State of the Science Fact Sheet: Deep Sea Mining

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION •UNITED STATES DEPARTMENT OF COMMERCE

This document represents the state of the science as described by NOAA scientists and policy experts and approved by NOAA's Science Council.

Deep Sea Mining (DSM) refers to the extraction of critical mineral deposits on or below the seafloor. Of the 50 critical minerals identified as essential to U.S. economic and national security, at least 37 are found in seafloor deposits. Marine critical minerals include manganese, nickel, copper, cobalt, and zinc, which are essential elements for manufacturing high-technology devices, advanced batteries, and national defense applications. To date, no commercial-scale DSM has occurred globally; however, the rising costs of terrestrial sources, improvements in deep-sea technology and capabilities, and the potential for supply chain disruptions have reinvigorated discussions of DSM potential.

NOAA has long-standing licensing and permitting authority for deep-sea mineral exploration and commercial recovery by U.S. companies in international waters and in the development of science related to the potential impacts of deep seabed mining (DSM) via the Deep Seabed Hard Mineral Resources Act (DSHMRA, 30 U.S.C. §§ 1401-1473 (1980)). From 1975-1980, NOAA conducted DSM tests in cooperation with sea mining development companies and studied the potential benthic impacts from deep seabed mining into the 1990s. Although these studies were not conclusive as to the significance of DSM impacts, their findings were used to develop the precautionary and adaptive management framework of NOAA's DSHMRA exploration and commercial recovery regulations (15 CFR parts 970 and 971). Complementing NOAA's DSHMRA responsibilities, NOAA's mission and related responsibilities for conserving and managing marine ecosystems and resources (such as fisheries and aquaculture, protected and endangered species, and marine sanctuaries) are directly relevant to DSM. NOAA's research and observational capabilities can advance efforts to understand better and evaluate DSM's environmental impacts.

Critical mineral deposits are found in oceans around the world. The most common types of marine minerals are (1) manganese nodules on the abyssal seafloor that grow at a rate of 1 to 10 cm per million years, (2) similarly slow-growing polymetallic crusts found on seamounts, and (3) metal sulfide deposits formed by faster hydrothermal processes at mid-ocean ridges and submarine volcanoes. Deep-sea exploration continues to reveal new locations of critical mineral deposits globally, including in polar regions. Characterization and additional research of these sites will improve our understanding of their associated biodiversity, ecological functions, vulnerability to disturbance, mineral formation processes, and economic value.

What could be the impacts of DSM?

Detailed baseline data to understand the impacts of DSM to marine environments and ecosystems are lacking. As of January 2024, only 52% of U.S. waters have been bathymetrically mapped to modern standards, with only 26% of the seafloor mapped globally; and less than 3% characterized with additional detail. Deep-sea exploration routinely reveals new species whose biology and roles in the ecosystem are completely unknown. NOAA, in partnership with federal and international agencies, and academic, and commercial collaborators, continues to provide valuable environmental baseline data on the deep sea through science-driven exploration and open data sharing. These efforts are a first step toward identifying DSM's potential environmental impacts due to disturbance or loss of deep-sea habitat.

DSM activities will likely impact the ocean environment from the seafloor to the surface. Likely impacts include the disturbance of seafloor sediments by DSM machinery, destruction of benthic habitats, and generation of sediment plumes altering the composition of both benthic and deep midwater communities. Biological/ecological impacts may include smothering, suffocation, bioaccumulation of toxic metals, food supply changes, and marine life damage. Connections among seafloor, mid-water, and surface ecosystem functions (including for commercially important fisheries) need to be better understood before the significance of these impacts on marine ecosystems can be assessed. The potential impacts of DSM-introduced underwater noise and light have not yet been studied. **The spatial and temporal scales of these impacts have yet to be determined, as well as what resulting impacts there may be to ecosystem-critical elements such as oxygen, carbon, iron and nutrients and their interconnected marine biogeochemical cycles.**

