Exploration and Research of Mid-Atlantic Deepwater Hard Bottom Habitats and Shipwrecks With Emphasis on Canyons and Coral Communities

Cruise Report for the 2011 Multibeam Mapping Survey

Contract No. M10PC00100

Prepared for:

Gregory S. Boland
Contracting Officer's Representative
U.S. Department of the Interior
Bureau of Ocean Energy Management
381 Elden Street, MS 4041
Herndon, Virginia 20170-4817
Telephone: (703) 787-1711

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List of Preparers:

Steve W. Ross
Co-Chief Scientist
UNCW, Center for Marine Science
5600 Marvin Moss Lane
Wilmington, North Carolina 28409

Sandra D. Brooke
Co-Chief Scientist
Oregon Inst. Marine Biology
63466 Boat Basin Road
Charleston, Oregon 97420

CSA International, Inc.
8502 SW Kansas Avenue
Stuart, Florida 34997

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1. INTRODUCTION

CSA International, Inc. (CSA) is contracted to conduct three field sampling efforts, or cruises, associated with the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE)—funded contract "Exploration And Research Of Mid-Atlantic Deepwater Hard Bottom Habitats And Shipwrecks With Emphasis On Canyons And Coral Communities," Contract No. M10PC00100. This report describes the first cruise of the Canyons project field effort using the National Oceanic and Atmospheric Administration, Office of Ocean Exploration and Research's (NOAA, OER's) ship *Nancy Foster* (4-17 June 2011) to conduct mapping of the target study areas.

1.1 BACKGROUND AND OBJECTIVES

Submarine canyons are dominant features of the outer continental shelf and slope of the U.S. East Coast from Cape Hatteras, North Carolina to the Gulf of Maine. They are important conduits of anthropogenic pollutants, organic carbon, and sediments from shallow to deeper waters and support ecologically important ecosystems, such as cold seeps and hard bottom and coral habitats. The geology of these features has been well studied; however, despite their high productivity, biological data are limited (particularly deeper than 200 m). Much of the biological data available for these canyons is represented by unpublished reports, unanalyzed data sets, and anecdotal observations. The canyons between Cape Hatteras and Cape Cod, Massachusetts are the subject of potential oil exploration, intensive fisheries, and are possible National Marine Sanctuary candidates, yet are less well known than those further north.

In 2010, BOEMRE initiated a 4-year, multi-disciplinary "Atlantic Deepwater Canyons" study which focuses on ecologically significant habitats (cold seeps, hardbottoms, and shipwrecks) in Norfolk, Washington, and Baltimore canyons. One of the first activities preceding intense multidisciplinary sampling is to obtain detailed bathymetric maps of the major Mid-Atlantic canyons, which will help guide future sampling activities. Such multibeam sonar mapping was the primary activity during this cruise (**Figure 1**). The project study region was off Virginia, Maryland, and Delaware, including Norfolk, Washington, Accomac, and Baltimore canyons, and the areas surrounding them, in water depths of approximately 100-1,000 m (see **Figures 1-3**). Additional areas were mapped during the cruise, including a small wreck off North Carolina (as a system test), deep water survey lines going to and returning from the canyons study area, and a section of The Point off Cape Hatteras, North Carolina. Some multibeam surveys have already been conducted in the study area (**Figure 2**), and we prioritized those areas that had not been mapped (e.g., Baltimore Canyon, **Figure 2**) or that needed improved resolution over existing data (e.g., Norfolk Canyon area, **Figure 2**). Additional cruise activities included hydrographic profiles, water sampling, and searching for a benthic lander. Education and outreach activities were incorporated into the cruise using the North Carolina Museum of Natural Sciences' internet site. The internet site was established before the cruise to document progress and facilitate public awareness of the project. The site will be maintained and expanded as the project progresses and can be viewed at: http://naturalsciences.org/education/online-adventures. The objectives of the cruise were as follows:

1. Conduct multibeam sonar mapping of selected Middle Atlantic Bight deep water canyons, shipwreck sites, and surrounding areas and process data at sea to the extent possible.
2. Conduct hydrographic profiles of the water column to support multibeam mapping.
3. Collect water samples for analysis of aragonite saturation state and particulate organic matter (POM).
4. Attempt the retrieval of the Cape Lookout benthic lander (in route to and/or from study area).
5. Conduct limited education and outreach activities (internet postings, essays).

2.0 METHODS

2.1 SURVEY PERSONNEL

Participants for the survey are presented in **Table 1**. The science crew came from North Carolina, Washington, Florida, Rhode Island, and Massachusetts, assembling on the ship in Charleston, South Carolina on 3-4 June 2011. We conducted 24-hour operations. The scientific crew was divided into a day and a night watch.

Table 1. Multibeam Mapping Survey personnel, affiliations, and roles.

Name	Affiliation	Role
Dr. Steve W. Ross	University of North Carolina – Wilmington (UNCW)	Chief Scientist
Dr. Sandra Brooke	Oregon Institute of Marine Biology (OIMB)	Co-Chief Scientist
Dr. Rod Mather	University of Rhode Island (URI)	Scientist-archaeology
Dr. Daniel Brothers	USGS	Scientist-mapping
Dr. Jason Chaytor	USGS	Scientist-mapping
Megan Prescott	University of Washington (UW)	Student
Veronica Holton	College of Charleston	Student
Caitlin Casar	USGS	Student/technician

2.2 FIELD METHODS

Survey data collection included systematic multibeam sonar mapping, along with the collection of hydrographic profiles and seawater samples at discrete locations. This section presents a brief description of field data collection methods for these sampling parameters.

