NOAA Ship *Okeanos Explorer* Program

MAPPING DATA REPORT

CRUISE EX0909 Leg 3

Mapping Field Trials

Hawaiian Islands

October 1 - 21, 2009

Honolulu, HI to Honolulu, HI

Report Contributors:

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1. Introduction

The *Okeanos Explorer* Program

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

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

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

Okeanos Explorer Management – a unique partnership within NOAA

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

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2. Report Purpose

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

This report provides details about mapping operations of EX0909 Leg 3 field trial cruise conducted from Oct 1 – 21, 2009.

3. Cruise Objectives

The objectives of the cruise have been outlined in the cruise instructions [2] which included primary objectives to test, troubleshoot, refine and evaluate EX mapping systems, sensors, protocols and procedures to support systematic exploration and secondary objective to map the areas in the vicinity of the Hawaiian Islands which are of national and regional interest.

4. Participating personnel

NAME	ROLE	AFFILIATION
CDR Joseph Pica	Commanding Officer	NOAA Corps
LT Nicola VerPlanck	Field Operations Officer	NOAA Corps
Mashkoor Malik	Expedition Coordinator/Mapping Team Lead	NOAA OER (ERT, Inc.)
Elaine Stuart	Senior Survey Technician	NOAA OMAO

Lillian Stuart	Survey Technician	NOAA OMAO
LTJG Megan Nadeau	Mapping Watchstander	NOAA Corps
Kelly Elliot	Mapping Watchstander	NOAA OER(20/20, Inc.)
Melissa Johnson	Mapping Watchstander	NOAA OER Intern
Adam Lemire	Mapping Watchstander	NOAA OER Intern
Webb Pinner	Telepresence Lead	NOAA OER (20/20, Inc.)

5. Cruise Statistics

Dates	10/1/09 – 10/21/2009
Weather delays	0
Total non-mapping days	5
Total survey mapping days	15
Total transit mapping days	2
Line kilometers of survey	5855
Beginning draft	13’11”(fwd)14’3.5” (aft)
Average ship speed for survey	8.7 Kts

6. Mapping sonar setup

NOAA *Okeanos Explorer* (EX) is equipped with a 30 kHz Kongsberg EM 302 multibeam sonar and a 3.5 kHz Knudsen sub-bottom profiler (SBP 3260). During this cruise EM 302 bottom bathymetric and backscatter data were collected. Additionally, water column data logging for EM 302 was turned on where interesting features were observed in the water column, however no notable water column targets were picked up during this cruise.

The ship used a POS MV ver. 4 to record and correct the multibeam data for any motion. C-NAV GPS system provided DGPS correctors with position accuracy expected to be better than 2.0 m.

All the corrections (motion, sound speed profile, sound speed at sonar head, draft, sensor offsets) are applied during real time data acquisition in SIS ver. 1.04. XBT casts (Deep Blue, max depth 760 m) were taken every 6 hours (0000, 0600, 1200 and 1800 local time). XBT cast data were converted to SIS compliant format using NOAA Velocwin ver. 8.92 Plus. When the time allowed, CTD casts up to 800 m were also conducted to provide training to the deck, bridge and survey departments in lieu of the 1200 XBT cast. Complete list of XBT and CTD casts conducted is provided in Section 10.

During July 2009 the ship reported one of the transmit boards defective (TX 36 # 16). The board was replaced on 4 Sept, 2009 with a spare board sent in by Kongsberg, Inc. However, the same board (TX 36 # 16) failed a BIST on 3 October, 2009. The EM 302, in spite of one defective transmit board, provided good quality data during the initial tests soon after departing Honolulu, HI. Based on these initial tests, it was decided that ship will continue its mapping mission. The affects of the defective transmit board on the data quality was assessed through out the cruise by comparing this cruise data with earlier cruises. In presence of heavy seas, the data showed residual motion artifacts but it could not be determined conclusively if these artifacts are due to the defective transmit board. The ship expects to receive the replacement board once back in Honolulu, HI and further tests are being planned to ensure that these data quality issues are addressed after replacement of the defective TX board.

7. Data acquisition summary

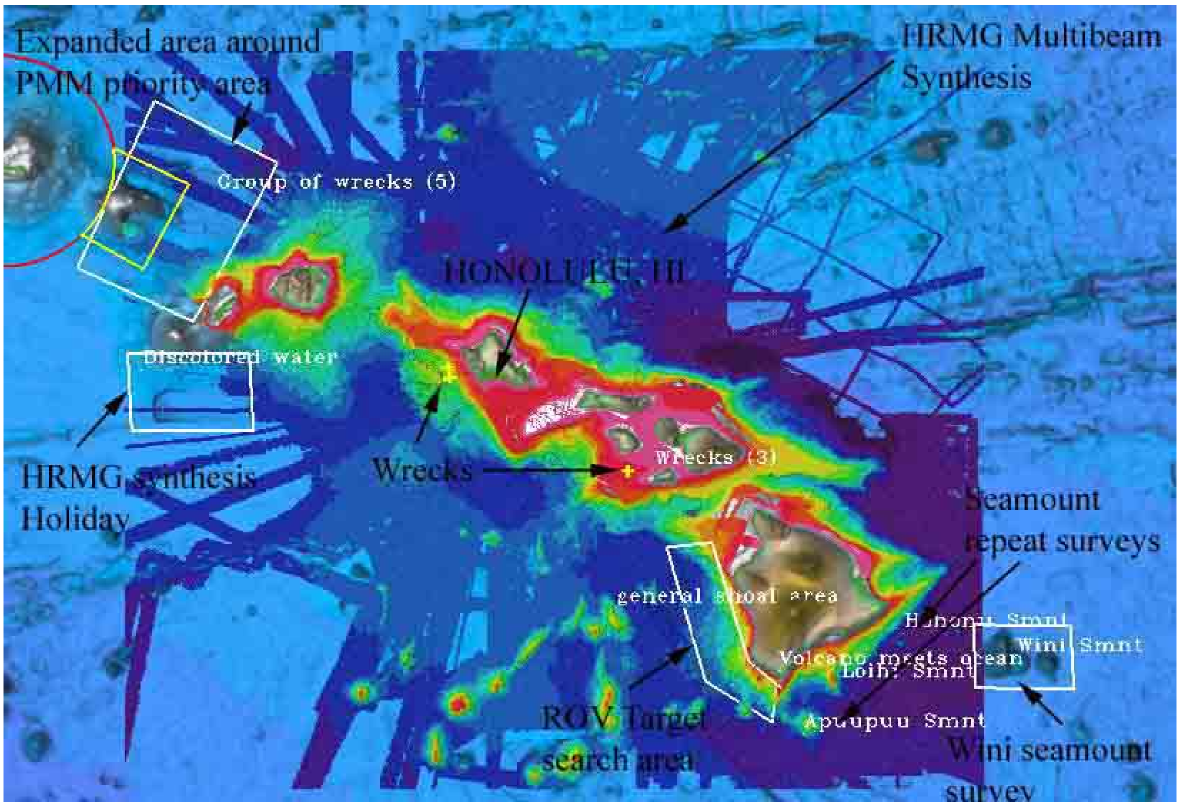

Figure 1. Over view of planned mapping areas during EX0909_Leg 3 cruise (shown as white boxes). Image compiled in Fledermaus using Sandwell and Smith as the background data and HRMG synthesis data.

The ship departed Honolulu, HI on 1 October, 2009. The data were collected during the transit from Honolulu, HI to the working grounds (Oct. 1 - 3) in the vicinity of Wini Seamount. During the transit the ship collected data over the Hawaii Mapping Research Group (HMRG) identified holidays. The ship worked around Wini Seamount from Oct. 3 – 6 mapping the extent of Wini Seamount. The weather in this area provided some serious challenges to the data quality. The lines were being run ~ 30 degrees off the swell and still a lot of bubble sweep down episodes were degrading the bathymetric and backscatter data quality severely. It was decided to devote some time to determine the best possible course for the multibeam operations. On Oct. 4, a star line pattern was run over Wini Seamount which enabled the ship to collect the multibeam data in several different directions with respect to swell. The details of the results are provided in the following sections. Four distinct peaks were mapped around Wini Seamount. No craters were observed on the Wini seamount. The ship then transited to the west of the Big Island (Hawai'i). During the transit, several seamounts including Apuupu, Loihi and Hononu seamounts were mapped. The ship reached west of the Big Island mapping area on Oct. 7 and started collecting data in support of future ROV dives. The ship conducted mapping operations in this area till Oct 10. On Oct. 11 the ship started a 72 hour long dynamic positioning (DP) test to test the endurance of DP system and its ability to hold station and conduct maneuvers necessary in support of ROV operations. A separate report is being generated for these tests [7]. While holding station, ~ 1 hour of multibeam sonar data was collected to help identify the variability of multibeam bathymetric and backscatter data on 11 October. However, due to several factors including large seafloor slope and variations in ship's heading the preliminary processing of these data indicate that this experiment will need to be repeated again with more favorable conditions (most importantly - relatively flat seafloor)

The ship concluded DP test on Oct. 14 ~ 1200 and anchored off Kona waiting for the steering pump spare part. The ship stayed at anchor from Oct. 14 1500 –Oct. 15 1530 off Kona, HI. During this time the spare part for the steering pump was picked up and also the crew enjoyed a few hours of liberty in Kona, HI. The ship commenced her transit to the Papahanaumokuakea Marine National Monument (PMNM) working grounds. During the transit, a wreck site was investigated to detect the wreck of the USS Blue Gill (SS- 242). In spite of detecting several features both in backscatter and bathymetric data, with comparable sizes to the reported size of the wreck, the multibeam data was not able to conclusively detect the wreck. More work with the ROV is recommended to determine the location of this wreck. The ship arrived in the working areas around PMNM on Oct. ~ 2300.

As a result of the addition of a DP evolution (~ 4 days) in the cruise schedule, planned mapping of HMRG holidays off Kauai Island. (use Island or add 'Is." To the acronym list) was cancelled and also the PMNM expanded mapping area was reduced to cover only the PMNM priority area. The shallow regions in this area showed a depth separation between 65-600 m, therefore due to time constrains, not all the holidays were covered in the shallow area. EM 302 suffered a malfunction where it stopped forming received beams on Oct. 19 for ~ 4 hours. Several restarts of the SIS computer and the TRU did not bring back the multibeam system. The problem was resolved as the system was put in simulator mode and angular coverage settings were changed. Kongsberg is being contacted to record this problem. The ship wrapped up mapping operations in PMNM area on Oct. 20 at 0730 and commenced transit towards Honolulu, HI. The ship arrived in Honolulu, HI on Oct. 21, 2009 at ~ 1000.

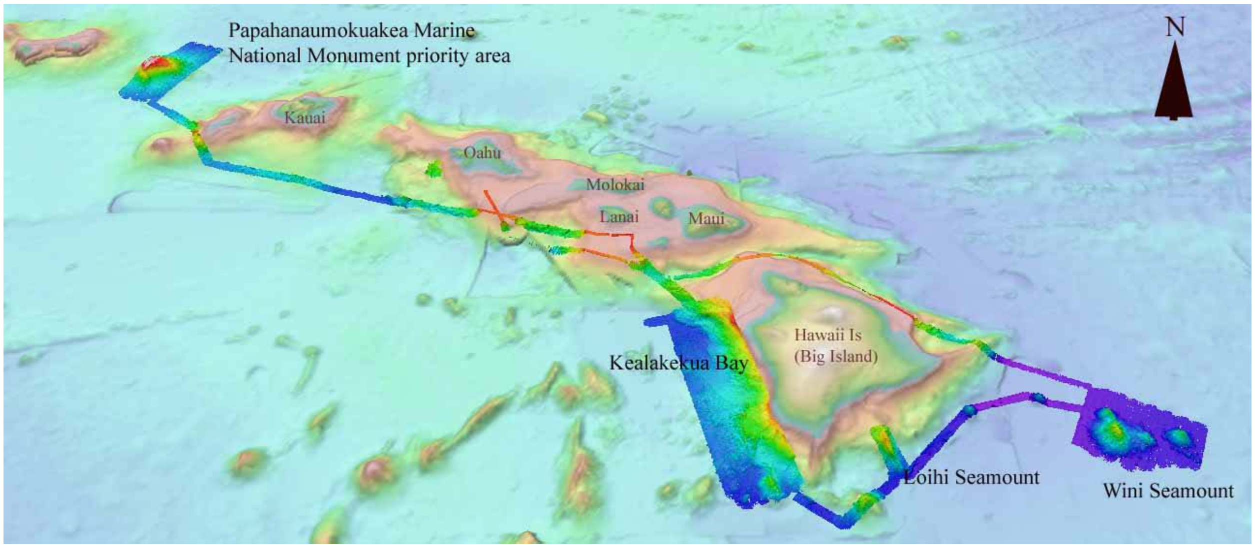

Figure 2. Over view of the EX0909 Leg mapping areas (50 m grid) overlaid with bathymetry from ETOPO 1 [8]. Image compiled in Fledermaus.

8. Data processing

Angular offsets used during this cruise in the multibeam system are tabulated below. For complete processing unit setup (PU Setup) utilized for the cruise, please refer to Appendix A.

Table 1. Angular offsets for Transmit (TX) and Receive (RX) transducer

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

Onboard processing of bathymetric data was done in CARIS HIPS ver. 6.1 where the data were cleaned in ‘Swath Editor’ and ‘Subset Editor’. No tidal corrections were applied during post processing; however, no appreciable differences were observed between different lines by not applying tidal corrections.

Onboard processing of bottom backscatter data were conducted using UNH research tool ‘Geocoder’. The results obtained during fair weather were encouraging but during the days when the weather was choppy, a lot of bubble sweep down episodes degraded bottom backscatter data quality severely. At the time this report was filed, it was unclear whether the weather effects could be taken care of during post processing. The ship is also expected to contact Kongsberg, Inc. regarding these backscatter artifacts. Please note that only limited processing of backscatter data was completed during the cruise.

9. Results

This section describes briefly the results of the data collected during this cruise. This section has been divided into three main sub-sections: (1) Mapping areas (2) System analysis and (3) Wreck investigation.

Mapping Areas

HMRG multibeam sonar synthesis holiday mapping

The University of Hawaii, Hawaii Mapping Research Group (HMRG) has compiled a synthesis of multibeam sonar data around the Hawaiian Islands [5], however, there are a few areas around the islands where there are only minimal multibeam data available. During the transit from Honolulu, HI to Wini Seamount, the transit line was planned to pass over several of the HMRG holidays passing north of the Hawaii Island (Big Island). Major data holidays in HMRG multibeam synthesis that were targeted during this cruise are tabulated below:

Table 2. HMRG multibeam data synthesis holidays.

Latitude (N)	Longitude (W)	Depth (m)
20.871	157.811	-529.55
20.418	157.044	-676.20
20.251	156.393	-3013.54
20.396	155.670	-1251.46
19.951	155.073	-339.75

The following images show the data holiday areas that were filled by EM 302 data.

