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Law of the Sea Cruise to Map the Western Insular Margin and 2500-m Isobath of Guam and the Northern Mariana Islands. Cruise Report

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CRUISE REPORT

USNS *Bowditch*

U.S. Law of the Sea cruise to map the western insular margin and 2500-m isobath of Guam and the Northern Mariana Islands

CRUISE BD06-1

October 13, to November 12, 2006

Naha, Okinawa, Japan to Apra Harbor, Guam

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UNH-CCOM/JHC Technical Report 06-100

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Introduction

An exhaustive study of the U.S. data holdings pertinent to the formulation of U.S. potential claims under the United Nations Convention of the Law of the Sea (UNCLOS) identified several regions where new bathymetric surveys are needed (Mayer, et al., 2002). The report recommended that multibeam echosounder (MBES) data are needed to rigorously define (1) the foot of the slope (FoS), a parameter of a UNCLOS-stipulated formula lines, and (2) the 2500-m isobath, a parameter of a UNCLOS-stipulated cutoff line. Both of these parameters, the first a precise geodetic isobath and second a geomorphic zone, are used to define an extended claim. The Center for Coastal and Ocean Mapping/Joint Hydrographic Center (CCOM/JHC) of the University of New Hampshire was directed by the U.S. Congress, through funding to the U.S. National Oceanic and Atmospheric Administration (NOAA) to conduct the new surveys and archive the resultant data. This is the report of the U.S. Law of the Sea cruise to map the Guam and Northern Mariana Islands western insular margin (Figs.1 and 2).

NOAA entered into an agreement with the US Naval Oceanographic Office (NAVOCEANO) to perform the survey beginning October 13. 2006. NAVOCEANO made available the 329-ft, 5000-ton hydrographic ship USNS *Bowditch* (Fig. 3) with a hull-mounted Kongsberg Simrad EM121A MBES as well as a Knudsen 320 B/R 3.5-kHz chirp sub-bottom profiler and a BGM-5 Bell Gravity Meter. The schedule for the cruise called for a single 30-day leg of operations that includes a 3.5-day transit from Naha, Okinawa, Japan.

NAVOCEANO was responsible for system calibration, data collection and quality control and overall cruise management whereas the UNH/NOAA representative performed the bathymetry, acoustic-backscatter and 3.5-kHz profiler processing aboard ship. The overall responsibility of cruise planning, both before and during the cruises, was the responsibilities of the UNH/NOAA representative aboard ship.

The cruise began with a 3.5-day, 1860 km, transit from Naha, Okinawa, Japan to an area near the northwest corner of the area to be mapped (Fig. 1). A patch test (exclusive of a yaw calibration) was performed in this area and was followed by 26 days of progressively mapping the margin from north to south. The cruise ended on November 13, 2006 in Apra Harbor, Guam. The cruise mapped a total of ~160,000 km^2 in 26 survey days and collected 7899 line km of MBES and 3.5-kHz profiler lines with an average speed of 13 kns. A summary of the cruises is given in Table 1.

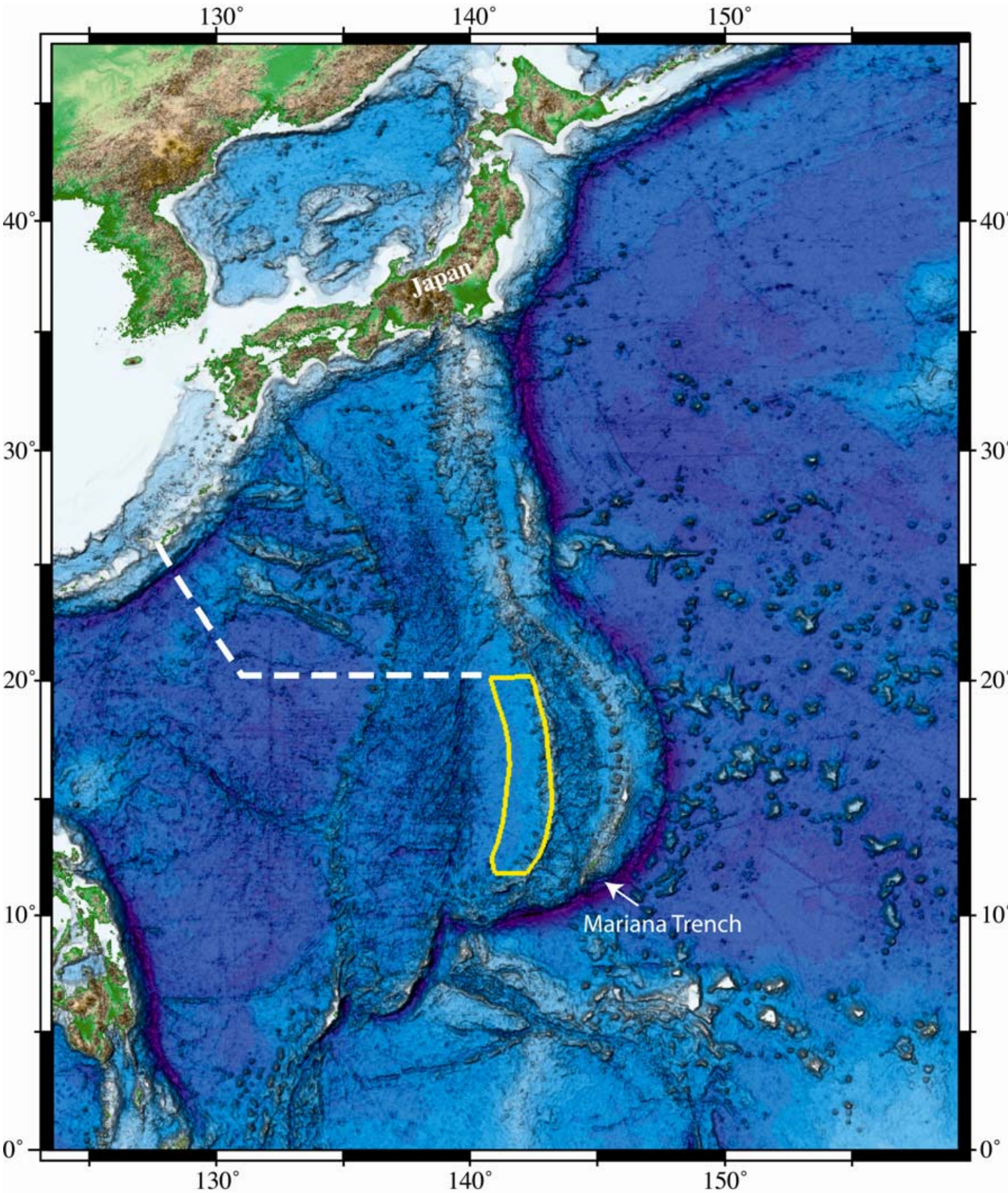


Figure 1. Transit track (white dashed line) from Naha, Okinawa, Japan to the patch test area. Yellow polygon outlines the survey area.

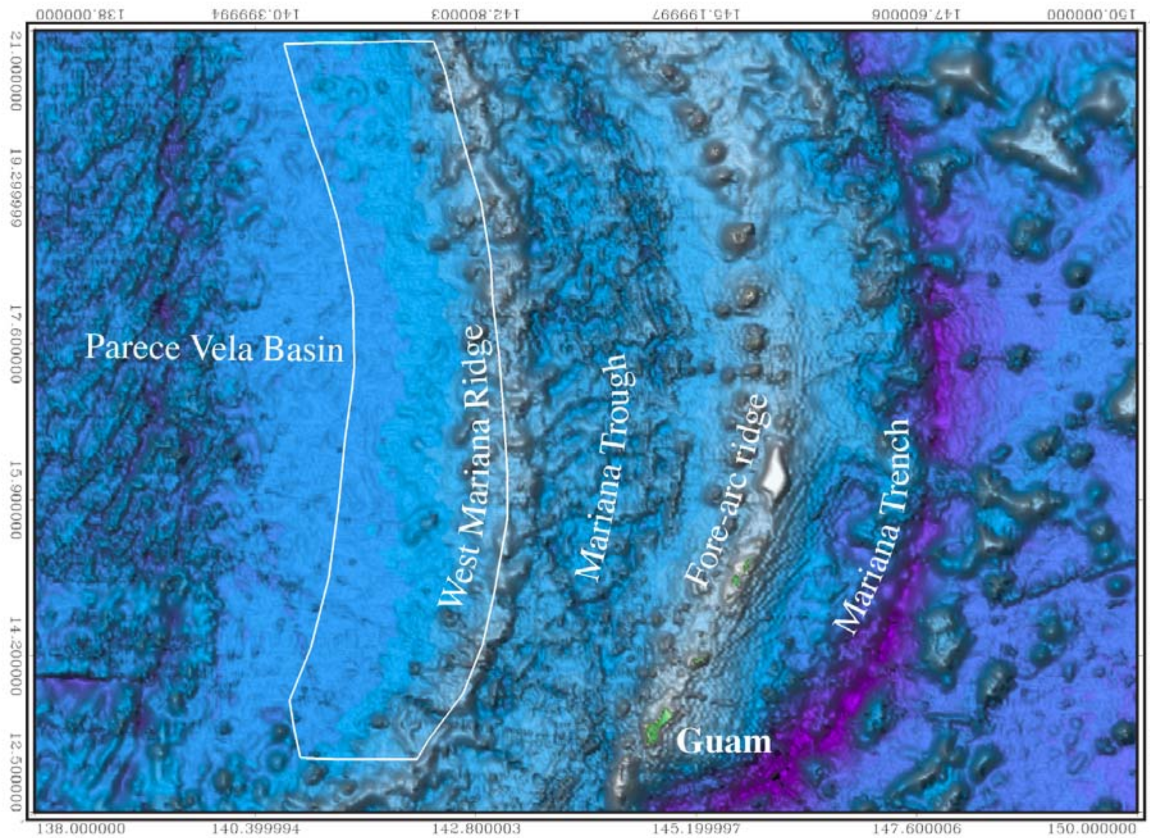


Figure 2. Map of area to be mapped (white polygon). Background is ETOPO2 digital bathymetry.

Figure 3. USNS *Bowditch* used to map the western margin of Guam and the Northern Mariana Islands.

The Multibeam Echosounder System and Associated Systems

A hull-mounted Kongsberg Simrad EM121A MBES system was used to map bathymetry and acoustic backscatter. The EM121A is a 12-kHz, MBES system that generates 121-1˚ receive apertures over a 120˚ swath. An Applied Microsystems Ltd Smart SV&T sound-velocity sensors are used to measure the sound speed at the sonar array for accurate beamforming. Equiangular beamforming for the EM121A produced seafloor footprints of each receive beam that grows with angle away from nadir. For beams at near-normal incidence, the depth values are determined by center-of-gravity amplitude detection but for most of the beams the depth is determined by interferometric phase detection. Individual soundings are spaced approximately every 50 m, regardless of survey speed. The manufacturer states that, at the 7-ms pulse length used during this survey (deep mode), the system is capable of depth accuracies of 0.3 to 0.5% of water depth. A pulse length of 7 ms was used in depths shallower than 3000 m but was increased to 20 ms in deeper depth.

The motion reference units (MRU) included a HIPPY 120C for heave, pitch and roll and a Sperry Model Mark 39 gyro for yaw. The MBES system can incorporate transmit beam steering up to ±10˚ from vertical, roll compensation up to ±10˚ and can perform yaw corrections as well. An Applanix POS/MV 320 version 3 inertial motion unit (IMU) was used only for navigation. The POS/MV was interfaced with two Trimble Force 5 GRAM-S GPS receivers using Navcom Defense Electronics Starfire SF2050R Wide Area Differential-Aided GPS (DGPS) that provide position fixes with an accuracy of < ±0.5 m. All horizontal positions were georeferenced to the WGS84 ellipsoid and mapping (vertical referencing) was to instantaneous sea level.

The Simrad EM121A is capable of simultaneously collecting full time-series acoustic backscatter along with the bathymetry. This represents a time series of backscatter values across each beam footprint on the seafloor. If the received amplitudes are properly calibrated to the outgoing signal strength, receiver gains, spherical spreading, and attenuation, then the calibrated backscatter should provide clues as to the composition of the surficial seafloor.