2.2.1 Multibeam Sonar Mapping

Most multibeam sonar mapping was conducted using a hull-mounted Simrad EM 1002, a 95 kHz echo sounder capable of mapping to water depths of approximately 1,000 m utilizing 111 beams per ping over a maximum coverage sector of 150° (equidistant beam spacing). A Reson 7125 multibeam system was used for mapping selected sites in shallower waters. This is a dual frequency system (200 and 400 kHz) capable of mapping at high resolution to water depths of about 300 m. Raw data were corrected for sound velocity and tidal variation and post-processed using Caris hydrographic and sonar data processing software (CARIS HIPS and SIPS, version 7.0) to produce bathymetric and backscatter maps. The multibeam mapping was conducted during transit at normal cruising speed, as well as slower speed (about 6 kn) for the major sites of interest.

2.2.2 Hydrographic Profiles and Water Sampling

Water column sampling was conducted using a recording hydrographic profile probe or CTD (conductivity, temperature, depth), mounted on a rosette sampler device fitted with water sampling bottles. Hydrographic profiles of the water column were collected at selected locations using a SeaBird 911*Plus* recording probe measuring turbidity using an accessory Seapoint turbidity probe (formazin turbidity units [FTU]), dissolved oxygen (mg/L), altitude (m), depth (m), conductivity (Siemens/m), temperature (^{o}C), salinity, and pH. In addition to these selected point samples, two hydrographic profile transects were collected down the axes of Baltimore and Norfolk canyons. Water samples were collected in 1.5 L Niskin water sampling bottles from specific depths in the water column at selected stations during the hydrographic profile upcast. Collected water samples are being processed according to standard protocols for analysis of aragonite saturation state, nutrient concentrations, and POM.

3.0 FIELD RESULTS

Overall, the cruise was successful and all objectives were accomplished, except retrieval of the benthic lander. The weather was extremely good and contributed to cruise success.

3.1 SURVEY CHRONOLOGY

5 June 2011 – The *Nancy Foster* departed Charleston, South Carolina at approximately 1,000 hrs, enroute to the benthic lander location off Cape Lookout, North Carolina. In transit, a test was conducted of the two different multibeam systems was conducted on a small shipwreck site off Cape Fear, North Carolina. The vessel arrived at the benthic lander location at approximately mid-morning, where approximately 1.5 hrs was spent acoustically interrogating the lander. No response was received from the lander, so the vessel transited to Baltimore Canyon, about 260 nmi north. Upon reaching deep water, multibeam mapping commenced at normal cruising speed. Before reaching the Baltimore Canyon location, the vessel slowed to locate and map a shipwreck in the southeast corner of Norfolk Canyon.

6 June 2011 – The vessel arrived in the Baltimore Canyon area about noon and began hydrographic profile and multibeam mapping operations.

7 June 2011 – Hydrographic profile and multibeam mapping operations continued.

8 June 2011 – Hydrographic profile and multibeam mapping operations continued.

9 June 2011 – Multibeam mapping area continued until 1230 hrs. A seven-station hydrographic profile transect was then conducted down the axis of Baltimore Canyon. Water samples were taken at three of these stations (three depths at each station) for analysis of aragonite saturation state, and three additional stations (two depths at each station) were sampled for POM. The final cast at the head of Baltimore Canyon was for hydrographic profile data only.

10 June 2011 – Multibeam mapping was completed at Baltimore Canyon and the head of Accomac Canyon. Some time was spent searching for two shipwreck locations (unsuccessfully), and the vessel began a transit to Washington Canyon about 1700 hrs.

11 June 2011 – Most of the day was spent mapping Washington Canyon. Later in the day, the vessel surveyed the large shipwreck target box.

12 June 2011 – The vessel continued the survey of the shipwreck target box and found four wrecks. The wrecks were first mapped using the lower-resolution multibeam system and one of the wrecks was later mapped using the higher-resolution system.

13 June 2011 – Mapping of the shipwreck locations was completed at about 0830 hrs. A six-station hydrographic profile transect was then conducted down the axis of Norfolk Canyon, along with the collection of water samples from three of the stations for aragonite saturation state analysis and three stations for POM. After completion of this transect and sample collection, the vessel surveyed another section of the shipwreck target box and located one wreck (totaling five wrecks within this area). The remainder of the day was spent surveying this area for additional shipwrecks.

14 June 2011 – Surveys for shipwrecks were completed with no additional wrecks located. At this point, all survey objectives were completed within the canyons study area, and the vessel began its transit back to Charleston. On the way back, a portion of a very rugged canyon area off Cape Hatteras (The Point) was mapped.

15 June 2011 – Continued transit to Charleston.

16 June 2011 – The vessel arrived in port at 0900 hrs and began demobilization.

3.2 MULTIBEAM MAPPING

Bathymetry Mapping

Overall, 1,397.65 sq km of sea bottom were mapped with the multibeam sonars during this cruise (**Figure 1**). Of this total area, 997.63 sq km (71 percent) were mapped in the Mid-Atlantic Bight in and around the major canyons. **Figures 5**, **6**, and **7** provide some bathymetric details of Baltimore, Washington, and Norfolk canyons, respectively.

Archaeological Discoveries and Mapping

Mapping in the vicinity of Baltimore and Washington canyons produced three low-priority targets that could be indicative of shipwrecks, whereas the mapping in and to the north of Norfolk Canyon produced six high-priority targets that are certainly indicative of shipwrecks. Included among the latter were five previously unidentified sites which are likely to be the remains of the so-called "Billy Mitchell Fleet." Those sites almost certainly include the remains of the battleship *Ostfriesland*, the cruiser *Frankfurt*, and the destroyers G-102, S132, and V-43. The remainder of the "Billy Mitchell Fleet" sunk off Virginia consists of the submarines U-117, U-140, and UB-148, all of which have been identified by Rod Mather during previous cruises to the Mid-Atlantic Bight. An unidentified shipwreck was also discovered just to the south of Norfolk Canyon. In addition, high-resolution multibeam mapping of Norfolk, Baltimore, and Washington canyons revealed what are likely to be paleo-shorelines dating back to the last glacial maximum. This information is important for paleo-archaeological landscape reconstructions that could identify areas of possible ancient human habitation.

