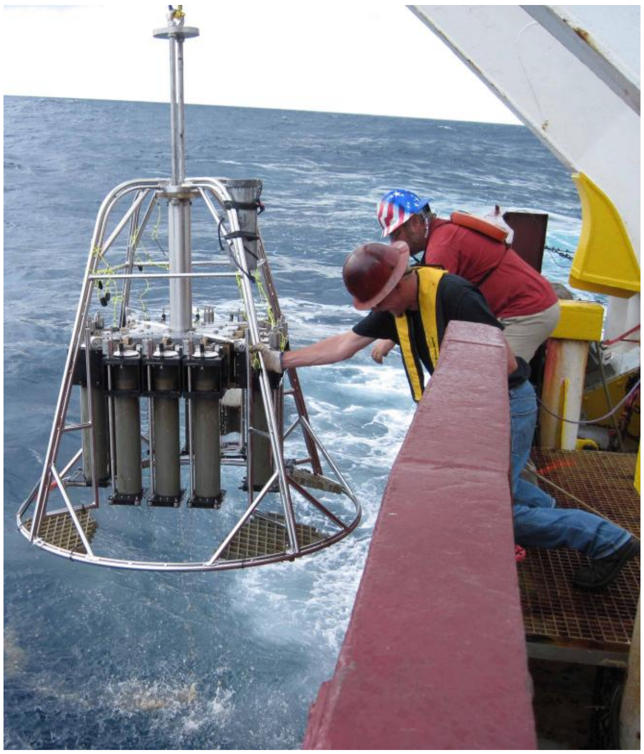
NOAA Technical Report NOS OR&R 25

JOINT ANALYSIS GROUP, DEEPWATER HORIZON OIL SPILL:

REVIEW OF PRELIMINARY DATA TO EXAMINE SUBSURFACE OIL IN THE VICINITY OF MC252#1, MAY 19 TO JUNE 19, 2010



Silver Spring, Maryland
August 2011

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National Ocean Service

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National Oceanic and Atmospheric Administration

United States Department of Commerce	National Oceanic and Atmospheric Administration	National Ocean Service
Rebecca M. Blank	Jane Lubchenco	David Kennedy
Acting Secretary	Administrator	Assistant Administrator

Foreword

The National Incident Commander for the Deepwater Horizon Oil Spill established the Joint Analysis Group (JAG) to examine the subsurface oceanographic data that was collected through the coordinated sampling efforts of vessels contracted for or owned by BP, NOAA, and academic scientists. The JAG is comprised of scientists from the National Oceanic and Atmospheric Administration, the Environmental Protection Agency, the Bureau of Ocean Energy Management, Regulation and Enforcement, the White House Office of Science and Technology Policy, BP, and several academic institutions.

The JAG is performing three major tasks:

- Integrate the data both spatially and temporally to allow their visualization and analysis.
- Analyze the data to describe the distribution of oil and the oceanographic processes that affect its transport.
- Issue periodic reports to the National Incident Command (NIC), the Unified Command, the public, and other researchers that include visualization, analysis, and synthesis products.

This Technical Report contains the second periodic report released by the JAG: "Review of Preliminary Data to Examine Subsurface Oil in the Vicinity of MC252#1, May 19 to June 19, 2010" and its related addendum, "Report 2 Data Supplement: June 20 to July 13."

This document is presented in its original form, with the exception of minor editorial changes and formatting.

Robert Haddad, Ph.D.
Chief, Assessment & Restoration Division
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June 1, 2011

Contents

Joint Analysis Group (JAG):
Review of Preliminary Data to Examine Subsurface Oil in the Vicinity of MC252#1, May 19 to June 19, 2010

1 Background

This report presents preliminary data from 227 stations collected by the R/V *Brooks McCall,* R/V *Ocean Veritas*, R/V *Walton Smith*, R/V *Thomas Jefferson*, and R/V *Gordon Gunter,* near the site of the BP Deepwater Horizon incident located in the Mississippi Canyon Lease Block area 252 (MC252) and the BP#1 wellhead (MC252#1). The data were collected from May 19 to June 19, 2010. The results from measurements taken below approximately 150 m were examined by the Joint Analysis Group (JAG) as a continuation of the analyses and data presented in its June 20, 2010, report.[1]

Until June 3, the MC252#1 well was releasing gas and oil from the broken riser pipe attached to the well. On June 3 the riser pipe was removed and a collection system installed to capture some of the escaping oil and gas. On May 27 the National Incident Command Flow Rate Technical Group estimated oil release rates of 12,000–19,000 barrel[2] per day and revised that estimate on June 15 to 35,000-65,000 barrels per day. About 300,000 gallons of chemical dispersant were added to the oil and gas flow at the wellhead during the period covered by this report. Throughout the data collection period, oil and gas escaping the collection system rose from the wellhead with some oil reaching the surface. Some of the oil escaping the collection system dissolves in the water column and some forms small droplets. The natural gas escaping the collection system partially dissolves in the water column.

2 Data Under Consideration

Figures 1–3 show the locations where each of the vessels collected data, and Figures 4–7 show when each vessel was collecting data. Each vessel deployed a Sea-Bird conductivity temperature and depth sensor (CTD) with a WET Labs ECO Colored Dissolved Organic Matter (CDOM) sensor and a Sea-Bird SBE 43 in situ dissolved oxygen (DO_2) sensor to measure continuous profiles of temperature, salinity, fluorescence and DO_2. The WET Labs ECO CDOM sensor (model FLCDRTD-1800) has been tested to determine the instrument's ability to detect MC252#1 well oil (see App. A). Information on procedures for processing and quality control of data from the CTDs and fluorometers can be found in Appendix B.

This report focuses on the fluorescence measurements from the MC252#1 well oil found between 1000- and 1300-m water depth, and not the ubiquitous background natural organic matter fluorescence found throughout the water column. This report does not include data on

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[1] Joint Analysis Group (JAG) Review of R/V *Brooks McCall* Data to examine Subsurface Oil, June 2010. See http://www.noaa.gov/sciencemissions/PDFs/JAG_Report_1_BrooksMcCall_Final_June20.pdf.

[2] One barrel of oil is 42 gallons.

DO_2 because these data could not be reliably interpreted from in situ Sea-Bird SBE 43 DO_2 measurements collected during these cruises. See Appendix C for further details.

3 Data and Information

Sample stations in this report extend from 1 km to about 52 km from the wellhead. Fluorescence measurements are the primary data used in this report to delineate the area in which oil occurs. Additional water samples have been collected and are undergoing chemical analysis to determine the levels of hydrocarbons present. Of the 227 stations considered for this report, 18 did not meet normalization processing criteria and so are not included in data plotted in Figures 8–46.[3] Figure 8 shows the mean CDOM fluorescence between 1000 m and 1300 m as a function of distance from the wellhead. These are the depths at which subsurface MC252#1 well oil is most often found in the previous JAG analysis (JAG, June 20, 2010[1]). Figure 8 shows the mean fluorescence decreasing with distance from the wellhead. Figure 9 shows the maximum CDOM fluorescence between 1000 m and 1300 m as a function of distance from the wellhead. An elevated value measured by the R/V *Walton Smith* can be seen at about 25 km (Fig. 9). The spatial frequency of measurements is not sufficient to capture all features of the plume dimensions away from the source, so there is uncertainty in the rate of decrease. The JAG has made recommendations to the Subsurface Monitoring Branch to help improve the spatial resolution of sampling.

Figure 9 illustrates the decrease in maximum fluorescence as a function of distance from the wellhead. Changes in the mean and maximum fluorescence according to sampling date are shown in Figures 10 and 11, respectively. Low values observed during mid-June are a function of vessel position afar from regions where the plume was previously documented.

Figures 12 to 43 show the daily location of the mean CDOM fluorescence measurements between 1000 and 1300 m.[4] The data values for these figures can be found in Appendix D. A circle's color indicates CDOM fluorescence values, with redder circles indicating higher values and open circles indicating where fluorescence was not above normalized background (see Appendix B for data processing methods). For the areas sampled, the data show decreasing fluorescence trending primarily west-southwest until June 2. In mid-June, fluorescence can be seen trending to the northeast. Figure 44 shows fluorescence values for all stations within 20 km of the wellhead, which excludes four distant stations[5] located near a natural seep. Figure 45 includes all stations. Finally, Figure 46 is a perspective view of data shown in Figure 45, with the locations of natural seeps that were acoustically mapped by the R/V *Gordon Gunter* and R/V *Thomas Jefferson*. There are natural seeps to the SSW and the NE on the figure.

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[3] Values not plotted are noted as "NaN" in the Appendix D data tables.

[4] Note in these figures, fluorescence measured 1 day at a location is plotted again the day after the measurements were made at the same location (i.e., 2-day persistence for each station). This was done to help visualize the patterns in the data.

[5] The excluded stations are R/V *Gordon Gunter* 2010_0529_003, 2010_0529_004, 2010_0530_006, and 2010_0530_007.

The information in this report will be continually updated and refined as additional chemical analytical data from these cruises become available and as results become available from subsequent cruises. Conclusions to date include the following:

• Fluorometry measurements show a recurring anomaly attributable to oil[1] that first appears at approximately 1000 m and is attenuated beyond 1300-m depth.

• The fluorometric anomaly is strongest near the release site, generally decreasing with distance, and trending primarily southwest to northeast consistent with the water movement along the isobath (Figs. 12–46).

• Natural organic substances contribute to the background fluorescence signal observed throughout the water column, so that the maximum in situ fluorometer response is not solely attributable to oil.

• There is a spatial and temporal variability in the magnitude of fluorometric anomalies.

• Active natural seeps have recently been mapped about 12 km southwest of the wellhead and about 17 km to northeast of the wellhead (Fig. 46).

• CTD DO_2 measurements show anomalies that begin around 1000 m and extend to 1300–1400 m. These anomalies cannot be reliably interpreted at this time for reasons described in Appendix C.

• DO_2 levels should continue to be monitored using polarographic sensors. Discrete samples from Niskin bottles using Winkler titration methods should be conducted to augment understanding of the potential effects of subsurface oil and gas releases and to validate electronic sensor measurements.

• The spatial coverage of the samples is not uniform around the wellhead. The full horizontal extent of the oil cannot yet be determined based on these data alone because these data are limited to a small radius around the MC 252#1 well. Additional sampling data are being collected and will be reported on in future data summaries.

• Based on instrument response curves, the minimum detection limit of the CDOM fluorometers in use during these cruises is approximately 1 ppm oil. Areas of oil below this level are not likely to be accurately detected, although they might be biologically meaningful, thus emphasizing the importance of analyzing water samples with more sensitive laboratory procedures.

• This report does not discuss the ecological consequences of the oil.

4 Development of this Report

The JAG was recognized formally by the National Incident Command (NIC) on June 8, 2010. The JAG operates at two levels for the development and release of its findings. For purposes of information exchange and metadata development, the group includes industry representatives responsible for providing data from contracted vessels. For the purposes of report development and approval of findings, only the federal agency representatives are involved. This report is the second in a series of data products from the JAG concerning data from the spill related to subsurface sampling.

This report contains preliminary data that has not been fully reviewed in accordance with NOAA's pre-dissemination review protocols. It is being released provisionally in the interest of providing vital information concerning the Deepwater Horizon/BP oil spill to the public as expeditiously as possible. This information is not a final agency product and will not be used to support any final agency determination or policy until it has been fully reviewed in accordance with NOAA's pre-dissemination review protocols.

Members of the Joint Analysis Group appointed to date:

Federal Membership

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Mr. Russ Beard, National Coastal Data Development Center, Stennis Space Center, MS

Dr. Jim Farr, NOAA Office of Response and Restoration, Seattle, WA

Dr. Jerry Galt, Contractor, NOAA Office of Response and Restoration, Seattle, WA

Dr. Hernan Garcia, Ocean Climate Laboratory, Silver Spring, MD

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Acknowledgments

The JAG acknowledges and thanks Dr. Samantha Joye (University of Georgia), the scientists and crew on the R/V *Walton Smith*, and their sponsoring agency, the National Science Foundation for contributing their CTD-derived data for inclusion in JAG analysis and reporting, and for encouraging other academic and private partners to do so as well.

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Figure 1: Subsurface Monitoring Stations within 5 km of the Wellhead

