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NOAA *Okeanos Explorer* Program

MAPPING DATA REPORT

EX1004 Leg 1

Exploration Indonesia
Guam to Bitung

June 08 - 20, 2010

Report Contributors:
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1. Introduction

The *Okeanos Explorer* Program

Commissioned in August 2008, the NOAA Ship *Okeanos Explorer* is the nation's only federal vessel dedicated to ocean exploration. With 95% of the world's oceans left unexplored, the ship's combination of scientific and technological tools uniquely positions it to systematically explore new areas of our largely unknown ocean. These exploration cruises are explicitly designed to generate hypotheses and lead to further investigations by the wider scientific community.

Using a high-resolution multibeam sonar with water column capabilities, a deep water remotely operated vehicle, and telepresence technology, *Okeanos Explorer* provides NOAA the ability to foster scientific discoveries by identifying new targets in real time, diving on those targets shortly after initial detection, and then sending this information back to shore for immediate near-real-time collaboration with scientists and experts at Exploration Command Centers around the world. The subsequent transparent and rapid dissemination of information-rich products to the scientific community ensures that discoveries are immediately available to experts in relevant disciplines for research and analysis

Through the *Okeanos Explorer* Program, NOAA's Office of Ocean Exploration and Research (OER) provides the nation with unparalleled capacity to discover and investigate new oceanic regions and phenomena, conduct the basic research required to document discoveries, and seamlessly disseminate data and information-rich products to a multitude of users. The program strives to develop technological solutions and innovative applications to critical problems in undersea exploration and to provide resources for developing, testing, and transitioning solutions to meet these needs.

Okeanos Explorer Management – a unique partnership within NOAA

The *Okeanos Explorer* Program combines the capabilities of the NOAA Ship *Okeanos Explorer* with shore-based high speed networks and infrastructure for systematic telepresence-enabled exploration of the world ocean. The ship is operated, managed and maintained by NOAA's Office of Marine and Aviation Operations, which includes commissioned officers of the NOAA Corps and civilian wage mariners. OER owns and is responsible for operating and managing the cutting-edge ocean exploration systems on the vessel (ROV, mapping and telepresence) and ashore including Exploration Command Centers and terrestrial high speed networks. The ship and shore-based infrastructure combine to be the only federal program dedicated to systematic telepresence-enabled exploration of the planet's largely unknown ocean.

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2. Report Purpose

The purpose of this report is to briefly describe the mapping data collection and processing methods, and to report the results of the cruise. For a detailed description of the *Okeanos Explorer* mapping capabilities, see appendix D and the ship's readiness report, which can be obtained by contacting the ships operations officer (ops.explorer@noaa.gov).

The talented and patient crew of the NOAA Ship *Okeanos Explorer* (*EX*) is greatly appreciated for their efforts in helping make the INDEX-SATAL 2010 mission a success.

3. Cruise Objectives

EX1004 Leg 1 signified the commencement of INDEX-SATAL 2010, a joint expedition between the Republic of Indonesia and the United States. The objectives of EX1004 Leg 1 were to: safely transit from Guam to Bitung, Indonesia; train new mapping personnel on the onboard mapping system; and map the waters of the Indonesia Sangihe Talaud Region offshore North Sulawesi, Indonesia. Specific objectives included collection of baseline data to support Leg II and III ROV operations, refinement of CTD and Tow-Yo operations, Exploration Command Center training (ECC), and refinement of communication pathways. Due to delays in obtaining the required ship work permits and clearances to work in Indonesian waters, the objectives changed to include mapping and CTD operations in an area west of Guam.

4. Participating personnel

NAME	ROLE	AFFILIATION
CDR Joseph Pica	Commanding Officer	NOAA Corps
Jeremy Potter	Expedition Coordinator	NOAA OER
LT Nicola VerPlanck	Field Operations Officer	NOAA Corps

Dave Butterfield	Designated Chief Scientist (ECC)	PMEL
Elaine Stuart	Senior Survey Technician	NOAA OMAO
Colleen Peters	Senior Survey Technician	NOAA OMAO
Joel DeMello	Mapping Watchstander	NOAA OER/UCAR Intern
Tom Kok	Mapping Watchstander	NOAA OER/UCAR Intern
Karl McLetchie	Mapping Watchstander	NOAA OER/UCAR Intern
LTJG Megan Nadeau	Mapping Watchstander	NOAA Corp
Mashkoor Malik	Mapping Team Lead	NOAA OER (ERT, Inc.)
Lillian Stuart	Mapping Watchstander	NOAA OMAO

5. Mapping Statistics

Dates	06/08/10-06/20/10
Weather delays	Nil
Total non-mapping days (due to transit in non US EEZ)	7
Total survey mapping days	5 (Partial days – No data while conducting CTD ops)
Total transit mapping days	2
Line kilometers surveyed	1490 km
Beginning draft	Fwd 15 feet 01 Inch Aft 14 feet 10.5 Inch

6. Mapping sonar setup and results

The NOAA Ship *Okeanos Explorer* (EX) is equipped with 30 kHz Kongsberg EM 302 multibeam sonar and a 3.5 kHz Knudsen sub-bottom profiler (SBP 3260). During this cruise EM 302 bottom bathymetric and backscatter data were collected. Additionally EM 302 water column data was 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 POS MV ver. 4 to record and correct the multibeam data for any motion. C-NAV GPS system provided DGPS correctors with position accuracy expected to be better than 2.0m.

All the corrections (motion, sound speed profile, sound speed at sonar head, draft, sensor offsets) are applied during real time data acquisition in SIS ver. 1.04. Expendable bathythermograph (XBT) casts (Deep Blue, max depth 760 m) were taken every 6 hours and in between when needed. The XBT cast data were converted to SIS compliant format using NOAA in house tool for XBT processing: Velocipy.

During May 2010. the ship reported one of the transmit boards defective. The Built In System Test (BIST) results conducted before departure show the transmit board # 16 as non-functional. The EM 302, in-spite of one defective transmit board, provided good quality data during the initial tests soon after departing Guam. Based on these initial tests it was decided that ship will

continue its mapping mission. The affects of the defective transmit board on the data quality was assessed throughout the cruise by comparing this cruise data with earlier cruises, however no significant affects of the bad transmit board were apparent.

On 12 June 2010, the BIST results indicated that RX32 board in slot # 2 is failing the BIST test. Consequently Kongsberg Inc support was notified who advised to reseat the board. On 15 June, 2010, the ship's ETs removed the RX32 board from the TRU and inserted the same board back into the TRU after inspection. A following BIST indicated all the RX32 boards passing all the BIST tests.

7. Data Acquisition and Processing, Data Quality Assessment

Due to revised ship schedule because of a delay in getting the ship's clearance from the Indonesian government, a new plan was initiated which included conducting mapping operations in vicinity of Guam. As per this plan several mapping /CTD expeditions were planned to utilize the time as the ship waits for the diplomatic clearance from Indonesia.

