DEEP-OCEAN STEWARDSHIP INITIATIVE

DOSI

INFORMATIONSHEET

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Life Moves Slowly in the Deep Ocean

The Challenge of Timescales in Ocean Restoration

Deep-ocean ecosystems change on significantly longer timescales than many coastal, fresh-water, or terrestrial ones, and failure to account for this difference can have irreversible consequences. For restoration efforts in the deep ocean to be effective, their governance and management must be informed by an understanding of the typically slow recovery rates of deep-ocean ecosystems.

Key Points

- Deep-ocean organisms can live for hundreds or thousands of years.
- Communities change slowly, on scales from decades to millennia.
- Few deep-ocean communities are amenable to restoration within human lifespans.
- Restoration of communities in the deep ocean is expensive and time-consuming.[i]
- Sustainable development of the ocean requires intergenerational equity.
- Because of the difficulties restoration poses in the deep ocean, preventing harm is the preferred option.

In the deep ocean, animal metabolism, growth, and reproduction play out over much longer timescales than in coastal, fresh-water, or terrestrial ecosystems. In general, these life history traits are very slow in deep-ocean organisms as a result of their evolution under relatively stable conditions of low food availability, high pressure, darkness, and low temperature. Deep-ocean ecosystem processes can operate on timescales that are orders of magnitude greater than human lifespans and governance institutions. For example, some species of deep-ocean corals can live for over 4000 years and successional dynamics on seamounts play out over millennia.[ii][iii]

Deep-ocean ecosystems are responsible for numerous services on which humans rely, but these services frequently go unrecognized and are difficult to quantify. Healthy, high functioning deep-ocean ecosystems sequester carbon, recycle nutrients, generate biomass, and provide unique genetic resources that cannot be found elsewhere on Earth. Many anthropogenic activities—pollution, offshore drilling, mining, fishing, and the cumulative impacts of climate change, for example—affect the deep ocean. Because of the slow recovery of deep-ocean ecosystems, activities carried out in the short term can have impacts that last decades or even centuries, much longer than in terrestrial and near-shore ecosystems. Determining appropriate ecological baselines, funding observation and monitoring that can observe long-term trajectories, and designing governance arrangements and institutions that can sustain long-term management is difficult, but doing so effectively is crucial to maintaining deep-ocean ecosystem functions and services.

In various international fora, states are actively engaged in determining approaches to managing human activities in the deep ocean, including how to incorporate the best available scientific knowledge into policy decisions. For example, a new **international legally binding instrument** (ILBI) to regulate biodiversity beyond national jurisdiction (BBNJ), has just been adopted. The UN Decade of Ecosystem Restoration is also ongoing, and restoration is seen as a solution to human impacts. However, the impacts of human activities in the deep ocean are often immediate, while achieving results from restoration takes time. In the deep ocean, restoration actions will require decades, centuries or longer to achieve their goals. Every consideration must be given to avoidance of impacts rather than restoration from their effects.

Types of Restoration

Restoration in deep-ocean ecosystems is a fairly new concept, and it is complex, poorly understood, and likely to be expensive to deploy and evaluate.[iv] As the Society for Ecological Restoration (SER) defines it, restoration is the "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed."[v]

Active v. Passive Restoration

Some methods for achieving restoration are **passive**, with a disturbed or damaged site simply left to recover over time without direct human action or actions designed to prevent further impacts. Some restoration is **active**, with humans intervening to promote and accelerate restoration. Examples of this in shallower waters include building artificial reefs to replace the habitat that natural reefs would have provided, or transplanting macroalgae to sites where the original macroalgal forests have declined. Broadly speaking, there are two types of restoration—compensatory and primary—and each poses special challenges in the deep ocean.[vi]

Compensatory v. Primary Restoration

Compensatory restoration makes up for the loss of ecosystem services indirectly. This can include establishing protections around an ecosystem similar to one previously scheduled for damage or destruction, or it can refer to monetary compensation equivalent to the ecosystem services lost through the damage or destruction of an ecosystem.[vii] Box 1 below contains examples of compensatory restoration.

Primary restoration returns a deteriorated ecosystem to a given baseline condition. Different restoration actions have different effects on measures of loss and extinction risk. Primary restoration includes direct actions that are targeted at returning the population to baseline conditions as measured by local extinction risk for a population or global extinction risk for a species. Box 2 below contains examples of primary restoration.

While deep-ocean researchers have been working to assess passive restoration sites, to identify and test new restoration strategies, and to implement pilot projects to study both passive and active restoration [vii], the process of ecosystem restoration is still better understood in shallow waters. However, even in shallow-water habitats such as mangroves, beaches, seagrasses, and shallow tropical coral reefs, the outcomes of restoration actions are not always as expected. This is due to the lack of information about species' life histories (reproductive mode, life span, etc.), interactions among species (competition, predation, symbiosis, etc.), and the connections between direct human impacts and climate change. For example, the larvae of some species require specific cues generated by the environment, individuals of the same species, or other species for settlement and metamorphosis to the adult form. Without these, the individual fails to reach adulthood and restoration efforts may fail. These types of uncertainties are even more pronounced in the deep ocean.

