Descriptive Report for seafloor mapping of areas off southern Maine

MCMI 2014

Introduction

The Maine Coastal Mapping Initiative conducted a multibeam survey using a Kongsberg EM 2040C multibeam in the waters off the coast of southern Maine. Data was acquired from June to October 2014. The survey was conducted as part of a grant from Bureau of Ocean and Energy Management (BOEM), for beach restoration and reconciliation. The bathymetry and backscatter will primarily be used to determine the potential for sandy deposits. The project also coincides with state efforts to update coastal data sets, and bring high resolution bathymetric maps into Maine waters. This grant allowed for the purchase of new multibeam sonar, positioning equipment, and other equipment needed for bathymetric mapping and bottom sampling. In addition to multibeam work the survey also conducted drop camera and bottom sampling to ground truth the data. The project provides new data in the areas covered by NOAA nautical charts 13286 in southern Maine, and 13296 and, 13288 in the Boothbay Harbor/ Linekin Bay region of Maine. These data were not collected or processed for navigational purposes, but are freely provided to NOAA for any use as the agency deems appropriate.

Survey Area

The survey area was located in and around the coast of southern Maine, from just south of Wells ME (43 17.1515), north to Fletcher Neck in Biddeford ME (43 26.4562). From the coast the area extends east, nearly 13 nautical miles (nm) in the southern end and nearly 9nm on the northern end. This part of the summer field season was conducted from 6/27/2014 to 10/06/2014. After the 6th of October the boat left its marina slip in Kennebunkport and moved north into the Boothbay region of Maine. Here the F/V Amy Gale continued to collect data in Boothbay Harbor and Linekin Bay. See figure 1 below.

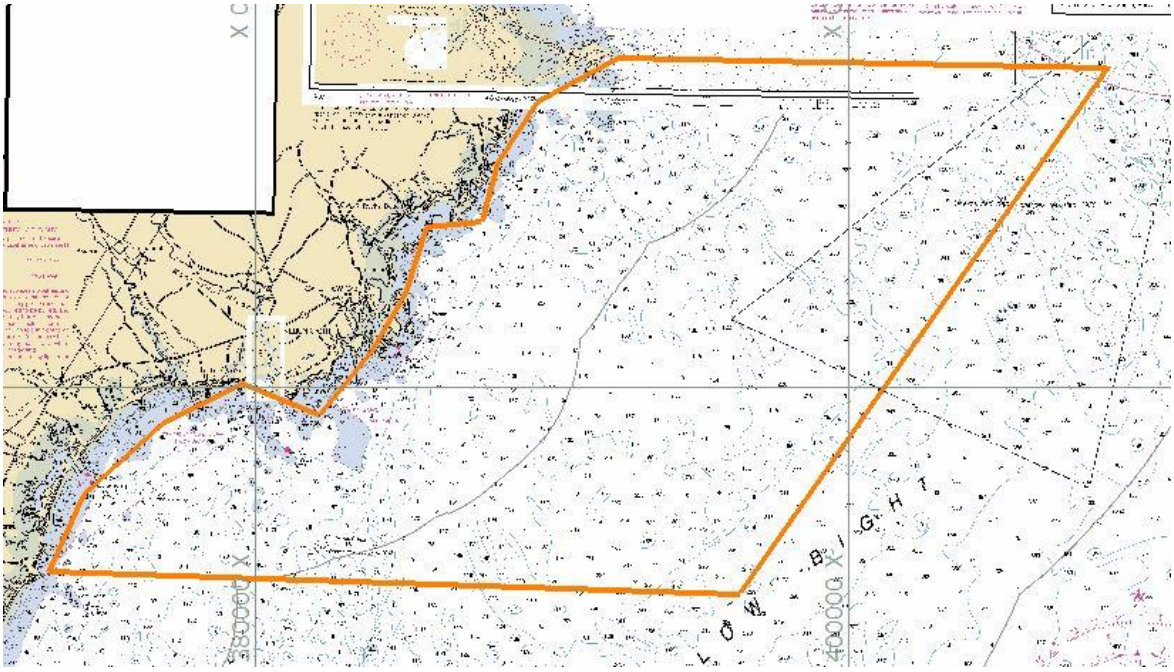

Figure 1: Survey area off coast of southern Maine.

