CRUISE REPORT

R/V *Kilo Moana*

U.S. Law of the Sea Cruise to Map the Western Flank of the Kingman Reef-Palmyra Atoll Section of the Line Islands, Equatorial Pacific Ocean

Cruise KM15-20
November 20 – December 20, 2015
Honolulu, HI to Honolulu, HI

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Contents

Section 1

Cruise Outline

KM15-20 was leg 2 of the continuing long-term bathymetric mapping of the area around Kingman Reef and Palmyra Atoll, in the equatorial Pacific. The objective of the cruise was to collect all of the bathymetric, acoustic backscatter, and sub-bottom data that might be useful to support a potential submission by the U.S. under the U.N. Convention on the Law of the Sea, Article 76 [1]. The responsibility for conducting the mapping was given to the National Oceanic and Atmospheric Administration (NOAA) by the U.S. Congress, and has been implemented since 2003 through a cooperative agreement with the Center for Coastal and Ocean Mapping and NOAA-UNH Joint Hydrographic Center at the University of New Hampshire.

This cruise supplements data from a prior cruise [2] to identify the morphology of the Foot of the Slope (FoS) around the northern end of the Line Islands chain, Figure 1.1. The cruise consisted of primary bathymetric mapping in water depths of approximately 5000 m using the R/V *Kilo Moana* (Figure 1.2), operated by the University of Hawai'i. The primary mapping sonar was a Kongsberg EM122 multibeam echosounder (bathymetry and acoustic backscatter), with a Knudsen Engineering 3260 chirp sub-bottom profiler, and a Bell Aerospace BGM-3 marine gravimeter. Motion measurement was provided by an ApplAnix POS/MV 320 GPS-aided inertial motion unit, while sound speed profile measurements were conducted using Sippican expendable bathythermograph (XBT) and expendable conductivity, temperature and depth (XCTD) probes. Details of the systems used can be found in Section 2. Scientific personnel for the cruise were provided by CCOM-JHC, Memorial University, University of Southern Mississippi, NOAA National Center for Environmental Information, and GEOMAR (Helmholtz-Zentrum für Ozeanforschung Kiel), and the marine technician group provided by University of Hawai'i. The personnel list can be found in Section 6.

The cruise started on 2015-11-20[1], with the *Kilo Moana* alongside at the University of Hawai'i Marine Facility in Honolulu, HI. Mobilization and dock-side testing was conducted on 2015-11-19. An opening gravity tie was conducted on 2015-11-20/1730, and the ship departed Honolulu, HI on 2015-11-20/1758. The ship moved to the fuel

[1] All dates and times within this report are given with respect to UTC unless otherwise specified.

dock to press the tanks full, and then proceeded to sea past the Aloha Tower, making 11.5 kt towards the patch test (multibeam calibration) area as indicated in Figure 1.1. As the ship came within range of the patch test area, an XCTD and an XBT (Deep Blue) were launched to confirm the calibration of the XBT system that was used for the remainder of the mission, and then a full patch test was conducted as described in Section 4.

The *Kilo Moana* then proceeded towards the first waypoint for the survey lines, but was forced to detour back to Honolulu to medevac an injured crew member. The *Kilo Moana* transferred the injured crewman by small boat in Kalihi Channel off Oʻahu, and then re-commenced transit to the first waypoint for the survey lines to commence core mapping for KM15-20. A parallel course was used for the second transit to provide some extra coverage of the area.

Routine mapping was then commenced. Sufficient XBTs were taken during the cruise to assess any changes in sound speed in the water mass surrounding the ship, with routine XBT launches at 0000, 0600, 1200, and 1800 UTC when possible, and other launches as required. Sound speed at the transducer head was compared with the sound speed at transducer depth from the most recent sound speed profile using the Kongsberg Seafloor Information System (SIS) software, and a new XBT launch was conducted when the difference between the two estimates was more than $0.5\,\text{ms}^{-1}$ for more than a few minutes. Details of the XBT launch frequency, location, and other metadata are provided in Appendix B.

A total of 11,234 km (6,066 nmi) of planned lines (excluding transits) were run in the survey area, including four cross-lines, used to analyze the consistency of the data as detailed in Appendix E, and as preliminary mapping for the follow-on leg 3 (using the NOAA Ship *Ronald H. Brown*), due to start 2016-01-11. The mapping effort was monitored by the science party and supervised by the Chief Scientist, with the assistance of the ship's crew and the University of Hawaiʻi resident marine technicians. Data quality was monitored in real-time using the watch stander stations in the ship's survey lab, and data processing and quality control was conducted during ship-board operations as detailed in Section 2.6 and Section 3. Ship-board preliminary data products were created to ensure data quality (see Appendix C), but final data products were constructed after the cruise.

Mapping continued until 2015-12-18/0058, at which point the ship broke line and made way for Honolulu, HI, arriving 2015-12-20/1758. A closing gravity tie was conducted at 2015-12-20/1830.

A total area of $164,200\,\text{km}^2$ ($47,873\,\text{nmi}^2$) was mapped (excluding transits) during the cruise in 22 survey days, Figure 1.3. There were five days of transit (including fueling), and three days lost to medical evacuation. A survey calendar is shown in Table 1.1.

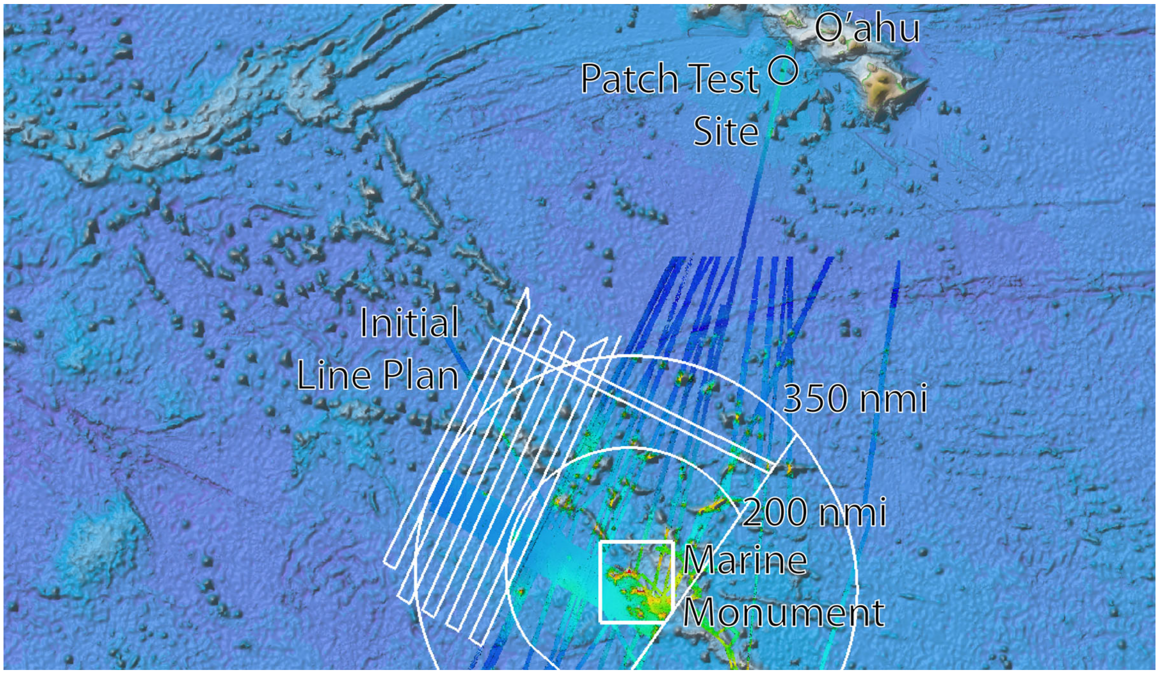


Figure 1.1: Overview of previously mapped area around Kingman Reef from cruise KM10-09 in 2010, and other pre-cruise data holdings, with overlay of the pre-cruise planned waypoints for KM15-20, and the selected patch test site.

Figure 1.2: The R/V *Kilo Moana* in Apia, Western Samoa, in 2010. The *Kilo Moana* is a SWATH (Small Water Area Twin Hull) vessel owned by the U.S. Navy and operated by the University of Hawai'i.

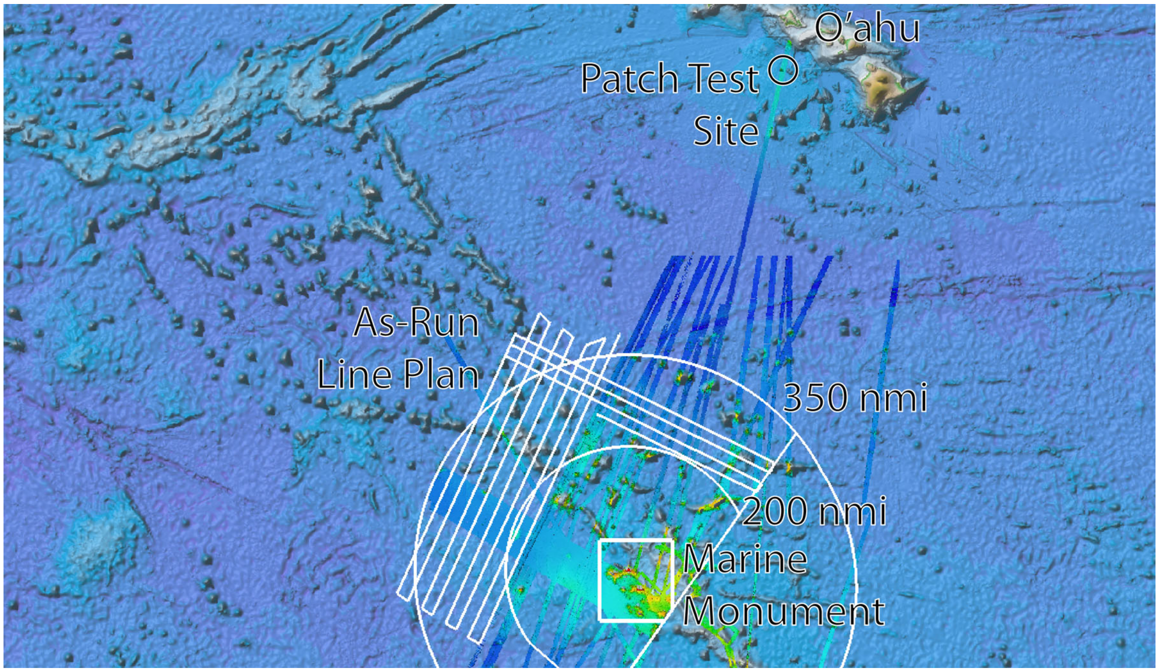


Figure 1.3: Overview of the lines as run during KM15-20. A total of 11,234 km (6,066 nmi) of lines were completed in 22 survey days, for a total of $164,200\,\text{km}^2$ ($47,873\,\text{nmi}^2$) covered.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
				19 Nov 323	20 Nov 324	21 Nov 325	22 Nov 326
Activity				Mobilization	Mob./Fueling	Transit/Patch Test	Transit/Medevac
XBTs Launched						6	4
	23 Nov 327	24 Nov 328	25 Nov 329	26 Nov 330	27 Nov 331	28 Nov 332	29 Nov 333
Activity	Medevac	Medevac/Transit	Transit	Survey/East	Survey/East	Survey/East	Survey/East
XBTs Launched	10	6	6	5	4	8	5
	30 Nov 334	1 Dec 335	2 Dec 336	3 Dec 337	4 Dec 338	5 Dec 339	6 Dec 340
Activity	Survey/East	Survey/East	Survey/East	Survey/East	Survey/West	Survey/West	Survey/West
XBTs Launched	4	6	5	6	6	5	6
	7 Dec 341	8 Dec 342	9 Dec 343	10 Dec 344	11 Dec 345	12 Dec 346	13 Dec 347
Activity	Survey/West	Survey/West	Survey/West	Survey/West	Survey/Crossline	Survey/Crossline	Survey/Crossline
XBTs Launched	5	5	9	7	4	5	4
	14 Dec 348	15 Dec 349	16 Dec 350	17 Dec 351	18 Dec 352	19 Dec 353	20 Dec 354
Activity	Survey/Crossline	Survey/Crossline	Survey/Crossline	Survey/Crossline	Survey/Transit	Transit	Transit/Demob
XBTs Launched	4	5	5	5	5	4	5

Table 1.1: Survey calendar for KM15-20's mapping mission.

Section 2

Survey Equipment

2.1 Multibeam Echosounder

Kilo Moana is equipped with a Kongsberg Maritime EM122 multibeam echosounder system (12 kHz), serial number 109[1]. The system generated sound in the region of 12 kHz in a wide swath across-track (of configurable width up to 150° but approximately 1° along-track), and then receives in a set of beams that are long along-track, but approximately 1° wide across-track. A sequence of up to nine acoustic sectors at frequencies varying from 11.550–12.598 kHz can be generated on transmit to compensate for ship's yaw, at a source level of approximately 220 dB re. 1μPa at 1 m. Optionally, the outer sectors of the transmit beam can be frequency modulated to improve overall signal-to-noise ratio. The system was operated in Deep FM high-density equidistant mode throughout the cruise, with a pulse length of approximately 15 ms. Pulse repetition rate varied with water depth, but has a period of approximately 20 s for the majority of the cruise.

An AML Smart SV&T, serial number 4599, was used to measure sound speed at the transducer. Calibration was conducted by the manufacturer on 2015-06-18; the certificates of calibration are in Appendix D.2.

Kongsberg Seafloor Information System (SIS), version 4.1.3 build 14 (2013-12-13) was used to monitor and control the EM122.

2.2 ApplAnix POS/MV Motion Sensor

The EM122 was provided with position and motion information using a ApplAnix POS/MV inertial motion unit (IMU) version 4, PCS serial number 2319, IMU serial number 331 (port antenna 60074837, starboard antenna 60108779), which was provided with wide-area satellite-based differential positioning corrections from a CNav

[1]There exists at least one other EM122 that also claims to be serial number 109 (specifically, on the *Marcus G. Langseth*). It is therefore unknown if this is an older serial number left over from the EM120 previously installed on *Kilo Moana*, or if all EM122 systems claim that this is their serial number, or if this is not actually a serial number in the conventional sense.

3050 WA-GPS receiver, serial number 21909. The POS/MV system provided motion estimates with uncertainty on the order of 0.02° (r.m.s.) for roll, pitch, and heading, heave accuracy of the maximum of 0.05 m (r.m.s.) or 5% of measured heave, and positioning accuracy of approximately 0.5 m (CEP).

ApplAnix MVPOS-view software, version 5.1.0.2, was used to monitor and control the performance of the POS/MV.

2.3 Knudsen 3260 Sub-bottom Profiler

The sub-bottom profiler (SBP) used was a Knudsen Engineering 3260 rack-mounted echosounder, serial number K2K-07-0911, connected to two permanently hull-mounted transducer arrays at 3.5 kHz (transmitter K2K-07-0884, 16 TR-75 Massa transducers) and 12 kHz (transmitter K2K-07-0890). The system was used at a nominal frequency of 3.5 kHz only so as not to interfere with the EM122, and was synchronized to the firing rate of the EM122 so as to minimize interference between the two systems. The source level of the 3260 is expected to be approximately 220 dB re. 1μPa at 1 m, but may vary in practice. The system was configured for 64 ms linear frequency modulated (LFM) pulses.

Knudsen EchoControlClient software, version 2.72, was used to monitor and control the system.

2.4 Gravity Meter

The *Kilo Moana* carries a Bell Aerospace BGM-3 marine gravimeter, with component part serial numbers 215 (sensor), 315 (CPS), and 322 (platform). The system is mounted in a secure space on the floor in the science office. The portable gravity meter used to provide tie-points was a Lacoste and Romberg Inc. model with no discernible model number, serial number 1.

2.5 XBT Launch System

The XBT launch system was a Sippican (Lockheed-Martin) Mk21 LM3A launcher, serial number illegible. The control computer was running version 2.1.1 of Sippican's WinMk21 software (Mk21Coeff 2.3.1, Mk21AL 2.3.1).

2.6 System Configuration

Figure 2.1 shows the placement of the instrument displays in the main lab. A summary of serial numbers and software versions is provided in Table 2.1.

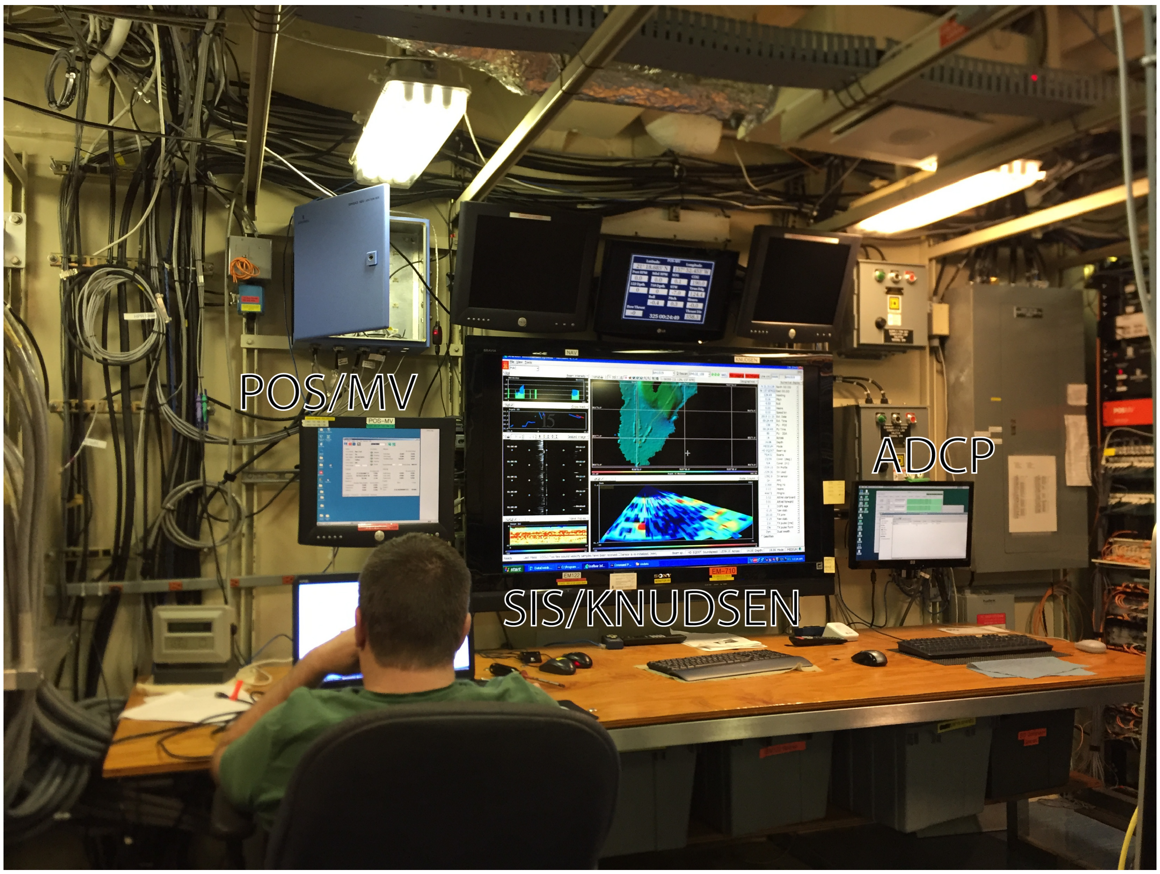


Figure 2.1: Instrument displays in the main lab of the *Kilo Moana* during KM15-20. The large center screen was used for both SIS and Knudsen displays, using a KVM switch to select the active display.

