Human dimensions indicators of coastal ecosystem services: A hierarchical perspective

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ABSTRACT

Coastal resource management revolves around defining the dynamic between people and the marine and coastal resources they use and depend upon for a large range of goods and services. The process of defining that dynamic is iterative and must account not only for changing natural resource conditions but also for changing social conditions. Decision-making therefore happens within a context of a social system that includes differing levels of capacity, commitment, economics, political mandates and pressures, and cultural and traditional frameworks. The aim of this paper is to introduce a hierarchical approach in which the large number of variables needed to measure the complex, numerous and abstract social concepts used to evaluate the delivery of ecosystem services can be aggregated into smaller sets of indicators, which can ultimately be aggregated into a single report card. These variables and indicators can identify and describe non-economic human dimensions societal benefits derived as ecosystem services that are readily collected, that can identify changes over time, and are appropriate to specific coastal regions. The identified indicators would capture changes in the delivery of overall ecosystem services impacted by, or that will impact, changes in particular sets of environmental characteristics that are valued by society at large.

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1. Introduction

Coastal management is driven by the values and priorities of society as expressed by our social, political, and economic systems (Kennedy and Thomas, 1995). Because of this, humans are implicit in the discussion of ecosystem services. Most benefits are readily apparent, such as those from recreation opportunities, seafood, jobs, and scenic views. People place importance on a wide variety of national, regional and local services provided by marine and coastal ecosystems, including tourism, recreation, fisheries, trade, and esthetic and cultural values. Other benefits, however, such as protection from disease, waste remediation and oxygen provision are not as readily noticed by people on a day-to-day basis. In total, all contribute to well-being and a higher quality life. Therefore, the way in which different shorelines and marine environments are managed, and what they are managed for, should be a reflection of what society wants from those environments.

Although it is the stated aim of most agencies and groups to provide such ecosystem services, management has largely been driven by an incomplete information picture with regard to the non-economic human dimensions of ecosystem services. While a

range of scientific data have been sought out for decision-making, existing information often lacks many of the different types of social sciences data necessary to help guide this socially driven, value-based process (Loomis and Paterson, 2014). Large-scale management must make informed decisions of what to regulate, what enterprises and initiatives to promote, how society wants the system to function as a whole, and which ecosystem goods and services are most important to citizens and businesses (Erneston et al., 2008; Turner et al., 2003). Decision-making happens within a context of a social system that includes differing levels of capacity, commitment, economics, political mandates and pressures, and cultural and traditional frameworks (Bellamy et al., 1999; Klug, 2002; Lockwood et al., 2010; Paterson, 2013).

While sophisticated indicators, and the metrics or variables needed to measure these indicators, may have been developed and utilized to track how some of these ecosystem services benefit society (Ranganathan et al., 2008; Vaze et al., 2006), the picture is incomplete. The aim of this paper to introduce a hierarchical approach in which the large number of variables needed to measure the complex, numerous and abstract social concepts used to evaluate the delivery of ecosystem services can be aggregated into smaller sets of indicators. These indicators can then, in turn, be aggregated into a single report card. The variables and indicators identified in this paper describe non-economic human dimensions societal benefits derived as ecosystem services that are readily

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collected, that can identify changes over time, and are appropriate to specific coastal regions. The identified indicators would capture changes in the delivery of overall ecosystem services impacted by, or that will impact, changes in particular sets of environmental characteristics that are valued by society at large.

This will enable these indicators to be used, in conjunction with a parallel set of biophysical and economic indicators, to adaptively manage regional resources in a holistic fashion. As with biophysical parameters, changes in non-economic ecosystem services and the values associated with those services can and should be measured and monitored over time. Again, as with any biophysical monitoring, standard social science procedures and methods should be adhered to in order to properly develop and monitor appropriate indicators for non-economic ecosystem services. The value of this paper is in its applicability to produce indicators that inform a Drivers-Pressures-Ecosystem Services-Response (DPSER) model (Kelble et al., 2013) for ecosystem-based management.