Equipment

Survey Vessel

All data was collected aboard the F/V Amy Gale, which is contracted to the MCMI. The vessel's original purpose is a lobster boat, the Amy Gale is a 35ft long and 12.5 ft. wide, and cruises at15 kts but data collection was conducted at 6.5 kts. The multibeam sonar was mounted to the bow along with the MRU, surface sound speed probe and dual GNSS antennas. The mount is raised and lowered via a pivot point at the edge of the bow by electric winch. The boat was captained by Caleb Hodgdon, and operated by Hodgdon Vessel Services. See figure 2 below.

Figure 2: F/V Amy Gale, with bow mounted transducer, MRU and antennas.

Hardware

EM 2040C Multibeam Echosounder
Seapath 330+ Inertial Navigation and attitude sensor
Dual GNSS antennas: differential GPS
MRU 5 Subsea bottle
AML MicroX Sound Velocity Probe
Digibar S Sound Speed Profiler
WildCo Grab Sampler

Software

Kongsberg Seafloor Information Systems (SIS): acquisition software
Kongsberg Seapath: navigation and position software
Hypack, Hysweep: line running/planning software, multibeam processing software
Digibar Pro 3.0: sound speed cast/ profile software
QPS, Qimera, Fledermaus Multibeam processing, and data visualization

Multibeam sonar

A Kongsberg EM 2040C Multibeam echosounder was mounted on the bow via a flange to the pole on the Amy Gale. The sonar has the capabilities of 200, 300, and 400 KHz. The survey was run at 300 KHZ, at this range the sonar is capable of its full swath width of 130 degrees, whereas at 400 KHz the swath width comes in to 70 degrees. See Figure 3.

Navigation and Positioning

A Seapath 330 system was used, which included an MRU 5 subsea bottle, and dual GNSS antennas. The motion reference unit (MRU) was mounted just above the sonar and serves as the reference point for all equipment. The antennas are in a fixed position above the water, and are hard mounted to the pole. The antennas are calibrated to a known distance and from there can be used as differential GPS to increase position accuracy. See Figure 3.

Sound Velocity Equipment

An Applied Microsystems MicroX sound velocity probe was mounted next to the MRU and was responsible for surface (transducer depth) sound speed. A Digibar S was used for sound speed throughout the water column. This was housed in a cage built from lobster trap wire for protect it from crashing on the bottom. The Digibar S logs; sound speed, pressure (depth), temperature and time; the probe is rated to 500m. See figure 3 and 4.