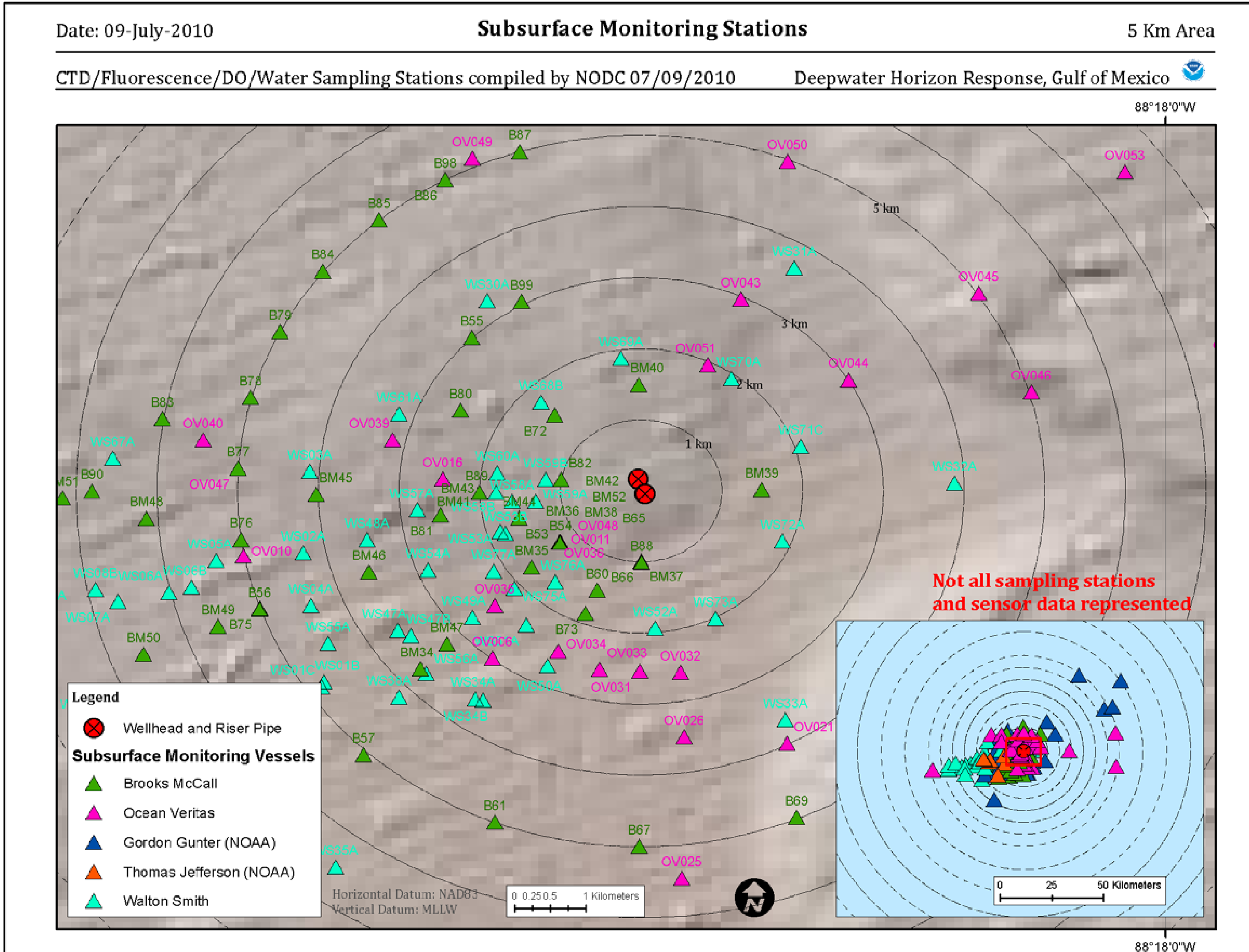


Figure 2: Subsurface Monitoring Stations within 20 km of the Wellhead

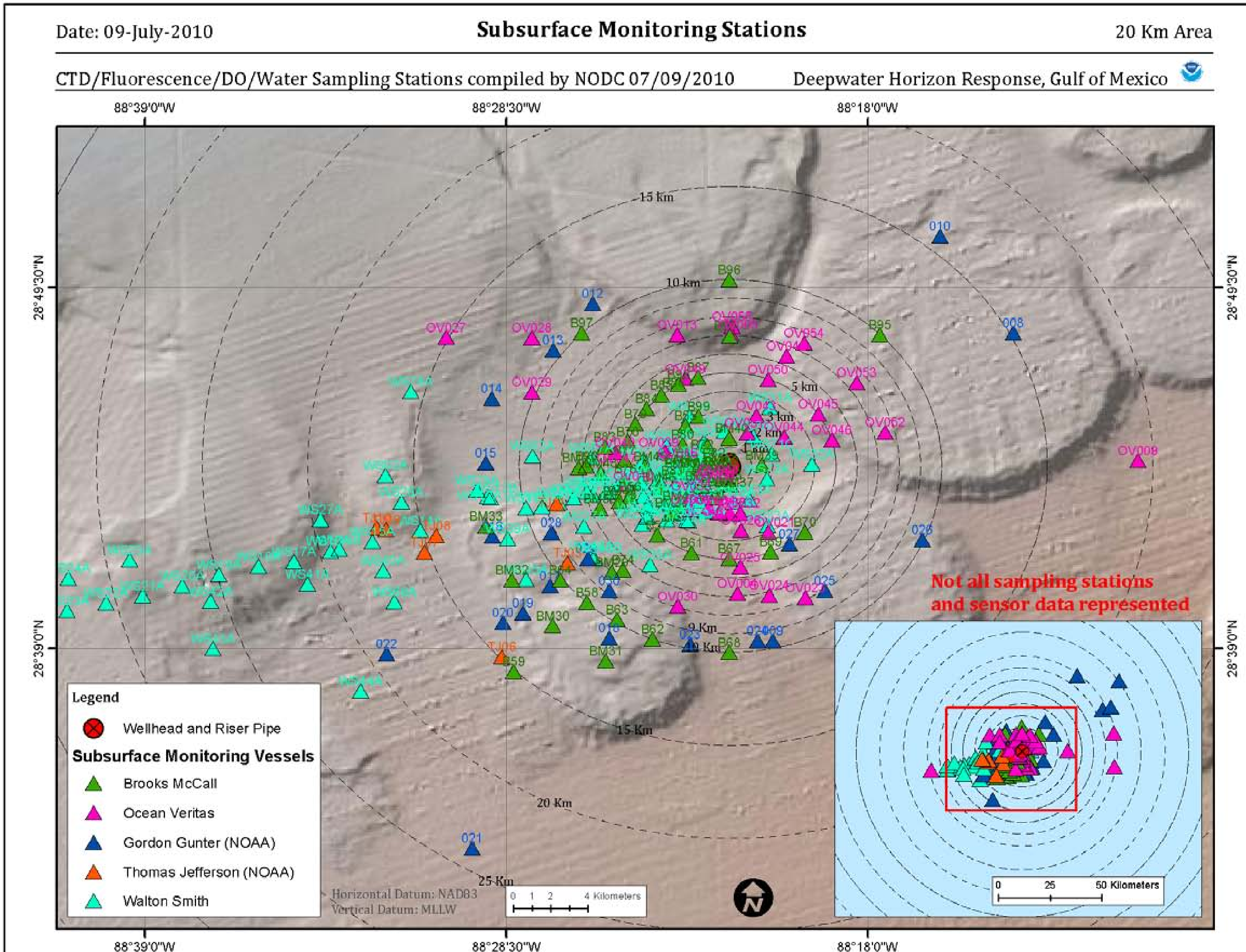


Figure 3: Subsurface Monitoring Stations within 50 km of the Wellhead

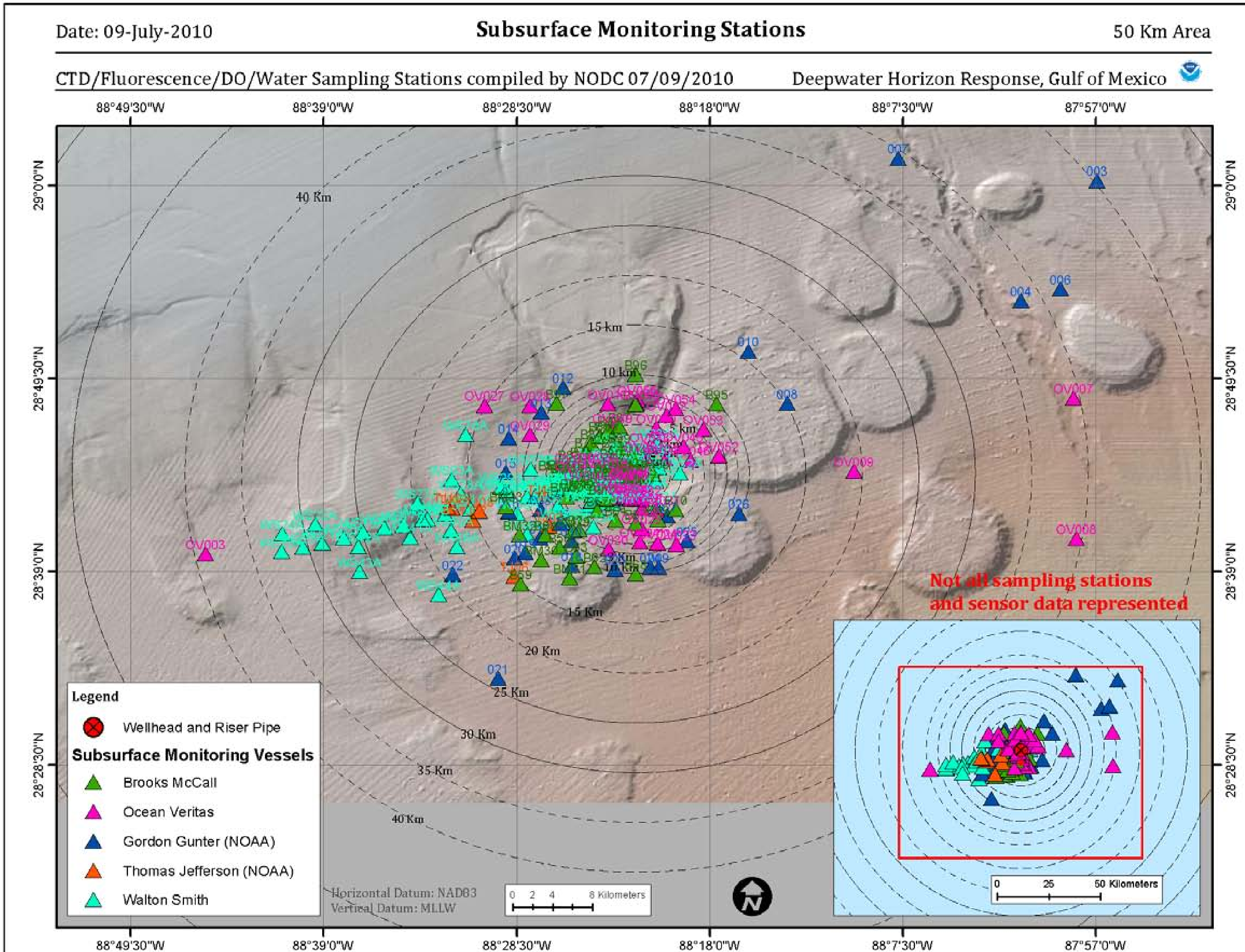


Figure 4: Subsurface Monitoring Stations Sampled May 15-26, 2010

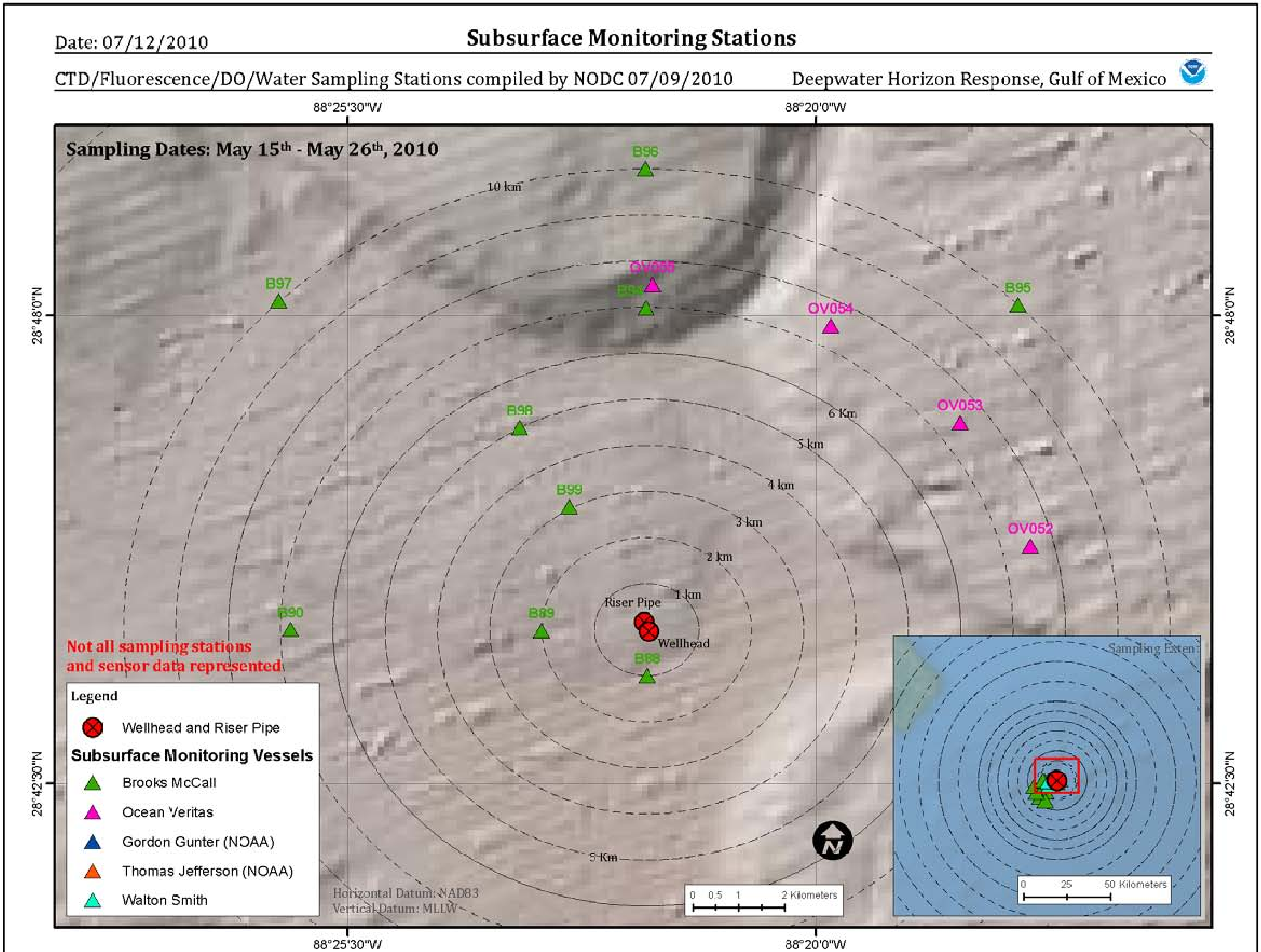


Figure 5: Subsurface Monitoring Stations Sampled May 26 to-June 2, 2010

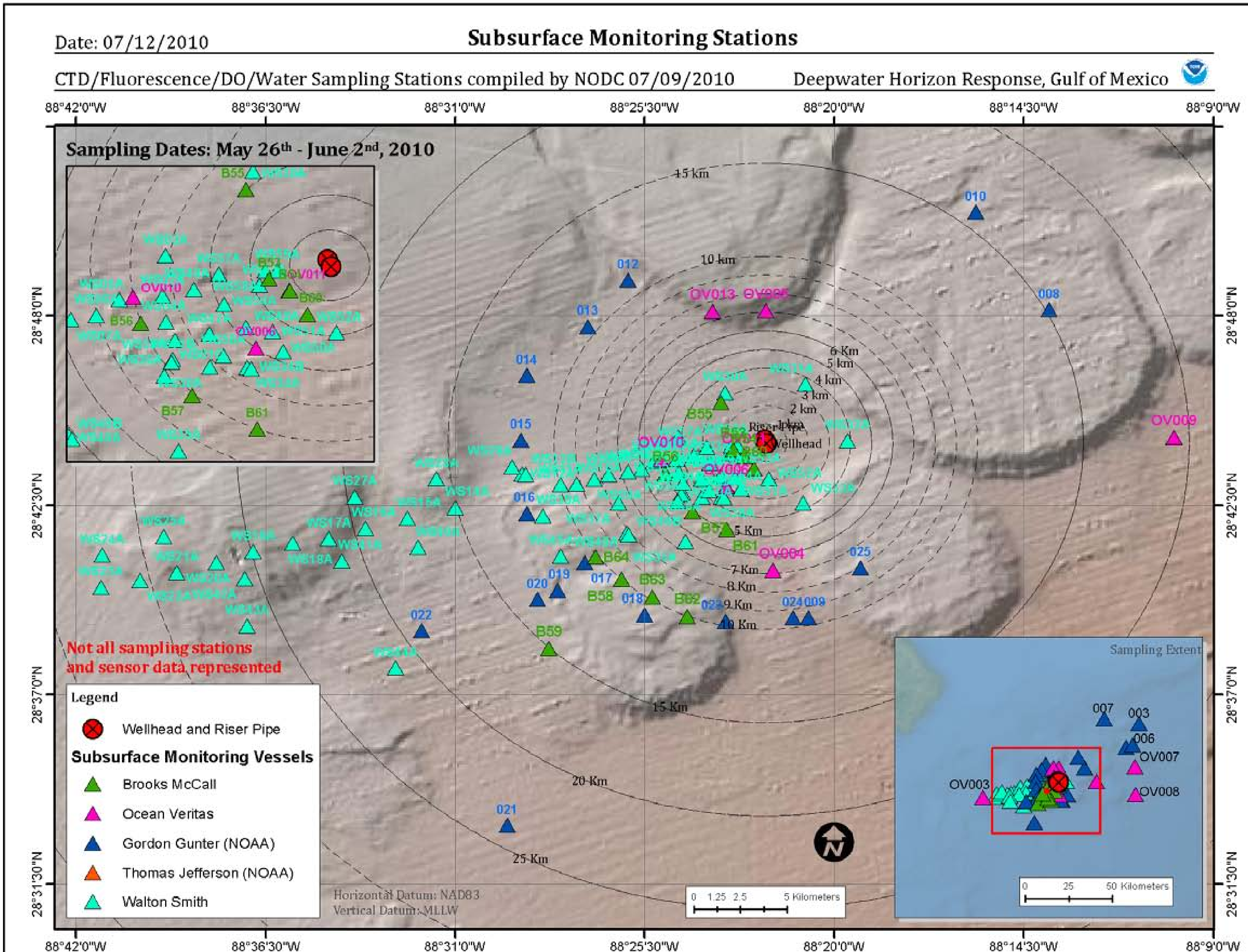


Figure 6: Subsurface Monitoring Stations Sampled June 2–9, 2010

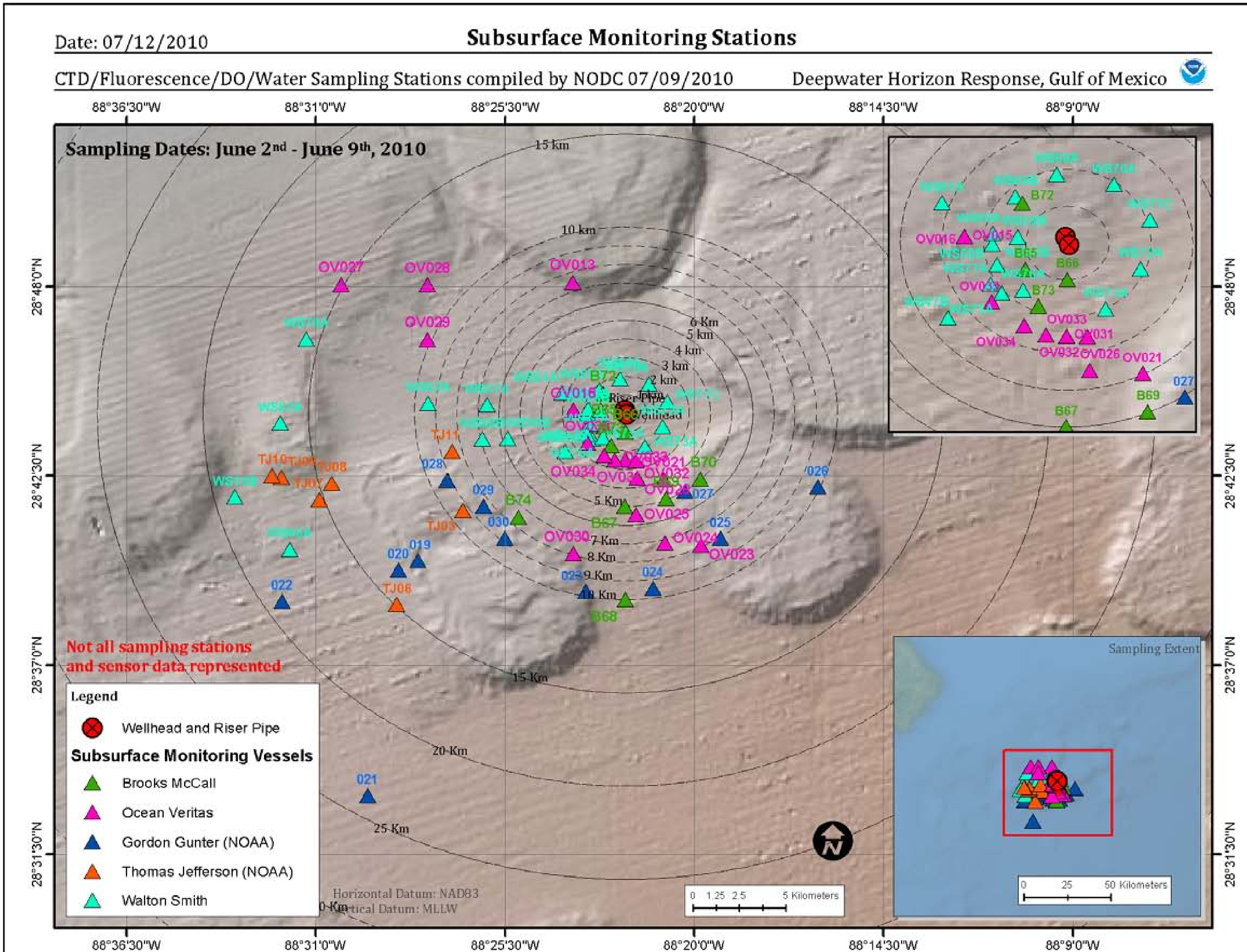


Figure 7: Subsurface Monitoring Stations Sampled June 9–16, 2010

