NOAA *Okeanos Explorer* Program

MAPPING DATA REPORT

CRUISE EX0801

Mapping Shake Down 2008

September 8 -26, 2008
Seattle, WA – Seattle, WA

Report Contributors:
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Date of Report: 30 March 2011

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1. Introduction

The *Okeanos Explorer* Program

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

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

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

Okeanos Explorer Management – a unique partnership within NOAA

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

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2. Report Purpose

NOAA ship *Okeanos Explorer* (EX) is the new ocean going vessel being upgraded by NOAA for ocean exploration mission. The ship has been outfitted with several state of the art sensors including multibeam sonar (EM 302 30 kHz), sub-bottom profiler (Knudsen 3.5 kHz) and single beam echo sounder (12 kHz).

This cruise was the first of the series of the cruises to test and validate performance of the newly installed multibeam sonar. During this cruise, Sea Acceptance Test (SAT) for the EM 302 multibeam sonar and EA 600 single beam echo sounder were carried out and the systems were successfully accepted by NOAA.

Please note that due to some unforeseen circumstances, this report was not generated at the time of the cruise. The reports generated by Kongsberg along with input from the ship's mapping staff was considered sufficient at that time (attached as Appendices C and D). However, later it was realized that the data collected during the cruise are useful for other line offices and hence a need for a descriptive report.

3. Cruise Objectives

The main objectives for the mapping shakedown cruise included:

1. Conduct Sea Acceptance Test (SAT) for acceptance of multibeam sonar.
2. Test and validate the correct installation of the mapping and ancillary sensors.
3. Test and validate the data acquisition capabilities.
4. Test and establish a detailed data management system including data processing pipelines.

5. Identify any shortcomings in the suite of hardware and software that are key to the success of the EX mission.

The secondary objectives of the cruise included:

1. Conduct 3-4 days of multibeam survey over a previously surveyed region (with a multibeam) to validate multibeam sonar performance against pre-existing multibeam data.
2. Train the ship staff in operation of EM 302.

4. Participating Personnel

NAME	ROLE	AFFILIATION
CDR Joseph Pica	Commanding Officer	NOAA Corps
LT Jeremy Weirich	Field Operations Officer	NOAA Corps
Mashkoor Malik	Mapping Team Lead	NOAA OER (ERT Inc.)
Elaine Stuart	Senior Survey Technician	NOAA OMAO
Colleen Peters	Senior Survey Technician	NOAA OMAO
Webb Pinner	Telepresence Team Lead	NOAA OER
P.Scott Hill	NCDDC representative	NOAA NCDDC
John Katebini	SCS Engineer	NOAA OMAO
Tom Stepka	SCS Engineer	NOAA OMAO
Kjell Nilson	EM 302 Engineer	Kongsberg, Inc
Chuck Hohing	EM 302 Engineer	Kongsberg, Inc
Grant Froelich	Mapping Physical Scientist	NOAA PHB

5. Data Acquisition Summary

As noted above, the primary goals were to test and validate performance of the EM 302 multibeam sonar. Kongsberg engineers (Kjell Nilson and Chuck Hohing) participated in the cruise.

The cruise was divided into two legs. Leg I (Sept 8 – 14, 2008) concentrated on conducting shallow and deep water patch test and allowed time for Kongsberg engineers to tweak the hardware and software for optimal performance. A brief deep water survey was conducted towards end of the leg to ensure that the system performance is acceptable. At the end of Leg I the ship anchored in Port Angeles, WA and Kongsberg engineers and other support staff were transferred to shore using one of the ship's small boats.

Leg II (Sept 14-26, 2008) consisted of collecting additional data in deep water and concentrated on providing opportunity for the ship's staff to learn about the system operations. Development and testing of mapping operation protocols, implementation of data processing pipelines, development of SOPs for multibeam operation, data acquisition, data processing and product generation etc were attempted. During last two weeks of the cruise, the mapping operations comprised of tests for different exploration mapping models i.e. stick (transits) and box models (survey areas) were completed. The areas mapped included an uncharted (but known – it shows up in ETOPO II data) underwater volcano site (near Brown Bear Seamount; ~ 2000 m depth; 129.45 W 46.38 N) and Juan deFuca Canyon (140-800 m depth) located in Olympic National Marine Sanctuary. Also wreck of USS Bugara was successfully mapped confirming high resolution capability of EX MBES.

Daily activities and data analysis are provided in the daily logs section. Reports from Scott Hill and Grant Froelich provided trip reports that are included as appendices A and B respectively. Appendices C and D provide the SAT report generated by Kongsberg for EM 302 and EA 600 respectively.

Some of the data collected during this cruise fell between '46°N latitude and the Canadian border' and therefore was subject to security classification (NOAA-1-89 dated Nov 1, 1989). Additional restriction were placed on the distribution of the data, however, in November 2008 NOAA received a notification lifting the High Resolution Bathymetry (HRB) restriction. The notification is attached as Appendix E.

The patch test results are summarized as below:

	Roll	Pitch	Heading
TX Transducer	0.0	0.0	359.98
RX Transducer	0.0	0.0	0.03
Attitude	0	-0.7	0.0

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

The area of operation is shown in figure 1.

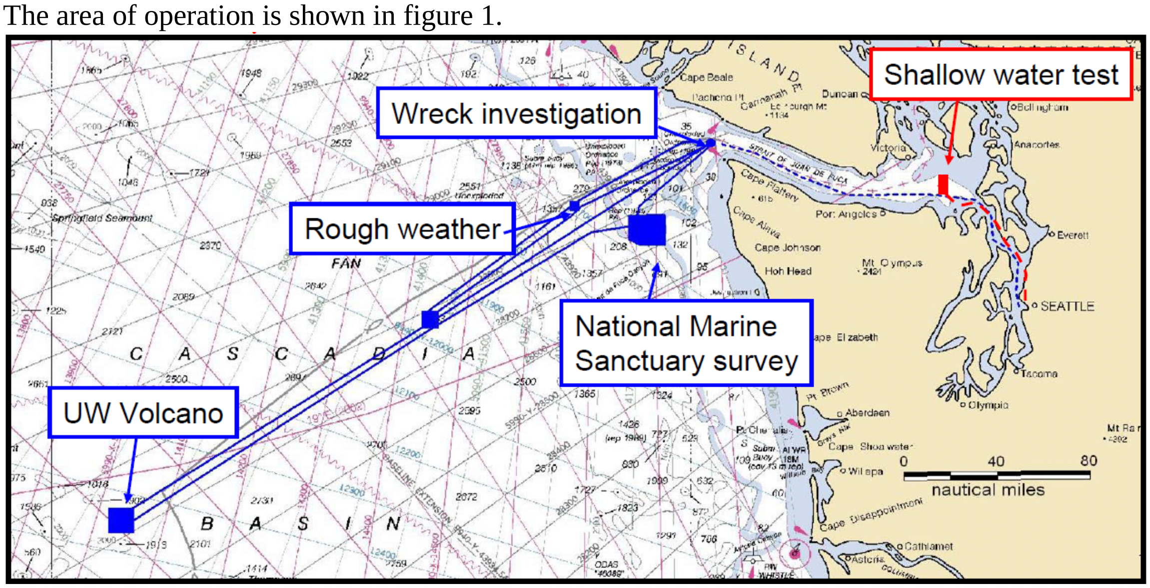


Figure 1: Areas of operation during EX0801 mapping shakedown cruise.

6. Cruise Statistics:

Project	No. of lines	No. of Profiles	No. of soundings	Total length (km)
Transit	186	228982	98510256	1427.6
Brown Bear FM Mode	10	5116	2210112	97.5
Brown Bear CW Mode	7	5514	2382048	79.5
OCNMS	87	404978	174950496	727.4
Grand Total	**290**	**644590**	**278052912**	**2331.9**

Table 2: Statistics of the cruise

7. Cruise Calendar

September, 2008						
Mon	**Tue**	**Wed**	**Thu**	**Fri**	**Sat**	**Sun**
8 Departure XBT and CTD comparison EM 302 setup System offset validation Shallow water roll calibration	9 Lost operations time due to ship's UPS failure Shallow water pitch calibration (Unexpected high pitch value encountered 4°) UPS failure again	10 Kongsberg engineers tweaking the software	11 Conducted deep water pitch calibration. Found pitch offset of 0.7° Time calibration conducted POS came online. Hooked POS directly to TRU for FM mode operations	12 Deep sea survey in water depth of < 2000 m Comparison of data in different line directions	13 Anchor at Port Angeles. Personnel Transfer	14 Commenced deep water testing operations
15 SIS training Emergency drills Continue transit towards Brown Bear Seamount	16 Commenced Brown Bear seamount reference survey. Collected data both in CW and FM mode	17 Commenced transit to OCNMS	18 Commenced data collection in OCNMS	19 CTD / XBT comparison. Found within 1 m/s	20 Changed survey line plan to run EW to reduce ship roll	21 Continue collecting data in OCNMS area
22 Run survey lines to cover data holidays Commence survey over USS Bugara	23 Mapping staff training Continue transit back towards Seattle, WA	24 Mapping staff training	25 Mapping Staff training	26 Arrived back to Seattle, WA	27	

8. Daily Cruise Log (ALL TIMES LOCAL HST)

September 8, 2008

0900 Departed sand point
1330 MB testing in progress preparing for CTD and XBT cast. CTD and XBT cast agree with in 1 m/s all depths.

