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NOAA Ship *Okeanos Explorer* Data Management Plan

2023 Field Season

This document was written by NOAA National Centers for Environmental Information with collaborations by NOAA Ocean Exploration and the Global Foundation for Ocean Exploration.

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Document Versioning History

Date	Version	Author(s)	Comments
2/14/2012	1.0	S. Gottfried	Initial Draft
3/23/2012	1.1	S. Gottfried	Updated Video Pipeline
2/6/2013	1.2	S. Gottfried	FY13 Updates
11/20/2013	1.3	S. Gottfried	FY14 Updates
11/17/2014	1.4	S. Gottfried	FY15 Updates
7/29/2015	2.0	S. Gottfried	Added Sampling Operations
3/18/2016	3.0	S. Gottfried	New Video data management procedures; PARR Compliance; Updated data pipelines
3/3/2017	3.1	M. Cromwell	FY17 Updates
8/23/2017	3.2	S. Gottfried	Added Appendix of Expeditions
1/31/2019	4.0	M. Cromwell, S. Gottfried	FY19 Updates including network overhaul, transfer of responsibilities
7/13/2020	4.1	M. Cromwell (with contributions from NCEI, NOAA Ocean Exploration, & GFOE)	FY20 Updates including GIS updates
3/1/2021	4.2	M. Cromwell	FY21 Updates
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9/15/2023	5.0	C. Ruby, A. Lienesch, J. Green, C. Reiser, J. Havrylkoff, S. Gottfried	Significant updates to ensure accuracy of information and usefulness to the general public

1. Document Purpose

The NOAA Ship *Okeanos Explorer* (EX) is owned and maintained by the NOAA Office of Marine and Aviation Operations (OMAO) and operated by the NOAA Ocean Exploration and the Global Foundation for Ocean Exploration (GFOE). EX is NOAA's only vessel solely dedicated to exploration of the deep ocean. The ship also deploys the remotely operated vehicles (ROV) *Deep Discoverer* and *Seirios*. At the conclusion of each expedition, data are sent to NOAA National Centers for Environmental Information (NCEI) for archive and public access.

This document outlines the plan for managing data and information recorded, collected, or otherwise generated by EX during the 2023 Field Season. This plan is intended to support a comprehensive and standardized approach to identifying, acquiring, displaying, archiving, and publishing EX mission data and information. See Appendix A for the 2023 EX Mission List. See NOAA Ocean Exploration 2023 Field Season web page or "NOAA Ship *Okeanos Explorer* FY23 Field Season Instructions" for a more complete overview of planned missions, operations, and participating institutions.

2. Document Authority

This guidance adheres to NCEI archival procedures, the NOAA Data Governance Council's (DGC) Procedural Directives, and the NOAA Public Access to Research Results (PARR). Authority for these requirements is explained in more detail below.

NOAA environmental and geospatial data are maintained in accordance with applicable Office of Management and Budget (OMB) regulations, including OMB Circulars A-16 and A-130; International Organization for Standardization (ISO) approved data standards; the Geospatial Profile of the Federal Enterprise Architecture; federal law related to records management within federal agencies – Sections 3101-3107 of Title 44 of the United States Code (44 U.S.C. 3101-3107); the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 et seq.); and the National Archives and Records Administration (NARA) Records Management Regulations – Parts 1220-1238 of Title 36 of the Code of Federal Regulations (36 CFR 1220-1238).

NOAA Administrative Order Information Access and Dissemination (NAO 205-17) establishes policy for distributing scientific and technical publications and ensuring compliance with NOAA's mission to provide environmental information to its user communities. Management of Environmental and Geospatial Data and Information (NAO 212-15) provides high-level direction that guides procedures, decisions, and actions regarding environmental data and information management throughout NOAA.

The NOAA PARR was published in response to the White House Office of Science and Technology Open Data Policy and prompted the issuance of Procedural Directives (Data Management Planning, Data Access, Data Citation, Data Documentation) and an update to the Data and Information Sharing Plan for Grants, Contracts and Collaborative Agreements.

3. Data Management Plan (DMP) Overview

All data recorded, products generated, and discoveries made during a mission will be made accessible to the general public as close to the collection date as possible. Exceptions to this will be noted in the individual mission Data Management Plans (DMP) when data need protection due to submerged cultural resources, foreign waters, or other reasons. Individual DMPs are found within the Project Instructions (Section 4.5). Public access to data will be achieved through a variety of discovery and access points (Section 6), including secure FTP servers, account controlled content management sites, metadata search engines, public access websites, and customized geospatial applications.

Data collected on, and products resulting from, EX missions will be managed by a collaborative group of individuals from NOAA Ocean Exploration, GFOE, OMAO, and NCEI.

The NOAA Ocean Exploration team is responsible for:

- planning and executing mission operations;
- determining what data and products to collect;
- funding data management and stewardship; and
- acquiring, processing, and storing, mapping data.

The GFOE team is responsible for:

- the maintenance and operation of NOAA Ocean Exploration's two submersible vehicles - ROV *Deep Discoverer* and Camera Platform *Seirios*;
- the architecture, maintenance and operations of the onboard network systems and processes;
- the network systems and processes at a shoreside location at the University of Rhode Island (URI) InnerSpace Center (ISC).

OMAO is responsible for:

- the maintenance and operation of EX,
- the data management of the hull-mounted sensors, except the multibeam sensor suite, which is handled separately, and
- the data transfer of the ship's near-real-time location and meteorological data to NCEI for the live tracking of ship operations.

The NCEI team is responsible for:

- the database supporting onboard sampling operations,
- the production and support of geospatial products, and
- the stewardship of the data (post mission).

The management of data collected by autonomous underwater vehicles (AUV) will be a joint effort between NOAA Ocean Exploration, AUV operators, and NCEI. Existing data management and archival pipelines will be leveraged where possible.

4. Instruments, Data Types & Procedures

Data recorded and products generated as a result of EX missions will be managed first by the strict enforcement of established procedures followed by specified mission and crew members, onboard personnel, and by a team of data managers both onboard and ashore. The Data Management Teams will follow established procedures to ensure data and metadata are archived correctly and made accessible through data discovery tools. This section will describe the instruments, data types, and data management procedures for each data collection described in Table 1. Data types within this table are generally grouped by how they are managed.

Table 1. The details for each of the expected data collections during the 2023 EX Field Season.

Collection	Included Data Types
4.2. Oceanographic & Meteorological Data	• Vessel navigation data • Shipboard meteorological data • Hull-mounted and over-the-side oceanographic sensor data
4.3. Geophysical Survey Mapping Data	• Multibeam seabed bathymetry and backscatter sonar data • Water column profile data • Sub-bottom profile data
4.4. ROV Data	• Video data • Still imagery • Oceanographic sensor data (onboard CTD) • Physical samples (biological, geological & water) • Navigation data[1] (vehicle coordinates, depth, altitude, heading, pitch & roll)
4.5. Supporting Documentation	• Project Instructions • Annual Mapping Readiness Reports • Mapping Equipment Calibration Reports • Expedition Reports • Dive Summaries & CTD Cast Summaries
4.6. Opportunistic Data	• NASA Aerosol Data
4.7. AUV Data	• Photomosaic Imagery • Laser-line bathymetry data • Multibeam bathymetry and backscatter sonar data • Water column sonar profile data • Sub-bottom profile data • Side scan sonar • Magnetometer • Navigation data

[1] Data only captured or retained for ROV *Deep Discoverer*, not *Seirios.*

4.1. Data Transfer Methods

NOAA Ocean Exploration prioritizes live interactions with shoreside scientists and the public. To facilitate near-real-time data access from shore, GFOE manages a ship-to-shore data synchronization system and complementary data server (exdata.tgfoe.org). This Shoreside Repository Server (SRS), commonly referred to as the "ExData Server", is located at the InnerSpace Center (ISC) in Rhode Island. GFOE retains data access via the ExData Server until data archival at NCEI has been confirmed, often longer. See Appendix B for folder structures and Appendix C for a description of folder contents and file naming conventions. It should be noted that only a subset of data is available in near-real-time due to the amount of data collected versus limitations of the available satellite bandwidth. It should also be noted that mapping data within the ExData Server are preliminary. Shoreside scientists and researchers that require near-real-time, pre-archival access to data should request user accounts through NOAA Ocean Exploration's Collaboration Tools web page.

Mapping data are physically transported to the University of New Hampshire (UNH) after every expedition for quality control (QC) and final mapping product generation. The QCd mapping data and final mapping products are then transferred to NCEI for archival and incorporation into public access portals. Following the completion of ROV expeditions, two complete copies of all digital ROV data are physically transported by two GFOE Data Team members traveling on separate flights. All submersible data, including video and imagery, are archived at and made available through NCEI. Biological and geological physical samples are carefully packaged and shipped to the Smithsonian National Museum of Natural History (SNMNH) and Oregon State University (OSU), respectively. Environmental DNA (eDNA) samples extracted from water samples are sent to the SNMNH as well. See Section 6 for a comprehensive list of data discovery and access portals.

