doi: 10.25923/bamn-9q27

Ocean Exploration and Research

Cruise Report: EX-10-04
INDEX SATAL 2010: Indonesia-USA Joint Deep-Sea Exploration (ROV/Mapping)

Sangihe Talaud Region, Indonesia

Leg 1: Guam, USA, to Bitung, Indonesia
(8, June, 2010 - 20, June, 2010)
Leg 2: Bitung, Indonesia, to Bitung, Indonesia
(23, June, 2010 - 14, July, 2010)
Leg 3: Bitung, Indonesia, to Bitung, Indonesia
(22, July, 2010 - 7, August, 2010)
Leg 4: Bitung, Indonesia, to Guam, USA
(14, August, 2010 - 19 August, 2010)

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June 26, 2021

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Abstract

The *INDEX-SATAL 2010* expedition was the maiden voyage of NOAA Ship *Okeanos Explorer*, which worked with the Indonesian research vessel (R/V) *Baruna Jaya IV.* U.S. and Indonesian scientists worked side-by-side on both ships as well as in shore-based Exploration Command Centers (ECCs) in Jakarta, Indonesia and Seattle, WA, where they received information in real time via satellite and high-speed Internet2 pathways, including high-definition (HD) video of the seafloor from the *Okeanos Explorer's* remotely operated vehicles (ROVs). The expedition consisted of four legs, with the *Okeanos Explorer* operating solo on the first and fourth legs, and both ships operating simultaneously—but in different areas—during the second and third legs. The expedition explored an area known as SATAL, a contraction of Sangihe and Talaud, two island chains stretching north of Sulawesi toward the Philippines. The joint science team mapped and explored Kawio Barat, an active undersea volcano that rises nearly 3,650 m (12,000 feet) from the seafloor. This expedition revealed a high marine diversity in the area extending into the deep ocean. International collaboration was highlighted by the inclusion of both American and Indonesian scientists on each ship, establishment and use of an ECC in Jakarta, and the complementary scientific work of each ship. The *Okeanos Explorer* mapped the deep ocean floor and water column, collecting oceanographic data and collecting HD video using an ROV, a capability the *Baruna Jaya IV* does not have. The *Baruna Jaya IV* mapped the seafloor in different locations and collected biological and inorganic samples, a capability the *Okeanos Explorer* did not have during the expedition.

The expedition, through the involvement of Indonesian and U.S. scientists, contributed to the Coral Triangle Initiative (http://www.coraltriangleinitiative.org, last accessed Oct. 2020), a partnership of six Southeast Asian countries whose waters cover a triangular-shaped area where the Indian and Pacific Oceans meet. The joint expedition was a powerful demonstration of this commitment, sharing knowledge in real time with scientists in Seattle and Jakarta, with students in their classrooms, and with the world in other venues and online.

This report can be cited as follows:
Potter, J., Kelley, E., Malik, M. and Lobecker, E. (2021). Cruise EX-10-04, 2010 INDEX SATAL 2010: Indonesia-USA Deep-Sea Exploration. Office of Ocean Exploration and Research, Office of Ocean Exploration and Research, Office of Oceanic and Atmospheric Research, NOAA, Silver Spring, MD 20910. OER Expedition Rep. 10-04. https://doi.org/10.25923/bamn-9q27

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Acknowledgements:

The dedication and efforts of the crews of NOAA Ship *Okeanos Explorer* and R/V *Baruna Jaya IV* were greatly appreciated, and made *INDEX-SATAL 2010* possible.

INDEX-SATAL 2010 mission partners included the NOAA Office of Ocean Exploration and Research (OER), Indonesia Ministry of Marine Affairs and Fisheries (BRKP-DKP), Indonesia Agency for the Assessment and Application of Technology (BPPT), Bandung Institute of Technology (ITB), U.S. Embassy Jakarta, The Exploratorium, and SeaWorld Indonesia. The Indonesian National Military (TNI) provided necessary security during the expedition. The Indonesia-U.S. Ocean Exploration Steering Committee efforts are greatly appreciated in helping to guide the development of the *INDEX-SATAL 2010* expedition.

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Patricia Fryer (University of Hawai'i [UH])
Larry Mayer (University of New Hampshire [UNH])
James Holden (University of Massachusetts at Amherst [UMass])
Timothy Shank (Woods Hole Oceanographic Institution [WHOI])
Verena Tunnicliffe (University of Victoria [UVic])
Nathan Buck (University of Washington [UW]/Joint Institute for the Study of the Atmosphere and Ocean [JISAO])

We also acknowledge Craig Russell, Steve Hammond, David McKinnie, and Susan Gottfried for their help with compiling this report.

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1. Introduction

By leading national and collaborative international efforts to explore the ocean and make ocean exploration more accessible, the NOAA Office of Ocean Exploration and Research (OER) is filling gaps in basic understanding of deep waters and the seafloor, providing deep-ocean data, information, and awareness. Ocean exploration is an interdisciplinary approach for assessing and investigating the physical, chemical, and biological characteristics of the ocean floor, the ocean itself, and the diversity of life forms that inhabit the marine environment. Ocean exploration is intended to yield a body of knowledge that may result in immediate benefit or may inform research hypotheses that result in new scientific understanding in the future. From mapping and characterizing previously unseen seafloor to collecting and disseminating data and information about deep waters and the seafloor—and the resources they hold—this work establishes a foundation of information and fills data gaps.

Using the latest tools and technology, OER explores unknown areas of the deep ocean. NOAA Ship *Okeanos Explorer* is one such tool. Working in close collaboration with government agencies, academic institutions, and other partners, OER conducts deep-sea exploration expeditions using the advanced technologies on *Okeanos Explorer*, mapping and characterizing areas of the ocean that have not yet been explored.

All data collected during *Okeanos Explorer* expeditions adhere to federal open-access data standards and are publicly available shortly after an expedition ends. This ensures the delivery of reliable scientific data needed to identify, understand, and manage key elements of the ocean environment.

Exploring, mapping, and characterizing the seafloor are necessary for a systematic and efficient approach to advancing the development of ocean resources, promoting the protection of the marine environment, and building a better appreciation of the value and importance of the ocean in our everyday lives. As the only U.S. federal program dedicated to ocean exploration, OER is uniquely situated to lead partners in delivering critical deep-ocean information to managers, decision makers, scientists, and the public—leveraging federal investments to meet national priorities.

2. Project Background

INDEX-SATAL 2010 (EX-10-04) was a joint ocean exploration expedition between NOAA Ship *Okeanos Explorer* and the Indonesian research vessel (R/V) *Baruna Jaya IV*. The expedition symbolized plans for a long-term commitment to the partnership between NOAA and representative Indonesian scientific ministries and agencies. For the 2010 expedition, the operations focused on the Sangihe Talaud (SATAL) region, which was proposed by Indonesian scientists as a priority area for ocean exploration (**Figure 1**). The Co-Principal Investigators anticipated that the Indonesian-U.S. Ocean Exploration Partnership would reveal new—and perhaps unique—discoveries, including but not limited to:

1. New ecosystems associated with seamounts, spreading centers, and the deep ocean (e.g., trenches) that are often centers for biologically-diverse communities of fishes and invertebrates (including corals);

2. Areas of volcanic and hydrothermal vent activity where biologically-unique communities typically are found in association with widely varying ambient water temperatures and extreme chemical environments; and,

3. Insights into ocean acidification processes, as well as the budgets and cycles of the deep ocean and volcanically-derived gases—such as carbon dioxide—that may have a role in climate and ecosystem variability.

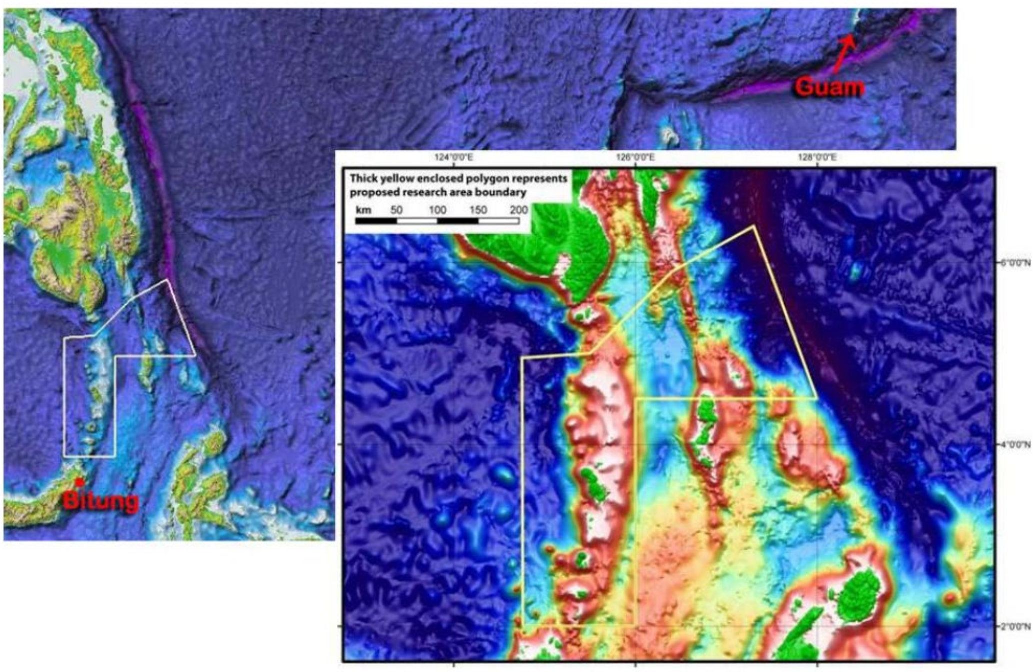

Figure 1. Overview of the *INDEX-SATAL 2010* exploration area.

2.1 Objectives for EX-10-04: *INDEX-SATAL 2010*

The primary science objectives for the joint Indonesia-U.S. 2010 exploration expedition included:

1. Locating sites of interest for exploration (e.g. deep-sea hydrothermal vents, coral reefs, cold seeps, and fish habitats);

2. Conducting geological, geophysical, biogeographical, and biodiversity assessments of these sites;

3. Mapping plume distributions (to increase the potential for discovering any near- and/or far-field biological consequences of dissolved or particulate chemical plume advection);
4. Initiating characterization of ecosystem relationships to both regional and local geological settings (including biological/habitat relationships) in the regions explored; and
5. Bathymetric mapping to reveal insights into active and historical submarine volcanic processes, local and regional current flow, and tectonic and structural processes that may include tsunamigenic risk.

The Indonesian partners agreed to provide the *Baruna Jaya IV* for approximately 28 days during the summer of 2010. The U.S. partners agreed to transit the *Okeanos Explorer* from Hawaiʻi to Indonesia and provide approximately 45 days of total time in Indonesian waters. The U.S. partners also agreed to build an Exploration Command Center (ECC) in Jakarta.

Based on shipboard capabilities of NOAA Ship *Okeanos Explorer* and R/V *Baruna Jaya IV*, the following data collection goals for the regions of interest were identified:

1. Acquisition of large-scale bathymetric coverage of the areas of interest using multibeam systems (*Baruna Jaya IV* and *Okeanos Explorer*);
2. Location of physical or chemical plumes from active volcanic and/or hydrothermal sites using the CTD/rosette systems (*Baruna Jaya IV* and *Okeanos Explorer*);
3. Collection of representative biota using fisheries equipment (*Baruna Jaya IV*);
4. Optical imaging of identified targets of interest to achieve geological and biological objectives using the *Okeanos Explorer*'s dual-bodied *Little Hercules* remotely operated vehicle (ROV) system;
5. Collection of bathymetric data for selected, relatively shallow-water areas using the *Baruna Jaya IV*'s multibeam system; and
6. Cataloging habitat types and biota along continuous deep-to-shallow water profiles in selected areas.

2.2 Programmatic Objectives

Mapping and ROV and Operations

Mapping objectives during each *Okeanos Explorer* cruise are to collect high-resolution acoustic data. At the time of the expedition, data were collected from the EM 302 multibeam. Mapping data were acquired during transits (when permissible), as well as on specific targets identified by the science team. Data from these systems were processed as quickly as possible in order to generate daily mapping products that supported ROV operations.

ROV objectives were to obtain high-quality video and sensor data on exploration targets to achieve the science objectives. This most often involved surveying benthic habitats and features in priority areas (e.g., deep corals and related benthic ecosystems, canyons, and seamounts). Benthic surveys were not only used to characterize the habitats in each target area, but also to ground truth the acoustic data with visual data (i.e., video). At the time of expedition, no sampling capability was available and no samples were taken.

Telepresence

Telepresence objectives were to provide real-time, high-quality video during ROV dives to shoreside scientists, managers and ECC visitors. Visitors to the Jakarta ECC passively watched the dives, while scientists, managers and students actively participated by watching the live video and communicating via teleconference and/or instant messaging. Telepresence was used to help achieve the science objectives by extending the science team well beyond those actually onboard the ship.

Data Management

Data management objectives were to collect, process, distribute, and archive cruise data as quickly and efficiently as possible. Effective data management provided a foundation of publicly-accessible information products to spur further exploration, research, and management activities; it also stimulated interest in the deep-sea environment and the excitement of exploration.

Education and Outreach

Education and outreach objectives included the engagement of the general public in ocean exploration through the Ocean Explorer website, both during and after each cruise. Web content included topical essays written before the cruise, daily updates, mission logs, highlight videos, still imagery, and mapping products—all of which are posted on the OER website: (https://oceanexplorer.noaa.gov/okeanos/explorations/10index/welcome.html, last accessed Dec. 2020). Educational materials, including grades 5-12 lesson plans, were also developed around the expedition and can be found at: https://oceanexplorer.noaa.gov/okeanos/explorations/10index/background/edu/edu.html (last accessed Dec. 2020). Educational experiences were also achieved through school tours to ECCs during live broadcasts. Critical webpages during the expedition were also made available in the Indonesian language.

3. Participants

At-sea personnel for EX-10-04 included the expedition coordinator, mapping specialists, ROV engineers, video engineers, data specialists, and onboard scientists. Shore-based science team members participated from remote ECCs and from their home locations via telepresence technology. Lists of these participants are provided in **Tables 1** and **2** below.

Table 1. NOAA Ship *Okeanos Explorer* onboard mission team personnel during EX-10-04.

		Leg1	Leg2	Leg3	Leg4
#	Role	Name	Name	Name	Name
1	Expedition Coordinator	Jeremy Potter	Jeremy Potter	Kelley Elliott	Elizabeth (Meme) Lobecker
2	Indonesian Science Lead	Michael Purwoadi	Xerandy	Ranier Arief Troa	
3	U.S. Science Liaison		John Sherrin	Santiago Herrera	
4	Indonesian TNI Official		Major Zayadi Muddan	Major Dian Adrianto	
5	Mapping Team Leader	Mashkoor Malik	Mashkoor Malik	Meme Lobecker	
7	Mapping Watchstander/ ROV Navigator	Lillian Stuart	Tom Kok	Tom Kok	Shannon Hoy
8	Mapping Watchstander/ ROV Navigator	Tom Kok	Karl McLetchie	Karl McLetchie	Elaine Stuart
9	Mapping Watchstander/ ROV Navigator	Karl McLetchie	Joel DeMello	Joel DeMello	
10	ROV Team Coordinator		Dave Lovalvo	Dave Lovalvo	
11	ROV Pilot 1		Dave Wright	Dave Wright	
12	ROV Pilot 2		Randy Pricket	Tom Orvosh	
13	ROV Pilot 3		Eric Prechtl	Craig Dawe	
14	ROV Co Pilot 1			Jon Mefford	
15	ROV Co Pilot 2		Joe Biscotti	Christopher Loo	
16	ROV Co Pilot 3		Brian Bingham	Vincent Howard	
17	ROV Video 1	Roland Brian	Tom Pierce	Roland Brian	
18	ROV Video 2		Roland Brian	Randy Visser	
19	Telepresence Lead	Webb Pinner	Webb Pinner	Webb Pinner	
20	Video/Telepresence Technician		Doug Jongeward	Brian Brinkman	
21	Additional Support Personnel	Nathan Buck Megan Nadeau Tom Pierce Joel DeMello			

Table 2. Shore-based science team participants for EX-10-04.

Personnel in ECCs during EX-10-04 Leg 1

Name	Affiliation	Role	Location
Steve Hammond	OER	U.S. Chief Scientist	Jakarta, Indonesia
Sugiarta Wiransantosa	BRKP	Indonesia Chief Scientist	Jakarta, Indonesia
John McDonough	OER	OER Deputy Director	Jakarta, Indonesia
David McKinnie	OAR	U.S./Indonesia Liaison	Jakarta, Indonesia
Ed Baker	PMEL	U.S. Scientist	PMEL—Seattle, WA
David Butterfield	PMEL	U.S. Scientist	PMEL—Seattle, WA
Sharon Walker	PMEL	US Scientist	PMEL—Seattle, WA
Joe Resing	PMEL	US Scientist	PMEL—Seattle, WA
Craig Russell	OER	OER Mission support	PMEL—Seattle, WA
Doug Jongeward	PMEL	ECC Technical Support	PMEL—Seattle, WA
Catalina Martinez	OER	OER Mission support	Inner Space Center (ISC)—Narragansett, RI
Elizabeth (Meme) Lobecker	OER	OER Mission support	UNH—Durham, NH

Personnel in ECCs during EX-10-04 Leg 2

Name	Affiliation	Role	Location
Steve Hammond	OER	U.S. Chief Scientist	Jakarta, Indonesia
Sugiarta Wiransantosa	BRKP	Indonesia Chief Scientist	Jakarta, Indonesia
Jim Holden	UMass	U.S. Scientist/Science Lead	Jakarta, Indonesia
David McKinnie	OAR	U.S./Indonesia Liaison	Jakarta, Indonesia
Patty Fryer	UH	U.S. Scientist	Jakarta, Indonesia
Catalina Martinez	OER	OER Mission Support	ISC—Narragansett, RI
Verena Tunnicliffe	UVic	Canadian Scientist	Victoria, BC
Ed Baker	PMEL	U.S. Scientist	Seattle, WA
Dave Butterfield	PMEL	U.S. Scientist/Science co-Lead	Seattle, WA
Jennifer Lin	UMass	U.S. Scientist	Seattle, WA
Cherisse du Preez	UVic	Canadian Scientist	Seattle, WA
Craig Russell	OER	U.S./Indonesia Liaison	Seattle, WA
Kelley Elliott	OER	Web Coordinator/ Operations Support	Seattle, WA
Ridge Liepins	PMEL	Telepresence Technician	Seattle, WA
Kristine Kosinksi	UH	U.S. Scientist	Seattle, WA
Tim Shank	WHOI	U.S. Scientist	Woods Hole, MA
Santiago Herrera	WHOI	U.S. Scientist	Woods Hole, MA
Eleanor Bors	WHOI	U.S. Scientist	Seattle, WA; Woods Hole, MA
Catriona Munro	WHOI	U.S. Scientist	Woods Hole, MA

Jill McDermott	WHOI	U.S. Scientist	Woods Hole, MA

Personnel in ECCs during EX-10-04 Leg 3

Name	Affiliation	Role	Location
Steve Hammond	OER	U.S. Chief Scientist	Jakarta, Indonesia
Sugiarta Wiransantosa	BRKP	Indonesia Chief Scientist	Jakarta, Indonesia
Tim Shank	WHOI	U.S. Scientist/ Science Lead	Jakarta, Indonesia
David McKinnie	OAR	U.S./Indonesia Liaison	Jakarta, Indonesia
Jeremy Potter	OER	U.S./Indonesia Liaison	Jakarta, Indonesia
Catalina Martinez	OAR	OER Mission Support	ISC—Narragansett, RI
Craig Russell	OER	U.S./Indonesia Liaison	Jakarta, Indonesia
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Marjolaine Matabos	UVic	Canadian Scientist	Victoria, BC
Dustin Schomagel	UVic	Canadian Scientist	Victoria, BC
John Sherrin	UVic	Canadian Scientist	Victoria, BC
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Elizabeth Sibert	WHOI	U.S. Scientist	Woods Hole, MA
Eleanor Bors	WHOI	U.S. Scientist	Seattle, WA
David Butterfield	PMEL	U.S. Scientist	Seattle, WA
Julie Huber	Marine Biological Laboratory	U.S. Scientist	Seattle, WA
Ridge Liepins	PMEL	Telepresence Technician	Seattle, WA
Jim Holden	UMass	U.S. Scientist	Amherst, MA
Jennifer Lin	UMass	U.S. Scientist	Amherst, MA
Yusuf Surachman Djajadihardja	BPPT	Indonesian Scientist	Seattle, WA
Tryono		Indonesian Scientist	Seattle, WA

4. Methods

To accomplish its objectives, EX-10-04 used:

- NOAA Ship *Okeanos Explorer* and R/V *Baruna Jaya IV*.
- Dual-bodied ROV system (ROVs *Little Hercules* and *a camera platform*) to conduct daytime seafloor and water column surveys.
- Sonar systems (Kongsberg EM 302 multibeam sonar and Knudsen 3260 sub-bottom profiler) to conduct mapping operations at night and when the ROVs were on deck.
- A high-bandwidth satellite connection to provide real-time ship-to-shore communications (telepresence).

All environmental data collected by NOAA must be covered by a data management plan to ensure they are archived and publicly accessible. The data management plan for EX-10-04 is provided as Appendix A.

While *Baruna Jaya IV* conducted parallel operations in support of the *INDEX-SATAL 2010* mission, this cruise report covers only the detailed operations of *Okeanos Explorer*.

4.1 Ship Specifications

Relevant ship specifications for *Okeanos Explorer* and *Baruna Jaya IV* are provided as **Table 3**.

Table 3. Specifications for ships used during EX-10-04.

Indonesian R/V *Baruna Jaya IV*	NOAA Ship *Okeanos Explorer*	
Call sign: PLIQ		
Length overall (LOA): 60.4 m	Hull Number	337
Breadth: 12.1 m	Call letters	WTDH
Draft: 4.15 m	Launched	Oct 28, 1988
Gross register tonnage (GRT): 1,219 T	Delivered to NOAA	Sept 10, 2004
Main engine 2 × 1,100 PS Niigata 5PA5L	Commissioned	Aug 14, 2008
Single propeller	LOA	68.3 m (224 feet)
Speed: 8-9 knots	Breadth	13.1 m (43 feet)
Accommodation: 50 personnel	Draft	5.18 m (17 feet)
Builder: CMN, France	Range	9,600 nm
Launched: 1995	Endurance	40 days
6 ton A–Frame, 3-ton Crane	Main propulsion	2,800 hp General electric DC drive motors
1,000 m for bottom trawl & up to 6,000 m for mooring line)	Cruising speed	10 knots
Gilson winch (2)	Mapping speed	8 knots
Otter winch (2)	Berthing	46
Otter	Commissioned Officers	6
Hydrographic winch/Gantry	Licensed engineers	3
Cold Storage: 20t (-10 C), 1t (-20 C)	Crew	18
	Scientists	19

4.2 Equipment

4.2.1 ROV and Camera Platform

The EX is equipped with a 4,000 meter rated two-body ROV system composed of a camera platform (**Figure 2**) and ROV, *Little Hercules* (**Figure 3**). The *Little Hercules* ROV came to the *Okeanos Explorer* through collaboration between OER and Dr. Robert Ballard's Institute for Exploration (IFE) at the University of Rhode Island (URI). *Little Hercules* went through an extensive four-month overhaul before the expedition that included a new motor controller and power bottle system, an upgraded fiber-optic multiplexer system, a new ultra-short baseline (USBL) Tracking System, a full-color imaging sonar, a new conductivity, temperature, and depth (CTD) sensor, two new single-chip color charge-coupled device (CCD) cameras, two new light-emitting diode (LED) lights, two 400-watt hydrargyrum medium-arc iodide (HMI) lights and a high-definition (HD) video camera. New tethers, new tether terminations, a new transformer, a new electrical junction box, new depth and altitude sensors, a new light bar, and a new version of control software were also installed.

