UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE

Office or Response and Restoration
Silver Spring, Maryland 20910

CRUISE REPORT[1]

VESSEL: *Hi'ialakai* (HI-05-04)

CRUISE PERIOD: 13 June–07 July 2005

AREA OF OPERATION: Main Hawaiian Islands (MHI)

TYPE OF OPERATION: The Office of Ocean Exploration sponsored high-resolution multibeam surveying to support management needs for detailed information on the depth and character of the seafloor around the island of Ni'ihau and the top of Penguin Bank in the Main Hawaiian Islands. Coastal marine areas ranging in depths between 20 m and 100 m were specifically targeted during the survey. A secondary purpose of the cruise was to provide training on multibeam surveying and data processing techniques to personnel associated with the Pacific Islands Fisheries Science Center and with the National Marine Sanctuary Program.

ITINERARY:

13 June Start of cruise. Embarked John Rooney (Chief Scientist-Mapping Team), Bruce Appelgate (Co-chief Scientist-Mapping Team), Scott Ferguson (Mapping Team), Joyce Miller (Survey Lead), Emily Lundblad (Mapping Team), Jonathan Weiss (Mapping Team), Allysa Aaby (Mapping Team), Jeremey Jones (Mapping Team), Christine Taylor (Mapping Team).

[1] PIFSC *Hi'ialakai* Cruise Report CRHI-05-002
Issued 12 August 2005

Departed Honolulu at 1000 and went into Pearl Harbor to refuel. Set up coverage files from multibeam survey data collected on a cruise aboard the University of Hawaii's R/V *Kilo Moana* that just returned from Ni'ihau. Conducted training on multibeam surveying theory and operation. Disembarked Scott Ferguson. Got underway at 1745. Did a CTD cast off Kewalo Basin and conducted a heading calibration confirmation test. Transited to Barbers Point and conducted a roll calibration confirmation test. Departed for Ni'ihau Island.

14-18 June Arrived at Ni'ihau Island. Held safety training on the launching and recovery of the survey launch R/V *Ahi*, as well as fire and abandon ship drills. Deployed the *Ahi* to conduct daylight multibeam surveying of shallow waters close to shore and commenced around the clock shipboard multibeam surveying as well, conducting CTD casts as necessary.

19 June Departed Ni'ihau at 0300 for Port Allen, Kauai. Commenced a small boat personnel transfer at 0600, disembarking Christine Taylor and embarking Erik Franklin (Mapping Team). Returned to Ni'ihau and resumed daylight multibeam surveying with the R/V *Ahi* and full-time shipboard surveying.

20 June Completed shipboard and launch-based multibeam surveying of depths between 20 m and 100 m around Ni'ihau. Departed for Penguin Bank at 1930.

21-24 June Arrived at Penguin Bank. Commenced surveying nearshore during daylight hours with the R/V *Ahi*. Commenced and day and night shipboard multibeam surveying of the western half of Penguin Bank, conducting CTD casts as necessary to calculate sound velocity profiles.

25 June Departed Penguin Bank for Ala Wai Harbor, Oahu. Arrived at 0800 and conducted a personnel transfer by small boat, disembarking Joyce Miller, Emily Lundblad, and Erik Franklin and embarking Joe Chojnacki (Mapping Team) and Susan Vogt (Mapping Team). Returned to Penguin Bank and resumed surveying operations as before.

26 June – 02 July Completed multibeam surveying of the western half of Penguin Bank as well as several miles of surveying along the western ends of the north and south shores of Molokai between depths of approximately 20 m and 80 m. Completed surveying gaps in existing multibeam coverage of the 100-fathom curve around Penguin Bank at the request of the embarked representative of the National Marine Sanctuaries Program.

03-06 July Commenced surveying nearshore waters between the 20-m isobath and existing multibeam data, which starts at about 100 m along the north shore of Molokai. About 90% of that area (approximately 90 km^2) was surveyed, including all areas that can be safely surveyed by the ship.

07 July Transited to Snug Harbor, collecting multibeam data for about the first half of the transit. Arrived about 0800. Conducted post-cruise meeting aboard the ship. Disembarked Rooney, Appelgate, Weiss, Aaby, Vogt, Jones, and Chojnacki.

MISSIONS AND RESULTS:

A. Complete heading and roll calibration confirmation tests.

Calibration confirmation test data were collected for the heading and roll calibrations. Preliminary results suggest that both calibrations are close. A report has been prepared and forwarded to the NOAA Pacific Hydrographic Branch. See Appendix A for results which the Hi'ialakai's Survey Department is forwarding to NMAO.

B. Survey shallow waters (20 m to 100 m depths) around Ni'ihau.

1. Seven days of ship and launch-based multibeam surveying were conducted in the shallow waters around Ni'ihau. Coverage was completed for depths between 20 m and 100 m, with additional data collected at deeper depths as well. A total of 272 km^2 of multibeam survey data were collected. See Table 1 for survey statistics and Figure 2 for processed bathymetry for Ni'ihau. Dr. Bruce Appelgate is the Director of Operations for the Hawaii Mapping Research Group at the University of Hawaii and has a great deal of experience with all aspects of multibeam surveying. He provided an analysis of the performance of the multibeam systems and related equipment during this cruise, based on his own experience and with input from scientists and members of the ship's compliment who assisted with surveying during this cruise. That analysis can be found in Appendix B.