4.2. Oceanographic & Meteorological Data

The oceanographic data packages include **Oceanographic**, **Meteorological**, and **Navigational** data collected by the EX and the ROVs. This section will primarily focus on data collected by EX, see Section 4.4 for more information about the ROVs oceanographic and navigational data. These data are archived at NCEI.

Instrumentation

The EX is equipped with an integrated suite of oceanographic, meteorological, and navigational instrumentation. The EX has an over-the-side deployable Conductivity, Temperature, and Depth (CTD) instrument mounted on a rosette frame for collecting water column profile data and up to 12 water samples; a flowthrough thermosalinograph; and two Acoustic Doppler Current Profilers (ADCPs). Additionally, NOAA Ocean Exploration maintains an inventory of eXpendable BathyThermographs (XBTs) for collecting water column temperature and depth. Automated sound velocity profiles (asvp) are derived from the CTDs or XBTs.

Near-Real-Time Data Management

Hull-mounted oceanographic, meteorological, and navigational data are recorded 24/7 while the EX is underway. These data are continuously synchronized to redundant systems on two physically separate shipboard networks (OMAO and GFOE). Similar to other NOAA vessels, these data are monitored by OMAO's Scientific Computing System (SCS) and recorded to OMAO's shipboard network. In parallel, GFOE uses a suite of custom software to perform the same function as OMAO's SCS with enhancements specific to the EX. These enhancements include descriptive file names as well as the ability to halt the near-real-time data delivery to shore during restricted operations (further described in Section 5). These two shipboard networks receive the exact same data input via a GFOE developed active serial splitting matrix. Both networks timestamp data as it arrives and write the results in a Comma Separated Value format using the ".RAW" file extension. Both networks create separate data files for each UTC day. This documentation will focus on the data saved to GFOE's network since those data have enhanced folder structures and file naming conventions. See Appendix B for folder structures and Appendix C for a description of folder contents and file naming conventions.

During non-restricted EX operations, an email containing the ship's position and a snapshot of SCS meteorological data are delivered to NCEI every 15 minutes. These data are processed to populate GIS services which feed into the Live Operations Map. The GIS services are hosted on Esri's ArcGIS Online and maintained by NCEI.

Oceanographic data (excluding ADCP data) are periodically uploaded to the shoreside ExData Server. Data are usually available to participating scientists within a few hours of the original recording.

Additionally, GFOE maintains a chatroom, available from shore, for operation discussions that provides a real-time vehicle position and CTD data update. Transcripts of the chatroom are also made available via the ExData Server.

Post-Mission Data Management

NCEI pulls all oceanographic, meteorological, and navigational data (excluding ADCP data) from GFOE's ExData Server. NCEI generates metadata records (ISO8601) for these data using information from the Expedition Reports and Dive Summary documents. Data from sensors monitored through the SCS are archived in their native format and are not quality controlled. Raw data from CTD casts and XBT firings are also archived. Oceanographic data and their associated metadata are packaged and submitted into NCEI's Oceanographic Archive for long-term storage. OMAO is responsible for transferring the ADCP data to the University of Hawaii (UH) for archival purposes; however, as of 2023, that data pipeline is still under development. OER will bulk transfer raw ADCP data to NCEI via hard drives for inclusion in the oceanographic data packages at the end of the field season.

Additionally, NCEI pulls raw ship navigation data from the ExData Server to generate simplified ship tracks for incorporation into the discovery and access products. See Section 6.5 for more information regarding GIS services.

Long-Term Data Archival Location

All oceanographic, meteorological, and navigational data collected by the EX are archived at NCEI where they will be maintained and made publicly available for at least 75 years. See Section 6 for a comprehensive list of data discovery and access portals.

4.3. Geophysical Survey Mapping Data

The geophysical survey mapping data include all sonar data and derived products. The geophysical data packages include **Multibeam Bathymetry and Backscatter**, **Water Column Backscatter**, **Sub-Bottom Profiles**, and associated ancillary data. These data are archived at NCEI.

Instrumentation

The EX is equipped with an integrated suite of sonar instrumentation, including a Kongsberg EM 304 MKII multibeam sonar (nominal frequency of 26 kHz), five frequencies of Simrad EK60/EK80 split-beam sonars (18, 38, 70, 120, and 200 kHz), and a Knudsen Chirp 3260 Sub-Bottom Profiler (3.5 kHz). The 18 kHz split-beam sonar is also recorded through the SCS as the ship's depth reading. For more information about mapping sonar equipment and ancillary systems, and annual calibration results refer to the NOAA Ship *Okeanos Explorer* Mapping Systems Readiness Report 2023. This document is updated throughout the year with equipment information and calibration as needed.

Near-Real-Time Data Management

Throughout the expedition raw data for all three sonar types are sent to the SRS in their respective native sensor format. As multibeam bathymetry data are processed and field products are created, individual processed point files in generic sensor format (GSF) and daily bathymetric grids in various formats (.sd, geotiff (elevation), geotiff (color), .kml, and .xyz) are also sent to shore.

Participating scientists wanting access to the raw multibeam in near-real-time can pull the individual files with the metadata that provides operational and provisional processing steps and a disclaimer for non-QC status of the data.

During non-restricted EX operations, daily GeoTiff images of the seafloor bathymetry are automatically ingested into the near-real-time bathymetric grids layer within the Live Operations Map. This GIS service is hosted on Esri's ArcGIS Online and maintained by NCEI. The daily bathy grids GIS service is publicly available through the ArcGIS Online group: NOAA Ocean Exploration Data (NCEI). Note that these services reflect preliminary, non-QC'd bathymetry grids. See Section 6.5 for more information regarding GIS services.

Post-Mission Data Management

All mapping sonar data and ancillary data (multibeam, water column, sub-bottom, and sound velocity) are saved to a hard-drive. This hard-drive is brought back to the University of New Hampshire Center for Coastal and Ocean Mapping (UNH CCOM) for post-processing by NOAA Ocean Exploration.

A full complement of multibeam sonar data from a 30-day EX expedition which the Kongsberg EM 304 multibeam system runs continuously will produce 200-300 Gigabytes of raw multibeam and water column data.

At UNH, the NOAA Ocean Exploration team will post-process the multibeam bathymetry and backscatter data through the following steps:

- The raw (level-0) data will be saved to the UNH CCOM file servers, where they will be quality checked.
- The processed data (level-1) is exported as full resolution data files in a non-proprietary format – .gsf files (cleaned not gridded).
- The post-processing steps used to produce the level-1 data will be documented.
- Grids (level-2 products) will be generated from the level-1 data files.
- The post-processing steps used to produce the level-2 data products will be documented.
- The level-1 data, level-2 products, post-processing steps, and working data processing spreadsheets will be copied to the hard drive in a new folder. A processing spreadsheet will contain the temporal and spatial limits of each file and any supplemental information documenting problems or issues that affected the quality of the data in that file.

For more information about mapping operations and associated reporting, refer to the NOAA OER Mapping Procedures Manual.

Once post-processing is completed, the following data are submitted to NCEI:

- A collection-level metadata record
- Raw (level-0) mapping data in native sensor format, including:
    - EM 304 Bathymetry and Backscatter (.kmall)
    - EM 304 Water Column Backscatter (.kmwcd)
    - EK60/EK80 Water Column Backscatter (.raw and .idx)
    - Knudsen 3260 Sub-bottom Profiler (.sgy, .kea, and .keb)
- Post-processed, quality assured, and edited (level-1) data files, including:
    - EM 304 Bathymetry and Backscatter (.gsf),
- Specific data products (level-2), including:
    - EM 304 Bathymetry and Backscatter - cleaned and gridded bathymetry data in the following formats: GeoTIFF and floating point geotiffs, ASCII xyz files, KMZ files, and Fledermaus .sd files.
    - Knudsen 3260 Sub-bottom - Images of processed data and shapefiles of navigation
- Water column profile data, including raw data from XBTs and/or CTDs and processed sound speed profiles in .asvp format.

- Ancillary data, including:
    - EM 304 only - Built-in-System-Test Reports, Telnet Logs, and Processing Unit Parameters
    - Expedition Report
    - Logs including a Watch Log, Processing Log, Weather Log, and Sound Speed Log
- CTD and/or XBT profile data used for calibration in multibeam survey

Once received, NCEI ingests the data and products into their appropriate geophysical archive (multibeam, water column, sub-bottom).

Additionally, NCEI generates an array of multibeam bathymetry geospatial data products – including simplified bathymetry coverage polygons as well as web optimized, high resolution gridded bathymetry image services and tile layers – for incorporation into the discovery and access products. These bathymetry geospatial data products are often referred to as Level 3 products. See Section 6.5 for more information regarding GIS services.

Long-Term Data Archival Location

All finalized geophysical survey mapping data and products are archived at NCEI where they will be maintained and made publicly available for at least 75 years. See Section 6 for data discovery and access portals.