During dives the camera platform is suspended from the A-frame by the primary umbilical, while *Little Hercules (LH)* is free to explore to the extent of its neutrally buoyant 40m tether. The camera platform serves as lighting and imaging platform, looking down to illuminate and image the area around LH, while LH, decoupled from the ship's motion, can collect stable HD imagery of the seafloor.

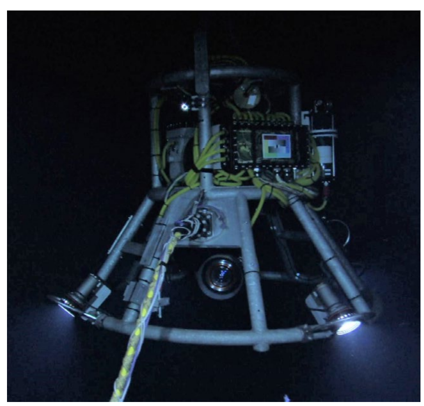


Figure 2. The Camera Platform, as originally designed and built by Pheonix International (left, credit: Dave Lovalvo, Eastern Oceanics). The image on the right shows the camera platform as reconfigured and used during the INDEX SATAL expedition.

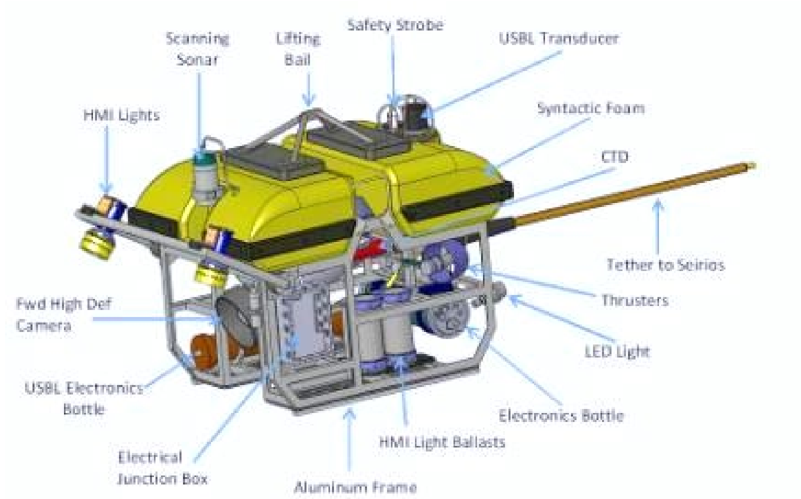


Figure 3. Diagram of IFE's Little Hercules ROV detailing the location of key components.

The main scientific data product returned from the vehicles is the HD video and still imagery. *Little Hercules* is equipped with an HD Camera (Insite Zeus Plus) mounted on a rotator unit (Remote Ocean Systems R-25-FB) which allows it to tilt from viewing straight ahead to straight down. Both vehicles rely on high intensity *(*HMI) lights to illuminate their surroundings. *Little Hercules* is equipped with a pair of HMI Lights with flood reflectors (Deep Sea Power and Light 400W Sea Arc 2). Finally, to provide scale to the imagery, LH has a pair of parallel, camera mounted red lasers (DSPL Micro SeaLasers), separated by 10cm. *Little Hercules* carries a CTD (Seabird 49 FastCAT) that returns only conductivity, temperature, and depth measurements.

The remaining sensors on the vehicles are dedicated to navigating and positioning during dives. These sensors include depth gauges, altimeters, inertial measurement unit (LH), scanning sonar's, and Ultra Short Baseline (USBL) tracking transponders.

4.2.2 Mapping Capabilities

Okeanos Explorer was equipped with a 30 kHz Kongsberg EM 302 multibeam sonar and a 3.5 kHz Knudsen sub-bottom profiler (SBP 3260) during this expedition (Lobecker et al., 2011). During *INDEX-SATAL 2010*, EM 302 bottom bathymetric and backscatter data were collected. Additionally, EM 302 water column data were logged for most of the cruises, when the ship worked offshore Guam in an area where identification of hydrothermal vents was a priority. The ship used a Position and Orientation System for Marine Vessels (POS MV), Applanix ver. 4, to record and correct the multibeam data for any motion. The C-Nav Global Positioning System (GPS) provided Differential GPS (DGPS) correctors with position accuracy expected to be better than two meters.

All the corrections (motion, sound speed profile, sound speed at sonar head, draft, and sensor offsets) were applied during real-time data acquisition in Seafloor Information System (SIS), ver. 1.04. Expendable bathythermograph (XBT) casts (Deep Blue, maximum depth of 760 m) were taken every six hours and in between if needed. XBT cast data were converted to an SIS-compliant format using Velocipy, a NOAA in-house tool for XBT processing.

Multibeam Echo Sounder (MBES)

Okeanos Explorer is equipped with a Kongsberg Maritime EM 302 multibeam sonar system. The sonar system was hull mounted by Todd Shipyard in Seattle during 2006/2007. The installation was accepted after field tests in September 2008. The EM 302 receiver and transmit arrays are arranged in a transducer fairing installed between frame 15 and 42 (**Figure 4**). The topside electronics (trans-receiver unit—primary user [PU] unit) for the EM 302 are located in an enclosed closet in the ship's library, and the EM 302 control and acquisition software SIS station is located in main mission space in the Control Room on the 01 deck. A remote on/off switch is also located next to the SIS acquisition station. The SIS computer is located in the rack room (**Figure 4**).

Figure 4. EM302 hardware (Clockwise from left) EM 302 Transmit Receive Unit (TRU) unit, transducer fairing, elements of EM 302 being installed inside the fairing, and the TRU remote on/off switch.

The nominal frequency of EM 302 is 30 kHz. The system can be operated in two modes—continuous waveform (CW) or frequency modulated (FM) mode. The distinctive advantage of FM mode is that larger swath coverage can be realized as compared to traditional deepwater multibeam systems. The sonar also utilizes multi-ping technology (dual swath) where two pings are simultaneously sent into water thereby increasing the data density.

Positioning and Orientation Equipment

The Applanix/TSS POS MV estimates position, heading, attitude, and heave of the vessel. The inertial measurement unit (IMU) is located in the fan room in front of the ship's library (between frames 35-40) (**Figure 5**). The system includes the POS MV computer system (PCS), an IMU, and two GPS antennas (**Figure 6**).

Figure 5. POS MV hardware. From left to right: IMU and granite block, IMU, and the IMU under protective housing.

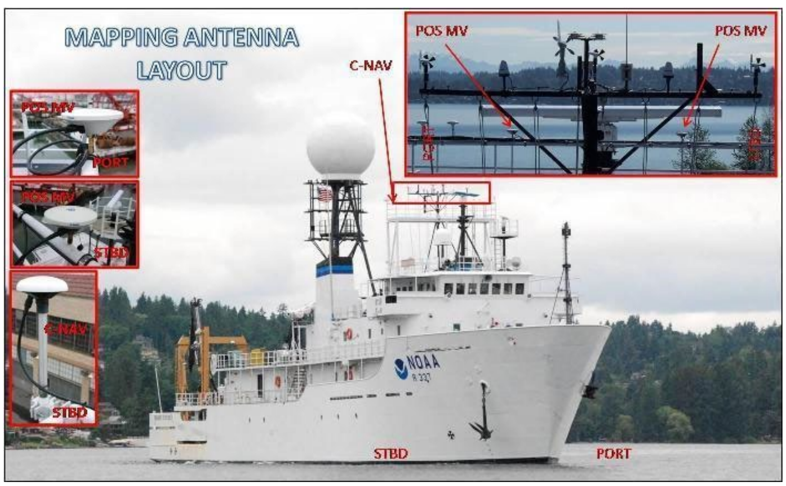


Figure 6. The arrangement of the miscellaneous antennas onboard , including the Civil Navigation (CNAV) GPS antenna and the POS MV port and starboard antennas.

Sound Speed Measurements

Vertical Profiling:

Okeanos Explorer has several systems for conducting vertical profiling of the water column. A seabird Electronics Model 9/11+ CTD is installed in a 24-position rosette frame with a seabird SBE-32 carousel (**Figure 7**). There are 24 2.5L niskin bottles. The SBE 9+ underwater unit has a depth capability of 6800 meters and a dual conductivity/temperature sensor pair. This system has four ports available for up to 8 auxiliary sensors. Additional sensors installed on the CTD frame may include: Light Scattering, Dissolved Oxygen (DO), Oxygen Reduction Potential (ORP) and Altimeter.

Okeanos Explorer, at the time of this expedition was outfitted with two Sea-Bird Electronics, Inc., (SBE) 9/11Plus CTDs, each with dual “3Plus Temperature” and “4C Conductivity” sensors. “3Plus Temperature” sensors are certified by SBE to demonstrate temperature measurement drift of less than 0.001 °C and time measurement accuracy within 0.065 ± 0.010 seconds. “4C Conductivity” sensors are ideally suited for obtaining horizontal data with towed systems or vertical data with lowered systems. This unit is capable of collecting temperature, conductivity, pressure and depth in real time; salinity and sound velocity are calculated in real time via SBE Seasave acquisition software. One complete package is used to collect data and the other is kept as a spare. The ship must hold station to conduct a CTD cast. The CTD is lowered through the water column at 60 m/min.

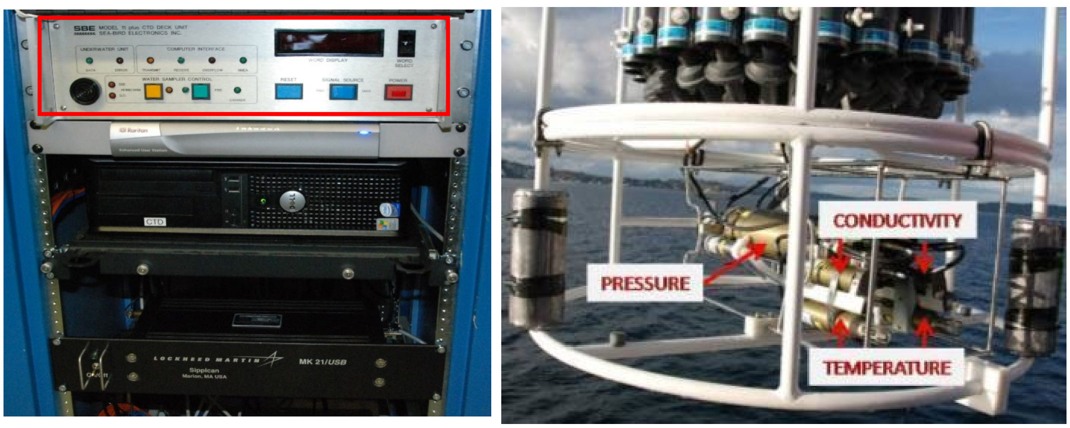


Figure 7. Ship CTD system (Left) Deck Unit (SBE 11) for acquisition of real time sound speed profile from SBE 9 plus CTD (Right) Horizontal mounted CTD with dual Temperature and Conductivity sensors and SBE 32 Carousel for 24-bottle water sampling.

Lockheed Martin Sippican XBT casts were conducted on the aft deck with a portable launcher (**Figure 8**). Expendable sound velocity (XSV) probes were also used to measure sound velocity directly. The data were collected in real time with the WinMK21 acquisition software. The major difference between the CTD and XBT is that an XBT/XSV cast can be completed while the ship is underway. The “Deep Blue” XBT probes can be launched at ship speeds of up to 20 knots, and collect data to a maximum depth of 760 m. A small amount of XBT-T5 probes are available onboard, to be used for comparisons casts when CTD operations are not available. XBT-T5 probes can be launched at ship speeds of up to six knots and collect data to a maximum depth of 1,830 m.

Figure 8. Sippican XBT launch setup from the aft deck (left). Deck unit for Sippican XBT (right).

4.4 Telepresence Capability Overview

A key and unique capability of the *Okeanos Explorer* is its ability to allow explorers and audiences ashore to participate in the expedition in real time. Using telepresence, explorers at shore-based ECCs can view live HD video from the ship, watch ROVs and mapping systems, transfer data at high speeds, and talk directly to explorers on the ship and at other ECCs around the world.

The telepresence capability supporting the *Okeanos Explorer* is composed of several categories of advanced technology infrastructure: network, video, audio communications, data logging, data transfer, and data management (**Figure 9**).

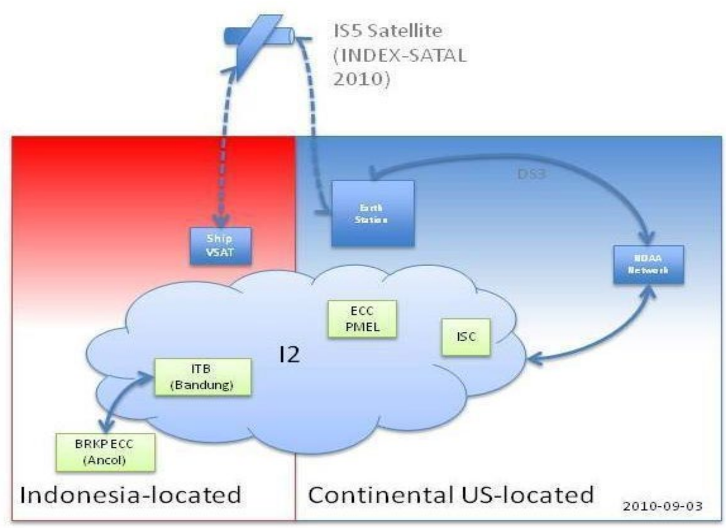


Figure 9. Overview of the telepresence setup used during the *INDEX-SATAL 2010* expedition.

VSAT and Network Infrastructure

The network infrastructure supporting the telepresence capability includes several ship-based, space-based, and shore-based components. Onboard, the ship contains a robust local area network (LAN) connecting all of the exploration systems for operations and data transmission. To move data and information off the ship to the shore, the ship utilizes a 3.7m C-Band Very Small Aperture Terminal (VSAT) to transmit high-speed data or video up to 20 megabits-per-second (Mbps) and receive data up to five Mbps. The C-Band VSAT transmits to and receives from a global beam linear or circular polarization C-Band satellite (the actual satellite utilized depends on the planned operating area; during *INDEX-SATAL 2010*, Intelsat 5 [IS-5] with linear polarization was used) via either or both a high-speed and low-speed modem (the modem used depends upon the data types and destinations). The satellite connects to a shore-based earth station located in the continental U.S. (the earth station used depends on the satellite used and earth station availability for the selected satellite; during *INDEX-SATAL 2010*, the Steele Valley Satellite Earth Station near Perris, California, was utilized). From the earth station, all data and information are sent via a high-speed fiber optic cable to the NOAA network (actual entry location into the NOAA network depends on earth station used and the nearest NOAA network entry point; during *INDEX-SATAL 2010*, the NOAA network entry point was at NOAA headquarters in Silver Spring, Maryland). From the NOAA network, the information is split in two directions. Video is sent directly out onto Internet2 as a multicast video signal. Audio intercom communications are sent out onto standard commodity Internet, and the data are transferred to relevant locations via Internet2, commodity Internet, or the NOAA proprietary network, depending on the destination and routing from the ship. During *INDEX-SATAL 2010*, an additional link to Internet2 was made from ITB Bandung to BRKP Ancol via leased Physical Network Inventory (PNI) fiber optic cable. This provided BRKP with the necessary bandwidth and Internet2 link to host the Jakarta ECC.

Video Recording and Real-time Streaming

The video infrastructure supporting the telepresence capability includes video collection, encoding, broadcast, and decoding technologies. Onboard the ship is a video collection system capable of recording 240 hours of HD video from four onboard HD cameras, 12 onboard standard definition cameras, one ROV-based HD camera, one camera platform HD camera, and several standard definition “work” cameras on both the ROV and camera platform. The video recording system can record in raw format or at variable configurable compression rates or resolutions. Any of these video sources, or video of shipboard computer data acquisition screens, can be streamed to shore.

When the high-speed VSAT is active and connected to a satellite, an onboard video engineer selects the specific video sources to encode into MPEG-4 video (the actual number and compression of broadcast video feeds is dependent upon the available VSAT bandwidth, which varies depending on the mission). Through this process, EX is capable of streaming up to three of these compressed, but still full, high-definition video feeds to shore simultaneously. The selected encoded video is then broadcast from the ship via the VSAT, via a video router, as RTP multicast video onto Internet2. As a multicast video stream on Internet2, any Internet2 location can view the live video with a hardware or software MPEG-4 decoder, with less than a three second delay. ECCs utilize Mac-based VLC software decoding to decode and view the video feeds. URI's Inner Space Center (ISC), a development center for telepresence capabilities, utilizes hardware decoders to decode and view the live video feeds.

Intercom Communications

All shipboard and shore-based audio components of the telepresence network use a centralized intercom system for managing shipboard and ship-to-shore communications (**Figure 10**). This intercom network facilitates communication between users working in the *Okeanos Explorer* control room, the ship's officers on the bridge, the ship's deck department (via wireless headsets), and participants located at shore-side ECC. Audio communications between the ship- and shore-based explorers allow real-time collaboration, daily operations planning, and the ability to expand the breadth and depth of expertise engaged in a mission. Onboard the ship, there are 12 Real-time syndication (RTS) intercom stations, each configured with talk and listen privileges, depending on the user roles at that station. Each onboard station connects to an intercom mainframe or hub. Via the ship's low-speed VSAT modem, the intercom hub on the ship manages all ship-based traffic and communicates with a shore-based intercom hub located at the ISC. The intercom hub at the ISC links each of the shore-based RTS intercoms at each ECC and manages all shore-based traffic. The two hubs pass intercom voice data to one another and then to the appropriate shore- or ship-based destinations. All voice traffic is carried over standard commodity Internet. The protocol used is a proprietary, third-party voice over Internet protocol (VoIP).

Figure 10. The VoIP intercom system leverages the ship's Internet connectivity to connect all of the ship-based and shore-based intercom units into a single system. This allows all participants, regardless of

location, to easily communicate with all other participants. Left: Scientist David Butterfield at the Seattle ECC communicates with participants on the ship and at the Jakarta ECC. Right: A close-up view of an RTS unit in *Okeanos Explorer*'s control room.

The intercom system is integrated with *Okeanos Explorer*'s video streaming and video recording subsystems, allowing the intercom audio to be heard in the live video streams and in the recorded video clips.

Instant Messaging for Real-Time Data Logging and Collaboration

Data logging for specific expedition activities is an important part of creating a record of observations, activities, system status, and other pertinent information. The expedition used a "group chat room" - a data logging system that allowed ship- and shore-based personnel to log their observations and activities in a central location and simultaneously allow users to see others' log entries (**Figure 11**). This data logging system is an Extensible Messaging and Presence Protocol (XMPP) -based system. The system utilized a shore-based XMPP server and open-source ship- and shore-based XMPP clients. Each operational user is provided user access to authenticate to the server. Once authenticated, the user may log in at will or view others log entries at any time during an expedition. Each log entry records the user name, date, and time of the observation.

Through this XMPP instant messaging (IM) service, scientists participating in the expedition either onboard the ship or on shore are able to communicate and log observations about ongoing operations in real-time. IM communications can either be directly between two individuals, or "person-to-person" collaboration, or via a group chat room. *Okeanos Explorer* operations use a dedicated group chat room call the *Okeanos* "Eventlog" for participants to share information about the expedition in real-time (e.g. notifying the team on shore of delays due to weather), and to record observations about science activities observed both at sea and on shore in real-time. Each day, a resulting Eventlog file is generated with all entries time-stamped to match the ship's clocks and serves as a complete record for all cruise events and science observations.

Figure 11. An example of chat log entries.

Real-time Access to Data and Operational Information

Data transfer to and from the ship is a critical capability to any successful telepresence-enabled operation. Data transferred and received can have a variety of uses or audiences—from scientists to the general public. Each audience or user requires a unique access point specific to the user and use. Regardless of the access point, all data are transferred off the ship via the VSAT. Depending on data type, either the high-speed or low-speed modem is used. Data required for operational purposes are transferred to shore and located on either a shore-based managed file transfer protocol (FTP) server or a shore-based content management system (CMS) server accessible on standard Internet. Each server has unique capabilities and purposes. The FTP server handles high-volume, high-frequency data transfers. The CMS handles low-volume, low-frequency data transfers and sharing of critical operational information. Both the FTP and CMS servers require user authentication to access the data. However, the FTP and CMS also both serve non-operational “products” for public use via anonymous login or open web pages, respectively. Products posted in these locations can be used for education, outreach, media, and communications activities. During telepresence-enabled expeditions, participating scientists are able access the latest data and products generated during the cruise from these servers, further enabling their ability to participate remotely in the cruise.

Exploration Command Centers (ECCs)
Shore-side participants interact with the shipboard team through ECCs, allowing explorers to join in the ongoing exploration from shore. ECCs are also an education and outreach venue, and are used for live events with the vessel.

Once configured appropriately, the ECCs mimics the layout and functionality of the control rooms on board *Okeanos Explorer* (Coleman 2012). The large monitors and video decoding hardware available to ECC participants display the same three primary video feeds seen on board the ship. The intercom unit enables direct two-way communication between the watch leader in the shipboard control room and the scientists at the ISC and ECCs. The intercom station also enables shipboard personnel to listen to shore-based conversations, and vice versa. The additional computer workstations in each ECC provide Internet access to web-based tools that include the data and operational information from the ongoing cruise. Where appropriate, processing software is also made available on the workstations to assist the ECC-based scientists with interpreting the real-time data.

The primary role of the ECCs is to provide a broader base of intellectual capital to exploration, and allow explorers to explore from shore. Three ECCs were online and used during the INDEX SATAL Expedition. They were located at:

- NOAA Pacific Marine Environmental Laboratory (PMEL), Sand Point, Seattle, WA
- University of Rhode Island's Inner Space Center, Narragansett, RI
- Jakarta, Indonesia

The *Okeanos Explorer* transmitted three live video and data feeds to the ECCs in Jakarta and the U.S., where Indonesian and U.S. scientists participated in the expedition in real-time by monitoring the live video, communicating with the ship and shore-based science team via instant messaging and RTS intercoms, and taking part in daily ship-to-shore science planning meetings. Each day, virtual meetings were held with both the shipboard and shore-side scientists to discuss that day's operations, and finalize plans for the following day. During ROV dives, the three live video feeds generally included the primary HD camera on *Little Hercules*, the primary HD camera on the Camera Sled showing *Little Hercules* at work, and another computer data screen to provide situational awareness of the ongoing operation – such as the Hypack Navigation screen showing the location of the ship, each vehicle, and where they were in relation to the seafloor in real-time. When the ROV was not in the water, the multibeam data acquisition was generally streamed to shore, along with at least one video feed of the shipboard mission spaces to provide situational awareness of what was happening at sea to scientists on shore. In addition to the real-time transmissions, a complete data archive was provided to DKP at the end of the expedition (For more details about data management, refer to Appendix A: Data Management Plan).

