



Project Instructions: EX-21-02, 2021 Technology Demonstration (AUV & Mapping)

Date Submitted: May 6, 2021

Platform: NOAA Ship *Okeanos Explorer*

Project Number: EX-21-02

Project Title: EX-21-02 2021 Technology Demonstration

Project Dates: May 14 to 27, 2021

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Expeditions and Exploration, Division Chief
NOAA Office of Ocean Exploration and Research

Approved by: 41660199 **Dated:** _____
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Date: 2021.05.11 08:26:28 -04'00'
Captain Nicholas Chrobak
Commanding Officer
NOAA Marine Operations Center — Atlantic

I. Overview

A. Brief Summary and Project Period

May 14 to 27, 2021

Port Canaveral, Florida to Norfolk, Virginia

EX-21-02 2021 Technology Demonstration (Autonomous Underwater Vehicle/Mapping)

This document contains project instructions specific to EX-21-02. For the annual, cross-expedition details, see the “NOAA Ship *Okeanos Explorer* FY2021 Field Season Instructions (<https://doi.org/10.25923/83ze-r686>).” This expedition will commence on May 14, 2021, in Port Canaveral, Florida, and conclude on May 27, 2021 in Norfolk, Virginia. Operational capable, AUV operations will focus on transitioning the *Orpheus* AUVs to fully operational integration and validation of novel Terrain Relative Navigation software (TRN) into the AUVs, potential deployment over priority locations and general AUV shakedown objectives. eDNA sampling will include regular ship CTD casts and processing of water column samples onboard. Mapping operations may include fine tuning of acoustic data workflows and will focus on any unmapped areas in US water deeper than 200 meters. Operations are expected to occur exclusively in US waters. Operations are expected to take place off of the coasts of Florida, Georgia, South Carolina, North Carolina and Virginia with focused operations on the US Blake Plateau and potentially the mid-Atlantic canyons.

B. Days at Sea

Of the 14 days at sea (DAS) scheduled for this expedition, all are funded by OAR. This project is estimated to exhibit a High Operational Tempo due to 24 hour operations including AUV deployments, CTDs and overnight mapping.

C. Operating Area

EX-21-02 will focus operations on the US Southeast and mid-Atlantic Canyons. Priority mapping areas are indicated in Figure 1. (The waypoints for the general working area and proposed cruise track are in Appendix B.)

EX-21-02 Areas of Operation

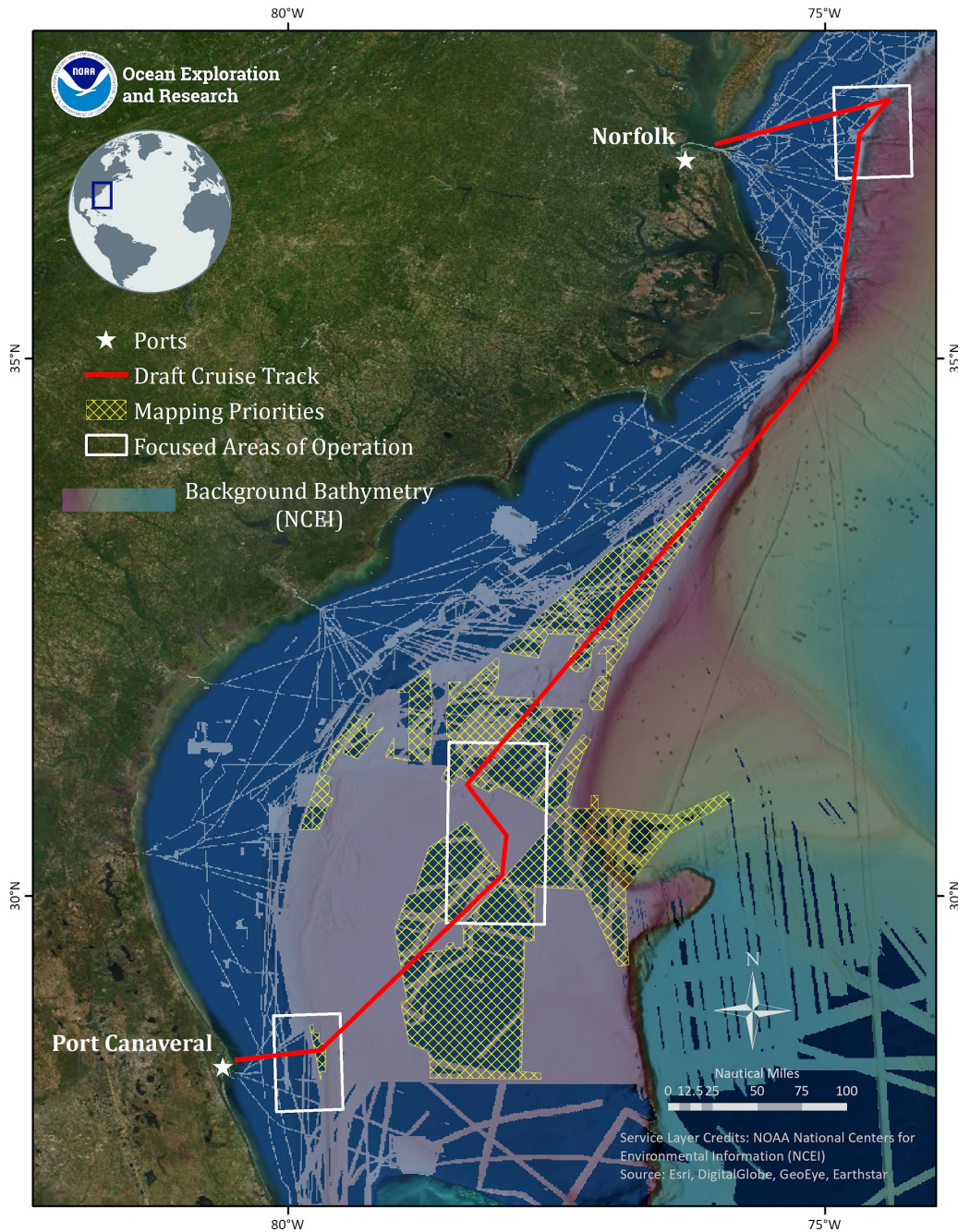


Figure 1. Map showing the general operating area for EX-21-02. The Draft Cruise Track does not include mapping survey lines, AUV deployment or CTD locations which are subject to change based on technology development results, field conditions and the discretion of the commanding officer. Note the draft cruise track at this scale does not include hazards to navigation for passage in and out of port.

D. Summary of Objectives

EX-21-02 operations will involve a short transit east of Cape Canaveral followed by focused overnight ocean mapping operations that will occur mostly in deep water (>200 m). The first 2-3 days will be spent deploying small boats and AUVs for acoustic calibration in shallow (<100m) of water. Pending successful calibrations, the ship will transit to the central Blake Plateau to complete a USBL calibration. Once complete, the remaining days at sea will focus on daytime AUV deployments and CTD casts and overnight operations will focus on mapping priority areas. As a technology demonstration, the mission team anticipates that at any time during the expedition should technical issues arise, the team will change to 24 hour mapping operations, with CTD casts. Should all AUV technical objectives be met, the team may request to transit north to the vicinity of Norfolk and Washington Canyons to complete AUV operations east of Norfolk, Virginia. See Appendix A for an elaboration of procedures/objectives and the “NOAA Ship *Okeanos Explorer* FY2021 Field Season Instructions” for more information.