4.4. ROV Data

EX regularly deploys the two-body ROV system: *Deep Discoverer* (D2) and camera platform *Seirios* (CP). This ROV system is owned by NOAA Ocean Exploration and developed, maintained, and operated by GFOE. This system is capable of exploring depths down to 6,000 meters and offers a variety of ocean surveying and sampling capabilities. D2 is the main exploration platform used to capture high definition (HD) video and still imagery; environmental parameters; and biological, geological, and water samples. A majority of these data are archived at NCEI, with the exception of physical specimen samples.

Instrumentation

Both ROVs are equipped with a suite of high definition Insite Pacific video cameras; SeaBird SBE-911 Plus CTDs with dissolved oxygen, turbidity, and oxidation reduction potential sensors; and various inertial navigation systems. A complete list of capabilities and specifications is located in Appendix F.

Near-Real-Time Data Management

A csv file containing a list of all cameras and sensors installed on both ROVs is created for every dive. This file includes model, serial number and placement on the vehicles for each item listed. To ensure accuracy, this information is reviewed at the beginning of each expedition and updated mid-expedition if any

equipment is replaced. This csv file is reviewed before every dive to confirm all sensors onboard have not changed without being documented. NCEI uses this csv file for metadata generation.

Video

The EX EVS system captures video from both ROV main cameras. The full-resolution of D2's main HD camera is: 1080i, 147 Mbps, ProRes 422. The full-resolution of *Seirios* main HD camera is: 1080i, 33Mbps, ProRes 422 Proxy.

Each vehicles' main camera feed is broadcasted to shore in near-real-time using the ship's telepresence technologies. Live videos are broadcasted over two streams: the Internet 1 stream is distributed over YouTube for passive public participation on NOAA Ocean Exploration's YouTube Channel, and the Internet 2 is delivered to actively participating shoreside scientists. A real-time video annotations system (SeaTube V3.0) developed by Ocean Network Canada (ONC) is used during dive operations to tag date/time markers of 1) significant events (i.e., on bottom, off bottom, sampling operation start, sampling operation end, etc.) and 2) video annotations of habitat, species, substrate, etc. (provided by participating scientists both onboard and ashore).

Video streams are recorded "deck-to-deck", meaning the videos start during ROV launch and end after ROV recovery. Deck-to-deck videos are voluminous and cause complications during file transfer and data archival. To improve the overall management of these data, videos are programmatically divided into 5 minute segments, and are transcoded to a web-streaming quality (640x360p360p 1.5 Mbps MPEG-4 H.264). The low-resolution files are saved to the ShipBoard Repository Server (SBRS) and then transferred via Rsync to the Shoreside Repository Server (SRS).

The vehicles have multiple secondary cameras that record high-definition video and high-resolution cameras are installed at strategic locations onboard the ship. Oftentimes, secondary cameras may capture events worth preserving (e.g., the collecting of specimens). EX has onboard videographers who work to preserve video segments during the dive operations from the secondary cameras and the ship deck cameras. Video segments to be preserved will be marked and saved onboard the EX using the EVS Instant Replay System through collaboration and guidance via the onboard and remote science team leads.

Additionally, the videographer creates a dive highlight video or dive trailer using the most interesting video footage available. An Editor Decision List is made for each video product generated; this list identifies audio and video segments used for product creation. All source material used to produce highlight videos is collected and saved with the highlights. These dive trailers, or dive highlight videos, are saved in three different resolutions:

- full-resolution (1080i, 147 Mbps, ProRes 422),
- low-resolution (640x360p, 1.5Mbps, MPEG-4 H.264), and
- web-resolution (720p, 8Mbps, MPEG-4 H.264).

All video segments are saved with strict file naming conventions (as described in Appendix C).

Still Imagery

After every dive, video editors go through all video footage and create "frame grabs" (i.e., still images) of interesting or scientifically significant subjects (e.g., rare fauna, species previously unknown to science, peculiar animal behavior, etc.). There is always at least one image created per video file. Still images are also created around a physical sample collection event. Still images can be captured from any recorded video stream from the shipboard videographers or shoreside scientists via SeaTube.

D2 has a designated still camera situated directly above the primary video camera. The still camera captures publication quality still images. Three versions of each image is saved to ExData:

- Highlight - artistically edited, full resolution images (JPEGs)
- Original - unedited, full resolution images (JPEGs)
- Unprocessed - unedited, full resolution raw images (DNGs)

Images are also generated when processing physical samples in the ship's wet lab. The process for generating these "wet lab images" is further described within the "Specimen Samples" section below.

All images are saved with strict file naming conventions (as described in Appendix C).

Oceanographic & Navigational Data

Oceanographic data collected by the ROVs are periodically uploaded to the shoreside ExData Server. Data are usually available to participating scientists within a few hours of the original recording.

Several ROV data streams are combined, interpolated and filtered to create an ROV navigation dive track and a down sampled 1 second temporal frequency (1Hz) ROV navigation dive track. Position data from the vehicle ultra-short baseline (USBL) navigation system is converted from decimal minutes to decimal degrees, is filtered using a rolling median filter to remove bad position fixes, and is indexed by the sample time. The vehicle's Doppler velocity log (DVL) altitude and Paroscientific pressure sensor data are indexed by sample time and any altitude value greater than 100 m is considered a bad value and removed. The navigation, depth and altitude are then combined and interpolated using a time-based interpolation. To create the 1Hz track this data is then downsampled using the pad method where the last good data point is used. These are only produced using D2's data stream.

In addition to the ROV navigation track and the 1Hz version of that file, GFOE also creates a KML version of the dive track. The ROV navigation dive track is downsampled until it contains only 2000 points to meet limits set by Google Earth. These points are then converted to the KML format. The Hypack target file waypoints are also converted to the KML format. This product is only produced using D2's data stream.

A dive summary text file detailing time and location for notable dive events (i.e., deployment/recovery, on/off bottom, water column transects, etc.) is also created. These times are determined by button presses made throughout the dive by the navigator on a simple Graphical User Interface (GUI). Coordinates are automatically gathered from the ROV navigations files, using time as the common denominator. This product is only produced for D2.

ROV heading, pitch, and roll data are not processed or collated into the previously mentioned ROV navigation tracks. These data are archived in their raw format and are only captured for D2.

Additionally, GFOE maintains a chatroom, available from shore, for operation discussions that provides a real-time vehicle position and CTD data update. Transcripts of the chatroom are also made available via the ExData Server.

Physical Samples

The ROV may collect biological, geological, and water samples during scientific ROV dives. Sample Data Managers (SDM) from NCEI will participate onboard all scientific ROV missions and assist science leads during sampling operations and web-lab processing/preservation procedures. Information about each sample collection is recorded within the onboard Microsoft Access Sampling Operations Database Application (SODA).

When a specimen is identified for collection, the videographer clips out a wide shot of the specimen and surrounding environment - this clip starts as the ROV approaches the specimen, includes laser placement on specimen, and ends after collection. When a sample is collected using the manipulator arm, the manipulator arm holds the specimen in front of the main ROV camera. The videographer also clips video from secondary cameras as needed to fully document the specimen and its surrounding environment. Still images are captured detailing various stages of specimen collection and the surrounding environment. A snapshot of the environmental parameters, location, and vehicle depth are captured in the EX control room upon successful sample retrieval. This data collection is triggered by the science leads submitting an onboard sampling web form. Additionally, the start and end times of the sampling operation are noted in SeaTube, the ONC annotation software.

As the ROV ascends to the surface, specimen information collected in the control room is entered into the SODA database. The SDM then uses a SODA database routine to print labels in preparation for specimen processing in the EX wet lab.

Once the ROV is on deck, specimens are brought to the EX wet lab and processed in the order by which specimen is more likely to degrade the quickest. Science leads and the SDM photograph each specimen with the appropriate label, ruler, and color scale; record any applicable descriptors within SODA; collect a DNA sample; and preserve the specimen. Associated organisms found on the primary biological or geological specimens (e.g., small crustaceans and brittle stars) are removed, photographed, and placed in small containers with associate sample labels identifying the specimen and their host rocks, corals, or sponges.

After all preservation procedures have been completed, the SDM organizes the wet lab images, reports, summary files in a directory. That directory is then synchronized to the Sample folder in CruiseData, the onboard repository where all expedition data is gathered before sending it to shore. In order to avoid duplicating data, symbolic links to all sample-related video and imagery are also created in the Sample folder.

Post-Mission Data Management

Video

The following source and product videos (in 5 minute segments) are transferred to NCEI via hard drive for data archival:

- D2's main HD camera (deck-to-deck + low resolution proxies)
- CP's main HD camera (deck-to-deck + low resolution proxies)
- Secondary camera events of note (not, deck-to-deck)

Metadata extraction routines extrapolate geospatial information from SCS data, scientific annotations from SeaTube and the scientific chatroom log, and other available resources to build a comma-delimited file for each individual video file (low-res, high-res, and all resolutions of highlight videos). These comma-delimited files are used to programmatically populate an ISO metadata template to produce ISO metadata records for each video file. These ISO metadata records are maintained by NCEI and are necessary for data discovery and access (see Section 6.2).