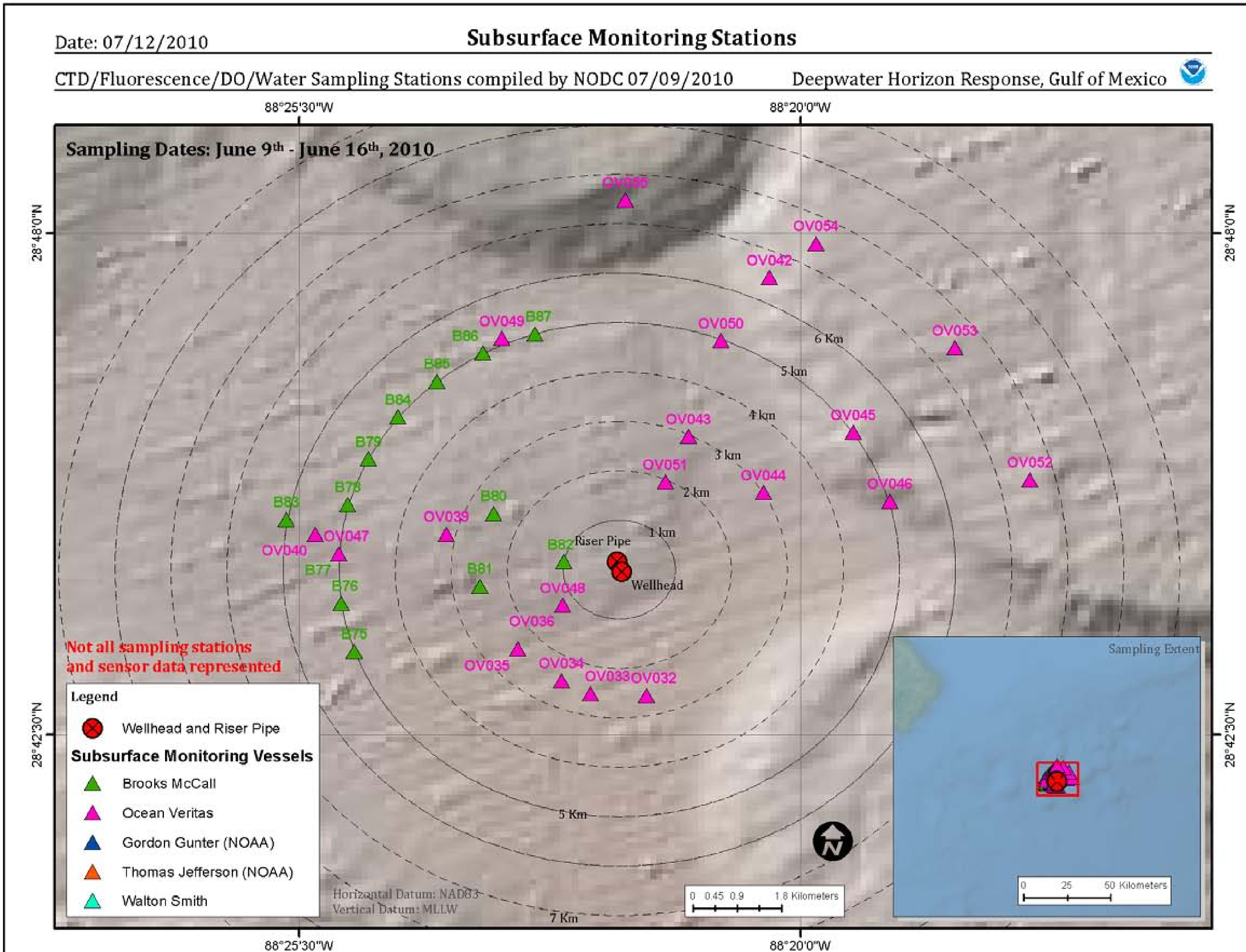


Figure 8: Mean Fluorescence (ppb QSDE) vs. Distance from the Wellhead

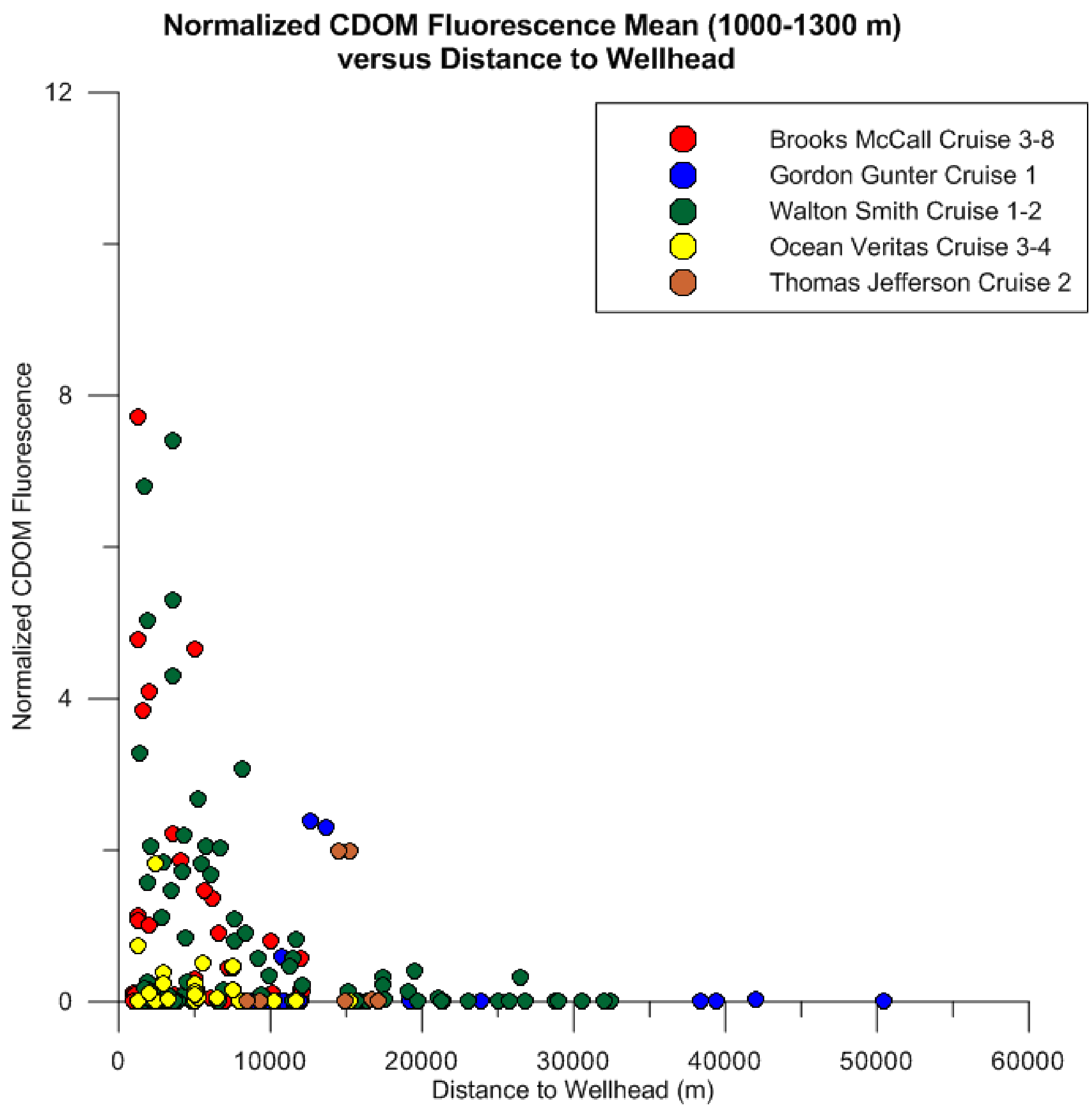
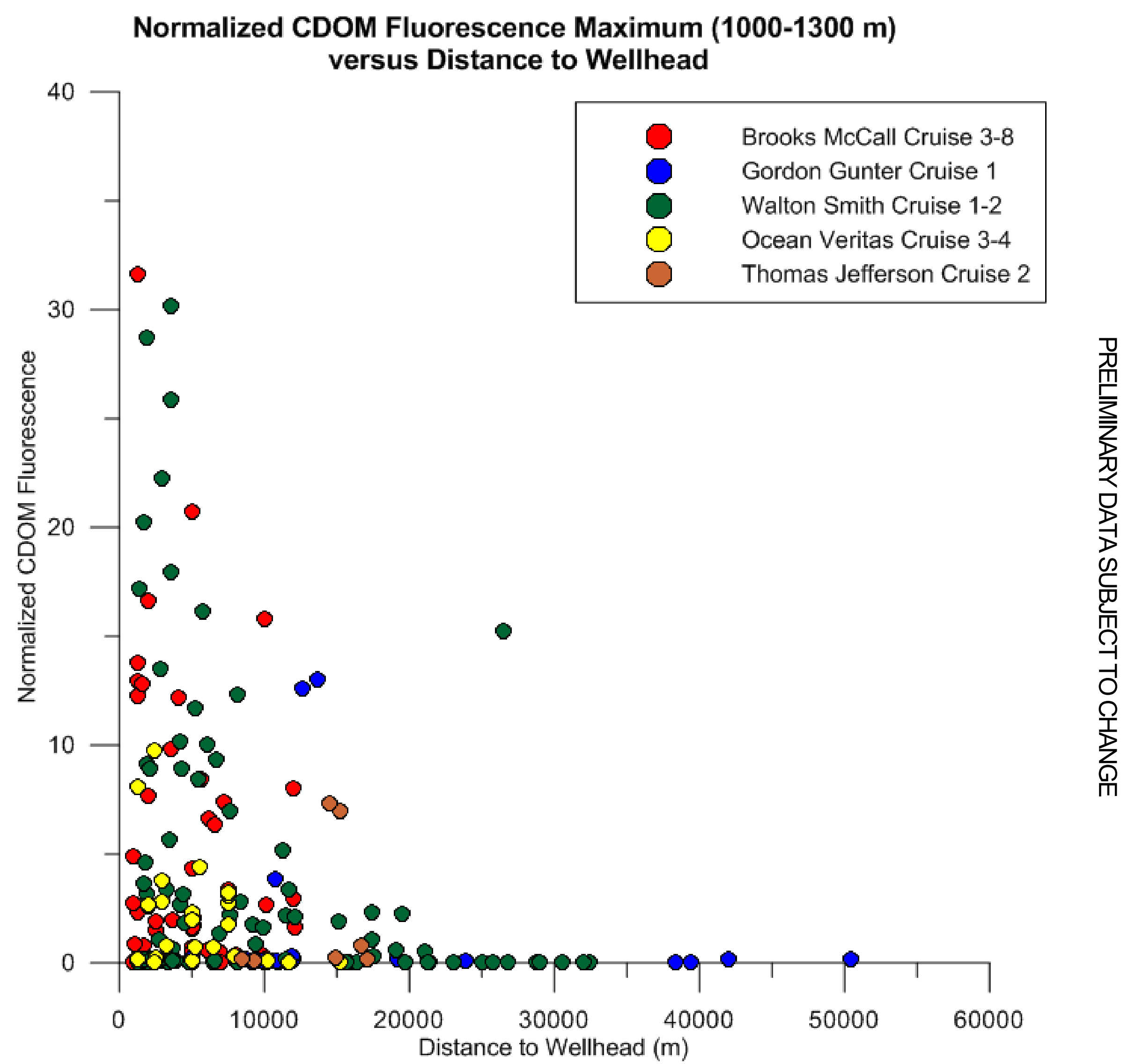


Figure 9: Maximum Fluorescence (ppb QSDE) vs. Distance from the Wellhead



PRELIMINARY DATA SUBJECT TO CHANGE

Figure 10: Mean Fluorescence (ppb QSDE) vs. Time of Observation

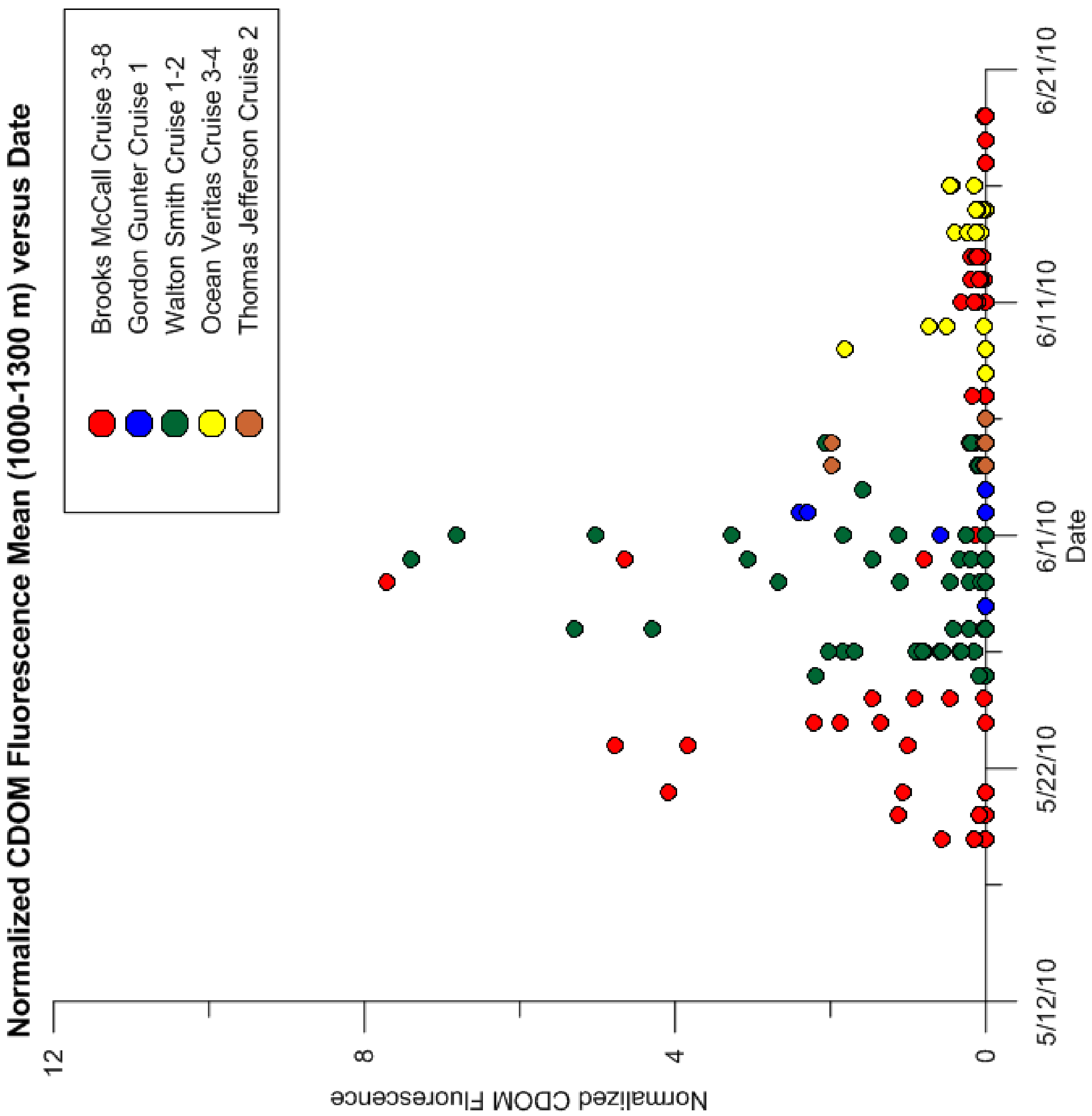


Figure 11: Maximum Fluorescence (ppb QSDE) vs. Time of Observation

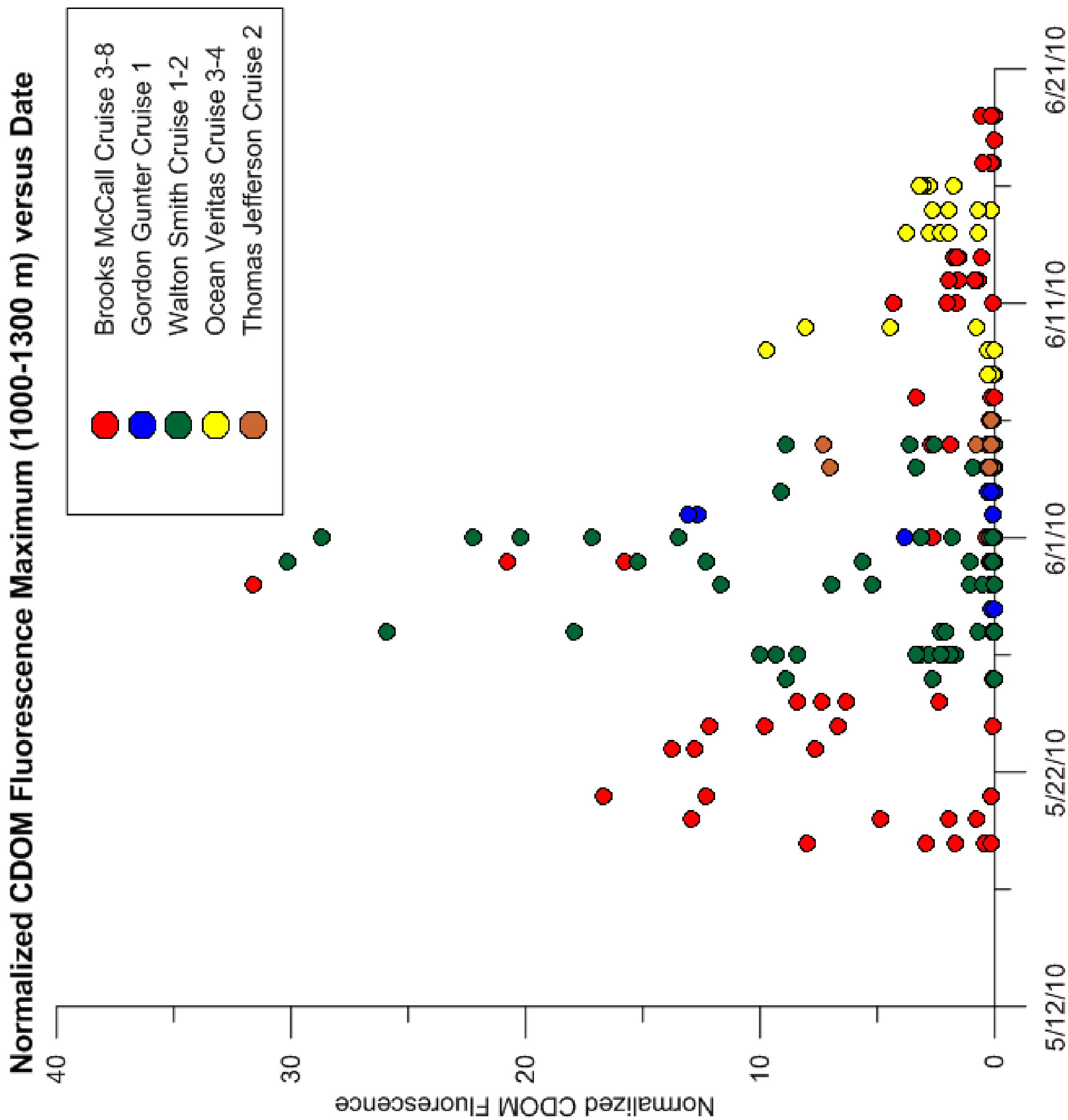
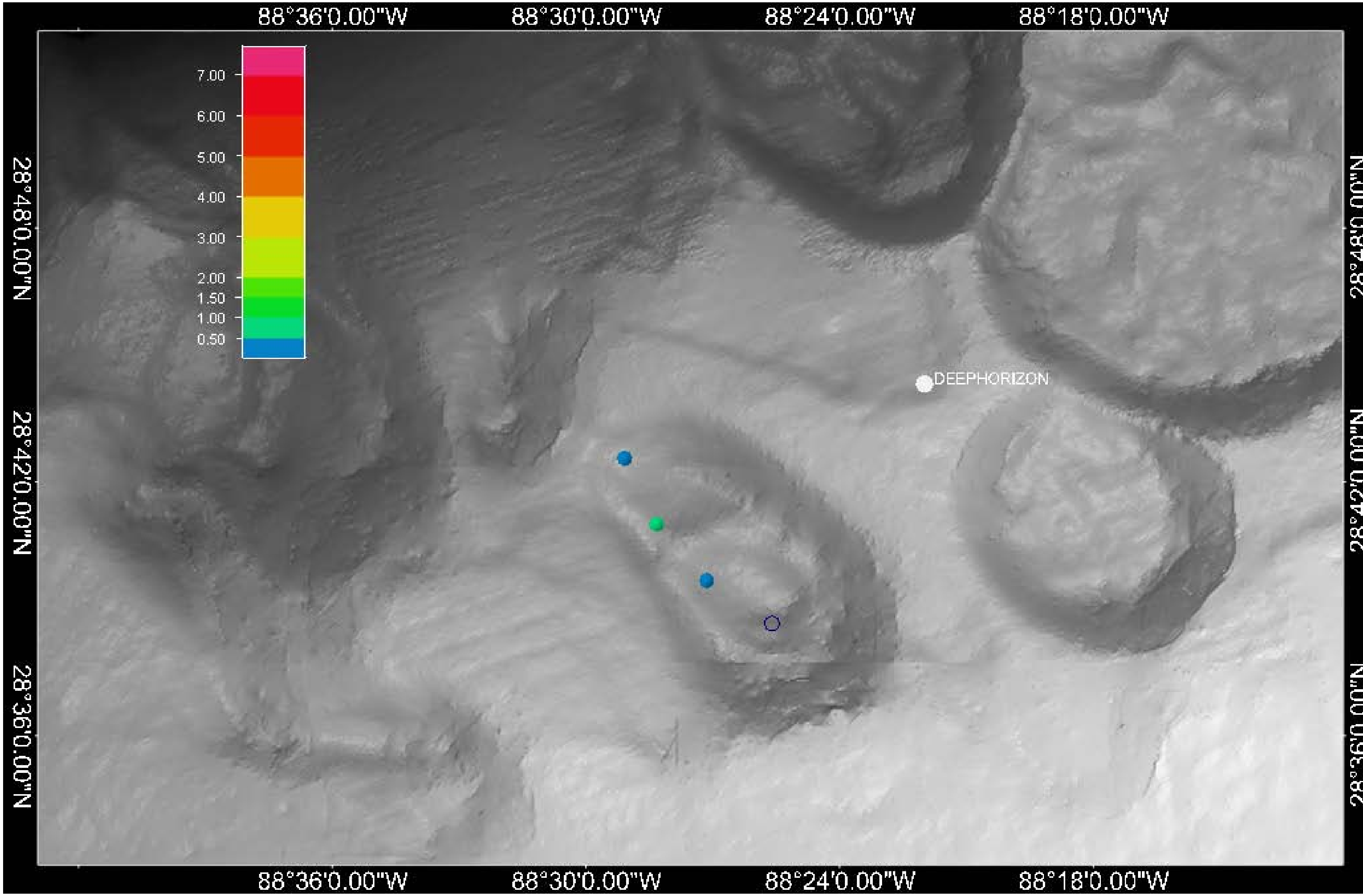
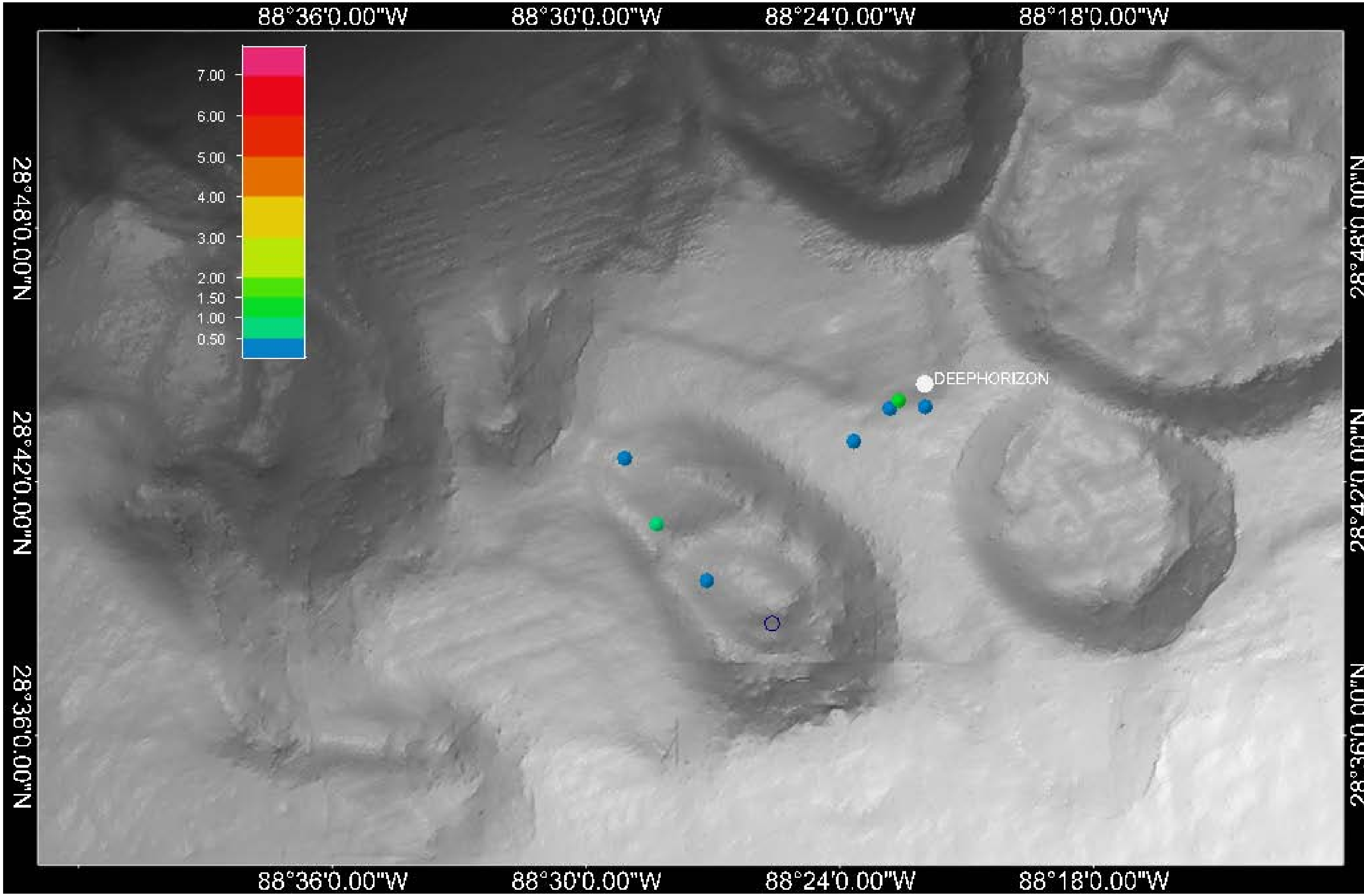