1. *Orpheus* AUV Objectives

One of the primary goals of EX-21-02 is the novel testing and validation of utilization of TRN and operational readiness of WHOI’s *Orpheus* AUVs. These are modular, relatively inexpensive, 11,000 meter depth rated AUVs which will enable systematic exploration of hadal depths. They can also be deployed for a variety of scientific objectives such as reconnaissance missions, seafloor and water column characterization and sampling. TRN, developed by National Aeronautics and Space Administration (NASA) engineers for planetary surface exploration, is the enabling technology for mission navigation due to the ability to provide a map-relative position estimate rather than one defined in inertial coordinates (e.g., latitude-longitude). The onboard team will include engineers from NASA Jet Propulsion Laboratory (NASA JPL). This is critical at hadal depths (>6,000), in which multibeam maps may be resolution limited, and/or are subject to conventional inertial drift by a vehicle. Optical (seafloor image-driven) TRN will provide a map-relative position that is accurate on the scale of the real-time acquisition of mosaicked seafloor images. Through overlapping camera imaging systems, collaborative software, and methodologies being deployed on the Mars Helicopter ([TRN on 2020 Perseverance Rover Mission](#)), the team will demonstrate viability of TRN and transfer this approach to subsea navigation.

Another goal will be to develop strategies for optimizing efficiency of multiple vehicle missions. The goal would be to have vehicles sharing information at first non-real time and later exploring the feasibility of real time. By deploying both vehicles on a series of dives, the team will be able to establish multiple intersecting imaged tracks with correlating

environmental sensor data and test algorithms for intersection detections. Intersection points between different paths will be calculated enabling imagery to be stitched together cumulatively over the duration of the cruise to produce additional coverage of the seafloor. These tracks can then be ground truthed via a surface ultrashort baseline acoustic transducer (USBL) to be pole mounted on the *Okeanos*. Paths and detected objects can also be ground truthed when compared to EM304 multibeam bathymetry.

In addition to developing further assets that explore the Hadal Zone, the *Orpheus* AUVs have the potential to help OER meet objectives in the National Ocean Mapping, Exploration and Characterization (NOMECA) Strategy. These relatively inexpensive, modular AUVs can provide reconnaissance data for further exploration, data meant for characterization and ground truth mapping data. Such assets would help OER to further its capabilities.

External links:

[The Rise of *Orpheus*](#)

[HADEX Technology](#)

Specific Objectives for *Orpheus* AUVs

- Load AUVs during while inport in Port Canaveral, Florida (tentatively May 10th)
 - Load supporting equipment and spares during the inport, about 4 pallets total of vehicles and equipment
- Develop launch and recovery procedures of *Orpheus* AUVs (Figure 2) in coordination with Chief Bosun, Chief Engineer, Operations Officer, Commanding Officer and Mission Team the development of launch and recovery.
 - Ship and Mission Teams will approach these AUVs with the intention of OER plans to possibly incorporate these AUVs into future operations
 - Develop a Standard Operating Procedures document for launch and recovery
- Load and hang an USBL during AUV operations to support subsea navigation
- Conduct TRN calibration using small boats during first 3-4days of EX-21-02
 - Deploy AUVs, then deploy small boats with hanging transponder
 - Small boat follows submerged AUV in 30-60 meters of water
 - Objective is critical for TRN calibration. If weather window does not allow for operations outside of Port Canaveral, a backup area will have to be selected
 - Figure 3 displays a diagram for TRN calibration



- Figures 4a and 4b displays possible locations outside of Port Canaveral for small boat operations
- Deploy and test of two *Orpheus* AUVs
 - Troubleshoot and resolve general readiness and shakedown items
- Test and validate us of TRN software
 - Ground truth AUV navigation data with other data sources onboard
- Enable remote mission planning from shore
- Test AUV sensors (CTD, altimeter, inertial sensors, lights, thrusters)
- Collect underwater images of AUVs using hand held ROVs
 - BlueROV2: <https://bluerobotics.com/store/rov/bluerov2/>

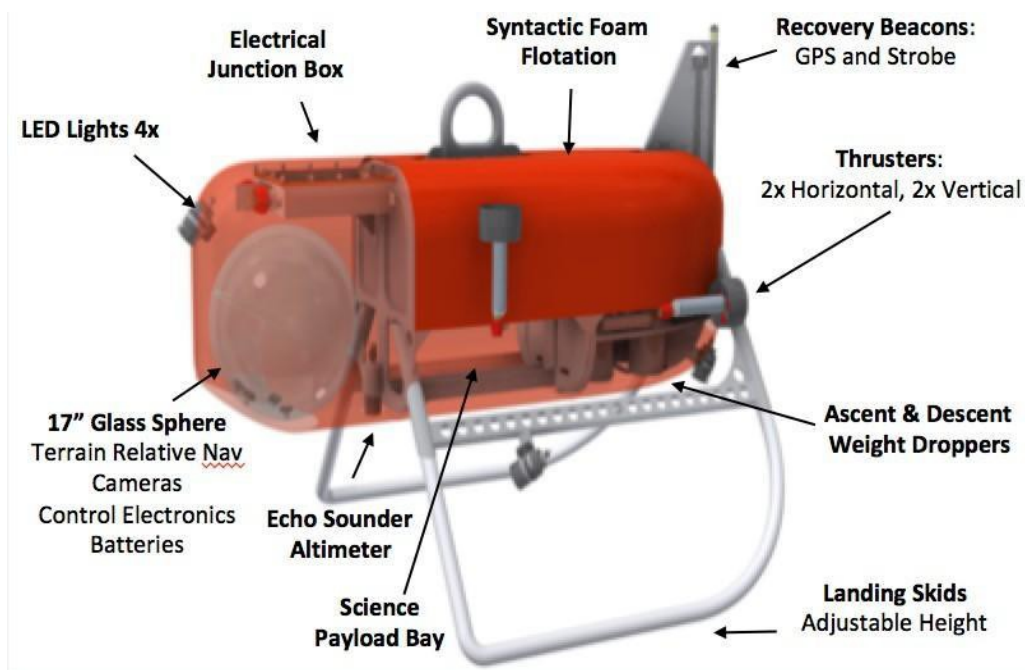
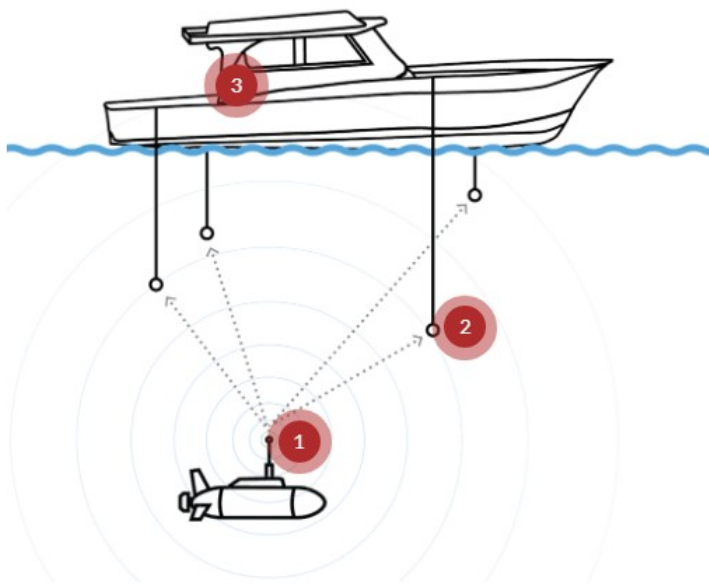


Figure 2: The 550 pound vehicle (in air) is 70" L x 50" W x 48" H with an integrative JPL/NASA cubeat design for flexible science payload of at least 30 lbs wet weight, 30 L volume.