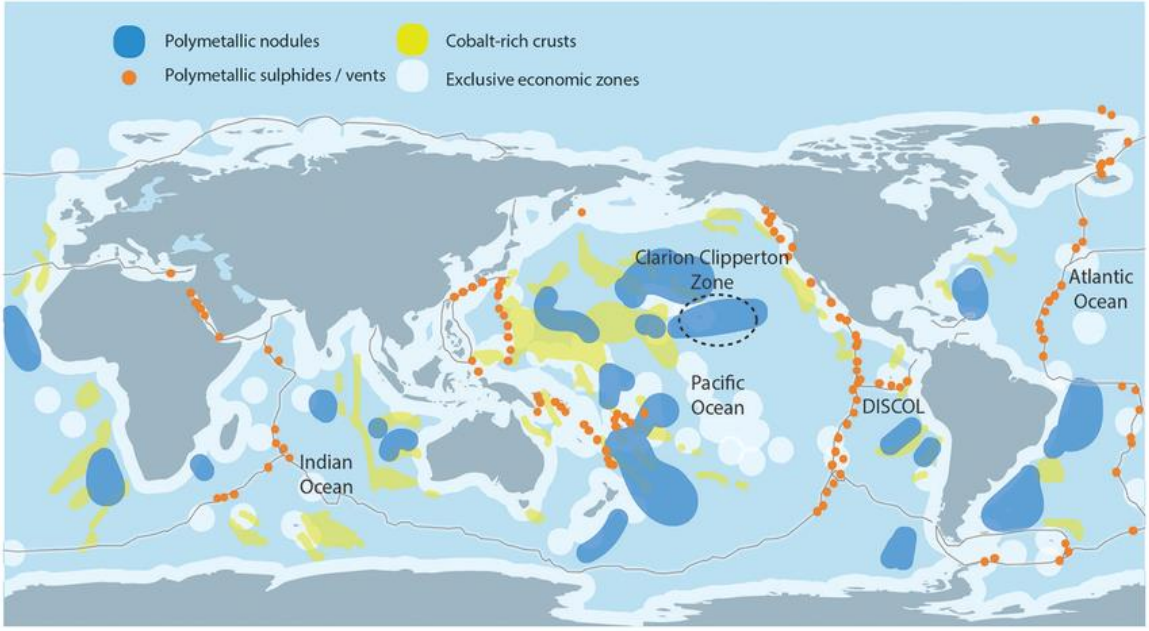

Figure 1. This map is based on a number of sources, specifically, Miller, K. (2018).A world map illustrating the locations of the three primary marine mineral deposits: polymetallic nodules (blue), polymetallic or seafloor massive sulfides (orange), and cobalt-rich ferromanganese crusts (yellow).

The significance of impacts on deep-sea ecosystems following disturbances from DSM is not yet known. Life in some energetically-rich habitats, such as at hydrothermal vents, can begin to recolonize within years to decades after a disturbance. However, deep-sea corals and sponges often grow only a few millimeters per year, meaning they may not regenerate for many hundreds of years after being damaged, if they recover at all. Dredge marks in sediment created up to 40 years ago during simulated mining experiments in a manganese nodule-rich area appear unchanged today. Taken together, these observations suggest that there is significant variability in the rate and ability of various deep-sea ecosystems to recover after disturbances. Additional scientific data are required to better understand this variability and to determine the metrics that should be used to assess DSM's environmental sustainability.

DSM's potential environmental and ecological impacts could pose an uneven distribution of economic benefits and negative impacts on cultural heritage sites and commercial and subsistence fisheries. The disturbance of the seabed and the release of sediment plumes could impact marine ecosystems in ways we do not yet fully understand, potentially posing significant concerns for marginalized or Indigenous communities, particularly on islands. The uncertainty surrounding plume transport and the effects of surface processing on water quality further heightens concerns, particularly for fisheries that depend on stable ocean habitats and clear water conditions.

The International Seabed Authority Mining Code

DSM is a global issue. Each nation has the ability to regulate seabed mining within its national waters. In the United States, the Bureau of Ocean Energy Management is responsible for issuing DSM leases in U.S. waters and has expertise in deep-sea science from which to draw. In other nations' EEZs, DSM proposals are currently being developed despite the uncertainty in DSM's impacts.

The International Seabed Authority (ISA) is the organization through which States Parties to the United Nations Convention on the Law of the Sea (UNCLOS) regulate exploration and exploitation activities in areas beyond national jurisdiction. Under UNCLOS, the ISA must ensure effective protection for the marine environment from harmful effects that may arise from DSM activities (reference ISA website). The US has not yet ratified UNCLOS, and therefore participates as an "observer" at ISA meetings. The ISA manages exploration contracts in areas beyond national jurisdiction—with the exclusion of the Antarctic region, which the Protocol on Environmental Protection governs pursuant to the Antarctic Treaty— and is currently developing regulations for mineral resource exploitation. Each nation has the ability to regulate seabed mining within their national waters, and DSM proposals are currently being developed in several countries despite the uncertainty in DSM's impacts.