Figure 12: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 19 May 2010



PRELIMINARY DATA SUBJECT TO CHANGE

Figure 13: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 20 May 2010



PRELIMINARY DATA SUBJECT TO CHANGE

Figure 14: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 21 May 2010

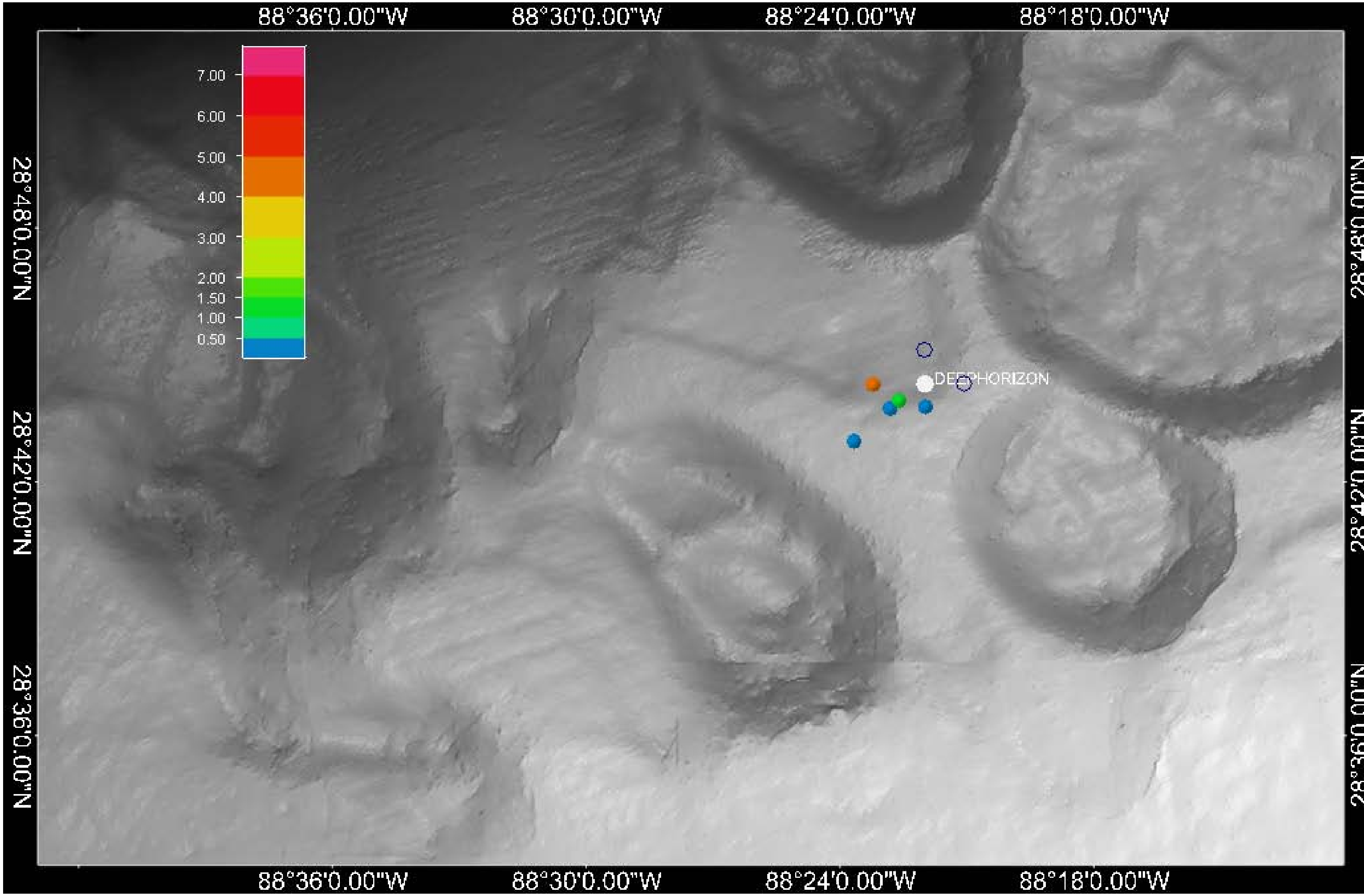


Figure 15: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 22 May 2010

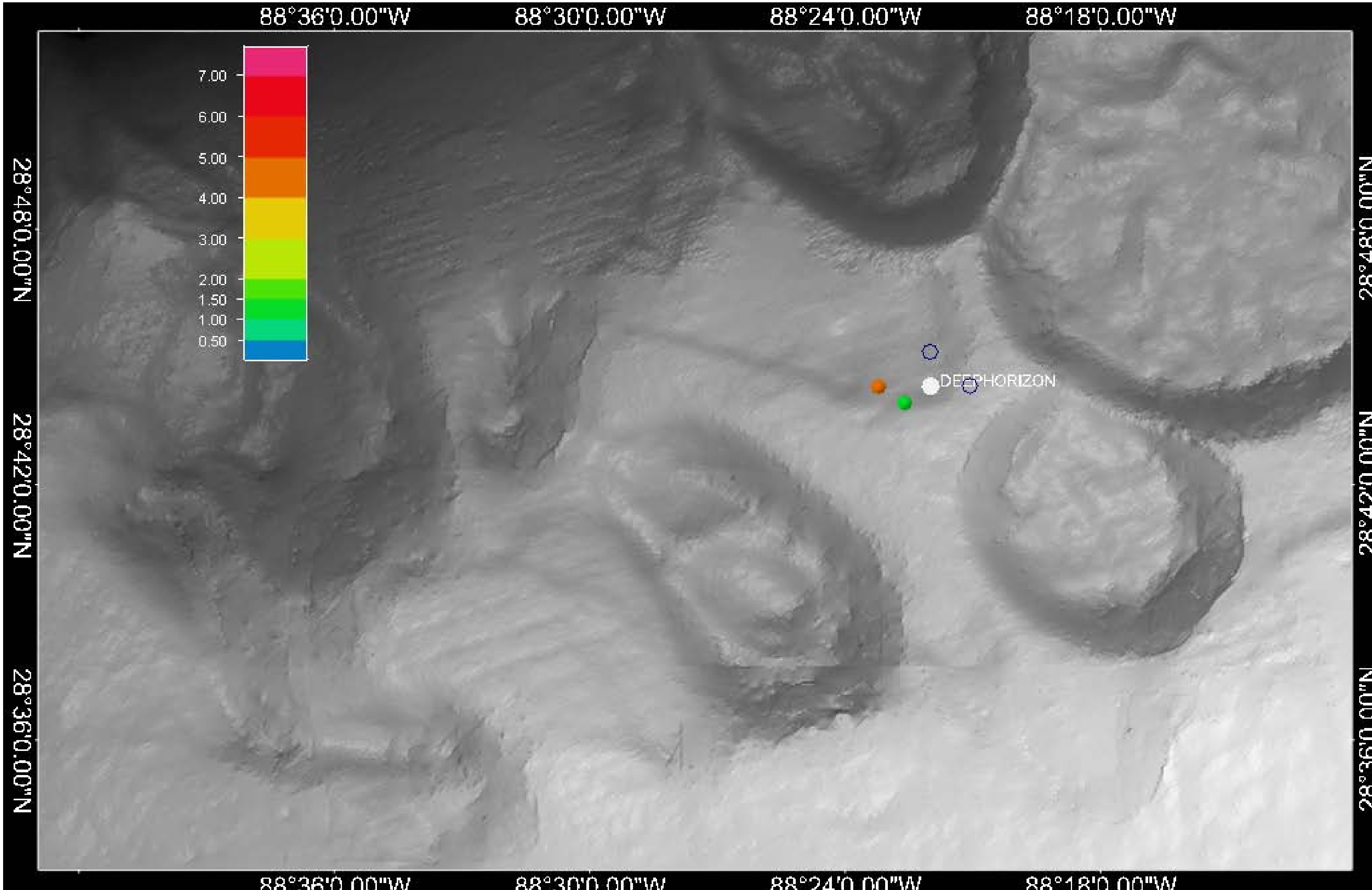


Figure 16: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 23 May 2010

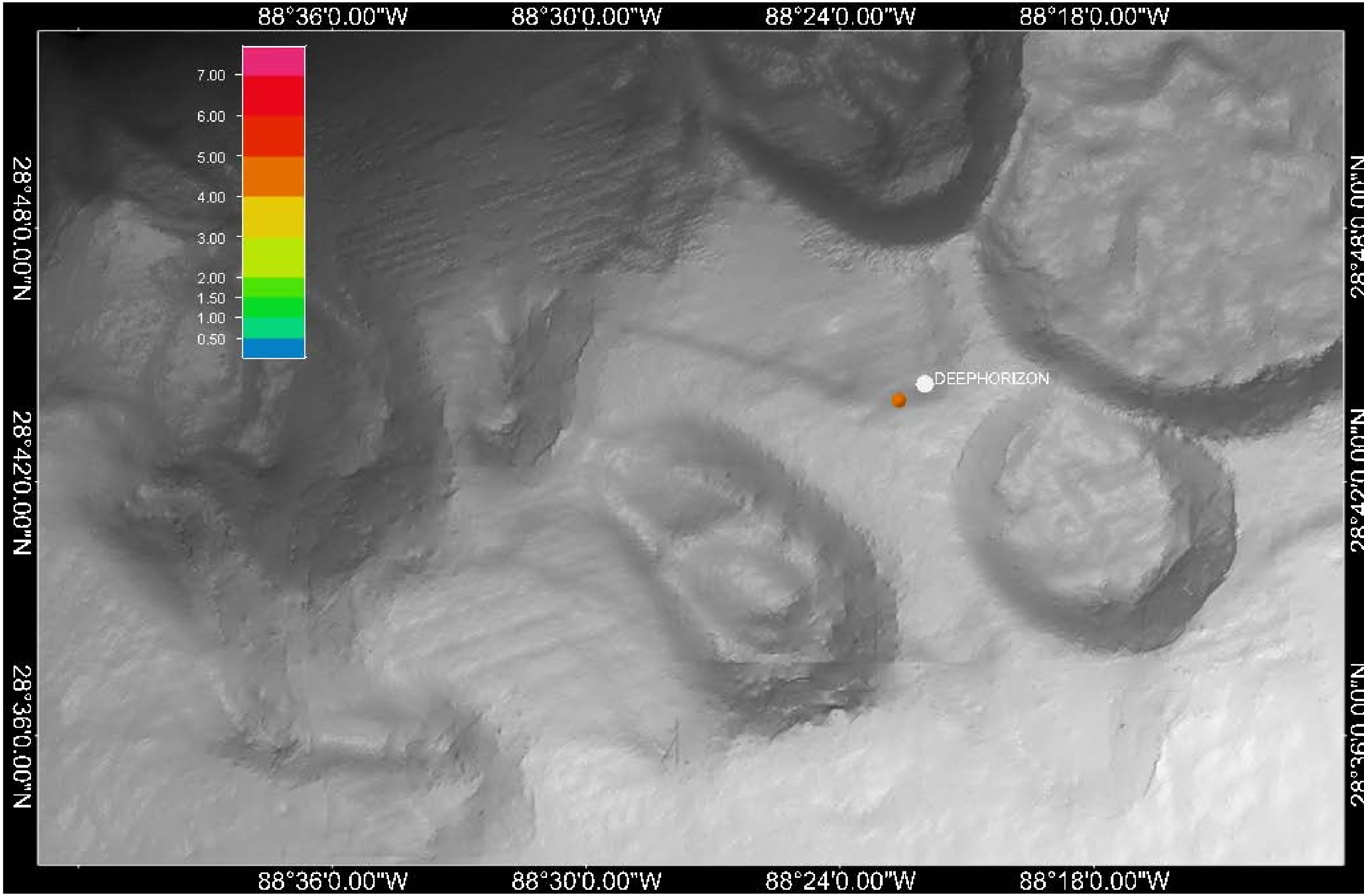


Figure 17: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 24 May 2010

