2011

U.S. Law of the Sea Cruise to Complete the Mapping of Necker Ridge, Central Pacific Ocean

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CRUISE REPORT

RV *Kilo Moana*

U.S. Law of the Sea Cruise to Complete the Mapping of Necker Ridge, Central Pacific Ocean

CRUISE KM1121

July 31, to August 10, 2011

Honolulu, HI to Honolulu, HI

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Durham, NH 03824

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UNH-CCOM/JHC Technical Report 11-001

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Introduction

An exhaustive study of the U.S. data holdings pertinent to the formulation of U.S. potential claims of an extended continental shelf under Article 76 of the United Nations Convention of the Law of the Sea (UNCLOS) (Mayer, Jakobsson, & Armstrong, 2002) was undertaken in 2002. The Mayer et al. (2002) report recommended that multibeam echosounder (MBES) data are needed to rigorously define (1) the foot of the slope (FoS), a parameter in the two UNCLOS-stipulated formula lines, and (2) the 2500-m isobath, a parameter in one of the UNCLOS-stipulated cutoff lines. Both of these parameters, the first one a precise geodetic isobath and the second one a geomorphic zone, are used to define an extended continental shelf claim. The Center for Coastal and Ocean Mapping/Joint Hydrographic Center (CCOM/JHC) of the University of New Hampshire was directed by the U.S. Congress, through funding to the U.S. National Oceanic and Atmospheric Administration (NOAA) to conduct the new surveys. Although Necker Ridge was not identified as one of the regions where new bathymetric surveys are needed, subsequent U.S. State Department Extended Continental Shelf (ECS) Task Force teams determined that Necker Ridge should be mapped. The cruise objective was to complete the mapping of the bathymetry of Necker Ridge (Figure 1) that was begun in 2009 using the NOAA Ship *Okeanos Explorer* (EX0909). Both the 2009 and the present 2011 mapping were in direct support of the U.S. ECS Task Force. The 2009 mapping captured the 2500-m isobath on Necker Ridge, but the junction of Necker Ridge with the Hawaiian Ridge and the lower flanks of Necker Ridge that transition to the adjacent deep-sea floor were not mapped (Figure 2) because the 30-kHz multibeam system of *Okeanos Explorer* made mapping in water deeper than~4000 m very inefficient. The 12-kHz multibeam system of the RV *Kilo Moana* is designed for these depths.

Other than the 2009 mapping, Necker Ridge has several single multibeam swaths that cross the ridge and one swath along the summit, although these lines were collected with, for the most part, older first- or second-generation multibeam systems (Figure 3) and do not provide the coverage needed at the critical areas mentioned above.

Surprisingly, only one single-channel seismic line that crosses the ridge could be found in the public archives. The regional bathymetry for survey planning used the version 13.1 (2010) updated 1-arc minute predicted bathymetry dataset of Smith and Sandwell (http://topex.ucsd.edu/cgi-bin/get_data.cgi).

NOAA contracted through NSF-UNOLS (National Science Foundation University National Oceanographic Laboratory System) with the University of Hawai'i to use their 186-ft, 3060-ton RV *Kilo Moana* (Figure 4), a SWATH (small water area twin hull) vessel with a hull-mounted Kongsberg EM122 MBES as well as a Knudsen 3260 B/R 3.5-kHz chirp sub-bottom profiler and a Carson gravimeter, for the mapping survey.

The UNH chief scientist was responsible for the organization and direction of the cruise, as well as the calibration of the multibeam system prior to mapping. He was also responsible for the collection, quality control and processing of the bathymetry, acoustic-backscatter and chirp sub-bottom data aboard ship. Gravity data were collected on a not-to-interfere basis and the University of Hawaii processed the gravity data post cruise.

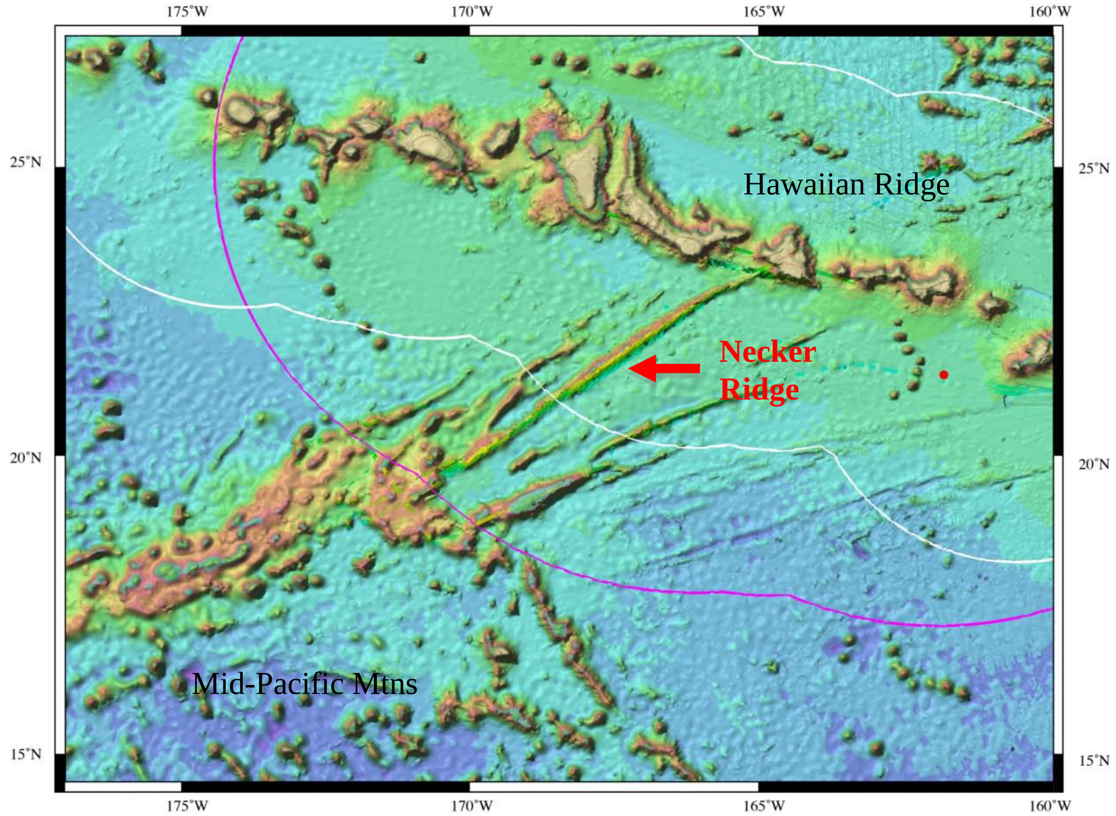

Figure 1. Location of Necker Ridge. Bathymetry from Sandwell and Smith 1-arc-minute bathymetry. White semicircle is U.S. EEZ; purple semicircle is 350 nmi limit.

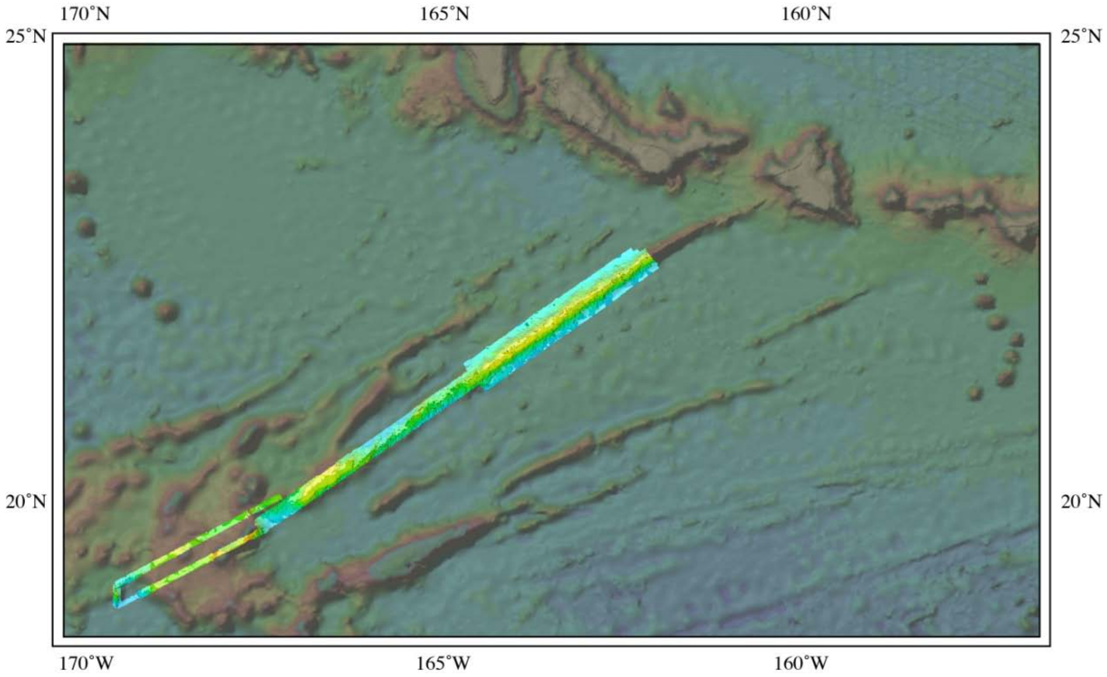

Figure 2. Okeanos Explorer EX0909 multibeam data on Necker Ridge.

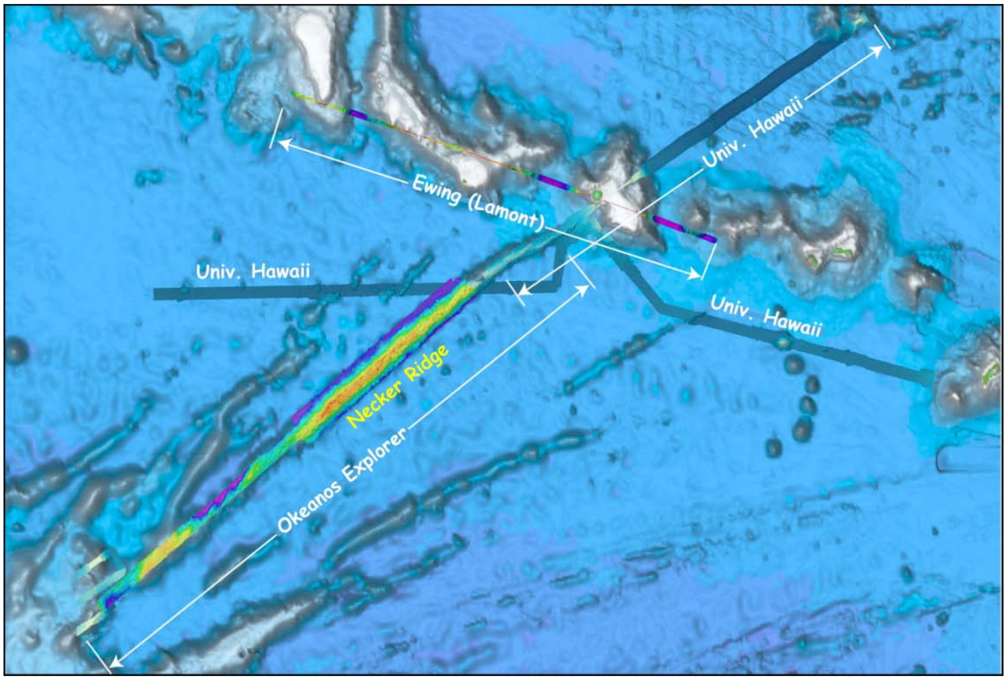

Figure 3. Existing multibeam bathymetry data for Necker Ridge.

The cruise began with a 29-hr transit to an area selected from the predicted bathymetry data to be adequate for a patch test (Figure 5). A full patch test, including a calibration of the XBT system with a CTD cast, was performed here. The patch-test filenames have "patch" as a suffix to the line number. The next 6.5 days consisted of systematically completing the mapping Necker Ridge. The cruise ended with 44 hr 930 km, transit to Honolulu, HI, which paralleled the outward transit for overlapping bathymetric coverage. The cruise mapped a total of 47.394 km^2 in 6.5 survey days and collected 5077 line km of MBES lines with an average speed of 11.5 knts. A summary of the cruises is given in Table 1.

Figure 4. R/V *Kilo Moana* used to map the Kingman-Palmyra area.

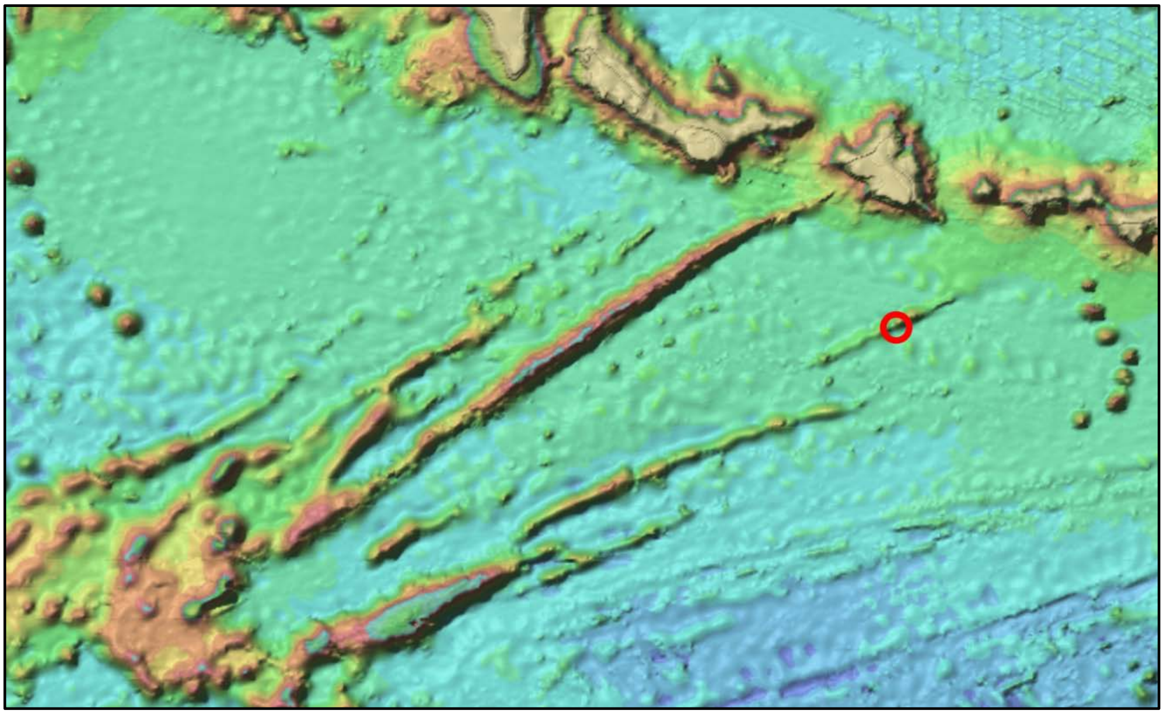

Figure 5. Location of the patch test (red circle).

Table 1. Cruise Statistics

Julian dates	JD213 to JD223
Dates	July 31 to August 10, 2011
Weather delays	0 days
Total non-mapping days (transits)	3.5 days
Total mapping days	6.5 days
Total area mapped	47,394 km^2
Total line kilometers	5077.5 km (2741.6 nmi)
Beginning draft	7.6 m
Ending draft	7.6 m
Average ship speed for survey	11.6 kts

The Multibeam Echosounder System and Associated Systems

The hull-mounted Kongsberg Maritime EM122 MBES system aboard RV *Kilo Moana* is a 12-kHz multibeam echosounder that transmits a 1° wide (fore -aft) acoustic pulse and then generates 432-2° receive apertures ("beams") over a 150° swath. The system can automatically adjust the pointing angles of the receive beams to maximize the achievable coverage or a maximum aperture can be defined by the operator. The transmit cycle can be rapidly duplicated to provide two swaths per ping, each transmitted with a small along-track offset that compensates for water depths and ship speed to generate a constant sounding spacing in the along-track direction. This mode can provide as many as 864 soundings per transmit cycle swath (432 soundings per swath) in the high-density dual-swath mode. With more than one sounding generated per beam in the high-density mode, the horizontal resolution is increased and is almost constant over the entire swath when run in the equidistant mode. In addition, the transmit beams can be steered as much as 10° forward or aft to reduce the effects of specular reflection at nadir and near-nadir angles.

The EM122 uses both continuous wave (CW) and frequency modulation (FM) pulses with pulse compression on reception to increase the signal-to-noise ratio. The transmit pulse is split into several independently steered sectors to compensate for vessel yaw. The system is pitch, yaw and roll stabilized to compensate for vehicle motion during transmission. The 15-ms pulse length (deep mode) used in this survey includes a significantly longer FM chirp pulse waveform for the outer transmit sectors. Its bandwidth corresponds to the resolution of the 15-ms CW pulse of the inner and mid-range transmit sectors but the longer duration of the FM chirp pulse allows pulse compression on reception for a gain in signal-to-noise ratio of about 15 dB. Kongsberg Maritime states that, at the 15-ms pulse length, the system is capable of depth accuracies of 0.3 to 0.5% of water depth. The Konsberg Maritime EM122 Product Description should be consulted for the full details of the MBES system. The installed software versions used on the Seafloor Information System (SIS) and the transmit-receive unit (TRU) systems are given in Table 2.

Table 2. Kongsberg and Knudsen software version numbers

System	Software Version
Seafloor Information System	3.8.3, build 89
TRU CPU	1.2.3, March 21, 2011
TRU DDS (DDS)	3.5.2 Oct., 13, 20107
TRU BSP (BSV)	2.2.3 July 02, 2009 “new”
TRU RX (RSV)	1.1.11, Feb. 18, 2010
TRU TX (TSV)	36 LC1.11, June 17, 2008
PU (PSV)	1.2.3 March 21, 2011
EM122 Datagram (DSV)	3.1.2 Sept. 20 2007

Knudsen software version number

EchoControlClient	2.29

A hull-mounted Applied Microsystems Ltd Smart SV&T sound-speed sensor (SN 4844) was used to measure the sound speed at the MBES array for accurate beam forming. The sensor was calibrated at the factory in January 2010. Beam forming during this cruise used the high-density equidistant mode with FM enabled and Automatic mode in deep water. For receive beams at near-normal incidence, the depth values are determined by center-of-gravity amplitude detection, but for most of the beams, the depth is determined by split-beam phase detection. The spacing of individual sounding is approximately every 50 m, regardless of survey speed.