Still Imagery

NCEI pulls still imagery from GFOE's ExData Server and creates an ISO metadata record for the imagery. Still images are then zipped and archived by dive within the NCEI Oceanographic Archive packages.

Oceanographic

The CTD data from both ROVs is archived in their native format. The ROV raw navigation files, processed dive tracks, and dive events log are downloaded by NCEI from the ExData Server. Metadata files are generated for these data and they are submitted to NCEI's Oceanographic Archive along with the video annotations, scientific chat logs, and still imagery.

Additionally, NCEI produces an array of geospatial data services from the ROV navigation files and dive event logs. See Section 6.5 for more information regarding GIS services.

Physical Samples

Physical samples are carefully packaged and shipped to their appropriate repository, typically within 24-48 hours after reaching port. Digital files exported from SODA specifically for the Smithsonian National Museum of Natural History (SNMNH) Invertebrate Zoology Repository and the Oregon State University Marine Geology Repository are delivered to the curators with the shipments.

Multiple SODA reports are exported for sample tracking, reporting, and metadata generation. These sample reports and a static copy of the SODA database are archived within NCEI's Oceanographic Archive.

Additionally, NCEI produces a geospatial data service providing visualization to sample collection sites. See Section 6.5 for more information regarding GIS services.

Long-Term Data Archival Location

The following ROV data and products are archived at NCEI where they will be maintained and made publicly available for at least 75 years.

- High definition video data from D2's and *Seirios*'s main camera feeds (deck-to-deck)
- Video clips from alternate cameras that showcase sampling activities
- Scientific video annotations
- Still images
- Oceanographic data (CTD and dissolved oxygen data)
- Navigation data from D2 only (vehicle coordinates, depth, altitude, heading, pitch & roll)

Physical samples will be archived at the following locations:

- Invertebrate organisms go to the Invertebrate Zoology Collection at the Smithsonian's National Museum of Natural History (SNMNH).
- Fish go to the Division of Fishes of the Vertebrate Zoology Collection at SNMNH.
- Geological samples go to the Marine and Geology Repository NOAA Collection (NOAA Rocks) at Oregon State University.
- eDNA water samples go to the Biorepository at SNMNH.

See Section 6 for a comprehensive list of data discovery and access portals.

4.5. Supporting Documentation

NOAA Ocean Exploration produces 4 documents on an annual basis for EX operations:

- Field Season Instructions - document describing what is planned for the upcoming field season.
- Mapping Readiness Report - document describing the status of mapping equipment and results from the annual calibration.
    - Calibration Report EK60/80 - document describing the calibration of the EK60 and EK80 instruments.
- Calibration Report EM 304 - document describing the calibration of the EM 304 multibeam sonar.

Each EX mission produces 3 types of official documents:

- Project Instructions - document describing what is planned for an upcoming EX mission.
- Expedition Reports - document describing what actually occurred during an EX mission.
- Dive Summaries (ROV missions only) - document describing what occurred during an ROV deployment.

All planning documents, expedition summary reports, and scientific publications are published in the NOAA Central Library catalog.

4.6. Opportunistic Data

Since 2012, the EX has been a ship of opportunity for NASA's Maritime Aerosol Network (MAN). Ship personnel collect NASA Aerosol Data from Microtops II sun photometers. Information about the program can be found on this NASA web page. These data are archived with NASA and are accessible through NASA's AERONET. NCEI also links to these data within the various data discovery and access portals described in Section 6.

4.7. AUV Data

During the 2023 Field Season, EX is expected to have 3 technology demonstration missions utilizing 3 designated autonomous underwater vehicles (AUV). A complete list of capabilities and specifications for each AUV is located in Appendix F.

Instrumentation

One EX mission will deploy the man-portable Iver 3 AUV operated by Orca Maritime. The Iver 3 AUV is equipped with an EdgeTech 2205 sonar that simultaneously collects side scan data at 600KHz/1600KHz and multibeam bathymetry data on the 600 KHz frequency. The Iver 3 AUV can also tow a Marine Magnetics Explorer total field magnetometer as an optional attachment.

Two other EX missions will deploy the large AUVs Mola Mola and Eagle Ray. These AUVs will be operated by the University of Southern Mississippi (USM) during an Ocean Exploration Cooperative Institute project. The scientific payloads for Mola Mola are a Voyis Insight Micro color still camera and a laser-line bathymetry system. The scientific payloads for Eagle Ray are a Norbit WBMS multibeam echosounder (512 beams, typical 400kHz, depth resolution <10mm), a GeoAcoustics polarity-preserving chirp sub-bottom profiler (typical 3.5-12kHz), a SeaBird FastCAT CTD, and an Ocean Floor Geophysics magnetometer.

Data Management & Long-Term Data Archival

The management of AUV data will be a joint effort between NOAA Ocean Exploration, AUV operators, and NCEI. Existing data management and archival pipelines will be leveraged where possible. See the DMP section within individual Project Instructions for AUV data access and archive locations. Project Instructions for every EX mission are discoverable through the NOAA Central Library catalog.

5. Underwater Cultural Heritage (UCH) Data Responsibilities

Restricted data resulting from Underwater Cultural Heritage (UCH) sites are expected to be a part of some EX missions. Restricted data may be encountered with intention or unexpectedly. For example, in the course of acquiring or post-processing bathymetric data, features on the seafloor may be unexpectedly discovered which are of potential cultural or historical significance. These discoveries may include wrecks of ships or aircraft, the recognizable debris from wrecks, or other items which may appear anthropogenic in origin and have some associated cultural or historical significance. Data resulting from UCH require special consideration in data management which often results in the UCH site location information being restricted. This is done to protect culturally sensitive sites from activities that may alter or disturb the UCH.

If a potential UCH site is located, the real-time data transmission to shore is halted and the Expedition Coordinator will consult with NOAA Ocean Exploration's Marine Archaeologist, who will contact other relevant entities to notify them of the discovery and consult with them regarding the historical significance of the discovery. The Marine Archaeologist and the Expedition Coordinator will coordinate with the appropriate management authorities to discuss next steps and any data restrictions.

If the discovery is determined to be historically or culturally significant, the onboard data managers (GFOE and OMAO) will change the "cruise variables" to trigger a set of automated workflows that segregate data containing location information into special "Restricted" directories. These workflows have been developed over time by the GFOE data team and currently segregate all multibeam products, CTDs, XBTs, ASVPs, ROV products, georeferenced video and imagery, event logs, and SCS data. This protocol also halts the transmission of real-time location data delivery to shore-side servers, including the EX Live Operations Map (Section 6.1). The Expedition Coordinator will share the restricted folder data inventory with OER's Marine Archaeologist.

If it is determined that the discovery is not historically or culturally significant or it is determined that no harm will result by disclosing position information, no change to standard data management procedures is required.

The responsibility for labeling and tracking restricted data for EX rests with the Expedition Coordinator and NOAA Ocean Exploration's Science and Technology (S&T) Division. Led by NOAA Ocean Exploration's Marine Archaeologist, the S&T division maintains documentation to prevent the unnecessary public release of these restricted data in accordance with Section 304[2] of the National Historic Preservation Act of 1966 (NHPA) and the Sunken Military Craft Act.

[2] Although still referred to as Section 304 by practitioners, NHPA Section 304 was repealed by Public Law 113-287 and recodified at 54 U.S.C § 307103.

Restricted data are not included within the public data discovery and access portals. Contact archaeology.oceanexploration@noaa.gov or oer.info.mgmt@noaa.gov for restricted data requests.

6. Data Discovery & Access Portals

Data collected on EX missions are publicly accessible through a variety of webpages and map viewers. NCEI archives data by type so there are numerous NCEI data type specific map viewers and data access points. The NCEI NOAA Ocean Exploration Data Management Team has a suite of products which collate EX data collections despite the data being archived in different data type specific archives. These NOAA Ocean Exploration specific NCEI-managed data access points are described below.

6.1. Live Operations Map

The *Okeanos Explorer* Live Operations Map provides near-real-time information about the EX's current location and meteorological readings, the expedition ship track, and daily bathymetric products. The EX's current position, meteorological readings, and ship track are automatically updated every 15 minutes; whereas the daily bathymetric grids are automatically updated every 6-12 hours with provisional multibeam mosaics generated by shipboard personnel. Additionally, shipboard personnel maintain a live station log service which provides deployment information for non-ROV operations (e.g., CTD deployments, calibration sites, etc.). This map and all of the underlying GIS services are maintained by NCEI.