2. Primary and secondary editing of the data were completed and two bathymetric grids were generated. One grid features a 5-m grid cell size and encompasses data collected at depths of 100 m or shallower. The second grid includes all the data collected at depths shallower than 200 m, at a resolution of 20 m.

B. Survey shallow waters (20 m to 100 m depths) on Penguin Bank.

1. A total of 12 days of ship-based multibeam surveying and 11 days of surveying from the *Ahi* were conducted in the shallow waters of Penguin Bank. Coverage was completed for the eastern half of the bank at depths between 20 m and 100 m, with additional data collected at deeper depths as well to fill gaps in existing coverage, particularly along the 100-fathom isobath. A total of approximately 520 km^2 of multibeam survey data were collected.

2. Primary (swath) editing of the data was completed, along with approximately one third of the secondary (area-based) editing.

3. Upon completion of the eastern half of Penguin Bank and gap filling of previously collected data, 4 days of ship time remained. Although not originally planned as a mission for the cruise, moderate wind and swell conditions provided an unusual and hard to schedule opportunity to survey nearshore areas of Molokai's north shore. The last 4 days of surveying concentrated on filling a few gaps in existing offshore coverage, and in surveying nearshore depths between 20 m and 100 m. A total of approximately 90 km^2 of multibeam survey data were collected. Primary editing of these data were completed, except for a few files collected during the transit from Molokai back to Oahu.

C. Conduct training in multibeam surveying theory and operations.

1. A secondary but important mission of the cruise was to conduct training on multibeam surveying theory and operations. Personnel associated with the Pacific Island Fisheries Science Center received hands on training on the different aspects of multibeam data collection and processing. Procedures for effective and efficient launch and ship-based data collection and processing were refined. Written instructions were generated or revised to further facilitate future training.

2. The NOAA Office of Ocean Exploration provided funding to cover travel expenses, enabling three personnel from the National Marine Sanctuaries Program to participate in the cruise. Two of them had no experience with multibeam surveying. They both received a week of training and some practical experience in both shipboard and launched-based data collection and processing. The third person spent several weeks aboard the *Hi'ialakai* on a previous mapping cruise, and was therefore able to fit into the watch rotation and make a positive contribution as soon as she embarked.

D. Test an underwater camera sled and collect optical benthic characterization data.

1. A total of 4 camera sled deployments were made on Penguin Bank, videotaping approximately 5.5 linear kilometers of seafloor. The camera sled tested successfully in most respects. Its position was tracked using the *Hi'ialakai*'s Trackpoint II ultrashort baseline acoustic tracking system. Although the Trackpoint II appeared to be able to track the approximate position of the camera sled, there was a high-frequency cross-track oscillation in the recorded position of the sled of up to 60 m. The oscillation appears to be related to yawing of the ship and was not observed in previous tests. Presumably a setting on the system was changed and can be resolved via ongoing discussions with the manufacturer.

2. Video imagery collected on Penguin Bank confirmed that several unusual features observed in multibeam data are fields of large and mobile sand waves. The sediment appears to be light colored, well-sorted, fine-grained sand that is free of silt and mud. As such it is a potentially valuable source of sand for beach renourishment purposes. It is recommended that

representatives from the State of Hawaii Department of Land and Natural Resources, Coastal Lands Program be notified of this find.

SCIENTIFIC PERSONNEL:

John Rooney, Chief Scientist, Joint Institute for Marine and Atmospheric Research (JIMAR), University of Hawaii (UH), Pacific Islands Fisheries Science Center (PIFSC), Coral Reef Ecosystem Division (CRED)
Bruce Appelgate, Co-Chief Scientist, Director of Operations, UH, Hawaii Mapping Research Group
Scott Ferguson, Systems Engineer, JIMAR, UH, PIFSC, CRED
Joyce Miller, Oceanographer, JIMAR, UH, PIFSC, CRED
Jeremey Jones, Marine Ecosytstem Specialist, JIMAR, UH, PIFSC, CRED
Joe Chojnacki, Marine Ecosystem Specialist, JIMAR, UH, PIFSC, CRED
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Emily Lundblad, GIS Specialist, JIMAR, UH, PIFSC, CRED
Allie Aaby, Mapping Specialist, JIMAR, UH, Hawaii Mapping Research Group
Susan Vogt, GIS Specialist, National Marine Sanctuary Program (NMSP), National Ocean Service (NOS)
Christine Taylor, GIS Specialist, NMSP, NOS
Erik Franklin, Biologist, NMSP, NOS
Andrew Rapp, Survey Technician, NOAA Ship *Hi'ialakai*
Jeremy Taylor, Ordinary Seaman, NOAA Ship *Hi'ialakai*

(/s/John Rooney)
Submitted by: ______________________________
John Rooney
Chief Scientist

(/s/David Kennedy)
Approved by: ______________________________
David Kennedy
Matrix Manager
Coral Reef Conservation Program

Attachments

Tables

Table 1. Data collection during cruise HI0504.

