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REPORT IN BRIEF

Approaches for Ecosystem Services Valuation for the Gulf of Mexico after the Deepwater Horizon Oil Spill

The unprecedented magnitude of the Deepwater Horizon oil spill presents significant challenges for oil spill responders and those tasked with assessing the impacts of the spill. Evaluating changes to ecosystem services—the benefits people receive from natural resources and processes—caused by the oil spill could expand the potential to capture and value the full breadth of impacts to the ecosystem and the public. This report assesses the methods and metrics that could help scientists effectively evaluate ecosystem services.

On April 20, 2010, the Deepwater Horizon platform drilling the Macondo well exploded, killing 11 oil workers and injuring another 17. The oil spill that followed was unprecedented in magnitude: over a period of three months, nearly 5 million barrels (approximately 200 million gallons) of crude oil leaked into the Gulf of Mexico. To prevent consumption of seafood that might have become contaminated by oil, 80,000 square miles of the U.S. Exclusive Economic Zone were closed to fishing over the short term, resulting in the loss of food, jobs, and recreation. The full scale of the effects of the spill over the longer term could be considerable.

The parties liable for the spill have the responsibility to "make the environment and the public whole" through compensation and restoration of natural resources injured as a consequence of the spill. This requires assessment of the extent and severity of an injury to a natural resource through a process known as the Natural Resources Damage Assessment (NRDA). In addition to quantifying the extent of damage, the assessment includes plans for developing, implementing, and monitoring restoration and compiles expenses for both assessment and restoration costs from those deemed responsible.

The magnitude and depth of the Deepwater Horizon oil spill, together with the inherent complexity of the Gulf of Mexico ecosystem, pose serious challenges to those charged with assessing damages and developing restoration plans. Since the *Exxon-Valdez* spill in Prince William Sound, Alaska in 1989, most

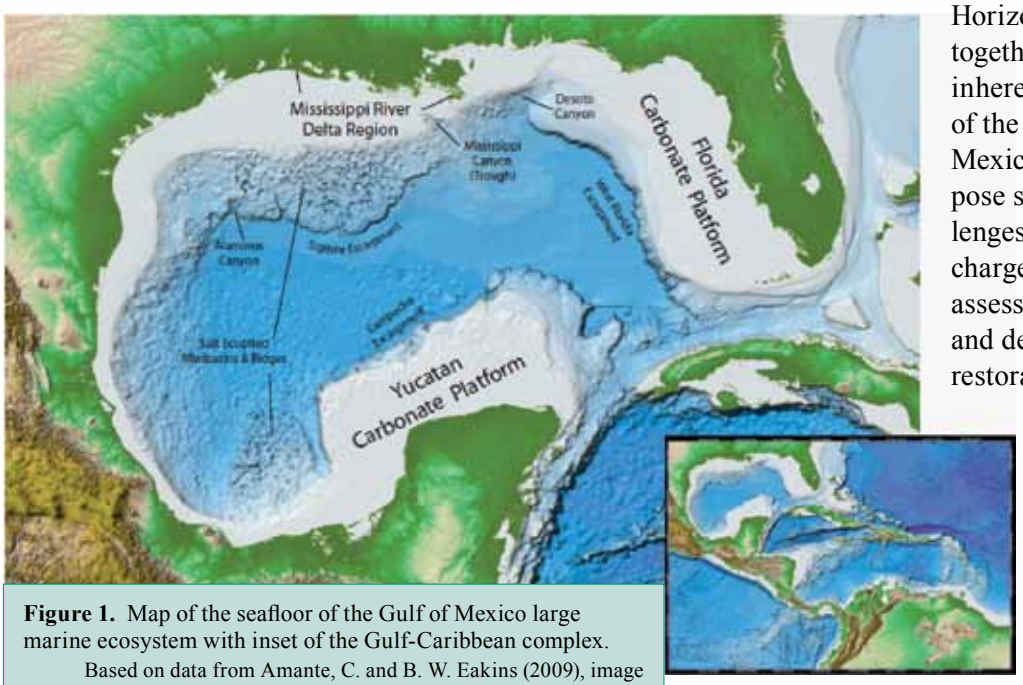

Figure 1. Map of the seafloor of the Gulf of Mexico large marine ecosystem with inset of the Gulf-Caribbean complex.
Based on data from Amante, C. and B. W. Eakins (2009), image constructed using Fledermaus visualization software.