Instrument	Part	Make	Model/Release	Serial Nr/Date
Multibeam Kongsberg EM122				
	Tranceiver Unit (TRU)	Kongsberg Maritime AS	309653	109
	SIS Workstation	Kongsberg Maritime AS	HWS-C3	47467B09
	SIS (software)	Kongsberg Maritime AS	4.1.3	12/13/2013
	TX36 (firmware)	Kongsberg Maritime AS	1.11	5/7/2013
	RX32 (firmware)	Kongsberg Maritime AS	1.11	2/18/2010
	BSP67B (firmware)	Kongsberg Maritime AS	2.2.3	7/2/2009
	CPU (firmware)	Kongsberg Maritime AS	1.3.2	1/29/2014
	DSV (firmware)	Kongsberg Maritime AS	3.1.6	1/4/2013
	DDS (firmware)	Kongsberg Maritime AS	3.5.9	9/26/2013
Applanix POS/MV 320				
	MV-320 (hardware)	Applanix Corporation	MV-320	2.8-7
	MV-320 PCS (hardware)	Applanix Corporation	MV-320	2319
	MV-320 IMU (hardware)	Applanix Corporation	MV-320	331
	MV-320 (software)	Applanix Corporation	5.03	3/3/2010
	Primary GPS Receiver	Applanix Corporation	BD950	4533A59357
	Primary Antenna	Trimble	//	60074837
	Secondary GPS Receiver	Applanix Corporation	BD950	4526A59102
	Secondary Antenna	Trimble	//	60108779
	MV-POSView (software)	Applanix Corporation	10003370	5.1.0.2
CNav 3050 Wide Area Differential GPS Receiver				
	CNav 3050 (hardware)	C & C Technologies, Inc.	3050	21909
Transducer Sound Speed Sensor AML Smart SV&T				
	Probe	AML Oceanographic	SV&T	004599
XBT System Sippicam MK21/USB				
	MK21 IO Board	Sippican	MK21/USB	00320
	WinMK21	Sea-Air Systems	2.1.1	2003
SBP Knudsen Chirp 3260				
	Topside Processor	Knudsen Eng. Ltd	D229-04331	K2K-07-0911
	Ch#1 3.5kHz (hardware)	Knudsen Eng. Ltd	//	K2K-07-0884
	Ch#1 3.5kHz (software)	Knudsen Eng. Ltd	D409-04195	2.64
	Ch#2 12kHz (hardware)	Knudsen Eng. Ltd	//	K2K-07-0890
	Ch#2 12kHz (software)	Knudsen Eng. Ltd	D409-04195	2.64
	Software EchoControlClient	Knudsen Eng. Ltd	2.72	//
Marine Gravity Meter System Bell BGM-3				
	Sensor	Bell Aerospace	BGM-3	219
	CPS	Bell Aerospace	BGM-3	315
	Platform	Bell Aerospace	BGM-3	322
Land Gravimeter for land ties Lacoste & Romberg				
	Geodetic Gravity Meter	Lacoste & Romberg Inc	//	1
Processing Software				
	HIPS/SIPS	CARIS	9.0.20	10/30/2015
	BASE Editor	CARIS	4.1.15	10/10/2015
	Chart Composer	CARIS	5.2	327192
	Fledermaus	QPS	7.4.5	9/16/2015
	FMGT	QPS	7.4.5	9/16/2015
	Sonarwiz	Chesapeake Technologies	6.01.0019	//
	HyPack MAX	Xylem	15.0.1.1	//

Table 2.1: Summary of serial numbers and software versions for the various components of the mapping system, including data processing software, used during the mapping mission.

Section 3

Data Protocols

3.1 Collection

Data collection was conducted subject to typical hydrographic protocols for deep water mapping. Static offsets for the positions of the components of the survey system were provided by *Kilo Moana* based on the latest survey report for the ship (dated 2015-03, Appendix D.1). Static angular offsets and time latency were assessed through the patch test procedure described in Section 4, and were applied in the SIS software and thence to the real-time processing module in the EM122.

The SIS software was configured to automatically start new line files every eight hours, but the lines were incremented manually every six hours on 0000, 0600, 1200, and 1800 UTC where possible given the survey lines. Line changes on the Knudsen 3260 were synchronized with the EM122 so that corresponding lines were always captured on each system. Turns were recorded separately for both systems, and kept isolated from the main data.

Speed of sound at the transducer was determined by an AML Smart SV&T sensor which was fed directly to the EM122 processing station in order to correct for refraction in the beam-steering computations. Sound speed profiles (SSP) in the upper part of the water column were derived from XBT launches and occasional XCTD launches (as required), extended using almanac data from the World Ocean Atlas 2009 (WOA09) using the UNOLS Multibeam Advisory Committee SVP Editor software, version 1.0.5, installed on the SIS workstation. After manual inspection, these extended and simplified profiles were then sent to the EM122 over the network in order to avoid any dropped pings or stop/start update cycles. Routine XBT launches were conducted at 0000, 0600, 1200, and 1800 UTC when possible to coincide with line changes in the data capture systems; where shorter lines were required, or line changes could not be synchronized to these six hour intervals, XBT launches were conducted approximately every six hours. In addition, the sound speed at transducer depth from the SSP was compared in the SIS console with the current real-time sound speed at the transducer; if a difference of more than $0.5\,\mathrm{ms}^{-1}$ was observed for more than a few minutes, a new XBT launch was initiated. The XBT launch system is described in Section 2.5, and the metadata for the launches and probes is given in Appendix B.

The Knudsen Engineering 3260 SBP was operated throughout the cruise, except during the patch test, typically with a nominal depth gate of 500 m about the expected depth. Full digital records were recorded in SEG-Y format.

The gravity meter calibration ties were conducted by the University of Hawai'i technicians, and are available in Appendix D.3.

Although not formally part of the cruise data, Acoustic Doppler Current Profiler (ADCP) data was collected continuously while underway. Data reduction and archive submission for this data was handled separately by University of Hawai'i.

3.2 Processing

Data from both the EM122 and the 3260 were made available on the *Kilo Moana*'s internal network using a network share from the ship's primary server. Files were copied from the server to local storage for archive and processing at the completion of each line. For purposes of efficiency in data processing, the data were separated into sub-projects. The transits to and from Honolulu were kept as two separate projects, and the mainscheme lines were separated into Operational Area East (lines 1–4) and Operational Area West (lines 5–8), primarily so that intermediate product grids did not become so large as to become cumbersome; the cross-lines were also maintained as a separate sub-project.

Data processing for the MBES bathymetry data was conducted using CARIS HIPS 9.0.20, with visualization products being created with QPS Fledermaus 7.4.5 via BAG files exported from HIPS. A separate flow-path between HIPS and HYPACK was established for intermediate gridded products being created in HIPS, so that current data could be placed in the same geographic context with prior data. GeoTIFF images were used for transfer. Data processing for the SBP data was conducted in Chesapeake SonarWiz 6.01.0019.

The MBES bathymetry data were processed using the CUBE algorithm, implemented in HIPS. A grid resolution of 100 m was used for all depths of water encountered. The CUBE calibration parameters used are given in Appendix D.4. Quality control of the MBES data was carried out by the watchstanders, ensuring that any anomalous depth measurements were either appropriately handled by the CUBE software in use within HIPS, or were remediated by hand if necessary. Comparisons between the cross-lines collected and the main-scheme lines were computed in CARIS BASE Editor 4.1.15, in order to assess the consistency of the data; comparisons between the main-scheme lines and the data collected during KM10-09 were also conducted to assess stability of depth determination. Results of these comparisons are given in Appendix E.

After the grid product was finalized in HIPS, surface filtering was applied to the raw data so that legacy point-cloud files of surface-consistent sounding observations could be generated for archival purposes. These were exported in ASCII format for use in future products. Grids were exported in BAG and GeoTIFF formats from HIPS, and separate grid in geographic coordinates were constructed in Fledermaus from the exported ASCII data. Preliminary data products were constructed onboard, and are illustrated in Appendix C, but final adjustment and product creation was conducted ashore.

The MBES backscatter data were processed using the GeoCoder algorithm, implemented in FMGT 7.4.5. A grid resolution of 50 m was used for all depths of water encountered. The calibration parameters used are given in Appendix D.5. Mosaics of backscatter were exported in GeoTIFF and Fledermaus SD format for review and combination with bathymetric data in the visualization environment.

Sub-bottom profiler data was processed using SonarWiz to the extent of converting the data into imagery and exporting it in forms suitable for correlation with the MBES data. No further quality control was conducted.

For compatibility with previous legs of the cruise, the filenames used by the SIS software were translated into sequential filenames, starting with line number 200. Translation tables for MBES and SBP data are provided in Section A. FGDC-compliant metadata was constructed semi-automatically for each line of MBES and SBP data at the end of the cruise.

Data from the cruise were archived by *Kilo Moana* for ingestion through the R2R program, and were made available after the cruise on portable hard drive. Separately, CCOM-JHC provided processed data with metadata to the National Centers for Environmental Information (NCEI) using the data center (formerly the National Geophysical Data Center) in Boulder, CO. The ship-board archive contained raw data from all instruments, including meteorological observations, ship bridge logs, navigation information, and other underway sensor information.

Section 4

Patch Test Results

Data for the patch test were captured and named separately from the main-scheme and transit lines, and held in a separate directory in the data archive. A total of six patch-test lines were run (Figure 4.1):

1. Across seamount at 12 kt ($A \rightarrow B$).
2. Reciprocal line at 12 kt ($B \rightarrow A$).
3. Re-occupation of line 1 at 6 kt ($A \rightarrow B$).
4. Parallel line to line 1, offset eastward, at 12 kt ($C \rightarrow D$).
5. Parallel line to line 1, offset west, at 12 kt ($E \rightarrow F$).
6. Reciprocal line to line 6, at 12 kt ($F \rightarrow E$).

A final line, $E \rightarrow F$, was also run, which is formally redundant for the patch test process, but which was necessary for re-positioning of the ship, and usable for further confirmation of results.

The data were ingested into CARIS HIPS in a project separate from that where the main-scheme lines were processed ("KM1520_PatchTest"), and conventional processing was applied to allow the data to be used in the calibration tool within HIPS. Examination of the data showed, over the various pairs of lines that can be used to solve for roll, pitch, latency, and yaw, that there was no distinctive pattern of offset-derived artifact in the data.

It was therefore concluded that the initial offsets (Figure 4.2) of:

1. Pitch: $-0.15°$.
2. Roll: $-0.08°$.
3. Yaw: $0.06°$.
4. Timing: 0 ms.

should remain operational for the duration of the survey.

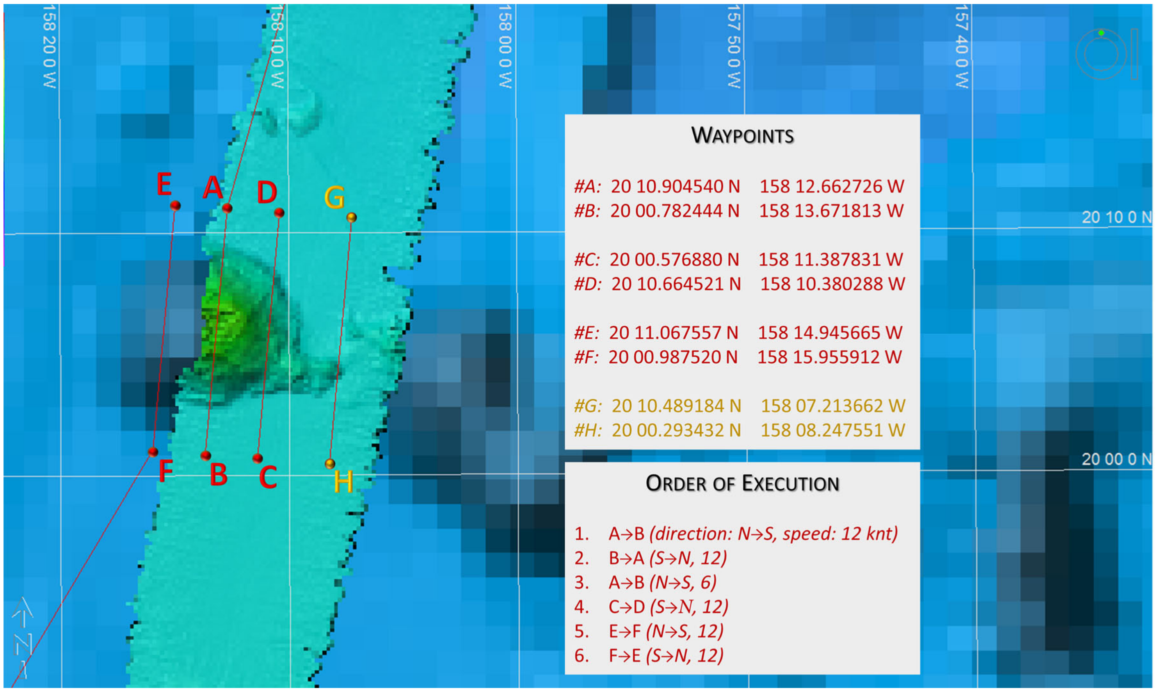
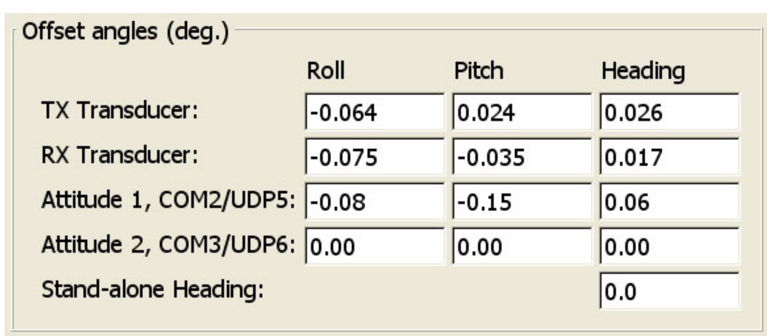


Figure 4.1: Patch-test line locations for KM15-20. The lines were run from $A \rightarrow B$ and $B \rightarrow A$ at 12 kt, and then $A \rightarrow B$ at 6 kt, then $C \rightarrow D$, $E \rightarrow F$, and finally $F \rightarrow E$ at 12 kt. The ship was required to reposition in order to continue to the operational area, and therefore re-ran a line from $E \rightarrow F$ as a redundant spare for patch test purposes. Line $G \leftrightarrow H$ was originally included as a backup yaw line, but was not required.


Offset angles (deg.)

	Roll	Pitch	Heading
TX Transducer:	-0.064	0.024	0.026
RX Transducer:	-0.075	-0.035	0.017
Attitude 1, COM2/UDP5:	-0.08	-0.15	0.06
Attitude 2, COM3/UDP6:	0.00	0.00	0.00
Stand-alone Heading:			0.0

Figure 4.2: Angular offsets in effect during KM15-20.

Section 5

Daily Narrative

2015-11-19 (JD 323) - U.H. Marine Facility, Honolulu, HI

Joined ship, alongside the pier of the University of Hawai'i Marine Facility. Confirmed that the XBT and XCTD supplies were loaded and stowed, and unpacked remainder of equipment for the data processing and survey monitoring.

2015-11-20 (JD 324) – U.H. Marine Facility, Honolulu, HI

Conducted opening gravity tie **1730** with University of Hawai'i marine technicians on reference point on east side of the pier. Slipped lines **1758** and moved to the fueling dock in Honolulu to press the tanks full before departing. Science in-brief and ship familiarization during fueling.

2015-11-21 (JD 325) – Fuel Dock, Honolulu, HI

Departed Honolulu **0120** for KM15-20. After configuring EM122 for survey parameters and restarting SIS, the EM122 failed to start pinging, and the 1PPS connection to the POS/MV also showed errors at the SIS console. A full reboot of SIS and the EM122 processing unit appeared to resolve this issue, and pinging commenced **0230** in approximately 560 m of water. Synchronization between EM122 and Knudsen (to avoid cross-talk) was finally achieved at **0425**, after the University of Hawai'i technicians identified, and replaced, a faulty synchronization cable. Thereafter, recording of transit data commenced.

The ship proceeded to the patch test site, arriving at **0756**. Immediately prior to arrival, an XCTD-1 and XBT were launched (Appendix B), and the XCTD profile was loaded into SIS for the patch test processing (Section 4). The XCTD and XBT profiles matched well, Figure 5.1. The patch test was completed at **1630**, and the ship then made way for the operational area. Routine XBT launches commenced with the **1800** line change.

2250: In an attempt to improve data quality, increased Knudsen power to four and adjusted the gain to $40 \log R$. Returned shortly afterwards to "Bottom referenced" TVG due to lack of improvement, but left power at four.