	Ni'ihau	Penguin Bank	North Shore
Days of Surveying	7	12	4
Area surveyed (km^2)	520	270	90
Survey rate (km^2/day)	74	23	23
Swath editing completed (%)	100	100	>90
Swath editing completed (%)	100	30	0
CTD casts	19	32	6
Seafloor video (km)	0	5.5	0

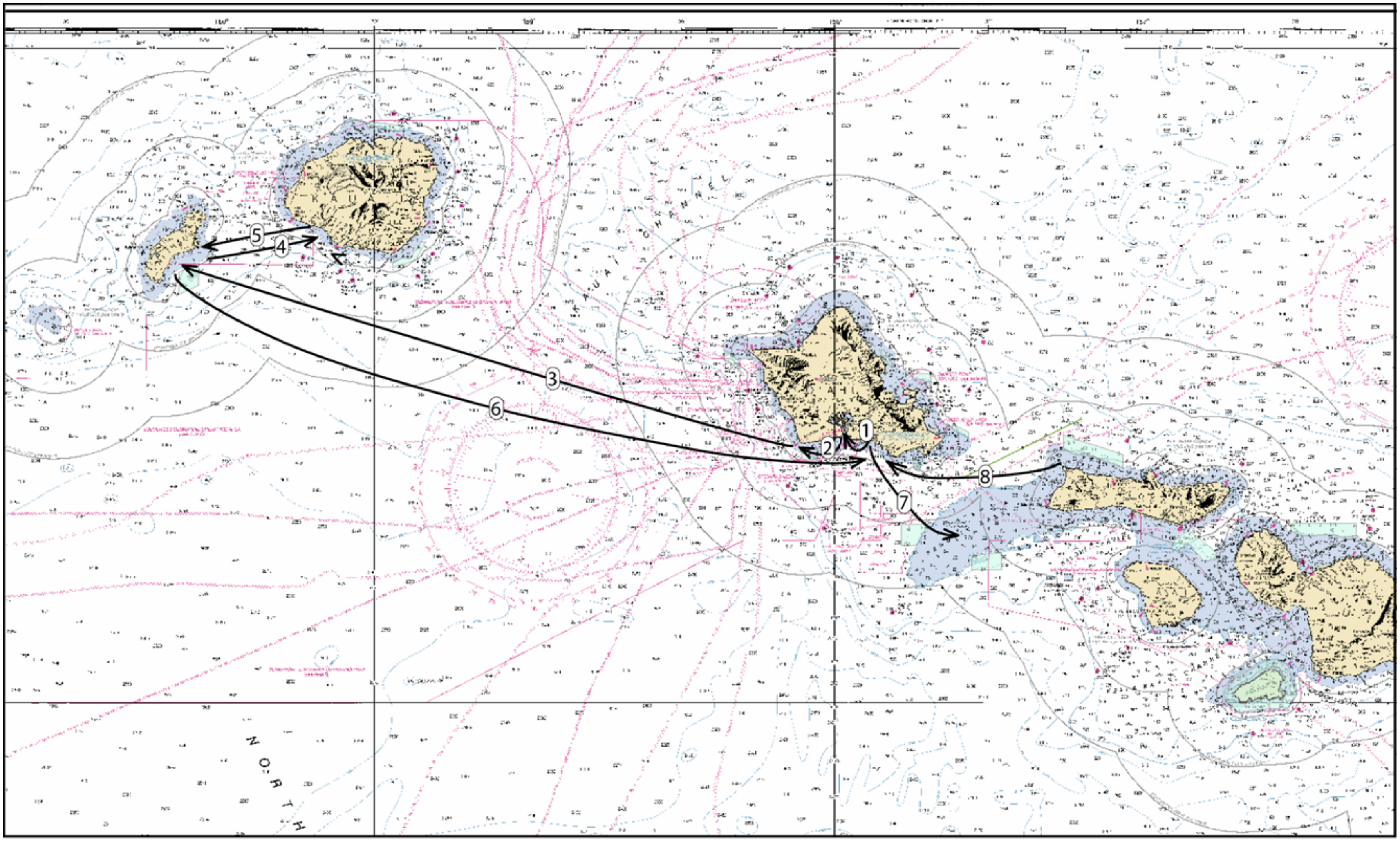


Figure 1. Cruise HI0504 summary cruise track. Numbers in ovals indicate the sequence in which transits occurred during the cruise.