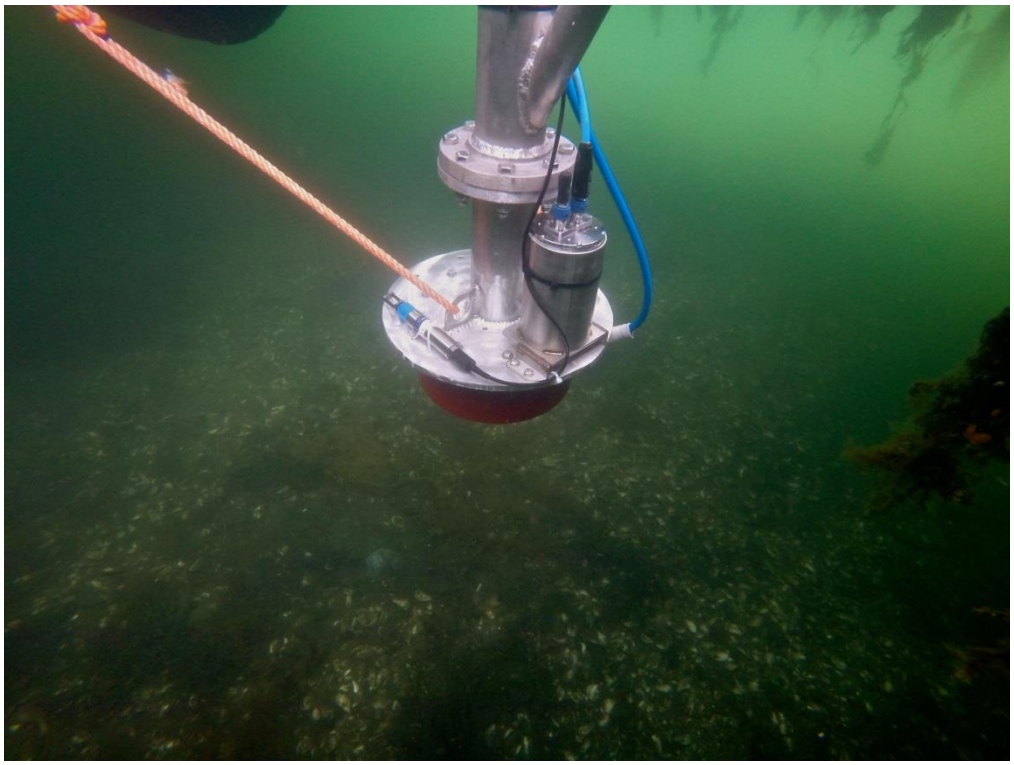

Figure 3: Underwater shot of 2040C transducer, MRU 5 subsea bottle, and surface sound speed probe.

Figure 4: Digibar S in its protective cage.