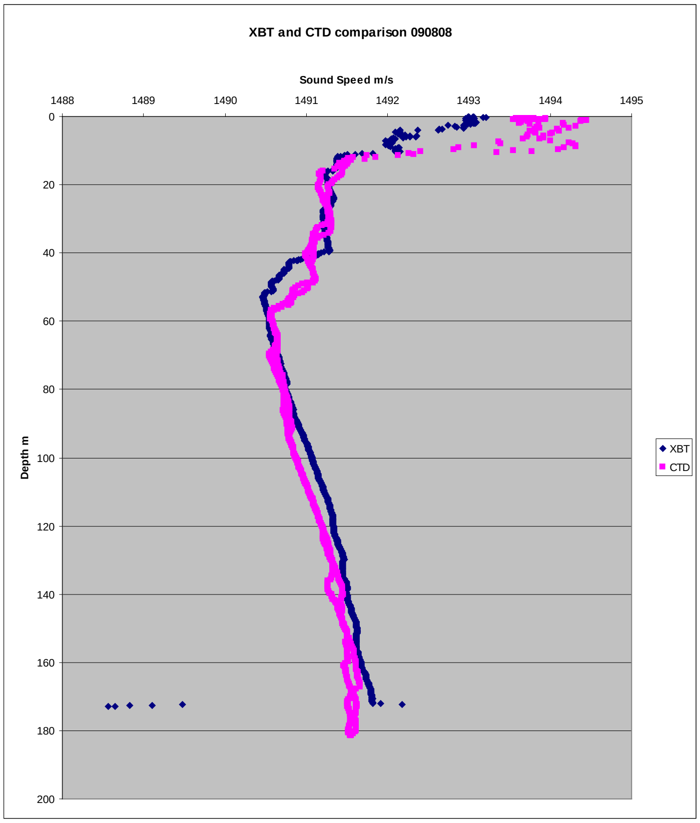


Figure 2. Graph of CTD to XBT comparison cast.

2100 Running Roll cal in harbor. Gridded data at 0.5 m resolution and still there are no significant data gaps. Roll calibration was tested against HIPS calibration tool and both the results provided 0 deg roll offsets. The lines used for Roll calibration were:

000_20080909_015016_ShipName.all
001_20080909_022646_ShipName.all

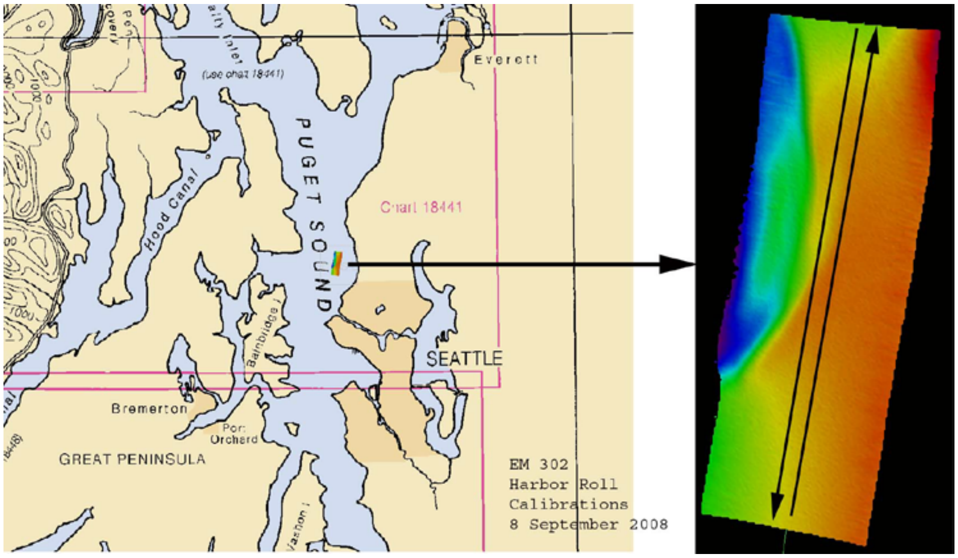


Figure 3. Screen grab taken in CARIS of gridded MBES data collected for roll calibration.

The calibrations results showed negligible offsets. Below is the figure for the HIPS calibration utility.

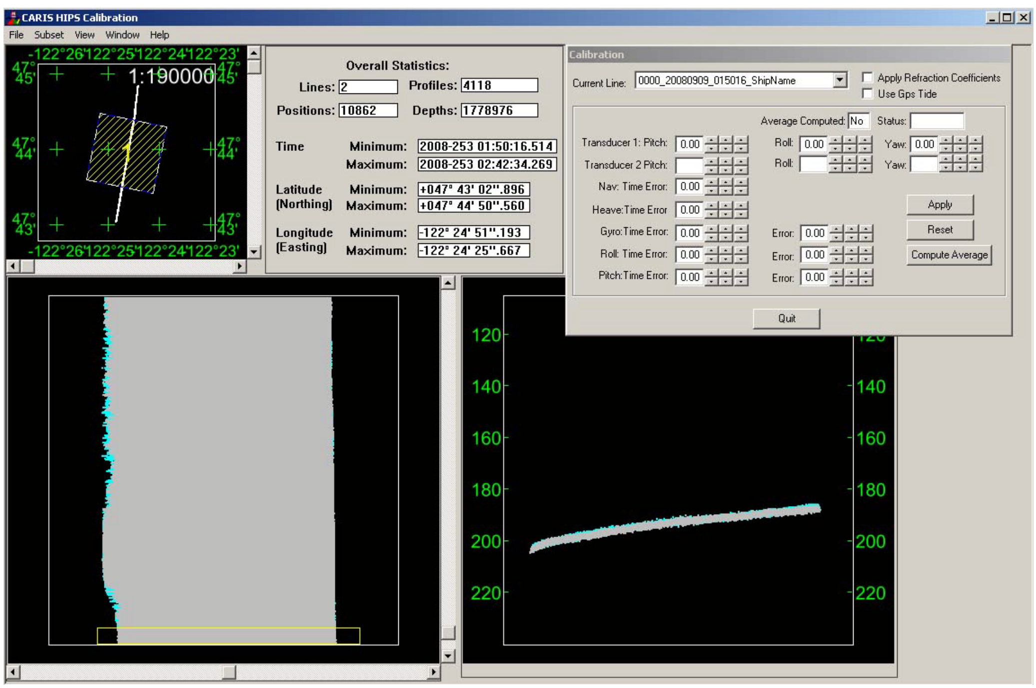


Figure 4. Screen grab of CARIS Calibration utility showing zero roll offset.

2300 Power failure. UPS alarm going on informed bridge.

September 9, 2008

0800 Lab equipment was secured last night as load balancing is conducted by ship ETs

1600 Ship ET staff is still working on the power issues

1700 Started surveying again with pitch calibration being run at the slope.

Line used for pitch calibration were
002_20080910_004230_Okeanos_Explorer.all
003_20080910_010730_Okeanos_Explorer.all

The results showed that there is a Pitch offset of -4 deg. After consultation with Simrad engineers it was decided that this pitch offset is more than expected and we should check again our sensor configuration including POS MV, C-NAV and EM 302.

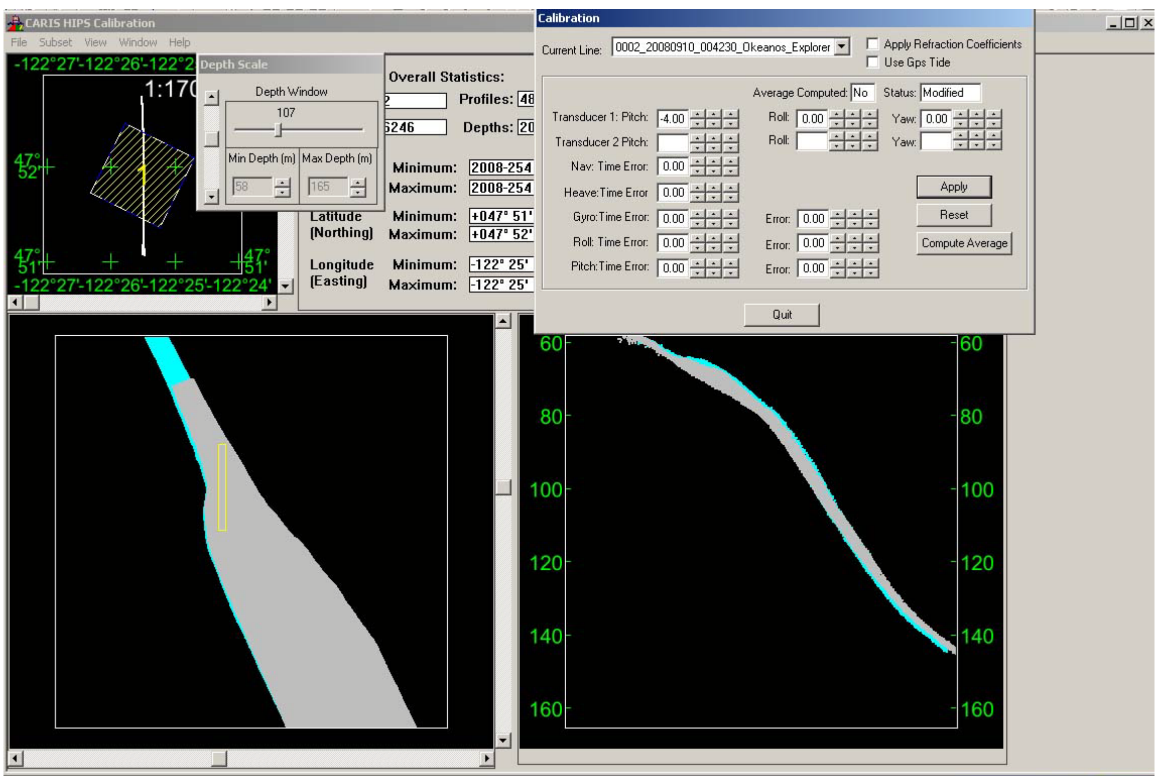


Figure 5. Screen grab of CARIS Calibration utility showing zero roll offset.

2000 Sensor configuration were checked by PS Grant for POS MV. C-Nav data was routed through POS to EM 302. The positioning is observed to be stable but seem to deteriorate during and after turns. All the offsets were found to be entered to POS and EM 302 correctly.

2030 The ship is observed to be trimmed aft and a physical check using clinometer at the location of POS MRU showed about 1 deg tilt aft.