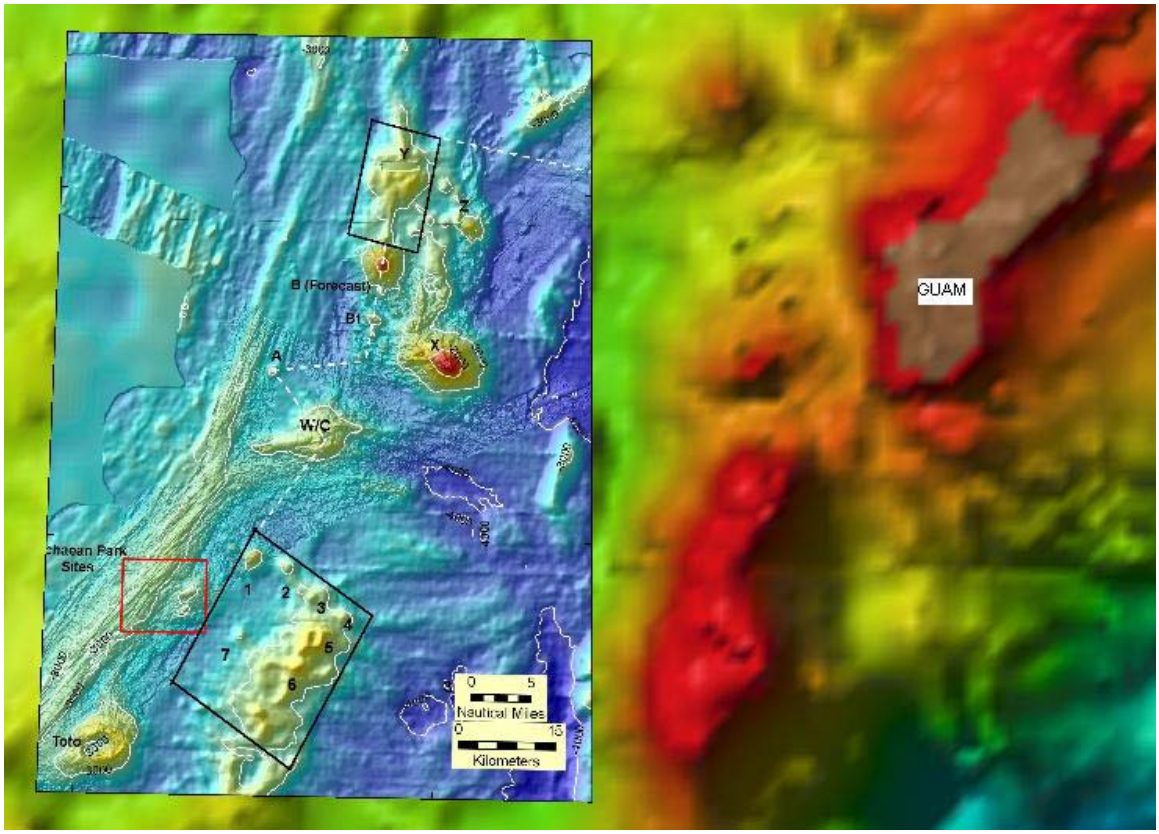

Figure 1. The first of the series of mapping areas included, covering areas shown in black boxes in the figure above. Site selections were made with input from NOAA's Pacific Marine Environmental Lab (PMEL). Background data Sandwell and Smith.

At the start of the cruise on 8 June, the data quality was observed to degrade in depths > 1500 m where the bottom detections were affected by severe side lobe interference. Different settings

were changed to see if the data quality can be improved including changing filter settings, changing the angular coverage and changing to different system modes. Setting the penetration filter setting to OFF provided the best results where the system was observed to be not affected by the strong side lobes.

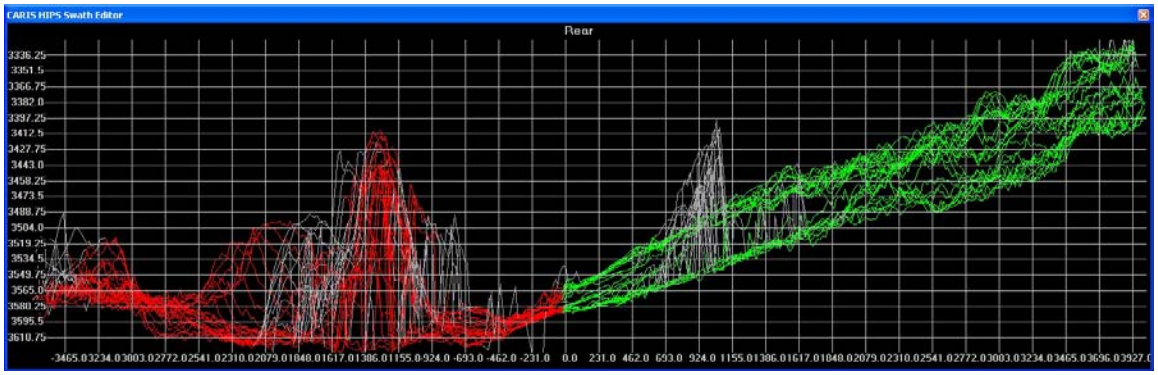

Figure 2. Caris HIPS 6.1 Swath Editor image showing 30 profiles collected (view from the rear of the ship) with penetration filter ON. Green and Red colors show the soundings STBD and PORT of the ship. The soundings which were deleted are shown in grey color. These soundings occur ~ 20° off nadir.

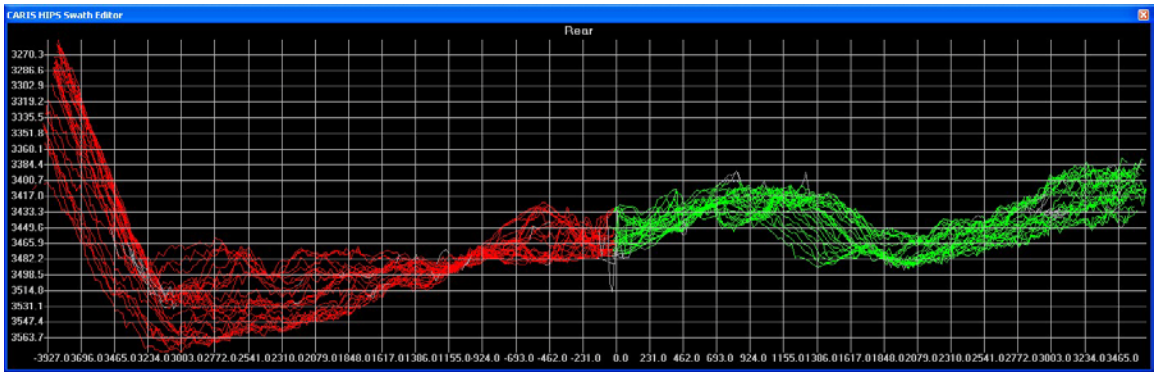

Figure 3. Caris HIPS 6.1 Swath Editor image showing 30 profiles collected (view from the rear of the ship) with penetration filter OFF.

The side lobe detection has been an ongoing problem for the EM 302 onboard since January 2010, when the system software was upgraded. Although the penetration filter setting is supposed to help with the erroneous detection below the seafloor, during this cruise it was evident that this filter is not working as intended. The problem in earlier cruises has been observed to be exacerbated over softer bottoms. The combination of calm waters and very hard bottom during this cruise did not provide an ideal test case scenario but it is recommended to keep this filter OFF for following cruises to test the validity of these observations while passing over softer bottoms. It is also not clear at this point if the reduction in swath width can be related to the system locking on to the side lobes. If the system does lock on the side lobe, the apparent signal to noise ratio of the system will be much less which can lead into reduction in the swath width. But again, this will need to be tested further during following cruises.

Angular offsets (based on patch test conducted in April 2010) are tabulated as below. For the complete processing unit setup (PU Setup) utilized for the cruise, please refer to Appendix A.

Several CTD casts were conducted during this cruise, but this report will not provide details about results of CTD casts as these casts were conducted under direct supervision of PMEL scientists who participated remotely and on the ship in the CTD operations and will be processing and analyzing the CTD data. Locations of CTD casts are provided in this report as Table 6c.

Table 1. Angular offsets for Transmit (TX) and Receive (RX) transducer as determined during a patch conducted in April 2010.

	Roll	Pitch	Heading
Tx Transducer	0.0	0.0	359.98
Rx Transducer	0.0	0.0	0.03
Attitude	0.0	-0.80	0.0

Onboard processing of bathymetric data was completed in CARIS HIPS ver. 6.1 where the data were cleaned in 'Swath Editor' and 'Subset Editor'. No tidal corrections were applied during post processing; however, no appreciable differences were observed between different lines by not applying tidal corrections. A nominal grid cell size of 50 m was chosen for the bathymetric grids. No processing of bottom and water column backscatter data was conducted onboard.

Nathan Buck from PMEL participated in this cruise as science representative. Dr. Dave Butterfield, from PMEL and stationed at the PMEL ECC, acted as designated chief scientist for this contingency cruise. All the planning and directions regarding CTD operations were received from shore. It was observed during the cruise that the ECC at Seattle (PMEL) is not well equipped to analyze the bathymetric data. A Geotiff image, IVS SD object and an ASCII gridded text file was provided on a daily basis to the ECC through the ftp site. Dr. Butterfield was provided with an IVS Fledermaus free viewer to view the bathymetric data in SD format, however, due to unavailability of the full suite of IVS Fledermaus software at the PMEL ECC, most of the line planning and selection of CTD casts were done onboard the ship with input from PMEL ECC interactively.