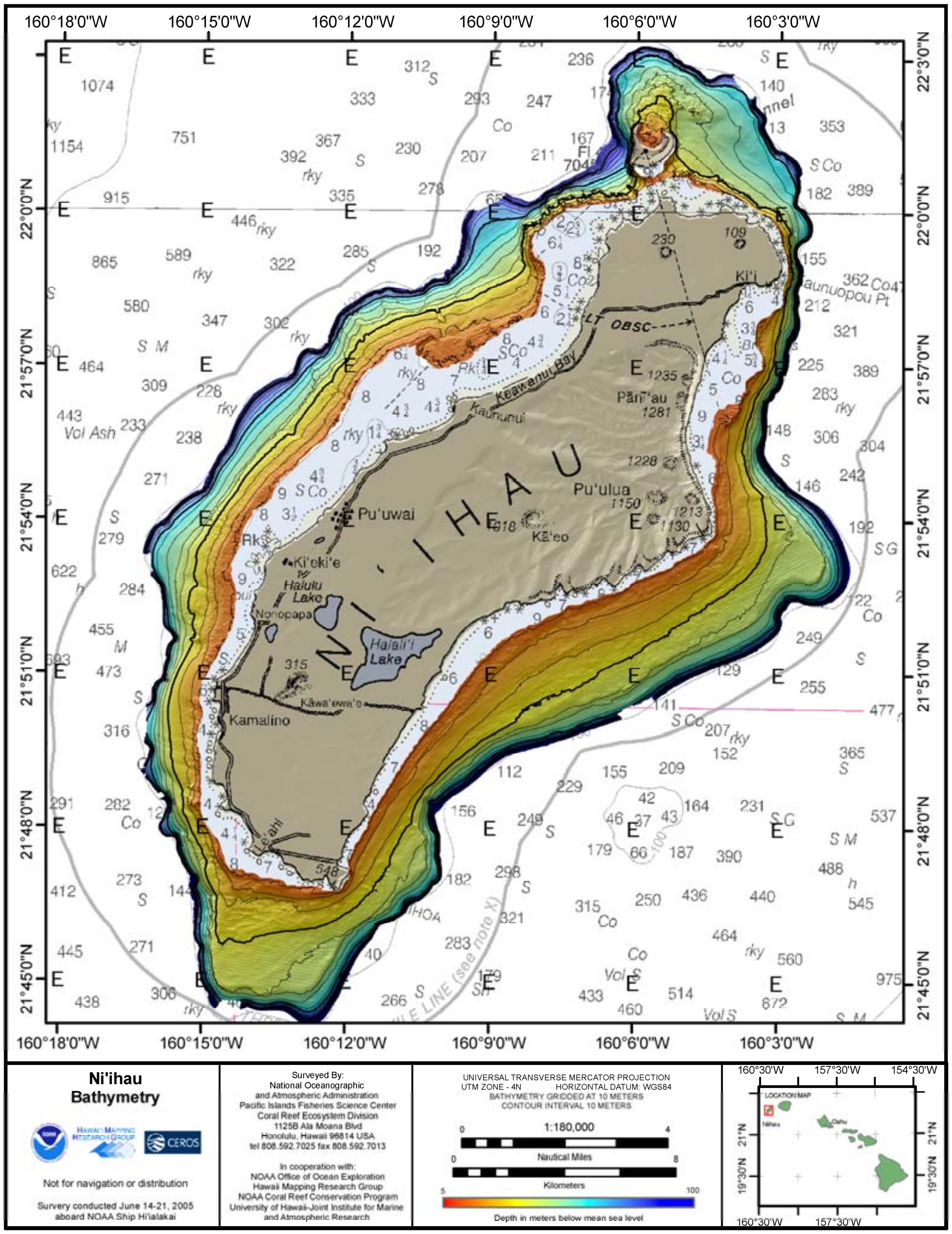


Figure 2. Nearshore bathymetry (10-m grid) from Ni'ihau at depths above 200 m. Note that release of these data will be restricted to management agencies only for a period of 2 years.

Appendix A

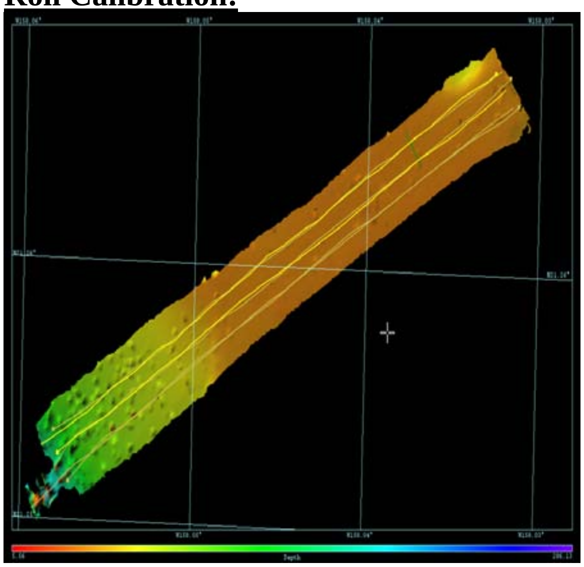
HI'IALAKAI em3002d PATCH TEST
South Oahu
June 16, 2005

Synopsis:

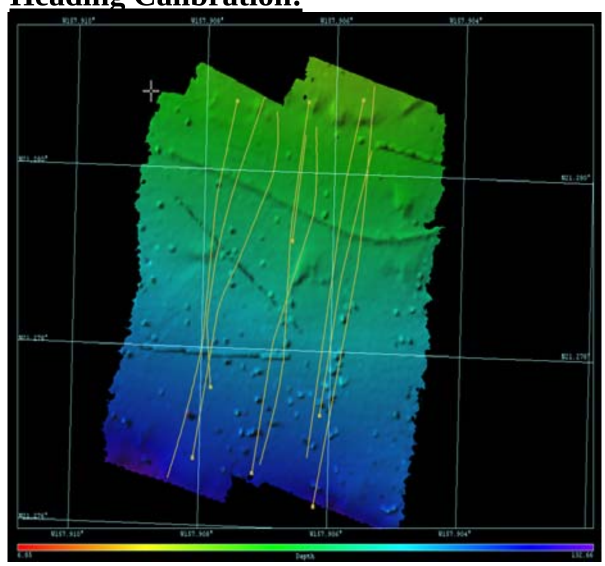
After departing Honolulu Harbor on the afternoon of June 16, 2005 the NOAA ship *HI'IALAKAI* conducted a Roll and Heading calibration for the em3002d multibeam sonar array. The calibration was performed in order to verify previous patch test results and in preparation for the immediate Ocean Exploration Cruise HI-05-04. Joyce Miller of the Coral Reef Ecosystem Division and survey tech. Andrew Rapp of the ships complement conducted the calibration. The location for the calibration is the same as the previous patch test. It was initially chosen both for its proximity to home port and for its geological properties. All related systems, such as DGPS, sound velocity, and the POS/mv were functioning properly.

