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Scientists' prioritization of global coastal research questions

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ABSTRACT

Complex coastal management challenges often span ecological and political boundaries, and involve competing demands from groups advocating alternative coastal management strategies. As a consequence, policy-makers require scientific evidence from across a range of disciplines. Implementing cross-disciplinary research and facilitating science-policy engagement are, however, a significant challenge in its own right. Seven recent ecologically oriented 'big question' exercises identified a variety of research questions potentially important for coastal and marine management. In this research, 592 coastal scientists from 91 different countries completed a survey that ranked those 20 coastally oriented research questions. There was a clear overall ordering of aggregated coastal research priorities but scientists did exhibit heterogeneity regarding priorities. Some prioritized ecological issues while others focused more on issues such as coastal resource use or global environmental change. The differences in opinion were largely disciplinary-based, highlighting the importance of, and challenges in, encouraging scientific collaboration across disciplines to support effective coastal zone management. In addition to the ranking of existing questions, scientists submitted an additional 340 potential priority research questions, thus broadening the participatory nature of the original exercises. New questions regarding coastal processes, contaminants and pollution, and monitoring were prominent. This first synthesis across 'big question' exercises should provide valuable insights into the diversity of scientists' opinions and help policy makers understand potentially conflicting science advice.

1. Introduction

Coasts of the world face multiple threats from resource exploitation [1], upland activities that affect land cover and watershed hydrological services [2,3], changes in watershed hydrology and coastal zones due to climate change [4,5], and sea level rise [6]. Policy makers need scientific research aligned with policy needs [7,8] to help inform choices regarding the conservation and management of coastal species and habitats, resolve conflicts over coastal resources, and contribute knowledge needed to help solve earth science grand challenges [9,10]. Coastal challenges, many of which span multiple spatial and temporal scales, require engagement with policy-makers on regional to international levels [11,12]. The complex and inter-related drivers of environmental change e.g., [9,13,14] and the urgent need for policy-relevant knowledge to manage the biosphere have led to a call for a new 'social contract' for science that would proportionally address the most urgent needs of society and communicate that knowledge widely in order to inform individual and governance decisions [12]. The scale of global environmental problems suggests that the coastally oriented scientific community has a collective responsibility to periodically reexamine its goals and activities in order to most effectively create and communicate knowledge needed to address those challenges.

Global coastal zone research themes that are integrative across biogeochemical, physical, and human dimensions of coastal change have been identified for the Land–Ocean Interactions in the Coastal Zone (LOICZ) Science Plan and Implementation Strategy [10]. Such global research themes are, however, necessarily broad at the global scale. The need to operationalize research prioritization has recently led to a variety of participatory 'big question' exercises between scientists and policy makers [15–21]. These ecologically oriented exercises have identified narrower research questions that are both relevant to policy-makers' needs and actionable in discrete research programs [8]. Facilitating and encouraging cross-disciplinary collaboration among disciplinary experts are central for answering these questions because complex problems at the intersection of environmental management and societal decision-making require expertise beyond that offered by any single discipline e.g., [9,22]. One goal of the LOICZ strategy, for example, was to overcome traditional disciplinary fragmentation between the natural and social sciences for coastal science [10].

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In this research, global coastal scientists' research priorities were assessed with a survey that asked scientists to rank 20 coastally oriented research questions derived from seven recent 'big question' exercises [15–21]. The first goal was to quantify and compare research priorities and orientation among scientists with different demographic profiles and from various professional disciplines. This could help increase our understanding of the opportunities for, and constraints to, cross-disciplinary collaboration for solving complex coastal conservation and management issues. The second goal was to use the survey as a platform for collecting additional research questions that may have been overlooked during the initial big question exercises. Five of the original exercises [16,17,19–21] specifically focused on the conservation of biological diversity, whereas this survey targeted coastal scientists from all disciplines. The results suggest that such syntheses can help build understanding of research prioritization that should, if used to inform the design of cross-disciplinary scientific collaboration, increase the potential for scientists from different disciplines to effectively align their coastal research with the needs of policy makers.