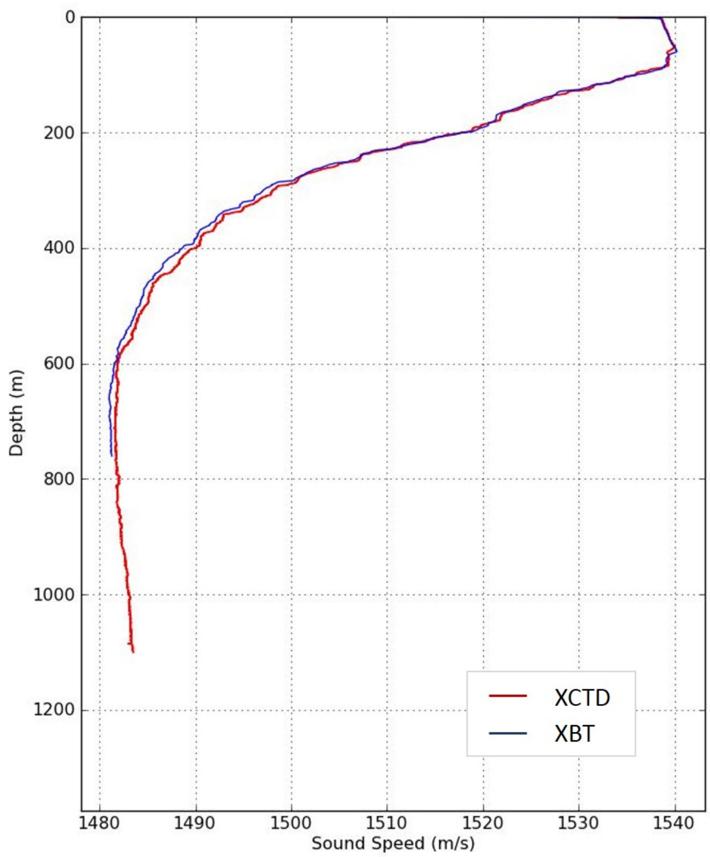


Figure 5.1: Comparison between sound speed profiles generated from the XCTD and XBT launched in sequence immediately prior to starting the patch test procedure. The two profiles matched well, providing confidence that the XBT system was generating data of suitable quality for mapping.

2015-11-22 (JD 326) – In Transit to Operational Area

At **0100**, the surface sound speed system began to behave erratically, jumping between values of zero, approximately the true value, and significantly higher sound speeds (order $1580\,\mathrm{ms}^{-1}$). The sound speed input method was switched to "profile" while the problem was investigated. After some digging, it appears that the proximal cause of the erratic behavior was that there was air trapped in the input strainer, causing false readings. After purging, the sensor readings returned to their more usual behavior: still jumping around, but at least less often, and (importantly) sufficiently less often that the input filters in SIS were able to remove the spikes before they affected the beamsteering. SIS was returned to using the sensor input at **0130**.

1928: Ship commenced tests with high-speed autopilot module in preparation for survey proper, the concern being that the control algorithm might cause significant amounts of yaw that would be detrimental to survey protocols. This caused some kinks in the transit line as the auto-pilot established control. After initial tracking, the Captain continued to tune the autopilot, while the survey crew monitored the effects on the data. No significant increasing in yawing was observed after the initial testing period.

2030: Due to a medical emergency involving an injured crew member, the Captain ordered an immediate course change, and a return to Hawai'i. The transit line was therefore terminated, and a new one started for the return leg. The *Kilo Moana* brought on all four engines, and started making way at approximately 14.5-15 kt, in order to complete the evacuation as quickly as possible.

2015-11-23 (JD 327) – Medical Evacuation to Hawai'i

During the transit, it became clear that the EM122 on the *Kilo Moana* had a signal-to-noise ratio (SNR) issue at the sector boundaries between the inner and outer sectors, Figure 5.2. This caused issues when the backscatter was generally lower, for example over sediment ponds between brighter seafloor ridges, leading to gaps in the data along-track. At **0127**, the swath width controls on the EM122 were adjusted to a maximum of ± 7000 m to test whether fixing the swath might improve the performance of the system; at the same time, the Knudsen transmit power was reduced to level three in order to reduce any potential cross-talk between the systems. Subsequent monitoring seemed to indicate that there was some improvement in the performance at the sector boundaries, although varying seafloor material made it hard to be definitive with this assessment. The EM122 was left with the fixed-swath configuration for further evaluation over the course of the transit back to Honolulu.

1801: For reasons unknown, shortly after a line change, SIS crashed during the collection of line 0020_180008_KM122.all. SIS was therefore restarted, while the Knudsen line was also restarted to resynchronize line numbering. Due to SIS failing to preserve its state after restarting, and in particular failing to increment the line counter, this process resulted in two "line 20" files being generated: 0020_180008_KM122.all, and 0020_180247_KM122.all. In order to preserve line consistency, 0020_180008_KM122.all (which consisted of only four pings) was removed.

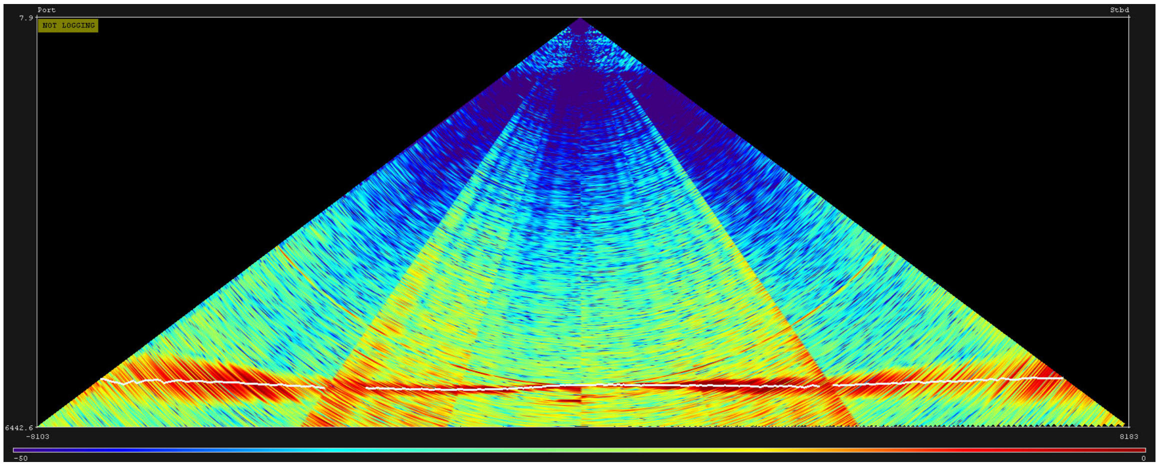


Figure 5.2: Watercolumn image of the EM122 during transit (at 14 kt), illustrating higher noise (lower SNR) on the sector boundaries, leading to gaps in bottom detection (white line).

2015-11-24 (JD328) – Medical Evacuation to Hawai‘i

At **0030**, switched MBES into automatic depth range determination, which resulted in it switching to "Medium" mode almost immediately (in approximately 600 m of water). Continued in automatic as the ship moved closer to O‘ahu for small-boat transfer.

0056: The *Kilo Moana* was required to secure the seawater pumping systems for approach to shore, and therefore the sound speed sensor on the hull stopped reading. The EM122 and Knudsen were therefore also secured.

0109: The *Kilo Moana*, having reached its closest point of approach to O‘ahu in the Kalihi channel off Honolulu Harbor, dropped a small-boat to complete the medical evacuation. At **0225**, the small-boat was recovered, and the *Kilo Moana* started on the transit back to the operational area.

1204: SIS crashed again (as before, shortly after a line change). Due to SIS failing to increment the line counter, this process resulted in two "line 25" files being generated: 0025_20151124_120025_KM122.all, and 0025_20151124_120339_KM122.all. In order to preserve numbering consistency, 0025_20151124_120025_KM122.all (which consisted of only a few pings) was removed from the archive.

1820: For approximately five minutes, the swath width controls in SIS were adjusted to test behaviors of the system in different regimes, specifically with respect to sector-boundary bottom detection issues.

2305: The sound speed sensor, having worked for several days without difficulties, began to behave erratically again, showing values intermittently at zero, or 30 ms^{-1} above the true value. Flushing the sea chest to remove trapped air appeared to resolve the issue, which was most likely caused by air leaking from the high-pressure air line that is used to flush contaminants from the chamber as required. In order to make this issue less likely to happen again, the Chief Engineer closed an upstream stop,

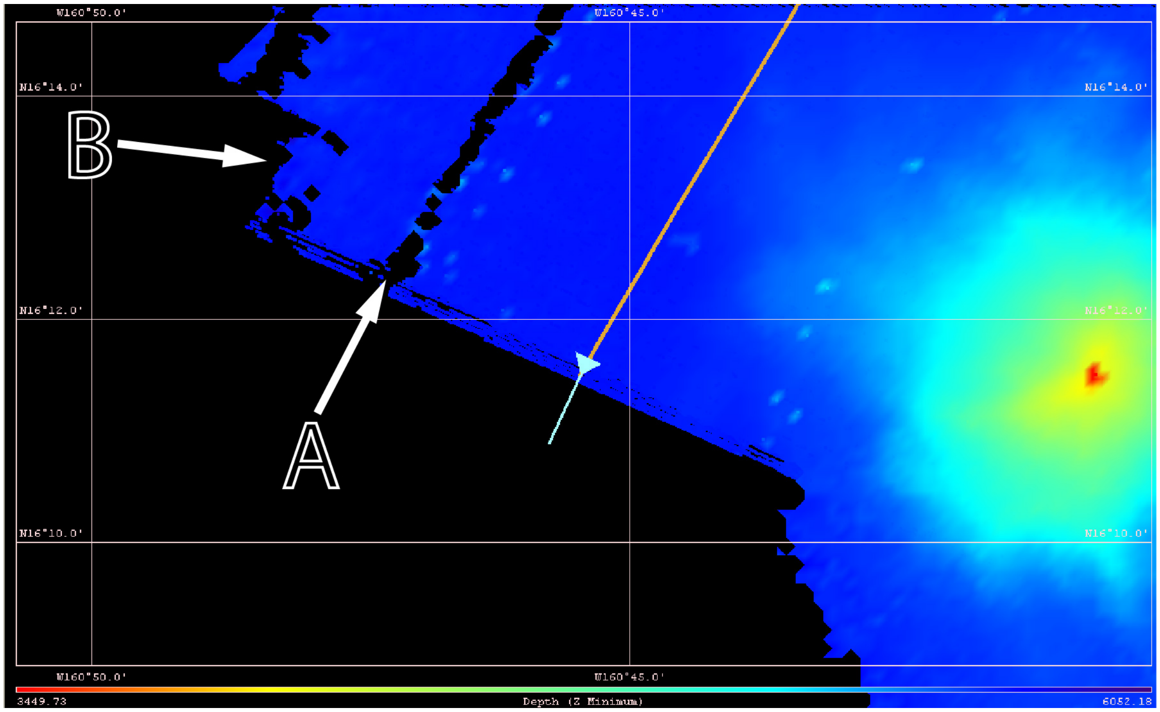


Figure 5.3: Example of EM122 data with FM mode disabled. The hypothesis that use of FM mode to improve signal-to-noise ratio in the outer sectors of the swath might be related to the prominent sector boundary bottom detection issues being observed (Arrow A) in the starboard side was tested. No significant improvement in bottom detection was observed, but the overall swath width did reduce (Arrow B), and the FM mode was therefore re-enabled.

and the University of Hawai‘i technicians added a prophylactic purging of the sea chest to their per-watch routine.

2015-11-25 (JD329) – Transit to Operational Area

At **0015**, it was discovered that the current track line was diverging from the planned path that would provide overlap with the previous transits. On further investigation, it appeared that the bathymetric grid generated by the processing software and used for planning had been misplaced geographically when entered into the planning software, leading to the planned points being shifted. New points were immediately planned, and the ship re-routed to provide better overlap with the prior transit lines. Repositioning commenced **0052**.

0725: In order to test whether using the FM functionality of the EM122 was implicated in the sector boundary problems being observed, the functionality was disabled for a period of time in a region where significant starboard-side sector boundary drop-outs were observed, Figure 5.3. There was no observed improvement in the sector boundary drop-outs, but the overall swath was significantly reduced. The EM122 was therefore returned to FM mode.

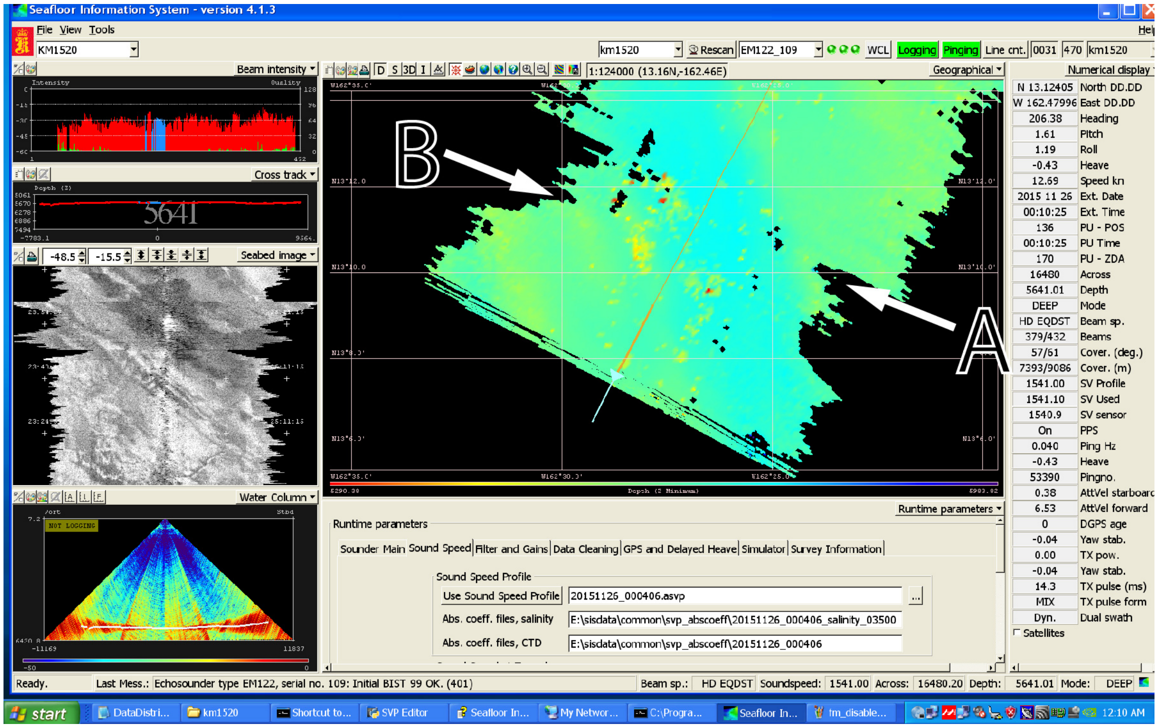


Figure 5.4: Effect of needle gunning on MBES swath width and data quality. *Kilo Moana* deck department personnel started needle gunning in the port-side forward hold (above the MBES) at arrow A, and ceased at arrow B, allowing the MBES to recover to the original swath width of approximately 17 km.

1750: University of Hawai‘i technicians reported that the flow-through seawater system feeding the thermosalinograph, fluorometer, and other wet-lab systems was secured to allow for some engineering maintenance on pipework. The seawater system was restarted at **1945**.

2355: *Kilo Moana* deck hands started needle-gunning in a space close to the sonar systems, which had an immediately deleterious effect on the swath width achievable by the EM122, Figure 5.4, and showed extra noise in the water column on the Knudsen. After a request to secure needle-gunning, the swath immediately recovered.

2015-11-26 (JD330) – Surveying in Operational Area East

As a matter of efficiency in data processing with lines that are approximately two days long, survey operations were divided logically into two halves: operational area east, comprised of lines 1–4, and operational area west, comprised of lines 5–8. This allowed for grids to be kept within manageable sizes during product development, but in no other way affected the processing of data, or conduct of the cruise.

0125: *Kilo Moana* started to turn in order to line up for the first survey line. Logging was secured for the duration of the turn.

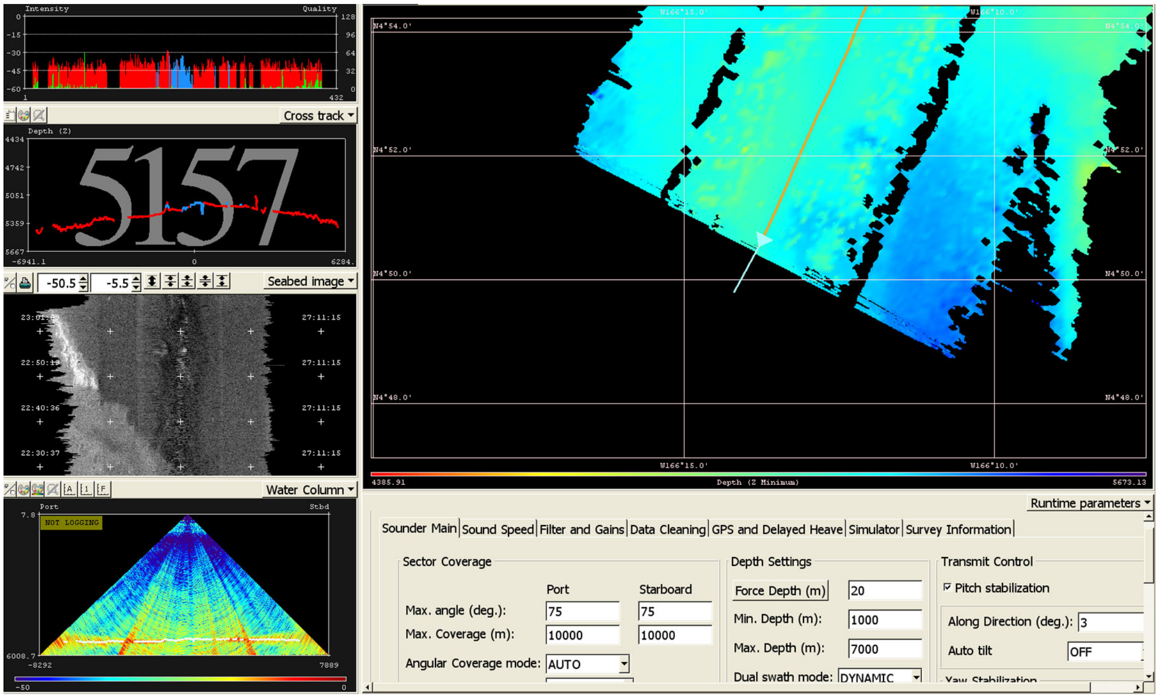


Figure 5.5: Anomalously low backscatter region in EM122 data, with consequent loss of signal at the sector boundaries where the EM122 SNR is lower than average. Similar signal loss and reduction in data quality was observed on the Knudsen 3260.

0136: With the ship steady on course, logging was re-started to begin the first line of the survey proper.