Patch Test locations:

Roll Calibration:



Heading Calibration:



Sea Conditions:

Throughout the course of the patch test, sea conditions were mild with slight variance. The standard is as follows.

Visibility- 10 n.m.
Wind Dir.- 080 degrees
Wind Spd.- 15 kts
Wave Height- 2-3 ft.
Wave Dir.- 100 degrees

Calibration Line Planning:
See Appendix **A**

Calibration Line figures:
Roll Calibration:

SIMRAD FILE	JD	TIME	LINE#	SPD KTS	DIR	ISS FILE NAME
0012	165	0905	Roll-1	6.0	238	himbb05165.d12
0013	165	0926	Roll-2	6.0	59	himbb05165.d13
0014	165	0949	Roll-3	6.0	238	himbb05165.d14
0015	165	1012	Roll-2	6.0	59	himbb05165.d15
0016	165	1032	Roll-1	6.0	238	himbb05165.d16
0017	165	1055	Roll-3	6.0	59	himbb05165.d17

Heading Calibration:

SIMRAD FILE	JD	TIME	LINE#	SPD KTS	DIR	ISS FILE NAME
ABORTED	165	0700				himba05165.d05
006	165	0740	Pipe-1	6.0	10	himba05165.d06
007	165	0745	Pipe-2	6.0	190	himba05165.d07
008	165	0753	Pipe-3	6.0	10	himba05165.d08
009	165	0800	Pipe-2	6.0	190	himba05165.d09
0010	165	0808	Pipe-1	6.0	10	himba05165.d10
0011	165	0815	Pipe-3	6.0	190	himba05165.d11

Results:
After running three parallel lines to the NE and three to the SW, the calibration was performed using the Calibration tool in the SIS software package. The results matched existing offsets.
4 calibration screen shots can be viewed in Appendix **B**.
Head 1 Roll.
Head 2 Roll.
Head 1 Heading.
Head 2 Heading.

Current em3002d Offsets:

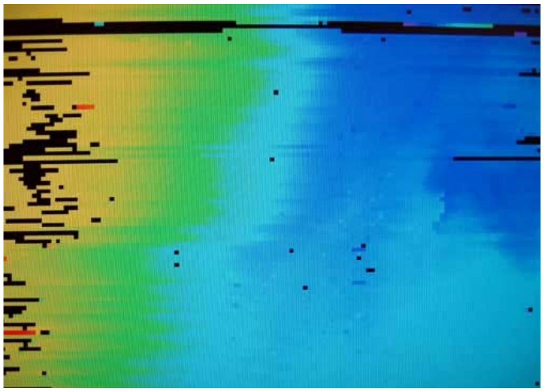
	Heading	Pitch	Roll
Port	0.0	1.10	0.12
Starboard	0.0	1.10	0.12

Appendix B

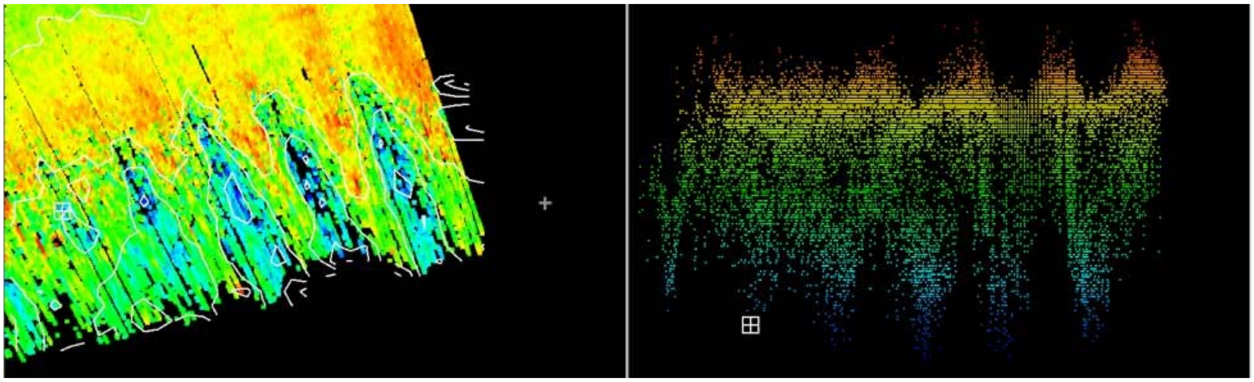
Multibeam performance: *Hi`ialakai* Cruise 05-04

1. Motion artifacts in em300 and em3002.

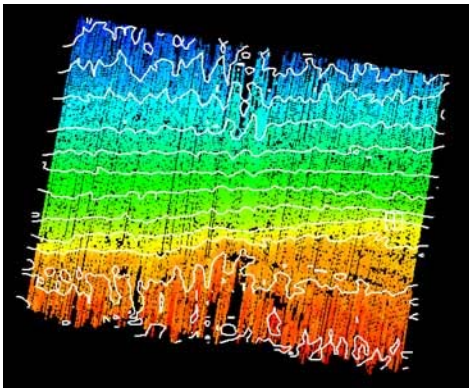
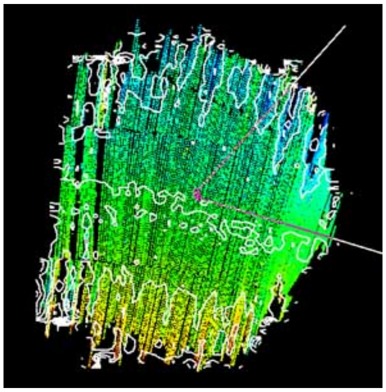
Motion artifacts are present in both the em300 and em3002 data. We found evidence for two kinds of errors: heave artifacts and roll artifacts. Evidence for heave artifacts includes vertical errors that are continuous and similar in amplitude all the way across the swath. Evidence for roll artifact includes increasing error amplitude with distance from nadir, with maximum error of several percent of water depth at far range. The following images illustrate these artifacts.



