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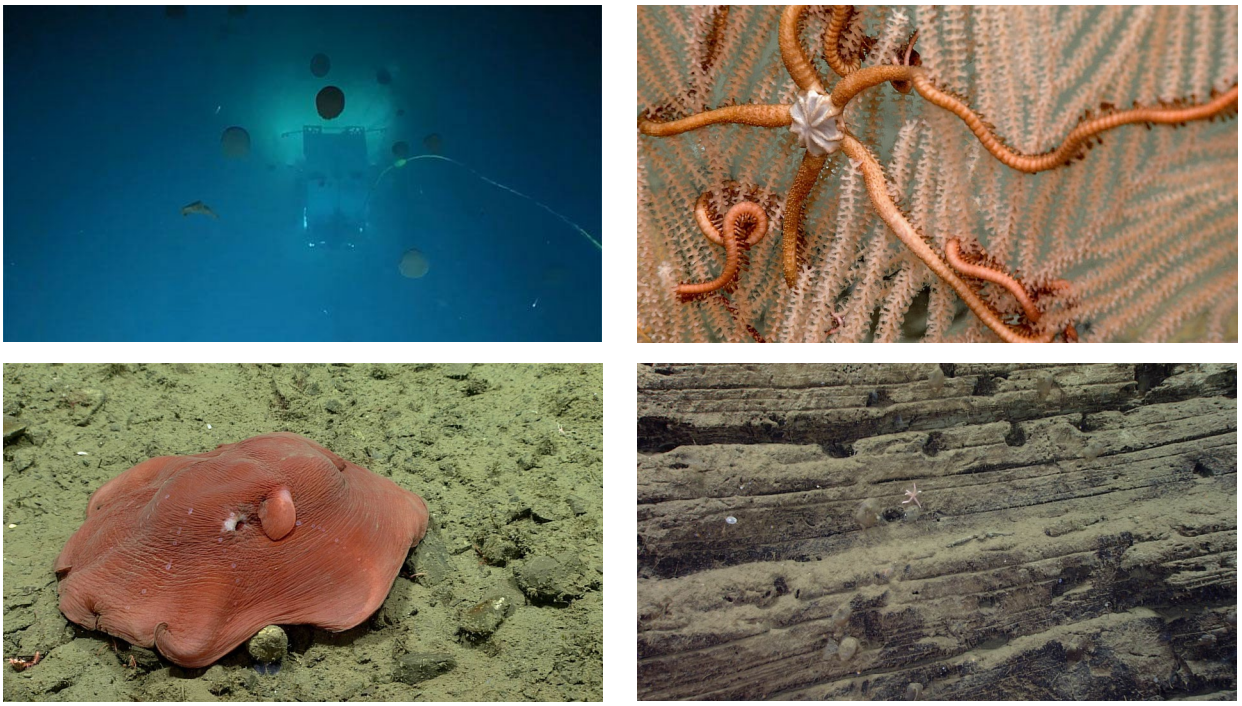
Expedition Report: EX2301, 2023 Shakedown + EXPRESS West Coast Exploration



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Abstract

From April 13-27, 2023 (Portland, Oregon, to Seattle, Washington), NOAA Ocean Exploration conducted the 2023 Shakedown + EXPRESS West Coast Exploration expedition (EX2301), a remotely operated vehicle (ROV) and Mapping expedition to shakedown the ROV, video, telepresence, seafloor mapping, and sampling operations aboard NOAA Ship Okeanos Explorer, as well as explore deep waters off the west coast of the United States. The ROV engineers tested and calibrated ROVs Deep Discoverer and Seirios motor controllers, auto position software, lighting systems, hydraulic systems, stills camera, high-definition ancillary ROV cameras, and sector-scanning sonar. Shakedown and readiness operations for the EM 304 MK II multibeam sonar system included a GNSS Azimuth Measurement Subsystem calibration, two patch tests, and a speed-noise test. Operations during this 15-day expedition included the completion of nine successful ROV dives, which were conducted in water depths ranging from 555 m to 3960 m for approximately 45:34 hours of bottom time and resulted in the collection of 92 samples. EX2301 also mapped 12,298 sq. km of seafloor (12,263 sq. km in the U.S. Exclusive Economic Zone). All data associated with this expedition have been archived and are publicly available through the NOAA archives.

Region of Operation: Pacific Ocean, off the west coast of California, Oregon, and Washington

Ports: Portland, Oregon to Seattle, Washington

Bounding Coordinates: 129.23° W, 34.54° N, 120.48° W, 49.08° N

Expedition Dates: April 13-27, 2023

Expedition Type: ROV and Mapping

Theme Keywords: EXPRESS, eDNA, shakedown, geohazards, energy, benthic habitats

Place Keywords: west coast, Olympic Coast, California, Oregon, Washington

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1. Introduction

NOAA Ocean Exploration is dedicated to exploring the unknown ocean, unlocking its potential through scientific discovery, technological advancements, and data delivery. By working closely with partners across public, private, and academic sectors, we are filling gaps in our basic understanding of the marine environment. This allows us, collectively, to protect ocean health, sustainably manage our marine resources, accelerate our national economy, better understand our changing environment, and enhance appreciation of the importance of the ocean in our everyday lives.

With priority placed on exploration of deep waters and the waters of the U.S. Exclusive Economic Zone (EEZ), NOAA Ocean Exploration applies the latest tools and technologies to explore previously unknown areas of the ocean, making discoveries of scientific, economic, and cultural value. By making collected data publicly available in increasingly innovative and accessible ways, we provide a unique and centralized national resource of critical ocean information. And, through live exploration video, online resources, training and educational opportunities, and public events, we share the excitement of ocean exploration with people around the world and inspire and engage the next generation of ocean scientists, engineers, and leaders.

NOAA Ocean Exploration uses NOAA Ship *Okeanos Explorer* to conduct much of this work. Data collected by NOAA Ocean Exploration on *Okeanos Explorer* off the west coast of California, Oregon, and Washington will contribute to EXpanding Pacific Research and Exploration of Submerged Systems (EXPRESS) campaign. EXPRESS is a multiyear, multi-institution cooperative research campaign in deep-sea areas off California, Oregon, and Washington, including the continental shelf and slope. EXPRESS data and information are intended to guide wise use of living marine resources and habitats, inform ocean energy and mineral resource decisions, and improve offshore hazard assessments.

NOAA Ocean Exploration's expeditions on *Okeanos Explorer* also contribute to the National Strategy for Mapping, Exploring, and Characterizing the United States Exclusive Economic Zone and Seabed 2030.

2. Expedition Overview

From April 13 to April 27, 2023, NOAA Ocean Exploration and partners conducted a telepresence-enabled ocean exploration expedition on *Okeanos Explorer* to evaluate the preparedness of mission systems for the 2023 field season, as well as collect critical baseline information and improve knowledge about unexplored and poorly understood deepwater areas off the west coast of California, Oregon, and Washington. Originally planned as two separate

expeditions (EX2301, 2023 Mapping Shakedown and EX2302, EXPRESS Shakedown - ROV & Mapping), operational and scheduling constraints led to the combination of both projects on a single expedition, renumbered as EX2301 (this report). Previous expeditions in this region include (EX0801) Okeanos Explorer: Mapping Operations Shakedown, (EX0902) Okeanos Explorer: ROV Field Trials - West Coast National Marine Sanctuaries, (EX0903) Okeanos Explorer: Mapping Field Trials - Mendocino Ridge, (EX0904) Okeanos Explorer: Water Column Exploration Field Trails on the Gorda Ridge and Blanco Fracture Zone, (EX0905) Okeanos Explorer: Mapping Field Trails - Mendocino Volcano Field I & II, (EX0907) Okeanos Explorer: Mapping Field Trials - Habitat Characterization around Cordell Banks, (EX1503L2) Okeanos Explorer: Tropical Exploration 2015, (EX2208) EXPRESS: West Coast Exploration 1.

During the 15 days at sea, there were nine remotely operated vehicle (ROV) dives, two mapping calibration patch tests, two conductivity, temperature, and depth (CTD) casts, 40 expendable bathythermograph (XBT) casts, and 12,298 sq. km of bathymetric data were collected (see **Figure 1**). Section 5 provides details about the expedition schedule and unplanned events. A station log detailing the location of each operation conducted is attached as a supplement.

Names, roles, and affiliations of science team members, both on ship and shore, are in **Appendix A**.

Figure 1. Locations of EX2301's track, 9 remotely operated vehicle dive sites, CTD cast (two co-located at STN001), and bathymetric data collected.

2.1 Rationale for Exploration

As part of the planning for this expedition, NOAA Ocean Exploration collaborated with the ocean science and management communities to assess exploration needs and data gaps in unknown and poorly known areas off the west coast of California, Oregon, and Washington. To define the operating area for this expedition, we considered the 2023 call for input, results from EXPRESS campaign meetings and EXPRESS campaign partners NOAA, Bureau of Ocean Energy Management (BOEM), United States Geological Survey (USGS), Monterey Bay Aquarium Research Institute (MBARI), and University of Southern California Sea Grant (USC Sea Grant), and known priorities from resource managers.

The continental shelf, slope, and deepwater regions offshore California, Oregon, and Washington are rich environments, home to deep-sea corals, chemosynthetic communities, and other sensitive habitats, as well as marine geohazards that threaten coastal communities with earthquakes, landslides, and tsunamis. Among these environments are vast energy resources in the form of seafloor minerals, wind, and waves. Mapping and exploring these deep waters results in critical baseline information that can be integrated into EXPRESS campaign core datasets to help guide wise use of living marine resources and habitats, inform ocean energy and mineral resource decisions, and improve offshore natural hazard assessments.

Data and information from this expedition will inform deep-sea management plans for habitat areas of particular concern, marine protected areas, and national marine sanctuaries, support local scientists and managers seeking to understand and manage deep-sea resources, and stimulate subsequent exploration, research, and management activities.

This expedition contributed to ongoing collaborations with the NOAA, BOEM, USGS, MBARI, and USC Sea Grant.

2.2 Objectives

EX2301 evaluated the preparedness of mission systems for the 2023 field season and addressed scientific themes and priority areas put forward by NOAA scientists and partners, including BOEM, USGS, MBARI, and USC Sea Grant, and the broader ocean science and management communities. The primary objective of the expedition was to explore deepwater areas off the west coast of California, Oregon, and Washington to provide baseline information to support science and management needs. Briefly, this expedition sought to:

- Calibrate, test, and evaluate the field readiness of the mapping sonar systems onboard *Okeanos Explorer.*
- Test and evaluate the field readiness of ROV *Deep Discoverer* and *Seirios*, as well as the supporting network and data pipeline onboard *Okeanos Explorer* and onshore.
- Collect high-resolution bathymetry in areas with no or low-quality mapping data.
- Investigate biogeographic patterns of deep-sea ecosystems and connectivity across the west coast for use in broader comparisons of deepwater habitats throughout the Pacific Ocean.
- Map, survey, and sample geological features within the Cascadia Margin and California Coast to better understand the geological context of the region.
- Acquire a foundation of ROV, sonar, and oceanographic data to better understand the characteristics of the water column and fauna that live there.
- Collect biology, geology, and water samples (for environmental DNA (eDNA) analysis) as dictated by expedition priorities and for public access.

- Evaluate a USGS prototype pump system for on-deck eDNA processing.
- Identify, map, and explore the diversity and distribution of benthic habitats, including fish habitats, deep-sea coral and sponge communities, chemosynthetic communities, and biological communities that colonize or aggregate around shipwrecks.
- Explore U.S. maritime heritage by identifying and investigating sonar anomalies, as well as characterizing shipwrecks.
- Engage a broad spectrum of the scientific community and the public in telepresence-based exploration.
- Provide a foundation of publicly accessible data and information products to spur further exploration, research, and management activities.

A full list of expedition objectives is in "Project Instructions: EX2302, EXPRESS Shakedown - ROV & Mapping" (Morrow, 2023).

3. Methodology

The primary systems used throughout EX2301 to accomplish objectives were:

- Sonar systems (Kongsberg EM 304 MKII multibeam sonar, Knudsen 3260 sub-bottom profiler, Simrad EK60 and EK80 split-beam sonars, and Teledyne acoustic Doppler current profilers) to conduct seabed and water column mapping operations, and provide situational awareness for ROV operations.
- NOAA Ocean Exploration's dual-bodied ROV system (ROVs *Deep Discoverer* and *Seirios*) to conduct daytime seafloor and water column visual surveys, as well as to collect a limited number of samples to help further characterize the deepwater fauna and geology of the region.
- A high-bandwidth satellite connection to provide real-time ship-to-shore communications (telepresence).

The following sections further detail the equipment and procedures used by NOAA Ocean Exploration during expeditions on *Okeanos Explorer*.

3.1 Acoustic Operations

Acoustic operations included Kongsberg EM 304 MKII multibeam sonar, Simrad EK60 and EK80 split-beam sonar, Knudsen 3260 sub-bottom profiler, and acoustic Doppler current profiler (ADCP) data collection to map the seafloor, sub-seafloor, and water column, as well as to provide operational information for ROV dives. Standard survey operations include concurrent collection of multibeam, split-beam, and sub-bottom sonar data synchronized using a Kongsberg Synchronization Unit (K-Sync) with the EM 304 MKII set as the master. The ADCPs

were secured during standard surveying operations due to interference with other sonars, but were used to collect data when entering and exiting port and during ROV operations. During conductivity, temperature, and depth system (CTD) and ROV operations, the EM 304 MKII multibeam sonar and Knudsen sub-bottom profiler were secured while the ADCPs and split-beam sonars collected data.