2015-11-27 (JD331) – Surveying in Operational Area East

Continued on survey line 1 under deteriorating weather conditions (significant swell, overcast, rain) which contributed to more significant yawing, and other motion effects.

0600: Weather improved as the ship headed further south, returning to very gentle Pacific rollers and light chop on the sea surface.

2315: The *Kilo Moana* entered a region with anomalously low backscatter, leading to significant loss of signal at the sector boundaries, Figure 5.5, and limited return, even at maximum gain, on the Knudsen.

2015-11-28 (JD332) – Surveying in Operational Area East

At **0155**, the *Kilo Moana* completed the first survey line. The turn off line was not recorded, and at **1600** the ship commenced mandatory steering drills; recording of the transit to the next line commenced at **0250**.

0404: Start of survey line 2.

1815: Four XBTs were lost to gusty winds over the fantail (approximately 30–35 kt) that caused the wire to short on the ship's hull. The fifth cast was marginally better, and was entered after significant editing.

2015-11-29 (JD333) – Surveying in Operational Area East

A routine day of surveying in Operational Area East.

2015-11-30 (JD334) – Surveying in Operational Area East

At **0214**, the *Kilo Moana* completed survey line 2; survey line 3 started at **0514**.

2015-12-01 (JD335) – Surveying in Operational Area East

At the line change at UTC midnight, water column logging was enabled (as a separate file) following a request from the beach for further data to assist in debugging the sector-boundary noise issues.

1438: Without any apparent prior malfunction, the SBP suddenly stopped working, evidenced by the display failing to update after multiple pings on the EM122.

1518: After the substitution of a blown power fuse on the Control Unit, the SBP data collection restarted. Throughout the troubleshooting of this issue, the EM122 data acquisition continued.

2015-12-02 (JD336) – Surveying in Operational Area East

At **0130** it was noticed that the Knudsen data failed to convert due to lack of positioning information. On investigation, the Knudsen client program also indicated that GPS data was unavailable. At **0150** the issue was discovered to be a misconfiguration of the capture system following the reboot after blowing a fuse. After reconfiguration, the Knudsen found the GPS string, and recording was re-started.

0205: End of survey line 3.

0207: MBES testing, in order to assist in determining the cause of the sector boundary noise (Figure 5.2), commenced. Sounding from the Knudsen was first secured. The *Kilo Moana* was then run through four cycles of testing; during each cycle, data was recorded for 10 min. while the ship steamed at a given speed, and thereafter sounding was secured, and a BIST test was conducted three times in sequence with the ship still under way. The four test speeds were 11.5 kt (normal survey speed), 8 kt, 6 kt, and drifting. The EM122 Topside Processor Unit (TPU) `telnet` interface was then used to run transmit BIST tests that could not be run from the SIS GUI. Sounding on Knudsen and EM122 was then re-started, and the ship was brought up to survey speed and directed to the next waypoint in order to continue with the survey. The results of the BIST tests, the bathymetry, backscatter, and water column data were all transferred ashore for further analysis; anecdotally, however, the noise appeared to be significantly abated for slower ship speeds.

0527: Start of survey line 4.

0635-0735: Deviation from the planned track (up to 2 km) due to presence of fishing vessels that refused to answer repeated hails from *Kilo Moana*, and refused to move from their position.

0802: The SIS process silently stopped working (in the meantime, the EM122 continued its regular duty cycle).

0808: A SIS restart was required to re-acquire user control over the EM122. This operation created a 1 km along-track gap in the data acquisition.

2015-12-03 (JD337) – Surveying in Operational Area East

At **1025**, the ship reported issues with main propulsion, and slowed to 6 kt until **1038** to investigate. Thereafter the ship returned to 12 kt and normal survey operations were resumed.

2015-12-04 (JD338) – Surveying in Operational Area East

At **0144**, the end of survey line 4 was reached. As a prophylactic measure after the SIS crash on 2015-02-02, the SIS computer was restarted. Sounding and logging recommenced **0149**.

0341: Start of survey line 5, beginning the second half of the survey mainscheme lines (i.e., Operational Area West).

2015-12-05 (JD339) – Surveying in Operational Area West

At **2347**, *Kilo Moana* completed survey line 5.

2015-12-06 (JD340) – Surveying in Operational Area West

At **0203**, *Kilo Moana* started survey line 6.

2015-12-07 (JD341) – Surveying in Operational Area West

At **2335**, *Kilo Moana* completed survey line 6.

2015-12-08 (JD342) – Surveying in Operational Area West

At **0132**, *Kilo Moana* started survey line 7.

2015-12-09 (JD343) – Surveying in Operational Area West

At **2133**, *Kilo Moana* completed survey line 7; survey line 8 started at **2347**.

2015-12-10 (JD344) – Surveying in Operational Area West

A routine day of surveying in Operational Area West.

2015-12-11 (JD345) – Surveying in Operational Area West

At **1614**, *Kilo Moana* completed survey line 8; crossline 1 started at **1704**.

1257: During the capture of file line 114, the Knudsen once again blew a high voltage output fuse, and had to be repaired and reset.

2015-12-12 (JD346) – Surveying Crosslines

At **0110**, the Knudsen started sounding again. In order to resynchronize line filenames, the EM122 was moved to file line 115 (leaving approximately 70 min. of data in file line 114).

2015-12-13 (JD347) – Surveying Crosslines

At **0928**, during the capture of file line 120, it was discovered that the Knudsen was having power issues due to a bad connection within the power inlet system. Specifically, one of the two phase lines to the system had arcing damage to the connector due to having worked loose on a strictly mechanical connection. This subsequently caused more significant power drain in the rest of the system due to higher line impedance, and therefore was causing fuses to fail (or, rather, to blow correctly and protect the remainder of the equipment). The University of Hawaiʻi technicians hard-soldered the failing connection, checked all of the fuses, and then restarted the system. When the Knudsen started sounding again a **1038**, it was not required to resynchronize line filenames.

1141: *Kilo Moana* completed crossline 1; crossline 2 started at **1320**.

2015-12-14 (JD348) – Surveying Crosslines

A routine day of survey on crossline 2.

2015-12-15 (JD349) – Surveying Crosslines

At **0220**, *Kilo Moana* completed crossline 2; crossline 3 started at **0412**.

2015-12-16 (JD350) – Surveying Crosslines

At **1918**, it became apparent that the Knudsen's synchronization mode had either been set, or had reset, to "internal" rather than "external." It was immediately returned to "external" synchronization; there was no clear indication for how long this had been in effect, or if indeed it had actually been in effect, since there was no evidence of cross-talk in the EM122 data.

2015-12-17 (JD351) – Surveying Crosslines

At **0011**, *Kilo Moana* completed crossline 3; crossline 4 started at **0152**.

2005: Differential correctors to the POS/MV were lost, and the system reverted to coarse acquisition (CA) mode. After investigation, it appeared that the problem was caused by a loose connection in the power feed to the receiver. The University of Hawaiʻi technicians reset the receiver and the POS/MV returned to RTCM DGPS correction mode, recovering accuracy of positioning as before.

2155: The POS/MV again indicated that there was some issue with accuracy, and the SIS console generated an alert indicating the attitude data rates were not as high as expected. At the same time, the bridge indicated that the Dynamic Positioning system was experiencing difficulties. These issues appeared to resolve on their own, suggesting that the problem may have been a faulty solution at the POS/MV, which would affect all systems.

2300: The surface sound speed sensor was observed to be reporting erroneous values, which appeared to have been caused by an increasing leak in the compressed air value used to flush contaminants from the seachest in which the sensor is mounted. Despite multiple attempts to improve the situation by purging air from the seachest, no improvement was observed. Therefore SIS was instructed to use the sound speed profile input instead of the sensor while the ship's engineers attempted to resolve the underlying problem of a leaking compressed air valve.

2015-12-18 (JD352) – Surveying Crosslines/In Transit to Honolulu

At **0020**, the sound speed sensor recovered, and SIS was instructed to use it again for surface sound speed corrections.

0058: The *Kilo Moana* broke line to start transiting back to Honolulu for the end of KM15-20.

0445: The *Kilo Moana* came to an abrupt halt, dropping speed over ground to steerage way before slowly picking up speed again. Speed slowly returned to normal over the next 15 min.

2015-12-19 (JD353) – In Transit to Honolulu

At **1755**, the *Kilo Moana* suffered a main propulsion casualty, and was forced to come to a halt for approximately an hour while repairs were made; the bridge used a single shaft to keep the ship's head pointed into the waves. The proximal cause of the power loss was a thermal cutout in drive electronics, most probably due to a faulty fan that supplies cooling air to the space. Logging was secured during the repair period. After completing repairs, the ship got underway again at **1900**.

2015-12-20 (JD354) – In Transit to Honolulu

At **1456**, *Kilo Moana*completed data acquisition for KM15-20. The ship arrived in Honolulu, HI at **1757** to complete KM15-20.

Section 6

Personnel List

The *Kilo Moana* provided deck officers, crew, and support personnel as appropriate for the safe operation of the ship. Two resident technicians were provided by University of Hawaiʻi to provide assistance in operating the computer and survey equipment on the ship, and to train the science part in their correct usage. The ship and scientific party are listed in Table 6.1.

Name	**Organization**	**Role**
Dr. Brian R. Calder	CCOM-JHC	Chief Scientist
Dr. Giuseppe Masetti	CCOM-JHC	Co-Chief Scientist
CAPT Gray Drewry	University of Hawai'i	Ship's Master
Kris Kopra	University of Hawai'i	Chief Mate
Kim Krueger	University of Hawai'i	Second Mate
Jim Scancella	University of Hawai'i	Third Mate
Joachim Heise	University of Hawai'i	Chief Engineer
Roland Arsenault	CCOM-JHC	Watchstander/Scientist
Rabine Keyetisu	CIDCO France	Watchstander/Scientist
Kandice Gunning	U. Southern Mississippi	Watchstander/Graduate Student
Meike Klischies	GEOMAR	Watchstander/Graduate Student
Sebastian Graber	GEOMAR	Watchstander/Graduate Student
Vincent Lecours	Memorial University	Watchstander/Graduate Student
David Neufeld	NOAA	Watchstander/Scientist
Michael Force	USFWS	Bird Observer
Trevor Young	University of Hawai'i	Lead Technician
Sonia Brugger	University of Hawai'i	Technician

Table 6.1: Ship and science party personnel during KM15-20, leg 2 of the U.S. continental shelf mapping program around Kingman Reef-Palmyra Atoll, Line Islands.

References

[1] L. A. Mayer, M. Jakobsson, and A. A. Armstrong. The compilation and analysis of data relevant to a U.S. claim under the United Nations Law of the Sea Article 76. Technical report, Center for Coastal and Ocean Mapping and NOAA-UNH Joint Hydrographic Center, 2002.

[2] J. V. Gardner and B. R. Calder. U.S. law of the sea cruise to map the southern flank of the Kingman Reef-Palmyra Atoll section of the Line Islands, equatorial Pacific Ocean. Technical report, Center for Coastal and Ocean Mapping and NOAA-UNH Joint Hydrographic Center, 2010.

Appendix A

File Name Translations

In order to maintain compatibility with previous legs of the survey, lines from the SIS and Knudsen Engineering data capture software were renamed to provide a sequential line numbering scheme. The SIS renaming is detailed in Table A.1 and that for the Knudsen is detailed in Table A.2.

Table A.1: Line name translations for Kongsberg EM122 data files captured in SIS.

ID	Original Name	Translated Name
1	0000_20151121_042759_KM122	KingmanPalmyra_line_200tran
2	0001_20151121_043024_KM122	KingmanPalmyra_line_201tran
3	0002_20151121_075613_KM122	KingmanPalmyra_line_202patch
4	0003_20151121_085742_KM122	KingmanPalmyra_line_203patch
5	0004_20151121_100209_KM122	KingmanPalmyra_line_204patch
6	0005_20151121_115930_KM122	KingmanPalmyra_line_205patch
7	0006_20151121_132000_KM122	KingmanPalmyra_line_206patch
8	0007_20151121_142223_KM122	KingmanPalmyra_line_207patch
9	0008_20151121_152657_KM122	KingmanPalmyra_line_208patch
10	0009_20151121_162905_KM122	KingmanPalmyra_line_209tran
11	0010_20151122_000014_KM122	KingmanPalmyra_line_210tran
12	0011_20151122_060005_KM122	KingmanPalmyra_line_211tran
13	0012_20151122_120025_KM122	KingmanPalmyra_line_212tran
14	0013_20151122_180006_KM122	KingmanPalmyra_line_213tran
15	0015_20151122_203146_KM122	KingmanPalmyra_line_214tran
16	0016_20151122_203736_KM122	KingmanPalmyra_line_215tran
17	0017_20151123_000005_KM122	KingmanPalmyra_line_216tran
18	0018_20151123_060006_KM122	KingmanPalmyra_line_217tran
19	0019_20151123_120018_KM122	KingmanPalmyra_line_218tran
20	0020_20151123_180247_KM122	KingmanPalmyra_line_219tran
21	0021_20151123_180636_KM122	KingmanPalmyra_line_220tran
22	0023_20151124_023511_KM122	KingmanPalmyra_line_221tran
23	0024_20151124_060100_KM122	KingmanPalmyra_line_222tran
24	0025_20151124_120339_KM122	KingmanPalmyra_line_223tran
25	0026_20151124_180010_KM122	KingmanPalmyra_line_224tran
26	0027_20151125_000018_KM122	KingmanPalmyra_line_225tran
27	0028_20151125_060020_KM122	KingmanPalmyra_line_226tran

ID	Original Name	Translated Name
28	0029_20151125_120022_KM122	KingmanPalmyra_line_227tran
29	0030_20151125_180027_KM122	KingmanPalmyra_line_228tran
30	0031_20151126_000028_KM122	KingmanPalmyra_line_229tran
31	0032_20151126_013645_KM122	KingmanPalmyra_line_230
32	0033_20151126_060041_KM122	KingmanPalmyra_line_231
33	0034_20151126_120935_KM122	KingmanPalmyra_line_232
34	0035_20151126_180026_KM122	KingmanPalmyra_line_233
35	0036_20151127_000018_KM122	KingmanPalmyra_line_234
36	0037_20151127_060220_KM122	KingmanPalmyra_line_235
37	0038_20151127_094158_KM122	KingmanPalmyra_line_236
38	0039_20151127_120028_KM122	KingmanPalmyra_line_237
39	0040_20151127_180013_KM122	KingmanPalmyra_line_238
40	0041_20151128_000013_KM122	KingmanPalmyra_line_239
41	0042_20151128_024438_KM122	KingmanPalmyra_line_240turn
42	0043_20151128_040419_KM122	KingmanPalmyra_line_241
43	0044_20151128_061602_KM122	KingmanPalmyra_line_242
44	0045_20151128_120013_KM122	KingmanPalmyra_line_243
45	0046_20151128_180015_KM122	KingmanPalmyra_line_244
46	0047_20151129_000002_KM122	KingmanPalmyra_line_245
47	0048_20151129_035359_KM122	KingmanPalmyra_line_246
48	0049_20151129_060136_KM122	KingmanPalmyra_line_247
49	0050_20151129_120044_KM122	KingmanPalmyra_line_248
50	0051_20151129_180008_KM122	KingmanPalmyra_line_249
51	0052_20151130_000023_KM122	KingmanPalmyra_line_250
52	0053_20151130_021418_KM122	KingmanPalmyra_line_251turn
53	0054_20151130_051403_KM122	KingmanPalmyra_line_252
54	0055_20151130_120013_KM122	KingmanPalmyra_line_253
55	0056_20151130_180011_KM122	KingmanPalmyra_line_254
56	0057_20151201_000017_KM122	KingmanPalmyra_line_255
57	0058_20151201_060151_KM122	KingmanPalmyra_line_256
58	0059_20151201_120030_KM122	KingmanPalmyra_line_257
59	0060_20151201_151859_KM122	KingmanPalmyra_line_258
60	0061_20151201_180014_KM122	KingmanPalmyra_line_259
61	0062_20151202_000013_KM122	KingmanPalmyra_line_260
62	0063_20151202_020657_KM122	KingmanPalmyra_line_261turn
63	0064_20151202_024008_KM122	KingmanPalmyra_line_262turn
64	0065_20151202_030955_KM122	KingmanPalmyra_line_263turn
65	0066_20151202_034145_KM122	KingmanPalmyra_line_264turn
66	0067_20151202_042344_KM122	KingmanPalmyra_line_265turn
67	0068_20151202_052655_KM122	KingmanPalmyra_line_266
68	0069_20151202_080727_KM122	KingmanPalmyra_line_267
69	0070_20151202_120021_KM122	KingmanPalmyra_line_268
70	0071_20151202_180006_KM122	KingmanPalmyra_line_269
71	0072_20151203_000005_KM122	KingmanPalmyra_line_270
72	0073_20151203_060021_KM122	KingmanPalmyra_line_271
73	0074_20151203_120016_KM122	KingmanPalmyra_line_272
74	0075_20151203_180015_KM122	KingmanPalmyra_line_273
75	0076_20151204_000017_KM122	KingmanPalmyra_line_274
76	0077_20151204_014954_KM122	KingmanPalmyra_line_275turn