Water-column sound-speed profiles were calculated from casts of Sippican model Deep Blue (760 m maximum depth) expendable bathythermographs (XBTs) to measure temperature as a function of depth routinely every 6 hours and between scheduled casts as required. A Sea Bird Electronics model SBE 911+ CTD was used to calibrate the XBTs during the patch test.

All systems are referenced to a stable reference mark co-located with the HIPPY and Sperry Mark 39 gyro. The position of each system was surveyed relative to the reference mark providing a table of initial offsets (Table 1). A patch test was run immediately prior to the mapping to determine any offset corrections (Table 2).

Table 1. Initial system sensor offsets

Parameter	meters	Parameter	meters
draft	5.99	**MK39 Calibration**	
Alongship Offset	3.29	Calibration Date	3/14/06
Athwart Offset	0.00	MK39 Roll Delay	0.00
Motion Sensor Menu		MK39 Roll Offset-S	0.14
Calibration Date	n/a	MK39 Roll Offset-I	0.09
Roll/Pitch Input	Mk39	MK39 Roll Offset-D	-0.06
HIPPY/VRU Calibration		MK39 Pitch Offset-S	0.00
Roll Delay	0.00	MK39 Pitch Offset-I	0.00
HIPPY Roll Offset-S	0.00	MK39 Pitch Offset-D	0.10
HIPPY Roll Offset-I	0.00	Gyro Offset	-0.29
HIPPY Roll Offset-D	0.05	**Position System Menu**	
HIPPY Pitch Offset-S	0.00	Time Delay	0
HIPPY Pitch Offset-I	0.00	**ISS60 Vessel File**	
HIPPY Pitch Offset-D	0.59	EM121A Xducr Location X	0.00
		EM121A Xducr Location Y	0
		EM121A Xducr Location Z	0.00

Table 2. Offset corrections determined by Patch Test

Offset	Value
roll	0
pitch	0
yaw	0
latency	0

Ancillary Systems

A Knudsen 320B/R chirp 3.5-kHz high-resolution echosounder was deployed throughout the cruise. Because of a software limitation, the system as set up aboard *Bowditch* could record SEG-Y formatted data only in 5-minute segments before the file was closed and a new file was automatically opened. This limitation created a huge number of small files and was unacceptable for this project. Consequently, the 3.5-kHz data were recorded in Knudsen binary keb format. This rendered the data somewhat less than ideal because very few seismic-processing packages are able to read or convert the keb format. However, the data were processed aboard ship using commercial seismic-processing software (SonarWeb, from Chesapeake Technology, Inc.).

The Knudsen system was configured to operate in the low-frequency mode with a 500-m window. The automatic gain control (AGC) was disabled, the pulse length was set for a 24 ms chirp and the time varying gain (TVG) was set at “bottom reflection”. This produced a high-quality record and allowed the system to operate in the “autophase” mode.

A Bell BGM-5 gravity meter was run throughout the cruise. A land tie was made at the dock in Okinawa and another was made at the dock in Apra Harbor, Guam. The data were not processed aboard ship but were sent back to NAVOCEANO at the end of the cruise for processing.

MBES Data Processing

The raw Simrad multibeam bathymetry and acoustic backscatter data were processed aboard ship using the University of New Brunswick’s SwathEd software suite, version 7.28.06. Simrad raw.all files were collected by the onboard Simrad Merlin data acquisition system on a server and the file was copied to a UNH RAID disk array at the end of each line. Each raw.all file was renamed from the system-generated file name to *Mariana_Line_n_raw.all* (see Table 2) so that later each file could be easily identified to the area. Each raw.all file is composed of individual data packets of bathymetry, acoustic backscatter, navigation, parameters, sound-speed profiles, orientation and sound speed at the transducer. The first step in the processing separates each of these data packets into the individual files.

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

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

The entire region to be mapped was subdivided into 32 area maps and mosaics (Fig. 4). Each area map and mosaic was designed to maximize the spatial resolution allowed by the mapped water depths within the area. The region was also subdivided into larger North, Central and South regional maps and mosaics with 100 m/pixel spatial resolution (Fig. 5). Bathymetry and the full beam time series acoustic backscatter were gridded into the appropriate area maps and mosaics and the appropriate area maps and mosaics were gridded into the various regional maps.

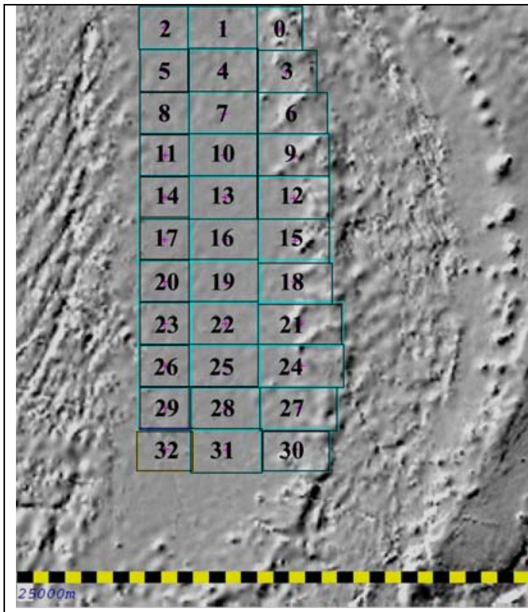


Figure 4. Index of subarea maps.

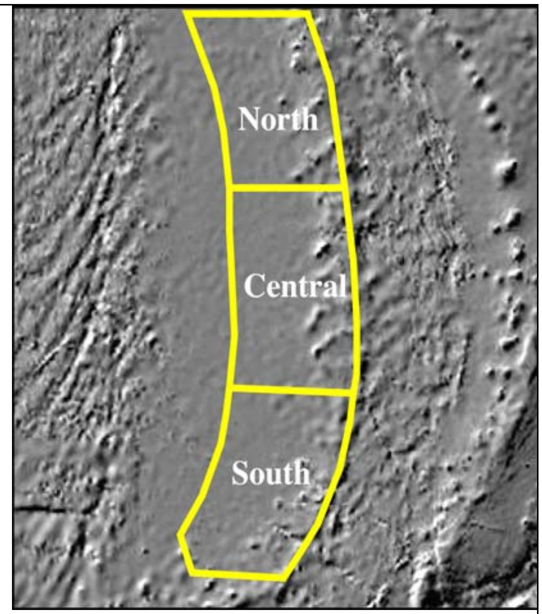


Figure 5. Index of regional maps

The Area: West Mariana Ridge and eastern half of the Parece Vela Basin

The area mapped during this cruise was defined in Mayer et al., 2002 as the western insular slope of the West Mariana Ridge and eastern Parece Vela Basin, both of which are located west of Guam and the Commonwealth of the Northern Mariana Islands (Fig. 2, white polygon). In order to satisfy the requirements of UNCLOS Article 76, the region between the ~1500 and 4800-m isobaths had to be mapped to provide the necessary bathymetry for the development of a potential U.S. claim beyond the U.S. EEZ.

The general region is located in the eastern Philippine Sea and is composed of the Parece Vela Basin on the west to the Mariana Trench on the east (Fig. 2). Geologically, the region is the Mariana island-arc system, with all the structural and physiographic elements of a classic island-arc-trench system (Karig, 1971). The specific area of the island-arc system mapped during this cruise is the eastern part of the back-arc basin (eastern Parece Vela Basin) and a inactive volcanic arc (West Mariana Arc).

The geological history of these two elements has been discussed by Karig (1971; 1975), Mrozowski and Hayes (1979)…. Karig (1971; 1975) and Mrozowski and Hayes (1979) suggest the Parece Vela Basin formed as a back-arc basin in the Late Oligocene to Early Miocene (~30 to ~17 Ma) by seafloor spreading along a N-S-trending axis (Mrozowski and Hayes (1979; Kasuga and Ohara, 1997). However, Kasuga and Ohara (1997) propose a second stage of spreading occurred late in the basin's evolution by a ridge axis rotated to NNW-SSE. A later suggestion by Okino et al. (1998) is that the Parece Vela Basin spreading center during this second stage was a series of short *en echelon* segments broken by numerous fracture zones. Apparently, seafloor speading ceased in the Parece Vela Basin about 17 Ma and the basin is presently inactive (Karig, 1971; Sdrolias, et al., 2004).

The West Mariana Ridge is an inactive volcanic island arc that appears to have ceased activity at ~5Ma in the Late Miocene to Early Pliocene (Karig, 1971;check DSDP). Karig (1971) suggested the West Mariana Ridge has subsided at least 1 km since volcanic activity ceased.

The eastern Parece Vela Basin is blanketed by a thick apron of Middle to Early Miocene volcaniclastic sediments derived from the now-dormant West Mariana Ridge. Seismic profiles of the eastern side of Parece Vela Basin shows sediment thicknesses in excess of 1500 m (Karig, 1971). Deep Sea Drilling Project Sites 53 and 59 and Ocean Drilling Site 450 drilled the distal portion of the eastern Parece Vela Basin and generally recovered only ~100 m of sediment before encountering XX Ma basement (Karig, 1975; Kroenke et al., 1981). Deposition of volcaniclastic sediments ceased in the Late Miocene (~10 Ma) and was replaced by slowly accumulating pelagic brown clay (Karig, 1971).

This cruise represents the first systematically collected multibeam data in this particular region of the eastern Parece Vela Basin and West Mariana Ridge although the Hydrographic Department of Japan has carried out extensive multibeam surveys immediately to the west and north of the survey area (Kasuga and Ohara, 1997; Okino et al., 1998; Okino et al., 1999).

Daily Log

JD 286 (Friday, October 13, 2006)

We departed Naha, Okinawa at 1600 L (0700 Z) and headed around the southwestern end of Okinawa and then on a southeast course of 165˚ that should put us south of a large tropical depression that was building west of Guam. The plan was to sail in behind the storm and miss the severe sea states. Our transit speed is 12 kns.

The EM121a was powered up at 1900 L and 6 of the 57 of the power amplifiers (32 through 37) showed red (fault) whereas all the others were green (good). The bad power-amplifier board was replaced and all showed green.

JD 287 (Saturday, October 14, 2006)

Continued transit at 12 kns. At about 1000 L the ship hove-to for repairs on one of the two stern thrusters. We got underway at 1300 L heading SE at 9 kns on only one thruster. The problem was with a hydraulic pump. The initial repairs did not solve the problem so the engineers continued to work on it while we transited at a reduced speed. The repairs were completed and the speed increased to 12 kns at 1800 L.

The EM121a power amplifier board shows numbers 33 and 37 are bad. They do not appear to affect the MBES data.

JD 288 (Sunday, October 15, 2006)

Continued transit at 12 kns. The course was changed to 090˚ at 0300 L and we steamed straight for the patch test area. All systems are up and running. It was discovered that when the Knudsen 320 B/R was configured to collect SEG-Y data, only 5 to 10 minutes worth of data were collected before the system automatically ended the file and started a new one. This created a zillion SEG-Y files. However, if the system was configured to write Knudsen .keb files, then one long, continuous file would be written. Knudsen was contacted and explained that the ship had a custom version of the software that limited the size of a SEG-Y file. Knudsen sent us a newer version of the software that eliminated this problem. However, before we could install the new software, permissions had to be given from NAVO/Stennis. Consequently, for the time being, only Knudsen .keb data are being collected.

JD 289 (Monday, October 16, 2006)

Continued transit at 12 kns on a course of 090˚. All systems are up and running.

JD 290 (Tuesday, October 17, 2006)

The transit was completed at 1300 L. We hove-to at the designated CTD station and the CTD was launched at 1330 L and lowered at a rate of 40 m/min. The CTD made it to 3100 m before the computer seized up and crashed. However, 3100 m is much deeper than the isothermal layer in this region, so this was not a problem for calculating the sound-speed profile. An adjacent XBT was cast after completion of the CTD cast. The two calculated sound-speed profiles were calculated and compared using the CTD-derived sound speed profile as the master to calibrate the XBT profile (Fig. 6). There is a offset of ~7 m/s (1542.4 m/s vs. 1536.6 m/s) between the two. The difference in the surface sound speed was 2.5 m/s but the two temperature sensors on the CTD were internally consistent (28.669˚ and 28.700˚). A second XBT was cast and the surface temperatures between the two XBTs were also internally consistent (26.60˚ and 26.42˚) but differed from the temperatures from the CTD. We were uncertain which system was correctly measuring the water temperature so the CTD was recalibrated and the XBT launchers were cleaned and checked with a calibration probe. Under the circumstances, we decided to make another CTD cast and bracket it with XBT casts before and after the CTD cast.