3.3 WATER COLUMN SAMPLING

Thirty-two hydrographic and water profile stations were sampled during this cruise (**Table 2**), and plots from the two transects down Baltimore and Norfolk canyon axes are provided (**Figure 4**). Niskin bottles were triggered at several depths at eight of the hydrographic and water profile sampling stations (**Table 2**), and these are being processed for aragonite saturation and nutrient data. Water samples were collected for analysis of POM at several depths at ten of the hydrographic and water profile sampling stations (**Table 2**).

3.4 EDUCATION OUTREACH, AND MEDIA

The project web site (http://naturalsciences.org/education/online-adventures) was set up as a "blog" to allow for easy posting of cruise activity logs. Four background essays and various photographs (from other related projects) were posted prior to this cruise. In addition to the introductory material, 10 blogs authored by various scientific personnel were posted to this site during the cruise. Statistics on the web site indicated that it was visited 1,947 times during the cruise. The site continues to be maintained by the North Carolina Museum of Natural Sciences.

4.0 FUTURE WORK

Water samples are currently being analyzed for aragonite saturation state and nutrient and POM concentrations. Although much of the cleaning of the multibeam data was done at sea by U.S. Geological Survey (USGS) scientists, these data continue to be cleaned and analyzed by USGS and other scientists involved in the Atlantic Deepwater Canyons project. A presentation on these multibeam data is planned for an upcoming American Geophysical Union meeting. The bathymetry and backscatter data collected during this cruise will be used to help locate potential hard bottom habitats, areas that may support deep-sea corals, and to select areas to explore in upcoming cruises. In addition, we have considerable post-processing of geophysical survey data to complete prior to the first sampling cruise next year.

Future plans for the project include the continuation of historical and archaeological research in support of the sampling cruises over the next two years and for potential National Register of Historic Places nominations. By the end of the project, we anticipate submitting a multi-property National Register nomination for the "Billy Mitchell Fleet."

Table 2

Water column stations sampled in the western North Atlantic (5-14 June 2011) in the region of the Middle Atlantic Canyons. D = Day (0700-2000 hr EST), N = Night (2000-0700 hr EST), S = Surface. * = water sample taken for aragonite saturation analysis. ** = water sample taken for POM analysis.

Station Number	Date	Day/ Night	Total Time (min)	Start Latitude (°N)	Start Longitude (°W)	End Latitude (°N)	End Longitude (°W)	Depth Range (m)
NF-2011-001	05-Jun-11	N	22	33°26.186	76°50.443	33°26.335	76°50.215	S-220
NF-2011-002	06-Jun-11	D	16	37°45.885	74°14.137	37°45.734	74°14.313	S-106
NF-2011-003	06-Jun-11	D	18	38°06.488	73°49.160	38°06.415	73°49.235	S-888
NF-2011-004	07-Jun-11	N	16	38°08.908	73°51.414	38°08.746	73°51.619	S-468
NF-2011-005	07-Jun-11	D	13	38°10.664	73°51.593	38°10.945	73°52.051	S-459
NF-2011-006	07-Jun-11	D	12	38°10.033	73°50.974	38°10.070	73°51.188	S-557
NF-2011-007	08-Jun-11	N	8	38°05.871	73°52.111	38°05.933	73°52.166	S-149
NF-2011-008*	08-Jun-11	D	22	37°56.654	73°52.446	37°56.909	73°52.340	S-1,025
NF-2011-009**	08-Jun-11	N	18	37°49.658	74°03.584	37°49.872	73°03.658	S-800
NF-2011-B10*	09-Jun-11	D	23	38°05.390	73°47.712	38°05.502	73°47.796	S-1,005
NF-2011-B11**	09-Jun-11	D	20	38°05.502	73°49.471	38°06.886	73°49.724	S-872
NF-2011-B12*	09-Jun-11	D	15	38°07.833	73°50.897	38°08.078	73°51.177	S-709
NF-2011-B13**	09-Jun-11	D	17	38°09.226	73°50.621	38°09.480	73°50.821	S-625
NF-2011-B14*	09-Jun-11	D	12	38°10.893	73°51.953	38°10.841	73°51.953	S-495
NF-2011-B15**	09-Jun-11	D	10	38°12.362	73°50.796	38°12.377	73°50.779	S-347
NF-2011-B16	09-Jun-11	D	6	38°14.632	73°50.096	38°14.644	73°50.107	S-163
NF-2011-017	10-Jun-11	D	17	37°50.470	74°04.519	37°50.535	74°04.830	S-571
NF-2011-018**	10-Jun-11	D	20	37°25.603	74°21.633	37°25.474	74°21.848	S-984
NF-2011-019**	11-Jun-11	D	22	37°22.771	74°23.310	37°22.449	74°23.298	S-740
NF-2011-020	11-Jun-11	D	6	37°18.102	74°29.909	37°18.001	74°29.929	S-182
NF-2011-021	12-Jun-11	D	6	37°18.568	74°32.022	37°18.326	74°32.131	S-95
NF-2011-022**	12-Jun-11	D	25	37°02.344	74°34.601	37°02.757	74°35.138	S-1,085
NF-2011-023	12-Jun-11	N	18	37°02.908	74°38.154	37°02.852	74°37.946	S-742
NF-2011-N24*	13-Jun-11	D	29	37°02.719	74°34.971	37°02.413	74°35.084	S-1,001
NF-2011-N25**	13-Jun-11	D	19	37°02.394	74°36.997	37°02.304	74°37.044	S-751
NF-2011-N26*	13-Jun-11	D	17	37°03.744	74°38.537	37°03.637	74°38.626	S-528
NF-2011-N27**	13-Jun-11	D	13	37°04.809	74°40.008	37°04.731	74°40.231	S-491
NF-2011-N28*	13-Jun-11	D	8	37°05.374	74°41.825	37°05.297	74°41.976	S-294
NF-2011-N29**	13-Jun-11	D	8	37°05.623	74°43.840	37°05.608	74°43.913	S-268
NF-2011-N30	13-Jun-11	D	7	37°06.229	74°45.625	37°06.167	74°45.701	S-106
NF-2011-031	13-Jun-11	D	5	36°54.824	74°49.065	36°54.803	74°49.031	S-52
NF-2011-032*	14-Jun-11	D	20	35°32.868	74°46.520	35°32.836	74°45.800	S-943

