A Comparison of Regional Marine Biodiversity Studies and Their Application to Ecosystem Approaches to 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 Approaches to Management" (EAM) [1] consider the entire ecosystem, including humans. The approach calls for a full integration of impacts on ecosystem function 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 it (based on answers to #2)?
- 4. What are the functional responses of the ecosystem to the extant patterns of biodiversity, and how might these be expected to change under various scenarios?

We compare the motivations, objectives, approaches, achievements and general "lessons learned" from four ecosystem-level studies of marine biodiversity conducted in diverse environments (Figure 1).

Our intent is to identify how information and results from the various studies can improve decision-making on marine and coastal issues, and how well the various approaches can meet the needs of EAM with respect to ecosystem function and biodiversity conservation.



Figure 1. Locations of four ecosystem research programs on marine biodiversity. Each of these programs has contributed to the Census of Marine Life, a 10-year scientific initiative beginning in 2000 to assess and explain the diversity, distribution, and abundance of life in the ocean.

[1] EAM is very close to Ecosystem-Based Management (EBM). EAM is generally defined as extending existing management foci (e.g., fisheries) to include additional considerations consistent with ecosystem management characteristics, while EBM implies a new management scheme primarily designed to address overall ecosystem considerations (Murawski, 2007).





Elements of Biodiversity

 Biodiversity can be conceptualized by three thematic elements that combine to influence the biological attributes of ecosystems: structure, composition and function.

• These elements can be represented in a hierarchy of spatial scales, ranging from landscapes to genes.

Biodiversity research programs can be directed at one or more of these elements.

• EAM uses insights provided by detailed research, rather than the myriad research results themselves. These insights are summarized or integrated as outputs, e.g., indicators to watch or manage for, general predictions, recommendations, etc. (Figure 2).



Figure 2. Elements of biodiversity research needed to support EAM.

Decreasing scales of biodiversity, from landscapes to genes, are depicted from the outer to inner core of each element.

Scientific program development over time is depicted above the horizontal arrow. (Feedback loops for iterative programs are not included.)

Examples of program drivers are listed on left, and outputs on right

(Adapted from Noss 1990; Cogan and Noji 2007)

References

- Cogan, C.B., and T.T. Noji. 2007. Marine classification, mapping, and biodiversity analysis. In: Todd, B.J. and H.G. Greene, eds. Mapping the Seafloor for Habitat Characterization. Geological Association of Canada, Special Paper 47, p. 129-139.
- Murawski, S. 2007. Ten myths concerning ecosystem approaches to marine resource management. *Marine Policy*, 31: 681-690.
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Comparative Focus of Four Programs

The relative contribution of each biodiversity element to decision-making is contextdependent, but it is important to make progress in each to improve understanding and, ultimately, management. Yet specific drivers, scientific expertise, funding and other factors affect the balance of every research program.

Figure 3 shows the relative balances in the programs we are comparing. We are examining how the different emphases contributed to immediate ecosystem-scale understanding and management needs, as well as what types of information gaps they left. On this basis we will suggest priorities for future studies.



Figure 3. At a glance: Relative focus by the four research programs on each of the biodiversity elements outlined in Figure 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

- >"Function" is one of the least studied elements of biodiversity in these, and most likely all, marine ecosystems.
- Investment in in-depth understanding of one or more of these biodiversity elements provides a foundation for addressing other issues in the future (in contrast with narrow, "emergency-driven" investigations which are hard to adapt to EAM applications).
- Historical studies provide an extremely useful context for assessing present-day ecosystem function.
- Understanding depends on details, and systems are inherently complex and variable. To inform EAM, this complexity must be reduced to simpler but still useful compartments by which to summarize the over-all status and likely trajectory of a system. The topology of Composition:Structure:Function, adapted from previous studies, seems to provide a useful way to begin this process. This topology also may be a useful vehicle for communicating between scientists, managers and stakeholders.
- Managers and scientists must build in realistic expectations of time and resources for planning, research, analysis, and reporting to meet the goals of EAM.