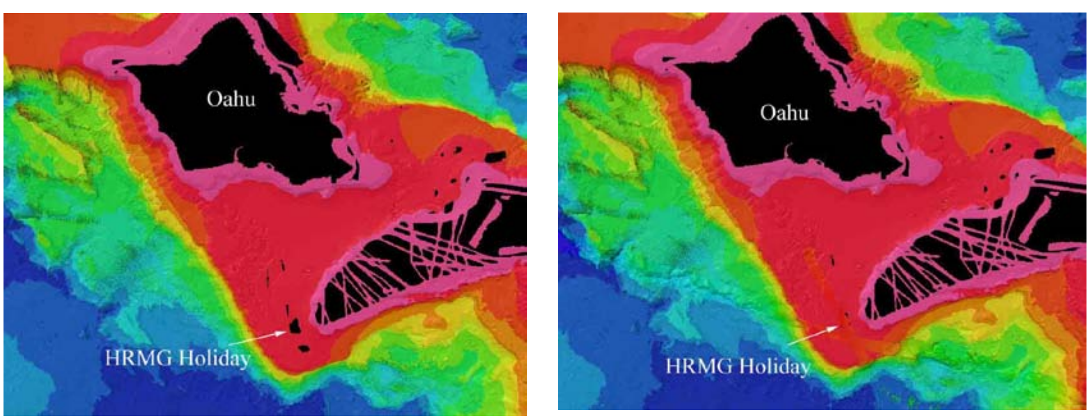

Figure 3. (Left) HRMG holiday (Right) EM 302 track line (50 m grid) over the HRMG holidays in vicinity of Oahu. Image compiled in Fledermaus.

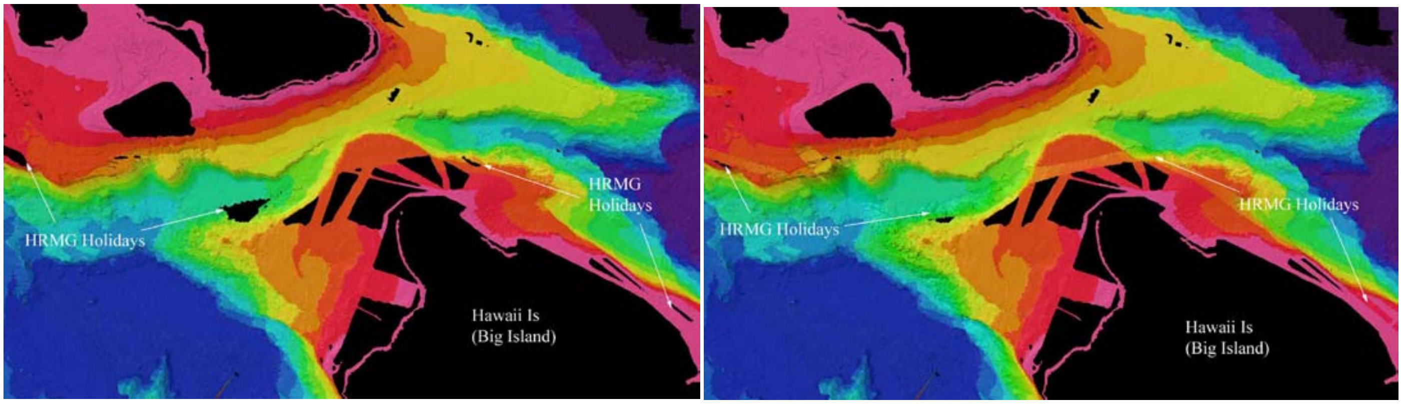

Figure 4. (Left) Image showing HRMG holidays in vicinity of the Big Island (Right) EM 302 track lines (50 m grid) over the HRMG holidays in vicinity of the Big Island. Image compiled in Fledermaus.

Wini and adjacent seamounts

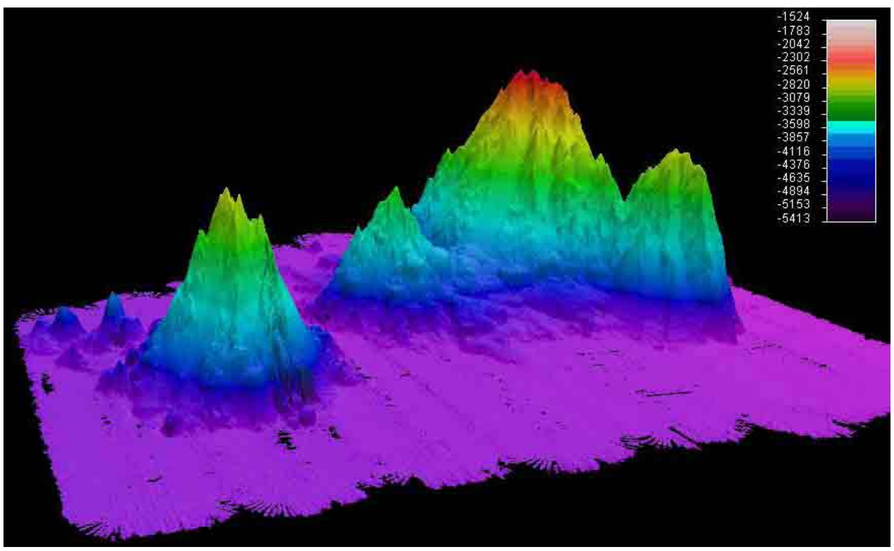

Figure 5. Fledermaus image showing Wini Seamount looking southwest after preliminary processing of the raw data. The 50 m grid image shows the three pinnacles in the background that form the Wini seamount. The seamount in the foreground is Alexander Seamount.

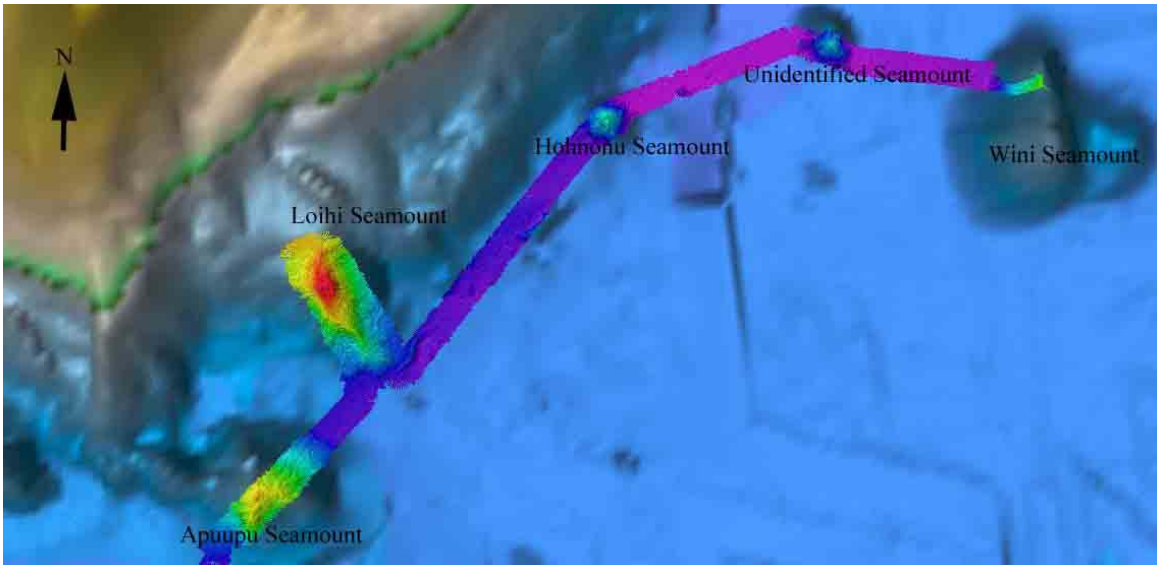

Figure 6. 50 m grid of the seamounts that were mapped partially while in transit from Wini Seamount to the mapping area west of the Big Island. The seamounts which were mapped included an unidentified (but known) seamount, and Hohnonu, Loihi and Apuupu Seamounts. Background data from Sandwell and Smith. Image compiled in Fledermaus.

During the transit from Wini Seamount to the west of the Big Island, a few lines were run over Loihi seamount. The data appears to show detailed structure over Loihi Seamount including three distinct calderas on top of Loihi Seamount. No water column targets were picked up on top of Loihi Seamount.

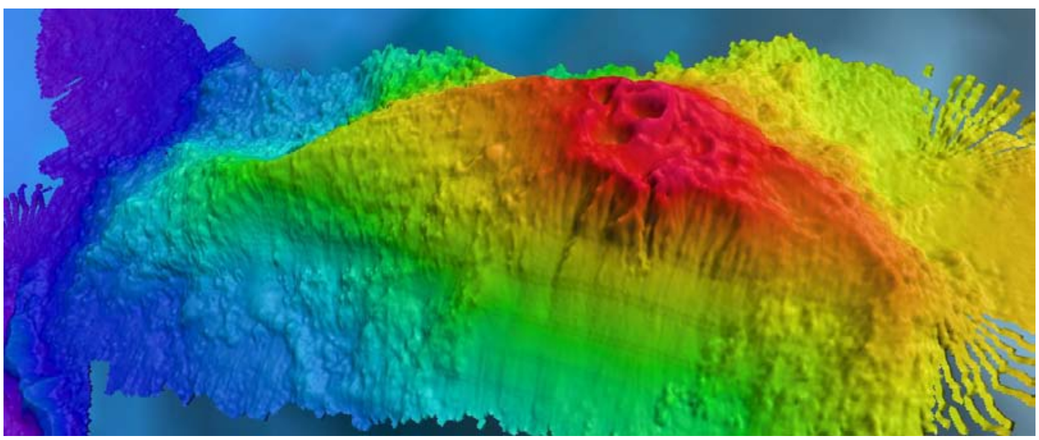

Figure 7. Bathymetric 50 m grid results over Loihi Seamount. Background data from Sandwell and Smith. Image compiled in Fledermaus.

Kealakekua Bay mapping area

This area has been well mapped and documented in the literature [e.g. 4] and provides a good opportunity to test the EM 302 performance against existing data sets. For the 2010 planned engineering dives for the ship's ROV, this area also provides a good test bed in relatively protected waters.

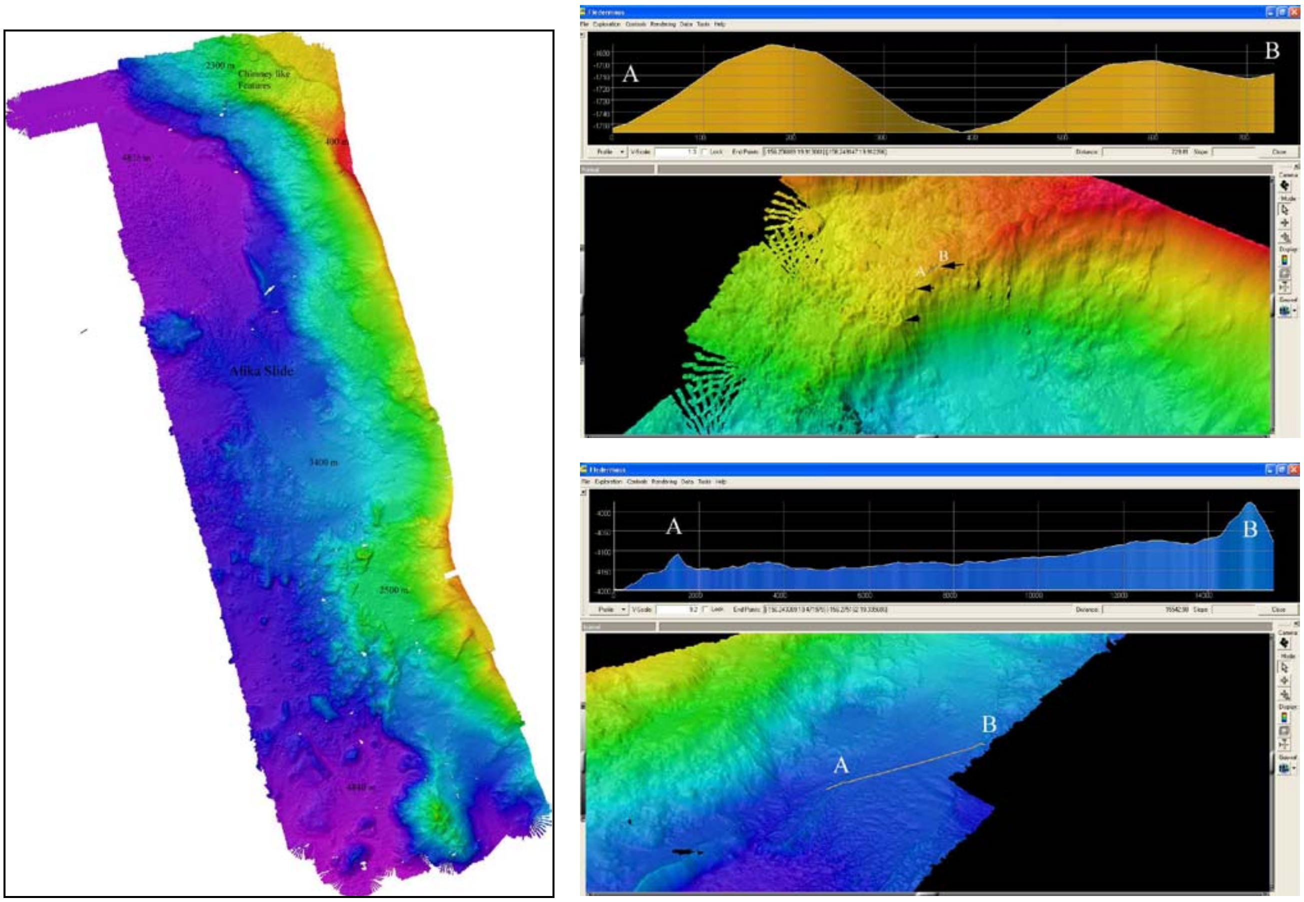

Figure 8. Left: Over view of the area mapped in the area west of the Big Island. Right top: Chimney- like features observed in the northern section of mapping area, provided with a depth profile across one of these features showing a crater with depth of 60 m with a diameter of ~ 200 m. Right bottom: Debris flow from the shallow part to the deeper regions forms a well defined region of ~ 9 km width which is very smooth with its boundary clearly marked (Alika slide [4]). All images are 50 m grids compiled in Fledermaus.

PMNM priority area mapping

Papahanaumokuakea Marine National Monument (PMNM) area was mapped from Oct. 18 – Oct. 20, 2009. The preliminary processing of the data show a shallow feature of ~ 65m with several slides visible around the feature. The depths fall off to ~ 4500 on the side of the feature.

