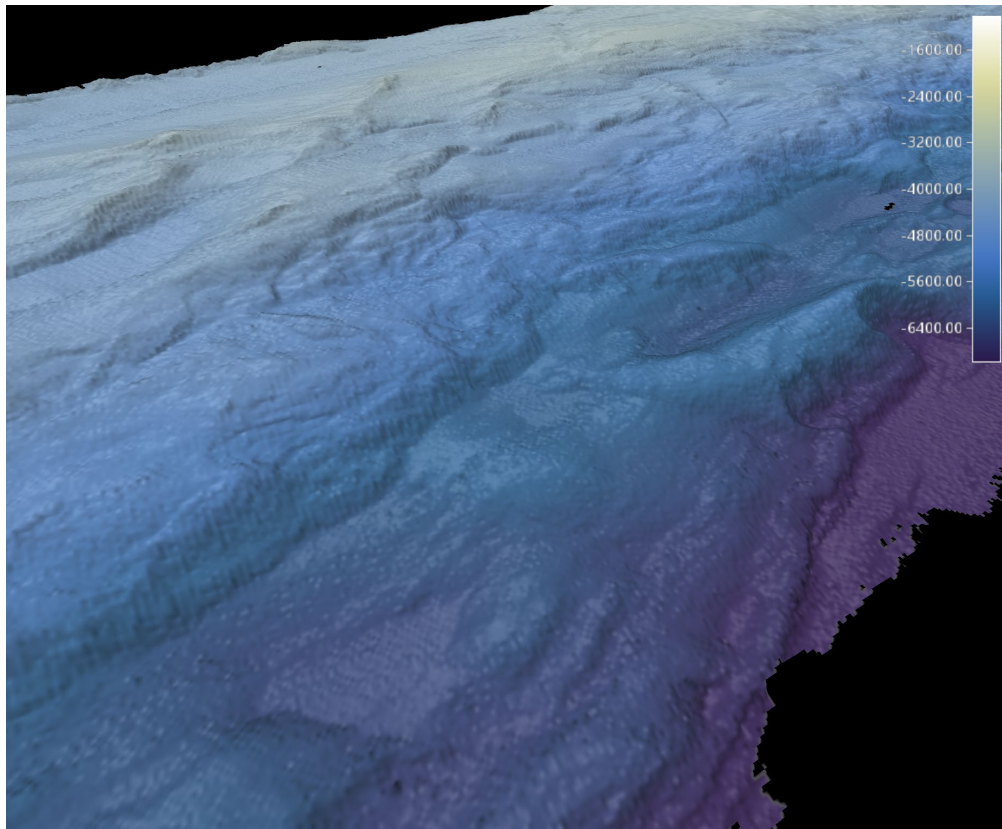


# Expedition Report: EX2303, Seascape Alaska 2: Aleutians Deepwater Mapping (Mapping)



Authors: Treyson Gillespie<sup>2</sup>, Thomas Morrow<sup>1</sup>, Erin Heffron<sup>2</sup>, Jason Meyer<sup>2</sup>, Rebecca Ruiz<sup>2</sup>, Ranna Zahabi<sup>2</sup>, Rose Leeger<sup>2</sup>, and Bryce DeWees<sup>3</sup>

Affiliations:

<sup>1</sup> NOAA Ocean Exploration

<sup>2</sup> University Corporation for Atmospheric Research

<sup>3</sup> NOAA Office of Marine and Aviation Operations

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## Abstract

From June 5-20, 2023 (Dutch Harbor, Alaska to Kodiak, Alaska), NOAA Ocean Exploration conducted mapping operations off the coast of the Aleutian Islands in U.S. waters, aiding in closing bathymetric gaps within this region. Expedition EX2303 collected 36,980 square kilometers of bathymetry and associated water column data within the U.S. Exclusive Economic Zone and Territorial Sea deeper than 200 m. During mapping operations, NOAA Ocean Exploration simultaneously collected EM 304 multibeam sonar bathymetry observations and Simrad EK60/EK80 split-beam fisheries sonar observations of biologic material in the water column, as well as Knudsen 3260 sub-bottom profiler observations of sub-seafloor geologic structure and sediment. A focused survey region targeted potential geological hazards along the Aleutian Trench. During the expedition, one conductivity, temperature, and depth (CTD) cast collected water samples for environmental DNA (eDNA) analysis. The exploratory mapping operations conducted during this cruise will provide initial characterization of the region and support further exploration. All data associated with this expedition will be archived and are publicly available through the NOAA archives.

