U.S Department of the Interior
U.S. Geological Survey

CRUISE REPORT

RV OCEAN ALERT CRUISE A1-98-HW

January 30 through February 23, 1998

Honolulu to Honolulu, Hawai'i

James V. Gardner[1] and John Hughes-Clarke[2]

Open-File Report
98-212

A jointly funded project by the US Corps of Engineers, US Environmental Protection Agency, and the US Geological Survey

Conducted under a Cooperative Agreement between the US Geological Survey and the Ocean Mapping Group, University of New Brunswick

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1998

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RV OCEAN ALERT CRUISE A1-98-HW
MAPPING HAWAII INSULAR SLOPES

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Cruise Objectives

The major objective of cruise A1-98 was to map portions of the insular slopes of Oahu, Kauai, Maui, Molokai, and Hawaii and to survey in detail US Environmental Protection Agency (USEPA) ocean dumping sites using a Simrad EM300 high-resolution multibeam mapping system. The cruise was a jointly funded project between the US Army Corps of Engineers (USCOE), USEPA, and the US Geological Survey (USGS). The USACOE and EPA are interested in these areas because of a series of ocean dump sites off Oahu, Kauai, Maui, and Hawaii (Fig. 1) that require high-resolution base maps for site monitoring purposes. The USGS Coastal and Marine Geology Program has several on-going projects off Oahu and Maui that lack high-precision base maps for a variety of ongoing geological studies. The cruise was conducted under a Cooperative Agreement between the USGS and the Ocean Mapping Group, University of New Brunswick, Canada.

The Simrad EM300 High-Resolution Multibeam Mapping System

This cruise pioneered the use of the Simrad EM300 high-resolution multibeam mapping system in the U.S. This system simultaneously collects georeferenced backscatter (similar to a sidescan image) and bathymetry with precise spatial referencing. The advantage of the Simrad EM300 over all other competing systems is that each depth determination is calculated from a phase detection as well as an amplitude detection, and then the "best" solution is selected, based on a set of statistical, quality-control parameters. The only operational Simrad EM300 system presently in the U.S. is owned and operated by C&C Technologies, Lafayette, LA., and is hull mounted on the leased Canadian-flag MV Ocean Alert, a 1,750 ton, 71-m , converted Canadian Coast Guard ship (Fig. 2).

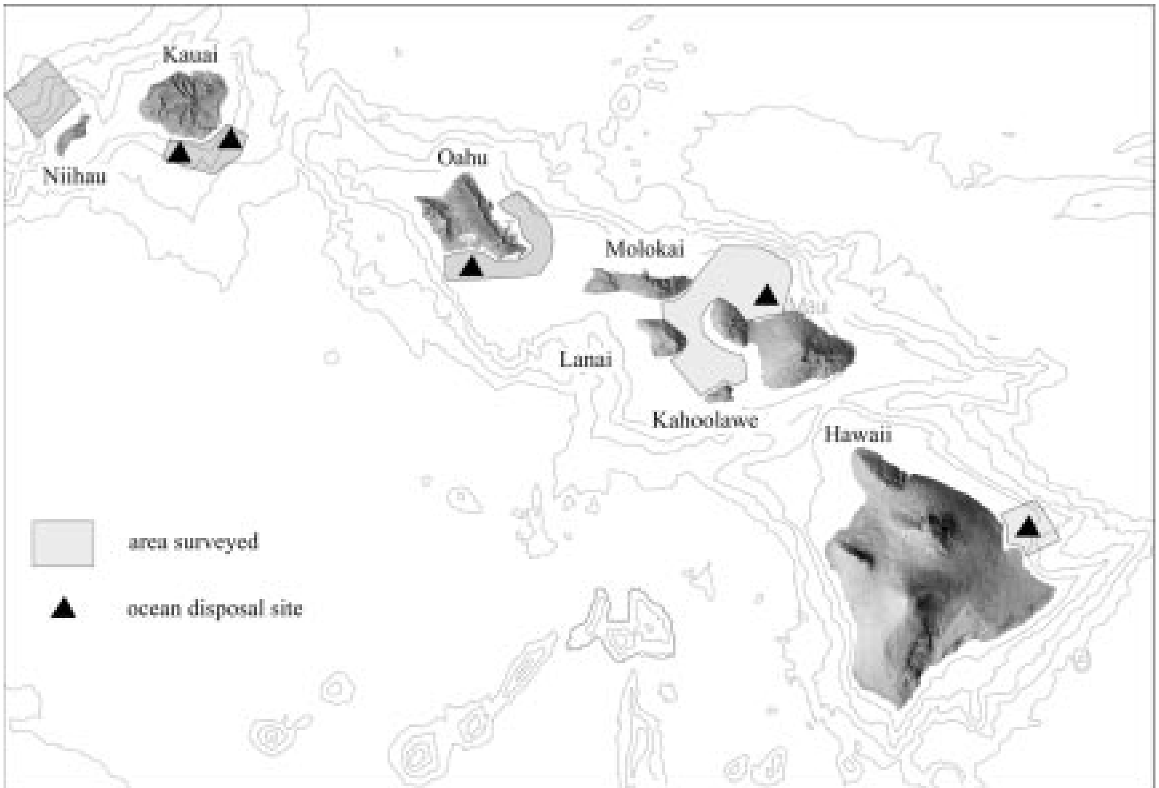

Figure 1. Index map of Hawaiian Islands and the areas surveyed during cruise A1-98-HW. Contour interval 1000 m.

Figure 2. The RV Ocean Alert

The EM300 system is a 30-kHz multibeam sonar system with up to 135 individual 1° (vertical) x 2° (horizontal) electronically formed beams (see Appendix 1 for details). The swath width and number of beams used during a survey is dependent on the water depth and mode of operation (see Table 1). The system can be operated in either equal-angle or equal-distance mode. The equal-angle mode generates 135 1°x2° receive beams and is configured so that, as the beam number increases from nadir, the size of the area imaged by each beam progressively increases. The equal-distance mode varies the individual beam angles so that the same size area is imaged by each beam, regardless of the angle away from nadir the beam is pointing. The Hawaiian surveys were operated in equal-angle mode because our initial sea trial off Honolulu showed this mode produced the best results in the 200 to 1500-m water depths we intended to survey. The EM300 incorperates roll, pitch, yaw, and heave compensations utilizing a POS/MV motion sensor that detects motions to 0.01° (Table 2). Yaw steering electronically separates the receive beam into 6 segments (3 per side) and steers each segment to compensate for ship yaw. This innovation provides a much more accurate geographic determination of the location of individual depth/backscatter values on the seafloor. The ship's heading was determined with a dual DGPS system with accuracies <0.1°. Positions and time stamps were provided with a kinematic DGPS system that gave reliable fixes one per second with ± 1-m accuracy.