Separate Receivers



1. Locator

The Locator transmits an acoustic signal which are picked up by the Receivers

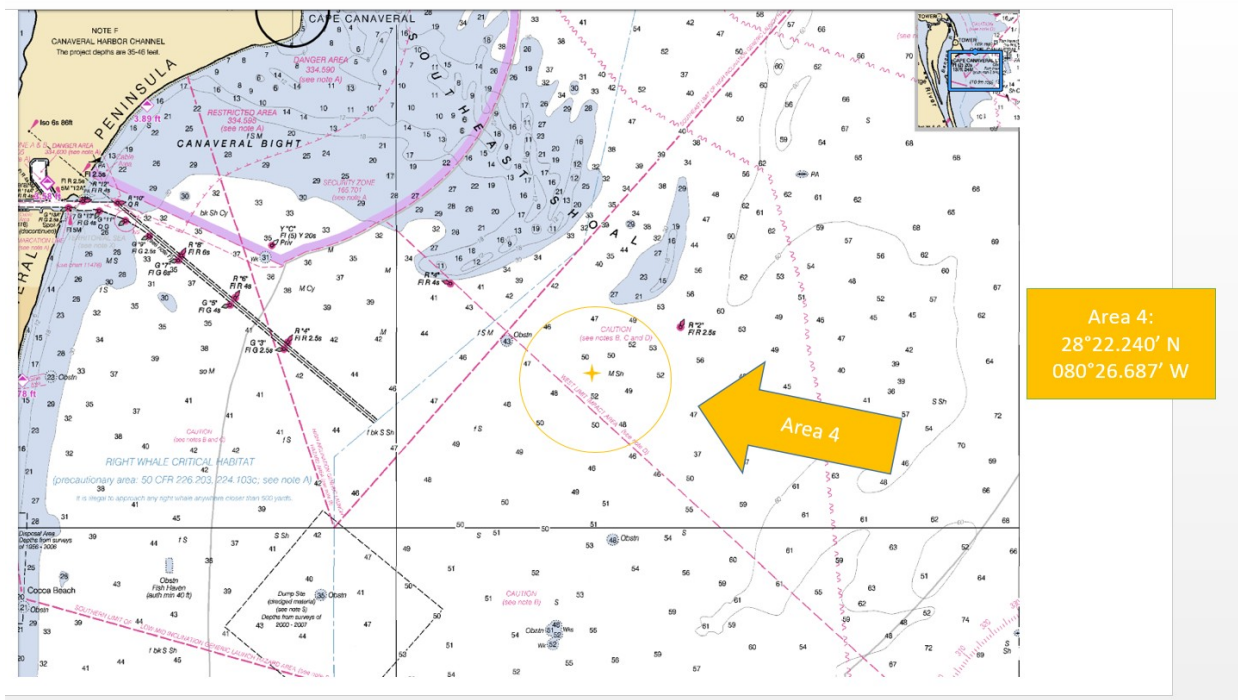
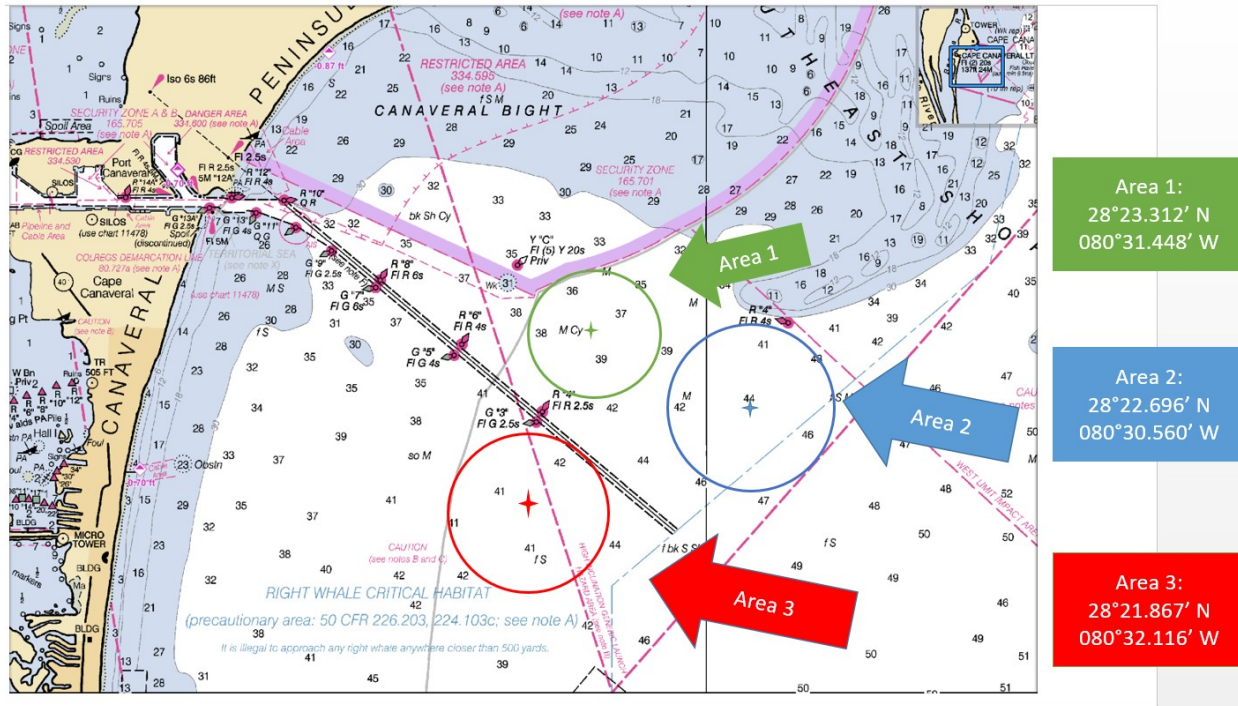
2. Baseline

The antenna or separate receivers picks up the acoustic signal from the Locator

3. Topside

The topside positioning computer uses advanced algorithms to triangulate and calculate the position of the Locator based on the received signals from the antenna/receivers

Figure 3: Diagram of small boat operations for TRN calibration. Four transponders are hung over the side on the small boat which would follow the *Orpheus* AUV as it transits at depth. Figure from <https://waterlinked.com/underwater-gps-g2/>.



Figures 4a and 4b: Possible locations for small boat TRN calibration operations

2. eDNA and Water Column Sampling Objectives

Conduct daily CTD casts using the ship's CTD rosette to collect water samples in the 12 10 liter Niskin bottles

- Conduct CTD operations while ship is on stations while AUVs are in the water
- Trigger CTD Niskin bottles at different depths in order to sample a diversity of zones.
 - The onboard team may use the EK60/80 sonars to target the deep scattering layer (DSL) as well as areas above and below the DSL.
- Conduct ship CTDs via a GFOE managed computer
- Record metadata for each CTD cast and water sample. Included would be UTC time, ship's position, date and depth.
- Record CTD environmental sensor data for each water sample.
 - Data will be entered into SODA sample database.

Complete and submit CTD Summary Form for every successful CTD cast

- Review and finalize CTD Summary Form
- Archive forms with NCEI.
 - Forms to be submitted through NCEI - OER Internal Products and Services Request Form
- Complete 'Summary Table for CTDs on EX-XX-XX' document and archive within final cruise report

Process Water Column Samples

- Process water samples in the Wetlab using onboard supplies. Water samples will be filtered using a vacuum pump. The DNA material is then captured onto the filter, which is then stored in a solution (in a vial) that makes the DNA stable at room temperature. About 2 liters of water will be filtered per sample. Vacuum filtration can take 1 -2 hours depending on the size of the filter and volume of the water being filtered.
- Store samples in the Wetlab until offload in Norfolk, VA.
 - Samples do not require any special environment. They will be stored in a Longmire's buffer solution at room temperature.



