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Review

Data requirements and tools to operationalize marine spatial planning in the United States

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ABSTRACT

The U.S. is adopting a Marine Spatial Planning (MSP) approach to address conflicting objectives of conservation and resource development and usage in marine spaces. At this time MSP remains primarily as a concept rather than a well-defined framework, however expanding anthropogenic impacts on coastal and marine areas reinforce the need to adopt an MSP approach to manage societal demands while preserving the marine environment. The development of theory and methods to implement MSP are on the rise across the nation to address coastal and marine environmental challenges. Critical components of marine spatial planning are (1) spatial data collection, (2) data management, (3) data analysis, and (4) decision support systems. Advances in geotechnology have increased access to spatial data enabling the development of decision support tools to organize, analyze, and inform the MSP process by projecting future scenarios. A review of the current literature reveals the available technological and methodological tools that are best suited for marine spatial planning, as well as suggests areas for further research in order to better inform this process in the U.S.

1. Introduction

Marine spatial planning is a concept that has rapidly gained momentum. Regional MSP projects are currently underway in the United States and abroad (Allnutt et al., 2012a; Collie et al., 2013). According to the United Nations Educational, Scientific, and Cultural Organization, "marine spatial planning is a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that are usually specified through a political process" (Ehler and Douvere, 2009). In June of 2009 the Obama administration created a Task Force to develop a framework for coastal and marine spatial planning. In December of that year, the U.S. Interagency Ocean Policy Task Force released an Interim Framework for Effective Coastal and Marine Spatial Planning. They summarize Coastal and Marine Spatial planning (CMSP) as "a public policy process for society to better determine how the oceans, coasts, and great lakes are sustainably used and protected now and for future generations." CMSP encompasses nearly identical concepts as MSP and may be more accurate given that coastal and marine space and processes are inextricably linked and should not be considered as distinct in a planning process. For the purpose of simplicity however, the more widely used term of MSP will be used in this paper.

The practice of marine spatial planning is made possible by the increasing availability of high quality spatial data (Collie et al., 2013). Various software and other tools allow for the management and analysis of this data and give practitioners the ability to create alternate management scenarios upon which planning decisions are made (Guerry et al., 2012; Melbourne-Thomas et al., 2010; Weijerman et al., 2013). It is important to remember that MSP is not a simple linear progression but rather a dynamic process with many feedback loops. Analyses of existing and future conditions will evolve as new information is identified and incorporated into the planning process (Yee et al., 2015). Understanding and

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utilization of the proper tools is essential for successful MSP endeavors (Halpern et al., 2012). The purpose of this review is to present and describe the kinds of tools that are available for MSP and provide examples from the current literature. Much discussion has occurred regarding MSP policy, frameworks, and best practices. As existing federal and state agencies prepare to shift their practices towards an MSP approach, a comprehensive review of data requirements and available tools is timely.

A primary goal of MSP is to support current and future uses of ocean ecosystems and maintain the availability of valuable ecosystem services for future generations (Douvere, 2008). An MSP process also addresses the legal, social, and economic aspects of governance, including the designation of authority, stakeholder participation, financial support, enforcement, monitoring, and adaptive management (UNEP, 2011). Key steps include (Ehler and Douvere, 2009) (Fig. 1):

1. Defining existing conditions through data collection;
2. Analyzing existing conditions using spatial ecological modeling, human dimension research methods, and cumulative impact assessments; and
3. Projecting future conditions using decision support tools.

Information generated throughout this process informs the preparation of a spatial management plan (Ehler and Douvere, 2009). These critical steps are facilitated by the use of data, software tools, and other well-defined spatially explicit methodologies (Papathanasiou and Kenward, 2014; Shucksmith and Kelly, 2014), which we will collectively refer to as “tools”. They fall into four major categories as relevant to MSP and will be the basis upon which this review is organized. The categories are: 1) data collection; 2) data management; 3) data analysis; and 4) decision support systems.