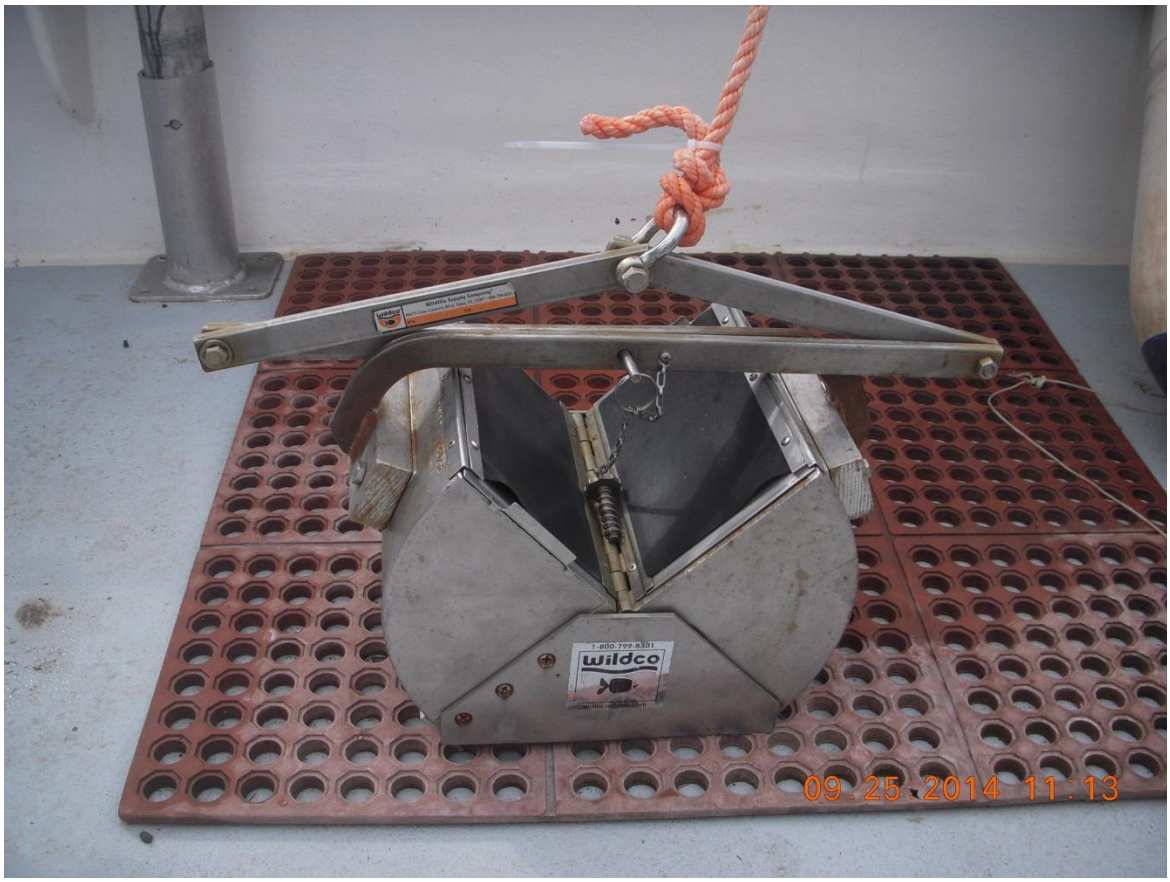

Figure 5: Wildco Grab Sampler, on back deck of F/V Amy Gale

Data Acquisition

Data Acquisition Software

- Data was collected using SIS software, which interfaces with the EM2040C sonar, SIS, is licensed by Kongsberg, and the program was given a complimentary license by Kongsberg.
- Seapath 330, software is used for position and attitude and interfaces with the MRU and GNSS antennas.
- Digibar Pro 3.0 software is the interface with the Digibar S. This software creates a .csv file which is put into SVP editor and changed into .asvp which is the format that SIS accepts.
- Hypack is used for line planning and line running. Hypack is integrated with position data from Seapath for line running.

Data Processing Software

A combination of software packages were use Hypack, Hysweep, and a preliminary version of QPS's Qimera software. After work much work individually and with assistance from NOAA IOCM, the decision was made to switch data processing to Qimera from Hypack. On this project Qimera proved to be a smoother and easier program to identify and resolve issues with the dataset. Qimera was used as the primary editing software, FMGT (GeoCoder) was used to create backscatter products and Fledermaus was used to create fly overs, and other images.

Survey Planning

A final survey area was agreed upon after discussions between the Maine Coastal Program, BOEM and NOAA, and mainly consisted of areas in federal waters. Line planning and coverage requirements were designed to meet the standards set forth by the BOEM grant, but also met requirements for NOAA hydrographic standards. Due to multiple changes in seafloor depths based off of existing charts, lines were planned at 25m intervals and some lines were skipped to maximize coverage, while maintaining consistent overlap. Cross lines were also run every 900m, as per BOEM requirement, and to act as a data quality check. Holidays in the data were avoided at all cost due to time restraints; we felt it was more time effective to have greater overlap than go back and fill holidays. When holidays did occur, as they did multiple times in Boothbay, we would run a few full length lines and then go back and fill the holiday. See figure 6.