Shakedown and readiness operations for the EM 304 MKII multibeam sonar system included a GNSS Azimuth Measurement Subsystem calibration, patch tests utilizing both POS MV and SeaPath positioning systems, and a speed-noise test. Additional information, including results for system calibrations, can be found in the "NOAA Ship *Okeanos Explorer* Mapping Systems Readiness Report 2023" (Candio et al. 2023).

Mapping operations were planned to maximize edge matching of existing data or to fill data gaps in areas with incomplete bathymetric coverage. In regions with no existing data, lines were optimized for potential discoveries and to complete relatively large continuous areas to support interpretation of features from bathymetry and backscatter. Targeted mapping operations were conducted west of Nitinat Canyon, outside the Olympic Coast National Marine Sanctuary. Mapping operations were carried out during overnight transits and other intervals between ROV dives.

More information about general equipment calibration procedures, data collection, processing, reporting, and archiving is in the "NOAA Ocean Exploration Deepwater Exploration Mapping Procedures Manual" (Hoy et al. 2020).

3.1.1 Equipment and Data Collection Methods

Detailed descriptions of mapping equipment, annual calibrations, and capabilities on *Okeanos Explorer* are in the "NOAA Ship *Okeanos Explorer* Mapping Systems Readiness Report 2023" (Candio et al. 2023). Any deviations from the readiness report are noted in the following sections.

Supplemental files may be added to the readiness report throughout the year if changes to the equipment are made, such as mid-season calibrations. Users of mapping data from EX2301 should refer to the 2023 readiness report and associated supplemental files for changes that may affect their analysis.

3.1.1.1 Multibeam Sonar

Okeanos Explorer is equipped with a 26 kHz Kongsberg EM 304 MKII multibeam sonar. The multibeam sonar was used to collect seafloor bathymetry, seafloor backscatter, and water column backscatter. Bathymetric and seafloor backscatter data are stored in .kmall files. Water column backscatter data are stored separately in .kmwcd files.

Throughout the expedition, mapping watchstanders monitored multibeam data quality in real time. Ship speed was adjusted to maintain data quality and sounding density as necessary, and line spacing was planned to ensure one-quarter to one-third swath-width overlap between lines, depending on the environmental conditions and impact on the quality of the outer swath regions. Maximum angles in the Seafloor Information System (SIS) were generally left open to 65°/65° during transit to maximize data collection and were adjusted on the port and starboard sides to ensure the best data quality and coverage. If outer beams were returning obviously spurious soundings (e.g., due to attenuation or low grazing angle), beam angles were gradually reduced and monitored closely until a high-quality swath was obtained.

Real-time surface sound speed values were provided by a Reson SV70 sound velocity probe mounted in close proximity to the EM 304 transducer and were monitored in Kongsberg's Seafloor Information System software (SIS) for deviations from the values determined by sound speed casts. Sound speed profiles were collected every six hours or more frequently as dictated by local oceanographic conditions (typically every two hours when operating in more dynamic areas).

Vessel positioning and attitude were measured by Applanix POS MV V5 and Kongsberg Seapath 380 positioning systems during data collection. This redundancy allows for either system to be the primary source of positioning/attitude for the multibeam data in the event that one of them fails. Positioning/attitude data were applied to the multibeam data in real time. The primary system used will be noted in the processing logs.

Additionally, multibeam mapping operations were conducted directly over planned ROV dive sites to collect seafloor mapping data to help refine dive plans. Targeted maritime heritage mapping surveys were conducted at 4-8 kn off the coast of Oregon to search for potential shipwrecks associated with World War II.

3.1.1.2 Sub-Bottom Profiler

Okeanos Explorer is equipped with a Knudsen 3260 sub-bottom profiler with a central frequency of 3.5 kHz. This sonar was used to collect echogram images of shallow geological layers underneath the seafloor from 10s-100s of m below the seafloor. Phase, range, and gain were monitored and optimized for data collection. New files were created when changes were made to pulse lengths and/or power settings.

3.1.1.3 Split-Beam Sonars

Okeanos Explorer is equipped with a suite of five Simrad EK60 and EK80 split-beam sonars: three general purpose transceivers (GBTs), the 18, 120, and 200 kHz sonars, and two wide-band transceivers (WBTs), the 38 and 70 kHz sonars. These quantitative scientific echosounders will

be calibrated to identify the target strength of water column acoustic reflectors (e.g., deep scattering layers, fish, gas bubbles from seeps), providing additional information about water column characteristics and anomalies.

Calibrations have not occurred in the Pacific Ocean for the FY23 field season at the time of writing, but are expected later in the season. The calibration files will be archived with the sonar data when available, and the calibration report will be available as a supplemental file to the 2023 mapping readiness report (Candio et al. 2023).

The split-beam sonars were used continuously throughout EX2301 during overnight mapping operations and daytime ROV operations. EK60 and EK80 data were used during ROV water column transects to detect the depth of the deep scattering layers.

3.1.1.4 Acoustic Doppler Current Profiler

Okeanos Explorer is equipped with two acoustic Doppler current profilers (ADCPs), a Teledyne Workhorse Mariner (300 kHz) and a Teledyne Ocean Surveyor (38 kHz). Depending on environmental conditions, the 300 kHz system provides ocean current data to a depth of approximately 70 m, and the 38 kHz system provides data to a depth of approximately 1,200 m. The ADCPs were used to gather data prior to ROV and CTD deployments to assess currents in support of safe operations.

3.1.2 Data Processing and Quality Assessment Methods

3.1.2.1 Multibeam Sonar Bathymetry and Seabed Backscatter

Full-resolution multibeam files (.kmall) were imported into QPS Qimera and then processed and cleaned of noise and artifacts. Outlier soundings were removed using multiple methods, including automatic filtering and/or manual cleaning with the swath and subset editing tools. The default sound speed scheduling method used was “Nearest-in-Time.” If another method was used, it was noted in the multibeam processing log that is archived with the dataset. Gridded digital terrain models were created using the weighted moving average algorithm and were exported in multiple formats using QPS Fledermaus. Daily bathymetric surfaces were created and sent to shore.

A final quality check of the data was performed on shore prior to submission to the archive. This involved additional fine cleaning of soundings and minimization of residual artifacts from sound speed biases and field-cleaning errors. Depth values were compared against orthogonal lines (crosslines) to evaluate the consistency of the multibeam sonar data collected during the expedition (**Figure 2**). A crossline analysis was completed using the Crosscheck Tool in QPS Qimera (**Table 1**) to evaluate the data against the Order 1 S-44 standards set by the International Hydrographic Organization (IHO 2008).

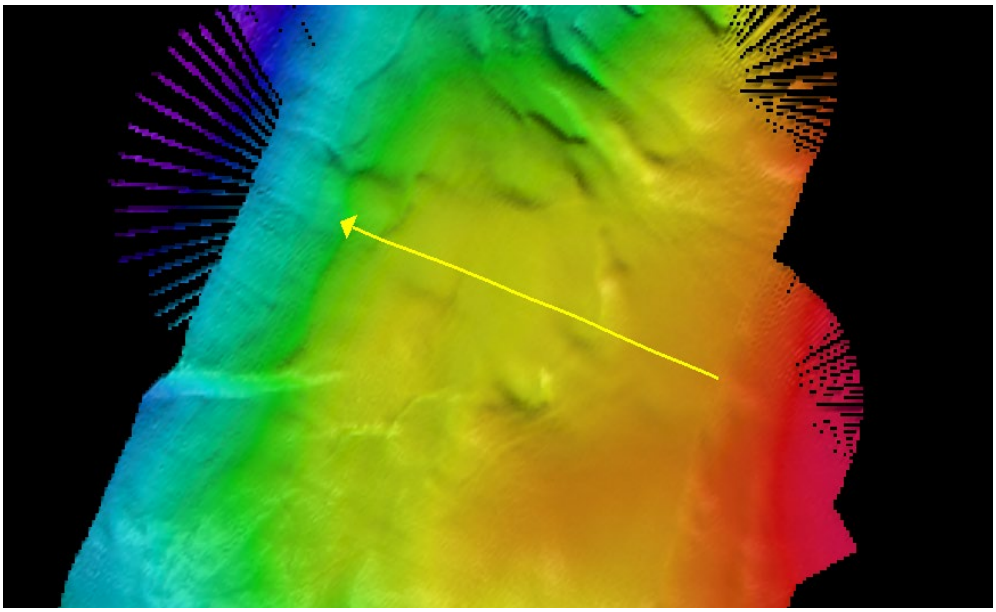

Figure 2. EX2301 crossline (shown in yellow) used for comparison against the bathymetric grid generated via orthogonal multibeam survey lines.

Crossline files: 0121_20230421_101502_EX2301_MB.kmall

Mainscheme line files:

0108_20230421_042230_EX2301_MB.kmall, 0109_20230421_052230_EX2301_MB.kmall, 0110_20230421_060410_EX2301_MB.kmall, 0111_20230421_061006_EX2301_MB.kmall, 0112_20230421_061837_EX2301_MB.kmall, 0113_20230421_062503_EX2301_MB.kmall, 0114_20230421_072503_EX2301_MB.kmall, 0118_20230421_082808_EX2301_MB.kmall, 0119_20230421_092809_EX2301_MB.kmall, 0120_20230421_101031_EX2301_MB.kmall, 0121_20230421_101502_EX2301_MB.kmall, 0122_20230421_104226_EX2301_MB.kmall, 0123_20230421_105802_EX2301_MB.kmall

Table 1. Crosscheck results.

Statistic	Value
Number of Points of Comparison	501,473
Grid Cell Size (m)	50
Difference Mean (m)	-0.000
Difference Median (m)	0.095
Difference Standard Deviation (m)	2.022
Difference Range (m)	-27.490, 23.937
Mean + 2* Standard Deviation (m)	4.045

Statistic	Value
Median + 2* Standard Deviation (m)	4.140
Data Mean (m)	-1792.542
Reference Mean (m)	-1792.542
Data Z-Range (m)	-2175.642, -1624.178
Reference Z-Range (m)	2174.233, -1631.021
Order 1 Error Limit (m)	23.3084
Order 1 # Rejected	2
Order 1 P-Statistic	3.98825e-06
Order 1 Survey	ACCEPTED

The results in **Table 1** confirm that the data collected meet International Hydrographic Organization Order 1 specifications for data quality.

Each line of cleaned full-resolution data was exported to a .gsf file (Level-01 data). The processed and cleaned files were used to create a static surface in QPS Qimera. This final surface was re-projected to the field geographic WGS84 reference frame in QPS Fledermaus and saved as an .sd file for archiving. Using QPS Fledermaus, this .sd bathymetric grid file was then exported as ASCII .xyz, color .tif, floating point .tif, and Google Earth .kmz files. The .gsf files were used to create daily backscatter mosaics using QPS Fledermaus FMGT.

All products maintain horizontal referencing to WGS84 (G1762) and vertical referencing to the assumed mean waterline (based on the waterline measured during the annual shakedown expedition). The draft values for *Okeanos Explorer* used during the expedition are in **Table 2** for the purpose of further post-processing, if desired by the user. Positioning data files for post-processing be requested by sending an email to ex.expeditioncoordinator@noaa.gov.

Table 2. *Okeanos Explorer*'s draft at the beginning and end of EX2301.

Location	Start of Expedition (04/13/2023)	End of Expedition (04/27/2023)
Forward	16' 9.5''	16' 10.5''
Aft Starboard	15' 10''	15' 4.5''
Aft Port	16' 0''	16' 2''

3.1.2.2 Multibeam Sonar — Water Column

EM 304 MKII water column files (.kmwcd) were reviewed in QPS FM Midwater or Qimera for anomalies (e.g., gas seeps and hydrothermal plumes). EM 304 MKII files (.kmwcd) that include

observed water column anomalies are flagged in the dataset's relevant processing logs. Locations of observed anomalies are provided in the data package (.shp and .csv files). All products maintain horizontal referencing to WGS84 (G1762) and vertical referencing to the assumed mean waterline.

3.1.2.3 Split-Beam Sonars

No anomalies were observed during this expedition. Calibration reports and files will be archived with the split-beam data.

3.1.2.4 Sub-Bottom Profiler

Using Natural Resources Canada's SEGYJp2 software, the raw files (.sgy) from the sub-bottom profiler were processed for gain to produce the clearest image of sub-bottom layers. The gain processed files were converted to jpeg images (.jpg) and shapefile tracklines (.shp).

3.1.2.5 Sound Speed

Raw sound speed profiles collected from XBTs and CTDs were processed using HydrOffice Sound Speed Manager and archived as .asvp files.

3.1.3 Data Collection and Processing Software

Table 3 provides a list of the data collection and processing software versions used during EX2301.

Table 3. Versions of data collection and processing software used during EX2301.

