A Comparison of Four Regional Marine Biodiversity Studies: Approaches and Application to Ecosystem-Based Management

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Introduction

One of the fundamental challenges in marine ecology and management is to understand how natural processes and human activities interact to affect the structure and function of marine ecosystems.

“Ecosystem Based Management” (EBM) considers the entire ecosystem, including humans. The approach calls for a full integration of impacts on ecosystems and for the conservation of biodiversity.

Challenges:

1. What is the extant biodiversity (composition and structure)?
2. How are the current patterns maintained (structure and processes)?
3. What is needed to conserve biodiversity (based on answers to #2)?

We compare the motivations, objectives, approaches, achievements and “lessons learned” from four ecosystem-level studies of marine biodiversity conducted in diverse environments. We develop a common approach to categorize these types of research studies, and thereby to better clarify the subset of biodiversity issues that particular studies address. Our intent is to examine the connections between research studies and decision-making on marine and coastal issues.

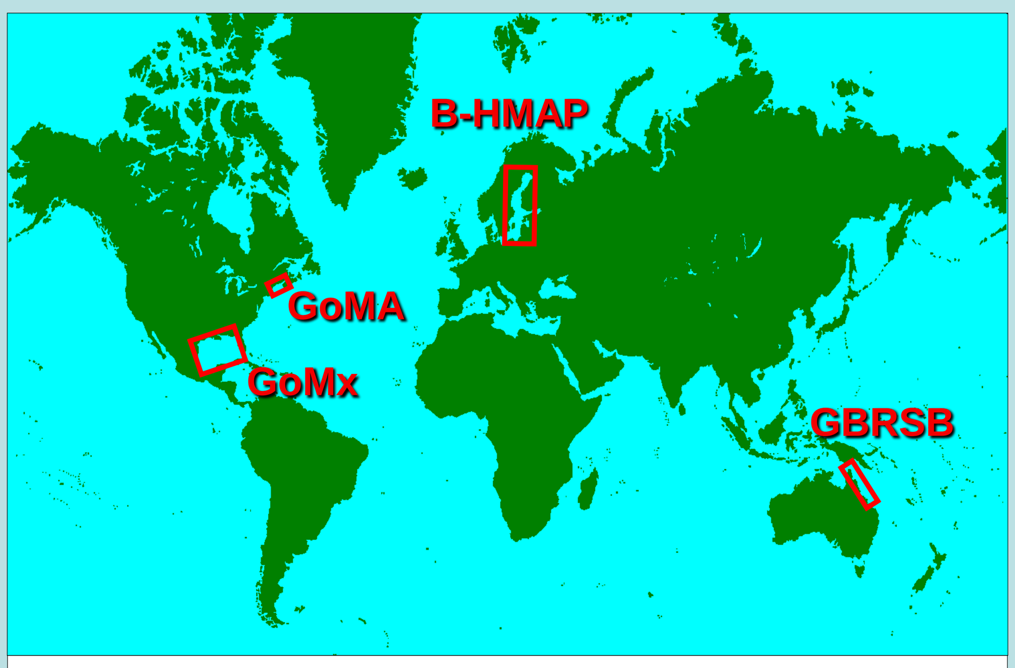

Fig 1. Locations of four regional research programs on marine biodiversity. Baltic Sea History of Marine Animal Populations (B-HMAP), Gulf of Maine Area Census of Marine Life (GoMA), Gulf of Mexico Biodiversity Assessment (GoMx), and Great Barrier Reef Seabed Biodiversity Project (GBRSB).