2. Data collection

The collection of pertinent spatial data is critical to the MSP process (Ehler and Douvere, 2009). For the purpose of this review we will make a distinction between the tools and technologies used for collecting primary data and the tools utilized by MSP practitioners to define, manage, and analyze this information. Ehler and Douvere (2009) identify five primary sources of data relevant to MSP, which include scientific literature; expert scientific opinion or advice; government sources; local knowledge; and direct field measurement. Most spatial planning efforts rely heavily on the first three sources (Ehler and Douvere, 2009). However local knowledge is increasingly recognized as an important source of information (Thornton and Scheer, 2012) and methods are in development to collect and incorporate this knowledge in the planning process (St. Martin and Hall-Arber, 2008). Direct-field measurements are typically outside the scope of MSP practitioners, though are sometimes necessary if significant knowledge gaps are identified. However, given that many MSP projects are large in scope, it can be difficult to obtain datasets that are consistent across the area of interest. This issue is particularly pronounced for ecological and human use data.

Current technology and methods have made available a great deal of spatially explicit data for use in MSP, especially in terms of ecological and environmental information. Palumbi et al. (2003) describe the application of some of the tools currently used in oceanography and marine ecology to inform the design of ocean reserves, which have implications for all aspects of MSP. Remote sensing data is a major source of ecological and environmental information. Human dimensions, including (spatial) information about human activities, have been less studied and often represent a knowledge gap in MSP (St. Martin and Hall-Arber, 2008). With the current proliferation of MSP initiatives this “missing layer” is

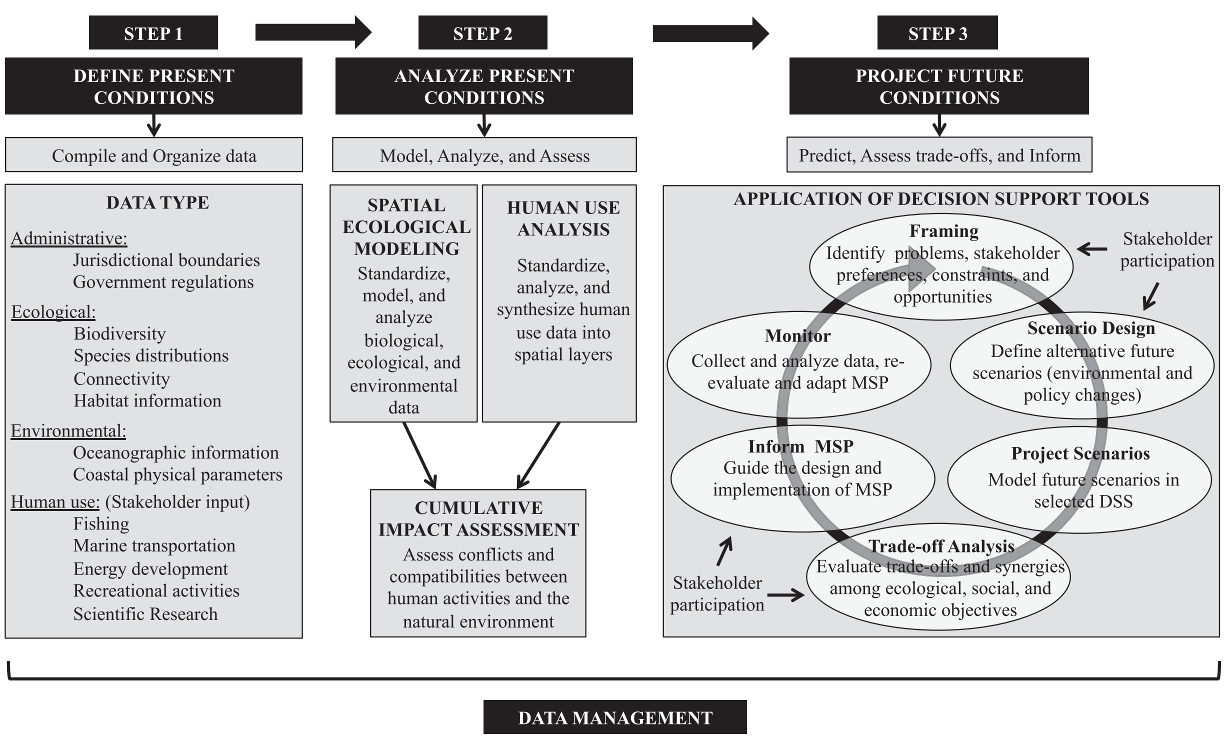

Fig. 1. Key steps within the MSP process related to data and information, adapted from Ehler and Douvere (2009): Step 1: Define present conditions through data collection; Step 2: Analyze existing conditions using spatial ecological modeling methods, human use analysis, and cumulative impact assessments; and Step 3: Project future conditions using decision support systems (DSS) and scenario modeling.