- Draft a standard operating procedure document for the collection and processing of water samples as well as associated senso and metadata, for the purpose of eDNA analysis.
- Update Sampling Supplies Inventory with amount of consumables (gloves, parafilm) used and any equipment which will permanently added to sampling equipment

3. Mapping Objectives

Any priority mapping system shakedown objectives unable to be completed during EX-21-01 will be completed as feasible during EX-21-02. These objectives may include the following:

- Finish calibration and testing of the new EM 304 multibeam sonar. Work may include patch tests, GAMS calibrations, deep roll verification lines, deep reference surveys, swath coverage testing, speed noise testing, built-in self tests, K-sync sonar synchronization testing, remote watchstanding testing, software updates to SIS, and testing of the OMAO sonar data acquisition system.
- Test cloud processing capabilities and workflow.
- Refine Standard Operating Procedures for mapping operations, software, and equipment.
- Monitor Ocean Survey 38 kHz ADCP for temperature spikes and data quality

Exploration Mapping

- Conduct strategic transits from Port Canaveral to operational areas and to Norfolk, including overlap with recent EM 304 data and previous EM 302 data for comparison with the EM 304 data equipped with the new transmit array.
- It is expected that AUV vehicle testing and CTD work will be done during the day, with most night-time operations dedicated to mapping work. If vehicle problems or rough weather impacts AUV testing, exploration mapping work will be conducted 24 hours per day as conditions allow. The staffing plan for this cruise intends for the augmenting Survey Tech to work day shifts. Night time mapping operations are planned to be staffed with mission team members.
- Execute mapping line plans as defined by onboard personnel, with real-time adjustments made to obtain complete seabed coverage as necessary. Mapping priorities will include new survey coverage of areas that have never been surveyed with multibeam sonars or that lack high quality data.
- Create daily standard bathymetry mapping products.
- Average survey speeds of 8.5-9 kts will be utilized during mapping operations.



- Transit speeds of 10kts may occasionally be requested in certain areas and as feasible.
- Collect sun photometer measurements as part of an Exploration Project of Opportunity (EPO).

Support WHOI Orpheus AUV Testing and eDNA CTD Casts

- Create custom geospatial products to support effective *Orpheus* AUV dive operations. Generate dive planning maps, assist with dive site selection to meet science objectives, and assist with the creation of post-dive map products. Dives may be planned on features mapped on previous cruises or on features newly mapped on the current cruise.
- Process multibeam bathymetry and seafloor and water column backscatter data as needed to plan and execute *Orpheus* dives.
- Collect ADCP data prior to deployment of AUVs to assess currents in the vicinity of planned dive operations.
- Collect EK 60/80 data prior to or during *Orpheus* dives and CTD casts to assist with identifying water column features of interest (e.g., deep scattering layers). This may be particularly useful in identifying biological layers to obtain water samples for eDNA testing.

4. Video Engineering Objectives

- Verify GFOE-managed telepresence systems perform as expected.

5. Network/Onboard Data Objectives

Any priority network/onboard data objectives unable to be completed during EX-21-01 will be completed as feasible during EX-21-02. These objectives may include the following:

- Verify newly deployed satellite modem and increased bandwidth service perform as expected (ship to shore increased from 15 to 20Mbps, shore to ship increased from 5 to 20 Mbps).
- Verify updated network prioritization and bandwidth allocation controls.
- Verify newly deployed WAN accelerator.
- Verify newly deployed underwater cultural heritage (UCH) data processes perform as expected.
- Verify data management file naming convention changes for the field season.



- Verify newly increased shipboard storage system performs as expected (from 145 to 382 TB of usable space).
- Test/evaluate syncing EM 304 .kml files to shore.

6. Data Management Objectives

- Archive standard *Orpheus* AUV environmental data, including imagery, video, CTD, position and deployment locations through CruisePack (<https://www.ngdc.noaa.gov/mgg/cruisePack/#:~:text=NCEI%20developed%20CruisePack%2C%20a%20data.complete%2C%20data%20packaging%20is%20automatic>)
- Develop further documentation regarding AUV data archival, AUV metadata and lessons learned regarding external data
- Develop document regarding the archival of water column sampling for eDNA purposes

7. Outreach, Communications and Education Objectives

- Document expedition activities and maximize in-house engagement efforts by frontloading written outreach efforts (e.g. background web content) and shifting Web Coordinator responsibilities towards onship media collection and sharing via the OER website and social media
- Ensure partners' media needs are defined and assets are shared in a timely fashion
- Broaden the reach and accessibility of expedition activities by hosting a large-scale live interaction for the public, streamed on multiple platforms in collaboration with the Inner Space Center and partners, as well as through typical expedition web and social media updates
- Collect media on the ship during science operations while maintain quality and safe conditions
- As requested, send media material to shore for additional product development
- Test Google Meet
 - Record data usage
- Test and implement StreamYard for live interactions

7. Ethanol Testing

- Test the quality of the ethanol now stored in the new ejectable 02 Deck barrel
- Record and updated internal OER Ethanol Test Guide and tracking



E. Participating Institutions

- National Oceanic and Atmospheric Administration (NOAA), Office of Ocean Exploration and Research (OER) — 1315 East-West Highway, Silver Spring, MD 20910 USA
- NOAA, National Centers for Environmental Information (NCEI) — Stennis Space Center, MS 39529 USA
- University Corporation for Atmospheric Research (UCAR) Programs for Advancement of Earth System Science — P.O. Box 3000, Boulder, CO 80307 USA
- University of New Hampshire (UNH) Center for Coastal and Ocean Mapping (CCOM) — Jere A. Chase Ocean Engineering Lab, 24 Colovos Road, Durham, NH 03824 USA
- Global Foundation for Ocean Exploration (GFOE) — P.O. Box 417, Mystic, CT 06355 USA
- University of Rhode Island Inner Space Center (ISC) — 215 South Ferry Road, Narragansett, RI 02882 USA
- Woods Hole Oceanographic Institution, 360 Woods Hole Rd, Woods Hole, MA 02543
- National Aeronautics and Space Administration Jet Propulsion Laboratory, 4800 Oak Grove Dr, Pasadena, CA 91109
- Ocean Exploration Cooperative Institute (OECI), 45 Upper College Road, Kingston, RI 02881

F. Personnel (Mission Party)

Mission personnel (see Table 1) will arrive in Port Canaveral on May 3, 2021 , and shelter in place for seven days from May 4 to May 10, 2021. Mission personnel will join the ship on May 11th, after the shelter-in-place (SIP) periods and two negative COVID-19 tests. Mission personnel will then be on board for the duration of the expedition until May 27th, 2021.

Table 1. Seagoing Mission Personnel

This list is tentative until travel is booked. Any deviations will be communicated to the operations officer.