**Region of Operation:** Aleutian Islands, Gulf of Alaska, Unalaska

**Ports:** Dutch Harbor, Alaska, USA to Kodiak, Alaska, USA

**Bounding Coordinates:** [-150.004161, 52.002161; -169.478161, 57.177167]

**Expedition Dates:** June 5-20, 2023

**Expedition Type:** Mapping

**Theme Keywords:** deep water mapping, mapping, bathymetry, Alaska, seascape Alaska

**Place Keywords:** Alaska, Pacific Ocean, west coast, Aleutian Islands, Kodiak Island

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**For further information, direct inquiries to:**

NOAA Ocean Exploration

1315 East-West Hwy, SSMC3 RM 2313

Silver Spring, MD 20910

Email: [ex.expeditioncoordinator@noaa.gov](mailto:ex.expeditioncoordinator@noaa.gov)



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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 NOAA Ship *Okeanos Explorer* around the Aleutian Islands will contribute to [Seascape Alaska](#). Seascape Alaska is a multiyear, multipartner cooperative research campaign with an aim to create accessible, high-quality modern seabed data for Alaskan waters to support U.S. research, resource management, sustainable economic growth, and the health and security of Americans. The goal of Seascape Alaska is working to fully map the U.S. waters off Alaska through collaborative efforts among federal, tribal, state, and nongovernmental partners with a wide range of interests and dependencies on mapping data across coastal and ocean waters throughout the U.S. EEZ.

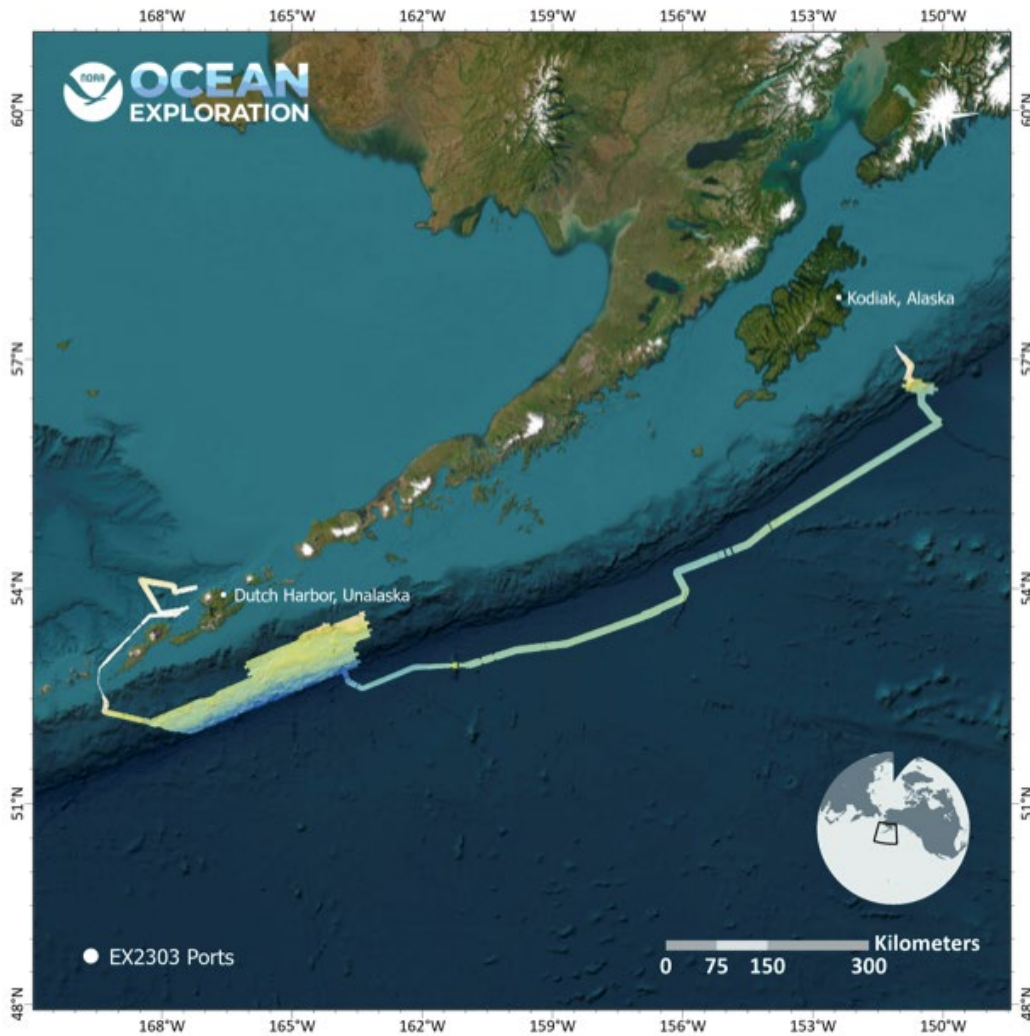
NOAA Ocean Exploration's expeditions on *Okeanos Explorer* contribute to the [National Strategy for Mapping, Exploring, and Characterizing the United States Exclusive Economic Zone](#) and [Seabed 2030](#).