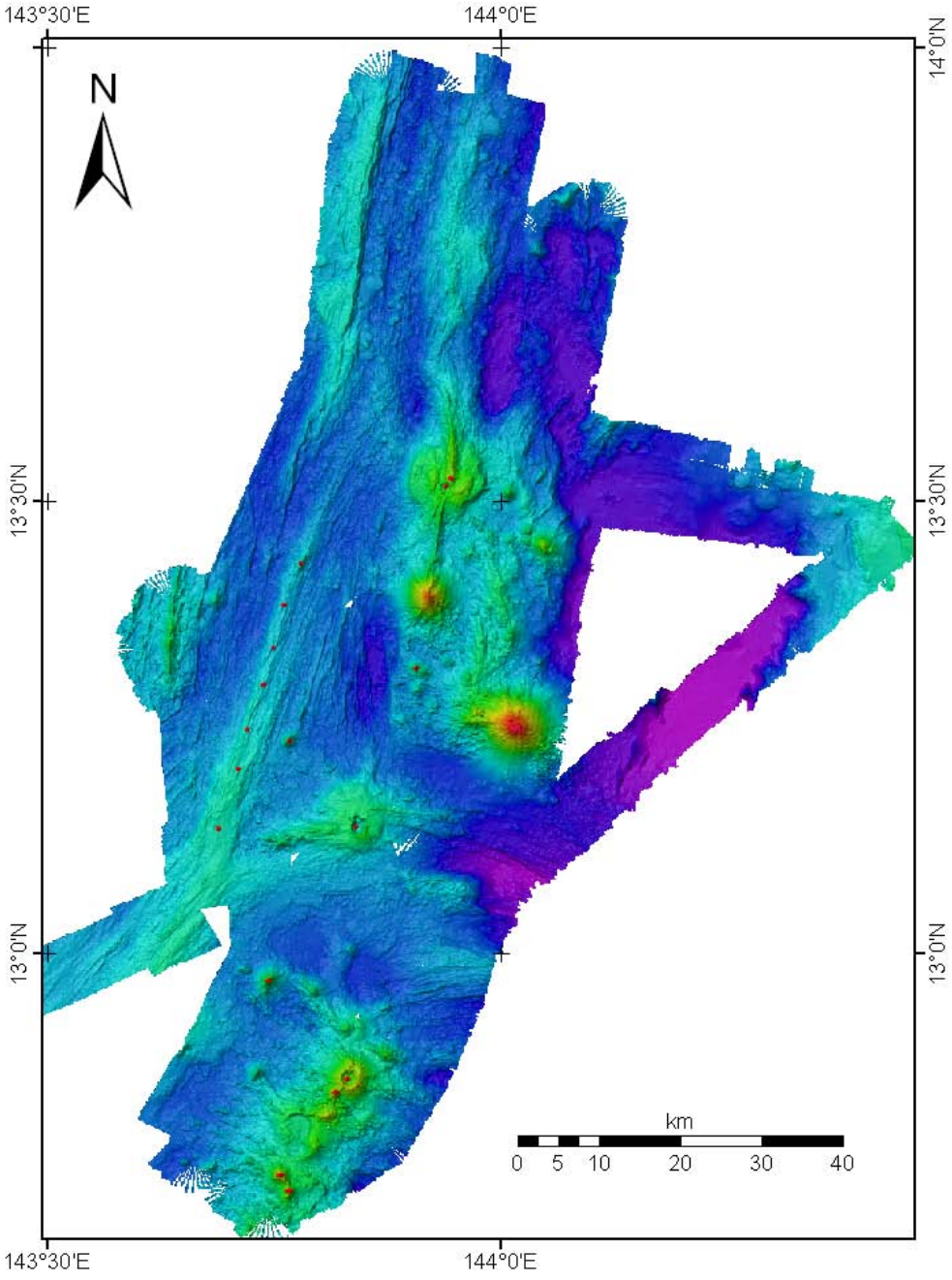

Figure 4. Final results of the bathymetric data collected during EX1004 Leg 1 offshore Guam. Red dots in the image above show the location of the CTD casts collected during this cruise. The image shows the processed Fledermaus data gridded at 50 m cell size. Image compiled in ArcMap.

8. Cruise Calendar

June 2010						
Mon	**Tue**	**Wed**	**Thu**	**Fri**	**Sat**	**Sun**
	8 Departed Guam 1630	9 Commenced mapping operations offshore Guam	10 Continue working in the northern and southern mapping boxes over night. CTD operations 0700.	11 Continue working in the western region of the exploration area. Conducting CTD operations from 0200 - 1700	12 BIST test Indicated failed RX32 board slot #2. Continued mapping and CTD operations	13 Continued mapping and CTD operations. Left the exploration areas in transit to US EEZ
14 Stopped all the data sensors	15 All mapping sensors remain secured. RX board reseated and passed BIST	16 Continue transit towards Bitung, Indonesia. No data being collected	17 Continue transit towards Bitung, Indonesia. No data being collected	18 Continue transit towards Bitung, Indonesia. No data being collected	19 Continue transit towards Bitung, Indonesia. No data being collected	20 Arrived Bitung, Indonesia

9. Daily cruise log

(ALL TIMES LOCAL Guam Time)

June 6-7, 2010
Mission party boarded the ship.

June 8, 2010
Ship left Apra Harbor Guam ~ 1630 to commence transit to the mapping area (Northern Box). Conducted training for participating mapping personnel. No mapping watches over night.

June 9, 2010

0800 Started mapping watches. Started collecting data in northern box.

June 10, 2010

Overnight collected mapping data until ~ 0430. Stopping to conduct CTD operations.

Resumed data collection at 1920.

June 11, 2010

Collected multibeam data till 0200 and stopped data acquisition for CTD operations. Resumed data collection at 1800.

June 12, 2010

Broke multibeam data collection at 0420 to head towards CTD site. Conducted BIST test which showed that RX32 board in slot #2 is failing unique firmware test. The recorded BIST were sent to Kongsberg. Resumed multibeam operations 1940.

June 13, 2010

Stopped multibeam operations ~ 0130 for CTD operations. The ship broke off the operations in the area around 0700. Started multibeam data acquisition while transiting towards US EEZ. The ship arrived at US EEZ boundary at 2330. All the sensors including multibeam, SCS sensors, single beam were secured.

June 14, 2010

Kongsberg engineer (Gregg Juergens) suggested to reseat the receive board to see if this will clear the failed BIST. Chief ET Richard took out the RX32 board and reseated it. A following BIST result showed that all the RX32 boards are passing all the BISTs. Transmit board # 16 (TX36LC) still remain in failed BIST status. All the mapping sensors remain secured.

June 15 – 20, 2010

All the scientific data collection and sensors were secured for transit just prior to entering foreign EEZ's of Palau and Micronesia. The ship arrived into port in Bitung, Indonesia, on June 20, 2010.

10. Appendices

Appendix A. Field Products

See Figure 4 above for a map of the data collected during EX1004 Leg 1.