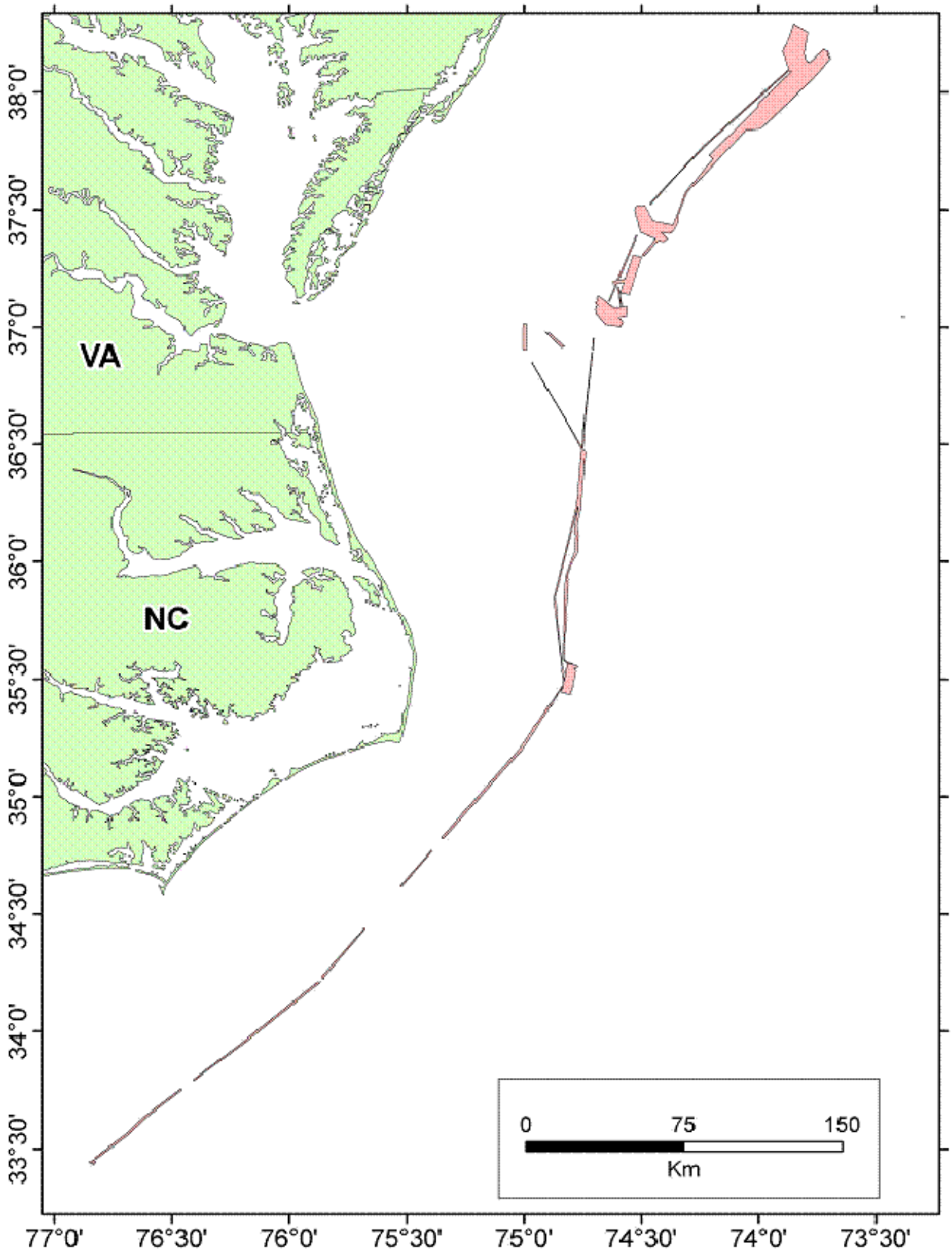


Figure 1. Total area mapped with multibeam sonar (shaded) during the June 2011 Multibeam Mapping Survey, representing 1397.65 sq. km.