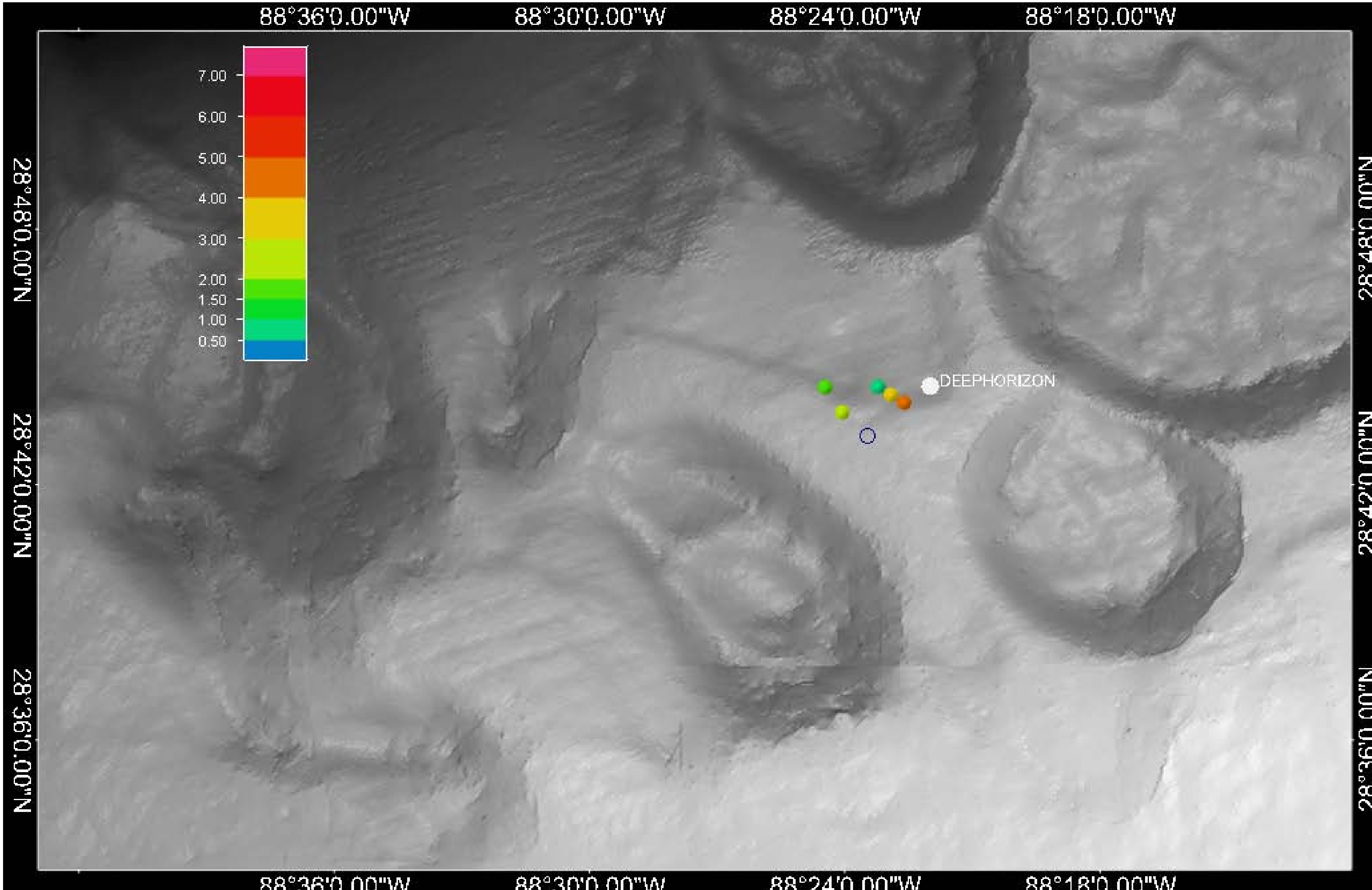


Figure 18: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 25 May 2010

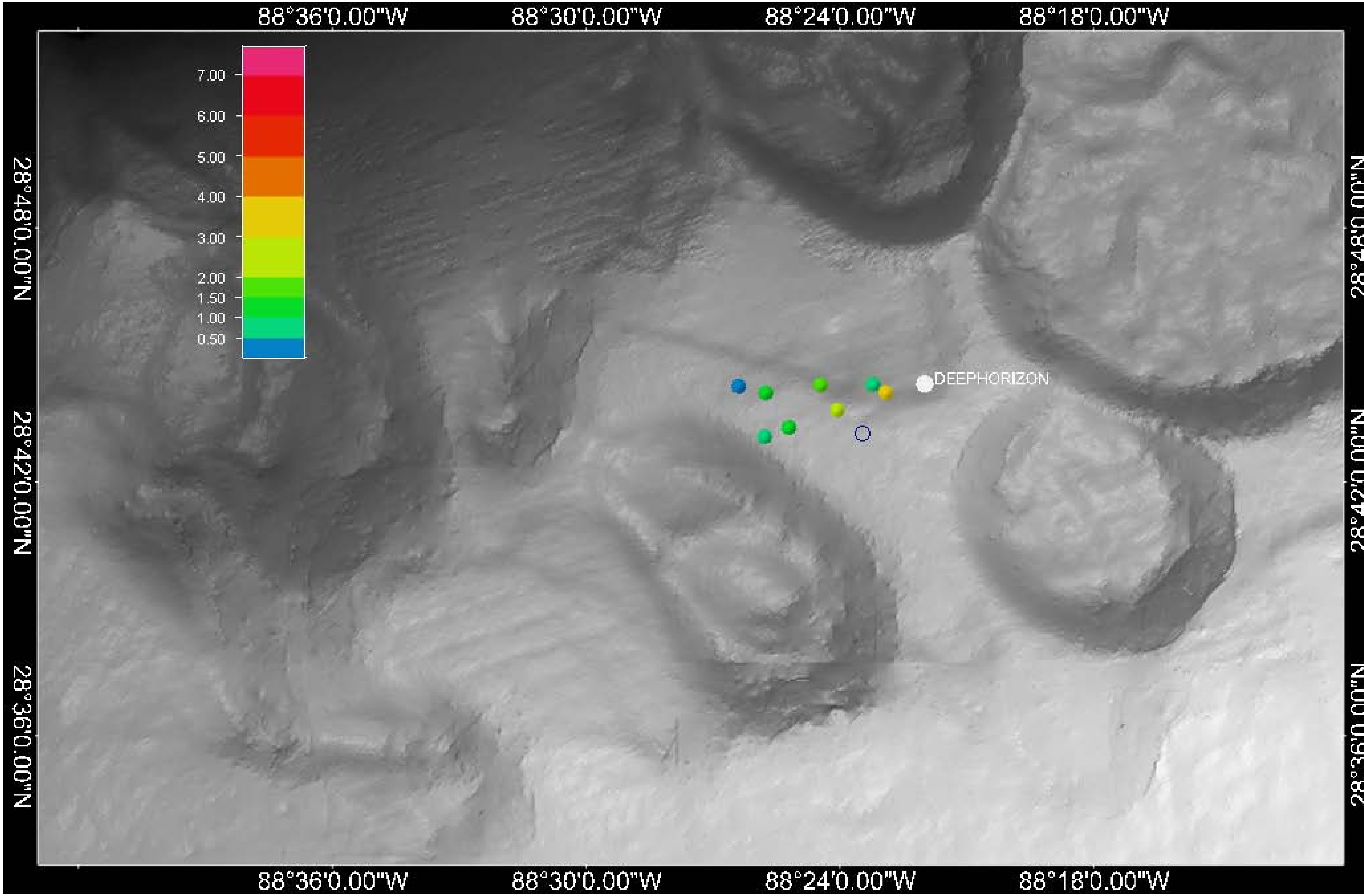


Figure 19: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 26 May 2010

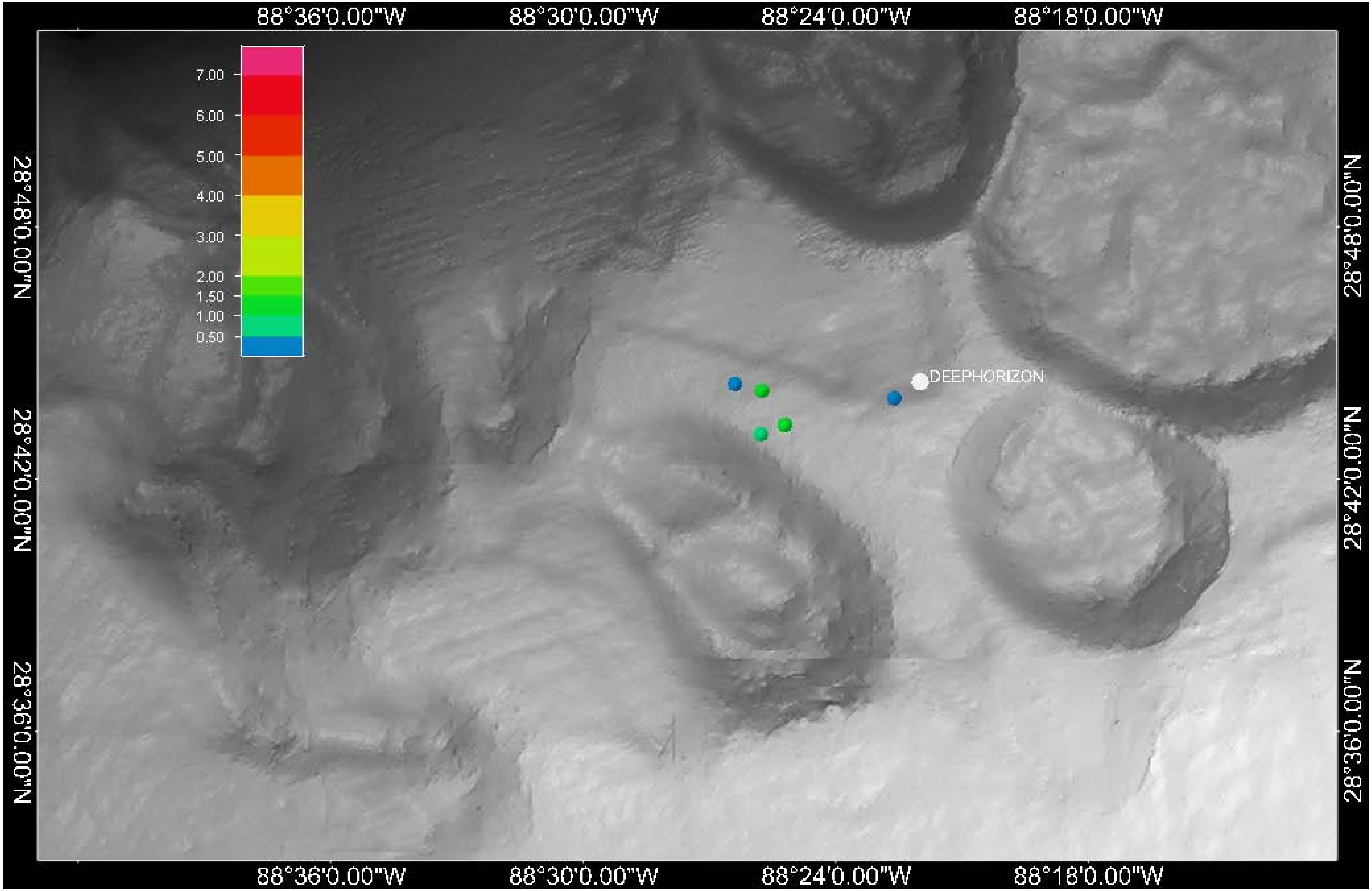


Figure 20: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 27 May 2010

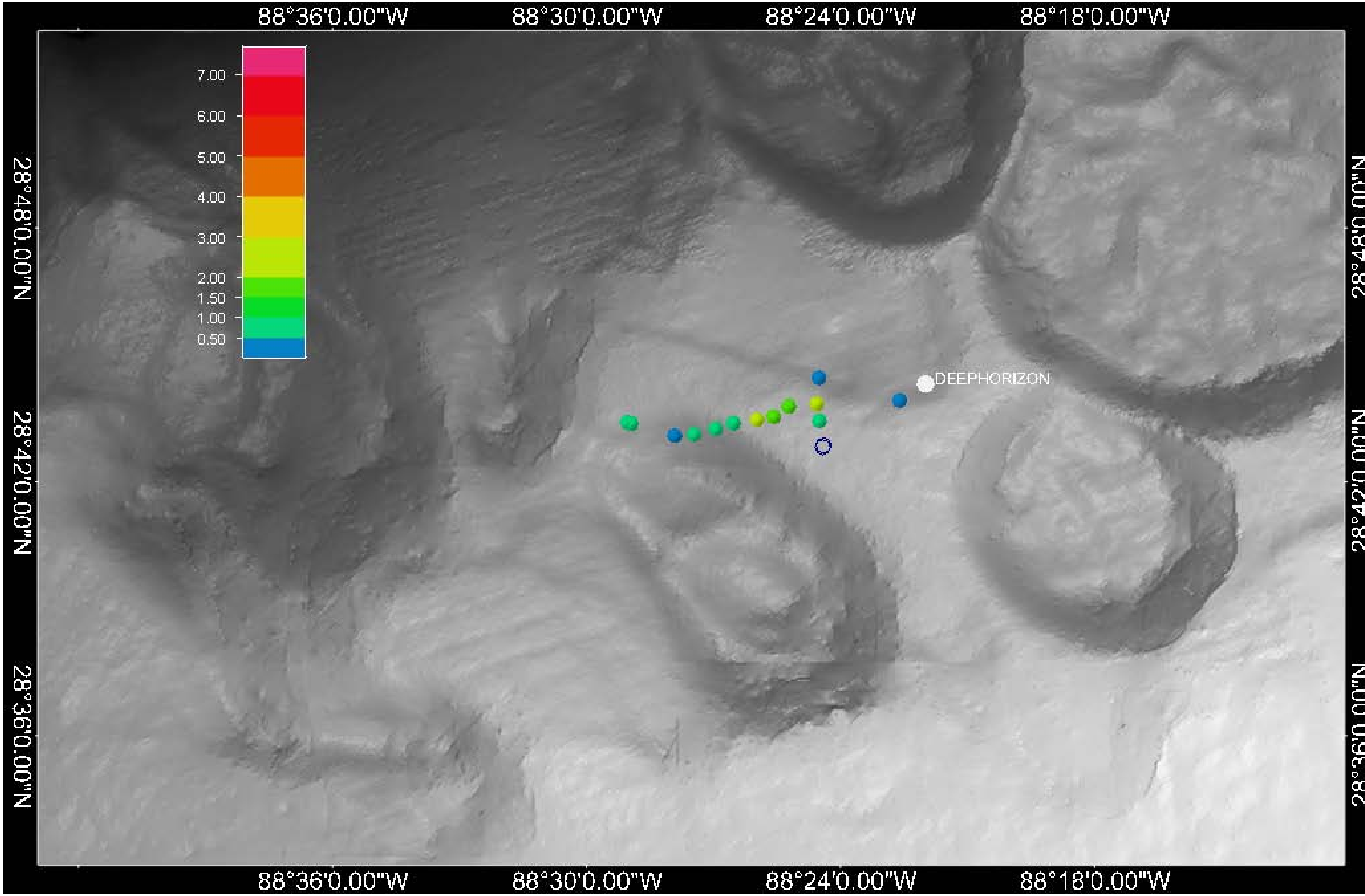


Figure 21: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 28 May 2010

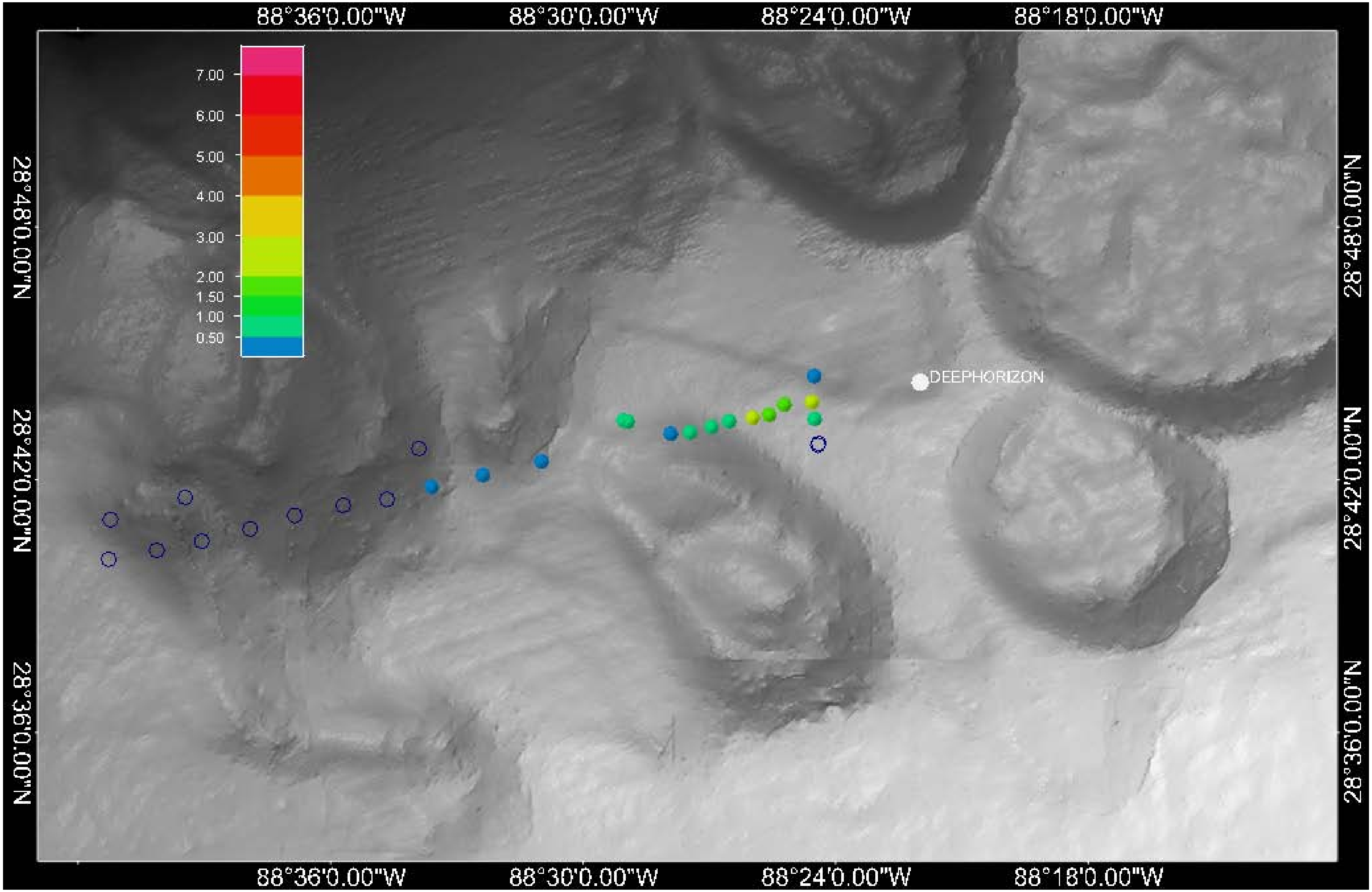


Figure 22: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 29 May 2010

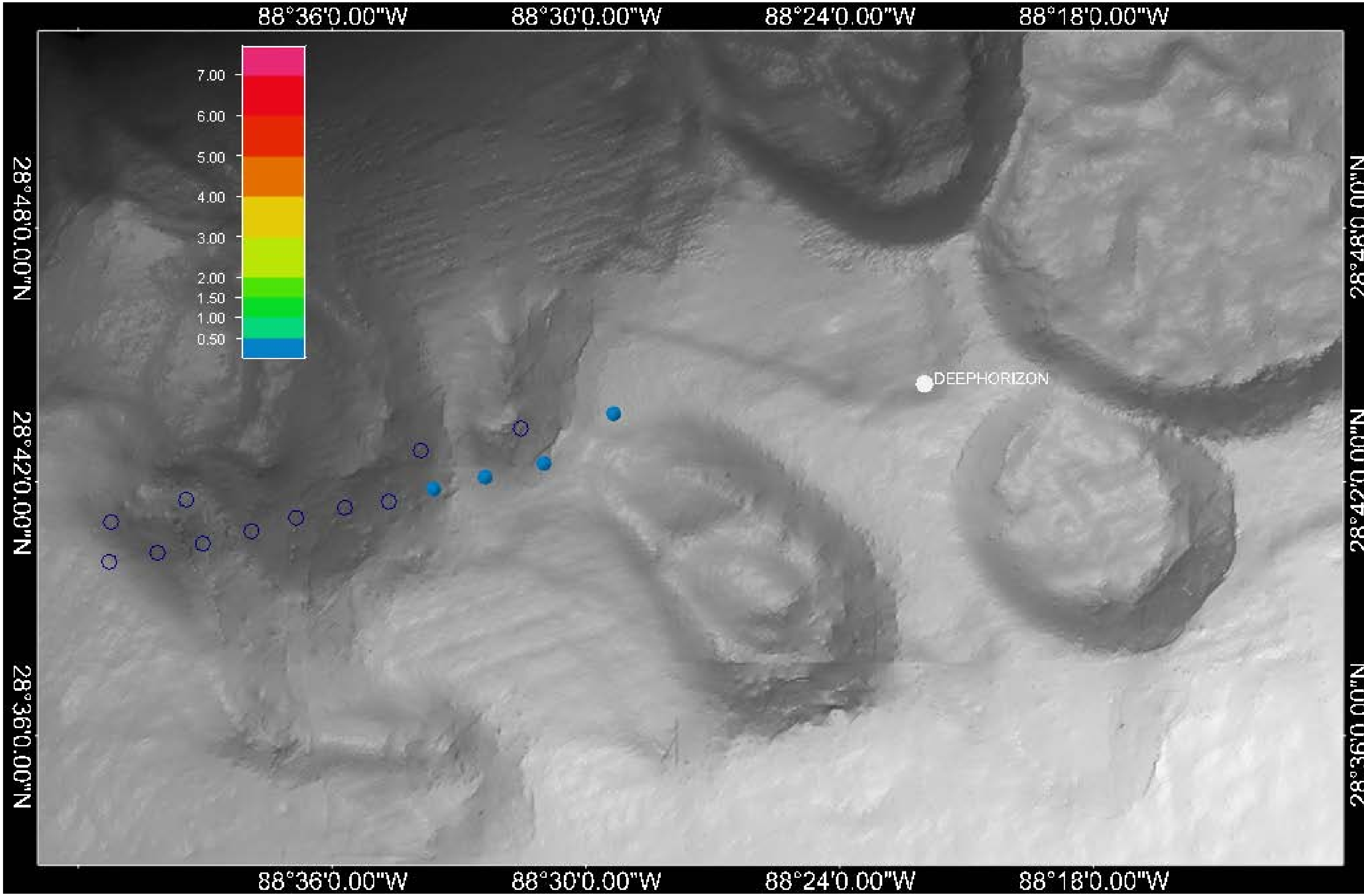