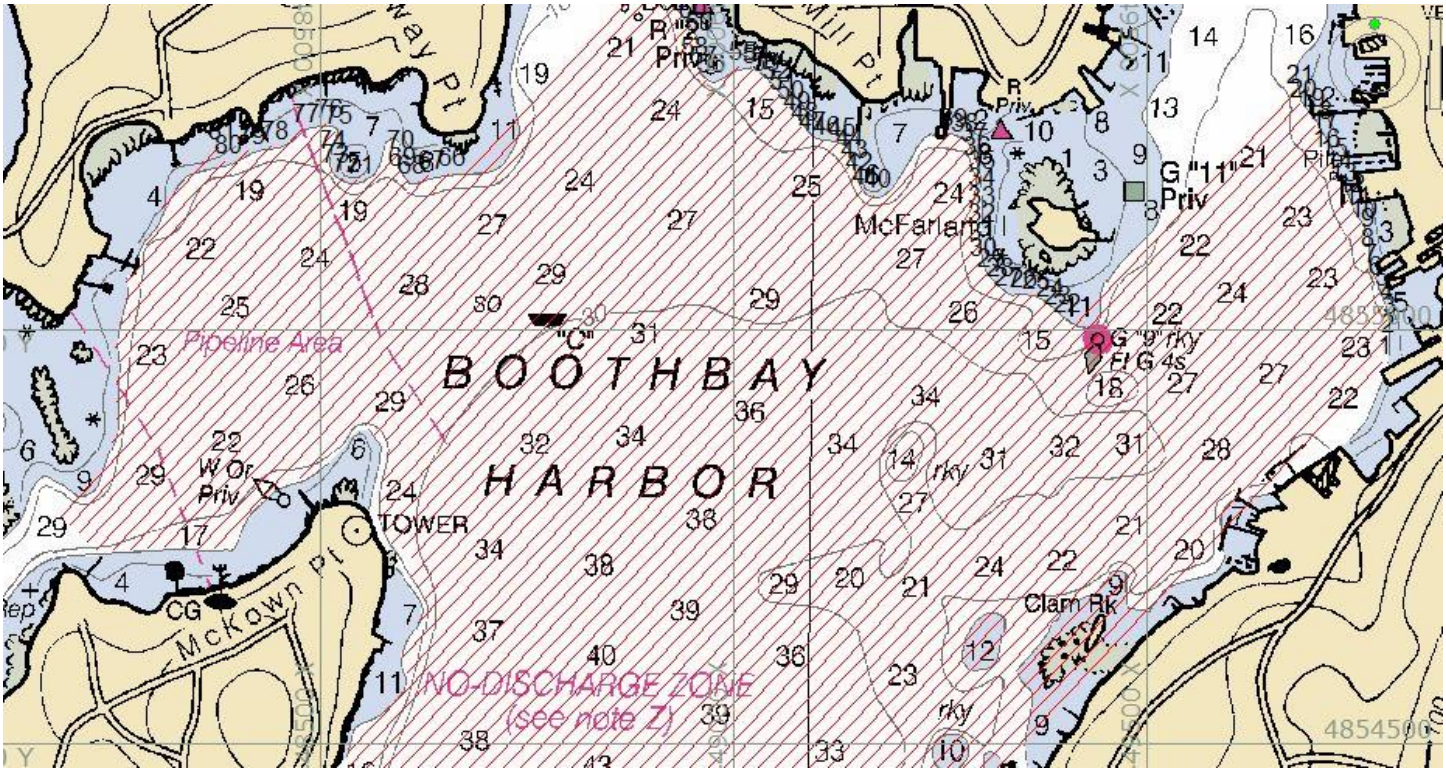

Figure 6: Survey plan in Boothbay Harbor.

Junction Survey

The MCMI survey was done in an area adjacent where the NOAA Ship Ferdinand Hassler has been conducting hydrographic work. The MCMI survey starts operations in the area planned for NOAA survey H12725 and junctions with surveys H12697 and H12698 which are both to the south of the focus area. See attached image. It has yet to be determined how the remainder of the BOEM area and survey H12725 will be conducted. See figure 7.

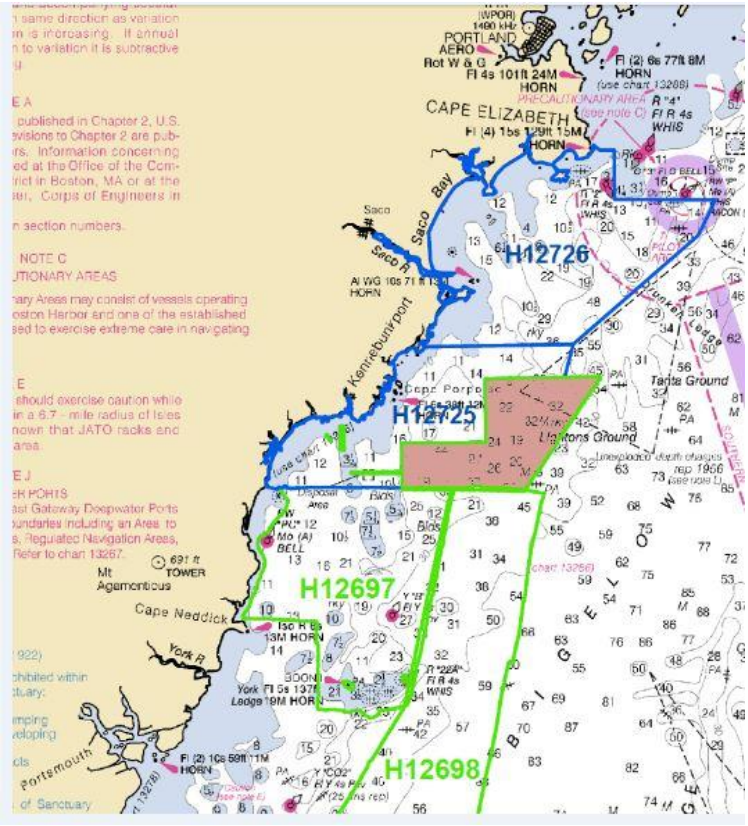

Figure 7: NOAA junction surveys, with overlay of MCMI surveyed area.