Table 1 Optimum water depths vs modes for the EM300 system

water depth (m)	mode	fixed swath width (m)
10 to 50	very shallow	150°
50 to 200	shallow	1500
200 to 700	meduim	1500
700 to 2200	deep	3000
>2200	very deep	3000

Sound velocity profiles (SVP) were calculated several times each day so that raytracing techniques could be used to determine the effect of acoustic refraction in the water principally caused by variations in water temperature. Accurate ray tracing allows the precise location of each beam's projection on the seafloor. A SeaBird CTD was deployed at least once a day to get a good reference SVP, but this measurement requires the ship to hove to and a typical cast took about 30 minutes. Sippican T5 expendable bathythermographs (0 to 1830-m water depth) were routinely collected several times a day to determine water structure because they could be obtained while underway. Two additional sound velocity profilers are installed at the transducer arrays to determine the speed of sound in water directly at the transducer. All the SVP data are fed directly into the Simrad EM300 processor for instantaneous raytracing of the individual beams.

Table 2. Systems Specifications

Simrad EM300	see Appendix 1
	135 1°x2° beams
	6 kw output power
	source 240 dB (ref 1μPa @ 1 m)
mode	equal angle
active roll, pitch, heave, and yaw compensation	
positioning	DGPS
heading (gyro)	dual DGPS
motion sensing	POS/MV model 320
water velocity	daily SeaBird CTD
	several/day T5 XBTs

Like many of the state-of-the-art high-resolution multibeam mapping systems, the Simrad EM300 utilizes both amplitude (backscatter) and phase detection (bathymetry), but unlike any others, the EM300 uses both for each determination of the bottom depth for each beam, resulting in a measurement accuracy of $<0.2\%$ of water depth (RMS). Details of high-resolution multibeam mapping systems can be found in Hughes-Clarke, et al. (1996).

The Party Chief, Mr. Art Kleiner, oversaw a staff of surveyors and programmers from C & C Technologies, Inc who operated the EM300 system. The data were processed aboard ship by the senior author (JVG) and several graduate students from the Ocean Mapping Group, University of New Brunswick (Table 3).

Table 3. Scientific Staff of cruise A1-98

Name	Dates aboard vessel
Capt. George Brawley	1/30-2/23
Mr. James Chance, C&C Technologies	1/30 -2/4
Mr Art Kleiner, C&C Technologies	1/30-2/23
Dr. John Hughes-Clarke, OMG, Univ. of New Brunswick	1/30-2/4
Dr. James V. Gardner, USGS	1/30-2/23
Mr. Mike Torresan, USGS	1/30-2/4
Mr Tim Patro, C&C Technologies	1/30-2/23
Mr. Pablo Mejia, C&C Technologies	1/30-2/23
Mr. Guy Guidry, C&C Technologies	1/30-2/23
Mr. Ryan Larsen, C&C Technologies	1/30-2/23
Mr. Edouard Kammerer, OMG, Univ. of New Brunswick	1/30-2/23
Mr. Sean Galway, OMG, Univ. of New Brunswick	1/30-2/23
Mr. Luciano Fonseca, OMG, Univ. of New Brunswick	2/4-2/10
Mr. Hou Tianhang, OMG, Univ. of New Brunswick	2/10-2/23
Mr. Kjell Nilsen, Konsberg Simrad	1/30-2/6
Mr. Rolf Iversen, Konsberg Simrad	1/30-2/4

All post-cruise processing will be performed by JVG. Data processing (Fig. 3) consisted of (1) editing the navigation to flag bad fixes; (2) editing each ping of each beam, flagging outliers, bad data, etc., (3) merging the depth and backscatter data with the cleaned navigation, (4) reducing all depth values to mean low low water based on predicted tides; (5) performing additional refraction corrections for correct beam raytracing; (6) separating out the amplitude measurements for conversion to backscatter, (7) gridding depth and backscatter at the highest resolution possible with water depth, (8) regridding individual subareas of bathymetry and backscatter into final map sheets, (9) gridding and contouring the bathymetry, and (10) generation of the final maps. Nearly finalized maps were completed aboard ship during the cruise and final maps were completed within one month of the end of the cruise. Final maps will be published as USGS Miscellaneous Investigations I-Map Series.