Freely and Publicly Accessible Data, As Soon as Possible

A key tenet of the *Okeanos Explorer* model is that data are made available to the public without proprietary rights as soon as possible, except when national security, regulatory, or trustee responsibilities require additional protections or restrictions on the data. Therefore, data management is a critical function of any exploration expedition. Onboard the *Okeanos Explorer,* a unique and prototype-integrated data management system is utilized to ensure accurate and efficient data and metadata generation and management. Onboard the *Okeanos Explorer* resides a Cruise Information Management System (CIMS) that auto-generates metadata for data collected by the ship and deployed sensors and systems. Metadata are automatically sent daily via low-speed VSAT to a shore-based data center. The data center catalogs the metadata and prepares for data ingestion, triggering a host of shore-based data center accession activities. Upon receipt of the actual data (transmission method depends on data type and size), the data center packages the data and metadata and begins the accession process to ensure the integrity of the data is maintained, that the data and metadata are accessible to the public as soon as possible, and that they are stored in a secure and widely accessible national data center for long-term archive.

4.4 Operations

The 2010 ocean exploration expedition involved two deep-ocean research vessels (the *Baruna Jaya IV* and the *Okeanos Explorer*) operating in coordination to achieve the expedition's science objectives. The *Baruna Jaya IV* conducted bathymetric surveys in relatively shallow waters (generally less than 1,500 m) and collected seawater CTD measurements at selected points (**Figure 12**, **Table 5**) as well as fisheries-related sample collection and assessments (**Figure 13**, **Table 6**). The *Baruna Jaya IV* also served as a base of operations for small boats involved in shallow-water bathymetry and habitat assessments, including setting up Autonomous Reef Monitoring Structure (ARMS). The setting up of ARMS was completed by a joint team of Indonesia-U.S. scientists. (See https://oceanexplorer.noaa.gov/okeanos/explorations/10index/logs/aug01/aug01.html, last accessed Dec. 2020). ARMS are long-term collecting devices developed to mimic the structural complexity of coral reef habitats and to attract colonizing invertebrates and algae. They were developed by the Coral Reef Ecosystem Division of the NOAA PIFSC in conjunction with the Census of Coral Reefs Project (CReefs) of the Census of Marine Life (CoML) as a standard and systematic method to investigate and monitor the diversity of lesser-known reef organisms. The six ARMS deployed along Sangihe Island (**Table 4**) are the first of these installed in Indonesian waters. They join the 400 ARMS that already exist in coral reefs across the globe.

The first site, SAG-01, was located near the southern tip of Tahuna Harbor. The reef flat extended approximately 10 m from the shoreline, then dropped to a wall from three meters to 15 m, and gradually sloped down to 30 m. ARMS were installed at SAG-01 near the base of the wall at 15 m. Each unit was approximately three meters apart from one another. The habitat on the slope was dominated by rubble, sand, and macroalgae intermixed with small colonies of *Acropora* sp.

The second site, SAG-02, was located approximately two kilometers south of the harbor entrance. The reef at this location sloped gradually from three meters to 20 m. ARMS were installed at 15 m and each unit was separated by approximately three meters. The habitat was dominated by macroalgae and rubble.

Table 4. Location of ARMS installed.

Location	Site	Latitude	Longitude	Depth (m)	# ARMS installed
Sangihe Island	SAG-01	N 3.59816	E 125.48658	15	3
Sangihe Island	SAG-02	N 3.57787	E 125.48504	15	3

The *Okeanos Explorer* collected bathymetric data of deeper waters (generally more than 1,500 m) and collected towed- and point-CTD measurements (**Table 7**) to help identify plumes and other anomalies. Where areas of interest were indicated by bathymetric, multibeam backscatter, or CTD data, the *Okeanos Explorer* deployed a dual-bodied ROV for detailed investigation using HD video cameras (**Table 8**).

Though water samples were collected using the *Okeanos Explorer* CTD/rosette, no biological or physical samples were collected using the *Okeanos Explorer*. Instead, *Baruna Jaya IV* collected biological and physical samples.

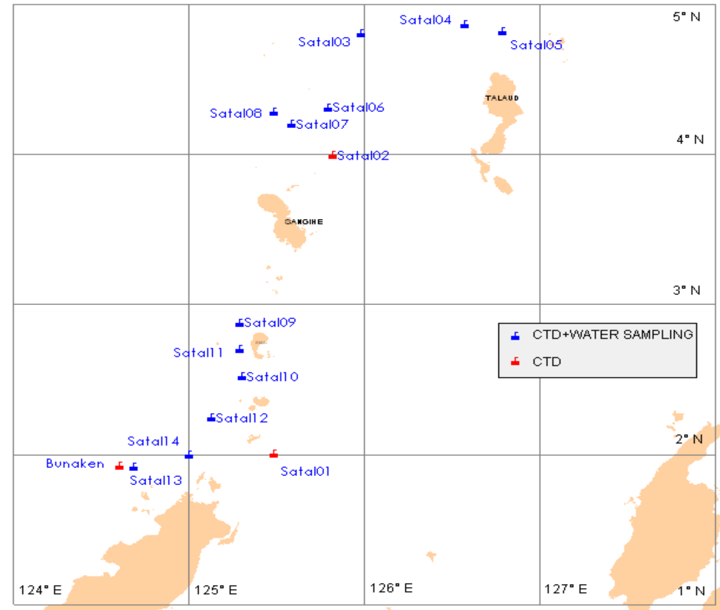


Figure 12. CTD casts and CTD water samples collected by R/V *Baruna Jaya IV* (*Image courtesy of R/V* Baruna Jaya IV).

Table 5. CTD locations conducted by R/V *Baruna Jaya IV* (*Information courtesy of R/V* Baruna Jaya IV).

ID	Latitude	Longitude
1	2.0445	125.4963
2	3.99258	125.821
3	4.80319	125.9837
4	4.867708	126.5741
5	4.818667	126.7897
7	4.19867	125.5885
8	4.279469	125.4822
9	2.86828	125.2953
10	2.51444	125.3008
11	2.6962	125.2865
12	2.2462	125.1217
13	1.92954	124.705

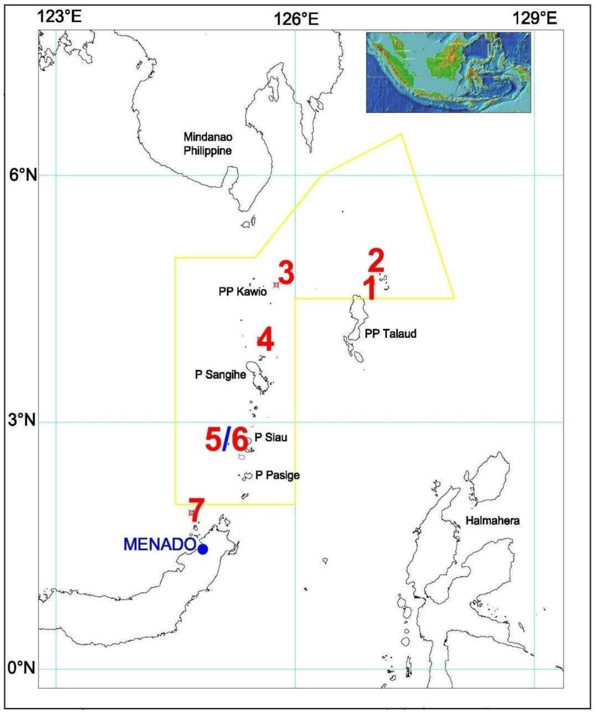


Figure 13. Location of the trawl stations conducted by R/V *Baruna Jaya IV*.

Table 6. Location of the trawl stations conducted by R/V *Baruna Jaya IV*.

Trawl Station	Longitude	Latitude
1	126.9667	4.7
2	127.0125	4.861111
3	125.7639	4.664444
4	125.5594	4.0
5	125.2844	2.704444
6	125.3344	2.704444
7	Missing	Missing

Table 7. CTD casts collected by *Okeanos Explorer* during EX-10-04 Leg 2.

CTD Cast Station	Date	Latitude (N)	Longitude (E)	Water samples (Depth in m)
EX1004L2_01	62710	4.6762	125.0852	No Samples
EX1004L2-02	62910	4.6723	125.0868	No Samples
EX1004L2-03	62910	4.6760	125.0870	No Samples
EX1004L2-04	62910	4.6778	125.0875	No Samples
EX1004L2-05	70210	3.7780	125.3705	No Samples
EX1004L2-06	70210	3.7757	125.3718	No Samples
EX1004L2-07	70210	3.7738	125.3743	No Samples

EX1004L2-08	70210	3.7715	125.3792	No Samples
EX1004L2-09	70610	5.2675	126.6175	No Samples
EX1004L2-10	70610	5.3268	126.6132	No Samples
EX1004L2-11	70710	5.8723	127.2533	No Samples
EX1004L2-12	71109	2.8480	125.0680	No Samples
EX1004L2-13	71109	2.6267	125.0863	No Samples
EX1004L3-01	72410	2.1364	124.9013	702, 650, 600, 400
EX1004L3-02	72510	2.136072	124.9071	No Samples
EX1004L3-03	72510	2.27052	124.8304	No samples
EX1004L3-04	80310	4.675833	125.0878	1800, 1760, 1684, 1630, 1572, 1875, 1785, 1767, 1712, 1694, 1644,
EX1004L3-05	80610	2.6839	125.2591	1500, 1440, 1400, 1350, 1300, 1250, 1200
EX1004L3-06	80610	2.687733	125.2569	No samples

Table 8. ROV dives conducted during the cruise —linear distance was computed from the KML files of the dive tracks in Google Earth.

Dive Number #	Date (GMT)	Latitude (N)	Longitude (E)	Time At bottom (UTC)	Off bottom (UTC)	Time (hours) Approx.	Linear transect distance Approx. (km)
EX-10-04 Leg 2							
1	062910	4.6785	125.0730	0220	0717	5	1.5
2	063010	4.6765	125.0873	0219	0714	5	0.8
3	070110	4.6683	125.2542	0304	0757	5	1.4
4	070210	4.0127	125.2800	0130	0735	6	2.2
5	070310	3.7788	125.3697	0055	0814	7	2.4
6	070510	5.3773	126.7669	0313	0633	3	1.1
7	070610	5.2494	126.6563	0325	0736	4	0.8
8	070810	5.0780	126.6521	0211	0709	5	1.1
9	070910	4.9512	125.7848	0110	0713	6	1.6
10	071010	3.3413	125.2817	0328	0637	3	0.9
11	071110	2.8627	125.0343	0110	0820	6	1.4
12	071210	2.6247	125.0863	0122	0655	6.5	1.1
13	071210	2.8442	125.0584	2131	0553	6	1.8
EX-10-04 Leg 3							
1	072210	2.8479	124.0655	2045	0543	9	2.3
2	072410	2.1367	124.9019	0110	0756	7	1.6
3	072510	2.2665	124.8353	0211	0722	5	1.5

4	07/2610	2.2690	124.8177	0215	0705	5	1.2
5	072710	2.8303	124.9812	0240	0618	4	0.9
6	072810	4.2482	125.2647	0135	0745	6	1.4
7	072910	4.6763	125.0873	0224	0705	5	1.1
8	073010	5.4034	126.5901	0212	0804	6	1.3
9	080110	4.6962	126.8468	0135	0730	6	1.9
10	080110	4.8912	127.0151	2224	0449	6	1.7
11	080210	4.6762	125.0873	2131	0515	8	1.2
12	080410	3.5981	125.1419	0323	0716	4	1.5
13	080510	2.6977	125.2841	0141	0804	6.5	1.5
14	080610	2.6865	125.2578	0123	0648	5	1.0
Total						**150 Hours (Approx)**	**38.2 km (Approx)**

5. Clearances and Permits

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: (https://www.nepa.noaa.gov/docs/NOAA-NAO-216-6A-Companion-Manual-03012018.pdf, last accessed May 2021) describes the agency's specific procedures for NEPA compliance.

An environmental review memorandum was completed for *Okeanos Explorer* expedition EX-10-04 in accordance with Section 4 of the companion manual. Based upon this review, a categorical exclusion was determined to be the appropriate level of NEPA analysis necessary, as no extraordinary circumstances existed that required the preparation of an environmental assessment or environmental impact statement. Additionally, an Implementing Arrangement (Appendix B) between the U.S. government and the Republic of Indonesia government established an exploration partnership between the two countries, and the Republic of Indonesia gave clearance approval for *Okeanos Explorer* to operate in its territorial waters.

6. Schedule

EX-10-04 was a four-leg expedition that spent a total of 58 days at sea, from June 8, 2010, to August 19, 2010. It departed from the Territory of Guam, U.S., went to Bitung, Indonesia, and concluded in the Territory of Guam, U.S. A total of 27 ROV dives were conducted during EX-10-

04. For more detailed information about each day of the expedition, Daily Logs are available on the OER website at: https://oceanexplorer.noaa.gov/okeanos/explorations/10index/logs/dailyupdates/dailyupdates.html.

Table 9. Expedition Schedule.

June 2010						
Mon	**Tue**	**Wed**	**Thu**	**Fri**	**Sat**	**Sun**
	8 Departed Guam 1630.	9 Commenced mapping operations offshore Guam.	10 Continued mapping operations offshore Guam. CTD operations 0700.	11 Continued mapping operations offshore Guam. Conducted CTD operations from 0200 – 1700.	12 Built-in self-test (BIST) indicated failed RX32 board slot #2. Continued Mapping and CTD operations.	13 Continued mapping and CTD operations. Left the exploration areas in transit to U.S. exclusive economic zone (EEZ).
14 Stopped all the data sensors.	15 All mapping sensors remain secured. RX board reseated and passed BIST.	16 Continued transit toward Bitung, Indonesia. No data were collected.	17 Continued transit toward Bitung, Indonesia. No data were collected.	18 Continued transit toward Bitung, Indonesia. No data were collected.	19 Continued transit toward Bitung, Indonesia. No data were collected.	20 Arrived Bitung, Indonesia.
21	22	23	24 Departed Bitung, Indonesia. Arrived working grounds 1600 Started mapping operations 1630.	25 Conducted mapping in the western boundary of the EX2 mapping area.	26 Continued mapping in the EX2 mapping area. Passed over Kawio Barat.	27 Conducted CTD casts over Kawio Barat from 0800-1700. Resumed mapping overnight.
28 Continued mapping in south eastern portion of EX2 mapping area.	29 0800-Conducted ROV Dive 01 over Kawio Barat. Conducted CTD operations until 1900. Resumed mapping in EX2 mapping area.	30 Conducted ROV Dive 02 over Kawio Barat. Resumed mapping west of EX2 mapping area during night.				

JULY 2010						
			1 Conducted ROV Dive 03 over "Site R". Resumed mapping in the shallow areas between the islands.	2 Conducted ROV Dive 04 over "Bulan". Conducted two cross lines over the bathymetric data collected so far.	3 Conducted ROV Dive 05 over "Naung Traverse". At 1800, ship transited toward mapping area EX1.	4 Conducted mapping operations in EX1 area.
5 Conducted ROV Dive 06 over "Paradise Valley".	6 Conducted ROV Dive 07 over "Black Hole". Resumed mapping. Conducted CTD cast #10.	7 Conducted mapping in the deeper areas of the EX1 box.	8 Conducted ROV Dive 08 over "K1".	9 Conducted ROV Dive 09 over "The Eye" in the area transit from EX1 to EX2 box. Transited to EX1 box.	10 Conducted ROV Dive 10 in EX2 box.	11 Conducted ROV Dive 11 over "South Mount".
12 Conducted ROV Dive 12 over "Site J". Overnight mapped in the SW area of approved exploration box.	13 Conducted ROV Dive 13 over "Site K" again. Secured all sensors while outside the approved exploration area.	14 Arrived Bitung, Indonesia.				
		21 Sailing delayed due to personnel delayed arrival.	22 Depart Port of Bitung, North Sulawesi, 0745. Mapped overnight after crossing working grounds boundary.	23 Mapped in the morning and overnight. Conducted ROV Dive 01 on "Site K".	24 Mapped in the morning and overnight. Conducted CTD cast and ROV Dive 02 on "Site T".	25 Mapped in the morning and overnight. Conduted ROV Dive 03 on "Site G".
26 Mapped in the morning and overnight. Conducted ROV Dive 04 on "Site G".	27 Mapped in the morning and overnight. Conducted ROV Dive 05 on "Site K".	28 Mapped in the morning and overnight. Conducted ROV Dive 06 on "Landak" near "Site 7".	29 Mapped in the morning and overnight. Conducted ROV Dive 07 on Kawio Barat.	30 Mapped in the morning and overnight. Conducted ROV Dive 08 on "Eastern Pujada Ridge", a shallow ridge in NE.	31 Mapping operations 24 hrs. No ROV dive.	

AUGUST 2010						
						1 Mapped in the morning and overnight. Conducted ROV Dive 09 on “BJIV_1” target near North Talaud.
2 Mapped in the morning and overnight. Conducted ROV Dive 10 on “Zona Senja”, a BJIV shallow target in 300 m near North Talaud.	3 Mapped in the morning and overnight. Conducted ROV Dive 11 on Kawio Barat for high-level event with Silver Spring. Two CTD casts collected in the evening over Kawai Barat.	4 Mapped in the morning and overnight. Conducted ROV Dive 12 on “Memeridge ” site.	5 Mapped in the morning and overnight. Conducted ROV Dive 13 on “Gelembung”, at a seamount found by BJIV near Siau Island.	6 Mapped in the morning and evening until 2300. Conducted ROV Dive 14 on “Gelembung II”, at a seamount found by BJIV. Overnight transit to Bitung. Secured all sensors while travelling outside the approved *INDEX-SATAL 2010* exploration area.	7 Arrived at the port of Bitung, North Sulawesi, at 0830.	
					14 Departed Port of Bitung, North Sulawesi, Indonesia.	15 Continued transit to Guam. All scientific sensors secured.
16 Continued transit to Guam. All scientific sensors secured.	17 Continued transit to Guam. All scientific sensors secured.	18 Continued transit to Guam. All scientific sensors secured.	19 Commenced EM 302 testing and mapping operations.	20 Arrived Guam. Secured at the dock at 0807.		

7. Results

The *INDEX-SATAL 2010* expeditions resulted in a wide variety of environmental data, ranging from detailed bathymetry maps (**Figure 14**) to the collection of critical data to understand geological and habitat settings, as well as documentation of the biodiversity of the region (**Table 10**). The expedition also leveraged telepresence technology to broadly engage scientists and the public on shore. The science team from both countries worked with Indonesian and U.S. public affairs and communications experts to make educational products for print, Internet, and TV media. Two port calls were organized at the beginning and the end of the cruise for education and outreach purposes. The details of the expeditions were catalogued at oceanexplorer.noaa.gov. The expeditions resulted in:

Table 10. Exploration metrics.

39	Days at sea on the *Okeanos Explorer* exploring the SATAL region
>36K	Square kilometers were mapped with the EM 302 multibeam system to identify features for exploration
33	CTD casts were conducted to characterize the water column
27	ROV dives were completed during the expedition
~4	Terabytes of data collected (ship sensors, ROV sensors, CTD, multibeam, etc.)
150	Hours of ROV dives and operations
>40	Possible new species observed

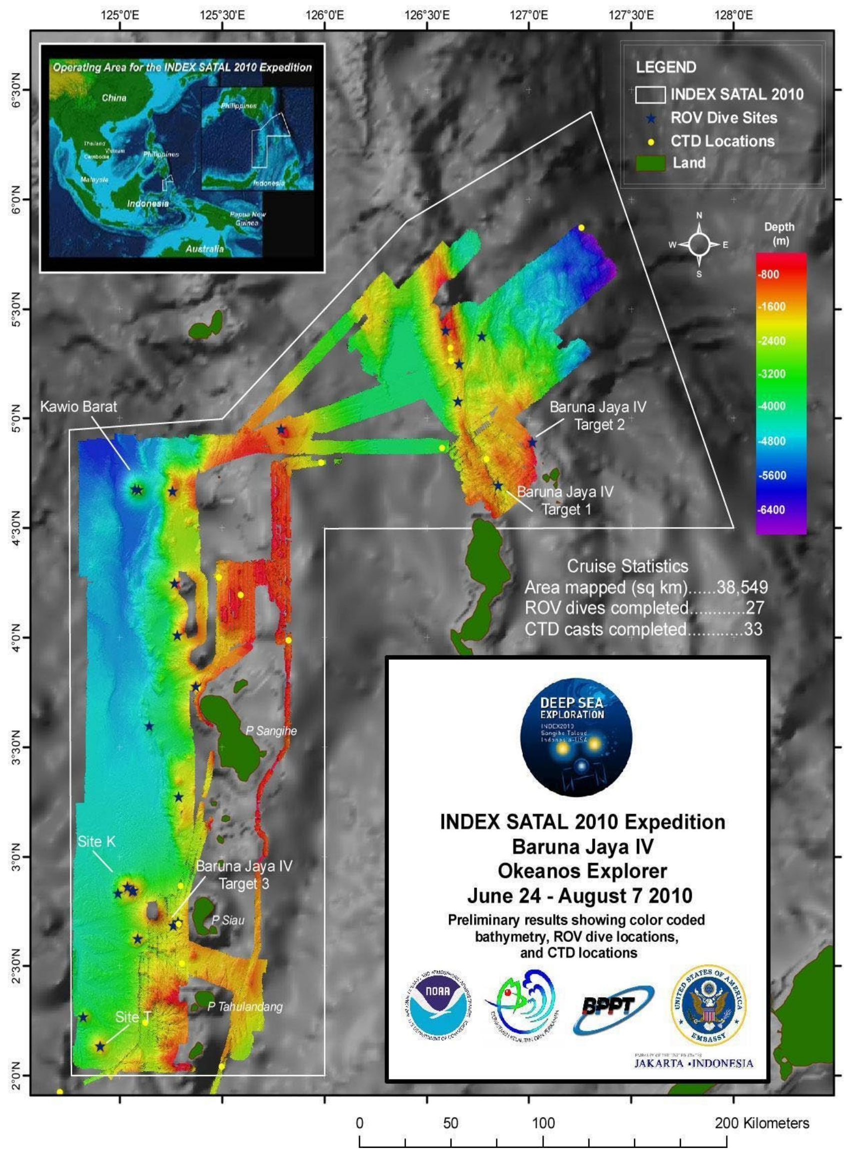


Figure 14. Overview summary map of results of data collected by *Okeanos Explorer* and *Baruna Jaya IV*.

7.1 Geomorphology and Geology

(The information in this section has been largely excerpted from Lobecker et al., 2010c and Priyadi et al., 2010)

The high-resolution bathymetry revealed new details of the seafloor morphology in this complex tectonic system. At least five seamounts were mapped, including a previously unknown 1,500-meter-high seamount and the submarine volcano, Kawio Barat—which rises approximately 3,500 meters from the seafloor, and is the site of white smokers and surprisingly dense and diverse deepwater biological communities. Several additional features were observed, including submarine channels, fans, and debris aprons with blocks up to 1,200 m in diameter, accretionary ridges and basins, trenches, and some flat-topped seamounts. These well-defined features are consistent with the complex interactions between arc development, mass wasting, and subduction (Lobecker et al., 2010c).

Two submarine volcanoes (Naung and Kawio Barat) were characterized by a variety of extrusive volcanic features from which magmatic composition and eruption types can be inferred (Priyadi et al., 2010). Lavas observed around Kawio Barat appeared to be relatively coarse grained with little flow structure, although flow textures were sometimes observed in areas with relatively high relief. Younger, overlying lava flows appeared to be finer grained and characterized by glassy surfaces. Such flows presumably have less silica and, being more fluid, formed pillow and sheeting sheet flows. The lavas are likely all basaltic in composition and are related to the subduction systems of the Sangihe Arc. The less fluid and coarser grained lavas may be somewhat more evolved (i.e., more andesitic in composition). The stratigraphic relationship of these two lava types may be evidence of a change in magmatic composition from more differentiated magma to a less differentiated one. If so, this observation may be evidence of a new phase of magma generation associated with increasing subduction activity.