Figure 23: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 30 May 2010

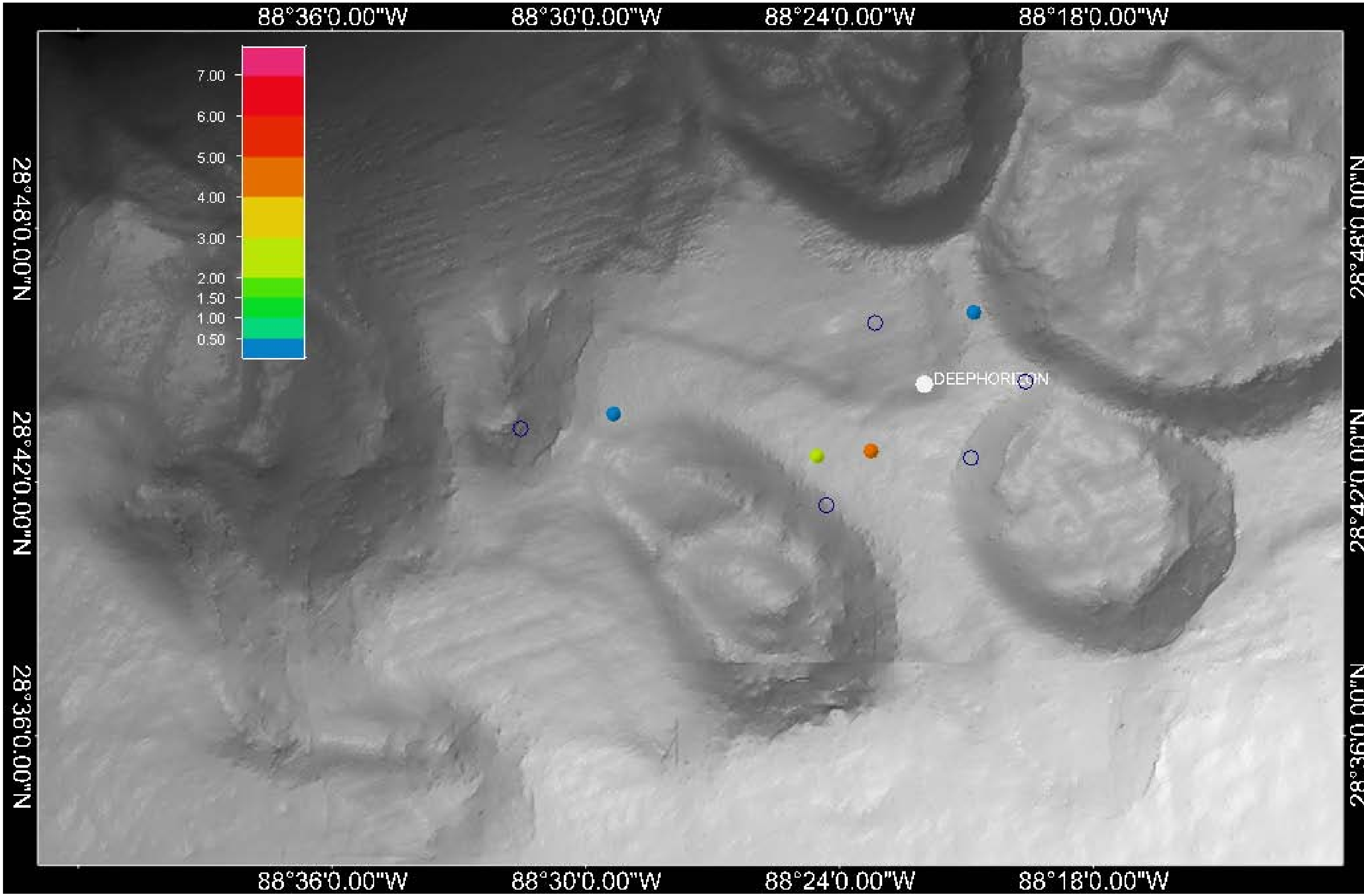


Figure 24: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 31 May 2010

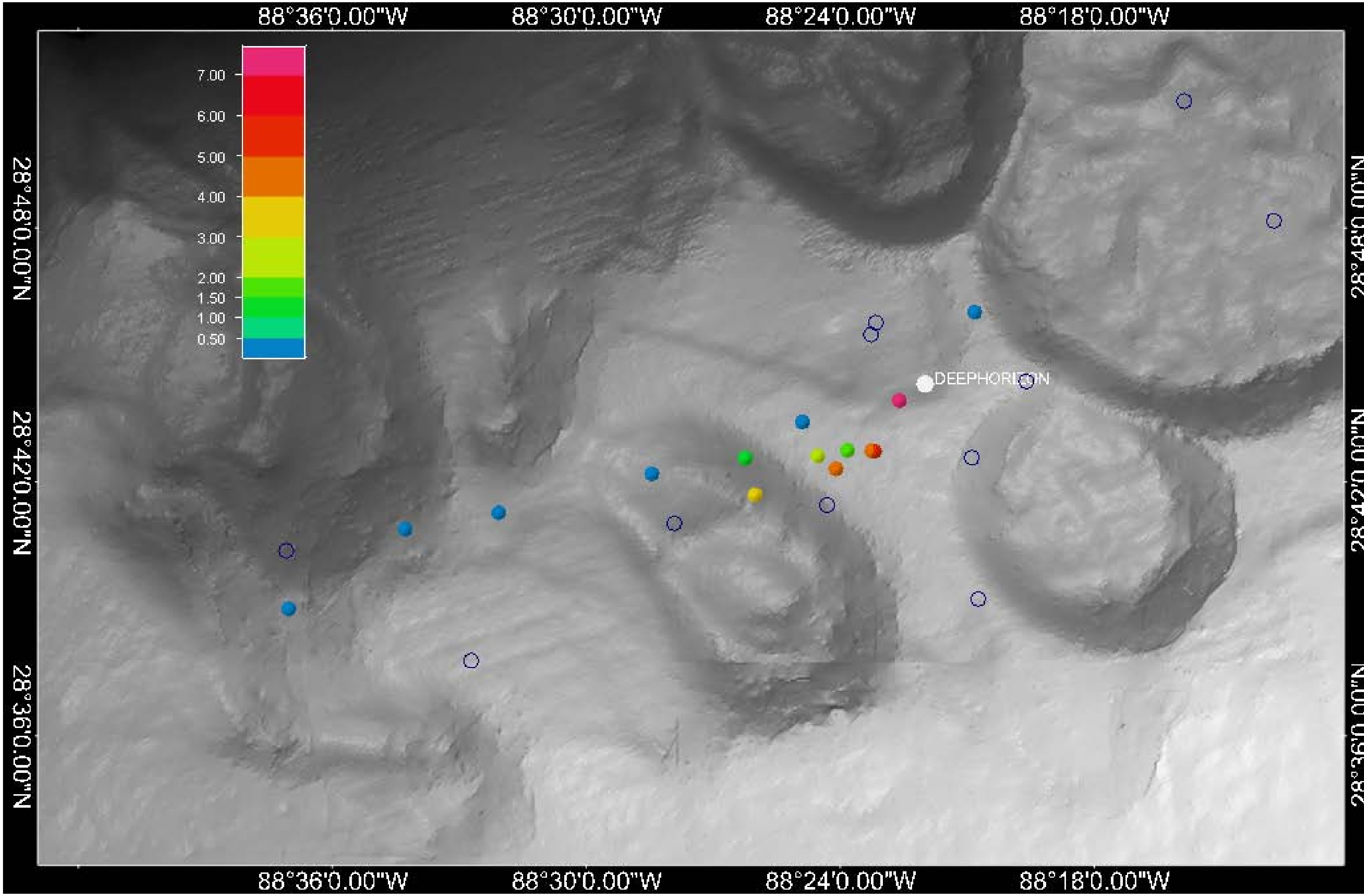


Figure 25: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 01 June 2010

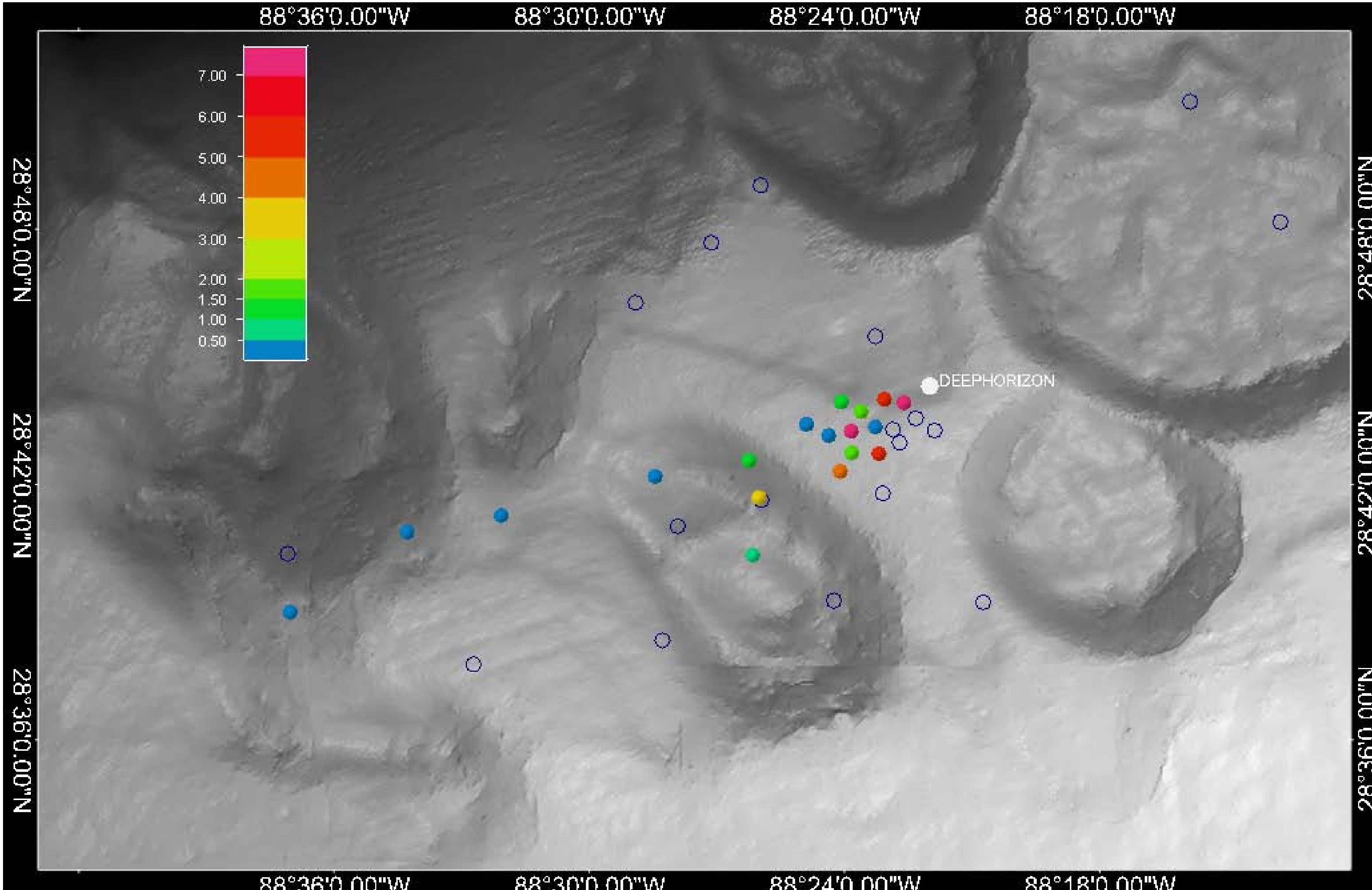


Figure 26: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 02 June 2010

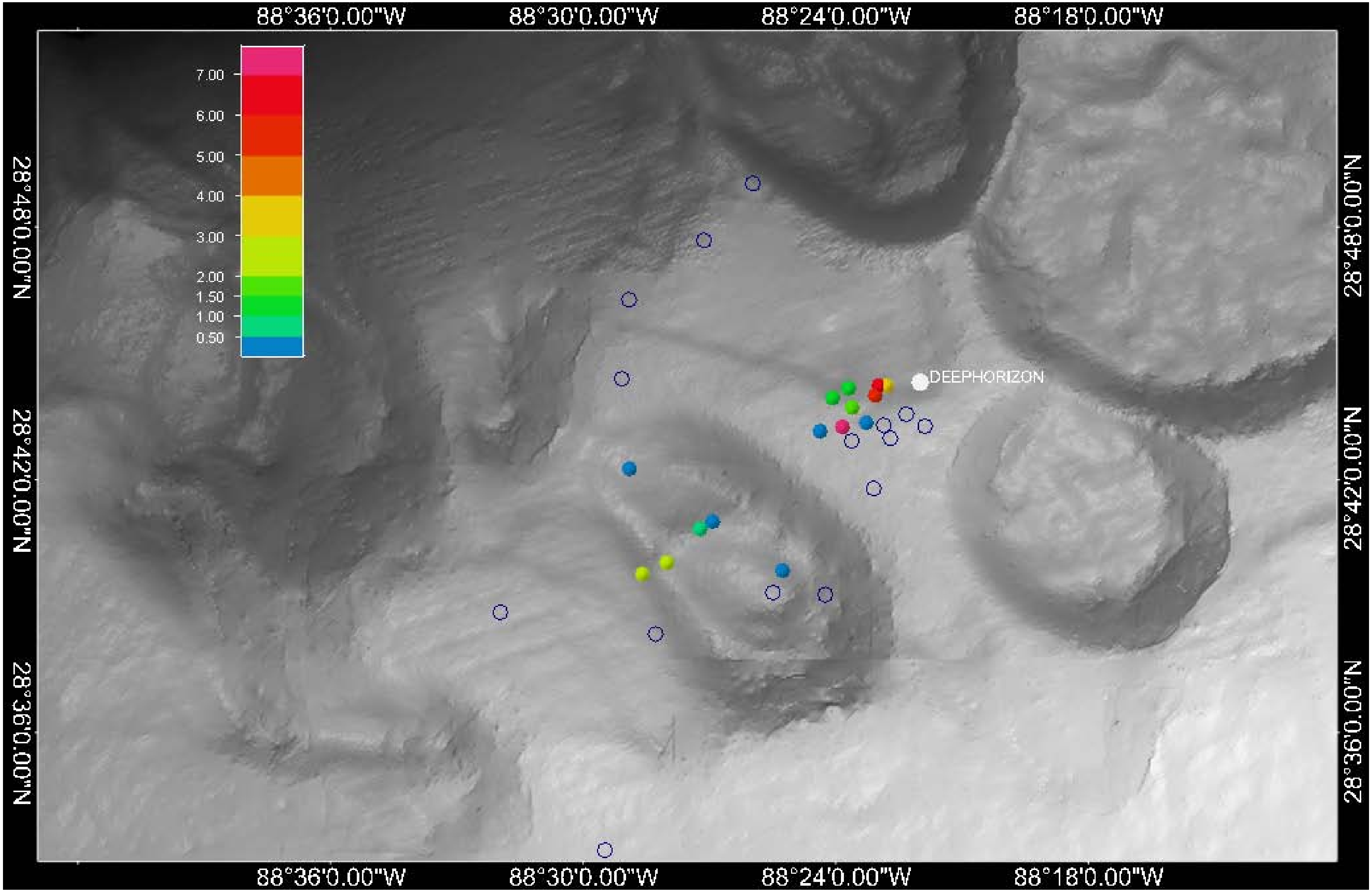


Figure 27: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 03 June 2010

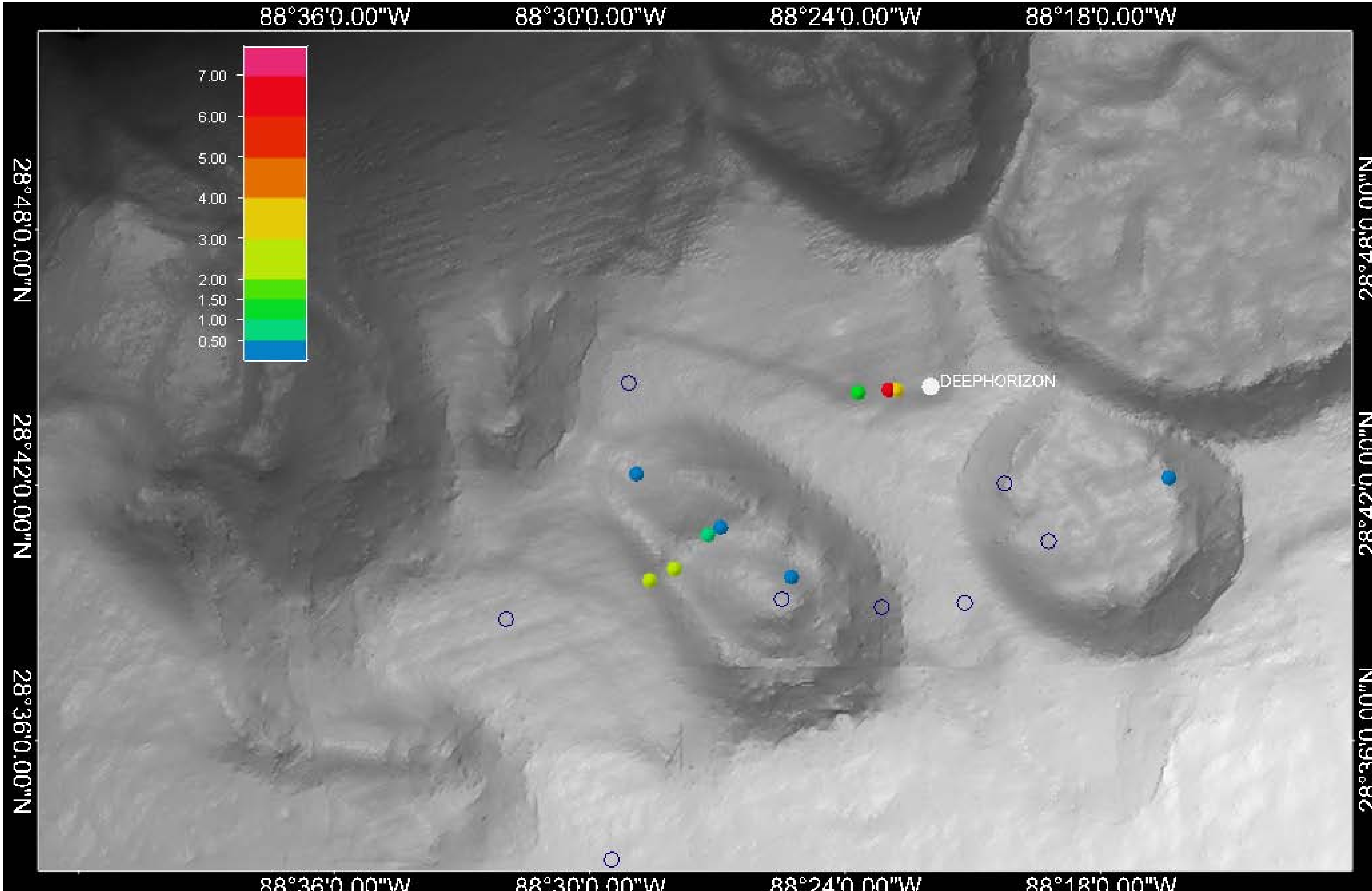


Figure 28: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 04 June 2010

