NOAA *Okeanos Explorer* Program

MAPPING DATA REPORT

CRUISE EX0909 Leg 2

Mapping Field Trials

Necker Ridge

September 12-26, 2009

Honolulu, HI to Honolulu, HI

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 B and the ship's readiness report, which can be obtained by contacting the ships operations officer (ops.explorer@noaa.gov).

3. Cruise Objectives

The objectives of the cruise have been outlined in the EX0909 Legs 1-4 cruise instructions which included primary objectives to test, troubleshoot, refine and evaluate EX mapping systems, sensors, protocols and procedures to support systematic exploration and secondary objective to map the areas in vicinity of Hawaiian Islands which are of national and regional interest.

4. Participating personnel

NAME	ROLE	AFFILIATION
CDR Joseph Pica	Commanding Officer	NOAA Corps
Catalina Martinez	Expedition Coordinator	NOAA OER
LT Nicola Verplanck	Field Operations Officer	NOAA Corps
Elaine Stuart	Senior Survey Technician	NOAA OMAO
Colleen Peters	Senior Survey Technician	NOAA OMAO
Andrea LeBarge	Mapping Watchstander	NOAA OER / UCAR / UNH Intern
Tyanne Faulkes	Mapping Watchstander	Intern
Heather Jackson	Mapping Watchstander	Intern
Frederico Garcia-Uribe	Mapping Watchstander	Intern

Jack Payette	Mapping Watchstander	Intern

5. Cruise Statistics

Dates	9/12/09 – 09/26/2009
Weather delays	0
Total non-mapping days	1
Total survey mapping days	7
Total transit mapping days	6
Line kilometers of survey	1694 (915 nm)
Beginning draft	13’11”(fwd)14’3.5” (aft)
Average ship speed for survey	9.0 kts

6. Mapping sonar setup

NOAA *Okeanos Explorer* (EX) is equipped with a 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. Additional water column data logging was turned on when interesting features were observed in the water column.

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 2.0 m.

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. XBT casts (Deep Blue, max depth 760 m) were taken every 6 hours (0000, 0600, 1200 and 1800 local time) and in between if needed. XBT cast data were converted to SIS compliant format using NOAA Velocwin ver. 8.92 Plus.

During July 2009, the ship reported one of the transmit boards defective. Upon arrival of the ship in Honolulu, HI on September 3rd, the replacement transit board was installed and the defective board replaced. The Built In System Test (BIST) results conducted after installation in Pearl Harbor show all tests passed and the replacement board as fully functional—although with high noise levels (between 70-75dB)—which were attributed to interference from being in a major port. No further tests were performed at that time with the understanding that another BIST and multiple TX noise levels would be done once the ship was away from Pearl Harbor. Soon after departing Honolulu, HI on September 12th, the BIST was performed as well as the multiple TX noise level tests, the BIST giving good results and the TX noise showing low levels between 45-55 dB.

7. Data acquisition plan

The data were collected during transit from Honolulu, HI to working grounds (12-14 September) and from the working grounds (September 21-25) in vicinity of Necker Ridge. Data acquisition in the working grounds was carried out 14-21 of September 2009. On September 25, the ship collected data over two reported wrecks while conducting small boat operations on the western side of Oahu.

The lines were planned to run parallel alongside previous data with nominal line spacing of 5000-6000 m traveling southwest down Necker Ridge. The lines run to the west of Necker Ridge were drawn to explore as many different features as possible over a large area (reconnaissance mapping), instead of acquiring 100% bottom coverage, finishing with a cross line for data quality assurance.

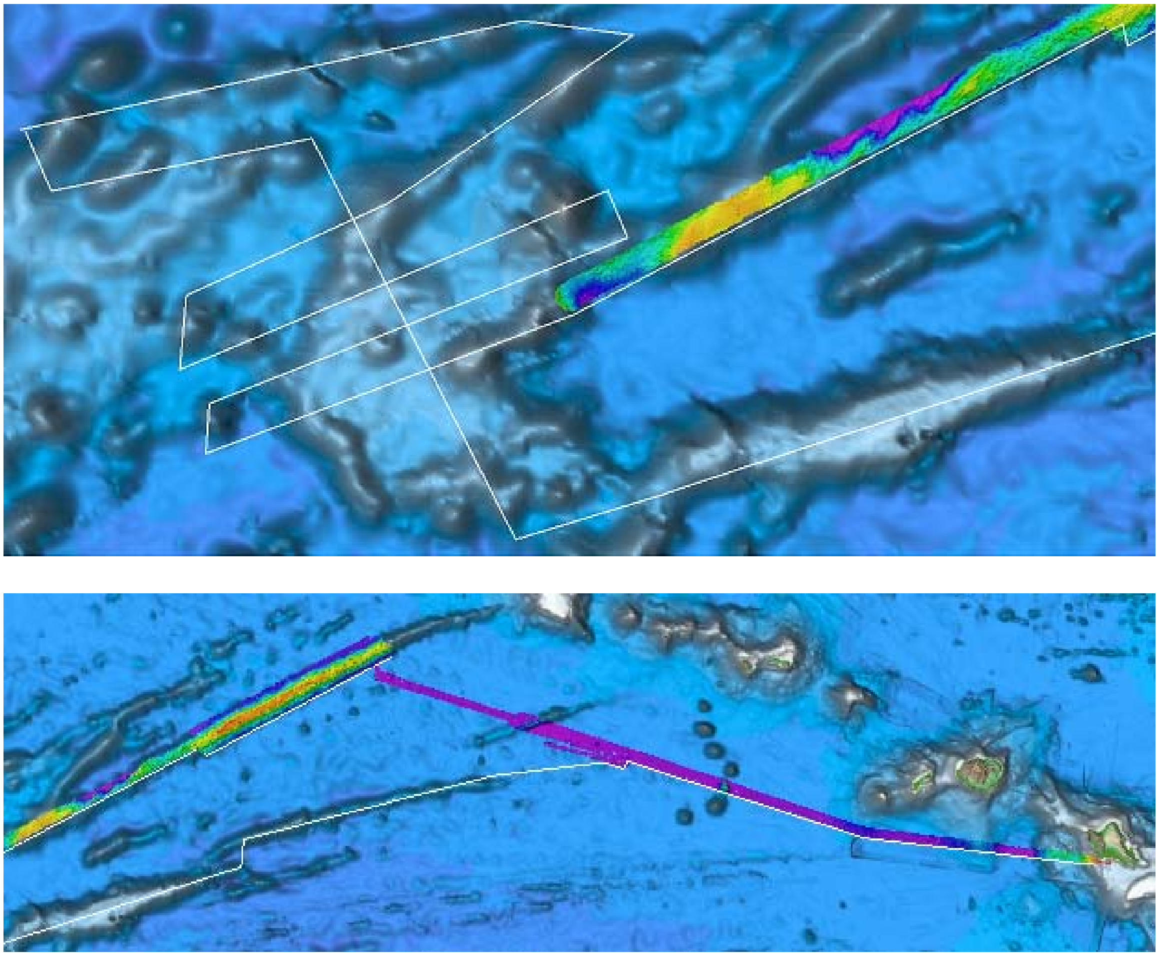


Figure 1. Overview showing the line plans created down the southern side of Necker Ridge, the lines run to the west of the ridge, and the transit line to the Hawaiian island of Oahu.

A patch test was completed on 14 September in the northern section of Necker Ridge. The last patch test was carried out in on 25 August in the same location, the purpose being to compare the data before and after the bad transmit board was replaced. In May 2009, the initial patch test was performed for the field season and similar results were obtained for this patch test. The track lines used for the patch test are tabulated in Table 1. Roll, pitch, navigation time delay and heading offsets were run during current patch test. Only roll, pitch and navigation time delay offsets were checked in the former two patch tests. See all three patch test results in Table 2.

