NOAA *Okeanos Explorer* Program

MAPPING DATA REPORT

CRUISE EX1305

Summer Ecosystem Monitoring Survey

August 2 – September 5, 2013
North Kingstown, RI to North Kingstown, RI

Report Contributors:
Mashkoor Malik, Jacklyn James, Jerry Prezioso
5 September, 2013

NOAA Office of Ocean Exploration and Research
1315 East-West Hwy, SSMC3, #10210
Silver Spring, MD 20910

Northeast Fisheries Science Center
National Marine Fisheries Service
28 Tarzwell Drive, Narragansett, RI 02882

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

The purpose of this report is to briefly describe the mapping data collection and processing methods, and to report the major results of the cruise. For a detailed description of the *Okeanos Explorer* mapping capabilities, see Appendix B as well as the ship's readiness report, which can be obtained by contacting the ships Operations Officer (ops.explorer@noaa.gov).

This report focuses on mapping activities during EX1305 only.

3. Cruise Objectives

The cruise had numerous objectives to address research goals of several programs within the Ecosystem Process Division of the NEFSC and outside collaborators including: climate research program, Ocean acidification program, ecosystem science in support of stock assessments program, science in support of ecosystem assessments program, development of new technologies to support ecosystem studies, habitat mapping and NEFSC outreach and education objectives. The specific objectives included [1]:

1) Assess changing biological and physical conditions which influence the sustainable productivity of the living marine resources of the northeast continental shelf ecosystem using CTD's and bongo nets at stations located at predetermined randomly stratified locations. CTD will collect electronic data on temperature, salinity, density, and oxygen.

2) Trends in ocean acidification and nutrient levels will be determined by collecting water samples using a rosette sampler at predetermined fixed locations.

3) Detail incursion of Labrador Current water into the Gulf of Maine by conducting CTD casts in deep basin areas.

4) Collect samples for the Census of Marine Zooplankton Project by the use of 20-cm bongos piggybacked above the 61-cm bongos.

5) Analyze the size spectrum of water column particles using the Laser In-Situ Scattering and Transmissometry (LISST) instrument.

6) Determine the abundance and distribution of larval and juvenile yellowtail flounder (*Limanda ferruginea*) in the survey areas surveyed.

7) Report northern right whale and other marine mammal bird and turtle sightings.

8) Collect acoustic data using the EK60 single beam unit from along the cruise track, as well as SCS data.

9) Collect data with new optical plankton equipment, the Imaging FlowCytobot plumbed into the Scientific Seawater System

10) Conduct sea floor mapping in the Wilkinson and Georges Basin areas of the Gulf of Maine.

11) Conduct opportunistic Isaacs-Kidd midwater trawls near areas of puffin habitat that are near our planned cruise track in the Gulf of Maine.

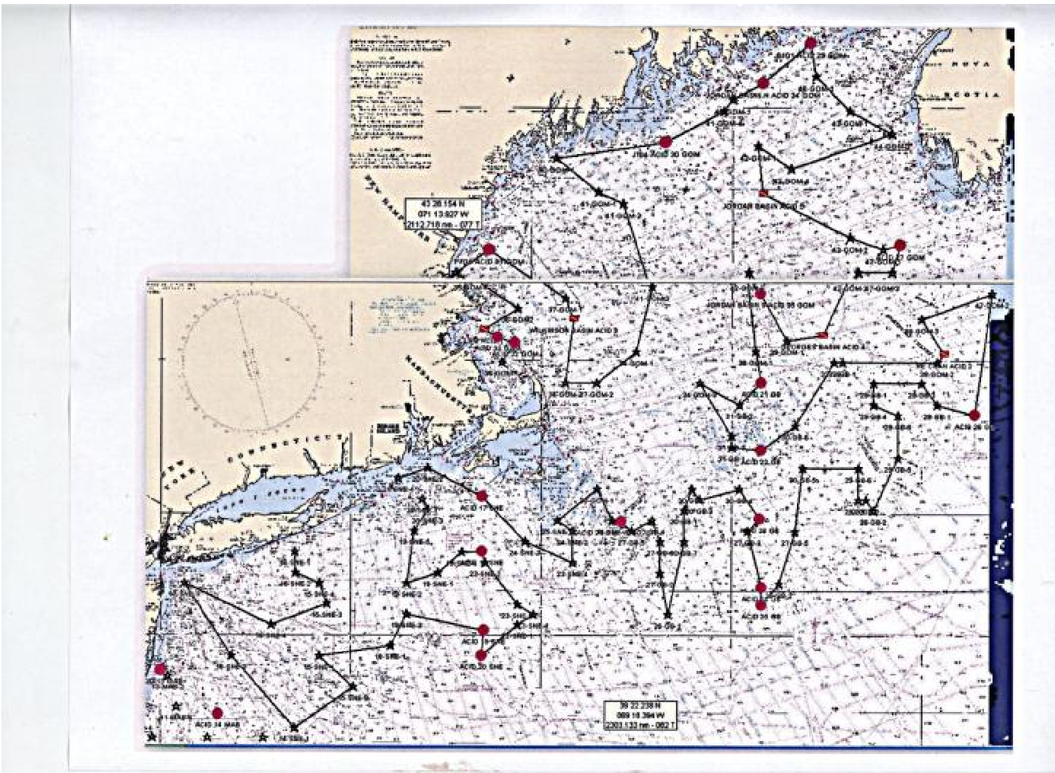

Figure 1. Proposed cruise track for *Okeanos Explorer* Summer Ecosystems Monitoring Survey, during 23 August – 4 September 2013. (Image from [1])

Note: Objectives # 8 and 10 are addressed in this report.

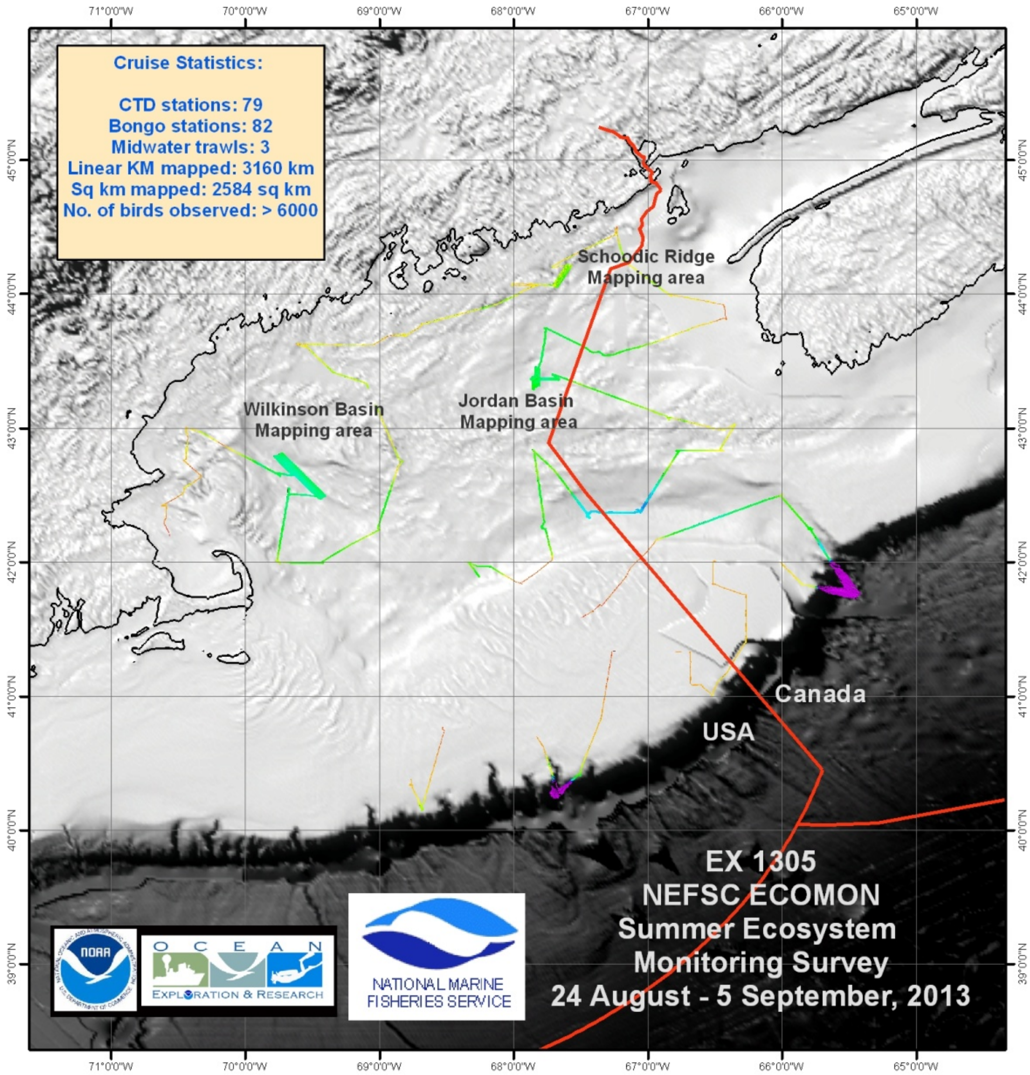

Figure 2: Multibeam data collected during EX1305.