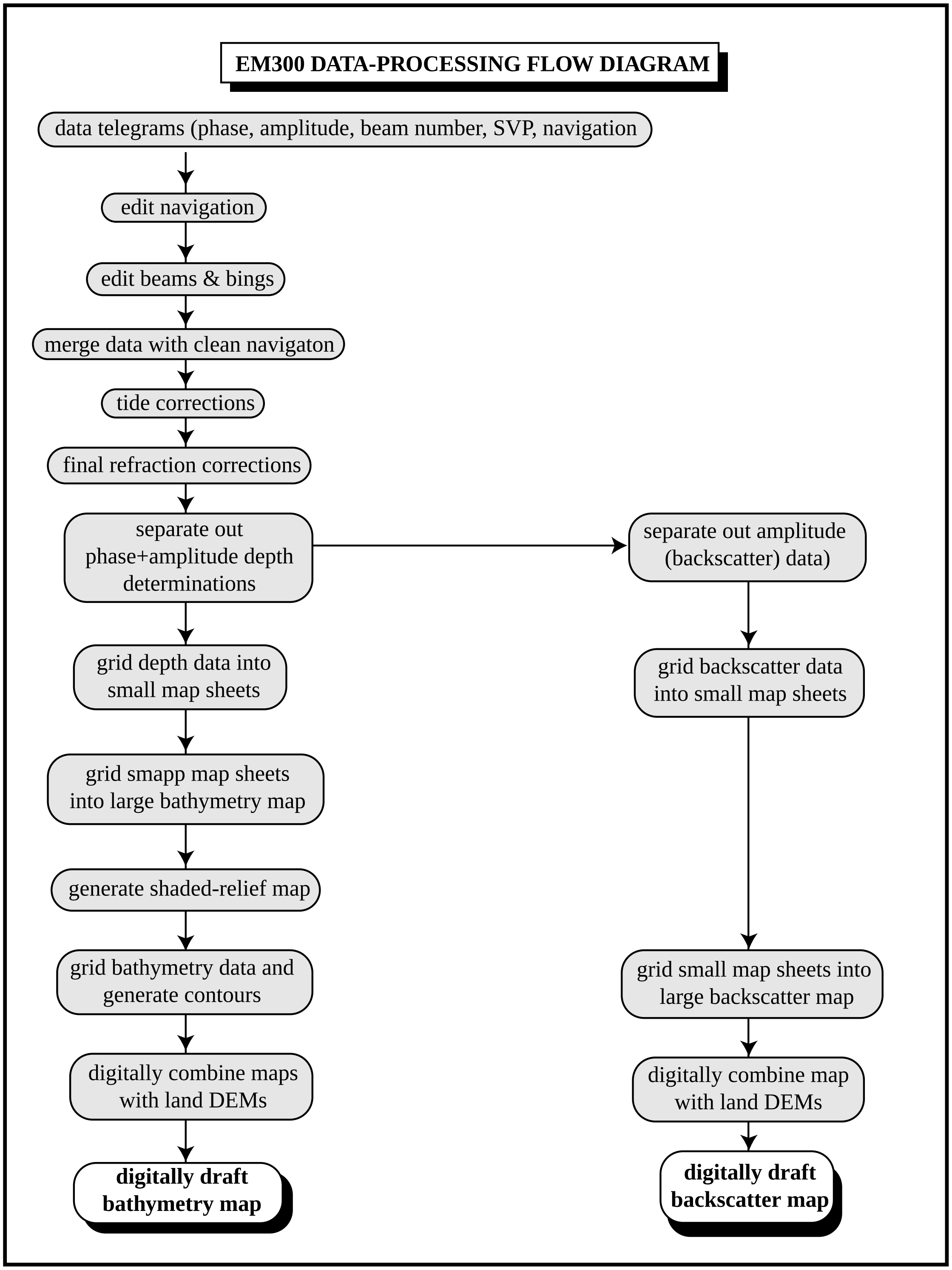

Figure 3. Processing flow diagram used to process the raw Simrad EM300 data telegrams.

The Maps

The large overview maps of backscatter and shaded relief that accompany this report were generated from large-scale subarea maps. The high-resolution subarea maps were regridded at the coarsest resoltuion of the subarea sheets within each area. This regridding reduces resolution in the shallower areas but allows the entire area to be mapped at a constant grid size. The detailed maps of each disposal site were produced at the maximum resolution allowable for the data. Both the backscatter and the bathymetry maps were gridded at the same scale for both the individual subarea (Appendix 2) and for the overview map.

The color-coded bathymetric charts represent the more traditional method of displaying bathymetry. The contours were derived from the gridded, tide-corrected depths. The resultant contours were smoothed by a 3-point running average in the overview maps, but are unsmoothed in the subarea maps. Even at the original contour grid, more than 90% of the data must be discarded so as to only show some chosen contour interval. A much better representation of bathymetry, using 100% of the data is a shaded-relief map.

A shaded-relief map (Fig. 4) is a pseudo-sun-illumination of a topographic surface using the Lambertian scattering law (equation 1), where B is the pseudo-sun brightness, I is the maximum brightness, and Φ is the angle between the pseudo sun and a normal to the bathymetric surface.

$$B = I(\cos \Phi) \qquad (1)$$

The backscatter map (Fig. 5) is a representation of the amount of acoustic energy, at 30 kHz, that is scattered back to the hull-mounted receiver. Backscatter can be thought of as albedo; that is, the actual reflectance of the seafloor to 30-kHz sound. The Simrad EM300 system has been calibrated at the factory (to an rms pressure referenced to 1 μPa at 1 m from the transmitter) and all gains, TVGs, etc. that are applied during signal generation and detection are recorded for each beam and removed from the backscatter amplitude value prior to recording. Consequently, the backscatter can be calibrated to an absolute

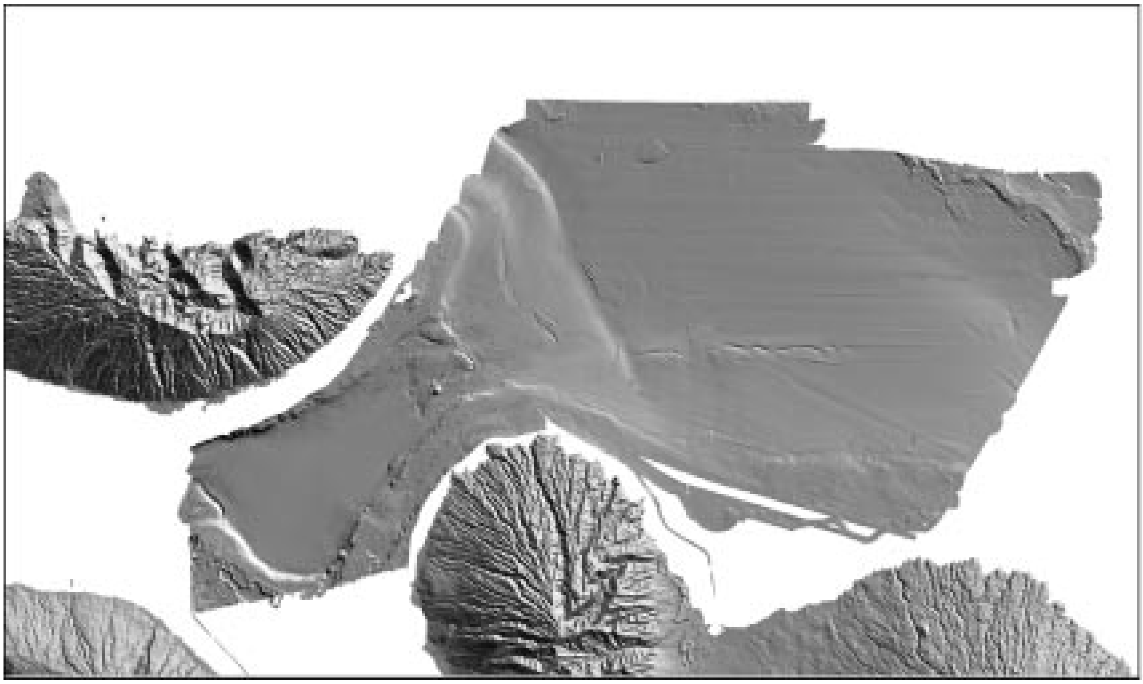

Figure 4. Preliminary, shipboard-produced shaded-relief map of north Maui and Maui Channel. Artifical sun is at azimuth of45˚ and an elevation of 45˚. The data were gridded at 20-m spatial resolution. The fuzzy dark stripes are the outer-beam artifacts shown in closeup in figure 6 and discussed in text. compart with Figure 5.