Above - Image of artifact in em300 data. Note that depth artifact extends across entire swath with equal amplitude, consistent with what's expected from un- or miscorrected heave. Amplitude of error is ~.5 meters in ~120 meters water.



Above - Images of artifact in em300 data. Only the outer 1/3 of the starboard side of the swath is shown here. In this case, the depth artifact becomes progressively worse with distance from nadir, consistent with a roll artifact. Amplitude of error at swath edge is ~ 1 meter in 100 meters of water. At nadir, there is no recognizable error.

Above - Images of artifacts in em3002 data. The images are from different locations, and each shows the entire swath. About 200 pings are shown in each. The artifacts here are consistent with roll error because the depth artifact becomes progressively worse with distance from nadir. The amplitude of error at swath edge is ~ 2% of water depth. The error diminishes to zero at nadir.

2. CTD winch problems.

The CTD winch was inoperable for several days due to mechanical problems. During this period we used the smaller CTD, deployed using a hand line, to collect sound speed profiles. Without this backup we would have been prevented from working. Thanks for having a good backup system.

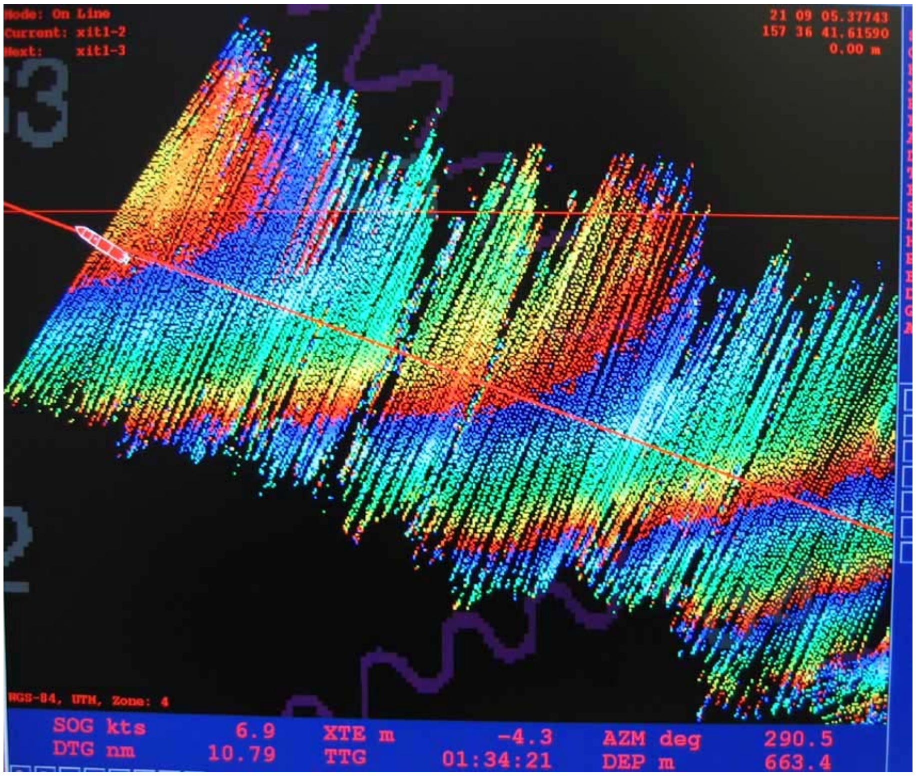
3. Sea State Limitation of Sonars.

The quality of the em300 data degraded rapidly with sea state and ship speed on this trip. This problem was also evident on the em3002, but to a lesser degree. We were fortunate that nearly all of our survey areas were in shallow waters where the em3002 was the primary mapping system, and at no time during this cruise were we unable to survey using the em3002 due to sea state. However, because of the sea state limitation we opted to survey more slowly (6 knots versus desired 8 knots) with the em3002 than we otherwise would have, resulting in less total area surveyed.