The second CTD cast and two additional XBT casts confirmed the readings from the first comparisons. The second comparison shows the CTD is consistently recording water temperatures of ~0.3˚C cooler compared to the XBTs. The differences in sound speed between the CTD- and XBT-derived values is consistently ~4 m/s. It was unclear what the problem is; either the CTD sensors are out of calibration or the high near-surface salinities (Fig. 7), that are significantly greater than the assumed 30 PSU for the XBT calculations, are affecting the calculations of sound speed.

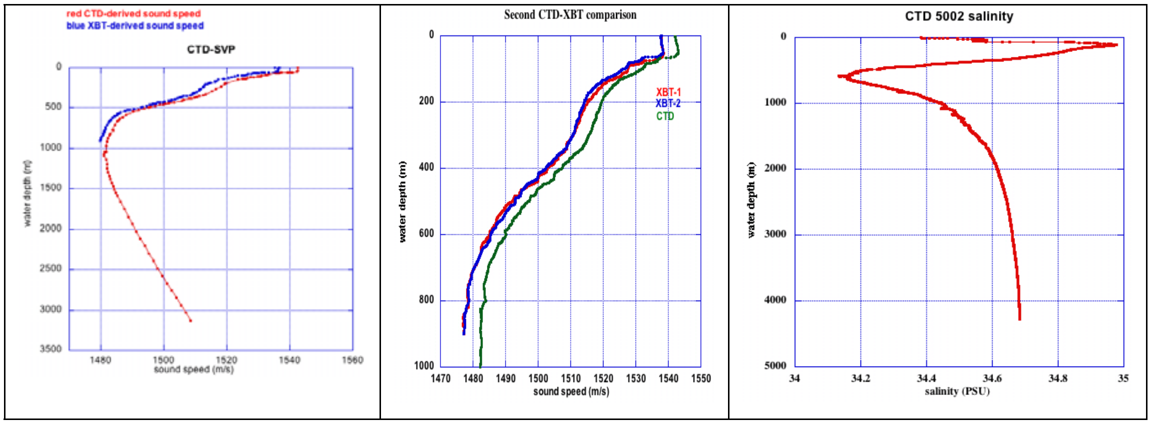


Figure 6. Comparison of sound-speed profiles calculated from CTD and XBTs. Left panel is the first set of casts and middle panel is second set. Not the consistent ~4 m/s offset between the CTD and XBT-derived sound speeds. Right panel is the profile of salinity.

The CTD-XBT comparisons were made from casts from the starboard XBT launcher. It was checked over by the ETs and they determined it had a grounding problem. The port XBT launcher was used for an additional XBT cast and its profile matched the CTD temperature profile. Both XBT launchers were cleaned and checked out but the port launcher was used for the primary one.

JD 291 (Wednesday, October 18, 2006)

We retraced our path on a course of 270˚ to a sharp ridge with 25 to 29˚ slopes (Fig. 7) for a patch-test area. The patch test was completed at 1500 L and we immediately began to map the first dip line up the insular margin from west to east. The results of the patch test showed no offset adjustments were necessary. The one change made was to set

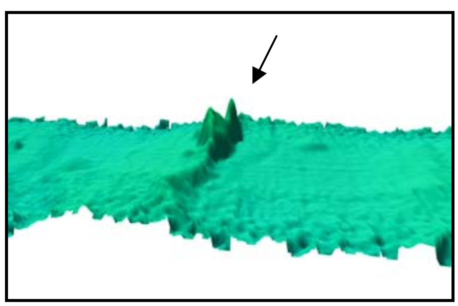


Figure 7. Oblique view of patch test area, looking north. Vertical exaggeration 10x. Ridge (arrow) stands ~130 m high with 30˚ slopes on the E and W flanks.

The absorption coefficient was reset to 0.6 dB/km, following the Simrad curves (Simrad manual) for deep-water settings. The absorption coefficient had been set at 1.2 dB/km, a value the manual states is typically used for mapping in waters ~300 m deep.

The first line of the survey was the NE-running dip line running up the insular slope from the west side of the mapping polygon to the east side. The purpose of this line is to locate the 2500-m isobath and to provide a cross check for each line in the main survey. The cross line was completed and we transited to the start of line 1 at the NE corner of the survey polygon. Line 1 commenced with all systems collecting excellent-quality data.

JD 292 (Thursday, October 19, 2006)

Lines 2 and 3 were run along the shallow eastern edge of the survey area with 3 minor course changes to conform to the NAVO survey polygon. This run consisted of two lines because of the change in the Julian day. Ship speed was ~12 kns and conditions were ideal for mapping. Line 4 completed the eastern edge of the mapping block, but after processing the data it was seen that we had not mapped the 2500-m isobath in along about half the length of the line. Permission had to be sought from NAVO/Stennis before we could venture outside the mapping polygon, so we had to await word from NAVO/Stennis before we put an additional line on the east side to complete this part of the mapping. In the mean time, we continued to map in long N-S lines progressing to the west.

JD 293 (Friday, October 20, 2006)

Routine day of mapping under ideal conditions. All systems producing high-quality data. The first cross-check analysis was run (Fig. 8), even though the area of coverage has rugged bathymetry and the lower flank of an extinct volcano. The mean difference between the two surfaces is 2.3 m ($\sigma = \pm 30$ m), the mean water depth is 3609 m, giving a precision of 0.1% of water depth.

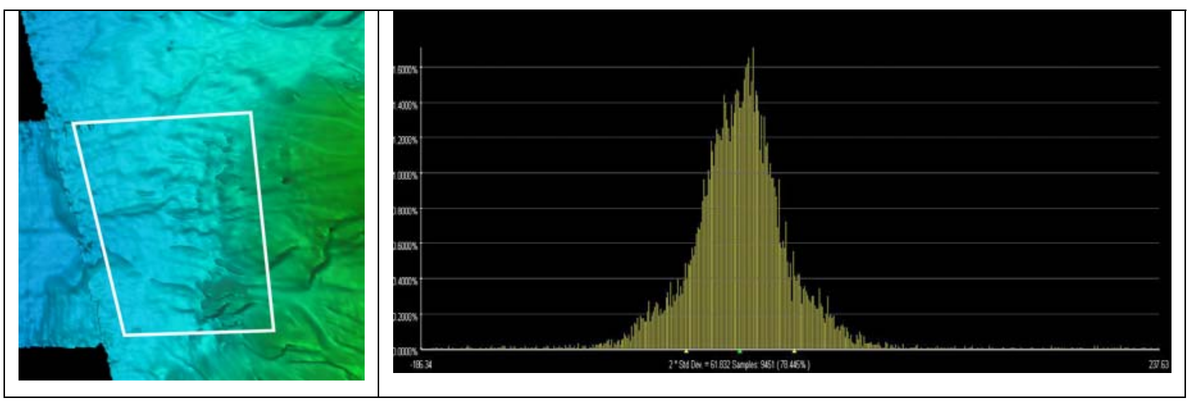


Figure 8. Left panel is area of overlap (white polygon) for first cross check. Right panel is a plot of the difference between the two surfaces as a percentage of water depth. The precision is ±0.1%.

JD 294 (Saturday, October 21, 2006)

Routine day of mapping under ideal conditions. All systems producing high-quality data. We are still awaiting permission from the Navy to extend our survey to the east to complete the mapping of the 2500-m isobath. So, in order to not leave the area before we got the permission, we spent about 12 hrs filling in holidays that occurred on the summits of several volcanoes. One of the volcanoes, Stingray Shoal, rises to less than 24 m as measured by the Knudsen 3.5-kHz profiler. As we approached the shoal, the EM1002 was fired up and we collected a grid of lines so as to better define the summit. NOAA chart 51004 shows 8 fathoms (14.6 m) for the shoal. Our mapping did not define the shoalest depth, but we were able to place the summit at ~450 m east of its charted location.

We were back on line at 1700 L and commenced mapping along the west side of our mosaic.

JD 295 (Sunday, October 22, 2006)

Routine day of mapping under ideal conditions. All systems producing high-quality data. Still no permission from the Navy to map the eastern edge to complete the 2500-m isobath.

JD 296 (Monday, October 23, 2006)

The ship lost the autopilot during the night and had to run a circle while the autopilot came back on line. This occurred in the southern part of Line 22.

Routine day of mapping under ideal conditions. All systems producing high-quality data.

JD 297 (Tuesday, October 24, 2006)

The wind came up to 20 kns during the night and stayed steady all day. The seas became pretty lumpy and the data suffered a bit, but not enough to slow down. We continued to map at ~12.5 kns.

A ~5-minute gap occurred in logging Simrad data on Line 32 but the data were captured on the GSF file. Simrad file 0033 was a zero-length file and was deleted from the data.

At about 1000 L we received permission from the Navy to map along the eastern boundary of our area to complete the mapping of the 2500-m isobath. We turned east after Line 26 was completed (~0130 Z) and ran a dipline (Line 27) along the southern border of the North map sheet. We then turned north on a course that continued the mapping east of the eastern border of the North map sheet on Line 28. Line 28 mapped the 2500-m isobath so we spent the rest of the day filling in holidays on the various volcanoes.

JD 298 (Wednesday, October 25, 2006)

The wind and seas abated a bit during the night but the wind stayed a steady 15 kns. We completed filling in holidays and transited to the western margin of the North map sheet and continued to fill in the North map to the west. By early afternoon, the wind had come up to 20 kns again and the seas got lumpy. All systems producing high-quality data.

The Simrad Merlin logging system crashed at ~0815 Z (~1815 L) as we were leading into Line 45. We had to circle back around to the lead-in point as the EM121A was brought back online. It took ~15 minutes to get Merlin rebooted and back online.

The consequence of this is that there is no Simrad Line 0045, GSF file d05 or Knudsen line 0035 for day 061025.

JD 299 (Thursday, October 26, 2006)

We completed mapping in holidays at the southeastern corner of the North map and transited to the SW corner of the North map to complete the mapping of the western side of that map. The seas and wind were relative calm and all systems produced excellent-quality data.

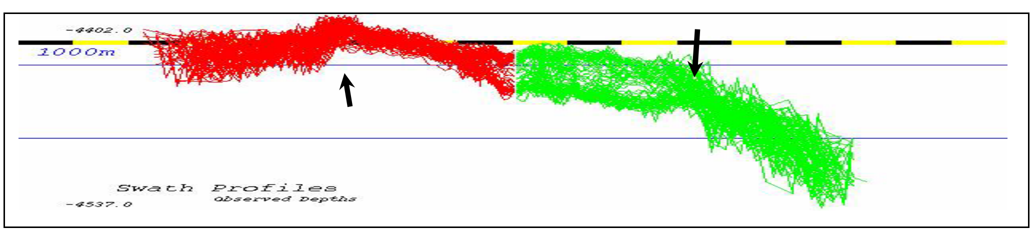
JD 300 (Friday, October 27, 2006)

The wind came back up to a steady 20 kns during the night and persisted throughout the day. The seas were lumpy but the data appears unaffected. Routine day of mapping.

A peculiar artifact of the EM121A collecting data in Deep mode (7 ms pulse length) became apparent in deep-water lines (>4000 m) where the seafloor is rather flat. At an angle of ~30˚ at either side of nadir, the swath changes to a steeper gradient that continues to the outer beams (Fig. 9 top panel). This artifact, called "railroad tracks" is conspicuous on the DTM (Fig. 9 middle and lower panel). This same artifact was found during the EM121A mapping of the U.S. Atlantic margin. To date, the artifact has defied attempts to correct it in the data. According to Simrad, it is a known engineering flaw but was never corrected. The differences in depths caused by the artifact is ~10 m, or ~0.2% of the water depth. This difference is well within the specifications of the EM121A and the survey requirements, so there is no degradation of the quality of the overall survey.

JD 301 (Saturday, October 28, 2006)

Routine day of mapping. All systems collecting high-quality data. A cross check was run on Line 49 versus Dipline 1 to analyze the precision of the soundings in a relatively flat area. The results (Fig. 10) show that the sounding precision is ±0.1% of water depth in 4350 m depths. The wind was blowing a steady 25 kns and the seas stayed lumpy all day but the data quality did not appear to suffer. Ship motion stayed less than 3˚ of roll and pitch. Ship speed was ~12 kns.