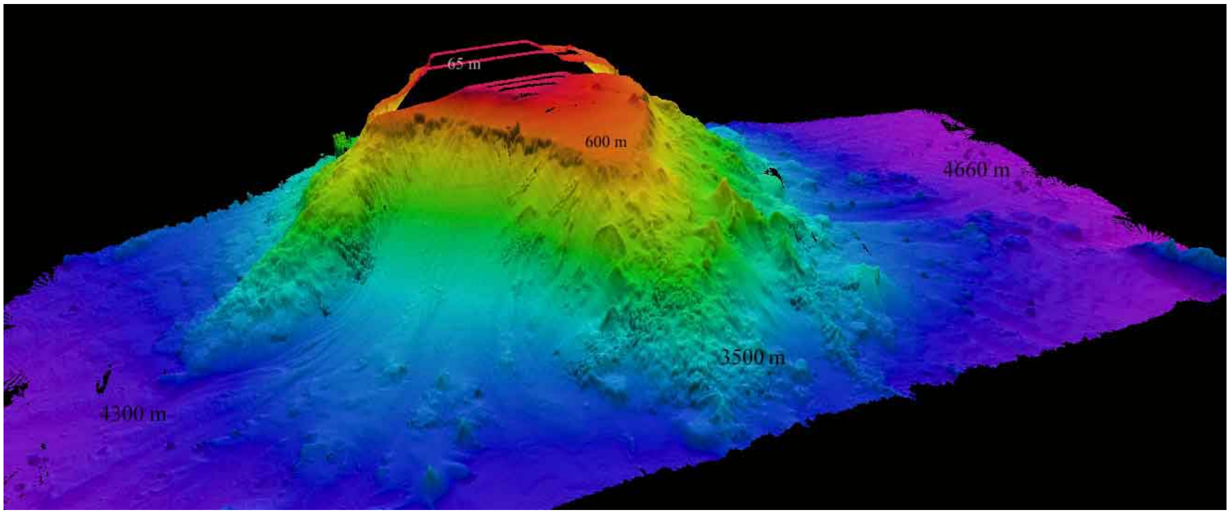

Figure 9. Preliminary results of the EM 302 bathymetric data over the PMNM priority—50 m grid, compiled in Fledermaus.

System analysis

Evaluation of best course for optimal EM 302 data collection

It has been realized that EM 302 multibeam sonar seems to perform better when the ship is not heading into the swell/sea right ahead. This experiment was meant to provide data to quantitatively analyze the effect of ship heading with respect to the sea waves and swells.

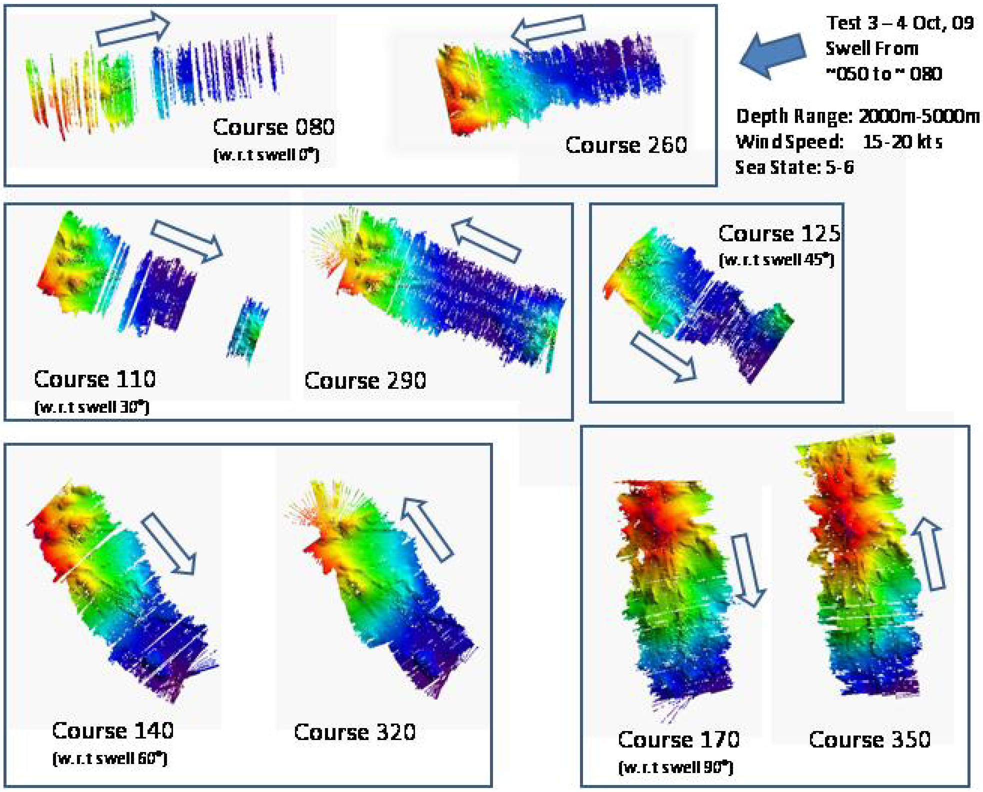

Figure 10. Image showing mapping results with lines run over Wini Seamount in different directions. Data compiled in ArcMap with 50 m grids created in Fledermaus.

Track lines over ~ 10 miles were collected while running the ship in directions of 000, 180, 030, 210, 060, 240, 090 and 270, with respect to the swell. The results indicate that the best direction to run the survey lines is beyond 30 degrees from the swell. However, for the lines perpendicular to the swell, although the data quality was observed to be the best, the ship rolled violently.

Apart from serious design modifications, the ship is expected to continue to have the bubble sweep down issues. It is suggested that weather conditions should be considered while laying out the mapping plan to avoid track directions less than 30 degrees with respect to swell to avoid severe bubble sweep down related degradation of data.

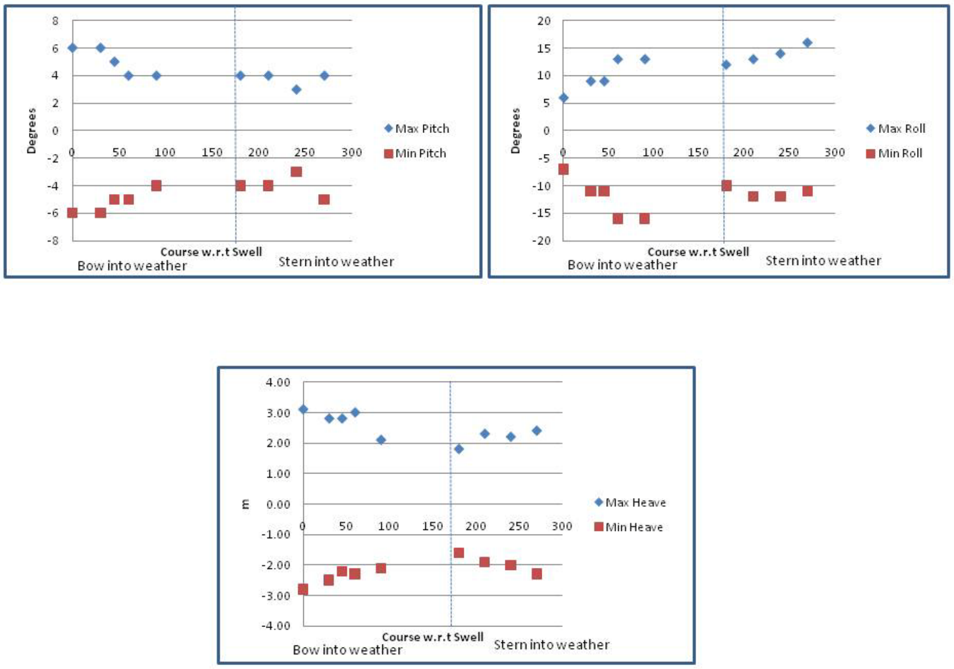

Figure 11. Results of heave, roll and pitch observed while running mapping lines in different directions with respect to swell.

Evaluation of multibeam bathymetric data variability during DP test

Dynamic Positioning (DP) system onboard enables the ship to hold station within few meters with the help of a bow thruster and two stern thrusters. Three sets of 100 pings were collected over a period of ~ 1 hour. In ideal conditions (calm conditions, no heading and position variations), the same beam is expected to be sampled over 100 pings and therefore enables a computation to infer uncertainty due to the sonar system itself. Field evaluations of multibeam sonar bathymetric data variability by holding station using DP system has been attempted by de Moustier [6]. A strict requirement described by [6] is to have a relatively flat seafloor so as to enable ping to ping comparison in presence of small variations in ship's heading. EM 302 system compensates for ship's motion (pitch and roll stabilization) therefore the same beam may not be falling over the same part of the seafloor in presence of ship motion. If the seafloor is relatively flat these variations will have minimal impact but during this experiment the seafloor depth varied (across track) by more than 1000 m. It is expected that further processing of these results will be carried on shore and it is recommended that this experiment be repeated to assess uncertainty of the EM 302 bathymetric data which is an essential component of over sonar uncertainty.

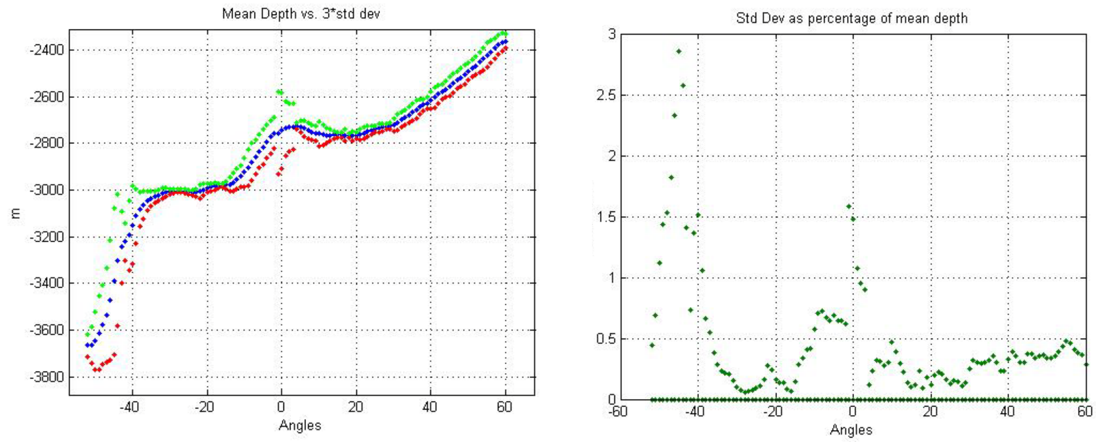

Figure 12. (Left) Mean depth plotted against transmit angle (Blue). Red and green points show the 3 x Std deviations of bathymetric data. (Right) Standard deviation plotted as percentage of mean depth plotted against transmit angle. Please note that the plot on the right is not symmetrical. Also the percentage of std deviation seems to be exceptionally large beyond 40 degrees transmit angle.

Wreck investigation

Three wrecks' location was provided by KayleenKeller (http://papahanaumokuakea.gov/). The locations of these wrecks are listed below:

Table 3. WWII submarine wreck locations.

Ship Name	Latitude	Longitude	Depth (m)	Dimensions*
SS 133 – S-28	21.3333	-158.333	2300	66.8 (L), 6.3 (B), 4.9 (D)
SSk 242 Bluegill	20.59166	-156.90829	500	95 (L), 8.3 (B), 5.2 (D)
SS 393 Queenfish	21.43167	-158.345	2600	94.9 (L), 8.3 (B), 5.1 (D)

* L – Length; B – Beam, D- Draft. Source: wikipedia.org

All of these wrecks are WWII submarines.

USS SS-28 and USS Queenfish

The USS SS-28 and USS Queenfish wrecks were investigated during EX0909-Leg 2 (Sept. 2009). The wreck sites were mapped for several hours running several lines over the wreck sites; however, no features mimicking wrecks were observed in the bathymetric and backscatter data. Images showing the bathymetric data collected over these expected wreck sites are provided below:

NOTE: These two wrecks were explored during EX0909-Leg 2. For a complete list of multibeam lines that were collected over these features, please consult the cruise report for EX0909-Leg 2 cruise [3].

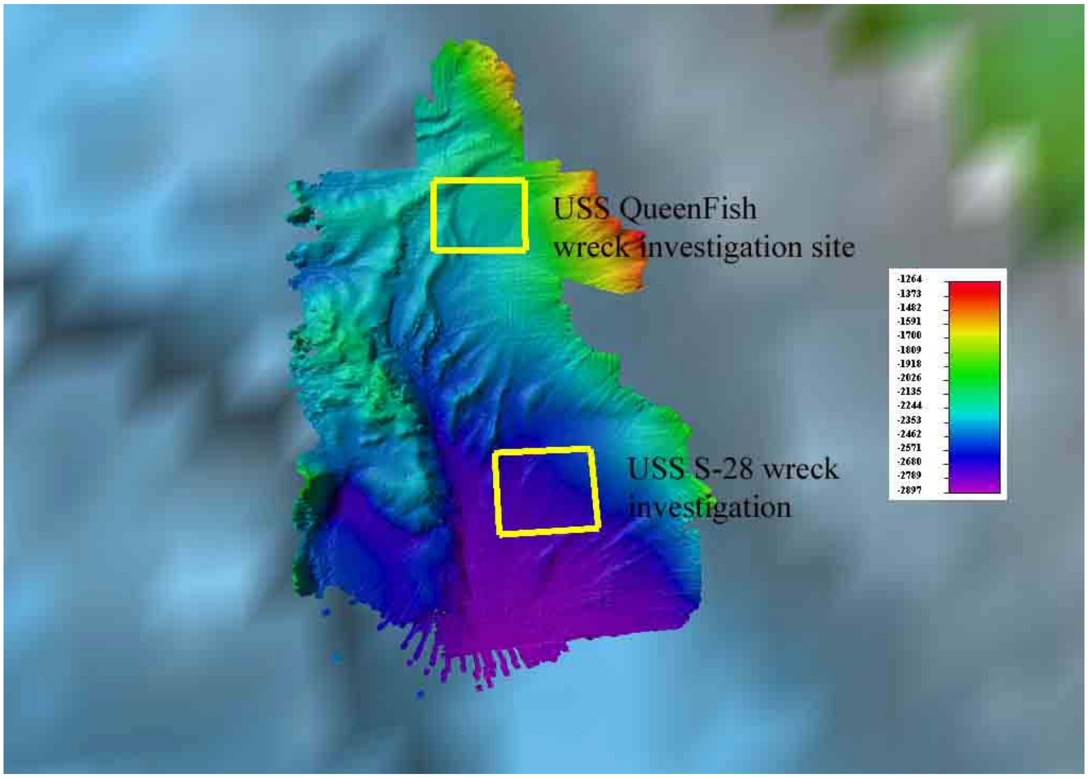

Figure 13. : Overview of the EM 302 data (50 m grid) collected in vicinity of wreck sites of SS-133 and USS Queenfish. Background data from Sandwell and Smith, images compiled in Fledermaus.