Volcanic rock types associated with Naung volcano are predominantly pyroclastic deposits overlying basalt flows. Pyroclastic deposits include layers of light to dark brown lapilli deposited as 2-30 cm thick layers as well as unconsolidated clastic materials. The occurrence of pebble-size igneous fragments associated with the pyroclastics appears to indicate phreatic to phreatomagmatic explosions. Such explosions may have originated as a consequence of seawater access to sub-seafloor magma sources via widespread fractures in the area. An alternative source mechanism could be highly-differentiated magmas associated with the relatively thick volcanic basement that is characteristic of the Sangihe subduction zone.

7.2 Biodiversity

(The information in this section has been largely excerpted from Herrera et al., 2010)

Besides mapping the geophysical structure of the seafloor of the area, the video and trawl observations provided valuable biological information. More than 25 deep-sea habitats were discovered, and the team explored between 250 meters to more than 3,600 meters in the virtually unexplored Sulawesi Sea (also called the Celebes Sea) of Indonesia. Habitats observed included hydrothermally-active volcanoes, seamounts and ocean ridges, coral habitats hosting specific types of faunal species, organic falls (including wood and coconuts), and sediment-covered slopes and plains. Throughout the depths, diverse benthic habitats harbored distinctly different ecosystems, including thriving chemosynthetic and non-chemosynthetic communities (**Figure 15, Table 10**).

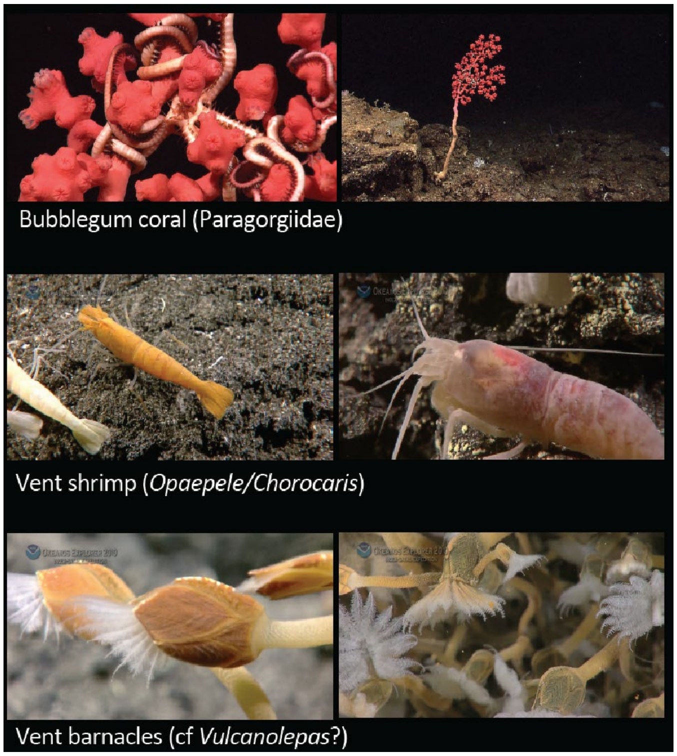


Figure 15. A few representative images of potential new species discovered during the *INDEX-SATAL 2010* expedition by *Okeanos Explorer* ROV.

In the Coral Triangle (CT), where over 65 percent of the world's reef-forming coral species are known to exist in shallow waters and constitute approximately 12 percent of all coral species, perhaps 40 potential new deepwater species were observed and imaged (**Figure 16**, Herrera et al., 2010; Tunnicliffe et al., 2016). A greater number of potential new species of other animals were also observed.

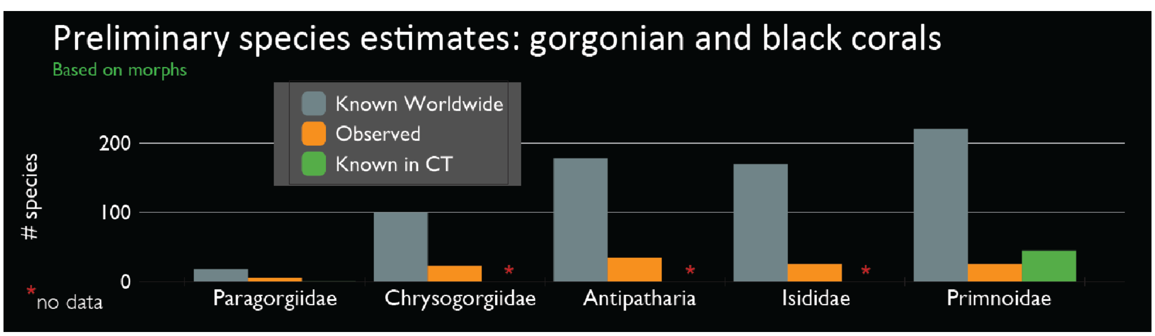


Figure 16. Preliminary species estimates for gorgonian and black corals showing the number of species observed during the *INDEX-SATAL 2010* expedition in comparison to the number of species previously known to exist worldwide and in the Coral Triangle. (Image from Herrera et al., 2010).

INDEX-SATAL 2010 exploration of the deep sea occurred across Wallace's Line and in close proximity to Weber's line. Wallace's line is an imaginary line postulated by A. R. Wallace as the dividing line between Asian and Australian fauna in the Malay Archipelago. Weber's Line—an imaginary line postulated by M.C.W. Weber—is a line of supposed 'faunal balance' between the Oriental and the Australasian faunal regions within Wallacea. Wallacea consists of isolated islands that were never recently connected by continental landmasses and, thus, was populated by species capable of crossing the straits between islands. Weber's Line runs through this transitional area, at the tipping point between dominance by species of Asian vs. Australian origin (**Figure 17**). The abundance of habitats generated by the high number of geological and biological features and depth ranges present in the deep CT (e.g., ridges, seamounts, island margins, plains, and rock types), and the complex history of tectonic dynamics of this region are among the likely causes for the high biodiversity found during this mission. Tectonic history and diverse habitats may also be factors that have played a similar role shaping the diversity of shallow-water assemblages of the region.

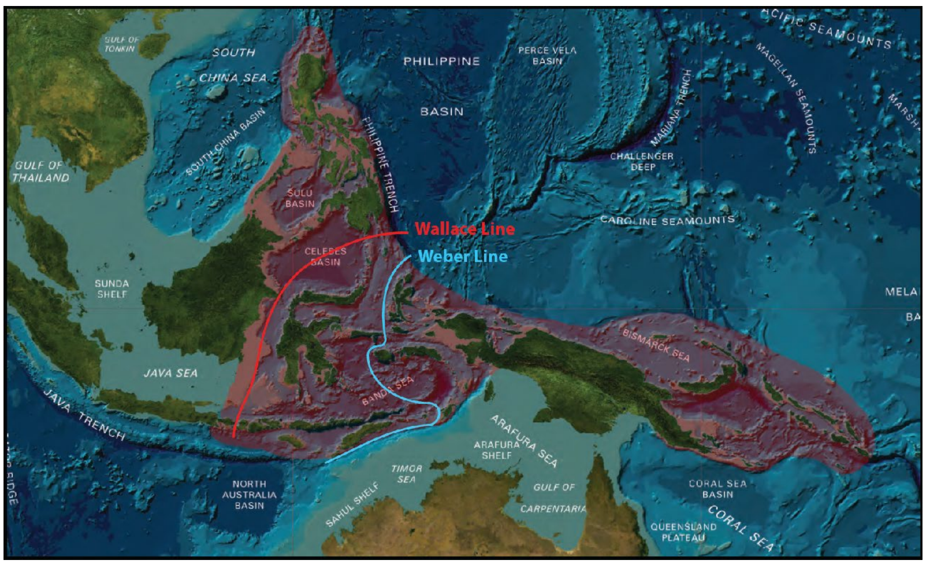


Figure 17. Map of the Celebes Sea region where biogeographic patterns observed on land led to lines drawn to explain breaks in species distribution. (Image from Herrera et al., 2010).

The CT is the epicenter of shallow-water marine biodiversity. This area includes regions from the EEZs of Indonesia, Malaysia, Papua New Guinea, Philippines, Solomon Islands, and Timor-Leste. The shallow-water coral reefs in the CT contain 76 percent of all the zooxanthellate hermatypic scleractinian species in the world (Veron et al., 2009), which represent 12 percent of all the coral species, i.e., 605 out of 5,080 species (Cairns, 2007). These shallow-water reefs also contain 37 percent of all the reef fishes in the world. The species richness of a plethora of other groups—such as lobsters, stomatopods, gastropods, bryopsidale macroalgae, pontoniinae crabs, coral-associated barnacles, and bivalves—also peaks in the CT (Roberts et al., 2002; Bellwood & Meyers, 2002; Paulay & Meyer, 2006; Hoeksema, 2007; Reaka et al., 2008; Meyer & Macurda, 1977).

A handful of recent studies have also identified the CT region as a potential biodiversity epicenter for some deep-sea fauna (**Figure 18**). The greatest species diversities of azooxanthellate scleractinian corals, crinoids, and galatheid squat lobsters are found in the deep CT (Macpherson et al., 2010; Ameziane & Roux, 1997). However, biogeographic datasets for most other deepwater taxa remain largely incomplete, so no clear consensus regarding its importance in shaping the biodiversity in the deep ocean has been reached. Thus, the question of whether the extreme biodiversity observed in the shallow-water ecosystems in the CT extends into the deep-sea remains unanswered. The high-resolution imagery obtained from the 27 ROV dives revealed remarkably high abundances and diversity of animal species in deep waters, many of which appear to be novel.

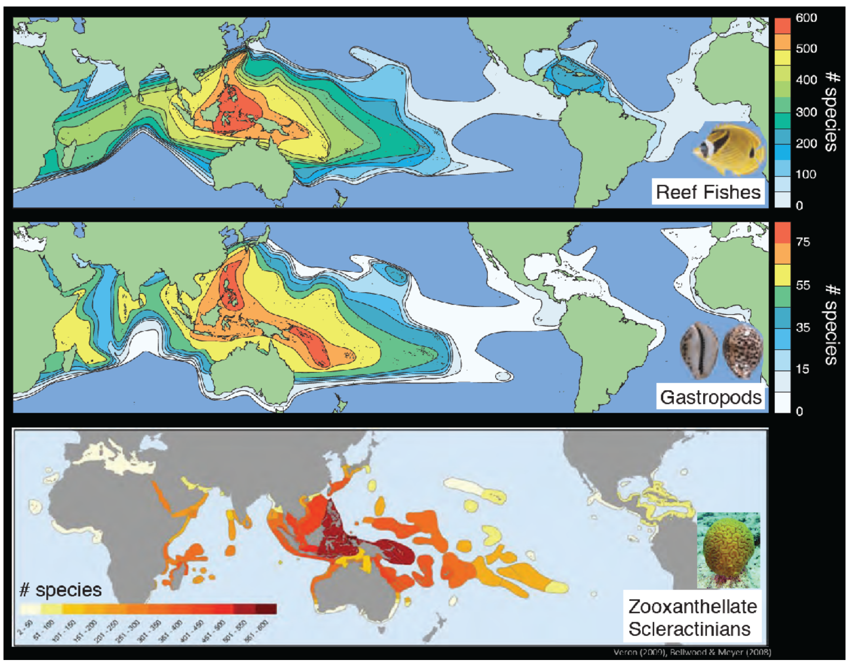


Figure 18. Biodiversity (number of species) distribution worldwide shows the significance of CT. (Image from Herrera et al., 2010).

On hard bottom substrates, cold-water corals were the dominant sessile macrofauna, in terms of biomass, followed by glass sponges (Hexactinellida) and sea lilies (Crinoidea) (**Figure 19**). The coral taxa observed in this area represent six large orders of cnidarians: antipatharians (black corals), scleractinians (stony corals), zoanthideans (gold corals), alcyonaceans (octocorals), pennatulaceans (sea pens), and anthoathecates (hydrocorals). Most sessile species, independently of their size class or taxonomic affiliation, harbor a wide variety of associated fauna. Brittle stars (Ophiuroidea), squat lobsters (Galatheoidea), shrimp (Caridea), amphipods (Amphipoda), anemones (Actinaria), zanthideans, barnacles (Cirripedia), hydroids (Hydrozoa), and worms (Polychaeta) are the animal groups most commonly found forming these associations.

In contrast, soft bottom habitats were dominated by stalked sponges, sea pens, sea cucumbers (Holothuroidea), and brittle stars. Other conspicuous fauna included fishes, hermit crabs (Paguridae), urchins (Echinoidea), and octopuses (Cephalopoda) (**Figure 19**).

In addition to the video observations of biodiversity by the *Okeanos Explorer*, *Baruna Jaya IV* collected bottom trawl samples and installed ARMS (See Section 4.4 for details).

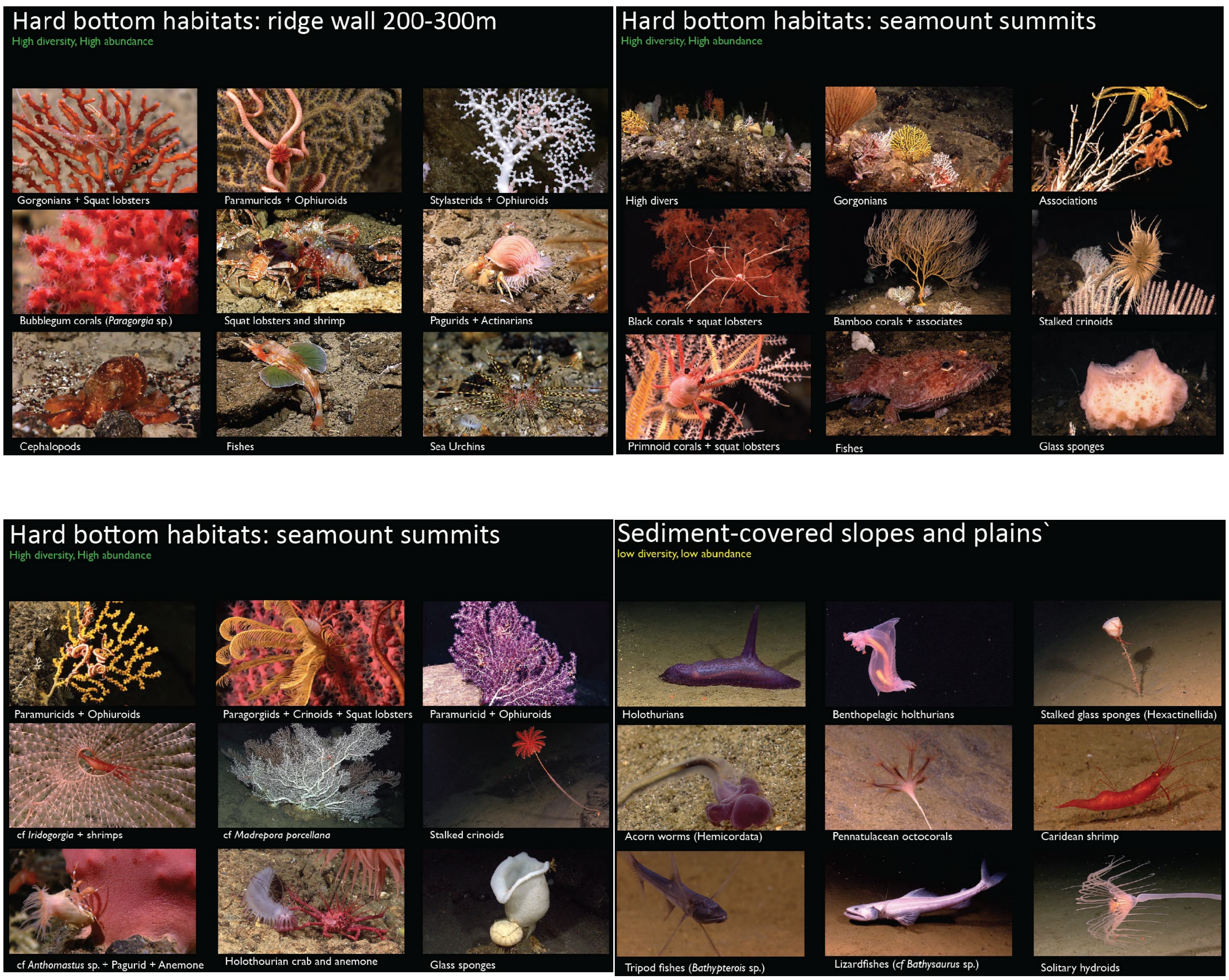


Figure 19. Representative species observed on hard bottom and the sediment-covered slopes and plains by *Okeanos Explorer* ROV.

7.3 Kawio Barat

(The information in this section has been largely excerpted from Makarim et al., 2010)

Kawio Barat submarine volcano has formed in response to the active tectonic conditions in Sangihe Talaud, an area that lies in the subduction zone between the Molucca Sea Plate and Celebes Sea Plate. Submarine volcanic activity in the western Sangihe volcanic arc is controlled by the west-dipping Molucca Sea Plate as it subducts beneath the Sangihe Arc. A secondary faulting system on Kawio Barat is in a northwest-to-southeast direction, and creates a network of deep cracks that facilitate hydrothermal discharge in this area.

Hydrothermal activity on Kawio Barat was first discovered by joint Indonesian/Australian cruises in 2003. In 2010, as part of the joint U.S./Indonesian *INDEX-SATAL 2010* expedition, CTD casts were conducted that confirmed continuing activity. Hydrothermal plumes were detected by light scattering (LSS) and Oxidation-Reduction Potential (ORP) sensors on the CTD package (**Figure 20**). LSS anomalies were found between 1,600-1,900 m, with ΔNTU levels of 0.020-0.040. ORP anomalies coincident with the LSS anomalies indicate strong concentrations of reduced species such as H_2S and Fe, confirming the hydrothermal origin of the plumes (Makarim et al., 2010).

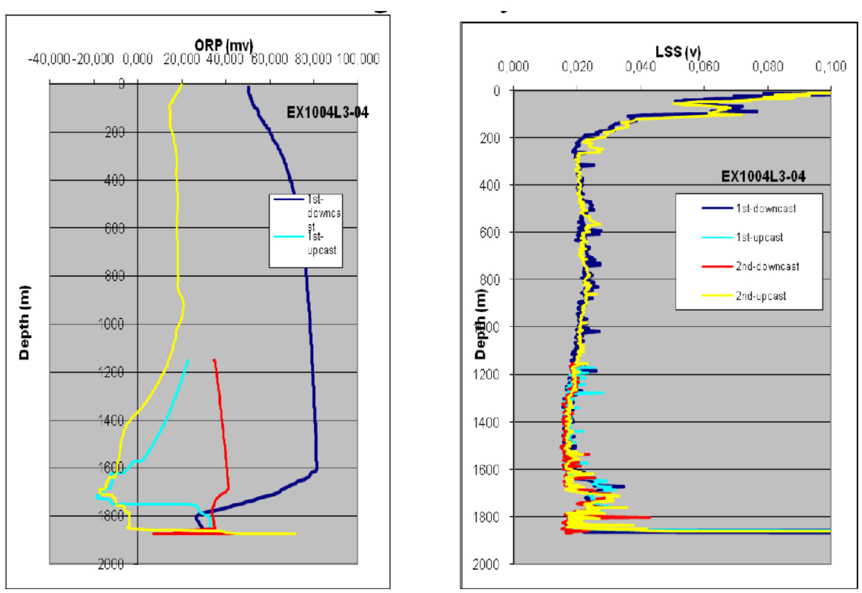


Figure 20. CTD cast with light scattering (LSS) and Oxidation-Reduction Potential (ORP) sensors showed anomalies from plumes between 1,600-1,900 m depth. Plumes from hydrothermal activities were indicated by strong concentrations of reduced species such as H_2S and Fe.

High levels of hydrothermal activity indicated by intense LSS and ORP measurements in the water column over Kawio Barat were later confirmed by direct video observations (Butterfield et al., 2010). None of the other volcanic features west of the Sangihe Arc that were investigated during the expedition had confirmed hydrothermal activity. ROV capabilities did not include physical sampling or temperature measurement, so the interpretation was based on visual comparison to other known sites. The steep western flank of Kawio Barat—from 2,000 m depth to the summit (1,850 m)—had many areas of white and orange staining on exposed rocks, with some elemental sulfur, and broad areas covered with dark volcaniclastic sand, but no active venting was seen. Kawio Barat has a summit ridge running WNW-ESE, with a major crosscutting ridge on the western portion of the summit. Hydrothermal activity was concentrated near the eastern side of this intersection, on both the northern and southern sides of the summit ridge. Venting on the northern side of the summit ridge was characterized by intense, white, particle-rich fluids emanating directly from the rocky substrate with frozen flows of elemental sulfur down slope. This type of venting is visually very similar to the venting seen on NW Rota-1, an actively erupting volcano in the Mariana Arc, and suggested that Kawio Barat was actively releasing magmatic gases rich in sulfur dioxide to produce the elemental sulfur flows, inferred fine particulate sulfur particles, and apparent acidic alteration. These hydrothermal features, along with the widespread occurrence of volcaniclastic deposits near the summit, suggest that Kawio Barat had experienced recent eruptive activity. In the southwest part of this summit chimney, drips of molten sulfur were observed in the proximity of microbial staining (**Figure 21**). In contrast, however, the south side of the summit had active metal sulfide chimneys venting clear to gray/black fluids. The vents seen on the south slope appeared identical to vents detected by the camera tow and reported by McConnachy et al. (2004). The visually dominant vent fauna was a type of stalked barnacle that covered much of the chimney surfaces, along with shrimp and scale worms (**Figure 22**).

Figure 21. Images from Kawio Barat (Left Panel) White and grey smokers of hydrothermal vents on the southwest of the Kawio Barat summit contained a lot of sulphate minerals. (Right Panel) Drips of molten sulfur were observed in the proximity of microbial staining in southwest part of the summit chimney.

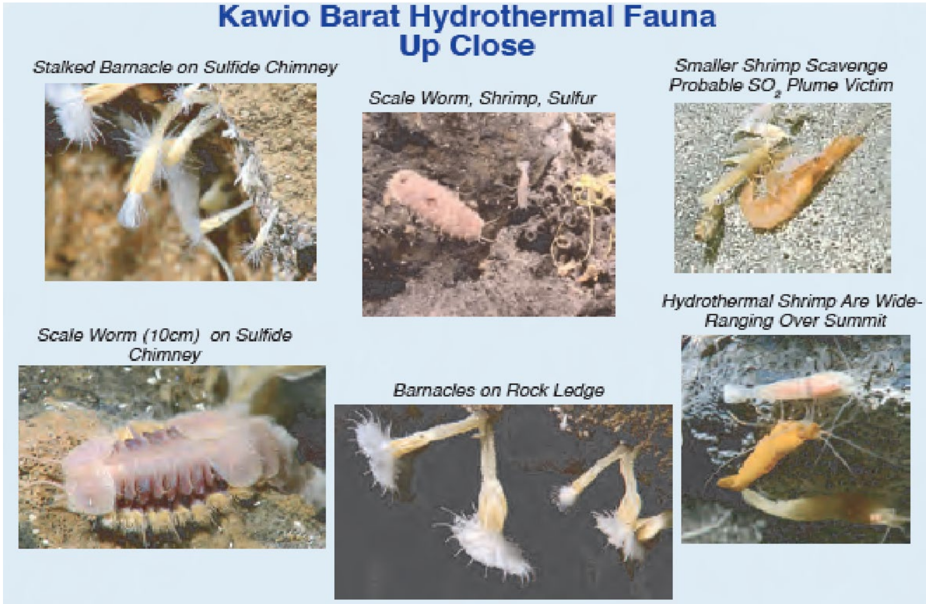


Figure 22. Representative images of fauna observed during the ROV dives over Kawio Barat in vicinity of hydrothermal activity.