Appendix B. Tables of data files collected

EX1004 LEG 1 XBT CASTS				
Date (GMT)	**Time (GMT)**	**XBT file name**	**Latitude**	**Longitude**
6/8/2010	22:22:25	XBT_060810_01	13 36.7572N	144 0.56836E
6/9/2010	6:36:44	XBT_060910_02	13 14.6071N	143 49.5585E
6/9/2010	14:29:30	XBT_060910_03	12 58.86365N	143 48.0498E
6/10/2010	14:29:44	XBT_061010_04	12 52.00305N	143 54.16797E
6/11/2010	6:07:04	XBT_061110_06	13 2.3938N	143 44.2148E
6/11/2010	14:33:07	XBT_061110_07	13 48.20825N	143 50.58398E
6/12/2010	8:31:02	XBT_061210_08	13 10.4597N	144 6.20508E
6/13/2010	6:29:09	XBT_061310_09	13 21.6450N	143 47.0449E
6/13/2010	12:32:22	XBT_061310_10	13 51.58667N	143 57.09082E
6/14/2010	4:33:40	XBT_061410_11	12 56.8898N	143 26.774E
6/14/2010	8:36:13	XBT_061410_12	12 40.23376N	142 48.78613E

EX1004 LEG 1 CTD CASTS			
Cast	**Station Name**	**Latitude**	**Longitude**
1	EX1004L1-V01	13.1398	-143.84
2	EX1004L1-V02	13.2349	-143.767
3	EX1004L1-V03	13.3152	-143.907
4	EX1004L1-V04 (a)	12.7383	-143.768
	EX1004L1-V04 (b)	12.7380	-143.765
5	EX1004L1-V05 (a)	12.7552	-143.758
	EX1004L1-V05 (b)	12.7550	-143.755
6	EX1004L1-V06	12.8466	-143.818
7	EX1004L1-V07	12.8614	-143.831
8	EX1004L1-V08	12.9698	-143.744
9	EX1004L1-V09 (a)	13.5156	-143.94
	EX1004L1-V09 (a)	13.5249	-143.945
10	EX1004L1-V10	13.1379	-143.689
11	EX1004L1-V11	13.2038	-143.711
12	EX1004L1-V12	13.2479	-143.72
13	EX1004L1-V13	13.2967	-143.738

14	EX1004L1-V14	13.3379	-143.749
15	EX1004L1-V15	13.4308	-143.779
16	EX1004L1-V16	13.3848	-143.761

EX1004 LEG 1 MULTIBEAM FILES					
Cruise Day No.	**Date (GMT)**	**File Name**	**Location**	**Survey Name**	**Remarks**
1	60810	0000_20100608_085532_EX.all	Transit	Transit	
1	60810	0001_20100608_085946_EX.all	Transit	Transit	
1	60810	0002_20100608_145943_EX.all	Transit	Transit	
1	60810	0003_20100608_195801_EX.all	Transit	Transit	
1	60810	0004_20100608_225621_EX.all	Offshore Guam	Offshore Guam Contingency	
2	60910	0005_20100609_000057_EX.all	Offshore Guam	Offshore Guam Contingency	
2	60910	0006_20100609_001527_EX.all	Offshore Guam	Offshore Guam Contingency	
2	60910	0007_20100609_002409_EX.all	Offshore Guam	Offshore Guam Contingency	
2	60910	0008_20100609_011044_EX.all	Offshore Guam	Offshore Guam Contingency	
2	60910	0009_20100609_022542_EX.all	Offshore Guam	Offshore Guam Contingency	
2	60910	0010_20100609_033155_EX.all	Offshore Guam	Offshore Guam Contingency	
2	60910	0011_20100609_052850_EX.all	Offshore Guam	Offshore Guam Contingency	
2	60910	0012_20100609_060437_EX.all	Offshore Guam	Offshore Guam Contingency	
2	60910	0013_20100609_060656_EX.all	Offshore Guam	Offshore Guam Contingency	
2	60910	0014_20100609_071841_EX.all	Offshore Guam	Offshore Guam Contingency	
2	60910	0015_20100609_085404_EX.all	Offshore Guam	Offshore Guam Contingency	
2	60910	0016_20100609_091740_EX.all	Offshore Guam	Offshore Guam Contingency	
2	60910	0017_20100609_102944_EX.all	Offshore Guam	Offshore Guam Contingency	
2	60910	0018_20100609_121229_EX.all	Offshore Guam	Offshore Guam Contingency	
2	60910	0019_20100609_121617_EX.all	Offshore Guam	Offshore Guam Contingency	
2	60910	0020_20100609_122937_EX.all	Offshore Guam	Offshore Guam Contingency	
2	60910	0021_20100609_123306_EX.all	Offshore Guam	Offshore Guam Contingency	
2	60910	0022_20100609_141758_EX.all	Offshore Guam	Offshore Guam Contingency	
2	60910	0023_20100609_142312_EX.all	Offshore Guam	Offshore Guam Contingency	
2	60910	0024_20100609_144256_EX.all	Offshore Guam	Offshore Guam Contingency	
2	60910	0025_20100609_162737_EX.all	Offshore Guam	Offshore Guam Contingency	

2	60910	0026_20100609_164625_EX.all	Offshore Guam	Offshore Guam Contingency	
2	60910	0027_20100609_165133_EX.all	Offshore Guam	Offshore Guam Contingency	
2	60910	0028_20100609_183814_EX.all	Offshore Guam	Offshore Guam Contingency	
2	60910	0029_20100609_233111_EX.all	Offshore Guam	Offshore Guam Contingency	
3	61010	0030_20100610_092204_EX.all	Offshore Guam	Offshore Guam Contingency	
3	61010	0031_20100610_104018_EX.all	Offshore Guam	Offshore Guam Contingency	
3	61010	0032_20100610_134530_EX.all	Offshore Guam	Offshore Guam Contingency	
3	61010	0033_20100610_150109_EX.all	Offshore Guam	Offshore Guam Contingency	
4	61110	0034_20100611_054000_EX.all	Offshore Guam	Offshore Guam Contingency	
4	61110	0035_20100611_080117_EX.all	Offshore Guam	Offshore Guam Contingency	
4	61110	0036_20100611_105111_EX.all	Offshore Guam	Offshore Guam Contingency	
4	61110	0037_20100611_125808_EX.all	Offshore Guam	Offshore Guam Contingency	
4	61110	0038_20100611_130126_EX.all	Offshore Guam	Offshore Guam Contingency	
4	61110	0039_20100611_132109_EX.all	Offshore Guam	Offshore Guam Contingency	
4	61110	0040_20100611_132703_EX.all	Offshore Guam	Offshore Guam Contingency	
4	61110	0041_20100611_154948_EX.all	Offshore Guam	Offshore Guam Contingency	
4	61110	0042_20100611_184346_EX.all	Offshore Guam	Offshore Guam Contingency	
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5	61210	0051_20100612_120222_EX.all	Offshore Guam	Offshore Guam Contingency	
5	61210	0052_20100612_123539_EX.all	Offshore Guam	Offshore Guam Contingency	

5	61210	0053_20100612_124009_EX.all	Offshore Guam	Offshore Guam Contingency	
5	61210	0054_20100612_134034_EX.all	Offshore Guam	Offshore Guam Contingency	
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5	61210	0056_20100612_142020_EX.all	Offshore Guam	Offshore Guam Contingency	
5	61210	0057_20100612_143032_EX.all	Offshore Guam	Offshore Guam Contingency	
5	61210	0058_20100612_143524_EX.all	Offshore Guam	Offshore Guam Contingency	
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6	61310	0061_20100613_002406_EX.all	Offshore Guam	Offshore Guam Contingency	
6	61310	0062_20100613_061606_EX.all	Offshore Guam	Offshore Guam Contingency	
6	61310	0063_20100613_063933_EX.all	Offshore Guam	Offshore Guam Contingency	
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6	61310	0074_20100613_210341_EX.all	Offshore Guam	Offshore Guam Contingency	
6	61310	0075_20100613_221641_EX.all	Offshore Guam	Offshore Guam Contingency	
6	61310	0076_20100613_225529_EX.all	Offshore Guam	Offshore Guam Contingency	
6	61310	0077_20100613_234843_EX.all	Offshore Guam	Offshore Guam Contingency	
7	61410	0078_20100614_003547_EX.all	Offshore Guam	Offshore Guam Contingency	
7	61410	0079_20100614_022512_EX.all	Offshore Guam	Offshore Guam Contingency	

7	61410	0080_20100614_023020_EX.all	Offshore Guam	Offshore Guam Contingency	
7	61410	0081_20100614_083013_EX.all	Transit to US EEZ	Transit	
7	61410	0082_20100614_113720_EX.all	Transit to US EEZ	Transit	

Appendix C: List of acronyms

BIST – Built In System Test

BJIV – Baruna Jaya IV

BPPT - Badan Pengkajian Dan Penerapan Teknologi (Indonesian Agency for the Assessment and Application Technology)