6.2. Video Portal

The NOAA Ocean Exploration Video Portal provides access to all archived, non-restricted NOAA Ocean Exploration videos. The web interface allows users to specify search parameters which query the video's metadata records. Users can then preview low-res video proxies, download low-res and high-res video, and access ROV dive summaries. Low-res videos are available for immediate download, while high-res videos require the user to place an order. High-res orders are typically fulfilled within 24 hours. This portal and all underlying metadata records are maintained by NCEI.

6.3. Data Atlas

The NOAA Ocean Exploration Data Atlas is an interactive map providing centralized access to a continuously-updated archive of EX data, information, and products. NCEI archives data types at varying rates so visit the Data Atlas often for new data releases and information updates related to the completion of data quality control measures; data archival; and the addition of related publications, lesson plans, and additional materials. This map and all of the underlying GIS services are maintained by NCEI. See Section 6.5 for more information on the GIS services.

6.4. Data Access Landing Pages

The *Okeanos Explorer* Data Access Landing Pages provide a centralized access point to all archived data. These pages contain the same data links found in the Data Atlas; however, the data are chronologically organized in a non-map format. Typically, these pages are not publicly available until many months post-mission. This is due to the fact that all required documents, data, and products must be received, processed, and archived by NCEI prior to the generation of these web pages. These pages are maintained by NCEI.

6.5. Geospatial Data Services

NCEI maintains a suite of geospatial data services for the EX, including: near-real-time and historical ship tracks (2D), multibeam survey polygons, ROV dive sites, ROV dive tracks (3D), ROV sample collection sites, and a station log. Note that many of these layers have been simplified for better web optimization. High-resolution bathymetry image services and tile layers are also supported. All of these geospatial data layers are hosted within Esri's ArcGIS Online and are available for download in a variety of non-proprietary formats. These cloud-based GIS services are publicly available and located on the ArcGIS Online group: NOAA Ocean Exploration Data (NCEI).

6.6. Documents & Publications

NOAA's Institutional Repository Ocean Exploration Program Collection web page provides centralized access to all accompanying expedition reports, dive summaries, and project documentation. This service is maintained by the NOAA Central Library in conjunction with NCEI.

Peer reviewed publications resulting from EX missions are cataloged and made available through the NOAA Ocean Exploration Bibliography. This service is also maintained by the NOAA Central Library in conjunction with NCEI.

6.7. Physical Sample Repositories

Biological samples of invertebrate organisms are archived in the Invertebrate Zoology Collections at the Smithsonian's National Museum of Natural History (SNMNH). See their Collections Access web page for information on how to access invertebrate samples.

Biological samples of fish are archived in the Division of Fishes of the Vertebrate Zoology Collections at the SNMNH. See their Collections Access web page for information on how to access fish samples.

Geological samples are archived in the Marine and Geology Repository at Oregon State University's NOAA Collection (NOAA Rocks). See their Request Samples web page for Information on how to access geological samples.

eDNA samples from collected water samples are archived in the SNMNH's Biorepository. See their Biorepository web page for information on how to access eDNA samples.

6.8. Other NCEI Data Access Points

NOAA Ocean Exploration data are also made available through NCEI's data type specific archive access portals, including:

- NCEI's Bathymetric Data Viewer
- NCEI's Water Column Sonar Data Viewer
- NCEI's Trackline Viewer
- NCEI's Marine Geophysical Data Archives Web Page
- NCEI's World Ocean Database
- NOAA's OneStop Dataset Search Page

7. Points of Contact

Operational questions should be directed to:

- NOAA Ocean Exploration's Expedition Coordinators
- EX.ExpeditionCoordinator@noaa.gov

Shipboard data management questions should be directed to:

- Global Foundation for Ocean Exploration (GFOE) Data Team
- data@tgfoe.org

Shoreside data management questions and data access inquiries should be directed to:

- National Centers For Environmental Information (NCEI) Data Management Team
- oer.info.mgmt@noaa.gov

Restricted data inquiries regarding UCH sites should be directed to:

- NOAA Ocean Exploration's Marine Archeologist
- archaeology.oceanexploration@noaa.gov

Appendices

Appendix A: 2023 Field Season EX Missions

See NOAA Ocean Explorations 2023 Field Season web page or "NOAA Ship *Okeanos Explorer* FY23 Field Season Instructions" for a more complete overview of planned missions, operations, and participating institutions.

- Shakedown + EXPRESS West Coast Exploration (EX2301): ROV + Mapping
- Seascape Alaska 1: Aleutians Deepwater Mapping (EX2302): Mapping + AUV Iver
- Seascape Alaska 2: Aleutians Deepwater Mapping (EX2303): Mapping Only
- Seascape Alaska 3: Aleutians ROV & Mapping (EX2304): ROV + Mapping
- Seascape Alaska 4: Gulf of Alaska Deepwater Mapping (EX2305): Mapping Only
- Seascape Alaska 5: Gulf of Alaska ROV Exploration & Mapping (EX2306): ROV + Mapping
- Seascape Alaska 6: Gulf of Alaska Transit Mapping (EX2307): Mapping
- EXPRESS: Exploration of Central California Coast (EX2308): USM AUV + Mapping
- EXPRESS: West Coast Exploration & Mapping (EX2309): USM AUV + Mapping

Appendix B: ExData Folder Structure

Data on the ExData Server (exdata.tgfoe.org/OkeanosCruises) follows a strict folder structure and file naming conventions. This standardization allows for automation and easier data management. The success of the data management strategy is highly-dependent upon the compliance of the onboard systems and personnel to ensure output files follow a defined folder organization and file naming convention. The date time format (yyyymmddThhmmssZ) follows the ISO8601 Standard.

The following describes the current folder structures and file naming conventions for FY23. *Note that this directory structure does not apply to the data once it's within NCEI's archives.*

OkeanosCruises
- >**EXyynn** (e.g., EX2301)
  - >**CTD**
    - >**asvp**
      - >**RESTRICTED**
    - >**CPCTD**
      - >**PROCESSED_DATA**
        - >**DiveSubfolders** (EXyynn_DIVE##_yyyymmdd)
        - >**ANCILLARY_FILES**
        - >**CNV_FILES**
        - >**PRESSURE_COMBINED_PLOTS**
        - >**TIME_COMBINED_PLOTS**
        - >**TIME_SINGLE_PLOTS**
        - CMD_LOG.TXT
          - >**RESTRICTED**
      - >**RESTRICTED**
    - >**ROVCTD**
      - >**PROCESSED_DATA**
        - >**DiveSubfolders** (EXyynn_DIVE##_yyyymmdd)
        - >**ANCILLARY_FILES**
        - >**CNV_FILES**
        - >**PRESSURE_COMBINED_PLOTS**
        - >**TIME_COMBINED_PLOTS**
        - >**TIME_SINGLE_PLOTS**
        - CMD_LOG.TXT
      - >**RESTRICTED**
    - >**SHIPCTD**
      - >**RESTRICTED**
    - >**XBT**
      - >**RESTRICTED**
    - README_QA.txt
  - >**EK60**
    - >**RESTRICTED**

>**Eventlogs**
>**Field_GSFs**
    >**RESTRICTED**
>**Imagery**
    >**DiveSubfolders** (EXyynn_DIVE##_yyyymmdd)
    >**TOPSIDE**
>**Multibeam**
    >**DailySubfolders** (EXyynn_MB_yyyymmdd_WGS{###}_###m)
    >**RESTRICTED**
    EXyynn_MB_DAILY_PRODUCTS_README_DATA.txt
>**Multibeam_Raw**
    >**RESTRICTED**
>**Products**
    >**HighlightImagery**
    >**HighlightVideo**
        >**Compressed**
        >**ProRes**
        >**ShotList**
        >**Web**
    >**ROV**
        >**DiveSubfolders** (EXyynn_DIVE##_yyyymmdd)
        >**RESTRICTED**
    >**ROVDiveSummaries**
>**Sample**
    >**DiveSubfolders** (EXyynn_DIVE##_yyyymmdd)
        >**Imagery**
            >**SampleSubfolders** (D##_##{B, W, G})
        >**Video**
            >**SampleSubfolders** (D##_##{B, W, G})
        >EXyynn_yyyymmdd_DAILY_SAMPLE_REPORT.pdf
        >EXYYnn_DIVE##_Sample_Products.txt
>**SBP**
    >**RESTRICTED**
>**SCSData**
    >**METOC**
    >**NAV**
    >**RESTRICTED**
        >**NAV**
        >**VEHICLES**
    >**VEHICLES**
>**Still_Cam_Imagery**
    >**DiveSubfolders** (EXyynn_DIVE##_yyyymmdd)
    >**Highlight**
    >**Original**

>**Unprocessed**
>**Video**
>**UPLOAD**
>**EDITORS_TOPSIDE**
>**PHOTOS**
>**VIDEOS**
README.txt
>**Video**
>**DiveSubfolders** (EXyynn_DIVE##_yyyymmdd)
>**Compressed**
>**ProRES**
>**TOPSIDE**
>**Audio**
>**ProRes**
EXyynn.manifest
EXyynn_yyyymmddThhmmssZ_warehouse1.hashdeep
EXyynn_restricted_files.txt
EXyynn_SCSData.md5deep.diff
EXyynn_shipboard_SCSData.md5deep
EXyynn_shore_SCSData.md5deep
ex_to_isc_comparison.txt
restricted_transition.log.csv

Appendix C: ExData Folder Descriptions & File Naming Conventions

CTD

This folder contains water column profiles made by different instruments during the expedition. It is divided into 5 subfolders: asvp, CPCTD, ROVCTD, SHIPCTD and XBT. Additionally, each subfolder contains a Restricted data folder for sensitive data.