## 2. Expedition Overview

From June 5-20, 2023, NOAA Ocean Exploration and partners conducted a telepresence-enabled ocean exploration expedition on *Okeanos Explorer* to collect critical baseline information and improve knowledge about unexplored and poorly understood deepwater areas

of the Gulf of Alaska and the Aleutian Islands (EX2303). Previous expeditions in this region include Seascope Alaska: Aleutians Exploration 1 (EX2302).

During the 16 days at sea 36,980 sq. km of bathymetric data were collected (see **Figure 1**). Section 5 provides details about the expedition schedule and unplanned events. Names, roles, and affiliations of science team members, both on ship and shore, are in **Appendix A**.



**Figure 1.** Map showing EX2303’s cruise track and collected bathymetric data. Depth is in meters and is displayed by color, where warm tones indicate shallower areas and cool tones indicate deeper areas.

## 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 of the Aleutian Islands. To define the operating area for this expedition, we considered the 2023 call for input and known priorities from resource managers.

Alaska's coastline is longer than that of any other U.S. state or territory and is approximately one-third of the entire U.S. coastline. Despite representing the largest distinct region of the U.S. Exclusive Economic Zone (EEZ), Alaska's waters remain one of the least explored areas in the United States. According to the "Progress Report on Unmapped U.S. Waters" (IOCM 2023), only 34% of Alaskan waters had been mapped to modern standards (100 meters) as of January 2023. Additionally, many of the deepwater habitats of the Gulf of Alaska, Aleutian Islands, and the Aleutian trench remain largely unexplored.

Mapping and exploring Alaska's deep waters will provide baseline information needed to sustainably manage and protect these areas. Filling data gaps and increasing the understanding of this region has far-reaching benefits, including safer navigation and community access, hazard mitigation, preservation of marine habitats and heritage, a deeper comprehension of natural resources, and fisheries management.

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 Alaska Fisheries Science Center, Bureau of Ocean Energy Management (BOEM), and the U.S. Geological Survey (USGS).

## 2.2 Objectives

EX2303 addressed scientific themes and priority areas put forward by NOAA scientists and partners and the broad ocean science and management communities. The primary objective of the expedition was to explore deepwater areas surrounding the Aleutian Islands to provide baseline information to support science and management needs. Briefly, this expedition sought to:

- Collect high-resolution bathymetry in areas with no or low-quality mapping data.