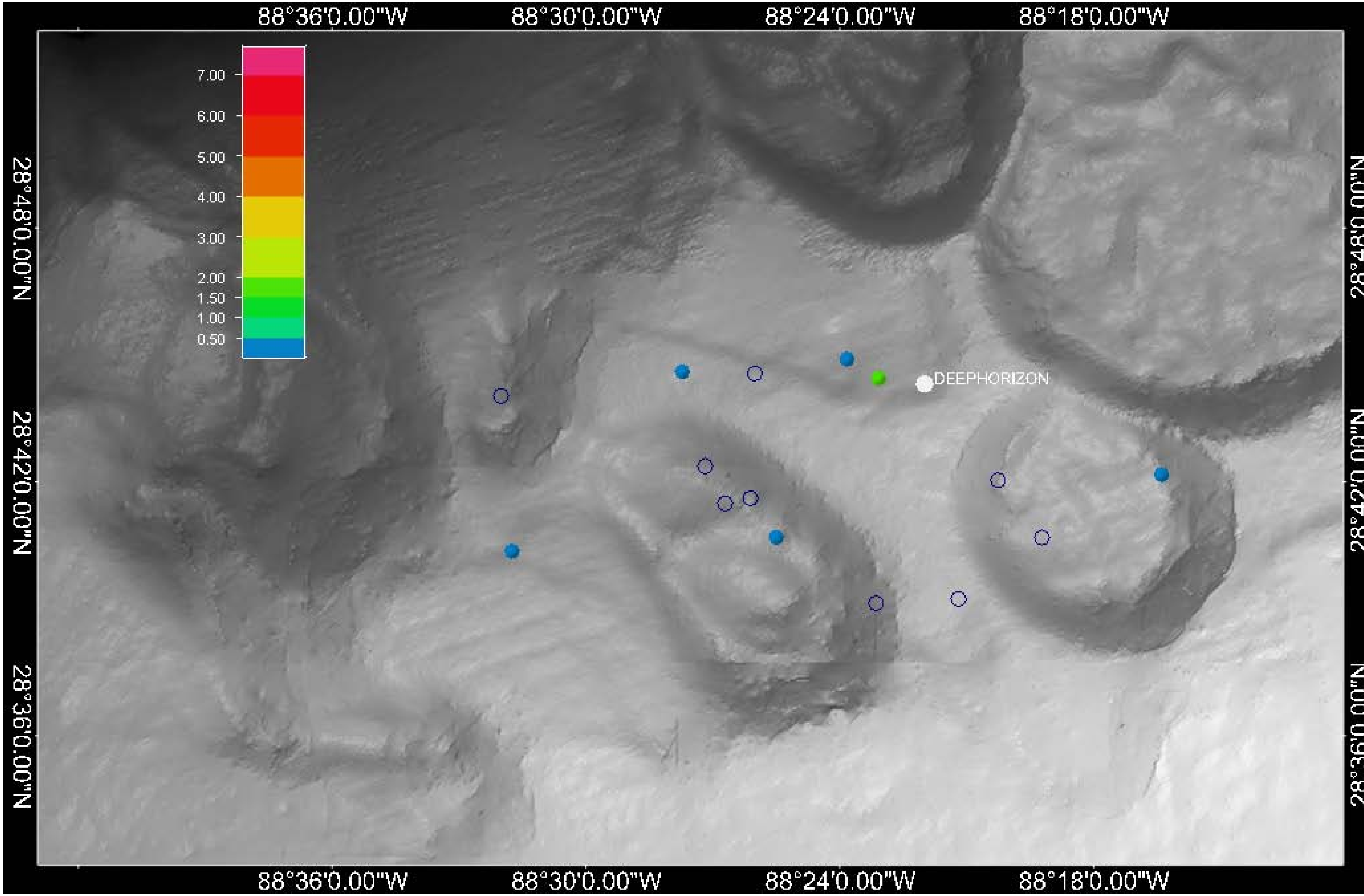


Figure 29: Mean Fluorescence ppb (QSDE) between 1000 and 1300m on 05 June 2010

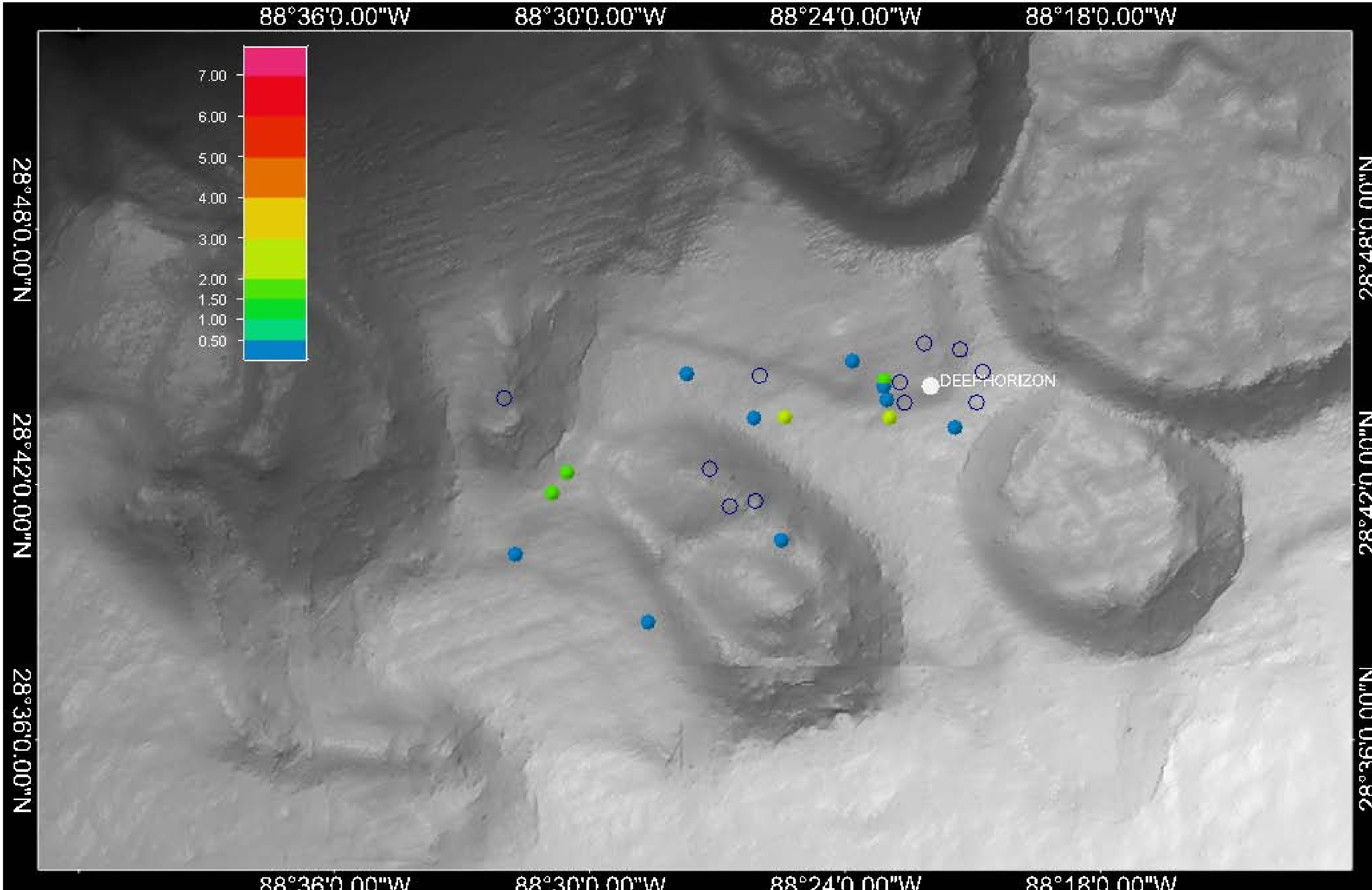


Figure 30: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 06 June 2010

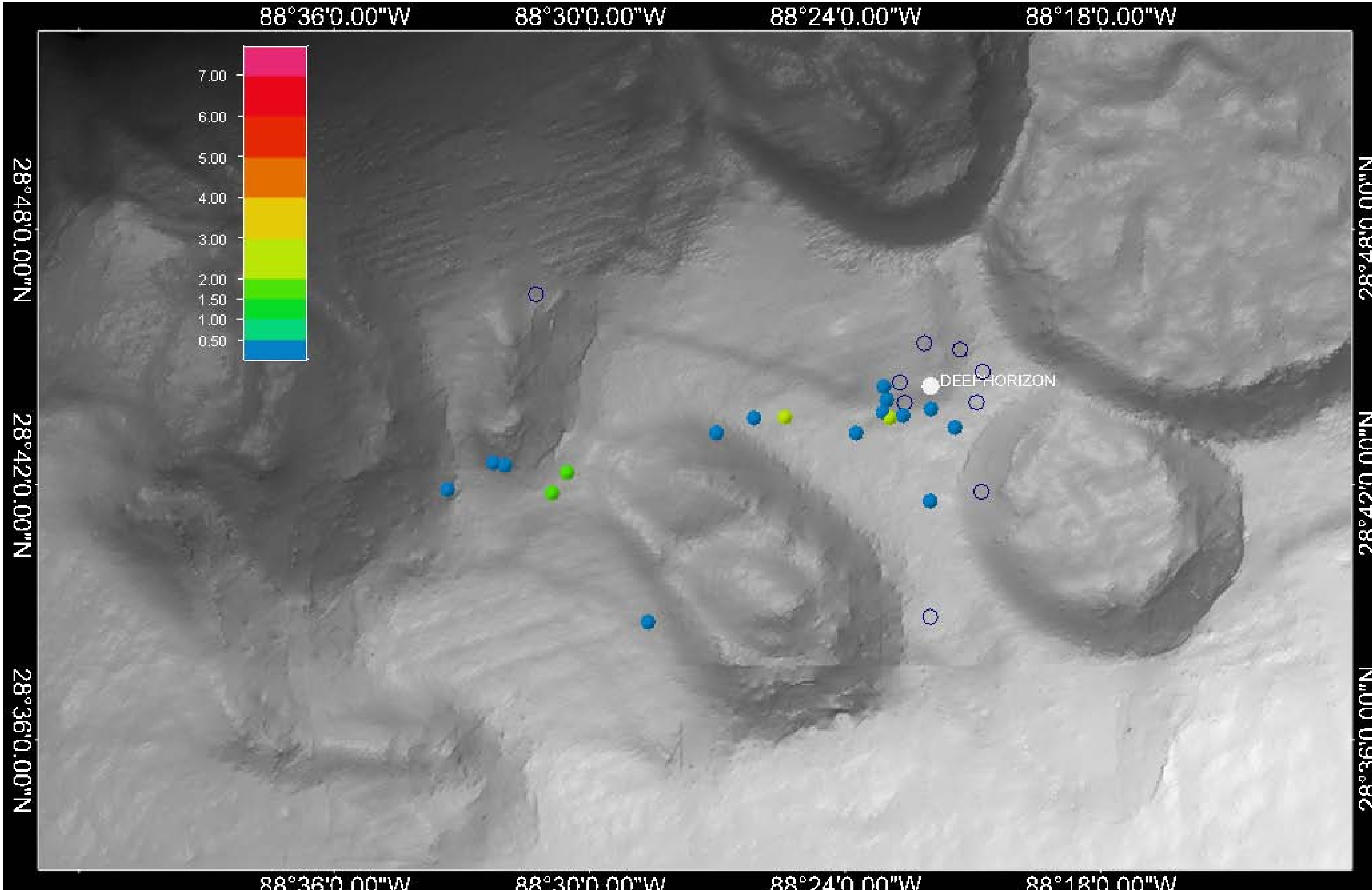


Figure 31: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 07 June 2010

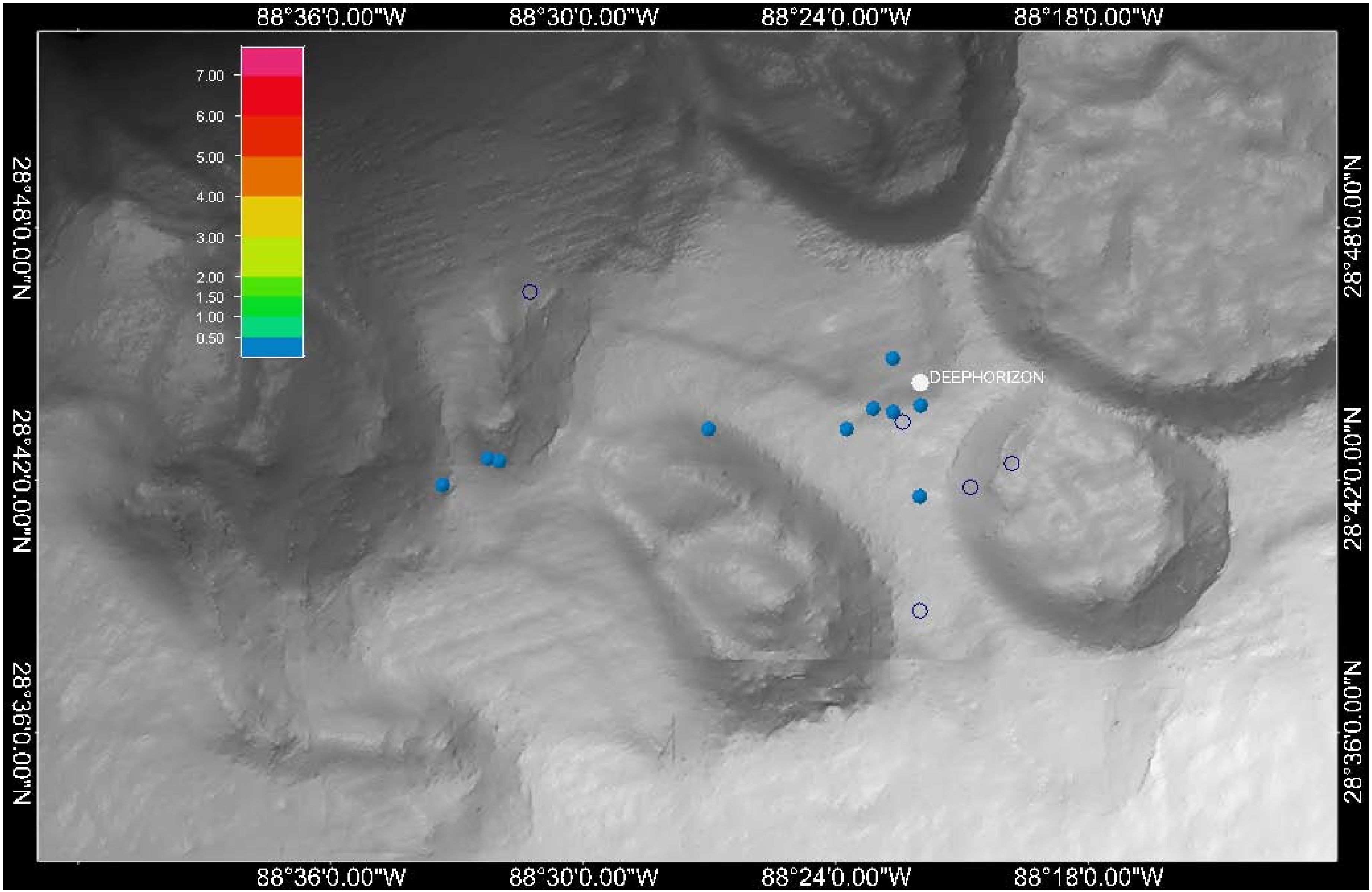


Figure 32: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 08 June 2010

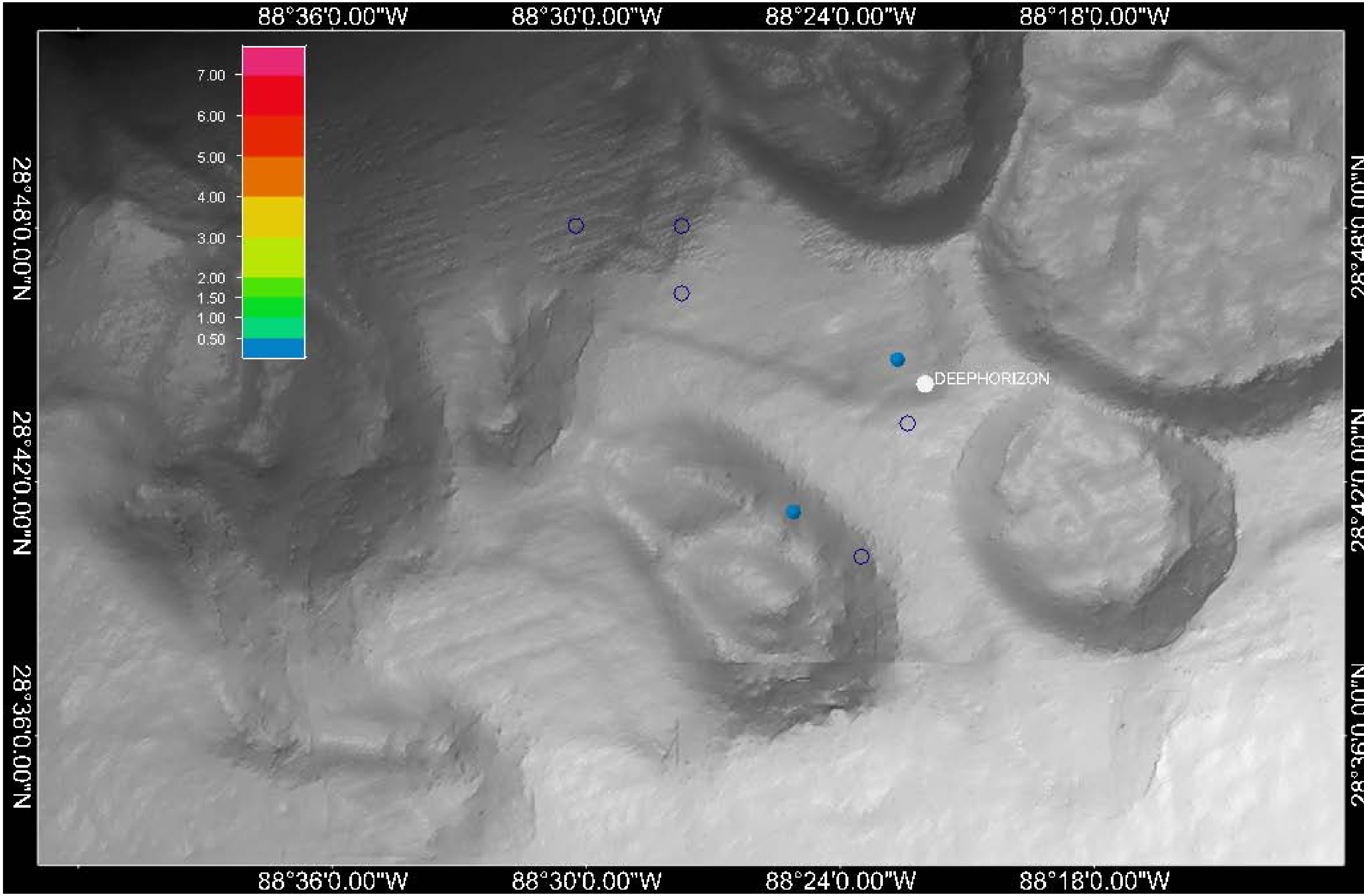


Figure 33: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 09 June 2010

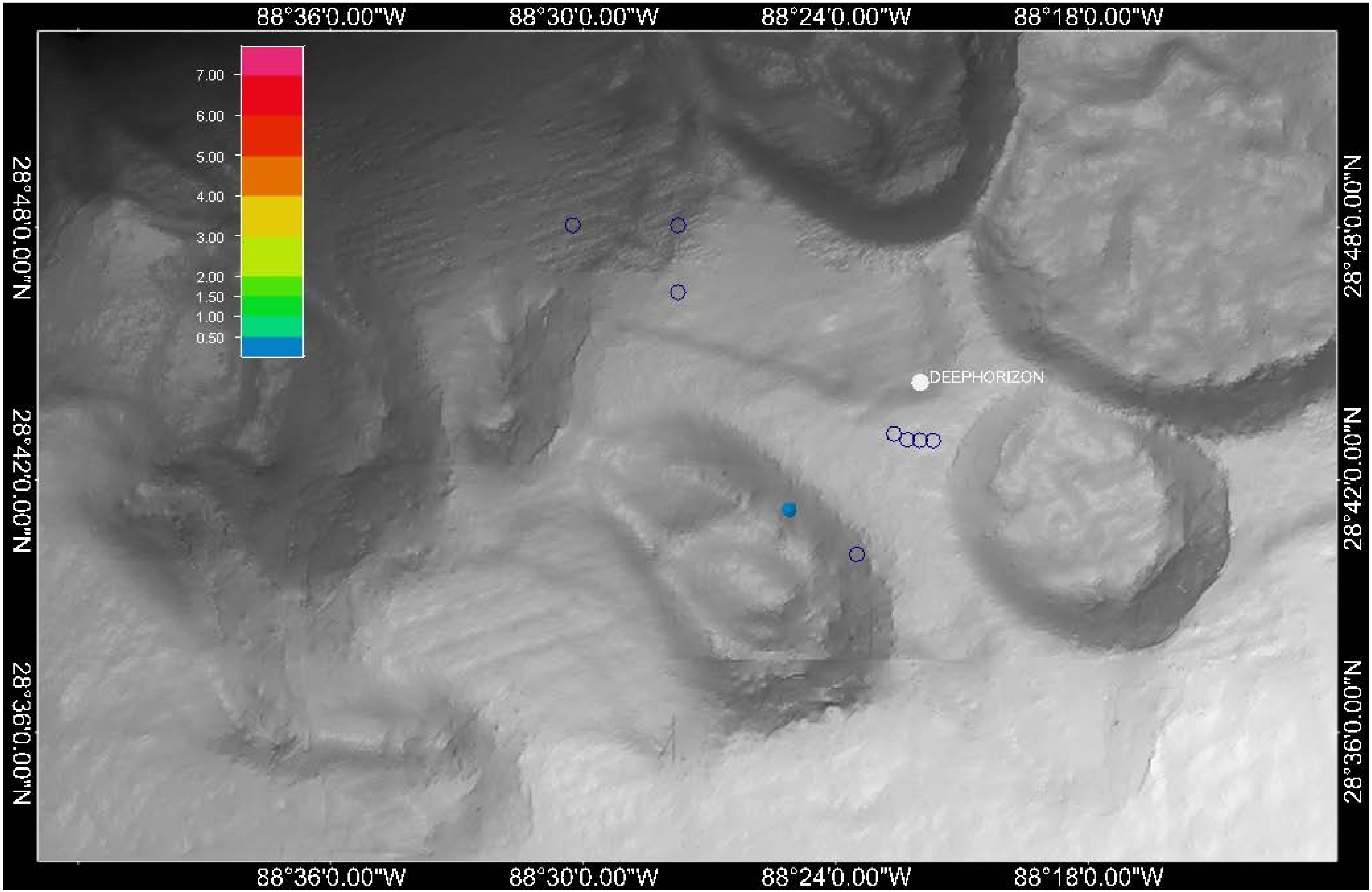