4. Participating Personnel

NAME	ROLE	AFFILIATION
CDR Ricardo Ramos	Commanding Officer	NOAA Corps
ENS Kasey Sims	Field Operations Officer	NOAA Corps
Jerry Prezioso	Chief Scientist	NOAA/NMFS Narragansett, RI
Tamara Holzwarth-Davis	Oceanography operations	NOAA/NMFS Woods Hole, MA
Cristina Bascunan	Oceanography operations	NOAA/NMFS Woods Hole, MA
Liwei Zhu	Student volunteer	URI / GSO Narragansett, RI
Jenna Martin-Fisher	Student volunteer	University of Maine
Patrick Bledsoe	Student volunteer	URI/GSO Narragansett, RI
Jacklyn James	Suvery technician	NOAA OMAO
Mashkoor Malik	Mapping Specialist	NOAA OER Silver Spring, MD
Emily Brownlee	FlowCytobot Specialist	WHOI Woods Hole, MA

Nicholas Metheny	Marine mammal/bird observer	CUNY Staten Island, NY
Glen Davis	Marine mammal/bird observer	CUNY Staten Island, NY

5. Summary of Results

The cruise included EK60 single beam mapping through out the cruise. While, EM 302 data collection was attempted round the clock, the sound speed profiles were not collected regularly as the cruise was not staffed for 24 hours of multibeam operations. However, the bongo stations and CTD cast stations provided opportunistic sound speed casts for multibeam sonar. The frequency of these available sound speed casts, however, varied between 4-12 hours. At times, the system would loose the bottom tracking and was not able to regain the bottom without user intervention.

An example of such a case is included below:

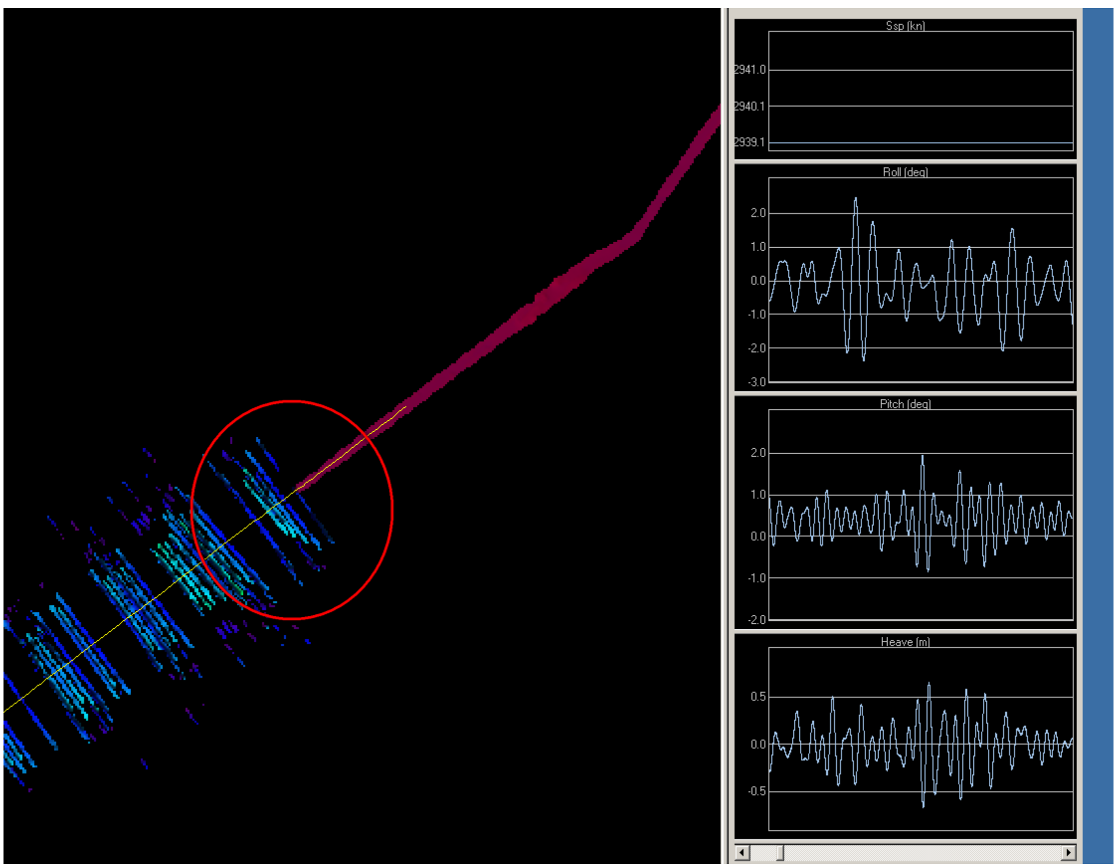

Figure 3: An example of EM 302 lossing bottom. The red circle denotes where the bottom was lost. The panel on the right shows the ship's attitude at the time. Image from CARIS HIPS.

Besides opportunistic data collection round the clock, three sites were mapped during this cruise. These sites included Jordan basin, Schoodic Ridge and Wilkinson Basin. These sites were chosen based on feed back from several scientists including Dr. Peter Auster (Univ. of Conn.), Andy Armstrong (JHC/UNH) and assessment of the previsouly unmapped areas in the Gulf of Maine based on data held at NGDC.

a. EK 60 operations

A team of scientists from NEFSC carried out calibration of EK 60 using a standard sphere method on 24 August 2013. The calibration report is included as Appendix E.

Round the clock EK 60 operations were conducted. Most of times, the system was not monitored during real time. The EK 60 data were visually inspected for any distinct features/ failures daily but detailed analysis of the EK 60 data was not performed onboard.

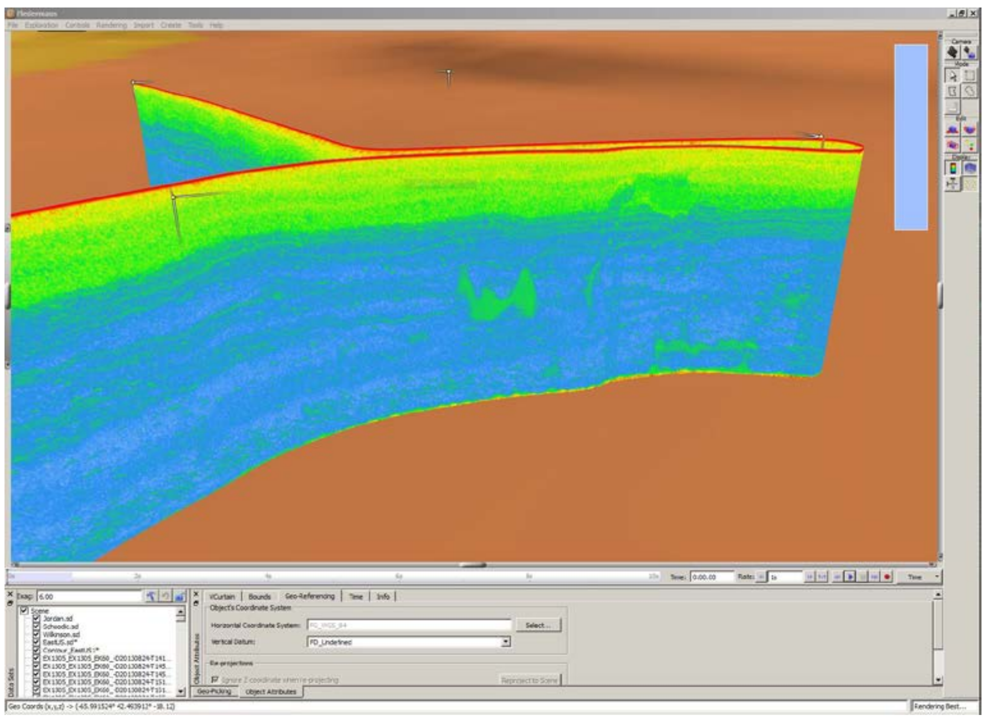

Figure 4: Examples of EK 60 curtain displayed in the QPS Fledermaus. A large fish school is visible in the middle of the image.

b. Jordan Basin Mapping

The resulting map in the Jordan basin is shown below:

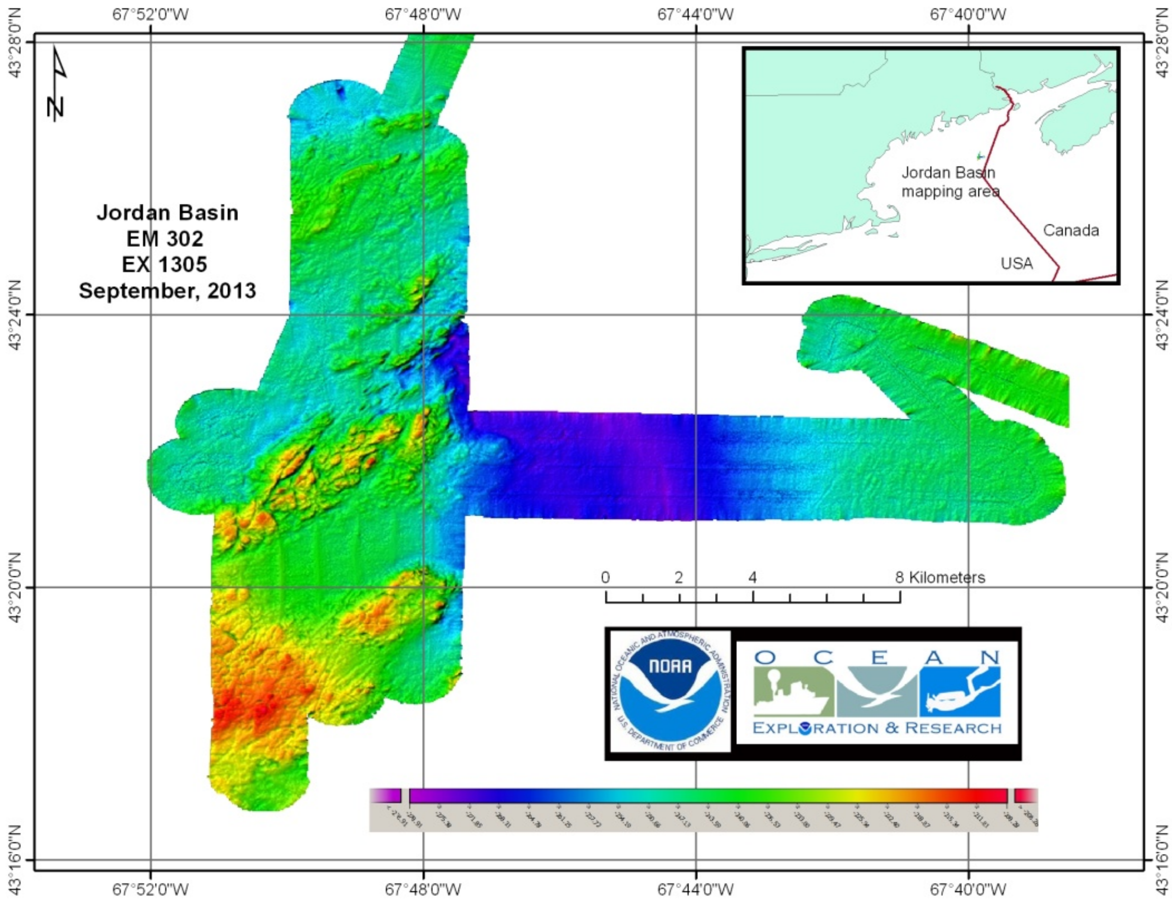

Figure 5: Bathymetric data collected in vicinity of Jordan Basin.

c. *Schoodic Ridge mapping*

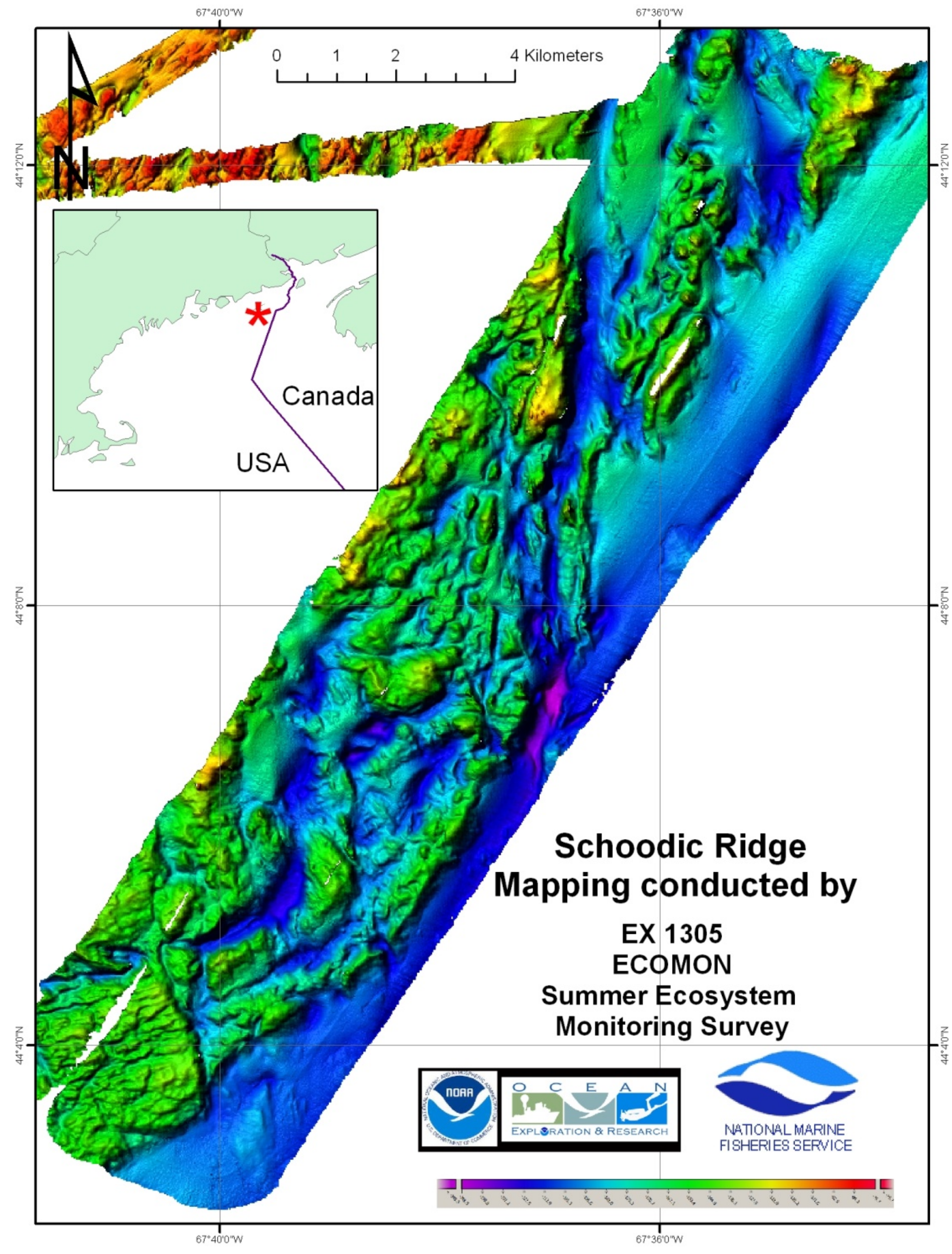

Figure 6: Bathymetric collected in vicinity of Schoodic Rdge.

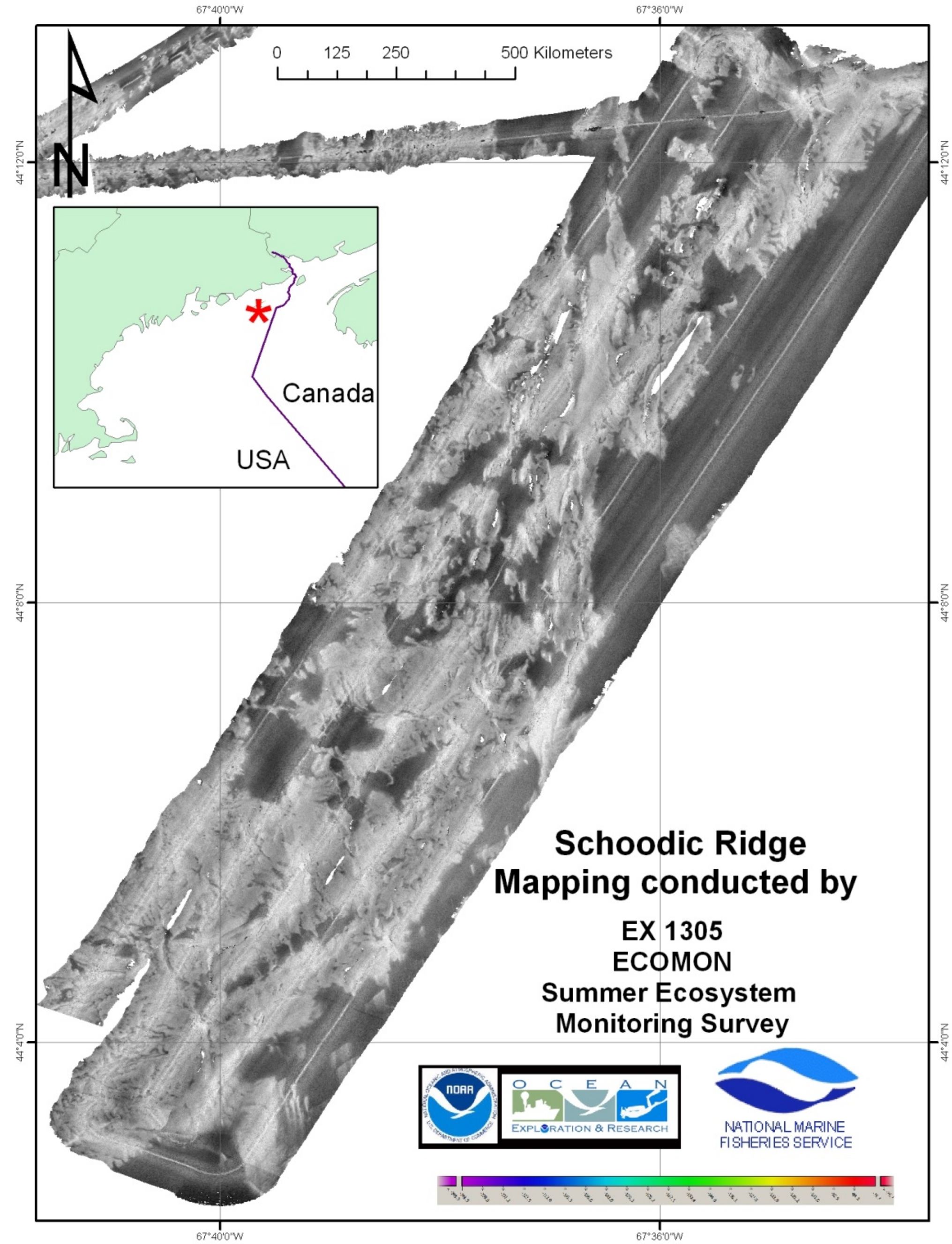

Figure 7: Backscatter collected in vicinity of Schoodic Ridge.