8. Data Deposition and Archival

8.1 Data Collected

During the expedition, NOAA Ship *Okeanos Explorer* collected over 36,000 square kilometers of multibeam bathymetric and backscatter data in the Indonesian EEZ. The details of the multibeam sonar setup, data acquisition, files generated, and data processing are included in the corresponding mapping data reports (Malik et al., 2010a; Malik et al., 2010b; Lobecker et al., 2010a; Lobecker et al., 2010b). The EX-10-04 Data Management Plan can be found in Appendix A. These mapping data reports are available from:

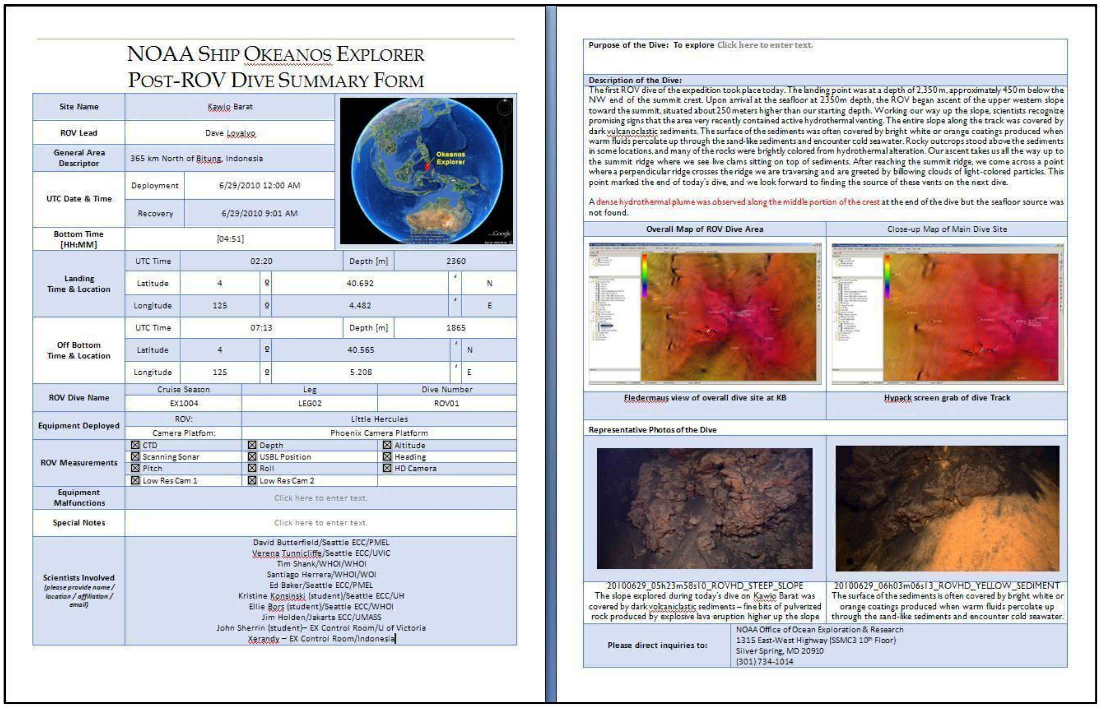
- EX1004L1: https://repository.library.noaa.gov/view/noaa/12477
- EX1004L2: https://repository.library.noaa.gov/view/noaa/12478
- EX1004L3: https://repository.library.noaa.gov/view/noaa/12479
- EX1004L4: https://repository.library.noaa.gov/view/noaa/12480

A total of 27 ROV dives were conducted. Only high-resolution video data were collected from the ROV and the camera platform HD video cameras. The scientists onboard and at ECCs closely monitored each dive. During each dive, a running commentary was maintained by both the onboard and shore-based scientists using a group chat room called the “Eventlog” (see section “Instant Messaging for Real-Time Data Logging and Collaboration”). An example of Eventlog entries for a dive conducted on June 29, 2010, is provided below (**Figure 23**). Eventlogs for each dive can be accessed through Digital Atlas: https://www.ncei.noaa.gov/maps/oer-digital-atlas/mapsOE.htm.

Date	Time (GMT)	Author	Event entry
6/29/2010	0:20:35	okeanosexplorer	The ROV "little hercules" is in the water. The first ROV deployment of the INDEX SATAL 2010 mission is now
6/29/2010	0:29:30	marzamarzuki	This is a test of the Jakarta iChat. Anyone getting this?
6/29/2010	0:29:41	craigrussell	Confirmed.
6/29/2010	0:30:35	okeanosexplorer	okeanos here, good to have you online Jakarta
6/29/2010	0:41:54	marzamarzuki	Hallo Seattle, are you there ?
6/29/2010	0:46:16	PMEL ECC	Hi Jakarta! This is Seattle.
6/29/2010	0:47:01	PMEL ECC	We are online, getting the live feeds, and getting everyone here set up on the collaboration tools and websites.
6/29/2010	1:03:34	webbpinner	This is DIVE NUMBER EX1004_LEG2_ROV01
6/29/2010	1:22:04	okeanosexplorer	Seattle and Silver Spring ECC's, can you please type into the log who is at your respective command centres?
6/29/2010	1:24:19	verenatunnicliffe	All: It will be awkward to name Dives with EX, LEG and ROV numbers: think of all the images, videos and data to annotate. A unique simple number is the Hercules dive number. Thoughts?
6/29/2010	1:27:37	okeanosexplorer	Verena I have passed your suggesstion along to those on the ship, a response will follow later
6/29/2010	1:38:56	kelleyelliott	Partcipants in the Seattle ECC include: Kelley Elliott (OER), Margot Bohan (OER), David Butterfield (PMEL), Verena Tunnicliffe (UVIC), Ed Baker (PMEL), Kristine Kosinski (UH), Eleanor (Ellie) Bors (WHOI), Ridge Liepins (PMEL), and
6/29/2010	1:39:49	santiagoherrera	All: I am happy to be joining in from my lab, with continuous phone contact to the Seattle ECC, ROV video and
6/29/2010	1:45:22	craigrussell	Great to have you online, Tim. -Craig Russell
6/29/2010	1:47:06	davebutterfield545	Proposed CTD way points: start 125 3'51.96", 4 40'18"
6/29/2010	1:47:34	davebutterfield545	CTD way point 2 125 05'00", 4 40'26"
6/29/2010	1:48:48	davebutterfield545	Goal is to start with vertical at way point 1, then move from 1 to 2 raising and lowering the CTD (to within about
6/29/2010	1:51:11	davebutterfield545	Seattle note: Ridge and Jim have made some progress with the video recording. The hardware has limitations and
6/29/2010	1:54:01	marzamarzuki	ECC Jakarta uses DVR from pioneer to have standard def recorder and slingbox to sent the streaming from
6/29/2010	1:57:11	davebutterfield545	Is the input to your DVR the HDMI from the VLC source?
6/29/2010	1:58:54	okeanosexplorer	Update from the Okeanos Explorer: local EX time is 1000. We are continuing our descent over the summit of Kawio Barat. We are currently at a depth of 1850m and expect to reach the bottom shortly.
6/29/2010	2:01:04	marzamarzuki	Our DVR input is from slingbox, slingbox input is from S-Video output computer
6/29/2010	2:20:25	okeanosexplorer	Update from the Okeanos Explorer: local EX time is 1020. We have reached the seafloor on the western flank of
6/29/2010	2:21:22	okeanosexplorer	surrent depth is 2353m
6/29/2010	2:21:23	davebutterfield545	ROV on bottom, depth 3
6/29/2010	2:21:50	okeanosexplorer	current depth is 2353m
6/29/2010	2:22:03	davebutterfield545	ROV on bottom, depth 2353
6/29/2010	2:23:08	okeanosexplorer	shrimp spotted swimming above the seafloor
6/29/2010	2:23:52	santiagoherrera	looks really cemented -ts
6/29/2010	2:24:14	verenatunnicliffe	Bottom is sediment with mottled suface; scaour around large rock
6/29/2010	2:24:59	verenatunnicliffe	Loose rubble on sediment

Figure 23. Example of few entries in the Eventlog during the dive conducted on June 29, 2010.

For each dive, a dive summary was developed soon after completion of the dive to capture important information about the dive and also include few representative images. The dive summary form was completed by close collaboration between the onboard staff and the shore-based scientists at ECCs. A dive summary from the first dive of the expedition (conducted on June 29, 2010) is provided below as an example (**Figure 24**). Each dive summary can be individually downloaded from the NOAA repository: https://repository.library.noaa.gov/.



NOAA SHIP OKEANOS EXPLORER
POST-ROV DIVE SUMMARY FORM

Site Name	Kawio Barat					
ROV Lead	Dave Lovalvo					
General Area Descriptor	365 km North of Bitung, Indonesia					
UTC Date & Time	Deployment	6/29/2010 12:00 AM				
	Recovery	6/29/2010 9:01 AM				
Bottom Time [HH:MM]	[04:51]					
Landing Time & Location	UTC Time	02:20		Depth [m]	2360	
	Latitude	4	º	40.692	′	N
	Longitude	125	º	4.482	′	E
Off Bottom Time & Location	UTC Time	07:13		Depth [m]	1865	
	Latitude	4	º	40.565	′	N
	Longitude	125	º	5.208	′	E
ROV Dive Name	Cruise Season	Leg	Dive Number			
	EX1004	LEG02	ROV01			
Equipment Deployed	ROV:	Little Hercules				
	Camera Platfom:	Phoenix Camera Platform				
ROV Measurements	☒ CTD	☒ Depth	☒ Altitude			
	☒ Scanning Sonar	☒ USBL Position	☒ Heading			
	☒ Pitch	☒ Roll	☒ HD Camera			
	☒ Low Res Cam 1	☒ Low Res Cam 2				
Equipment Malfunctions	Click here to enter text.					
Special Notes	Click here to enter text.					
Scientists Involved (please provide name / location / affiliation / email)	David Butterfield/Seattle ECC/PMEL Verena Tunnicliffe/Seattle ECC/UVIC Tim Shank/WHOI/WHOI Santiago Herrera/WHOI/WOI Ed Baker/Seattle ECC/PMEL Kristine Konsinski (student)/Seattle ECC/UH Ellie Bors (student)/Seattle ECC/WHOI Jim Holden/Jakarta ECC/UMASS John Sherrin (student)– EX Control Room/U of Victoria Xerandy – EX Control Room/Indonesia					

Purpose of the Dive: To explore Click here to enter text.

Description of the Dive:
The first ROV dive of the expedition took place today. The landing point was at a depth of 2,350 m, approximately 450 m below the NW end of the summit crest. Upon arrival at the seafloor at 2350m depth, the ROV began ascent of the upper western slope toward the summit, situated about 250 meters higher than our starting depth. Working our way up the slope, scientists recognize promising signs that the area very recently contained active hydrothermal venting. The entire slope along the track was covered by dark vulcanoclastic sediments. The surface of the sediments was often covered by bright white or orange coatings produced when warm fluids percolate up through the sand-like sediments and encounter cold seawater. Rocky outcrops stood above the sediments in some locations, and many of the rocks were brightly colored from hydrothermal alteration. Our ascent takes us all the way up to the summit ridge where we see live clams sitting on top of sediments. After reaching the summit ridge, we come across a point where a perpendicular ridge crosses the ridge we are traversing and are greeted by billowing clouds of light-colored particles. This point marked the end of today's dive, and we look forward to finding the source of these vents on the next dive.

A dense hydrothermal plume was observed along the middle portion of the crest at the end of the dive but the seafloor source was not found.

Overall Map of ROV Dive Area	Close-up Map of Main Dive Site
Fledermaus view of overall dive site at KB	Hypack screen grab of dive Track

Representative Photos of the Dive

20100629_05h23m58s10_ROVHD_STEEP_SLOPE The slope explored during today's dive on Kawio Barat was covered by dark volcaniclastic sediments – fine bits of pulverized rock produced by explosive lava eruption higher up the slope	20100629_06h03m06s13_ROVHD_YELLOW_SEDIMENT The surface of the sediments is often covered by bright white or orange coatings produced when warm fluids percolate up through the sand-like sediments and encounter cold seawater.

Please direct inquiries to:	NOAA Office of Ocean Exploration & Research 1315 East-West Highway (SSMC3 10th Floor) Silver Spring, MD 20910 (301) 734-1014

Figure 24. An example of the dive summaries compiled during the expedition; this summary shows the details of the first dive of the expedition, conducted on June 29, 2010.

The multibeam data results from both *Okeanos Explorer* and *Baruna Jaya IV* are available at the NOAA National Centers for Environmental Information (NCEI) website and can be located by visiting: https://maps.ngdc.noaa.gov/viewers/bathymetry/ (last accessed Dec. 2020). To access these data, click on the Search Bathymetric Surveys button, either select "NOAA Ship Okeanos Explorer" from the Platform Name dropdown menu and select "EX1004" from the Survey ID dropdown menu for the *Okeanos Explorer* data, or select "Baruna Jaya IV" from the Platform Name dropdown menu and "INDEX2010" from the Survey ID dropdown menu for the *Baruna Jaya IV* data. Click OK, and the ship track for the cruise will appear on the map. Click the ship track for options to download data.

8.2 OER Data Discoverability Tools

All data collected by *Okeanos Explorer* are archived and publically available within 90 days of the end of each cruise via the NCEI online archives. Data can be accessed via the OER Digital Atlas at https://www.ncei.noaa.gov/maps/oer-digital-atlas/mapsOE.htm (Last accessed Dec. 2020). To access these data, click on the Search tab, and enter "EX1004L1" for Leg 1, "EX1004L2" for Leg 2, "EX1004L3" for leg 3, or "EX1004L4" for Leg 4. Click on the point that represents the desired cruise to access data options. In the pop-up window, select the Data Access tab to download data.

Products created during the cruise—including the ship track, shaded bathymetry, dive locations and tracks, ship's meteorological and oceanographic sensor data, and status reports —can be viewed on the interactive OER Digital Atlas.

Additional data requests, including daily situation reports, internal operation records, and data from previous archived expeditions can be sent to: oer.info.mgmt@noaa.gov.

8.3 Video Data

Okeanos Explorer video data are publicly available shortly after each expedition. Highlight videos and still images can be found on the OER website at https://oceanexplorer.noaa.gov/okeanos/explorations/10index/ (Last accessed Dec. 2020). Additionally, expedition video data can be found using the OER Video Portal at https://www.nodc.noaa.gov/oer/video/ (Last accessed Dec. 2020).

9. References

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10. Appendices

Appendix A: Data Management Plan

Note: The appendix is based on documentation available at the time of the expedition and may contain information that is outdated. For any further question or assistance with the data access please contact: oer.info.mgmt@noaa.gov

Data Management Plan Overview

The data collected and/or recorded and products generated as a result of the *INDEX-SATAL 2010* mission will be managed by an Integrated Product Team (IPT) charged with managing data and products for OER. The IPT is comprised of personnel from OER, the NOAA Data Centers, and other extramural partners.

In a new exploration paradigm, data recorded, products generated, and reported discoveries made during an *Okeanos Explorer* mission will be made discoverable and accessible to the general public in as close to real-time as possible.

Discoverability and accessibility to these data will be made available through a variety of access points, including the ECC, secure FTP servers, account controlled content management sites, metadata search engines, public access websites, and geospatial applications called Digital Atlas and *Okeanos* Atlas.

Data Management Disclaimer

This plan is based on the latest information as of May 20, 2010, and assuming a best-case scenario for operations planned for the NOAA Ship *Okeanos Explorer* (EX) and the *Baruna Jaya IV* (BJIV) during the *INDEX-SATAL 2010* mission.

Project Summary

This joint project involves two vessels, the EX and the Indonesian BJIV, in the SATAL region in Indonesian waters. During the mission and at port calls in between the expedition legs, data and data products will be shared between the two vessels and the ECCs via a communication and data exchange strategy. This document describes the proposed communication and data exchange strategies.

Data Exchange During Mission

Communication Strategy

The principal Indonesian scientists and the principal U.S. scientists will be stationed at one of the ECCs in Jakarta, Indonesia, or Seattle, Washington. There will be a telepresence or teleconference capability on the BJIV, the EX, and at each of the ECCs, including ECCs elsewhere in the U.S. Using this capability, the science teams can collaborate with the ships and each other to develop the latest plans using the latest data and information. Data, including scientific data as well as video, images, Eventlogs, and data products, will be shared through the shoreside redistribution server at URI for the benefit of the science teams as well as the benefit of other project partners, including educators, media and public affairs representatives, website managers, and data managers. The communications strategy during the mission is illustrated in **Figure A1**.

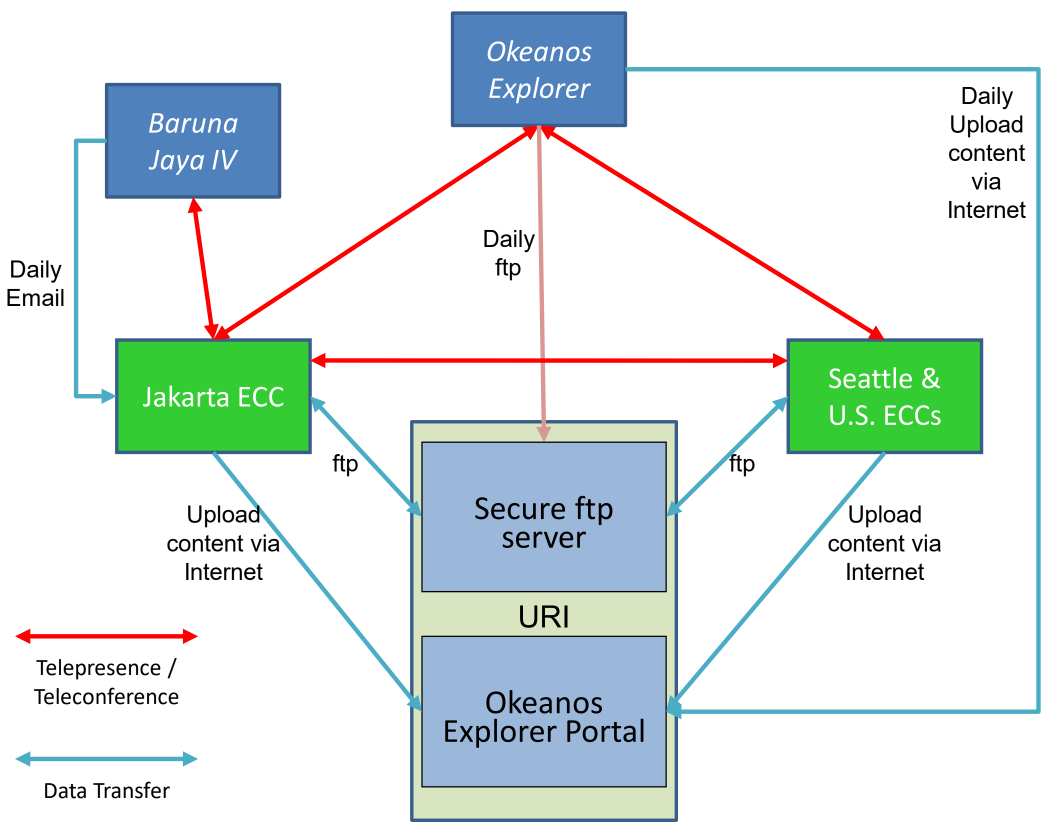


Figure A1. Communications Strategy

The EX, the BJIV, and the ECCs will be able to collaborate through telepresence or via teleconferencing throughout the mission. Data from the EX necessary for these collaboration sessions can be transmitted to the FTP server at URI or can be uploaded to the *Okeanos*

Explorer Portal. Data from the BJIV can be emailed to the Jakarta ECC; and the responsible party at the Jakarta ECC can transmit the data to the FTP server at URI or upload to the *Okeanos Explorer* Portal. The EX will have an automated data transfer session at a time of low bandwidth use to transmit the shipboard hull-mounted, flow-through or off-board sensor data; specific multibeam data products; and selected images and video clips.

Data Exchange Strategy

The data exchange strategy is illustrated in **Figure A2**. The BJIV will only have the ability to send data via email and will do so throughout the project via the ECC at Jakarta, who will, upon receipt, FTP it to the URI server. Each day, the BJIV will email a GeoTIF of that day's multibeam survey and an American Standard Code for Information Interchange (ASCII) file containing the ship's position and the readings of the BJIV's meteorological and oceanographic (METOC) sensor suite. If a CTD cast is performed from the BJIV, the resulting CTD profile image will be emailed, and if a notable event or discovery is made, a log with an accompanying image will be emailed.

Each day, the EX will submit a package of data, HD and low-resolution video, images, and other information using the VSAT to the URI FTP server. Additionally, some video clips and images chosen for media use or special product generation—along with daily situation reports, daily logs, and some products—will be uploaded to the *Okeanos Explorer* Portal, a Plone CMS also hosted at URI, to be entered into standard operating procedures (SOPs) to move the content through an approval process and released for public consumption.