Box 1: Examples of Compensatory Restoration

- Industrial chemicals contaminated the waters at certain sites along the Los Angeles coastline. Artificial reefs at a different site were able to provide anglers with the same catch numbers as their original fishing sites.[xxvii]

- Because of an oil spill in Chesapeake Bay, scientists constructed artificial oyster reefs at a new site and calculated the extent to which the new system was able to replace the swimming, fishing, and picnicking facilities that the old site provided before it became oiled.[xxviii]

Box 2: Examples of Primary Restoration

- After an oil spill in Louisiana's Lake Barre, ecologists planted new salt marshes to evaluate whether they would be able to restore the system to its pre-spill state.[v] They monitored the restoration efforts and found that these interventions replaced the marsh's functions much more quickly than had the sites been left alone.

- As part of the response to an oil spill in Chesapeake Bay, researchers tested the possibility of restoring cold-water gorgonian coral gardens damaged by artisanal fishery operations in the Mediterranean by attaching coral colonies to cobble supports—creating a shape that resembles a badminton shuttlecock—and throwing them onto the ocean surface to sink to the seafloor. The study found that coral restoration has potential to be cost-effective and to work at large scales in deep environments, but more research will be needed to see whether this bears out in real-world application. The full results of their work will only be evident within 10-50 years.[ix]

Long Temporal Scales Present Challenges for Deep-Ocean Restoration

Shifting Baselines: What is the Target for Restoration?

With any restoration attempt, "shifting baseline syndrome," or the tendency to mistake the current condition of an ecosystem as the target for its restoration even if it reflects an already deteriorated state, poses a problem.[x] Establishing baseline targets for species abundance, biodiversity, or ecosystem function is a challenge exacerbated by natural ecosystem fluctuations and the long-term effects of climate change. It is an especially difficult task in the deep ocean, where so much is left to explore that we lack sufficient data to make these judgements with confidence.

In some cases, a lack of data may make it impossible to determine whether a system has been restored to its true baseline or not. In other cases, ecosystems are complex enough that the interactions that prevent a return to past conditions are not fully understood yet. If the uncertainties of ecological regime changes are not accounted for and monitored concurrently with restoration actions, even reversing the main driver of ecosystem change might not have a noticeable impact.[xi]

Short-Term Decision-Making for Long-Term Goals: How Long Do Impacts Persist in the Deep Ocean?

Because of the long lifecycles of many deep-ocean organisms, the impacts of human activities do not always become obvious until it is too late to counter them.

For example, the orange roughy is a deepwater fish that is slow to mature and long-lived, with a lifespan of over 200 years.[xii] Because its lifecycle was poorly understood, the orange roughy was overfished through the 1970s and 80s, with many fish caught before they could reproduce. The fishery collapsed, with stocks still estimated to be only 10-30% of their original size.[xiii] It is likely they will still take decades to recover. The case illustrates that management decisions made without adequate knowledge of their longer-term context cannot account for relatively slow trends. Although this is just one prominent example of overfishing, there are many others that have led to a wider recognition that deep-ocean fisheries need to be managed differently. In the European Union, this realization led to a complete ban on bottom trawling at depths below 800 meters in 2016.[xiv]

Can Monitoring Timescales Be Aligned with Ecological Timescales in the Deep Ocean?

Good management requires regular reporting and review. The slow rate of change in the deep ocean makes monitoring recovery from human impacts difficult. This presents two problems: (1) It is hard to observe and measure the impacts of restoration efforts because they are so protracted and the results so removed in time from the disturbance and intervention, and (2) existing reporting and review cycles are too short to translate effectively to the deep ocean.

An example of a mismatch between restoration efforts and their intended goals can be seen in the Gulf of Mexico, following the Deepwater Horizon oil spill. Deep-water corals affected by the spill appear to be on a trajectory that will take at least 50 years to recover from the impacts, if they recover at all, but this finding was only possible after frequent and painstaking re-imaging of impacted corals over the course of nearly 10 years.[xv][xvi] In such cases, any monitoring of impacts, restoration, and potential recovery in these habitats—and the institutional frameworks that support these—will have to be on a temporal scale that greatly exceeds a human lifespan.

Some cases are even more challenging. For example, deep-ocean black corals on mid-ocean seamounts have long been known for their medicinal potential: their Latin name *Antipatharia* translates as "against disease." These corals can live for centuries or longer in colonies that can persist for over 4000 years.[xvii] The corals are of great interest in the development of pharmaceuticals, but monitoring efforts to restore them must be done over such a long timescale as to present a nearly intractable challenge.