CTD/asvp

This folder contains Automated Sound Velocity Profiles (ASVP) made by the mapping team. They are derived from files in the XBT folder or CTD files in CPCTD, ROVCTD or SHIPCTD folders. Every ASVP has the same name as the file used to create it except for the extension which changes to .asvp.

Files follow this filename conventions:

- EXyynn_{AXBT|CTD|SSM|XBT}###_yyyymmddThhmmssZ.asvp

CTD/CPCTD

This folder contains CTD casts from Seirios SBE 911 plus CTD. All raw files without any filtering or processing are placed in this folder. Any files that have been filtered or processed are organized in dive subfolders. If the device is restarted for any reason during the dive a number is appended to the end of the filename for all subsequent files to avoid overwriting data.

Header files: include software version, serial number, configuration, etc.

- EXyynn_DIVE##_yyyymmdd_CPCTD_{#}.hdr

Data files: hexadecimal raw data created by Seasave from a real-time data stream.

- EXyynn_DIVE##_yyyymmdd_CPCTD_{#}.hex

Instrument configuration files: contain the number, type and calibration coefficients.

- EXyynn_DIVE##_yyyymmdd_CPCTD_{#}.XMLCON

CTD/ROVCTD

This folder contains CTD casts from Deep Discoverer SBE 911 plus CTD. All raw files without any filtering or processing are organized in dive subfolders name . If the device is restarted for any reason during the dive a number is appended to the end of the filename for all subsequent files to avoid overwriting data.

Header files: include software version, serial number, configuration, etc.

- EXyynn_DIVE##_yyyymmdd_ROVCTD_{#}.hdr

Data files: hexadecimal raw data created by Seasave from a real-time data stream.

- EXyynn_DIVE##_yyyymmdd_ROVCTD_{#}.hex

Instrument configuration files: contain the number, type and calibration coefficients.

- EXyynn_DIVE##_yyyymmdd_ROVCTD_{#}.XMLCON

CTD/SHIPCTD

This folder contains CTD casts from the ships SBE 911 plus CTD. None of the files are processed or filtered in any way.

Header files: include software version, serial number, configuration, etc.

- EXyynn_CTD###_yyyymmddThhmmssZ.hdr

Data files: hexadecimal raw data created by Seasave from a real-time data stream.

- EXyynn_CTD###_yyyymmddThhmmssZ.hex

Instrument configuration files: contain the number, type and calibration coefficients.

- EXyynn_CTD###_yyyymmddThhmmssZ.xmlcon

Converted data files: created from hexadecimal files and contain the same data in a human-readable format.

- EXyynn_CTD###_yyyymmddThhmmssZ.cnv

CTD/XBT

eXpendable Bathythermograph (XBT) files are saved in this directory and they are also used to produce ASVP files.

- EXyynn_{A}XBT###_yyyymmddThhmmssZ.{txt}

EK60

This folder contains files produced by the hull-mounted single-beam EK60/EK80 sonars.

- EXyynn_EK60-Dyyyymmdd-Thhmmss.{raw|idx}

Eventlogs

During ROV dives, shipboard personnel communicate with shoreside scientists via a chatroom. These chatroom transcripts and the SeaTube annotations are saved to this folder.

Annotations name convention:

- EXyynn_DIVE##_ANNOTATIONS.csv

Transcripts name convention:

- EXyynn_EVT_yyyymmdd.txt

Field_GSFs

This folder contains preliminary GSF files from the EM304 multibeam system.

- ####_yyyymmdd_HHmmss_EXyynn_MB_EM304.gsf

Imagery

This folder is divided into dive subfolders - each ROV dive has its own correlating

subfolder.

Imagery/DiveSubfolders

After every dive, video editors go through all video footage and create “frame grabs” (i.e., still images) of interesting or scientifically significant subjects (e.g., black corals, peculiar animal behavior, etc.). There is always at least one image created per video file. Still images are also created around a physical sample collection event.

- EXyynn_IMG_yyyymmddThhmmssZ_{camera}_[descriptor].jpg
- EXyynn_IMG_yyyymmddThhmmssZ_D##_##{B|G|W}_##.jpg

Imagery/TOPSIDE

Video editors take images during operations during the entire expedition and place those in this folder.

- EXyynn_IMG_yyyymmdd_[descriptor].jpg

Multibeam

This directory contains the multibeam daily products created by the mapping team. Data is presented in various formats and divided with each day underway in a different subfolder. This folder also contains a Restricted data folder for sensitive data.

- EXyynn_MB_###m_WGS{###}_yyyymmdd.{kmz|sd|tif|xyz}
- EXyynn_MB_###m_WGS{###}_yyyymmdd_fp.tif

Multibeam_Raw

Files from the Kongsberg EM304 hull-mounted multibeam sonar are saved here. This folder also contains a Restricted data folder for sensitive data.

- ####_yyyymmdd_hhmmss_EXyynn_MB.{kmall|kmwcd}

Products

This folder contains subfolders for various video and imagery products representing the discovery highlights of what was observed during a particular cruise. Each subfolder contains subfolders for each subsequent ROV dive.

Products/HighlightImagery

A few images are selected and color corrected per dive as representative examples of that exploration for engagement and outreach purposes.

- EXyynn_IMG_yyyymmddThhmmssZ_{camera}_[descriptor]_CC.jpg
- EXyynn_IMG_yyyymmddThhmmssZ_D##_##{B|G|W}_##_CC.jpg

Products/HighlightVideo

At least one short highlight video is produced per dive for engagement and outreach purposes. Each video editor also creates a longer video with a theme that relates to the current expedition. These videos are encoded into three different video formats with each saved to a different subfolder.

Products/HighlightVideo/Compressed

This format is a lower resolution mp4 file with a bit rate of 1.5Mbps.

- EXyynn_VID_yyyymmdd_[DIVE##]_[descriptor]_Low.mp4

Products/HighlightVideo/ShotList

These are csv files containing a list of all media (videos and images) used in the creation of each highlight video.

- EXyynn_VID_yyyymmdd_[DIVE##]_[descriptor].csv

Products/HighlightVideo/Web

This is the lowest resolution format produced by the program. Files are mp4 with a bit rate of 8 Mbps.

- EXyynn_VID_yyyymmdd_[DIVE##]_[descriptor]_Web.mp4

Products/ROV

Files within this folder are divided in dive subfolders and contain navigation and vehicle information.

Summary file: contains timestamps and location for the start, bottom and end of dive. It also contains duration, time at bottom and maximum depth reach during the exploration.

- EXyynn_DIVE##.txt

Targets file: contains hypack targets in kml format.

- EXyynn_DIVE##_HypackTargets_converted.kml

Path file: contains the 2-D ROV trajectory in kml format.

- EXyynn_DIVE##_Path.kml

Sensor list file: contains serial number and model of sensors mounted on both ROVs in csv format.

- EXyynn_DIVE##_RovSensorList.csv

Track files: contain timestamped ROV position information during the dive in csv format.

- EXyynn_DIVE##_RovTrack1Hz.csv EXyynn_DIVE##_RovTrack.csv

Products/ROVDiveSummaries

Comprehensive dive summaries created by the expedition coordinator containing general information, participants, bathymetry, specimen imagery and collected sample's data.

- EXyynn_DIVE##_yyyymmdd_ROVDiveSummary_Final.docx

Sample

This directory contains all sample-related products created by the onboard sample data manager (SDM). The top-level folder is divided in dive subdirectories and also contains the samples database and files listing all sample imagery and video.

- EX_SODA_FYnn_EXyynn.accdb

- EXyynn_ImageFilesBySpecimen.csv
- EXyynn_VideoFilesBySpecimen.csv

Sample/Dive

This directory contains the imagery directory and the video directory as well as two reports of the daily sample and products reports.

- EXyynn_yyyymmdd_DAILY_SAMPLE_REPORT.pdf

Sample/Dive/Imagery

This directory is divided into specimen subfolders, which contain all wet-lab images taken by the SDM and symbolic links to the sample "frame grabs" taken by the ROV. A subfolder is created for every primary specimen. The descriptor after the date/time stamp is D##_##{B|G|W}_##, where the numbers refer to the dive, specimen collected and camera number respectively. Camera codes are described in Appendix D.