Data Acquisition and Monitoring

The same daily procedure was used for the entirety of our time in the southern Maine focus area, and only slightly changed in the Boothbay Harbor region due to cold weather. After a transit to the survey area from the dock, lowering the pole and tighten ratchet straps to marked location. All electric power to the computers was provided by a 2000 watt Honda generator. The computers were turned on and the Seapath would connect and stabilize before any further steps were begun. When the Seapath stabilized a sound speed cast was conducted and applied in the SIS software, afterwards a line was selected and the days mapping began. While in Boothbay Harbor the sonar and other equipment was left in the water due to the cold weather, but the rest of the procedure remained the same. Data files were logged in SIS in .all format, and real time bathymetric grids were produced and saved directly onto the hydrographic workstation computer, lines were run in a north south pattern, lines were usually 2.5 to 3.5nm in length. The sonar was set to 300 KHz and depth mode was set at Auto. The boat would run lines between 6.5 kts and 7 kts. Sound speed cast were taken as needed, when the surface sound speed and the sound speed profile differed by more than 2.0 m/s than a new cast was taken. Either the line and boat would be stopped and a cast taken there, and then return on the line, or the line was run to its extents and a new cast was taken after the end of the line.

Figure 8: Work station with SIS display on right and Hypack on left.

Vessel Mobilization

Sensor Offsets

Mobilization of the F/V Amy Gale occurred in the first two weeks of June in Boothbay Harbor. All sensors were set up vertically on the same pole so as to reduce horizontal offsets, this type of setup in theory allows for one patch test of the pole, and from there the pole could in theory be moved from boat to boat without changes in the offset values. Offset values were measured by hand; these values include reference point to each antenna, and reference point to the transducer. The MRU was set as the reference point in the Seapath navigation computer. A separate value for waterline to transducer is also needed (draft), this value is entered into the SIS software; however it appears that it was not properly saved, and resulted in files with no value for draft. Once offset values are entered into the Seapath computer they are fed directly into the processing unit for the sonar, and are used real time for motion. For this reason instrument offsets were recorded as zeros in the SIS software. Since the draft value was not properly recorded in SIS it was applied during processing with Qimera, this value was .933m.

Instrument	X	Y	Z	
Antenna 1	-0.098	-1.250	-2.969	
Antenna 2	-0.098	-1.248	-3.024	
Sonar	-.192	0	.194	
Sonar to waterline	Middle	Bottom		
	.883	.933		

Patch Test

Two patch tests were conducted aboard the Amy Gale. The first test was conducted in Boothbay Harbor in mid-June, but the values had not been properly saved, it was determined that another test was needed, and deeper water would provide better values for the patch test. A series of lines were run to determine the latency, pitch

roll, and heading offset. The patch test was processed in the SIS software, and saved directly into the software. An additional set of roll lines were conducted in Boothbay Harbor, but it was determined that changes were minimal. No dynamic draft corrections were made to the data. See attached table and figure 9.

Roll	-0.03
Pitch	-0.35
Heading	-0.67
Latency	0

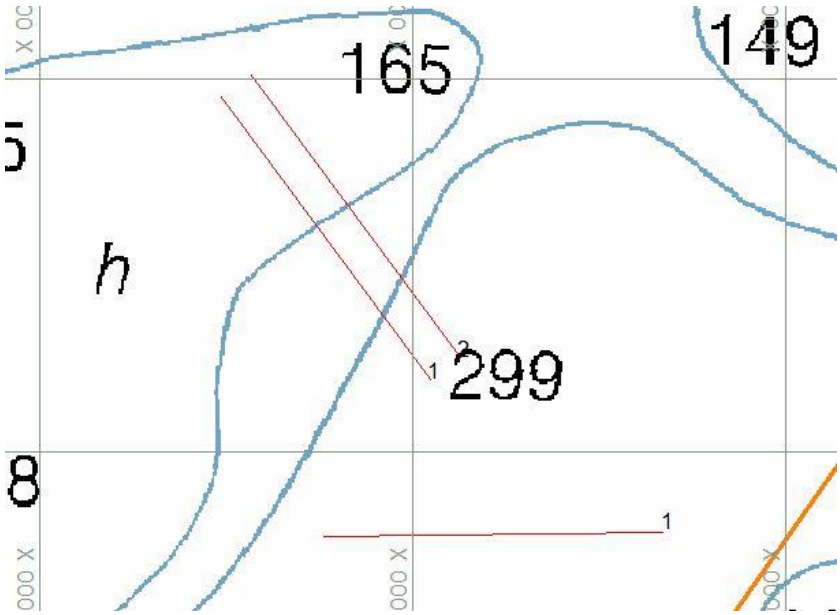

Figure 9: Patch test lines, in eastern section of BOEM focus area.