Elements of Biodiversity

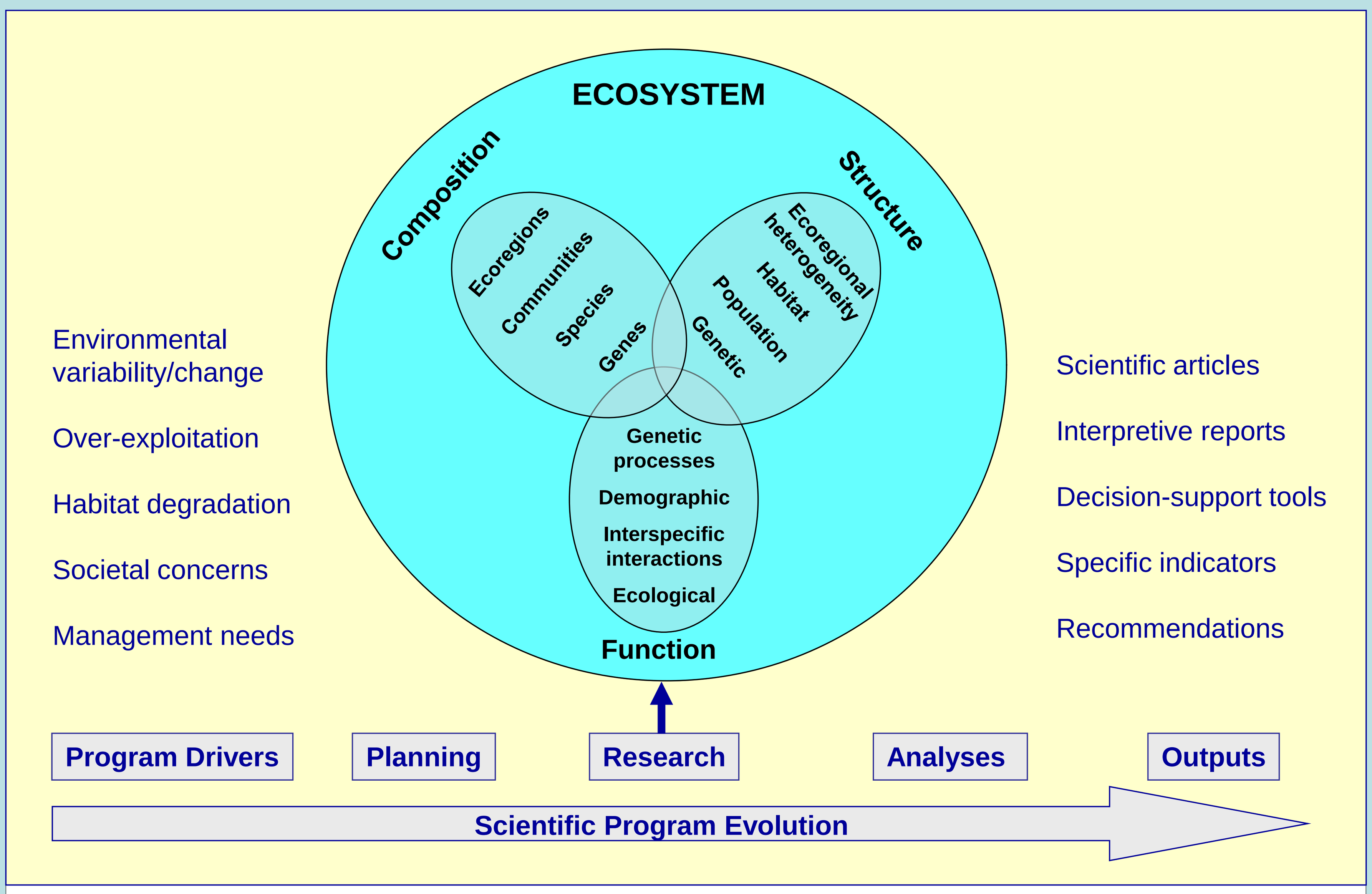

Fig 2. Elements of biodiversity research and monitoring needed to support EBM. Decreasing scales of biodiversity, from ecoregions to genes, are depicted from the outer to inner core of each element. Scientific program evolution over time is depicted above the horizontal arrow. Examples of program drivers are listed on left, outputs on right (Adapted from Noss 1990; Cogan & Noji 2007).

The full spectrum of biodiversity encompasses multiple levels of biological organization. Biodiversity can be conceptualized by three thematic elements that combine to influence the biological attributes of ecosystems: **Composition, Structure, and Function (CSF)**.

Compositional biodiversity elements represent the identity and variety of biodiversity within the system.

Structural elements are concerned with physical organization or pattern within the system, including both biotic and abiotic variables that modulate patterns.

Functional elements are processes that operate at various spatial, ecological, and evolutionary scales to mold biodiversity composition and structure. These range from genetic processes to natural and anthropogenic forcing variables.

These three elements can be represented in a hierarchy of spatial scales, ranging from ecoregions to genes (Fig 2). **We refer to this hierarchical representation as a CSF template** (Ellis et al. submitted; Lawton et al. submitted).

