Field	Study Information
Title	Pacific Deepwater Investigations, Research, and Technology (PAC-DIRT) (PC-26-01)
Administered by	Pacific OCS Region
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Conducting Organization(s)	TBD
Total BOEM Cost	TBD
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Final Report Due	TBD
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Problem	There is very limited understanding of collector/benthic and dewatering/midwater sediment plumes associated with seabed mineral mining, which hinders robust environmental analyses of potential impacts and ability to establish project design criteria for proposed mining plans.
Intervention	Investigate sediment plume dynamics and potential impacts through a series of laboratory experiments, field observations, and modeling to predict plume distribution and organism response.
Comparison	Study will compare collector and dewatering plumes; and collect data on sediment composition, particle behavior, ecotoxicology, and relevant oceanographic parameters (e.g., bathymetry, currents) to understand how these parameters influence plume dynamics.
Outcome	Increased understanding of how environmental factors influence the spatial and temporal distribution of a sediment plume, as well as its potential biological and ecological impacts. This information will help define the area of potential effect when evaluating mining plans, which is needed for NEPA and consultations.
Context	Pacific OCS Region, specifically Central and/or Western Pacific

BOEM Information Need(s): Recent directives, such as EO 14285 (*Unleashing America's Offshore Critical Minerals and Resources*), EO 14154 (*Unleashing American Energy*), and SO 3417 (*Addressing the National Energy Emergency*), have identified seabed mineral resources as a top priority. Development of these resources will require environmental analyses at multiple stages throughout the process, such as leasing and any subsequent plan approvals. This study would inform those environmental analyses required under the National Environmental Policy Act and consultations required by other laws, such as the Endangered Species Act and the Magnuson-Stevens Fishery Conservation and Management Act. Specifically, affected environment descriptions, potential impact analyses, and appropriate mitigation strategies will need information on the composition of the sediment plume, its behavior and extent (both spatially and temporally), biological community response, and factors that influence these variables. This study is also responsive to public comments on the *Request for Information and Interest-Commercial Leasing for Outer Continental Shelf Minerals Offshore American Samoa*, which have identified sediment plumes as an important environmental consideration.

Background: One potential impact of seabed mining is the introduction of suspended sediment and discharges. Polymetallic nodules are found on abyssal plain environments with naturally very low sedimentation rates (< 0.5 cm/k.y.; Dutkiewicz et al. 2020). Under "traditional" technologies, seabed mining of polymetallic nodules may generate two sediment plumes: one created by the landing and movement of a collector vehicle on the seafloor (collector or benthic plume; Gazis et al. 2025), and one created by the discharge of sediment and water after removing ore-bearing materials (dewatering or midwater plume; Munoz-Royo et al. 2021). Both plumes have three main phases: discharge (i.e., from the vehicle wake or midwater release), buoyancy-driven spread, and passive transport (Peacock & Ouillon 2023). Sediment composition, particle behavior (Gillard et al. 2019), local currents, local bathymetry, and discharge depth (midwater) can influence these phases through complex interactions. Therefore, further work is necessary in proposed Central and Western Pacific lease locations, where the above factors are expected to differ from where past field experiments have occurred in the Clarion-Clipperton Fracture Zone (CCZ) (e.g., Muñoz-Royo et al. 2022, El Mousadik et al. 2024, Gazis et al. 2025).

These sediment plumes can impact biological communities, both on the seafloor and in the water column. Sediment plumes could impact water column communities by clogging suspension feeders (Stenvers et al. 2023), diluting organic matter, disrupting microbial processes (Orcutt et al. 2020), and introducing light and noise (Drazen et al. 2020). A collector plume can increase local suspended sediment concentrations four orders of magnitude higher than background conditions, be detected over kilometers, and blanket adjacent areas in centimeters of sediment (Gazis et al. 2025). It has been estimated that 50% of deep-sea species can be affected by less than one order of magnitude increase (van der Grient & Drazen 2023). Responses can range from changes in behavior, feeding, growth, reproduction, physiology, stress, and mortality. This disturbance can also dilute organic matter concentrations in surface sediments, which may affect infauna and deposit feeders if they survive the initial disturbance (Fukushima et al. 2022). In previous experiments, there was still visible evidence and measured impacts of plume redeposition decades after initial disturbance, e.g., nodule burial and infill, and significant differences in biological communities (Jones et al. 2025, Simon-Lledó et al. 2019). In addition, dewatering plumes may enhance concentration of toxic metals that, in turn, may accumulate over time in the tissues of midwater species and propagate through the food web, affecting higher trophic level predators and local seafood resources (van der Grient and Drazen 2021).