An Applanix POS/MV model 320 version 4 inertial motion unit (IMU) (with TrueHeave) was interfaced to a NovAtel OEM2-3151R global positioning system (GPS) receiver to provide position fixes with an accuracy of ~±2 m. The IMU provides roll, pitch and yaw at accuracies of better than 0.02˚ at 100 Hz. A 5-minute run-in for each line insured the IMU settled prior to the start of logging. The MBES system can incorporate transmit beam steering up to ±10° from vertical, roll compensation up to ±10° and can perform yaw corrections as well. All horizontal positions were georeferenced to the WGS84-derived ellipsoid and vertical referencing was to instantaneous sea level.

The Kongsberg Maritime EM122 is capable of simultaneously collecting full time-series acoustic backscatter that is co-registered with each bathymetric sounding. The full time-series backscatter is a time series of acoustic-backscatter values across each beam footprint on the seafloor. If the received amplitudes are properly calibrated to the outgoing signal strength, receiver gains, spherical spreading, and attenuation, then the corrected backscatter should provide clues as to the composition of the surficial seafloor. However, the interpreter must be cautious because the 12-kHz acoustic signal undoubtedly penetrates the seafloor to an unknown, but significant (meters) depth, thereby generating a received signal that is a function of some unknown combination of acoustic impedance, seafloor roughness and volume reverberation.

The sound-speed profiles derived from frequent XBT casts (see below) were used to raytrace each MBES receive signal to the seafloor and back to the receiver to compensate for the refraction effects within the water column.

In addition to the MBES, the RV *Kilo Moana* is equipped with a Knudsen 3260 high-resolution chirp profiler and a Carson gravimeter. These data were continuously collected throughout the cruise.

All of the raw 2009 *Okeanos Explorer* EX0909 multibeam files from Necker Ridge were reprocessed by the senior author prior to the cruise to ensure uniform editing of the bathymetry and to extract the acoustic backscatter. The original EX0909 field files were renamed NeckerRidge_line_X, where X is a consecutive line number starting with 1 (see Appendix 1). Many of the EX0909 lines were outside the area of interest but they were processed for completeness, although they are not included in this report.

The University of Hawai'i (UH) assigned the 2011 cruise designator as KM11-21. All raw MBES files were initially labeled by the Kongsberg Seafloor Information System (SIS) data capture software with a unique file designator but the files were renamed to NeckerRidge_line_X, where X is a consecutive line number starting with 100 (see Appendix 2). Transit lines and patch test lines were given line numbers prefixed with "tran" or "patch", respectively. The renaming was done so that the individual lines would be unequivocally identified with the survey area in the future.

Water-column sound-speed profiles were routinely collected every 6 hrs during the cruise as well as anytime the sound speed measured at the hull-mounted transducer differed by 0.5 m/s from the value at the transducer depth from the XBT-derived sound speed. Sound speeds were calculated from measurements of water temperature vs depth using Sippican Deep Blue expendable bathythermographs (XBTs). Deep Blue XBTs have a 760-m maximum depth of measurement so the profiles were extrapolated to 12,000 m using Kongsberg software to provide a profile throughout the water column. A Sea Bird Electronics model SBE-911+917+ CTD was used to calibrate the XBTs during the patch test. The two temperature sensors (serial no. 2013 and 2700), the conductivity sensor (serial no. 3326) and the pressure sensor (serial number 92859) were last calibrated by Sea Bird Electronics on May 27, 2011 (Appendix 8). Derived sound-speed profiles derived from the two systems (CTD vs XBT) from data collected during the patch test were compared between the systems to calibrate the XBT (see Daily Log JD213).

A full patch test was conducted in the survey area to ensure sensor offsets were correct. Table 3 and Table 4 show the sensor offsets used for the survey.

Table 3. Initial system sensor offsets

Location Offsets				Angular Offsets		
Sensor	**Forward**	**Stbd**	**Down**	**Roll**	**Pitch**	**Heading**
POS 1	0.00	0.00	0.00	–	–	–
POS 2	0.00	0.00	0.00	–	–	–
POS 3	0.00	0.00	0.00	–	–	–
Tx tdr	-3.27	-0.053	0.803	-0.064	0.024	0.026
Rx tdr	1.156	-1.225	0.804	-0.092	0.044	0.046
Attitude 1	0.00	0.00	0.00	0.09	0.00	0.00
Attitude 2	0.00	0.00	0.00	0.00	0.00	0.00

Departure draft….7.6 m bow Final draft….7.6 m

Table 4. Offset corrections determined by Patch Test.

Offset	Value
roll	-0.05°
pitch	0
yaw	0
latency	0

Ancillary Systems

Knudsen 3260 chirp subbottom profiler

A Knudsen 3260 chirp subbottom profiler was deployed throughout the cruise. The system is a hull-mounted system that produces a 3.5-kHz FM signal with a 2-kHz bandwidth. The system has adjustable pulse lengths up to 64 ms, power and gain settings that allows it to acquire good bottom detection and subbottom resolution to about 50 m subbottom. The profiler was synchronized with the EM122 so that the EM122 took precedence over the profiler during the profiler transmit and receive cycles. The synchronization eliminated any interference of the profiler signal with the multibeam signal. The chirp digital data were recorded in SEG-Y format and processed with Chesapeake Technologies, Inc. SonarWeb software. SEG-Y line names were changed to Necker_3.5kHz_line_X.sgy (Appendix 2) where X is a consecutive line number. The sgy line numbers do not correspond with the MBES line numbers.

Carson gravity meter

A Carson gravimeter (Carson Gravity Meter and Instrument Co. model 6300), a refurbished LaCoste-Romberg Model S-33 meter, was run on a hands-off basis, not to interfere with the MBES operations. Land ties were made at Honolulu prior to and at the end of the cruise (see Appendix 4). Post-cruise processing of the gravity data will be done by the University of Hawai’i geophysics group.

MBES Data Processing

The raw multibeam bathymetry and acoustic backscatter data were processed aboard ship using the University of New Brunswick's SwathEd software suite, version 20091218. Each Kongsberg .all file was collected by the onboard Kongsberg SIS data-acquisition system. Once a line was completed, the .all file was copied to a server that could be accessed by the UNH computer via the shipboard network. Each .all file was renamed from the Kongsberg-generated file name to *NeckerRidge_line_n.all* (see Appendix 2) so that later each file could be easily identified to the area and cruise. The line numbers commenced with NeckerRidge_line_tran100 beginning with the transit to Necker Ridge and then commenced to NeckerRidge_line_1XX when the actual mapping began. Each .all file is composed of individual data packets of beam bathymetry (range and angle), beam average and full time-series acoustic backscatter, navigation, parameters, sound-speed profiles, orientation and sound speed at the transducer. The first step in the processing separates each of these data packets into the individual files.

The second step in the processing plots the navigation file so that any bad fixes can be flagged. Once this step is completed, the validated navigation is merged with the bathymetry and acoustic backscatter files.

The third step involves editing (flagging) individual soundings that appear to be fliers, bad points, multipaths, etc. The entire file of soundings is viewed and edited in a sequence of steps through the file. Once the bathymetry file has been edited, the valid individual soundings are gridded into subarea DTM maps and the co-registered valid acoustic backscatter full beam time series is assembled into a file and gridded into subarea mosaics.

The entire region to be mapped was subdivided into 14 subarea bathymetry maps and (Fig. 6). Each subarea map was designed to maximize the spatial resolution allowed by the mapped water depths within the area.

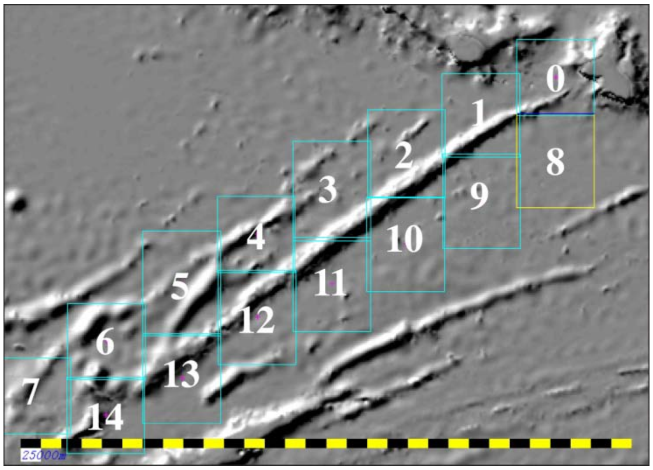

Figure 6. Subareas for Necker Ridge.

The Area: Necker Ridge

Necker Ridge is an aseismic bathymetric elevation that spans 650 km from the Mid-Pacific Mountains on the southwest to the Hawaiian Ridge on the northeast (Figure 1). The summit of the ridge varies in water depths from ~1800 to ~3500 m and the ridge rises 2500 to 3000 m above the adjacent abyssal seafloor. Two large, generally flat-topped areas of Necker Ridge are shallower than ~1850 m; one a 70-km long section in the southwest and the other a 165-km long section in the northeast. The southern flank of the ridge is steeper (~20˚) than the northern flank (~10˚). The ridge trends N55E to 22.77˚N/166.13˚W where the northern-most 165 km has a trend of N65E. There is a pronounced N31E cross grain of summit ridges that occurs in the central deeper region. The *Okeanos Explorer* multibeam bathymetry shows the morphology of the ridge is composed of numerous stacked lobate volcanic flows.

The origin of the ridge has been debated since the 1970s. Dredged rocks from Necker Ridge have been dated at 82.5 Ma (Saito and Ozima (1977) whereas Atwater et al. (1989) show from marine magnetics that the adjacent oceanic crust was formed within the Cretaceous Quiet Zone that spans from 83 to 119 Ma. Necker Island, at the junction of Necker Ridge and the Hawaiian Ridge, has been dated at ~10 Ma by Dalrymple et al. (1974), clearly demonstrating no genetic relationship between the two ridges. The trend of Necker Ridge is oblique to the trends of the nearby Murray and Molokai Fracture Zones, suggesting the ridge is not related to either fracture zone. Dredged rocks from the SW flank of Necker Island were dated at ~71 Ma (Clague and Dalrymple (1975), which suggests that Necker Island may be the NE end of Necker ridge that was uplifted as it passed over the Hawaiian hot spot. Bridges (1997) observed that the trend of some seamounts SW of the Hawaiian Ridge are parallel to the Necker Ridge trend, which suggests the seamounts formed at the same time as Necker Ridge. Consequently, Necker Ridge may have formed by mid-plate volcanism.

The depths of the two flat-topped sections of Necker Ridge occur at roughly the same water depth as the flat top of nearby Horizon Guyot (1500 to 1850 m depths). This suggests that both ridges might have been at sea level sometime in their past and that the entire region has since subsided nearly 2 km. However, Lonsdale et al. (1972) argue that the flat surfaces of Horizon Guyot are not the result of erosion at sea level but perhaps are the result of overlapping volcanic flows. Nevertheless, DSDP Site 171 drilled a 173-m section from the summit of Horizon Guyot and recovered Cretaceous (100 to 110 Ma) lagoonal sediments at the basalt-sediment contact (Winterer et al., 1973). These results demonstrate that Horizon Guyot clearly was at sea level during the Cretaceous.

Strong currents (>15 cm/s) on the summit of nearby Horizon Guyot were measured by Lonsdale et al (1972; Cacchione et al., 1978) and, in addition, they recovered sediment cores that show evidence of winnowing and erosion. This suggests that the surficial sediments of both Horizon Guyot and Necker Ridge are presently being modified by relative strong deep-sea currents.

Daily Log

JD 212 (Sunday, July 31, 2011)

We departed Honolulu at 0800L (1800Z) and steamed at 12 knts to the patch test site. The MBES and Knudsen 3260 subbottom profiler were turned on and the transit line (NeckerRidge_line_tran100) began at 1935Z. A Deep Blue XBT was cast once in 2500+ m of water to get a proper sound-speed profile for the transit line. XBTs will be cast every 6 hr during the transit. We continued to configure the MBES and Knudsen systems as we transited and began to collect excellent-quality data on both systems. The MBES was achieving 2.9 x water depth in 4400 m depths.

When processing the first line, it was discovered that the Knudsen was not recording navigation information into the SEG-Y header. It turned out that the NMEA data was not set at 9600 baud rate on the COM1 Peripheral Port assignment window. Once set at 9600, navigation began to be received. A short line was recorded to make certain navigation was being properly recorded. However, the SonarWeb software could not read the navigation.

JD 213 (Monday, August 1, 2011)

We continued on the transit to the patch test site under ideal conditions. The MBES continued to collect good-quality data with a swath width that varied between 2.6 and 2.9 x water depth. Although the Knudsen SEG-Y files could not be read by SonarWeb, the software brought out on the cruise to read these data, because of some issue with the navigation format, we confirmed that the navigation is being properly written into the SEG-Y file. Consequently, we continued to record the Knudsen data and will sort out the issue post-cruise.

We arrived at the patch test site (22.062308˚N/164.197602˚W, ~4750 m water depth) at 1315L (2325Z) and made a CTD cast to establish the standard against which we will compare the sound-speed profile calculated from the XBT cast. The seafloor is very flat in this area and without any potential dangers to the CTD. Conditions were perfect for the cast. The first dip was halted because the SeaBird CTD deck unit would not record any data being collected. The CTD was brought back aboard and about a half hour was spent rebooting the deck unit and checking all connections, etc. Finally, the unit began to record data. The CTD cast was made to 4500 m and took about 4 hrs because the light weight of the unit required the line speed to be slow. An XBT cast (no. 763; see Appendix 4) was made after the CTD was secured on deck. A comparison of the two casts (Figure 7) shows good agreement between the two.

We next transited to WP1 to begin the pitch and timing calibration run of the patch test. No data were recorded on the transit to WP1. The pitch and timing patch tests (patch109, patch110 and patch111; Figure 8.) show no static offset was necessary. From there we moved to a flat area to conduct the roll test (patch112 and patch113). A roll bias of -0.05˚ was found, using both SwathEd and SIS analyses, and was entered into the EM122 SIS. A small knoll was mapped on the starboard swath of line patch112 so, after the roll test was completed, we steamed a reciprocal course offset by 12 km that put the knoll on our port swath for the test for yaw misalignment. The heading test showed no static offset was necessary.

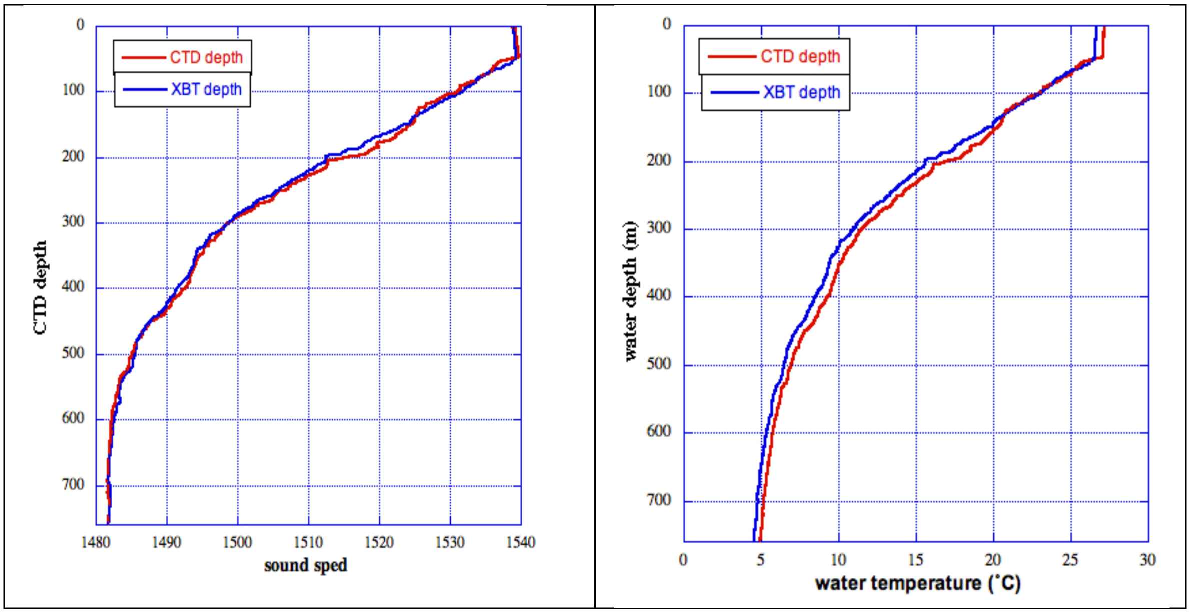

Figure 7. (A) Comparison of CTD vs XBT temperature profiles and (B) comparision of CTD vs XBT calculated sound speeds.

Summary of patch test lines (see Fig. 8).

The pitch line running from WP1 to WP2 at 12 knts is line patch109
The pitch line running from WP2 to WP1 at 12 knts is line patch110
The timing line running from WP1 to WP2 at 6 knts is line patch111
The roll line running from WP3 to WP4 at 12 knts is line patch112
The roll line running from WP4 to WP3 at 12 knts is line patch113
The yaw line running from WP5 to WP5 at 12 knts is line patch114
Line patch 112 and line patch114 were used for yaw calibration

As part of re-ballasting, engineering ran pumps from approx. 1840-1855; no interference was observed on EM122 or Knudsen 3260.

JD 214 (Tuesday, August 2, 2011)

An ideal day for mapping with relatively small seas and ~15 knt winds. Both the MBES and the Knudsen were collecting high-quality data. The first half of the day was spent completing the transit to the beginning of the mapping lines.