CIMS – Cruise Information Management System

CO – Commanding Officer

CTD – conductivity temperature and depth

CW – continuous wave

dB – decibels

DGPS –Differential Global Positioning System

DTM – digital terrain model

ECS – Extended Continental Shelf

EEZ –Exclusive Economic Zone

ET – Electronics Technician

EX – NOAA Ship *Okeanos Explorer*

FM – frequency modulation

FOO – Field Operations Officer

INDEX-SATAL – Indonesia Exploration–Sangihe Talaud Region

kHz - kilohertz

Km – kilometers

KM – Kongsberg Maritime AS

Kt(s) – knots

LT – lieutenant

LTJG – lieutenant junior grade

Ma – megaannum

MBES – multibeam echosounder

NCDDC – National Coastal Data Development Center

NGDC – National Geophysical Data Center

NOAA – National Oceanic and Atmospheric Administration

NODC – National Oceanographic Data Center

OER – Office of Ocean Exploration and Research

OMAO – Office of Marine and Aviation Operations

PMEL – Pacific Marine Environmental Laboratory

ROV – Remotely Operated Vehicle

RX – receive

SST – Senior Survey Technician

SV – sound velocity

TNI –Tentara Nasional Indonesia (Indonesian Navy)

TRU – transmit and receive unit

TSG - thermosalinograph

TX – transmit

UNCLOS – United Nations Convention on the Law of the Sea

UNH-CCOM/JHC – University of New Hampshire Center for Coastal and Ocean Mapping / Joint Hydrographic Center

UPS – uninterruptable power supply

USBL – ultra-short base line

WD – water depth

XBT – expendable bathythermograph

Appendix D: EM302 description and operational specs

EM 302 : Ideal for Ocean Exploration

There are several features of the Okeanos Explorer's 30 kHz multibeam that make it an excellent tool for ocean exploration. The following is a brief description of these features.

Depth Range

The system is designed to map the seafloor in water depths of 10 to 7000 meters. This leaves only the deepest parts of the deeper ocean trenches out of the EM 302's reach. Moreover, operational experience on the *Okeanos Explorer* has shown consistent EM 302 bottom detection at depth ranges in excess of 8000m.

High Density Data

In multibeam data, the denser the data, the finer resolution maps you can produce. The system can operate in dual swath, or multiping mode, which results in increased along track data density. This is achieved by detecting two swaths per ping cycle, resulting in up to 864 beams per ping.

The Okeanos Explorer mapping team typically operates the multibeam in high density equidistant ping mode, which results in up to 864 soundings on the seafloor per ping.

Full Suite of Data Types Collected

The system collects seafloor backscatter data, which provides information about the character of the seafloor in terms of bottom type.

The system also collects water column backscatter data, which has the ability to detect gaseous plumes in the water column. The full value of this feature is still being realized.

FM chirp mode is utilized in water depths greater than 1000 meters, and allows for the detection of the bottom further out from nadir than with previous 30 kHz systems.

Multibeam Primer

The area of the seafloor covered, or ensonified, by a single beam within a pulse of sound, or ping, is called the beam footprint. This beam footprint is defined in terms of the across track and along track values. Both of these values are dependent on water depth and the beam width at which the sound pulse is transmitted and received. The across track beam width value is also dependent on the receive angle, or "listening" angle, of the system, and the angle from nadir which it is received from. The receive angle for the receive transducer on the Okeanos Explorer EM302 is 1°, which is the smallest possible angle currently available for the EM302 system. The further out from nadir a sounding occurs, the larger the footprint will be. For example, as seen in Table 1 below, in 2000 meters of water, a beam footprint will have a radius of 18 meters at nadir but 25 meters by the time it hits the seafloor at an angle 140 degrees out from nadir.

Calculated acrosstrack acoustic beam footprint for EM 302 (high density ping mode, 432 soundings/profile)

Water depth (m)	Angle from nadir			
50	1 deg RX center	90 deg	120 deg	140 deg
100	1	0.5	1	1
200	2	1	2	3
400	4	2	3	5
1000	7	4	6	10
2000	18	9	16	25
4000	35	19	32	-
6000	70	37	-	-
7000	105	56	-	-

Table 2. Calculated across track EM 302 beam footprint. Reference: Kongsberg Product description, Kongsberg document 302675 Rev B, Date 14/06/06, p. 17.

Calculated acrosstrack sounding density for EM 302 (high density ping mode, 432 soundings/profile)			
Water depth (m)	**Swath Width**		
50	90 deg	120 deg	140 deg
100	0.2	0.4	0.9
200	0.5	0.8	1.7
400	0.9	1.6	3.5
1000	1.9	3.2	6.9
2000	4.6	8.1	17.4
4000	9.3	16.2	-

Table 3. Calculated across track EM 302 sounding density. Reference: Kongsberg Product description, Kongsberg document 302675 Rev B, Date 14/06/06, p. 17.

Acrosstrack sounding density describes the spacing between individual soundings on the seafloor in the acrosstrack direction. The maximum swath of the EM 302 is 150 degrees. At this swath, the sounding density will be the least dense, since the beams will be spread out over a larger horizontal distance over the seafloor. As the swath angle (width) is decreased, the sounding density will increase, as the same number of beams are now spread out over a smaller horizontal distance over the seafloor.

Calculated ping rate and alongtrack resolution for EM 302					
140 deg swath, one profile per ping					
			Alongtrack distance between profiles (m)		
Water depth (m)	**Swath Width (m)**	**Ping Rate (pings/second)**	**@4 kts**	**@8 kts**	**@12 kts**
50	275	3.2	0.7	1.2	1.9
100	550	1.8	1.1	2.2	3.3

200	1100	1	2.1	4.2	6.3
400	2200	0.5	4.1	8.2	12.2
1000	5500	0.2	10	20	30
2000	8000	0.1	15.2	30.5	45.7
4000	8000	0.06	19.2	38.5	57.7
6000	8000	0.04	24.5	49	73.4

Table 4. Calculated ping rate and along track EM 302 sounding density, one profile per ping. Reference: Kongsberg Product description, Kongsberg document 302675 Rev B, Date 14/06/06, p. 15.

Calculated ping rate and alongtrack resolution for EM 302					
140 deg swath, two profiles per ping					
Water depth (m)	**Swath Width (m)**	**Ping Rate**	**Alongtrack distance between profiles (m)**		
			@4 kts	**@8 kts**	**@12 kts**
50	275	3.2	0.3	0.6	0.9
100	550	1.8	0.6	1.1	1.7
200	1100	1	1.1	2.1	3.2
400	2200	0.5	2	4.1	6.1
1000	5500	0.2	5	10	15
2000	8000	0.1	7.6	15.2	22.8

Table 5. Calculated ping rate and along track EM 302 sounding density, two profiles per ping. Reference: Kongsberg Product description, Kongsberg document 302675 Rev B, Date 14/06/06, p. 15.