Ecosystem services describe the benefits people receive from a multitude of resources and processes that are provided by ecosystems. They are produced as a consequence of the functioning of the ecosystem—the interactions of plants, animals and microbes with each other and with the environment.

assessments have been applied to events of more limited extent and scale. For a spill the size of the Deepwater Horizon, an "ecosystem services approach" may complement the Natural Resources Damage Assessment and offer a broader opportunity to capture, value, and appropriately restore the full breadth of impacts to the ecosystem and the public.

This report provides guidance on methods for identifying important ecosystem services, for understanding the relevant spatial and temporal scales that need to be studied, and for establishing a baseline understanding of the ecosystem critical to assessing the injuries caused by the oil spill. Finally, the report considers the difficult task of assigning value to the impacted ecosystem services.

Approaches to Assessing and Evaluating Ecosystem Services

The National Oceanic and Atmospheric Administration has developed well-tested methods for assessing injury and impacts to natural resources. For past spills, losses have been measured in ecological terms—for example the number of acres of habitat damaged or wildlife injured—which can be translated into potential restoration projects, such as the restoration of a given area of habitat or number of wildlife species. Where damages do not translate easily into a particular restoration project, funds may be provided as compensation to be applied at a later date when a suitable restoration project is identified.

However, these assessment approaches focus more on the implicit value of the habitat or organisms than on the ultimate value of the resource to humans, and therefore may not capture the whole value provided by the ecosystem. There is growing recognition that taking an ecosystem services approach by linking changes in ecosystems to consequent changes in human well-being would help lead to more informed management and policy. This broader view may be of value for understanding an event of the magnitude, duration, depth, and complexity of the Deepwater Horizon oil spill, and may offer more approaches for restoration projects.

Box 1: Understanding the Gulf of Mexico Ecosystem

The Gulf of Mexico is a remarkably rich and complex ecosystem that provides a wealth of services. In coastal areas, the ecosystem supports a tourism industry worth an estimated $19.7 billion per year and offers storm surge protection and habitat for migrating waterfowl. In addition, the ecosystem provides food, biochemical and medicinal compounds, clean water, and energy in the form of crude oil and natural gas.

Humans have had significant impacts on the Gulf of Mexico for many years through many different activities. For example, channels were cut through the marsh to support the oil and gas industry and levies were constructed for flood control, both of which contributed to the loss of coastal wetlands. Nutrients from fertilizers used in agriculture travel down to the Gulf in the waters of the Mississippi and Atchafalaya rivers, creating plankton blooms that can deplete oxygen and create massive "dead zones" covering thousands of square miles of Gulf seafloor.

Methods to Establish a Baseline

In order to assess the impacts of the Deepwater Horizon oil spill, scientists need to understand ecosystem conditions before the spill took place. However, establishing baseline conditions for a region as vast and complex as the Gulf of Mexico is a daunting task. The physical, chemical, and biological environments of the region change over time—for example, there are natural variations in meteorological and hydrologic conditions that lead to changes in sea surface temperatures, water currents, and flood conditions which, in turn, lead to changes in the ecology.

Assessment is further complicated by human-made changes to the environment (see Box 1). Because many ecosystem services were diminished or degraded prior to the oil spill, realistic baselines will need to be established in order to distinguish the effects of the oil spill from other activities that have negative effects on ecosystem services.

The baselines against which the impact of the spill can be judged are dynamic, both temporally and spatially. Hence, analyses of the impacts of the Deepwater Horizon oil spill will need to take into account the fundamental complexity of the Gulf of Mexico ecosystem, and the past and ongoing affects of phenomena, both natural and human-induced, that are unrelated to the Deepwater Horizon oil spill.