Software	Purpose	Version
SIS	EM 304	5.10.2
EK80	EK suite	2.0.0
EchoControl	Knudsen	4.09
UHDAS	ADCPs	14.04
AMVERSEAS	Autolaunch XBT	9.3
WinMK21	XBT	3.0.2
K-Sync	Synchronization	1.9.0
Qimera	Bathymetry	2.3.4
FMGT	Backscatter	7.9.5
FM Midwater	Water Column	7.9.3
Sound Speed Manager	Sound Speed Profiles	2021.1.6
NRCan (SegJp2)	Sub-Bottom	1.0

Software	Purpose	Version
Fledermaus 7	Visualization/Data Analysis	7.8.11

3.2 ROV Operations

ROV dive operations supported the expedition objectives in Section 2.2 and included high-resolution visual surveys of seafloor and water column habitats as well as geological and biological sampling. Each ROV dive was approximately 8 hours, conditions and logistics permitting. Dives were primarily conducted during the day. Information about the general process of site selection, collaborative dive planning, scientific equipment on the ROVs, and the approach to benthic exploration used on *Okeanos Explorer* can be found in Kennedy et al. (2019) and Quattrini et al. (2015).

During each benthic dive, the ROVs descended to the seafloor and then moved from waypoint to waypoint, documenting the geology and biology of the area. During dives, science team members on ship and shore identified each organism observed to the lowest taxon possible based on data available during real-time assessment and provided geological interpretations of the observed substrate. These observations were recorded using a cloud-based, crowd-sourced annotation system developed by Ocean Networks Canada called SeaTube. They will go through quality control at the University of Hawai‘i’s Deep-Sea Ecology Lab, led by Jeff Drazen prior to archiving.

Detailed information about ROV operations is in the “NOAA Ocean Exploration ROV and Telepresence Deepwater Exploration Procedures Manual” (Galvez et al. Forthcoming).

3.3 Sampling Operations

A limited number of geological, biological, and water samples were collected on the seafloor using ROV *Deep Discoverer*’s manipulator arms and associated tools and stored in the bioboxes, rock boxes, rotary suction sampler jars, and Niskin bottles as well as Niskin bottles mounted on the CTD. The primary purpose of the sampling operations was to collect voucher samples that will be publicly available for site characterization. In addition, geological samples were collected for rock type description, and biological samples were collected of organisms that represented potential new species, range or depth extensions, dominant species at a site, and/or rare morphotypes, and to support biological connectivity studies.

At the time of collection, the date, time, latitude, longitude, depth, salinity, temperature, and dissolved oxygen content were recorded for each sample.

After vehicle recovery, samples were examined for associated organisms, labeled, photographed, and entered into the Sampling Operations Database Application (SODA, Gottfried et al. 2023) with all relevant metadata. Any associated organisms found were separated from primary samples and processed separately as "associate" samples.

Detailed information about sampling operations is in the "NOAA Ocean Exploration Sampling Procedures Manual" (Dunn et al. 2023).

3.3.1 Geological Samples

Geological samples were air dried and placed in rock bags or small containers depending on the size of the sample. These samples will be shipped to the Marine and Geological Repository at Oregon State University after the conclusion of the NOAA Ocean Exploration field season on *Okeanos Explorer*. The samples will be sectioned, photographed, and their data will be entered into the university's online database. Polished thin sections will be made for each lithified sample.

3.3.2 Biological Samples

Biological samples were subsampled for inclusion in the Smithsonian National Museum of Natural History Biorepository for future DNA barcoding and DNA extraction. For this purpose, a small subsample (~1 cm^2) was removed from the original sample and placed in 95% analytical grade ethanol (EtOH).

For most of the biological samples, the remainder of the sample was also preserved in 95% EtOH. For select taxa, vouchers or subsamples were preserved in 10%, 5%, or 4% buffered formalin per recommendations from taxonomic experts and guidance provided by the Smithsonian National Museum of Natural History. Details of the preservation of each biological sample are in the associated metadata record. All voucher samples and subsamples were shipped to the Smithsonian National Museum of Natural History for long-term archiving and public access.

3.3.3 Water/eDNA Samples

As many as five 1.7 L water samples per dive were collected in ROV Niskin bottles for eDNA analysis. During benthic dives, water samples were collected at the discretion of the science leads. Depths and locations are recorded with water sample metadata.

In addition, as many as twelve 10 L water samples per dive were collected in CTD-mounted Niskin bottles, of which two liters were used for eDNA analysis.

Once on board the ship, water samples were filtered and treated using one of two processes, either the standard *Okeanos Explorer* procedure (Dunn et al. 2023) or following a procedure

accompanying the USGS pump system (see section 3.6). During the CTD cast, samples were processed via both methods for comparison.

Standard processing used a 0.45 µm filter, and the filters were fixed with DNA/RNA Shield, a preservative that keeps DNA stable at room temperature. A subset of standard processed samples were stored frozen for a methodological comparison. Samples processed using the USGS pump system were filtered using 0.22 µm Sterivex filter canister and stored frozen.

For each dive's set of water samples, a negative control of distilled water was processed at the same time. Details of the timing and associated collection data for each water sample are in the associated metadata record. All eDNA samples were shipped to the Smithsonian National Museum of Natural History for further processing (DNA extraction and sequencing), long-term archiving, and public access.

3.4 Conductivity, Temperature, and Depth

CTD measurements were collected by two different methods. The most frequent method was with the integrated ROV CTD system (Seabird (SBE) 9/11+). This system records data from the CTD, dissolved oxygen (DO), and oxygen reduction potential (ORP) sensors on every dive. The second method was using a dedicated CTD (also a SBE 9/11+) lowered with a winch to provide better information on the critical properties of the water column. In addition to DO and ORP sensors, the dedicated CTD includes a measured light scattering sensor (LSS).

3.6 Novel Technologies and Opportunistic Tools

During EX2301, partners at the USGS provided three identical pump systems to aid in onboard processing of eDNA samples. The three peristaltic pumps require additional space on deck around the CTD rosette or ROV after recovery as well as power and supporting science personnel to process water samples from recovered Niskin bottles. In contrast to *Okeanos Explorer* standard eDNA operations, the pump systems filter water through self-contained Sterivex canister filters, which are then preserved in a frozen state and sent to the repository for analysis and archiving.

4. Environmental and Historical Compliance

General records of multi-expedition environmental and historical compliance are in the "NOAA Ship *Okeanos Explorer* FY23 Field Season Instructions" as appendices and supplements (Cuellar 2023).

Overviews of expedition-specific compliance activities are provided below. Copies of associated records of compliance are in **Appendix B** or as attached supplements.

4.1 Environmental Compliance

Pursuant to the National Environmental Policy Act (NEPA), NOAA Ocean Exploration is required to include in its planning and decision-making processes appropriate and careful consideration of the potential environmental consequences of actions it proposes to fund, authorize, and/or conduct. The companion manual (NOAA 2017) for NOAA Administrative Order 216-6A: Compliance with the National Environmental Policy Act, et al. describes the agency's specific procedures for NEPA compliance.

An environmental review memorandum was completed for all *Okeanos Explorer* expeditions in 2023 in accordance with Section 4 of the companion manual in the form of a categorical exclusion worksheet. Based on this review, a categorical exclusion was determined to be the appropriate level of NEPA analysis necessary, as no extraordinary circumstances existed that required the preparation of an environmental assessment or environmental impact statement. NOAA Ocean Exploration is preparing a programmatic environmental assessment to cover future expeditions.

As required under Section 7 of the Endangered Species Act (ESA), NOAA Ocean Exploration conducted an informal consultation with NOAA Fisheries' Office of Protected Resources to request their concurrence with our biological evaluation determining that *Okeanos Explorer* operations conducted as part of EX2301 may affect, but are not likely to adversely affect, ESA-listed marine species. NOAA Ocean Exploration received a letter dated March 14, 2022, from the NMFS ESA Interagency Cooperation Division that concurs with NOAA Ocean Exploration that the proposed action may affect, but is not likely to adversely affect ESA-listed species and designated and proposed critical habitat in the action.

NOAA Ocean Exploration requested an Essential Fish Habitat (EFH) consultation for expeditions on NOAA Ship *Okeanos Explorer* to the Pacific Ocean region for operations during the 2023 field season. The Letter of Acknowledgement was received on August 3, 2022, from the Assistant Regional Administrator for the NOAA Office of Habitat Conservation stating that these expeditions will not adversely impact EFH.

NOAA Ocean Exploration requested a permit for operations within the National Marine Sanctuaries (NMS) and a permit was granted on March 20, 2023. No operations during EX2301 occurred within NMS boundaries.

4.2 Historical Compliance

NOAA Ocean Exploration's maritime heritage-related activities are informed by the Federal Archaeology Program (FAP), U.S. legislation on the treatment of cultural remains, and the

United Nations Educational, Scientific and Cultural Organization (UNESCO) "Convention for the Protection of the Underwater Cultural Heritage" (UNESCO 2001). Thus, NOAA Ocean Exploration adheres to the research standards and management practices directed by the National Historic Preservation Act of 1966 (NHPA, 54 U.S.C. 300101 *et seq*.) and follows the guidelines in the Rules Concerning Activities Directed at Underwater Cultural Heritage, an annex to the "Convention on the Protection of the Underwater Cultural Heritage." No maritime heritage-related activities occurred during EX2301.

5. Schedule

Table 4 provides a day by day breakdown of EX2301. Eleven dives were scheduled, nine dives happened (details are in **Tables 6 and 7**). Weather conditions prohibited a dive on 4/18 and the dive on 4/22 was canceled after vehicles lost power during the dive on 4/20.

Table 4. EX2301 schedule.

Date (UTC)	Activity
4/12	Mobilization.
4/13	Departure at 1015 local time and transit through Columbia River, small boat transfer of Kongsberg dynamic positioning (DP) technician and DP testing from 2130 to 0730 on 4/14.
4/14	DP testing concluded and Kongsberg DP technician departed via small boat transfer. Conducted GAMS calibration, ultra-short baseline (USBL) calibration after deploying USBL beacon. CTD cast prior to patch test multibeam calibration, initiated at 2100.
4/15	Patch test concluded, Dive 01, Tillamook Flats (Shakedown) and overnight transit mapping to Dive 02 site.
4/16	Weather conditions prohibit diving, transit mapping en route to Dive 02 site.
4/17	Dive 02, Mendocino Flats (Shakedown) with early recovery due to worsening conditions, overnight transit mapping to Dive 03 site. Live interaction with Western Washington University Oceanography class.
4/18	Dive delayed to 4/20 due to conditions, conducted gap-filling mapping operations south of dive site. Live interaction with students from Maritime High School in Seattle, WA.
4/19	Dive 03, Deep Mendocino Flats (Shakedown) and overnight transit mapping to Dive 04 site. Live interaction with the Western Washington University Marine and Coastal Sciences program.
4/20	Dive 04, Trinidad Slump (Shakedown), and overnight transit mapping to Dive 05.

Date (UTC)	Activity
4/21	Dive 05, Horseshoe (Shakedown) aborted early due to power loss on vehicles, transit mapping to patch test site. Live interaction with the College of Charleston BEnthic Acoustic Mapping and Survey (BEAMS) Program.
4/22	Multibeam patch test with backup/alternate positioning system, overnight transit mapping to Dive 06 site.
4/23	Dive 06, North Astoria Canyon (Shakedown), transit mapping overnight to Dive 07 site. Live Interaction USGS Eastern Ecological Science Center Open House
4/24	Dive 07, Quinault Canyon, transit mapping overnight to Dive 08 site.
4/25	Dive 08, Nitinat Canyon, overnight mapping of Nitinat Canyon. Live interactions with the Taholah School and the Quileute Tribal School.
4/26	Dive 09, Nitinat Canyon 2, compass calibration, multibeam speed noise test, and overnight mapping south of Nitinat Canyon. Live interaction with the Makah Tribe Neah Bay High School.
4/27	Transit and arrival in Seattle, WA.
4/28	Demobilization .

6. Results

This section details the results of EX2301. Metrics for the expedition's major scientific work are in **Table 5**. A station log detailing the location of each operation conducted is provided as a supplemental file to this expedition report.

Table 5. Summary of scientific metrics for EX2301.

Metrics	Totals
Days at Sea	15
Days at Sea in U.S. Waters	15
Linear km Mapped by EM 304	2,243.49
Sq. km Mapped by EM 304	12,298
Sq. km Mapped by EM 304 in U.S. Waters	12,263
Vessel CTD Casts	2
XBT Casts	40
ROV Dives	9
ROV Dives in U.S. Waters	9
Maximum ROV Seafloor Depth (m)	3,956

Metrics	Totals
Minimum ROV Seafloor Depth (m)	555
Total Time on Bottom (hh:mm:ss)	45:34:00
Water Column Survey Time (hh:mm:ss)	00:00:00
Total ROV Time (hh:mm:ss)	45:34:00
Potential Undescribed or Novel Species and New Records Observed*	3
Dives During Which Living Corals and Sponges Were Observed	7
Dives During Which Chemosynthetic Communities Were Observed	0
Dives During Which Active Seeps/Vents Were Observed	0
Dives During Which Diverse Benthic Communities Were Observed	3
Total Samples	92
Biological Samples (Primary)	14
Biological Associate Samples	26
Geological Samples	1
Geological Associate Samples	3
eDNA Water Samples	48
Actively Participating Scientists, Students, and Resource Managers	20

* Organisms unknown to science or an extension of their known range of geolocation or depth

The primary objective of EX2301 was to conduct mapping and ROV shakedown operations in preparation for the 2023 field season. Relevant goals are highlighted here.