ID	Original Name	Translated Name
77	0078_20151204_034143_KM122	KingmanPalmyra_line_276
78	0079_20151204_060051_KM122	KingmanPalmyra_line_277
79	0080_20151204_120030_KM122	KingmanPalmyra_line_278
80	0081_20151204_180007_KM122	KingmanPalmyra_line_279
81	0082_20151205_000031_KM122	KingmanPalmyra_line_280
82	0083_20151205_060117_KM122	KingmanPalmyra_line_281
83	0084_20151205_120020_KM122	KingmanPalmyra_line_282
84	0085_20151205_180010_KM122	KingmanPalmyra_line_283
85	0086_20151205_234736_KM122	KingmanPalmyra_line_284turn
86	0087_20151206_020312_KM122	KingmanPalmyra_line_285
87	0088_20151206_060640_KM122	KingmanPalmyra_line_286
88	0089_20151206_120026_KM122	KingmanPalmyra_line_287
89	0090_20151206_180020_KM122	KingmanPalmyra_line_288
90	0091_20151207_000005_KM122	KingmanPalmyra_line_289
91	0092_20151207_060252_KM122	KingmanPalmyra_line_290
92	0093_20151207_120014_KM122	KingmanPalmyra_line_291
93	0094_20151207_180010_KM122	KingmanPalmyra_line_292
94	0095_20151207_233505_KM122	KingmanPalmyra_line_293turn
95	0096_20151208_013246_KM122	KingmanPalmyra_line_294
96	0097_20151208_060027_KM122	KingmanPalmyra_line_295
97	0098_20151208_120013_KM122	KingmanPalmyra_line_296
98	0099_20151208_180006_KM122	KingmanPalmyra_line_297
99	0100_20151209_000022_KM122	KingmanPalmyra_line_298
100	0101_20151209_060028_KM122	KingmanPalmyra_line_299
101	0102_20151209_120026_KM122	KingmanPalmyra_line_300
102	0103_20151209_180005_KM122	KingmanPalmyra_line_301
103	0104_20151209_213316_KM122	KingmanPalmyra_line_302turn
104	0105_20151209_234715_KM122	KingmanPalmyra_line_303
105	0106_20151210_060200_KM122	KingmanPalmyra_line_304
106	0107_20151210_120014_KM122	KingmanPalmyra_line_305
107	0108_20151210_180003_KM122	KingmanPalmyra_line_306
108	0109_20151211_000008_KM122	KingmanPalmyra_line_307
109	0110_20151211_055926_KM122	KingmanPalmyra_line_308
110	0111_20151211_120019_KM122	KingmanPalmyra_line_309
111	0112_20151211_161425_KM122	KingmanPalmyra_line_310turn
112	0113_20151211_170422_KM122	KingmanPalmyra_line_311
113	0114_20151212_000046_KM122	KingmanPalmyra_line_312
114	0115_20151212_012401_KM122	KingmanPalmyra_line_313
115	0116_20151212_060607_KM122	KingmanPalmyra_line_314
116	0117_20151212_120007_KM122	KingmanPalmyra_line_315
117	0118_20151212_180010_KM122	KingmanPalmyra_line_316
118	0119_20151213_000010_KM122	KingmanPalmyra_line_317
119	0120_20151213_060339_KM122	KingmanPalmyra_line_318
120	0121_20151213_114122_KM122	KingmanPalmyra_line_319turn
121	0122_20151213_132049_KM122	KingmanPalmyra_line_320
122	0123_20151213_180025_KM122	KingmanPalmyra_line_321
123	0124_20151214_000007_KM122	KingmanPalmyra_line_322
124	0125_20151214_055957_KM122	KingmanPalmyra_line_323
125	0126_20151214_120017_KM122	KingmanPalmyra_line_324

ID	Original Name	Translated Name
126	0127_20151214_180020_KM122	KingmanPalmyra_line_325
127	0128_20151215_000007_KM122	KingmanPalmyra_line_326
128	0129_20151215_021955_KM122	KingmanPalmyra_line_327turn
129	0130_20151215_041222_KM122	KingmanPalmyra_line_328
130	0131_20151215_060224_KM122	KingmanPalmyra_line_329
131	0132_20151215_120006_KM122	KingmanPalmyra_line_330
132	0133_20151215_180023_KM122	KingmanPalmyra_line_331
133	0134_20151216_000013_KM122	KingmanPalmyra_line_332
134	0135_20151216_060015_KM122	KingmanPalmyra_line_333
135	0136_20151216_120023_KM122	KingmanPalmyra_line_334
136	0137_20151216_180010_KM122	KingmanPalmyra_line_335
137	0138_20151217_001118_KM122	KingmanPalmyra_line_336turn
138	0139_20151217_015307_KM122	KingmanPalmyra_line_337
139	0140_20151217_060244_KM122	KingmanPalmyra_line_338
140	0141_20151217_120013_KM122	KingmanPalmyra_line_339
141	0142_20151217_180014_KM122	KingmanPalmyra_line_340
142	0143_20151218_005844_KM122	KingmanPalmyra_line_341tran
143	0144_20151218_060021_KM122	KingmanPalmyra_line_342tran
144	0145_20151218_120021_KM122	KingmanPalmyra_line_343tran
145	0146_20151218_180011_KM122	KingmanPalmyra_line_344tran
146	0147_20151219_000004_KM122	KingmanPalmyra_line_345tran
147	0148_20151219_060014_KM122	KingmanPalmyra_line_346tran
148	0149_20151219_120024_KM122	KingmanPalmyra_line_347tran
149	0150_20151219_180013_KM122	KingmanPalmyra_line_348tran
150	0152_20151219_185925_KM122	KingmanPalmyra_line_349tran
151	0153_20151220_000057_KM122	KingmanPalmyra_line_350tran
152	0154_20151220_060023_KM122	KingmanPalmyra_line_351tran
153	0155_20151220_120022_KM122	KingmanPalmyra_line_352tran

Table A.2: Line name translations for Knudsen Engineering 3260 data files.

ID	Original Name	Translated Name
1	0001_325_0429_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_201tran.sgy
2	0002_325_0756_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_202patch.sgy
3	0003_325_0856_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_203patch.sgy
4	0004_325_0957_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_204patch.sgy
5	0005_325_1159_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_205patch.sgy
6	0006_325_1319_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_206patch.sgy
7	0007_325_1422_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_207patch.sgy
8	0008_325_1526_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_208patch.sgy
9	0009_325_1629_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_209tran.sgy
10	0010_326_0000_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_210tran.sgy
11	0011_326_0600_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_211tran.sgy
12	0012_326_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_212tran.sgy
13	0013_326_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_213tran.sgy
14	0015_326_2037_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_214tran.sgy
15	0016_327_0000_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_215tran.sgy
16	0017_327_0340_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_216tran.sgy

ID	Original Name	Translated Name
17	0018_327_0600_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_217tran.sgy
18	0019_327_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_218tran.sgy
19	0020_327_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_219tran.sgy
20	0021_327_1804_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_220tran.sgy
21	0023_328_0235_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_221tran.sgy
22	0024_328_0601_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_222tran.sgy
23	0025_328_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_223tran.sgy
24	0026_328_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_224tran.sgy
25	0027_329_0000_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_225tran.sgy
26	0028_329_0600_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_226tran.sgy
27	0029_329_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_227tran.sgy
28	0030_329_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_228tran.sgy
29	0031_330_0000_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_229tran.sgy
30	0032_330_0136_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_230.sgy
31	0033_330_0600_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_231.sgy
32	0034_330_1209_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_232.sgy
33	0035_330_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_233.sgy
34	0036_331_0000_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_234.sgy
35	0037_331_0602_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_235.sgy
36	0038_331_0942_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_236.sgy
37	0039_331_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_237.sgy
38	0040_331_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_238.sgy
39	0041_332_0000_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_239.sgy
40	0042_332_0244_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_240turn.sgy
41	0043_332_0404_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_241.sgy
42	0044_332_0616_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_242.sgy
43	0045_332_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_243.sgy
44	0046_332_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_244.sgy
45	0047_333_0000_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_245.sgy
46	0048_333_0354_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_246.sgy
47	0049_333_0601_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_247.sgy
48	0050_333_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_248.sgy
49	0051_333_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_249.sgy
50	0052_334_0000_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_250.sgy
51	0053_334_0214_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_251turn.sgy
52	0054_334_0514_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_252.sgy
53	0055_334_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_253.sgy
54	0056_334_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_254.sgy
55	0057_335_0000_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_255.sgy
56	0058_335_0601_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_256.sgy
57	0059_335_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_257.sgy
58	0060_335_1518_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_258.sgy
59	0061_335_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_259.sgy
60	0062_336_0000_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_260.sgy
61	0063_336_0151_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_261turn.sgy
62	0067_336_0423_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_265turn.sgy
63	0068_336_0527_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_266.sgy
64	0069_336_0808_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_267.sgy
65	0070_336_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_268.sgy

ID	Original Name	Translated Name
66	0071_336_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_269.sgy
67	0072_337_0000_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_270.sgy
68	0073_337_0600_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_271.sgy
69	0074_337_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_272.sgy
70	0075_337_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_273.sgy
71	0076_338_0000_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_274.sgy
72	0077_338_0149_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_275turn.sgy
73	0078_338_0341_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_276.sgy
74	0079_338_0601_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_277.sgy
75	0080_338_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_278.sgy
76	0081_338_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_279.sgy
77	0082_339_0000_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_280.sgy
78	0083_339_0601_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_281.sgy
79	0084_339_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_282.sgy
80	0085_339_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_283.sgy
81	0086_339_2347_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_284turn.sgy
82	0087_340_0203_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_285.sgy
83	0088_340_0606_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_286.sgy
84	0089_340_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_287.sgy
85	0090_340_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_288.sgy
86	0091_341_0000_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_289.sgy
87	0092_341_0603_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_290.sgy
88	0093_341_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_291.sgy
89	0094_341_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_292.sgy
90	0095_341_2335_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_293turn.sgy
91	0096_342_0132_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_294.sgy
92	0097_342_0600_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_295.sgy
93	0098_342_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_296.sgy
94	0099_342_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_297.sgy
95	0100_343_0000_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_298.sgy
96	0101_343_0600_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_299.sgy
97	0102_343_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_300.sgy
98	0103_343_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_301.sgy
99	0104_343_2133_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_302turn.sgy
100	0105_343_2347_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_303.sgy
101	0106_344_0602_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_304.sgy
102	0107_344_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_305.sgy
103	0108_344_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_306.sgy
104	0109_345_0000_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_307.sgy
105	0110_345_0559_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_308.sgy
106	0111_345_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_309.sgy
107	0112_345_1614_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_310turn.sgy
108	0113_345_1704_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_311.sgy
109	0114_346_0000_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_312.sgy
110	0115_346_0123_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_313.sgy
111	0116_346_0606_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_314.sgy
112	0117_346_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_315.sgy
113	0118_346_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_316.sgy
114	0119_347_0000_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_317.sgy

ID	Original Name	Translated Name
115	0120_347_0603_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_318.sgy
116	0121_347_1141_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_319turn.sgy
117	0122_347_1320_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_320.sgy
118	0123_347_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_321.sgy
119	0124_348_0000_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_322.sgy
120	0125_348_0600_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_323.sgy
121	0126_348_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_324.sgy
122	0127_348_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_325.sgy
123	0128_349_0000_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_326.sgy
124	0129_349_0220_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_327turn.sgy
125	0130_349_0413_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_328.sgy
126	0131_349_0602_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_329.sgy
127	0132_349_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_330.sgy
128	0133_349_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_331.sgy
129	0134_350_0000_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_332.sgy
130	0135_350_0600_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_333.sgy
131	0136_350_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_334.sgy
132	0137_350_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_335.sgy
133	0138_351_0011_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_336turn.sgy
134	0139_351_0153_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_337.sgy
135	0140_351_0602_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_338.sgy
136	0141_351_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_339.sgy
137	0142_351_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_340.sgy
138	0143_352_0058_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_341tran.sgy
139	0144_352_0600_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_342tran.sgy
140	0145_352_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_343tran.sgy
141	0146_352_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_344tran.sgy
142	0147_353_0000_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_345tran.sgy
143	0148_353_0600_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_346tran.sgy
144	0149_353_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_347tran.sgy
145	0150_353_1800_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_348tran.sgy
146	0152_353_1859_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_349tran.sgy
147	0153_354_0000_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_350tran.sgy
148	0154_354_0600_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_351tran.sgy
149	0155_354_1200_70884_CHP3.5_FLT_000.sgy	KingmanPalmyra_line_352tran.sgy

Appendix B

XBT Launch Metadata

A total of 172 XBTs were launched during the course of the survey, Figure B.1, of which 9 (5%) failed on or after launch. The metadata associated with these launches are given in Table B.1 on the following pages, and are available digitally with the cruise report archive.

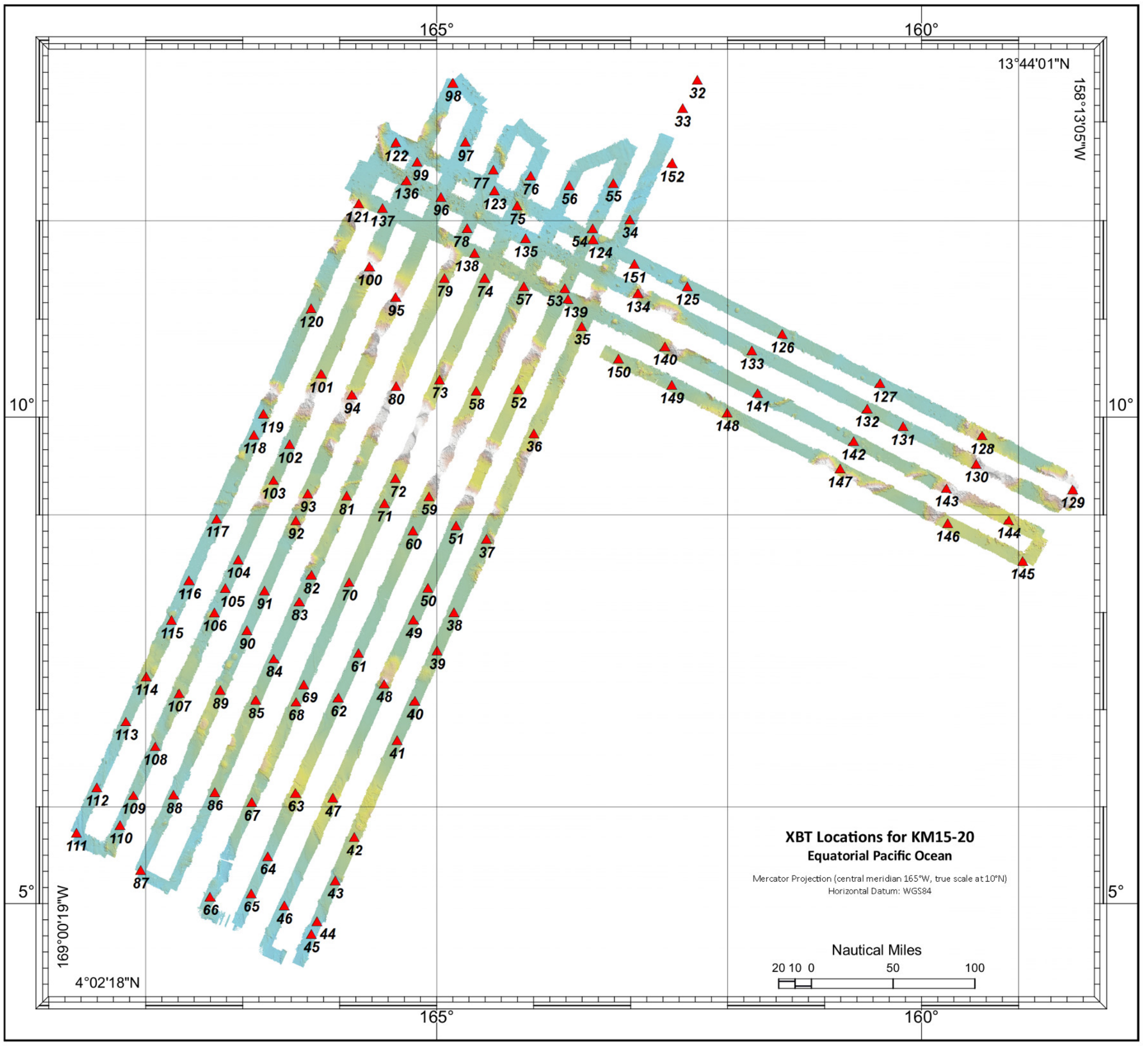


Figure B.1: Locations of the XBTs launched during the course of the survey in an attempt to understand the sound speed profile structure of the water column and therefore correct for refraction.

Table B.1: Metadata of XBT launches conducted during KM15-20

#	Serial Number	Date and Time	Latitude (N)	Longitude (W)	Maximum Depth (m)	TDR SS (m/s)	MultiBeam Filename	Additional Notes
1	1096920	2015-11-21 04:56	20 43.031	158 03.184	760.4	1532.6	20151121_045650	Deep Blue
2	13093594	2015-11-21 07:28	20 16.082	158 11.194	1100.1	1538.8	20151121_072837	XCTD-1
3	1096924	2015-11-21 07:38	20 14.084	158 11.788	760.4	1533.9	//	Deep Blue - Not Loaded
//	1096928	2015-11-21 14:05	//	//	//	//	//	Deep Blue - Busted Wire
4	1096929	2015-11-21 14:08	20 02.294	158 15.813	760.4	1534.0	20151121_140814	DeepBlue
//	1096925	2015-11-21 18:02	19 46.012	158 25.277	//	//	//	Deep Blue - Failed
5	1096921	2015-11-21 18:08	19 45.084	158 25.847	760.4	1534.6	20151121_180842	Deep Blue
6	1096714	2015-11-21 22:23	19 04.406	158 50.954	760.4	1534.3	20151121_222328	Deep Blue
7	1096715	2015-11-22 00:05	18 47.669	159 01.292	760.4	1534.3	20151122_000515	Deep Blue
8	1096718	2015-11-22 05:58	17 46.209	159 38.058	760.4	1534.4	20151122_055833	Deep Blue
9	1096722	2015-11-22 12:07	16 43.770	160 17.199	760.4	1535.2	20151122_120745	Deep Blue
10	1096716	2015-11-22 18:02	15 42.441	160 54.458	760.4	1535.4	20151122_180214	Deep Blue
11	1096717	2015-11-23 00:04	15 54.599	160 42.315	760.4	1535.4	20151123_000420	Deep Blue
12	1096719	2015-11-23 01:32	16 13.355	160 32.596	760.4	1536.1	20151123_013412	Deep Blue
13	1096723	2015-11-23 05:56	17 09.478	160 03.424	760.4	1535.3	20151123_055638	Deep Blue
14	1096724	2015-11-23 11:10	18 17.805	159 27.638	760.4	1534.3	20151123_111016	Deep Blue
15	1096720	2015-11-23 15:06	19 08.683	159 00.843	760.4	1534.8	20151123_150625	Deep Blue
16	1096725	2015-11-23 17:00	19 33.641	158 47.691	760.4	1534.1	20151123_170042	Deep Blue
17	1097289	2015-11-23 18:10	19 49.438	158 39.328	760.4	1534.5	20151123_181250	Deep Blue
18	1097288	2015-11-23 19:53	20 11.802	158 27.431	760.4	1533.8	20151123_195350	Deep Blue
19	1097287	2015-11-23 22:01	20 40.940	158 11.918	760.4	1534.1	20151123_220334	Deep Blue
20	1097286	2015-11-23 23:12	20 55.022	158 04.440	760.4	1533.2	20151123_231234	Deep Blue
21	1097282	2015-11-24 00:03	21 05.694	157 58.761	760.4	1533.6	20151124_000309	Deep Blue
22	1097283	2015-11-24 06:02	20 37.605	158 12.378	760.4	1533.7	20151124_060311	Deep Blue
23	1097278	2015-11-24 11:20	19 42.366	158 45.500	760.4	1534.9	20151124_112021	Deep Blue
24	1097279	2015-11-24 16:54	18 44.026	159 19.960	760.4	1533.9	20151124_165426	Deep Blue
25	1097284	2015-11-24 18:05	18 31.241	159 27.598	760.4	1533.9	20151124_180517	Deep Blue
26	1097280	2015-11-24 19:19	18 17.636	159 35.614	760.4	1534.7	20151124_192103	Deep Blue
27	1097281	2015-11-25 00:00	17 28.905	160 04.192	760.4	1535.4	20151125_000054	Deep Blue
28	1097285	2015-11-25 01:54	17 08.136	160 12.064	760.4	1535.8	20151125_015622	Deep Blue