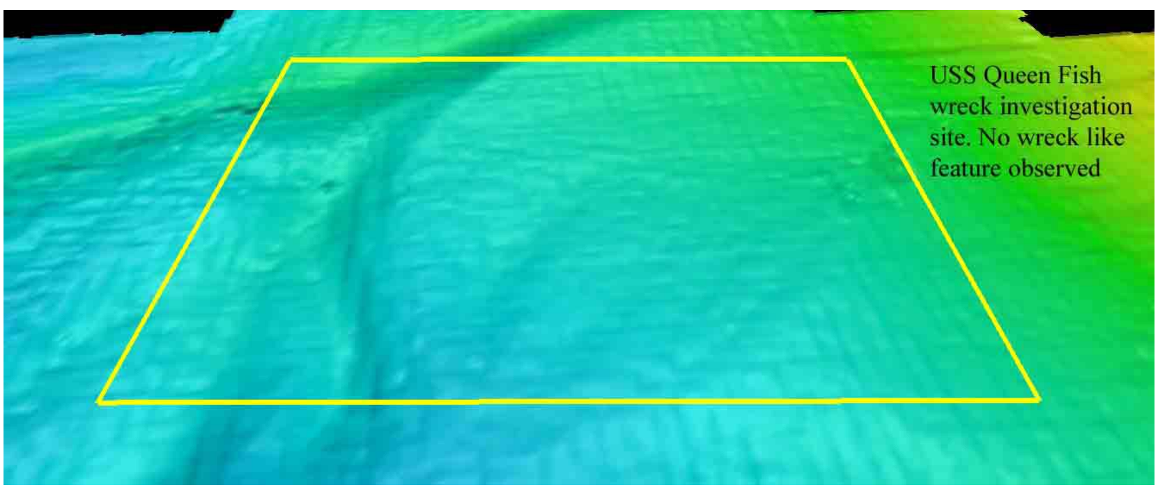

Figure 14. An oblique view of bathymetric data collected over reported wreck site of USS Queenfish (50 m grid). The area is marked with a square with 3000 m dimensions. Image compiled in Fledermaus.

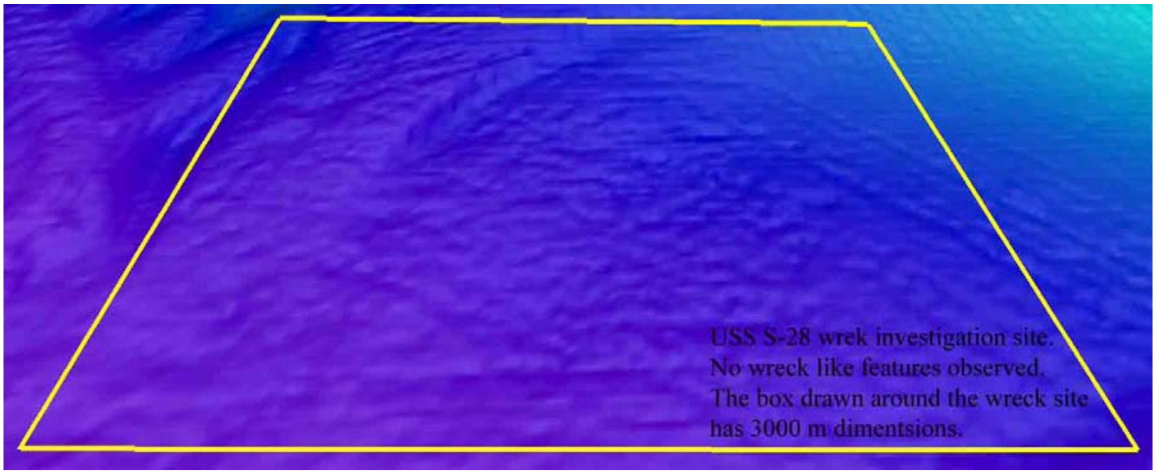

Figure 15. An oblique view looking north over the expected wreck site of USS S-28. No wreck-like features were observed in the EM 302 bathymetric (50 m grid) and backscatter data. Image compiled in Fledermaus.

USS Bluegill

The ship investigated the USS Bluegill wreck site location during the night of 15/16 October, 2009. A total of four passes were made in an area ~ 2-3 km around the reported position of the wreck. Several features with comparable sizes to the wreck were discernable in both bathymetric and backscatter data. Due to a large number of geological features around the reported position of the wreck, on the seafloor it was not possible to conclusively determine the location of the wreck by the EM 302 data alone. Future work using the ROV is recommended to investigate the targets detected by the EM 302. The following images show the results of EM 302 data around the wreck location.

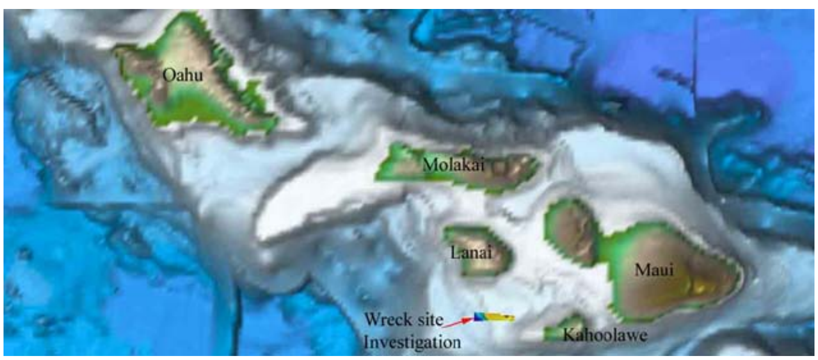

Figure 16. Over view of the EM302 USS Bluegill 50 m grid wreck investigation site. Background data from Sandwell and Smith, images compiled in Fledermaus.

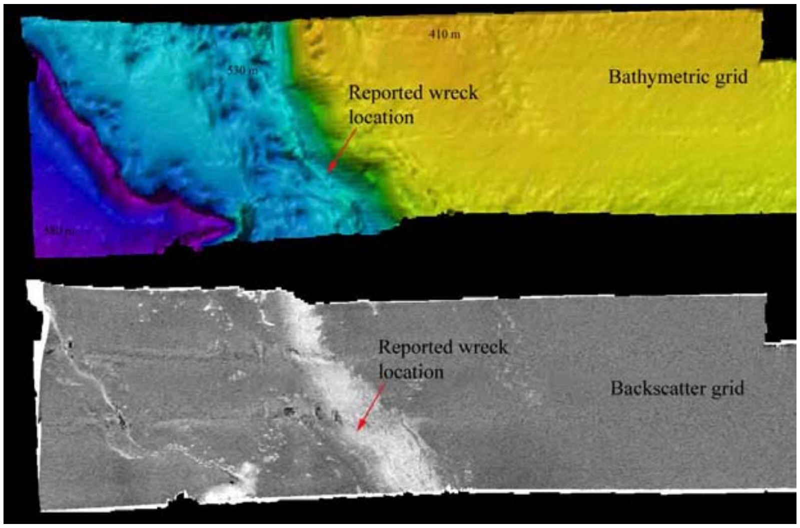

Figure 17. Bathymetric and backscatter grid around the USS Bluegill wreck site.

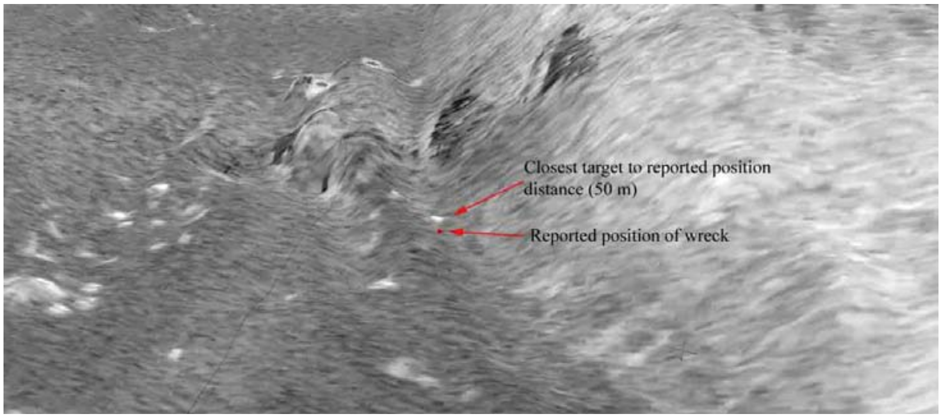

Figure 18. Zoomed in view from Geocoder around the reported wreck position of USS Bluegill. Several bathymetric and backscatter targets were identified close to the reported wreck position with closest backscatter target ~ 50 m from the reported wreck position.

10. Cruise Calendar

October 2009						
Mon	**Tue**	**Wed**	**Thu**	**Fri**	**Sat**	**Sun**
			1 Ship departed Honolulu, HI ~ 1500. Intern training, Heavy weather	2 Ship in transit to Wini Seamount. Going north of Big Island trying to cover HMRG holidays	3 Arrived Wini Seamount. Conducted star lines to assess best course w.r.t to swell	4 Continue running main-scheme lines over Wini Seamount

5 Continue running main-scheme lines over Wini Seamount. CTD cast at 1215 to 800 m	6 Finished Main scheme lines. Transiting towards other seamounts. CTD cast at 1215 to 800 m	7 Arrived west of Big Island mapping site. Conducted CTD cast to 800 m at 1215	8 Continue running main scheme lines in area west of Big Island. CTD cast to 800 conducted Small boat ops	9 Keleakekua Bay survey. CTD cast to 800 m. Small boat ops.	10 Kealeakekua Bay survey. CTD cast to 800 m. Small boat ops.	11 72 hrs DP test in progress, started 1200. Multibeam remains secured
12 72 hrs DP test in progress	13 72 hrs DP test in progress	14 Concluded 72 hrs DP test ~ 1200. Anchor Kealakekua Bay	15 Lifted anchor 1530. Commenced transit towards the wreck site	16 Investigation of USS Bluegill wreck. Continue transit towards the wreck site	17 Commenced working in PMNM area	18 Continue mapping ops in PMNM area CTD cast to 800 m
19 Continue mapping ops in PMNM area CTD cast to 800 m. EM302 malfunction for ~ 4 hrs	20 Commenced transit towards Honolulu, HI	21 Arrived Honolulu, HI				

11. Daily Cruise Log

(ALL TIMES LOCAL HDT)

October 1, 2009

Departed from Honolulu, HI ~ 1500. Got into heavy weather with lot of pitching and heaving during the night. The multibeam was not performing well due to a lot of bubble sweep down problems.

October 2, 2009

Continue transit towards Wini seamount covering HMRG holidays west and north of the Big Island. Weather conditions are sea-state 5-6 with 6-8 feet of swell. Multibeam performance remains degraded due to heavy weather.

October 3, 2009

Arrived Wini Seamount working grounds ~0700. Started the main scheme lines. Sea-state is 4-5 with wind 15-20 kts. Swell direction: From ~ 050 ~ 080.

Plan to run a star pattern to find out the best course in heavy weather. It has been realized that multibeam seem to perform better when the ship is not heading into the swell/sea right ahead. This experiment is meant to provide data to quantitatively analyze the effect of ship heading with respect to the sea waves and swells.

The ship stopped to fix the CNAV comport connection. ETts physically removed the com port and tightened the connection. During this stop the multibeam was stopped also and a BIST test showed that transmit board # 16 is bad. The board was then swapped with board # 18 and another BIST showed that board # 18 is now bad – confirming that it is the board and not the slot. Upon verification from OPSO it was learnt that the same board (Board # 16) failed in August and was replaced by a spare sent in from Kongsberg. The boards were then placed in their respective places (non-functioning board is now at slot # 16 again).

October 4, 2009

Continue to run the main scheme lines. Finished acquisition of star pattern lines 04 Oct 0100. Collected lines in directions of 000, 180, 030, 210, 060, 240, 090 and 270 with respect to the swell. The results indicate that the best direction to run the survey lines is beyond 30 degrees from the swell. However, for the perpendicular to the swell lines, although the data quality was observed to be best but the ship rolled violently.

October 5, 2009

Continue running lines over Wini Seamount. CTD cast conducted 1215-1300 to train survey, deck and bridge to a depth of 800 m.

October 6, 2009

Finished running main scheme lines over Wini Seamount in the morning. Transiting towards other seamounts.

1210-1325 – Conducted CTD cast

The ship transited to the west of Big Island mapping area over night going over the seamounts which were identified in the existing satellite derived and HMRG data sets.

The ship also transited over features which appear to have a shape of horse shoe. These features rise ~ 45 - 60 m above the seafloor and have a diameter of ~ 800 - 1100 m.

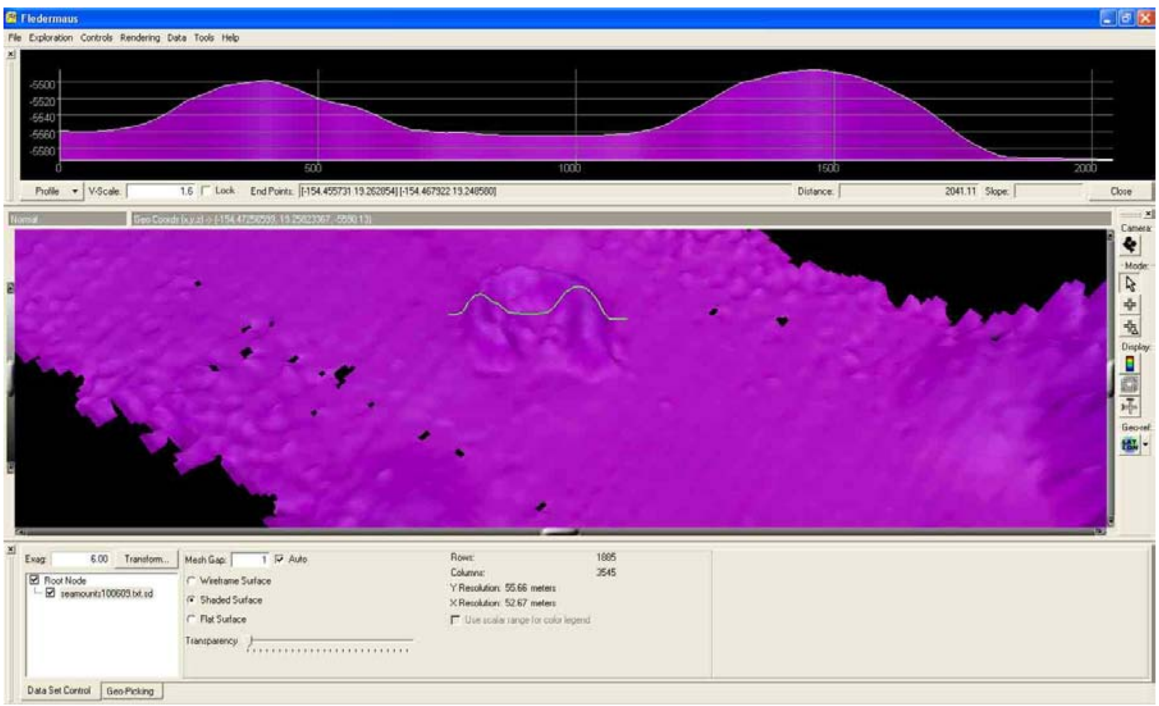

Figure 19. Horseshoe-like feature (50 m grid) observed on October 6 in Fledermaous.

