



Key principles of marine ecosystem-based management

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ABSTRACT

Ecosystem-Based Management (EBM) has gained international popularity in recent years, but the lack of consensus on its definition has precluded the use of a universal implementation framework. The large number and variety of principles that make up EBM, and the diversity in perspectives among key management players, has impeded the practical application of EBM. Agreement on a list of the essential ingredients of EBM is vital to successful application. A frequency analysis of EBM principles was conducted to identify the Key Principles that currently define EBM, from a list of twenty-six principles extracted from a subset of the EBM theoretical/conceptual literature (covering a range of published sources across disciplines and application types). Fifteen Key Principles were identified (in descending frequency of appearance in the literature): **Consider Ecosystem Connections, Appropriate Spatial & Temporal Scales, Adaptive Management, Use of Scientific Knowledge, Integrated Management, Stakeholder Involvement, Account for Dynamic Nature of Ecosystems, Ecological Integrity & Biodiversity, Sustainability, Recognise Coupled Social-Ecological Systems, Decisions reflect Societal Choice, Distinct Boundaries, Interdisciplinarity, Appropriate Monitoring, and Acknowledge Uncertainty.** This paper also examines the development of EBM principles over time, leading to predictions on the directions EBM will take in the future. The frequency analysis methodology used here can be replicated to update the Key Principles of EBM in the future. Indeed, further research on potential emerging Key Principles such as 'Consider Cumulative Impacts', 'Apply the Precautionary Approach' and 'Explicitly Acknowledge Trade Offs' will help shape EBM and its successful application in the management of marine activities.

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1. Introduction

There is no debate surrounding the intrinsic value of global marine ecosystems [1,2] or the immense pressures humans have inflicted on them [2–4]. With rapid population growth and densely inhabited coastal areas, our dependence on marine resources is greater than ever [5]. The overuse and mismanagement of ecosystem services – e.g., through overexploitation, habitat loss and pollution – have placed great pressure on marine systems [4–6], thereby threatening the future of marine ecosystems, and the services they provide [5,6].

Traditional silo-structured management, focusing on a single species or sector, is widely seen as insufficient [7,8]. It has failed to protect marine systems from human pressures [5] or fishery stock collapses [9,10] and in turn these failures have deeply impacted the

humans that depend on these resources [2,11]. The consequences of ineffective conventional management systems, along with the desire to restore and maintain ecosystem health, have induced a desire for change. Thus, while there is not always agreement on the exact direction management should take, there is a general consensus on the need for improvement in conventional management practices.

The third point of broad consensus relates to some of the goals of the change toward new management approaches, specifically to better acknowledge and incorporate aspects such as biodiversity, the complexity of social-ecological systems, the need for stakeholder participation and the appropriate use of incentives (e.g. [12]). These considerations are reflected to some extent in the widely-accepted shift to the more holistic approach known as Ecosystem-Based Management (EBM), generally seen not as a strategy that manages the ecosystems themselves, but rather one that manages the human activities that have an impact on ecosystems, and takes these effects into account when making management decisions [13].

However, consensus breaks down when it comes to the details of what principles should be included within EBM. There are wide variations in the definitions of EBM, and in the environments or

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sectors to which it can be applied, leaving EBM without a universal application framework [14]. As a result, EBM implementation is taking place in many different forms with various combinations of principles. In particular, the respective emphasis placed on ecological, social, and governance factors [14] will depend on the EBM principles utilized, the degree to which each are applied, as well as the overarching objectives of the organization implementing EBM [15]. For example, the Food and Agriculture Organization of the United Nations' (FAO) Ecosystem Approach to Fisheries, which focuses on balancing ecological, governance and socio-economic factors [14], differs from that adopted by various government and nongovernmental organizations, e.g., Greenpeace's Ecosystem Approach which emphasizes ecological factors [16].