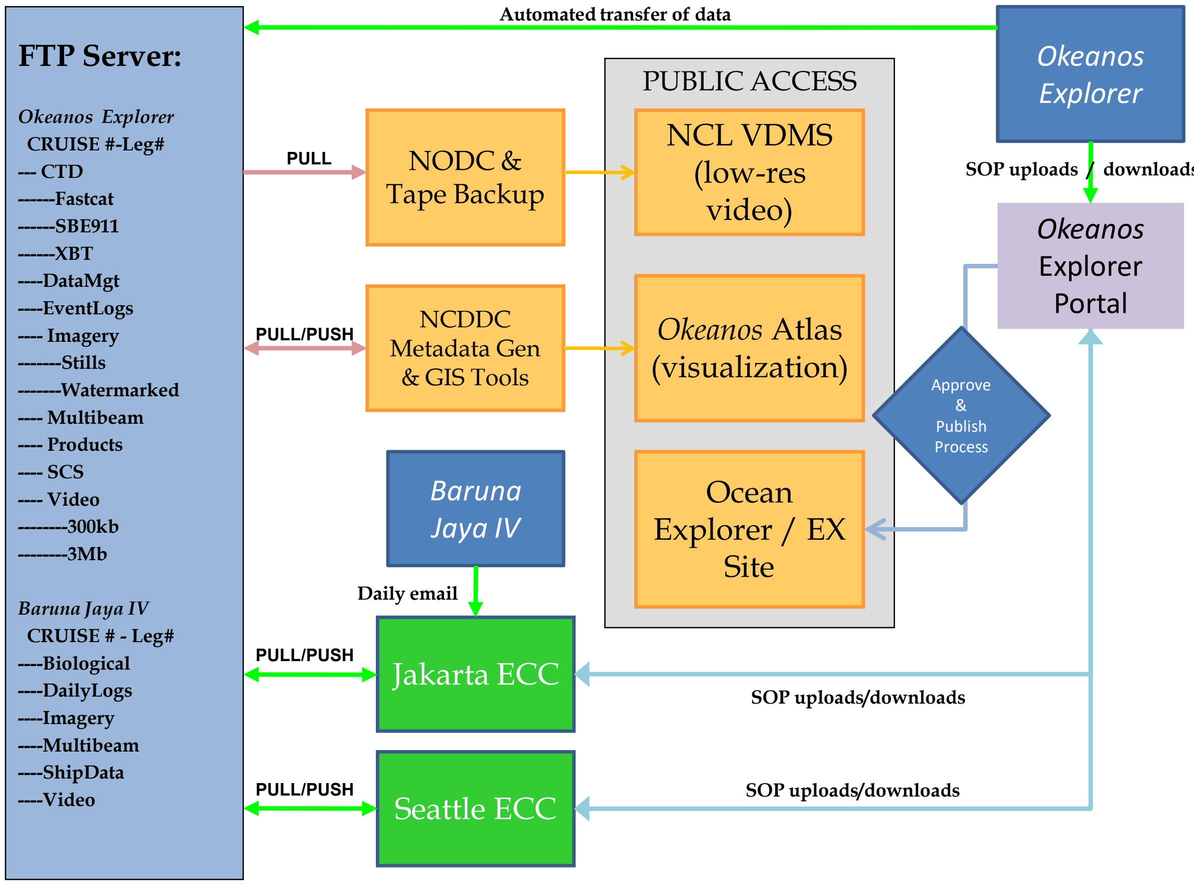


Figure A2. Data Exchange Strategy

Shoreside Redistribution Server

The shoreside redistribution server at URI has a secure FTP server and a CMS, called the *Okeanos Explorer* Portal, in place for the *INDEX-SATAL 2010* mission. SOPs for transmitting data to the shoreside redistribution server at URI are documented in a series of published SOPs for the mission:

- *Okeanos Explorer* Portal Protocols Standard Tasks
- Plone FTP Site SOPs
- Daily Highlight Image Protocols
- *Okeanos Explorer* Portal: SOPs *INDEX-SATAL 2010* Participants
- iChat Server Protocols for *INDEX-SATAL 2010* Participants

The data management team at the NOAA National Coastal Data Development Center (NCDDC) will have access to this server. NCDDC procedures will ensure that metadata are compliant with the government and Library of Congress standards, and are generated and saved to the FTP server with the corresponding video files. The data management team at the NOAA

National Oceanographic Data Center (NODC) will pull the contents from the FTP server each day, according to a manifest file and an SOP, into a secure, private, and dedicated storage space for a tape backup and for pickup by the NOAA Central Library (NCL). Through another SOP, the NCL will pull the low-resolution, web streaming quality video segments and the corresponding metadata into the ocean exploration digital video (OEDV), their server dedicated for the Video Data Management System (VDMS), for access through the online library catalog, NOAALink, and the catalog record set up for the *INDEX-SATAL 2010* mission.

FTP Server

On the secure FTP server at URI, there will be two main folders for the *Okeanos Explorer* and *Baruna Jaya IV* information. Beneath those main folders will be subfolders for cruise leg identification; and beneath those will be subfolders for the separate data types that will be transmitted. The file names should use a naming convention that includes the date in YYYYMMDD format.

/OkeanosCruises
  /EX1004_Leg# (Cruise Designation)
    /CTD
      /Fastcat (CTD and ASVP files from the ROV's Seabird FastCAT, for the given day)
      /SBE911 (CTD and ASVP files from the ship's SBE911+, for the given day)
      /XBT (CTD and ASVP files from the ship's XBTs, for the given day)
    /DataMgt (HDF5 files used by the EX Data management team)
    /EventLogs (Eventlog files, for the given day)
/Imagery
    /Stills (Still imagery, for the given day)
    /Watermarked (Watermarked images, for the given day)
    /In-situ_Products (In situ products, for the given day)
/Multibeam (ASCII .xyz files and cumulative GeoTIFs from the multibeam survey for the given day)
/SCS (ASCII data files for the ROV and ship's sensors that are collected by the Scientific Computer System, for the given day)
    /Video (Video clips from the given day)
      /300kb (low-resolution, web-streaming quality)
      /3Mb (HD)

/BarunaJayaIVCruises
    /Biological
/CTD
    /DailyLogs

/Imagery
/Multibeam
/ShipData
/Video

Okeanos Explorer Portal

The data management team will check daily for publicly releasable products on the *Okeanos Explorer* Portal. Some daily logs with images, web-streaming quality video clips, and images may be displayed on the Okeanos Atlas during the mission.

Data Exchange Agreements and Archive Strategies

At a data management meeting in April 2010, an agreement was made as to the data types and formats that would be exchanged between the U.S. and Indonesia, along with the time frame and the method of exchange. The following sections outline those agreed upon details.

Multibeam Survey Data/Products

Data Exchange: U.S. to Indonesia (Survey Mapping)

When	Data Type	Data Format	How
Daily	Cumulative Image	GeoTIF	ftp server (automated)
Post-site survey*	Cleaned and edited Grid	Digital Terrain Model (.dtm)	ftp server (manual)
Post-site survey	Survey Processed Image	Fledermaus .sd format	ftp server (manual)
Post-site survey	Cleaned and edited xyz file	ASCII file with longitude, latitude, and depth (unprojected geographic coordinates in decimal degrees using a WGS84 datum)	ftp server (manual)
3 weeks after EX data reaches UNH	Raw, processed ASCII xyz, products generated from cleaned data, Final mapping summary	.all, .wcd, ASCII, GeoTIF, .dtm, .sd, .pdf	Hard drive delivery

* "survey" of a particular area may take hours to days

Figure A3. Multibeam Survey Data Exchange Agreement (U.S. to Indonesia)

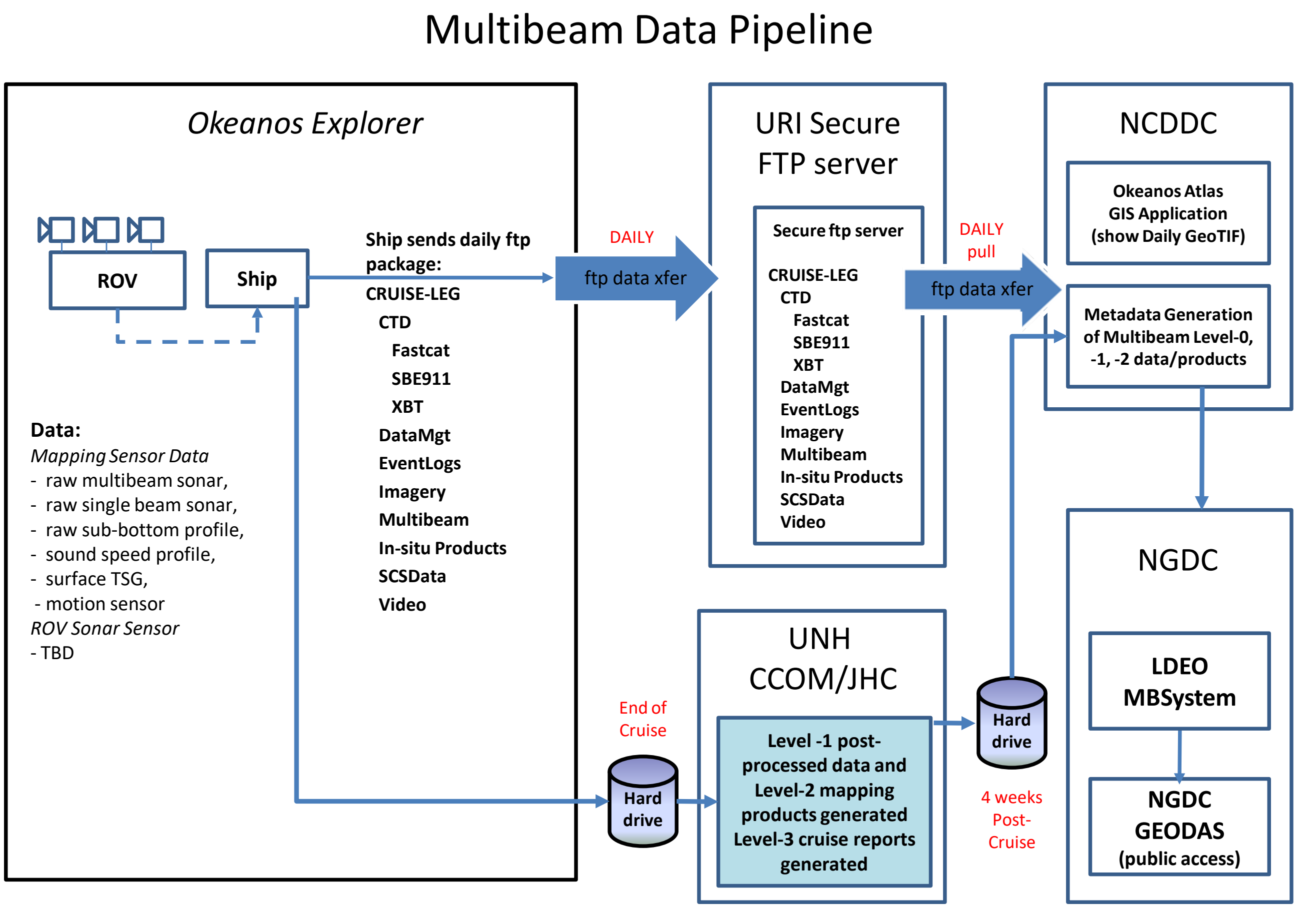
Note 1: If the automated FTP transfer is not functioning properly, the expedition coordinator should delegate the *task of transmitting the daily cumulative GeoTIF and the corresponding .xyz file to the URI FTP server.*

Note 2: There may be more than one survey during a leg, so the post-site survey actions may happen more than once in a leg.

The daily cumulative GeoTIF will be picked up by the GIS team at the NCDDC and geospatially displayed in the Okeanos Atlas as soon as possible after it is received. The GeoTIF and the corresponding .xyz file may be made accessible to the Education team's Expedition Education Module (EEM) to fulfill their goals of having lesson plans using near real-time multibeam survey data. The daily and end of survey data and products will not be archived.

The multibeam survey data collected by bottom-looking sensors and complementary sensors and the products generated after the data is returned to and post-processed at UNH after the mission will be archived at the National Geophysical Data Center (NGDC) in Boulder, CO. These data will be accompanied with a collection level metadata record for the NGDC. In addition, the submission to NGDC will include the following:

- Raw (level-0) mapping survey data
- Post-processed, quality assured, and edited (level-1) data
- Specific data products (level-2) including GeoTIF images and gridded bathymetric files
- Comprehensive mapping survey data cruise summary (level-3) report



*Due to the size of the data files, all multibeam raw data transfer is handled via hard drive exchange. Using CIMS, NCDDC creates individual metadata files for each level 0 data file, and works with UNH to create metadata for all post-processed data files and products. NCDDC will submit data/metadata to NGDC for archive.

Figure A4. Multibeam Survey Data Pipeline

Data Class	Instrument	Data Type	Format	Metadata Granularity	Archive Center
GEO	Kongsberg Simrad EM 302 (30 kHz)	Multibeam Bathymetry, Bottom Backscatter, Water Column Backscatter (proprietary format read into MBSystem)	.all, .wcd (propriet ary)	1 meta rec per .all file in Multibeam Data folder and subfolders	NGDC
GEO	Kongsberg EA600 (12 kHz)	Singlebeam (x,y,depth)	.txt, .xyz (ASCII), .dg, .out, .raw (propriet ary)	1 meta rec = SingleBeam Raw Data folder	NGDC
GEO	Knudsen CHIRP 3260 (3.5 kHz)	Sub-bottom profile	.sgy, .kea, .keb (propriet ary) .	1 meta rec = Subbottom Profile Data folder	NGDC
OCN	Calculated	Sound Velocity (m/s)	.asvp (ASCII)	1 meta rec = Profile_Data/SVP or Profile_Data/ASVP	NGDC

Figure A5. Multibeam Survey Metadata/Archive Instructions

Video/Imagery Data/Products

Data Exchange: U.S. to Indonesia (Images/Video)

When	Data Type	Data Format	How
Daily	Up to two hours of Video segments	Low-res and High-Def resolution .mov	ftp server (automated)
Regularly	Digital Still Images or Frame Grabs	High-definition	ftp server (automated)

Video clips will follow the following naming convention:

YYYYMMDD_HHMMSS_Cam_<optional caption>_Res.mov

where Cam is the camera source ID and Res is either 'hd' for high-definition or 'web' for low-resolution. An initial caption can be placed between the Cam and Res indicators between two underscore characters ('_'). The naming convention is the initial source for metadata for the video clips.

Images and Framegrabs will need a similar naming convention, yet to be determined.

Figure A6. Video Data Exchange Agreement (U.S. to Indonesia)

Video segments and images to be preserved will be marked and saved onboard the EX through collaboration with the remote science team. These selected multimedia files will be sent via automated processes to transmit the data to the secure FTP server at URI. Video segments and images intended to be used for media or public outreach can also be uploaded to the *Okeanos Explorer* Portal, a Plone CMS also hosted at URI, to be entered into SOPs to move the content through an approval workflow in the Portal and released for public consumption.

Each day, the daily packet of data and information transmitted to the URI FTP server will contain up to two hours of video segments marked for preservation. These clips will be saved in two resolutions—HD and web-streaming, low-resolution quality.

Low-resolution video segments will be archived at the NCL in Silver Spring, MD, a division of NODC. All of the data and information from the URI FTP server, including the HD video segments will be temporarily stored in private and dedicated storage space on the NODC server and periodically backed up in a scheduled tape rotation.

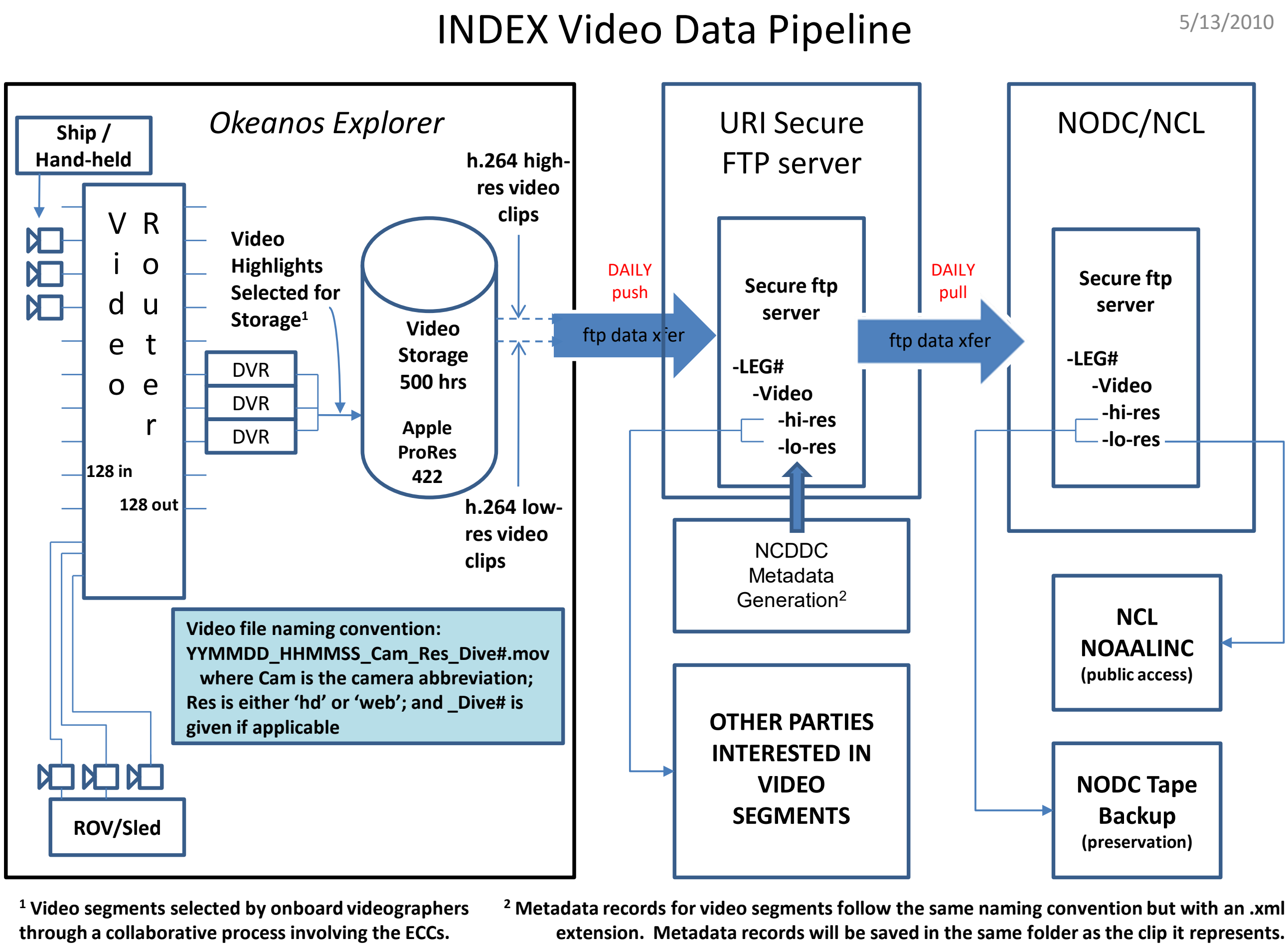


Figure A7. Video Data Pipeline

Oceanographic/Meteorological/Navigational Data

Data Exchange: U.S. to Indonesia (METOC, Nav, Other)

When	Data Type	Data Format	How
Daily	SCS Data (navigation, weather, oceanographic)	ASCII	ftp server (automated)
Daily	SCS Compressed Data including vessel, ROV, and Sled sensors	HDF5	ftp server (automated) & ftp via Fleet 77
When available	CTD Cast Data	ASCII	ftp server (automated)
When available	XBT Cast Data	ASCII	ftp server (automated)
When available	Event Logs	ASCII	ftp server (automated)

Figure A8. Oceanographic/Meteorological/Navigational Data Exchange Agreement (U.S. to Indonesia)

Data from hull-mounted, off-board, and submersible vehicle METOC sensors monitored through the ship's Scientific Computer System (SCS) will be archived at the NODC Marine Data Stewardship Division (MDSD) in Silver Spring, MD. A collection level metadata record describing the data inventory to be archived at the NODC/MDSD will be included with the data submission.

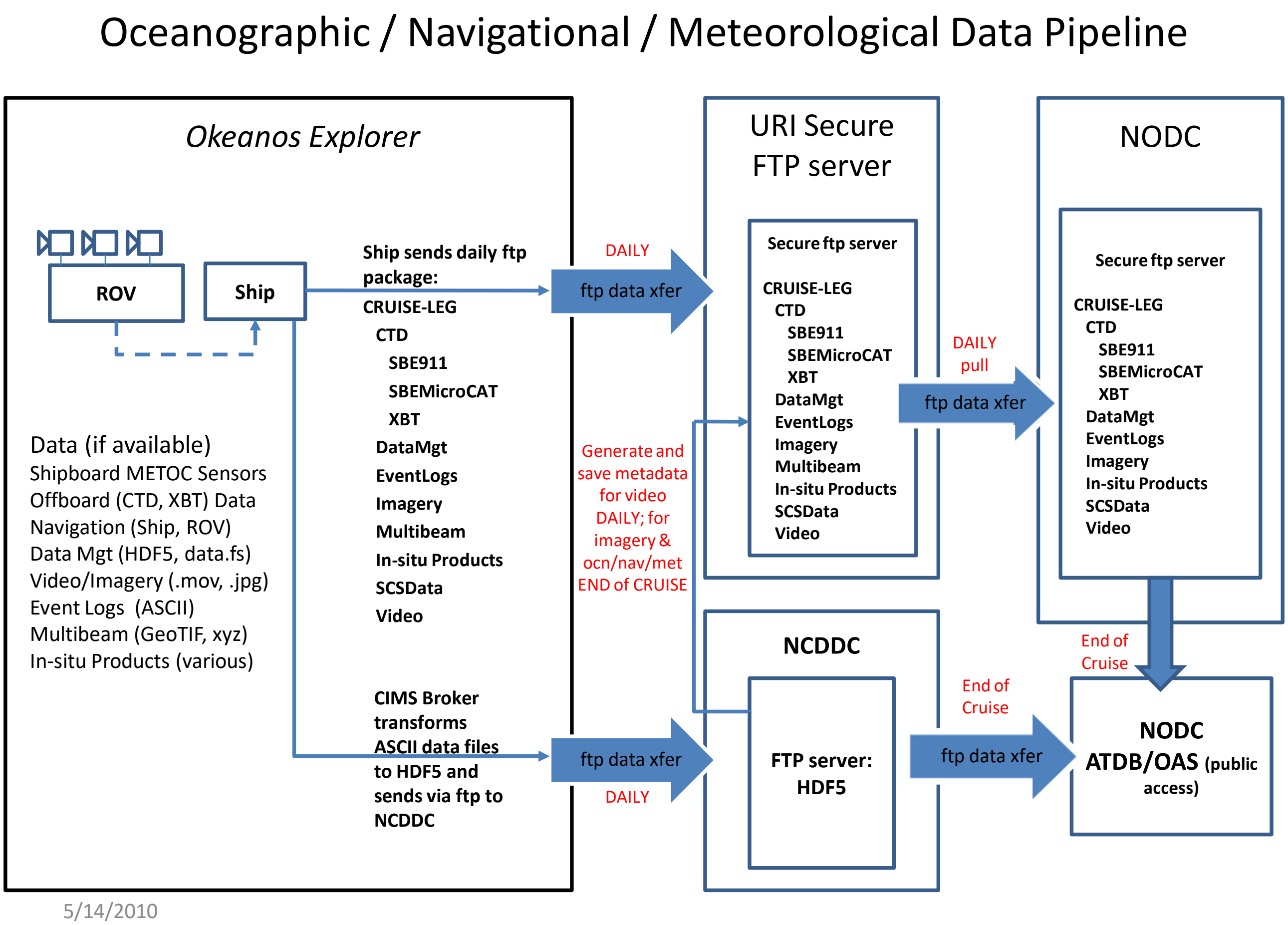


Figure A9. Oceanographic/Meteorological/Navigational Data Pipeline

Data Class	Instrument	Data Type	Format	Metadata Granularity	Archive Center
MET	RM Young 61202V	Barometric Pressure (mB)	.raw (ASCII)	1 meta rec = baro*.raw files in SCS_Data/Met folder	NODC/MDSD
MET	RM Young 41382VC	Air Temperature (deg C)	.raw (ASCII)	1 meta rec = met*.raw files in SCS_Data/Met folder	NODC/MDSD
MET	RM Young 41003P	Relative Humidity (Pct)	.raw (ASCII)	1 meta rec = met*.raw files in SCS_Data/Met folder	NODC/MDSD
MET	RM Young 05106/RM Young 05306B	Relative Wind Speed (knots)/Relative Wind Direction (degrees)	.raw (ASCII)	1 meta rec = Wind*.raw files in SCS_Data/Met and SCS_Data/Wind folder	NODC/MDSD
MET	Derived	True Wind Speed (knots)/True Wind Direction (degrees)	.raw (ASCII)	1 meta rec = SCS_Data/TWind folder	NODC/MDSD
MET	Epply PSP and PIR	Solar Radiation (kWh/m2)	.raw (ASCII)	1 meta rec = met*.raw files in SCS_Data/Met folder	NODC/MDSD
NAV	Applanix POS MV 320	Location, Heading, Attitude (Decimal degrees, degrees, degrees)	.raw (ASCII)	1 meta rec = SCS_Data/POSMV folder	NODC/MDSD
NAV	CNAV DGPS/C-NAV 2000	Global Position (Decimal degrees)	.raw (ASCII)	1 meta rec = SCS_Data/CNAV and SCS_Data/DGPS	NODC/MDSD
NAV	Gyro Compass	Compass Readings	.raw (ASCII)	1 meta rec = SCS_Data/Gyro folder	
OCN	SeaBird SBE-9plus	Conductivity, Temperature, Depth	.raw (ASCII)	1 meta rec = SCS_Data/CTD folder and Profile_Data/CTD folder	NODC/MDSD
OCN	SeaBird SBE-45 Micro	Temperature, Salinity, Sound Velocity (deg C, psu, m/s)	.raw (ASCII)	1 meta rec = SCS_Data/SciSwSys folder	NODC/MDSD
OCN	Sippican MK-21 eXpendable BathyThermograph (XBT)	Temperature, Depth, Sound Velocity (deg C, meters, m/s)	.edf (ASCII)	1 meta rec = Profile_Data/XBT folder	NODC/MDSD
OCN	Calculated	Sound Velocity (m/s)	.asvp (ASCII)	1 meta rec = Profile_Data/SVP or Profile_Data/ASVP	NODC/MDSD

Figure A10. Oceanographic/Meteorological/Navigational Metadata/Archive Instructions

Data Exchange: Indonesia to U.S.