An Ecosystem Services Approach to Damage Assessment

Implementing an ecosystem approach to damage assessment requires an understanding of the complex linkages amongst various ecosystem components,

Figure 2. This illustration shows some of the various components and processes of the Gulf of Mexico ecosystem.
Source: Alan Joyner, Red Twine Art & Design.

including the impact of humans on the structure and function of the ecosystem, the resulting changes in ecosystem services, and how these changes affect human well-being.

1. ***Determining the impact of human actions on the structure and function of the ecosystem***

Scientists will need to investigate each ecosystem service by carrying out specific types of sampling and analysis to complement the information collected under the existing damage assessment process. In order to extend the current damage assessment to include an ecosystem services approach, scientists need to understand how these various components have been affected by human actions, the consequences for the structure and function of the ecosystem, and ultimately the changes in ecosystem services caused by the spill.

2. ***Establishing how changes in the ecosystem lead to changes in ecosystem services***

Once the impacts on ecosystem function and structure are identified, the second step is to determine the ecosystem production functions –how the ecosystem transforms inputs into outputs such as fishery landings.

For some ecosystem services, ecological production functions are fairly well understood and data exist that can help quantify the amount of a service provided. However, for many other ecosystem services, a lack of mechanistic understanding and data inhibits accurate quantification of ecosystem services. The complexity of marine ecosystems makes it difficult to understand how disturbances to an ecosystem will reverberate through the system and ultimately lead to changes in the provision of ecosystem services.

In general, establishing models of ecological production functions is perhaps the greatest challenge facing the application of an ecosystem services approach to damage assessment. Utilizing the extensive data that have been collected for the Natural Resource Damage Assessment process and employing the existing models for Gulf of Mexico ecosystem function presents an opportunity to enhance understanding of the provision of ecosystem services in the Gulf of Mexico.

3. ***Establishing how changes in the provision of ecosystem services affect human well-being***

The third component of the ecosystem services approach focuses on establishing the values of ecosystem services. This involves combining economic methods with ecological assessments to estimate the value of changes in ecosystem services as a result of environmental impacts.

Valuation methods are used to provide a common, quantitative measure to facilitate comparisons among various services as an indication of how much the availability of the service contributes to the improvement in human well-being. The economic approach to valuation begins with individuals and the tradeoffs they are willing to make. By measuring what an individual is willing to

give up in terms of a common monetary metric, the economic approach to valuation generates measures of the relative value of goods and services. For example, how much money would people be willing to give up in exchange for restoring a coastal ecosystem? Answering this question involves identifying which ecosystem services would be affected by restoration and by how much. For instance, restoration might lead to improved fishing, improvement in water quality, and greater storm protection. Economic methods—such as revealed preference, stated preference and cost-based methods—could then be applied to assess the value of these improvements in ecosystem services. Alternatively, in the case of damage to the environment, valuation methods could be applied to assess how much value has been lost as a consequence of reduced ecosystem services. Primary research on the values of ecosystem services would provide additional grounding for the Deepwater Horizon damage assessment.

Conclusion

It will take many years to fully understand the long-term effects and impacts of the Deepwater Horizon oil spill, but efforts are underway to assess the damages caused by the event and develop appropriate restoration projects. Given the vast amount of data collected and research currently being conducted in the Gulf of Mexico, the committee believes that efforts to apply an ecosystem services approach will result in an improved understanding of the full suite of impacts of the oil spill and lead to additional options for restoration of the ecosystem.

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The National Academies appointed the above committee of experts to address the specific task requested by the National Oceanographic and Atmospheric Administration. The members volunteered their time for this activity; their report is peer-reviewed and the final product signed off by both the committee members and the National Academies. This report brief was prepared by the National Research Council based on the committee's report.

For more information, contact the Ocean Studies Board at (202) 334-2714 or visit http://dels.nas.edu/osb. Copies of *Approaches for Ecosystem Services Valuation for the Gulf of Mexico after the Deepwater Horizon Oil Spill* are available from the National Academies Press, 500 Fifth Street, NW, Washington, D.C. 20001; (800) 624-6242; www.nap.edu.