Table 1. Survey lines utilized for the patch test

Date (GMT)	Line	Start (GMT)	Stop (GMT)	Sound Velocity	SOG (Knots)	Hdg	Seas	Comments
091509	0000_20090915_031554_EX	0315	0457	XBT_11	8	325	2-3	Upslope
091509	0001_20090915_045735_EX	0457	0516	XBT_11	9.5	N/A	2-3	Turn
091509	0002_20090915_051631_EX	0516	0700	XBT_11	8	140	2-3	Downslope
091509	0003_20090915_070025_EX	0700	0727	XBT_11	8	N/A	2-3	Turn
091509	0004_20090915_072748_EX	0727	1032	XBT_11	4	325	2-3	Upslope
091509	0005_20090915_103254_EX	1032	1046	XBT_11	2.6	N/A	2-3	Turn
091509	0006_20090915_104622_EX	1046	1415	XBT_11	4	140	2-3	Downslope
091509	0007_20090915_141555_EX	1415	1538	XBT_12	11	330	2-3	Transit
091509	0008_20090915_153819_EX	1538	1603	XBT_12	8	4	2-3	Yaw Test Line
091509	0009_20090915_160300_EX	1603	1633	XBT_12	8	151	2-3	Transit
091509	0010_20090915_163334_EX	1633	1651	XBT_12	9	4	2-3	Yaw Test Line
091509	0011_20090915_165359_EX	1651	1800	XBT_12	9	N/A	2-3	Transit to Survey
091509	0012_20090915_205537_EX	2055	2117	XBT_13	10.5	007	2-3	Yaw Correction
091509	0013_20090915_211709_EX	2117	2141	XBT_13	8	N/A	2-3	Turn
091509	0014_20090915_214110_EX	2141	2314	XBT_13	9.8	180	2-3	Yaw Correction

Table 2. Patch test results

Patch Tests Results	Roll	Pitch	Navigation time	Heading
May 2009 results	0	-0.7	0	
August 2009 results	0	-0.7	0	
September 2009 results	0	-0.7	0	0

8. Data acquisition and processing

Angular offsets are tabulated as below. For complete processing unit setup (PU Setup) utilized for the cruise, please refer to Appendix A.

Table 3. Angular offsets for Transmit (TX) and Receive (RX) transducer

	Roll	Pitch	Heading
Tx Transducer	0.0	0.0	359.98
Rx Transducer	0.0	0.0	0.03
Attitude	0	-0.7	0.0

Onboard processing of bathymetric data was done in CARIS HIPS ver. 6.1 during which 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.

The cross line yielded a favorable comparison between two (Lines 16 & 35) of the five main scheme lines. The other two (Line 23, and Lines 28 & 29) saw differences in spots of up to six meters in 2500 m of water.

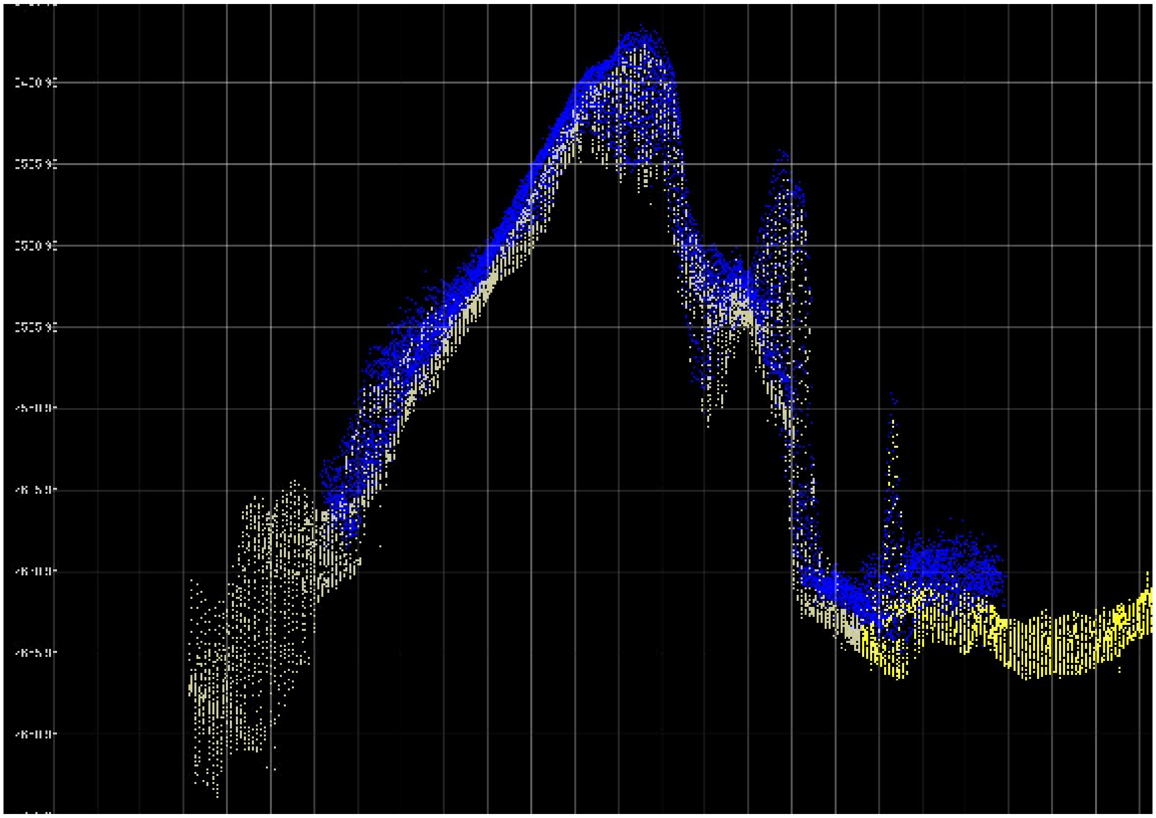


Figure 2. Screengrab of subset editor in CARIS HIPS showing the difference between the cross line (blue) and the main scheme lines (yellow and white). Image credit: NOAA

9. Cruise Calendar

September 2009						
Mon	**Tue**	**Wed**	**Thu**	**Fri**	**Sat**	**Sun**
	8 Sailing delayed for VSAT repairs. MTN personnel arrive.	9 Alongside at Ford Island. MTN repairing VSAT.	10 Alongside at Ford Island. MTN repairing VSAT.	11 Alongside at Ford Island. MTN repairing VSAT.	12 Depart Ford Island, Pearl Harbor to test VSAT off coast of Oahu. Begin transit to Necker Ridge.	13 Continue transit to Necker Ridge.
14 Continue transit to Necker Ridge. Conduct patch test.	15 Finished patch test. Began mapping Necker Ridge.	16 Continue mapping Necker Ridge and the area to the west.	17 Continue mapping area to west of Necker Ridge.	18 Continue mapping area to west of Necker Ridge.	19 Continue mapping area to west of Necker Ridge.	20 Continue mapping area to west of Necker Ridge. Deep CTD cast.

21 Begin transit. Mapping Horizon Guyot.	22 Continue transit.	23 Continue transit.	24 Continue transit.	25 Arrive and begin mapping wreck sites at West Oahu.	26 Arrive at Pearl Harbor. End of Cruise.	

10. Daily cruise log

(ALL TIMES LOCAL HDT)

September 8 – 11, 2009

Sailing delayed for VSAT repairs, ship alongside at Ford Island. Three MTN personnel onboard to fix machinery within dome. Watch standing interns have arrived on board and await departure.

September 12, 2009

0930 ~ depart Ford Island, Pearl Harbor to conduct VSAT test offshore of Oahu, HI. 0830-1400 ~ conducted orientation, multibeam and XBT training, with deployment of first cast, to watch standing interns. 1630 ~ Small boat transfer of two out of three MTN personnel after the day's successful VSAT testing. 2100 ~ begin mapping watches on transit to Necker Ridge in an effort to obtain coverage from former transit lines to and from these working grounds.

September 13, 2009

Continued transit to Necker Ridge. 0900 ~ noticed a serious lag in the real time data going into SCS data from not updating properly. The ET's looked into it and noticed the C drive was full. Shut down SCS to clear out drive and then resumed data acquisition at 1200. Multibeam data quality has improved from last cruise's transit with the replacement of the defective board. Data also shows good overlap with previous data.