- Map, survey, and sample geological features near to the Aleutian Islands to better understand the geological context of the region.
- Acquire a foundation of sonar and oceanographic data to better understand the characteristics of the water column and fauna that live there.
- 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.
- 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: EX2303, Seascape Alaska 2: Aleutians Deepwater Mapping (Mapping)” (Morrow, 2023).

## 3. Methodology

The primary systems used throughout EX2303 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 (ADCP)) to conduct seabed and water column mapping operations.
- 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. During conductivity, temperature, and depth system (CTD), the EM 304 multibeam sonar and Knudsen sub-bottom profiler were secured to allow the ADCPs and split-beam sonars to collect data.

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 in U.S. waters off the coast of Alaska and south of the Aleutian Islands. Mapping operations occurred 24 hours/per day.

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. So, users of mapping data from EX2303 should refer to the 2023 readiness report to see if any supplemental files report 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 .kml files as beam-averaged backscatter values and as full time-series values (snippets) within each beam. 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 (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 MKII transducer and were monitored in 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 was 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 and were stored in .kml files. The primary system used is noted in the processing logs.

### 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 10s to 100s of meters 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 were 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 were performed after EX2303, during expedition EX2305, and these calibration values are most appropriate for the EX2305 dataset. The calibration files will be archived with the sonar data when they become available, and the calibration report is available as a supplemental file to the 2023 mapping readiness report (Candio et al. 2023).

The split-beam sonars were used continuously throughout EX2303 during 24-hour mapping operations.

### 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.

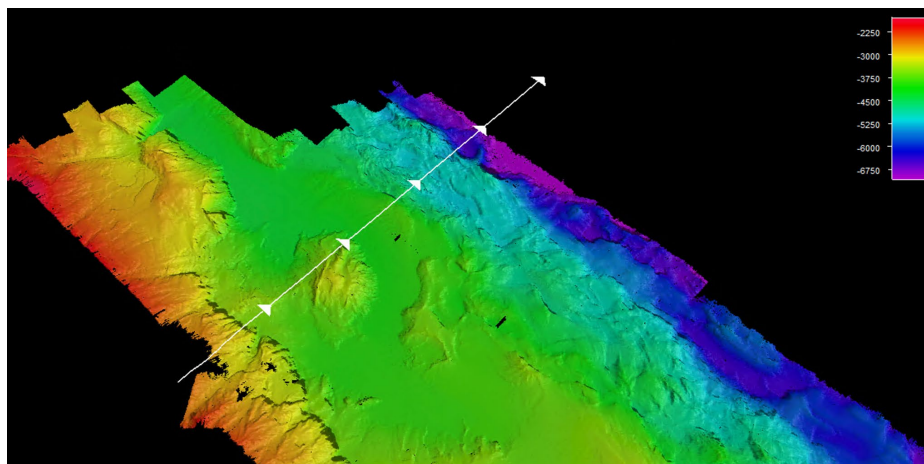
The ADCPs were used to gather data prior to CTD deployments to assess currents in support of safe operations.

## 3.1.2 Data Processing and Quality Assessment Methods

### 3.1.2.1 Multibeam Sonar Bathymetry and Seabed Backscatter

Full-resolution multibeam files (.kml) 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” with an SVP crossfade value of 60 seconds. 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.** EX2303 crossline (white arrows) used for comparison against the bathymetric grid generated via orthogonal multibeam survey lines. Depth is in meters and is displayed by color, where warm tones indicate shallower areas and cool tones indicate deeper areas.

Crossline files:

0335\_20230617\_020905\_EX2303\_MB  
0336\_20230617\_030905\_EX2303\_MB  
0337\_20230617\_040905\_EX2303\_MB  
0338\_20230617\_050905\_EX2303\_MB  
0339\_20230617\_060905\_EX2303\_MB

Mainscheme line files:

0070\_20230608\_061042\_EX2303\_MB  
0071\_20230608\_071042\_EX2303\_MB  
0078\_20230608\_095630\_EX2303\_MB  
0079\_20230608\_105630\_EX2303\_MB  
0129\_20230610\_004621\_EX2303\_MB  
0133\_20230610\_040803\_EX2303\_MB  
0181\_20230611\_203204\_EX2303\_MB  
0187\_20230612\_010014\_EX2303\_MB  
0188\_20230612\_014546\_EX2303\_MB  
0189\_20230612\_015319\_EX2303\_MB  
0242\_20230613\_223604\_EX2303\_MB  
0251\_20230614\_063527\_EX2303\_MB  
0252\_20230614\_071314\_EX2303\_MB  
0275\_20230615\_012120\_EX2303\_MB  
0276\_20230615\_022120\_EX2303\_MB  
0285\_20230615\_095514\_EX2303\_MB  
0286\_20230615\_102357\_EX2303\_MB  
0310\_20230616\_072809\_EX2303\_MB  
0324\_20230616\_181817\_EX2303\_MB

**Table 1.** Crosscheck results.

Statistic	Value
Number of Points of Comparison	1115998
Grid Cell Size (m)	100.00
Difference Mean (m)	-0.636
Difference Median (m)	0.103
Difference Standard Deviation (m)	7.877
Difference Range (m)	-135.80, 93.14
Mean + 2* Standard Deviation (m)	16.390
Median + 2* Standard Deviation (m)	15.856
Data Mean (m)	-4061.368
Reference Mean (m)	-4060.732
Data Z-Range (m)	-7036.23, -2260.99
Reference Z-Range (m)	-7026.37, -2253.97
Order 1 Error Limit (m)	52.792
Order 1 # Rejected	462
Order 1 P-Statistic	0.000
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 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](mailto:ex.expeditioncoordinator@noaa.gov).

**Table 2.** *Okeanos Explorer's* draft at the beginning and end of EX2303.

Location	Start of Expedition (06/05/2023)	End of Expedition (06/20/2023)
Forward	15' 7.5"	13' 4.5"
Aft Starboard	16' 1"	16' 5"
Aft Port	16' 1"	15' 9"

### 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). No anomalies were observed during this expedition.

### 3.1.2.3 Split-Beam Sonars

No anomalies were observed during this expedition.

Calibration reports and files are archived with the split-beam data.

### 3.1.2.4 Sub-Bottom Profiler

Using Natural Resources Canada's SEGYP2 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 expendable bathythermographs (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 EX2303.

**Table 3.** Versions of data collection and processing software used during EX2303.

Software	Purpose	Version
SIS	EM 304	5.11.2
EK80	EK suite	2.0.0
EchoControl	Knudsen	4.09
UHDAS	ADCPs	14.04

Software	Purpose	Version
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
Fledermaus 7	Visualization/Data Analysis	7.8.11

### 3.3 Sampling Operations

A limited number of water samples were collected on the seafloor using 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.

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

#### 3.3.3 Water/eDNA Samples

Twelve 10 liter (l) water samples 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 using a 0.45 µm filter, and the filters were fixed with DNA/RNA Shield, a preservative that keeps DNA stable at room temperature. For each set of water samples, a negative control of tap 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 using a dedicated CTD ( SBE 9/11+) lowered with a winch to provide better information on the critical properties of the water column. In addition to dissolved oxygen (DO) and oxidation-reduction potential (ORP) sensors, the dedicated CTD includes a measured light scattering sensor (LSS).

## 3.2 Sun Photometer Measurements

NOAA Ocean Exploration gathers limited at-sea measurements aboard *Okeanos Explorer* to support a NASA-led, long-term research effort that assesses marine aerosols. As time allowed on cloud-free days, onboard personnel collected georeferenced sun photometer measurements for the Maritime Aerosol Network (MAN) component of the Aerosol Robotic Network (AERONET). AERONET is a network of sun photometers that measure atmospheric aerosol properties around the world. MAN complements AERONET by conducting sun photometer measurements on ships of opportunity to monitor aerosol properties over the global ocean.

## 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 supplemental files (Cuellar 2023).

Overviews of expedition-specific compliance activities are provided below. Copies of associated records of compliance are in **Appendix B** or attached to this document as 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 EX2303 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 EX2303 occurred within NMS boundaries.