Primary Sample Naming Conventions:

- EXyynn_IMG_yyyymmddThhmmssZ_D##_##{B|G|W}_##.jpg
- EXyynn_IMG_yyyymmddThhmmssZ_SMPSTL_D##_##{B|G|W}_L##.cr2
- EXyynn_IMG_yyyymmddThhmmssZ_SMPWLF_D##_##{B|G|W}_L##.jpg
- EXyynn_IMG_yyyymmddThhmmssZ_MICRO_D##_##{B|G|W}_(M|A|S##)_M##.{cr2|JPG}

Associate Sample Naming Conventions:

- EXyynn_IMG_yyyymmddThhmmssZ_SMPSTL_D##_##{B|G|W}_A##{B|G}_L##.cr2
- EXyynn_IMG_yyyymmddThhmmssZ_SMPWLF_D##_##{B|G|W}_A##B|G}_L##.jpg
- EXyynn_IMG_yyyymmddThhmmssZ_MICRO_D##_##{B|G|W}_(M|A|S##)_M##.{cr2|JPG}

Sample/Dive/Video

This directory is divided into specimen subfolders, which contain symbolic links to the low-resolution videos recorded by the ROV. A subfolder is created for every primary specimen. The new descriptor after the date/time stamp is D##_##{B|G|W}_##, where the numbers refer to the dive, specimen collected and camera number respectively. Camera codes are described in Appendix D.

- EXyynn_VID_yyyymmddThhmmssZ_D##_##{B|G|W}_##_Low.mp4

SBP

Files created by the Knudsen hull-mounted sub-bottom profiling sonar are saved in this folder. This folder also contains a Restricted data folder for sensitive data. Data are synchronized to shore during expeditions.

- EXyynn_SBP_####_yyyy_###_####_###.{kea|keb}
- EXyynn_SBP_####_yyyy_###_####_#####_CHP3.5_FLT_###.sgy

SCSData

SCSData/METOC

These are files containing oceanographic and meteorological data from different ship sensors. Data is continuously recorded into csv files, which are split at midnight UTC.

SCSData/NAV

Navigational data from different ship sensors is continuously recorded into this directory. Files are split at midnight UTC and saved in csv format.

SCSData/VEHICLES

Data coming from multiple sensors onboard both ROVs is recorded into this directory. Files are split at midnight UTC and saved in csv format.

Still_Cam_Imagery

Still_Cam_Imagery/DiveSubfolders

Each still image captured by D2's Canon R3 camera has three versions: Highlight, Original, and Unprocessed.

Still_Cam_Imagery/DiveSubfolders/Highlight

This folder contains the artistically edited JPEGs. Images are edited in Adobe Lightroom and/or Photoshop.

- EXyynn_IMG_yyyymmddThhmmss.ssZ_ROVSTL_cc.jpg

Still_Cam_Imagery/DiveSubfolders/Original

This folder contains the unedited, original JPEGs, produced by the camera

- EXyynn_IMG_yyyymmddThhmmss.ssZ_ROVSTL.jpg

Still_Cam_Imagery/DiveSubfolders/Unprocessed

- This folder contains the unedited, original raw files for use in photo editing softwares.
- EXyynn_IMG_yyyymmddThhmmss.ssZ_ROVSTL.dng

Still_Cam_Imagery/DiveSubfolders/Video

This folder contains 4K resolution videos.

- EXyynn_VID_yyyymmddThhmmss.ssZ_ROVSTL.mp4

UPLOAD

These are various files related to the expedition that do not belong in any other directory.

There is no type, structure or name conventions set for these files. This folder is primarily used by shipboard personnel to transfer large files to shore.

Video

This directory contains all video footage recorded subsea by the ROVs. Files and organized into dive folders and further divided into format subfolders.

Video/DiveSubfolders

Video/DiveSubfolders/Compressed

This folder contains the low-resolution copy of the original footage. Videos are split into 5 minute files in mp4 format. Camera codes are in Appendix D.

- EXyynn_VID_yyyymmddThhmmssZ_{camera code}_[descriptor]_Low.mp4
- EXyynn_VID_yyyymmddThhmmssZ_D##_##{B|G|W}_##_Low.mp4

Video/DiveSubfolders/ProRes

This folder contains the high-resolution video files.

- EXyynn_VID_yyyymmddThhmmssZ_{camera code}_[descriptor].mov
- EXyynn_VID_yyyymmddThhmmssZ_D##_##{B|G|W}_##.mov

Video/TOPSIDE

This directory is divided into Video Imagery and Audio subfolders. Video editors place here files that have been used for highlights but are not part of the official expedition products in any other folders.

- EXyynn_VID_yyyymmdd_[descriptor].{wav|WAV}
- EXyynn_VID_yyyymmdd_[descriptor].{png|PNG|jpg|JPG|jpeg|JPEG}
- EXyynn_VID_yyyymmdd_[descriptor].{mov|MOV|mp4|MP4}

Appendix D: Camera Codes for File Naming Conventions

NOTE: Where camera codes have a parenthetical number, the number should be considered a condensed form of the code. Condensed codes are only used with physical sample related video (and derivative still images) to accommodate filename length restrictions of the video recording system.

Camera Placement	Camera Description	Camera Code
ROV	Primary HD Camera (Zeus+)	ROVHD (01)
ROV	Secondary Camera (Mini-Zeus)	ROVHD2 (02)
ROV	Secondary HD camera facing low forward and to port to view manipulator arm of ROV (HDMSC 4150)	PTMAN (04)
ROV	Secondary HD camera facing low forward and to starboard to view manipulator arm of ROV (HDMSC 4150)	SBMAN (05)
ROV	Still / Video camera mounted above ROVHD (Canon R3)	ROVSTL
ROV	Pilot PanTiltZoom camera, provides frontal view of ROV (Titan)	ROVPLT (03)
ROV	View forward from aft port side, provides view of port side of vehicle (HDMSC 4150)	ROVPT (06)
ROV	View forward from aft starboard side, provides view of starboard side of vehicle (HDMSC 4150)	ROVSB (07)
ROV	View aft from near tether (HDMSC 4150)	ROVAFT (08)
ROV	View of the suction sampler jar (HDMSC 4150)	ROVJAR (11)
ROV	View from port manipulator arm (HDMSC 4150)	ROVAUX1
ROV	View of Doppler Velocity Log / Suction hose (HDMSC 4150)	ROVAUX2
Camera Platform	Primary HD Camera (Zeus+)	CPHD
Camera Platform	Rear facing camera with view of umbilical (Nova)	CPUMB
Camera Platform	Pilot camera facing forward (Aurora)	CPPLT
Camera Platform	Camera with downward facing view (Cyclops)	CPSDWN
Camera Platform	Camera with compensator gauge view (IT1000)	CPCMP
Starboard Side of Fantail	Starboard HD Video Camera	SBROBO

Post Side of Fantail	Port HD Video Camera	PTROBO
Front of ROV/Mapping Control Room	Control Room Front HD Video Camera	CRROBO
Back of ROV/Mapping Control Room	Control Room Rear HD Video Camera	CR2ROBO
Dry Lab	Dry Lab HD Video Camera	DLROBO
Portable	HD video from the ship Sony EX3 handheld camera	EX3
Computer Feed	Pulled from DVI-HDSDI scan converters	DVI
Multi-Display	HD Video	MULTI
Bridge Mast	Closed-Circuit Television Camera	MASTCCTV
Port Bridge Wing	Closed-Circuit Television Camera	PTBRDGCCTV
Starboard Bridge Wing	Closed-Circuit Television Camera	SBBRDGCCTV
Starboard Working Deck (CTD Launch)	Closed-Circuit Television Camera	SBDECKCCTV
Aft Deck	Closed-Circuit Television Camera	AFTDECKCCTV
ROV/Mapping Control Room	Closed-Circuit Television Camera	CRCCTV
Generator Room	Closed-Circuit Television Camera	GENCCTV
Upper Motor Room	Closed-Circuit Television Camera	MOTORCCTV
Winch Room Looking at Traction Winch and Storage Drum	Closed-Circuit Television Camera	WINCHCCTV
Various	Composite of First 9 CCTVs	3X3CCTV
Fantail Looking at Transom	Closed-Circuit Television Camera	WIRECCTV
Winch Room Looking	Closed-Circuit Television Camera	SHEAVECCTV

at Traction Winch Sheave		
ROV	Primary HD Camera (Zeus+)	ROVHD (01)
ROV	Secondary Camera (Mini-Zeus)	ROVHD2 (02)
ROV	Secondary HD camera facing low forward and to port to view manipulator arm of ROV (HDMSC 4150)	PTMAN (04)
ROV	Secondary HD camera facing low forward and to starboard to view manipulator arm of ROV (HDMSC 4150)	SBMAN (05)
ROV	Still / Video camera mounted above ROVHD (Canon R3)	ROVSTL

Appendix E: ROV & AUV Specifications

ROV *Deep Discoverer*

Specifications:

- Size (length, width, height): 3.2 meters, 2.0 meters, 2.6 meters
- Weight: 4.400 kilograms
- Ascent / Descent Rate: 30 meters / minute
- Max. Operating Depth: 6,000 meters
- Propulsion : 6 thrusters, 7.5 HP electric

Standard Sensors:

- SeaBird SBE-911 Plus CTD (conductivity, temperature, and depth system) with dissolved oxygen, turbidity, and oxidation reduction potential sensors
- Tritech SeaKing DFS Dual frequency sector scan sonar, 200-meter range, 325 and 725 kilohertz
- Woods Hole Oceanographic Institution high-temperature probe, up to 400°C
- BlueView M900/2250 dual frequency multibeam sonar, 100-meter range, 15 hertz update rate, 130° field of view

Lighting and Imaging:

- 28 Deep Sea Power and Light LED lamps (8 on swing arms)
- 3 high-definition Insite Pacific video cameras:
    - Zeus Plus (tilt/18x optical zoom), its primary ROV camera, labeled ROVHD;
    - Mini Zeus (pan/tilt); and
    - Titan Plus (pan/tilt/zoom)
- 6 high-definition Deep Sea Power and Light HD Multi SeaCam wide-angle video cameras
- 1 custom packaged Canon R3 still camera with an RF24mm macro lens and high-definition video capability

Navigation:

- iXSea Phins fiber optical/inertial navigation system (0.05° heading accuracy)
- RDI Workhorse Navigator 600 kilohertz Doppler velocity log (DVL)
- Control software supports high-resolution navigation using DVL bottom lock and Phins heading reference with an accuracy of 0.1% of distance traveled
- TrackLink 10000HA ultra-short baseline (USBL) acoustic tracking system with positioning accuracy of 0.25° (26 meters at 6,000 meters depth)
- Tritech PA500 altimeter, 0.3-50-meter range
- Paroscientific 8B7000-I depth sensor
- Lord MicroStrain 3DM inertial motion unit (IMU)

Sampling:

- 1 hydraulic force feedback seven-function Kraft Predator manipulator arm
- 1 hydraulic seven-function Schilling Orion manipulator arm

- 4 bio boxes
- 2 rock boxes, 1 with a lid
- 1 rotary suction sampler with 5 2.7-liter sample jars
- 5 1.7-liter individually triggered Niskin bottles
- ~10 kilograms of payload available for samples

Camera Platform *Seirios*

Specifications:

- Size (length, width, height): 3.3 meters, 1.1 meters, 1.2 meters
- Weight: 1,830 kilograms
- Ascent / Descent Rate: 30 meters / minute
- Max. Operating Depth: 6,000 meters
- Propulsion: 6 thrusters, 7.5 HP electric

Standard Sensors:

- SeaBird SBE-911 Plus CTD (conductivity, temperature, and depth system) with dissolved oxygen, turbidity, and oxidation reduction potential sensors
- Tritech SeaKing DFS Dual frequency sector scan sonar, 200-meter range, 325 and 725 kilohertz

Lighting and Imaging:

- 18 LED lamps
- 1 high-definition Insite Pacific Zeus Plus video camera with tilt capability, its primary camera, labeled CPHD
- 3 standard-definition Insite Pacific video cameras: Titan (pan/tilt/zoom), Aurora, Nova
- 1 standard-definition Insite Pacific Cyclops wide-angle video camera
- 1 standard-definition Deep Sea Power and Light Super Wide-I SeaCam

Navigation:

- TrackLink 10000HA USBL acoustic tracking system with positioning accuracy of 0.25° (26 meters at 6,000 meters depth)
- Tritech PA200 altimeter, 1-100-meter range
- Paroscientific 8B7000-I depth sensor
- Lord MicroStrain 3DM inertial motion unit (IMU)

Iver 3 AUV[3]

Specifications:

- Maximum Operating Depth: 200 meters
- Diameter: 5.8 inches (15cm)
- Length: 86 inches (218cm)
- In-Air Weight: 85lbs (39kg)
- Speed: 2-3 knots
- DVL bottom lock: 4.25 hours at 2.5 knots
- Estimated endurance: 4 hours (sonar survey)
  6 hours (water quality survey)

Navigation:

INS: iXBlue PHINS C3 fiber-optic gyro
DVL: Teledyne RDI Explorer (600hkz)
Depth Sensor: Keller PAA-30X / 30 Bar
GPS: WASS GPS
Object Avoidance: Imagenex Echosounder

Communications:

- Acoustic Modem: Teledyne Benthos
- Radio: 2.4 GHz telemetry radio control/communications
- Iridium: Tracking/ status updates, basic commands
- WiFi: Remote access
- Ethernet: GigE Ethernet wet connect

Sensors:

- Side Scan Sonar: EdgeTech 2205 600/1600 kHz
- Interferometric Bathymetry: EdgeTech 2205 600 kHz
- Sound Velocity Sensor: AML
- 4 Port MultiParameter Sonde: YSI EXO1
  - fDOM, DO, CT, Total Algae

Power:

- Lithium Ion Batteries: 780 Watt hours swappable battery section

[3] Information pulled from: https://www.orcamaritime.com/auv-survey on 14 September 2023.

Mola Mola Photo Survey AUV[4]

Specifications:

- Max. depth: 2000 m
- Size: 2 m length, 1.5m height
- Mass: 225 kg
- Endurance: up to 8 hours
- Typical survey parameters: 3 m altitude, 1.7 m line spacing, 0.20 m/s
- Launch and recovery: crane lift with quick-release and recovery hooks

Scientific payload:

- Voyis Insight Micro, consisting of a color still camera
- Fore and aft LED arrays, and a
- Laser-line bathymetry system

Navigation:

- IXblue Phins III (inertial navigation system),
- Teledyne RDI 1.2 MHz DVL,
- Masterclock combined GNSS receiver and time server,
- Paroscientific depth sensor,
- Tritech forward-look-ing altimeter

Maneuvering:

- Three magnetically-coupled thrusters,
- electromagnet-operated descent weight system,
- passive stability in pitch and roll for uniformity of optical data

Communication/Tracking:

- Surface
    - Ubiquiti 2.4 GHz ethernet radio,
    - Xeos combined Iridium tracking, and
    - Strobe beacon
- Submerged
    - Sonardyne AvTrak 6 combined USBL tracking transponder and acoustic modem

Shipboard equipment:

- Vehicle operation and mission management computers,
- 1U-sized charger,
- cradle for deck storage and maintenance,
- Sonardyne Ranger 2 transceiver on pole or hull-mount for comms and tracking

[4] Information pulled from: https://www.usm.edu/hydrographic-science-research-center/2021molamolaflyer.pdf on 14 September 2023.

Safety:

- Self-powered tracking hardware, Terrain/obstacle avoidance system

Power:

- Kraken SeaPower 50V52 pressure tolerant battery - 2.6 kWh at 52 V (nominal)

Eagle Ray AUV[5]

Specifications:

- Max. depth: 2200 m
- Size: 5 m length, 0.7m diameter
- Mass: 900 kg
- Endurance: up to 30 hours, 180 km
- Typical survey parameters: 15 to 50 m altitude,1.75 m/s speed
- Launch and recovery: articulated stern ramp with rack and pinion drive and lifted by vessel's A-Frame, crane lift lugs, pop-off recovery float

Scientific payload:

- Norbit WBMS multibeam echosounder (512 beams, typical 400kHz, depth resolution <10mm),
- GeoAcoustics polarity-preserving chirp sub-bottom profiler (typical 3.5-12kHz),
- SeaBird FastCAT CTD,
- Ocean Floor Geophysics magnetometer,
- wet and dry space for additional payloads

Navigation:

- IXblue Phins C7 inertial navigation system,
- Nortek 500 kHz DVL,
- Masterclock GNSS receiver and time server,
- Paroscientific depth sensor,
- Kongsberg forward-looking altimeter

Maneuvering:

- Single thruster, fore planes, and aft planes, allowing rapid pitched transit to survey altitude and stable heave-mode altitude-keeping while on survey

Communication/Tracking:

- On surface:
    - Ubiquiti 2.4 GHz ethernet radio,
    - Iridium satellite modem,
    - Xeos combined Iridium tracking, and
    - Strobe beacon
- Submerged:
    - Sonardyne AvTrak 6 combined USBL tracking transponder and acoustic modem

Shipboard equipment:

- Computer rack and multiple monitors for vehicle operation and mission management,
- deck-mounted launch and recovery system,

[5] Information pulled from: https://www.usm.edu/hydrographic-science-research-center/2021eaglerayflyer.pdf on 14 September 2023.

- optional 20’ maintenance and charging container,
- Sonardyne Ranger 2 transceiver on pole or hull-mount for comms and tracking

Safety:

- Self-powered tracking hardware,
- ISE bottom avoidance routine,
- ISE fault response logic, and
- emergency drop weight

Power:

- 30 kWh Li-ion from 18 Onyx 48V batteries modules within the pressure housing