reflectance of the seabed . However, the amount of energy, measured in decibels (equation 2), where I_1 is the measured backscattered amplitude and I_2 is the reference pressure of 1, is some

$$dB= 10\log (I_1/I_2) \qquad (2)$$

complex function of constructional and destructional interference caused by the interaction of an acoustic wave with a volume of sediment (Gardner et al., 1991) or, in the case of hard rock, the seabed. The backscatter from the EM300 from a sedimented area represents volume reverberation to at least 10 cm subbottom depth caused by seabed and subsurface interface roughnesses above the Rayleigh criteria (a function of acoustic wave length), volume inhomogenieties larger than about half the wavelength (2.5 cm), the composition of the sediment, and its bulk properties (water content, bulk density, etc.). Although, it is not yet possible to determine a unique geological facies from the backscatter value, reasonable predictions can be made based on the local geology of the islands.

It can not be stressed too strongly that one of the great advantages of this survey is that the bathymetry is completely georeferenced with the backscatter. That means that each pixel on the map has a latitude, longitude, depth, and backscatter value assigned to it.

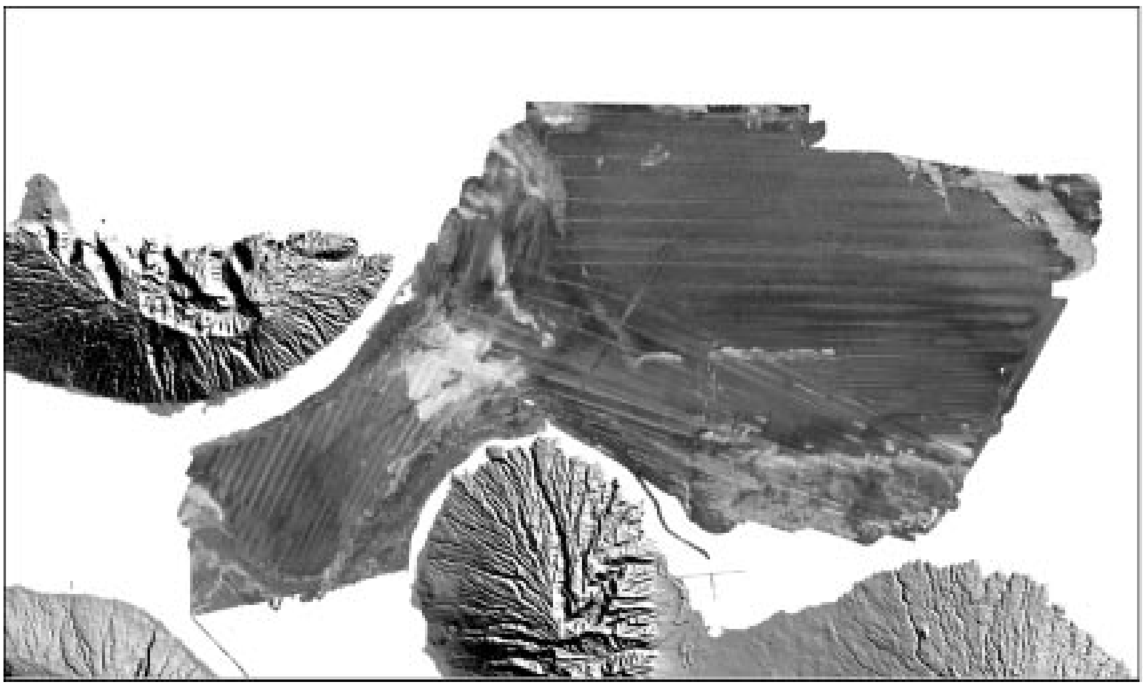

Figure 5. Preliminary, shipboard-produced backscatter map of north Maui and Maui Channel. Light areas represent high backscatter. The data were gridded at 20-m spatial resolution. The data holidays (gaps) were surveyed in the final version. Compare with Figure 4.

Cruise Daily Log

The following is a daily log of noteworthy events during the cruise. All times are local standard Hawaii time (GMT-10) and designated as “L”. The ship arrived in Honolulu on January 28. All computer equipment were loaded on January 28 and set up with the usual minor problems. All the computer networking, etc. were completed on January 29. Customs presented a problem because the ship is registered Canadian (considered foreign by US Customs), and the crew are Canadian and Philipino. The scientific staff included two Norwegian, several Canadian, and several US citizens. US Customs dictated that we could not depart until all souls were cleared; clearance was expected to take a day or two. In addition, we could not get a slot at the fuel dock until 1000 Friday January 30. However, we still had two major problems. Firstly, both engines on the starboard shaft (twin screws, variable pitch props) were down and the Chief Engineer could not determine the problem. Secondly, after being allowed to run some patch tests in Mamala Bay on January 29, it was determined that we have +50 dB noise from the ship. A series of noise tests, shutting down mechanical systems one by one, did not isolate the cause of the noise. The EM300 is only getting ~3 x water depth in 1500 m of water although the data look good. The C&C group continued to investigate the noise problem while we awaited our slot at the fuel dock. Some of the noise (~10 dB) was eliminated by properly grounding the UPS on the clean electrical circuit. The remaining noise (~37 dB) is suspected to be the result of the combination of the required pitch/rpm required to push us along at 8 to 10 kts. Mechanical noise, cavitation, and resonate beating of the two propellers are suspects.

Friday, January 30 (JD 30)

We completed fueling at 1700 L but the Simrad engineers encountered a potential problem with the transducer depth offset. We spent another 5 hours at the fuel dock testing depths with a lead line. Everything worked out to be a non problem and we departed the fuel dock at 2200L and began collecting data.

Survey Line 0 was designated as the southern-most line run during the patch test. Line 1 was a no-data line and Line 2 began at the eastern end of Line 0.

Saturday, January 31 (JD 31)

We ended Line 4 two-thirds the way along the line at ~0830L so that we could run a squat test (the change in ship draft versus ship speed) during daylight while Mike Field was stationed on Diamond Head with the differential GPS reference station. We were back to running survey lines at 1300L with three engines on line.