When	Data Type	Data Format	How
Daily	Survey Images	GeoTIF (not cumulative)	Email to ECC ECC transmit to ftp site
Daily	Ship track and sensor readings from Baruna Jaya IV	ASCII – format description required; suggested format given	Email to ECC ECC transmit to ftp site
Post-Leg I, II	xyz multibeam files	ASCII (.ira files in UTM zone instead of geographic; easting, northing, depth)	DVD
Post-Leg I, II	CTD data	ASCII	DVD
Periodically	CTD Profile	.jpg with location	Email to ECC ECC transmit to ftp site
Periodically	Text log with image (if possible)	Any non-proprietary format	ECC collab; email to ftp site
Periodically	Biological	Image, ASCII data	ECC collab; email to ftp site

Figure A11. Data Exchange Agreement (Indonesia to U.S.)

At the April 2010 Data Management Planning meeting, an agreement was made on the data types, formats, and transmission methods for a data exchange during the *INDEX-SATAL 2010* mission. **Figure A11** describes this agreement.

Post-Mission Data Management

Product	Release?	Archive?	Format/Size	Archive Center	Originator
Daily Situation Report	No	No	.doc/ <500K	n/a	Expedition Coordinator
Quick Look Report	Yes	Yes	.pdf/	NCL	Lead Scientist
Final Cruise Plan	Yes	Yes	.pdf	NCL	Expedition Coordinator
Final Cruise Assessment	No	No		n/a	Expedition Coordinator
Final Cruise Summary Report*	Yes	Yes	.pdf	NCL	Lead Scientist
Final Cruise Mapping Data Report*	Yes	Yes	.pdf	NCL, NGDC	Mapping Survey Lead Scientist
Gridded Mapping Data Products*	Yes	Yes	GeoTIFF (.tif), xyz grids (.txt), IVS objects (.dtm, .sd, .shade, .geo), screen shots (.bmp)	NCL, NGDC	Mapping Survey Lead Scientist

Reports and Products

Figure A12. Products/Reports for Archive

***Approval Process required before publishing**

Figure A12 describes the current understanding of the reports and products to be archived as a result of the *INDEX-SATAL 2010* mission. The reports mentioned can be picked up from the *Okeanos Explorer* Portal by the Data Management team when they are ready for archive or otherwise emailed to the Data Management Coordinator. The products from the mapping survey team will be delivered via hard drive several weeks post-cruise. See **Figure A4** for an illustration of that pipeline.

Geographic Information Systems (GIS)

Links to these archived data sets and products will be discoverable through the Okeanos Atlas, a GIS application developed and maintained at NCDDC, a division of NODC. The Atlas will display the ship's hourly track and an hourly snapshot of selected METOC sensors along the track. Sometime after the cruise's end, the hourly track will be thinned to a daily track that will be displayed from a geospatial database. The following lists the geospatial layers that will represent the cruise in the GIS.

Geographic Information Data Layers

Layer	Data Source	GIS format	Additional Data, if available
Cruise Tracks	EX and BJ4 (if avail)	Line	Daily snapshot of METOC sensor readings (if available)
ROV/Sled Tracks	EX	Line	Possibly geotagged images will be available to view
Survey Images	Survey Teams on EX and BJ4	Image overlay	GeoTIF split into .png and World File, corresponding xyz file in ASCII
Daily Logs	EX and BJ4 (when available)	Related product	Text and associated image
CTD Casts	EX and BJ4 (when available)	Point	CTD Profile
Final Cruise Summary Report	Expedition Coordinator	Related product	
Final Cruise Mapping Data Report	Multibeam Survey Lead	Related product	
Mapping Data Products	Multibeam Survey Lead	Related product	

Expedition Education Modules (EEM) and Lesson Plans

OER's Education Team will develop an EEM and specific lesson plans for the *INDEX-SATAL 2010* mission. If possible, the IPT will provide the following for near real-time data to be used in these Education products.

Data and Products for Education Use

Description of Data or Product	From (Format)	To (Format)
Multibeam xyz (lat, lon, depth) grid	/Multibeam on FTP Server (ASCII xyz file)	NCDDC (convert to ASCII .csv & shapefile)
Survey image for Okeanos Atlas GIS overlay	/Multibeam on FTP Server (GeoTIF)	NCDDC (convert to .png)
3D fly-through imagery	/Multibeam on FTP Server (.sd)	NCDDC (convert to .mov)
SCS navigation, meteorology, oceanographic sensors	NCDDC FTP server (hdf5)	NCDDC (convert to ASCII .csv)
SeaBird output data files (not through SCS)	/CTD/SBE911 (Seabird output)	NCDDC (convert to ASCII .csv)

Data Management Points of Contact

The following table lists the points of contact for the successful implementation of this Data Management Plan for the *INDEX-SATAL 2010* mission (For current point of contacts please email oer.info.mgmt@noaa.gov.

INDEX-SATAL 2010 Data Management POC

Who	Role	Org	Email Address
Jeremy Potter	Mission Coordinator	OER	Jeremy.Potter@noaa.gov
Catalina Martinez	Expedition Coordinator	OER	Catalina.Martinez@noaa.gov
Webb Pinner	Technical Director	OER	Webb.Pinner@noaa.gov
Sharon Mesick	IPT Federal Program Manager	NCDDC	Sharon.Mesick@noaa.gov
Susan Gottfried	IPT Data Management Coordinator	NCDDC	Susan.Gottfried@noaa.gov
Scott Hill	IPT Software Team Lead	NCDDC	P.Scott.Hill@noaa.gov
Michael Purwoadi	Indonesia Data Management Coordinator	BPPT	purwoadi@ceo.bppt.go.id
Betsy Gardner	IPT GIS Lead	NCDDC	Betsy.Gardner@noaa.gov

IMPLEMENTING ARRANGEMENT

BETWEEN
THE GOVERNMENT OF THE UNITED STATES OF AMERICA
AND
THE GOVERNMENT OF THE REPUBLIC OF INDONESIA

CONCERNING
U.S. - INDONESIA SCIENTIFIC AND TECHNICAL COOPERATION IN OCEAN EXPLORATION, INCLUDING HYDROTHERMAL VENTS, VOLCANOLOGY, SEAFLOOR MAPPING, OCEANOGRAPHY, HABITAT CHARACTERIZATION, DEEP SEA FLORA AND FAUNA, AND OCEAN EXPLORATION TECHNOLOGY

PREAMBLE

This Implementing Arrangement establishes an Indonesia-U.S. Ocean Exploration Partnership under the Memorandum of Understanding between the Ministry of Marine Affairs and Fisheries and the National Oceanic and Atmospheric Administration on Marine and Fisheries Science, Technology, and Applications Cooperation signed on September 18, 2007 at Jakarta (hereinafter referred to as the "MOU"). This Implementing Arrangement is subject to the MOU's authorities, terms, and conditions.

The parties to this Implementing Arrangement are the Agency for Marine and Fisheries Research of the Ministry of Marine Affairs and Fisheries (KKP), and the National Oceanic and Atmospheric Administration of the U. S. Department of Commerce (NOAA), (hereinafter referred to as the "Parties"). The Parties shall encourage other Indonesian agencies to join the Indonesia-U.S. Partnership on Ocean Exploration.

For the purposes of this Implementing Arrangement, the term "Indonesian waters" refers to the seas adjacent to the land territory of the Republic of Indonesia over which the Republic of Indonesia has sovereignty, sovereign rights, or jurisdiction in accordance with the 1982 United Nations Convention on the Law of the Sea.

ARTICLE I FOCUS

This Implementing Arrangement is focused on ocean exploration in Indonesian waters and the Indonesian Exclusive Economic Zone to understand the marine environment, indentify new research questions that will lead to improved ocean management and conservation, and to make the public aware of Indonesia's unique and vital ocean resources.

ARTICLE II PURPOSE AND AREAS OF COOPERATION

The purpose of the Indonesia-U.S. Ocean Exploration Partnership is to generate new data that will help Indonesian scientists, marine resource managers, and the public gain a new understanding of the oceans and seas vital to all Indonesians.

RAI

A. *Indonesian and U.S. Interests*

This Implementing Arrangement furthers Indonesian and U.S. interests in the following areas, among others:

1. Understanding physical, chemical, and biological aspects of the Indonesian marine environment;

2. Applying new and innovative technologies to increase the efficiency and effectiveness of ocean exploration activities;

3. Managing, analyzing, and distributing new ocean exploration data for the benefit of scientists, marine resource managers, and the public; and

4. Educating the public about ocean exploration, discoveries and findings, and the importance of the marine environment to Indonesia and the world.

B. *Cooperative Activities*

Ocean exploration is an interdisciplinary approach for surveying and investigating the physical, chemical, and biological characteristics of the ocean floor, the ocean itself, and the diversity of life forms that inhabit the marine environment. Ocean exploration is intended to yield a body of knowledge that may result in immediate benefit, or may inform research hypotheses that result in new scientific understanding in the future.

Cooperative activities carried out by this partnership may include, but are not limited to:

1. Cooperation in ocean exploration guided by scientists from Indonesia and the U.S. working together to identify science priorities for ocean exploration in Indonesia, designing ocean exploration work plans to address those priorities, and collaborating to implement work plan activities;

2. Joint analysis by Indonesian and U.S. scientists to analyze the results of ocean exploration activities to advance the state of scientific knowledge in areas of mutual interest;

3. Ocean exploration technology transfer through collaborative activities that expose Indonesian and U.S. scientists to new approaches and techniques;

4. Training and capacity building to support KKP and other Indonesian agency interests in ocean exploration and the disciplines that comprises it;

5. Education and outreach to promote greater understanding of the marine environment; and,

6. Other areas as may be mutually agreed.

C. *Expected Outcomes*

It is anticipated that the Indonesian-U.S. Ocean Exploration Partnership will reveal new and perhaps unique discoveries. These may include, but are not limited to:

1. New ecosystems associated with seamounts, spreading centers, and deeps (e.g., trenches) that are often centers for biologically diverse communities of fish and invertebrates, including corals;

2. Areas of volcanic and hydrothermal vent activity where biologically unique communities typically are found in association with widely varying ambient water temperatures and extreme chemical environments; and,

3. Insights into ocean acidification processes, as well as the budgets and cycles of deep ocean, volcanically derived gases, such as carbon dioxide, that may have a role in climate and ecosystem variability.

D. *Benefits of Partnership*
Consistent with the principles of the Agreement between the Government of the Republic of Indonesia and the Government of the United States of America on Scientific and Technological Cooperation signed on March 29, 2010, the Parties intend that both Parties will contribute to the Indonesia-U.S. Ocean Exploration Partnership with scientific benefits to be shared freely under the general terms of Memorandum of Understanding on Marine and Fisheries Science, Technology, and Applications—Cooperation—and the specific terms of this Implementing Arrangement. The Parties further intend that the Indonesian agencies involved in Partnership activities will gain, among other benefits:

1. Exposure to the technology and systems the United States intends to use in joint exploration activities conducted under this Implementing Arrangement;
2. New data sets and information resources;
3. Sponsored travel to the United States to work with counterparts on ocean exploration-related activities;
4. Familiarization with ocean exploration instruments and systems; and,
5. New government-to-government agency partnerships and new scientist-to-scientist relationships.

ARTICLE III MEANS OF COOPERATION

The Parties shall facilitate ocean exploration activities under this Implementing Arrangement through:

A. Exchanges of scientific and technical information;

B. Exchanges of scientists and technical experts;

C. The conduct of joint ocean exploration expeditions on Indonesian and/or U.S. vessels;

D. The conduct of joint research, analysis, and publication of results;

E. Training and capacity building workshops and seminars;

F. Official visits; and

G. Other means as agreed to by the Parties.

ARTICLE IV DEFINITIONS

The following definitions apply to this Implementing Arrangement:

A. "Data" is the output of the various instruments and sensors used in the Indonesian-U.S. Ocean Exploration Partnership. Data is quality controlled and verified for accuracy;

B. "INDEX" is the Indonesian-U.S. Ocean Exploration Partnership formed to conduct collaborative ocean exploration expeditions in Indonesia and other areas of mutual interest;

C. "INDEX-SATAL 2010" is the Indonesia-U.S. expedition to the Sangihe Talaud region, planned to commence in June 2010;

D. "Information" is a product or series of products created to add value to data through analysis, graphical display, or other processes;

E. "Internet2" is a research Internet network and technology that allows for advanced network functionality and multicast data transmissions. Internet2's multicast transport protocol allows a single data stream to be received by any number of clients simultaneously;

F. "Ocean exploration" is an interdisciplinary approach for surveying and investigating the physical, chemical, and biological characteristics of the ocean floor, the ocean itself, and the diversity of life forms that inhabit the marine environment;

G. "Telepresence" is the data and communications system that links the NOAA Ship *Okeanos Explorer* or other ocean exploration vessel instruments and sensors to data centers and Exploration Command Centers via high-speed satellite links, and very high bandwidth Internet connections;

H. "Exploration Command Center" refers to a system of video monitors, intercom systems, servers, and other equipment to allow Indonesian-U.S. Ocean Exploration Partnership scientists to participate in ocean exploration activities via a telepresence connection to the NOAA Ship *Okeanos Explorer* or other appropriately equipped vessels participating in Indonesia-U.S. Ocean Exploration Partnership activities. Exploration Command Centers require Internet2 connectivity; and

I. "Training" consists of structured and non-structured learning experiences to support Indonesian partners' access to ocean exploration technology and participation in INDEX activities. Training may include voyages, short courses, and opportunities to work with NOAA and other U.S. based scientists on similar activities.

ARTICLE V EXPLORATION AND RESEARCH PROGRAM

The Parties agree that the Indonesia-U.S. Ocean Exploration Partnership will include voyages of exploration on both Indonesian and U.S. ships, development and application of new technologies for ocean exploration, data management and dissemination so that all Indonesians can access new data and information and share it with the international community, and educational outreach to share the discoveries and findings of the Partnership with the general public.

A. *Three-Year Strategic Plan*
The Parties agree to develop a three-year Indonesia-U.S. Strategic Plan for ocean exploration that shall provide a framework for annual Indonesia-U.S. Ocean Exploration Partnership activities. These activities shall be documented in an annual work plan. The Strategic Plan shall be appended to this Implementing Arrangement.

B. *Annual Work Plan*
The Parties agree to develop annual work plans under the Indonesia-U.S. Ocean Exploration Partnership Strategic Plan. These annual plans shall describe specific ocean exploration activities and any additional terms and conditions that are necessary to implement those activities. The Parties further commit to implement annual work plan activities subject to the availability of funds and other resources.

C. *Indonesia-U.S. Science Team*
The Parties agree to form an Indonesia-U.S. Ocean Exploration Science Team composed of, but not limited to, experts in marine geology, volcanology, chemical and physical oceanography, macro- and micro-biology; and marine technologies, such as sonar mapping systems, and water column mapping and sampling systems.

1. The Exploration Science team shall be responsible for:

   a. Identifying science priorities for ocean exploration in Indonesia;

   b. Developing a long-term strategy;

   c. Designing annual ocean exploration work plans;

   d. Assisting with permit applications and other administrative requirements;

   e. Participating in ocean exploration expeditions, either on board ocean exploration vessels or in Exploration Command Centers as appropriate;

f. Collaborating on analysis of scientific data collected during ocean exploration expeditions and jointly, as well as individually authoring scientific papers for publication in refereed and non-refereed journals and publications. Joint Indonesian-U.S. publications are strongly encouraged. All publications shall acknowledge the contributions of the INDEX Partners;

g. Participating in public education and outreach activities to promote a ocean exploration and the importance of oceans to the public and decision makers; and

h. Conducting other activities as appropriate to advance Indonesian, U.S., and international ocean exploration and to promote an understanding of the marine environment.

2. KKP and NOAA shall designate Co-Chief Scientists for the Indonesian-U.S. Ocean Exploration Partnership. The Co-Chief Scientists shall be responsible for collaboratively guiding ocean exploration activities, leading the development of annual work plans, chairing meetings of the Exploration Science Team described above, and facilitating all other scientific aspects of the Partnership.

3. The Co-Chief Scientists shall designate a single Expedition Coordinator for each vessel involved in INDEX operations. The Expedition Coordinators shall serve as single points of contact for the *Okeanos Explorer*, *Baruna Jaya IV*, and any other vessels engaged in exploration under the Indonesia-U.S. Ocean Exploration Partnership and shall be responsible for operational decision-making in consultation with the vessel commanding officer.

4. Other Indonesian agencies, institutions, and organizations may participate in the Indonesia-U.S. Ocean Exploration Partnership and the Exploration Science Team. These include, but are not limited to:

a. Badan Pengkajian Dan Penerapan Teknologi (Agency for the Assessment and Application of Technology);

b. Kementerian Energi dan Sumber Daya Mineral (Ministry of Energy and Mineral Resources);

c. Kementerian Pertahanan (Ministry of Defense) and Tentara Nasional Indonesia (Indonesian National Armed Forces);

d. Kementerian Pendidikan Nasional Republik Indonesia (Ministry of Education);

e. Institute of Technology at Bandung; and

f. Lembaga Ilmu Pengetahuan Indonesia (Indonesian Institute of Science).

5. The Exploration Science Team shall meet at least once each year in Indonesia to review results of the past year's activities against the annual work plan and to prepare the next year's ocean exploration work plan.

D. *Telepresence*: Telepresence allows a greater number of scientists in different land-based locations to participate actively in expeditions than would be possible using conventional communications and provides an innovative way to engage the public, media, and classrooms in real-time ocean exploration.

E. *Exploration Command Center*: The Exploration Command Center (ECC) is the primary means by which Indonesian scientists will participate in INDEX expeditions that may take place using telepresence technology installed aboard Indonesian or U.S. ships. The Exploration Command Center houses video monitors, intercom systems, servers, and other equipment to allow Indonesian-U.S. Ocean Exploration Partnership scientists to participate in ocean exploration activities via a telepresence connection to the *Okeanos Explorer* or other appropriately equipped vessels participating in Indonesia-U.S. Ocean Exploration Partnership activities.

1. High-definition video that the *Okeanos Explorer* acquires during INDEX expeditions shall be transmitted in real-time or near-real time to the Exploration Command Center for immediate review by ECC scientists. Other data the *Okeanos Explorer* collects shall be made available to the Jakarta ECC as soon as is practicable. Scientists in similar Exploration Command Centers in the U.S. shall also participate in the expedition have concurrent access to this information. Any number of Indonesian scientists may participate in Exploration Command Center activities.

2. During INDEX expedition Remotely Operated Vehicle operations, the Parties agree to staff the Exploration Command Center with Indonesian and U.S. scientists, as mission requirements dictate. In some circumstances, the ECC may operate 24 hours a day/7 days a week.

F. *Modes of Operation:* The Exploration Science Team shall determine initial cruise tracks for INDEX expedition vessels. In general, the exploration model consists of multibeam and other instrument surveys along a track line. Where features of potential interest are identified, the science team shall direct the ship's mission crew to conduct a more detailed exploration using Remotely Operated Vehicle and other available instrumentation. The Indonesian and U.S. scientists in the Exploration Command Centers shall direct the movements of the Remotely Operated Vehicle in real-time via communications with on-board technicians.

G. *Indonesian Scientists' Participation aboard the Okeanos Explorer:* To meet joint Indonesian-U.S. objectives for introducing Indonesian Ocean Exploration Partnership participants to ocean exploration methodologies and technologies, the Exploration Science Team Co-Chairs shall designate at least two Indonesian scientists to be aboard the *Okeanos Explorer* while she is conducting joint exploration activities in Indonesian waters. During Remotely Operated Vehicle operations, however, it will be possible to berth only one Indonesian scientist in addition to the TNI-AL observer. Berth space aboard the vessel is extremely limited because of the large crew required for Remotely Operated Vehicle operations.

H. *U.S. Scientist Participation aboard Indonesian Vessels:* U.S. scientists may participate in ocean exploration activities aboard Indonesian vessels engaged in Indonesian-U.S. Ocean Exploration Partnership expedition at the discretion of the Parties.

I. *Tentara Nasional Indonesia Angkatan Laut (TNI-AL) Participation aboard the Okeanos Explorer:* NOAA shall invite one TNI-AL security officer to be aboard the *Okeanos Explorer* or other NOAA-provided vessels while the vessel operates in Indonesian waters.

J. *Capacity Building.* Capacity building is an important element of the Indonesia-U.S. Ocean Exploration Partnership. NOAA agrees to provide capacity building through workshop and other formal venues as well as informal training by identifying opportunities for Indonesian and U.S. experts to work side-by-side on Ocean Exploration Annual Work Plan activities. Specifically, NOAA plans to provide capacity building opportunities on:

1. Ocean exploration systems, including ship operations, Remotely Operated Vehicle systems and operations, telepresence, Exploration Command Center equipment and operations, and other elements of *Okeanos Explorer* systems and instruments;

2. *Okeanos Explorer* operations, by providing opportunities for Indonesian counterparts to work side-by-side with NOAA scientists, engineers, technicians and crew;

3. Data management and archiving, including data formats, quality assurance and control, storage, access, dissemination, integration with international data holdings, such as the International Council for Science World Data System; and

4. Other opportunities the Parties may identify and agree to pursue.

K. *Public Education and Outreach*
The Indonesian-U.S. Ocean Exploration Partnership offers unique and important opportunities to reach the Indonesian and U.S. publics for educational and awareness purposes. KKP and NOAA agree to include public education and outreach elements in each annual Ocean Exploration Partnership work plan to help ensure the results and benefits of the Partnership are distributed as widely as possible.

