Case Study: Functional biogeography and the valuation of deep-sea ecosystem services.

Contact:

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Topic: What is the functional biogeography of deep-sea communities? How do these functions benefits society and how will these benefits change under future climate scenarios?

Background:

The deep sea is one of the largest biomes on the planet and it provides many ecosystem services to society. These services are largely derived from ecosystem functions that are mediated by microbial communities whose activities alter the availability of nutrients, mitigate greenhouse gasses emission, and are intrinsically linked to carbon cycles globally. However, our understanding of these processes are hampered by severe under sampling. Less than 1 square meter of an environment that covers 63% of the globe has been analyzed for microbial community structure and even less is known about the functions of those habitats. Further, this environment is under threat of increased exploitation for mineral and fish resources and our best global climate models predict overlapping alterations to temperature, production, pH, and oxygen throughout this environment. The great unknown of the deep sea is now the frontier of industry and climate change.

Ecosystem services frameworks allow for a coupling of ecological and social science approaches to inform societal decisions. In this framework, ecosystem functions, or intermediate services (e.g. C and N cycling, secondary production) can be used in a cost-benefit analysis, allowing for effective communication of the societal relevance of certain ecological processes (Figure 1). This can be an especially powerful tool in habitats, such as the deep sea, where time and space separate ecological functions from the direct societal benefits (ecosystem services) that are derived from them.

Quantifying ecosystem function across the entire deep sea, aiding the understanding about the ecosystem goods and services derived from this area, is difficult largely because of the vastness and heterogeneity of the deep sea. Heterogeneity is created at small scales by biogenic structures (e.g. tube worm burrows, CaCO3 precipitation) and at regional scales by structures such as seamounts, canyons, hydrothermal vents and cold seeps. With improvements in sequencing and bioinformatics techniques, it is now possible to quantify the variability in ecosystem functions provided by microbial communities across a variety of spatial scales, an approach termed functional biogeography.



**Fig. 2:** Ecosystem services of deep-sea microbial communities. Values from Armstrong et al. 2011; further valuation possible with market based (MB) or official value/carbon market (OV/CM) approaches

Here we propose to couple genomic sequencing of deep-sea sediment from around the globe with an ecosystem service valuation framework to identify how variable services are, the relative value of certain habitats, and how these services and their value is likely to change over time. At the base of this is genomic analysis of over 200 in hand deep-sea sediment samples collected around the world through international collaboration. These data would be placed in an oceanographic context to relate location to function and through spatial-temporal comparisons allow predictive power to how these environments and their traits will change over time. The patterns in function found will be integrated into ecosystem function and then related to global ecosystem services. As an ultimate goal of conservation is conserving ecosystem function, we can use these patterns, particular those functions that relate directly to services (and thus contribute directly to human well-being), to guide management decisions at both local and international levels.

Existing Data:

* Amplicons of >250 deep sea microbial samples and in hand samples from all ocean basins and depths from 200->4000m water depth.

Data Needs:

 - Genomic analysis of existing (DNA extracted – sequencing needed), integration of data repository and sequencing data (Rolling decks, BCO-DMO, OOI, ONC, Sat Data – all data available), Valuation of deep-sea services informed by microbial function data (frameworks available but data emerging/lacking).

Desired Area(s) of Expertise for Students:

This project would excel with students who have experience in genomics, bioinformatics and statistics, social science/economics, biology, oceanography, geography and policy analysis.