There continued to be lots of vexing Simrad problems involving yaw corrections, some strange motion artifact, and a one-ping delay between the depth information in the data telegram and the backscatter information. This last artifact shows in the data as a series of track-normal noise stripes. The Simrad personnel are trying to track the problem.

Sunday, February 1 (JD 32)

The Pearl Harbor Port Authorities would not allow us to go inside the restricted zone of submarine buoys so the area west of the harbor entrance was not surveyed. However, we did get permission to survey the Honolulu harbor entrance restricted zone. Bugs continued to show up in the Simrad software but the Simrad folks and JHC continued to run them down and fix them. Our survey speed settled down to about 9.5 kts but the swath width was less than advertised or hoped for.

This day was spent surveying the shallowest area off south Oahu so that obstacles (coral reefs, small sail boats, jet skiers, swimmers, etc.) could be seen in daylight and avoided.

Monday, February 2 (JD 33)

Routine day of surveying the east Oahu margin. We also ran two survey-normal lines for system calibration and also to see what ranges and modes were appropriate for deep water. We got to 3200 m water depth and were getting 4500-m swath in the very-deep mode. We determined that in water depths <50 m we should run in very shallow mode, at 50 to 200 m we should be in shallow mode, at 200 to 700 m we should be in medium mode, 700 to 2200 m we should be in the deep mode, and at depths > 2200 m we should be in the very deep mode (Table 4).

Tuesday, February 3 (JD 34)

We completed the survey of the east slope of Oahu then moved back to the south slope to fill in small holes. Also, it was discovered that the Simrad data telegrams got scrambled at times where one telegram would have the correct depth information but would contain the previous telegram's amplitude data. The scrambling appears to occur when the system goes into very shallow water (<50) and then back into deeper water. It turned out that all of our Gulf of Mexico shallow-water areas and our shallow-water south Oahu data have the problem of mismatched datagrams. Pablo Mejir (of C&C Technologies, Inc.) successfully wrote some software to unscramble the data telegrams and no data were lost.

We spent most of the day running a tighter grid of survey lines over the south Oahu ocean disposal site so as to have the best possible survey for the USCOE and USEPA. We then finished up the day running lines along our southern boundary.

Wednesday, February 4 (JD 35)

We completed the Oahu survey at 0900L and transited to a point outside Honolulu harbor. A water taxi arrived at 1000L to take off James Chance, John Hughes-Clarke, and Mike Torresan and bring aboard Luciano Fonseca (an OMG graduate studentFinally, at 1300L we cleared US Customs and departed the Oahu area. Weran a westward line towards deep water and Kauai. Once around Barbers Point, the southwest end of Oahu we hit 15-ft swells and 30 kt northwesterly winds. The wind and swell slowed us down because we had to head directly into them. We made a dogleg track so that the remaining Simrad engineer could determine how deep the EM300 would produce usable data. Certainly, at 3500 m we were still getting reasonable data but by 4000 m the data were pretty dirty.

We arrived at the beginning of the Kauai survey at 2300L and immediately began to collect excellent-quality data. The swell was modest and the winds died down to <20 kts.

Thursday, February 5 (JD 36)

We surveyed the Kauai area and halved the line spacing over the two Kauai ocean dump sites. We spent considerably more time on the Kauai survey because we had to put off the remaining Simrad engineer at Port Allen at 1000L on Friday. We spent the day completing the planned survey, filling in data gaps, and then extended the survey to the south because we had already surveyed the reef front in shallow water.

It appears that in the deep-water mode the TVG for the amplitude data is somehow different than in the medium mode. We see the mean level of the backscatter (mean DN) is lower in the deep-water mode than in the medium mode. This can be corrected during post-cruise processing.

Friday, February 6 (JD 37)

The Kauai survey was completed at 0900L so that the Simrad engineer could disembark by the work boat to Port Allen. The work boat was back aboard by 1030L . However, we were warned that the Pacific Missile Range was conducting naval operations with surface missile launches and the direct passage to the northern slope of Niihau, our next survey area was restricted. Consequently, we were forced to transit south of Niihau and begin the Niihau survey on the southwest corner of the island. We steamed at full speed, rather than survey speed, to make up for the added distance of our new transit. We begain the Niihau survey at 1330L The Niihau survey was run for Monterey Bay Aquarium Research Institute (MBARI) in exchange for them running the USGS Hilo survey. The exchange saved both groups about 36 hours of non-productive transiting between the island chain.

Saturday, February 7 (JD 38)

The Niihau survey continued throughout the day. The EM300 was able to collect excellent-quality data (i.e. good bottom detect) in 4200 m but it must be emphasized that sea conditions were calm and the bottom was highly reflective (<-20 dB). The Niihau survey was completed at 2330L and we commenced our eastward transit to Maui. The transit lines were layed out so that they added a south line to our existing surveys at Kauai and Oahu. An additional line was collected for MBARI between Niihau and Kauai

Sunday, February 8 (JD 39)

We transited all day, making our way to the northwest Maui area. We positioned a transit line along the north side of Molokai to establish a base line for the MBARI survey in this area. After we completed the baseline, we continued to the northwest Maui area.

Monday, February 9 (JD 40)

We arrived in the north Maui area and began the survey at 0130L, running the shallow lines first, then working out into deeper water. The day was routine with the only surprises being large pods of whales flopping all over the sea surface. It was quite a sight. We had a slight problem with the Simrad system not accepting the sound velocity data. The consequences were that the system did not automatically ray trace the individual beams. Luckily, my OMG processing software allows for this problem and I was able to correct the problem. I then went back over the data collected to date and discovered the problem had persisted throughout the cruise. Consequently, I looked at the data from the previous surveys and found the same problem with the Oahu data so I reprocessed the Oahu data set and backed up the new data on the magneto-optical archive disk.

Tuesday, February 10 (JD 41)

We broke off our survey line at 0930L to steam to the buoy off Kahalui, Maui to change out L. Fonseca and bring aboard H. Tianhang. The purpose of taking the time to do this changeout was to give the graduate students at the Ocean Mapping Group valuable experience at sea with a high-resolution multibeam mapping system. We anticipated the changeout taking only one hour. However, because we were required by U.S. Customs to provide additional documentation for clearence, we did not leave until 1400 L. We continued surveying the north Maui area throughout the day without further incident.

At 2055 L the Simrad EM300 stopped pinging. No warning, it just stopped. The system was rebooted and came right back up by 2125 L. The cause of the crash remains unknown. Refraction has become a big problem in the region north of Maui. The Sea Bird CTD and frequent XBT drops allows the Simrad software to correct for refraction for awhile, but then, within a mile or so, severe refraction creeps back into the data. This problem will have to be corrected during post-cruise reprocessing.