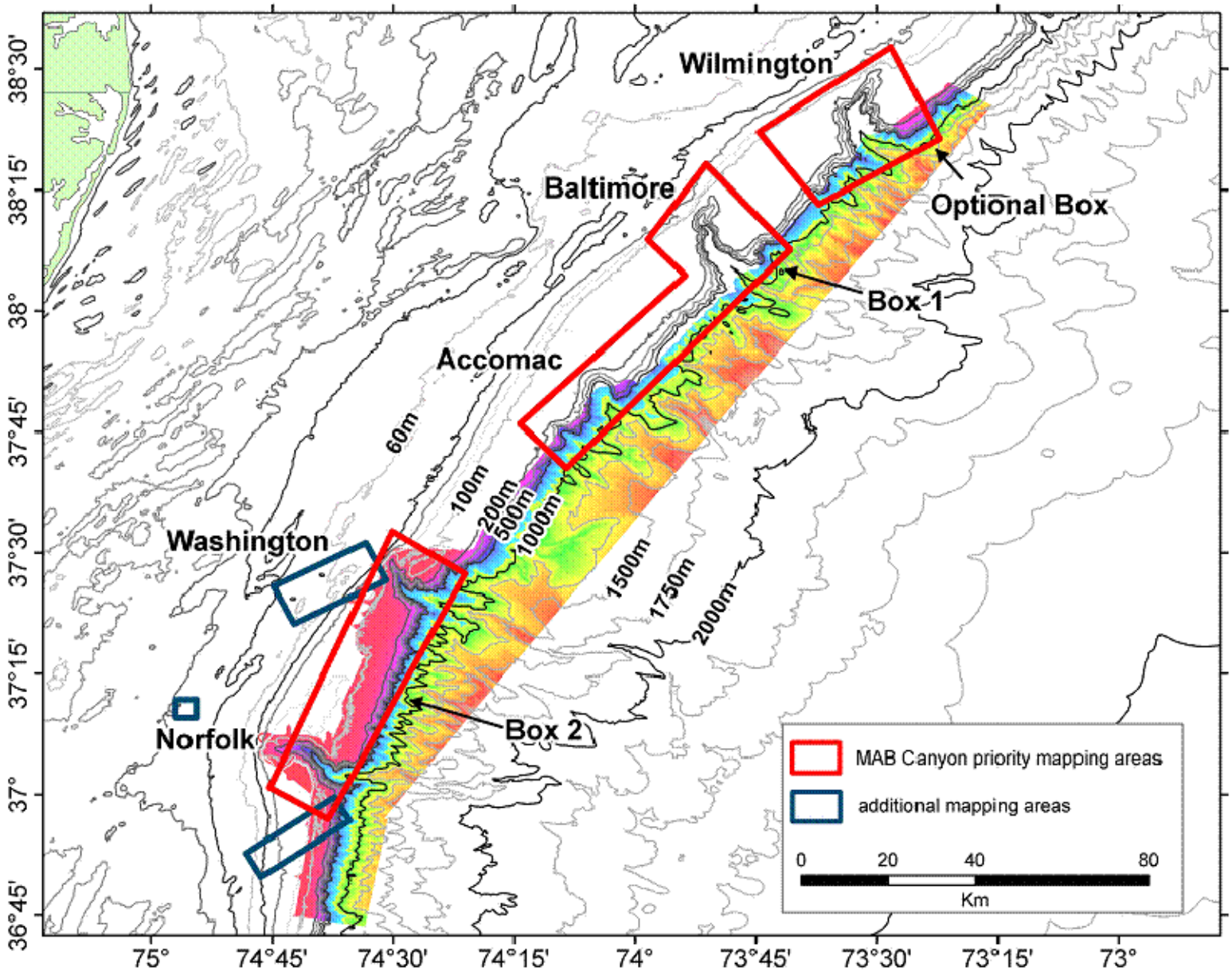


Figure 2. Middle Atlantic Canyon target areas for multibeam sonar mapping during the June 2011 Multibeam Mapping Survey. Multicolored areas represent existing multibeam sonar data collected by USGS.

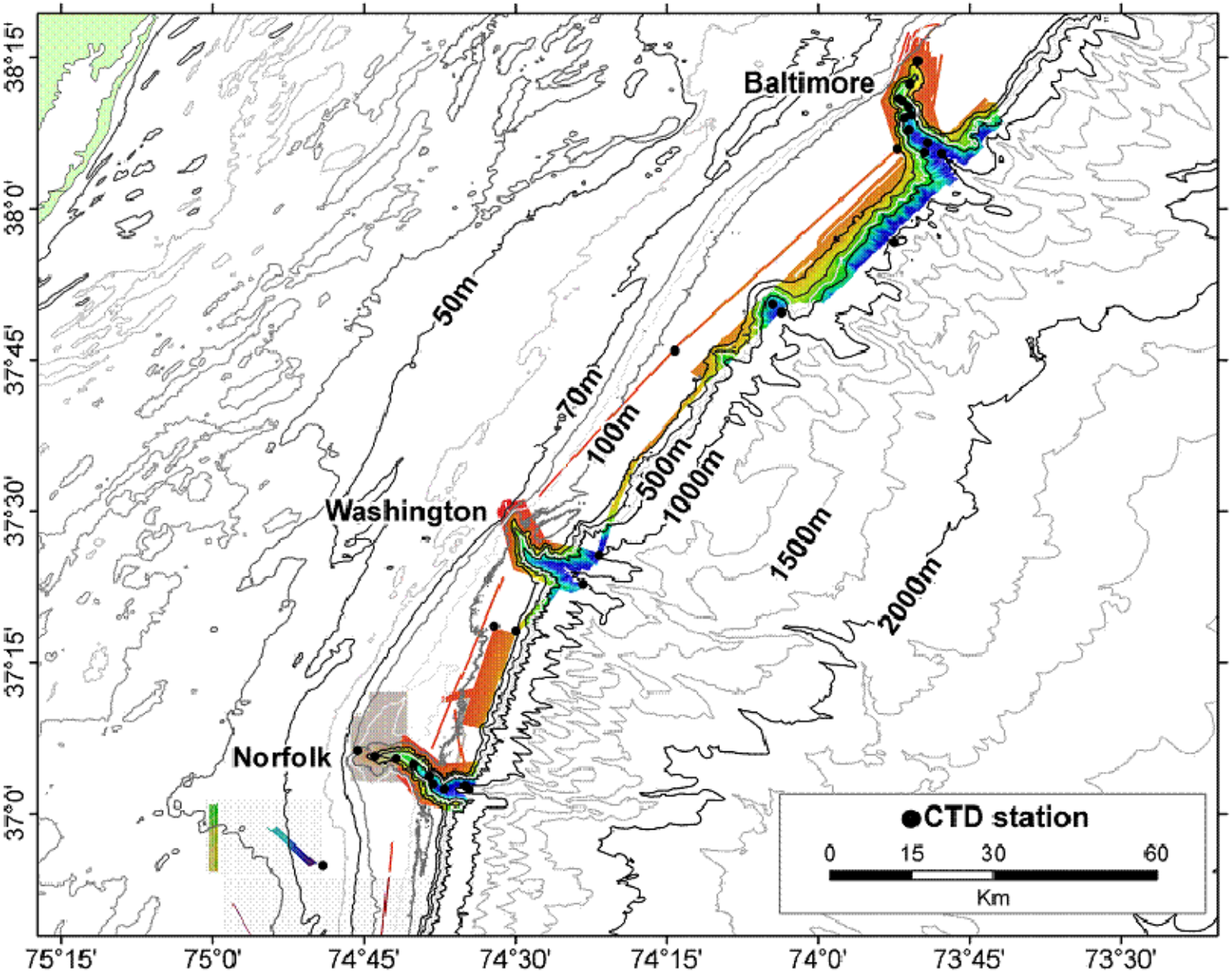


Figure 3. Color shaded areas represent new multibeam sonar data collected for Middle Atlantic canyons during the June 2011 Multibeam Mapping Survey. Hydrographic profile stations are also plotted on the map. Some additional data were collected outside this area.