Reference: Kongsberg Product Description: EM 302 multibeam echosounder

Appendix E: EM302 PU Parameters

```
#// Database Parameters

#// Seafloor Information System
#// Kongsberg Maritime AS
#// Saved:  2010.06.16 10:06:03

#// Build info:
#* SIS:              [Version: 3.6.4,
Build: 174 , DBVersion 16.0 CD
generated: Mon Mar 30 2009
14:00:00]
[Fox ver = 1.6.29]
[db ver = 16, proc = 16.0]
[OTL = 4.0.-95]
[ACE ver = 5.5]
[Coin ver = 2.4.4]
[Simage ver = 1.6.2a]
[Dime ver = DIME v0.9]
[STLPort ver = 513]
[FreeType ver = 2.1.9]
[TIFF ver = 3.8.2]
[GeoTIFF ver = 1230]
[GridEngine ver = 2.3.0]

#* Language          [3] #// Current
language, 1-Norwegian, 2-
German,3-English, 4-Spanish

#* Type              [302]
#* Serial no.        [101]
#* Number of heads   [2]
#* System descriptor [50331648]
#// 03000000

#//
**********
**********
*********
#// Installation parameters

#{ Input Setup #// All Input setup
parameters

  #{ COM1 #// Link settings.

    #{ Com. settings #// Serial line
parameter settings.
      #* Baud rate:       [9600]
      #* Data bits        [8]
      #* Stop bits:       [1]
      #* Parity:          [NONE]
    #} Com. settings

    #{ Position #// Position input
settings.
      #* None            [1] [0]
      #* GGK             [1] [0]
      #* GGA             [1] [1]
      #* GGA_RTK         [1] [0]
      #* SIMRAD90        [1] [0]
    #} Position
```

```
    #{ Input Formats #// Format
input settings.
      #* Attitude          [0] [0]
      #* MK39 Mod2 Attitude,  [0]
[0]
      #* ZDA Clock          [1] [1]
      #* HDT Heading        [0] [0]
      #* SKR82 Heading      [0] [0]
      #* DBS Depth          [1] [0]
      #* DBT Depth          [1] [0]
      #* EA500 Depth        [0] [0]
      #* ROV. depth         [1] [0]
      #* Height, special purp [1] [0]
      #* Ethernet AttVel     [0] [0]
    #} Input Formats

  #} COM1

  #{ COM2 #// Link settings.

    #{ Com. settings #// Serial line
parameter settings.
      #* Baud rate:         [19200]
      #* Data bits          [8]
      #* Stop bits:         [1]
      #* Parity:            [NONE]
    #} Com. settings

    #{ Position #// Position input
settings.
      #* None              [0] [1]
      #* GGK               [0] [0]
      #* GGA               [0] [0]
      #* GGA_RTK           [0] [0]
      #* SIMRAD90          [0] [0]
    #} Position

    #{ Input Formats #// Format
input settings.
      #* Attitude          [1] [1]
      #* MK39 Mod2 Attitude,  [0]
[0]
      #* ZDA Clock          [0] [0]
      #* HDT Heading        [0] [0]
      #* SKR82 Heading      [0] [0]
      #* DBS Depth          [0] [0]
      #* DBT Depth          [0] [0]
      #* EA500 Depth        [0] [0]
      #* ROV. depth         [0] [0]
      #* Height, special purp [0] [0]
      #* Ethernet AttVel     [0] [0]
    #} Input Formats

  #} COM2

  #{ COM3 #// Link settings.

    #{ Com. settings #// Serial line
parameter settings.
      #* Baud rate:         [4800]
      #* Data bits          [8]
      #* Stop bits:         [1]
      #* Parity:            [NONE]
    #} Com. settings

    #{ Position #// Position input
settings.
      #* None              [1] [1]
      #* GGK               [1] [0]
      #* GGA               [1] [0]
      #* GGA_RTK           [1] [0]
      #* SIMRAD90          [1] [0]
    #} Position

    #{ Input Formats #// Format
input settings.
      #* Attitude          [0] [0]
      #* MK39 Mod2 Attitude,  [0]
[0]
      #* ZDA Clock          [0] [0]
      #* HDT Heading        [1] [1]
      #* SKR82 Heading      [0] [0]
      #* DBS Depth          [1] [0]
      #* DBT Depth          [1] [0]
      #* EA500 Depth        [0] [0]
      #* ROV. depth         [1] [0]
      #* Height, special purp [1] [0]
      #* Ethernet AttVel     [0] [0]
    #} Input Formats

  #} COM3

  #{ COM4 #// Link settings.

    #{ Com. settings #// Serial line
parameter settings.
      #* Baud rate:         [9600]
      #* Data bits          [8]
      #* Stop bits:         [1]
      #* Parity:            [NONE]
    #} Com. settings

    #{ Position #// Position input
settings.
      #* None              [1] [1]
      #* GGK               [1] [0]
      #* GGA               [1] [0]
      #* GGA_RTK           [1] [0]
      #* SIMRAD90          [1] [0]
    #} Position

    #{ Input Formats #// Format
input settings.
      #* Attitude          [0] [0]
      #* MK39 Mod2 Attitude,  [0]
[0]
      #* ZDA Clock          [0] [0]
      #* HDT Heading        [0] [0]
      #* SKR82 Heading      [0] [0]
      #* DBS Depth          [1] [0]
      #* DBT Depth          [1] [0]
      #* EA500 Depth        [0] [0]
      #* ROV. depth         [1] [0]
      #* Height, special purp [1] [0]
      #* Ethernet AttVel     [0] [0]
    #} Input Formats

  #} COM4

  #{ UDP2 #// Link settings.

    #{ Com. settings #// Serial line
parameter settings.
      #// N/A
    #} Com. settings

    #{ Position #// Position input
settings.
      #* None              [1] [1]
      #* GGK               [1] [0]
      #* GGA               [1] [0]
      #* GGA_RTK           [1] [0]
      #* SIMRAD90          [1] [0]
    #} Position

    #{ Input Formats #// Format
input settings.
      #* Attitude          [0] [0]
      #* MK39 Mod2 Attitude,  [0]
[0]
      #* ZDA Clock          [0] [0]
      #* HDT Heading        [0] [0]
      #* SKR82 Heading      [0] [0]
      #* DBS Depth          [0] [0]
      #* DBT Depth          [0] [0]
      #* EA500 Depth        [1] [0]
      #* ROV. depth         [0] [0]
      #* Height, special purp [0] [0]
      #* Ethernet AttVel     [0] [0]
    #} Input Formats

  #} UDP2

  #{ UDP3 #// Link settings.

    #{ Com. settings #// Serial line
parameter settings.
      #// N/A
    #} Com. settings

    #{ Position #// Position input
settings.
      #* None              [0] [1]
      #* GGK               [0] [0]
      #* GGA               [0] [0]
      #* GGA_RTK           [0] [0]
      #* SIMRAD90          [0] [0]
    #} Position

    #{ Input Formats #// Format
input settings.
      #* Attitude          [0] [0]
      #* MK39 Mod2 Attitude,  [0]
[0]
      #* ZDA Clock          [0] [0]
      #* HDT Heading        [1] [0]
      #* SKR82 Heading      [0] [0]
      #* DBS Depth          [1] [0]
      #* DBT Depth          [1] [0]
      #* EA500 Depth        [0] [0]
      #* ROV. depth         [1] [0]
      #* Height, special purp [1] [0]
      #* Ethernet AttVel     [0] [0]
    #} Input Formats

  #} UDP3

  #{ UDP4 #// Link settings.

    #{ Com. settings #// Serial line
parameter settings.
      #// N/A
    #} Com. settings

    #{ Position #// Position input
settings.
      #* None              [0] [1]
      #* GGK               [0] [0]
      #* GGA               [0] [0]
```

```
      #* GGA_RTK            [0] [0]
      #* SIMRAD90           [0] [0]
    #} Position

    #{ Input Formats #// Format
input settings.
      #* Attitude           [1] [0]
      #* MK39 Mod2 Attitude,  [0]
[0]
      #* ZDA Clock          [0] [0]
      #* HDT Heading        [1] [0]
      #* SKR82 Heading      [0] [0]
      #* DBS Depth          [1] [0]
      #* DBT Depth          [1] [0]
      #* EA500 Depth        [0] [0]
      #* ROV. depth         [1] [0]
      #* Height, special purp [1] [0]
      #* Ethernet AttVel     [0] [0]
    #} Input Formats

  #} UDP4

  #{ UDP5 #// Link settings.

    #{ Com. settings #// Serial line
parameter settings.
      #// N/A
    #} Com. settings

    #{ Position #// Position input
settings.
      #* None              [0] [0]