Wednesday, February 11 (JD 42)

Refraction in the north Maui area continued to plague the data and it will require a major effort in post-cruise processing to fix each ping. A problem cropped up early in the morning with the battery charger in the Simrad transducers. The battery has been drained, possibly from a short or from a bad UPS. Art Kleiner reset the UPS and everything appears to check out fine. Simrad was called and offered no suggestions.

The cable of the Sea Bird CTD winch got all twisted and caused an hour delay while it was untwisted and reterminated. There is a continuing problem with the Simrad rejecting the Sea Bird CTD data but it is accepting XBT data. The effect is to not automatically compensate for acoustic refraction but my OMG software is handling it.

A major problem surfaced today with the Simrad EM300. The outer yaw-steering sectors on both sides appears to not be performing correctly. The bathymetry in the outer beams has a 2 to 5-m shift across both outer sectors (port and starboard) relative to the middle sectors (arrows in Fig. 6). The shaded-relief images show dramatically show the artifact. The C&C programmers are puzzling over the potential causes.

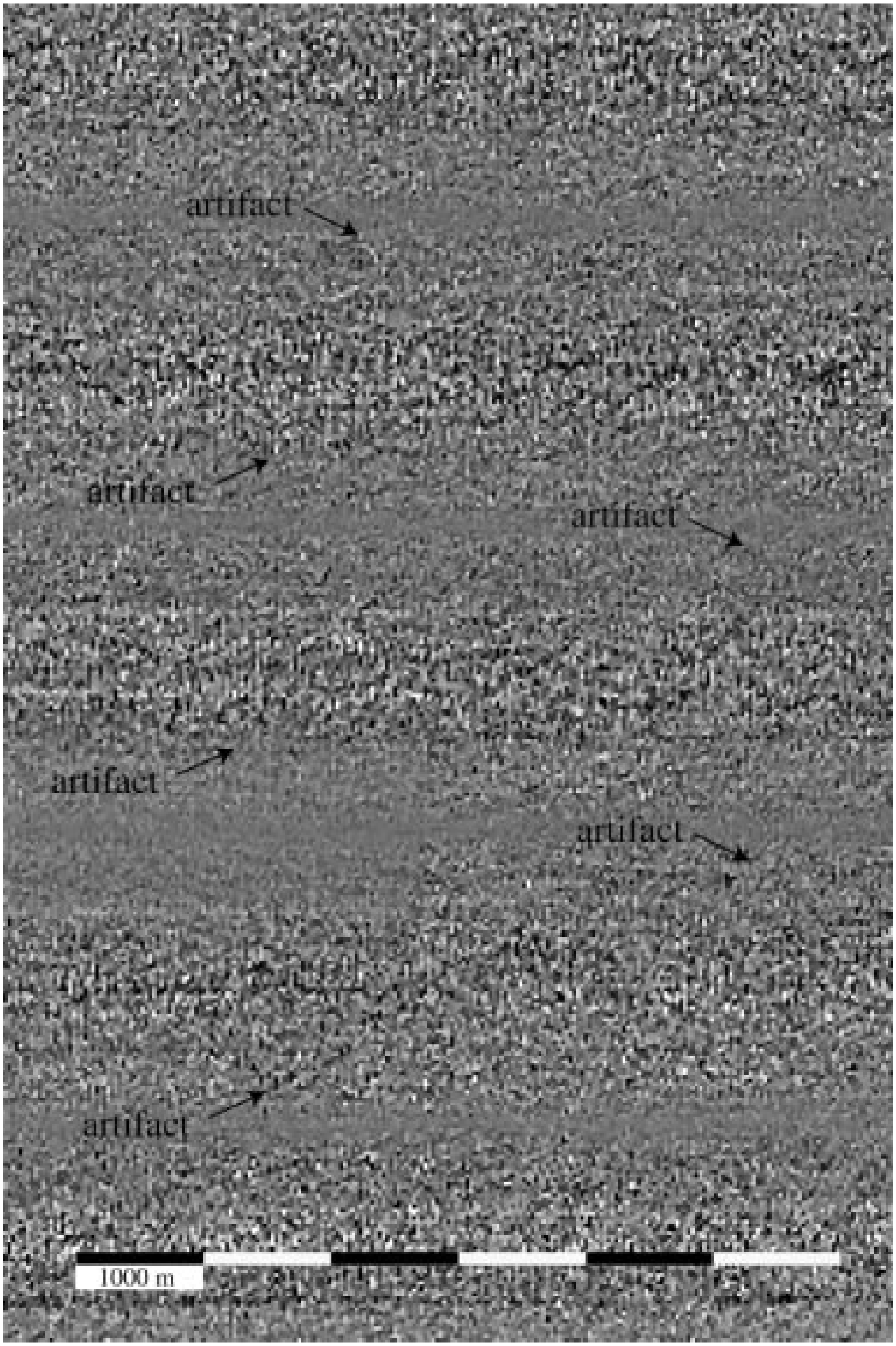

Figure 6. Close-up view of shaded-relief image showing depth artifacts created by the outer-beam sectors not correctly compensating for ship yaw.

Thursday, February 12 (JD 43)

The outer-sector problem persists. All of the north Maui area deeper than about 200 m shows the strong depth offset. At the suggestion of John Hughes-Clarke, we turned the power to the Simrad system off, then back on, and then rebooted. This may solve the problems we were having with the bad yaw-stearing sectors. The entire north Maui dataset will have to be reprocessed with a sector fix. We completed the north Maui area at 1100L but did not go back to resurvey the area with the bad sector steering. We immediately commenced to map the Maui Channel area.

The problem with the battery backup for the Simrad system continues to plague us. The battery is at the verge of being completely discharged, thereby giving us no emergency power for an orderly shutdown should the ship's power go out. In addition, the water column appears to be changing rapidly, causing a lot of problems with refraction corrections. We are taking several XBTs each day but are now running low on XBTs. We have enough for only three launches a day until the end of the cruise.

Friday, February 13 (JD 44)

Awoke this morning to the biggest crisis yet. The galley has run out of coffee filters, so they stopped making coffee! We showed them how to use paper towels for filters until we can get an emergency supply in Honolulu on the 15th at the Chief Mate exchange. We continued to have the problem with the outer beams of the DTM files giving a 1 to 3 m height offset (Fig. 6). No resolution yet.