This study proposes a multi-year, multi-phase effort to investigate sediment plume dynamics and organism responses for incorporation into mandated environmental analyses. Upcoming expeditions to the Central and Western Pacific may provide low-cost opportunities to collect data and samples to support this study. For example, characterization of oceanographic parameters, such as bathymetry (via multibeam echosounder) and currents (via acoustic doppler current profiler), could support understanding of plume ignition and propagation (Munoz-Royo et al. 2022, Gazis et al. 2025). Physical sediment samples could be analyzed in the laboratory for sediment composition, particle behavior (e.g., flocculation), and used in ecotoxicology studies. These data could be integrated to provide a regional understanding of the potential impacts from mining-generated sediment plumes. As more site-specific data are collected, they can be used to refine models and interpretations.

Objective(s): The overall purpose of this study is to investigate sediment plume dynamics and potential impacts through a series of laboratory experiments, field observations, and modeling. Objectives include:

- Assess biological and ecological responses to mining-generated sediment plumes
- Understand regional sediment composition and behavior in the Central and Western Pacific
- Take steps towards a validated model of sediment plume behavior that can be used for the various proposed lease areas
- Establish baseline oceanographic and ecological conditions in areas of potential seabed mineral resources
- Determine potential links between midwater communities and tuna fisheries in American Samoa

Methods: This study proposes several approaches to address wide-ranging objectives directly related to understanding sediment plume dynamics and potential impacts. Upcoming cruises in the Central and Western Pacific present opportunities to collect oceanographic data and physical sediments samples from the region.

Physical sediment samples could be used in a series of laboratory experiments to address several objectives. The U.S. Geological Survey has facilities capable of keeping deep-sea organisms at ambient temperature, initially built for Deepwater Horizon oil spill restoration efforts. These facilities, including at-sea holding systems, could be used to evaluate biological sensitivities to suspended sediments through a dose-response experiment on several taxa (e.g., fish larvae, other pelagic taxa, nodule-dependent taxa, varying trophic guilds, congeners). Results would help identify suspended sediment concentrations at which organisms respond and characterize the response.

A second laboratory experiment could use physical samples to characterize particles (e.g., grain size, shape, composition) and their behavior (e.g., flocculation, settling, turbidity current propagation). Results would help assess how long a plume could stay suspended and, subsequently, how far it could potentially travel. Data collected could be used to initialize model experiments. Modeling experiments would include a sensitivity analysis of how sediment plume behavior depends on factors such as bathymetry and collector technology (for benthic plumes); discharge depth (for midwater plumes); currents, and the sediment itself (for benthic and midwater plumes). A goal of the sensitivity analysis is to identify observational parameters needed to narrow uncertainties in plume behavior and inform future observational experiments and monitoring.

Oceanographic data collection would help refine modeling efforts as well as identify depths at which environmental impacts may be exacerbated. For example, in the CCZ, the oxygen minimum zone strongly affects the vertical distribution of water column biomass (Perelman et al. 2021). This may warrant investigation of physical midwater features (e.g., CTD casts), and associated midwater communities through discrete collections (e.g., MOCNESS tows) and water column sampling (e.g., environmental DNA). Understanding the vertical distribution of biomass, species, and the environmental factors that influence them can support development of mitigation measures to minimize potential impacts of a dewatering plume.

Although there are very little data in the Western Pacific, some samples do exist. In 2006, the NOAA Ship *Okeanos Explorer* collected 14 Cobb trawls down to 600 m in American Samoa. In 2017, a subsequent expedition completed midwater transects to 1500 m. Analysis of these data could begin to characterize midwater species in the region, which may be important prey for the commercially important tuna fishery. To determine if tuna prey upon midwater species that may be affected by midwater plumes, tuna stomach content analyses (from samples collected at the American Samoa cannery) could be analyzed.

Specific Research Question(s):

1. What is the biological response of potentially plume-impacted species (and/or congeners) to elevated concentrations of suspended sediment?
2. What is the composition and behavior of regional sediments?
3. How long and at what rate will the plume redeposit?
4. What are the horizontal and vertical footprints of mining-generated plumes?
5. What species comprise the midwater communities in American Samoa? Are these communities important prey for the commercially important tuna fishery?

Current Status: N/A

Publications Completed: N/A

Affiliated WWW Sites: N/A

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