2100 Two lines running in same direction but different ship speed were collected at 4 and 8 Kts.

0006_20080910_030637_Okeanos_Explorer.all

0008_20080910_035701_Okeanos_Explorer.all

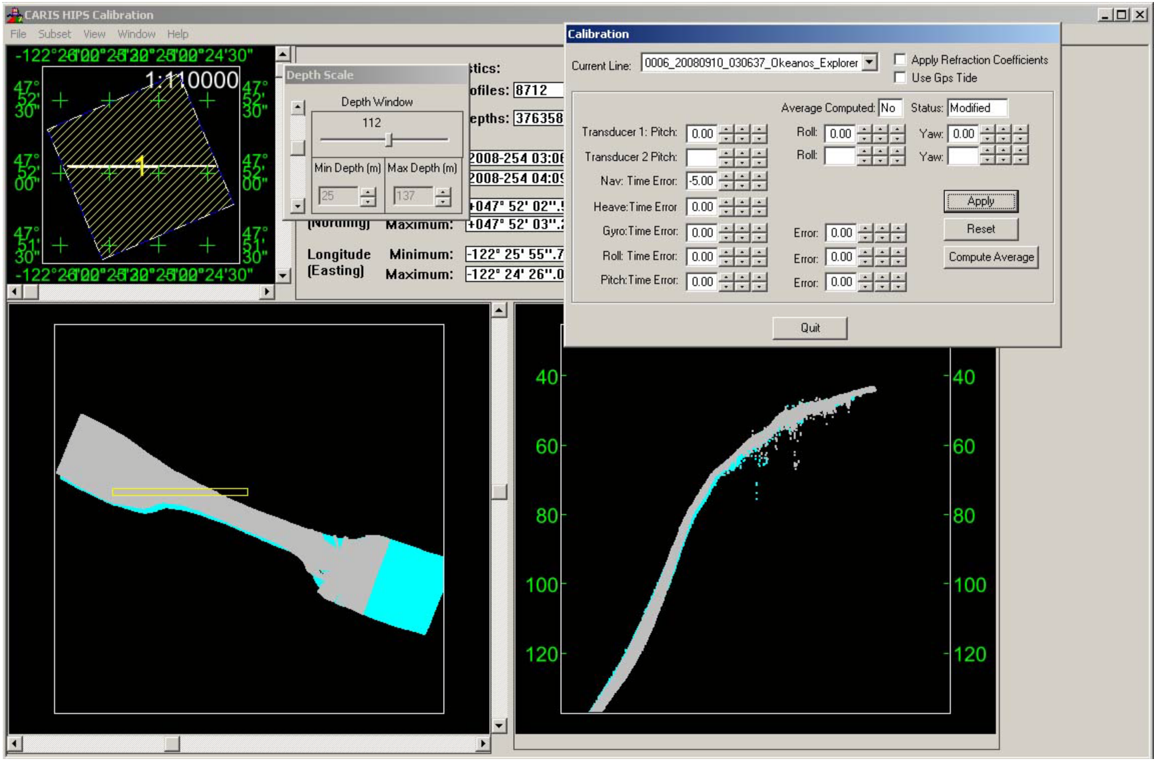


Figure 6. Screen grab of CARIS Calibration utility showing zero timing latency.

The location for the Pitch and Nav time along with the lines that were run for these tests is presented below:

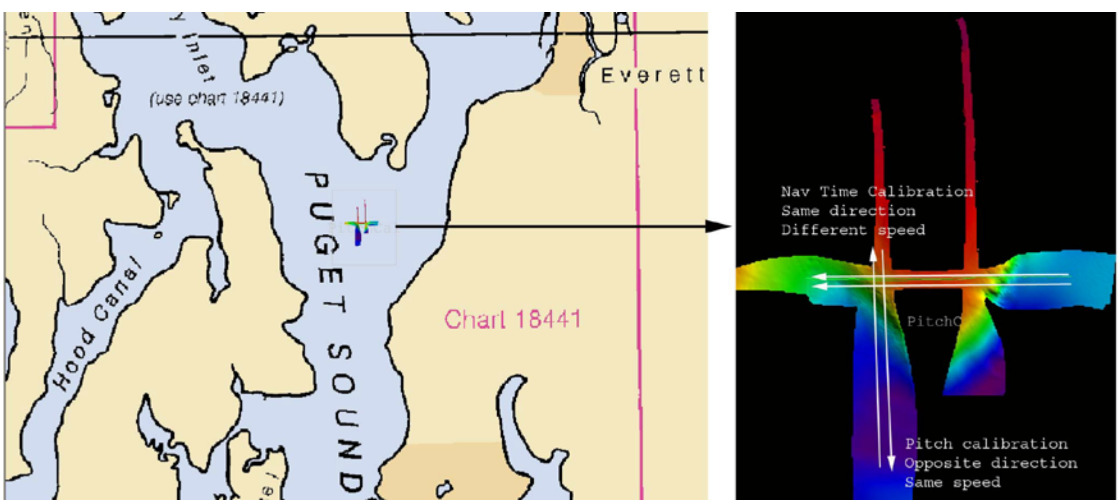


Figure 7. Screen grab of CARIS showing patch test lines.

Pitch offset of 4 deg and Nav time offset of 4 seconds are unexpectedly large values and Kongsberg engineers are going to work tonight to see if there are any software bugs that may be causing this.

2200 UPS alarm is ON. Colleen is informing Bridge about it.

2230 Ship ET requested to turn off any equipment that is not needed for ship ops. Shutting down EM 302. Securing for the day.

September 10 – 11, 2008

Ship worked in two deep areas to ascertain any calibration offsets. The pitch value was found to be -0.7 deg and timing was found to be 0 seconds.

FM mode needs the direct connection of TRU to POS to find the vector to the sea floor (not fully understood). POS came online 11 September PM to do FM mode testing. The results with FM mode do not look great. The outer beams seem to flap about as much as 10-12 m.

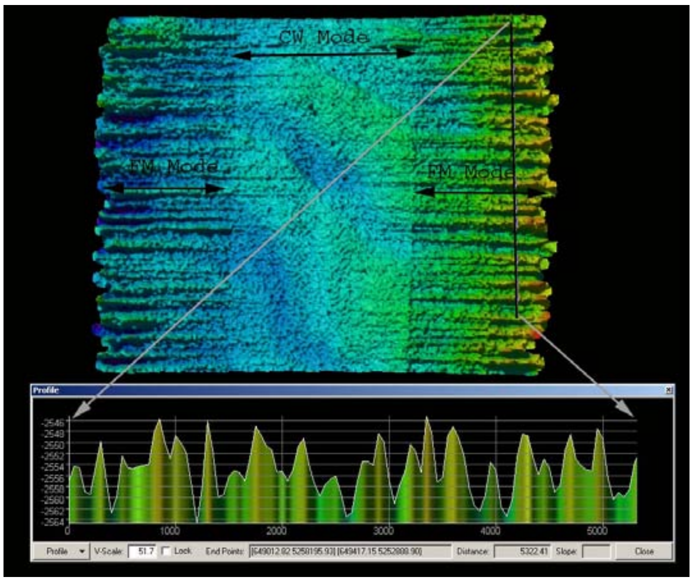


Figure 8. Screen grab taken in Fledermaus showing outer beam flapping and sector boundaries.

Kjell and others from Simrad are continuously tweaking the software to improve the results.

1830 Started surveying in Olympic coast national marine sanctuary. We anticipate to continue working in this area till tomorrow afternoon when we transit to Port Angeles to drop the personnel off.

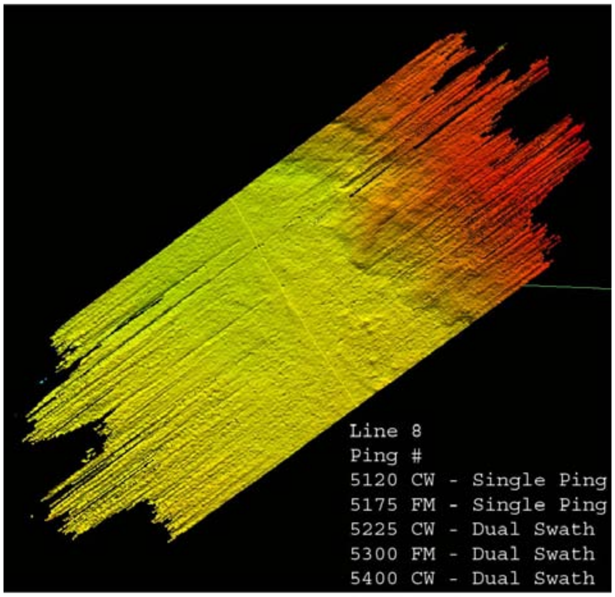


Figure 9. Screen grab taken in CARIS showing swath coverage variations between CW and FM modes, and dual and single swath modes.

September 12, 2008

Software tweaking. Chuck reported that they observed bubble sweep down problem in high seas especially when heading into seas.

Deeper Survey

Kongsberg ran a deep survey with water depths ranging between 1368 – 1863 m was run with lines running East west with a single cross line running North-South. The line spacing was set at 2 NM (~ 3750 m). A coverage of 3.5 ~ 4 times water depth was observed with FM mode. As shown in the picture below a coverage of 6000 m was observed in depth of ~ 1600m (~ 4 times water depth).