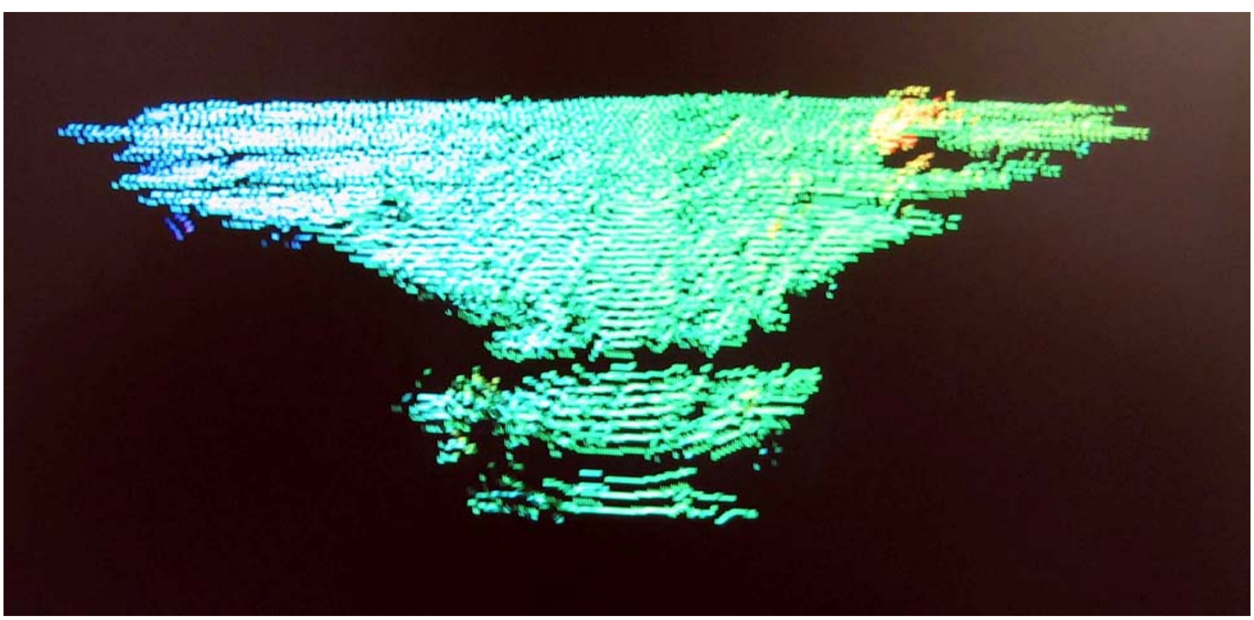
The em300 was severely sea state limited, and data degradation with increasing sea state was dramatic. This is a serious problem, because we encountered only calm-to-normal trade winds during this cruise, and even these conditions resulted in unacceptably degraded performance of the em300 system.

The probable cause of the data deterioration with sea state is bubble masking caused by bubbles sweeping down the hull when the bow pitches up/down, or when the ship moves forward through chop or swell. Strong evidence for bubble masking was provided by the behavior of the two mapping systems: when the ship pitched up and down over a wave, the em3002 would first lose bottom lock, and shortly afterward the em300 would lose bottom lock. The em3002 sonar array is farther forward than the em300, and the timing of the errors on the two systems is compatible with bubbles sweeping past first the em3002 and then the em300.

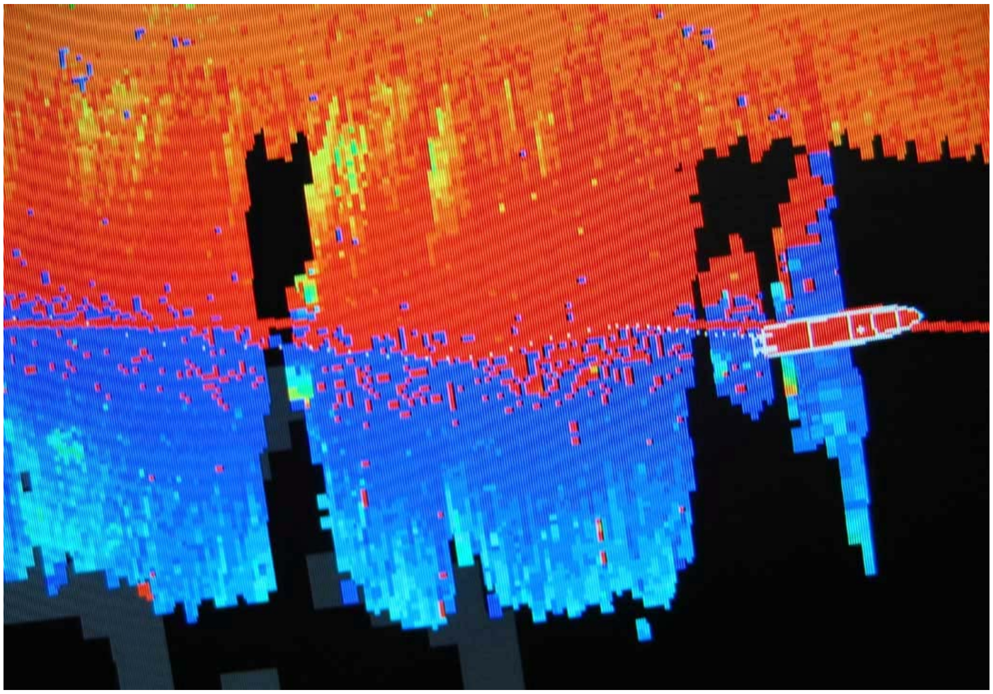
Examples of em300 data degradation due to sea state follow.



Above - em300 swath showing data dropouts caused by sea state and ship speed. This swath *should* have a continuous outer edge formed by equally wide pings, equal in width to the widest pings evident in this swath. Instead, data degradation (inferred from bubble masking) results in short, noisy pings and irregular swath coverage. These data were collected in 2-5 foot beam seas at a ship speed of 7 knots.



Above - Example showing how the em300 sonar responds to a bubble masking event. After losing bottom lock, the sonar issues a narrow ping to reacquire the bottom (bottom of figure). Once acquired, the sonar transmits progressively wider pings until the maximum swath width is achieved (top of figure). This process requires many pings, and the result is a long section of survey trackline that contains too-narrow pings, resulting in data gaps between adjacent swaths (see next figure).