d. *Wilkinson basin focused mapping areas*

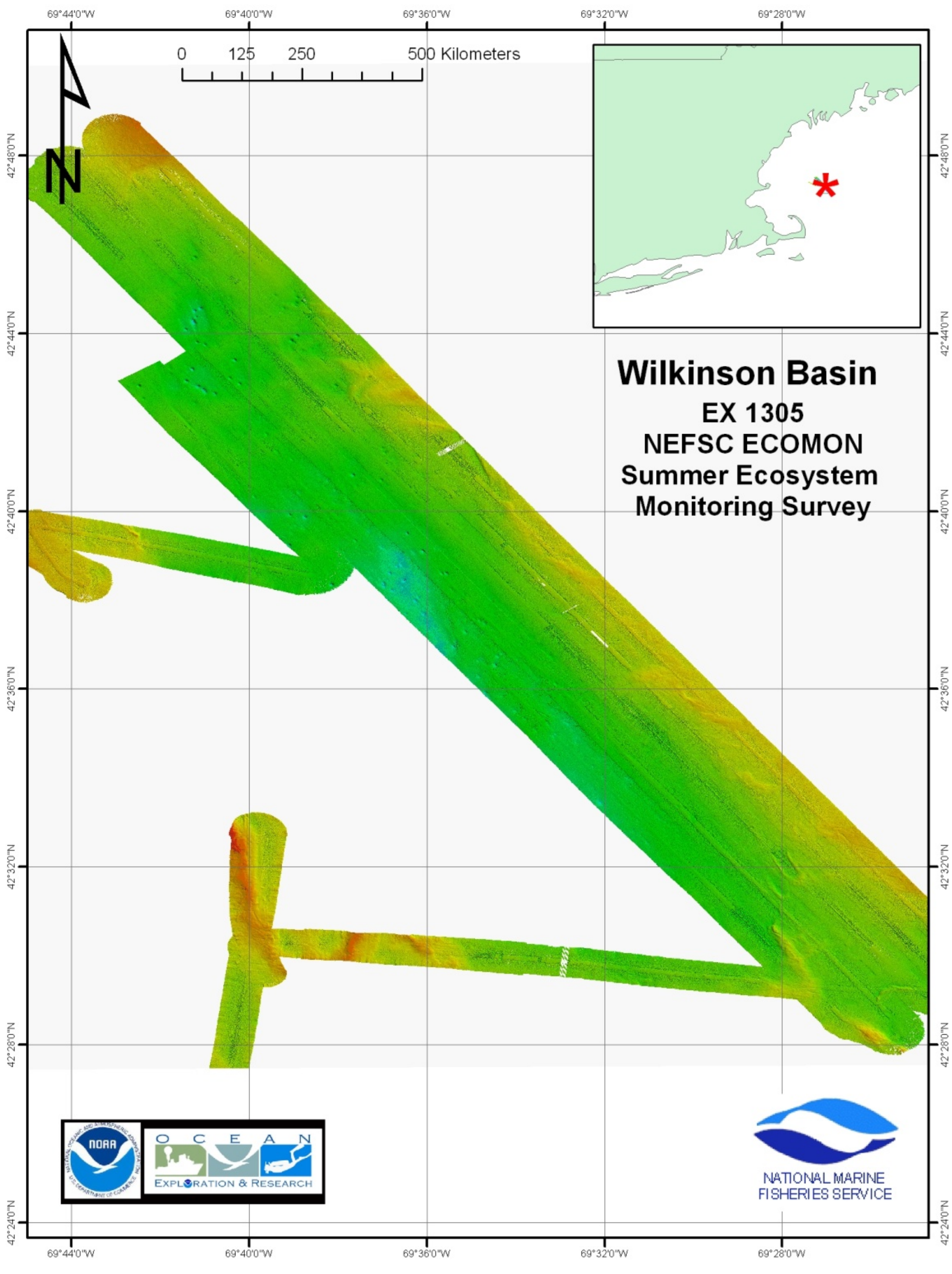

Figure 8: Bathymetry collected in location of Wilkinson Basin.

Various circular features were visible in the Wilkinson basin. No associated gas signals were observed in the water column data.

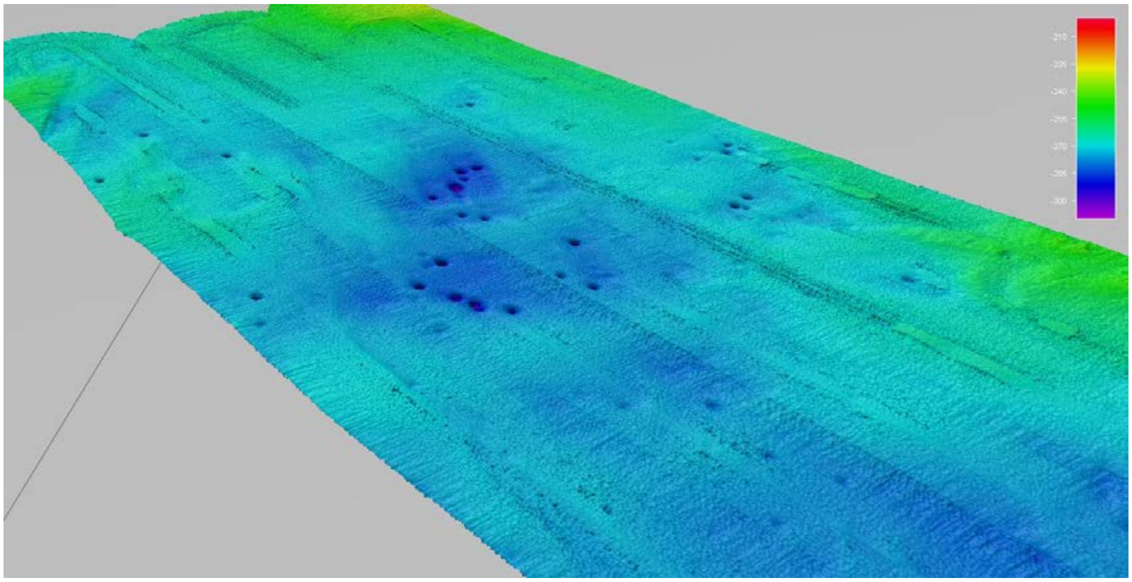

Figure 9: Circular features observed in Wilkinson basin.

6. Mapping Statistics

Dates	08/24/13-09/05/13
Weather delays	0 day
Total non-mapping days	12 days
Total survey mapping days	1 days
Total transit mapping days	11 days
Line kilometers of survey	3160 km
Square kilometers mapped	2584 sq km
Number of bathymetric multibeam files	209
Data volume of raw multibeam data files	41.3 GB
Number of water column multibeam files	209
Data volume of water column multibeam files	139 GB
Number of XBT casts	5
Number of CTD casts	79
Beginning draft	14'9" forward, 14'4" aft
Ending draft	14'3" forward, 14'2.5" aft
Average ship speed for survey	Not applicable

7. Mapping Sonar Setup

The NOAA Ship *Okeanos Explorer* is equipped with a 30 kHz Kongsberg EM 302 multibeam sonar. Appendix B contains a detailed description of sonar system functionality and technical specifications. For this cruise no changes were made to the standard setup of the mapping sonars onboard.

8. Data Acquisition and processing summary

Multibeam sonar (EM 302) data were acquired using Kongsberg Seafloor Information System (SIS ver. 3.6.4). SIS system accounts for all the static offsets and biases during real time acquisition. The motion data from the POS MV 320 (Ver. 4.0.2.0) was directly fed into SIS during data acquisition to account for ship motion (i.e. heave, roll, pitch). Yaw data was provided by the TSS gyro-compasses located on the bridge. Also the real time sound speed near the sonar head (dually measured by Reson Sound Speed sensor and a CTD sensor installed in proximity to the EM 302 receiver) was fed into SIS and the most updated acquired sound speed profile was used in real time to correct soundings for sound speed corrections during data acquisition. Unless there are problems observed in the data, there is no requirement to apply these corrections during post processing. The water column backscatter were collected all the time (except for few files listed in the multibeam data files list) which were recorded into separate to bottom bathymetry and backscatter data as *.wcd files.