Goal: Exercise and evaluate new stern thrusters, test and calibrate dynamic positioning system

- Dynamic positioning system calibrated successfully after leaving port.
- Conducted nine dives using dynamic positioning system and newly installed stern thrusters.

Goal: Prepare ROV and onboard teams for deployment and recovery operations, confirm ROV systems are operational, and assess new workflows

- Prior to departure, conducted several dunk tests and reviewed launch and recovery operations with bridge, aft conning, and deck department.
- USBL successfully calibrated and tested during following ROV dives.
- Conducted six shakedown dives through progressive depths from 600 to 4000 m.
- Tested all ROV systems, evaluated new stills workflow, troubleshooted auto heading and auto altitude functions.

- Conducted three science dives with full narration, sampling, and shore-side participation.
- Streamed all dives to shore, confirmed working video, audio, and data pipeline.
- Trained and cross-trained ROV team in pilot, copilot, and navigator roles.

Goal: Prepare ship-based mapping sonars for field season, calibrate and confirm offsets after dry dock

- Conducted strategic transits that maximize data collection over previously unmapped areas where possible.
- Confirmed functionality of EM 304 multibeam sonar and integration with all ancillary systems.
- Conducted GNSS Azimuth Measurement Subsystem (GAMS) calibration.
- Conducted geometric calibration of the system (patch test), including deep roll verification lines with both POS MV and SeaPath positioning systems
- Conducted speed/noise tests to assess how vessel speed affects noise levels at the receive array.
- Confirmed functionality and integration of the Knudsen 3260 Sub-Bottom Profiler with all ancillary systems.
- Conducted comparison casts between the Seabird 9/11Plus CTD, and Deep Blue XBTs.
- Confirmed functionality of both the 38 and 300 kHz ADCPs systems.

Goal: Collect critical baseline information to support priority NOAA science and management needs, as well as needs identified by the EXPRESS campaign

- Conducted close-up imaging operations on potential new, rare, and poorly documented organisms, as well as dominant members of benthic communities.
- Collected a total of 92 specimens for future study, including eDNA water samples, corals, sponges, echinoderms, and geologic samples.
- Evaluated a pump system for faster eDNA filtration after ROV recovery.
- Collected a suite of water samples for an eDNA methodology comparison.
- Collect samples of potential new species.
- Mapped 12,298 sq. km of seafloor.

6.1 Acoustic Operations Results

Prior to mapping operations, initial calibrations and tests confirmed that the EM 304 MK II multibeam system was prepared for the field season. These calibrations and tests included a GPS Azimuth Measurement Subsystem (GAMS) calibration, two co-located patch tests, one with each of the ship positioning systems (POS MV and SeaPath) as primary, and a speed noise

test. The available conditions and operational needs did not permit an extinction test or calibration of the EK60/EK80 split beam sonars.

Patch tests validated the residual angular offsets determined in 2022, and therefore no updates were made to the configuration. Additional information, including calibration results and offsets, are available in the 2023 mapping readiness report (Candio et al. 2023)

NOAA Ocean Exploration mapped 12,298 sq. km of seafloor during the 15 days at sea for EX2301. Of the 12,298 sq. km mapped, 12,263 sq. km was deeper than 200 m and within the U.S. Exclusive Economic Zone and Territorial Sea.

Acoustic mapping data are sent to the NOAA archives within 120 days of the end of an expedition. The 2023 mapping readiness report describes the data archived for each dataset, including file formats (Candio et al. 2023). Information about proprietary software and freeware that can handle the varying data types is in the "NOAA OER Deepwater Exploration Mapping Procedures Manual" (Hoy et al. 2020). **Appendix C** provides excerpts about mapping operations from daily situation reports to provide situational awareness for future users of the data collected during EX2301.

6.2 ROV Operations Results

Depth ranges explored during the nine ROV dives were between 555.0 and 3,955.8 m. During these dives, the ROVs spent 45:34 hours conducting benthic exploration and 0 hours conducting water column exploration. **Tables 6 and 7** contain dive-specific information.

Table 6. Summary information for the nine ROV dives conducted during EX2301.

Dive #	Site Name	Date (yyyymmdd)	On Bottom Latitude (dd)	On Bottom Longitude (dd)	Max Depth (m)	Min Depth (m)	Dive Duration (hh:mm:ss)	Bottom Time (hh:mm:ss)	Water Column Exploration Time (hh:mm:ss)
01	Tillamook Flats (Shakedown)	20230415	45.468238914563365	-124.75657591080105	657.4	555.0	8:05:42	07:23:27	00:00:00
02	Mendocino Flats (Shakedown)	20230417	40.17177376425868	-124.8913356646388	971.3	967.7	4:34:39	02:28:43	00:00:00
03	Deep Mendocino Flats (Shakedown)	20230418	40.13370182238214	-126.12657064065588	3955.8	3945.4	8:15:13	03:07:33	00:00:00
04	Trinidad Slump (Shakedown)	20230420	41.49387520296348	-125.0982977824019	2424.0	2315.1	8:05:09	04:57:16	00:00:00

Dive #	Site Name	Date (yyyymmdd)	On Bottom Latitude (dd)	On Bottom Longitude (dd)	Max Depth (m)	Min Depth (m)	Dive Duration (hh:mm:ss)	Bottom Time (hh:mm:ss)	Water Column Exploration Time (hh:mm:ss)
05	Horseshoe (Shakedown)	20230421	42.275941796150576	-125.07241306421736	1817.0	1791.4	5:54:09	03:17:40	00:00:00
06	North Astoria Canyon (Shakedown)	20230423	46.48901495681603	-125.8067607769054	2531.7	2406.1	8:01:48	05:04:02	00:00:00
07	Quinault Canyon	20230424	47.294462946072336	-125.2723766129122	1718.5	1597.1	8:06:29	05:41:01	00:00:00
08	Nitinat Canyon	20230425	48.153949972491255	-125.81364619273306	1104.8	901.6	8:10:17	06:36:13	00:00:00
09	Nitinat Canyon 2	20230426	48.176840553348896	-125.77389553421234	989.6	743.3	08:13:33	06:58:18	00:00:00

Table 7. Summary of scientific metrics for the nine ROV dives conducted during EX2301.

Dive #	Site Name	Undescribed Species	Corals & Sponges	Chemo-synthetic Community	Active Seeps & Vents	Diverse Benthic Community	Primary/ Associate Biological Samples	Primary/ Associate Geological Samples	Water Samples
01	Tillamook Flats (Shakedown)	0	absent	absent	absent	absent	0/0	0/0	6
02	Mendocino Flats (Shakedown)	0	absent	absent	absent	absent	0/0	0/0	6
03	Deep Mendocino Flats (Shakedown)	0	present	absent	absent	absent	1/0	0/0	6
04	Trinidad Slump (Shakedown)	0	present	absent	absent	absent	1/0	0/0	6
05	Horseshoe (Shakedown)	0	present	absent	absent	absent	0/0	0/0	0
06	North Astoria Canyon (Shakedown)	0	present	absent	absent	absent	1/2	0/1	6
07	Quinault Canyon	0	present	absent	absent	absent	4/5	0/0	6
08	Nitinat Canyon	0	present	absent	absent	absent	5/8	0/2	6

Dive #	Site Name	Undescribed Species	Corals & Sponges	Chemo-synthetic Community	Active Seeps & Vents	Diverse Benthic Community	Primary/ Associate Biological Samples	Primary/ Associate Geological Samples	Water Samples
09	Nitinat Canyon 2	0	present	absent	absent	absent	2/11	1/0	6

6.3 Sampling Operations Results

A total of 92 samples were collected during EX2301: one geological sample, 14 biological samples, 29 associate samples (specimens attached to primary biological or geological samples), and 48 water samples for eDNA analysis (**Table 7** includes results by dive). An additional 36 water samples were collected via CTD for eDNA analysis. **Appendix D** contains complete inventories of geological, biological, and water samples collected.

There was one geological sample that was purposely collected (primary sample) as well as three samples that were incidentally collected (associate samples). In total, these samples amounted to four individuals. Highlights are noted in Section 6. **Table D1** in **Appendix D** contains full details about the geological samples collected.

There were 14 biological samples that were purposely collected (primary samples) as well as 26 samples that were incidentally collected (associate samples). In total, these samples amounted to 43 individuals. Highlights are noted in Section 6. **Table D2** in **Appendix D** contains full details about the biological samples collected.

There were 48 water samples collected for eDNA analysis. **Table D3** in **Appendix D** contains full details about the water samples collected.

6.4 Novel Technologies and Opportunistic Tools

During EX2301, scientists evaluated a USGS peristaltic pump system (**Figure 3**) for offloading and processing water samples collected via Niskin bottles mounted on the ROV and CTD frame. Multiple eDNA samples were extracted from a series of CTD samples and processed via either the USGS pump system or with NOAA Ocean Exploration's standard eDNA procedure (Dunn et al. 2023) in order to provide a comparative data set.

With the exception of the comparative CTD samples, all other water samples collected on EX2301 were processed using the USGS peristaltic pump system on deck. The flow rate of the pump system is significantly higher than the laboratory system used in typical NOAA Ocean Exploration operations and processing times were significantly reduced. The pump system also connects directly to the Niskin bottles on deck, which minimized the

opportunity for sample contamination via multiple transfers from the bottle to the filtering cup, but impeded ROV recovery operations, which had to pause during pumping. After several iterations the ROV team and science team were able to coordinate efficient setup and takedown of the pump system during ROV recovery and minimize the impacts to the recovery timeline.

Figure 3. Science leads Paige Koenig (left) and Alexis Weinnig (right) process water samples using the USGS peristaltic pump system (lower) to extract water samples from the Niskin bottles on ROV *Deep Discoverer*.

6.5 Engagement

EX2301 engaged with audiences around the world, opening a window of understanding into the deep sea. Highlights included:

- Live video feeds received over 50,600 views, and associated web content received more than 12,800 page views during EX2301.
- 8 live interactions were conducted while the expedition was underway to engage a diversity of audiences.
- Over 35 news/web articles covered EX2301. Stories appeared in national and local media outlets and on websites throughout the country, such as the Charlotte Observer

and Seattle Times. This coverage amplified the impact of the expedition, increasing the audience reached.

- At the end of the expedition, while docked in Seattle, NOAA Ocean Exploration hosted ship tours for 25 individuals, including members of the media, representatives from the Port of Seattle and the Seattle Aquarium, and staff from NOAA and the U.S. Geological Survey

- A public port event on April 29th drew over a thousand people who were given tours to see and learn about *Okeanos Explorer* and the remotely operated vehicles used to explore the deep ocean and also engage with a variety of NOAA offices.

7. Data Access

All data collected during NOAA Ocean Exploration expeditions and associated products are made publicly available via the NOAA archives, NOAA's National Centers for Environmental Information (NCEI), the NOAA Institutional Repository, and the Smithsonian National Museum of Natural History and Oregon State University sample repositories, unless protected (e.g., data associated with specific maritime heritage sites). Data collected by NOAA must be covered by a data management plan to ensure they are archived and publicly accessible. The data management plan for EX2301 is in the "Project Instructions: EX2302, EXPRESS Shakedown - ROV & Mapping" (Morrow 2023).

The primary tools for accessing data collected during this expedition and archived at NCEI are the EX2301 data landing page, the NOAA Ocean Exploration Data Atlas, and the NOAA Ocean Exploration Video Portal. Refer to the NOAA Ocean Exploration Data Access web pages for help navigating expedition data. Other resources include the NOAA Ocean Exploration Data (NCEI) ArcGIS online group, which provides access to all NOAA Ocean Exploration geospatial data services managed by NCEI, including the geospatial data layers found in the data atlas, and the NOAA Ocean Exploration Data Management website.

NCEI makes data publicly available over time as quality-control measures are completed, data are released, and publications and related materials are published. Thus, not all data and products will be made available at the same time. To access data and products from EX2301 that aren't yet public, request assistance by submitting a data request form or sending an email to oer.info.mgmt@noaa.gov.

7.1 Digital Data/Product Locations

The locations for directly accessing specific types of digital data collected during EX2301 and products documenting expedition results (at the time of writing this report) are provided in

Table 8.

Table 8. Online locations for direct access to digital data collected during EX2301 and products documenting expedition results (at the time of writing this report).