      #* GGK               [0] [0]
      #* GGA               [0] [0]
      #* GGA_RTK           [0] [0]
      #* SIMRAD90          [0] [0]
    #} Position

    #{ Input Formats #// Format
input settings.
      #* Attitude          [0] [0]
      #* MK39 Mod2 Attitude,  [0]
[0]
      #* ZDA Clock          [0] [0]
      #* HDT Heading        [0] [0]
      #* SKR82 Heading      [0] [0]
      #* DBS Depth          [0] [0]
      #* DBT Depth          [0] [0]
      #* EA500 Depth        [0] [0]
      #* ROV. depth         [0] [0]
      #* Height, special purp [0] [0]
      #* Ethernet AttVel     [1] [1]
    #} Input Formats

    #{ Attitude Velocity settings #//
Only relevant for UDP5 on EM122,
EM302 and EM710, currently
      #* Attitude 1         [1] [1]
      #* Attitude 2         [1] [0]
      #* Use Ethernet 2     [1] [1]
      #* Port:              [5602]
      #* IP addr.:
[192.168.2.20]
      #* Net mask:
[255.255.255.0]
    #} Attitude Velocity settings

  #} UDP5

  #{ Misc. #// Misc. input settings.
    #* External Trigger    [1] [0]
  #} Misc.

#} Input Setup

#{ Output Setup #// All Output setup
parameters

  #* PU broadcast enable  [1] [1]
  #* Log watercolumn to s [1] [1]

  #{ Host UDP1 #// Host UDP1
Port: 16100

    #{ Datagram subscription #//
      #* Depth             [0] [0]
      #* Raw range and beam a [0]
[0]
      #* Seabed Image       [0] [0]
      #* Central Beams      [0] [0]
      #* Position           [0] [0]
      #* Attitude           [0] [0]
      #* Heading            [0] [0]
      #* Height             [0] [0]
      #* Clock              [0] [0]
      #* Single beam echosoun [0]
[0]
      #* Sound Speed Profile  [0] [1]
      #* Runtime Parameters   [0] [1]
      #* Installation Paramet [0] [1]
      #* BIST Reply          [0] [1]
      #* Status parameters    [0] [1]
      #* PU Broadcast        [0] [0]
      #* Stave Display       [0] [0]
      #* Water Column        [0] [0]
      #* Internal, Range Data [0] [0]
      #* Internal, Scope Data [0] [0]
    #} Datagram subscription

  #} Host UDP1

  #{ Host UDP2 #// Host UDP2
Port: 16101

    #{ Datagram subscription #//
      #* Depth             [1] [1]
      #* Raw range and beam a [1]
[1]
      #* Seabed Image       [1] [1]
      #* Central Beams      [1] [0]
      #* Position           [1] [1]
      #* Attitude           [1] [1]
      #* Heading            [1] [1]
      #* Height             [1] [1]
      #* Clock              [1] [1]
      #* Single beam echosoun [1]
[1]
      #* Sound Speed Profile  [0] [1]
      #* Runtime Parameters   [0] [1]
      #* Installation Paramet [0] [1]
      #* BIST Reply          [1] [1]
      #* Status parameters    [0] [1]
      #* PU Broadcast        [1] [0]
      #* Stave Display       [0] [1]
      #* Water Column        [0] [1]
      #* Internal, Range Data [1] [0]
      #* Internal, Scope Data [1] [0]
    #} Datagram subscription

  #} Host UDP2

  #{ Host UDP3 #// Host UDP3
Port: 16102

    #{ Datagram subscription #//
      #* Depth             [0] [1]
      #* Raw range and beam a [0]
[0]
      #* Seabed Image       [0] [0]
      #* Central Beams      [0] [0]
      #* Position           [0] [0]
      #* Attitude           [0] [1]
      #* Heading            [0] [0]
      #* Height             [0] [1]
      #* Clock              [0] [0]
      #* Single beam echosoun [0]
[1]
      #* Sound Speed Profile  [0] [1]
      #* Runtime Parameters   [0] [0]
      #* Installation Paramet [0] [1]
      #* BIST Reply          [0] [0]
      #* Status parameters    [0] [0]
      #* PU Broadcast        [0] [0]
      #* Stave Display       [0] [0]
      #* Water Column        [0] [0]
      #* Internal, Range Data [0] [0]
      #* Internal, Scope Data [0] [1]
    #} Datagram subscription

  #} Host UDP3

  #{ Host UDP4 #// Host UDP4 Port
16103

    #{ Datagram subscription #//
      #* Depth             [1] [1]
      #* Raw range and beam a [1]
[0]
      #* Seabed Image       [1] [0]
      #* Central Beams      [1] [0]
      #* Position           [1] [0]
      #* Attitude           [1] [0]
      #* Heading            [1] [0]
      #* Height             [1] [0]
      #* Clock              [1] [0]
      #* Single beam echosoun [1]
[0]
      #* Sound Speed Profile  [1] [0]
      #* Runtime Parameters   [1] [0]
      #* Installation Paramet [1] [0]
      #* BIST Reply          [1] [0]
      #* Status parameters    [1] [0]
      #* PU Broadcast        [1] [0]
      #* Stave Display       [1] [0]
      #* Water Column        [1] [0]
      #* Internal, Range Data [1] [0]
      #* Internal, Scope Data [1] [0]
    #} Datagram subscription

  #} Host UDP4

  #{ Watercolumn #// Host UDP4
Port 16103

    #{ Datagram subscription #//
```

```
      #* Depth              [1] [1]
      #* Raw range and beam a [1]
[1]
      #* Seabed Image       [1] [1]
      #* Central Beams      [1] [0]
      #* Position           [1] [1]
      #* Attitude           [1] [1]
      #* Heading            [1] [1]
      #* Height             [1] [1]
      #* Clock              [1] [1]
      #* Single beam echosoun [1]
[1]
      #* Sound Speed Profile  [1] [1]
      #* Runtime Parameters   [1] [1]
      #* Installation Paramet [1] [1]
      #* BIST Reply          [1] [1]
      #* Status parameters    [1] [1]
      #* PU Broadcast        [1] [0]
      #* Stave Display       [1] [0]
      #* Water Column        [1] [1]
      #* Internal, Range Data [1] [0]
      #* Internal, Scope Data [1] [0]
    #} Datagram subscription

  #} Watercolumn

#} Output Setup

#{ Clock Setup #// All Clock setup
parameters

  #{ Clock #// All clock settings.
    #* Source:           [1] #//
External ZDA Clock
    #* 1PPS Clock Synch.   [1] [1]
    #* Offset (sec.):     [0]
  #} Clock

#} Clock Setup

#{ Settings #// Sensor setup
parameters

  #{ Positioning System Settings #//
Position related settings.

    #{ COM1 #// Positioning System
Ports:
      #* P1T              [0] #//
System
      #* P1M              [0] #//
Enable position motion correction
      #* P1D              [0.000] #//
Position delay (sec.):
      #* P1G              [WGS84] #//
Datum:
      #* P1Q              [1] #//
Enable
      #* Pos. qual. indicator [] #//
    #} COM1

  #} Positioning System Settings

  #{ Motion Sensor Settings #//
Motion related settings.

    #{ COM2 #// Motion Sensor
Ports:
      #* MRP              [RP] #//
Rotation (POSMV/MRU)
      #* MSD              [0] #//
Motion Delay (msec.):
      #* MAS              [1.00] #//
Motion Sensor Roll Scaling:
    #} COM2

  #} Motion Sensor Settings

  #{ Active Sensors #//
    #* APS              [0] [COM1]
#// Position:
    #* ARO              [2] [COM2]
#// Motion:
    #* AHE              [2] [COM2]
#// Motion:
    #* AHS              [3] [COM3]
#// Heading:
  #} Active Sensors

#} Settings

#{ Locations #// All location
parameters

  #{ Location offset (m) #//

    #{ Pos, COM1: #//
      #* P1X              [0.00] #//
Forward (X)
      #* P1Y              [0.00] #//
Starboard (Y)
      #* P1Z              [0.00] #//
Downward (Z)
    #} Pos, COM1:

    #{ Pos, COM3: #//
      #* P2X              [0.00] #//
Forward (X)
      #* P2Y              [0.00] #//
Starboard (Y)
      #* P2Z              [0.00] #//
Downward (Z)
    #} Pos, COM3:

    #{ Pos, COM4/UDP2: #//
      #* P3X              [0.00] #//
Forward (X)
      #* P3Y              [0.00] #//
Starboard (Y)
      #* P3Z              [0.00] #//
Downward (Z)
    #} Pos, COM4/UDP2:

    #{ TX Transducer: #//