2. Methods

2.1. Selection of questions

Sixty coastally oriented candidate questions from among recent exercises [15–21] were identified. Those questions fell from eight broad themes: aquaculture; coastal management; fisheries; human health; marine systems; marine protected areas; species management; and watershed management. After accounting for redundancies, questions that were primarily marine or terrestrial – rather than specifically coastal – in orientation, or questions that were very broad in scope, the number of questions for this survey was reduced to 20.

2.2. Survey instrument

An Internet survey was used for data collection (an example of a full survey is available from the corresponding author). In the survey, respondents were randomly assigned to 1 of 300 sets of best-worst scaling (BWS) ranking comparisons [23]. In each of 15 ranking comparisons (e.g., Fig. 1) per survey asked each respondent was asked to choose her or his relatively most and least important research question from among subsets of 4 of the 20 questions. BWS rankings force respondents to discriminate among the research questions by choosing the most distinct pairs. This prevents respondents from consistently using the middle points or one of the end points as they might with rating scales.

The BWS approach permitted a full ranking of all 20 questions for each individual completing the survey. At the end of the BWS comparisons, respondents could replace up to three of their least preferred research questions (i.e., those ranked 18, 19, or 20, which were calculated 'on the fly' during the survey) with alternatives and provide rationale about why they proposed those questions. Each replacement question was then rated by the authors as to how close it was to any of the 20 existing questions in the survey with a simple scale of 1 (extremely close) to 5 (unique). There was also an additional category for very broad questions or questions that had been explicitly dealt with in prior big question exercises [15–21]. Passages from these questions were then coded (using NVivo 9, www.qsrinternational.com) with user-defined labels based on emergent themes from the initial set of priority questions and iteratively derived from the newly submitted questions.

2.3. Sample

In order to collect opinions across the broad range of the coastal science community, an ISI Web of Science search was used to identify 1947 articles (2005–2010) on coastal threats, aquatic pollution, management, and governance from 470 journals (full list available from corresponding author). From these, a sample of 2078 unique authors (from 91 countries) with email contact information was constructed. Following standard protocol [24], individuals were contacted up to five times by email between 24 May and 23 June 2011.

2.4. Data analysis

2.4.1. Quantification of aggregate and individual priorities

The statistical analysis proceeded in three stages. First, mean probabilities for each respondent choosing each of the 20 questions as their top priority in the BWS comparisons were calculated with Hierarchical Bayesian (HB) analysis [25]. The HB approach is useful because it permits individuallevel probabilities of choice to be estimated. In non-technical terms, the HB algorithm estimates how different individual scientists' research priorities are relative to other scientists, a simpler task that than estimating each scientist's priorities independently. Individual-level data on how much priorities differ from the sample average are then used to adjust the algorithm to reflect the optimal mix of individual preferences and sample average.

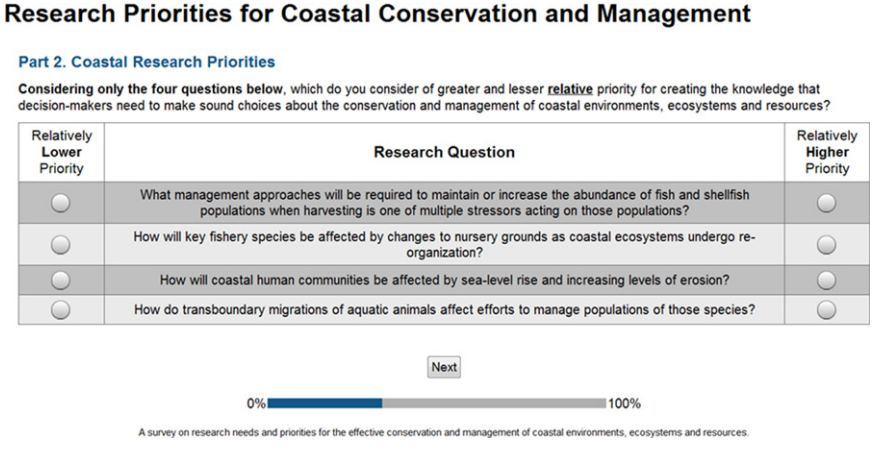

Fig. 1. Example of a best-worst scaling (BWS) ranking comparison.