Data/Product Type	Description
EM 304 Bathymetry and Backscatter Data	EM 304 bathymetric and backscatter data, supporting informational logs, and ancillary files are available through NCEI's Bathymetric Data Viewer POSPac and BS correction files can be requested from oar.oer.exmappingteam@noaa.gov
Water Column Data (EM 304 and EK60/EK80)	EM 304 and EK60/EK80 water column data, supporting data, and informational logs are available through NCEI's Water Column Sonar Data Viewer
Knudsen 3260 Sub-Bottom Profiler Data	Sub-bottom data, supporting data, and informational logs are available in NCEI's Trackline Geophysical Data Viewer
Sound Speed Profiles	Ancillary sound speed profiles are available with the mapping data through NCEI's Bathymetric Data Viewer.
Oceanographic Dataset	Oceanographic data and products are available from NCEI. These data include data from shipboard sensors, including navigational data, meteorological data (wind), and oceanographic data (bathythermograph, sound velocity probe, thermosalinograph); additional data and products include profile data (CTD and XBT), event logs, images, ROV ancillary data, and sample data
Sun Photometer Measurements	Sun photometer measurements are available through NASA's Marine Aerosol Network
SeaTube Annotations	Annotations from ROV dives with associated video (with a snapshot capability) and geospatial and sensor data are available through Sea Tube
Dive Summaries	Individual ROV/AUV dive summaries and associated ROV dive data are available as supplemental files to this report
CTD Summaries	Individual CTD summaries for shipboard CTD casts are available as supplemental files to this report
Reports and Papers	Reports and peer-reviewed papers are available through the NOAA Ocean Exploration Library Guide and the NOAA Institutional Repository

7.2 Physical Sample Repositories

The following repositories archive samples collected during NOAA Ocean Exploration expeditions on *Okeanos Explorer*. More information about how to access physical samples is on the NOAA Ocean Exploration website.

Biological Samples

Department of Invertebrate Zoology
Smithsonian National Museum of Natural History, Museum Support Center
MRC 534, 4210 Silver Hill Road, Suitland, MD 20746

DNA and eDNA Samples

Biorepository
Smithsonian National Museum of Natural History, Museum Support Center
4210 Silver Hill Road, Suitland, MD 20746

Geological Samples

Marine and Geology Repository
Oregon State University
Burt 346, Corvallis, OR 97331-5503

References

Candio, Samuel, Thomas Morrow, Shannon Hoy, Charlie Wilkins, Dan Freitas, Treyson Gillespie. 2023. NOAA Ship *Okeanos Explorer* Mapping Systems Readiness Report 2023. NOAA Ocean Exploration, National Oceanic and Atmospheric Administration. United States. https://doi.org/10.25923/cder-qt47.

Cuellar, Samuel. 2023. *NOAA Ship* Okeanos Explorer *FY23 Field Season Instructions*. NOAA Ocean Exploration, National Oceanic and Atmospheric Administration. United States. https://doi.org/10.25923/f06c-5x38.

Dunn, Christopher, Thomas Morrow, Matt Dornback, Kasey Cantwell, Abigail Reft, Kimberly Galvez, Rachel Medley, Adrienne Copeland, Christa Rabenold, Bill Moser, Courtney Wickel, Michael O'Mahoney, Karen Reed, Mike Vecchione, Stephanie Bush, Dave Pawson, and Doug Eernisse. 2023. NOAA Ocean Exploration Biological and Geological Sampling Procedures Manual. NOAA Ocean Exploration. National Oceanic and Atmospheric Administration. United States. https://doi.org/10.25923/x741-bj60

Galvez, Kimberly, Kasey Cantwell, Kelley Suhre, Shannon Hoy, Christa Rabenold, Megan Cromwell, Caitlin Ruby, Anna Lienesch, Scott France, Upasana Ganguly, Caitlin Adams, Sam Candio, Matt Dornback, Charlie Wilkins, Amanda Maxon, Scott Sorset, Adrienne Copeland, Christopher Dunn, Todd Gregory, Chris Ritter, Andy O'Brien, Susan Gottfried, Art Howard, Roland Brian, Brian R.C. Kennedy, Elizabeth Lobecker, Shane Guan, Michael Ford, Melissa Ryan, and Rachel Medley. Forthcoming. *NOAA Ocean Exploration ROV and Telepresence Deepwater Exploration Procedures Manual*. NOAA Ocean Exploration, National Oceanic and Atmospheric Administration. United States.

Gottfried, Susan, Megan Cromwell, Barry Eakins, Madalyn Newman, Katharine Weathers, Lauren Jackson, and Anna Lienesch. 2023 *Sampling Operations Database Application (SODA) Manual 2023*. National Centers for Environmental Information, National Oceanic and Atmospheric Administration. United States. https://doi.org/10.25923/cpnq-8e58.

Hoy, Shannon, Elizabeth Lobecker, Sam Candio, Derek Sowers, Grant Froelich, Kevin Jerram, Rachel Medley, Mashkoor Malik, Adrienne Copeland, Kasey Cantwell, Charlie Wilkins, and Amanada Maxon. (2020). *Deepwater Exploration Mapping Procedures Manual*. NOAA Ocean Exploration, National Oceanic and Atmospheric Administration. United States. https://doi.org/10.25923/jw71-ga98.

IHO (International Hydrographic Organization). 2008. *IHO Standards for Hydrographic Surveys*, 5th edition. International Hydrographic Bureau. International Hydrographic Organization Special Publication, S-44. https://iho.int/uploads/user/pubs/standards/s-44/S-44_5E.pdf.

Kennedy, Brian R.C., Kasey Cantwell, Mashkoor Malik, Christopher Kelley, Jeremy Potter, Kelly Elliott, Elizabeth Lobecker, Lindsay McKenna Gray, Derek Sowers, Michael P. White, Scott C. France, Stephen Auscavitch, Christopher Mah, Virginia Moriwake, Sarah R.D. Bingo, Meagan Putts, and Randi D. Rotjan. 2019. "The unknown and the unexplored: Insights into the Pacific

deep-sea following NOAA CAPSTONE expeditions." *Frontiers in Marine Science* 6:480. https://doi.org/10.3389/fmars.2019.00480.

Morrow, Thomas. 2023. *Project Instructions: EX2302, EXPRESS Shakedown - ROV & Mapping*. NOAA Ocean Exploration, National Oceanic and Atmospheric Administration. United States. https://doi.org/10.25923/90f5-g265.

NOAA (National Oceanic and Atmospheric Administration). 2017. *Policy and Procedures for Compliance with the National Environmental Policy Act and Related Authorities*. NOAA. United States. https://www.noaa.gov/sites/default/files/2021-10/NOAA-NAO-216-6A-Companion-Manual-03012018%20%281%29.pdf.

Quattrini, Martha S. Nizinski, Jason D. Chaytor, Amanda W. J. Demopoulos, E. Brendan Roark, Scott C. France, Jon A. Moore, Taylor Heyl, Peter J. Auster, Brian Kinlan, Carolyn Ruppel, Kelley P. Elliott, Brian R.C. Kennedy, Elizabeth Lobecker, Adam Skarke, and Timothy M. Shank. 2015. "Exploration of the canyon-incised continental margin of the northeastern United States reveals dynamic habitats and diverse communities." *PLoS One* 10:e0139904. https://doi.org/10.1371/journal.pone.0139904.

UNESCO (United Nations Educational, Scientific and Cultural Organization). 2001. Convention for the Protection of the Underwater Cultural Heritage. UNESCO. France. https://unesdoc.unesco.org/ark:/48223/pf0000126065.

Appendix A: EX2301 Science Team Members

EX2301 included onboard mission personnel (**Table A1**) as well as shore-based science personnel (**Table A2**) who participated remotely via telepresence.

Table A1. EX2301 onboard mission team personnel.

Name	Role	Affiliation
Morrow, Thomas	Expedition Coordinator	NOAA Ocean Exploration
Gillespie, Treyson	Watch Lead	UCAR
Freitas, Dan	Watch Lead	UCAR
Weinnig, Alexis	Science Lead	USGS
Koenig, Paige	Science Lead	UCAR
Ritter, Chris	ROV Lead	GFOE
McLetchie, Karl	ROV Engineer	GFOE
Mefford, Jon	ROV Engineer	GFOE
Unema, Levi	ROV Engineer	GFOE
Kennison, Sean	ROV Engineer	GFOE
Murphy, Lars	ROV Engineer	GFOE
Mohr, Bobby	ROV Engineer	GFOE
Wright, Chris	Data Engineer	GFOE
Aragon, Fernando	Data Engineer	GFOE
Meyers, Jim	Data Engineer	GFOE
Doros, Brian	Video Engineer	GFOE
Brian, Roland	Video Engineer	GFOE
Howard, Art	Video Editor	GFOE
Clifton, Jennifer	Watch Lead in-training	UCAR
Marranzino, Ashley	Sample Data Manager in-training	NOAA Ocean Exploration
Ruby, Caitlin	Sample Data Manager	NCEI

Table A2. EX2301 shore-based science team members who participated via telepresence.

Name	Role	Affiliation
Crum, Emily	Communication Coordinator	NOAA Ocean Exploration
Mah, Christopher	Shore-Based Scientist	Dept. of Invertebrate Zoology, NMNH Smithsonian
Vecchione, Michael	Shore-Based Scientist	NOAA and Smithsonian NMNH
Lindgren, Annie	Shore-Based Scientist	Portland State University
Lindsay, Dhugal	Shore-Based Scientist	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
Sulak, Kenneth	Shore-Based Scientist	USGS
Everett, Meredith	Shore-Based Scientist	NOAA
Hill, Jenna	Shore-Based Scientist	USGS
France, Scott	Shore-Based Scientist	University of Louisiana at Lafayette
Judkins, Heather	Shore-Based Scientist	Univ. South Florida St. Petersburg
Carney, Robert	Shore-Based Scientist	Louisiana State University
Escobar, Elva	Shore-Based Scientist	UNAM
Collins, Allen	Shore-Based Scientist	NOAA & Smithsonian
Powell, Abigail	Shore-Based Scientist	Lynker NWFSC
Ford, Mike	Shore-Based Scientist	NOAA
Auscavitch, Steven	Shore-Based Scientist	Boston University
Clarke, Elizabeth	Shore-Based Scientist	NOAA
Markello, Kelly	Shore-Based Scientist	California Academy of Sciences
Cahoon, Emily	Shore-Based Scientist	Oregon State University
Barrett, Nolan	Shore-Based Scientist	Georgia Institute of Technology
Waddell, Jenny	Shore-Based Scientist	NOAA Olympic Coast National Marine Sanctuary

Appendix B: EX2301 Environmental and Historical Compliance Documentation

The Endangered Species Act (ESA) Programmatic Letter of Concurrence covering this expedition is attached to this document as a supplement.

The National Environmental Policy Act (NEPA) Categorical Exclusion worksheet is attached to this document as a supplement.

Figure B1. EFH Consultation letter

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
650 Capitol Mall Suite 5-100
Sacramento, California 95814

August 3, 2022

Refer to NMFS No: [WCRO-2022-01863]

Genene Fisher
Deputy Director
NOAA Office of Ocean Exploration and Research
Silver Spring, Maryland 20910

Re: Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for Deep-Sea Exploration Activities Aboard NOAA Ship *Okeanos Explorer* in 2022-2024

Dear Ms. Fisher:

NOAA's National Marine Fisheries Service (NMFS) has reviewed the NOAA Office of Ocean Exploration and Research's (OER) letter dated July 1, 2022 requesting an abbreviated essential fish habitat (EFH) consultation for the field activities to be conducted aboard the NOAA Ship *Okeanos Explorer* in the West Coast and Alaska Regions in 2022-2024. Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) and the Fish and Wildlife Coordination Act (FWCA) require federal agencies to consult with us on all actions that may adversely affect EFH and other aquatic resources. The EFH consultation process is guided by the requirements of our EFH regulations at 50 CFR 600 Subpart K, which mandates the preparation of EFH assessments and generally outlines each agency's obligations in this consultation process. In support of this consultation process, you provided a notice of the proposed action and your agency's conclusion regarding impacts on EFH. Your request references previously completed EFH consultations between NOAA Fisheries Greater Atlantic and Southeast Regions and OER and NOAA's National Centers of Coastal Ocean Science (NCCOS) for similar research activities conducted in U.S. federal waters of the Gulf of Mexico, South Atlantic Bight and Caribbean in 2018-2020 and activities in the Greater Atlantic Region and Southeast Atlantic from 2019 to 2021. After reviewing the above information, NMFS provides this response pursuant to section 305(b)(4)(A) of the MSA and the FWCA.

Proposed Action

NOAA Ship *Okeanos Explorer* expeditions in 2022 thru 2024 will contribute to the West Coast Expanding Pacific Research and Exploration of Submerged Systems (EXPRESS) campaign and the regional Seascape Alaska campaign. EXPRESS is the latest evolution of the multi-year, multi-ship campaign that will help develop mitigation measures for operations occurring in the region and continued support of marine protected areas. Other initiatives include the Nippon Foundation-GEBCO Seabed 2030 initiative and the National Strategy for Ocean Mapping, Exploring, and Characterizing the United States Exclusive Economic Zone (NOMEC), which looks to produce a bathymetric map of the world ocean floor by 2030.