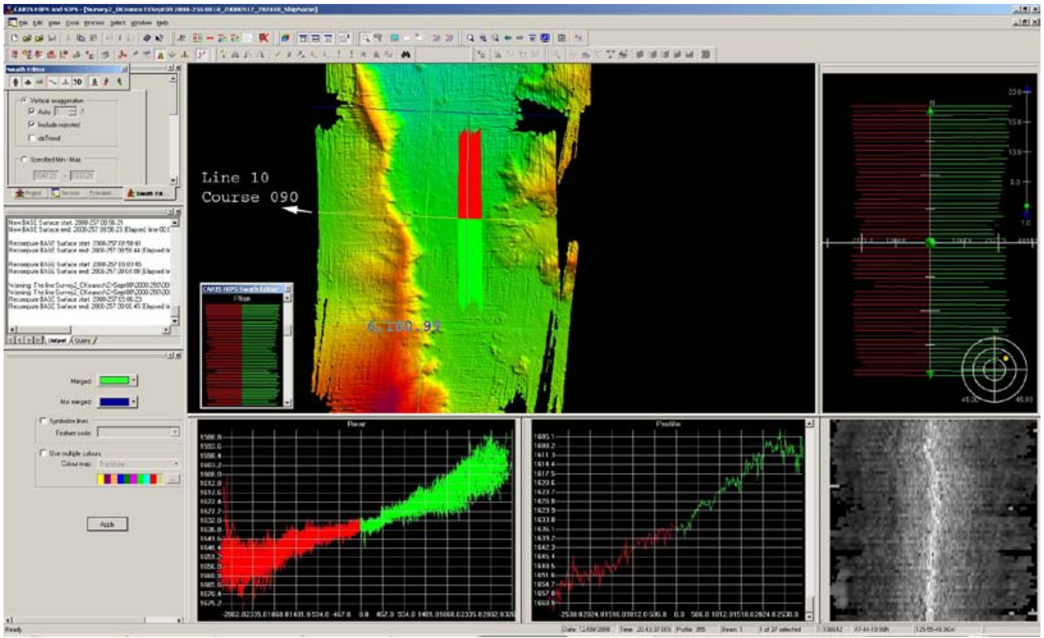
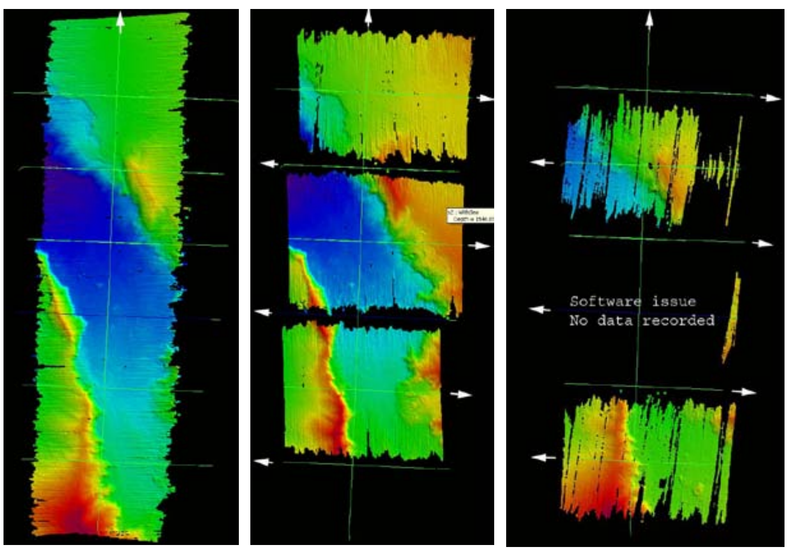


Figure 10. Screen shot taken in CARIS showing data quality degradation dependent on ship heading and seas condition.

The survey lines which were run with the seas showed a dramatic difference as compared to the lines run against the seas.



Swell was coming from West.

The complete survey (figure below) shows outer beam noise.

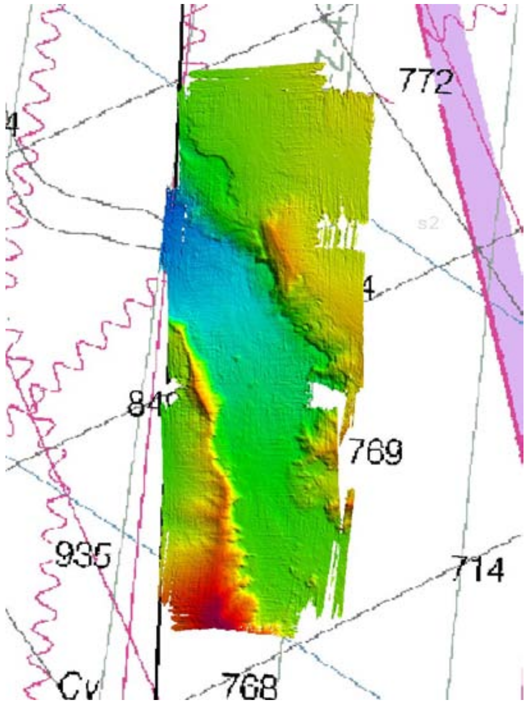


Figure 11. Screen shot taken in CARIS showing data quality degradation dependent on ship heading and seas condition

September 13, 2008

Transit to Port Angeles. Anchor at ~ 0800. Transferring personnel. Will be heading out to open sea 14 Sept 2008 PM.

September 14, 2008

1300 Installed Arc on Multibeam computer # 1 and installed IVS Fledermaus on SCS 1 machine. The license files for both the soft wares are not available presently. Have emailed Craig about Arc license key and will be emailing IVS about Fledermaus license key.

September 15, 2008

0900-1100 SIS training conducted with the mapping team
1300-1600 Emergency drills carried out

1800 Processed the data that has been logging since 0230 (Till line 17).

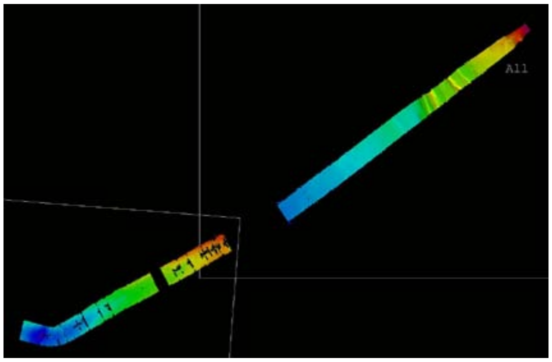


Figure 12. Screen shot taken in CARIS showing data quality degredation dependent on ship heading and seas condition.

The noise mostly looks like bubble sweep down issues. Tested a data quality by gridding the data at 10 m and there were no excessive gaps observed in the data.

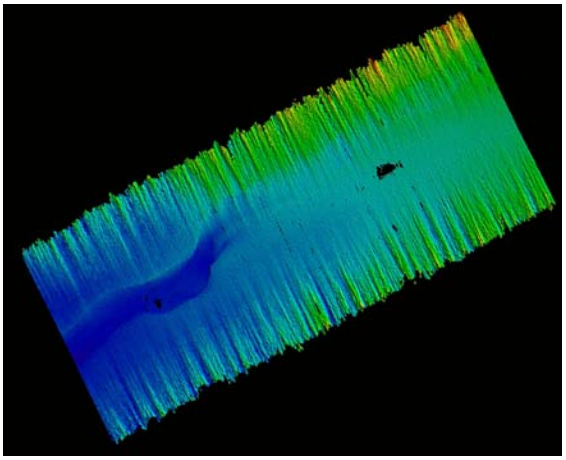


Figure 13. Screen grab taken in CARIS showing 10 m grid data from Line 14 on the transit to Brown Bear Seamount collected using FM mode.

10 m grid data from Line 14 on the transit to Brown Bear Seamount collected using FM mode.

Previously available data sets when compared with present EM 302 data show a bias of ~ 20 m (< 0.01 % of water depth) with present data set shallower than previous data sets. As can be noted in the figure below that this area seem to be an tectonically active area with a probable change in detailed morphology and structures. However, on the smooth flat surfaces the depths can be expected to remain same.

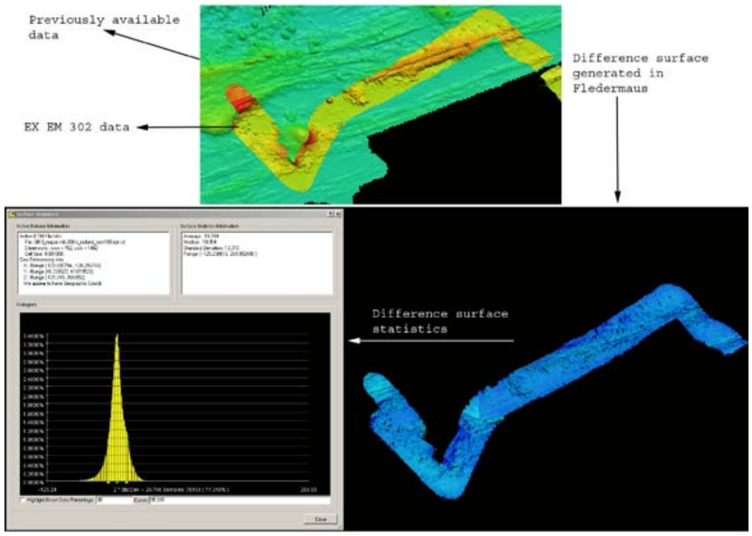


Figure 14. Screen grab taken in Fledermaus showing difference between previously collected multibeam data and new EX data.

Comparing the Brown bear reference surface with the old data set also provide an average difference of about ~ 20 m.