CARIS HIPS/SIPS v.7.1.2 SP 2 was used to edit the bathymetric data from the EM 302 multibeam. Edited data was exported to ASCII text files and then imported to QPS Fledermaus Ver. 7.3.4 Build 371 for further processing, visualization, quality control, and product generation.

EK 60 data were collected using Kongsberg GPT firm ware version 2.2.1 in the *.raw data file format.

The QPS Fledermaus MidWater software package (Ver. 7.3.4 Build 371) was used to process EM 302 water column backscatter and EK 60 data and view the resulting Fledermaus SD objects. The programs are the best method available to the mapping department for water column data processing.

EM 302 Trouble Shooting

In flat seafloor areas, it was noticed that bottom tracking algorithm is not working properly This was mostly evident in the featureless seafloor regions. Although not conclusive, but it is suspected that this problem was most prevalent to the softer sediment seafloor types. The problem was also more pronounced in the near nadir region in the area where amplitude detection is employed. More than one distinct, with almost similar amplitude returns were observed near the most likely seafloor location in the water column data (Figure ?).

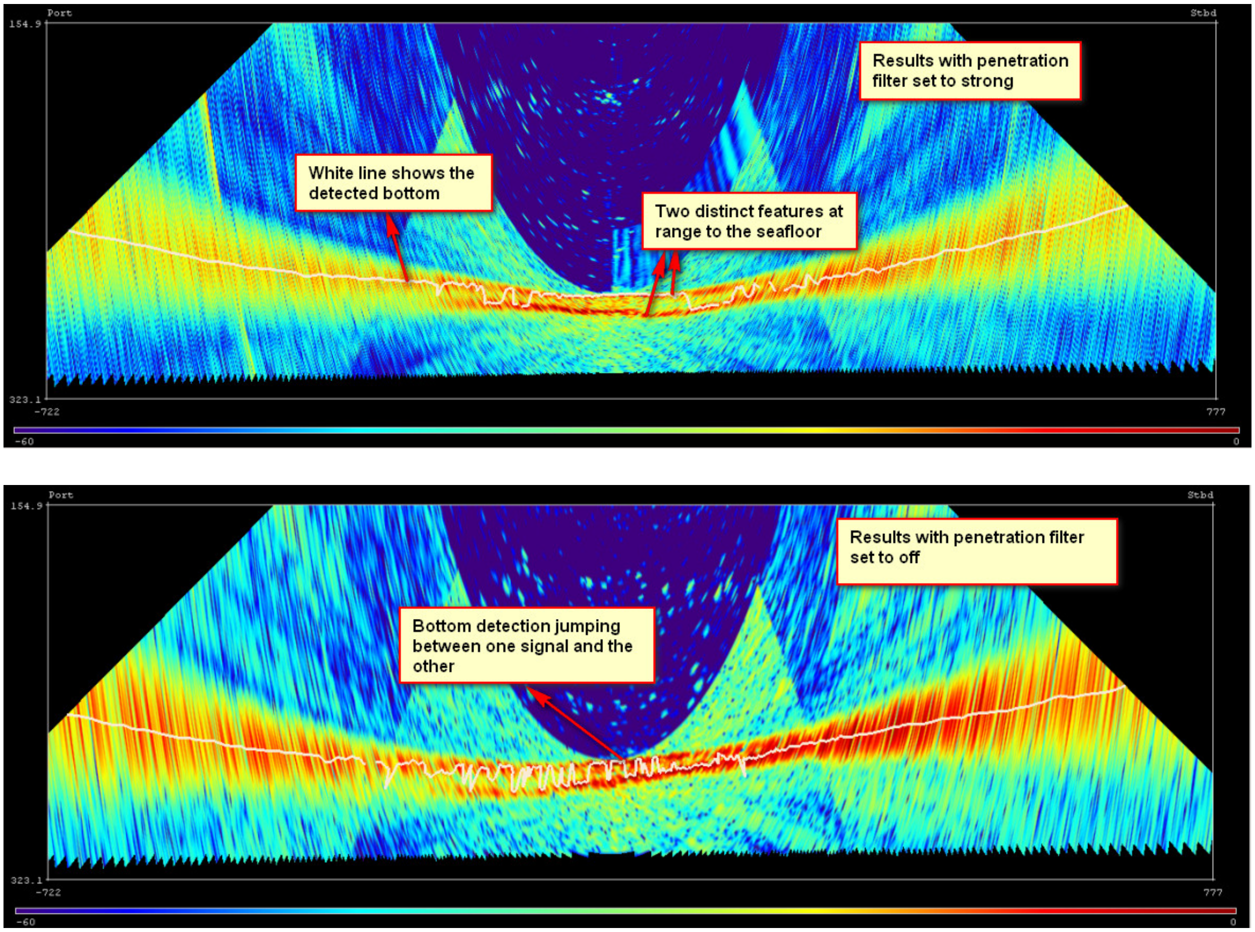

Figure 10: Water column display showing distinct targets very close to the seafloor.

Anticipating that this problem may be related to the absorption in the upper layer of the seafloor, user controlled filters (spike filter, penetration filter: Filters and gains in SIS display) were enabled, which resulted in the picking of the shallowest return from the seafloor. This approach however, did not work well in all the areas where the deeper signal appear to be return from the seafloor. The two signals in the water colmn display were observed to differ as much as 10-20 m (Figure 11). At time of compilation of this report, the cause or rectification of this issue is not known. A support request is being generated for the EM302 manufacturer (Kongsberg, Inc).

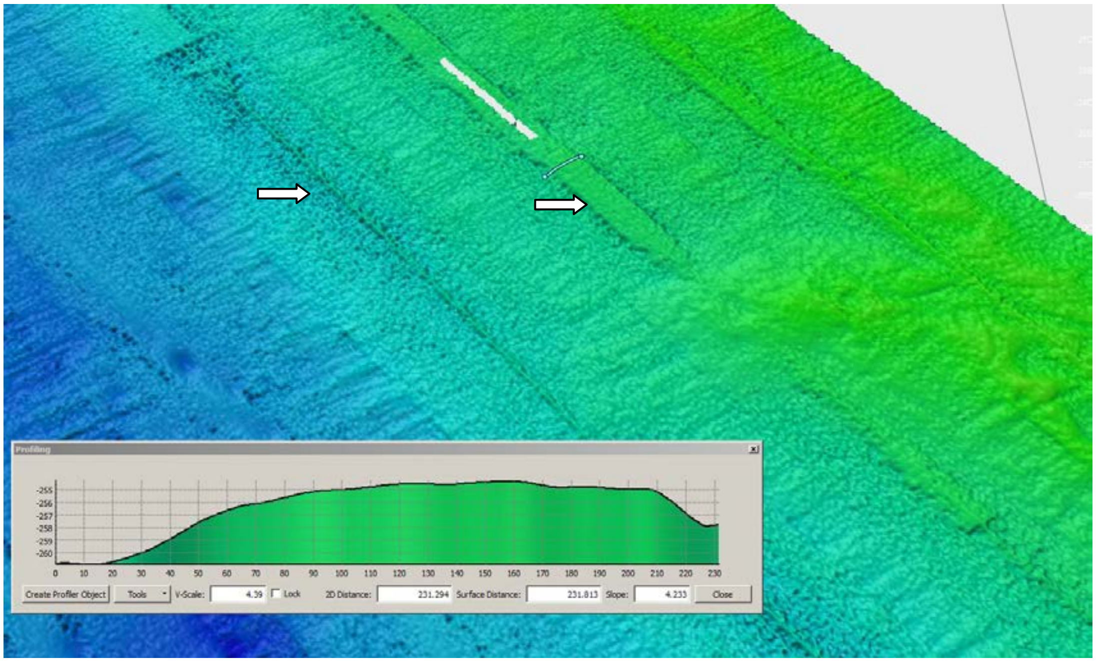

Figure 11: Artifacts resulting due to the inaccurate bottom tracking. The ridge like structure follows the ship track and can be as high as 5-15 m from the surrounding seafloor. The arrows indicate the ridge like structure or high noise in the data corresponding to the filter used as shown in the figure 10.

As editing of the artifact creates large data holidays, it was experimented with to leave the user controlled filters off and the system determine which signal is related to the seafloor. This resulted in system jumping between two signals and resulting data contained high noise. However, this was determined to be a better solution as the data editing is possible to some extent. It is realized that both situations result in sub-optimal quality data.

9. Data Archival Procedures

All the underway data collceted by SCS, EM 302 and EK 60 data from the cruise are being prepared to be submitted to NCDDC where the data are being prepared for onward submission to the archival centers. Following is the brief data pipeline excerpts from Data management plan, EX1305.

“All station and biological data will be electronically recorded. At the completion of the cruise, all data will be electronically transmitted to the NEFSC data management system based in Woods Hole, MA. Samples and data collected for specific individuals, agencies or organizations will be processed by same. Plankton samples will be processed through the NEFSC laboratory in Narragansett, RI. Data from the CTD will be processed at the NEFSC Woods Hole Laboratory.