Consistent with previous expeditions in the Gulf of Mexico, western Atlantic, and Pacific, OER will work with the scientific community and public to characterize unknown and poorly-known areas through telepresence-based exploration including deep water mapping systems. Mapping and remotely operated vehicle (ROV) operations generally occur in water depths of 200 meters (m) and greater. During OER operations, expedition teams would conduct: seafloor, sub-bottom and water column mapping using multibeam, split-beam, sub-bottom profiler and acoustic Doppler current profiler (ADCP) sonar systems; oceanographic data collection primarily using the vessel's CTD rosette and expendable bathythermographs (XBTs); and seafloor and water column data collection using an integrated, two-body ROV system and additional unmanned surface vehicles (USVs) and autonomous underwater

vehicle systems (AUVs). Using ROV and AUV systems during expeditions to visually investigate unknown and poorly known deep water habitats within and around priority areas will help to establish baseline habitat characterization and species inventories for scientists and managers.

Magnuson-Stevens Fishery Conservation and Management Act Comments

Action Area and Essential Fish Habitat Affected by the Project

The action areas covered by this request encompass the marine environment in the areas around the North Pacific Ocean, Eastern Pacific Ocean, the Gulf of Alaska (GOA) and the eastern Aleutian Chain, and the vessel transit areas between ports, including but not limited to ports of call located in North America and Pacific Islands. Separate EFH consultations will be submitted for operations located in the Pacific Island Region.

U.S. West Coast

OER anticipates spending the majority of the FY2022 and FY2024 field season along the U.S. Pacific Coast contributing to the EXPRESS campaign. This work will also address priorities identified from the 2020 Consortium for Ocean Leadership (COL) workshop. Mapping priorities include filling in the gaps in current mapping coverage deeper than 200 m with high-resolution data offshore of California, Oregon, and Washington, and providing baseline data for further exploration. ROV and AUV exploration priorities are to be determined depending on the needs of ocean resource managers and partners and the ocean science community, and are anticipated to include geological hazards, deep sea corals, seamounts, and critical minerals/seeps. Operations in the Pacific Ocean are expected to commence in October, 2022. The majority of these surveys will take place in the U.S. Exclusive Economic Zone (EEZ) but may deviate in track lines, locations, and timing for various reasons (e.g., crew safety, inclement weather, mechanical issues).

The proposed field activities off the West Coast occur within EFH for various federally managed fish species within the Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, and Highly Migratory Species Fishery Management Plans (FMPs). In addition, the project would occur within rocky reef and "areas of interest," which are designated as habitat areas of particular concern (HAPC) for various federally managed fish species within the Pacific Coast Groundfish FMP. Although the proposed field activities would occur primarily in deeper waters, the proposed action could occur within the vicinity of other HAPCs identified in the Pacific Coast Groundfish and Pacific Coast Salmon FMPs, including canopy kelp, seagrasses, or estuaries, such as when leaving or returning to ports. HAPC are described in the regulations as subsets of EFH which are rare, particularly susceptible to human-induced degradation, especially ecologically important, or located in an environmentally stressed area. Designated HAPC are not afforded any additional regulatory protection under the MSA; however, federal projects with potential adverse impacts to HAPC will be more carefully scrutinized during the consultation process.

Alaska

NOAA OER's operations in the region during FY2023 will focus on supporting the existing SeaScape Alaska effort. Mapping operation priorities include gaps in mapping coverage deeper than 200 m offshore of the GOA, and the eastern Aleutian chain. ROV and AUV exploration priorities include geological hazards, deep sea corals, seamounts, and critical minerals/seeps. OER plans to conduct operations in Alaskan waters with a concentrated effort in the GOA and the eastern Aleutian Chain. Weather conditions and transit times may impact operations causing exact start and end dates to vary by a few days or weeks expanding the duration of corresponding expeditions. The GOA can be accessible as early as April, and the Aleutians are best from June to September.

The North Pacific Fishery Management Council (NPFMC) has identified EFH for nearshore marine waters in the vicinity of the GOA and the eastern Aleutian Chain to include EFH for all five species of Pacific salmon. There are no anadromous rivers in the project area. The proposed project location is designated as EFH for groundfish and scallops. The proposed field activities off the coast of Alaska occur within EFH for various federally managed fish species within the Bering Sea and Aleutian Islands Groundfish, Gulf of Alaska Groundfish, Scallop, and Salmon FMPs. HAPCs within EFH are areas where fisheries management identifies a need to conserve sensitive, rare habitats from anthropogenic activities such as fishing practices or developmental stress. In order to protect HAPCs, certain habitat protection areas and habitat conservation zones have been designated. The following HAPCs have

been designated in the project area: Alaska Seamount Habitat Protection Areas, GOA Coral Habitat Areas of Particular Concern and Bowers Ridge Habitat Conservation Zone. As noted previously, there are no additional regulatory protections under the MSA for HAPCs; however, federal projects with potential adverse impacts to HAPC will be more carefully scrutinized during the consultation process.

Effects of the Action

The NMFS West Coast and Alaska Regions have reviewed information provided on the proposed activities, as well as the conservation measures and best management practices incorporated into the action to address adverse effects to EFH. Adverse effects to EFH would include bottom disturbance, increased turbidity, impacts associated with sample collection, and increased sound. However, the proposed action includes measures to avoid, minimize, or otherwise offset those adverse effects to EFH. For instance, to the extent practicable, hard-bottom and other sensitive habitats (e.g., corals, seagrass) would be avoided when anchoring or operating equipment, machinery will maintain an appropriate altitude off the bottom, cameras and other technology will be used to detect and avoid collisions, and speed and the type of equipment used will be adjusted depending upon the environmental conditions. In addition, only portions of specimens will be collected whenever possible to avoid mortality and minimize adverse effects to associated habitats. Increased sound in the marine environment from vessel operation or sonar emissions would only be expected to result in temporary behavioral effects. Therefore, in our joint assessment of the overall activity including the experimental design, the nature of collection, and the scope of the proposed activities, we have no additional EFH conservation recommendations to provide pursuant to Section 305(b)(2) of the MSA.

Supplemental Consultation

Pursuant to 50 CFR 600.920(l), OER must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH conservation recommendations.

Fish and Wildlife Coordination Act Comments

The purpose of the FWCA is to ensure that wildlife conservation receives equal consideration, and is coordinated with other aspects of water resources development [16 U.S.C. 661]. The FWCA establishes a consultation requirement for Federal departments and agencies that undertake any action that proposes to modify any stream or other body of water for any purpose, including navigation and drainage [16 U.S.C 662(a)]. Consistent with this consultation requirement, NMFS provides recommendations and comments to Federal action agencies for the purpose of conserving fish and wildlife resources. The FWCA allows the opportunity to offer recommendations for the conservation of species and habitats beyond those currently managed under the MSA.

As described in the EFH effects analysis, NMFS has determined that bottom habitat, potentially including biogenic and rocky reef habitats, will be negatively impacted by proposed project activities. Given the importance of this habitat to a variety of fish and wildlife species, the proposed conservation measures to avoid or minimize adverse effects to EFH are also considered necessary to address negative impacts to fish and wildlife resources managed under the FWCA.

Thank you for consulting with NMFS and considering our comments. If you have any questions regarding this response, please contact Eric Chavez via email at Eric.Chavez@noaa.gov or Charlene Felkley at Charlene.Felkley@noaa.gov for questions related to the West Coast or Alaska, respectively.

Sincerely,

Ryan J. Wulff
Assistant Regional Administrator
for Sustainable Fisheries
West Coast Region

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Date: 2022.08.04 14:27:22 -08'00'

Gretchen Harrington
Assistant Regional Administrator
for Habitat Conservation
Alaska Region

Appendix C: Excerpts from Daily Situation Reports

The following entries were excerpted from the daily expedition situation reports provided by the shipboard team to the onshore support team and therefore are somewhat informal in language. They are included here to provide situational awareness for future users of the mapping and ROV data collected during this expedition. All times are in local ship time (-8 hours from UTC).

April 13

Departed Vigor Shipyard at 1015 this morning. The bow thruster was briefly unresponsive when attempting to depart at 0900. Troubleshooting by engineering department resolved the problem.

Dives rescoped for anticipated weather, which is expected to exceed diving capabilities on 16-17 April. Current operations will take advantage of weather conditions to accomplish USBL calibration, multibeam patch test, and engineering shakedown dive 1 before securing for transit south to avoid worsening conditions.

April 14

GAMS calibration conducted in the morning after finishing DP testing overnight. After a short transit, the ship went into DP and deployed USBL beacon for USBL calibration. USBL calibration completed and beacon recovered. Afternoon drills confirmed equipment and crew readiness for emergency situations. Following drills, a CTD cast was conducted in preparation for EM 304 multibeam patch test with POS MV as primary positioning system. CTD cast to 1000 m tested the full sensor suite and Niskin bottles. Water from the Niskin bottles was processed for eDNA samples with comparative methodologies. Initiated patch test following CTD cast at 2100 ship time, through overnight operations. ROV team prepared for tomorrow's engineering dive.

April 15

Conducted first shakedown dive of the season to 600 m depth for engineering tests. UHDAS reported POS dropouts apparent in ADCP data from earlier in the expedition. POS dropout occurred again near the end of the dive, immediately prior to recovery. After assessing the risk, the dive supervisor approved recovery and the onboard team began assessing the problems with the POS system. Logs were sent to Applanix. Transit mapping operations commenced overnight and will continue through poor sea state tomorrow 16 April, en route to the dive site for 17 April.

April 16

Transit day, heading south to avoid worsening conditions off the coast of Oregon. Further consultations with Applanix after sending logs indicated we were receiving intermittent L2 signal on the primary POS MV antenna. After replacement, signal improved and issues appear to be resolved, continuing to monitor performance. Dive plan set for tomorrow will be to 1000 m for additional shakedown objectives. Most personnel took extra time to rest due to lost sleep in rough conditions.

April 17

Engineering dive to 1000 m recovered early around 1400 due to increased weather conditions, threatening a safe recovery. Live interaction with Western Washington University originally scheduled for 1400 was moved to the dry lab to avoid conflicting with operations and conducted without incident. After recovery, the wardroom used extra time on station to train and practice DP maneuvers until 1630. Conditions for diving tomorrow seem unfavorable, but planning to arrive on-site and set up to evaluate in the morning. Line plan developed for gap-filling bathymetric survey in the event of no dive.

April 18

Dive was canceled due to weather conditions after several delays to attempt launch between squalls and across mixed conditions. Mapping team set a line plan to gap fill south of the dive site, with a scheduled attempt to dive on the same site the following day. Conditions required slow speeds to manage quality mapping acquisition and avoid pounding too much on the hull. POS MV system continues to function well. Conducted live interaction with students from Maritime High School in Seattle, WA.

April 19

Returned to dive 3 site and carried out a successful dive to 4000 m. ROV team continues to test and calibrate systems. Science team supported the dive with narration and one biological sample was collected. Science team held a live interaction with the Western Washington University Marine and Coastal Sciences program. Survey team generated survey products from overnight mapping and prepared dive navigation products.

April 20

Dive 4 today on Trinidad Slump, a slump feature on the Cascadia Margin. Despite mapping attempts to identify and land on a hard surface, it appears most shelf break dives will land on sedimented bottoms. Reviewed and prepped UCH dive protocols for tomorrow's dive.

April 21

Emergency recovery initiated after vehicles lost power at 1800 m. ROV team initiated troubleshooting immediately once on deck. Survey team used available time to transit back to the patch test site.

April 22

While ROV team troubleshoots and repairs Seirios from the lost power event on 21 April, the mapping team performed a patch test using the alternate positioning system SeaPath as primary. ROV team anticipates diving operations will resume on 23 April.

April 23

Conducted a 2500 m dive on a small canyon north of Astoria Canyon for engineering shakedown objectives. This was the first dive since the power loss and emergency recovery on 21 April. ROV operated without additional issues and the ROV team is confident in the repairs from 22 April. Overnight transit mapping en route to destination.

April 24

Dive to 1700 m in Quinault Canyon, just outside Olympic Coast National Marine Sanctuary. Overnight transit mapping to the next dive site.

April 25

Overnight mapping operations provided critical bathymetry coverage in a dive area with many submarine cables. Early morning discussions with ROV and mapping teams resolved a dive site in Nitinat Canyon that maximized science objectives while staying clear of potential submarine cable obstructions. Conducted a successful dive in Nitinat Canyon with full shoreside science participation and sampling operations. Survey team prepared a targeted survey to investigate several potential targets on backscatter overnight for the dive on April 26. After the dive, conducted speed noise test, target investigation, and gap filled mapping west of Nitinat Canyon.

April 26

Second dive in Nitinat Canyon, east of first dive site, targeting a slope on the south side of the canyon and a strong reflector in the backscatter mosaic. Conducted dive with full shoreside participation and sampling operations. Target was revealed to be a rocky outcrop and not a UCH site. Secured for transit through Straits of Juan de Fuca and into port. Started demobilization and data QA/QC.

April 27

Arrival in Seattle, QA/QC and demobilization continues.

Appendix D: Inventories of Geological, Biological, and eDNA Water Samples

Tables D1-D3 provide inventories of the geological, biological, and water samples for eDNA analysis collected during EX2301. Detailed sample inventories are available from the NCEI archive via the Ocean Exploration Data Atlas: https://www.ncei.noaa.gov/maps/ocean-exploration-data-atlas/

Table D1. Inventory of geological samples collected during EX2301.