Offshore monitoring requires large ships costing around USD$100k per day to operate. One study of a hypothetical deep-ocean coral restoration project has estimated that up to 80% of its cost would be the ship-time for ongoing monitoring.[vii] Both the monetary cost and the carbon footprint of these activities must be taken into consideration when determining the frequency and duration of monitoring that restoration actions will require.

Intergenerational Equity

Intergenerational equity is a principle that has shaped environmental governance for decades, and it is embedded in the Law of the Sea, which declares the seabed and its resources the “common heritage of (hu)mankind,” a global, public common for both present and future generations. Achieving intergenerational equity is a challenge even on land and near shore, but the great disparities between the speed of deep-ocean processes and human ones make it a particularly salient one for deep-ocean governance.[xix][xx]

In 1987, the UN’s “Our Common Future” report introduced sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”[xxi] This understanding of sustainable development is further embedded in the UN’s Sustainable Development Goals, perhaps most clearly expressed in Goal 14, “Life Under Water,” which calls for nations to “conserve and sustainably use the oceans, seas, and marine resources for sustainable development.” This implies an obligation to consider the time needed for ecosystem recovery from actions taken in the deep-ocean interventions of the present.

While thus far the common heritage of humankind principle has been limited to mineral resources, the recently adopted BBNJ agreement calls on states to “act as stewards of the ocean in areas beyond national jurisdiction on behalf of present and future generations.” Throughout the BBNJ talks, some states insisted that equity must not be considered only among nations and people, but that it also requires ensuring a sustainable future, one in which our choices in the present do not leave future generations worse off. Doing so requires a deeper understanding of the limitations and opportunities of deep-ocean restoration and a governance framework that allows for its judicious use when possible.

The Way Forward

Meeting the potential for deep-ocean restoration requires creating and maintaining science and research infrastructure, not only to establish these systems for future generations, but also to create a baseline of long-term observations and knowledge—a legacy of past environmental conditions—that can inform wise deep-ocean restoration choices. As our restoration capacity in the deep ocean is currently limited by lack of knowledge, we may continue to learn more of the viability of restoration alternatives. We cannot, however, afford to lose the important planetary-scale functions that the deep ocean carries out while we learn from these actions. Preventing and halting ecosystem damage are the first essential steps towards designing a more sustainable future.

Accounting for temporal scales necessitates not only looking into the past; it also requires looking towards a changing future. An effective high seas governance framework needs long-term infrastructure—both scientific infrastructure to support the continuity of ongoing research at deep-ocean timescales, and durable institutional arrangements that can ensure that such research continues to inform management.[xxiii] Recent research into designing dynamic governance frameworks suggest that international agreements could account for future shifts in ecological conditions by providing tools at different spatiotemporal scales.[xxiv]

Restoration and monitoring efforts must be matched to the potential recovery times of the species and ecosystems that may be impacted by human activity or targeted for marine genetic resources. In some situations, this may require additional fundamental research into the growth rates, reproductive periodicity, and lifespans of the species affected. A deep-ocean governance framework will have to consider these issues and provide a mechanism for its stipulations to be carried out, in some cases over the course of multiple human generations.

The UN General Assembly has declared 2021-2030 the UN Decade of Ecosystem Restoration as well as the UN Decade of Ocean Research for Sustainable Development.[xxv][xxvi] While much of the focus of the Decade programs is on shallow waters or on land, linkages among the programs can help raise awareness about the complexities of restoration on long timescales in the deep ocean. The initiatives associated with these programs will focus on balancing ecological, social, and developmental priorities in seascapes where different forms of ocean use interact, with the aim of fostering long-term resilience. Several Ocean Decade Actions are focused specifically on the deep ocean, including SEABED 2030, which sets out to map the remaining 80% of the ocean floor that remains uncharted at a resolution comparable to maps of the moon or Mars by 2030; and Challenger 150, which seeks to identify data gaps, standardize the collection of deep-sea biological data, and improve global capacity for deep ocean exploration. Along with these, the Decade has already endorsed several projects aimed at greater longevity of observation. Actions like these can help us better understand what might constitute deep-ocean restoration, manage ocean resources, and reverse ecosystem degradation by bringing our understanding of marine timescales into the mainstream of policy and planning.

This information sheet was prepared by the DOSI BBNJ Working Group, which provides scientific and technical information to the development of a new international legally binding instrument for the conservation and sustainable use of biodiversity in ABNJ under the 1982 United Nations Convention on the Law of the Sea.

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About DOSI:

The Deep-Ocean Stewardship Initiative is a global network of experts that integrate science, technology, policy, law and economics to advise on ecosystem-based management of resource use in the deep ocean and strategies to maintain the integrity of deep-ocean ecosystems within and beyond national jurisdiction.

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