The first survey line (NeckerRidge_line 117) was begun at 2354Z (1354L). An XBT cast (XBT no. 766) was made at the start of this line. This line trends NW along the southern base of Necker Island. The remainder of the day was spent in routine mapping.

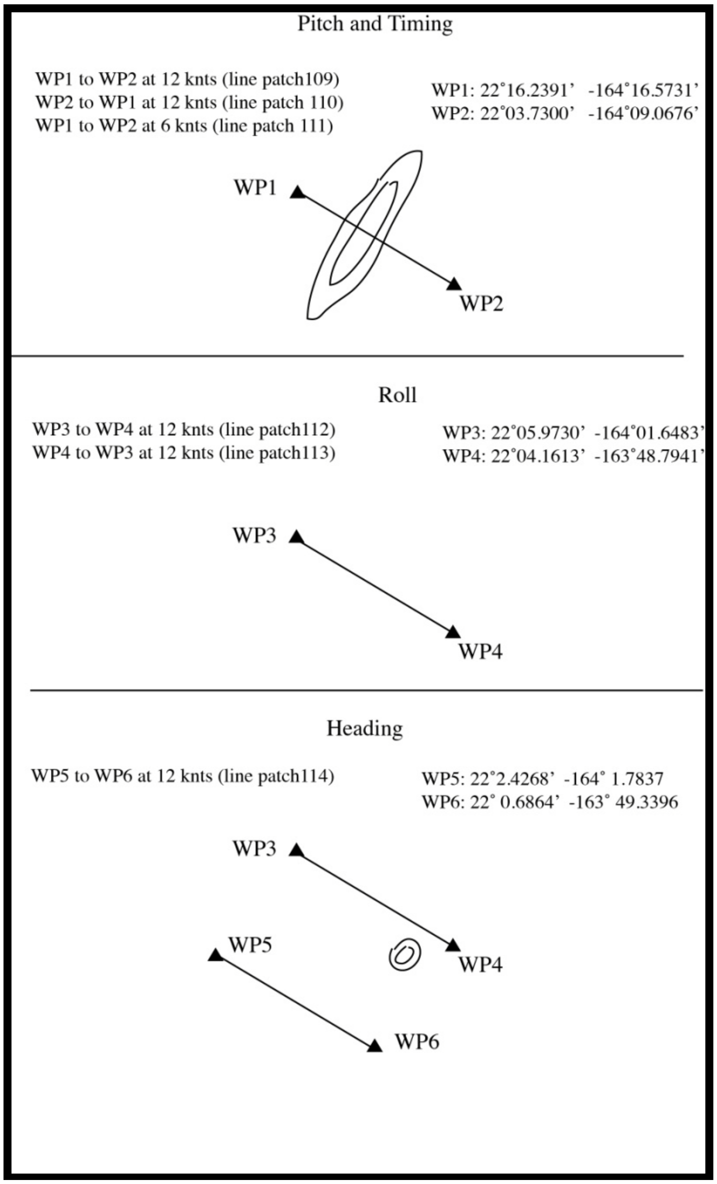

Figure 8. Patch test design.

JD 215 (Wednesday, August 3, 2011)

Today was a routine day of mapping, collecting high-quality data with ideal conditions. We completed the mapping of the northern-most Necker Ridge as it approaches the Hawaiian Ridge (Figure 9). The remainder of the cruise will be focused on mapping the base-of-slope zone on both the north and south sides of Necker Ridge.

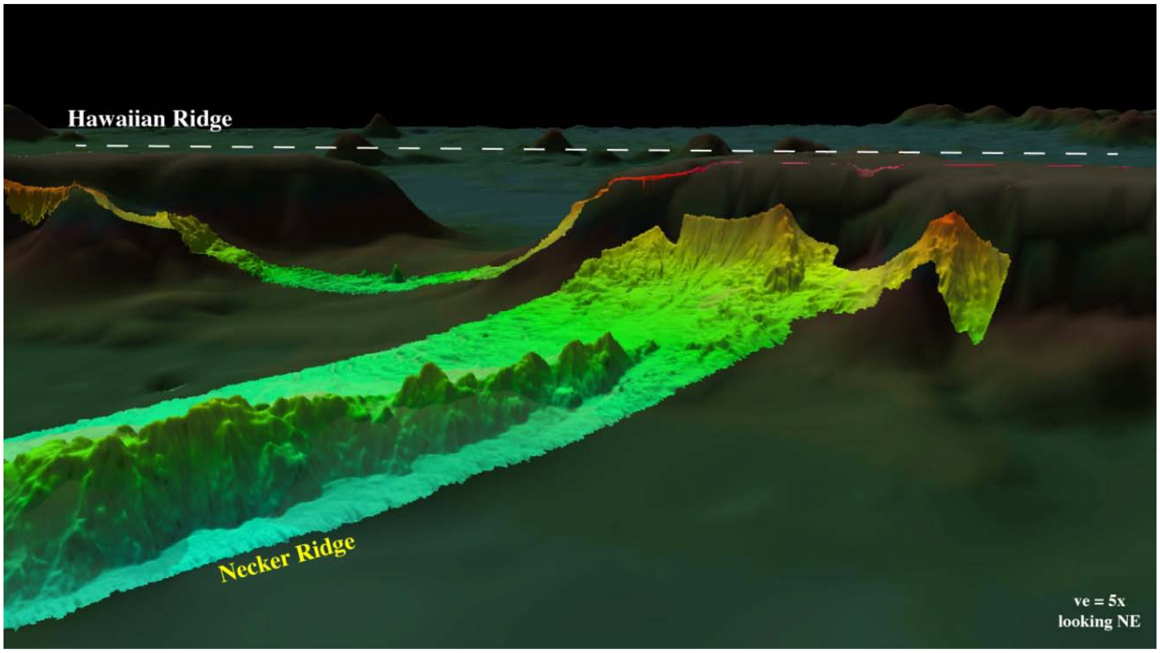

Figure 9. Perspective view of Necker Ridge as it approaches the Hawaiian Ridge.

JD216 (Thursday, August 4, 2011)

Routine day of mapping. Conditions ideal and collecting high-quality data. The day was spent mapping the southeast side of Necker Ridge and outside the Papahānaumokuākea Marine National Monument boundary.

JD217 (Friday, August 5, 2011)

Routine day of mapping. Conditions ideal and collecting high-quality data. The day was spent mapping on the southern portion of the southeast side of Necker Ridge down to the Mid-Pacific Mountains. The e-mail satellite link failed in the middle of the afternoon, leaving us without email to the outside world.

JD218 (Saturday, August 6, 2011)

Routine day of mapping. Conditions ideal and collecting high-quality data. The day was spent mapping on the southern portion of the northwest side of Necker Ridge as far south as the Mid-Pacific Mountains. The wind picked up to 20 knts in the afternoon and the swell and seas built up to ~6 to 8 ft and directly on our bow on line 143. The e-mail satellite link was still down.

The Kongsberg SIS began to report grossly inaccurate port and starboard ranges even though the SIS map view showed soundings at the appropriate ranges.

The data so far show that Necker Ridge formed as a series of stacked volcanic flows (Figure 10); and surprisingly, little evidence of landslides.

At 0505Z (1705L) just before the start of line 143, the Knudsen crashed. The Knudsen client and the power supply were rebooted but to no avail. Finally, the Windows machine was rebooted and the Knudsen came back alive at 1721L. However, it reset the Knudsen-assigned SEG-Y line number to 116.

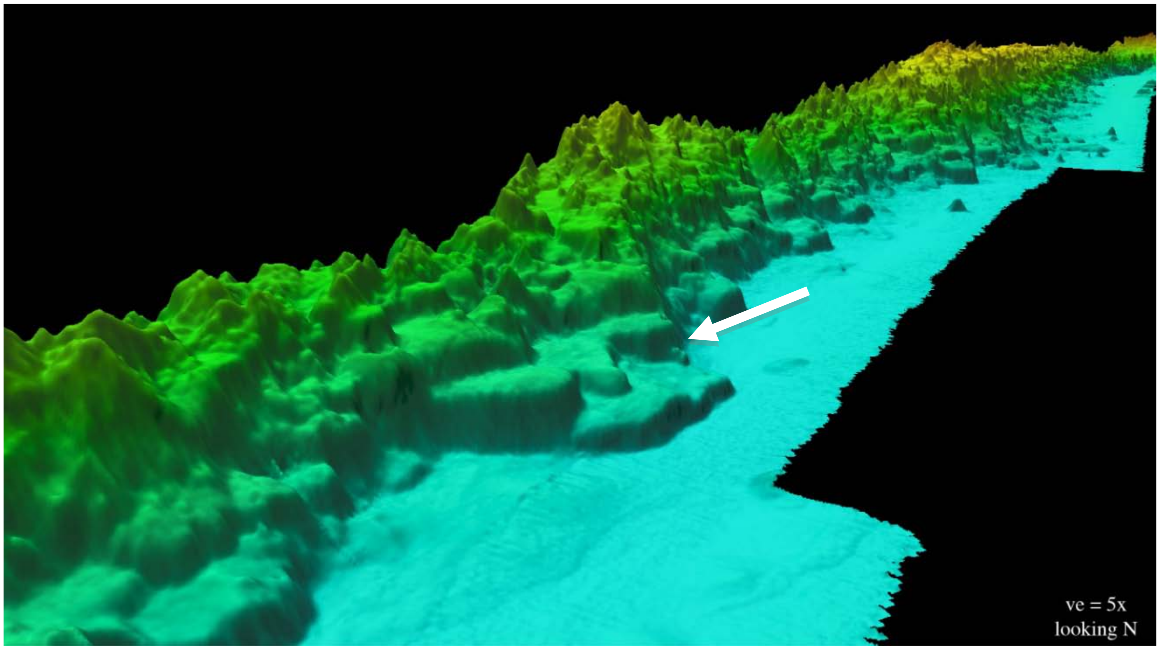

Figure 10. Perspective view of southern side of Necker Ridge showing construction of ridge by stacked volcanic flows (white arrow).

JD219 (Sunday, August 7, 2011)

Conditions were a bit lumpy with ~20 knt winds and 6 ft seas, but data quality continued to be high. About 0117L the Knudsen reported no GPS was available, presumably because the GPS feed was being interpreted as a serial mouse due to the recent reboot. Rebooted the Knudsen without the GPS being plugged in and the system appeared to recover appropriately. It did, however, reset the line numbers again, so stopped, reset to the next sequential line number, confirmed GPS operation again, and then restarted logging.

Line 148 was extended to the NE to capture the ridge that trends north off the southern guyot (Fig. 12).

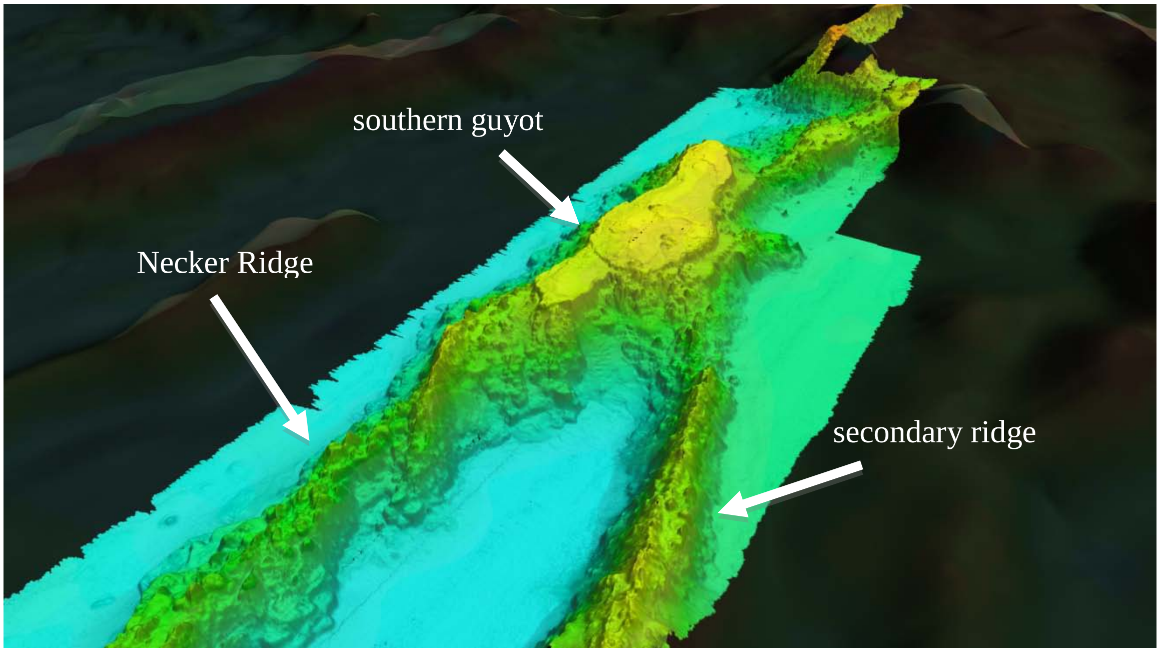

Figure 11. Perspective view of southern guyot and secondary ridge that branches off of the main Necker Ridge. Vertical exaggeration 5x, looking south.

JD220 (Monday, August 8, 2011)

Line 153 was broken off at 0700L (1800Z) and the mapping of Necker Ridge was completed. We turned east for the transit to Honolulu with all systems continuing to collect data to the buoy at Honolulu.

JD221 (Tuesday, August 9, 2011)

Continued to transit to Honolulu with all systems collecting data.

JD222 (Wednesday, August 10, 2011)

Continued to transit to Honolulu with all systems collecting data. Data collection terminated 0445L (1445Z), with the lights of Honolulu to port. Arrived at Sand Island, Snug Harbor dock at 0735L (1735Z).

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Table 5. Cruise Personnel.

Dr. James V. Gardner………………………..UNH Chief Scientist
Dr. Brian R. Calder……………………....UNH Co-Chief Scientist
Capt. Richard (Rick) Meyer…………….…………..Ship’s Master
Mr. Ben Colello……………………….………..UH Party Chief
Mr. Paul Johnson……………………….….…UNH Data Manager
Mr. Dave Hashisaka……………………..………UH Technician
Mr. David Armstrong…………………….....UNH Watchstander
Ms. Briana Sullivan………………………...UNH Watchstander
Mr. Hadar Sade………………………………UNH Watchstander
Dr. Barry Eakin……………………………...NOAA Watchstander

Appendix 1 - Conversion table of 2011 KM11-21 Kongsberg SIS-assigned .all file names to UNH file names by Julian Day.

JD	Data Folder	Kongsberg file name KM.all	UNH file name .all	Notes
212	**110731**	**0000_20110731_193526**	**NeckerRidge_line_tran100**	transit from Hono
		0001_20110731_200531	NeckerRidge_line_tran101	transit
		0001_20110731_210159	NeckerRidge_line_tran102	transit
		0002_20110731_224837	NeckerRidge_line_tran103	transit
213	**110801**	**0003_20110801_000017**	**NeckerRidge_line_tran104**	**transit**
		0004_20110801_060014	NeckerRidge_line_tran105	transit
		0005_20110801_120010	NeckerRidge_line_tran106	transit
		0006_20110801_180129	NeckerRidge_line_tran107	transit
		0007_20110801_220507	NeckerRidge_line_tran108	transit
214	**110802**	**0008_20110802_061430**	**NeckerRidge_line_patch109**	**WP1-WP2 patch**
		0009_20110802_074715	NeckerRidge_line_patch110	WP2-WP1 patch
		0010_20110802_091001	NeckerRidge_line_patch111	WP1-WP2 patch
		0011_20110802_123450	NeckerRidge_line_patch112	WP3-WP4 patch
		0012_20110802_135942	NeckerRidge_line_patch113	WP4-WP3 patch
		0013_20110802_153526	NeckerRidge_line_patch114	WP5-WP6 patch
		0014_20110802_170158	NeckerRidge_line_tran115	transit
		0015_20110802_180025	NeckerRidge_line_tran116	transit
215	**110803**	**0016_20110803_235131**	**NeckerRidge_line_117**	**survey**
		0017_20110803_012144	NeckerRidge_line_118	survey
		0018_20110803_060004	NeckerRidge_line_119	survey
		0019_20110803_090942	NeckerRidge_line_120	survey
		0020_20110803_120011	NeckerRidge_line_121	survey
		0021_20110803_171631	NeckerRidge_line_122	survey
		0022_20110803_182334	NeckerRidge_line_123	survey
		0023_20110803_000009	NeckerRidge_line_124	survey
216	**110804**	**0024_20110804_024554**	**NeckerRidge_line_125**	**survey**
		0025_20110804_060000	NeckerRidge_line_126	survey

JD	Data Folder	Kongsberg file name KM.all	UNH file name .all	Notes
		0026_20110804_104444	NeckerRidge_line_127	survey (cross-line)
		0027_20110804_110912	NeckerRidge_line_128	survey
		0028_20110804_120203	NeckerRidge_line_129	survey
		0029_20110804_180011	NeckerRidge_line_130	survey
		0030_20110804_184303	NeckerRidge_line_131	survey
217	**110805**	**0031_20110804_000016**	**NeckerRidge_line_132**	**survey**
		0032_20110805_062119	NeckerRidge_line_133	survey
		0033_20110805_120501	NeckerRidge_line_134	survey
		0034_20110805_180026	NeckerRidge_line_135	survey
		0035_20110805_204713	NeckerRidge_line_136	survey
218	**110806**	**0036_20110806_000026**	NeckerRidge_line_137	survey
		0037_20110806_060020	NeckerRidge_line_138	survey
		0038_20110806_120604	NeckerRidge_line_139	survey, cross-line
		0039_20110806_140847	NeckerRidge_line_140	survey
		0040_20110806_180025	NeckerRidge_line_141	survey
219	**110807**	**0041_20110807_000004**	**NeckerRidge_line_142**	**survey**
		0042_20110807_050601	NeckerRidge_line_143	survey
		0043_20110807_060004	NeckerRidge_line_144	survey
		0044_20110807_124949	NeckerRidge_line_145	survey
		0045_20110807_155654	NeckerRidge_line_146	survey, spare (DNG)
		0046_20110807_162946	NeckerRidge_line_147	survey
		0047_20110807_180004	NeckerRidge_line_148	survey
		0048_20110807_225021	NeckerRidge_line_149	survey
220	**110808**	**0049_20110808_000011**	**NeckerRidge_line_150**	**survey**
		0050_20110808_015700	NeckerRidge_line_151	survey
		0051_20110808_060006	NeckerRidge_line_152	survey
		0052_20110808_120253	NeckerRidge_line_153	survey
		0053_20110808_170523	NeckerRidge_line_tran154	transit to Honolulu
221	**110809**	0054_20110809_000003	NeckerRidge_line_tran155	transit to Honolulu
		0055_20110809_060010	NeckerRidge_line_tran156	transit to Honolulu
		0056_20110809_092337	NeckerRidge_line_tran157	transit to Honolulu
		0057_20110809_120015	NeckerRidge_line_tran158	transit to Honolulu
		0058_20110809_181118	NeckerRidge_line_tran159	transit to Honolulu
222	**110810**	0059_20110810_000016	NeckerRidge_line_tran160	transit to Honolulu
		0060_20110810_060004	NeckerRidge_line_tran161	transit to Honolulu
		0061_20110810_120104	NeckerRidge_line_tran162	transit to Honolulu

Appendix 2 - Conversion table of 2009 EX0909 .all file names to UNH file names by Julian Day.