September 14, 2009

Continued transit to Necker Ridge and patch test site. The CNAV position going into the POS/MV began to become uneven, showing that the errors seen in this area are still present as with the previous cruise. The C-NAV reception from WAAS satellite is poor because where the ship is working, it has limited coverage but the POS/MV is still showing position accuracy within 1-2 m when exceeding the ship's user defined accuracy parameters, and this small number will not affect accuracy of the multibeam. A 10 m sound velocity error was observed in the transit data, both in the previous and current data. Difference in degrees between the TSG temperature sensor and the last profile information taken has remained consistent at one to two degrees but because the ship is transiting over such a large distance during a day, sound velocity profiles are going to vary a great deal. Since 10 m only represents 2% of the data at this depth, it was considered unnecessary to take XBTs more than every six hours. 1700 ~ began patch test.

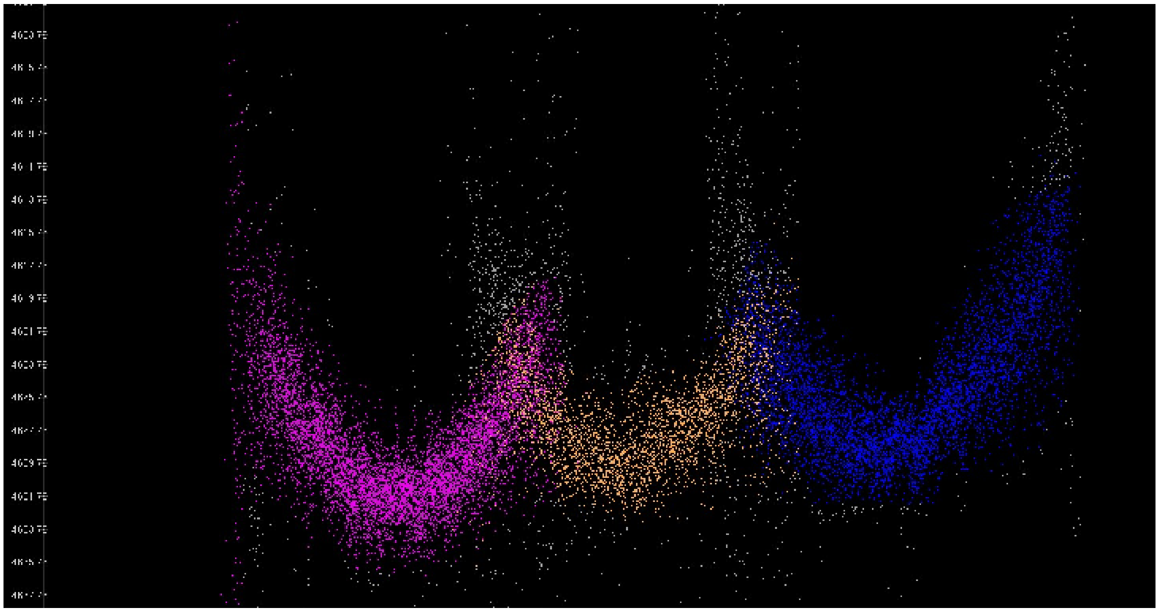


Figure 3. Screen grab of the sound velocity error. Pink, orange and blue show sounding points from the current line as well as lines from previous transits, and the grey represent points that were manually rejected in the HIPS subset editor (water depth approx 4600 m).

September 15, 2009

0700 ~ finished patch test and began mapping operations along Necker Ridge. Upon initial processing of the patch test data, a -1.1 degree heading offset was observed. PS Mashkoor Malik was notified at UNH, who enlisted the help of Dr. Jim Gardner, who both agreed that this was an unusually large offset. They also both concluded that a second heading test, using the same yaw test lines, should be run with this offset applied, as well as finding another “linear” feature on a flat surface at some point during the cruise for another test. After the heading lines were rerun with the -1.1 offset, the data still required a new offset of 0.7, which showed that applying an offset was not solving this problem. Additionally, when the data was processed in Caris, a large difference of 20-25 m was noticed in the outer beams between the two lines. The heading offset was changed back to zero and the ship resumed mapping along Necker Ridge. After the first lines had been processed along the ridge, ribbing artifacts were still present in the outer beams. The same amount of error was observed as initially detected from the first lines run along Necker Ridge on August 26th of 2-10 m. Since the results of the patch test found that no offsets needed to be applied, it seems unlikely that it is a heading or roll artifact. PS Malik will contact Kongsberg rep. Jared Harris for additional insight into this problem and to see whether or not this could be an issue within SIS or the TRU.

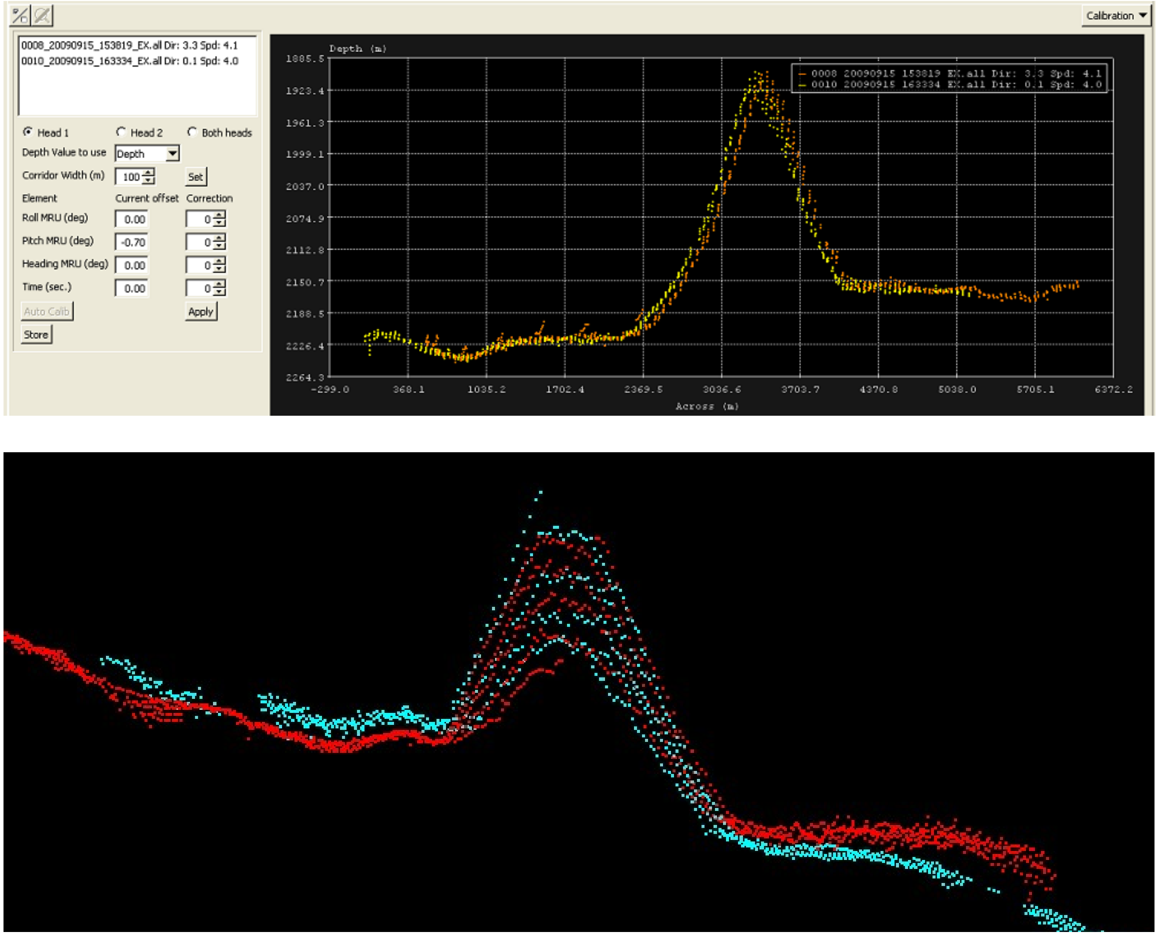


Figure 4. Top – The calibration screen in SIS showing the offset in the heading lines. Bottom – The heading lines in Caris subset editor after the -1.1 degree offset had been applied in SIS.