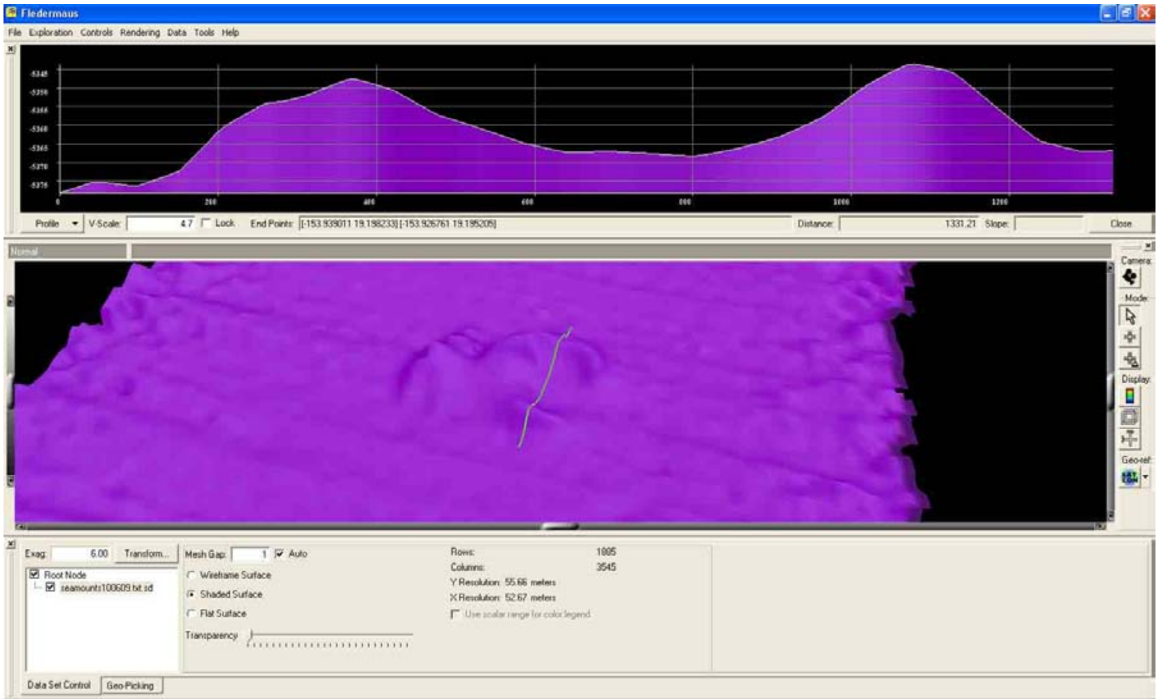

Figure 20. Horseshoe-like feature (50 m grid) observed on October 6 in Fledermaus.

The information about these features was sent to Dr. Hammond which initiated following reply:

“ "Stephen R. Hammond" <Stephen.R.Hammond@noaa.gov> [Fri 09 Oct 2009 01:23:55 AM EDT]:*

> Craig (and Mashkoor),
>
The first feature, and possibly the second, look like small, sedimented volcanic cones of the type I discussed in that paper I sent to you a while back. The breached crater/caldera morphology is very common along the Juan de Fuca Ridge as well as elsewhere along the East Pacific Rise. I suspect these are quite old features that are roughly the age of the crust on which they lie, i.e., that they formed on, or in close proximity, to a spreading center. ----Steve”

October 7, 2009

The ship started running main scheme line in the area west of Big Island. A CTD cast was conducted to 800 m of water depth at 1215.

October 8, 2009

The ship continued running main scheme lines in the Kealakekua Bay area west of Big Island. CTD cast up to 800 m water depth conducted at 1215.

October 9, 2009

The ship continues to run the lines over Kealakekua Bay area. Lavolvo was contacted today to provide input for the mapping areas to find suitable targets for ROV engineering dives.

October 10, 2009

Small boat operations were conducted to run the small boat to break in the engine. CTD cast was conducted to 800 m water depth. Continue mapping ops in Kealeakekua Bay.

October 11, 2009

72 hrs DP test continues. ~ 45 minutes of data while the ship held station (in water depths of 2400 – 3600 m) were collected to assess the variability of bathymetric and backscatter data. The preliminary results however indicate that further processing will be required to determine the usability of these data sets for assessing the variability of multibeam bathymetric data.

October 12-14, 2009

72 hrs DP test concluded on 14 Oct ~ 1500. The ship then transited towards Kona to anchor from 14 Oct 1500 – 15 Oct 1500.

October 15, 2009

The ship commenced transit towards the USS Bluegill wreck ~ 1530 and reached the reported location ~ 2300. The ship then ran 3 track lines around the wreck. But the multibeam sonar was not able to positively identify the location of the wreck. More details about the data processing are provided in the data acquisition and processing section.

October 16, 2009

Continue transit towards PMNM mapping area west of Kauai.

October 17, 2009

Arrived PMNM working grounds ~ 0130. Commenced mapping in the area.

October 18, 2009

Secured TSG pump due to large swells. Multibeam performance also degraded. Continue working in PMNM priority area. The area gets very shallow near the boundary of PMNM and swath coverage decreases to ~ few hundred meters. Therefore the top of the shallow feature was not covered to full extent leaving considerable holidays. Several small lines were run over the feature but it is inevitable that there will be holidays on top of the feature. The reported least depth (on the NOAA chart) is 19 fathoms (~ 40 m). The least depth observed during the mapping over the feature was observed to be ~ 65 m.

October 19, 2009

Ship continues to work in PMNM priority area. EM 302 suffered a major failure ~ 1800 when it stopped forming receive beams. The system (TRU, HWS) was restarted several times. This problem happened earlier during mapping season in May 2009 while working in similar depths (~ 1000 – 2000 m). A BIST test did not show any thing malfunctioning. It is thought that this problem is related to the overloading of SIS computer while working in shallower waters where the ping rate is high enough to overload the SIS computer. The system restarted working after putting the system in PU simulator mode and also changing the minimum and maximum angular coverage.

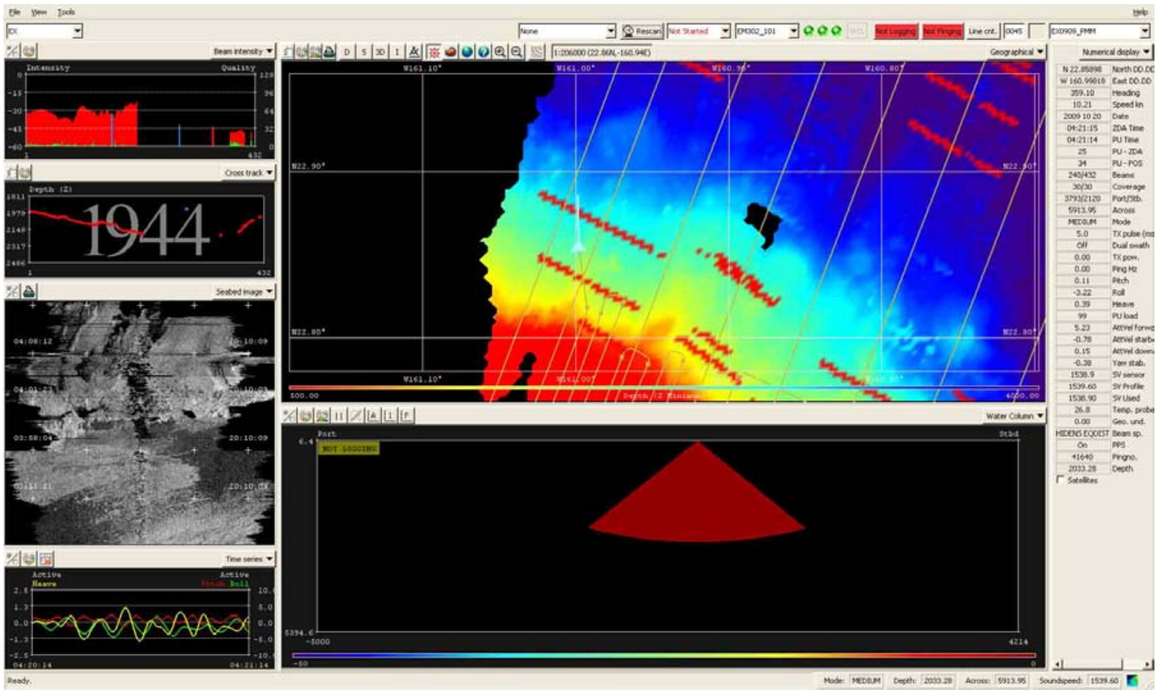

Figure 21. SIS screen shot of EM 302 malfunction showing a red triangle in the water column data indicating that no receive beam are being formed.

Overnight ship wrapped up mapping operations around PMNM working area and started transit towards Honolulu, HI.

October 20, 2009

Continued transit towards Honolulu, HI. Last science watch 1600 – 0000. Multibeam was left on unattended from 21 Oct 0000 – 0730. Arrived off Honolulu, HI ~ 0730 and multibeam operations were ceased.

October 21, 2009

Arrived Honolulu, HI.

12. Acknowledgements

Several personnel and organizations contributed heavily towards successful completion of this cruise. The efforts of ship board mapping team and ship's staff and crew is greatly appreciated in running day to day operations effectively, efficiently and most importantly safely. The Mapping Team would especially like to thank the CO (CDR Pica), OPS Officer (Lt VerPlanck) and crew of the NOAA Ship *Okeanos Explorer* for their guidance, help and assistance in running the mapping operations during this cruise. The contributions of Margo Edwards (University of Hawaii, Hawaii Mapping Research Group), Joyce Miller (Joint Institute for Marine and Atmospheric Research), John Rooney (Pacific Islands Benthic Habitat Mapping Center), Kayleen Keller (Papahānaumokuākea Marine National Monument) and Jonathan Weiss (University of Hawaii) toward identification of the areas that were mapped during this cruise are appreciated. Steve Hammond (NOAA), Jim Gardner (University of New Hampshire) and Meme Lobecker (NOAA) provided necessary shore support.

13. References

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14. Appendices

Appendix A: Tables of data files collected

EX0909 LEG 3 SOUND VELOCITY FILES					
Date (GMT)	**Time (GMT)**	**XBT/CTD Filename**	**Latitude**	**Longitude**	**Remarks**
10/02/2009	02:30:11	XBT_100109_01	21 11.950N	157 55.740W	Transit
10/02/2009	11:02:36	XBT_100209_02	20 25.8N	157 5.4W	Transit
10/02/2009	16:04:07	XBT_100209_03	20 16.2N	156 34.2W	Transit/Rough sea state
10/02/2009	22:45:33	XBT_100209_04	20 23.068N	155 58.026W	Transit
10/03/2009	04:12:41	XBT_100309_05	20 11.58N	155 21.57W	Transit
10/03/2009	10:15:04	XBT_100309_06	19 40.2N	154 35.4W	Transit
10/03/2009	16:09:16	XBT_100309_07	19 22.2N	153 52.2W	Transit
10/03/2009	23:11:59	XBT_100309_08	19 2.300N	153 54.780W	Wini Seamount/ Sea state test
10/04/2009	04:24:48	XBT_100409_09	19 1.254N	153 45.825W	Wini Seamount/ Sea state test
10/04/2009	10:28:59	XBT_100409_10	18 58.2N	153 58.2W	Wini Seamount/ Preceding line 1
10/04/2009	15:52:29	XBT_100409_11	19 17.4N	153 46.8W	Wini Seamount line 2
10/04/2009	22:07:27	XBT_100409_12	19 11.530N	153 47.180W	Wini Seamount/ Preceding line 7
10/05/2009	04:09:03	XBT_100509_13	18 51.890N	153 55.310W	Wini Seamount/
10/05/2009	10:22:35	XBT_100509_14	18 52.2N	153 48.6W	Wini Seamount
10/05/2009	16:03:29	XBT_100509_15	19 1.8N	123 36.6W	Wini Seamount on line 0020
10/05/2009	22:15:11	CTD_100509_01	19 03.94N	153 29.01W	Wini Seamount preceding line 0025
10/06/2009	04:42:17	XBT_100509_16	18 59.664 N	153 25.309 W	Wini Seamount on line 0030
10/06/2009		XBT_100609_17			Bad Cast
10/06/2009	10:17:52	XBT_100609_18	18 50.4N	153 24W	Wini Seamount line 0034
10/06/2009	16:11:39	XBT_100609_19	18 58.188N	154 1.24W	Wini Seamount line 0042
10/06/2009	22:22:41	CTD_100609_02	19 14.74N	154 07.15W	Transit from Wini Smt to Loihi
10/07/2009	04:27:58	XBT_100709_20	18 15.398 N	154 53.059 W	Transit from Wini Smt to Loihi
10/07/2009	09:53:27	XBT_100709_21	18 53.24 N	155 15.56 W	Above Loihi Crater remove diacritical marking
10/07/2009	16:27:14	XBT_100709_22	18 39.797 N	155 52.022 W	Kealakekua Bay
10/07/2009	22:18:32	CTD_100709_03	19 32.37N	156 05.89W	Kealakekua Bay
10/08/2009	04:06:30	XBT_100809_23	19 39.412N	156 10.488W	Kealakekua Bay
10/08/2009	10:24:17	XBT_100809_24	18 37.276N	155 54.261W	Kealakekua Bay
10/08/2009	16:05:21	XBT_100809_25	19 24.390N	156 9.452W	Kealakekua Bay
10/08/2009	22:12:59	CTD_100809_04	19 34.44N	156 14.34W	Kealakekua Bay
10/09/2009	04:30:50	XBT_100909_26	19 2.210 N	156 6.576 W	Kealakekua Bay
10/09/2009	10:22:42	XBT_100909_27	19 2.224N	156 9.483W	Kealakekua Bay
10/09/2009	16:16:00	XBT_100909_28	19 54.800N	156 26.22W	Kealakekua Bay

10/09/2009	22:17:25	CTD_100909_05	19 21.99N	156 17.44W	Kealakekua Bay
10/10/2009	04:11:40	XBT_101009_29	18 35.151N	156 5.302W	Kealakekua Bay
10/10/2009	10:11:14	XBT_101009_30	19 29.138N	156 22.374W	Kealakekua Bay
10/10/2009	16:06:12	XBT_101009_31	19 26.982N	156 24.727W	Kealakekua Bay
10/10/2009	22:21:39	CTD_101009_06	18 5.86N	156 16.44W	Kealakekua Bay
10/11/2009	04:10:35	XBT_101109_32	18 44.718N	156 49.700W	Kealakekua Bay
10/11/2009	10:21:50	XBT_101109_33	19 44.587N	156 5.824W	Kealakekua Bay
10/11/2009	16:05:41	XBT_101109_34	19 55.901N	156 31.481 W	Kealakekua Bay
10/16/2009	04:09:38	XBT_101609_35	19 55.585N	156 20.019W	Kealakekua Bay/Transit
10/16/2009	10:22:55	XBT_101609_36	20 36.134N	156 53.584W	Wreck site
10/16/2009	10:27:23	XBT_101609_37	20 36.139N	156 52.967W	Wreck site
10/16/2009	16:02:54	XBT_101609_38	20 47.993N	157 43.419W	Transit
10/16/2009	22:42:51	XBT_101609_39	21 9.41309N	158 57.7187W	Transit
10/17/2009	04:18:36	XBT_101709_40	21 26.644N	159 59.208W	Transit
10/17/2009	10:21:47	XBT_101709_41	22 10.425N	160 45.382W	Transit
10/17/2009	16:11:38	XBT_101709_42	22 57.535N	160 37.892W	PMNM
10/17/2009	22:20:05	CTD_101709_07	22 20.05N	160 56.36W	PMNM
10/18/2009	04:11:59	XBT_101809_43	23 02.041N	160 42.278W	PMNM
10/18/2009	10:21:24	XBT_101809_44	22 22.828N	161 1.632W	PMNM
10/18/2009	16:14:14	XBT_101809_45	22 55.443N	160 51.274W	PMNM
10/18/2009	22:21:50	CTD_101809_08	22 34.87N	161 02.81W	PMNM
10/19/2009	04:19:57	XBT_101909_46	22 52 830N	160 58.599W	PMNM
10/19/2009	10:20:28	XBT_101909_47	22 35.172N	161 7.621W	PMNM
10/19/2009	15:57:21	XBT_101909_48	22 44.374N	160 54.552W	PMNM
10/19/2009	22:39:03	CTD_101909_09	22 35.14N	161 03.35W	PMNM
10/20/2009	04:17:25	XBT_102009_49	22 50.937N	160 59.801W	PMNM
10/20/2009	10:26:04	XBT_102009_50	22 47.419N	160 41.196W	PMNM
10/20/2009	16:04:43	XBT_102009_51	22 29.135N	160 46.490W	PMNM
10/20/2009	22:44:20	XBT_102009_52	21 37.876N	160 19.3457W	PMNM
10/21/2009	04:27:31	XBT_102109_53	21 24.823N	159 30.272W	Transit Home