JD	Data Folder	NOAA file name EX.all	UNH file name raw.all	Notes
269	**090826**	**0000_20090826_060627**	**NeckerRidge_line_1**	cross line
		0001_20090826_074756	NeckerRidge_line_2	
		0002_20090826_134758	NeckerRidge_line_3	

		0003_20090826_194800	NeckerRidge_line_4	
270	**090827**	**0004_20090827_014801**	**NeckerRidge_line_5**	
		0005_20090827_014801	NeckerRidge_line_6	turn
		0006_20090827_014801	NeckerRidge_line_7	
		0007_20090827_014801	NeckerRidge_line_8	
		0008_20090827_014801	NeckerRidge_line_9	
		0009_20090827_014801	NeckerRidge_line_10	
		00010_20090827_014801	NeckerRidge_line_11	
271	**090828**	**00011_20090828_000005**	**NeckerRidge_line_12**	
		00012_20090828_060009	NeckerRidge_line_13	
		00013_20090828_120001	NeckerRidge_line_14	
		00014_20090828_180003	NeckerRidge_line_15	
272	**090829**	**00015_20090829_235954**	**NeckerRidge_line_16**	
		00016_20090829_060000	NeckerRidge_line_17	
		00017_20090829_071403	NeckerRidge_line_18	turn
		00018_20090829_075708	NeckerRidge_line_19	
		00019_20090829_135707	NeckerRidge_line_20	
		00020_20090829_195712	NeckerRidge_line_21	
		00021_20090829_225506	NeckerRidge_line_22	turn
273	**090830**	**00022_20090830_001857**	**NeckerRidge_line_23**	
		00023_20090830_045121	NeckerRidge_line_24	
		00024_20090830_105121	NeckerRidge_line_25	
		00025_20090830_152556	NeckerRidge_line_26	turn
		00026_20090830_155314	NeckerRidge_line_27	
		00027_20090830_215315	NeckerRidge_line_28	
274	**090831**	**00028_20090831_000200**	**NeckerRidge_line_29**	
		00029_20090831_053021	NeckerRidge_line_30	turn
		00030_20090831_071142	NeckerRidge_line_31	
		000310_20090831_074507	NeckerRidge_line_32	
		00032_20090831_075255	NeckerRidge_line_33	
		00033_20090831_15248	NeckerRidge_line_34	
		00034_20090831_195248	NeckerRidge_line_35	
		00035_20090831_212522	NeckerRidge_line_36	turn
		END OF EX0909 LEG 1	**END OF EX0909 LEG 1**	

JD	Data Folder	NOAA file name EX.all	UNH file name raw.all	Notes
288	**090915**	**00000_20090915_183202**	**NeckerRidge_line_37**	
		00001_20090915_200611	NeckerRidge_line_38	
		00002_20090915_231400	NeckerRidge_line_39	
289	**090916**	**00003_20090916_000008**	**NeckerRidge_line_40**	
		00004_20090916_060005	NeckerRidge_line_41	
		00005_20090916_090305	NeckerRidge_line_42	
		00006_20090916_104732	NeckerRidge_line_43	turn
		00007_20090916_105216	NeckerRidge_line_44	turn
		00008_20090916_112543	NeckerRidge_line_45	

JD	**Data Folder**	**NOAA file name EX.all**	**UNH file name raw.all**	**Notes**
		00009_20090916_112751	NeckerRidge_line_46	
		00010_20090916_172750	NeckerRidge_line_47	
		00011_20090916_180858	NeckerRidge_line_48	turn
		00012_20090916_191853	NeckerRidge_line_49	turn
		00013_20090916_220359	NeckerRidge_line_50	
		00014_20090916_233127	NeckerRidge_line_51	
290	**090917**	**00015_20090917_053129**	**NeckerRidge_line_52**	
		00016_20090917_061300	NeckerRidge_line_53	
		00017_20090917_121306	NeckerRidge_line_54	
		00018_20090917_161621	NeckerRidge_line_55	turn
		00019_20090917_161841	NeckerRidge_line_56	
		00020_20090917_174411	NeckerRidge_line_57	turn
		00021_20090917_175028	NeckerRidge_line_58	
		00022_20090917_225134	NeckerRidge_line_59	
291	**090918**	**00023_20090918_000006**	**NeckerRidge_line_60**	
		00024_20090918_060010	NeckerRidge_line_61	
		00025_20090918_080622	NeckerRidge_line_62	turn
		00026_20090918_081059	NeckerRidge_line_63	turn
		00027_20090918_093101	NeckerRidge_line_64	turn
		00028_20090918_093549	NeckerRidge_line_65	
		00029_20090918_153550	NeckerRidge_line_66	
		00030_20090918_210712	NeckerRidge_line_67	turn
		00031_20090918_210834	NeckerRidge_line_68	turn
		00032_20090918_221256	NeckerRidge_line_69	
		00033_20090918_231052	NeckerRidge_line_70	
		00034_20090918_235957	NeckerRidge_line_71	
292	**090919**	**00035_20090919_002823**	**NeckerRidge_line_72**	
		00036_20090919_062816	NeckerRidge_line_73	
		00037_20090919_070208	NeckerRidge_line_74	
		00038_20090919_130211	NeckerRidge_line_75	
		00039_20090919_153938	NeckerRidge_line_76	turn
		00040_20090919_154221	NeckerRidge_line_77	
		00041_20090919_182357	NeckerRidge_line_78	
		00042_20090919_231617	NeckerRidge_line_79	
293	**090920**	**00043_20090920_0000043**	**NeckerRidge_line_80**	
		00044_20090920_060005	NeckerRidge_line_81	
		00045_20090920_083624	NeckerRidge_line_82	turn
		00046_20090920_084808	NeckerRidge_line_83	
		00047_20090920_101204	NeckerRidge_line_84	
		00048_20090920_104419	NeckerRidge_line_85	60 pings
		00049_20090920_104528	NeckerRidge_line_86	
		00050_20090920_164527	NeckerRidge_line_87	
		00051_20090920_215028	NeckerRidge_line_88	
294	**090921**	**00052_20090921_0000043**	**NeckerRidge_line_89**	
		00053_20090921_0000043	NeckerRidge_line_90	
		00054_20090921_0000043	NeckerRidge_line_91	turn
		00055_20090921_0000043	NeckerRidge_line_92	
		00056_20090921_0000043	NeckerRidge_line_93	

JD	Data Folder	NOAA file name EX.all	UNH file name raw.all	Notes
		END OF EX0909 LEG 2	**END OF EX0909 LEG 2**	

Appendix 3 - Conversion table of KM11-21 Knudsen-assigned .sgy file names to UNH file names by Julian Day.

JD	Data Folder	Knudsen file name .sgy	UNH file name .sgy	Notes
216	**110803**	**Necker_70884_121**	**Necker_3.5kHz_line_117**	
		Necker_70884_122	Necker_3.5kHz_line_118	
		Necker_70884_123	Necker_3.5kHz line_119	
		Necker_70884_124	Necker_3.5kHz line_120	
		Necker_70884_125	Necker_3.5kHz line_121	
		Necker_70884_126	Necker_3.5kHz line_122	
		Necker_70884_127	Necker_3.5kHz line_123	
216	**110804**	**Necker_70884_128**	**Necker_3.5kHz line_124**	
		Necker_70884_129	Necker_3.5kHz line_125	
		Necker_70884_130	Necker_3.5kHz line_126	
		Necker_70884_131	Necker_3.5kHz line_127	
		Necker_70884_132	Necker_3.5kHz line_128	
		Necker_70884_133	Necker_3.5kHz line_129	
		Necker_70884_134	Necker_3.5kHz line_130	
217	**110805**	**Necker_70884_135**	**Necker_3.5kHz line_131**	
		Necker_70884_136	Necker_3.5kHz line_132	
		Necker_70884_137	Necker_3.5kHz line_133	
		Necker_70884_138	NeckerR_3.5kHz line_134	
		Necker_70884_139	Necker_3.5kHz line_135	
218	**110806**	**Necker_70884_140**	**Necker_3.5kHz line_136**	
		Necker_70884_141	Necker_3.5kHz line_137	
		Necker_70884_142	Necker_3.5kHz line_138	
		Necker_70884_143	Necker_3.5kHz line_139	
		Necker_70884_144	Necker_3.5kHz line_140	
219	**110807**	**Necker_70884_145**	**Necker_3.5kHz line_141**	
		Necker_70884_116	Necker_3.5kHz line_142	
		Necker_70884_146	Necker_3.5kHz_line_143	
		Necker_70884_147	Necker_3.5kHz_line_144	
		Necker_70884_148	Necker_3.5kHz_line_145	
		Necker_70884_149	Necker_3.5kHz_line_146	
		Necker_70884_150	Necker_3.5kHz_line_147	
		Necker_70884_151	Necker_3.5kHz_line_148	
		Necker_70884_152	Necker_3.5kHz_line_149	
		Necker_70884_153	Necker_3.5kHz_line_150	
		Necker_70884_154	Necker_3.5kHz_line_151	

JD	Data Folder	Knudsen file name .sgy	UNH file name .sgy	Notes
		Necker_70884_155	Necker_3.5kHz_line_152	
220	**110808**	**Necker_70884_156**	**Necker_3.5kHz line_153**	
		Necker_70884_157	Necker_3.5kHz_line_154	
		Necker_70884_158	Necker_3.5kHz_line_155	
		Necker_70884_159	Necker_3.5kHz_line_tran156	start transit 2 Hono
221	**110809**	Necker_70884_160	Necker_3.5kHz_line_tran157	transit 2 Hono
		Necker_70884_161	Necker_3.5kHz_line_tran158	transit to Honolulu
		Necker_70884_162	Necker_3.5kHz_line_tran159	transit to Honolulu
		Necker_70884_163	Necker_3.5kHz_line_tran160	transit to Honolulu
		Necker_70884_164	Necker_3.5kHz_line_tran161	transit to Honolulu
222	**110810**	Necker_70884_165	Necker_3.5kHz_line_tran162	transit to Honolulu
		Necker_70884_166	Necker_3.5kHz_line_tran163	transit to Honolulu
		Necker_70884_167	Necker_3.5kHz_line_tran164	transit to Honolulu

Appendix 4 - Locations of XBT casts

XBT number	Latitude	Longitude	Serial Number	TYPE
757	21.25865	-158.39360	01097246	Deep Blue
758	21.35522	-160.41613	01097017	Deep Blue
759	21.56947	-161.67417	01097016	Deep Blue
759a	21.69073	-162.28493	01097016	Deep Blue
761	21.82892	-162.97842	01097014	Deep Blue
762	21.88713	-163.24093	01097018	Deep Blue
763	22.08502	-164.05143	01097019	Deep Blue
764	22.24447	-163.96942	01097020	Deep Blue
765	22.69783	-164.27242	01097021	Deep Blue
766	22.80417	-164.34303	01097025	Deep Blue
767	23.25517.	-164.65208	01097022	Deep Blue
768	22.97627	-165.76603	01097024	Deep Blue
769	23.04292	-164.81800	01097023	Deep Blue
770	23.42208	-164.76317	01160562	Deep Blue
771	23.12700	-165.28758	01160563	Deep Blue
772	22.84867	-165.83167	01160564	Deep Blue
773	22.86400	-165.62178	01160558	Deep Blue
774	23.19290	-164.97600	01160559	Deep Blue
775	23.25517	-164.65208	01160565	Deep Blue
776	22.57200	-166.01225	01160561	Deep Blue
777	22.10283	-166.70922	01160557	Deep Blue
778	22.03200	-166.80817	01160560	Deep Blue
779	23.25517	-164.65208	01160556	Deep Blue
780	21.61285	-167.39247	01160555	Deep Blue
781	21.20033	-168.14973	01160554	Deep Blue
782	20.59400	-169.02958	01097230	Deep Blue
783	19.85600	-170.09785	01097231	Deep Blue

784	19.76817	-170.22367	01097232	Deep Blue
785	19.87633	-169.92250	01097237	Deep Blue
786	20.56478	-168.92750	01097236	Deep Blue
787	21.20900	-168.00467	01097234	Deep Blue
788	21.45535	-168.26460	01097235	Deep Blue
789	20.37000	-169.82717	01097238	Deep Blue
790	19.94833	-170.43000	01097239	Deep Blue
791	19.91892	-170.63317	01097240	Deep Blue
792	20.13148	-170.32835	01097241	Deep Blue
793	20.59983	-169.65317	01097233	Deep Blue
794	20.58042	-170.00392	01096653	Deep Blue
795	19.76817	-170.22367	01096649	Deep Blue
796	21.07428	-168.97668	01096645	Deep Blue
797	21.73633	-168.02567	01096652	Deep Blue
798	21.95883	-167.70425	01096648	Deep Blue
799	22.32442	-167.13917	01096644	Deep Blue
800	22.32258	-166.54450	01096643	Deep Blue
801	22.32377	-165.76337	01096647	Deep Blue
802	22.32433	-165.61967	01096651	Deep Blue
803	22.32495	-165.12718	01096650	Deep Blue
804	22.32500	-164.54000	01096646	Deep Blue
805	22.32750	-163.85833	01096642	Deep Blue
806	22.12413	-163.35917	01097266	Deep Blue
807	21.76642	-162.16633	01097267	Deep Blue
808	21.52383	-160.95133	01097270	Deep Blue
809	21.45770	-160.48287	01097274	Deep Blue
810	21.37000	-159.24467	01097271	Deep Blue

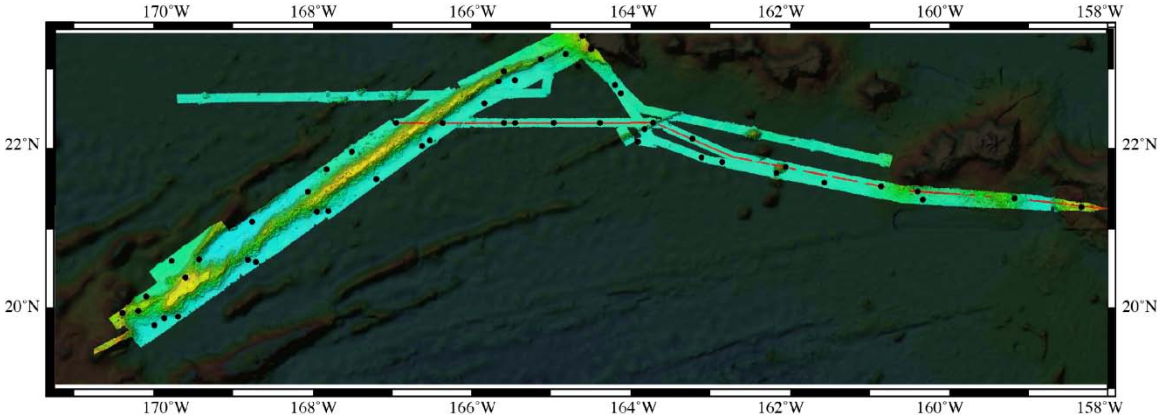
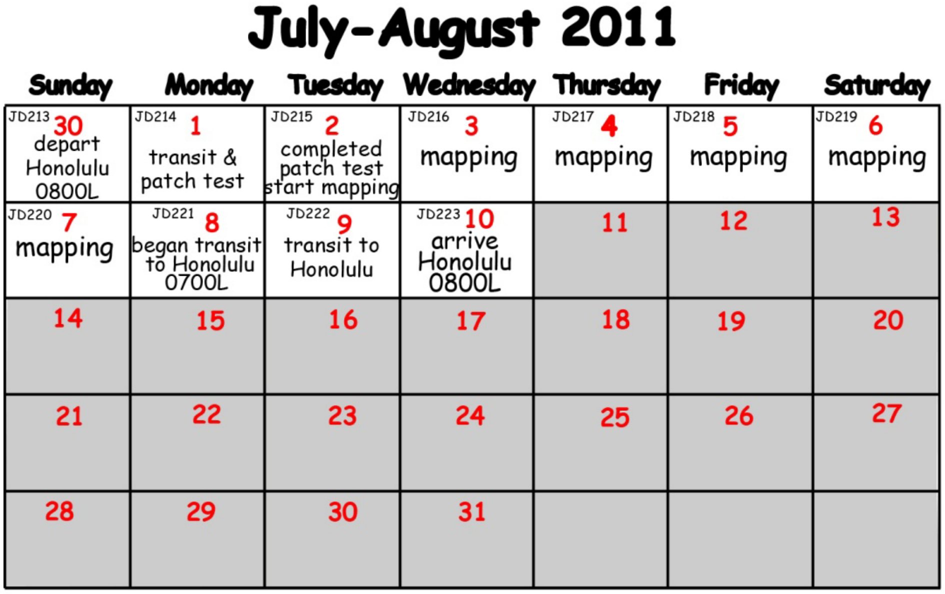


Figure 12. Map of locations of XBT (black dots). Foreground is bathymetry acquired on this cruise. See Appendix 4 for positions.