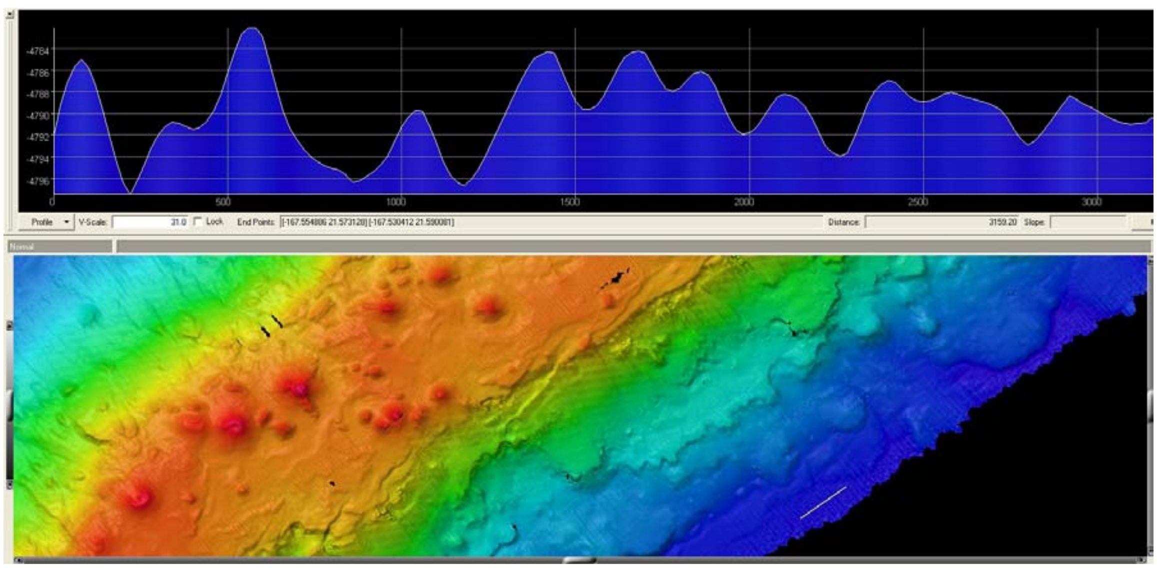


Figure 5. Ribbing artifacts seen in Fledermaus.

September 16, 2009

The midnight XBT repeatedly got an error message which prevented a successful cast. The cause was found to be a ground fault in the wires which the ET's were able to troubleshoot and fix the next morning. Thus both the midnight and 6 am cast were not conducted, and the 6 m sound velocity profile from the previous data was still applied in SIS. At around 10 am, the XBT cable was fixed, and a successful XBT was completed and entered in SIS. A CTD cast was begun at 1215 pm to 800 m and applied to the data at 1:30 pm. CTD's will be done daily at noon for the duration of mapping operations in the Necker Ridge area for training purposes. 2100 ~ Finished collecting data along Necker Ridge and began exploring the area to the west.

September 17, 2009
Continued mapping exploration west of Necker Ridge. 1930 ~ EM302 beginning to have problems tracking the bottom (bubble sweep down issues) from ship heading into the seas. The sea state was 4-6 ft. Data collected was not the best quality until 2200 when ship turned onto the next line.

September 18, 2009
Continue mapping west of Necker Ridge. 0145-0215 ~ two complete navigation dropouts in SIS and POS/MV where all indicator field and lights turned red from CNAV losing its lock on the WAAS satellite. After a few moments, accuracy parameters in POSView resumed to normal green status. Attitude data took the longest to return within accuracy parameters at 0236. 1110-1130 ~ three PPS time synchronization outages in SIS. The ET's looked it and concluded that this problem is linked to the CNAV position outages that have been taking place recently since precision timing comes with position data from the CNAV satellite. The ship is currently in between the two CNAV satellites and will continue to have trouble getting reliable position information until the ship turns back towards Honolulu.

September 19, 2009
Continue mapping west of Necker Ridge.

September, 20 2009
Continue mapping west of Necker Ridge. 0600 ~ noticed that SCS position did not match position on the bridge because sensor information not updating properly in SCS. ET's looked into it and rebooted the SQL database server and position updated properly in SCS afterwards. 0830-1130 ~ a deep CTD cast was performed to a depth of 4200 m and a XBT directly afterwards to compare the profiles. The comparison yielded results of up to 8 m/s difference, which most likely was the result from the casts not being taken exactly at the same time from the same spot. Another CTD/SVP comparison will be done with tomorrow's cast at noon with the addition of these two components if possible. After the casts were complete, the ship began the cross line that covers four of the six mainscheme lines.

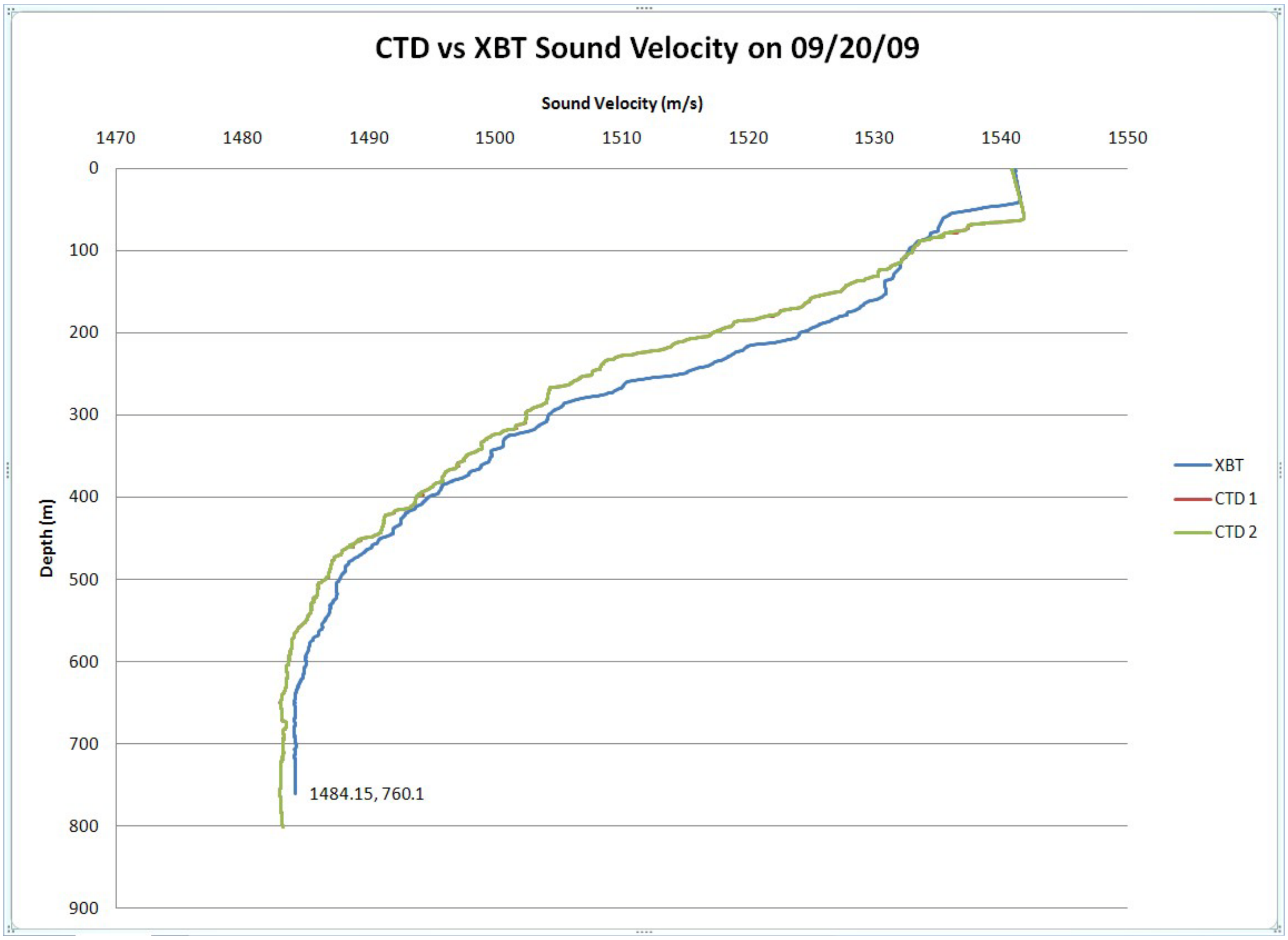


Figure 6. Comparison between XBT & CTD sound velocity measurements.