Data collected by Okeanos Explorer underway systems will be documented and processed by OER and data center personnel in accordance with NAO 216-101, and according to processes detailed in the NOAA Ship Okeanos Explorer FY13 Data Management Plan [3], Section VII Data and Product Pipelines (A) Oceanographic Data Archive Pipeline and (B) Multibeam Data Archive Pipeline. Specifically, the Okeanos Explorer telepresence system and two-body ROV system will not be employed on EX1305 and those procedures will not be implemented. Receipt of archive confirmation is anticipated 60-90 days post cruise and will be forwarded to the Commanding Officer and to the Chief Scientist.

Note: The Chief Scientist has verified that all data will be available for public release."

10. Cruise Calendar

Mon	Tue	Wed	Thu	Fri	Sat	Sun
				23 Aug Mission party arrives onboard. Fueling operations in progresss.	24 Aug Ship departed N. Kingstown, RI. Conducted EK 60 calibration. EK 60 calibration team dropped off via small boat.	25 Aug Commenced sampling at designated stations.
26 Aug Continue sampling and EK 60 data acquistion	27 Aug Continue Sampling and EK 60 data acquistion	28 Aug Continue sampling and EK 60 data acquisition	29 Aug Continue sampling and EK 60 data acquisition	30 Aug Continue sampling and EK 60 data acquisition	31 Aug Completed Jordan Basin mapping. Continue sampling and EK 60 data acquistion	1 Sept Completed Schoodic Ridge mapping. Continue sampling and EK 60 data acquistion
2 Sept Continue sampling and EK 60 data acquisition	3 Sept Continue sampling and EK 60 data acquisition. Wilkinson basin mapping conducted	4 Sept Continue sampling and EK 60 data acquisition. EM 302 data acquisition secured. EK 60 data acquistion secured.	5 Sept Arrive North Kingstown, RI			

11. References

[1] Lobecker, E., Malik, M., Nadeau, M. and Skarke, A., Mapping Systems Readiness Report 2012, NOAA Ship *Okeanos Explorer*, March 2012.

[2] North East Fisheries Science Center, Project instructions, Summer Ecosystem Monitoring Survey, 26 July 2013.

[3] Gottfried, S., Okeanos Explorer, FY 13 Data management Plan, February 2013.

12. Appendices

Appendix A: Tables of data files collected

Table of Multibeam EM 302 files collected. File Name format:
Line Number _ Date_Time_CruiseID_MB.all

Multibeam File	Water Column file	Comments
0000_20130826_043104_EX1305_MB	0000_20130826_043104_EX1305_MB.wcd	
0001_20130826_063104_EX1305_MB	0001_20130826_063104_EX1305_MB.wcd	
0002_20130826_083104_EX1305_MB	0002_20130826_083104_EX1305_MB.wcd	
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0081_20130831_095850_EX1305_MB	0081_20130831_095850_EX1305_MB.wcd	Jordan Basin mapping
0082_20130831_100808_EX1305_MB	0082_20130831_100808_EX1305_MB.wcd	Jordan Basin mapping
0083_20130831_110401_EX1305_MB	0083_20130831_110401_EX1305_MB.wcd	Jordan Basin mapping
0084_20130831_111538_EX1305_MB	0084_20130831_111538_EX1305_MB.wcd	Jordan Basin mapping
0085_20130831_114544_EX1305_MB	0085_20130831_114544_EX1305_MB.wcd	Jordan Basin mapping
0086_20130831_114956_EX1305_MB	0086_20130831_114956_EX1305_MB.wcd	Jordan Basin mapping
0087_20130831_121924_EX1305_MB	0087_20130831_121924_EX1305_MB.wcd	Jordan Basin mapping
0088_20130831_125048_EX1305_MB	0088_20130831_125048_EX1305_MB.wcd	Jordan Basin mapping
0089_20130831_125456_EX1305_MB	0089_20130831_125456_EX1305_MB.wcd	Jordan Basin mapping
0090_20130831_134313_EX1305_MB	0090_20130831_134313_EX1305_MB.wcd	Jordan Basin mapping
0091_20130831_134807_EX1305_MB	0091_20130831_134807_EX1305_MB.wcd	Jordan Basin mapping
0092_20130831_140329_EX1305_MB	0092_20130831_140329_EX1305_MB.wcd	Jordan Basin mapping
0093_20130831_140803_EX1305_MB	0093_20130831_140803_EX1305_MB.wcd	Jordan Basin mapping
0094_20130831_142446_EX1305_MB	0094_20130831_142446_EX1305_MB.wcd	Jordan Basin mapping
0095_20130831_142832_EX1305_MB	0095_20130831_142832_EX1305_MB.wcd	Jordan Basin mapping
0096_20130831_144750_EX1305_MB	0096_20130831_144750_EX1305_MB.wcd	Jordan Basin mapping
0097_20130831_145307_EX1305_MB	0097_20130831_145307_EX1305_MB.wcd	Jordan Basin mapping
0098_20130831_151920_EX1305_MB	0098_20130831_151920_EX1305_MB.wcd	Jordan Basin mapping
0099_20130831_152351_EX1305_MB	0099_20130831_152351_EX1305_MB.wcd	Jordan Basin mapping
0100_20130831_155033_EX1305_MB	0100_20130831_155033_EX1305_MB.wcd	Jordan Basin mapping
0101_20130831_165032_EX1305_MB	0101_20130831_165032_EX1305_MB.wcd	
0102_20130831_175032_EX1305_MB	0102_20130831_175032_EX1305_MB.wcd	
0103_20130831_185032_EX1305_MB	0103_20130831_185032_EX1305_MB.wcd	
0104_20130831_195033_EX1305_MB	0104_20130831_195033_EX1305_MB.wcd	
0105_20130831_205033_EX1305_MB	0105_20130831_205033_EX1305_MB.wcd	
0106_20130831_215032_EX1305_MB	0106_20130831_215032_EX1305_MB.wcd	
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0108_20130831_235032_EX1305_MB	0108_20130831_235032_EX1305_MB.wcd	
0109_20130901_005032_EX1305_MB	0109_20130901_005032_EX1305_MB.wcd	
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0111_20130901_025032_EX1305_MB	0111_20130901_025032_EX1305_MB.wcd	
0112_20130901_035032_EX1305_MB	0112_20130901_035032_EX1305_MB.wcd	
0113_20130901_045032_EX1305_MB	0113_20130901_045032_EX1305_MB.wcd	
0114_20130901_055032_EX1305_MB	0114_20130901_055032_EX1305_MB.wcd	