There is a danger that, due to the sheer number of ecosystem services provided to us by coastal environments, the quantity of possible non-economic indicators and the variables used to measure those indicators may be virtually limitless. In order to ensure the utility of this effort to managers and decision makers, it is important to be able to consolidate or aggregate first the variables and then the associated indicators into a smaller number of status checkpoints that are managerially relevant and easily communicated. These indicators can be further aggregated to an easily evaluated "report card". This implies the importance of a hierarchical approach where individual variables combined into indicators specific to one component of a particular ecosystem service can be aggregated with other indicators that represent different components of the same service to provide information at the report card level that is functional, practical, and valid. The ultimate purpose of this paper is to identify and describe a hierarchical process (variables, to indicators of an ecosystem service, to an index) focusing upon variables and indicators that could potentially fulfil the role of measuring coastal ecosystem services benefits from a non-economic, human dimensions perspective.

2. Ecosystem services

Ecosystem services can be defined as the services, both tangible and intangible, created by ecological characteristics that are explicitly tied to social value (Ranganathan et al., 2008). In other words, ecosystem services are the outcomes of ecosystem functions that yield value to people socially, economically or culturally (Wallace, 2007). From a human dimensions perspective they represent the things provided by the marine and coastal environment that people care about. Negative changes to those services that result in a reduction of benefits to the people that utilize them can have large impacts upon social structure and function.

An ecosystem services approach to resource management moves beyond how people affect ecosystems to instead include how people depend on and benefit from ecosystems (Reyers et al., 2009). Explicitly accounting for these benefits, using a range of economic and non-economic metrics, can reveal hidden benefits and costs to many current practices not typically measured by market forces or considered in management deliberations. Understanding these benefits and costs will result in improved decisions that most readily reflect the true value of the natural environment to society (Clua et al., 2005). Since many of the benefits derived from ecosystem services, and the trade-off costs of acceptable environmental impacts, are often not part of the traditional economy or directly traded in markets, many important and highly relevant ecosystem services are often neglected when decisions are made (Turner

et al., 2003). These valuations are off the ledgers of the public and policymakers, and thus taken for granted, yet are nonetheless integral to human well-being (Costanza, 2000; Costanza et al., 1999). Not properly incorporating these services into management scenarios, along with economic and non-economic valuations of them, contributes to the gradual erosion of essential, communal life support services such as climate regulation, carbon storage, cultural heritage, esthetics, erosion protection, and waste disposal. Balancing the demands between public goods, private enterprise, development, and resource protection has become the major natural resource management challenge. Instead of simply "protecting" ecosystems from development or any potential adverse environmental impacts, an ecosystem approach also considers how to best invest in managing ecosystems for sustainable development and use. Our daily lives depend on a range of services the natural environment provides including energy security, biodiversity, food production, fresh water provisions, health, natural hazard protection, infrastructure and housing (Rechkemmer and von Falkenhayn, 2009).

3. The measurement of ecosystem services

Indicators can show the current status of an ecosystem service or its value, or can reveal if something is changing and in what direction that change is occurring, in this case the biological, physical, economic or social aspects of marine and coastal ecosystem services. Indicators are often direct measures, such as the number of people that live in a discrete area, the average income of a population, or the number of boats in a commercial fishing fleet. However, they may also be proxies or indirect measures based upon a relationship between what can be measured and an actual focus of interest that might be harder, more expensive or impossible to measure. For example, measuring the number of recreational tour guides can be used to provide information about any change in the quality of a recreation resource or experience. It might be that an increase in the number of tour guides is an indicator of an improved resource condition which has led to an increase in demand for recreational opportunities and thus ecosystem service value. In contrast, however, an increase in the number of tour guides may be a signal that a resource is potentially being overused and/or degraded, and ecosystem service value will begin to decline. Knowing that a change is taking place, the direction of the change, and perhaps the degree of change allows potential negative trends to be mitigated through policy or technology changes, or allows the development of policy to take advantage of beneficial opportunities. Social indicators are used on many scales from local to global and can be used to assess changes in societal benefits from changes in ecosystem services.

As stated previously, ecosystem services are the outcomes of ecosystem functions that yield value to people socially or economically. Unfortunately, it is virtually impossible to define a small number of direct human dimensions indicators that will address the full range of potential coastal ecosystem services. Human dimensions science encompasses a large and diverse range of disciplines, including but not limited to sociology, geography, psychology, economics, anthropology, outdoor recreation, political science, health and public administration. Not only would the task of developing a completely comprehensive list of indicators for all ecosystem services specific to every disciplinary perspective relevant to human dimensions be daunting, but the product would be virtually unusable. The indicators presented in this paper are a subset derived from an undefined larger, effectively limitless, pool of indicators. They also provide the option of being able to be aggregated into a hierarchy as initially described in Section 1.