#	Name (Last, First)	Title	Date Aboard	Date Disembark	Gender	Affiliation	Nationality
1	White, Michael	Expedition Coordinator	05/11	05/27	M	OER (CNSP ¹)	USA



2	Galvez, Kimberly	Expedition Coordinator in Training	05/11	05/27	F	OER (CNSP ¹)	USA
3	Sowers, Derek	Mapping Lead	05/11	05/27	M	OER (CNSP ¹)	USA
4	Meyer, Jason	Mapping Watch Lead	05/11	05/27	M	UCAR	USA
5	Freitas, Daniel	Mapping Watch Lead	05/11	05/27	M	UCAR	USA
6	Shank, Timothy	<i>Orpheus</i> Science Lead	05/11	05/27	M	WHOI	USA
7	Machado, Casey	<i>Orpheus</i> Engineer Lead	05/11	05/27	F	WHOI	USA
8	Howard, Art	Videographer	05/11	05/27	M	GFOE	USA
9	Klesh, Andy	<i>Orpheus</i> Engineer	05/11	05/27	M	NASA JPL	USA
10	Smith, Russell	<i>Orpheus</i> Engineer	05/11	05/27	M	NASA JPL	USA
11	Egan, Katharine	eDNA Lead	05/11	05/27	F	OER	USA
12	Everett, Meredith	eDNA Subject Matter Expert	05/11	05/27	F	Northwest Fisheries Science Center	USA
13	Meyers, Jim	Data/Computer Admin	Onboard EX-21-01	Onboard EX-21-01	M	GFOE	USA
14	Wright, Chris	Data/Computer Admin	Onboard EX-21-01	Onboard EX-21-01	M	GFOE	USA
15	Doros, Brian	Video Engineer	05/11	05/27	M	GFOE	USA
16	Gulbraa, Rachel	Communications Lead	05/11	05/27	F	OER/UCAR	USA
17	Kaelbein, Jessica	OECI Videographer	05/11	05/27	F	ISC/URI	USA

¹ Cherokee Nation Strategic Programs



1. Foreign National Guests Access to OMAO Facilities and Platforms

Foreign national access to *Okeanos Explorer* or other federal facilities will not be required for this expedition.

G. Administrative

1. Points of Contact

Table 2. Points of Contact

Operations	Name, Title	Office	Address	Phone/Fax	Email
Ship		Marine Operations Center, Atlantic	439 West York Street Norfolk, VA 23510-1145	(757) 441-6776/ (757) 441-6495	
Ship	LCDR Fiona Matheson, NOAA	Chief, Operations Division, Atlantic	439 West York Street Norfolk, VA 23510-1145	(757) 441-6842/ (757) 441-6776	Chiefops.MOA@noaa.gov
Mission (primary)	Michael P. White, Expedition Coordinator	NOAA Office of Ocean Exploration and Research	24 Colovos Road Durham, New Hampshire 03824	(631) 561-9802	michael.white@noaa.gov
Mission (primary)	CDR Nicole Manning, NOAA Commanding Officer	NOAA Ship <i>Okeanos Explorer</i>	NOAA Ship <i>Okeanos Explorer</i> Attn: Name or Department 47 Chandler Street Newport, RI 02841	(401) 439-7848	CO.Explorer@noaa.gov
Mission (primary)	LT Bryan Pestone, NOAA Operations Officer	NOAA Ship <i>Okeanos Explorer</i>	NOAA Ship <i>Okeanos Explorer</i> Attn: Name or Department 47 Chandler Street Newport, RI 02841	(808) 659-9179 x221	ops.explorer@noaa.gov
Mission (other)	Kasey Cantwell, Operations Chief	NOAA Office of Ocean Exploration and Research	1315 East-West Highway, Silver Spring, MD 20910	(301) 717-7776	kasey.cantwell@noaa.gov
Mission	Rachel Medley,	NOAA Office	1315 East-West	(301)	rachel.medley



(other)	Chief, Expeditions and Exploration Division	of Ocean Exploration and Research	Highway, Silver Spring, MD 20910	789-3075	@noaa.gov
Mission (other)	Alan Leonardi, Director	NOAA Office of Ocean Exploration and Research	1315 East-West Highway, Silver Spring, MD 20910	(301) 734-1016 Mobile: (202) 631-1790	alan.leonardi@noaa.gov

2. Diplomatic Clearances

None required.

3. Licenses and Permits

See Appendix D.

4. Shipments

The *Okeanos Explorer* operations officer should be notified of any shipments to the ship. Send an email describing the shipment (including size and number of items) to OPS.Explorer@noaa.gov.

For shipments to arrive while in port in Port Canaveral at the start of the expedition, **shipments should arrive no later than May 10th, 2021** and be mailed to the following address:

NOAA Ship Okeanos Explorer
C/O: Ambassador Services
Attn: *Name or Department*
245 Challenger Rd
Cape Canaveral, FL 32920

For shipments to arrive while in port in Norfolk, VA after the expedition, **shipments should arrive no later than June 7th, 2021** and should be mailed to the following address:

NOAA Ship Okeanos Explorer
Marine Operations Center - Atlantic
ATT: Name or Department



439 West York Street
Norfolk, VA. 23510

5. COVID-19 Plan for Mission Personnel

In accordance with “NOAA OER COVID-19 Field Operations Expectations and Information” (see summary in Appendix E), all mission personnel must have received a negative COVID-19 test prior to travel to the port of call. Any mission personnel who test positive will be disqualified from sailing, and backup personnel will be activated as mission objectives and priorities dictate.

Mission personnel will undergo OMAO testing on May 7th starting 0800 on Day 4 of the Shelter in Place at Home2 Suites by Hilton, Cape Canaveral Cruise Port, 9004 Astronaut Blvd, Cape Canaveral, FL 32920.

If any mission personnel test positive for COVID-19 during the OMAO-required shelter-in-place periods:

- NOAA Marine Health Services will notify the individuals who test positive that they are not cleared to board the ship. OER will reimburse the individual for 14 days of shelter-in-place lodging to complete their isolation and for a COVID-19 test to confirm they are negative prior to returning home.
- The expedition coordinator will be notified of any mission personnel who are not cleared to sail (but they will not be told why).
- The expedition coordinator will notify the OER operations chief.
- The expedition coordinator will determine, in consultation with the ship’s commanding officer, OER operations chief, and appropriate parties, whether the mission will continue without the uncleared personnel.

If any mission personnel develop COVID-19-like symptoms while underway, [OMAO protocols](#) will be strictly followed. The expedition coordinator (or designee if they are unable to fulfill this role) will remain the primary point of contact for all mission personnel. Additional support with onshore logistics for impacted mission personnel will be provided by:

LTJG Christopher "J" Dunn, NOAA
Expeditions Operations Leader, Expeditions and Exploration Division
NOAA Office of Ocean Exploration and Research
215 South Ferry Road
Narragansett, RI 02882



Desk: (401) 874-6478
Cell: (262) 995-3410

II. Operations

The expedition coordinator is responsible for ensuring mission personnel are trained in planned operations and are knowledgeable about expedition objectives and priorities. The commanding officer is responsible for ensuring all operations conform to the ship's accepted practices and procedures.

A. Expedition Itinerary

Table 3 summarizes the expedition itinerary. All times and dates are subject to prevailing conditions and the discretion of the commanding officer. This is an approximate itinerary and is subject to change based on objective completion.

Table 3. Expedition Itinerary

Date	Activities
May 3	Mission team travels to SIP locations in Port Canaveral, Florida
May 4	First full day of SIP. Daily health screening.
May 5	Second full day of SIP. Daily health screening.
May 6	Third full day of SIP. Daily health screening. OMAO testing for all mission personnel.
May 7	Fourth full day of SIP. Daily health screening.
May 8	Fifth full day of SIP. Daily health screening.
May 9	Sixth full day of SIP. Daily health screening.
May 10	Seventh full day of SIP. Daily health screening. Ship arrives in Port Canaveral from EX-21-01
May 11	Mission team moves aboard late in the day. Merge bubbles with onboard ship personnel. Load mission equipment. Ship's crane support requested.
May 12	Mobilization inport at Port Canaveral commercial port. AUV assembly and securing to deck. Wet Lab set-up. Mission safety orientation and ship familiarization meetings. Crane operations requested. Connect mission personnel to mission internet.
May 13	Mobilization inport at Port Canaveral commercial port. AUV dunk test alongside. Practice AUV launch and recovery. Crane operations requested. Request to ping sonars alongside. Continued ship orientation and safety meetings. Possible load of WHOI 20ft container
May 14	Depart Port Canaveral. Dunk AUVs using port side crane on a tether. Transit east to the deep-water mapping area.