Saturday, February 14 (JD 45)

Today we got a phone call from the Coast Guard relaying a public inquiry from citizens on Maui with regard to the nature and possible impacts of our survey, especially concerning the safety of whales, distance restriction from whales, and dumping sewage and garbage. I called the Coast Guard and provided them with an explanation of our mission, which apparently satisfied the public concerns. We received another call from the Coast Guard an hour after the first one asking additional questions about what we were doing and our conversation satisfied them that we were OK. They inquired about why there was no Notice to Mariners about our operations and I informed them that C&C had contacted the Coast Guard in Honolulu and spoke to a Mr. Dick Spears. Mr. Spears was given the dates, type of operations, the ship, etc. and he elected not to place the information in Notice to Mariners. That explanation also satisfied the Coast Guard.

We completed the Maui Channel (Poilolo Channel) at 2200L. We transited through the Lanai area (Auau Channel) and commenced mapping at 2330L the Kahoolawe area (Kealaikahiki Channel).

Sunday, February 15 (JD 46)

We broke off mapping in the Kahoolawe area at 0600L to transit to Honolulu for the exchange of Chief Mates. While on the transit to Honolulu I received a phone call from a Mr. Honda of the NMFS. He inquired as to whether we had specific permission to operate in the Humpback Whale National Marine SanctuaryI suggested he contact Mr. Allen Tom of the NOAA National Marine Sanctuary Program, Kihea, Maui. I had informed Mr. Tom in Nov. ‘97 of our cruise and he was enthusiastic about our objectives. I also informed Mr. Honda of my visit to Silver Springs where I informed all the NOAA Sanctuary people of our intent to map the Hawaiian sanctuaries. He said he would "get back to me before 1500L

At 1400L I received a conference phone call from the Coast Guard, Kihea that included Allen Tom (NOAA Office of Marine Sanctuaries), Gene Nita (NMFS), Dick Honda (NMFS), and Emily Gardner (State of Hawaii). They asked questions concerning towing, power, power dropoff, and frequency. Finally Ms Gardner asked if it was possible for the ship to alter course if we came within 100 yds of a whale. Evidently, we were surveying during the prime whale-mating season. In addition, she was worried about small cetaceans and dolphins. I gave a standing order to the Captain (who was in the ship's office with me during the call) that the ship was to alter course at any time so as to stay at least 100 yds away from any whale or small cetacean. All those on the conference call heard my order and it seemed to satisfy them. After a 20 minute conversation, I received permission from them to continue our survey.

We did not get back to the survey line until 1800L. We commenced to map in the Kahoolawe area and immediately saw the yaw-steering sector artifact in the C&C display. We were now convinced there is a problem with the yaw-steering sectors. The artifact occurs whether or not we have yaw steering activated or off.

Monday, February 16 (JD 47)

We continued to map in the Kahoolawe area. The outer-sector problem continued to perplex us, Simrad in Norway, and C&C in Lafayette. Email and faxes have been passed back and forth, but no apparent solution has been suggested. At 1000L we hove to and ran an exhaustive noise test on the ship. We powered down everything except the emergency generator (still have >45 dB vs the ~37 dB we measured off Oahu during our Oahu trials under similar conditions, then turned off the emergency generator and went on one generator (still at >45 dB), etc.

A circuit board fried in the Simrad system when it was powered back up. The Simrad ethernet connection is not operating so that there is no communications between the Simrad system and the data-acquisition system. Consequently, we could not collect data. This posed a major dilemma; C&C do not carry spares because of the expense. By 1400L the C&C boys located a breaker that had tripped off when we powered the ship down for the noise test. When the breaker was reset, the Simrad system came right back up. We were back on line and collecting data by 1430L.

I discovered, while trying to clean up some data stored on my backup MO drive, that my MO drive can not read directories and files off of the MO disks. I fear it is because of the dirty non-filtered air that is being pumped into the lab. All the computers and keyboards are covered with black soot, apparently because outside air is being piped directly into the lab. This has left me with only two backups; the Exabyte and the DLT, both of which take several hours to backup files.

Tuesday, February 17 (JD 48)

We continued to survey the area north of Kahoolawe and we still have the outer-sector artifact problem. Nothing eventful occurred all day.

Wednesday, February 18 (JD 49)

We continued to survey the area north of Kahoolawe and we still have the outer-sector artifact problem. Simrad engineers in Oslo contacted us and have determined that one of the pc boards in the yaw-sector beam forming might be defective. They will send a replacement to Honolulu.

Thursday, February 19 (JD 50)

Today was our first day of overcast skies. The sun didn't really come out until well into the afternoon. Winds were light and the sea was calm. We continued to survey the area north of Kahoolawe between Lanai and Maui. The area is shallow (<100 m) and has taken ~36 hr more to map than anticipated. However, the effort was well worth the time expended because the maps are spectacular. Several platform reefs, numerous pinnicle reefs, terraces and fields of patch reefs are clearly evident.

We were continued to be puzzled by the strange outer-sector artifact. The C&C display, contoured at 0.1 m (showing color-coded raw data) does not show much of anything one would call an artifact. The outer beams are a little shabby, but there is no mismatch, depth offset, or linear trend. However, I see the artifact in the *processed* shaded-relief and contour data. Two facts we know: (1) the Simrad engineer Kjell Nilsen decreased the outer-sectors TVGs just as he departed the ship after mapping Kauai; and (2) our artifacts showed up the first surveyed flat area (north Maui) after Kjell left the ship. It's hard to determine anything from the Niihau and Kauai surveys because nothing is flat in those areas.

It could be that the *EM300_Beam_Weight_Mask* file that gets used by the -*custom_weight)* flag of the *weigh_grid* program in the JHC software needs to be adjusted for the new TVGs that Kjell tuned in? Might this be why we see the artifact and the C&C boys don't? When I contour a flat area at 3-m contour interval I see the artifact in the contours, yet the C&C display does not see it at 0.5 m contour interval. However, C&C does not process the data, but rather, they simply take a mean value for each beam and grid that value. This method effectively smoothes the variance and this probably explains why I see the artifact and they do not.

Friday, February 20 (JD 51)

Another cloudy day but calm seas. The Kahoolawe area was finally completed at 0330L. We were immediately poised to begin the Lanai area, a vast stretch of area between the islands of Lanai and Maui all less than 100-m deep.