Appendix 5. Cruise Calendar



July-August 2011

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
JD213 30 depart Honolulu 0800L	JD214 1 transit & patch test	JD215 2 completed patch test start mapping	JD216 3 mapping	JD217 4 mapping	JD218 5 mapping	JD219 6 mapping
JD220 7 mapping	JD221 8 began transit to Honolulu 0700L	JD222 9 transit to Honolulu	JD223 10 arrive Honolulu 0800L	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

Appendix 6. Gravity land-tie Data

Date: July 30, 2011 (pre-cruise tie)

Base Station Code: ISGN 71 gravity = 978923.4 mgal

Port: Snug Harbor, Sand Island, Honolulu, HI

Cruise: KM11-21

Gravity Base Station Location (Lat/lon):
Ship's meter

Time (UTC)	Reading	Spring Tension	Height above sea level
2219	6995.93	6996.26	1.85 m
2225	6995.66	6996.00	1.85 m
2242	6995.89	6995.89	1.85 m

Base station value (mgal)

Ship Location (Port, Pier, etc.): water to pier = 1.85 m; ship to land tie+28.9 m; deck height to pier= 1.9 m

Land Meter ID (Serial No.): Carson (LaCoste Romberg,) s/n 1

Location	Time (UTC)	Reading	Height above Sea level
First pier measurement	2219	2119.42	
Second pier measurement	2225	2119.465	
	2242	2119.62	
		From portable meter	

Comments:

Operator: Ben Colello

Appendix 7. Kongsberg EM122 BIST Test Results

BIST test at Sand Island dock, Honolulu prior to departure

```
Saved: 2011.07.31 00:20:45
Sounder Type:  122, Serial no.:  109
Date       Time          Ser. No.    BIST      Result
--------------------------------------------------------------------

2011.07.31 00:13:01.986  109         0         OK

Number of BSP67B boards: 2
BSP 1 Master 2.3 090702 4.3 070913 4.3 070913
BSP 1 Slave 2.3 090702 6.0 080902
BSP 1 RXI FPGA 3.6 080821
BSP 1 DSP FPGA A 4.0 070531
BSP 1 DSP FPGA B 4.0 070531
BSP 1 DSP FPGA C 4.0 070531
BSP 1 DSP FPGA D 4.0 070531
BSP 1 PCI TO SLAVE A1 FIFO: ok
BSP 1 PCI TO SLAVE A2 FIFO: ok
BSP 1 PCI TO SLAVE A3 FIFO: ok
BSP 1 PCI TO SLAVE B1 FIFO: ok
BSP 1 PCI TO SLAVE B2 FIFO: ok
BSP 1 PCI TO SLAVE B3 FIFO: ok
BSP 1 PCI TO SLAVE C1 FIFO: ok
BSP 1 PCI TO SLAVE C2 FIFO: ok
BSP 1 PCI TO SLAVE C3 FIFO: ok
BSP 1 PCI TO SLAVE D1 FIFO: ok
BSP 1 PCI TO SLAVE D2 FIFO: ok
BSP 1 PCI TO SLAVE D3 FIFO: ok
BSP 1 PCI TO MASTER A HPI: ok
BSP 1 PCI TO MASTER B HPI: ok
BSP 1 PCI TO MASTER C HPI: ok
BSP 1 PCI TO MASTER D HPI: ok
BSP 1 PCI TO SLAVE A1 HPI: ok
BSP 1 PCI TO SLAVE A2 HPI: ok
BSP 1 PCI TO SLAVE A3 HPI: ok
BSP 1 PCI TO SLAVE B1 HPI: ok
BSP 1 PCI TO SLAVE B2 HPI: ok
BSP 1 PCI TO SLAVE B3 HPI: ok
BSP 1 PCI TO SLAVE C1 HPI: ok
BSP 1 PCI TO SLAVE C2 HPI: ok
BSP 1 PCI TO SLAVE C3 HPI: ok
BSP 1 PCI TO SLAVE D1 HPI: ok
BSP 1 PCI TO SLAVE D2 HPI: ok
BSP 1 PCI TO SLAVE D3 HPI: ok
BSP 2 Master 2.3 090702 4.3 070913 4.3 070913
BSP 2 Slave 2.3 090702 6.0 080902
BSP 2 RXI FPGA 3.6 080821
BSP 2 DSP FPGA A 4.0 070531
BSP 2 DSP FPGA B 4.0 070531
BSP 2 DSP FPGA C 4.0 070531
BSP 2 DSP FPGA D 4.0 070531
BSP 2 PCI TO SLAVE A1 FIFO: ok
BSP 2 PCI TO SLAVE A2 FIFO: ok
BSP 2 PCI TO SLAVE A3 FIFO: ok
BSP 2 PCI TO SLAVE B1 FIFO: ok
```

```
BSP 2 PCI TO SLAVE B2 FIFO: ok
BSP 2 PCI TO SLAVE B3 FIFO: ok
BSP 2 PCI TO SLAVE C1 FIFO: ok
BSP 2 PCI TO SLAVE C2 FIFO: ok
BSP 2 PCI TO SLAVE C3 FIFO: ok
BSP 2 PCI TO SLAVE D1 FIFO: ok
BSP 2 PCI TO SLAVE D2 FIFO: ok
BSP 2 PCI TO SLAVE D3 FIFO: ok
BSP 2 PCI TO MASTER A HPI: ok
BSP 2 PCI TO MASTER B HPI: ok
BSP 2 PCI TO MASTER C HPI: ok
BSP 2 PCI TO MASTER D HPI: ok
BSP 2 PCI TO SLAVE A1 HPI: ok
BSP 2 PCI TO SLAVE A2 HPI: ok
BSP 2 PCI TO SLAVE A3 HPI: ok
BSP 2 PCI TO SLAVE B1 HPI: ok

BSP 2 PCI TO SLAVE B2 HPI: ok
BSP 2 PCI TO SLAVE B3 HPI: ok
BSP 2 PCI TO SLAVE C1 HPI: ok
BSP 2 PCI TO SLAVE C2 HPI: ok
BSP 2 PCI TO SLAVE C3 HPI: ok
BSP 2 PCI TO SLAVE D1 HPI: ok
BSP 2 PCI TO SLAVE D2 HPI: ok
BSP 2 PCI TO SLAVE D3 HPI: ok

Summary:
BSP 1: OK
BSP 2: OK
--------------------------------------------------------------------

2011.07.31 00:13:03.469  109         1         OK

High Voltage Br. 1
------------------
TX36   Spec: 108.0  - 132.0
0-1   120.9
0-2   121.7
0-3   121.3
0-4   120.9
0-5   121.7
0-6   122.1
0-7   122.1
0-8   121.7
0-9   121.3
0-10   121.3
0-11  121.7
0-12  121.7
0-13  121.3
0-14  121.7
0-15  121.7
0-16  121.7
0-17  121.7
0-18  121.3
0-19  121.3
0-20  121.7
0-21  121.3
0-22  121.3
0-23  121.3
0-24  121.3
```

```
High Voltage Br. 2
------------------
TX36   Spec: 108.0  - 132.0
0-1   120.9
0-2   120.9
0-3   120.9
0-4   121.3
0-5   122.2
0-6   122.2
0-7   121.7
0-8   121.7
0-9   120.9
0-10   121.7
0-11  122.2
0-12  121.7
0-13  120.9
0-14  121.7
0-15  121.3
0-16  120.9
0-17  120.9
0-18  122.2
0-19  121.7
0-20  122.2
0-21  121.7
0-22  121.3
0-23  121.3
0-24  121.7

Input voltage 12V
-----------------
TX36   Spec: 11.0  - 13.0
0-1    11.9
0-2    11.9
0-3    11.9
0-4    11.8
0-5    11.8
0-6    11.9
0-7    11.9
0-8    11.9
0-9    11.8
0-10    11.8
0-11   11.8
0-12   11.9
0-13   11.8
0-14   11.8
0-15   11.9
0-16   11.8
0-17   11.8
0-18   11.9
0-19   11.8
0-20   11.9
0-21   11.9
0-22   11.8
0-23   11.9
0-24   11.9

Digital 3.3V
------------
TX36   Spec:  2.8  -  3.5
0-1     3.3
0-2     3.3
```

```
0-3     3.3
0-4     3.3
0-5     3.3
0-6     3.3
0-7     3.3
0-8     3.3
0-9     3.3
0-10     3.3
0-11    3.3
0-12    3.3
0-13    3.3
0-14    3.3
0-15    3.3
0-16    3.3
0-17    3.3
0-18    3.3
0-19    3.3
0-20    3.3
0-21    3.3
0-22    3.3
0-23    3.3
0-24    3.3

Digital 2.5V
------------
TX36   Spec:  2.4  -  2.6
0-1     2.5
0-2     2.5
0-3     2.5
0-4     2.5
0-5     2.5
0-6     2.5
0-7     2.5
0-8     2.5
0-9     2.5
0-10     2.5
0-11    2.5
0-12    2.5
0-13    2.5
0-14    2.5
0-15    2.5
0-16    2.5
0-17    2.5
0-18    2.5
0-19    2.5
0-20    2.5
0-21    2.5
0-22    2.5
0-23    2.5
0-24    2.5

Digital 1.5V
------------
TX36   Spec:  1.4  -  1.6
0-1     1.5
0-2     1.5
0-3     1.5
0-4     1.5
0-5     1.5
0-6     1.5
0-7     1.5
```

```
0-8     1.5
0-9     1.5
0-10     1.5
0-11    1.5
0-12    1.5
0-13    1.5
0-14    1.5
0-15    1.5
0-16    1.5
0-17    1.5
0-18    1.5
0-19    1.5
0-20    1.5
0-21    1.5
0-22    1.5
0-23    1.5
0-24    1.5


Temperature
-----------
TX36   Spec: 15.0  - 75.0
0-1    32.0
0-2    32.0
0-3    31.2
0-4    30.4
0-5    31.2
0-6    31.6
0-7    31.6
0-8    29.6
0-9    31.6
0-10    31.2
0-11   30.0
0-12   29.6
0-13   30.4
0-14   31.2
0-15   30.8
0-16   30.0
0-17   31.6
0-18   32.4
0-19   31.6
0-20   32.4
0-21   32.4
0-22   31.2
0-23   32.0
0-24   32.4

Input Current 12V
-----------------
TX36   Spec:  0.3  -  1.5
0-1     0.6
0-2     0.6
0-3     0.6
0-4     0.5
0-5     0.5
0-6     0.5
0-7     0.5
0-8     0.5
0-9     0.5
0-10     0.5
0-11    0.5
```

```
0-12    0.5
0-13    0.5
0-14    0.6
0-15    0.6
0-16    0.5
0-17    0.5
0-18    0.5
0-19    0.5
0-20    0.5
0-21    0.5
0-22    0.5
0-23    0.5
0-24    0.5

TX36   power test passed

IO   TX   MB Embedded      PPC Embedded     PPC Download
2.11 One CPU1.13 Reduced Performance: 1 voice/Mar  5 2007/1.07 Jun
17 2008/1.11

TX36 unique firmware test OK

--------------------------------------------------------------------

2011.07.31 00:13:18.170  109         2         OK

Input voltage 12V
-----------------
RX32   Spec: 11.0  - 13.0
7-1    11.7
7-2    11.7

Input voltage 6V
----------------
RX32   Spec:  5.0  -  7.0
7-1     5.7
7-2     5.7

Digital 3.3V
------------
RX32   Spec:  2.8  -  3.5
7-1     3.3
7-2     3.3

Digital 2.5V
------------
RX32   Spec:  2.4  -  2.6
7-1     2.5
7-2     2.5

Digital 1.5V
------------
RX32   Spec:  1.4  -  1.6
7-1     1.5
7-2     1.5

Temperature
-----------
RX32   Spec: 15.0  - 75.0
7-1    30.0
7-2    31.0
```

```
Input Current 12V
-----------------
RX32   Spec:  0.4  -  1.5
7-1     0.6
7-2     0.6

Input Current 6V
----------------
RX32   Spec:  2.4  -  3.3
7-1     2.9
7-2     2.7

RX32   power test passed

IO   RX   MB Embedded      PPC Embedded     PPC Download
1.12 Generic1.14 GenericMay  5 2006/1.06 May  5 2006/1.07 Feb 18
2010/1.11

RX32 unique firmware test OK

--------------------------------------------------------------------

2011.07.31 00:13:18.236  109         3         OK

High Voltage Br. 1
------------------
TX36   Spec: 108.0  - 132.0
0-1   120.9
0-2   121.3
0-3   121.3
0-4   120.9
0-5   121.7
0-6   121.7
0-7   121.7
0-8   121.7
0-9   121.3
0-10   121.3
0-11  121.7
0-12  121.7
0-13  121.3
0-14  121.7
0-15  121.7
0-16  121.3
0-17  121.7
0-18  121.3
0-19  121.3
0-20  121.7
0-21  121.3
0-22  121.3
0-23  121.3
0-24  121.3

High Voltage Br. 2
------------------
TX36   Spec: 108.0  - 132.0
0-1   120.9
0-2   120.9
0-3   120.9
0-4   121.3
0-5   121.7
```

```
0-6   121.7
0-7   121.7
0-8   121.7
0-9   120.9
0-10   121.7
0-11  122.2
0-12  121.7
0-13  120.9
0-14  121.7
0-15  121.3
0-16  120.9
0-17  120.5
0-18  122.2
0-19  121.7
0-20  122.6
0-21  121.7
0-22  121.3
0-23  121.3
0-24  121.7

Input voltage 12V
-----------------
TX36   Spec: 11.0  - 13.0
0-1    11.9
0-2    11.9
0-3    11.9
0-4    11.8
0-5    11.8
0-6    11.9
0-7    11.9
0-8    11.9
0-9    11.8
0-10    11.8
0-11   11.8
0-12   11.9
0-13   11.8
0-14   11.8
0-15   11.9
0-16   11.8
0-17   11.8
0-18   11.9
0-19   11.8
0-20   11.9
0-21   11.9
0-22   11.8
0-23   11.9
0-24   11.9

RX32   Spec: 11.0  - 13.0
7-1    11.8
7-2    11.7

Input voltage 6V
----------------
RX32   Spec:  5.0  -  7.0
7-1     5.7
7-2     5.7

TRU  power test passed
---------------------------------------------------------------------
```

```
2011.07.31 00:13:18.353  109         4         OK

EM 122 High Voltage Ramp Test
Test Voltage:20.00  Measured Voltage: 18.00 PASSED
Test Voltage:60.00  Measured Voltage: 59.00 PASSED
Test Voltage:100.00  Measured Voltage: 100.00 PASSED
Test Voltage:120.00  Measured Voltage: 121.00 PASSED
Test Voltage:80.00  Measured Voltage: 85.00 PASSED
Test Voltage:40.00  Measured Voltage: 45.00 PASSED

6 of 6 tests OK

--------------------------------------------------------------------

2011.07.31 00:15:42.443  109         5         OK

BSP 1 RXI TO RAW FIFO: ok
BSP 2 RXI TO RAW FIFO: ok
--------------------------------------------------------------------

2011.07.31 00:15:47.326  109         6         OK

Receiver impedance limits [350.0 700.0] ohm
Board  1      2      3     4
 1: 565.6  514.9
 2: 568.6  553.4
 3: 565.2  563.5
 4: 567.7  563.3
 5: 571.0  574.0
 6: 547.7  581.1
 7: 560.7  585.5
 8: 571.2  582.9
 9: 528.8  500.0
10: 541.3  560.2
11: 572.5  548.5
12: 561.5  549.3
13: 538.3  582.3
14: 588.2  529.6
15: 526.5  571.0
16: 559.1  575.7
17: 514.3  560.1
18: 517.3  576.5
19: 575.0  581.4
20: 577.7  583.3
21: 575.8  526.3
22: 531.2  585.4
23: 570.9  586.0
24: 568.2  555.5
25: 543.9  582.1
26: 584.6  602.5
27: 576.0  508.1
28: 555.6  563.8
29: 563.1  519.4
30: 509.2  575.3
31: 553.9  610.9
32: 556.4  553.2

Receiver Phase limits [-20.0 20.0] deg
Board  1      2      3     4
 1:  -0.8    3.8
 2:  -1.3    0.1
```

```
 3:  -1.3   -0.4
 4:  -1.1   -0.1
 5:  -0.6   -1.4
 6:   0.1   -1.2
 7:  -0.5   -1.4
 8:  -1.2   -2.3
 9:   2.2    4.7
10:   0.7   -0.2
11:  -1.1    0.8
12:  -0.1    0.2
13:   1.8   -1.1
14:  -2.4    2.8
15:   2.9   -0.4
16:  -0.6   -0.9
17:   4.2    0.4
18:   3.5   -1.6
19:  -1.5   -1.5
20:  -2.0   -2.3
21:  -1.8    3.4
22:   2.3   -2.1
23:  -1.0   -1.6
24:  -1.4    1.1
25:   1.3   -2.0
26:  -2.2   -2.9
27:  -0.9    4.3
28:  -0.1   -0.3
29:  -0.6    4.3
30:   3.6   -0.4
31:   0.6   -3.2
32:  -0.5    1.5
Rx Channels test passed
---------------------------------------------------------------------

2011.07.31 00:16:19.261  109         7         OK

Tx Channels test passed
---------------------------------------------------------------------

2011.07.31 00:19:00.085  109         8         OK

RX NOISE LEVEL

Board No: 1          2

 0:        76.5       75.1   dB
 1:        74.8       74.2   dB
 2:        76.5       73.9   dB
 3:        72.6       69.5   dB
 4:        65.1       71.4   dB
 5:        75.7       67.2   dB
 6:        76.3       73.8   dB
 7:        75.4       76.1   dB
 8:        73.7       77.5   dB
 9:        75.7       69.5   dB
10:        75.7       62.6   dB
11:        74.3       74.2   dB
12:        76.0       71.6   dB
13:        74.2       69.8   dB
14:        75.1       75.9   dB
15:        66.1       76.1   dB
16:        77.0       75.4   dB
```

```
17:         72.5       59.7   dB
18:         74.8       60.7   dB
19:         75.8       64.0   dB
20:         74.3       67.9   dB
21:         74.9       62.9   dB
22:         74.7       63.5   dB
23:         72.1       76.1   dB
24:         77.3       73.9   dB
25:         75.4       72.0   dB
26:         75.3       74.7   dB
27:         74.7       70.8   dB
28:         71.4       72.4   dB
29:         65.3       75.2   dB
30:         76.3       69.1   dB
31:         73.1       77.6   dB

Maximum noise at Board 2 Channel 31 Level:  77.6 dB

Broadband noise test
------------------
Average noise at Board 1   74.7 dB    OK
Average noise at Board 2   73.1 dB    OK

--------------------------------------------------------------------
2011.07.31 00:19:06.435  109         9         OK

RX NOISE SPECTRUM

Board No:    1          2

10.0 kHz:     67.1       65.8   dB
10.2 kHz:     69.1       67.0   dB
10.3 kHz:     69.7       67.9   dB
10.4 kHz:     71.0       69.3   dB
10.6 kHz:     72.4       70.5   dB
10.7 kHz:     72.4       70.7   dB
10.9 kHz:     72.9       70.8   dB
11.0 kHz:     72.7       70.6   dB
11.2 kHz:     73.1       70.8   dB
11.3 kHz:     71.5       70.2   dB
11.4 kHz:     72.1       70.2   dB
11.6 kHz:     72.6       70.2   dB
11.7 kHz:     72.2       70.2   dB
11.9 kHz:     72.1       69.9   dB
12.0 kHz:     72.7       69.8   dB
12.1 kHz:     70.1       69.1   dB
12.3 kHz:     70.8       68.9   dB
12.4 kHz:     70.1       68.6   dB
12.6 kHz:     70.1       67.9   dB
12.7 kHz:     69.1       67.6   dB
12.9 kHz:     68.7       66.8   dB
13.0 kHz:     68.1       66.6   dB

Maximum noise at Board 1 Frequency 11.2 kHz Level:  73.1 dB

Spectral noise test
------------------
Average noise at Board 1   71.2 dB    OK
Average noise at Board 2   69.3 dB    OK
--------------------------------------------------------------------
```

```
2011.07.31 00:19:12.785  109         10        OK

CPU: KOM CP6011
Clock 1795 MHz
Die   42 oC (peak: 40 oC @ 2011-07-31 - 00:13:04)
Board 43 oC (peak: 44 oC @ 2011-07-31 - 00:19:10)
Core  1.33 V
3V3   3.28 V
12V   11.91 V
-12V  -12.04 V
BATT  3.49 V
Primary network: 157.237.14.60:0xffff0000
Secondary network: 192.168.1.122:0xffffff00
--------------------------------------------------------------------

2011.07.31 00:19:12.819  109         15        OK
EM 122

BSP67B Master: 2.2.3 090702
BSP67B Slave: 2.2.3 090702
CPU: 1.2.3 110321
DDS: 3.5.2 101013
RX32 version : Feb 18 2010 Rev 1.11
TX36 LC version : Jun 17 2008 Rev 1.11
VxWorks 5.5.1 Build 1.2/2-IX0100 May 16 2007, 11:31:17
--------------------------------------------------------------------
```