EX0909 LEG 3 EM302 MULTIBEAM FILES					
JD	**Date (GMT)**	**File Name**	**Location**	**Survey Name**	**Remarks**
275	100209	0000_20091002_030850_EX	In Transit	EX0909_HawaiiIs _Transit	Rough seas
275	100209	0001_20091002_085816_EX	In Transit	EX0909_HawaiiIs _Transit	Not as rough seas beginning of line/ towards end of line rough seas- bad data
275	100209	0002_20091002_145817_EX	In Transit	EX0909_HawaiiIs _Transit	Rough seas, data very bad
275	100209	0003_20091002_171952_EX	In Transit	EX0909_HawaiiIs _Transit	Rough seas
275	100209	0004_20091002_192920_EX	In Transit	EX0909_HawaiiIs _Transit	Moderate seas
275	100209	0005_20091002_211445_EX	In Transit	EX0909_HawaiiIs _Transit	Sea state 6
276	100309	0006_20091003_010549_EX	In Transit	EX0909_HawaiiIs _Transit	Moderate seas
276	100309	0007_20091003_034436_EX	In Transit	EX0909_HawaiiIs _Transit	Rough seas
276	100309	0008_20091003_074325_EX	In Transit	EX0909_HawaiiIs _Transit	Rough seas
276	100309	0009_20091003_133005_EX	In Transit	EX0909_HawaiiIs _Transit	Rough Seas
276	100309	0000_20091003_164419_EX	Wini SeaMnt	Wini SeaMnt	Swells >5 ft
276	100309	0000_20091003_232450_EX	Wini SeaMnt	SeaStateLines	Moderate seas
277	100409	0001_20091004_000003_EX	Wini SeaMnt	SeaStateLines	Moderate seas
277	100409	0002_20091004_010542_EX	Wini SeaMnt	SeaStateLines	Moderate seas
277	100409	0003_20091004_021816_EX	Wini SeaMnt	SeaStateLines	Moderate seas
277	100409	0004_20091004_034252_EX	Wini SeaMnt	SeaStateLines	Swells 4-6 ft
277	100409	0005_20091004_045101_EX	Wini SeaMnt	SeaStateLines	Swells 4-6 ft
277	100409	0006_20091004_061112_EX	Wini SeaMnt	SeaStateLines	Swells 4-6 ft
277	100409	0007_20091004_071114_EX	Wini SeaMnt	SeaStateLines	Swells 4-6 ft
277	100409	0008_20091004_082301_EX	Wini SeaMnt	SeaStateLines	Swells 4-6 ft
277	100409	0001_20091004_110818_EX	Wini SeaMnt	Wini Sea Mnt	10 ft seas, wind 20 kts
277	100409	0002_20091004_111226_EX	Wini SeaMnt	Wini Sea Mnt	10 ft seas, wind 20 kts
277	100409	0003_20091004_151508_EX	Wini SeaMnt	Wini Sea Mnt	Turn line
277	100409	0004_20091004_154255_EX	Wini SeaMnt	Wini Sea Mnt	Line heading SW with following seas
277	100409	0005_20091004_185006_EX	Wini SeaMnt	WiniSeamnt	Turn line
277	100409	0006_20091004_191628_EX	Wini SeaMnt	WiniSeamnt	Swells 3-5ft
277	100409	0007_20091004_230428_EX	Wini SeaMnt	WiniSeamnt	Turn Line
277	100409	0008_20091004_23374_EX	Wini SeaMnt	WiniSeamnt	Swells 3-5ft
277	100409	0009_20091004_235955_EX	Wini SeaMnt	WiniSeamnt	Swells 3-5ft
278	100409	0009_20091005_012123_EX	Wini SeaMnt	SeaStateLines	Swells 3-5ft
278	100509	0010_20091005_023244_EX	Wini SeaMnt	WiniSeamnt	Moderate seas
278	100509	0011_20091005_035853_EX	Wini SeaMnt	WiniSeamnt	Moderate seas
278	100509	0012_20091005_040454_EX	Wini SeaMnt	WiniSeamnt	Moderate seas
278	100509	0013_20091005_053210_EX	Wini SeaMnt	WiniSeamnt	Moderate seas
278	100509	0014_20091005_055847_EX	Wini SeaMnt	WiniSeamnt	Moderate seas
278	100509	0015_20091005_072326_EX	Wini SeaMnt	WiniSeamnt	Moderate seas
278	100509	0016_20091005_074748_EX	Wini SeaMnt	WiniSeamnt	Moderate seas

278	100509	0017_20091005_104617_EX	Wini SeaMnt	Wini SeaMnt	Moderate seas – turn line
278	100509	0018_20091005_110734_EX	Wini SeaMnt	Wini SeaMnt	Moderate/heavy seas
278	100509	0019_2091005_144142_EX	Wini SeaMnt	Wini SeaMnt	Moderate seas-turn line
278	100509	0020_20091005_150654_EX	Wini SeaMnt	Wini SeaMnt	Moderate seas
278	100509	0021_20091005_175313_EX	Wini SeaMnt	Wini SeaMnt	Moderate seas
278	100509	0022_20091005_181631_EX	Wini SeaMnt	Wini SeaMnt	Moderate seas
278	100509	0023_20091005_210604_EX	Wini SeaMnt	Wini SeaMnt	Moderate seas
278	100509	0024_20091005_213244_EX	Wini SeaMnt	Wini SeaMnt	Moderate seas
278	100509	0025_20091005_225335_EX	Wini SeaMnt	Wini SeaMnt	Moderate seas
279	100609	0026_20091006_000004_EX	Wini SeaMnt	Wini SeaMnt	Moderate seas
279	100609	0027_20091006_004606_EX	Wini SeaMnt	Wini SeaMnt	Moderate seas
279	100609	0028_20091006_011302_EX	Wini SeaMnt	Wini SeaMnt	Moderate seas
279	100609	0029_200091006_033347_EX	Wini SeaMnt	Wini SeaMnt, Turn Line	Moderate seas
279	100609	0030_20091006_035641_EX	Wini SeaMnt	Wini SeaMnt	Moderate seas
279	100609	0031_20091006_060127_EX	Wini SeaMnt	Wini SaMnt, Turn line	Moderate seas
279	100609	0032_20092006_062541_EX	Wini SeaMnt	Wini SeaMnt	Moderate seas
279	100609	0033_20092006_082543_EX	Wini SeaMnt	Wini SaMnt, Turn line	Moderate seas
279	100609	0034_20091006_084543_EX	Wini SeaMnt	Wini SeaMnt	Moderate seas
279	100609	0035_20091006_103404_EX	Wini SeaMnt	Wini SeaMnt	Moderate seas-transit to holiday lines
279	100609	0036_20091006_115856_EX	Wini SeaMnt	Wini SeaMnt	Holiday lines – Mod. Seas
279	100609	0037_20091006_134224_EX	Wini SeaMnt	Wini SeaMnt	Holiday line - turn
279	100609	0038_20091006_134727_EX	Wini SeaMnt	Wini SeaMnt	Holiday line
279	100609	0039_20091006_153116_EX	Wini SeaMnt	Wini SeaMnt	Holiday line - turn
279	100609	0040_20091006_153451_EX	Wini SeaMnt	Wini SeaMnt	Holiday line
279	100609	0041_20091006_155736_EX	Wini SeaMnt	Wini SeaMnt	Holiday line – turn
279	100609	0042_20091006_155958_EX	Wini SeaMnt	Wini SeaMnt	Holiday line
279	100609	0043_20091006_184004_EX	Wini SeaMnt	Wini SeaMnt	Holiday Line – Turn
279	100609	0044_20091006_184228_EX	Wini SeaMnt	Wini SeaMnt	Holiday line
279	100609	0045_20091006_191619_EX	Wini SeaMnt	Wini SeaMnt	Holiday line - Turn
279	100609	0046_20091006_191904_EX	Wini SeaMnt	Wini SeaMnt	Holiday line
279	100609	0047_20091006_201542_EX	Wini SeaMnt	Wini SeaMnt	Holiday line
279	100609	0010_20091006_202029_EX	In Transit	EX0909_HawaiiIs _Transit	Transit to Loihi
279	100609	0011_20091006_232300_EX	In Transit	EX0909_HawaiiIs _Transit	Transit to Loihi
280	100709	0012_20091007_000115_EX	In Transit	EX0909_HawaiiIs _Transit	Transit to Loihi
280	100709	0013_20091007_003715_EX	In Transit	EX0909_HawaiiIs _Transit	Strange 'C' structure in the backscatter data
280	100709	0014_20091007_023923_EX	In Transit	EX0909_HawaiiIs _Transit	Transit to Loihi
280	100709	0015_20091007_003715s_EX	In Transit	EX0909_HawaiiIs _Transit	Transit to Loihi
280	100709	0016_20091007_031453_EX	In Transit	EX0909_HawaiiIs _Transit	Turn line before Loihi
280	100709	0017_20091007_063801_EX	Loihi SeaMnt	EX0909_HawaiiIs _Transit	First Loihi line/wcd file
280	100709	0018_20091007_081733_EX	Loihi SeaMnt	EX0909_HawaiiIs _Transit	Loihi – turn line
280	100709	0019_20091007_083336_EX	Loihi SeaMnt	EX0909_HawaiiIs _Transit	Second Loihi MS line

280	100709	0020_20091007_090038_EX	Loihi SeaMnt	EX0909_HawaiiIs _Transit	Broke line to turn into center of crater
280	100709	0021_20091007_090225_EX	Loihi SeaMnt	EX0909_HawaiiIs _Transit	Line over crater west to east
280	100709	0022_20091007_091744_EX	Loihi SeaMnt	EX0909_HawaiiIs _Transit	Turn line
280	100709	0023_20091007_092107_EX	Loihi SeaMnt	EX0909_HawaiiIs _Transit	Second line over crater east to west
280	100709	0024_20091007__093603_EX	Loihi SeaMnt	EX0909_HawaiiIs _Transit	Loihi Seamount turn line
280	100709	0025_20091007_093958_EX	Loihi SeaMnt	EX0909_HawaiiIs _Transit	Leaving Loihi Seamount south
280	100709	0026_20091007_104833_EX	In Transit	EX0909_HawaiiIs _Transit	Turn line to transit Big Island
280	100709	0027_20091007_111954_EX	In Transit	EX0909_HawaiiIs _Transit	Transit line to Kealakekua Bay
280	100709	0028_20091007_135205_EX	In Transit	EX0909_HawaiiIs _Transit	Transit line to Kealakekua Bay
280	100709	0029_20091007_135701_EX	In Transit	EX0909_HawaiiIs _Tranist	Transit line to Kealakekua Bay
280	100709	0000_20091007_160407_EX	Kealakekua	EX0909_Kealakek ua_Bay	Kealakekua Bay Survey
280	100709	0001_20091007_16656_EX	Kealakekua	EX0909_Kealakek ua_Bay	Kealakekua Bay Survey
280	100709	0002_20091007_190019_EX	Kealakekua	EX0909_Kealakek ua_Bay	Kealakekua Bay Survey
280	100709	0003_20091007_220612_EX	Kealakekua	EX0909_Kealakek ua_Bay	This line is a mistake and does not need to be converted into Caris.
280	100709	0004_20091007_230029_EX	Kealakekua	EX0909_Kealakek ua_Bay	Kealakekua Bay Survey
281	100809	0005_20091008_000010_EX	Kealakekua	EX0909_Kealakek ua_Bay	Kealakekua Bay Survey
281	100809	0006_20091008_014330_EX	Kealakekua	EX0909_Kealakek ua_Bay	Kealakekua Bay Survey
281	100809	0007_20091008_021104_EX	Kealakekua	EX0909_Kealakek ua_Bay	Kealakekua Bay Survey
281	100809	0008_20091008_081106_EX	Kealakekua	EX0909_Kealakek ua_Bay	Kealakekua Bay Survey
281	100809	0009_20091008_102720_EX	Kealakekua	EX0909_Kealakek ua_Bay	Kealakekua Bay Survey
281	100809	0010_20091008_105404_EX	Kealakekua	EX0909_Kealakek ua_Bay	Kealakekua Bay Survey
281	100809	0011_20091008_124815_EX	Kealakekua	EX0909_Kealakek ua_Bay	Kealakekua Bay Survey
281	100809	0012_20091008_184814_EX	Kealakekua	EX0909_Kealakek ua_Bay	Kealakekua Bay Survey
281	100809	0013_20091008_191801_EX	Kealakekua	EX0909_Kealakek ua_Bay	Kealakekua Bay Survey
281	100809	0014_20091008_193905_EX	Kealakekua	EX0909_Kealakek ua_Bay	Kealakekua Bay Survey
281	100809	0015_20091008_230002_EX	Kealakekua	EX0909_Kealakek ua_Bay	Kealakekua Bay Survey
282	100909	0016_20091008_011123_EX	Kealakekua	EX0909_Kealakek ua_Bay	Kealakekua Bay Survey
282	100909	0017_20091009_071120_EX	Kealakekua	EX0909_Kealakek ua_Bay	Kealakekua Bay Survey
282	100909	0018_20091009_072235_EX	Kealakekua	EX0909_Kealakek ua_Bay	Kealakekua Bay Survey

282	100909	0019_20091009_074514_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
282	100909	0020_20091009_134514_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
282	100909	0021_20091009_154908_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
282	100909	0022_20091009_160954_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
282	100909	0023_20091009_215324_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
282	100909	0024_20091009_231111_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
283	101009	0025_20091010_004934_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
283	101009	0026_20091010_042454_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
283	101009	0027_20091010_044701_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
283	101009	0028_20091010_104655_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
283	101009	0029_20091010_124116_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
283	101009	0030_20091010_130233_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
283	101009	0031_20091010_203311_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
283	101009	0032_20091010_231004_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
284	101109	0033_20091011_000052_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
284	101109	0034_20091011_010527_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
284	101109	0035_20091011_010858_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
284	101109	0036_20091011_032930_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
284	101109	0037_20091011_034014_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
284	101109	0038_20091011_094011_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
284	101109	0039_20091011_115910_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
284	101109	0040_20091011_120131_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
284	101109	0041_20091011_144946_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
284	101109	0042_20091011_150651_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
284	101109	0043_20091011_180317_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
284	101109	0044_20091011_180339_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
284	101109	0045_20091011_180933_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
284	101109	0046_20091011_183548_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
284	101109	0047_20091011_190247_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey
284	101109	0048_20091011_205902_EX	Kealakekua	EX0909_Kealakekua_Bay	Kealakekua Bay Survey