September 21, 2009

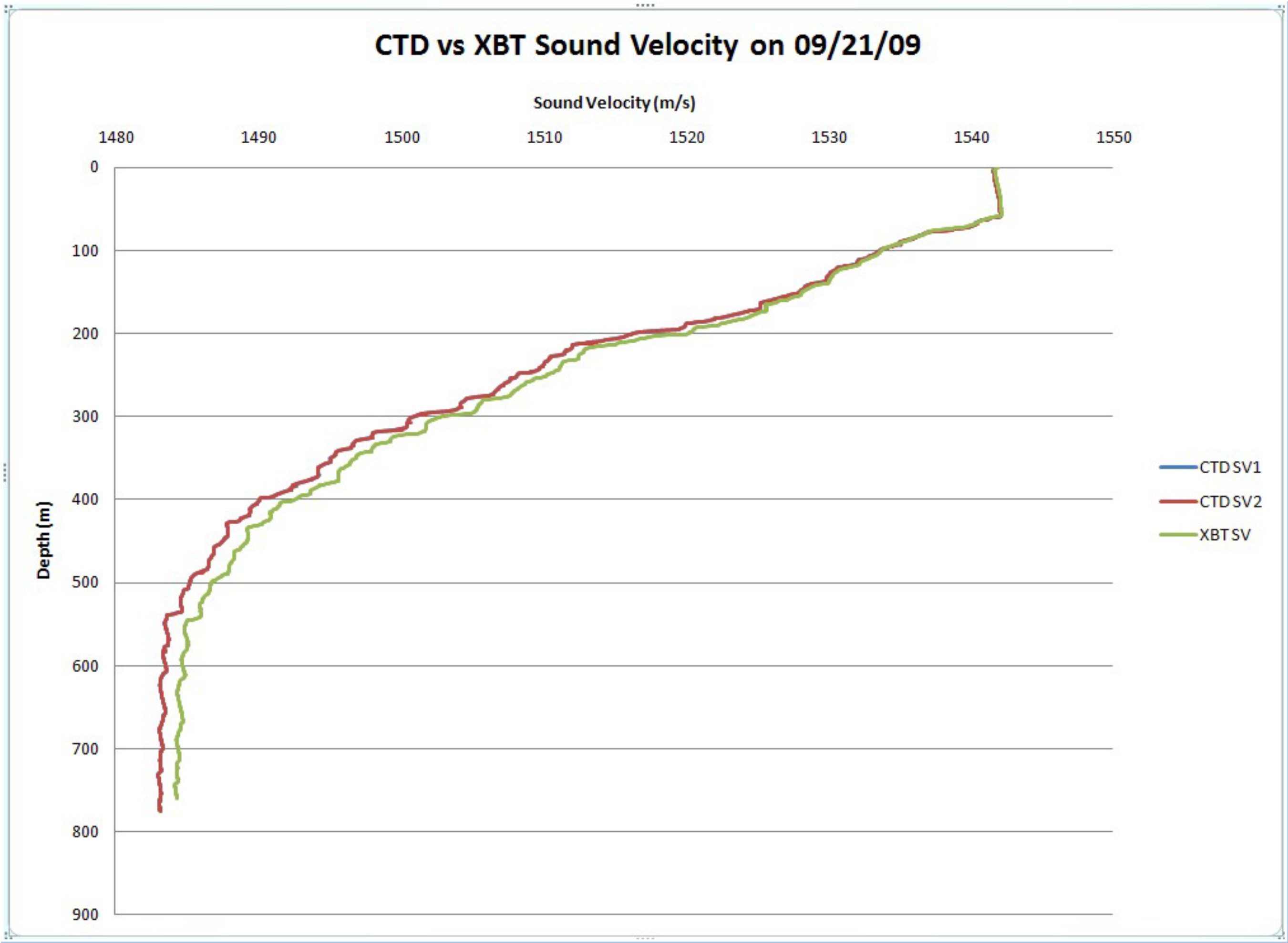


Figure 7. The results of the CTD/XBT comparison done on 9/21/09.

Continue mapping the cross line and beginning transit back towards Oahu around 0100 over Horizon Guyot (or Tablemount) to the south of Necker Ridge. A successful XBT was conducted while the CTD was traveling down to 800 m which resulted in a much closer overall comparison of 0-2 m/s.

September 22, 2009

Continue transit. 1000 ~ Ship transit ahead of schedule so turned around and collected 100 NM more of data (50 NM in each direction) in the area of Wisconsin Seamount.

September 23, 2009

Continue transit. 0915 Tom Steptka from EEB called to troubleshoot the SCS sensor delay problem. 1025 shut down ACQ in SCS to monitor CPU usage when SCS is not running. Had to reboot server to get ACQ to start up again; SCS and ACQ restarted at 1045. 1125 Troubleshooting ended with no definitive answer to the problem. Instructed to watch CPU usage next time there is a major sensor delay in SCS or crash and contact Tom Steptka with the findings. 1450 ~ Multibeam computer restarted itself because of an automatic update that was being forced onto it over the network. ET's changed the automatic update option from "user defined" to "disabled" so that this will not happen again in the future. The ET's will make sure that the same has been done for the other acquisition machines, namely for the SCS servers, the EA600 and the Knudsen sub-bottom profiler. Once the multibeam acquisition machine and SIS had been restarted, an error message came up saying that there was a problem with the grid engine and that SIS needed to be restarted. Both the computer and SIS were restarted and the error message came up again and the grid was only showing real time coverage with no history. It was decided to carry on with the transit for now and wait until there was more time to reset the whole multibeam system and troubleshoot further.

September 24, 2009
Continue transit. During daily 1215 CTD, the multibeam was completely shut down and SIS was restarted after a few minutes, while keeping the TRU off and the simulator was run as a troubleshooting method to try and reset SIS. After a few minutes of running simulator, stopped it and closed SIS. Restarted TRU and SIS with no error message and grid displayed normally after that.

September 25, 2009
Arrive at wrecks sites off western coast of Oahu. 0430 ~ begin mapping operations of two wreck sites and one linear feature to test the Yaw once again to troubleshoot the ribbing anomaly.

September 26, 2009
Arrive at Ford Island in Honolulu, HI. End of cruise.

11. Appendices

Appendix A: Tables of data files collected

EX0909 LEG 2 SOUND VELOCITY FILES					
Date (GMT)	**Time (GMT)**	**XBT/CTD Filename**	**Latitude (DD)**	**Longitude (DD)**	**Remarks**
09122009	23:21:00	XBT_091209_01	21.2295613N	157.6124348W	Transit to survey grounds
09132009	07:20:33	XBT_091309_02	21.2872883N	158.5056315W	Transit
09132009	10:08:21	XBT_091309_03	21.2887898N	159.0079753W	Transit
09132009	16:05:58	XBT_091309_04	21.2920655N	160.0957356W	Transit
09132009	22:45:40	XBT_091309_05	21.397815N	161.1557128W	Transit
09142009	04:21:11	XBT_091409_06	21.6344726N	162.2779785W	Transit
09142009		XBT_091409_07			Bad Cast
09142009	10:05:38	XBT_091409_08	21.8391113N	163.2793456W	Transit
09142009	16:04:27	XBT_091409_09	22.0548583N	164.3395508W	Transit
09142009	21:44:34	XBT_091409_10	22.2532755N	165.3616536W	Transit
09152009	02:39:02	XBT_091509_11	22.4104085N	166.2650065W	Patch Test