End of dock BIST Test

BIST test underway in 4000 m water depths with Knudsen 3260 subbottom profiler on

```
Saved: 2011.07.31 22:48:20
Sounder Type:  122, Serial no.:  109
Date       Time          Ser. No.    BIST      Result
--------------------------------------------------------------------
2011.07.31 22:39:48.507  109         0         OK

Number of BSP67B boards: 2
BSP 1 Master 2.3 090702 4.3 070913 4.3 070913
BSP 1 Slave 2.3 090702 6.0 080902
BSP 1 RXI FPGA 3.6 080821
BSP 1 DSP FPGA A 4.0 070531
BSP 1 DSP FPGA B 4.0 070531
BSP 1 DSP FPGA C 4.0 070531
BSP 1 DSP FPGA D 4.0 070531
BSP 1 PCI TO SLAVE A1 FIFO: ok
BSP 1 PCI TO SLAVE A2 FIFO: ok
BSP 1 PCI TO SLAVE A3 FIFO: ok
BSP 1 PCI TO SLAVE B1 FIFO: ok
BSP 1 PCI TO SLAVE B2 FIFO: ok
BSP 1 PCI TO SLAVE B3 FIFO: ok
BSP 1 PCI TO SLAVE C1 FIFO: ok
BSP 1 PCI TO SLAVE C2 FIFO: ok
BSP 1 PCI TO SLAVE C3 FIFO: ok
BSP 1 PCI TO SLAVE D1 FIFO: ok
BSP 1 PCI TO SLAVE D2 FIFO: ok
BSP 1 PCI TO SLAVE D3 FIFO: ok
BSP 1 PCI TO MASTER A HPI: ok
BSP 1 PCI TO MASTER B HPI: ok
BSP 1 PCI TO MASTER C HPI: ok
```

```
BSP 1 PCI TO MASTER D HPI: ok
BSP 1 PCI TO SLAVE A1 HPI: ok
BSP 1 PCI TO SLAVE A2 HPI: ok
BSP 1 PCI TO SLAVE A3 HPI: ok
BSP 1 PCI TO SLAVE B1 HPI: ok
BSP 1 PCI TO SLAVE B2 HPI: ok
BSP 1 PCI TO SLAVE B3 HPI: ok
BSP 1 PCI TO SLAVE C1 HPI: ok
BSP 1 PCI TO SLAVE C2 HPI: ok
BSP 1 PCI TO SLAVE C3 HPI: ok
BSP 1 PCI TO SLAVE D1 HPI: ok
BSP 1 PCI TO SLAVE D2 HPI: ok
BSP 1 PCI TO SLAVE D3 HPI: ok
BSP 2 Master 2.3 090702 4.3 070913 4.3 070913
BSP 2 Slave 2.3 090702 6.0 080902
BSP 2 RXI FPGA 3.6 080821
BSP 2 DSP FPGA A 4.0 070531
BSP 2 DSP FPGA B 4.0 070531
BSP 2 DSP FPGA C 4.0 070531
BSP 2 DSP FPGA D 4.0 070531
BSP 2 PCI TO SLAVE A1 FIFO: ok
BSP 2 PCI TO SLAVE A2 FIFO: ok
BSP 2 PCI TO SLAVE A3 FIFO: ok
BSP 2 PCI TO SLAVE B1 FIFO: ok
BSP 2 PCI TO SLAVE B2 FIFO: ok
BSP 2 PCI TO SLAVE B3 FIFO: ok
BSP 2 PCI TO SLAVE C1 FIFO: ok
BSP 2 PCI TO SLAVE C2 FIFO: ok
BSP 2 PCI TO SLAVE C3 FIFO: ok
BSP 2 PCI TO SLAVE D1 FIFO: ok
BSP 2 PCI TO SLAVE D2 FIFO: ok
BSP 2 PCI TO SLAVE D3 FIFO: ok
BSP 2 PCI TO MASTER A HPI: ok
BSP 2 PCI TO MASTER B HPI: ok
BSP 2 PCI TO MASTER C HPI: ok
BSP 2 PCI TO MASTER D HPI: ok
BSP 2 PCI TO SLAVE A1 HPI: ok
BSP 2 PCI TO SLAVE A2 HPI: ok
BSP 2 PCI TO SLAVE A3 HPI: ok
BSP 2 PCI TO SLAVE B1 HPI: ok
BSP 2 PCI TO SLAVE B2 HPI: ok
BSP 2 PCI TO SLAVE B3 HPI: ok
BSP 2 PCI TO SLAVE C1 HPI: ok
BSP 2 PCI TO SLAVE C2 HPI: ok
BSP 2 PCI TO SLAVE C3 HPI: ok
BSP 2 PCI TO SLAVE D1 HPI: ok
BSP 2 PCI TO SLAVE D2 HPI: ok
BSP 2 PCI TO SLAVE D3 HPI: ok

Summary:
BSP 1: OK
BSP 2: OK
---------------------------------------------------------------------

2011.07.31 22:39:49.991  109         1         OK

High Voltage Br. 1
------------------
TX36   Spec: 108.0  - 132.0
0-1   120.9
0-2   121.7
```

```
0-3   121.3
0-4   121.3
0-5   121.7
0-6   122.1
0-7   122.1
0-8   121.7
0-9   121.3
0-10   121.7
0-11  122.1
0-12  121.7
0-13  121.7
0-14  121.7
0-15  121.7
0-16  121.7
0-17  121.7
0-18  121.3
0-19  121.3
0-20  121.7
0-21  121.3
0-22  121.3
0-23  121.3
0-24  121.3

High Voltage Br. 2
------------------
TX36   Spec: 108.0  - 132.0
0-1   120.9
0-2   120.9
0-3   120.9
0-4   121.3
0-5   122.2
0-6   122.2
0-7   121.7
0-8   121.7
0-9   121.3
0-10   121.3
0-11  122.2
0-12  121.7
0-13  120.9
0-14  121.7
0-15  121.3
0-16  120.9
0-17  120.5
0-18  122.2
0-19  121.7
0-20  122.6
0-21  121.7
0-22  121.3
0-23  121.3
0-24  121.7

Input voltage 12V
-----------------
TX36   Spec: 11.0  - 13.0
0-1    11.8
0-2    11.8
0-3    11.9
0-4    11.8
0-5    11.8
0-6    11.9
0-7    11.9
```

```
0-8    11.9
0-9    11.8
0-10    11.8
0-11   11.8
0-12   11.9
0-13   11.8
0-14   11.8
0-15   11.8
0-16   11.7
0-17   11.8
0-18   11.9
0-19   11.8
0-20   11.9
0-21   11.8
0-22   11.8
0-23   11.8
0-24   11.9

Digital 3.3V
------------
TX36   Spec:  2.8  -  3.5
0-1     3.3
0-2     3.3
0-3     3.3
0-4     3.3
0-5     3.3
0-6     3.3
0-7     3.3
0-8     3.3
0-9     3.3
0-10     3.3
0-11    3.3
0-12    3.3
0-13    3.3
0-14    3.3
0-15    3.3
0-16    3.3
0-17    3.3
0-18    3.3
0-19    3.3
0-20    3.3
0-21    3.3
0-22    3.3
0-23    3.3
0-24    3.3

Digital 2.5V
------------
TX36   Spec:  2.4  -  2.6
0-1     2.5
0-2     2.5
0-3     2.5
0-4     2.5
0-5     2.5
0-6     2.5
0-7     2.5
0-8     2.5
0-9     2.5
0-10     2.5
0-11    2.5
0-12    2.5
```

```
0-13    2.5
0-14    2.5
0-15    2.5
0-16    2.5
0-17    2.5
0-18    2.5
0-19    2.5
0-20    2.5
0-21    2.5
0-22    2.5
0-23    2.5
0-24    2.5

Digital 1.5V
------------
TX36   Spec:  1.4  -  1.6
0-1     1.5
0-2     1.5
0-3     1.5
0-4     1.5
0-5     1.5
0-6     1.5
0-7     1.5
0-8     1.5
0-9     1.5
0-10     1.5
0-11    1.5
0-12    1.5
0-13    1.5
0-14    1.5
0-15    1.5
0-16    1.5
0-17    1.5
0-18    1.5
0-19    1.5
0-20    1.5
0-21    1.5
0-22    1.5
0-23    1.5
0-24    1.5

Temperature
-----------
TX36   Spec: 15.0  - 75.0
0-1    39.6
0-2    40.0
0-3    39.2
0-4    37.6
0-5    39.2
0-6    39.2
0-7    39.2
0-8    37.2
0-9    38.8
0-10    38.0
0-11   37.2
0-12   36.8
0-13   37.6
0-14   38.4
0-15   38.0
0-16   38.0
0-17   39.6
```

```
0-18   40.4
0-19   40.0
0-20   40.4
0-21   40.4
0-22   38.8
0-23   39.6
0-24   40.0

Input Current 12V
-----------------
TX36   Spec:  0.3  -  1.5
0-1     0.6
0-2     0.6
0-3     0.6
0-4     0.5
0-5     0.5
0-6     0.5
0-7     0.6
0-8     0.5
0-9     0.5
0-10     0.5
0-11    0.6
0-12    0.5
0-13    0.5
0-14    0.6
0-15    0.6
0-16    0.5
0-17    0.6
0-18    0.5
0-19    0.5
0-20    0.5
0-21    0.6
0-22    0.6
0-23    0.6
0-24    0.5

TX36   power test passed

IO   TX   MB Embedded      PPC Embedded     PPC Download
2.11 One CPU1.13 Reduced Performance: 1 voice/Mar  5 2007/1.07 Jun
17 2008/1.11

TX36 unique firmware test OK

--------------------------------------------------------------------

2011.07.31 22:39:50.108  109         2         OK

Input voltage 12V
-----------------
RX32   Spec: 11.0  - 13.0
7-1    11.7
7-2    11.7

Input voltage 6V
----------------
RX32   Spec:  5.0  -  7.0
7-1     5.7
7-2     5.7

Digital 3.3V
```

```
------------
RX32   Spec:  2.8  -  3.5
7-1     3.3
7-2     3.3

Digital 2.5V
------------
RX32   Spec:  2.4  -  2.6
7-1     2.5
7-2     2.5

Digital 1.5V
------------
RX32   Spec:  1.4  -  1.6
7-1     1.5
7-2     1.5

Temperature
-----------
RX32   Spec: 15.0  - 75.0
7-1    40.0
7-2    40.0

Input Current 12V
-----------------
RX32   Spec:  0.4  -  1.5
7-1     0.6
7-2     0.6

Input Current 6V
----------------
RX32   Spec:  2.4  -  3.3
7-1     2.8
7-2     2.7

RX32   power test passed

IO   RX   MB Embedded      PPC Embedded     PPC Download
1.12 Generic1.14 GenericMay  5 2006/1.06 May  5 2006/1.07 Feb 18
2010/1.11

RX32 unique firmware test OK

--------------------------------------------------------------------

2011.07.31 22:39:50.174  109         3         OK

High Voltage Br. 1
------------------
TX36   Spec: 108.0  - 132.0
0-1   120.9
0-2   121.7
0-3   121.3
0-4   121.3
0-5   121.7
0-6   121.7
0-7   122.1
0-8   121.7
0-9   121.3
0-10   121.7
0-11  121.7
```

```
0-12  121.7
0-13  121.7
0-14  121.7
0-15  121.7
0-16  121.7
0-17  121.7
0-18  121.3
0-19  121.3
0-20  121.7
0-21  121.3
0-22  121.3
0-23  121.3
0-24  121.7

High Voltage Br. 2
------------------
TX36   Spec: 108.0  - 132.0
0-1   120.9
0-2   120.9
0-3   120.9

0-4   121.3
0-5   122.2
0-6   121.7
0-7   121.7
0-8   121.7
0-9   120.9
0-10   121.7
0-11  122.2
0-12  121.7
0-13  120.9
0-14  121.7
0-15  121.3
0-16  120.9
0-17  120.9
0-18  122.2
0-19  121.7
0-20  122.6

0-21  121.7
0-22  121.3
0-23  121.3
0-24  121.7

Input voltage 12V
-----------------
TX36   Spec: 11.0  - 13.0
0-1    11.8
0-2    11.8
0-3    11.9
0-4    11.8
0-5    11.8
0-6    11.9
0-7    11.9
0-8    11.9
0-9    11.8
0-10    11.8
0-11   11.8
0-12   11.9
0-13   11.8
0-14   11.8
```

```
0-15   11.9
0-16   11.7
0-17   11.8
0-18   11.9
0-19   11.8
0-20   11.9
0-21   11.9
0-22   11.8
0-23   11.9
0-24   11.8

RX32   Spec: 11.0  - 13.0
7-1    11.8
7-2    11.7

Input voltage 6V
----------------
RX32   Spec:  5.0  -  7.0
7-1     5.7
7-2     5.7

TRU  power test passed

--------------------------------------------------------------------

2011.07.31 22:39:50.291  109        4         OK

EM 122 High Voltage Ramp Test
Test Voltage:20.00  Measured Voltage: 19.00 PASSED
Test Voltage:60.00  Measured Voltage: 59.00 PASSED
Test Voltage:100.00  Measured Voltage: 100.00 PASSED
Test Voltage:120.00  Measured Voltage: 121.00 PASSED
Test Voltage:80.00  Measured Voltage: 85.00 PASSED
Test Voltage:40.00  Measured Voltage: 45.00 PASSED

6 of 6 tests OK

--------------------------------------------------------------------

2011.07.31 22:42:14.381  109        5         OK

BSP 1 RXI TO RAW FIFO: ok
BSP 2 RXI TO RAW FIFO: ok

--------------------------------------------------------------------

2011.07.31 22:42:19.264  109        6         OK

Receiver impedance limits [350.0 700.0] ohm
Board  1      2      3     4
 1: 555.2  506.9
 2: 554.9  544.7
 3: 553.0  554.6
 4: 555.8  562.7
 5: 561.7  568.0
 6: 538.5  576.4
 7: 547.9  580.8
 8: 559.4  569.8
 9: 519.7  495.5
10: 532.7  555.8
11: 560.3  542.2
```

```
12: 549.5  548.1
13: 529.2  581.4
14: 575.0  530.9
15: 518.8  568.8
16: 552.9  569.5
17: 508.5  557.2
18: 509.9  566.8
19: 562.3  572.8
20: 566.6  581.3
21: 562.1  521.8
22: 524.4  582.4
23: 559.4  582.6
24: 557.6  551.3
25: 536.9  569.7
26: 570.7  592.4
27: 563.7  502.3
28: 544.8  557.9
29: 554.5  515.7
30: 504.5  570.9
31: 544.5  608.7
32: 547.5  553.7

Receiver Phase limits [-20.0 20.0] deg
Board  1      2      3     4
 1:  -0.7    4.0
 2:  -1.0    0.4
 3:  -1.0   -0.1
 4:  -1.0   -0.5
 5:  -0.6   -1.4
 6:   0.1   -1.2
 7:  -0.3   -1.4
 8:  -1.0   -1.7
 9:   2.0    4.5
10:   0.6   -0.3
11:  -0.9    0.9
12:   0.1   -0.1
13:   1.7   -1.4
14:  -2.1    2.3
15:   2.7   -0.6
16:  -0.8   -0.9
17:   3.8    0.3
18:   3.2   -1.2
19:  -1.4   -1.2
20:  -2.0   -2.5
21:  -1.5    3.3
22:   1.9   -2.2
23:  -1.0   -1.8
24:  -1.3    1.0
25:   1.0   -1.4
26:  -1.9   -2.5
27:  -0.8    4.3
28:  -0.1   -0.3
29:  -0.8    4.2
30:   3.1   -0.4
31:   0.5   -3.4
32:  -0.6    1.2
Rx Channels test passed
--------------------------------------------------------------------

2011.07.31 22:42:51.216  109         7         OK
```

```
Tx Channels test passed
--------------------------------------------------------------------
2011.07.31 22:45:32.023  109         8         OK

RX NOISE LEVEL

Board No: 1          2

 0:        70.0       58.9   dB
 1:        64.8       57.7   dB
 2:        65.3       57.1   dB
 3:        60.0       53.1   dB
 4:        52.4       54.1   dB
 5:        61.6       50.4   dB
 6:        61.9       58.7   dB
 7:        62.9       61.9   dB
 8:        58.2       67.2   dB
 9:        60.2       53.6   dB
10:        60.8       46.4   dB
11:        58.6       57.1   dB
12:        59.8       54.9   dB
13:        58.4       53.3   dB
14:        60.1       59.7   dB
15:        56.2       59.8   dB
16:        63.0       59.0   dB
17:        55.3       44.9   dB
18:        58.2       44.7   dB
19:        59.3       47.6   dB
20:        58.2       50.5   dB
21:        59.0       48.0   dB
22:        58.8       47.9   dB
23:        61.8       60.0   dB
24:        68.2       58.4   dB
25:        59.2       56.2   dB
26:        59.4       59.4   dB
27:        58.1       55.6   dB
28:        57.2       58.4   dB
29:        52.4       62.0   dB
30:        60.4       57.8   dB
31:        58.6       70.1   dB

Maximum noise at Board 2 Channel 31 Level:  70.1 dB

Broadband noise test
------------------
Average noise at Board 1   61.8 dB    OK
Average noise at Board 2   59.8 dB    OK
--------------------------------------------------------------------

2011.07.31 22:45:38.373  109         9         OK

RX NOISE SPECTRUM

Board No:    1          2

10.0 kHz:     58.6       57.0   dB
10.2 kHz:     61.2       58.3   dB
10.3 kHz:     61.1       58.1   dB
10.4 kHz:     63.9       60.8   dB
10.6 kHz:     62.4       61.3   dB
10.7 kHz:     64.2       60.2   dB
```

```
10.9 kHz:     65.4       59.9   dB
11.0 kHz:     63.9       60.5   dB
11.2 kHz:     60.8       59.0   dB
11.3 kHz:     61.2       58.8   dB
11.4 kHz:     61.7       59.6   dB
11.6 kHz:     62.4       61.5   dB
11.7 kHz:     62.8       60.9   dB
11.9 kHz:     61.7       59.0   dB
12.0 kHz:     60.5       57.9   dB
12.1 kHz:     60.8       57.7   dB
12.3 kHz:     62.1       57.1   dB
12.4 kHz:     63.2       58.1   dB
12.6 kHz:     60.6       56.4   dB
12.7 kHz:     59.5       56.2   dB
12.9 kHz:     58.2       54.6   dB
13.0 kHz:     57.1       54.2   dB

Maximum noise at Board 1 Frequency 10.9 kHz Level:  65.4 dB

Spectral noise test
------------------
Average noise at Board 1   61.9 dB    OK

Average noise at Board 2   58.9 dB    OK

--------------------------------------------------------------------

2011.07.31 22:45:44.723  109         10        OK

CPU: KOM CP6011
Clock 1795 MHz
Die   48 oC (peak: 58 oC @ 2011-07-31 - 21:09:06)
Board 51 oC (peak: 54 oC @ 2011-07-31 - 21:47:54)
Core  1.33 V
3V3   3.28 V
12V   11.91 V
-12V  -12.04 V
BATT  3.50 V
Primary network: 157.237.14.60:0xffff0000
Secondary network: 192.168.1.122:0xffffff00
--------------------------------------------------------------------

2011.07.31 22:45:44.757  109         15        OK

EM 122

BSP67B Master: 2.2.3 090702
BSP67B Slave: 2.2.3 090702
CPU: 1.2.3 110321
DDS: 3.5.2 101013
RX32 version : Feb 18 2010 Rev 1.11
TX36 LC version : Jun 17 2008 Rev 1.11
VxWorks 5.5.1 Build 1.2/2-IX0100 May 16 2007, 11:31:17
--------------------------------------------------------------------
```