Above - Data gaps in em300 data caused by bubble masking, and the manner in which the em300 gradually resumes its full swath width after each event, result in wide data gaps.

4. Simrad acquisition software problems.

Simrad acquisition displays occasionally (about once per day) froze or stopped communicating with the SAIC ISS-2000 data acquisition system. Each case required rebooting the Simrad computer and cycling the power on the Simrad sonar processing unit. This performance is unacceptable.

5. SAIC data acquisition software problems.

SAIC ISS-2000 waterfall displays would occasionally (several times per day) freeze, and then recover, with a loss of data. Usually only backscatter data was lost, but on several occasions bathymetry was lost as well. Accompanied by error message indicating time synch mismatch: "GPS time lags host by X.XXX seconds" and then "Data out of bounds: X missing pings."

This behavior seemed to become progressively worse with time, but could be cleared by rebooting the SIS and ISS computers. For the last week of the cruise, we rebooted the computers on a daily basis.

6. EM300 yaw stabilization problem.

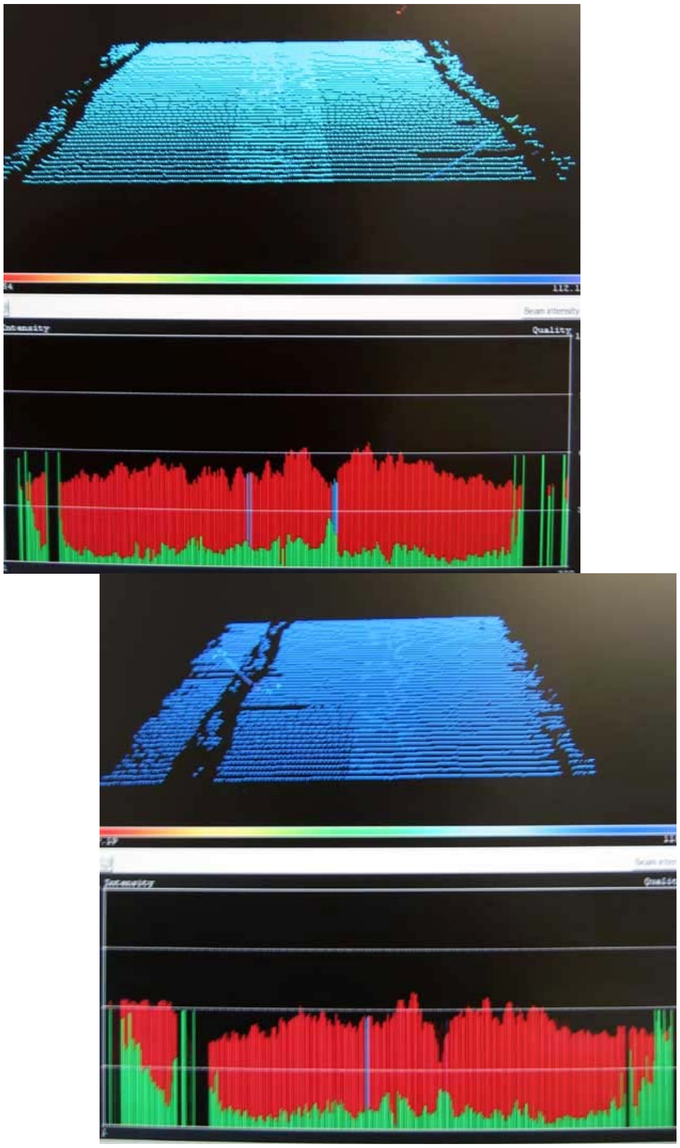
In shallow water (50 meters or less), the EM300 yaw stabilization produces cross-track steps in the bathymetry. These steps correspond to the boundaries between transmit sectors (the transmit beam is divided into different sectors that are steered fore or aft to compensate for variations in the ship's heading). When we disabled yaw stabilization, the steps went away, and bathymetry was continuous across track. In deeper water (50+ meters) this problem didn't appear to occur or was not significant enough to be observed. We speculate that the bathymetric steps between sectors may be an artifact that occurs in water that's too shallow for the em300 (perhaps a near-field effect?). We operated the em300 in deep water with yaw stabilization on and observed no irregularities.

7. ISS-2000 windowing problems.

Throughout the cruise GUIs on the ISS-2000 computer behaved incorrectly, and the system became inoperable. This type of problem occurred about once per day. This was manifested by pull-down menus that either stopped working or didn't do anything when clicked. Or an application would freeze become unresponsive. In some cases the problem could be postponed by closing other applications on the ISS-2000 computer (such as the survey planning manager), but eventually the problem would recur. To rectify the problem we halted acquisition, closed the ISS-2000 application, and rebooted the computer.

8. Missing beams on em3002.

The em3002 drops a part of its swath in some regions where the seafloor is flat. The oddity here is that the part of the swath that is lost is not at the farthest range, and that backscatter amplitudes seem to be high enough to support good bathymetry soundings. As the images below indicate, good bathymetry soundings were recorded at ranges farther than where the beam dropouts are observed. Beam dropouts were observed on both port and starboard sides, although dropouts on the port side were more common.



Above - examples of dropped beams on port and starboard sides of the em3002 data. Top images show perspective views of about 50 bathymetry pings, with the most recent ping at the top of the display. The bottom images show echo amplitude for each beam in the most recent ping. Note gaps that correspond to the beam dropouts observed in the upper images.