284	101109	0049_20091011_213954_EX	Kealakekua	EX0909_Kealakekua_Bay	Disregard this line; no need to convert in Caris.
289	101609	0030_20091016_021714_EX	In Transit	EX0909_HawaiiIs_Transit	Kealakekua Bay/Transit
289	101609	0031_20091016_044349_EX	In Transit	EX0909_HawaiiIs_Transit	In Transit to wreck site
289	101609	0032_20091016_084814_EX	In Transit	USS Bluegill	Wreck Line
289	101609	0033_20091016_090241_EX	In Transit	USS Bluegill	Wreck Line
289	101609	0034_20091016_095123_EX	In Transit	USS Bluegill	Wreck Line
289	101609	0035_20091016_095906_EX	In Transit	USS Bluegill	Wreck Line
289	101609	0036_20091016_104045_EX	In Transit	USS Bluegill	Wreck Line
289	101609	0037_20091016_105229_EX	In Transit	USS Bluegill	Wreck Line
289	101609	0038_20091016_111927_EX	In Transit	USS Bluegill	Wreck Line
289	101609	0039_20091016_112255_EX	In Transit	USS Bluegill	Wreck Line
289	101609	0040_20091016_113131_EX	In Transit	USS Bluegill	Wreck Line
289	101609	0041_20091016_113616_EX	In Transit	USS Bluegill	Wreck Line
289	101609	0042_20091016_113937_EX	In Transit	USS Bluegill	Wreck Line
289	101609	0043_20091016_115727_EX	In Transit	USS Bluegill	Wreck Line
289	101609	0044_20091016_175732_EX	In Transit	EX0909_HawaiiIs_Transit	Transit to PMNM area
290	101709	0045_20091017_235734_EX	In Transit	EX0909_HawaiiIs_Transit	Transit to PMNM area
290	101709	0046_20091017_055728_EX	In Transit	EX0909_HawaiiIs_Transit	Transit to PMNM area
290	101709	0000_20091017_100629_EX	In Transit	EX0909_PMNM	Transit to PMNM
290	101709	0001_20091017_112609_EX	PMNM	EX0909_PMNM	PMNM Survey
290	101709	0002_20091017_165214_EX	PMNM	EX0909_PMNM	PMNM Survey
290	101709	0003_20091017_170909_EX	PMNM	EX0909_PMNM	PMNM Survey
290	101709	0004_20091017_231225_EX	PMNM	EX0909_PMNM	PMNM Survey
290	101709	0005_20091017_232952_EX	PMNM	EX0909_PMNM	PMNM Survey
291	101809	0006_20091018_000009_EX	PMNM	EX0909_PMNM	PMNM Survey
291	101809	0007_20091018_043845_EX	PMNM	EX0909_PMNM	PMNM Survey
291	101809	0008_20091018_045509_EX	PMNM	EX0909_PMNM	PMNM Survey
291	101809	0009_20091018_103849_EX	PMNM	EX0909_PMNM	PMNM Survey
291	101809	0010_20091018_110243_EX	PMNM	EX0909_PMNM	PMNM Survey
291	101809	0011_20091018_170246_EX	PMNM	EX0909_PMNM	PMNM Survey
291	101809	0012_20091018_175051_EX	PMNM	EX0909_PMNM	PMNM Survey
291	101809	0013_20091018_181201_EX	PMNM	EX0909_PMNM	PMNM Survey
291	101809	0014_20091018_230544_EX	PMNM	EX0909_PMNM	PMNM Survey
291	101809	0015_20091018_235958_EX	PMNM	EX0909_PMNM	PMNM Survey
292	101909	0016_20091019_003110_EX	PMNM	EX0909_PMNM	PMNM Survey
292	101909	0017_20091019_005604_EX	PMNM	EX0909_PMNM	PMNM Survey
292	101909	0018_20091019_060601_EX	PMNM	EX0909_PMNM	PMNM Survey
292	101909	0019_20091019_062409_EX	PMNM	EX0909_PMNM	PMNM Survey
292	101909	0020_20091019_113100_EX	PMNM	EX0909_PMNM	PMNM Survey
292	101909	0021_20091019_113609_EX	PMNM	EX0909_PMNM	PMNM Survey
292	101909	0022_20091019_123731_EX	PMNM	EX0909_PMNM	PMNM Survey
292	101909	0023_20091019_124748_EX	PMNM	EX0909_PMNM	PMNM Survey
292	101909	0024_20091019_140045_EX	PMNM	EX0909_PMNM	PMNM Survey
292	101909	0025_20091019_140330_EX	PMNM	EX0909_PMNM	PMNM Survey
292	101909	0027_20091019_152025_EX	PMNM	EX0909_PMNM	PMNM Survey
292	101909	0028_20091019_154345_EX	PMNM	EX0909_PMNM	PMNM Survey
292	101909	0029_20091019_164028_EX	PMNM	EX0909_PMNM	PMNM Survey

292	101909	0030_20091019_171403_EX	PMNM	EX0909_PMNM	PMNM Survey
292	101909	0031_20091019_182611_EX	PMNM	EX0909_PMNM	PMNM Survey
292	101909	0032_20091019_183402_EX	PMNM	EX0909_PMNM	PMNM Survey
292	101909	0033_20091019_194052_EX	PMNM	EX0909_PMNM	PMNM Survey
292	101909	0034_20091019_194833_EX	PMNM	EX0909_PMNM	PMNM Survey
292	101909	0035_20091019_205041_EX	PMNM	EX0909_PMNM	PMNM Survey
292	101909	0036_20091019_210018_EX	PMNM	EX0909_PMNM	PMNM Survey
292	101909	0037_20091019_222454_EX	PMNM	EX0909_PMNM	PMNM Survey
292	101909	0038_20091019_232558_EX	PMNM	EX0909_PMNM	PMNM Survey
293	102009	0039_20091020_000002_EX	PMNM	EX0909_PMNM	PMNM Survey
293	102009	0040_20091020_005159_EX	PMNM	EX0909_PMNM	PMNM Survey
293	102009	0041_20091020_010120_EX	PMNM	EX0909_PMNM	PMNM Survey
293	102009	0042_20091020_023445_EX	PMNM	EX0909_PMNM	PMNM Survey
293	102009	0043_20091020_024431_EX	PMNM	EX0909_PMNM	PMNM Survey
293	102009	0044_20091020_040645_EX	PMNM	EX0909_PMNM	PMNM Survey
293	102009	0045_20091020_080513_EX	PMNM	EX0909_PMNM	PMNM Survey
293	102009	0046_20091020_104036_EX	PMNM	EX0909_PMNM	PMNM Survey
293	102009	0047_20091020_104305_EX	PMNM	EX0909_PMNM	PMNM Survey
293	102009	0048_20091020_123937_EX	PMNM	EX0909_PMNM	PMNM Survey
293	102009	0047_20091020_172824_EX	In Transit	EX0909_Hawaii Is_Transit	Moderate seas
293	102009	0048_20091020_173451_EX	In Transit	EX0909_Hawaii Is_Transit	Moderate seas
293	102009	0049_20091020_233451_EX	In Transit	EX0909_Hawaii Is_Transit	Moderate seas
294	102109	0050_20091021_000002_EX	In Transit	EX0909_Hawaii Is_Transit	Moderate seas
294	102109	0051_20091021_060006_EX	In Transit	EX0909_Hawaii Is_Transit	Moderate seas
294	102109	0052_20091021_100157_EX	In Transit	EX0909_Hawaii Is_Transit	Moderate seas

Appendix B: EM302 description and operational specs

EM 302 : Ideal for Ocean Exploration

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

Depth Range

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

High Density Data

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

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

Full Suite of Data Types Collected

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

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

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

Multibeam Primer

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

Calculated acrosstrack acoustic beam footprint for EM 302 (high density ping mode, 432 soundings/profile)	
Water depth (m)	**Angle from nadir**

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

Table 4. Calculated across track EM 302 beam footprint. Reference: Kongsberg Product description, Kongsberg document 302675 Rev B, Date 14/06/06, p. 17.

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

Table 5. Calculated across track EM 302 sounding density. Reference: Kongsberg Product description, Kongsberg document 302675 Rev B, Date 14/06/06, p. 17.

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

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

100	550	1.8	1.1	2.2	3.3
200	1100	1	2.1	4.2	6.3
400	2200	0.5	4.1	8.2	12.2
1000	5500	0.2	10	20	30
2000	8000	0.1	15.2	30.5	45.7
4000	8000	0.06	19.2	38.5	57.7
6000	8000	0.04	24.5	49	73.4

Table 6. Calculated ping rate and along track EM 302 sounding density, one profile per ping. Reference: Kongsberg Product description, Kongsberg document 302675 Rev B, Date 14/06/06, p. 15.

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

Table 7. Calculated ping rate and along track EM 302 sounding density, two profiles per ping. Reference: Kongsberg Product description, Kongsberg document 302675 Rev B, Date 14/06/06, p. 15.

Reference: Kongsberg Product Description: EM 302 multibeam echosounder

Appendix C: EM302 PU Parameters

#// Database Parameters

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

#// Build info:
#* SIS: [Version: 3.6.1, Build: 174, DBVersion 16.0 CD generated: Tue Nov 11 15:39:05 2008]
[Fox ver = 1.6.29]
[db ver = 16, proc = 16.0]
[OTL = 4.0.-95]
[ACE ver = 5.5]
[Coin ver = 2.4.4]
[Simage ver = 1.6.2a]
[Dime ver = DIME v0.9]
[STLPort ver = 513]
[FreeType ver = 2.1.9]
[TIFF ver = 3.8.2]
[GeoTIFF ver = 1230]
[GridEngine ver = 2.3.0]

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

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

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

#{ Input Setup #// All Input setup parameters

#{ COM1 #// Link settings.

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

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

#{ Input Formats #// Format input settings.
#* Attitude [0] [0]
#* MK39 Mod2 Attitude, [0] [0]
#* ZDA Clock [1] [1]

#* HDT Heading [0] [0]
#* SKR82 Heading [0] [0]
#* DBS Depth [1] [0]
#* DBT Depth [1] [0]
#* EA500 Depth [0] [0]
#* ROV. depth [1] [0]
#* Height, special purp [1] [0]
#* Ethernet AttVel [0] [0]
#} Input Formats

#} COM1

#{ COM2 #// Link settings.

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

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

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

#} COM2

#{ COM3 #// Link settings.

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

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

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

#} COM3

#{ COM4 #// Link settings.

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

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

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

#} COM4

#{ UDP2 #// Link settings.

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

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

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

#} UDP2

#{ UDP3 #// Link settings.

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

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

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

#} UDP3

#{ UDP4 #// Link settings.

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

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

#{ Input Formats #// Format input settings.

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

#} UDP4

#{ UDP5 #// Link settings.

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

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

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

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

#} UDP5

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

#} Input Setup

#{ Output Setup #// All Output setup parameters

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

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

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

#} Host UDP1

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

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

#} Host UDP2

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

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

#} Host UDP3

#{ Host UDP4 #// Host UDP4 Port 16103

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

#} Host UDP4

#{ Watercolumn #// Host UDP4 Port 16103

#{ Datagram subscription #//
#* Depth [1] [0]
#* Raw range and beam a [1] [0]
#* Seabed Image [1] [0]
#* Central Beams [1] [0]
#* Position [1] [0]

#* Attitude [1] [0]
#* Heading [1] [0]
#* Height [1] [0]
#* Clock [1] [0]
#* Single beam echosoun [1]
[0]
#* Sound Speed Profile [1] [0]
#* Runtime Parameters [1] [0]
#* Installation Paramet [1] [0]
#* BIST Reply [1] [0]
#* Status parameters [1] [0]
#* PU Broadcast [1] [0]
#* Stave Display [1] [0]
#* Water Column [1] [1]
#* Internal, Range Data [1] [0]
#* Internal, Scope Data [1] [0]
#} Datagram subscription

#} Watercolumn

#} Output Setup

#{ Clock Setup #// All Clock setup
parameters

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

#} Clock Setup

#{ Settings #// Sensor setup
parameters

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

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

#} Positioning System Settings

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

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

#} Motion Sensor Settings

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

#} Settings

#{ Locations #// All location
parameters

#{ Location offset (m) #//

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

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

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

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

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

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

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

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

#} Location offset (m)

#} Locations

#{ Angular Offsets #// All angular
offset parameters

#{ Offset angles (deg.) #//

#{ TX Transducer: #//
#* S1R [0.0] #// Roll
#* S1P [0.00] #//
Pitch
#* S1H [359.98] #//
Heading
#} TX Transducer:

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

#{ Attitude 1, COM2: #//
#* MSR [0.00] #//
Roll
#* MSP [-0.70] #//
Pitch
#* MSG [0.00] #//
Heading
#} Attitude 1, COM2:

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

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

#} Offset angles (deg.)