Within our own data set the comparison of depths look also very closely aligned. The following image is obtained using FM data from EM 302 collected on 16 Sept 2008. The depths from 5 different survey lines run at different courses seem to align very well with each other within about 20 m (again < 0.01 % of water depth)

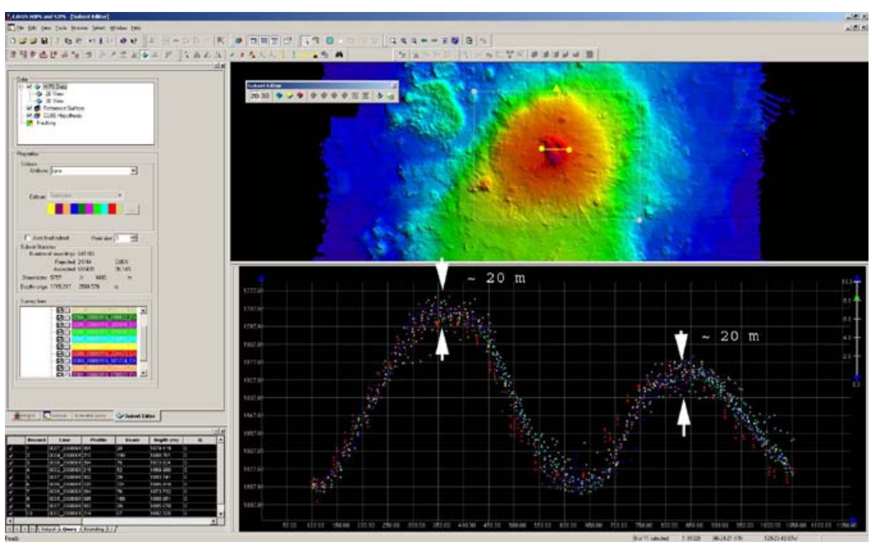


Figure 15. Screen grab taken in CARIS showing EX data collected in FM and CW modes to be in agreement to <0.01% water depth.

1930 Switched to CW mode to assess the coverage and data quality as compared to FM mode.

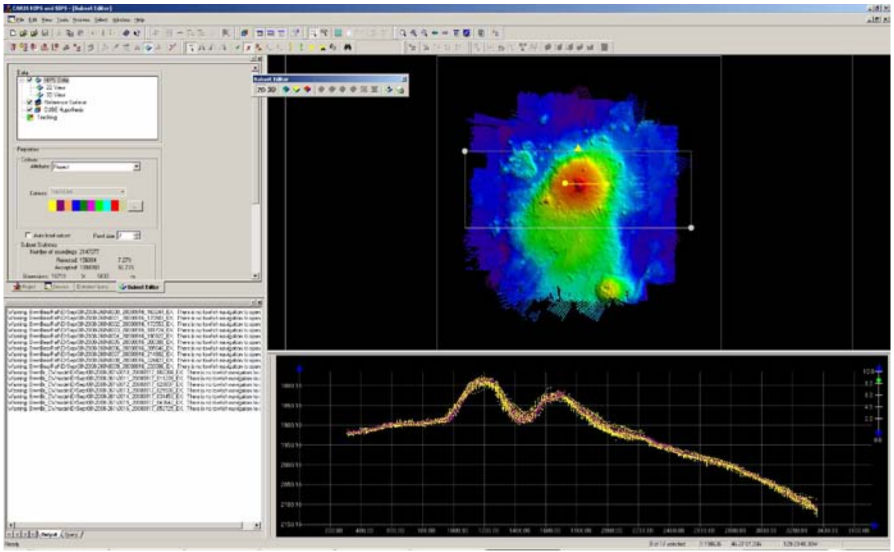


Figure 16. Screen grab taken in CARIS showing EX data collected in FM and CW modes to be in agreement to <0.01% water depth.

Favorable comparison was achieved between CW and FM mode. The DTM from both modes looks almost similar during analysis in HIPS and Fledermaus. The soundings from both the modes were found to match very closely as depicted in above picture.

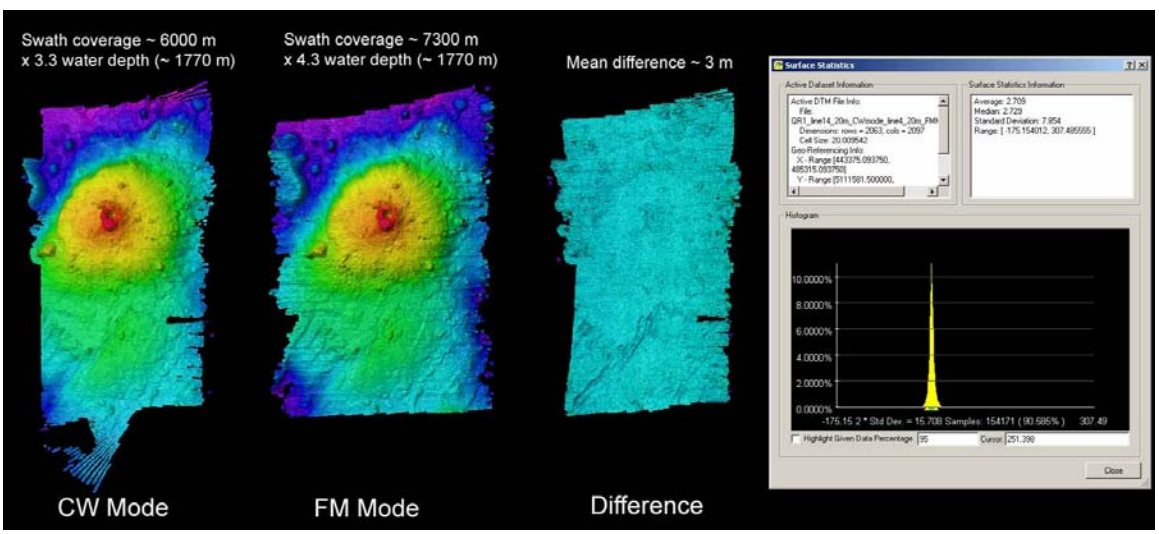


Figure 17. Screen grab taken in Fledermaus showing swath coverage difference while operating in FM and CW modes.

The mean difference in depth was observed to be only about 3 m. The swath coverage in FM mode was however found to be much higher as compared to CW mode. Compare 4.3 times water depth coverage as compared to 3.3 times water depth for CW mode. The slight ribbing artifacts were found in both the modes and do not deteriorate data quality to any significant level. The weather and sea conditions were very calm with very little ship motion. It is recommended that a similar test be carried out in comparatively rougher weather to gauge the performance of the two modes.

Heading cal in deep water using a distinct object – Looked at deep water data at brown bear site and the two lines run in opposite direction were compared and no heading discrepancy was found between them when viewed in subset editor of Caris HIPS.

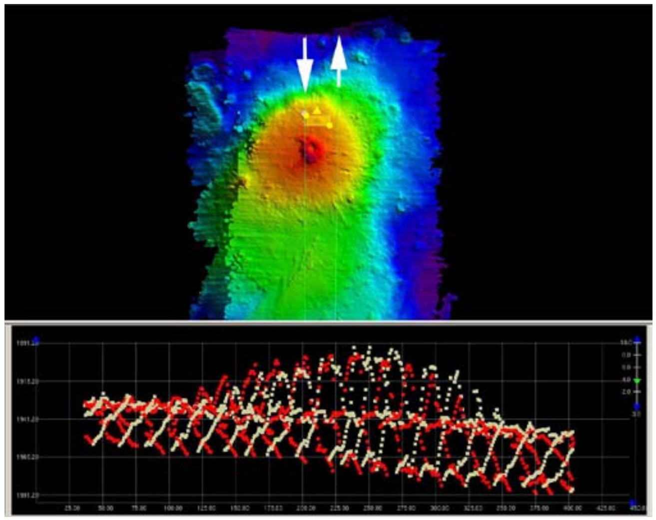


Figure 18. Screen grab taken in CARIS showing verification of zero heading offset.

Depth	Along Track (Tx) 0.5 deg	Across Track (Rx) 1 deg
500	~4.5 m	~9.0 m
1000	~9.0 m	~18.0 m
2000	~18.0m	~36.0 m
3000	~ 27.0m	~52.0 m

Table: Approximate beam foot print size

September 17, 2008

Transit to OCNMS. Collecting data as during transit.
Did a brief session with Colleen and Elaine about processing data in Fledermaus and bringing data to ARC.

September 18, 2008

10:00 Started collected data in OCNMS with cross lines being run first. An XBT cast was carried on the morning. May have to modify the bridge line plane based on the coverage anticipated in each area. We do not have tide coverage from this area but Elaine is going to work with NOAA to see if we can get tide data for this area.

September 19, 2008

1530 Preparing for a CTD cast. XBT and TSG are also going to be shot. Comparison done by Colleen and Elaine agree with in a 1 m/s at all depths.

September 20, 2008

Continued mapping in OCNMS till about 0800-1200. Changed the line plan to run EW lines to reduce the ship roll.

1830 SIS machine is complaining of the low disk space. Colleen is going to shut down SIS and try to clean up the system at the end of line.

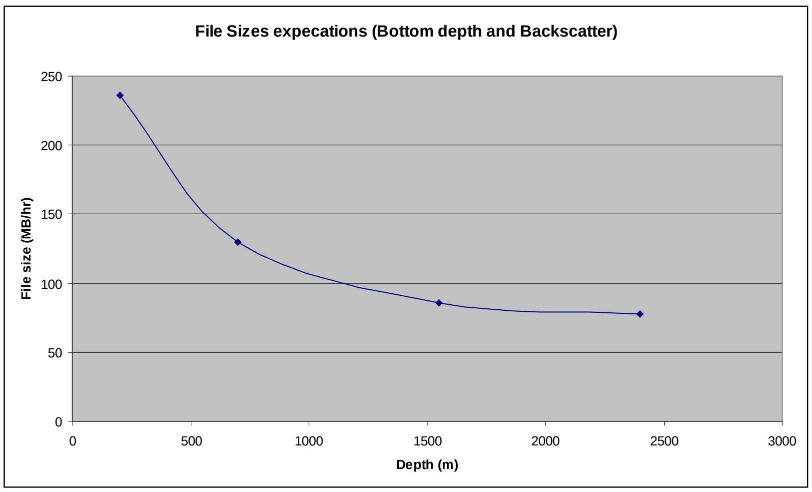


Figure 19. Graph showing file size expectations at different depths.