#	Serial Number	Date and Time	Latitude (N)	Longitude (W)	Maximum Depth (m)	TDR SS (m/s)	MultiBeam Filename	Additional Notes
29	1178910	2015-11-25 06:01	16 25.938	160 36.652	760.4	1535.5	20151125_060130	Deep Blue
30	1178911	2015-11-25 12:04	15 21.566	161 15.835	760.4	1535.2	20151125_120429	Deep Blue
31	1178912	2015-11-25 17:56	14 15.511	161 51.897	760.4	1534.8	20151125_175749	Deep Blue
32	1178913	2015-11-25 22:28	13 25.719	162 18.933	760.4	1535.6	20151125_222819	Deep Blue
33	1178909	2015-11-26 00:04	13 08.578	162 28.169	760.4	1535.8	20151126_000406	Deep Blue
34	1178908	2015-11-26 06:09	12 01.590	163 00.490	759.2	1535.9	20151126_061324	Deep Blue
35	1178907	2015-11-26 12:03	10 56.124	163 30.395	760.4	1536.7	20151126_120350	Deep Blue
36	1178906	2015-11-26 18:01	09 50.536	164 00.130	760.4	1537.1	20151126_180300	Deep Blue
37	1178902	2015-11-26 23:58	08 45.553	164 29.402	760.4	1537.8	20151126_000036	Deep Blue
38	1178904	2015-11-27 04:16	08 00.680	164 49.466	760.4	1538.5	20151127_041801	Deep Blue
39	1178905	2105-11-27 06:35	07 36.911	165 00.060	760.4	1538.5	20151127_063542	Deep Blue
40	1096758	2015-11-27 09:37	07 05.790	165 13.900	760.4	1539.4	20151127_093733	Deep Blue
41	1096759	2015-11-27 12:04	06 41.660	165 24.641	760.4	1539.5	20151127_120428	Deep Blue
//	1096760	2015-11-27 18:02	05 42.216	165 50.957	370.6	1539.4	//	Deep Blue - Failed
42	1096761	2015-11-27 18:06	05 41.707	165 51.195	760.4	1535.5	20151127_180527	Deep Blue
43	1096755	2015-11-27 20:43	05 14.972	166 02.982	760.4	1540.0	20151127_204530	Deep Blue
44	1096754	2015-11-27 23:14	04 49.730	166 14.158	760.4	1540.3	20151127_231432	Deep Blue
45	1096756	2015-11-27 23:59	04 41.612	166 17.724	760.4	1540.3	20151128_000212	Deep Blue
46	1096750	2015-11-28 06:19	04 59.329	166 34.615	760.4	1540.3	20151128_061915	Deep Blue
47	1096751	2015-11-28 12:04	06 06.085	166 04.527	760.4	1539.6	20151128_120407	Deep Blue
//	1096757	2015-11-28 18:01	07 12.182	165 34.546	760.4	1538.8	//	Deep Blue - Bad cast
//	1096752	2015-11-28 18:04	07 12.666	165 34.326	760.4	1538.8	//	Deep Blue - Bad cast
//	1096753	2015-11-28 18:10	//	//	//	//	//	Deep Blue - Cut
//	1211390	2015-11-28 18:13	07 14.118	165 33.662	760.4	1539.1	//	Deep Blue - Bad cast
48	1211389	2015-11-28 18:23	07 16.448	165 32.605	760.4	1539.1	20151128_182650	Deep Blue
49	1211394	2015-11-28 22:09	07 55.944	165 14.635	760.4	1538.4	20151128_220918	Deep Blue
50	1211338	2015-11-29 00:01	08 15.520	165 05.722	760.4	1538.3	20151129_000207	Deep Blue
51	1211398	2015-11-29 03:48	08 53.763	164 48.195	760.4	1537.4	20151129_034810	Deep Blue
52	1211387	2015-11-29 12:04	10 17.447	164 09.660	760.4	1536.8	20151129_120400	Deep Blue
53	1211393	2015-11-29 18:00	11 19.382	163 40.883	760.4	1536.3	20151129_180234	Deep Blue
54	1211392	2015-11-29 21:24	11 55.802	163 23.847	760.4	1535.7	20151129_212559	Deep Blue
55	1211391	2015-11-30 00:00	12 23.293	163 10.984	760.4	1535.7	20151130_000159	Deep Blue

#	Serial Number	Date and Time	Latitude (N)	Longitude (W)	Maximum Depth (m)	TDR SS (m/s)	MultiBeam Filename	Additional Notes
56	1211397	2015-11-30 06:13	12 21.570	163 38.070	760.4	1535.9	20151130_061308	Deep Blue
57	1211396	2015-11-30 12:03	11 20.343	164 06.373	760.0	1536.8	20151130_120325	Deep Blue
58	1211395	2015-11-30 17:59	10 16.586	164 35.654	760.4	1536.5	20151130_180116	Deep Blue
59	1234581	2015-12-01 00:03	09 11.845	165 05.097	760.4	1536.7	20151201_000356	Deep Blue
60	1234585	2015-12-01 02:05	08 50.615	165 14.723	760.4	1535.7	20151201_020514	Deep Blue
61	1234589	2015-12-01 09:21	07 35.269	165 48.711	760.4	1537.7	20151201_092114	Deep Blue
62	12345582	2015-12-01 12:03	07 07.673	166 01.088	760.4	1538.4	20151201_120324	Deep Blue
63	1234586	2015-12-01 17:54	06 08.881	166 27.417	760.4	1539.3	20151201_175610	Deep Blue
64	1234583	2015-12-01 21:55	05 29.898	166 44.814	760.4	1539.8	20151201_215533	Deep Blue
65	1234590	2015-12-02 00:11	05 06.859	166 55.089	760.4	1540.2	20151202_001230	Deep Blue
66	1234587	2015-12-02 06:07	05 04.839	167 20.299	760.4	1540.0	20151202_060727	Deep Blue
67	1234584	2015-12-02 11:14	06 03.223	166 54.600	760.0	1539.2	20151202_111422	Deep Blue
68	1234588	2015-12-02 16:59	07 05.268	166 27.191	760.0	1538.2	20151202_165947	Deep Blue
69	1230605	2015-12-02 18:00	07 16.125	166 22.380	760.4	1538.0	20151202_180218	Deep Blue
70	1234609	2015-12-03 00:01	08 19.062	165 54.392	760.4	1537.7	20151203_000337	Deep Blue
71	1234613	2015-12-03 04:40	09 07.649	165 32.684	760.4	1536.9	20151203_044020	Deep Blue
72	1234606	2015-12-03 06:07	09 22.625	165 25.980	760.4	1536.8	20151203_060948	Deep Blue
73	1234591	2015-12-03 12:03	10 23.470	164 58.604	760.4	1536.1	20151203_120312	Deep Blue
74	1234610	2015-12-03 18:00	11 25.281	164 30.568	760.4	1536.2	20151203_180201	Deep Blue
75	1234614	2015-12-03 22:14	12 09.414	164 10.408	760.4	1535.6	20151203_221535	Deep Blue
76	1234615	2015-12-04 00:00	12 27.570	164 02.109	760.4	1535.1	20151204_000105	Deep Blue
77	1234592	2015-12-04 06:04	12 31.348	164 25.043	760.4	1535.4	20151204_060412	Deep Blue
78	1234611	2015-12-04 09:24	11 55.930	164 41.345	760.4	1536.4	20151204_092603	Deep Blue
79	1234612	2015-12-04 12:16	11 25.407	164 55.377	760.0	1536.1	20151204_121618	Deep Blue
80	1234616	2015-12-04 18:02	10 19.604	165 25.375	760.4	1535.8	20151204_180403	Deep Blue
81	1234607	2015-12-04 23:55	09 12.189	165 55.906	760.4	1536.3	20151204_235641	Deep Blue
82	1234608	2015-12-05 04:29	08 23.555	166 17.759	760.4	1537.1	20151205_043023	Deep Blue
83	1179245	2015-12-05 06:06	08 06.994	166 25.170	760.4	1537.3	20151205_060657	Deep Blue
84	1179249	2015-12-05 09:30	07 32.042	167 40.795	760.4	1538.2	20151205_093020	Deep Blue
85	1179248	2015-12-05 12:03	07 06.437	166 52.184	760.4	1538.4	20151205_120403	Deep Blue
86	1179247	2015-12-05 17:57	06 09.548	167 17.517	760.4	1538.9	20151205_175902	Deep Blue
87	1179246	2015-12-06 02:03	05 21.304	168 03.293	760.4	1539.3	20151206_020304	Deep Blue

#	Serial Number	Date and Time	Latitude (N)	Longitude (W)	Maximum Depth (m)	TDR SS (m/s)	MultiBeam Filename	Additional Notes
88	1179244	2015-12-06 06:10	06 07.814	167 42.799	760.4	1538.9	20151206_061009	Deep Blue
89	1179243	2015-12-06 12:03	07 12.468	167 14.143	760.0	1538.7	20151206_120352	Deep Blue
90	1179242	2015-12-06 15:35	07 49.326	166 57.732	760.4	1537.2	20151206_153555	Deep Blue
91	1179241	2015-12-06 18:02	08 13.966	166 46.738	760.4	1537.0	20151206_180306	Deep Blue
92	1179240	2015-12-06 22:22	08 57.114	166 27.400	760.4	1536.4	20151206_222418	Deep Blue
93	1179239	2015-12-07 12:04	09 13.602	166 19.992	760.4	1536.3	20151207_000412	Deep Blue
94	1179238	2015-12-07 06:05	10 14.172	165 52.680	760.4	1535.5	20151207_060549	Deep Blue
95	1234596	2015-12-07 12:05	11 13.673	165 25.609	760.4	1535.6	20151207_120510	Deep Blue
96	1234595	2015-12-07 18:08	12 14.909	164 57.613	760.4	1535.6	20151207_180909	Deep Blue
97	1234600	2015-12-07 21:22	12 48.039	164 42.361	760.4	1534.8	20151207_212342	Deep Blue
98	1234599	2015-12-08 01:35	13 23.986	164 50.146	760.4	1534.6	20151208_013727	Deep Blue
99	1234594	2015-12-08 06:00	12 36.240	165 12.313	760.0	1535.7	20151208_060052	Deep Blue
100	1234598	2015-12-08 12:02	11 32.288	165 41.709	760.0	1535.5	20151208_120236	Deep Blue
101	1234593	2015-12-08 18:02	10 26.801	166 11.601	760.4	1535.4	20151208_180401	Deep Blue
102	1234597	2015-12-08 21:58	09 43.827	166 31.130	760.4	1535.9	20151208_220033	Deep Blue
103	1234604	2015-12-09 00:01	09 21.670	166 41.107	760.4	1536.0	20151209_000147	Deep Blue
104	1234603	2015-12-09 04:26	08 33.069	167 02.953	760.4	1536.7	20151209_042610	Deep Blue
105	1234602	2015-12-09 06:02	08 15.331	167 10.914	760.4	1536.9	20151209_060251	Deep Blue
106	1234601	2015-12-09 07:24	08 00.438	167 17.589	760.4	1537.6	20151209_072459	Deep Blue
107	1234536	2015-12-09 12:04	07 10.675	167 39.795	760.4	1537.8	20151209_120432	Deep Blue
108	1234534	2015-12-09 15:07	06 37.802	167 54.422	760.0	1538.8	20151209_150727	Deep Blue
109	1234535	2015-12-09 18:02	06 07.517	168 07.853	760.4	1538.5	20151209_180101	Deep Blue
110	1234533	2015-12-09 19:47	05 49.083	168 16.029	760.4	1539.2	20151209_194830	Deep Blue
111	1234540	2015-12-09 23:52	05 44.471	168 42.917	760.4	1539.2	20151209_235109	Deep Blue
112	1234539	2015-12-10 02:26	06 12.470	168 30.482	760.4	1538.7	20151210_022607	Deep Blue
113	1234538	2015-12-10 06:05	06 53.109	168 12.357	760.4	1538.4	20151210_060513	Deep Blue
114	1234537	2015-12-10 08:41	07 20.862	167 59.965	760.4	1537.4	20151210_084124	Deep Blue
115	1234544	2015-12-10 12:02	07 55.753	167 44.387	760.0	1537.4	20151210_120252	Deep Blue
116	1234543	2015-12-10 14:23	08 20.171	167 33.410	760.0	1536.4	20151210_142353	Deep Blue
117	1234542	2015-12-10 18:00	08 58.254	167 16.259	760.4	1535.9	20151210_180342	Deep Blue
118	1234541	2015-12-10 22:55	09 49.487	166 53.091	760.4	1535.4	20151210_225505	Deep Blue
119	1178925	2015-12-11 00:05	10 02.285	166 47.102	760.4	1535.2	20151211_000544	Deep Blue

#	Serial Number	Date and Time	Latitude (N)	Longitude (W)	Maximum Depth (m)	TDR SS (m/s)	MultiBeam Filename	Additional Notes
120	1178924	2015-12-11 06:03	11 06.723	166 17.910	760.4	1535.2	20151211_060326	Deep Blue
121	1178923	2015-12-11 12:03	12 10.768	165 48.508	760.4	1534.8	20151211_120310	Deep Blue
122	1178922	2015-12-11 18:02	12 47.890	165 25.373	760.4	1535.1	20151211_180258	Deep Blue
123	1178921	2015-12-12 00:00	12 18.621	164 24.404	760.4	1535.0	20151212_000202	Deep Blue
124	1178920	2015-12-12 06:08	11 49.049	163 23.498	760.4	1534.6	20151212_060839	Deep Blue
125	1178919	2015-12-12 12:02	11 20.371	162 25.048	760.0	1534.3	20151212_120256	Deep Blue
126	1178918	2015-12-12 18:02	10 51.309	161 26.391	760.4	1535.2	20151212_180321	Deep Blue
127	1178917	2015-12-12 23:57	10 21.078	160 26.097	760.4	1535.5	20151212_235904	Deep Blue
128	1178914	2015-12-13 06:04	09 49.102	159 22.801	760.4	1534.8	20151213_060400	Deep Blue
129	1178915	2015-12-13 12:02	09 16.015	158 26.769	760.4	1535.0	20151213_120240	Deep Blue
130	1178916	2015-12-13 18:02	09 31.801	159 26.481	760.4	1534.4	20151213_180208	Deep Blue
131	1234564	2015-12-13 22:04	09 54.624	160 11.788	760.4	1534.9	20151213_220445	Deep Blue
132	1234568	2015-12-14 00:03	10 05.768	160 34.089	760.4	1534.8	20151214_000327	Deep Blue
133	1234559	2015-12-14 06:04	10 41.235	161 45.312	760.4	1534.6	20151214_060407	Deep Blue
134	1234563	2015-12-14 12:03	11 15.878	162 55.778	760.0	1534.5	20151214_120303	Deep Blue
135	1234567	2015-12-14 18:00	11 49.512	164 05.107	760.4	1534.9	20151214_180052	Deep Blue
//	13093589	2015-12-15 00:08	12 23.709	165 16.361	1100.0	//	//	XCTD-1 - Bad cast
136	1234560	2015-12-15 00:20	12 24.924	165 18.880	760.4	1535.2	20151215_002052	Deep Blue
137	1234558	2015-12-15 06:04	12 08.094	165 33.912	760.4	1535.1	20151215_060434	Deep Blue
138	1234562	2015-12-15 12:02	11 40.734	164 36.813	760.4	1535.1	20151215_120239	Deep Blue
139	1234566	2015-12-15 18:03	11 12.794	163 38.961	760.4	1535.7	20151215_180304	Deep Blue
140	13093591	2015-12-16 00:09	10 43.527	162 39.102	1100.1	1539.0	20151216_000930	XCTD-1
141	1234557	2015-12-16 06:03	10 15.203	161 41.649	760.0	1534.1	20151216-060308	Deep Blue
142	1234561	2015-12-16 12:04	09 45.683	160 42.349	760.0	1534.4	20151216_120402	Deep Blue
143	1234565	2015-12-16 18:03	09 16.823	159 44.867	760.4	1534.0	20151216_180338	Deep Blue
144	1234620	2015-12-16 22:06	08 57.309	159 06.290	760.4	1534.6	20151216_220655	Deep Blue
145	13093592	2015-12-17 01:59	08 32.134	158 57.856	1100.1	1539.2	20151217_020102	XCTD-1
146	1234624	2015-12-17 06:10	08 55.390	159 43.989	760.4	1534.3	20151217_061028	Deep Blue
147	1234619	2015-12-17 12:03	09 28.758	160 50.702	760.4	1534.2	20151217_120315	Deep Blue
148	1234623	2015-12-17 18:11	10 03.186	162 00.332	760.4	1534.3	20151217_181128	Deep Blue
149	1234627	2015-12-17 21:12	10 20.101	162 34.760	760.4	1534.7	20151217_211255	Deep Blue
150	13093593	2015-12-18 00:06	10 36.150	163 07.687	1100.1	1538.9	20151218_000601	XCTD-1

#	Serial Number	Date and Time	Latitude (N)	Longitude (W)	Maximum Depth (m)	TDR SS (m/s)	MultiBeam Filename	Additional Notes
151	1234628	2015-12-18 06:05	11 33.816	162 58.036	760.4	1534.1	20151218_060537	Deep Blue
152	1234626	2015-12-18 12:02	12 35.380	162 34.623	760.0	1534.1	20151218_120255	Deep Blue
153	1234622	2015-12-18 18:04	13 36.007	162 04.665	760.4	1533.8	20151218_180342	Deep Blue
154	1234618	2015-12-18 21:15	14 09.187	161 46.850	760.4	1533.3	20151218_211555	Deep Blue
155	1234625	2015-12-19 03:16	15 10.150	161 13.670	760.4	1532.2	20151219_031651	Deep Blue
156	1234621	2015-12-19 06:16	15 41.361	160 59.850	760.4	1532.6	20151219_061742	Deep Blue
157	1234555	2015-12-19 12:07	16 42.930	160 33.713	760.4	1532.2	20151219_120743	Deep Blue
158	1234556	2015-12-19 19:04	17 46.458	160 02.644	760.4	1532.0	20151219_190413	Deep Blue
159	1234554	2015-12-20 01:09	18 47.732	159 26.220	760.4	1532.8	20151220_010958	Deep Blue
160	1234553	2015-12-20 06:04	19 36.050	158 57.398	760.4	1532.3	20151220_060422	Deep Blue
161	13093586	2015-12-20 10:08	20 17.787	158 32.393	1100.0	1537.1	20151220_120859	XCTD-1
//	13093588	2015-12-20 12:03	20 36.971	158 20.918	1100.0	1536.5	//	XCTD-1 - Bad cast
162	13093587	2015-12-20 12:17	20 39.093	158 19.634	1100.0	1536.3	20151220_120344	XCTD-1

Appendix C

Ship-Board Preliminary Products

Grids of data collected during the survey were generated as quality control objects. A resolution of 100 m was generally used. The final 100 m composite of all of the data collected during this leg is shown in Figure C.1, with vertical exaggeration of 5× for shading, and artificial sun-illumination from the northeast. Acoustic backscatter was also processed as part of the quality control process; the final composite, at a resolution of 50 m is shown in Figure C.2.