09152009	14:28:19	XBT_091509_12	22.3726928N	166 19.91992W	Patch Test
09152009	20:35:00	XBT_091509_13	22.475293N	166 25.22461W	Yaw Correction
09162009	04:01:00	XBT_091509_14			Bad Cast
09162009	04:29:25	XBT_091609_15	21.8812175N	167.17356766 W	Survey
09162009	20:36:13	XBT_091609_16	20.546927833N	169.26259766 W	Survey, cast ok
09162009	22:32:25	CTD_091609_01	20.3725N	169.52966666 W	800 m
09172009	05:03:17	XBT_091709_17	19.280666667N	170.36273333 W	Lat, Lon approx.
09172009	10:16:10	XBT_091709_18	19.35324N	171.13726W	Lat, Lon approx.
09172009	16:04:23	XBT_091709_19	18 52.181N	172.06091W	Lat, Lon approx.
09172009	22:16:00	CTD_090709_02	19.402167N	171.514500W	800 m
09182009	04:01:00	XBT_091809_20	19.76511N	170.84673333 W	Survey, Nav.OK
09182009	10:07:08	XBT_091809_21	20.221N	170.49582666 W	Lat, Lon approx.
09182009	16:02:58	XBT_091809_22	20.221N	170.49582666 W	Survey
09182009	16:02:58	XBT_091809_22	19.641896667N	171.51680666 W	Survey
09182009	23:15:00	CTD_091809_03	19.3648N	172.26458333 W	800 m
09192009	04:20:48	XBT_091909_23	19.864815333N	171.754362W	Survey
09192009	10:06:31	XBT_091909_24	20.405670167N	171.03258466 W	Survey
09192009	16:04:36	XBT_091909_25			Bad Cast
09192009	16:12:12	XBT_091909_26	20.9908325N	170.4855795W	Survey
09192009	23:05:00	CTD_091909_04	20.78716N	171.83166666 W	800 m
09202009	04:05:05	XBT_092009_27	20.487677N	172.34990233 W	Survey
09202009	10:04:43	XBT_092009_28	20.488421667N	172.3477865W	Survey
09202009	16:06:12	XBT_092009_29	20.2333N	172.13166666 W	Survey
09202009	21:21:13	XBT_092009_30	20.353678333N	171.78697916 W	After CTD 4200 m
09202009	21:35:00	CTD_092009_05	20.34188N	171.7821W	4200 m
09212009	04:05:35	XBT_092109_31	19.489717667N	171.22255866 W	Survey
09212009	10:08:21	XBT_092109_32	18.7085775N	170.69931633 W	Survey
09212009	16:04:04	XBT_092109_33	18.971246333N	169.8781575W	Survey

09212009	22:28:00	CTD_092109_06	19.3915N	168.975W	800 m
09212009	22:36:55	XBT_092109_34	19.393491667N	168.97653W	NOT APPLIED, CTD QC
09222009	04:04:53	XBT_092209_35	19.690505N	168.3212565W	Survey
09222009	10:06:53	XBT_092209_36	20.161750N	167.55735683 W	Transit
09222009	16:07:58	XBT_092209_37	20.634303833N	166.835975W	Transit
09222009	23:24:00	CTD_092209_07	20.7300N	166.4850W	800 m
09232009	04:07:24	XBT_092309_38	20.662083N	166.91298833 W	Transit
09232009	10:05:06	XBT_092309_39	20.952140333N	166.02268883 W	Transit
09232009	16:04:16	XBT_092309_40	21.323803667N	165.06917316 W	Transit
09232009	23:40:00	CTD_092309_08	21.5900N	164.075500W	800 m
09242009	04:13:49	XBT_092409_41	21.7171875N	163.323177W	Transit
092409	10:07:40	XBT_092409_42	21.538635333N	162.39762366 W	Transit
092409	16:02:44	XBT_092409_43	21.355196167N	161.44794916 W	Transit
092409	23:28:00	CTD_092409_09	21.207500N	160.433333W	800 m
092509	04:06:07	XBT_092509_44	21.208158333N	159.70478516 W	Transit
092509	10:07:08	XBT_092509_45	21.210355667N	158.753418W	Transit
092509	14:10:31	XBT_092509_46	21.374833167N	158.40883783 W	Transit (SVP file applied to Yaw Test)

EX0909 LEG 2 EM302 MULTIBEAM FILES					
Cruise Day No.	**Date (GMT)**	**File Name**	**Location**	**Survey Name**	**Remarks**
1	091209	0000_20090912_214507_EX	Transit	EX0909_2_Transit	
2	091309	0001_20090913_040638_EX	Transit	EX0909_2_Transit	
2	091309	0002_20090913_100644_EX	Transit	EX0909_2_Transit	
2	091309	0003_20090913_160644_EX	Transit	EX0909_2_Transit	
2	091309	0004_20090913_191844_EX	Transit	EX0909_2_Transit	
3	091409	0005_20090914_000108_EX	Transit	EX0909_2_Transit	
3	091409	0006_20090914_060107_EX	Transit	EX0909_2_Transit	
3	091409	0007_20090914_120110_EX	Transit	EX0909_2_Transit	
3	091409	0008_20090914_180115_EX	Transit	EX0909_2_Transit	
4	091509	0009_20090915_000111_EX	Transit	EX0909_2_Transit	
-	-	-	-	EX0909_2_PatchTest (see table below)	

4	091509	0000_20090915_183202_EX	Survey	EX0909_NeckerRidge2	
		0001_20090915_20064_EX	Survey	EX0909_NeckerRidge2	
-	-	-	-	EX0909_2_PatchTest (see table below)	Yaw Correction
4	091509	0002_20090915_231400_EX	Survey	EX0909_NeckerRidge2	Resume Survey
5	091609	0003_20090916_000008_EX	Survey	EX0909_NeckerRidge2	
5	091609	0004_20090916_060005_EX	Survey	EX0909_NeckerRidge2	Line cut at 3 hours?
5	091609	0005_20090916_090305_EX	Survey	EX0909_NeckerRidge2	
5	091609	0006_20090916_104732_EX	Survey	EX0909_NeckerRidge2	
5	091609	0007_20090916_105216_EX	Survey	EX0909_NeckerRidge2	
5	091609	0008_20090916_112543_EX	Survey	EX0909_NeckerRidge2	
5	091609	0009_20090916_112751_EX	Survey	EX0909_NeckerRidge2	
5	091609	0010_20090916_112751_EX	Survey	EX0909_NeckerRidge2	
5	091609	0011_2009016_180858_EX	Survey	EX0909_NeckerRidge2	Break line to pick up glass float
5	091609	0012_20090916_191853_EX	Survey	EX0909_NeckerRidge2	Resume survey
5	091609	00013_20090916_220359_EX	Survey	EX0909_NeckerRidge2	Break for CTD
5	091609	0014_20090916_233127_EX	Survey	EX0909_NeckerRidge2	Survey
6	091709	0015_20090917_053129_EX	Survey	EX0909_NeckerRidge2	New area, second part of survey
6	091709	0016_20090917_061300_EX	Survey	EX0909_NeckerRidge2	Survey
6	091709	0017_20090917_121306_EX	Survey	EX0909_NeckerRidge2	Survey
6	091709	0018_20090917_161621_EX	Survey	EX0909_NeckerRidge2	Turn Line
6	091709	0019_20090917_161841_EX	Survey	EX0909_NeckerRidge2	Survey
6	091709	0020_20090917_174411_EX	Survey	EX0909_NeckerRidge2	Turn Line
6	091709	0021_20090917_175028_EX	Survey	EX0909_NeckerRidge2	Survey
6	091709	0022_20090917_225134_EX	Survey	EX0909_NeckerRidge2	Survey
7	091809	0023_20090918_000006_EX	Survey	EX0909_NeckerRidge2	Survey
7	091809	0024_20090918_060010_EX	Survey	EX0909_NeckerRidge2	Survey
7	091809	0025_20090918_080622_EX	Survey	EX0909_NeckerRidge2	Turn Line
7	091809	0026_20090918_081059_EX	Survey	EX0909_NeckerRidge2	Survey
7	091809	0027_20090918_093101_EX	Survey	EX0909_NeckerRidge2	Turn Line
7	091809	0028_20090918_093549_EX	Survey	EX0909_NeckerRidge2	Survey
7	091809	0029_20090918_153550_EX	Survey	EX0909_NeckerRidge2	Survey
7	091809	0030_20090918_210712_EX	Survey	EX0909_NeckerRidge2	Turn line
7	091809	0031_20090918_210834_EX	Survey	EX0909_NeckerRidge2	Break line b/c PPS turned off
7	091809	0032_20090918_211256_EX	Survey	EX0909_NeckerRidge2	Survey
7	091809	0033_20090918_231052_EX	Survey	EX0909_NeckerRidge2	Resume Survey
7	091809	0034_20090918_235957_EX	Survey	EX0909_NeckerRidge2	Survey
8	091909	0035_20090919_002823_EX	Survey	EX0909_NeckerRidge2	Survey
8	091909	0036_20090919_062816_EX	Survey	EX0909_NeckerRidge2	Survey
8	091909	0037_20090919_070208_EX	Survey	EX0909_NeckerRidge2	Survey
8	091909	0038_20090919_130211_EX	Survey	EX0909_NeckerRidge2	Survey
8	091909	0039_20090919_153938_EX	Survey	EX0909_NeckerRidge2	Survey.