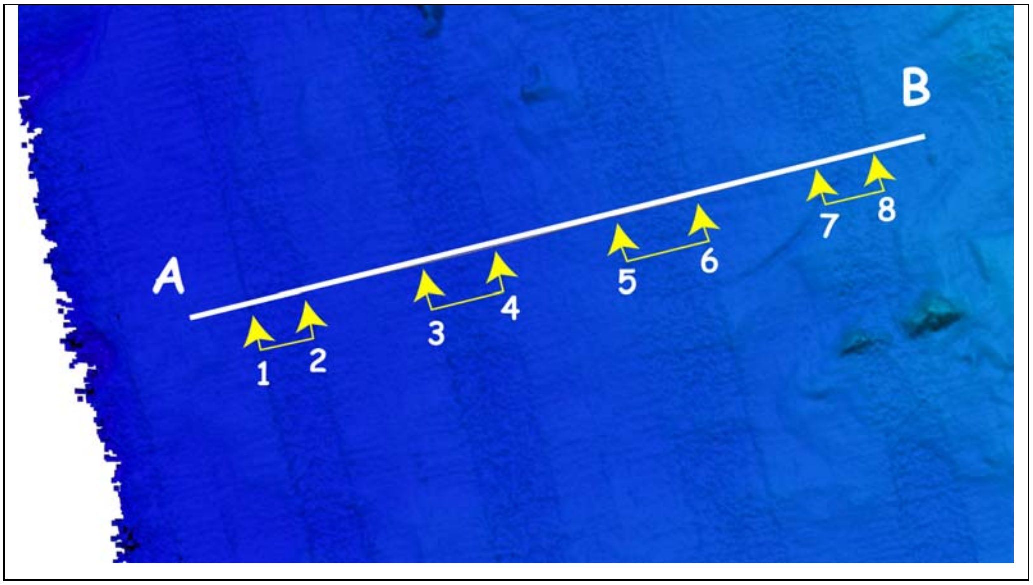


Figure 9. upper: swath profile of soundings showing artifact that produces a change at ~30˚ from nadir (black arrows). Middle: DTM shows the effects of the artifact. The artifact is the area between the yellow arrowheads 1-2, 3-4, 5-6 and 7-8. Lower: Profile A-B showing the depth effect of artifact. Numbered yellow arrowheads correspond to middle panel arrowheads.

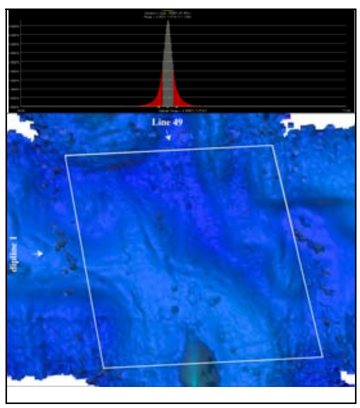


Figure 10. Cross-check analysis in relative flat seafloor. Precision is 0.1% of water depth. Red area in upper panel is >1 σ.

JD 302 (Sunday, October 29, 2006)

Routine day of mapping. The wind and seas calmed during the night and but by 1000 L the wind was back to ~25 kns and the seas became lumpy again. All systems continuing to produce high-quality data.

JD 303 (Monday, October 30, 2006)

Routine day of mapping. We began to see beams in the range of beams 20 to 25 and 95 to 100 being rejected by the Simrad software (Fig. 11). The water depth was around 4400 m, close to the deep end of the range for Deep mode and it was suspected these rejected beams might be the result of the two power amplifiers that have failed.

The MBES was in the Deep mode and it might be that the signal-to-noise ratio in these deep waters is too low to be considered reliable by the Simrad software. Fortunately, the dropped beams do not show on the DTM when gridded at 100 m/pixel. No spare power-amplifier boards were available aboard ship so the only solutions were to either change mode to Very Deep mode or increase the pulse length in Deep mode to 20 ms. The change would increase the pulse width to 25 ms from 7 ms in the Deep mode. An experiment was run with the EM121A in Very Deep mode during the last 10 minutes of Line 54. The beam rejections by Simrad software did not occur in Very Deep mode. Next, the system was put back into Deep mode and the pulse length increased to 20 ms.

Line 57 was run in Deep mode and a 20-ms pulse length to compare to Line 56 with a 7-ms pulse length. The increased pulse length eliminated the rejected beams and produced a full ±60° swath width.

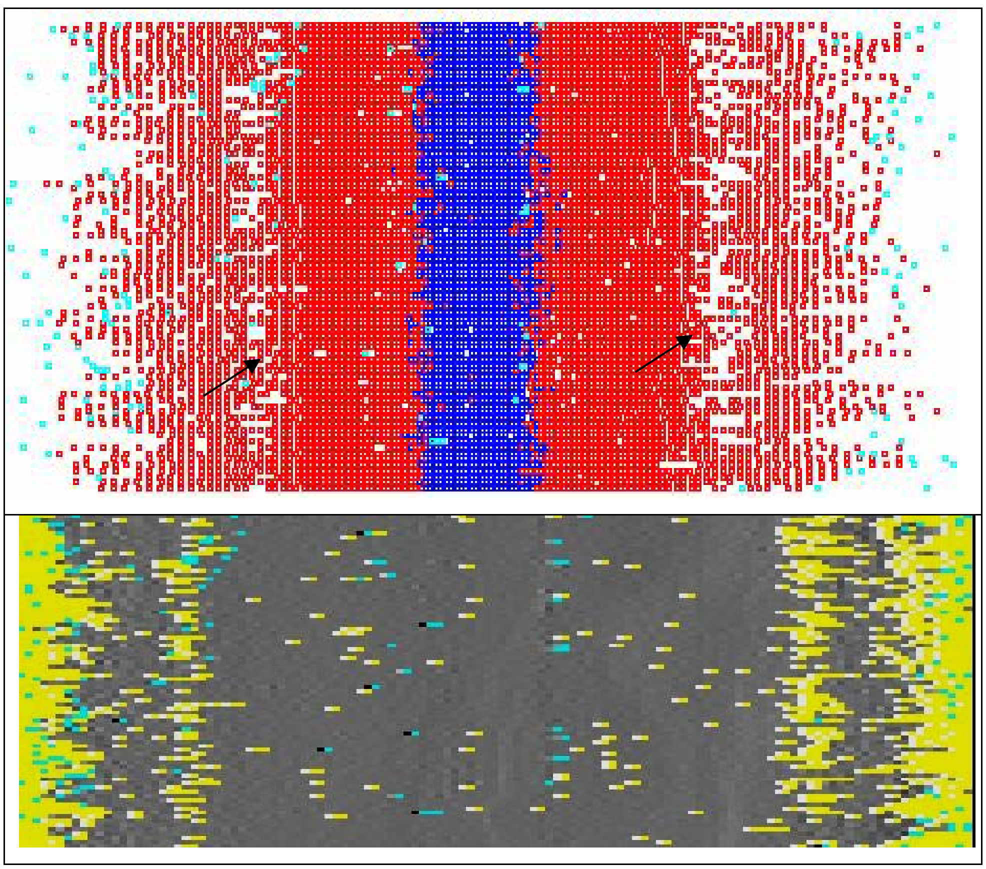


Figure 11. Upper panel: map view of individual soundings of a short segment of Line 54. Black arrows point to beams rejected by Simrad software in Deep mode with a 7 ms pulse length. Lower panel: map view of DTM same segment showing Simrad rejected beams (yellow).

JD 304 (Tuesday, October 31, 2006)

Routine day of mapping. Conditions ideal for mapping and data quality is high.

JD 305 (Wednesday, November 1, 2006)

Completed mapping in the North map sheet in the early morning and ran a dipline 2 up the margin to begin mapping in the Central map sheet. Conditions continue to be ideal. The pulse length was changed from 20 ms to 15 ms (Deep mode) at 305/0404 Z. The pulse length was changed from 15 to 10 ms at 305/0504 Z because of shoaling depths.

JD 306 (Thursday, November 2, 2006)

Routine day of mapping.

JD 307 (Friday, November 3, 2006)

Routine day of mapping. Conditions ideal for mapping.

JD 308 (Saturday, November 4, 2006)

An attempt was made to fill in a large holiday on the summit of a seamount. Line 70 was broken and we steamed to the east and passed over the seamount. The EM1002 was turned on and we discovered that the summit was not a peak like the others already mapped but rather it is a large (6 km diameter) guyot with depths of only ~20 m. The summit is too shallow to be mapped with the MBES systems aboard, so we transited back to the end of Line 70 and continued it north. Conditions ideal for mapping.

JD 309 (Sunday, November 5, 2006)

Routine day of mapping in ideal conditions. The pulse length was increased from 7 to 15 ms during Line 76 (308/2127 Z) because of the deeper water. The pulse length was increased from 15 to 20 ms on Line 77 (309/0157 Z).

At 309/0816 Z (1816 L) the POS/MV heading failed. Line 78 was terminated and work on the POS/MV began to reacquire heading information. The GAMS was reset and the POS/MV reacquired heading. The entire episode lost 1 hour of data (Line 78) and it took another 1.5 hr to fix the POS/MV and transit to the beginning of the line (Line 79). Line 78 was deleted from the data files.

Line 79 was terminated early 309/1138 Z) to make a 5-hr excursion to fill in three large holidays that occurred in the DTM because of relatively shallow seamounts.

JD 310 (Monday, November 6, 2006)

The holiday fill-in lines were completed in the middle of the night and Line 83 was continued where Line 79 was terminated. Conditions continued to be ideal for mapping and data quality was high. The seamounts of the West Mariana Ridge extend much farther to the west than occurs in the North map section. This has caused a series of small holidays over the shallow summits of the seamounts. The EM121A is not the ideal MBES for mapping these summit regions so the holidays were left in the DTM.

The Merlin logging system crashed at 310/0839Z (1839 L) during the beginning of Line 85. The Merlin system was rebooted and the entire line was rerun as Line 86. Line 85 was deleted from the system.

JD 311 (Tuesday, November 7, 2006)

Routine day of mapping. A 4-ft swell picked up during the night and continued to build during the day. By mid-afternoon, the seas were lumpy and the ship was taking 10˚ rolls.

The POS/MV locked up at 311/1919Z and line 90 had to be broken, a 360˚ loop was steamed to reacquire the POS/MV and Line 90a continued the track to the north. The Knudsen 3.5-kHz profiler line was incremented at the line break.

JD 312 (Wednesday, November 8, 2006)

The seas continued to be lumpy on top of a 6-ft swell and we were taking rolls of ±10˚. The data suffered somewhat from the ship motion, but not enough to be of concern. The POS/MV locked up during the night but was quickly restarted with little loss of data.

JD 313 (Thursday, November 9, 2006)

The seas calmed and the data quality improved over yesterday. Routine day of mapping.

JD 314 (Friday, November 10, 2006)

Routine day of mapping. Cross-check analysis shows precision of soundings at 0.6% of water depth for the full swath.

JD 315 (Saturday, November 11, 2006)

Routine day of mapping.

JD 316 (Sunday, November 13, 2006)

The mapping was halted during Line 100 at JD315/1859 Z because time had run out and we began the 24-hr transit to Apra Harbor, Guam.

JD 317 (Monday, November 14, 2006)

Arrived at Apra Harbor, Guam at 0700 L.

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Table 3. Cruise Statistics

Leg	JD dates	Line kilometers (km)
1	286 to 317	11,916

Weather delays ....0 days
Total non-mapping days (transits)..........5.0 days
Total mapping days ....25.0 days
Line kilometers of survey..............................km
Total area mapped ....92,111 km^2

Figure 12. Map of locations of XBT and CTD casts. Backdrop is the newly acquired bathymetry. See Table 6 for details.