May 15	Day time small boat operations with AUV deployment in shallow water east of Port Canaveral for TRN calibration. Remain outside 3 nautical miles.
May 16	Day time small boat operations with AUV deployment in shallow water east, northeast of Port Canaveral for TRN calibration. Remain outside of 20 nautical miles from shore. Possible CTD operations. Overnight mapping operations.
May 17	Day time small boat operations with AUV deployment in shallow water east, east of Port Canaveral for TRN calibration. Morning CTD operations. Remain outside 3 nautical miles.
May 18	Day time small boat operations with AUV deployment in shallow water east, east of Port Canaveral for TRN calibration. Possible CTD operations. Overnight mapping operations, transit to central Blake Plateau.
May 19	AUV operations. CTD cast and water sample collection. Overnight Mapping
May 20	AUV operations. CTD cast and water sample collection. Overnight Mapping
May 21	AUV operations. CTD cast and water sample collection. Overnight Mapping
May 22	AUV operations. CTD cast and water sample collection. Overnight Mapping
May 23	AUV operations. CTD cast and water sample collection. Overnight Mapping
May 24	AUV operations. CTD cast and water sample collection. Overnight Mapping.
May 25	AUV operations. CTD cast and water sample collection. Overnight transit and mapping operations north.
May 26	Transit mapping operations.
May 27	Arrive Norfolk, Virginia. Demobilization. Crane operations request. COVID bubble breaks.
May 28	Continued demobilization if necessary

B. Staging and De-Staging

Crane operations and ship's force support are requested on May 11, May 12 and May 13th to move AUVs and supporting equipment (approximately 5 pallets of material) from shore to ship. Ship's force is also requested to assist with staging and securing AUVs on ship. On May 13th, the mission team proposes a full walkthrough and dry run of AUV launch and recovery operations, with a possible dunk test of AUVs. Mission team will also require support for the installation of WHOI owned USBL pole mount. This installation will include mounting to the deck and running cables into mission spaces, likely the Dry Lab.

On May 27th and 28th the mission team requires crane operations to support demobilization to remove AUVs and supporting equipment from the ship. C. Operations To Be Conducted



1. Telepresence/Outreach Events

- Three live video feeds will be used throughout the expedition to provide situational awareness for onshore personnel.
- Live interactions are planned for this expedition in coordination with partnering institutions. Groups and dates are still being identified.
- There will be one live interaction on May 5th during Shelter in Place

2. Port Events and Ship Tours

No public port events or ship tours are planned for this expedition.

3. Special/Unusual Operations or Requests

There are no special or unusual operations or requests for this expedition.

D. SCUBA Dive Plans

All SCUBA dives are to be conducted in accordance with the requirements and regulations of the [NOAA Diving Program](#) and require the approval of the ship's commanding officer. No science dives are planned during EX-21-02, but the ship may plan training, safety drills, or maintenance dives.

E. Applicable Restrictions

Not applicable.

III. Equipment

A detailed list of equipment provided by the ship and OER is in the "NOAA Ship *Okeanos Explorer* FY2021 Field Season Instructions." There are no specific changes relative to this expedition.

OER and its partners will for EX-21-02 will be provided sample processing supply and equipment for eDNA extraction, 2 WHOI owned *Orpheus* AUVs, TRN calibration transponders and equipment, and a WHOI own USBL pole mount.

IV. Hazardous Materials

A. Policy and Compliance

See the "NOAA Ship *Okeanos Explorer* FY2021 Field Season Instructions."



B. Inventory

Table 4. Inventory of Hazardous Materials That Will Be On Board for EX-21-02

Item	Use	Approximate Locations
95% denatured ethanol (30 gal)	Sample preservation	02 Deck in EtOH storage barrel
Formaldehyde (2 gal) to be buffered into 10% buffered formalin	Sample preservation	Wetlab, under the chemical hood
Chaos buffer (325 mL) (4 M guanidine thiocyanate, 0.5% N-lauroylsarcosine, 25 mM Tris pH 8.0, 0.1 M beta-mercaptoethanol)	Sample preservation	Wetlab, under the chemical hood
AquaShield	Underwater lubricant	ROV workshop fire cabinet, pit
Dow Corning 4	Electrical insulating compound	ROV workshop fire cabinet, pit
Fluid film spray	Silicone lubricant	ROV workshop fire cabinet
Isopropanol alcohol (2 gal)	Solvent	ROV workshop fire cabinet
Scotchkote	Electrical insulating compound	ROV workshop fire cabinet
3M silicone spray	Silicone lubricant	ROV workshop fire cabinet
Synthetic AW hydraulic oil, ISO-22	Amsoil (AWG-05)	Hangar, pit, vehicles
Tap Magic cutting fluid	Cutting/machining lubricant	ROV workshop fire cabinet
Tap Magic heavyweight cutting fluid	Cutting/machining lubricant	ROV workshop fire cabinet
Tuff Coat M	Marine lubricant	Winch room
Dow Corning Molykote 111	Valve lubricant and sealant	ROV workshop fire cabinet, pit
WD40	Lubricant	ROV workshop fire cabinet
Loktite	Bolt adhesive	ROV workshop fire cabinet
Shell Diala S2	Vitrea	Hangar, vehicles
Por-15	Paint kit	ROV workshop fire cabinet
Aeroshell 41	Hydraulic fluid	Hangar, ROV <i>Deep Discoverer</i>
Ultratane	Butane fuel	ROV workshop fire cabinet
Rust-oleum	Protective enamel	ROV workshop fire cabinet
Flux-Off	Soldering flux remover	ROV workshop fire cabinet
Propane	Torch fuel	ROV workshop fire cabinet
Pliobond 25	General adhesive	Tool room
AP 120 Metal Prep	Degreaser/cleaner for metal surfaces	Pit

Butane fuel	Torch refill	Tool room
PVC cement	Adhesive for PFV plastic piping	Tool room
Phosphoric acid	Ferrous metal rust removal	Tool room
Pipetite paste	Plumbing sealant	Tool room/pit
Spindle oil 10, ROS PT	Lubricant/compensation oil	Tool room
DC557	Silicon grease	Tool room/pit
Tether potting catalyst	Two-part epoxy catalyst	Pit
Tether potting compound	Two-part epoxy ingredient	Pit
ThermaPlex bearing grease	Lubricant	Pit
Tritech SeaKing	Compensator oil for sonar head	Pit
Bleach (1 qt)	Sterilization and sample preservation	Cabinet under sink