8	091909	0040_20090919_154221_EX	Survey	EX0909_NeckerRidge2	Survey
8	091909	0041_20090919_182357_EX	Survey	EX0909_NeckerRidge2	Turn line, same survey line
8	091909	0042_20090919_231617_EX	Survey	EX0909_NeckerRidge2	Resume Survey
9	092009	0043_20090920_000004_EX	Survey	EX0909_NeckerRidge2	Survey
9	092009	0044_20090920_060005_EX	Survey	EX0909_NeckerRidge2	Survey
9	092009	0045_20090920_083624_EX	Survey	EX0909_NeckerRidge2	Turn line
9	092009	0046_20090920_084808_EX	Survey	EX0909_NeckerRidge2	Survey
9	092009	0047_20090920_101204_EX	Survey	EX0909_NeckerRidge2	Survey
9	092009	0048_20090920_104419_EX	Survey	EX0909_NeckerRidge2	Turn Line
9	092009	0049_20090920_104528_EX	Survey	EX0909_NeckerRidge2	Survey
9	092009	0050_20090920_164527_EX	Survey	EX0909_NeckerRidge2	Survey
9	092009	0051_20090920_215028_EX	Survey	EX0909_NeckerRidge2	Resume survey
9	092009	0052_20090920_235955_EX	Survey	EX0909_NeckerRidge2	Survey
10	092109	0053_20090921_055954_EX	Survey	EX0909_NeckerRidge2	Survey
10	092109	0054_20090921_104918_EX	Survey	EX0909_NeckerRidge2	Turn Line
10	092109	0055_20090921_105222_EX	Survey	EX0909_NeckerRidge2	Survey
10	092109	0056_20090921_165219_EX	Survey	EX0909_NeckerRidge2	Survey
10	092109	0010_20090921_233218_EX	Transit	EX0909_2_Transit	Changed survey to transit
10	092109	0011_20090921_000121_EX	Transit	EX0909_2_Transit	Transit
11	092209	0012_20090922_060127_EX	Transit	EX0909_2_Transit	Transit
11	092209	0013_20090922_091556_EX	Transit	EX0909_2_Transit	Turn
11	092209	0014_20090922_092004_EX	Transit	EX0909_2_Transit	Transit
11	092209	0015_20090922_112616_EX	Transit	EX0909_2_Transit	Turn
11	092209	0016_20090922_113029_EX	Transit	EX0909_2_Transit	Transit
11	092209	0017_20090922_173030_EX	Transit	EX0909_2_Transit	Transit
11	092209	0018_20090922_200444_EX	Transit	EX0909_2_Transit	Turn
11	092209	0019_20090922_200957_EX	Transit	EX0909_2_Transit	Short transit line + turn
11	092209	0020_20090922_203119_EX	Transit	EX0909_2_Transit	Transit, ship moved 1000 m stbd
11	092209	0021_20090922_232417_EX	Transit	EX0909_2_Transit	Resume transit
11	092209	0022_20090922_232955_EX	Transit	EX0909_2_Transit	Transit
12	092309	0023_20090923_023822_EX	Transit	EX0909_2_Transit	Turn line
12	092309	0024_20090923_024037_EX	Transit	EX0909_2_Transit	Transit, Across ridge
12	092309	0025_20090923_031306_EX	Transit	EX0909_2_Transit	Turn line
12	092309	0026_20090923_031543_EX	Transit	EX0909_2_Transit	Transit, Up ridge
12	092309	0027_20090923_082007_EX	Transit	EX0909_2_Transit	Turn
12	092309	0028_20090923_082408_EX	Transit	EX0909_2_Transit	Transit across ridge
12	092309	0029_20090923_084217_EX	Transit	EX0909_2_Transit	Turn
12	092309	0030_20090923_084646_EX	Transit	EX0909_2_Transit	Transit
12	092309	0031_20090923_144638_EX	Transit	EX0909_2_Transit	Transit

12	092309	0032_20090923_171844_EX	Transit	EX0909_2_Transit	Transit
12	092309	0033_20090923_230838_EX	Transit	EX0909_2_Transit	Resume transit after CTD#8
12	092309	0034_20090924_000000_EX	Transit	EX0909_2_Transit	Transit
12	092309	0035_20090924_005421_EX	Transit	EX0909_2_Transit	Break line after restart SIS
12	092309	0036_20090924_013223_EX	Transit	EX0909_2_Transit	Turn
12	092309	0037_20090924_013756_EX	Transit	EX0909_2_Transit	Transit
13	092409	0038_20090924_030105_EX	Transit	EX0909_2_Transit	Turn
13	092409	0039_20090924_031201_EX	Transit	EX0909_2_Transit	Transit
13	092409	0040_20090924_033552_EX	Transit	EX0909_2_Transit	Turn
13	092409	0041_20090924_033807_EX	Transit	EX0909_2_Transit	Transit
13	092409	0042_20090924_093805_EX	Transit	EX0909_2_Transit	Transit
13	092409	0043_20090924_153810_EX	Transit	EX0909_2_Transit	Transit
13	092409	0044_20090924_203516_EX	Transit	EX0909_2_Transit	Transit
13	092409	0045_20090924_231545_EX	Transit	EX0909_2_Transit	Resume transit after CTD#9
14	092509	0046_20090925_000002_EX	Transit	EX0909_2_Transit	Transit
14	092509	0047_20090925_055959_EX	Transit	EX0909_2_Transit	Transit
14	092509	0048_20090925_120004_EX	Transit	EX0909_2_Transit	Transit
14	092509	0049_20090925_125514_EX	Transit	EX0909_2_Transit	Turn Line
14	092509	0050_20090925_125953_EX	Transit	EX0909_2_Transit	Transit
14	092509	0051_20090925_142720_EX	Transit	EX0909_2_Transit	Transit to Yaw Test
14	092509	0052_20090925_143334_EX	Transit	EX0909_2_Transit	Transit to Yaw Test
14	092509	0053_20090925_143418_EX	Survey	EX0909_2_Transit	Start of Yaw Test
14	092509	0054_2009025_145644_EX	Survey	EX0909_2_Transit	Yaw Test Turn Line
14	092509	0055_20090925_145853_EX	Survey	EX0909_2_Transit	Yaw Test
14	092509	0056_20090925_150745_EX	Survey	EX0909_2_Transit	Yaw Test Turn Line
14	092509	0057_20090925_151046_EX	Survey	EX0909_2_Transit	Yaw Test
14	092509	0058_20090925_153430_EX	Survey	EX0909_2_Transit	Transit to “H” Pattern Wreck
14	092509	0059_20090925_161112_EX	Survey	EX0909_2_Transit	“H” Pattern Wreck
14	092509	0060_20090925_162352_EX	Survey	EX0909_2_Transit	“H” Pattern Wreck Turn Line
14	092509	0061_20090925_162603_EX	Survey	EX0909_2_Transit	“H” Pattern Wreck
14	092509	0062_20090925_163443_EX	Survey	EX0909_2_Transit	“H” Pattern Wreck Turn Line
14	092509	0063_20090925_163755_EX	Survey	EX0909_2_Transit	“H” Pattern Wreck
14	092509	0064_20090925_165201_EX	Survey	EX0909_2_Transit	“H” Pattern Wreck Turn Line
14	092509	0065_20090925_165551_EX	Survey	EX0909_2_Transit	“H” Pattern Wreck
14	092509	0066_20090925_170353_EX	Survey	EX0909_2_Transit	“H” Pattern Wreck Turn Line