END OF BIST TEST

Appendix 8 - Cross-check analyses

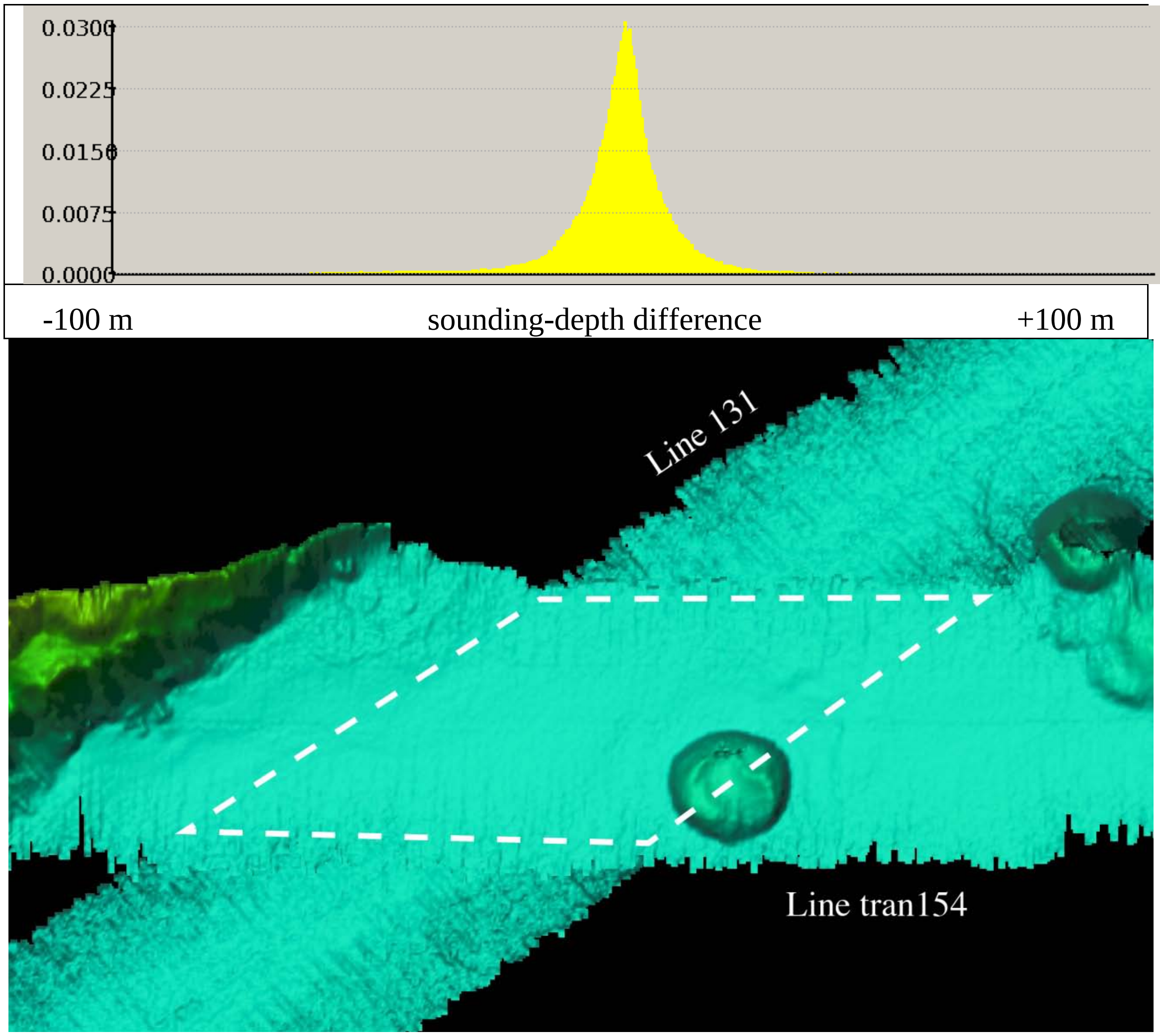
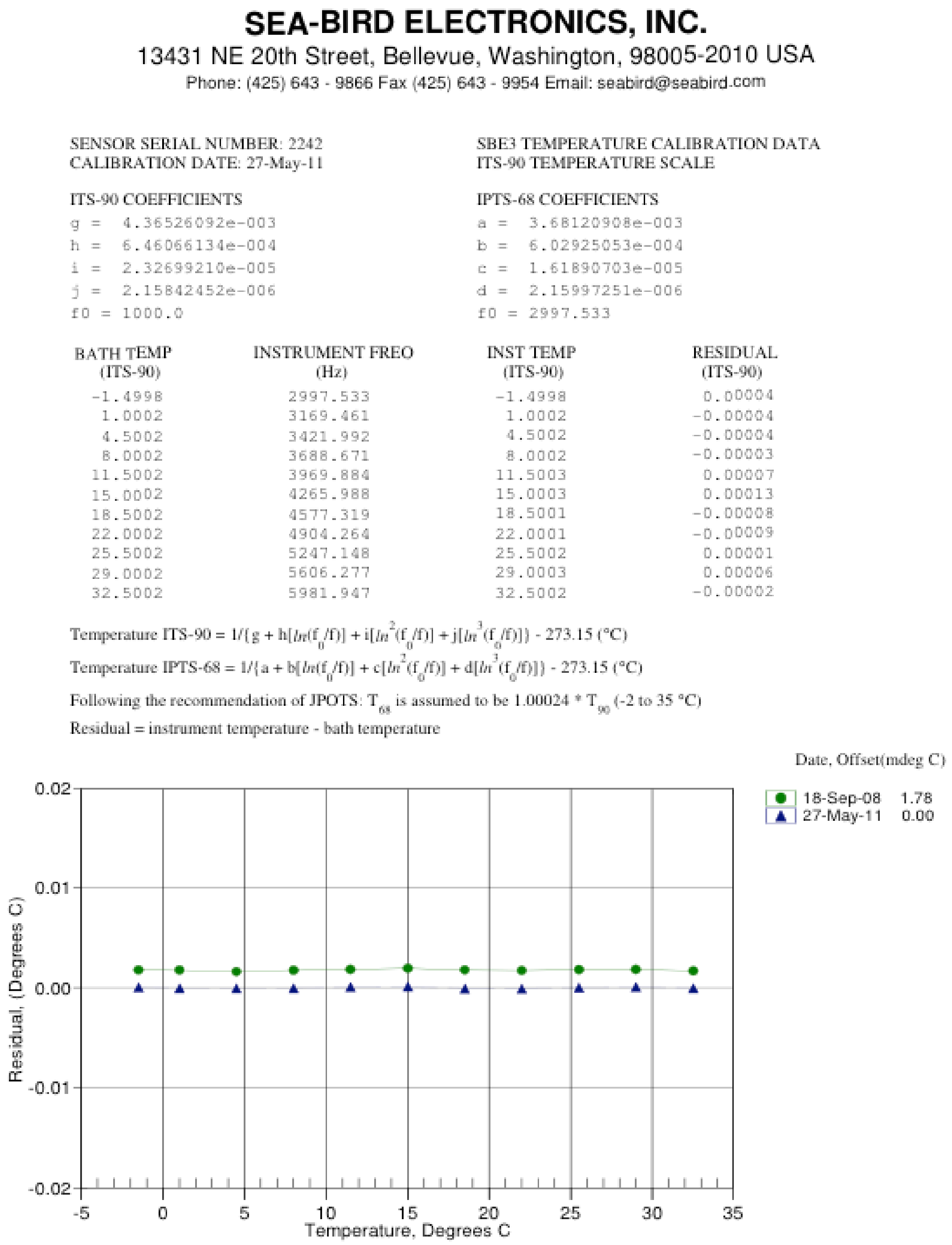


Figure 13. (upper) Histogram of sounding-depth differences from cross-line check of Lines 131 and tran 154 (lower) DTM showing area of cross-line check (dashed polygon).

Line 131 vs tran154	Mean water depth	4700 m
	Mean Z difference	-2.6 m
	Standard deviation	11.31 m
	Number of samples	186,457
	Percent of water depth	0.5% at 2σ

Appendix 9 - Calibration Reports for the CTD



SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 2242
CALIBRATION DATE: 27-May-11

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS
g = 4.36526092e-003
h = 6.46066134e-004
i = 2.32699210e-005
j = 2.15842452e-006
f0 = 1000.0

IPTS-68 COEFFICIENTS
a = 3.68120908e-003
b = 6.02925053e-004
c = 1.61890703e-005
d = 2.15997251e-006
f0 = 2997.533

BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.4998	2997.533	-1.4998	0.00004
1.0002	3169.461	1.0002	-0.00004
4.5002	3421.992	4.5002	-0.00004
8.0002	3688.671	8.0002	-0.00003
11.5002	3969.884	11.5003	0.00007
15.0002	4265.988	15.0003	0.00013
18.5002	4577.319	18.5001	-0.00008
22.0002	4904.264	22.0001	-0.00009
25.5002	5247.148	25.5002	0.00001
29.0002	5606.277	29.0003	0.00006
32.5002	5981.947	32.5002	-0.00002

Temperature ITS-90 = $1/\{g + h[\ln(f_0/f)] + i[\ln^2(f_0/f)] + j[\ln^3(f_0/f)]\} - 273.15$ (°C)

Temperature IPTS-68 = $1/\{a + b[\ln(f_0/f)] + c[\ln^2(f_0/f)] + d[\ln^3(f_0/f)]\} - 273.15$ (°C)

Following the recommendation of JPOTS: T_{68} is assumed to be 1.00024 * T_{90} (-2 to 35 °C)

Residual = instrument temperature - bath temperature

SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 2242
CALIBRATION DATE: 27-May-11

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS
g = 4.36526092e-003
h = 6.46066134e-004
i = 2.32699210e-005
j = 2.15842452e-006
f0 = 1000.0

IPTS-68 COEFFICIENTS
a = 3.68120908e-003
b = 6.02925053e-004
c = 1.61890703e-005
d = 2.15997251e-006
f0 = 2997.533

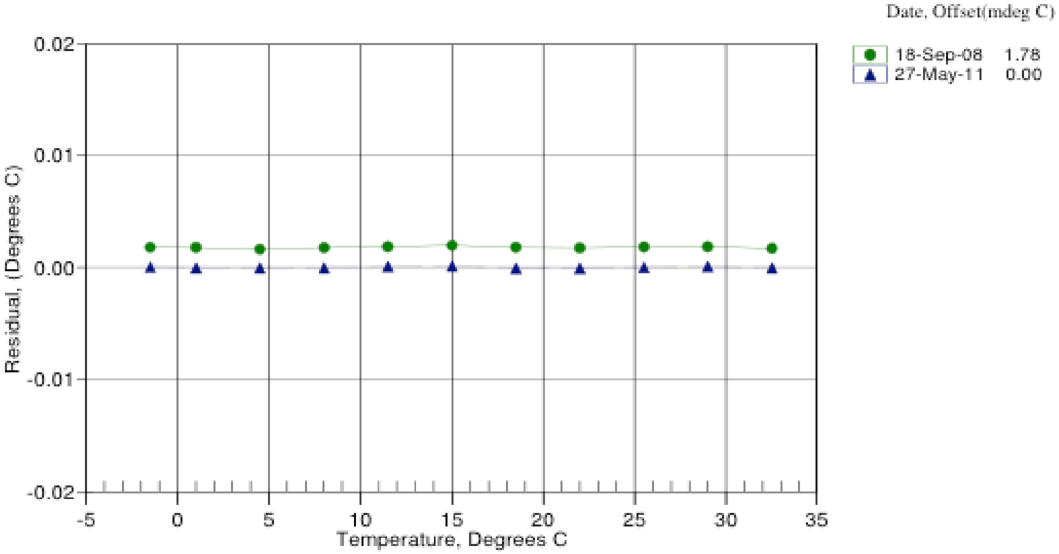
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.4998	2997.533	-1.4998	0.00004
1.0002	3169.461	1.0002	-0.00004
4.5002	3421.992	4.5002	-0.00004
8.0002	3688.671	8.0002	-0.00003
11.5002	3969.884	11.5003	0.00007
15.0002	4265.988	15.0003	0.00013
18.5002	4577.319	18.5001	-0.00008
22.0002	4904.264	22.0001	-0.00009
25.5002	5247.148	25.5002	0.00001
29.0002	5606.277	29.0003	0.00006
32.5002	5981.947	32.5002	-0.00002

Temperature ITS-90 = $1/\{g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]\} - 273.15$ (°C)

Temperature IPTS-68 = $1/\{a + b[ln(f_0/f)] + c[ln^2(f_0/f)] + d[ln^3(f_0/f)]\} - 273.15$ (°C)

Following the recommendation of JPOTS: T_{68} is assumed to be $1.00024 * T_{90}$ (-2 to 35 °C)

Residual = instrument temperature - bath temperature



SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA
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SENSOR SERIAL NUMBER: 1579
CALIBRATION DATE: 08-Jul-10

SBE4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Seimens/meter

GHIJ COEFFICIENTS

g = -4.09660741e+000
h = 5.23370055e-001
i = 5.06487439e-004
j = 3.45563621e-006
CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