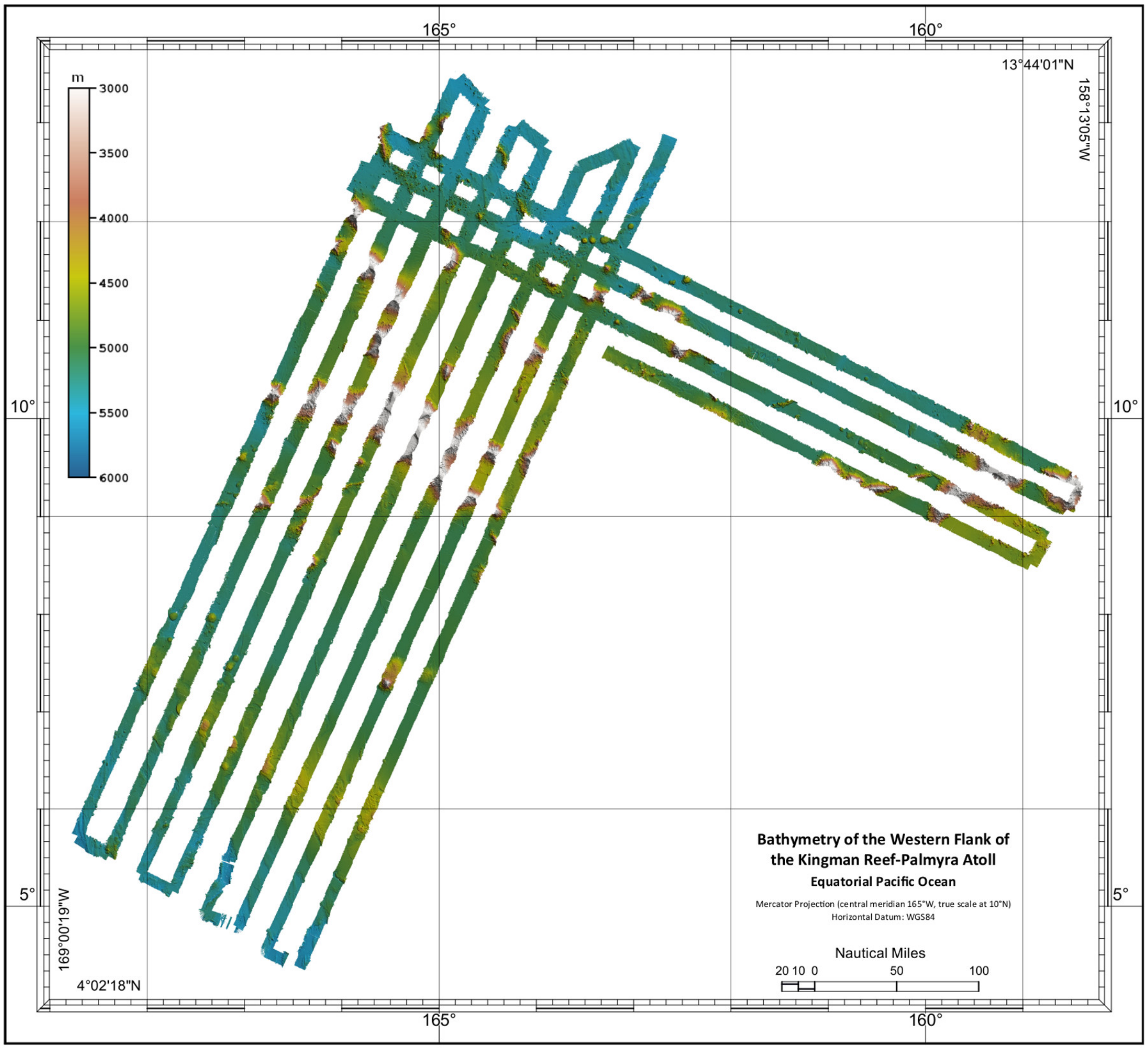


Figure C.1: Shaded relief bathymetry of the western flank of the Kingman Reef-Palmyra Atoll region of the equatorial Pacific Ocean.

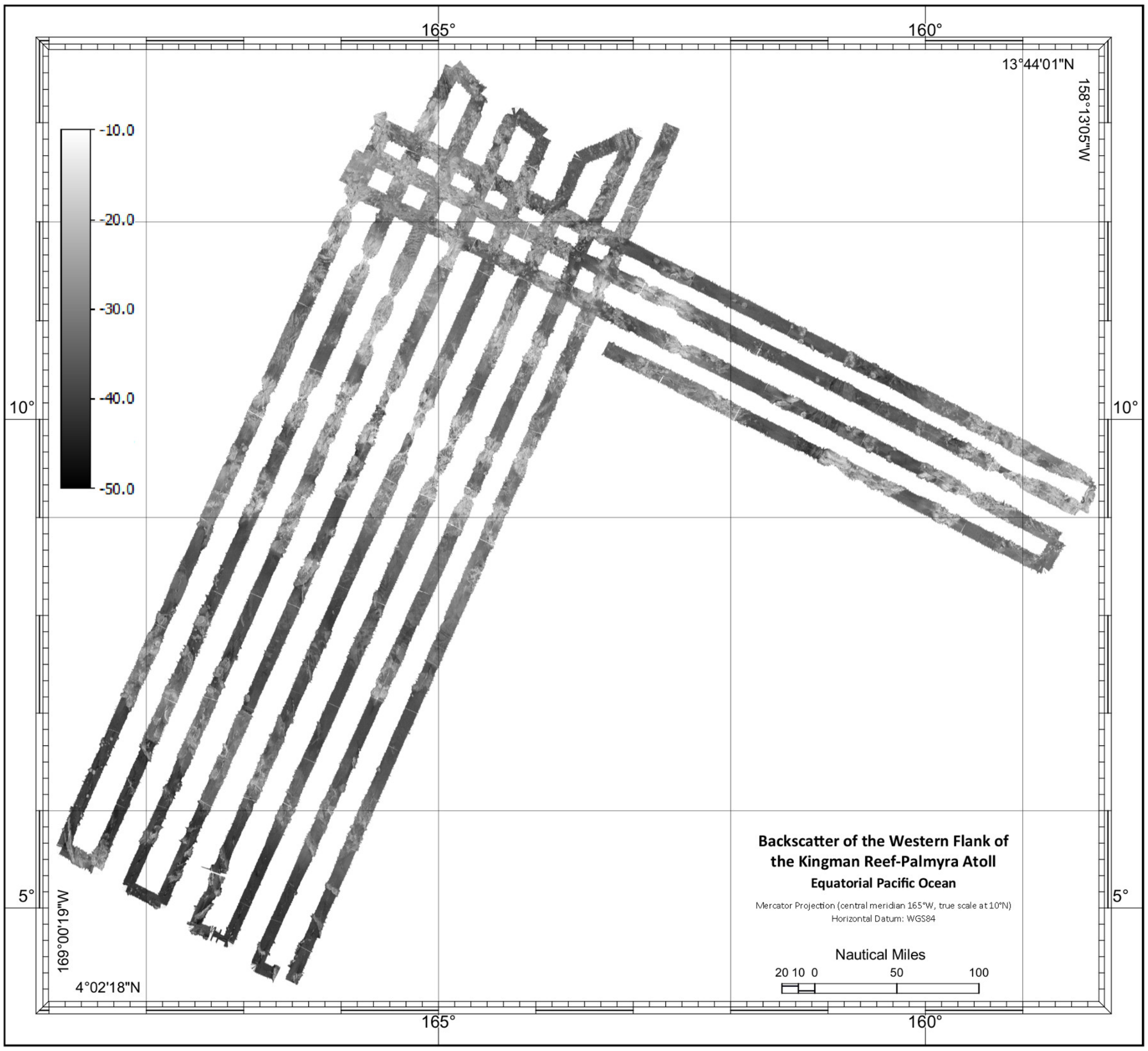


Figure C.2: Acoustic backscatter associated with Figure C.1.

Appendix D

Calibration Data

D.1 Installation Parameters

The positioning offsets for the EM122 are shown in Figure D.1, as derived from SIS installation parameters. A graphical outline of the locations of the various sensors is given in Figure D.2.

D.2 Sound Speed Sensors

The certificate of calibration for the AML Smart SV&T module's sound speed sensor is given in Figure D.3; the calibration certificate for the temperature sensor is given in Figure D.4.

D.3 Gravity Ties

D.3.1 Calibration

A bias determination was conducted on the *Kilo Moana*'s BGM-3 gravimeter on 2014-06-05, Figure D.5. The common reference station for all measurements is station 0010.53, with description as shown in Figure D.6; the gravity station plaque is shown in Figure D.7.

D.3.2 Observations

The opening and closing gravity tie information is provided in Figure D.8.

D.4 CUBE Algorithm Parameters

The CUBE algorithm implementation in HIPS was configured with CARIS' "deep" settings. These set the reference IHO uncertainty to S.44 ed. 4 order 3 ($a = 1.0$, Location offset (m)

	Forward (X)	Starboard (Y)	Downward (Z)
Pos, COM1:	0.00	0.00	0.00
Pos, COM3:	0.00	0.00	0.00
Pos, COM4/UDP2:	0.00	0.00	0.00
TX Transducer:	-3.27	-0.053	0.803
RX Transducer:	1.156	-1.225	0.804
Attitude 1, COM2/UDP5:	0.00	0.00	0.00
Attitude 2, COM3/UDP6:	0.00	0.00	0.00
Waterline:			-6.82

Figure D.1: Installation parameters for the EM122 on the *Kilo Moana* during KM15-20.

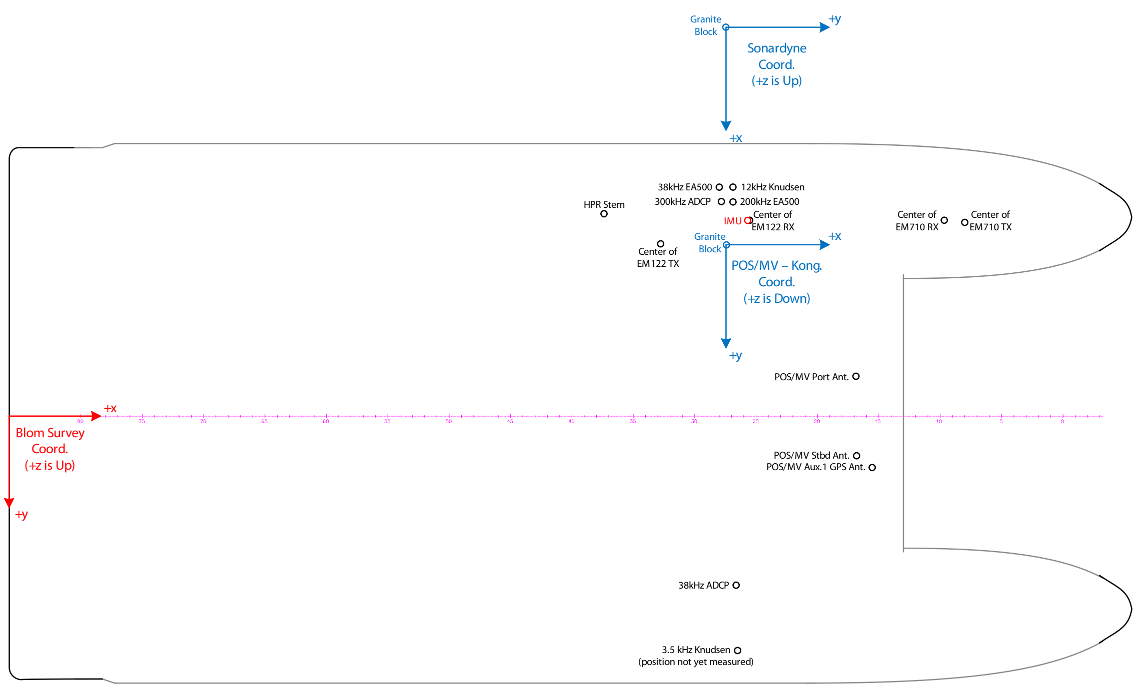


Figure D.2: Graphical layout of *Kilo Moana* instruments as provided by University of Hawai'i for KM15-20.

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Certificate of Calibration

Customer:	Ocean Technology Group
Asset Serial Number:	004599
Asset Product Type:	Smart SV&T Instrument, 500m Housing
Calibration Type:	Sound Velocity
Calibration Range:	1400 to 1550 m/s
Calibration RMS Error:	.0163
Calibration ID:	004599 999999 202395 180615 222956
Installed On:	

Coefficient A:	1.539509E+3	Coefficient H:	0.000000E+0
Coefficient B:	-1.131910E+2	Coefficient I:	0.000000E+0
Coefficient C:	8.540824E+0	Coefficient J:	0.000000E+0
Coefficient D:	-4.633874E-1	Coefficient K:	0.000000E+0
Coefficient E:	0.000000E+0	Coefficient L:	0.000000E+0
Coefficient F:	0.000000E+0	Coefficient M:	0.000000E+0
Coefficient G:	0.000000E+0	Coefficient N:	0.000000E+0

Calibration Date (dd/mm/yyyy): 18/6/2015

Certified By:

AML Oceanographic

Robert Haydock
President, AML Oceanographic

AML Oceanographic certifies that the asset described above has been calibrated or recalibrated with equipment referenced to traceable standards. Please note that Xchange™ sensor-heads may be installed on assets other than the one listed above; this calibration certificate will still be valid when used on other such assets. If this instrument or sensor has been recalibrated, please be sure to update your records. Please also ensure that you update the instrument's coefficient values in any post-processing software that you use, if necessary. Older generation instruments may require configuration files, which are available for download at our Customer Centre at www.AMLoceanographic.com/support

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Figure D.3: Certificate of calibration for AML Smart SV&T sound speed sensor.

AML OCEANOGRAPHIC
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Certificate of Calibration

Customer:	Ocean Technology Group
Asset Serial Number:	004599
Asset Product Type:	Smart SV&T Instrument, 500m Housing
Calibration Type:	Temperature
Calibration Range:	-2 to +45 Deg C
Calibration RMS Error:	.0275
Calibration ID:	004599 999999 T21006 170615 214741
Installed On:	

Coefficient A:	-4.905647E+1	Coefficient H:	0.000000E+0
Coefficient B:	3.170410E-3	Coefficient I:	0.000000E+0
Coefficient C:	-5.532417E-8	Coefficient J:	0.000000E+0
Coefficient D:	5.630989E-13	Coefficient K:	0.000000E+0
Coefficient E:	0.000000E+0	Coefficient L:	0.000000E+0
Coefficient F:	0.000000E+0	Coefficient M:	0.000000E+0
Coefficient G:	0.000000E+0	Coefficient N:	0.000000E+0

Calibration Date (dd/mm/yyyy): 17/6/2015

Certified By:

AML Oceanographic

Robert Haydock
President, AML Oceanographic

AML Oceanographic certifies that the asset described above has been calibrated or recalibrated with equipment referenced to traceable standards. Please note that Xchange™ sensor-heads may be installed on assets other than the one listed above; this calibration certificate will still be valid when used on other such assets. If this instrument or sensor has been recalibrated, please be sure to update your records. Please also ensure that you update the instrument's coefficient values in any post-processing software that you use, if necessary. Older generation instruments may require configuration files, which are available for download at our Customer Centre at www.AMLoceanographic.com/support

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Figure D.4: Certificate of calibration for AML Smart SV&T Temperature sensor.

BGM-3 DOCKSIDE CALIBRATION .... BIAS DETERMINATION

BGM-3 S/N: 219 SHIP: Kilo Moana

DATE: 5 June 2014 PERSONNEL: Hgrr

PORT/PIER/BERTH Snug Harbor, HI

DATE: 5 Jun 14 **J.D.** 157 **TIME GMT:** 0900 **TO:** 2000 **MEAN:** ~~0930~~ 1930 Z

LAND GRAVITY STA.#: 0010.53 STATION NAME Snug Harbor

STA GRAVITY VALUE @ PIER LEVEL (from description) 978 923.44 MGAL (e.g., 979750.33)

WATER HT TO PIER (in feet) 5.58 * .094 = + 0.52 MGAL (e.g., 10.33)

BASE g @ SEA LEVEL 978923.96 MGAL (e.g., 979760.33)

SENSOR FACTORY SCALE FACTOR (SF).: 5.073231097 MGAL/PULSE (e.g., 4.999555)

AVG. PULSE COUNTS (PC) (average of 3600 values) 24725.473 PULSE (e.g., 24995.555)

(PC * SF) = 125438.04 MGAL (e.g., 124966.65)
(e.g., 24995.555*4.999555)

BASE g at SL − (PC*SF) = **BIAS =** 853485.92 **MGAL** (e.g., 854793.68)
(e.g., 979760.33-124966.65)

TIME 0900 WATER HEIGHT TO PIER 5.42 feet

TIME 1930 WATER HEIGHT TO PIER 5.58 feet

TIME 2000 WATER HEIGHT TO PIER 5.75 feet

AVERAGE WATER HT TO PIER 5.58 **feet**

COMMENTS

File name 2190000.157
Start second = 32400

Figure D.5: Dock-side bias determination for the *Kilo Moana*'s Bell BGM-3 gravimeter.