## 5. Schedule

**Table 4** provides a day by day breakdown of EX2303.

**Table 4.** EX2303 schedule.

Date (UTC)	Activity
06/02	Mobilization in Dutch Harbor, Alaska
06/03	Departure Delay
06/04	Departure Delay
06/05	Depart Dutch Harbor, Alaska begin transit mapping to priority survey area
06/06	Transit mapping
06/07	Begin mapping priority survey area
06/08	Priority mapping
06/09	Priority mapping
06/10	Priority mapping
06/11	Priority mapping
06/12	Priority mapping
06/13	Priority mapping
06/14	Priority mapping
06/15	Priority mapping
06/16	Priority mapping



Date (UTC)	Activity
06/17	Transit mapping
06/18	Transit mapping
06/19	Transit mapping and CTD cast, live interaction with Indigenous Geoscientist group
06/20	Arrive in Kodiak, Alaska

## 6. Results

This section details the results of EX2303. 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 EX2303.

Metrics	Totals
Days at Sea	16
Days at Sea in U.S. Waters	16
Linear km Mapped by EM 304	5051
Sq. km Mapped by EM 304	36,980
Sq. km Mapped by EM 304 MKII in U.S. Waters	36,980
Vessel CTD Casts	1*
XBT Casts	88
eDNA Water Samples	12
Total Samples	12

\* A brief “dunk test” of the CTD rosette to 5 m with no profiling and no sample collection was logged as CTD001. The following CTD cast (CTD002) descended to depth and collected both profiles and samples. CTD001 does not include any data and should be ignored.

### 6.1 Acoustic Operations Results

NOAA Ocean Exploration mapped 36,980 sq. km of seafloor during the 16 days at sea for EX2303, all of which 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 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 EX2303.

## 6.2 Sampling Operations Results

A total of 12 water samples for eDNA analysis were collected during EX2303. **Appendix D** contains complete inventories of water samples. Once on board the ship, water samples were filtered using a 0.45 µm filter, and the filters were fixed with DNA/RNA Shield, a preservative that keeps DNA stable at room temperature. For each dive’s set of water samples, a negative control of tap 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.

## 6.3 Engagement

EX2303 engaged with audiences around the world, opening a window of understanding into the deep sea. Highlights included:

- 1 live interaction and 5 ship tours were conducted to engage a diversity of audiences. Participants of an Indigenous Geoscience Community Workshop in Ketchikan, Alaska were able to connect with the ship during EX2303. Once in port, ship tours were provided to several groups including several media outlets ( Associated Press, Kodiak Daily Mirror, KMXT radio, and others), educators from the Kodiak Island Borough School District, staff from Alaska Sea Grant and the National Centers for Environmental Information, leadership from the Alutiiq Museum and interns from the Center for Alaskan Coastal Studies.

## 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 EX2303 is in the “Project Instructions: EX2303, Seascope Alaska 2: Aleutians Deepwater Mapping (Mapping)” (Morrow, 2023).

The primary tools for accessing data collected during this expedition and archived at NCEI are the [NCEI data access landing pages](#), 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 EX2303 that aren't yet public, request assistance by submitting a [data request form](#) or sending an email to [oar.info.mgmt@noaa.gov](mailto:oar.info.mgmt@noaa.gov).

## 7.1 Digital Data/Product Locations

The locations for directly accessing specific types of digital data collected during EX2303 and products documenting expedition results (at the time of writing this report) are provided in **Table 6**.

**Table 6.** Online locations for direct access to digital data collected during EX2303 and products documenting expedition results (at the time of writing this report).

