complex way making their operationalization very difficult, and indicators may also be defined independently of stakeholder objectives and the decision-making process.

SDM should result in decision-making processes for EBM that are more consistent and transparent. SDM will help build trust in the process. Stakeholders are likely to feel more engaged with the planning and implementation of EBM if they are involved and see their values reflected since the beginning of the process.

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Table 1. Original set of objectives and attributes of West Coast Aquatic (WCA) based on the draft goals for aquatic management on the west coast of Vancouver Island (WCVI) (WCA 2009). FN means First Nations.

Objectives	Attributes		
Integration and collaboration	• Collaboration with other states and global links; • Shared responsibilities;	• Integrated and participatory management; • Efficient communication;	• Responsible and participatory decisions; • Sustainable and holistic management consistent with traditional values.
Sustainable economic benefits	• Opportunities for locals; • Sustainable social, cultural and economic benefits; • Balance ecological, social and economic aspects;	• Future generations; • Conservation first in fisheries management; • Sustainable fisheries and aquaculture;	• Sustainable management; • FN access to natural resources; • Monitoring, enforcement and regulations.
Healthy ecosystems	• Ecosystem productivity; • Healthy, diverse and resilient ecosystems; • EBM and values in planning and decision-making; • Adaptive management;	• Integrity of fish and habitat; • Genetic diversity (salmon and other species); • Conservation as a first priority; • Precautionary approach;	• Plans for natural disasters; • Adaptation to climate change; • Network of marine protected areas; • Species at risk protection; • Waste water management (water pollution and disposal management).
Healthy, prosperous and safe communities and waterways	• Safety (infrastructure, modernized transportation, and response services); • Health (ecosystem health and community health);	• Vibrancy (diversified economies, cultural practices); • Partnerships;	• Traditional knowledge into decision-making.
FN reconciliation and relationships strengthening	• Respecting aboriginal rights and title; • Clear understanding of the needs of FN; • Ensuring benefits for FN;	• Participation of FN in decision-making; • FN as the second priority after conservation; • Ensuring FN access to natural resources;	• FN sharing the wealth of marine resources; • Resolutions between FN and other governments.
Knowledge information and technology	• Stewardship efforts; • Expertise and knowledge from diverse sources; • Integration of information and knowledge on	• Education; • Passing on traditional knowledge; • Training for users, managers, stewards,	• Equipment and technology; • Information gathering.

	ecosystem health;	community capacity;	
Capacity building	• Safety and efficiency of marine transportation and shipping; • Resource use and management;	• Improve FN economic self sufficiency and community stability; • Stakeholders participation in aquatic conservation;	• Modernization of the Canadian Coast Guard fleet; • New industries; • Strong FN cultures.
Good governance	• Establishment of priorities;	Public reporting;	• Responsibility and accountability.

Table 2. New structure of fundamental objectives, attributes and indicators for a decision-making framework for EBM. FN means First Nations. CS means constructed scales.

Fundamental objectives	Attributes	Attributes components	Indicators
Foster economic benefits	Distribute benefits and costs across stakeholders and over time	Net benefits	Net present value
		Income	Net income per year
		Employment	Number of skilled, unskilled, temporal and permanent jobs
		Goods	Weight
Foster healthy ecosystems	Minimize adverse effects on ecosystem integrity	Diversity	Species richness and evenness within defined boundaries
			Community composition: species richness and abundance of selected groups
			Community composition: mean trophic level
			Community/habitat diversity
		Productivity	Biomass per trophic level
			Target species catch and biomass
		Marine environmental quality	Concentrations of toxics in sediments, water and biota
			Habitat quality (area impacted or magnitude of the activity that impact the habitat)
			Noise
			Atmospheric pollution
Foster healthy communities	Avoid adverse effects on health and safety	People	Number of people exposed, magnitude and probability of the risk
			Illness and death associated to marine resources or the alternative
		Private and public property	Number of private or public property exposed, magnitude and probability of the risk
	Avoid adverse effects on vibrancy	Access to natural resources	CS: Are the conditions of access fair?
			CS: Are the conditions of access impacted?
			CS: Is the compensation fair?
		FN rights and title	CS: Are FN rights, treaties and title respected?
			CS: To what level of satisfaction?
		Cultural practices	CS: Impacts on identified cultural practices
			CS: Is the compensation fair?
		Aesthetics	CS: Perceived magnitude of the visual, odor and water quality impacts
Foster good governance	Foster participatory management	Representativeness	CS: Were all stakeholders represented in the process?
		Fairness	CS: Were there opportunities for the public and stakeholders to participate in the decision-making process?

		Competence	CS: Was there a capacity building program and training opportunities for locals?
	Foster shared responsibilities		CS: Do all members agree with the distribution of tasks? CS: Do the members have the capacity to do the work they were tasked with?
	Foster alignment with other plans		CS: Were synergies and partnerships made during the process?
	Foster social agreements	Resolutions between FN and other governments	CS: To what extent there is respectful relationship between FN and other governments?
	Foster a precautionary approach		CS: Was there a comprehensive consideration of possible negative effects of human activities? CS: Was a monitoring plan adopted to evaluate the harm on ecosystem and human health? CS: Do proponents of actions/activities have responsibility to demonstrate small likelihood of major harm? CS: Were alternatives adopted to reduce harm? CS: If uncertainty was the reason for inaction, was there a concrete plan adopted to reduce uncertainties?
Foster adaptive management	Foster learning from other participants		CS: How did the board solve the conflicts? CS: How did the board learn from conflict resolution? CS: Did stakeholders learn during the process?
Fundamental objectives	Attributes	Attributes components	Indicators
Foster adaptive management	Foster learning from the process		CS: Are the members satisfied with the process experience? CS: Was new information identified and integrated to the process? CS: Were there opportunities to review and adjust agreements and policies? CS: Were there learning opportunities over time?
	Foster treating policies as experiments		CS: Were key sources of uncertainty identified? CS: Were opportunities to reduce uncertainty identified? CS: Did members define means of applying policies to realize such opportunities? CS: Were those policies implemented?