Appendix A. Elaboration of Procedures/Objectives

None



Appendix B. Waypoints

EX-21-02 Areas of Operation

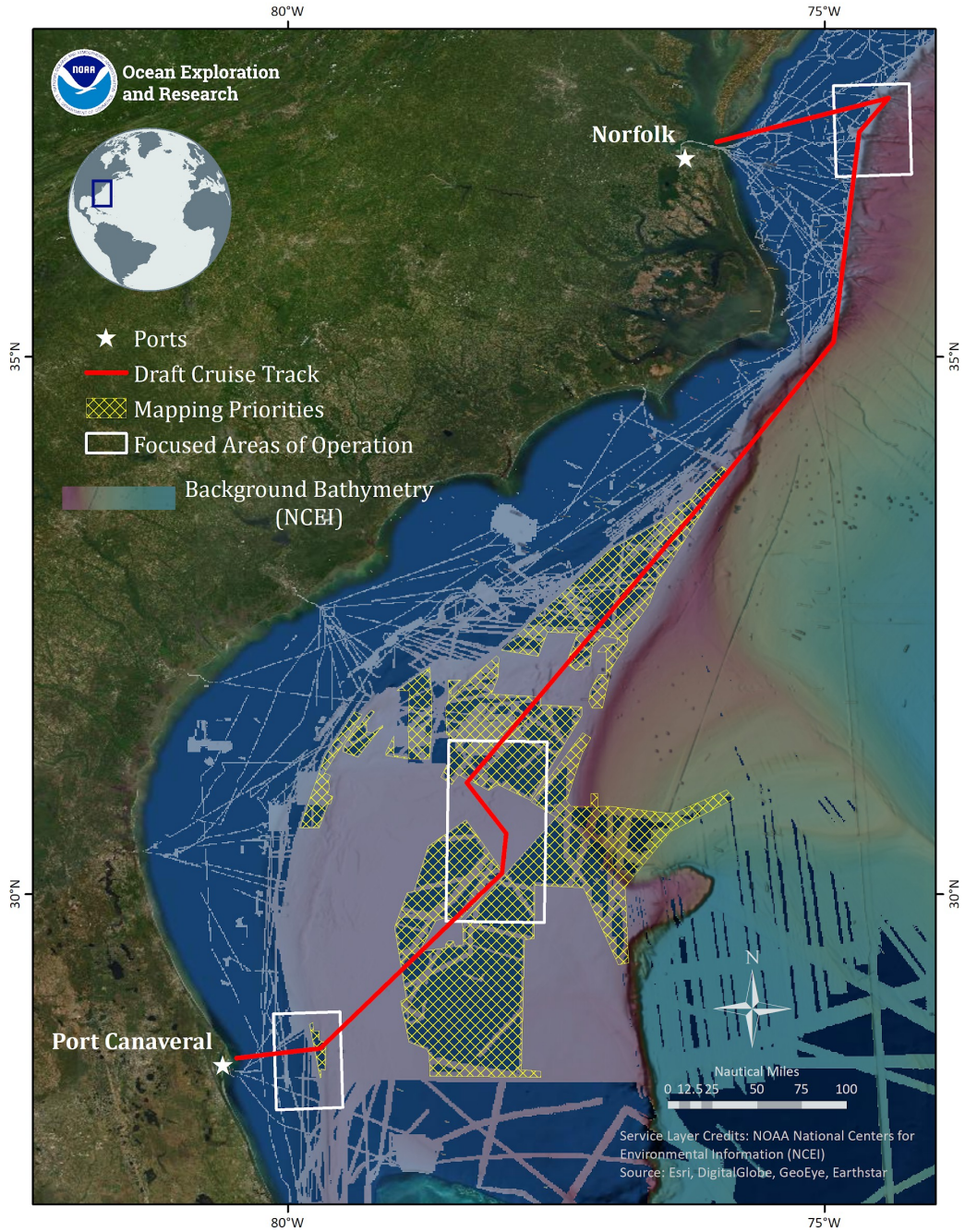


Figure B1 (for reference). Map showing the general operating area for EX-21-02.

Table B1. Waypoints for Draft Cruise Track (red line)

Latitude (D DM)	Longitude (D DM)
28 28.3632N	080 28.8936W
28 33.8346N	079 42.0948W
30 11.523N	078 00.528W
30 33.7584N	077 58.134W
31 02.1726N	078 20.1228W
33 55.0722N	075 54.5178W
35 08.289N	074 54.9648W
37 05.4702N	074 40.7496W
37 24.6126N	074 24.333W
37 00.0468N	076 00.4392W

Appendix C. Data Management Plan

Okeanos Explorer Mission EX2102 Data Management Plan

Report Date: 2021-03-17

1. General Description of Data to be Managed

1.1 Name and Purpose of the Data Collection Project:

2021 Technology Demonstration

AUV operations during EX2102 will focus on transitioning the *Orpheus* AUVs to be fully operational, and integration and validation of the novel Terrain Relative Navigation software



(TRN). eDNA sampling will be an objective of regular ship CTD casts and processing of water column samples onboard. Mapping operations may include fine tuning of acoustic data workflows and will focus on any unmapped areas in US water deeper than 200 meters.

1.2 Summary Description of the data to be collected:

Mapping data in and around the Blake Plateau and off the coasts of Florida, Georgia, South Carolina, North Carolina and Virginia.

1.3 Keywords or phrases that could be used to discover the data:

AUV, Blake Plateau, Cape Canaveral, CTD, eDNA, EM304, expedition, exploration, explorer, Jet Propulsion Laboratory, JPL, mapping survey, marine education, multibeam, multibeam backscatter, multibeam sonar, multi-beam sonar, National Aeronautics and Space Administration, NASA, National Ocean Mapping Exploration and Characterization, noaa, noaa fleet, NOMEK, Norfolk, ocean, ocean discovery, ocean education, ocean exploration, ocean exploration and research, ocean literacy, ocean research, oceans, OER, okeanos, okeanos explorer, Orpheus AUV, Port Canaveral, R337, Rhode Island, science, scientific computing system, scientific mission, scientific research, SCS, sea, sea acceptance trials, Seabed 2030, single beam sonar, singlebeam sonar, single-beam sonar, site characterization, sonar anomalies, Southeastern US Continental Margin, South Atlantic Bight, Southeast Deep-sea Coral Initiative, stewardship, sub-bottom profile, systematic exploration, technology, Terrain Relative Navigation, transformational research, TRN, undersea, underwater, Washington Canyon, water column backscatter

1.4 If this mission is part of a series of missions, what is the series name?

Okeanos Mapping Cruises

1.5 Planned or Actual Temporal Coverage of the data:

Start Date: 2021-04-14 and End Date: 2021-04-27

1.6 Actual or Planned Geographic Coverage of the data:

Northernmost Boundary: 37.85 and Southernmost Boundary: 27.52

Westernmost Boundary: -80.99 and Easternmost Boundary: -73.91

1.7 What data types will be created or captured and submitted for archive?



Bottom Backscatter, Cruise Plan, Cruise Summary, CTD (processed), CTD (product), CTD (raw), Data Management Plan, EK60 Split Beam Data, EK80 Split Beam Data, Launch and Recovery Locations, Multibeam (image), Multibeam (processed), Multibeam (product), Multibeam (raw), Navigational Data, SCS Output (compressed), SCS Output (native), Seafloor Imagery, Sound Velocity Profile, Sub-Bottom Profile data, Temperature data, Water Column Backscatter, XBT (raw)

1.8 What platforms will be employed?

NOAA Ship Okeanos Explorer

2 Points of Contact for this Data Producing Project

Overall POC: Michael White, michael.white@noaa.gov

Title: Expedition Coordinator

Affiliation: NOAA Office of Ocean Exploration and Research

Phone: (301) 938-8460

3 Points of Contact for Managing the Data

Data POC: Megan Cromwell, Andy O'Brien

Data POC Title: Stewardship Data Management, Onboard and shoreside data management

Data POC Email: megan.cromwell@noaa.gov, andrew.obrien@tgfoe.org

4 Resources

4.1 Have resources for management of these data been identified?

Yes

4.2 Approximate percentage of the budget devoted to data management. (specify % or unknown)

Unknown

5 Data Lineage and Quality



5.1 What is the processing workflow from collection to public release?

SCS data shall be delivered in its native format as well as an archive-ready, documented, and compressed NetCDF3 format to NCEI-MD; AUV seafloor imagery, water column profile data and navigation data will be delivered in ASCII format to NCEI-MD; EM304 and EK60/80 output data and metadata along with water column profiles used for calibration will be compressed and delivered in a bagit format to NCEI-CO.