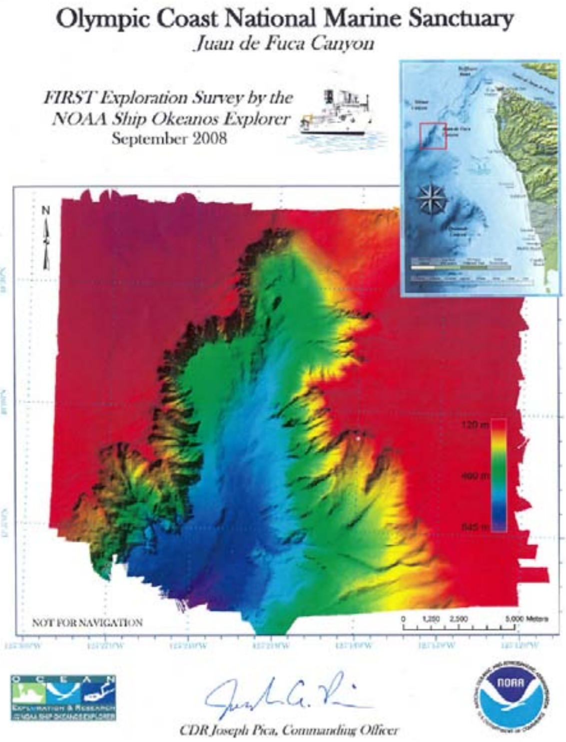
File sizes at different depths were documented for *.all file that saves bottom depth and bottom backscatter. The water column data at all the different depths was not collected during this cruise except for testing WC data at 2550 m depth. At this depth water column data file was found to be about 5.3 times the size of the *.all file.

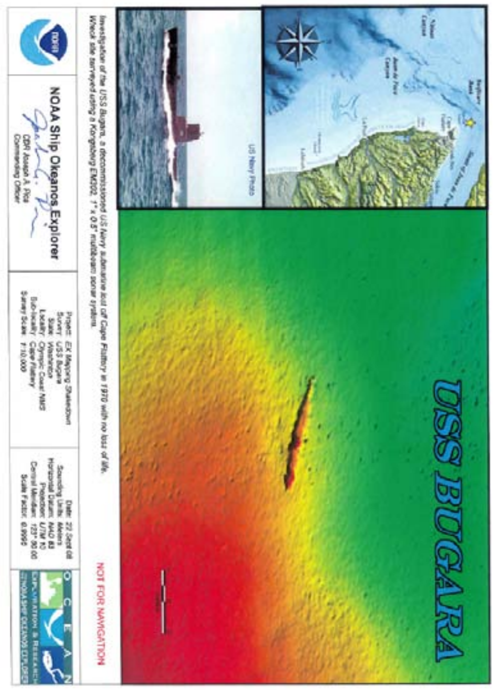
September 21, 2008

Continue working on OCNMS survey area. With lines running EW and with line spacing of ~ 800 we are leaving some data holidays that will be filled by running split lines.

September 22, 2008

Finishing up the data holidays in OCNMS area and then the plan is to over USS Bugara wreck to test the resolution of EM 302. 2010 Just went over wreck of USS Buruga. The wreck measures 90 m fore-aft and about 10 m in width. The ship staff created a memorial map sheet with CO signature commemorating the first multibeam survey by NOAA Ship *Okeanos Explorer* over OCNMS and USS Bugara. These are shown below.





September 23, 2008

SIS failed to start a new survey. On detailed investigation it was revealed that the database system of SIS is corrupted. SIS did not get to work even after defragmentation etc until rep from Kongsberg suggested that we should run 'C:\Program files\..SIS\QCL\reinstall.bat' that will reinstall the data base system in SIS. After doing this the system is now running fine. Tested with creating a new survey and it seems to be working fine along with logging data at the correct place.

9. Appendices

Tables of Multibeam Sonar EM 302 Data Files Collected

EX0801 MULTIBEAM FILES			
Date (GMT)	File Name	Survey Name	Remarks
9/8/2008	0000_20080908_214416_ShipName.all	Puget_Sound	Leg I
9/8/2008	0001_20080908_231334_ShipName.all	Puget_Sound	Leg I
9/9/2008	0002_20080909_011026_ShipName.all	Puget_Sound	Leg I
9/9/2008	0003_20080909_011301_ShipName.all	Puget_Sound	Leg I
9/9/2008	0000_20080909_015016_ShipName.all	RollCal	Leg I
9/9/2008	0001_20080909_022646_ShipName.all	RollCal	Leg I
9/9/2008	0002_20080909_032108_ShipName.all	RollCal	Leg I
9/9/2008	0000_20080909_041320_ShipName.all	Pitchcal_8sep08	Leg I
9/9/2008	0001_20080909_043944_ShipName.all	Pitchcal_8sep08	Leg I
9/9/2008	0002_20080909_050357_ShipName.all	Pitchcal_8sep08	Leg I
9/9/2008	0003_20080909_052342_ShipName.all	Pitchcal_8sep08	Leg I
9/9/2008	0000_20080909_234439_Okeanos_Explorer.all	Pitchcal_9sep08	Leg I
9/10/2008	0001_20080910_001808_Okeanos_Explorer.all	Pitchcal_9sep08	Leg I
9/10/2008	0002_20080910_004230_Okeanos_Explorer.all	Pitchcal_9sep08	Leg I
9/10/2008	0003_20080910_010730_Okeanos_Explorer.all	Pitchcal_9sep08	Leg I
9/10/2008	0004_20080910_021605_Okeanos_Explorer.all	Pitchcal_9sep08	Leg I
9/10/2008	0005_20080910_024240_Okeanos_Explorer.all	Pitchcal_9sep08	Leg I
9/10/2008	0006_20080910_030637_Okeanos_Explorer.all	Pitchcal_9sep08	Leg I
9/10/2008	0007_20080910_032810_Okeanos_Explorer.all	Pitchcal_9sep08	Leg I
9/10/2008	0008_20080910_035701_Okeanos_Explorer.all	Pitchcal_9sep08	Leg I
9/10/2008	0000_20080910_173240_ShipName.all	transit	Leg I
9/10/2008	0001_20080910_175437_ShipName.all	transit	Leg I
9/10/2008	0002_20080910_182437_ShipName.all	transit	Leg I
9/10/2008	0003_20080910_185437_ShipName.all	transit	Leg I
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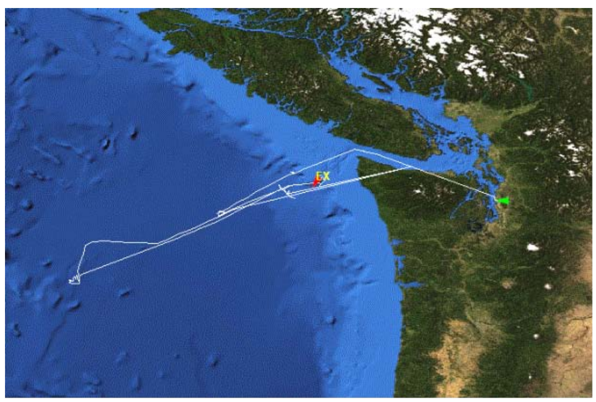
Appendix A: Trip Report from Scott Hill – NOAA National Coastal Data Development Center
Date: September 24, 2008
From: P. Scott Hill
To: Rost Parsons

Subj: Trip Report

Event: *Okeanos Explorer* Mapping Shakedown Cruise
Dates: September 8-13
Location: Puget Sound and off the Washington State Coast

NCDDC Attendees: P. Scott Hill
Notable NOAA Attendees: Webb Pinner (OER), John Katerbini (OMAO), Tom Stepka (OMAO), Mashkoor Ahmad Malik (*Okeanos Explorer* Physical Scientist)
Other Notable Attendees:

Overview: On this cruise, the new EM302 multibeam system was calibrated and tested onboard the *Okeanos Explorer*. To accomplish this, the ship did several test runs of the EM302 in the shallow waters of the Puget Sound and out to 250 nautical miles off the Washington state for testing in over water over 3000 meters deep.



Cruise path off the Washington coast for the *Okeanos Explorer* Ocean Mapping Shakedown Cruise (from 9/8 through 9/14)

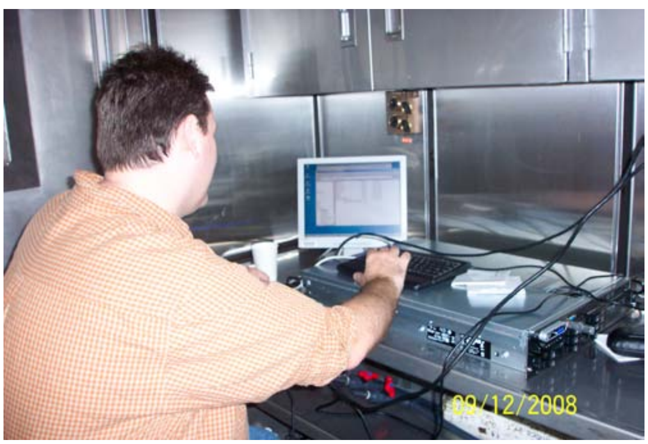
My role on the cruise was to test the CIMS Broker software in generating metadata for the EM302 raw data files. This included testing the Broker's ability to retrieve positional data from the Scientific Computing System (SCS) and transmit the completed metadata records to CIMS. The Broker utilizes software adapters to communicate with each of these systems. Currently, we have developed adapters to allow the Broker to receive or exchange data with the raw data files of the EM302, the SCS, and CIMS itself. Exercising these in unison in a "live" environment to automatically generate metadata was the primary goal of this effort.

Ultimately this goal was achieved but with limited success. The Broker was able to create only four metadata records for 4 raw data files out of the 110 files generated by the EM302 during my leg of the cruise. A long list of factors discussed in the Observations and Recommendations sections of this document prevented creating metadata for the remaining files. However, each of the unresolved problems encountered during the cruise leg should be easily addressed after the *Okeanos* returns to port if not sooner.

While on the ship, I also took the opportunity to perform other tasks. I installed CIMS on the new Telepresense web server. This will allow CIMS to be accessible at the telepresense centers and here at NCDDC. I had discussions with Mashkoor about bathometry data products that might be produced on the ship and strategies we could employ to automate metadata generation from them. I also talked with Webb Pinner about generating metadata from CTD (conductivity, temperature, depth) water column sensor data.