GRAVITY STATION DESCRIPTION

LAT.	21° 18' 57.5" N	STATION NO.	0010.53
LONG.	157° 53' 10.8" W	COUNTRY	U.S.A.
POSIT. REF.	19367, 36th Ed.	STATE/PROVINCE	HAWAII
ELEV.		CITY/NEAREST CITY	HONOLULU
ELEV. REF.		STATION NAME	SNUG HARBOR
		1971 DATUM g	978,923.44

__ INTERNATIONAL __ EXCENTER __ CALIBRATION __ NATIONAL __ AIRPORT __ HARBOR CONTROL X HARBOR

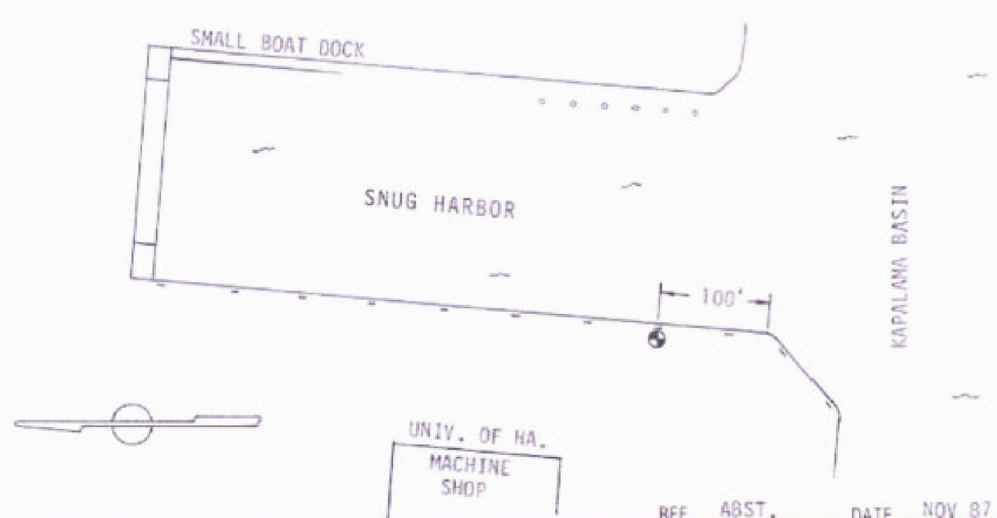
= DoD 0070-F

DESCRIPTION

THE STATION IS LOCATED AT SNUG HARBOR, HONOLULU, HAWAII. IT IS TWO FEET WEST OF THE SECOND CLEAT, WHICH IS 100 FEET, FROM THE SOUTH END OF THE HARBOR. THIS WHARF IS LABELED "MARINE EXPEDITIONARY CENTER" AND IS PART OF THE UNIV. OF HAWAII.

REF ABST. DATE NOV 87

DIAGRAM



REF ABST. DATE NOV 87

DATE	OBS. BY	INST.	SOURCE	STATION OF REF.	1971 VALUE	Δg	
12 NOV 87	S. LANGFORD	G-207	112	0010.22	978,937.96	-14.51	ABABA
9 JAN 88	D. BILLS	G-208	112	0010.22	978,937.96	-14.53	ABABA
21 JUN 88	J. COTTEN	G-848	110	0010.52	978,926.53	-3.11	ABA
21 JUN 88	E. GREMILLION	G-848	110	0010.52	978,926.53	-3.09	ABA

Figure D.6: Description of the gravity reference station at Snug Harbor, Honolulu, HI used for gravity ties before and after KM15-20.

Figure D.7: Gravity station monument plaque corresponding to the station description in Figure D.6.

Gravity Ties

Opening Station: Honolulu, HI

R/V Kilo Moana Gravity Tie Form

Cruise ID	**KM1520**
Date	**11/20/2015**
Port	**UH Marine Center, Honolulu HI 96819**
Operator	**Trevor Young**

Pre-cruise

Ships Position	Lat 21.315731 N	Long 157.886285 W	
Shipboard BGM	Shipboard BGM reading (mGal) 125420	Height of pier over main deck (m)	
Portable GPS time			
Portable GPS Position	Lat	Long	Alt
L&R Readings	#1 1670.062	#2 1664.85	#3
L&R Readings Time	#1 07:35 HST	#2 07:38 HST	#3

Post-cruise

Ships Position	Lat 21.315701 N	Long 157.886299 W	
Shipboard BGM	Shipboard BGM reading (mGal) 125298	Height of pier over main deck (m)	
Portable GPS time			
Portable GPS Position	Lat	Long	Alt
L&R Readings	#1 1680.845	#2 1685.851	#3 1681.073
L&R Readings Time	#1 08:38 HST	#2 08:44 HST	#3 08:45 HST

Notes

Pre-cruise land tie: Heavy wind driven rain.

Figure D.8: Gravity tie information for both opening and closing ties for KM15-20.

$b = 0.023$), and use standard CUBE reference parameters except that the distance capture scale is set to 0.20 and the minimum distance is set to 2.0 m.

D.5 GeoCoder Algorithm Parameters

The GeoCoder implementation in FMGT was set to the standard configuration for FMGT 7.4.4b. This configures the algorithm to carry out transmit and receive power/gain corrections, apply beam pattern corrections, accept all beams, use the absorption coefficients from file, and apply no backscatter bias. The algorithm uses a "flat" AVG correction with window size of 300 pings, computing statistics in logarithmic space. The mosaic used the "blend" method with a 50% inter-line bending, and dB mean estimation. Navigation was taken from the default source in the input file, with automatically determined sonar defaults. Dual swath compensation was turned off. The default processing pipeline was used.

Appendix E

Data Consistency Analysis

E.1 Introduction

In order to assess the consistency of the soundings being measured with the EM122, the data collected on main-scheme lines were compared with the cross-lines, and the data from the previous leg in this area. Although this does not assess the true uncertainty of the soundings, it does estimate the consistency. The cross-lines consisted of Kongsberg lines 113–120 (first line), 122–128 (second line), 130–137 (third line), and 139–142 (fourth line).

E.2 Method

The data collected were ingested in CARIS HIPS from Kongsberg Maritime "raw" format and processed as described in Section 3.2. The main-scheme and cross-lines were made separately into gridded products, and the cross-check analysis was then conducted in CARIS BASE Editor by surface comparison. Data from the previous leg of the mission were recovered from the processed data, and then ingested into BASE Editor.

E.3 Results

The analyses of all of the crossings in the dataset are presented in the digital version of the dataset. Comparison of the data collected during the present leg using the main-scheme and cross-lines (Figure E.1) showed that the differences were limited to the range $[-304.2, 247.2]$ m with mean -0.1 m and standard deviation 14.2 m, approximately 0.25% of the water depth in the area (Figure E.2). The area of overlap between the current data and the previous leg compares the data against EM122 also from the *Kilo Moana*. The differences (Figure E.3) show a range of $[-274.6, 464.3]$ m, with mean 0.2 m and standard deviation 9.3 m, approximately 0.18% of the water depth in the area (Figure E.4). The higher standard deviation for the comparison

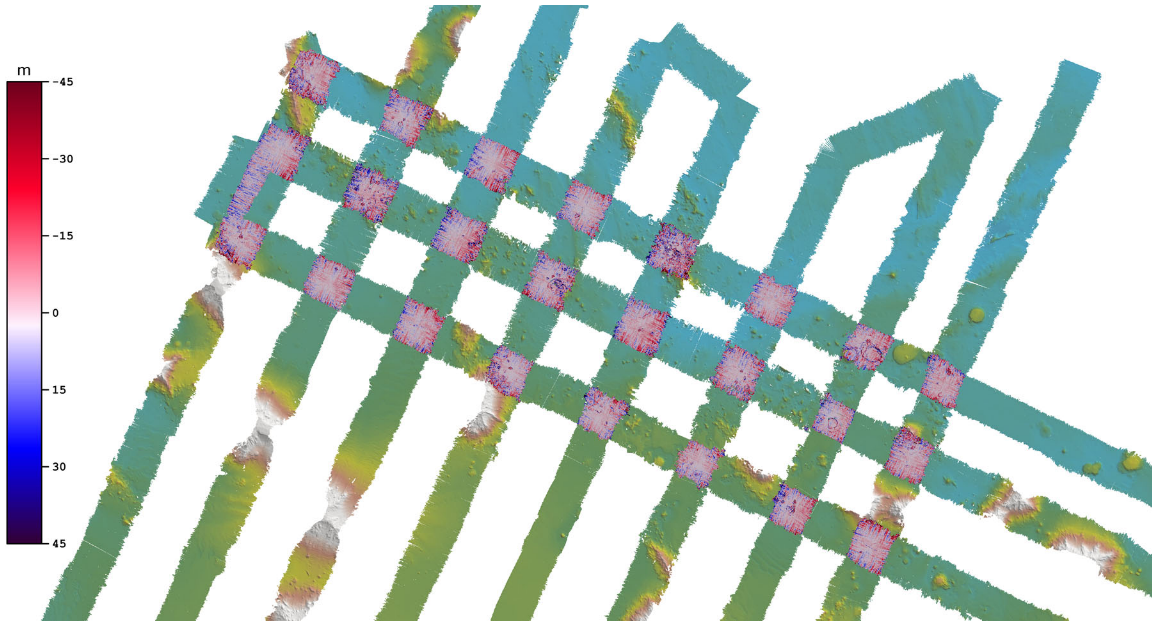


Figure E.1: Surface difference between main-scheme and cross-lines from this leg, with survey outline. The differences range from -304.2 m to 247.2 m, with mean -0.1 m and standard deviation 14.2 m.

between main-scheme and cross-lines is likely a product of the area used for comparison, which has significantly higher dynamic range and spatial frequencies than the area of overlap between the current and previous legs.

E.4 Summary

The results show that in almost all cases, the data meet (and generally exceeds) the requirement of being within 0.5% of the water depth in the area at the 95% confidence level. The data are therefore all within the specification required for this survey.

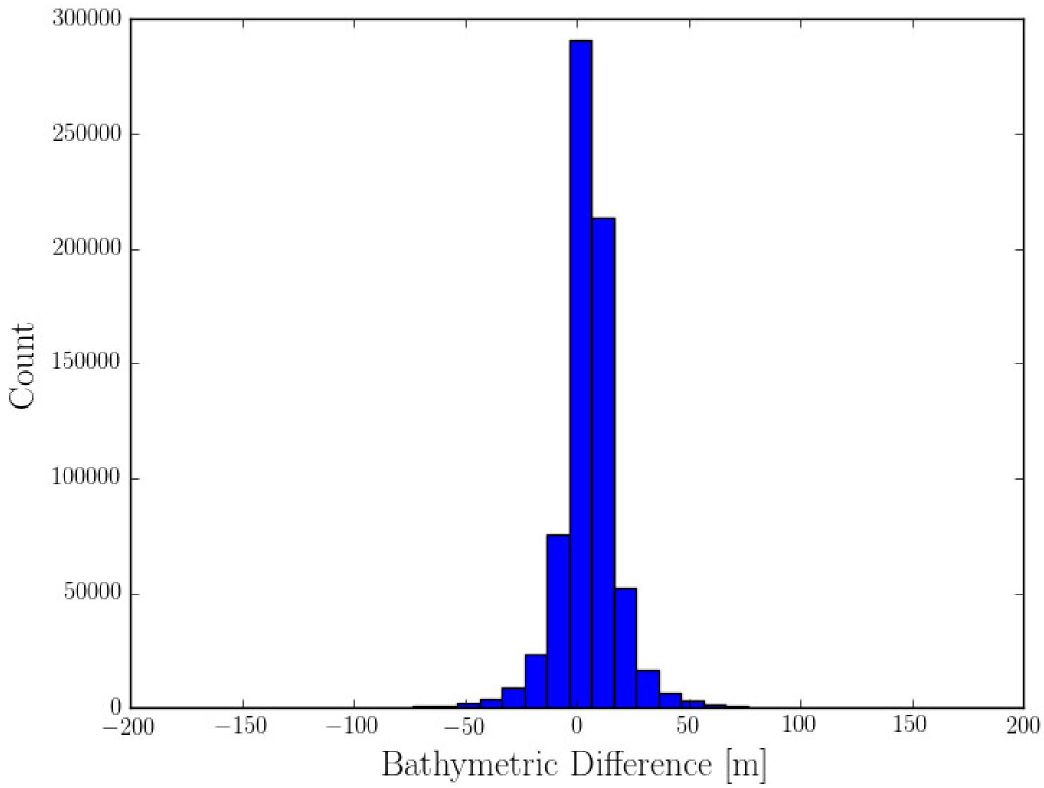


Figure E.2: Histogram of surface differences between main-scheme and cross-lines from this leg.

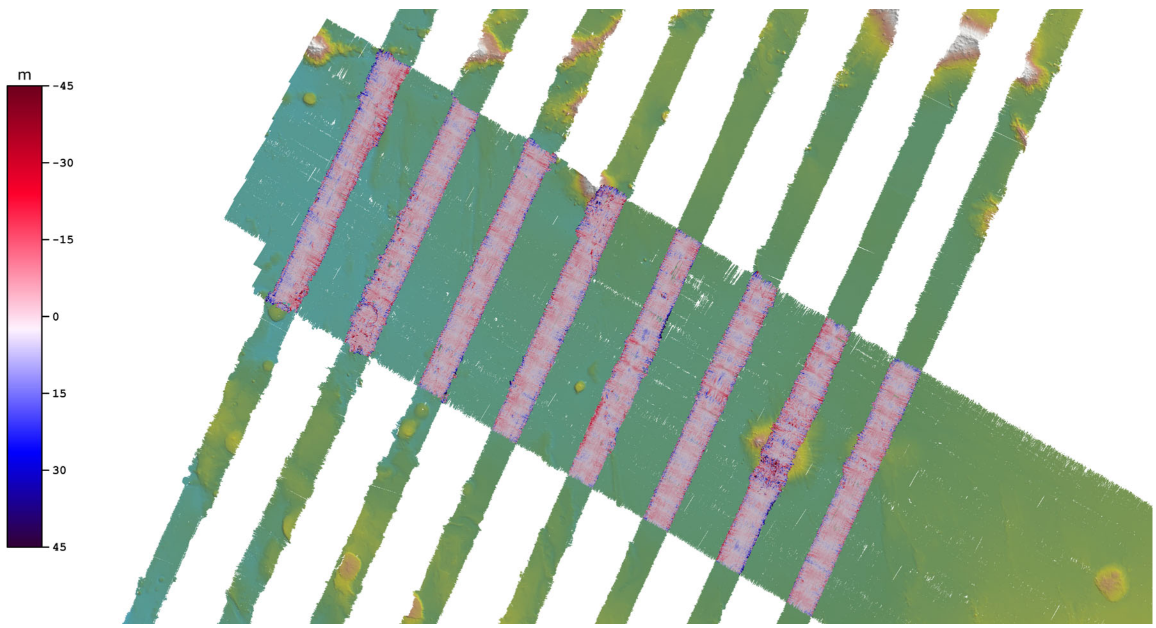


Figure E.3: Surface difference between current survey and the previous leg in the area, with survey outline. The differences range from -274.6 m to 464.3 m, with mean 0.2 m and standard deviation 9.3 m.

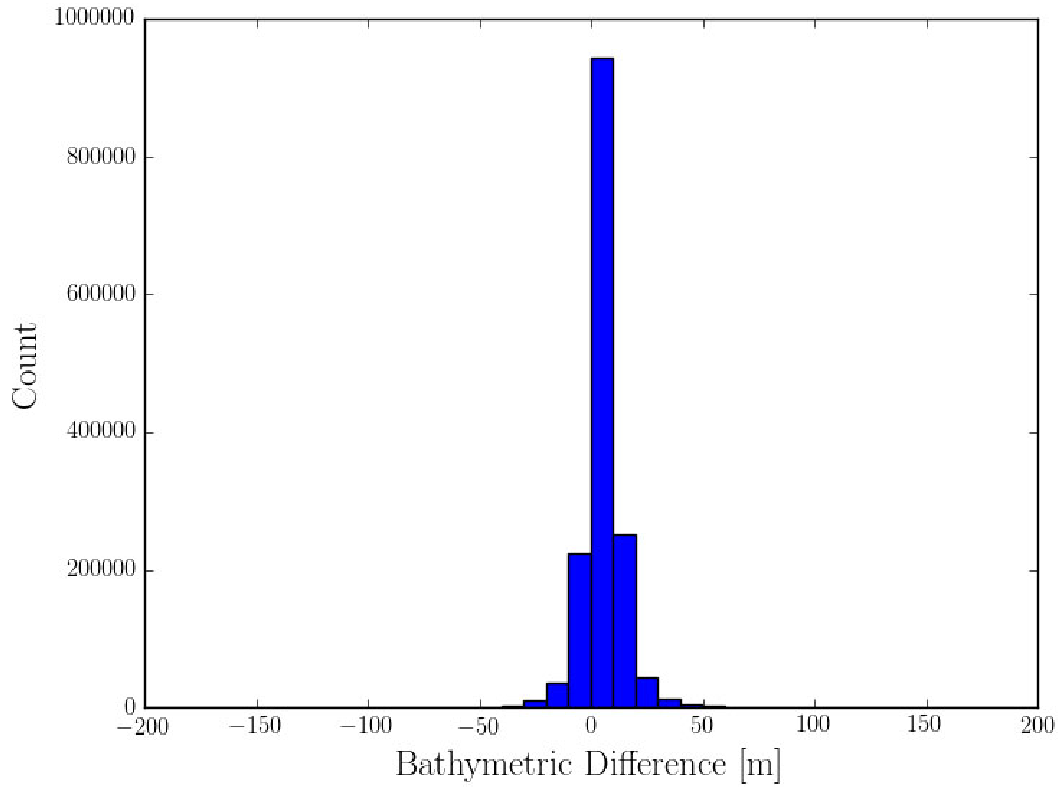


Figure E.4: Histogram of surface differences between the current survey and the previous leg in the area.