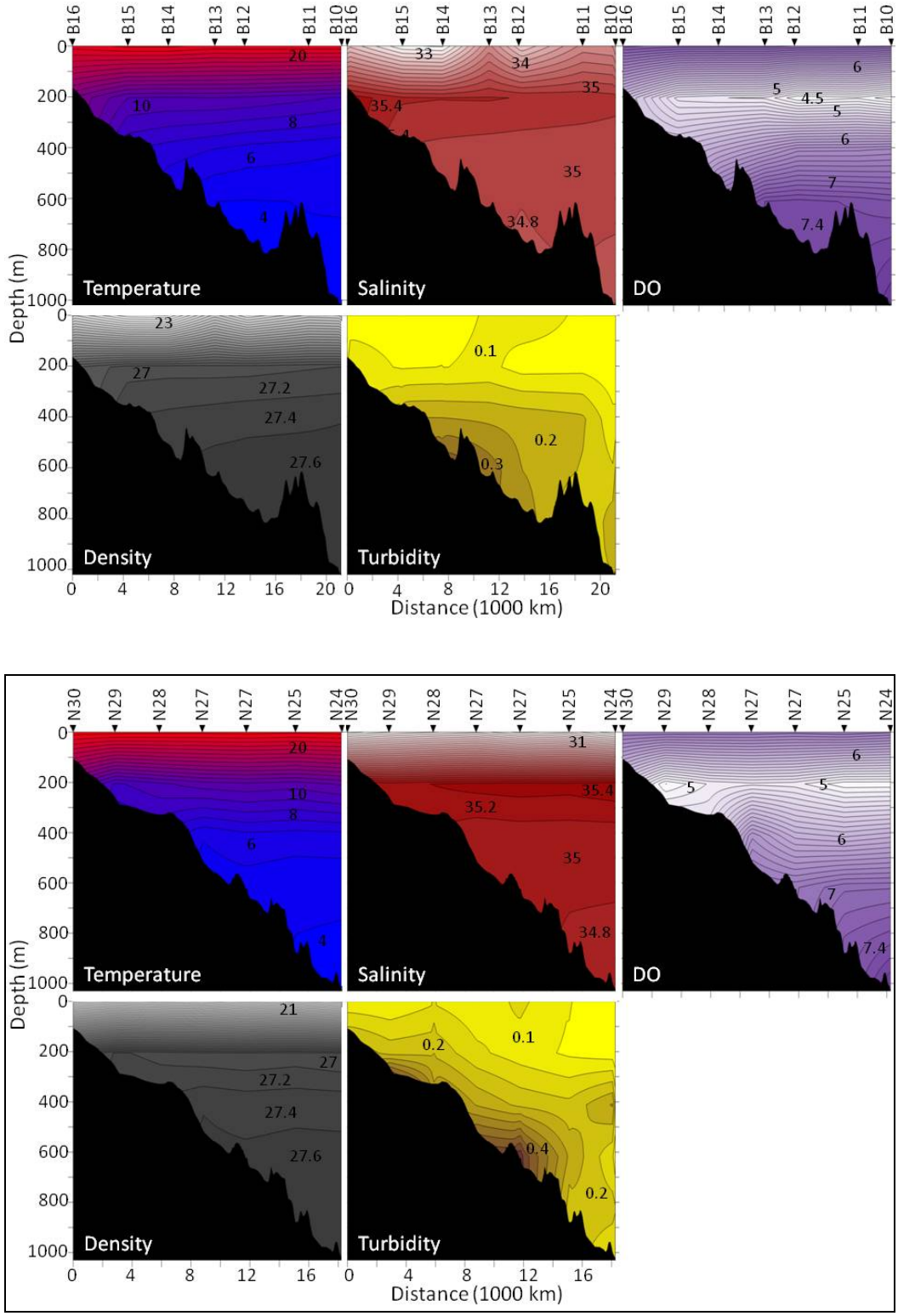
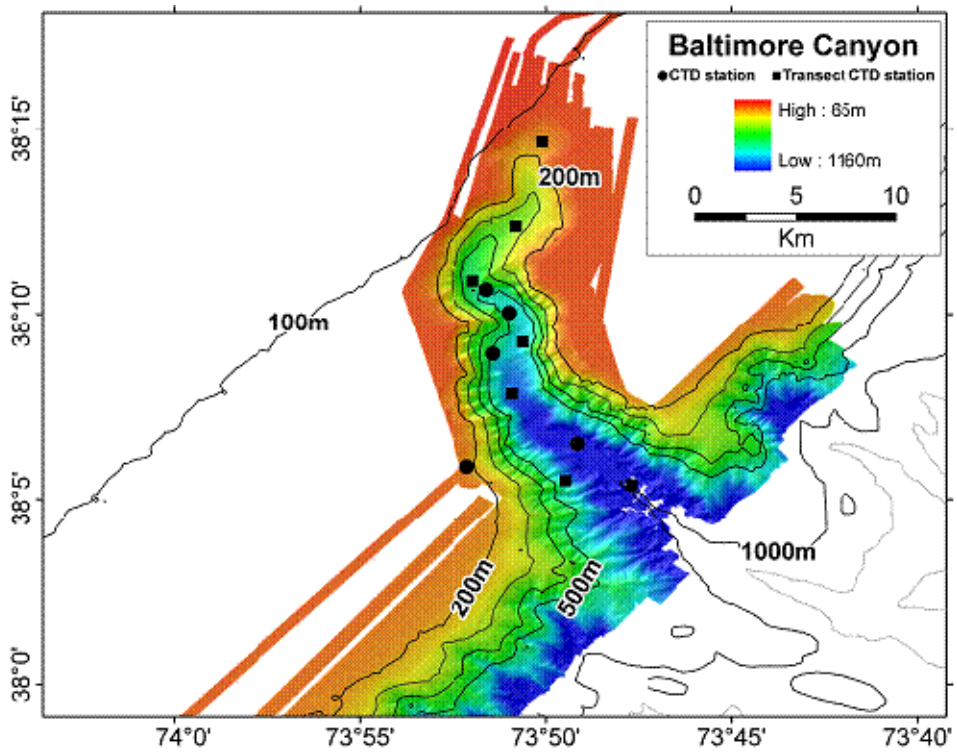