Observations:
This was the first opportunity to test the Broker's SCS adapter on the ship and with an instance of SCS that was actively gathering data. As might be expected, several problems were encountered. Unexpected changes in SCS sensor configuration data impacted both the Broker and the SCS code responsible for returning that data to the Broker. The library selected to communicate with the Broker was also the source of issues with the communication between the two systems. As each problem was identified, it was quickly dealt with and communications between the two systems was finally established.

The other series of issues encountered were related to the file properties of the EM302 raw data files. Two critical pieces of metadata that the Broker requires are the creation and last modified timestamps of the raw data files. Midway through my leg of the cruise we discovered that the computers critical to processing the raw data files had system clocks that were running from over a day off to over a year off of the current time. Furthermore, neither system was having its clock synchronized with the ship's time server. One of the servers was corrected that night, but the next day it was discovered that the other was still off by a day. This took us to the last day of my leg. Rather than risk leaving empty handed if there were still date issues, I modified the Broker's adapter that processes the file timestamps to take into account one period of clock offsets so that we would have correct metadata generated for at least some of the files. This would also allow us to verify that the Broker was both working correctly and communicating with all external systems properly. This change did allow us to automatically process the metadata for that set of files.



Hard at work in the wet lab resolving issues

Both John Katebini and Webb Pinner were of tremendous help to me throughout the troubleshooting and problem resolution activities during the cruise. Both made it known that they were there to help me and readily dropped what there were doing to assist me with problems as they were identified.

Recommendations:

- To help prevent future clock synchronization issues, the NetApps data server and the EM302 data acquisition computers need to use the *Okeanos* network time server. This will require the installation of an additional network card in the data acquisition computer. (Update from Webb Pinner onboard *Okeanos*: "This has been dealt with, the Multibeam Acq workstations and NetApps servers are now sync'd with GPS time (UTC timezone)")

- The additional network card for the acquisition computer will allow it communicate with other systems on the ship's network, including the NetApps data server. This will allow the raw data files to be copied over the network from the acquisition computer to the NetApps server instead of using a thumbdrive to accomplish this. Furthermore, a file copy utility can be used to copy the files automatically at timed intervals while preserving the file timestamps. This utility could also be used to transport data files from other systems to the NetApps server for purposes of backup, metadata gathering by the Broker, and in preparation of sending to the archive centers. (Update from Webb Pinner onboard *Okeanos*: "The Multibeam Acq workstation now has direct access to the NetApps server")

- The Broker needs have the code removed that was used to account for the time offset on the files for which metadata was successfully gathered. This code was created to account for the clock offset for that data set with those particular skewed timestamps.

- The Broker also needs additional logic added regarding how it selects which GPS sensor to use from SCS. It will need to test that the GPS currently being used has data for the necessary time periods, and if not, iterate through the SCS GPS sensors until an appropriate sensor is found.

- The Broker needs to generate a separate log of which files have been successfully represented by metadata in CIMS. A log also needs to be generated for which files were not successfully sent to CIMS and reason why it could not complete the processing of those files. This will aid developers and data managers with quickly and easily seeing which systems are having problems, what the problems are, and hopefully what corrective actions need to be taken.

- I need to make another trip to the *Okeanos* once the items listed above have been accomplished. This will also need to occur after *Okeanos* has produced one additional set of data files from the EM302 while SCS was running to gather GPS data for that time frame. This trip will be to verify that all of the items have been successfully implemented.

- From talking with Webb, it sounds like the Broker's adapter being used for the EM302 data could also be used for CTD data. All that would be needed is Broker access to the CTD data files and some information to configure the Broker for working with those files. On the next trip to the *Okeanos*, we should attempt to test this as well.

- The new EM302 system has been configured to write the water column data it collects to a separate file from the rest of the bathymetry data. NCDDC needs to determine if the archive centers are interested in the water column data. If so, we need get the appropriate configuration data so that the Broker can process the metadata for these files. This should require adding that configuration data to the Broker with no additional coding.

Copy:
Russ Beard
Rost Parsons
Mary O'Chery
Fred Zeile

Departing *Okeanos*

Appendix B: Trip Report *OKEANOS EXPLORER* September 8-13 2008
By Grant Froelich

Deployment goals:
The purpose of my deployment was to provide assistance during patch testing operations for the Kongsberg EM 302 multibeam system and discuss a data pipeline from the *OKEANOS EXPLORER* to PHB.

Sound Speed:
The first day of operations was spent mainly getting the correct inputs and outputs configured as well as testing equipment for the first time. The first ever CTD cast using a SeaBird SBE 911 plus from the EX was taken as well as a XBT cast. The results were plotted and compared in Microsoft Excel with favorable results. An attempt to process the CTD cast data through Velocwin was made to generate an ASVP formatted corrector file for the multibeam acquisition software but it failed. SST Colleen Peters and I contacted Ruby Becker at HSTP for assistance and after several tests determined that the new Seabird Seasave software generates an incompatible format for Velocwin. Velocwin will be updated to read the new format. In the interim, a work around procedure has been developed to get CTD data from the SBE 911 plus to the Kongsberg SIS software used for multibeam data acquisition.

The SBE 45 TSG used to provide surface sound speed correctors for the multibeam was found to be a few meters per second faster than contemporary CTD or XBT deployments. Two temperature sensors are in place for the TSG, a "External" and a "Internal" sensor. The External is located in the bow thruster room closest to the seawater intake. The Internal is located in the wetlab in the aft of the vessel. The water is piped from the bow thruster room to the wetlab on the exterior of the vessel. External water temperatures were always higher than Internal temperatures which is contrary to what one would assume to be likely on warm, sunny days. One theory is that the Dynamic Positioning system (DP) which uses the bow thruster and was used heavily during the cruise is either heating up the space the temperature sensor is in causing a inaccurate reading or the bow thruster cooling water discharge is heating the water being sampled. Further investigation may take place when the vessel is alongside. The calibration to the sensor was also more than a year old.

Data Inputs:
The SIS software required several inputs to operate correctly, including heave, pitch and roll from the POS MV and a position and date/time NMEA string. Originally, SIS was configured to have the position and date/time string come from the C-Nav unit. The quality of this data was not good enough for multibeam operations and the POS MV was then configured to output position and date/time data to SIS.

Several days were spent trying to get Hypack to talk to the POS MV through the network connection. After many unsuccessful attempts at configuring Hypack and the POS MV, it was determined that because the two units resided on different networks on the ship, the network switches were interfering with the POS MV UDP broadcast and the Hypack computer was not receiving the data. After consultation with the IT support personnel onboard about the security implications, the two computers were placed on the same network and the problem was resolved.

The EM 302 can use a FM Chirp mode during deep water acquisition. To correct for Doppler affect, the TRU needs a separate message with "Attitude Velocity" data. After consulting the POS MV V4 User ICD document, it was determined that Group 102 would provide the data needed. The POS MV was then configured to output the data to the TRU via the network.

C-Nav:
The C-Nav system onboard EX is used primarily to supply DGPS correctors to the POS MV. It had been configured to output position and date/time data to SIS as well. During multibeam data acquisition it was noticed that the position data was wandering in a S pattern and the RMS values for the position data in the POS MV would climb to unrealistic numbers when DGPS correctors are being used (>1 meter RMS). To fix the wandering position data in SIS, the input was changed to the POS MV, which immediately solved the problem. It was noticed that the RMS values for the position would climb during turns and settle out after steadying up on line for a few minutes. After looking at the C-Nav configuration screen it was determined that the C-Nav unit was losing all the satellites during turns and not able to supply the DGPS correctors to the POS MV for that period which increased the RMS values. The FOO believes that the C-Nav antenna placement is to blame. It is located directly beneath a metal flag pole extension.

Power:
Operations were severely affected by numerous UPS power failures. Most of the day on the 9th was spent troubleshooting the cause with no data being collected until late in the afternoon. Currently the EX is running at about 90% load on the UPS systems with not everything being turned on. Additionally, the power system wiring diagrams supplied by the contractors were found to be woefully incorrect, adding to the confusion. With more major systems yet to be turned on and tested this is a big issue that will need to be addressed.

Line Formats:
The EX currently has MapInfo 7.0 installed to aid in planning. The version of Hydro_MI installed was quite old and was not able to produce lines for SIS or for use in the DP system. The most recent version of Hydro_MI was tested but was found to be incompatible with the version of MapInfo. A large amount of time was spent on converting lines into a format the DP system would recognize. Two versions of Hydro_MI (6_10_2 and 6_3_1) have now been sent to the EX for testing with their MapInfo version which will hopefully cut down on the time spent on line file conversions.

Patch tests:
The main goal of this leg was to patch test the first ever 0.5° x 1.0° Kongsberg EM 302. Several representatives and engineers from Kongsberg were present to aid with the process and provide hardware and software tweaks to optimize the system. A roll bias calibration was successfully performed the first night. Several attempts were made at pitch and latency calibrations but with no success. Some were due to lines being driven too far apart and some were due to the fact that calibration values did not make sense with reality. There were several tests with a 4° pitch bias and 4 second latency bias. After a few days of troubleshooting and transiting to new calibration locations, a successful calibration was performed for both pitch and latency. A heading calibration was not performed.

FM Mode:

It was noticed during deep water data acquisition using the FM mode that roll-like artifacts appeared in the outer beams. During CW mode it was not as apparent. Several tests were performed with assistance from the Kongsberg engineers to determine the source and magnitude of the error, but were inconclusive given the large sea state during the testing, and the lack of real-time surface sound speed correctors from the TSG. The engineers will take data back with them and will perform more number crunching and provide more software and hardware tweaks based on their findings. However, it may simply be that the outer beam artifacts are a result of extremely small errors which are magnified over the very long distances the multibeam is sending energy.