#} Angular Offsets

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

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

#} ROV. Specific

#{ System Parameters #// All system
parameters

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

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

#} System Parameters

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

#{ Sounder Main #//

#{ Sector Coverage #//

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

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

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

#} Sector Coverage

#{ Depth Settings #//
#* FDE [4700] #//
Force Depth (m)
#* MID [500] #// Min.
Depth (m):
#* MAD [6000] #//
Max. Depth (m):
#* DSM [0] #// Dual
swath mode: OFF
#* PMO [0] #// Ping
Mode: AUTO
#* FME [1] #// FM
enable
#} Depth Settings

#{ Stabilization #//
#* YPS [1] #// Pitch
stabilization
#* TXA [3] #// Along
Direction (deg.):

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

#} Stabilization
#} Sounder Main

#{ Sound Speed #//

#{ Sound Speed at Transducer #//
#* SHS [0] #// Source
SENSOR
#* SST [14672] #//
Sound Speed (dm/sec.):
#* Sensor Offset (m/sec [0.0] #//
#* Filter (sec.): [5] #//
#} Sound Speed at Transducer

#} Sound Speed

#{ Filter and Gains #//

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

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

#{ Normal incidence sector #//
#* TCA [12] #// Angle
from nadir (deg.):
#} Normal incidence sector

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

#{ Data Cleaning #//
#* Active rule:
[AUTOMATIC1] #//
#{ AUTOMATIC1 #//
#*
PingProc.maxPingCountRadius
[10]
#* PingProc.radiusFactor
[0.050000]
#* PingProc.medianFactor
[1.500000]
#* PingProc.beamNumberRadius
[3]
#* PingProc.sufficientPointCount
[40]
#* PingProc.neighborhoodType
[Elliptical]
#* PingProc.timeRule.use
[false]
#* PingProc.overhangRule.use
[false]
#* PingProc.medianRule.use
[false]
#*
PingProc.medianRule.depthFactor
[0.050000]
#*
PingProc.medianRule.minPointCoun
t [6]
#* PingProc.quantileRule.use
[false]
#*
PingProc.quantileRule.quantile
[0.100000]
#*
PingProc.quantileRule.scaleFactor
[6.000000]
#*
PingProc.quantileRule.minPointCou
nt [40]
#* GridProc.minPoints
[8]
#* GridProc.depthFactor
[0.200000]
#*
GridProc.removeTooFewPoints
[false]
#*
GridProc.surfaceFitting.surfaceDegr
ee [1]
#*
GridProc.surfaceFitting.tukeyConsta
nt [6.000000]
#*
GridProc.surfaceFitting.maxIteration
[10]
#*
GridProc.surfaceFitting.convCriterio
n [0.010000]

```
    #* GridProc.surfaceDistanceDepthRule.use            [false]
    #* GridProc.surfaceDistanceDepthRule.depthFactor      [0.050000]
    #* GridProc.surfaceDistancePointRule.use            [false]
    #* GridProc.surfaceDistancePointRule.scaleFactor      [1.000000]
    #* GridProc.surfaceDistanceUnitRule.use            [false]
    #* GridProc.surfaceDistanceUnitRule.scaleFactor       [1.000000]
    #* GridProc.surfaceDistanceStDevRule.use            [false]
    #* GridProc.surfaceDistanceStDevRule.scaleFactor      [2.000000]
    #* GridProc.surfaceAngleRule.use [false]
    #* GridProc.surfaceAngleRule.minAngle               [20.000000]
    #* SonarProc.use [false]
    #* SonarProc.gridSizeFactor [4]
    #* SonarProc.mergerType [Average]
    #* SonarProc.interpolatorType [TopHat]
    #* SonarProc.interpolatorRadius [1]
    #* SonarProc.fillInOnly [true]
  #} AUTOMATIC1

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

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

Appendix D: List of acronyms

BIST – Built In System Test

CO – Commanding Officer

CIMS – Cruise Information Management System

CTD – conductivity temperature and depth

CW – continuous wave

dB – decibels

DGPS –Differential Global Positioning System

DTM – digital terrain model

ECS – Extended Continental Shelf

ET – Electronics Technician

EX – NOAA Ship *Okeanos Explorer*

FM – frequency modulation

FOO – Field Operations Officer

Hr - hour

kHz - kilohertz

Km – kilometers

KM – Kongsberg Maritime AS

Kt(s) – knots

Ma – megaannum

MBES – multibeam echosounder

NCDDC – National Coastal Data Development Center

NGDC – National Geophysical Data Center

NOAA – National Oceanic and Atmospheric Administration

NODC – National Oceanographic Data Center

OER – Office of Ocean Exploration and Research

OMAO – Office of Marine and Aviation Operations

OPS – Operations Officer

PMNM – Papahanaumokuakea Marine National Monument

ROV – remotely operated vehicle

SST – Senior Survey Technician

SV – sound velocity

TRU – transmit and receive unit

TSG - thermosalinograph

UNCLOS – United Nations Convention on the Law of the Sea

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

UPS – uninterruptable power supply

US EEZ – United States Exclusive Economic Zone

USBL – ultra-short base line

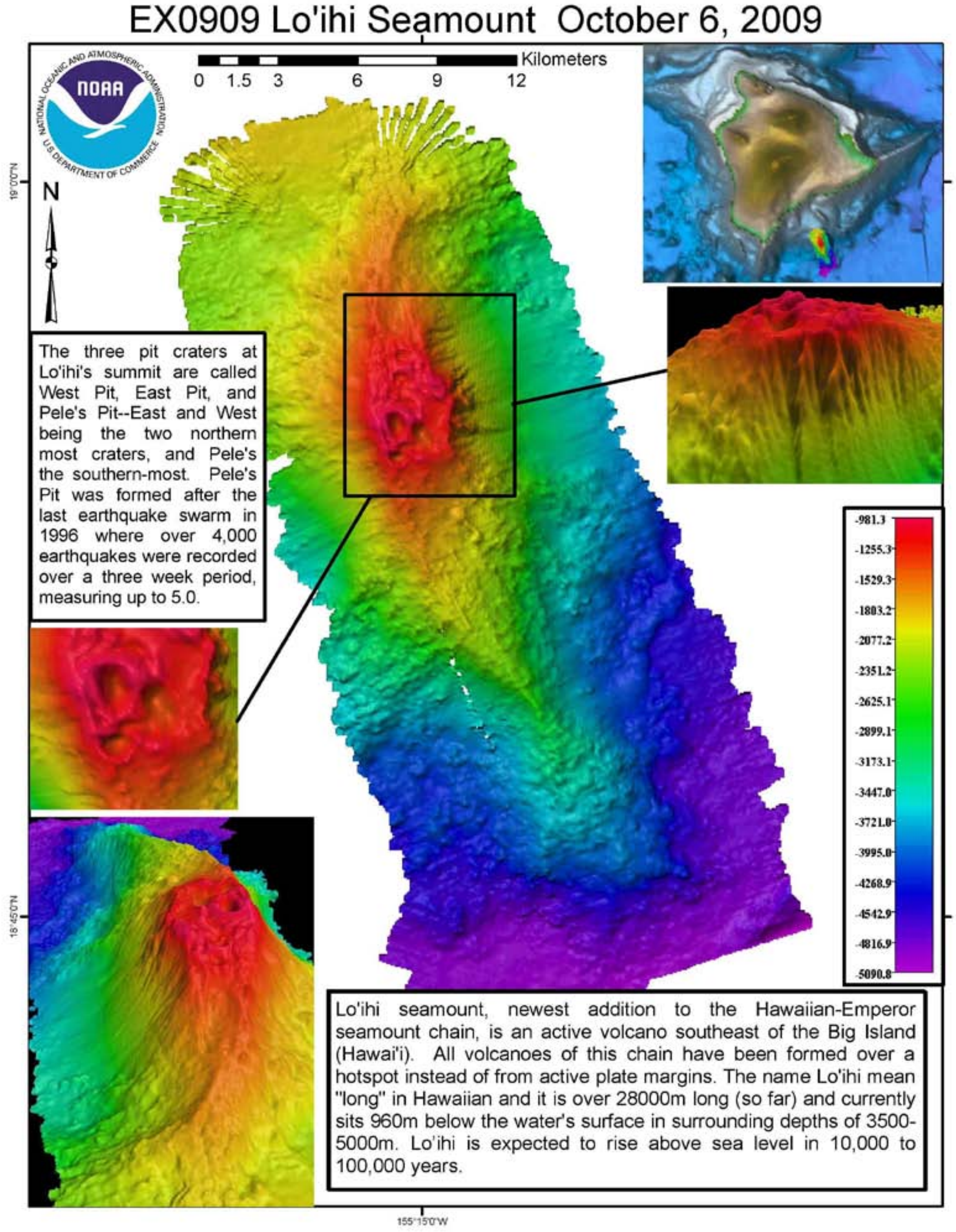
WD – water depth

w.r.t. – with respect to

XBT – expendable bathythermograph

Appendix E: Field products generated during the cruise

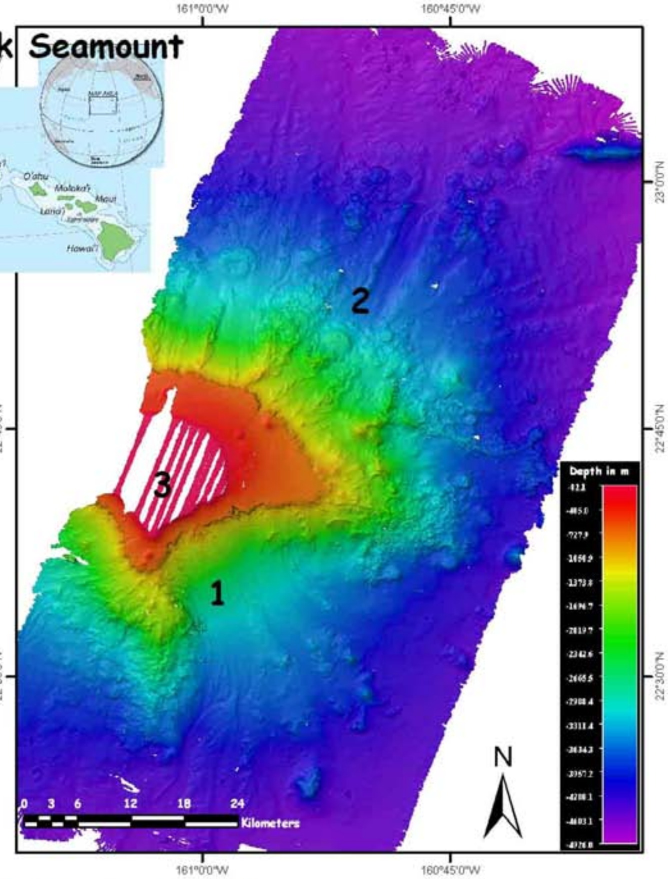
Several products were constructed based on the data collected during this cruise to provide a synopsis of mapping activities. The map sheets are provided below:



Map Sheet 1. Loihi Seamount. Data credit: NOAA Ship *Okeanos Explorer*. Map sheet created by Elaine Stuart with ArcMap.

Mapping the Seafloor

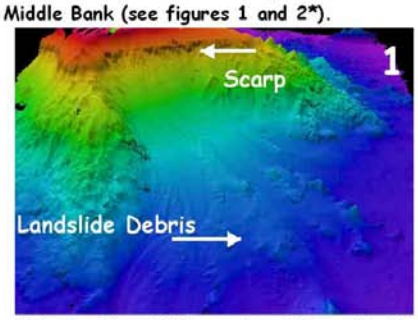
Middle Bank Seamount



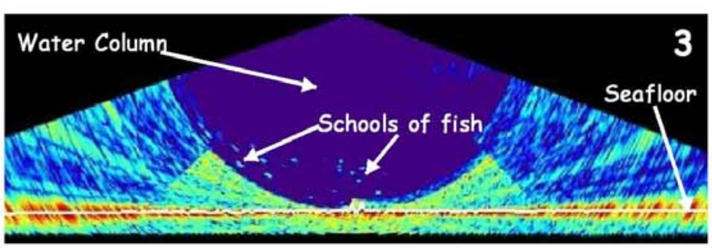
The Okeanos Explorer is a NOAA ship that is specifically designed to explore and map the unknown regions of seafloor and bring the data back for scientists to use in future research.

Ocean explorers use sound to create images of the features on the ocean floor and put the images together to create a map. Seafloor maps are important because they help scientists get a better understanding of underwater systems, such as volcanoes and marine ecosystems. To the right is a seafloor map of Middle Bank Seamount. Middle Bank is located just southeast of the Papahanaumokuakea National Monument and was mapped during an Okeanos Explorer exploration cruise in October 2009.

Seafloor maps are usually vary detailed and can clearly show features, such as the submarine landslide and lava ponds on Middle Bank (see figures 1 and 2*).



*The location of figures 1 and 2 can be found in the main seafloor map.

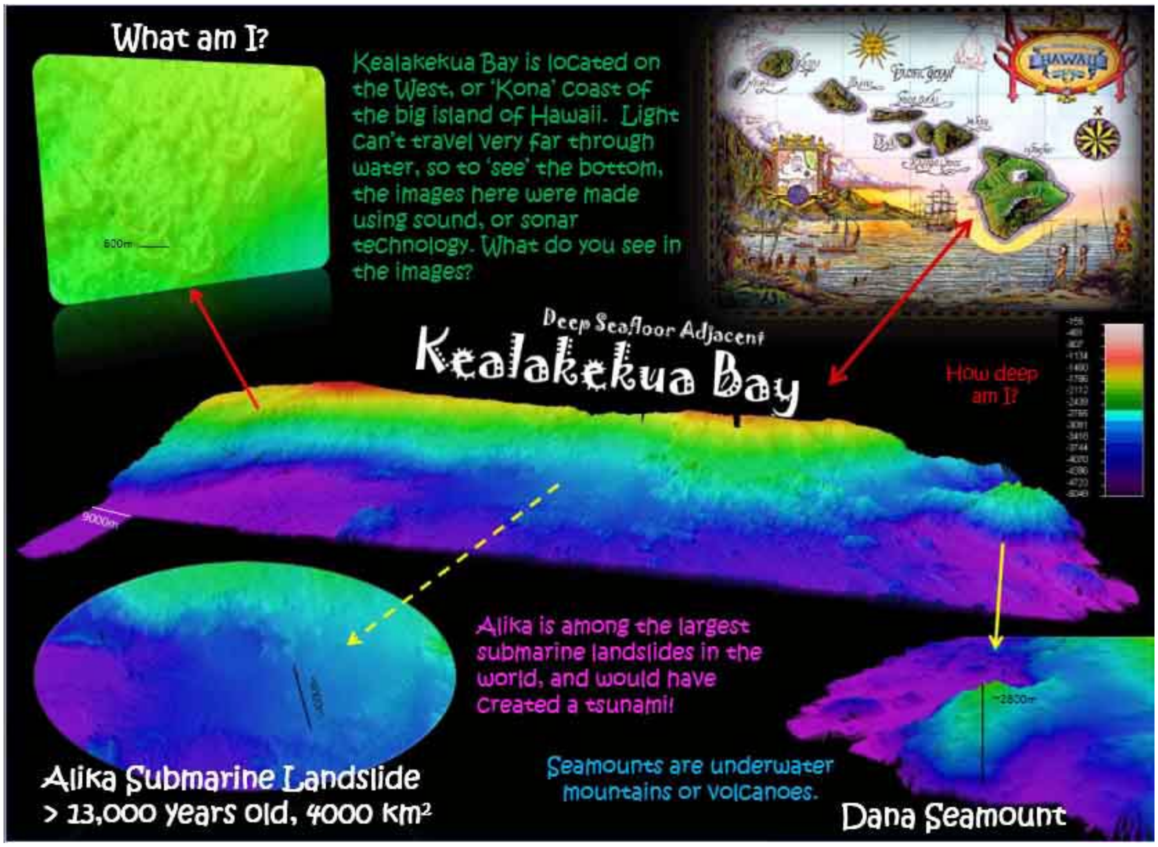


Sound can also be used to detect objects in the water column, or the water between the boat and the seafloor. Figure 3 is an image of the water column data over the shoals of Middle Bank in which schools of fish can be detected in the data.

In the figure, the red line is the seafloor and the dark blue area is the water column. The white dots in the water column are large schools of fish. This data can be very important to marine biologists who may want to study the ecosystems on seamounts or to conservationists who may want to incorporate this area in the Papahanaumokuakea Monumnent.

Multibeam data collected by NOAA Okeanos Explorer; Map and figures compiled by Melissa Meiner-Johnson

Map Sheet 2. A poster showing the mapping around Middle Bank seamount – a PMNM priority area. Data credit: NOAA Ship *Okeanos Explorer*. Map sheet created by Melissa Johnson with ArcMap.



Map Sheet 3. A map sheet with audience focus on school going children showing few of interesting features in vicinity of Kealakekua Bay mapping area. Data credit: NOAA Ship *Okeanos Explorer*. Map sheet created by Kelley Elliott and Lillian Stuart.