Figure 4. Water column data for hydrographic profile transects conducted down the axes of Baltimore Canyon (top panels) and Norfolk Canyon (bottom panels) during the June 2011 Multibeam Mapping Survey. Station numbers are across the top. DO = dissolved oxygen.



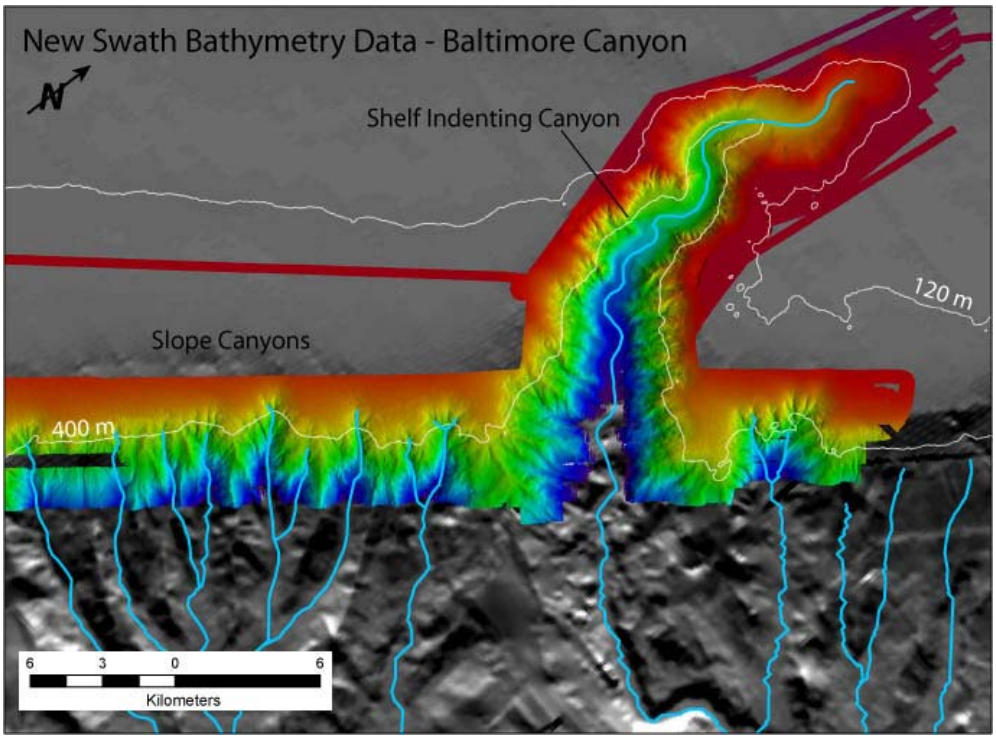


Figure 5. Expanded views of Baltimore Canyon illustrating area mapped with multibeam sonar during the June 2011 Multibeam Mapping Survey. Hydrographic profile (CTD) stations are also noted (top panel).