Biodiversity research programs can be directed at one or more of these elements. EBM uses insights provided by detailed research, rather than the myriad research results themselves. These insights are summarized or integrated as outputs, such as indicators to watch or manage for, general predictions, recommendations, etc. (Fig. 2). A monitoring-research continuum is needed to describe the system and to monitor changes over time, ultimately building system understanding.

This CSF template allows us to assess broad areas of knowledge and gaps. It is also a useful vehicle for communicating between scientists, managers and stakeholders.

Relative Program Focus

It is important to study each biodiversity element to improve understanding and, ultimately, management.

However, specific drivers, scientific expertise, funding, logistics, and other factors affect the balance of every research program.

We adapted the CSF template to examine the balance within these research programs (Fig 3). The figure at right shows that function is the least studied − and therefore the least understood − element of marine biodiversity across the four programs.

We suspect this imbalance of biodiversity knowledge is true for most marine ecosystems.

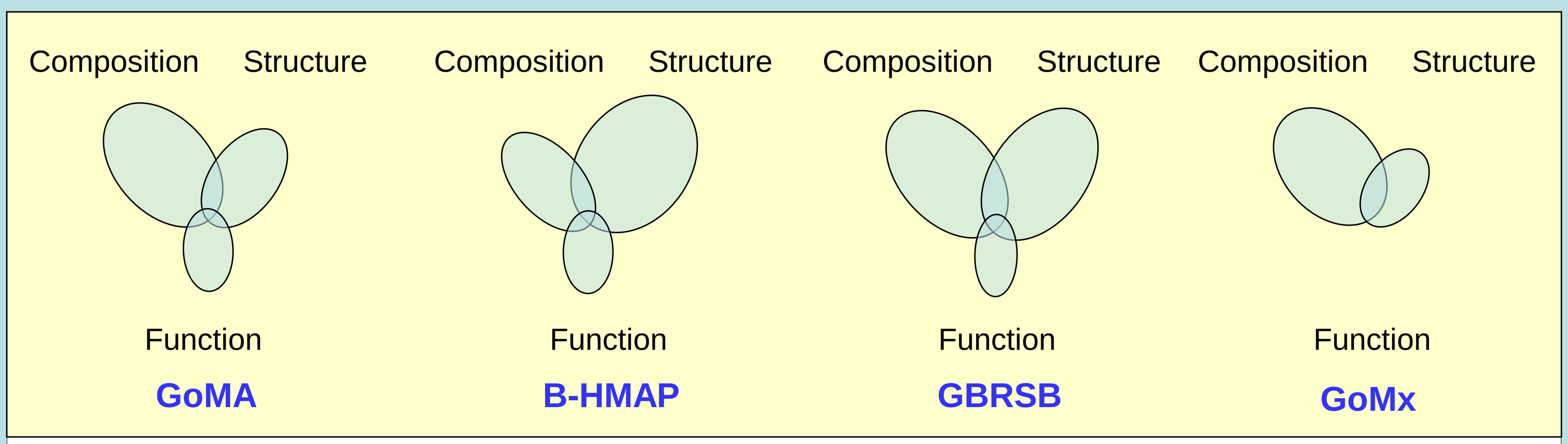

Fig 3. Program focus at a glance. Relative focus by the four research programs on each biodiversity element outlined in Fig 2. Approximate proportion of effort allocated *within* each program is depicted by the relative size of the three ellipses. (No attempt has been made to scale effort across programs.)

Insights

- Understanding depends on details, and systems are inherently complex and variable. To inform EBM, this complexity must be reduced to simpler but still useful compartments to summarize the overall status and likely trajectory of a system. The CSF template provides a useful way to begin this process.
- For a well-rounded understanding of biodiversity within an ecosystem, it would be ideal to study all three elements equally; however, this is an unlikely scenario. Thus, when planning a new program we recommend considering the relative status of knowledge, uncertainty, and risks across the three elements before deciding which element(s) to focus on first. Investment in in-depth understanding of one or more elements of biodiversity provides a foundation for addressing other issues in the future.
- To increase knowledge of biodiversity at the scale of an ecosystem requires ambitious, long-term research programs that bring together many collaborators and sources of funding. Managers and scientists must build in realistic expectations of time and resources needed for such large undertakings, including development, implementation, communicating results, and, ultimately, any related management actions.
- Given that our knowledge of biodiversity in marine ecosystems is incomplete, ocean managers must operate with integrated and precautionary approaches that aim to maintain biodiversity as a key element of EBM.

References

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