Data/Product Type	Description
EM 304 MKII Bathymetry and Backscatter Data	EM 304 MKII bathymetric and backscatter data, supporting informational logs, and ancillary files are available through NCEI's <a href="#">Bathymetric Data Viewer</a>  POSPac and BS correction files can be requested from <a href="mailto:oar.oer.exmappingteam@noaa.gov">oar.oer.exmappingteam@noaa.gov</a>
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 <a href="#">Water Column Sonar Data Viewer</a>
Knudsen 3260 Sub-Bottom Profiler Data	Sub-bottom data, supporting data, and informational logs are available in NCEI's <a href="#">Trackline Geophysical Data Viewer</a>
Sound Speed Profiles	Ancillary sound speed profiles are available with the mapping data through NCEI's <a href="#">Bathymetric Data Viewer</a> and the <a href="#">expedition's oceanographic dataset</a>

Data/Product Type	Description
Oceanographic Dataset	<a href="#">Oceanographic data and products</a> 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
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 <a href="#">NOAA Ocean Exploration Library Guide</a> and the <a href="#">NOAA Institutional Repository</a>

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## Appendix A: EX2303 Science Team Members

EX2303 included onboard mission personnel (**Table A1**).

**Table A1.** EX2303 onboard mission team personnel.

Name	Role	Affiliation
Morrow, Thomas	Expedition Coordinator	NOAA Ocean Exploration
Meyer, Jason	Mapping Watch Lead	University Corporation for Atmospheric Research
Heffron, Erin	Mapping Watch Lead	University Corporation for Atmospheric Research
O'Brien, Andrew	Data Manager	Global Foundation for Ocean Exploration
Wright, Chris	Data Manager	Global Foundation for Ocean Exploration
Durbin, Mark	Data Manager	Global Foundation for Ocean Exploration
Brian, Roland	Videographer	Global Foundation for Ocean Exploration
Doros, Brian	Video Engineer	Global Foundation for Ocean Exploration
Ruiz, Rebecca	Explorer-in-Training	University Corporation for Atmospheric Research
Zahabi, Ranna	Explorer-in-Training	University Corporation for Atmospheric Research
Leeger, Rose	Explorer-in-Training	University Corporation for Atmospheric Research

## Appendix B: EX2303 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]

Geneve 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 (NOMECS), 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.

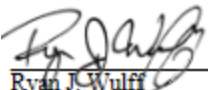
**Fish and Wildlife Coordination Act Comments**

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

HARRINGTON.GRETCHEN  
EN.ANNE.1365893833  
Gretchen Harrington  
Assistant Regional Administrator  
for Habitat Conservation  
Alaska Region

Digitally signed by  
HARRINGTON.GRETCHEN/EN.ANNE.1365  
893833  
Date: 2022.08.04 14:27:22 -0800

## 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 data mapping collected during this expedition. All times are in local ship time (-8 hours from UTC).

### May 31 - June 02

Mission personnel arrived on the vessel. All personnel onboard as of 01 JUNE.. Explorers-in-Training started learning about mapping, map projections, and reading SOPs to familiarize themselves with operations.

### June 03 - June 04

Mission personnel are familiarizing with documentation, working on ancillary projects, and confirming all systems are ready to sail. Explorers-in-Training continue to receive instruction on cleaning and have been working with a training data set while familiarizing with mapping softwares.

### June 05

Ship departed Dutch Harbor at 1430 underway to priority mapping regions.

### June 06

Survey continues gap-filling near Bogoslov Island, with a transit southwest to begin working priority mapping regions south of the Aleutians. Data team, survey tech, and mapping team explored options for projecting live coverage from SIS to HYPACK to support better real-time acquisition comparisons among pre-existing data. Sea conditions increased through the day as the ship transited to the south side of the Aleutian Islands, data quality remained satisfactory.

### June 07

Mapping continued in the priority 2 region. With conditions decreased, high quality observations continued. Survey team has noted some minor issues related to downslope tracking and are working with the mapping community to isolate and resolve these issues.

### June 08

Survey continues in priority area 2. Slope mistracking issues continue and are being troubleshooted with Kongsberg, advise disabling penetration filter and will update acquisition

setup SOP to include this information. Live mapping coverage is now being reported in HYPACK, which will assist with active line adjustment.

## June 09

Survey continues with calm sea state. Survey team continues to adjust swath and line plans to maximize quality coverage over steep and variable terrain in the Aleutian trench. Data team continued progress on the EM304 MKII SBP functionality test, preparing a workstation for additional Kongsberg software to test capabilities. EiTs have started developing a CTD cast project to collect eDNA samples. Weather is expected to worsen on the eastern edge of the mapping region briefly.