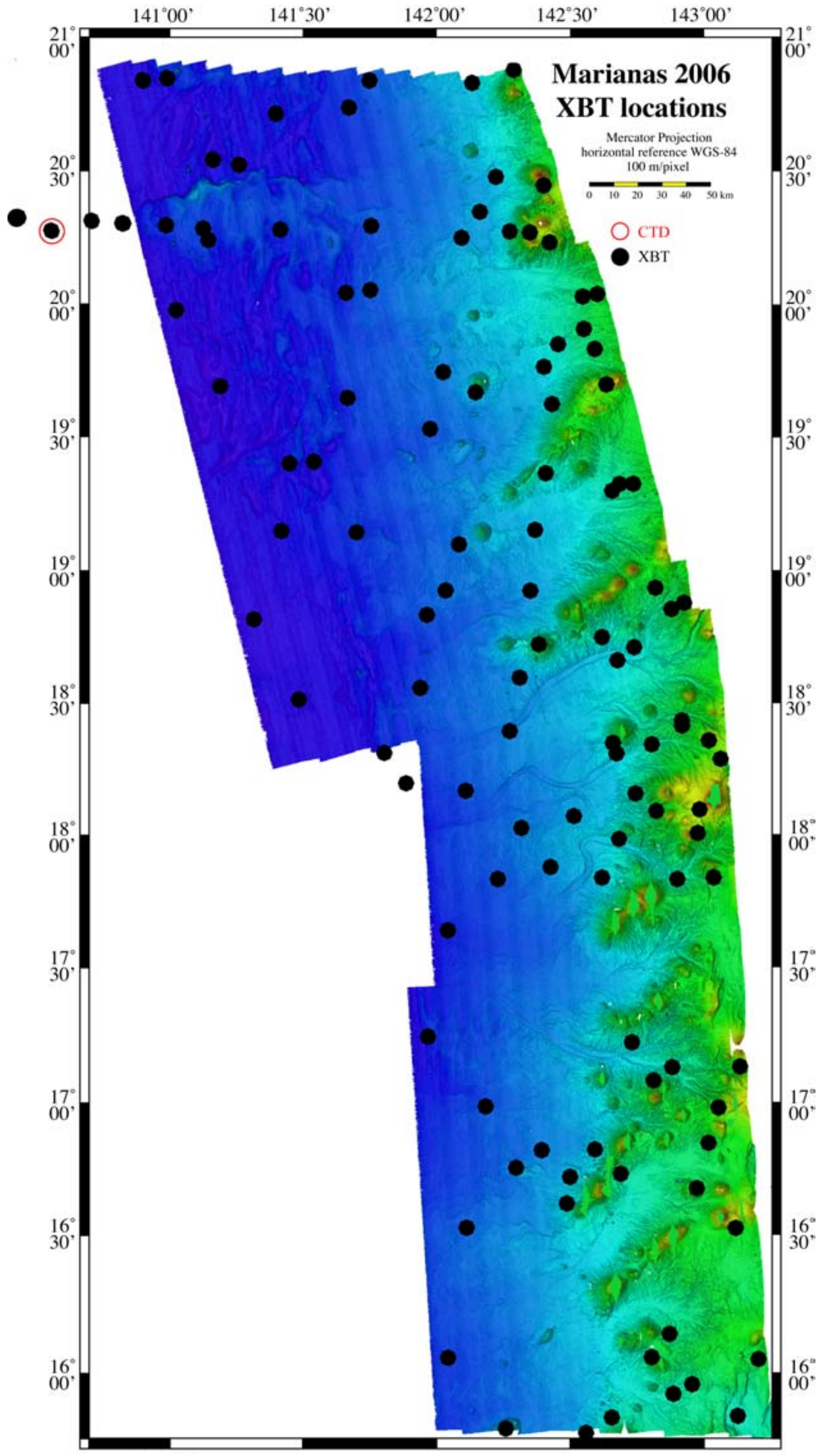


Table 4. Conversion table of NAVO raw.all and NAVO GSF file names to UNH file names by Julian Day

JD	Data Folder	NAVO file name _raw.all	UNH file name _raw.all	NAVO GSF file name
290	**061017**	**0002_171006_233250**	**Marianas_line_patch1**	**62mba06290_p_100.d05**
290	061017			62mba06291_p_100.d01
291	**061018**	**0003_181006_004332**	**Marianas_line_patch2**	**62mba06291_p_100.d02**
291	061018	0004_181006_015220	Marianas_line_patch3	62mba06291_p_100.d03
291	061018	0005_181006_042016	Marianas_line_patch4	62mba06291_p_100.d04
291	061018	0006_181006_054627	Marianas_line_transit10	62mba06291_p_100.d05
				62mba06291_p_100.d06
291	061018	0007_181006_070600	Marianas_line_1 (dipline)	62mba06291_p_100.d07
291	061018	0008_181006_191547	Marianas_line_2	62mba06291_p_100.d08
292	061018	0009_181006_211136	Marianas_line_3	62mba06291_p_100.d09
292	**061019**	**0010_191006_000036**	**Marianas_line_4**	**62mba06292_p_100.d01**
292	061019	0011_191006_082929	Marianas_line_5	62mba06292_p_100.d02
292	061019	0012_191006_210004	Marianas_line_6	62mba06292_p_100.d03
293	**061020**	**0013_201006_003116**	**Marianas_line_7**	**62mba06293_p_100.d01**
293	061020	0014_201006_031846	Marianas_line_8	62mba06293_p_100.d02
293	061020	0015_201006_110517	Marianas_line_9	62mba06293_p_100.d03
294	**061021**	**0016_211006_004813**	**Marianas_line_10**	**62mba06294_p_100.d01**
294	061021	0017_211006_033112	Marianas_line_11	62mba06294_p_100.d02
294	061021	0018_211006_041727	Marianas_line_12	62mba06294_p_100.d03
294	061021	0019_211006_045514	Marianas_line_13	62mba06294_p_100.d04
294	061021	0020_211006_052049	Marianas_line_14	62mba06294_p_100.d05
294	061021	0021_211006_054748	Marianas_line_15	62mba06294_p_100.d06
294	061021	0022_211006_060906	Marianas_line_16	62mba06294_p_100.d07
294	061021	0023_211006_063700	Marianas_line_17	62mba06294_p_100.d08
294	061021	0024_211006_070130	Marianas_line_18	62mba06294_p_100.d09
294	061021	0025_211006_081834	Marianas_line_19	62mba06294_p_100.d10
294	061021	0026_211006_194550	Marianas_line_20	62mba06294_p_100.d11
295	**061022**	**0027_221006_000243**	**Marianas_line_21**	**62mba06295_p_100.d01**
295	061022	0028_221006_084434	Marianas_line_22	62mba06295_p_100.d02
295	061022	0029_221006_223033	Marianas_line_23	62mba06295_p_100.d03
296	**061023**	**0030_231006_000007**	**Marianas_line_24**	**62mba06296_p_100.d01**
296	061023	0031_231006_120040	Marianas_line_25	62mba06296_p_100.d01
297	**061024**	**0032_241006_000704**	**Marianas_line_26**	**62mba06297_p_100.d01**
297	061024	0034_241006_011940	Marianas_line_27 (dip)	62mba06297_p_100.d02
297	061024	0035_241006_041502	Marianas_line_28	62mba06297_p_100.d03
297	061024	0036_241006_140144	Marianas_line_29	62mba06297_p_100.d04
297	061024	0037_241006_152208	Marianas_line_30	62mba06297_p_100.d05
297	061024	0038_241006_184032	Marianas_line_31	62mba06297_p_100.d06
297	061024	0039_241006_203446	Marianas_line_32	62mba06297_p_100.d07
297	061024	0040_241006_230241	Marianas_line_33	62mba06297_p_100.d08

Table 4 continued

JD	Data Folder	NAVO file name _raw.all	UNH file name _raw.all	NAVO GSF file name
298	**061025**	**0041**_251006_000013	**Marianas_line_34**	**62mba06298_p_100.d01**
298	061025	0042_251006_010858	Marianas_line_35	62mba06298_p_100.d02
298	061025	0043_251006_031355	Marianas_line_36	62mba06298_p_100.d03
298	061025	0044_251006_064230	Marianas_line_37	62mba06298_p_100.d04
298	061025	0046_251006_084459	Marianas_line_38	62mba06298_p_100.d06
298	061025	0047_251006_104605	Marianas_line_39	62mba06298_p_100.d07
298	061025	0048_251006_123654	Marianas_line_40	62mba06298_p_100.d08
298	061025	0049_251006_141137	Marianas_line_41	62mba06298_p_100.d09
298	061025	0050_251006_151802	Marianas_line_42	62mba06298_p_100.d10
298	061025	0051_251006_154742	Marianas_line_43	62mba06298_p_100.d110
298	061025	0052_251006_171836	Marianas_line_44	62mba06298_p_100.d12
298	061025	0053_251006_204501	Marianas_line_45	62mba06298_p_100.d13
299	**061026**	**0054_261006_001744**	**Marianas_line_46**	**62mba06299_p_100.d01**
299	061026	0055_261006_135144	Marianas_line_47	62mba06299_p_100.d02
300	**061027**	**0056_271006_000038**	**Marianas_line_48**	**62mba06300_p_100.d01**
300	061027	0057_271006_034016	Marianas_line_49	62mba06300_p_100.d02
300	061027	0058_271006_172415	Marianas_line_50	62mba06300_p_100.d03
301	**061028**	**0059_281006_000009**	**Marianas_line_51**	**62mba06301_p_100.d01**
301	061028	0060_281006_075441	Marianas_line_52	62mba06301_p_100.d02
301	061028	0061_281006_220928	Marianas_line_53	62mba06301_p_100.d03
302	**061029**	**0062_291006_000009**	**Marianas_line_54**	**62mba06302_p_100. d01**
302	061029	0063_291006_123539	Marianas_line_55	62mba06302_p_100.d02
303	**061030**	**0064_301006_000035**	**Marianas_line_56**	**62mba06303_p_100.d01**
303	061030	0065_301006_023518	Marianas_line_57	62mba06303_p_100.d02
303	061030	0066_301006_165408	Marianas_line_58	62mba06303_p_100.d03
304	061031	0067_311006_000016	Marianas_line_59	62mba06304_p_100.d01
304	061031	0068_311006_070919	Marianas_line_60	62mba06304_p_100.d02
304	061031	0069_311006_214250	Marianas_line_61 (dip2)	62mba06304_p_100.d03
305	**061101**	**0070_011106_000008**	**Marianas_line_62 (dip2)**	**62mba06305_p_100.d01**
305	061101	0071_011106_062809	Marianas_line_63	62mba06305_p_100.d02
305	061101	0072_011106_091755	Marianas_line_64	62mba06305_p_100.d03
306	**061102**	**0073_021106_000006**	**Marianas_line_65**	**62mba06306_p_100.d01**
306	061102	0074_021106_015427	Marianas_line_66	62mba06306_p_100.d02
306	061102	0075_021106_155016	Marianas_line_67	62mba06306_p_100.d03
307	**061103**	**0076_031106_000012**	**Marianas_line_68**	**62mba06307_p_100.d01**
307	061103	0077_031106_064902	Marianas_line_69	62mba06307_p_100.d02
307	061103	0078_031106_184806	Marianas_line_70	62mba06307_p_100.d03
307	061103	0079_031106_205029	Marianas_line_71	62mba06307_p_100.d03
307	061104	0080_041106_220526	Marianas_line_72	62mba06308_p_100.d01
308	**061104**	**0081_041106_000007**	**Marianas_line_73**	**62mba06308_p_100.d01**

Table 4 continued.