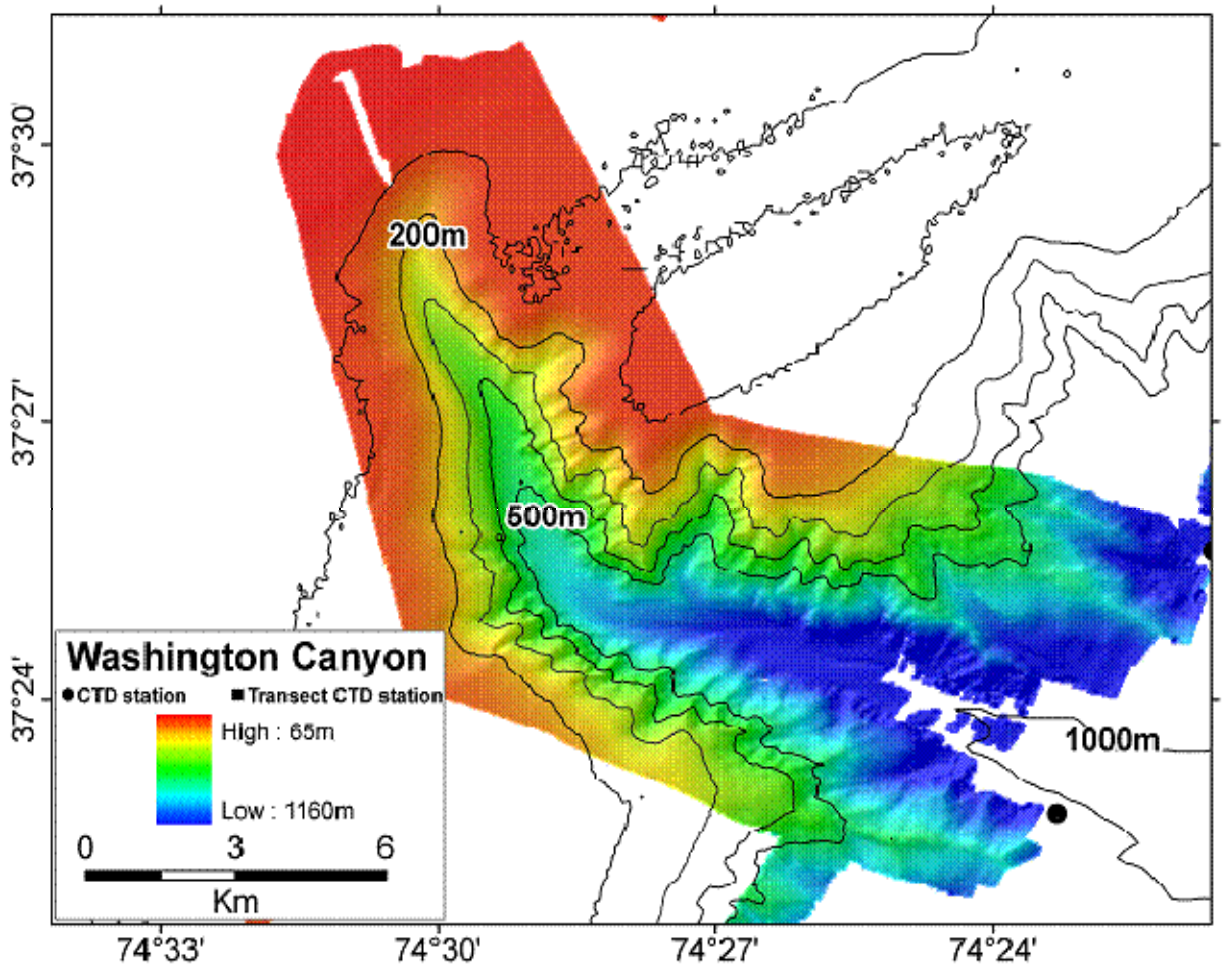


Figure 6. Expanded view of Washington Canyon illustrating area mapped with multibeam sonar during the June 2011 Multibeam Mapping Survey. Hydrographic profile (CTD) stations are also noted.

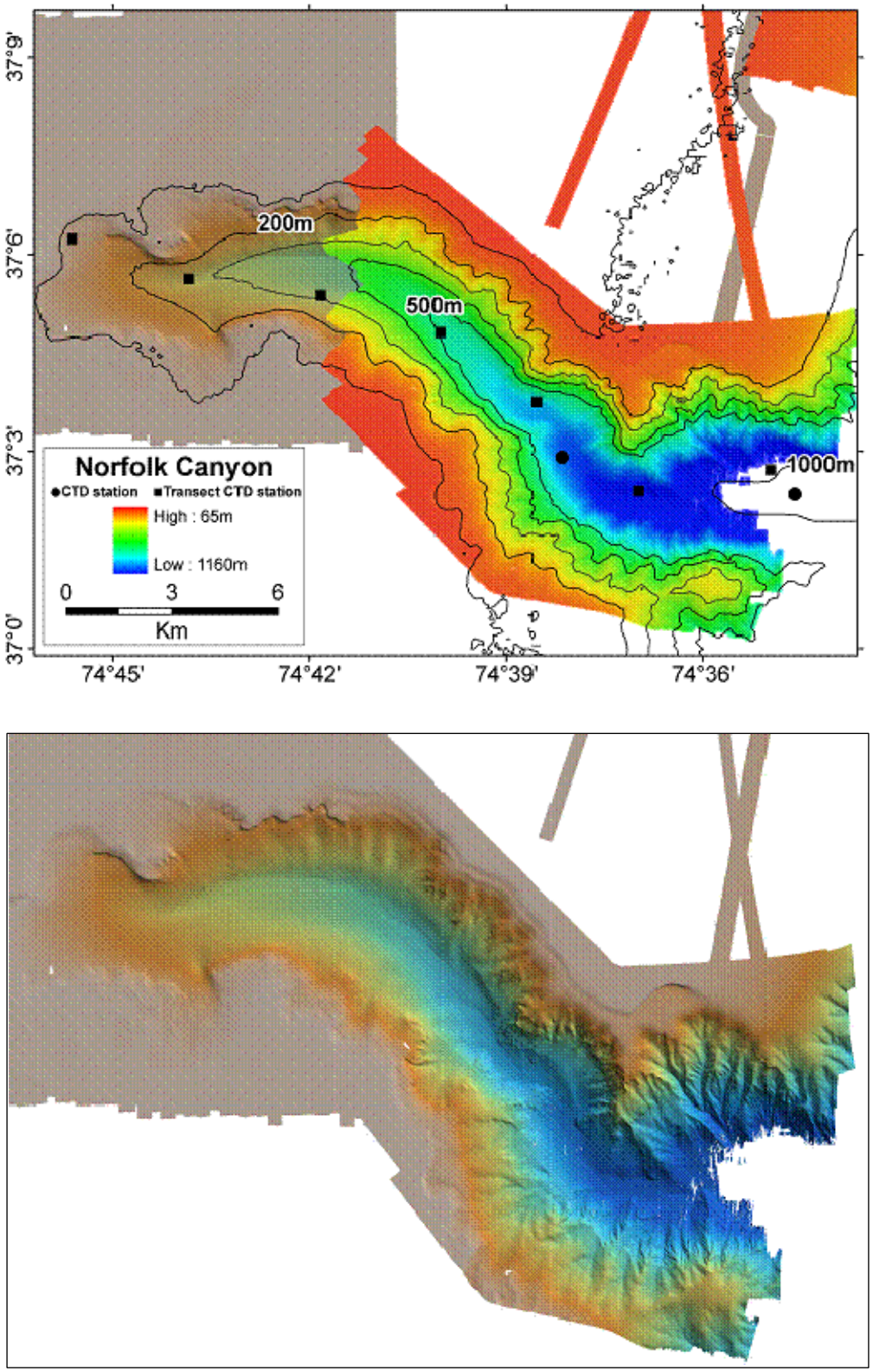


Figure 7. Expanded views of Norfolk Canyon illustrating area mapped with multibeam sonar during the June 2011 Multibeam Mapping Survey. Hydrographic profile (CTD) stations are also noted (top panel).