ARTICLE VI EXPLORATION ACTIVITIES

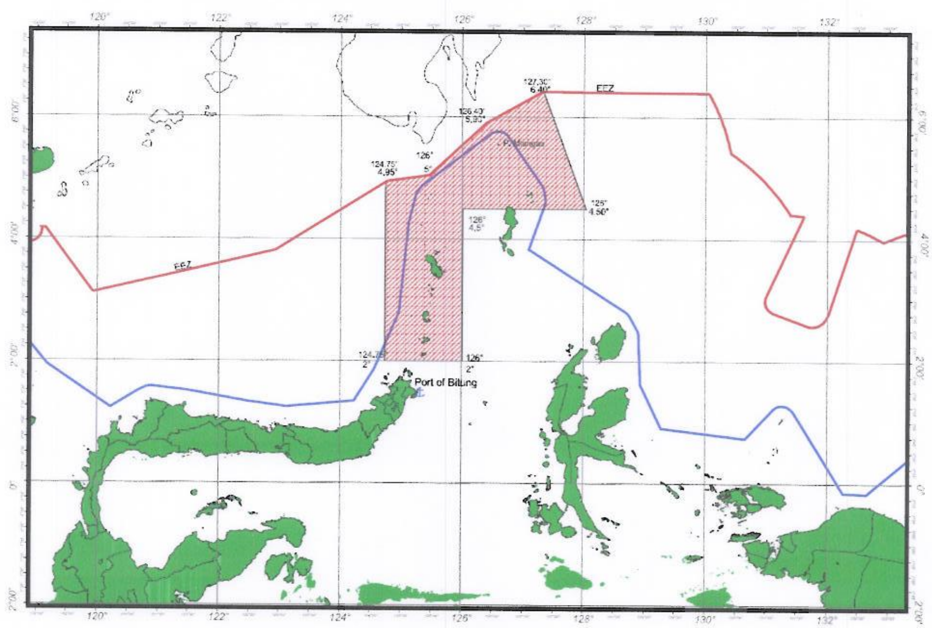
A. *First Year Activities: INDEX SATAL 2010*
The primary activity for the first year of the Partnership is the visit of the NOAA Ship *Okeanos Explorer* to Indonesia to participate in the first-ever Indonesian-U.S. Ocean Exploration Expedition to the Sangihe Talaud region ("INDEX SATAL 2010"). The *Okeanos Explorer* operates to maximize the potential for ocean exploration discoveries using high-resolution mapping, remotely operating vehicle, water column mapping and sampling, and other equipment tailored for, and dedicated to, ocean exploration, including telepresence. Expedition details are described in the INDEX SATAL 2010 Science Plan. To conduct INDEX SATAL 2010:

1. *Okeanos Explorer.* NOAA agrees to bring the *Okeanos Explorer* to Indonesia for its maiden international expedition in June 2010, assuming the Government of Indonesia grants the necessary permits, clearances, and other needed approvals.

2. *Indonesian Research Vessel.* KKP agrees to provide an appropriate research vessel to join the *Okeanos Explorer* as part of INDEX SATAL 2010. Other Indonesian research vessels may participate in INDEX SATAL 2010 at the discretion of Indonesian-U.S. Ocean Exploration Partnership members.

3. *First Year Area of Exploration:* Based on science planning workshops in November 2008, February 2009, and October 2009 that included KKP, other Indonesian agencies, and NOAA, the Parties agree that INDEX SATAL 2010 should focus generally in the area depicted below. Approximate coordinates are:

2.0° N 124.75° E	6.4° N 127.5° E
2.0° N 126° E	5.9° N 126.4° E
4.5° N 126° E	5.0° N 125.5° E
4.5° N 128° E	4.95° N 124.75°



This area is subject to review by the Exploration Science Team, permit conditions, clearances, and other considerations that may result from the planning and consultation process among the Parties and other Indonesian agencies that may participate in the Indonesia-U.S. Ocean Exploration Partnership and INDEX SATAL 2010.

4. *Official Travel and Capacity Building:* To support Indonesian participation in INDEX SATAL 2010, NOAA agrees to provide the following official travel and capacity building opportunities pending NOAA approvals and clearances. It is expected that the Indonesian participants in these travel, training, and capacity building activities will be involved actively in INDEX SATAL 2010. The specific details (e.g. dates of training and travel) shall be documented in a memorandum exchanged between the Parties before 1 May 2010:

   a. *Bathymetry and Seafloor Mapping:* NOAA shall host two qualified Indonesian scientists (including a TNI-AL hydrographer) to participate in a three-week bathymetry and hydrographic survey short course at one of NOAA's hydrographic survey centers. NOAA shall fund travel, accommodations, and per diem expenses for the course.

   b. *Ocean Exploration Systems and Ship Operations:* During a portion of the *Okeanos Explorer* transit to Indonesia, NOAA shall invite two qualified Indonesian scientists aboard the vessel to work side-by-side with U.S. counterparts. These Indonesian scientists would then serve as Exploration Command Center coordinators—one in the Jakarta ECC and one in the Seattle ECC (see below). NOAA shall fund travel to and from a rendezvous point and provide berthing and meals at no charge.

   c. *Exploration Command Center Technology:* NOAA technicians shall support installation of the Exploration Command Center in Jakarta. The installation process shall include side-by-side exposure to advanced Internet and communications technologies used in the ECC.

   d. *Exploration Command Center Operations:* NOAA shall support two members of the INDEX Science Team and one of the participants in paragraph VI.A.4.b above to join U.S. INDEX Science Team members in the Seattle Exploration Command Center for a period of up to three weeks during INDEX SATAL 2010 when Remotely Operated Vehicle operations are planned.

   e. *Data Management and Archiving:* NOAA shall support two qualified Indonesian scientists to work for up to two weeks with NOAA data management experts at a selected NOAA Data Center following the INDEX SATAL 2010 expedition. NOAA shall fund travel, accommodation, and per diem expenses.

B. *Second Year Activities: INDEX 2011*

Following INDEX SATAL 2010, Science Team members shall convene to evaluate the results of the first expedition and to plan for INDEX 2011. The INDEX Science Team shall identify exploration activities within the INDEX themes and prepare detailed cruise and operation plans. Other planned ocean exploration or research activities conducted by Indonesian ocean exploration partners, may be included under the INDEX umbrella.

1. *NOAA-Provided Exploration Assets:* Contingent on the availability of funds and the priorities identified by the INDEX Science Team, NOAA agrees to provide the *Okeanos Explorer* or another ocean exploration asset (for example, a U.S. university exploration vessel) for a 2011 INDEX expedition.

2. *Indonesian Exploration Assets:* Contingent on the availability of funds and the priorities identified by the INDEX Science Team, KKP agrees to coordinate with other appropriate Indonesian agencies to provide an Indonesian research and/or exploration vessel to conduct exploration in conjunction with NOAA-provided exploration vessels and equipment.

3. *2011 Area of Exploration:* The INDEX 2011 geographical exploration area may be within the target areas defined for INDEX SATAL 2010 or another area as identified by the INDEX Science Team, taking into account Indonesia's geographic diversity, and subject to all appropriate permit and clearance requirements.

4. *Official Travel, Training and Capacity Building:* NOAA shall support official travel, training and capacity building consistent with the purposes of this Implementing Arrangement and needs and priorities identified by INDEX participants and the INDEX Science Team. A specific training plan shall be documented in a memorandum to be finalized following the INDEX Science Team meeting that follows INDEX SATAL 2010.

C. *Third Year Activities: INDEX 2012*

Following INDEX 2011, Science Team members shall convene to evaluate the results of the first expedition and to plan for INDEX 2012. The INDEX Science Team shall identify exploration activities within the INDEX themes and prepare detailed cruise and operation plans. Other planned ocean exploration or research activities conducted by Indonesian ocean exploration partners, may be included under the INDEX umbrella.

1. *NOAA-Provided Exploration Assets:* Contingent on the availability of funds and the priorities identified by the INDEX Science Team, NOAA agrees to provide the *Okeanos Explorer* or another ocean exploration asset (for example, a U.S. university exploration vessel) for a 2012 INDEX expedition.

2. *Indonesian Exploration Assets:* Contingent on the availability of funds and the priorities identified by the INDEX Science Team, KKP agrees to coordinate with other appropriate Indonesian agencies to provide an Indonesian research and/or exploration vessel to conduct exploration in conjunction with NOAA-provided exploration vessels and equipment.

3. *2012 Area of Exploration:* The INDEX 2012 geographical exploration area may be within the target areas defined for INDEX SATAL 2010 or another area as identified by the INDEX Science Team, taking into account Indonesia's geographic diversity, and subject to all appropriate permit and clearance requirements.

4. *Official Travel, Training and Capacity Building:* NOAA shall support official travel, training and capacity building consistent with the purposes of this Implementing Arrangement and needs and priorities identified by INDEX participants and the INDEX Science Team. A specific training plan shall be documented in a memorandum to be finalized following the INDEX Science Team meeting that follows INDEX 2011.

ARTICLE VII EXPOSURE TO TECHNOLOGY AND TRANSFER OF EQUIPMENT

The Parties are intended to have full exposure to the technology employed in ocean exploration by either Indonesian or U.S. participants in the Indonesian- U.S. Ocean Exploration Partnership, subject to (i) the Parties' applicable laws and regulations, and (ii) the provisions regarding intellectual property rights delineated in Annex I of the MOU.

A. *Exposure to Technology*

NOAA shall facilitate access to multibeam survey, Remotely Operated Vehicle, and telepresence technology through visits by Indonesian scientists and engineers to the *Okeanos Explorer* and other NOAA facilities, side-by-side collaboration during equipment installation and testing, training, and operations.

B. *Contribution of Exploration Command Center and Supporting Equipment*
NOAA shall contribute a complete, operating Exploration Command Center to KKP, including computers, high-resolution monitors, intercom, keyboards and controllers, racks, cables, uninterruptible power supplies, and other supporting equipment. NOAA shall ship this equipment to KKP in Jakarta at its own expense. NOAA shall train Indonesian technicians in ECC systems, including design, components, integration, and installation. NOAA technicians shall support KKP and other counterparts to provide familiarization and operational training on the ECC equipment.

C. *Exploration Command Center Infrastructure*
KKP agrees to provide a suitable secure space to house the Exploration Command Center. At a minimum, the space should measure about 30 square meters and include:

1. A multicast-enabled (Internet2) very high bandwidth connection to with a minimum service of 20 Mb/s;

2. 20 amperes at 220v electrical service available to power the ECC and additional equipment appropriate to the ECC such as personal laptops and printers;

3. Standard telephone with speakerphone for discrete communications with the *Okeanos Explorer* and other shore and ship-based participants;

4. A printer and large-format plotter to support scientific observation and analysis during expedition operations;

5. Climate control appropriate for proper operation of the ECC equipment;

6. Security systems appropriate for the ECC technology and equipment;

7. 24/7 access during ocean exploration expeditions and other events that require the use of the ECC; and

8. Chairs, tables, and other furnishings for at least ten ECC scientists and technicians.

ARTICLE VIII EXPEDITION DATA ACQUISITION, MANAGEMENT, ARCHIVING, AND DISTRIBUTION

Ocean exploration is of greatest value when data from expeditions are made available as quickly as possible to the broadest possible number of potential users. Potential beneficiaries of ocean exploration data include scientists, marine resource managers and users, educators, and the public. The following paragraphs describe how data collected under the INDEX Partnership will be managed:

A. *Simultaneous Access*
All Partnership data shall be made available to the Parties at the same time, or as close to the same time as practicable. The Parties agree to provide each other full sets of exploration data on media and in formats that can be read by commercial or free software as soon as practicable after each expedition leg and at the end of each joint expedition.

B. *Public Availability*
The Parties agree to make all data available to the public in real time, near-real time, or as soon as practicable, depending on data type, and to facilitate the public's access to INDEX data.

C. *Ocean Exploration Partnership Website*
NOAA agrees to create pages on its Ocean Exploration website dedicated to the Indonesia-U.S. Ocean Exploration Partnership and each joint expedition in English to provide information, data, and products to the interested public. KKP agrees to host, or make arrangements for another

Indonesian agency to host, similar pages and to translate relevant material into Bahasa Indonesia to help ensure the highest possible value of the Partnership's expedition results to the Indonesian public.

D. *Archived Data*
The Parties agree to provide each other full sets of archived exploration data on media and in formats that can be read by commercial or free software as soon as practicable after each joint expedition. These data are in addition to data the Parties receive in real time or near-real time under paragraph A above. The Parties agree to make these archived data available to government agencies, academic institutions and other interested parties to further Indonesia-U.S. Ocean Exploration Partnership objectives.

E. *Special Products*
The Parties agree to develop special products, such as educational posters and maps based on Indonesia-U.S. Ocean Exploration Partnership expedition data.

ARTICLE IX RESPONSIBILITIES OF THE PARTIES

A. *Coordination*
The Parties shall be responsible for coordinating and engaging with government agencies in their own countries, as appropriate and necessary and in accordance with applicable laws and regulations, for the completion of Indonesia-U.S. Ocean Exploration Partnership activities. Examples include research permits, visas, and vessel clearances. The Parties shall designate leads for coordination activities as appropriate and needed.

B. *Participation*
Each Party shall participate fully in Indonesian-U.S. Ocean Exploration Partnership annual work plan activities by providing staff, facilities, and other support necessary for implementing annual work plans and as mutually determined by the Parties. Such support shall be subject to the availability of personnel and appropriated funds and will be in accordance with the laws and regulations of the contributing Party's country.

C. *Funding Mechanisms*
This Implementing Arrangement is not a mechanism for a transfer of funds between the Parties. However, funding and other assistance from the United States to Indonesia in furtherance of this Implementing Arrangement may be provided to KKP directly, or to third parties through subsequently awarded contracts, grants, cooperative agreements, and other mechanisms. Such third parties may include, but are not limited to, universities, commercial entities and international and national non-governmental organizations, as mutually agreed by the Parties. The Parties shall coordinate regarding the selection of any such third parties.

D. *Funding*

1. Each Party shall be responsible for funding its own participation in the Indonesian-U.S. Ocean Exploration Partnership unless otherwise agreed. Such agreement shall be in the form of an amendment to this Implementing Arrangement. In addition, there shall be no transfers of funds between the Parties unless otherwise agreed. Such agreement shall be in the form of an amendment to this Implementing Arrangement.

2. The Parties shall finance, co-finance or otherwise support activities described in the annual Indonesia-U.S. Ocean Exploration Partnership work plan as agreed to by the Parties and in accordance with the laws and regulations of their respective countries.

E. *Release from Taxes and Customs Duties*
KKP agrees to facilitate the exemption of equipment and supplies provided by NOAA under this Implementing Arrangement from all taxes, including value-added taxes, and customs duties; and to facilitate the provision of necessary documents and approvals for such exemption in a timely manner consistent with the laws and regulations of the Government of Indonesia.

F. *Samples and Material Transfer Agreements*
It is not expected that the *Okeanos Explorer* or other NOAA assets used in INDEX SATAL 2010 will collect geological or biological samples. Should subsequent INDEX annual work plans call for NOAA assets to collect samples, however, a Material Transfer Agreement shall be concluded in accordance with applicable laws and regulations of the Parties or as mutually agreed by the Parties.

G. *Participation in International Activities*
The Parties shall support the participation of its science and engineering participants in the Indonesian-U.S. Ocean Exploration Partnership in international conferences and meetings, as appropriate, to share expedition research results and to advance ocean exploration

ARTICLE X THIRD PARTY PARTICIPATION

The Parties may, by mutual consent, request the participation of third parties in the Indonesia-U.S. Ocean Exploration Partnership and in carrying out activities under the annual Ocean Exploration Partnership work plan, including activity implementation and financing. Third parties may include Indonesian academic institutions, or other entities. Scientists, researchers, and technical experts of public or private institutions of third countries or international organizations may, in appropriate cases, be invited by mutual consent of the Parties to participate at their own expense, unless agreed otherwise, in projects and programs being carried out under this Implementing Arrangement.

A. *Appropriate Partnerships*
In general, the Parties agree to seek appropriate partnerships with other government agencies, universities and research institutions, the private sector, and other organizations to the extent these partnerships enhance or expand the bilateral ocean exploration partnership.

B. *WOC and the UNESCO/IOC Anniversary*
As an activity that resulted from of the May 2009 World Ocean Conference, the Parties agree that INDEX SATAL 2010 should be designated as an event to mark the Intergovernmental Oceanographic Commission's 50th Anniversary, subject to each Party's applicable laws and regulation and IOC guidelines for its 50th Anniversary.

ARTICLE XI PROTECTION OF SENSITIVE TECHNOLOGY, LICENSE AND EXPORT RESTRICTIONS

The protection of sensitive technology and the transfer of unclassified export-controlled information or equipment between the Parties shall be in accordance with Annex II of the MOU.

ARTICLE XII COORDINATION, GOVERNANCE AND OTHER CONDITIONS

A. *Coordination*
Activities under this IA shall whenever possible be conducted jointly and in collaboration among KKP, and NOAA. To support this partnership, the Parties shall designate points of contact for the administration of this Implementing Arrangement as follows:

KKP: Dr. Budi Sulistiyo
Director, Research Center for Maritime Territories and Non-Living Resources
Agency for Marine and Fisheries Research
Ministry of Marine Affairs and Fisheries
Jl. Pasir Putih 1 Ancol Timur
Jakarta 14430

NOAA: John McDonough
Deputy Director
Ocean Exploration and Research Program
NOAA Research
1315 East-West Highway, 10th Floor
Silver Spring, MD 20910

B. *Protection of Intellectual Property*
The treatment of intellectual property furnished or created in the course of cooperative activities under this Implementing Arrangement shall be in accordance with Annex I of the MOU. Under this Implementing Arrangement, each party hereby grants the other permission to use, for domestic purposes, any technology developed under this Implementing Arrangement.

C. *Settlement of Disputes*
In the event that differences arise between the Parties with regard to the interpretation or application of this Implementing Arrangement, the Parties shall resolve them amicably by means of negotiations and consultations.

D. *Duration, Amendment, and Termination*

1. This Implementing Arrangement shall enter into force upon signature and shall terminate after five years. It may be extended for further five-year periods by written agreement of the Parties.

2. This Implementing Arrangement may be amended at any time by mutual written agreement of the Parties after consultation and confirmation.

3. Either Party may terminate this Implementing Arrangement at any time by providing 90 days' written notice to the other Party.

4. In the event this Implementing Arrangement is terminated, each Party shall be solely responsible for the payment of any expenses it has incurred during the course of implementing this Implementing Arrangement.

IN WITNESS THEREOF, the undersigned, being duly authorized by the respective governments, have signed this Implementing Arrangement.

Done in duplicate in the English language at Jakarta, Indonesia on June 10, 2010:

For The Government of The United States of America	For The Government of The Republic of Indonesia
Ambassador Cameron R. Hume	Dr. Gellwynn Jusuf

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Appendix D: Clearance Approval

REPUBLIC OF INDONESIA
CLEARANCE APPROVAL FOR INDONESIAN TERRITORY

No. M.F.A. : MB/422/VI/2010/SIN....14/VI/2010 (385/Kons.-10/VI/2010.-)

No.M.o.D. : ....

No.M.o.T. : 197593/06/11/166/10

SUB DIREKTORAT ANGLASUS DAN PENUNJANG ANGKUTAN LAUT
REG. NO. : /22
TANGGAL 14 06 2010

The following scheduled ship has been approved by the Indonesian Government:

1. : a. Owner of ship : National Oceanic & Atmospheric Administration
b. Name of ship : OKEANOS EXPLORER
c. Nationality : USA
d. Call sign : WTDH
e. Type : Motor Ship
f. Dimensions : 68.3 meter (overall length)
g. Displacement : 2349 Gross Tonnage
h. Call sign : WTDH

2. CAPTAIN : CDR Joseph A Pica
3. CREW : 53 crews
4. PASSENGERS / CARGO : 6 Scientists & 17 technicians
5. a. Last port of call before entering Indonesia : Guam USA
b. Next port of call after leaving Indonesia : Guam USA
6. Dates/ports of call in Indonesia : 20 - 24 June 2010 Bitung Port
13 - 18 July 2010 Bitung Port
6 - 12 August 2010 Bitung Port
7. PURPOSE : To conduct ocean exploration

APPROVED BY

MINISTRY OF FOREIGN AFFAIRS	MINISTRY OF DEFENSE	MINISTRY OF TRANSPORTATION
Rahmadi Utomo Kasubdit Perijinan Penerbangan & Persetujuan Diplomatik (Signature and name)	A.n. Panglima TNI Asintel J. Unp Utomo, MA Kolonel Tek Nrp 505497 (Signature and name)	14 JUN 2010 MENGETAHUI KELENGKAPAN DOKUMEN A.N. DIREKTUR LALU LINTAS DAN ANGKUTAN LAUT KASUBDIT ANGKUTAN LAUT KHUSUS DAN PENUNJANG ANGKUTAN LAUT DWI HARMADJI (Signature and name)

APPLICANT

Appendix C: Acronyms

AGU—American Geophysical Union

ARMS—Autonomous Reef Monitoring Structure

ASCII—American Standard Code for Information Interchange

BIST—Built-in self-test

BJIV—R/V *Baruna Jaya IV*

BPPT—Indonesia Agency for the Assessment and Application of Technology

BRKP-DKP—Indonesia Ministry of Marine Affairs and Fisheries

CCD—Charge-coupled device

CIMS—Cruise Information Management System

CMS—Content management system

CNAV—Civil Navigation

CoML—Census of Marine Life

CReefs—Census of Coral Reefs Projects

CT—Coral Triangle

CTD—Conductivity, temperature, and depth

CW—Continuous waveform

DC—Direct current

DGPS—Differential Global Positioning System

Dishidros AL—TNI Marine Hydro-Oceanography Service

ECC—Exploration Command Center

EEM—Expedition Education Module

EEZ—Exclusive economic zone

EK60—Kongsberg 18 kHz split-beam fisheries sonar

EM 302—Kongsberg Maritime 30 kHz multibeam system

EX—NOAA Ship *Okeanos Explorer*

Fe—Iron

FM—Frequency modulated

FTP—File transfer protocol

GMT—Greenwich Mean Time

GPS—Global Positioning System

GRT—Gross register tonnage

H_2S—Hydrogen Sulfide

HD—High-definition

hp—Horsepower

HMI—Hydrargyrum medium-arc iodide

IFE—Institute for Exploration

IMU—Inertial measurement unit
IPT—Integrated Product Team
IS-5—Intelstat 5 satellite
ISC—Inner Space Center
ITB—Bandung Institute of Technology
JISAO—Joint Institute for the Study of the Atmosphere and Ocean
kHz—Kilohertz
LAN—Local area network
LED—Light-emitting diode
LOA—Length overall
LSS—Light scattering sensor
Mbps—megabit-per-second
MBES—Multibeam echo sounder
MDSD—NOAA Marine Data Stewardship Division
METOC—Meteorological and oceanographic
NCDDC—NOAA National Coastal Data Development Center
NCEI—NOAA National Centers for Environmental Information
NCL—NOAA Central Library
NEPA—National Environmental Policy Act
NGDC—NOAA National Geophysical Data Center
nm—Nautical miles
NOAA—National Oceanic and Atmospheric Administration
NODC—NOAA National Oceanographic Data Center
NTU—Nephelometric Turbidity Unit
OEDV—Ocean exploration digital video
OER—NOAA Office of Ocean Exploration and Research
ORP—Oxidation-Reduction Potential
PCS—POS/MV computer system
PMEL— Pacific Marine Environmental Laboratory
PI—Principal Investigator
PIFSC—NOAA Pacific Islands Fisheries Science Center
PNI—Physical Network Inventory
POS MV—Position and Orientation System for Marine Vessels
PSG-ESDM—Ministry of Energy and Mineral Resources-Geological Agency
PU—Primary user
ROV—Remotely operated vehicle
R/V—Research vessel
SATAL—Sangihe and Talaud region

SBE—Sea-Bird Electronics, Inc.
SCS—Scientific Computer System
SIS—Seafloor Information System
TNI—Indonesia National Military
TRU— Transmit Receive Unit
UH—University of Hawaiʻi
UMass—University of Massachusetts at Amherst
UNH—University of New Hampshire
URI—University of Rhode Island
USBL—Ultra-short baseline
UTC—Universal Time Coordinated
UVic—University of Victoria
UW—University of Washington
VDMS—Video Data Management System
VoIP—Voice over Internet Protocol
VSAT—Very Small Aperture Terminal
WHOI—Woods Hole Oceanographic Institute
XBT—Expendable bathythermograph
XMPP—Extensible Messaging and Presence Protocol
XSV—Expendable sound velocity