## June 10

Survey continues in the priority 2 polygon, with adjustments to line spacing and coverage as needed based on conditions and occasional whale encounters. SIS-HYPACK live view stopped working and troubleshooting is ongoing.

## June 11

Survey continues with conditions increasing. Data quality remains acceptable, but requires more overlap.

## June 12

Survey continues in mild conditions with quality data.

## June 13

Upon the recommendation of the EX2304 shore-side science party, we adjusted the survey polygon to cover the eastern section of the priority 2 area, which is of particular interest to USGS and other groups studying regional geohazards. Survey continues in mild conditions.

## June 14

Survey continues in the priority region along with the area requested in support of EX2304.

## June 15

Weather conditions negated CTD operations for the day and ship continued on survey lines in the priority area. Weather conditions slightly improved throughout the day.

## June 16

Sea state worsened this morning and then slacked off by evening, which impacted data quality during the earlier part of the day.

## June 17

Current transit speeds are holding at 10.5 kts and we expect to have extra operational time available upon arrival at the seep site south of Kodiak. Line plans have been adjusted to maximize gap-filling coverage.

## June 18

Transit survey continues en route to a potential seep site. QA/QC on products started as well as copying data for end of expedition offload. SIS gridding engine failure forced a new project.

## June 19

Arrived on site for a CTD cast at a previously-detected seep location. After a brief survey, set up for CTD at 1000 and cast to ~4400 m. Twelve water samples were collected and processed for eDNA, one bottle did not seal on recovery (2000m sample). A live interaction was held with the Indigenous Geoscience Community Workshop in Ketchikan, Alaska with approximately 25 attendees.

## June 20

Arrived in Kodiak, AK around 0900 local time. Ship moored at fueling pier and planned to move to cargo pier after fueling.

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

**Table D1** provides an inventory of water samples for eDNA analysis collected during EX2303.

**Table D1.** Inventory of water samples collected for eDNA analysis during EX2303.

Cast #	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)
2	CTD_002	1	DNA/RNA Shield	eDNA	20230619	20:21:32	56.6366	-150.487	4422.309	34.6825	1.5079	4.4624
2	CTD_002	2	DNA/RNA Shield	eDNA	20230619	20:33:14	56.6366	-150.487	4000.613	34.6814	1.4644	4.4759
2	CTD_002	3	DNA/RNA Shield	eDNA	20230619	20:53:45	56.63658	-150.487	3000.634	34.6555	1.5595	3.4194
2	CTD_002	4	DNA/RNA Shield	eDNA	20230619	21:14:58	56.63658	-150.487	2000.928	34.5914	1.8727	1.8999
2	CTD_002	5	DNA/RNA Shield	eDNA	20230619	21:26:26	56.63658	-150.487	1501.034	34.509	2.2705	0.949
2	CTD_002	6	DNA/RNA Shield	eDNA	20230619	21:38:12	56.63658	-150.487	1000.104	34.3721	2.9592	0.4276
2	CTD_002	7	DNA/RNA Shield	eDNA	20230619	21:44:11	56.63658	-150.487	801.109	34.3008	3.3239	0.4078
2	CTD_002	8	DNA/RNA Shield	eDNA	20230619	21:51:58	56.63658	-150.487	500.389	34.1447	3.8629	0.5568
2	CTD_002	9	DNA/RNA Shield	eDNA	20230619	21:56:54	56.63658	-150.487	350.414	34.0538	4.2361	0.8506

Cast #	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)
2	CTD_002	10	DNA/RNA Shield	eDNA	20230619	22:03:34	56.63658	-150.487	100.602	33.4211	5.1573	4.7347
2	CTD_002	11	DNA/RNA Shield	eDNA	20230619	22:06:30	56.6366	-150.487	50.297	32.6628	4.7261	9.0652
2	CTD_002	12	DNA/RNA Shield	eDNA	20230619	22:10:00	56.63658	-150.487	2.719	32.3815	8.7859	7.153