Water Level Corrections

Tidal data was applied in the processing stages of the survey. The tidal gauge from Portland ME (8418150), was used and then range and multiplier information was applied to get accurate data. Tidal data was related to MLLW, and all tidal data was gathered from NOAA Tides and Currents webpage. For part of the area in southern Maine the tide station in Portland Maine was used along with a -6 minute time corrector and x0.95 range corrector. The other part of the survey area only had range corrector of x0.95. See attached image. The survey area in Boothbay Harbor and Linekin Bay had a time corrector of -7 minutes and a range corrector of x0.97.

Data Processing

Processing Workflow

1. Create Project: define Datum and projection
2. Add Files: Metadata extracted and real time xyz converted to .qpd, including vessel configuration and sound velocity
3. Create Surface: initial validation and investigation
4. Patch Test and offsets: draft offset entered

5. Correct for tidal data
6. Create Cube surface
7. Edit surface and finalize
8. Export data

Horizontal and Vertical Datum

The data were collected and processed in WGS 84, UTM zone 19 North, and were related to MLLW, based off the Portland Maine tide gauge (8418150).

CUBE

Once preliminary surfaces were built and any obvious issues were addressed, a CUBE (Combined Uncertainty and Bathymetry Estimator) surface was created for editing and as a starting point for final products. CUBE creates multiple hypotheses based on the data. It will create a surface with the highest statistical probability based on the density of soundings, but also show other possible hypotheses, it allows for quick and accurate processing of the data. CUBE surfaces were built for each survey area, and the resolution was determined by the average depth in the survey area. The BOEM survey was gridded at 2m, and the survey conducted in the Boothbay Harbor region is gridded at .5m resolution. Editing of the CUBE surface was done in the 3D editor tool of Qimera, where it is possible to look at both the CUBE surface as well as the actual soundings.

Data Control

A survey comparison was conducted using the data collected by MCMI as well as the NOAA Ship Ferdinand Hassler. Data processed by MCMI using Qimera and data processed by NOAA IOCM using Caris are of the same area, and the Hassler conducted crosslines over the survey area. A surface difference test was run on the products, a difference of -0.29m between the MCMI and IOCM data, and a difference of 0.10m between the MCMI and the Hassler crossline data. The Hassler uses a RESON 7125 sonar.

Results

The total area surveyed in the BOEM study area was 40 square miles. The area surveyed in BoothBay Harbor was around 5 square miles. The combination of bathymetry and backscatter suggest that this area of Maine is very rocky, but does contain large areas of softer sediments towards the eastern edges of the southern Maine survey area. The bathymetry also suggests an area of past and current geologic activity.

Technical Difficulties

Multiple technical difficulties were had, but no major problems were had that shut down operations for a sustained period of time. Antenna cables from the Seapath came unterminated from Kongsberg, a Kongsberg rep Alexis Cardenas came from Nova Scotia to help with terminating the cables as well, as general installation of sonar equipment. A Null Modem was needed to receive the data stream from the Seapath to the Hypack software. Problems with the SIS software included: patch test data not being properly entered in the software, but this was fixed during data processing, we also had random drop out of the Multibeam swath, the day was called off early, but the problem did not occur again. The real time display on SIS was not properly gridding data, but it was determined that each SIS survey can only handle so much gridded data, a new survey was created and the problem was solved. When the SIS license ran out an attempt to use the Hypack/Hysweep

software to run as a controller, but was unsuccessful. Due to the lateness in the season the decision was made to stop surveying, and start decommissioning the boat.

Conclusion

The 2014 MCMI summer field season in the waters off the coast of southern were largely successful. Around 45 square miles were surveyed between the southern area and the area around Boothbay Harbor. Although the survey collected a large portion of the BOEM focus area, more time is needed to complete the area. The data collection was hampered by many days of poor weather, but despite that data collection did not run into many problems that could not be easily solved over the phone. Data processing for the most part ran smoothly, glitches were discovered in the testing phases of Qimera, but MCMI was successful in becoming the first full project completed with Qimera. A special thank you goes out to Lindsay Gee and his QPS team for allowing MCMI to test Qimera. The small offset with the Ferdinand Hassler data set suggest that there are no significant unresolved issues in the data.