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0116_20130901_075032_EX1305_MB	0116_20130901_075032_EX1305_MB.wcd	
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0119_20130901_105032_EX1305_MB	0119_20130901_105032_EX1305_MB.wcd	
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0123_20130901_145033_EX1305_MB	0123_20130901_145033_EX1305_MB.wcd	
0124_20130901_155033_EX1305_MB	0124_20130901_155033_EX1305_MB.wcd	Schoodic Ridge mapping
0125_20130901_161637_EX1305_MB	0125_20130901_161637_EX1305_MB.wcd	Schoodic Ridge mapping
0126_20130901_171637_EX1305_MB	0126_20130901_171637_EX1305_MB.wcd	Schoodic Ridge mapping
0127_20130901_172208_EX1305_MB	0127_20130901_172208_EX1305_MB.wcd	Schoodic Ridge mapping
0128_20130901_182208_EX1305_MB	0128_20130901_182208_EX1305_MB.wcd	Schoodic Ridge mapping
0129_20130901_183934_EX1305_MB	0129_20130901_183934_EX1305_MB.wcd	Schoodic Ridge mapping
0130_20130901_184328_EX1305_MB	0130_20130901_184328_EX1305_MB.wcd	Schoodic Ridge mapping
0131_20130901_194327_EX1305_MB	0131_20130901_194327_EX1305_MB.wcd	Schoodic Ridge mapping
0132_20130901_195407_EX1305_MB	0132_20130901_195407_EX1305_MB.wcd	Schoodic Ridge mapping
0133_20130901_205407_EX1305_MB	0133_20130901_205407_EX1305_MB.wcd	Schoodic Ridge mapping
0134_20130901_210616_EX1305_MB	0134_20130901_210616_EX1305_MB.wcd	Schoodic Ridge mapping
0135_20130901_211139_EX1305_MB	0135_20130901_211139_EX1305_MB.wcd	Schoodic Ridge mapping
0136_20130901_221139_EX1305_MB	0136_20130901_221139_EX1305_MB.wcd	Schoodic Ridge mapping
0137_20130901_221537_EX1305_MB	0137_20130901_221537_EX1305_MB.wcd	Schoodic Ridge mapping
0138_20130901_231537_EX1305_MB	0138_20130901_231537_EX1305_MB.wcd	
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0140_20130902_011538_EX1305_MB	0140_20130902_011538_EX1305_MB.wcd	
0141_20130902_021538_EX1305_MB	0141_20130902_021538_EX1305_MB.wcd	
0142_20130902_031537_EX1305_MB	0142_20130902_031537_EX1305_MB.wcd	
0143_20130902_041538_EX1305_MB	0143_20130902_041538_EX1305_MB.wcd	
0144_20130902_051538_EX1305_MB	0144_20130902_051538_EX1305_MB.wcd	
0145_20130902_061538_EX1305_MB	0145_20130902_061538_EX1305_MB.wcd	
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0166_20130903_031445_EX1305_MB	0166_20130903_031445_EX1305_MB.wcd	
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0168_20130903_051445_EX1305_MB	0168_20130903_051445_EX1305_MB.wcd	
0169_20130903_061445_EX1305_MB	0169_20130903_061445_EX1305_MB.wcd	
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0171_20130903_081444_EX1305_MB	0171_20130903_081444_EX1305_MB.wcd	
0172_20130903_091445_EX1305_MB	0172_20130903_091445_EX1305_MB.wcd	Wilkinson Basin mapping
0173_20130903_101445_EX1305_MB	0173_20130903_101445_EX1305_MB.wcd	Wilkinson Basin mapping
0174_20130903_111445_EX1305_MB	0174_20130903_111445_EX1305_MB.wcd	Wilkinson Basin mapping
0175_20130903_121445_EX1305_MB	0175_20130903_121445_EX1305_MB.wcd	Wilkinson Basin mapping
0176_20130903_124002_EX1305_MB	0176_20130903_124002_EX1305_MB.wcd	Wilkinson Basin mapping
0177_20130903_134002_EX1305_MB	0177_20130903_134002_EX1305_MB.wcd	Wilkinson Basin mapping
0178_20130903_134823_EX1305_MB	0178_20130903_134823_EX1305_MB.wcd	Wilkinson Basin mapping
0179_20130903_144823_EX1305_MB	0179_20130903_144823_EX1305_MB.wcd	Wilkinson Basin mapping
0180_20130903_154824_EX1305_MB	0180_20130903_154824_EX1305_MB.wcd	Wilkinson Basin mapping
0181_20130903_161623_EX1305_MB	0181_20130903_161623_EX1305_MB.wcd	Wilkinson Basin mapping
0182_20130903_162246_EX1305_MB	0182_20130903_162246_EX1305_MB.wcd	Wilkinson Basin mapping
0183_20130903_172246_EX1305_MB	0183_20130903_172246_EX1305_MB.wcd	Wilkinson Basin mapping
0184_20130903_182247_EX1305_MB	0184_20130903_182247_EX1305_MB.wcd	Wilkinson Basin mapping
0185_20130903_185804_EX1305_MB	0185_20130903_185804_EX1305_MB.wcd	Wilkinson Basin mapping
0186_20130903_190544_EX1305_MB	0186_20130903_190544_EX1305_MB.wcd	Wilkinson Basin mapping
0187_20130903_200544_EX1305_MB	0187_20130903_200544_EX1305_MB.wcd	Wilkinson Basin mapping
0188_20130903_210544_EX1305_MB	0188_20130903_210544_EX1305_MB.wcd	Wilkinson Basin mapping
0189_20130903_212637_EX1305_MB	0189_20130903_212637_EX1305_MB.wcd	Wilkinson Basin mapping
0190_20130903_222637_EX1305_MB	0190_20130903_222637_EX1305_MB.wcd	Wilkinson Basin mapping
0191_20130903_232637_EX1305_MB	0191_20130903_232637_EX1305_MB.wcd	Wilkinson Basin mapping
0192_20130903_235705_EX1305_MB	0192_20130903_235705_EX1305_MB.wcd	Wilkinson Basin mapping
0193_20130904_005704_EX1305_MB	0193_20130904_005704_EX1305_MB.wcd	Wilkinson Basin mapping
0193_20130904_005704_EX1305_MB	0194_20130904_015704_EX1305_MB.wcd	Wilkinson Basin mapping
0194_20130904_015704_EX1305_MB	0195_20130904_025705_EX1305_MB.wcd	Wilkinson Basin mapping
0195_20130904_025705_EX1305_MB	0196_20130904_032604_EX1305_MB.wcd	Wilkinson Basin mapping

0196_20130904_032604_EX1305_MB	0197_20130904_042604_EX1305_MB.wcd	Wilkinson Basin mapping
0197_20130904_042604_EX1305_MB	0198_20130904_052605_EX1305_MB.wcd	Wilkinson Basin mapping
0198_20130904_052605_EX1305_MB	0199_20130904_062604_EX1305_MB.wcd	Wilkinson Basin mapping
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0204_20130904_112604_EX1305_MB	0205_20130904_122604_EX1305_MB.wcd	
0205_20130904_122604_EX1305_MB	0206_20130904_132604_EX1305_MB.wcd	
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Appendix B: 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. The optimal depth for EM 302 has been found to be > 150 m.

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 multi-ping 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					
			Alongtrack distance between profiles (m)		
Water depth (m)	**Swath Width (m)**	**Ping Rate**	**@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.

Appendix C: Acronyms and abbreviations

BOEM: Bureau of Ocean Energy Management
CCOM: Center for Coastal and Ocean Mapping (UNH)
CTD: Conductivity, Temperature, Depth
EEZ: Exclusive Economic Zone
ERT Inc: Earth Resources Technologies, Inc
GSO: Graduate School of Oceanography (URI)
JHC: Joint Hydrographic Center (UNH)
MBES: Multibeam Echo Sounder
NCDDC: National Coastal Data Development Center
NMFS: National Marine Fisheries Service
NEFSC: North East Fisheries Science Center
NGDC: National Geophysical Data Center
NOAA: National Oceanic and Atmospheric Administration
OER: Office of Ocean Exploration and Research
OMAO: Office of Marine and Aviation Operations
SCS: Shipboard Computer System
SOP: Standard Operating Procedure
SST: Senior Survey Technician
ST: Survey Technician
UCAR: University Corporation for Atmospheric Research
UNH: University of New Hampshire
URI: University of Rhode Island
USGS: United States Geological Survey
XBT: Expendable Bathy Thermograph
CSIRO: The Commonwealth Scientific and Industrial Research Organisation

APPENDIX D:

CANADIAN FOREIGN FISHING VESSEL lICENCE

Fisheries and Oceans Pêches et Océans

FOREIGN FISHING VESSEL LICENCE **LICENCE DES BÂTIMENTS DE PÊCHES ÉTRANGERS**

COUNTRY: USA

VESSEL: OKEANOS EXPLORER

LICENCE NO: 000010

AMENDMENT NO: 0

(Replaces all Previous Licences)

Canadä

Fisheries and Oceans | Pêches et Océans

FOREIGN FISHING VESSEL LICENCE — LICENCE DES BÂTIMENTS DE PÊCHES ÉTRANGERS

Licence No 000010
Year: 2013

OKEANOS EXPLORER

Page No: 2
Amendment No: 0

VESSEL SPECIFICATIONS

Vessel: OKEANOS EXPLORER
Country: USA
Port of Registry: WOODS HOLE (MASS)
Side No: 337
Call Sign: WTDH
Registered No: R337

Length (m):
Crew:
Net Tonnage (t): 1616.0
Gross Tonnage (t): 2312.0
Calling Freq:
Working Freq:

Description of Vessel:

Type: RESEARCH VESSEL (FOREIGN)
Hull Colour: WHITE
Built: MOSS POINT, MISS, 1988

Log Book Information:

Fishing Log:
Production Log:
Transshipment Log:

Owner:

NOAA
NATIONAL MARINE FISHERIES SERVICE
166 WATER ST.

Master:

RAMOS, CDR RICARDO
NOAA, NATIONAL MARINE FISHERIES SERVIC

Agent:

KEITH, NATHAN
NOAA, NATIONAL MARINE FISHERIES SVC
166 WATER ST.
WOODS HOLE, MA 02543

Canada

Licence No 000010 **Year:** 2013	**OKEANOS EXPLORER**	**Page No:** 3 **Amendment No:** 0

1.0 REGIONAL DIRECTOR

The Regional Director-General designated under the Coastal Fisheries Protection Regulations for the purposes of this licence is the Regional Director-General of the Department of Fisheries and Oceans for the Maritimes Region.

2.0 AUTHORIZED ACTIVITIES

The above mentioned vessel, is authorized to enter that portion of Canadian Fisheries Waters known as Fishing Zone(s) 4, and to engage in fishing for the purposes of scientific research as described in this licence

2.1 AUTHORIZED COMMERCIAL FISHING ACTIVITIES

n/a

2.2 AUTHORIZED FISHERY SUPPORT ACTIVITIES

n/a

2.3 AUTHORIZED RESEARCH ACTIVITIES

The above mentioned vessel, is authorized to conduct the undernoted fisheries research:-

2.3.1 GENERAL RESEARCH

START DATE: August 19, 2013
END DATE: August 30, 2013
NORTHEAST CONTINENTAL SHELF ECOSYSTEM
(PELAGIC COMPONENTS)4X,5Y&GULF OF MAINE

2.4 AUTHORIZED PORT ACTIVITIES

n/a

3.0 FISHING AREAS

3.1 Known/expected coral concentrations occur in the areas of greater than 200 metres depth in Northeast Channel, along the edges of Georges Bank, and in the Jordan Basin area. These corals are considered important habitat and are the subject of conservation measures in Canadian waters. Caution should be taken to minimize gear interactions with corals if they are found during the study. (Contact: Glen Herbert; 902-426-9900; glen.herbert@dfo-mpo.gc.ca)

Survey will avoid the Northeast Channel Coral Conservation Area.