Dive #	Site Name	Sample #*	Sample ID	Preservation	Collection Rationale	Date (yyyymmdd)	UTC Time (hhmmss)	Latitude (dd)	Longitude (dd)	Depth (m)	Weight (kg)
06	North Astoria Canyon	EX2301_D06_01B_A01G	Mudstone	dried	Characteristic of Site	20230423	201741	46.491417	-125.80799	2454.006104	0.07999
08	Nitinat Canyon	EX2301_D08_04B_A03G	sediment	dried	Characteristic of Site	20230425	202138	48.154811	-125.815926	940.1530151	
08	Nitinat Canyon	EX2301_D08_05B_A02G	sediment	dried	Characteristic of Site	20230425	220230	48.154803	-125.816867	909.6380005	
09	Nitinat Canyon 2	EX2301_D09_02G	Glacial erratic	dried	Characteristic of Site	20230426	203521	48.172231	-125.774962	794.632019	2.85999

* Geological sample numbers with "_A##" indicate associate samples.

Table D2. Inventory of biological samples collected during EX2301.

Dive #	Site Name	Sample #*	Field Sample ID	Preservative	Collection Rationale	Date (yyyymmdd)	UTC Time (hhmmss)	Latitude (dd)	Longitude (dd)	Depth (m)	Salinity (ppt)	Temp (C)	Dissolved Oxygen (mg/l)
03	Deep Mendocino Flats	EX2301_D03_01B	Zoanthidea	95% EtOH	Characteristic of Site	20230419	195856	40.13366	-126.12615	3952.42603	34.66000	1.51500	3.64700
04	Trinidad Slump	EX2301_D04_01B	Asteroidea	95% EtOH	Potential Undescribed Species	20230420	220614	41.49497	-125.09556	2317.78906	34.62800	1.78500	2.41500

Dive #	Site Name	Sample #*	Field Sample ID	Preservative	Collection Rationale	Date (yyyymmdd)	UTC Time (hhmmss)	Latitude (dd)	Longitude (dd)	Depth (m)	Salinity (ppt)	Temp (C)	Dissolved Oxygen (mg/l)
06	North Astoria Canyon	EX2301_D06_01B	Corallimorpharia	10% Formalin	Dominant Fauna	20230423	201741	46.49142	-125.80799	2454.00610	34.63600	1.75300	2.36600
06	North Astoria Canyon	EX2301_D06_01B_A02B	Arthropoda	95% EtOH	Associate	20230423	201741	46.49142	-125.80799	2454.00610	34.63600	1.75300	2.36600
06	North Astoria Canyon	EX2301_D06_01B_A03B	Ophiuroidea	95% EtOH	Associate	20230423	201741	46.49142	-125.80799	2454.00610	34.63600	1.75300	2.36600
07	Quinault Fault	EX2301_D07_01B	Hexactinellida	95% EtOH	Potential Undescribed Species	20230424	183136	47.29553	-125.27332	1703.13098	34.55300	2.46900	1.09300
07	Quinault Fault	EX2301_D07_02B	Primnoa	95% EtOH	Potential Undescribed Species	20230424	191510	47.29600	-125.27351	1675.12695	34.53800	2.41700	1.16700
07	Quinault Fault	EX2301_D07_03B	Bathypathes	95% EtOH	Rare Fauna	20230424	204310	47.29673	-125.27401	1623.93201	34.53400	2.48300	1.07600
07	Quinault Fault	EX2301_D07_03B_A01B	Polychaeta	10% Formalin	Associate	20230424	204310	47.29673	-125.27401	1623.93201	34.53400	2.48300	1.07600
07	Quinault Fault	EX2301_D07_03B_A02B	Polychaeta	10% Formalin	Associate	20230424	204310	47.29673	-125.27401	1623.93201	34.53400	2.48300	1.07600
07	Quinault Fault	EX2301_D07_03B_A03B	Polychaeta	95% EtOH	Associate	20230424	204310	47.29673	-125.27401	1623.93201	34.53400	2.48300	1.07600
07	Quinault Fault	EX2301_D07_04B	Paragorgia	95% EtOH	Characteristic of Site	20230424	213715	47.29687	-125.27422	1612.36206	34.53200	2.47300	1.11900
07	Quinault Fault	EX2301_D07_04B_A01B	Ophiuroidea	95% EtOH	Associate	20230424	213715	47.29687	-125.27422	1612.36206	34.53200	2.47300	1.11900
07	Quinault Fault	EX2301_D07_04B_A02B	Polynoidae	10% Formalin	Associate	20230424	213715	47.29687	-125.27422	1612.36206	34.53200	2.47300	1.11900
08	Nitinat Canyon	EX2301_D08_01B	Farrea	95% EtOH	Characteristic of Site	20230425	181304	48.15439	-125.81491	1041.62195	34.41600	3.30400	0.44000

Dive #	Site Name	Sample #*	Field Sample ID	Preservative	Collection Rationale	Date (yyyymmdd)	UTC Time (hhmmss)	Latitude (dd)	Longitude (dd)	Depth (m)	Salinity (ppt)	Temp (C)	Dissolved Oxygen (mg/l)
08	Nitinat Canyon	EX2301_D08_01B_A01B	Pandalidae	95% EtOH	Associate	20230425	181304	48.15439	-125.81491	1041.62195	34.41600	3.30400	0.44000
08	Nitinat Canyon	EX2301_D08_02B	Hexactinellida	95% EtOH	Potential Undescribed Species	20230425	185115	48.15450	-125.81497	1025.57495	34.40900	3.31900	0.42800
08	Nitinat Canyon	EX2301_D08_02B_A01B	Caprella	10% Formalin	Associate	20230425	185115	48.15450	-125.81497	1025.57495	34.40900	3.31900	0.42800
08	Nitinat Canyon	EX2301_D08_03B	Chrysopathes	95% EtOH	Characteristic of Site	20230425	194936	48.15467	-125.81558	962.41998	34.34300	3.66600	0.36900
08	Nitinat Canyon	EX2301_D08_04B	Demospongiae	95% EtOH	Characteristic of Site	20230425	202138	48.15481	-125.81593	940.15302	34.35300	3.70400	0.34900
08	Nitinat Canyon	EX2301_D08_04B_A01B	Pandalidae	95% EtOH	Associate	20230425	202138	48.15481	-125.81593	940.15302	34.35300	3.70400	0.34900
08	Nitinat Canyon	EX2301_D08_04B_A02B	Amphipoda	95% EtOH	Associate	20230425	202138	48.15481	-125.81593	940.15302	34.35300	3.70400	0.34900
08	Nitinat Canyon	EX2301_D08_04B_A05B	Hydroida	95% EtOH	Associate	20230425	202138	48.15481	-125.81593	940.15302	34.35300	3.70400	0.34900
08	Nitinat Canyon	EX2301_D08_05B	Tretodictyidae	95% EtOH	Rare Fauna	20230425	220230	48.15480	-125.81687	909.63800	34.36100	3.64500	0.34200
08	Nitinat Canyon	EX2301_D08_05B_A01B	Pectinidae	95% EtOH	Associate	20230425	220230	48.15480	-125.81687	909.63800	34.36100	3.64500	0.34200
08	Nitinat Canyon	EX2301_D08_05B_A03B	Polynoidae	10% Formalin	Associate	20230425	220230	48.15480	-125.81687	909.63800	34.36100	3.64500	0.34200
08	Nitinat Canyon	EX2301_D08_05B_A04B	Polychaeta	10% Formalin	Associate	20230425	220230	48.15480	-125.81687	909.63800	34.36100	3.64500	0.34200
09	Nitinat Canyon 2	EX2301_D09_01B	Demospongiae	95% EtOH	Lab Assessment Required for ID	20230426	191156	48.17326	-125.77543	836.78497	34.31300	3.93900	0.34700

Dive #	Site Name	Sample #*	Field Sample ID	Preservative	Collection Rationale	Date (yyyymmdd)	UTC Time (hhmmss)	Latitude (dd)	Longitude (dd)	Depth (m)	Salinity (ppt)	Temp (C)	Dissolved Oxygen (mg/l)
09	Nitinat Canyon 2	EX2301_D09_01B_A01B	Ophiuroidea	95% EtOH	Associate	20230426	191156	48.17326	-125.77543	836.78497	34.31300	3.93900	0.34700
09	Nitinat Canyon 2	EX2301_D09_01B_A02B	Ophiuroidea	95% EtOH	Associate	20230426	191156	48.17326	-125.77543	836.78497	34.31300	3.93900	0.34700
09	Nitinat Canyon 2	EX2301_D09_01B_A03B	Polychaeta	10% Formalin	Associate	20230426	191156	48.17326	-125.77543	836.78497	34.31300	3.93900	0.34700
09	Nitinat Canyon 2	EX2301_D09_01B_A04B	Ophiuroidea	95% EtOH	Associate	20230426	191156	48.17326	-125.77543	836.78497	34.31300	3.93900	0.34700
09	Nitinat Canyon 2	EX2301_D09_01B_A05B	Ophiuroidea	95% EtOH	Associate	20230426	191156	48.17326	-125.77543	836.78497	34.31300	3.93900	0.34700
09	Nitinat Canyon 2	EX2301_D09_01B_A06B	Polychaeta	10% Formalin	Associate	20230426	191156	48.17326	-125.77543	836.78497	34.31300	3.93900	0.34700
09	Nitinat Canyon 2	EX2301_D09_01B_A07B	Pandalidae	95% EtOH	Associate	20230426	191156	48.17326	-125.77543	836.78497	34.31300	3.93900	0.34700
09	Nitinat Canyon 2	EX2301_D09_02G_A01B	Ophiotrichidae	95% EtOH	Associate	20230426	203521	48.17223	-125.77496	794.63202	34.29100	4.05500	0.38800
09	Nitinat Canyon 2	EX2301_D09_02G_A02B	Ophiotrichidae	95% EtOH	Associate	20230426	203521	48.17223	-125.77496	794.63202	34.29100	4.05500	0.38800
09	Nitinat Canyon 2	EX2301_D09_02G_A03B	Hydrozoa	95% EtOH	Associate	20230426	203521	48.17223	-125.77496	794.63202	34.29100	4.05500	0.38800
09	Nitinat Canyon 2	EX2301_D09_02G_A04B	Caprella	95% EtOH	Associate	20230426	203521	48.17223	-125.77496	794.63202	34.29100	4.05500	0.38800
09	Nitinat Canyon 2	EX2301_D09_03B	*Ampherasterer marianus*	5% Formalin	Rare Fauna	20230426	211426	48.17185	-125.77428	781.41101	34.28800	4.07800	0.39100

* Biological sample numbers with "_A##" indicate associate samples.

Table D3. Inventory of water samples collected for eDNA analysis during EX2301.

Dive #	Site Name	Sample #	Preservative	Collection Rationale	Date (yyyymmdd)	UTC Time (hhmmss)	Latitude (dd)	Longitude (dd)	Depth (m)	Salinity (ppt)	Temp (°C)	Dissolved Oxygen (mg/l)
01	Tillamook Flats	EX2301_D01_BLW	Frozen	eDNA	20230415	Blank sample						
01	Tillamook Flats	EX2301_D01_01W	Frozen	eDNA	20230415	181005	45.46655	-124.75560	558.15399	34.17500	4.94200	0.60600
01	Tillamook Flats	EX2301_D01_02W	Frozen	eDNA	20230415	181145	45.46651	-124.75568	554.64099	34.18000	4.94200	0.60800
01	Tillamook Flats	EX2301_D01_03W	Frozen	eDNA	20230415	181431	45.46636	-124.75560	558.41803	34.18100	4.94200	0.57200
01	Tillamook Flats	EX2301_D01_04W	Frozen	eDNA	20230415	181729	45.46622	-124.75540	553.30603	34.17700	4.94400	0.55300
01	Tillamook Flats	EX2301_D01_05W	Frozen	eDNA	20230415	181931	45.46608	-124.75548	556.76398	34.18100	4.94100	0.61500
02	Mendocino Flats	EX2301_D02_BLW	Frozen	eDNA	20230417	Blank sample						
02	Mendocino Flats	EX2301_D02_01W	Frozen	eDNA	20230417	200901	40.17287	-124.89248	843.54401	34.30100	4.09100	0.83400
02	Mendocino Flats	EX2301_D02_02W	Frozen	eDNA	20230417	200950	40.17289	-124.89248	820.18799	34.25500	4.17200	0.64400
02	Mendocino Flats	EX2301_D02_03W	Frozen	eDNA	20230417	201023	40.17288	-124.89250	804.50500	34.25400	4.20500	0.62300
02	Mendocino Flats	EX2301_D02_04W	Frozen	eDNA	20230417	201125	40.17290	-124.89243	777.90802	34.21600	4.30400	0.47400
02	Mendocino Flats	EX2301_D02_05W	Frozen	eDNA	20230417	201214	40.17290	-124.89245	755.23297	34.19900	4.37200	0.51000
03	Deep Mendocino Flats	EX2301_D03_BLW	Frozen	eDNA	20230419	Blank sample						