5.2 What quality control procedures will be employed?

Quality control procedures for the data from the Kongsberg EM304 is handled at UNH CCOM/JHC. Raw (level-0) bathymetry files are cleaned/edited into new data files (level-1) and converted to a variety of products (level-2). Data from sensors monitored through the SCS are archived in their native format and are not quality controlled. Data from CTD casts and XBT firings are archived in their native format. CTDs are post-processed by the data management team as a quality control measure

6 Data Documentation

6.1 Does the metadata comply with the Data Documentation Directive?

Yes

6.1.1 If metadata are non-existent or non-compliant, please explain:

Not Applicable

6.2 Where will the metadata be hosted?

Organization: An ISO format collection-level metadata record will be generated during pre-cruise planning and published in the NOAA OneStop catalog and an OER Web Accessible Folder (WAF) hosted at NCEI-MS for public discovery and access.

URL: https://data.noaa.gov/waf/NOAA/NESDIS/ncei/oer/iso_u/xml/

Metadata Standard: ISO 19115-2 Geographic Information with Extensions for Imagery and Gridded Data will be the metadata standard employed.

6.3 Process for producing and maintaining metadata:

Metadata will be generated via xml editors or metadata generation tools.



7 Data Access

7.1 Do the data comply with the Data Access Directive?

Yes

7.1.1 If the data will not be available to the public, or with limitations, provide a valid reason.

Not Applicable

7.1.2 If there are limitations, describe how data are protected from unauthorized access.

Account access to mission systems are maintained and controlled by the Program. Data access prior to public accessibility is documented through the use of Data Request forms and standard operating procedures.

7.2 Name and URL of organization or facility providing data access.

Organization: NOAA National Centers for Environmental Information (NCEI)

URL: <https://www.ncei.noaa.gov>

7.3 Approximate delay between data collection and dissemination. By what authority?

Hold time: Data are considered immediately publicly accessible as soon as possible after the mission, unless there are documented restrictions.

Hold authority: not applicable

7.4 Prepare a Data Access Statement

No data access constraints, unless data are protected under the National Historic Preservation Act of 1966.

8 Data Preservation and Protection

8.1 Actual or planned long-term data archive location:

Data from this mission will be preserved and stewarded through the NOAA National Centers for Environmental Information. Refer to the Okeanos Explorer Data Management Plan at NOAA's EDMC DMP Repository for detailed descriptions of the processes, procedures, and partners involved in this collaborative effort.



8.2 If no archive planned, why?

Not Applicable

8.3 If any delay between data collection and submission to an archive facility, please explain.

The EM304 output data is a new format not currently read by NCEI archive systems. The new file format is being added to the system capability. There will be an unknown delay for the archive of these .kml files. All other data will be archived within 60-90 days of receipt.

8.4 How will data be protected from accidental or malicious modification or deletion?

Data management standard operating procedures minimizing accidental or malicious modification or deletion are in place aboard the Okeanos Explorer and will be enforced.

8.5 Prepare a Data Use Statement

Data use shall be credited to NOAA Office of Ocean Exploration and Research.



Appendix D. Licenses, Permits, and Environmental Compliance

Pursuant to the National Environmental Policy Act (NEPA), OER 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 for NOAA Administrative Order 216-6A describes the agency's specific procedures for NEPA compliance.

An environmental review memorandum was completed for OER expeditions on *Okeanos Explorer* in 2021 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 exist that require the preparation of an environmental assessment or environmental impact statement. OER is preparing a programmatic environmental assessment to cover future expeditions.

As required under Section 7 of the Endangered Species Act (ESA), OER conducted an informal consultation with NOAA's National Marine Fisheries Service (NMFS) Office of Protected Resources to request their concurrence with OER's biological evaluation determining that OER's operations on *Okeanos Explorer* conducted 2021 may affect, but are not likely to adversely affect, ESA-listed marine species. In a Letter of Concurrence dated February 3, 2021, the chief of the ESA Interagency Cooperation Division in the NMFS Office of Protected Resources wrote that NMFS concurs with OER's determination.

In addition, OER consulted with the NMFS Greater Atlantic Fisheries Office (GARFO) on potential impacts of operations to essential fish habitat (EFH) in the greater Atlantic region under the Magnuson-Stevens Fishery Conservation and Management Act. OER received a letter of acknowledgement from GARFO on March 10, 2021, that covers expedition activities from April 1, 2021 until September 31, 2021.

Following is a copy of the NEPA Categorical Exclusion. The Endangered Species Act (ESA) Section 7 Letter of Concurrence and a Letter of Acknowledgement from the Greater Atlantic Regional Fisheries Office (GARFO) are in the ["NOAA Ship *Okeanos Explorer* FY2021 Field Season Instructions."](#)



Appendix E. Summary of OER COVID-19 Guidelines and Expectations



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COVID-19 Guidance and Expectations for OER Mission Personnel

Required Reading

Mission personnel must familiarize themselves with all the protocols in the required documents prior to traveling.

- OMAO COVID-19 Guidance (Phase VI)*
- NOAA Ship Okeanos Explorer Standing Orders*
- NOAA COVID-19 Safety Orientation Course*
- NOAA OER COVID-19 Field Operations Guidelines and Expectations
- OMAO COVID-19 Shipboard Safety Briefing for Marine Operations*

Summary of Guidance and Expectations

This summarizes what is required from mission personnel participating in NOAA Office of Ocean Exploration and Research (OER) field operations. For more detailed information, see the required documents above.

- At least 30 days before travel, mission personnel must take the *NOAA COVID-19 Safety Orientation Course*, review the Office of Marine and Aviation Operations (OMAO) *COVID-19 Shipboard Safety Briefing for Marine Operations*, and complete the OER Sailing Contact Form to provide a shipping address and to request a KN95 mask and/or a post-travel COVID-19 test kit.
- Prior to travel, OER recommends that mission personnel **shelter in place for seven days**. Four days before traveling to the port, mission personnel must test themselves using an **OER-supplied COVID-19 test kit**. OER requires that mission personnel receive a negative COVID-19 test prior to travel. For instructions regarding how to request, administer, and send the self-administered COVID-19 tests, refer to the OER COVID-19 Testing Fact Sheet.
- The **closest weekday prior to traveling (Monday-Friday, 0800-1600 ET)** mission personnel must submit the OMAO Reporting Risk Assessment Form to moa.health.services@noaa.gov and copy the medical officer, LCDR Peter Choi (byungyong.choi@noaa.gov) for awareness.
- Mission personnel must follow the [Centers for Disease Control and Prevention's COVID-19 best practices](#), including using risk avoidance measures while traveling. Mission personnel are required to wear a two-layer cloth and/or KN95 mask during the entirety of travel. OER will provide mission personnel with a KN95 mask upon request. Individuals are also encouraged to consider current CDC recommendations to wear more than one mask for added protection.
- After mission personnel complete their travel and before they join the ship, they must **shelter in place for seven days near the ship's port of call** to enable daily medical screenings. While sheltering in place, mission personnel must take **two (95% accuracy) COVID-19 tests provided by OMAO**. Mission personnel may join the ship once they have sheltered in place for seven days and receive two negative (95% accuracy) COVID-19 tests.
- While on the ship, mission personnel must follow the OMAO guidelines and the commanding officer's standing orders.
- At the conclusion of post-cruise/post-project travel, OER will provide mission personnel with a COVID-19 test kit upon request.

*Copies of the OMAO documents can be requested through the Marine Operations Center-Atlantic

Last Updated: 02/2/2021



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