14	092509	0067_20090925_170847_EX	Survey	EX0909_2_Transit	"H" Pattern Wreck

Appendix B: 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 4. 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 5. 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 6. 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					
			Alongtrack distance between profiles (m)		
Water depth (m)	**Swath Width (m)**	**Ping Rate**	**@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 7. 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 C: EM302 PU Parameters

```
#// Database Parameters

#// Seafloor Information System
#// Kongsberg Maritime AS
#// Saved:  2009.08.28 20:32:34

#// Build info:
#* SIS:            [Version: 3.6.1,
Build: 174, DBVersion 16.0 CD
generated: Tue Nov 11 15:39:05
2008]
[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, [1] [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] [0]
#* 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] [0]
#* 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] [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 [1] #// Datagram
#* 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 [0.0] #// Roll
#* S1P [0.00] #// Pitch
#* S1H [359.98] #// Heading
#} TX Transducer:

#{ RX Transducer: #//
#* S2R [0.0] #// Roll
#* S2P [0.00] #// Pitch
#* S2H [.03] #// Heading
#} RX Transducer:

#{ Attitude 1, COM2: #//
#* MSR [0.00] #// Roll
#* MSP [-0.70] #// 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 [4700] #// Force Depth (m)
#* MID [500] #// 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 [3] #// 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 [14672] #// Sound Speed (dm/sec.):
#* Sensor Offset (m/sec [0.0] #//
#* Filter (sec.): [5] #//
#} Sound Speed at Transducer

#} Sound Speed

#{ Filter and Gains #//

#{ Filtering #//
#* SFS [2] #// Spike Filter Strength: MEDIUM
#* PEF [2] #// Penetration Filter Strength: MEDIUM
#* RGS [1] #// Range Gate: NORMAL
#* SLF [1] #// Slope
#* AEF [1] #// Aeration
#* STF [1] #// Sector Tracking
#* IFF [1] #// Interference
#} Filtering

#{ Absorption Coefficient #//
#* ABC [5.718] #// 31.5 kHz
#} Absorption Coefficient

#{ Normal incidence sector #//
#* TCA [12] #// 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: [AUTOMATIC1] #//
#{ AUTOMATIC1 #//
#* 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.minPointCount [6]
#* PingProc.quantileRule.use [false]
#* PingProc.quantileRule.quantile [0.100000]
#* PingProc.quantileRule.scaleFactor [6.000000]
#* PingProc.quantileRule.minPointCount [40]
#* GridProc.minPoints [8]
#* GridProc.depthFactor [0.200000]
#* GridProc.removeTooFewPoints [false]
#* GridProc.surfaceFitting.surfaceDegree [1]
#* GridProc.surfaceFitting.tukeyConstant [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]
#} AUTOMATIC1

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

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

Appendix D: List of acronyms

BIST – Built In System Test CO – Commanding Officer

CIMS – Cruise Information Management System

CTD – conductivity temperature and depth

CW – continuous wave

dB – decibels

DGPS –Differential Global Positioning System

DTM – digital terrain model

ECS – Extended Continental Shelf

ET – Electronics Technician

EX – NOAA Ship *Okeanos Explorer*

FM – frequency modulation

FOO – Field Operations Officer

kHz - kilohertz

Km – kilometers

KM – Kongsberg Maritime AS

Kt(s) – knots

Ma – megaannum

MBES – multibeam echosounder

NM – nautical mile

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

ROV – remotely operated vehicle

SST – Senior Survey Technician

SV – sound velocity

TRU – transmit and receive unit

TSG - thermosalinograph

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

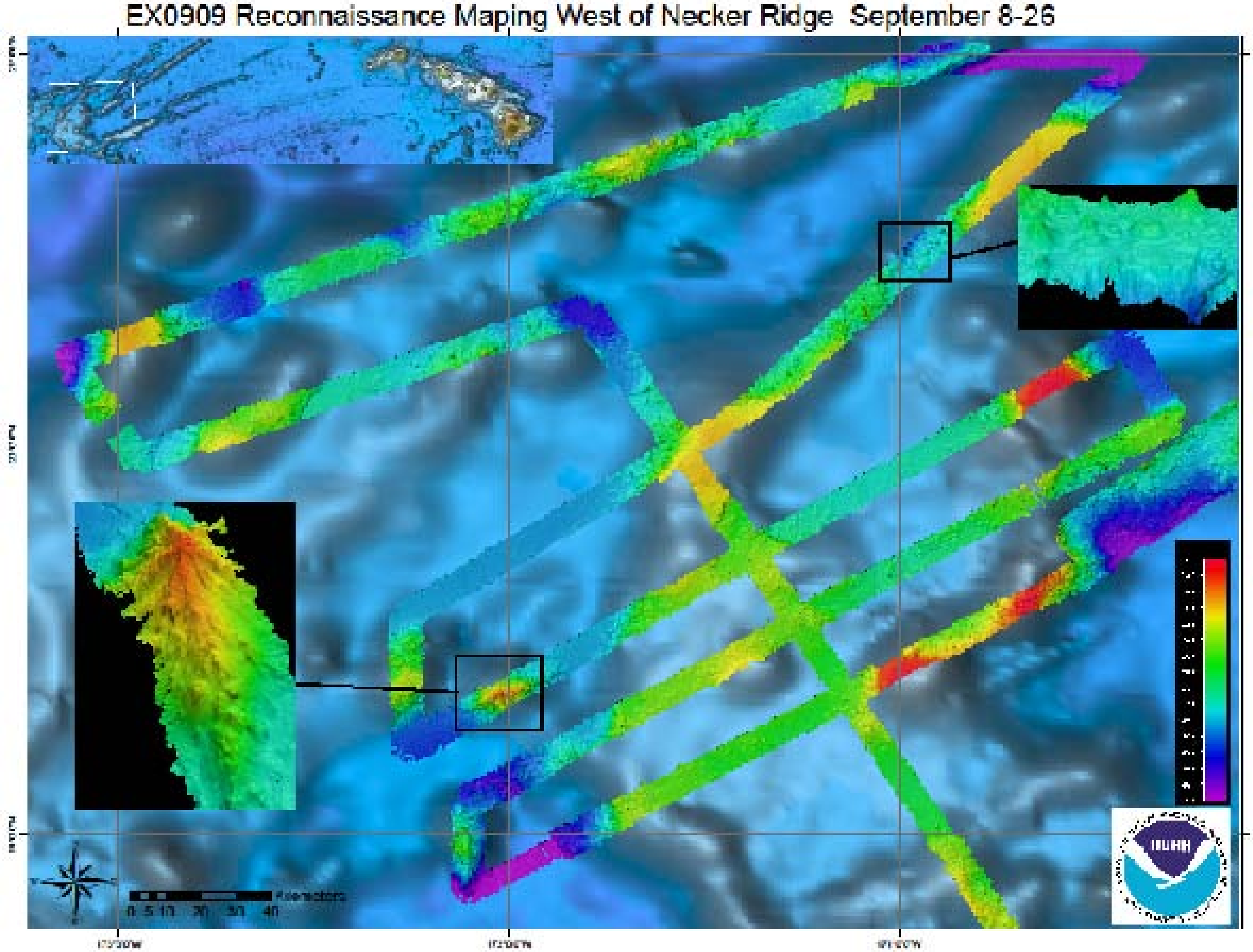
US EEZ – United States Exclusive Economic Zone

USBL – ultra-short base line

WD – water depth

XBT – expendable bathythermograph

Appendix E: Field products created during cruise



Field product generated using 50 meter cell size resolution grids of the reconnaissance area west of Necker Ridge. Shown are insets of a few of the interesting features observed in the data. A 1000 m seamount is found in 2600 m of water as well as an example of some dynamic topography of a shallow channel that cuts away into a deeper canyon. Images created in Fledermaus version 6. Image credit: NOAA