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03	Deep Mendocino Flats	EX2301_D03_02W	Frozen	eDNA	20230419	205906	40.13315	-126.12575	3948.44800	34.66200	1.49300	3.77600
03	Deep Mendocino Flats	EX2301_D03_03W	Frozen	eDNA	20230419	210005	40.13318	-126.12569	3948.79712	34.66400	1.49200	3.61100
03	Deep Mendocino Flats	EX2301_D03_04W	Frozen	eDNA	20230419	210103	40.13318	-126.12567	3947.98291	34.66900	1.49300	3.68100
03	Deep Mendocino Flats	EX2301_D03_05W	Frozen	eDNA	20230419	210203	40.13319	-126.12549	3947.63501	34.66800	1.49000	3.63600
03	Deep Mendocino Flats	EX2301_D03_06W	Frozen	eDNA	20230419	210303	40.13320	-126.12554	3947.47412	34.67200	1.48600	3.68000
04	Trinidad Slump	EX2301_D04_BLW	Frozen	eDNA	20230420	Blank sample						
04	Trinidad Slump	EX2301_D04_02W	Frozen	eDNA	20230420	220739	41.49495	-125.09558	2316.36890	34.62800	1.80400	2.46600
04	Trinidad Slump	EX2301_D04_03W	Frozen	eDNA	20230420	220847	41.49497	-125.09544	2314.02588	34.62800	1.78700	2.44300
04	Trinidad Slump	EX2301_D04_04W	Frozen	eDNA	20230420	220942	41.49488	-125.09542	2315.55908	34.62800	1.78600	2.45500
04	Trinidad Slump	EX2301_D04_05W	Frozen	eDNA	20230420	221033	41.49492	-125.09542	2313.87402	34.62800	1.80500	2.50100
04	Trinidad Slump	EX2301_D04_06W	Frozen	eDNA	20230420	221110	41.49489	-125.09528	2315.14697	34.62800	1.79000	2.49300
06	North Astoria Canyon	EX2301_D06_BLW	Frozen	eDNA	20230423	Blank sample						
06	North Astoria Canyon	EX2301_D06_02W	Frozen	eDNA	20230423	211810	46.49207	-125.80810	2412.42700	34.64100	1.77100	2.29700
06	North Astoria Canyon	EX2301_D06_03W	Frozen	eDNA	20230423	211919	46.49197	-125.80824	2413.04712	34.63200	1.76500	2.34800

Dive #	Site Name	Sample #	Preservative	Collection Rationale	Date (yyyymmdd)	UTC Time (hhmmss)	Latitude (dd)	Longitude (dd)	Depth (m)	Salinity (ppt)	Temp (°C)	Dissolved Oxygen (mg/l)
06	North Astoria Canyon	EX2301_D06_04W	Frozen	eDNA	20230423	212005	46.49201	-125.80830	2411.30811	34.63400	1.76400	2.34900
06	North Astoria Canyon	EX2301_D06_05W	Frozen	eDNA	20230423	212107	46.49203	-125.80837	2409.98291	34.63300	1.76100	2.39600
06	North Astoria Canyon	EX2301_D06_06W	Frozen	eDNA	20230423	212827	46.49210	-125.80847	2409.42993	34.63100	1.76800	2.38000
07	Quinault Fault	EX2301_D07_05W	Frozen	eDNA	20230424	214644	47.29690	-125.27431	1610.26001	34.52800	2.49500	1.05800
07	Quinault Fault	EX2301_D07_06W	Frozen	eDNA	20230424	215001	47.29694	-125.27436	1605.20605	34.53100	2.48800	1.07700
07	Quinault Fault	EX2301_D07_BLW	Frozen	eDNA	20230424	Blank sample						
07	Quinault Fault	EX2301_D07_07W	Frozen	eDNA	20230424	221433	47.26700	-125.27443	1592.57104	34.52200	2.50300	1.08000
07	Quinault Fault	EX2301_D07_08W	Frozen	eDNA	20230424	221702	47.29700	-125.27438	1592.23206	34.53200	2.48400	1.05000
07	Quinault Fault	EX2301_D07_09W	Frozen	eDNA	20230424	221837	47.29701	-125.27448	1592.13501	34.52900	2.49200	1.06300
08	Nitinat Canyon	EX2301_D08_BLW	Frozen	eDNA	20230425	Blank sample						
08	Nitinat Canyon	EX2301_D08_06W	Frozen	eDNA	20230425	223829	48.15450	-125.81722	908.62201	34.36500	3.62700	0.38700
08	Nitinat Canyon	EX2301_D08_07W	Frozen	eDNA	20230425	223959	48.15447	-125.81726	907.79401	34.36700	3.62300	0.38300
08	Nitinat Canyon	EX2301_D08_08W	Frozen	eDNA	20230425	224122	48.15447	-125.81730	908.86401	34.36200	3.63500	0.38000
08	Nitinat Canyon	EX2301_D08_09W	Frozen	eDNA	20230425	224259	48.15445	-125.81731	909.87500	34.35900	3.64200	0.34900

Dive #	Site Name	Sample #	Preservative	Collection Rationale	Date (yyyymmdd)	UTC Time (hhmmss)	Latitude (dd)	Longitude (dd)	Depth (m)	Salinity (ppt)	Temp (°C)	Dissolved Oxygen (mg/l)
08	Nitinat Canyon	EX2301_D08_10W	Frozen	eDNA	20230425	224449	48.15440	-125.81739	907.94000	34.36500	3.63400	0.35400
09	Nitinat Canyon 2	EX2301_D09_BLW	Frozen	eDNA	20230426	Blank sample						
09	Nitinat Canyon 2	EX2301_D09_04W	Frozen	eDNA	20230426	220508	48.17082	-125.77303	774.12701	34.27000	4.16500	0.37700
09	Nitinat Canyon 2	EX2301_D09_05W	Frozen	eDNA	20230426	220918	48.17077	-125.77307	774.26703	34.27600	4.13800	0.40100
09	Nitinat Canyon 2	EX2301_D09_06W	Frozen	eDNA	20230426	221745	48.17057	-125.77287	765.25598	34.27000	4.16500	0.43700
09	Nitinat Canyon 2	EX2301_D09_07W	Frozen	eDNA	20230426	222126	48.17051	-125.77277	763.31799	34.26800	4.17500	0.40600
09	Nitinat Canyon 2	EX2301_D09_08W	Frozen	eDNA	20230426	223535	48.17031	-125.77263	757.83301	34.26400	4.19100	0.37200
STN 01	CTD001	EX2301_CTD001_B01	Frozen	eDNA	20230415	020117	45.62547	-124.92842	1000	34.4071	3.6933	0.3554
STN 01	CTD001	EX2301_CTD001_B02	Frozen	eDNA	20230415	020124	45.62548	-124.92842	1000	34.4071	3.6933	0.3554
STN 01	CTD001	EX2301_CTD001_B03	Frozen	eDNA	20230415	020838	45.62548	-124.92842	801	34.3249	4.2138	0.2911
STN 01	CTD001	EX2301_CTD001_B04	Frozen	eDNA	20230415	020844	45.62548	-124.92842	801	34.3249	4.2138	0.2911
STN 01	CTD001	EX2301_CTD001_B05	Frozen	eDNA	20230415	022129	45.62548	-124.92842	303	34.0134	6.3101	2.1179

Dive #	Site Name	Sample #	Preservative	Collection Rationale	Date (yyyymmdd)	UTC Time (hhmmss)	Latitude (dd)	Longitude (dd)	Depth (m)	Salinity (ppt)	Temp (°C)	Dissolved Oxygen (mg/l)
STN 01	CTD001	EX2301_CTD001_B06	Frozen	eDNA	20230415	022135	45.62548	-124.92843	303	34.0134	6.3101	2.1179
STN 01	CTD001	EX2301_CTD001_B07	Frozen	eDNA	20230415	022721	45.62548	-124.92843	153	33.876	7.8983	3.6759
STN 01	CTD001	EX2301_CTD001_B08	Frozen	eDNA	20230415	022729	45.62548	-124.92928	153	33.876	7.8983	3.6759
STN 01	CTD001	EX2301_CTD001_B09	Frozen	eDNA	20230415	023155	45.62548	-124.92928	64	32.4527	8.576	8.4689
STN 01	CTD001	EX2301_CTD001_B10	Frozen	eDNA	20230415	023201	45.62548	-124.92843	64	32.4527	8.576	8.4689
STN 01	CTD001	EX2301_CTD001_B11	Frozen	eDNA	20230415	023550	45.62548	-124.92843	6	32.2789	9.5755	8.9519
STN 01	CTD001	EX2301_CTD001_B12	Frozen	eDNA	20230415	023550	45.62548	-124.92843	6	32.2789	9.5755	8.9519
STN 01	CTD001	EX2301_CTD001_B01_b	DNA/RNA Shield	eDNA	20230415	020117	45.62547	-124.92842	1000	34.4071	3.6933	0.3554
STN 01	CTD001	EX2301_CTD001_B02_b	DNA/RNA Shield	eDNA	20230415	020124	45.62548	-124.92842	1000	34.4071	3.6933	0.3554
STN 01	CTD001	EX2301_CTD001_B03_b	DNA/RNA Shield	eDNA	20230415	020838	45.62548	-124.92842	801	34.3249	4.2138	0.2911

Dive #	Site Name	Sample #	Preservative	Collection Rationale	Date (yyyymmdd)	UTC Time (hhmmss)	Latitude (dd)	Longitude (dd)	Depth (m)	Salinity (ppt)	Temp (°C)	Dissolved Oxygen (mg/l)
STN 01	CTD001	EX2301_CTD001_B04_b	DNA/RNA Shield	eDNA	20230415	020844	45.62548	-124.92842	801	34.3249	4.2138	0.2911
STN 01	CTD001	EX2301_CTD001_B05_b	DNA/RNA Shield	eDNA	20230415	022129	45.62548	-124.92842	303	34.0134	6.3101	2.1179
STN 01	CTD001	EX2301_CTD001_B06_b	DNA/RNA Shield	eDNA	20230415	022135	45.62548	-124.92843	303	34.0134	6.3101	2.1179
STN 01	CTD001	EX2301_CTD001_B07_b	DNA/RNA Shield	eDNA	20230415	022721	45.62548	-124.92843	153	33.876	7.8983	3.6759
STN 01	CTD001	EX2301_CTD001_B08_b	DNA/RNA Shield	eDNA	20230415	022729	45.62548	-124.92928	153	33.876	7.8983	3.6759
STN 01	CTD001	EX2301_CTD001_B09_b	DNA/RNA Shield	eDNA	20230415	023155	45.62548	-124.92928	64	32.4527	8.576	8.4689
STN 01	CTD001	EX2301_CTD001_B10_b	DNA/RNA Shield	eDNA	20230415	023201	45.62548	-124.92843	64	32.4527	8.576	8.4689
STN 01	CTD001	EX2301_CTD001_B11_b	DNA/RNA Shield	eDNA	20230415	023550	45.62548	-124.92843	6	32.2789	9.5755	8.9519
STN 01	CTD001	EX2301_CTD001_B12_b	DNA/RNA Shield	eDNA	20230415	023550	45.62548	-124.92843	6	32.2789	9.5755	8.9519
STN 01	CTD001	EX2301_CTD001_B01_c	Frozen	eDNA	20230415	020117	45.62547	-124.92842	1000	34.4071	3.6933	0.3554

Dive #	Site Name	Sample #	Preservative	Collection Rationale	Date (yyyymmdd)	UTC Time (hhmmss)	Latitude (dd)	Longitude (dd)	Depth (m)	Salinity (ppt)	Temp (°C)	Dissolved Oxygen (mg/l)
STN 01	CTD001	EX2301_CTD001_B02_c	Frozen	eDNA	20230415	020124	45.62548	-124.92842	1000	34.4071	3.6933	0.3554
STN 01	CTD001	EX2301_CTD001_B03_c	Frozen	eDNA	20230415	020838	45.62548	-124.92842	801	34.3249	4.2138	0.2911
STN 01	CTD001	EX2301_CTD001_B04_c	Frozen	eDNA	20230415	020844	45.62548	-124.92842	801	34.3249	4.2138	0.2911
STN 01	CTD001	EX2301_CTD001_B05_c	Frozen	eDNA	20230415	022129	45.62548	-124.92842	303	34.0134	6.3101	2.1179
STN 01	CTD001	EX2301_CTD001_B06_c	Frozen	eDNA	20230415	022135	45.62548	-124.92843	303	34.0134	6.3101	2.1179
STN 01	CTD001	EX2301_CTD001_B07_c	Frozen	eDNA	20230415	022721	45.62548	-124.92843	153	33.876	7.8983	3.6759
STN 01	CTD001	EX2301_CTD001_B08_c	Frozen	eDNA	20230415	022729	45.62548	-124.92928	153	33.876	7.8983	3.6759
STN 01	CTD001	EX2301_CTD001_B09_c	Frozen	eDNA	20230415	023155	45.62548	-124.92928	64	32.4527	8.576	8.4689
STN 01	CTD001	EX2301_CTD001_B10_c	Frozen	eDNA	20230415	023201	45.62548	-124.92843	64	32.4527	8.576	8.4689
STN 01	CTD001	EX2301_CTD001_B11_c	Frozen	eDNA	20230415	023550	45.62548	-124.92843	6	32.2789	9.5755	8.9519

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STN 01	CTD001	EX2301_CTD001_B12_c	Frozen	eDNA	20230415	023550	45.62548	-124.92843	6	32.2789	9.5755	8.9519