Faced with this fundamental difference in thinking on the Key Principles of EBM, the objective of this paper is, first, to provide a clear and up-to-date list of these Key Principles, derived from publications, and second, to consider implications for the future of EBM. It is hoped that this analysis will improve links between theory and practice of EBM, allowing more consistent applications to marine activities.

The research presented here contributes to building consensus relating to the Key Principles required within an EBM framework. This involves a brief review of the historical development of EBM and a systematic analysis of theoretical literature concerning EBM, which enables specification of a credible subset of recent publications, leading to development of a set of the crucial 'Key Principles' required to successfully implement EBM. This is accompanied by an analysis of the development of EBM principles over time, to identify which established principles have diminished in their acceptance as defining characteristics in the literature, and on the other hand, which more contemporary principles exhibit potential to become Key Principles in the future. Finally, principles put forth in two early syntheses by Holt and Talbot [17] and Mangel et al. [18] are compared with those prevalent in the EBM literature today. Although the principles from these works receive relatively little recognition in current marine EBM discussions, they provide a historical reference point and allow for the identification of EBM principles that may be under-emphasized today.

2. Background

2.1. What is EBM?

There is no single agreed-upon definition for EBM (also referred to as the Ecosystem Approach); these terms have been defined in many different ways to date. A typical definition of EBM acknowledges the complexity and interspecies relationship within ecological systems, but many also account for social and governance objectives, with the latter aspects broadening the range of definitions. On the one hand, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), for example, has a narrow set of ecological objectives, describing the ecosystem approach as 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” [19].

On the other hand, the United Nations Convention on Biological Diversity (CBD) integrates ecological, social and governance objectives, describing 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” [20].

The Communications Partnership for Science and the Sea (COMPASS) published a more in-depth, inclusive definition developed by over two hundred science and policy experts in the United States. EBM was defined there 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” [21].

EBM has recently gained momentum in marine management initiatives [22] and increasing attention in the fisheries sector. EBM syntheses include Sinclair and Valdimarsson [23] *Responsible Fisheries in the Marine Ecosystem*, Christensen and Maclean [24] *Ecosystem Approaches to Fisheries: A Global Perspective* and Link's [25] *Ecosystem-Based Fisheries Management: Confronting Tradeoffs*. The importance of considering human dimensions in marine EBM has been highlighted [26].

The rise in popularity of EBM has led to sector-specific variations, such as the Ecosystem Approach to Fisheries [27]. Each version of EBM has differing underlying principles (with some also providing frameworks for their implementation) and no single approach currently dominates the field of natural resource management [14]. Among academics, government agencies and NGOs, EBM has been defined in a variety of contexts (e.g. including general, terrestrial versus marine applications) as well as sectors such as forestry and the fishing industry.

2.2. A brief history of EBM principles

Despite EBM's more recent popularity, the philosophies behind it are far from new and in some areas have been practised by indigenous peoples for over ten thousand years [28]. Although not widely recognized, one of the first major initiatives to include overall ecosystem health in principles of natural resource management was in the 1970s [29], during a set of workshops on wildlife management attended by professionals across North America from a wide range of disciplines and organizations [17]. Indeed, prior to that point in time the term EBM does not seem to have appeared widely in the literature. The list of four management principles developed at the workshop, entitled *New Principles for the Conservation of Wild Living Resources* [17] 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 [29].

The four principles are as follows:

1. *The ecosystem should be maintained in a desirable state such that*
 - a. *consumptive and non-consumptive values could be maximized on a continuing basis,*
 - b. *present and future options are ensured, and*
 - c. *risk of irreversible change or long-term adverse effects as a result of use is minimized.*
2. *Management decisions should include a safety factor to allow for the facts that knowledge is limited and institutions are imperfect.*
3. *Measures to conserve a wild living resource should be formulated and applied so as to avoid wasteful use of other resources.*
4. *Survey or monitoring, analysis, and assessment should precede planned use and accompany actual use of wild living resources. The results should be made available promptly for critical public review [17].*

These principles focused on ecological objectives, as at this time “resource conservation was regarded primarily as a biological

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