JD	Data Folder	NAVO file name _raw.all	UNH file name _raw.all	NAVO GSF file name
308	061104	0082_041106_013456	Marianas_line_74	62mba06308_p_100.d02
308	061104	0083_041106_023422	Marianas_line_75	62mba06308_p_100.d03
308	061104	0084_041106_171052	Marianas_line_76	62mba06308_p_100.d04
309	**061105**	**0085_051106_000006**	**Marianas_line_77**	**62mba06309_p_100.d01**
309	*061105*	*0086_051106_*	*Marianas_line_78*	*62mba06309_p_100.d02*
309	061105	0087_051106_093404	Marianas_line_79	62mba06309_p_100.d03
309	061105	0088_051106_125057	Marianas_line_80	62mba06309_p_100.d04
309	061105	0089_051106_135725	Marianas_line_81	62mba06309_p_100.d05
309	061105	0090_051106_161247	Marianas_line_82	62mba06309_p_100.d06
309	061105	0091_051106_184144	Marianas_line_83	62mba06309_p_100.d07
310	**061106**	**0092_061106_000005**	**Marianas_line_84**	**62mba06310_p_100.d01**
310	*061106*	*0093_061106_*	*Marianas_line_85*	*62mba06310_p_100*
310	061106	0094_061106_134353	Marianas_line_86	62mba06310_p_100.d03
311	**061107**	**0095_071106_000006**	**Marianas_line_87**	**62mba06311_p_100.d01**
311	061107	0096_071106_012552	Marianas_line_88	62mba06311_p_100.d02
311	061107	0097_071106_054054	Marianas_line_89	62mba06311_p_100.d04
311	061107	0098_071106_174729	Marianas_line_90	62mba06311_p_100.d05
311	061107	0098_071106_200117	Marianas_line_90a	--
312	**061108**	**0099_081106_000007**	**Marianas_line_91**	**62mba06312_p_100.d01**
312	061108	0100_081106_085742	Marianas_line_92	62mba06312_p_100.d02
312	061108	0101_081106_195334	Marianas_line_93	62mba06312_p_100.d03
313	**061109**	**0102_091106_004302**	**Marianas_line_94**	**62mba06313_p_100.d01**
313	061109	0103_091106_145559	Marianas_line_95	62mba06313_p_100.d02
314	**061110**	**0104_101106_000012**	**Marianas_line_96**	**62mba06314_p_100.d01**
314	061110	0105_101106_060142	Marianas_line_97	62mba06314_p_100.d02
314	061110	0106_101106_195933	Marianas_line_98	62mba06314_p_100.d03
315	**061111**	**0107_101111_000017**	**Marianas_line_99**	**62mba06315_p_100.d01**
315	061111	0108_101111_104409	Marianas_line_100	62mba06315_p_100.d02
315	061111	0109_101111_190743	Marianas_line_101(tran)	62mba06315_p_100.d03
316	**061112**	**0110_101112_000014**	**Marianas_line_102(tran)**	**62mba06316_p_100.d01**
			END OF CRUISE	

Lines 78 and 85 deleted because of computer crashes.
tran is transit line

Table 5. Table of UNH line numbers and Knudsen file names by Julian Day

JD	Date	UNH Line no.	Knudsen File no.
291	**061018**	**Marianas_line_3**	**3**
292	**061019**	**Marianas_line_4**	**4**
292	061019	Marianas_line_5	5
292	061019	Marianas_line_6	6
293	**061020**	**Marianas_line_7**	**7**
293	061020	Marianas_line_8	8
293	061020	Marianas_line_9	9
294	**061021**	**Marianas_line_10**	**10**
294	061021	Marianas_line_11	-
294	061021	Marianas_line_12	-
294	061021	Marianas_line_13	-
294	061021	Marianas_line_14	-
294	061021	Marianas_line_15	-
294	061021	Marianas_line_16	-
294	061021	Marianas_line_17	-
294	061022	Marianas_line_18	18
294	061022	Marianas_line_19	19
294	061022	Marianas_line_20	20
295	**061023**	**Marianas_line_21**	**21**
295	061023	Marianas_line_22	22
295	061023	Marianas_line_23	23
296	**061024**	**Marianas_line_24**	**24**
296	061024	Marianas_line_25	25
297	**061024**	**Marianas_line_26**	**26**
297	061024	Marianas_line_27	27
297	061024	Marianas_line_28	28
297	061024	Marianas_line_29	29
297	061024	Marianas_line_30	30
297	061024	Marianas_line_31	31
297	061024	Marianas_line_32	32
297	061024	Marianas_line_33	33
298	061025	Marianas_line_34	34
298	**061025**	**Marianas_line_35**	**35**
298	061025	Marianas_line_36	36
298	061025	Marianas_line_37	37
298	061025	Marianas_line_38	38
298	061025	Marianas_line_39	39
298	061025	Marianas_line_40	40
298	061025	Marianas_line_41	41
298	061025	Marianas_line_42	42
298	061025	Marianas_line_43	43
298	061025	Marianas_line_44	44
298	061025	Marianas_line_45	45
299	**061026**	**Marianas_line_46**	**46**
299	061026	Marianas_line_47	47
300	**061027**	**Marianas_line_48**	**48**
300	061027	Marianas_line_49	49
300	061027	Marianas_line_50	50

Table 5 continued

JD	Date	UNH Line no.	Knudsen File no.
301	**061028**	**Marianas_line_51**	**51**
301	061028	Marianas_line_52	52
301	061028	Marianas_line_53	53
302	**061029**	**Marianas_line_54**	**54**
302	061029	Marianas_line_55	55
303	**061030**	**Marianas_line_56**	**56**
303	061030	Marianas_line_57	57
303	061030	Marianas_line_58	58
304	**061031**	**Marianas_line_59**	**59**
304	061031	Marianas_line_60	60
304	061031	Marianas_line_61 (dip)	61
305	**061101**	**Marianas_line_62 (dip)**	**62**
305	061101	Marianas_line_63	63
305	061101	Marianas_line_64	64
306	**061102**	**Marianas_line_65**	**65**
306	061102	Marianas_line_66	66
306	061102	Marianas_line_67	67
307	**061103**	**Marianas_line_68**	**68**
307	061103	Marianas_line_69	69
307	061103	Marianas_line_70	70
307	061103	Marianas_line_71	71
307	061103	Marianas_line_72	72
308	**061104**	**Marianas_line_73**	**73**
308	061104	Marianas_line_74	74
308	061104	Marianas_line_75	75
308	061104	Marianas_line_76	76
309	**061105**	**Marianas_line_77**	**77**
309	061105	Marianas_line_79	79
309	061105	Marianas_line_80	80
309	061105	Marianas_line_81	81
309	061105	Marianas_line_82	82
309	061105	Marianas_line_83	83
310	**061106**	**Marianas_line_84**	**84**
310	*061106*	*Marianas_line_85*	*85*
310	061106	Marianas_line_86	86
311	**061107**	**Marianas_line_87**	**87**
311	061107	Marianas_line_88	88
311	061107	Marianas_line_89	89
311	061107	Marianas_line_90	90
312	**061108**	**Marianas_line_91**	**91**
312	061108	Marianas_line_92	92
312	061108	Marianas_line_93	93
313	**061109**	**Marianas_line_94**	**94**
313	061109	Marianas_line_95	95
314	**061110**	**Marianas_line_96**	**96**

Lines 78 and 85 deleted because of computer crashes.
tran is transit line

Table 5 continued

314	061110	**Marianas_line_97**	**97**
314	061110	Marianas_line_98	98
315	**061111**	**Marianas_line_99**	**99**
315	061111	Marianas_line_100	100
315	061111	Marianas_line_101 (tran)	101
316	**061112**	**Marianas_line_102 (tran)**	**102**
		END OF CRUISE	

Table 6. Location of XBT casts

Longitude E	Latitude N	Number
140.9980	20.3035	16
140.7117	20.3190	17
140.8301	20.3091	18
140.8339	20.3097	19
140.4284	20.3334	20
140.5569	20.2810	21
141.1408	20.2911	22
141.7897	20.3012	23
142.3400	20.8980	24
142.6062	20.0301	25
142.6982	19.6931	26
142.8018	19.3128	27
142.8875	18.9140	28
142.7204	19.2862	29
142.4786	20.2372	30
142.4029	20.2747	31
142.5114	19.8476	32
142.7485	19.3117	33
142.8050	18.6866	34
142.6110	19.9056	35
142.4556	20.4554	36
142.1798	20.8486	37
142.2715	20.4888	38
142.3248	20.2798	39
142.4566	19.7608	40
142.7406	18.6367	41
142.4637	19.3533	42
142.2095	20.3550	43
142.1388	20.2556	44
142.4225	19.1360	45
142.4371	18.6973	46
142.1930	19.6635	47
141.7833	20.8583	48
142.0677	19.7407	49
142.3634	18.5701	50
142.9488	18.8328	51
142.6627	20.0396	52

142.6533	19.8292	53
142.4880	19.6185	54
142.4044	18.9032	55
142.6810	18.7256	56
142.9981	18.8566	57
142.3250	18.3654	58
142.1290	19.0809	59
142.0172	19.5230	60
141.7042	20.7544	61
141.7862	20.0551	62
142.0775	18.9041	63
142.0050	18.8106	64
141.6927	20.0448	65
141.4219	20.7311	66
141.6988	19.6423	67
141.9795	18.5307	68
141.7331	19.1268	69
141.4389	20.2872	70
141.2797	20.5352	71
141.5685	19.3975	72
141.8411	18.2813	73
141.4741	19.3912	74
141.1787	20.5544	75
141.0030	20.8662	76
141.1609	20.2470	77
141.4434	19.1321	78
141.5102	18.4862	79
141.2071	19.6866	80
140.9090	20.8583	81
141.0368	19.9793	82
141.3368	18.7934	83
141.9251	18.1653	84
142.7368	18.2798	85
143.0933	18.3301	86
143.1389	18.2591	87
143.2141	17.0806	88
143.2852	15.9600	89
143.1972	16.4624	90
143.1118	17.8046	91
143.0577	18.0655	92
143.1306	16.9233	93
143.2054	15.7420	94
143.0923	16.7884	95
143.0506	17.9749	96
142.9904	18.3864	97
142.9891	18.4056	98
142.9718	17.7987	99
143.0472	16.6145	100
143.0292	15.8632	101
142.9522	17.0778	102
142.8733	18.3146	103
142.8906	18.0596	104
142.8103	18.1265	105
142.8806	17.0268	106

142.9421	16.0564	107
142.9567	15.8261	108
142.8730	15.9665	109
142.7964	17.1734	110
142.7467	17.9526	111
142.7232	18.3203	112
142.6813	17.8040	113
142.7535	16.6696	114
142.7190	15.7355	115
142.6540	16.7622	116
142.5726	18.0397	117
142.4822	17.8446	118
142.5578	16.6568	119
142.6197	15.6778	120
142.4483	16.7593	121
142.3696	17.9941	122
142.2792	17.7984	123
142.3496	16.6917	124
142.3099	15.6928	125
142.2317	16.9269	126
142.1546	18.1367	127
142.0858	17.6014	128
142.1583	16.4621	129
142.0868	15.9636	130
142.0088	17.1945	131
142.5454	16.5555	132
143.2022	15.5360	133

Appendix 1. Cruise Calendar

October 2006

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	2	3	4	5	6	7
8	9	10	11	12	JD286 13 depart Naha, Okinawa 1600L	JD287 14 transit
JD288 15 transit	JD289 16 transit	JD290 17 transit CTD-XBT cal	JD291 18 patch test mapping in North	JD292 19 mapping in North	JD293 20 mapping in North	JD294 21 mapping in North
JD295 22 mapping in North	JD296 23 mapping in North	JD297 24 mapping in North	JD298 25 mapping in North	JD299 26 mapping in North	JD300 27 mapping in North	JD301 28 mapping in North
JD302 29 mapping in North	JD303 30 mapping in North	JD304 31 completed North				