Saturday, February 21 (JD 52)

The winds in Auau Channel were 30+ kts throughout the morning and picked up to 35 kts in the afternoon, causing a local chop that made things uncomfortable for awhile. The mapping was unaffected by the ship motion. The winds continued all day and into the night.

The Captain and/or Chief Engineer were adjusting ballast this afternoon and evidently did something unusual because we suddenly acquired a ~10° list. When I inquired about the list, I was told we didn’t have the appropriate ballast for our light fuel load.

Sunday, February 22 (JD 53)

The winds in Auau Channel increased during the night and by day break were sustained at 50 kts and gusting to 70 kts. Evidently, some local disturbance created all this wind although the National Weather Service forcast only 25-kt winds. The ship is very light on fuel and the winds heal us over >15° when on our beam. We changed the orientation of our survey lines from NNW-SSE to more N-S so that we would be either heading directly into the wind or have it on our stern. This made the ride more comfortable and kept us from rolling too much. The data continue to be good.

In the early afternoon the Captain and Chief Engineer began to be disturbed by our lack of ballast on the starboard side because of low fuel load. By late afternoon they voiced concern about running out of fuel before we could complete our survey. After dinner the Captain summonsed Art Kleiner to his cabin and informed him that we would have to head for Honolulu at 2100L because of his concern for lack of fuel, ballast, and the heavy seas between Molokai and Oahu. The Captain terminated the survey at 2100L. We did not complete the Auau Channel survey during this cruise (although C&C Technologies appreciated the problem and completed the survey in mid March at no additional cost). We ran a line north to the lee side of Molokai, then proceeded collecting data along the south coast of the island and then plowed our way to Honolulu.

Monday, February 23 (JD 54)

We arrived at the Honolulu buoy at 0130L (instead of the planned 1000L) and waited until the pilot arrived at 0800L and tied up to the fuel dock by 0900L. A summary of the cruse statistics is shown in Tables 4 and 5.

Table 4. Time spent on each survey area

Oahu	1/321 to 2/4/0900L	3.5 days
Kauai	2/4 2300L to 2/6 0900L	1.4 days
Niihau	2/6/1330L to 2/7 2330L	1.5 days[1]
North Maui	2/9 0300L to 2/12 1100L	3.2 days[2]
Maui Channel	2/12 1100L to 2/14 2200L	2.5 days
Kahoolawe	2/14 2330L to 2/20 0330L	4.5 days[3]
Lanai	2/20 0330L to 2/22 2100L	2.7 days

[1] Surveyed for MBARI in trade for them surveying NE Hawaii (Hilo) area to save transits

[2] Does not include 4.5 hr transferring people at Kahului, Maui

[3] Does not include 12 hr exchanging Chief Mates in Honolulu

Table 5. Cruise statistics

Average speed	10.3 kts
total line kms	5800 km
total area mapped	2800 km^2
days at sea	22.5.days
days mapping	19.3 days
patch test	1 day
transits	2.2 days

References Cited

Gardner, J.V., Field, M.E., Lee. H., Edwards, B.E., Masson, D.G., Kenyon, N., and Kidd, R.B., 1991 Ground truthing 6.5-kHz sidescan sonographs: What are we really imaging?. J. Geophys. Res., v.96, p. 5955-5974.

Hughes Clarke, J.E., Mayer, L.A., and Wells, D.E., 1996, Shallow-water imaging multibeam somars: A new tool for investigating seafloor processes in the coastal zone and on the continental shelf. Marine Geophysical Researches, 18: 607-629.

Appendix 1. Details of Simrad EM300

RX
sample rate: 4509 Hz
Bandwidth: 5000 Hz
Demod. frequency: 32565 Hz

TX
Power reduction 10 dB, 20 dB

Mode-dependent parameters:

Parameter/Mode	Very Deep	Deep	Medium	Shallow	Very Shallow
Depth Range	1000-5000 m	500-3000 m	100-1000 m	30-300 m	5-50 m
Pulse length	5 MS	5 MS	2MS	0.7 MS	0.7 MS
Delay between TX pulses	24 samples 5.32ms	24samples 5.32 ms	12 samples 2.66 ms	5 samples 1.11 ms	5samples 1.11 ms
TX pulses TX frequency beam angle (positive angles to port)	31 44° 1 32.5 31.5° 3 34 20.5° 5 32 -10° 7 33.5 0° 9 30.5 -10° 8 33 20.5° 4 31.5 -31.5° 4 30 -44° 2	31 69° 1 32.5 48° 3 34 33° 5 32 17° 7 33.5 0° 9 30.5 -17° 8 33 -33° 6 31.5 -38 4 30 -69° 2	31.5 60° 1 33 0° 3 30 -60° 2	31.5 60° 1 33 0° 3 30 -60° 2	31.5 60° 1 33 0° 3 30 -60° 2
Estimated max SL	240/234 dB (1°/2° beam)	238/232 dB (1°/2° beam)	230/dB (2°beam)	224 dB (2° beam)	
RX/TX Beamwidth	1° or 2°	1° or 2°	1° or 2°	2°	4°
Manually selected RX sector width	98°, 80°, 64°	150°, 140°, 128°, 114°, 98°, 80°, 64°	150°, 140°, 128°, 114°, 98°, 80°, 64°	150°, 140°, 128°, 114°, 98°, 80°, 64°	150°, 140°, 128°, 114°, 98°, 80°, 64°
BSP bandwidth (for beams close to normal incidence)	200 Hz (350 Hz)	200 Hz (350 Hz)	550 Hz (1000 Hz)	1000Hz	1000 Hz
RX beams	135	135	135	111	111

OUTPUT SAMPLE RATE	563 HZ	1127 HZ	2254 HZ	4509 HZ	4509 HZ

Appendix 2. Grid sizes for subarea sheets and overview maps for each survey area.

area	subarea sheet	grid size	overview map
Hawaii	area 1	30	30
Kahoolawe	area1	5	20
	area2	10	
	area3	20	
Kauai			20
	area0	10	
	area1	10	
	area2	5	
	area3	10	
	area4	20	
	area5	20	
	area6	20	
Lanai	area0	5	
Maui			20
	area0	4	
	area1	10	
	area2	20	
	area3	10	
	area4	20	
	area5	10	
	area6	4	
	area7	20	
	area8	20	
Maui Channel			30
	area0	10	
	area1	10	
Oahu			30
	area0	5	
	area1	5	
	area2	5	
	area3	5	
	area4	5	
	area5	5	
	area6	5	