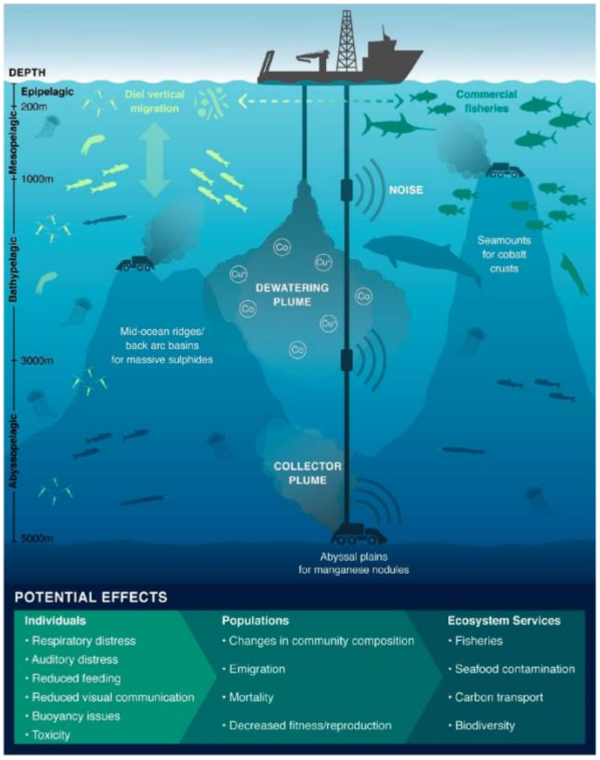

Figure 2. Sediment plumes and noise, from mining activities can potentially affect pelagic species in various ways. Image credit: from Drazen, Smith, Gjerde & Yamamoto, 2020 PNAS

NOAA's DSM Resources, Research Capabilities, and Activities

NOAA has extensive expertise in deep-sea science and is a leader in this field. Through public and private partnerships, NOAA develops innovative deep ocean science technologies and undertakes comprehensive, interdisciplinary, and systematic studies to understand baseline environmental conditions and potential impacts related to DSM. NOAA collaborates with other U.S. federal agencies on crosscutting deep-sea research, including the U.S. Geological Survey and the Bureau of Ocean Energy Management, which is responsible for issuing DSM leases in U.S. waters.

NOAA Ocean Exploration Program has supported numerous regional projects with relevance to DSM, including mapping unknown seafloor, and the collection and examination of unique biologic and geologic samples, including in mineral-rich areas of the deep-sea.

NOAA Pacific Marine Environmental Lab's Earth-Ocean Interactions Program (formerly the NOAA Vents Program) has, since 1983, contributed significantly to global, interdisciplinary, and systematic exploration, discovery, and foundational research of hydrothermal vent processes and ecosystem studies along the mid-ocean ridges and submarine arc volcanoes, where polymetallic sulfide mineral deposits are formed.

NOAA Fisheries conducts controlled experimental studies of fishing gear impacts on benthic habitat, which could be adapted to inform the characterization of DSM impacts and recovery.NMFS multidisciplinary ecosystem studies focused on the carbon cycle of water column communities, fishery movements, and protected species migrations can all contribute to baseline information needs.

NOAA Fisheries' Deep Sea Coral Research & Technology Program supports and coordinates exploration to locate deep-sea coral habitats and conducts research to characterize their associated communities. The program also monitors activities that could affect these sensitive areas and shares information with resource managers.

NOAA National Centers for Coastal Ocean Science (NCCOS) characterizes deep-sea environments by conducting benthic surveys and developing spatially explicit species distribution models of deep-sea coral communities throughout U.S. territorial waters. NCCOS also contributes to seafloor mapping, particularly in coastal and nearshore environments. In addition, NCCOS is a leader in developing Marine Spatial Planning models for siting of ocean industries and conducting geospatial Biogeographic assessments.

NOAA National Centers for Environmental Information manages and provides access to data gathered during research and exploration of the deep ocean and sea floor. Data are publicly available through interactive maps, data portals, and other products.

Other NOAA Research groups with deep ocean science capabilities are also addressing potential impacts related to DSM activities, including; PMEL Acoustics, 'Omics (eDNA), and deep- and biogeochemical- ARGO floats. Additionally, NOAA collaborates closely with its cooperative institutes, including the Ocean Exploration Cooperative Institute; Cooperative Institute for Climate, Ocean, & Ecosystem Studies; and Cooperative Institute for Marine Resources Studies, to enable access to additional expertise and capabilities of the academic and commercial sectors.

Conducting research in the deep-sea poses substantial practical and cost challenges and must be undertaken pursuant to a strategy that will yield results in which confidence can be placed and at the same time are cost-effective. NOAA will also need to be responsive and adaptable as technology develops and additional scientific discoveries may change the understanding of the potential impacts of DSM activities.