Notes:

Multibeam data from the EM 302 was successfully converted into HDCS format using the Simrad conversion tool. BASE surfaces were not able to be created because uncertainty models do not yet exist for this sonar. Shoal biased Swath surfaces were created for data inspection. Due to the many operating modes that the EM 302 can operate in (FM/CW, Single Swath (Dynamic and Fixed)/Dual Swath (Dynamic and Fixed), Equiangular/Equidistant/High Density Equidistant), many CARIS device models will need to be created and tested so that BASE surfaces and BAGs can be created.

The EM 302 was able to collect extremely dense data during this trip. During patch testing, a 0.5 meter surface was made of data collected in over 200 meters of water at a vessel speed of 9 knots with no data gaps. During the FM mode trials, 2 meter surfaces were made of data collected in over 2500 meters of water at a vessel speed of 8 knots with only slight data gaps that can be attributed to the rough sea state causing bubble sweep down. According to the Kongsberg engineers, during Dynamic mode, the along track spacing can actually be less than 0.5° depending on depth and vessel dynamics. During CW mode we typically saw a swath width of ~3.5x the water depth. During FM mode, we typically saw a swath width of ~4x the water depth.

A concern brought up at the beginning of the cruise was excessive bubble sweep down. Apparently the HI suffers from this problem and the FOO and ETs were concerned that this would happen to EX as well. During operations, some bubble sweep down was noticed but it was not overly excessive given the sea states. No sweep down was noticed while in the Puget Sound or during the transit from Lake Washington to Shilshole Bay.

A data pipeline from the EX to PHB has been discussed with OE PS Mashkoor Malik. EX will do its best to adhere to the FPM and Specs and Deliverables without putting an undue burden on a non-hydro ship. EX will document procedures and submit a DR and BAG surface for data sent to PHB. DTON submission requirements were also gone over with the FOO and Survey Techs.

Appendix C: EM 302 SAT acceptance signature page

10 ACCEPTANCE SIGNATURES

SEA ACCEPTANCE TEST for the EM 302 with SIS for NOAA *Okeanos Explorer* has been performed according to the test procedure.

The test is: Accepted / Not Accepted *(Circle as appropriate)*

Remarks

BUBBLE SWEEPDOWN IS MOST EVIDENT WHEN HEADING INTO THE WAVES. THE SHIP'S PITCHING CREATES BUBBLES WHICH CAN MASK THE MULTIBEAM ARRAYS. THE EA600 WAS ALSO AFFECTED BY MASKING. DURING THE SAT IT WAS OBSERVED THAT SHIP'S COURSES WITH WAVES ASTERN OR 90° TO THE SHIP WERE BEST FOR SURVEY PURPOSES. THE QUALITY OF THE MULTIBEAM DATA WAS MUCH BETTER IN THESE INSTANCES.

SURFACE SOUND VELOCITY WAS NOT USED DUE TO TSG FORMAT AND QUESTIONABLE ACCURACY. THE SOUND VELOCITY FROM THE PROFILE WAS USED.

THE EM302 HAS BEEN CALIBRATED AND IS READY FOR SURVEYING.

Test performed by (print name)	Position	Date
CHUCK HOPKINS	FIELD ENGINEER	

Test accepted by (print name)	Position	Date
JEREMY WEIRICH LCDR/NOAA	OPS OFFICER, EX	13SEPT 2008

Signature:

Signature:

Appendix D: EA 600 SAT acceptance signature page

4. ACCEPTANCE SIGNATURES

The **Sea Acceptance Test** for the EA 600, for NOAA, Okeanos Explorer has been performed according to the test procedure.

The test is: Accepted / Not Accepted *(Circle as appropriate)*

Remarks

Test performed by (print name)	Position	Date
Tony Dahlheim	(KONGSBERG FIELD TECH)	9/12/08
Test accepted by (print name)	**Position**	**Date**
JEREMY WEIRICH LCDR/NOAA	OPS OFFICER, EX	9/12/08

Signature: Tony Dahlheim

Signature:

Appendix E: Department of the Navy, Ser N84/8U166211 dated Nov 19, 2008.

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, DC 20350-2000

IN REPLY REFER TO
3142
Ser N84/8U166211
November 19, 2008

Dr. William Brennan
Acting Under Secretary of Commerce
For Oceans and Atmosphere
U.S. Department of Commerce
Washington, DC 20230

Dear Dr. Brennan:

I have coordinated a Navy position on lifting restrictions on the public release of High Resolution Bathymetry (HRB) data collected by NOAA from the restricted areas off the northwest and southeast coasts of the United States that were imposed by a January 7, 1985 memo from the Deputy National Security Advisor. You will recall that in a letter dated 27 June, 2008, Washington State Governor Christine Gregoire requested removal of Navy restrictions on the release of this data off the northwest coast. In a letter to Gov. Gregoire dated 28 August, 2008, VADM Lautenbacher and I agreed that Navy would move forward with a review of the HRB restrictions applied to NOAA data to determine whether they could be relaxed or rescinded. After further review, I am pleased to inform you that the Navy has agreed to remove the restrictions on release of NOAA-collected HRB data from restricted areas above, effective immediately. Our office will take the lead in providing a coordinated response to inform the Governor of this decision.

I look forward to continuing to work with NOAA on issues of mutual interest to our two agencies and to the nation. My point of contact is Dr. Wayne Estabrooks, CNO(N84TC) at telephone: (202)762-0578, email: wayne.estabrooks@navy.mil.

Sincerely,

D. A. GOVE
Rear Admiral, U.S. Navy
Oceanographer/Navigator of the Navy

Appendix F: List of acronyms

BIST – Built In System Test
CINMS – Channel Islands National Marine Sanctuary
CO – Commanding Officer
CTD – conductivity temperature and depth (equipment)

CW – continuous wave
dB – decibels
DGPS –Differential Global Positioning System
DNP – do not process
EEZ –Exclusive Economic Zone
ERT – Earth Resources Technology, Inc.
ET – Electronics Technician
EX – NOAA Ship *Okeanos Explorer*
FM – frequency modulation
FOO – Field Operations Officer
GMT – Greenwich Mean Time
URI GSO – University of Rhode Island Graduate School of Oceanography
Km – kilometers
KM – Kongsberg Maritime AS
Kt(s) – knots
LT – lieutenant
MBES – multibeam echosounder
MBNMS – Monterey Bay National Marine Sanctuary
NCDDC – National Coastal Data Development Center
NMFS – National Marine Fisheries Service
NOAA – National Oceanic and Atmospheric Administration
OCNMS – Olympic Coast National Marine Sanctuary
OAR – NOAA Office of Oceanic and Atmospheric Research
OARS – Offshore Analysis and Research Solutions
OER – NOAA Office of Ocean Exploration and Research
OMAO – NOAA Office of Marine and Aviation Operations
ORP – oxidation reduction potential
PHB – Pacific Hydro Branch
RX – receive
SAT – sea acceptance test
SIS – Seafloor Information System – Kongsberg proprietary software
SST – Senior Survey Technician
TRU – transmit and receive unit
TX – transmit
UNH-CCOM/JHC – University of New Hampshire Center for Coastal and Ocean Mapping / Joint Hydrographic Center
UPS – uninterruptable power supply
VSAT – very short aperture terminal
WD – water depth
XBT – eXpendable BathyThermograph

Appendix G. EM302 description and operational specs

EM 302 : Ideal for Ocean Exploration

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

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

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

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

Full Suite of Data Types Collected
The system collects seafloor backscatter data, which provides information about the character of the seafloor in terms of bottom type.

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

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

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

Calculated acrosstrack acoustic beam footprint for EM 302 (high density ping mode, 432 soundings/profile)				
Water depth (m)	**Angle from nadir**			
50	1 deg RX center	90 deg	120 deg	140 deg
100	1	0.5	1	1
200	2	1	2	3
400	4	2	3	5
1000	7	4	6	10
2000	18	9	16	25

4000	35	19	32	-
6000	70	37	-	-
7000	105	56	-	-

Table 1. Calculated across track EM 302 beam footprint. Reference: Kongsberg Product description, Kongsberg document 302675 Rev B, Date 14/06/06, p. 17.

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

Table 2. Calculated across track EM 302 sounding density. Reference: Kongsberg Product description, Kongsberg document 302675 Rev B, Date 14/06/06, p. 17.

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

Calculated ping rate and alongtrack resolution for EM 302					
140 deg swath, one profile per ping					
			Alongtrack distance between profiles (m)		
Water depth (m)	**Swath Width (m)**	**Ping Rate (pings/second)**	**@4 kts**	**@8 kts**	**@12 kts**
50	275	3.2	0.7	1.2	1.9
100	550	1.8	1.1	2.2	3.3
200	1100	1	2.1	4.2	6.3
400	2200	0.5	4.1	8.2	12.2
1000	5500	0.2	10	20	30
2000	8000	0.1	15.2	30.5	45.7
4000	8000	0.06	19.2	38.5	57.7
6000	8000	0.04	24.5	49	73.4

Table 3. Calculated ping rate and along track EM 302 sounding density, one profile per ping. Reference: Kongsberg Product description, Kongsberg document 302675 Rev B, Date 14/06/06, p. 15.

Calculated ping rate and alongtrack resolution for EM 302
140 deg swath, two profiles per ping

Water depth (m)	Swath Width (m)	Ping Rate	Alongtrack distance between profiles (m)		
			@4 kts	@8 kts	@12 kts
50	275	3.2	0.3	0.6	0.9
100	550	1.8	0.6	1.1	1.7
200	1100	1	1.1	2.1	3.2
400	2200	0.5	2	4.1	6.1
1000	5500	0.2	5	10	15
2000	8000	0.1	7.6	15.2	22.8

Table 4. Calculated ping rate and along track EM 302 sounding density, two profiles per ping. Reference: Kongsberg Product description, Kongsberg document 302675 Rev B, Date 14/06/06, p. 15.

Reference: Kongsberg Product Description: EM 302 multibeam echosounder