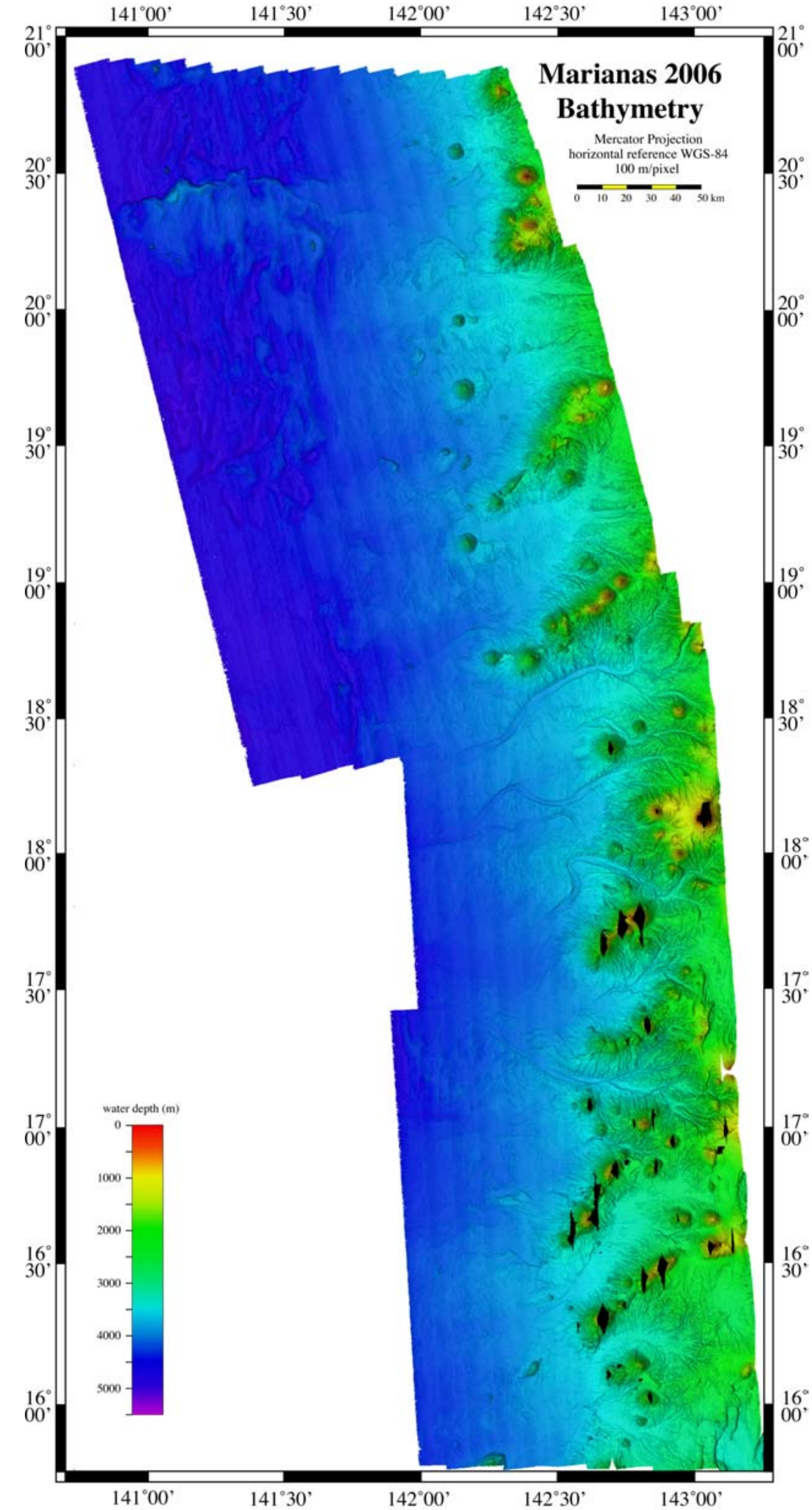
November 2006

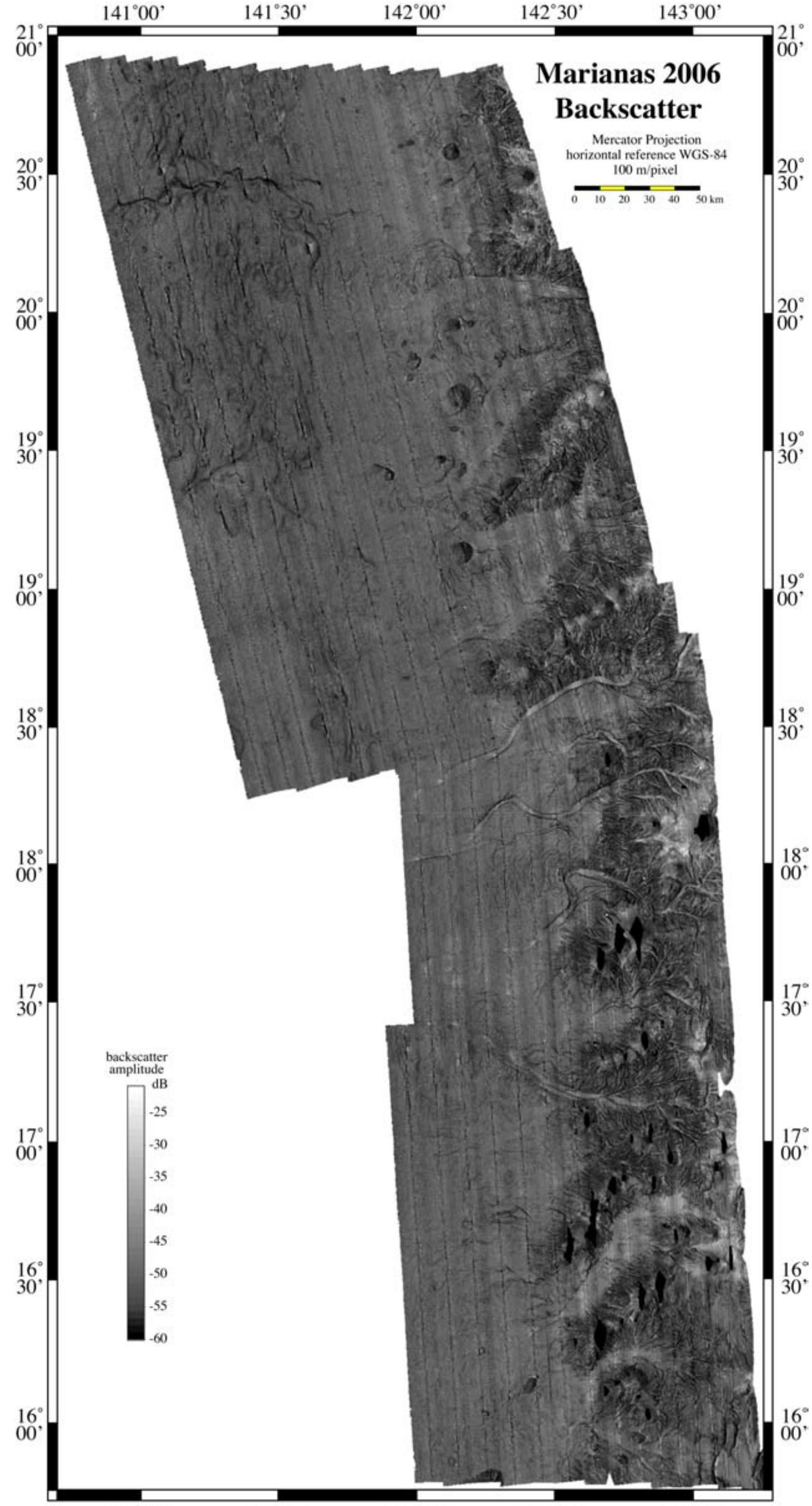
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			JD305 1 Dipline 2 & mapping in Central	JD306 2 mapping in Central	JD307 3 mapping in Central	JD308 4 mapping in Central
JD309 5 mapping in Central	JD310 6 mapping in Central	JD311 7 mapping in Central	JD312 8 mapping in Central	JD313 9 mapping in Central	JD314 10 mapping in Central	JD315 11 mapping in Central
JD316 12 transist	JD317 13 arrive Guam 0800 L	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

Appendix 2. Cruise Personnel

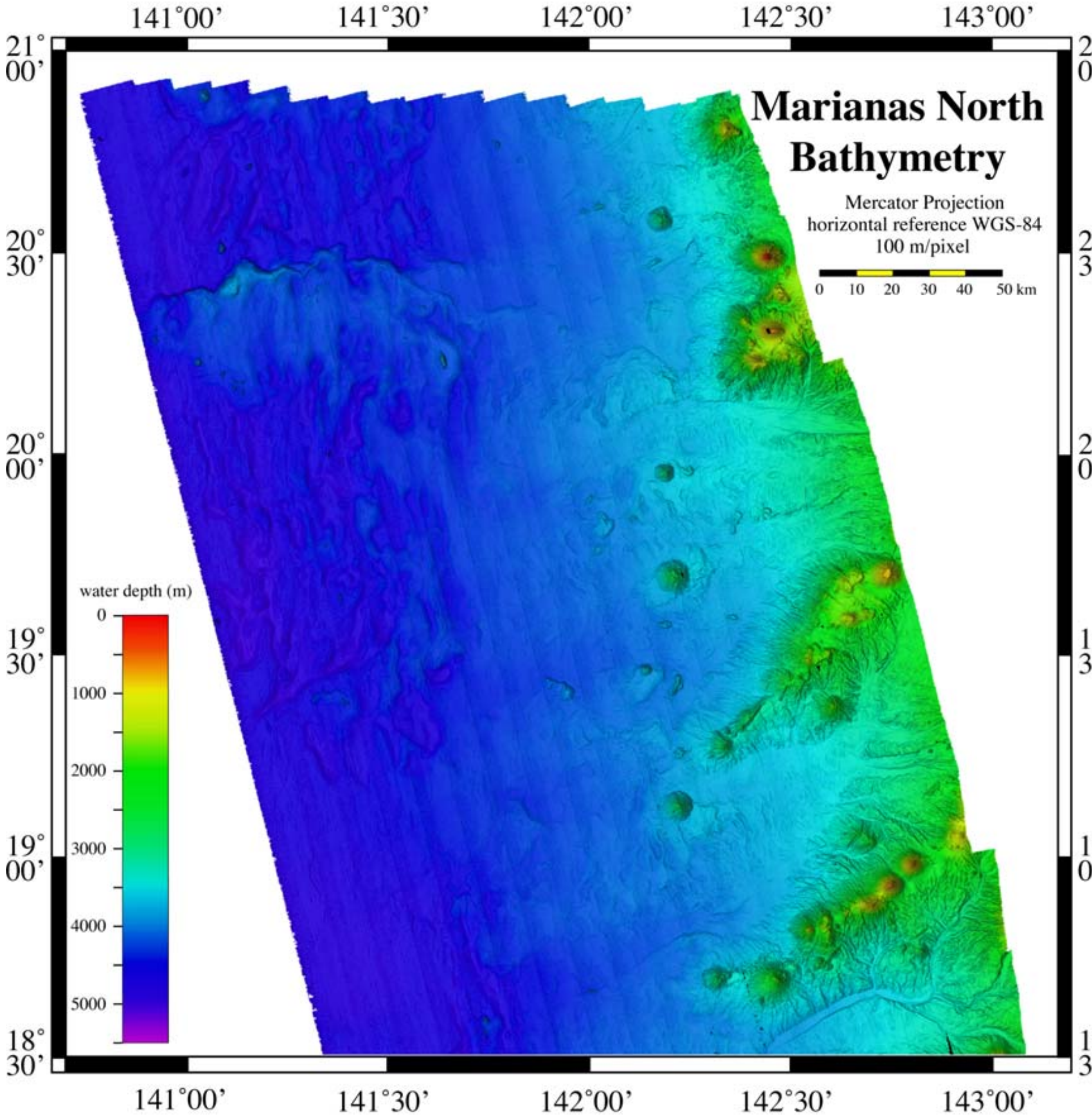
Dr. James V. Gardner	UNH/NOAA representative/Chief Scientist
Mr. Gordon Marsh	Senior NAVO Representative
Mr. Jerry A. Peschka, Jr.	Ship's Master
Mr. Glen Carson, Jr.	NAVO data manager
Mr. Larry Johnson	NAVO senior electronics technician
Mr. Steve Warner	NAVO electronics technician
Mr. William F. Taylor	NAVO watchstander
Ms. Stephanie Shiel	NAVO watchstander
Mr. Neil Duffin	NAVO watchstander
Ms. Elizabeth Clements	NAVY watchstander
Ms. Mica Mauratura	NAVY watchstander

Appendix 3. Color shaded-relief bathymetry and acoustic backscatter maps of western insular margins of Guam and the Northern Mariana Islands.