4.0 AUTHORIZED GEAR AND EQUIPMENT

4.1 Oceanographic Equipment

4.2 Mid-Water Trawl

4.3 Plankton nets (bongo)
CTD
Fluorometer
Thermosalinograph

5.0 PROHIBITED SPECIES

n/a

6.0 REPORTING REQUIREMENTS

6.1 The following reports shall be made via one of the three following methods:-

- via telephone (902) 426-9966, or,
- via fax (902) 426-5010, or,
- via e-mail licensing.dartmouth@dfo-mpo.gc.ca

6.2 In accordance with the Coastal Fisheries Protection Regulations the master of this vessel shall:-

(a) at least 24 hours prior to the entry of this vessel into Canadian fisheries waters, notify the Regional Director-General of the estimated time of entry of the vessel into such waters and the location of such entry.

(b) at least 24 hours prior to the entry and/or departure from a Canadian port this vessel shall notify the Regional Director-General of the estimated time of entry and/or departure of the vessel from such port.

(c) at lease 72 hours prior to the departure from Canadian fisheries waters, this vessel shall notify the Regional Director-General of the estimated time of departure of the vessel from such waters, and the location of such departure.

7.0 SPECIAL CONDITIONS

Licence No 000010 **Year:** 2013	**OKEANOS EXPLORER**	**Page No:** 5 **Amendment No:** 0

7.1 Master is to adhere to guidance contained in Canadian Coast Guard Annual Notice to Mariners: General Guidelines for Marine Mammal Critical Areas (5) for the Grand Manan Whale Sanctuary and Roseway Basin Area to Be Avoided.

While in vicinity of Bay of Fundy Vessel Traffic Services Zone, Master is to record and report North Atlantic right whale sightings to Canadian Coast Guard (Fundy Traffic, Channel 14). All whale records (post voyage) to be submitted to DFO (Contact: Lei Harris, 506-529-5838, lei.harris@dfo-mpo.gc.ca).

8.0 EXPLANATORY NOTES

8.1 Where in this licence a reference is made to a NAFO subarea, division or subdivision it means that subarea, division or subdivision described in ANNEX 111 of the "Convention on Future Multilateral Cooperation in the Northwest Atlantic Fisheries" that was ratified by Canada on November 30, 1978 and came into force on January 1, 1979.

8.2 Nothing in this licence shall be construed as authority under section 73 of the Species at Risk Act (SARA) to kill, harm, harass, capture or take an individual of a wildlife species that is listed as "extirpated", "endangered" or "threatened" as identified in Schedule 1 of SARA. If the activity authorized in this licence is expected to interact with an "extirpated", "endangered" or "threatened" species, you should apply for a harm permit within the terms of section 73 of SARA. For more information on SARA, phone: 1-866-891-0771 or go to www.sararegistry.gc.ca.;

FOREIGN FISHING VESSEL LICENCE | LICENCE DES BÂTIMENTS DE PÊCHES ÉTRANGERS

Licence No 000010 **Year:** 2013	**OKEANOS EXPLORER**	**Page No:** 6 of 6 **Amendment No:** 0

Issued By: Connie Farr

CONNIE FARR
FOREIGN LICENSING OFFICER

May 30, 2013
DATE

Approved By:

REGIONAL DIRECTOR

MAY 3 0 2013
DATE

Issued Location: HALIFAX

Appendix E: EK 60 calibration report

Okeanos Explorer EK60 calibration
Michael Jech, Joseph Godlewski
NEFSC, NMFS

The Simrad 18-kHz EK60 scientific echo sounder was calibrated at the Newport Naval anchorage in Narragansett Bay on 24 Aug. 2013. The Okeanos was anchored, 1-point anchor from the bow, in approximately 35 m of water. The 18-kHz system was calibrated using a 64-mm copper (Cu) sphere suspended underneath the split-beam transducer via three monofilament lines. The transducer had nominally 11o beam width (full angular beam width as measured at the half-power points). Transceiver settings, 1-ms pulse duration and 1 kW output power, were selected as they matched data collected by the Northeast Fisheries Science Center (NEFSC) during fisheries surveys. This was the first calibration of this system at these settings. As a result of this calibration, the transducer gain was set to 21.53 dB and the "SaCorrection" was set to -0.74 dB. These are modified from the default values of 22 dB and 0.0 dB for the transducer gain and SaCorrection, respectively.

The calibration sphere was suspended and moved throughout the acoustic beam using a wireless calibration system developed at the NEFSC. This system consists of three Cannon MAG-5HS Downriggers connected to an NEFSC designed Calibration Control Box (P/N EK60WCAL-10100) which provides power and control signals to the downrigger. (See Figure 1.) Each calibration control box contains a custom designed circuit board that provides the control signals for downrigger movement, as well as circuitry to read the quadrature signals (SIGA and SIGB) from the 3PS Encoder P/N QUAD101-01-01-01. The downrigger control signals are wirelessly transmitted to each calibration control box from a laptop PC in the Acoustics Lab of the research vessel. The control software ECHO_Cal is a JAVA-based GUI which allows the operator to control the movement of the downriggers using either on-screen buttons, or a CH Products IP Desktop joystick. The control software also provides an option to perform an automated movement of the sphere through the transducer beam without operator interaction. All control signals from the PC are transmitted wirelessly to each downrigger, eliminating the need to run cables to each downrigger position from the Acoustic Lab.

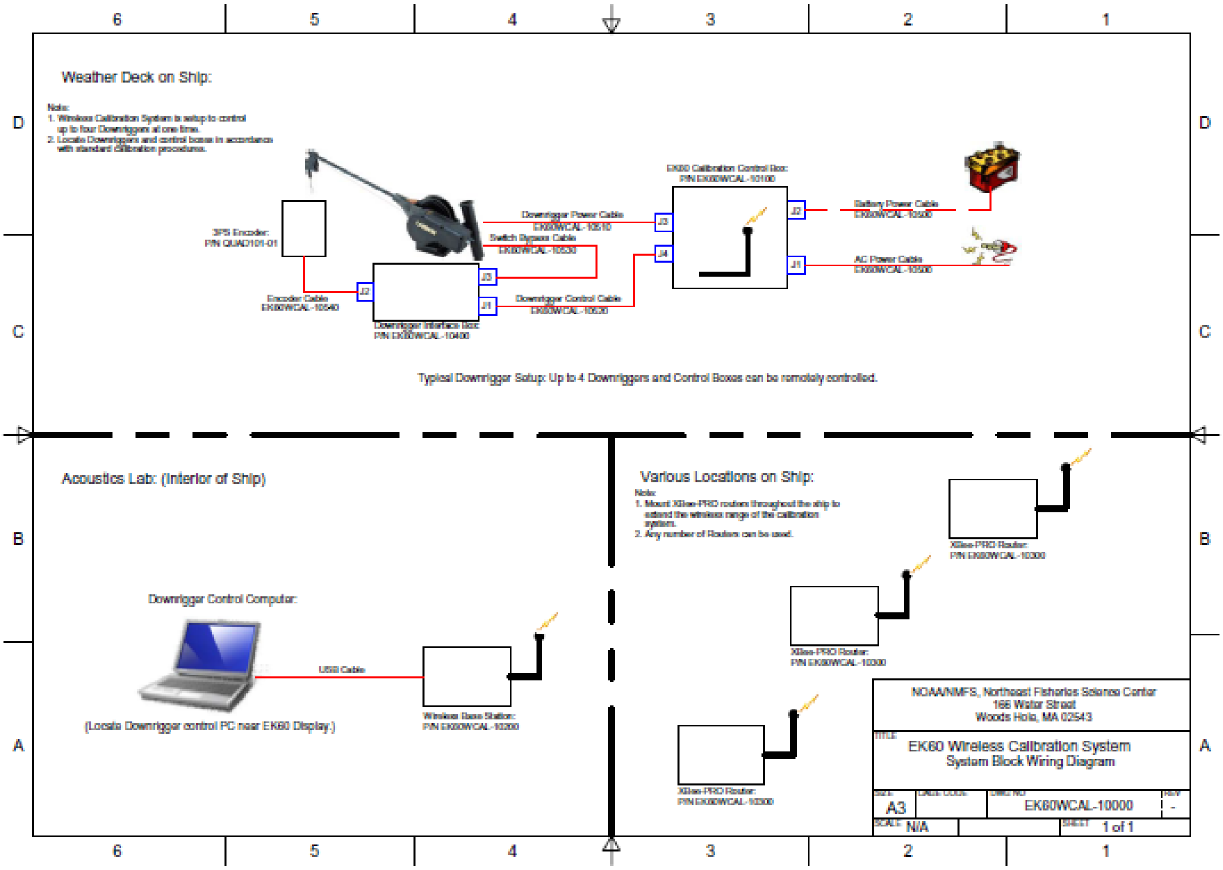

Figure 1. System Block Wiring Diagram