ABCDM COEFFICIENTS

a = 4.07434998e-004
b = 5.23643498e-001
c = -4.09746615e+000
d = -8.84908464e-005
m = 3.1
CPcor = -9.5700e-008 (nominal)

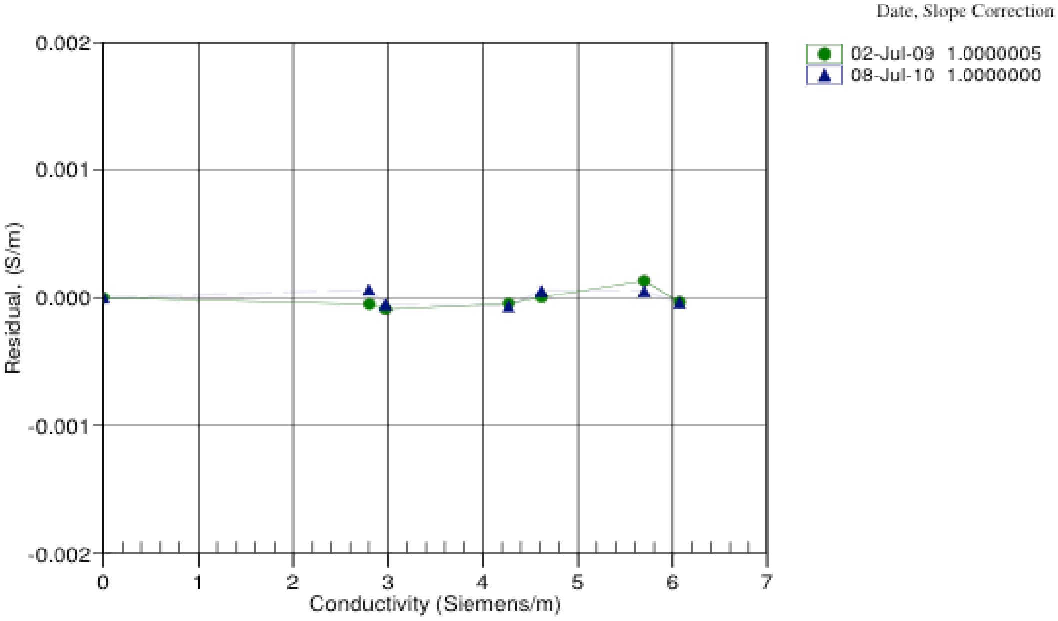
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREO (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.79389	0.00000	0.00000
-1.0000	34.7633	2.80070	7.80111	2.80077	0.00006
0.9999	34.7644	2.97194	8.00548	2.97189	-0.00005
15.0000	34.7660	4.26610	9.40664	4.26603	-0.00007
18.4999	34.7653	4.61232	9.74706	4.61237	0.00005
29.0000	34.7642	5.69474	10.74061	5.69479	0.00005
32.5000	34.7597	6.06724	11.06149	6.06720	-0.00004

Conductivity = $(g + hf^2 + if^3 + jf^4) / 10(1 + \delta t + \epsilon p)$ Siemens/meter

Conductivity = $(af^m + bf^2 + c + dt) / [10 (1 + \epsilon p)$ Siemens/meter

t = temperature[°C)]; p = pressure[decibars]; δ = CTcor; ϵ = CPcor;

Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients



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SENSOR SERIAL NUMBER: 2725
CALIBRATION DATE: 02-Feb-11

SBE4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Seimens/meter

GHIJ COEFFICIENTS
g = -9.99719479e+000
h = 1.50552688e+000
i = -1.00179950e-003
j = 1.63633375e-004
CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

ABCDM COEFFICIENTS
a = 1.08360687e-005
b = 1.50332089e+000
c = -9.99365187e+000
d = -8.67873860e-005
m = 4.9
CPcor = -9.5700e-008 (nominal)

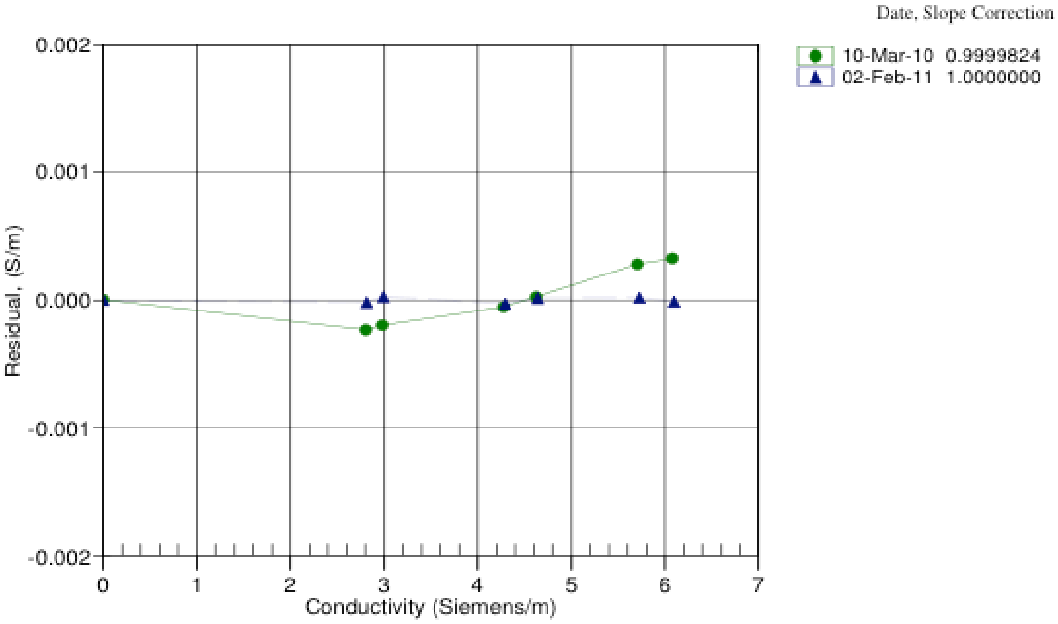
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.57816	0.00000	0.00000
-1.0000	34.9786	2.81643	5.03612	2.81641	-0.00002
1.0000	34.9774	2.98842	5.14827	2.98844	0.00003
15.0000	34.9755	4.28907	5.92746	4.28904	-0.00003
18.5000	34.9729	4.63689	6.11895	4.63691	0.00001
29.0001	34.9691	5.72453	6.68201	5.72455	0.00002
32.5000	34.9608	6.09833	6.86474	6.09831	-0.00001

Conductivity = $(g + hf^2 + if^3 + jf^4) / 10(1 + \delta t + \varepsilon p)$ Siemens/meter

Conductivity = $(af^m + bf^2 + c + dt) / [10 (1 + \varepsilon p)$ Siemens/meter

t = temperature[°C)]; p = pressure[decibars]; δ = CTcor; ε = CPcor;

Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients



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SENSOR SERIAL NUMBER: 0134
CALIBRATION DATE: 03-Nov-10p

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS
Soc = 0.3831
Voffset = -0.4994
Tau20 = 2.02

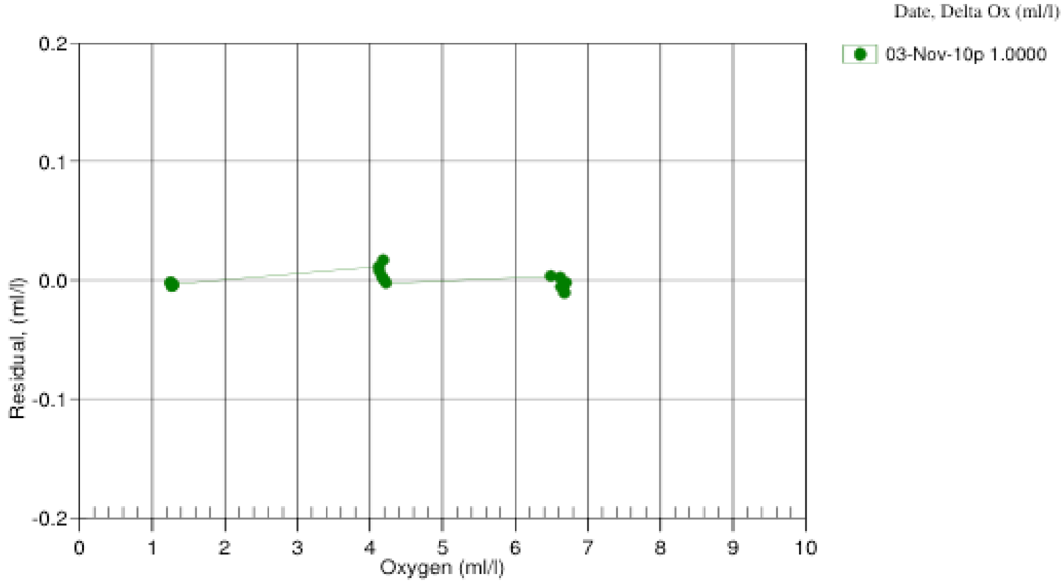
A = -3.0763e-003
B = 2.6206e-004
C = -4.4179e-006
E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS
D1 = 1.92634e-4
D2 = -4.64803e-2

H1 = -3.30000e-2
H2 = 5.00000e+3
H3 = 1.45000e+3

BATH OX (ml/l)	BATH TEMP ITS-90	BATH SAL PSU	INSTRUMENT OUTPUT(VOLTS)	INSTRUMENT OXYGEN(ml/l)	RESIDUAL (ml/l)
1.25	2.00	0.01	0.839	1.25	-0.00
1.26	6.00	0.02	0.879	1.25	-0.00
1.26	12.00	0.02	0.938	1.26	-0.01
1.28	20.00	0.02	1.019	1.28	-0.00
1.29	26.00	0.02	1.081	1.29	-0.00
1.29	30.00	0.02	1.121	1.29	-0.00
4.12	6.00	0.02	1.750	4.13	0.01
4.13	12.00	0.02	1.941	4.14	0.01
4.17	20.00	0.02	2.196	4.17	0.00
4.18	2.00	0.01	1.637	4.20	0.02
4.20	26.00	0.02	2.393	4.20	-0.00
4.22	30.00	0.02	2.531	4.22	-0.00
6.49	30.00	0.02	3.629	6.50	0.00
6.62	20.00	0.02	3.194	6.62	0.00
6.63	12.00	0.02	2.810	6.63	-0.01
6.67	6.00	0.02	2.516	6.66	-0.01
6.67	2.00	0.01	2.306	6.66	-0.01
6.70	26.00	0.02	3.519	6.69	-0.00

Oxygen (ml/l) = Soc * (V + Voffset) * (1.0 + A * T + B * T^2 + C * T^3) * OxSol(T,S) * exp(E * P / K)
V = voltage output from SBE43, T = temperature [deg C], S = salinity [PSU] K = temperature [deg K]
OxSol(T,S) = oxygen saturation [ml/l], P = pressure [dbar], Residual = instrument oxygen - bath oxygen



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SENSOR SERIAL NUMBER: 2013
CALIBRATION DATE: 07-Oct-10

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS
g = 4.16195950e-003
h = 6.36470633e-004
i = 2.20311047e-005
j = 2.33530550e-006
f0 = 1000.0

IPTS-68 COEFFICIENTS
a = 3.68121179e-003
b = 6.06697593e-004
c = 1.66337921e-005
d = 2.33691975e-006
f0 = 2169.280

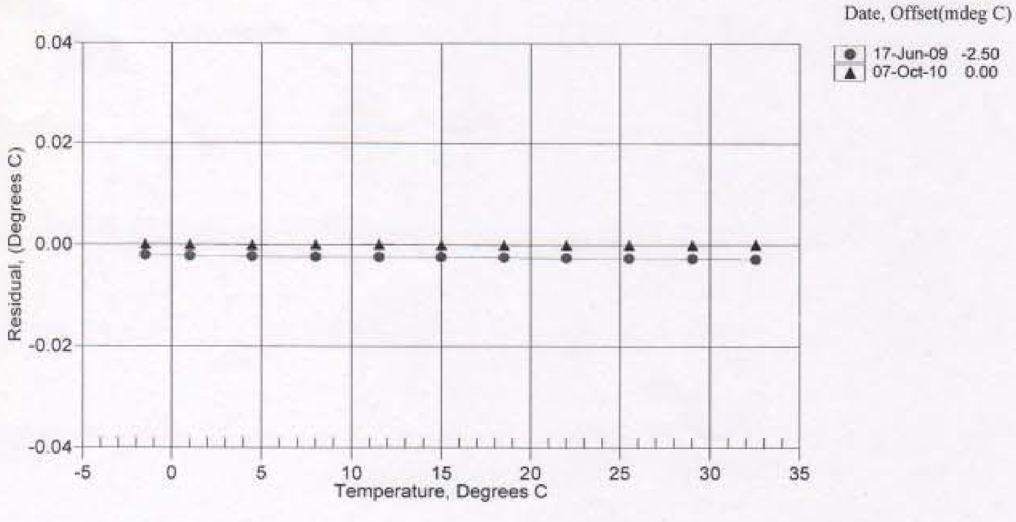
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	2169.280	-1.5000	0.00004
1.0000	2292.910	1.0000	-0.00003
4.5001	2474.438	4.5000	-0.00007
8.0000	2666.051	8.0000	0.00002
11.5000	2868.023	11.5001	0.00009
15.0001	3080.602	15.0001	-0.00001
18.5001	3304.038	18.5001	-0.00003
22.0001	3538.576	22.0001	-0.00001
25.5001	3784.441	25.5001	-0.00001
29.0001	4041.856	29.0001	-0.00000
32.5001	4311.033	32.5001	0.00001

Temperature ITS-90 = $1/\{g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]\} - 273.15$ (°C)

Temperature IPTS-68 = $1/\{a + b[ln(f_0/f)] + c[ln^2(f_0/f)] + d[ln^3(f_0/f)]\} - 273.15$ (°C)

Following the recommendation of JPOTS: T_{68} is assumed to be 1.00024 * T_{90} (-2 to 35 °C)

Residual = instrument temperature - bath temperature



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SENSOR SERIAL NUMBER: 0301
CALIBRATION DATE: 20-Sep-10p

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS
Soc = 0.4064
Voffset = -0.5066
Tau20 = 1.22

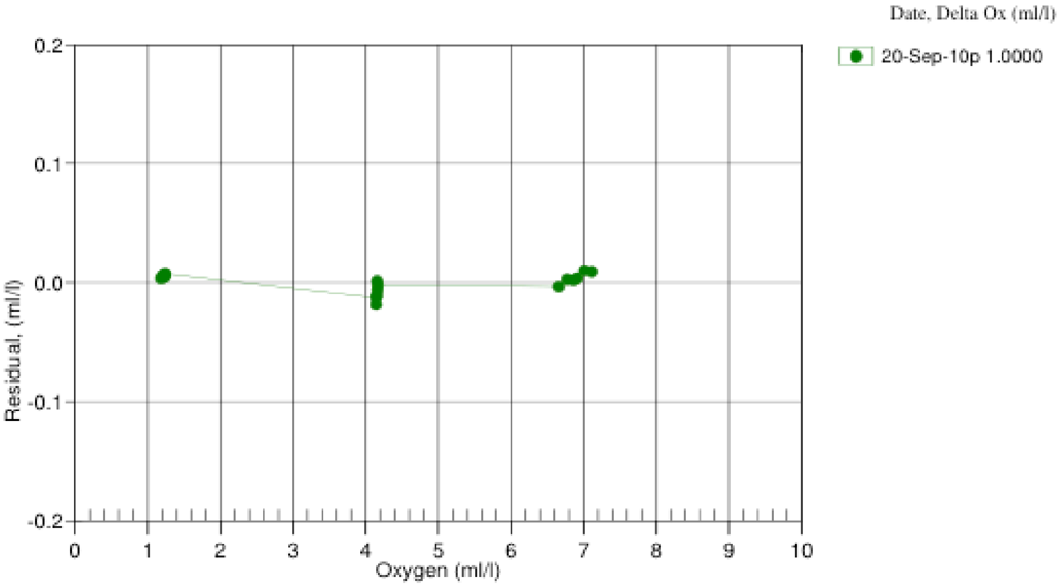
A = -2.4282e-003
B = 1.5236e-004
C = -2.6521e-006
E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS
D1 = 1.92634e-4
D2 = -4.64803e-2

H1 = -3.30000e-2
H2 = 5.00000e+3
H3 = 1.45000e+3

BATH OX (ml/l)	BATH TEMP ITS-90	BATH SAL PSU	INSTRUMENT OUTPUT(VOLTS)	INSTRUMENT OXYGEN(ml/l)	RESIDUAL (ml/l)
1.19	2.00	0.00	0.811	1.19	0.00
1.20	6.00	0.00	0.849	1.20	0.00
1.21	12.00	0.00	0.907	1.21	0.01
1.23	20.00	0.00	0.988	1.23	0.00
1.24	26.00	0.00	1.051	1.25	0.01
1.24	30.00	0.00	1.091	1.25	0.01
4.15	6.00	0.00	1.686	4.13	-0.01
4.15	2.00	0.00	1.561	4.13	-0.02
4.15	12.00	0.00	1.875	4.14	-0.01
4.16	30.00	0.00	2.457	4.16	0.00
4.17	20.00	0.00	2.130	4.16	-0.01
4.17	26.00	0.00	2.327	4.17	-0.00
6.66	30.00	0.00	3.627	6.66	-0.00
6.77	26.00	0.00	3.464	6.78	0.00
6.86	20.00	0.00	3.186	6.87	0.00
6.91	12.00	0.00	2.790	6.91	0.00
7.01	6.00	0.00	2.510	7.02	0.01
7.11	2.00	0.00	2.325	7.12	0.01

Oxygen (ml/l) = Soc * (V + Voffset) * (1.0 + A * T + B * T^2 + C * T^3) * OxSol(T,S) * exp(E * P / K)
V = voltage output from SBE43, T = temperature [deg C], S = salinity [PSU] K = temperature [deg K]
OxSol(T,S) = oxygen saturation [ml/l], P = pressure [dbar], Residual = instrument oxygen - bath oxygen



Appendix 10 - Color shaded-relief bathymetry and acoustic backscatter maps of Necker Ridge.