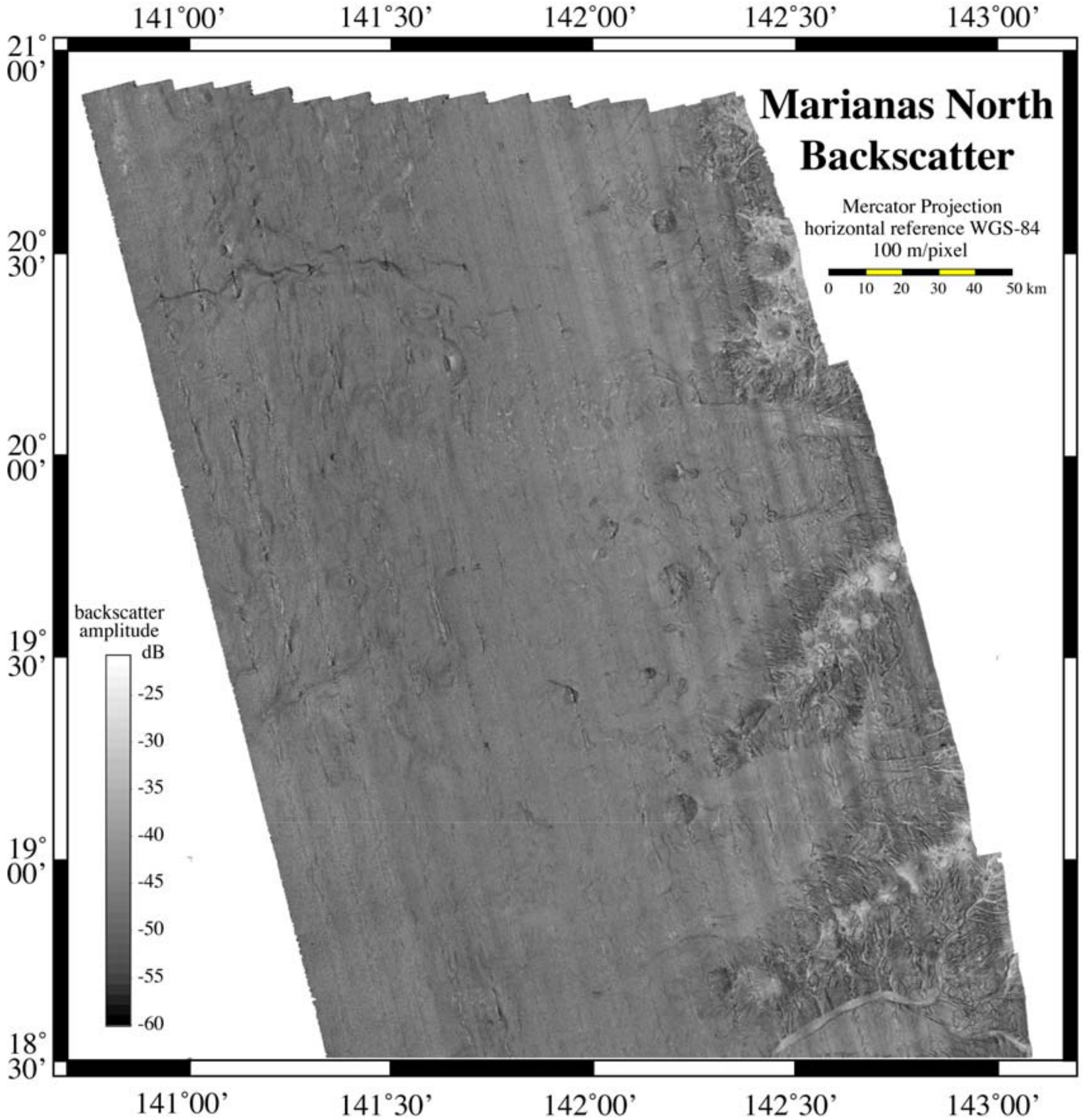


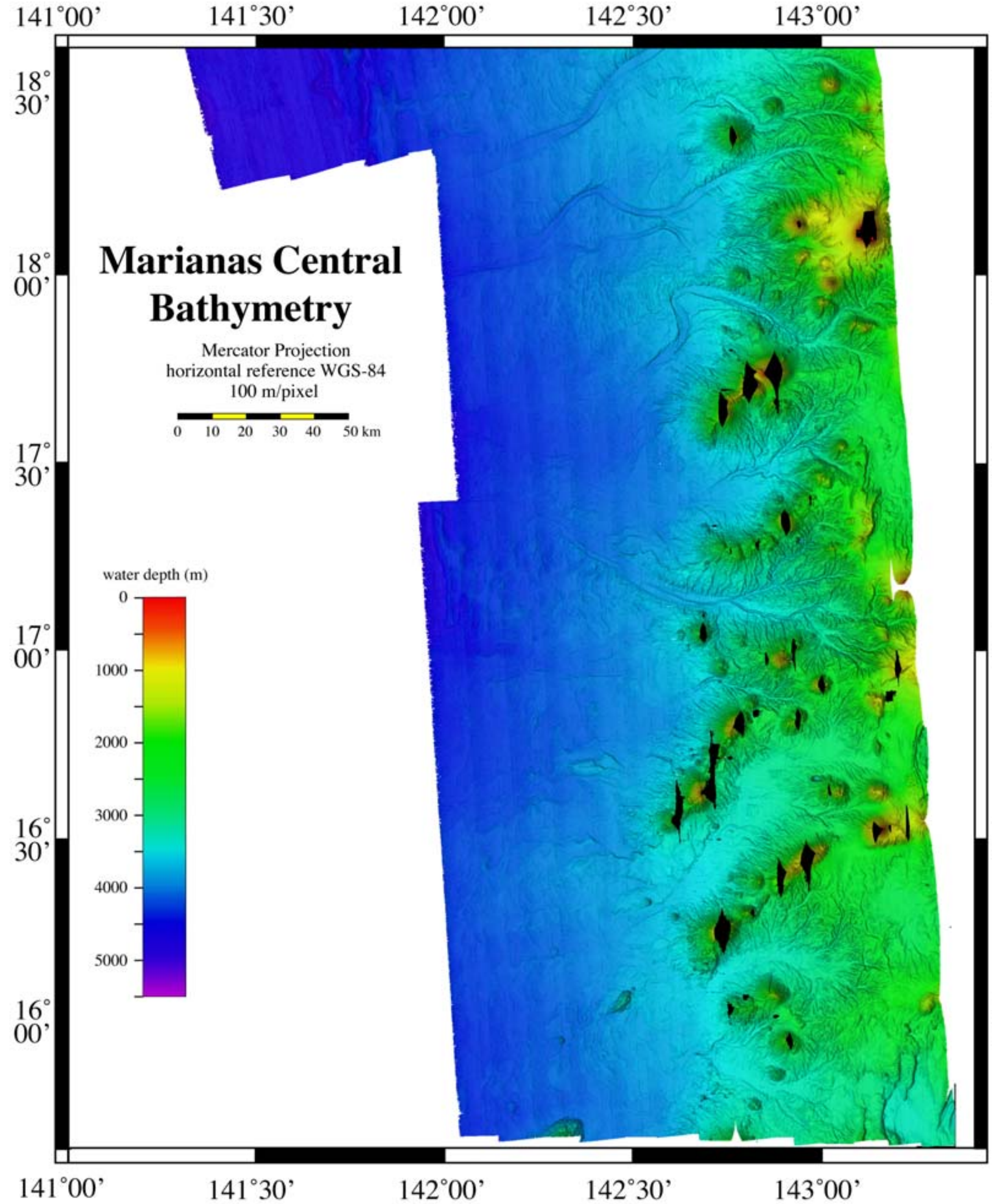


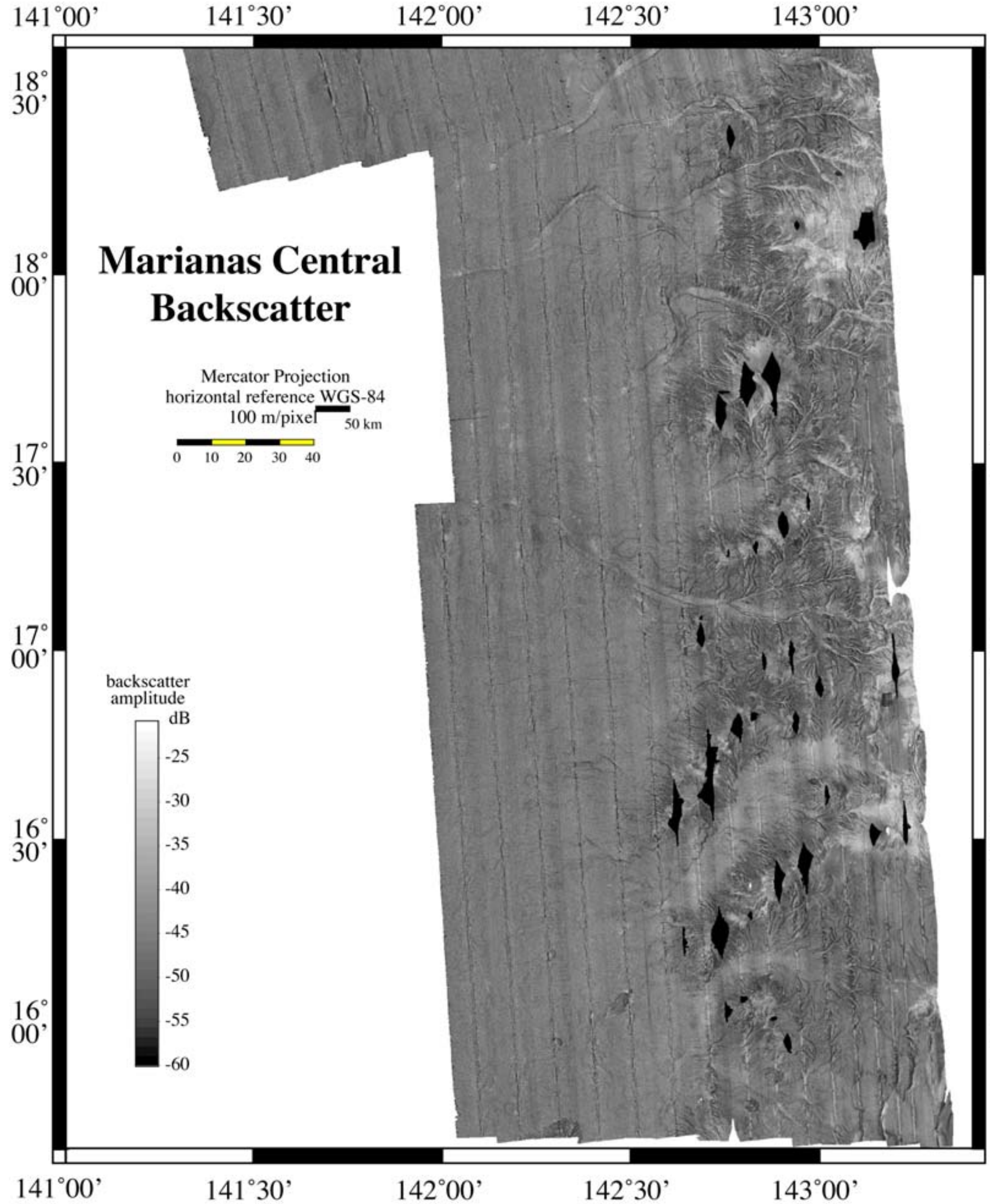
Marianas 2006
Backscatter
Mercator Projection
horizontal reference WGS-84
100 m/pixel
0 10 20 30 40 50 km
141°00'
141°30'
142°00'
142°30'
143°00'
21° 00'
20° 30'
20° 00'
19° 30'
19° 00'
18° 30'
18° 00'
17° 30'
17° 00'
16° 30'
16° 00'
backscatter amplitude
dB
-25
-30
-35
-40
-45
-50
-55
-60



141°00'
141°30'
142°00'
142°30'
143°00'
21° 00'
20° 30'
20° 00'
19° 30'
19° 00'
18° 30'
Marianas North Bathymetry
Mercator Projection
horizontal reference WGS-84
100 m/pixel
0 10 20 30 40 50 km
water depth (m)
0
1000
2000
3000
4000
5000


Marianas North
Backscatter
Mercator Projection
horizontal reference WGS-84
100 m/pixel
0 10 20 30 40 50 km
backscatter amplitude
dB
-25
-30
-35
-40
-45
-50
-55
-60
141°00'
141°30'
142°00'
142°30'
143°00'
21° 00'
20° 30'
20° 00'
19° 30'
19° 00'
18° 30'


141°00'
141°30'
142°00'
142°30'
143°00'
18° 30'
18° 00'
17° 30'
17° 00'
16° 30'
16° 00'
Marianas Central Bathymetry
Mercator Projection
horizontal reference WGS-84
100 m/pixel
0 10 20 30 40 50 km
water depth (m)
0
1000
2000
3000
4000
5000



141°00'
141°30'
142°00'
142°30'
143°00'
18° 30'
18° 00'
17° 30'
17° 00'
16° 30'
16° 00'
Marianas Central Backscatter
Mercator Projection
horizontal reference WGS-84
100 m/pixel
50 km
0 10 20 30 40
backscatter amplitude
dB
-25
-30
-35
-40
-45
-50
-55
-60