      #* S1X              [6.147] #//
Forward (X)
      #* S1Y              [1.822] #//
Starboard (Y)
      #* S1Z              [6.796] #//
Downward (Z)
    #} TX Transducer:

    #{ RX Transducer: #//
      #* S2X              [2.497] #//
Forward (X)
      #* S2Y              [2.481] #//
Starboard (Y)
      #* S2Z              [6.790] #//
Downward (Z)
    #} RX Transducer:

    #{ Attitude 1, COM2: #//
      #* MSX              [0.00] #//
Forward (X)
      #* MSY              [0.00] #//
Starboard (Y)
      #* MSZ              [0.00] #//
Downward (Z)
    #} Attitude 1, COM2:

    #{ Attitude 2, COM3: #//
      #* NSX              [0.00] #//
Forward (X)
      #* NSY              [0.00] #//
Starboard (Y)
      #* NSZ              [0.00] #//
Downward (Z)
    #} Attitude 2, COM3:

    #{ Waterline: #//
      #* WLZ              [1.838] #//
Downward (Z)
    #} Waterline:

  #} Location offset (m)

#} Locations

#{ Angular Offsets #// All angular
offset parameters

  #{ Offset angles (deg.) #//

    #{ TX Transducer: #//
      #* S1R              [0.00] #//
Roll
      #* S1P              [0.00] #//
Pitch
      #* S1H              [359.98] #//
Heading
    #} TX Transducer:

    #{ RX Transducer: #//
      #* S2R              [0.00] #//
Roll
      #* S2P              [0.00] #//
Pitch
      #* S2H              [0.03] #//
Heading
    #} RX Transducer:

    #{ Attitude 1, COM2: #//
      #* MSR              [0.00] #//
Roll
      #* MSP              [-0.80] #//
Pitch
      #* MSG              [0.00] #//
Heading
    #} Attitude 1, COM2:

    #{ Attitude 2, COM3: #//
      #* NSR              [0.00] #//
Roll
      #* NSP              [0.00] #//
Pitch
      #* NSG              [0.00] #//
Heading
    #} Attitude 2, COM3:

    #{ Stand-alone Heading: #//
```

```
      #* GCG              [0.00] #//
Heading
    #} Stand-alone Heading:

  #} Offset angles (deg.)

#} Angular Offsets

#{ ROV. Specific #// All ROV
specific parameters

  #{ Depth/Pressure Sensor #//
    #* DSF              [1.00] #//
Scaling:
    #* DSO              [0.00] #//
Offset:
    #* DSD              [0.00] #//
Delay:
    #* DSH              [NI] #//
Disable Heave Sensor
  #} Depth/Pressure Sensor

#} ROV. Specific

#{ System Parameters #// All system
parameters

  #{ System Gain Offset #//
    #* GO1              [0.0] #// BS
Offset (dB)
  #} System Gain Offset

  #{ Opening angles #//
    #* S1S              [0] #// TX
Opening angle:
    #* S2S              [1] #// RX
Opening angle:
  #} Opening angles

#} System Parameters

#//
**********
**********
*********
#// Runtime parameters


#{ Sounder Main #//

  #{ Sector Coverage #//

    #{ Max. angle (deg.): #//
      #* MPA              [70] #//
Port
      #* MSA              [70] #//
Starboard
    #} Max. angle (deg.):

    #{ Max. Coverage (m): #//
      #* MPC              [5000] #//
Port
      #* MSC              [5000] #//
Starboard
    #} Max. Coverage (m):

    #* ACM              [1] #//
Angular Coverage mode: AUTO
    #* BSP              [2] #// Beam
Spacing: HIDENS EQDIST
  #} Sector Coverage

  #{ Depth Settings #//
    #* FDE              [3200] #//
Force Depth (m)
    #* MID              [100] #// Min.
Depth (m):
    #* MAD              [6000] #//
Max. Depth (m):
    #* DSM              [0] #// Dual
swath mode: OFF
    #* PMO              [0] #// Ping
Mode: AUTO
    #* FME              [1] #// FM
enable
  #} Depth Settings

  #{ Stabilization #//
    #* YPS              [1] #// Pitch
stabilization
    #* TXA              [0] #// Along
Direction (deg.):

    #{ Yaw Stabilization #//
      #* YSM              [2] #//
Mode: REL. MEAN HEADING
      #* YMA              [300] #//
Heading:
      #* HFI              [1] #//
Heading filter: MEDIUM
    #} Yaw Stabilization

  #} Stabilization
#} Sounder Main

#{ Sound Speed #//

  #{ Sound Speed at Transducer #//
    #* SHS              [0] #// Source
SENSOR
    #* SST              [15000] #//
Sound Speed (dm/sec.):
    #* Sensor Offset (m/sec [0] #//
    #* Filter (sec.):    [5] #//
  #} Sound Speed at Transducer

#} Sound Speed

#{ Filter and Gains #//

  #{ Filtering #//
    #* SFS              [1] #// Spike
Filter Strength: WEAK
    #* PEF              [0] #//
Penetration Filter Strength: OFF
    #* RGS              [1] #// Range
Gate: NORMAL
    #* SLF              [1] #// Slope
    #* AEF              [1] #//
Aeration
    #* STF              [1] #// Sector
Tracking
    #* IFF              [1] #//
Interference
  #} Filtering

  #{ Absorption Coefficient #//
    #* ABC              [6.146] #//
31.5 kHz
  #} Absorption Coefficient

  #{ Normal incidence sector #//
    #* TCA              [6] #// Angle
from nadir (deg.):
  #} Normal incidence sector


  #{ Mammal protection #//
    #* TXP              [0] #// TX
power level (dB): Max.
    #* SSR              [0] #// Soft
startup ramp time (min.):
  #} Mammal protection
#} Filter and Gains

#{ Data Cleaning #//
  #* Active rule:
[STANDARD] #//
  #{ STANDARD #//
    #*
PingProc.maxPingCountRadius
[10]
    #* PingProc.radiusFactor
[0.050000]
    #* PingProc.medianFactor
[1.500000]
    #* PingProc.beamNumberRadius
[3]
    #* PingProc.sufficientPointCount
[40]
    #* PingProc.neighborhoodType
[Elliptical]
    #* PingProc.timeRule.use
[false]
    #* PingProc.overhangRule.use
[false]
    #* PingProc.medianRule.use
[false]
    #*
PingProc.medianRule.depthFactor
[0.050000]
    #*
PingProc.medianRule.minPointCoun
t              [6]
    #* PingProc.quantileRule.use
[false]
    #*
PingProc.quantileRule.quantile
[0.100000]
    #*
PingProc.quantileRule.scaleFactor
[6.000000]
    #*
PingProc.quantileRule.minPointCou
nt             [40]
    #* GridProc.minPoints
[8]
    #* GridProc.depthFactor
[0.200000]
    #*
GridProc.removeTooFewPoints
[false]
    #*
GridProc.surfaceFitting.surfaceDegr
ee             [1]
    #*
GridProc.surfaceFitting.tukeyConsta
nt             [6.000000]
```

```
    #* GridProc.surfaceFitting.maxIteration [10]
    #* GridProc.surfaceFitting.convCriterion [0.010000]
    #* GridProc.surfaceDistanceDepthRule.use [false]
    #* GridProc.surfaceDistanceDepthRule.depthFactor [0.050000]
    #* GridProc.surfaceDistancePointRule.use [false]
    #* GridProc.surfaceDistancePointRule.scaleFactor [1.000000]
    #* GridProc.surfaceDistanceUnitRule.use [false]
    #* GridProc.surfaceDistanceUnitRule.scaleFactor [1.000000]
    #* GridProc.surfaceDistanceStDevRule.use [false]
    #* GridProc.surfaceDistanceStDevRule.scaleFactor [2.000000]
    #* GridProc.surfaceAngleRule.use [false]
    #* GridProc.surfaceAngleRule.minAngle [20.000000]
    #* SonarProc.use [false]
    #* SonarProc.gridSizeFactor [4]
    #* SonarProc.mergerType [Average]
    #* SonarProc.interpolatorType [TopHat]
    #* SonarProc.interpolatorRadius [1]
    #* SonarProc.fillInOnly [true]
  #} STANDARD

  #{ Seabed Image Processing #//
    #* Seabed Image Process [1] [0]
  #} Seabed Image Processing
#} Data Cleaning

#{ Advanced param. #//
#} Advanced param.
```

Appendix F: Software versions in use during EX1004 Leg 1

Software	Version	Purpose
CARIS HIPS and SIPS	6.1 Service Pack 2	Multibeam processing
ECDIS		Ship line keeping
ESRI – ArcMap	9.3	Map products
Fledermaus	6.7.0h Build 419 Professional	Multibeam QC, Line planning
Fledermaus	7.2.0 Build 411 Professional, 32 bit Edition	
Hypack	9.0.0.22	Survey planning
Hypack	9.0.4.0	Realtime monitoring
Kongsberg SIS (installed 2/12/10)	3.6.4 build 174	EM302 data acquisition
Velocipy (NOAA)	10.7	XBT, ROV CTD processing
Velociwin (NOAA)	8.92	XBT processing