Figure 34: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 10 June 2010

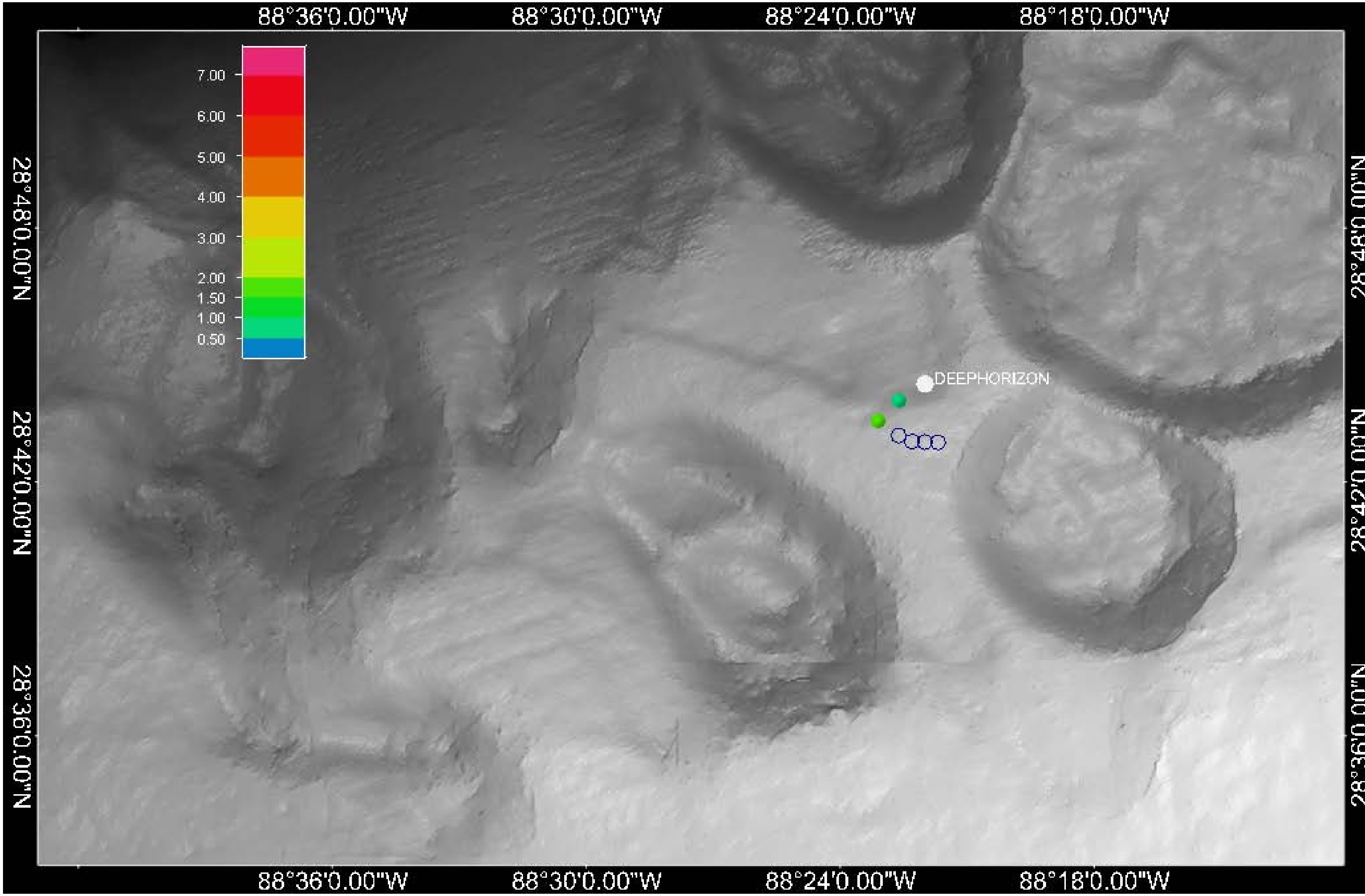


Figure 35: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 11 June 2010

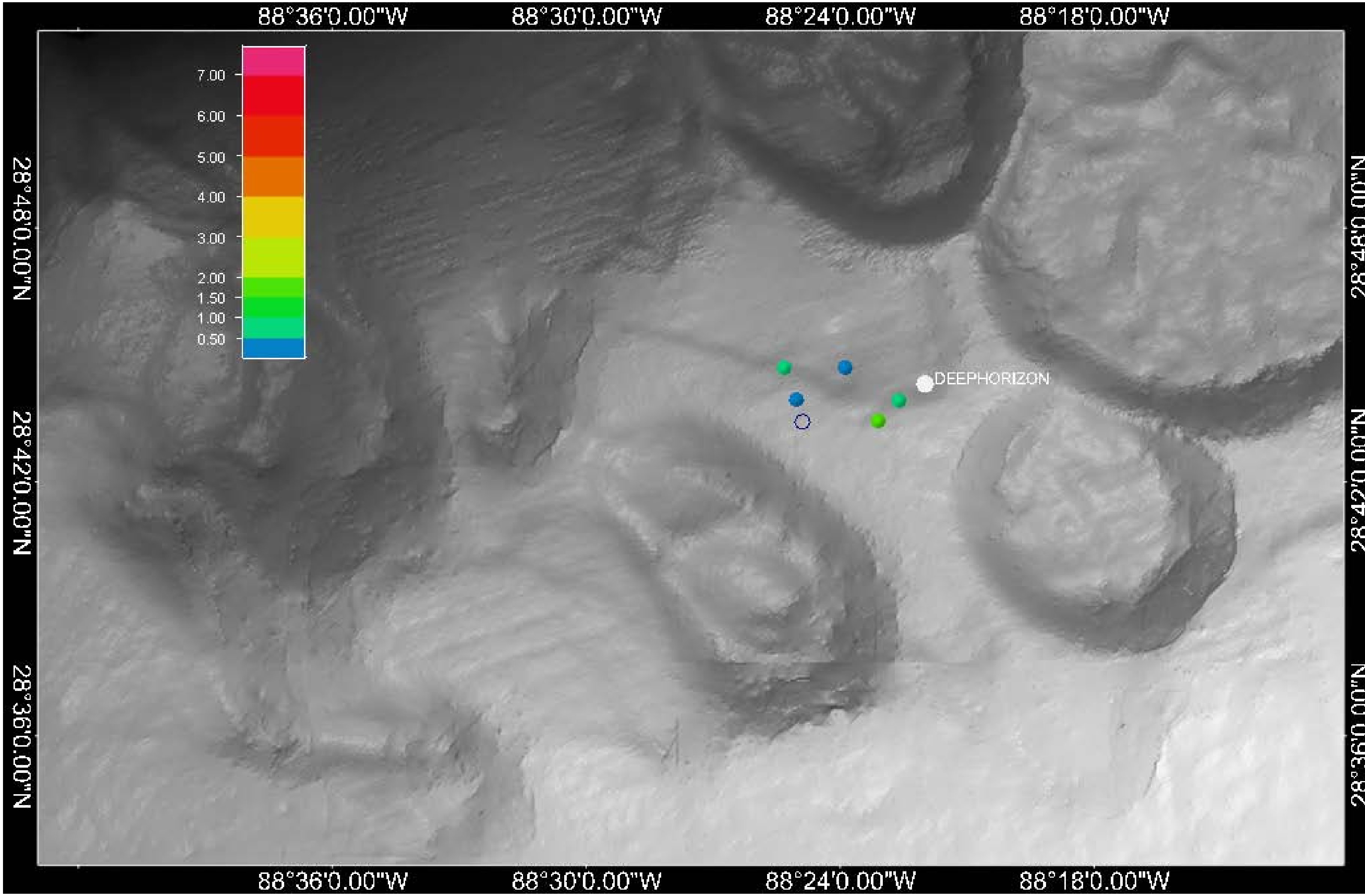


Figure 36: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 12 June 2010

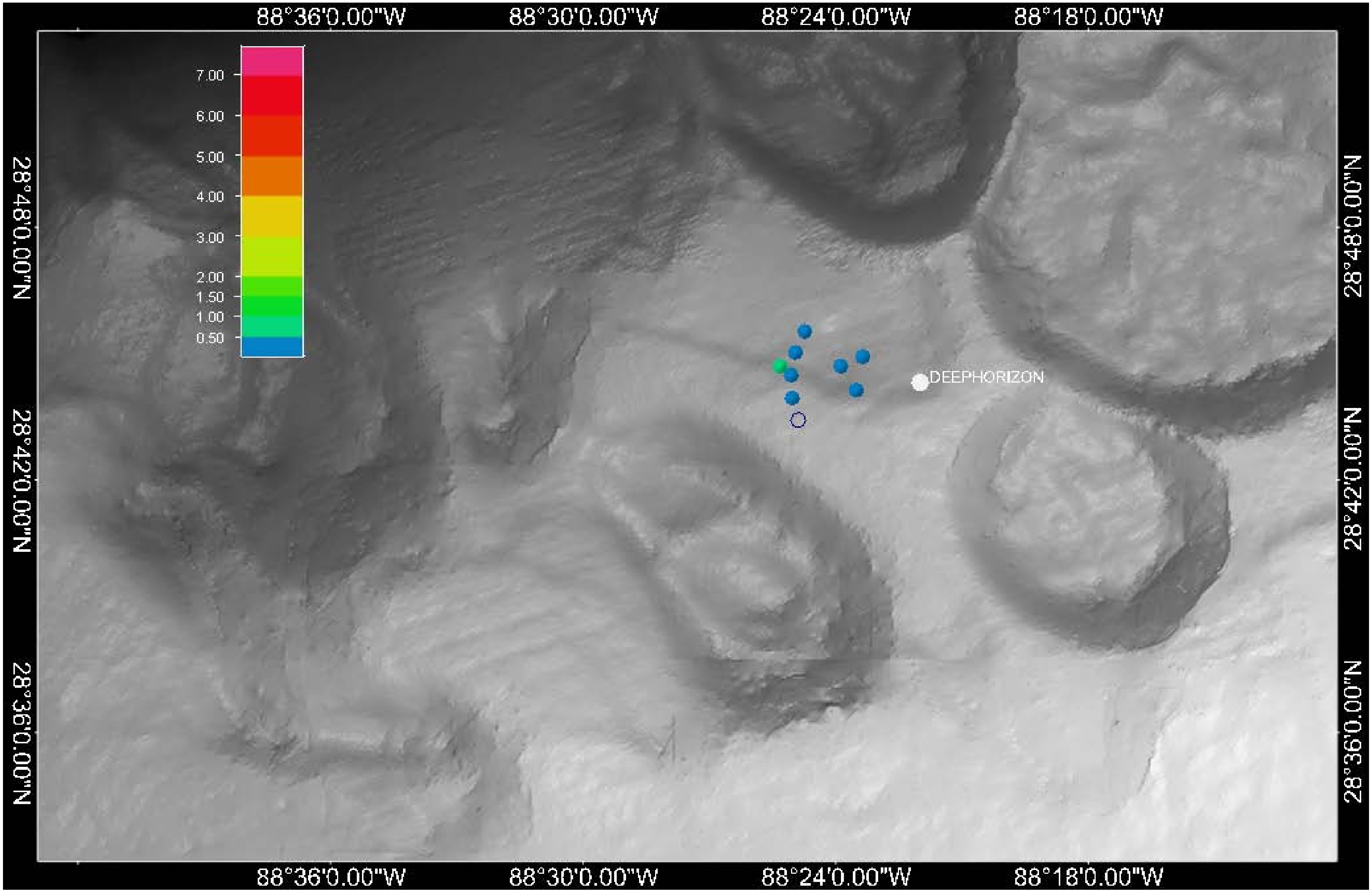


Figure 37: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 13 June 2010

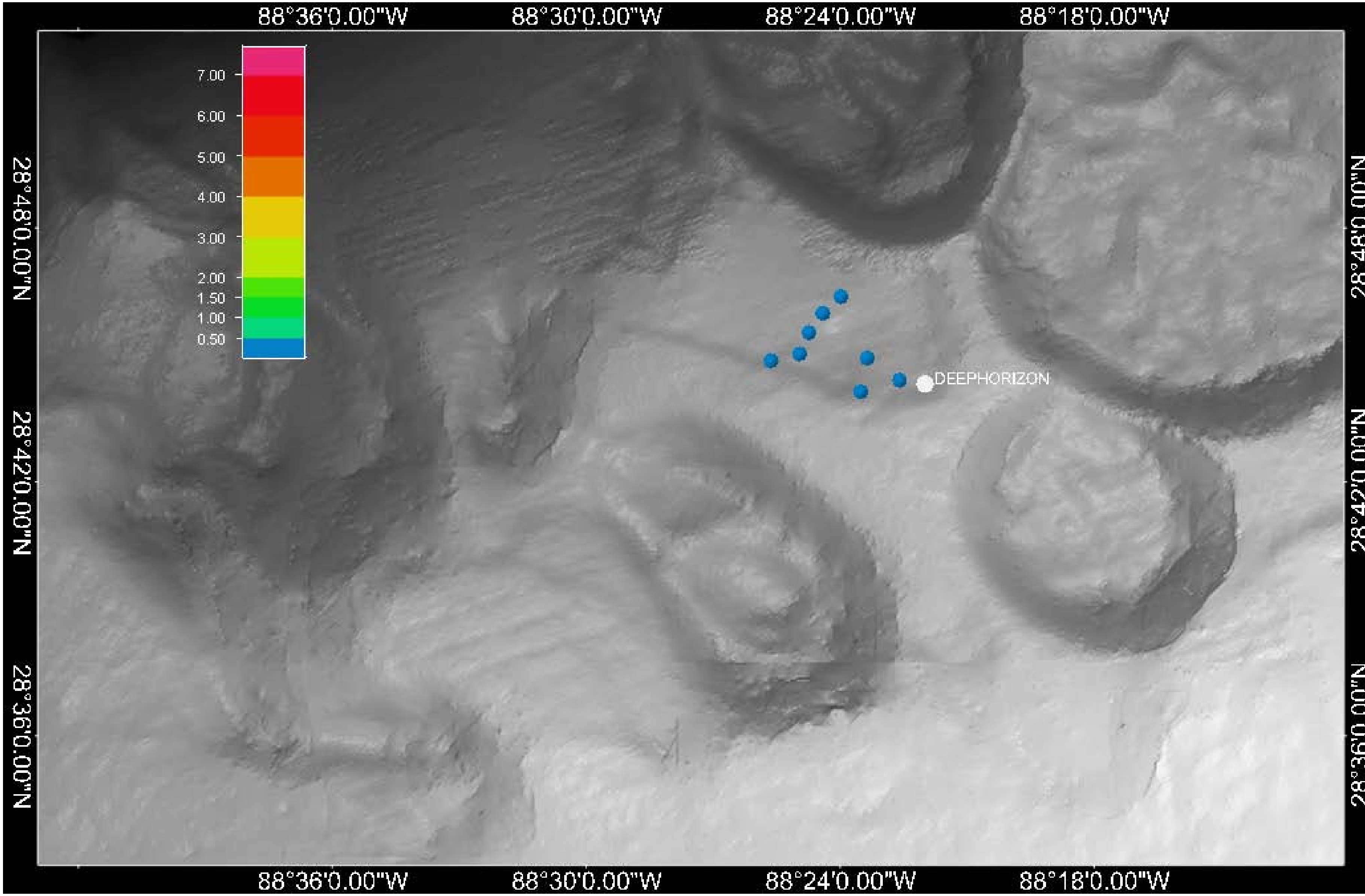


Figure 38: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 14 June 2010

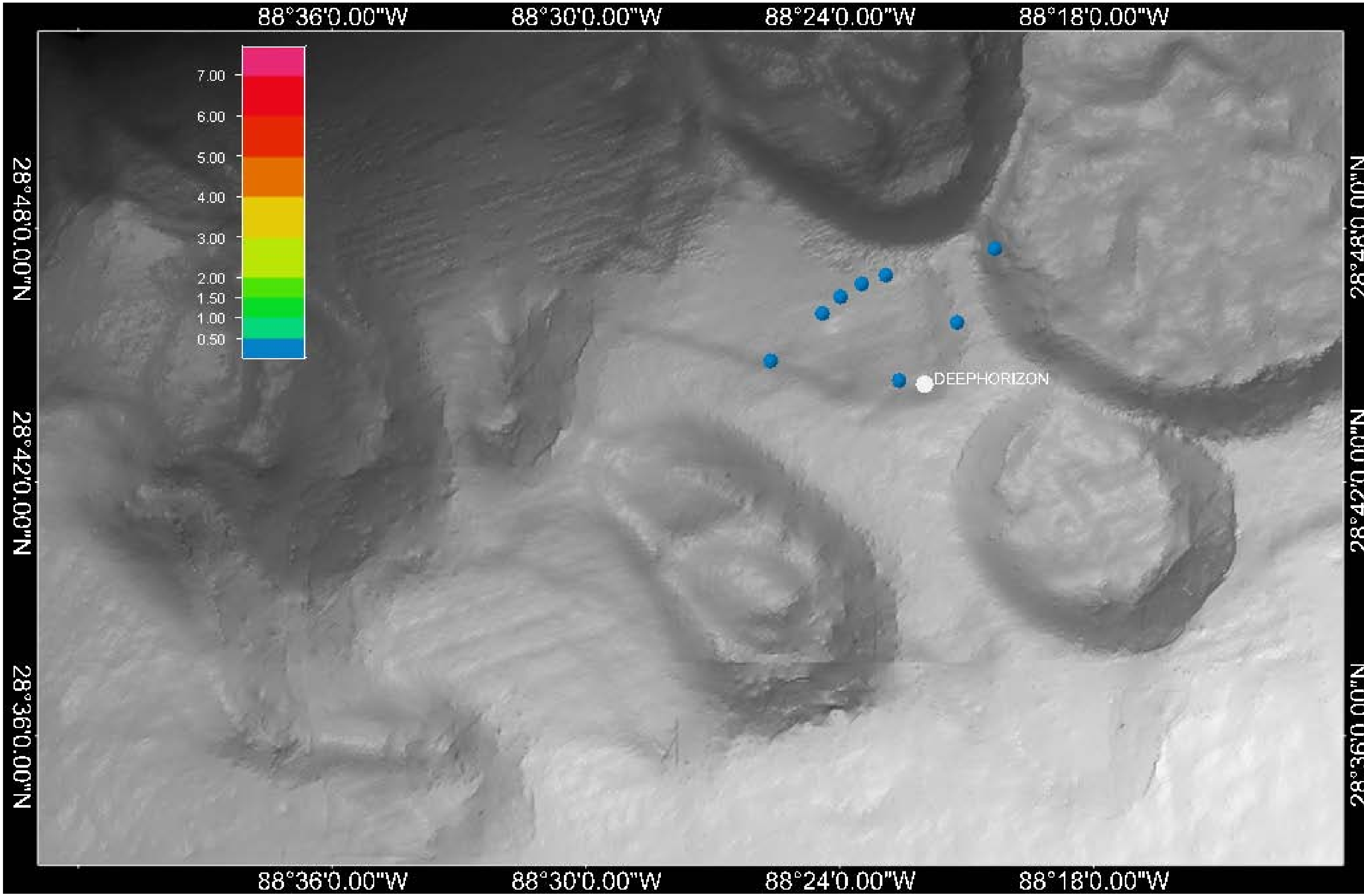


Figure 39: Mean Fluorescence ppb (QSDE) between 1000 and 1300m on 15 June 2010

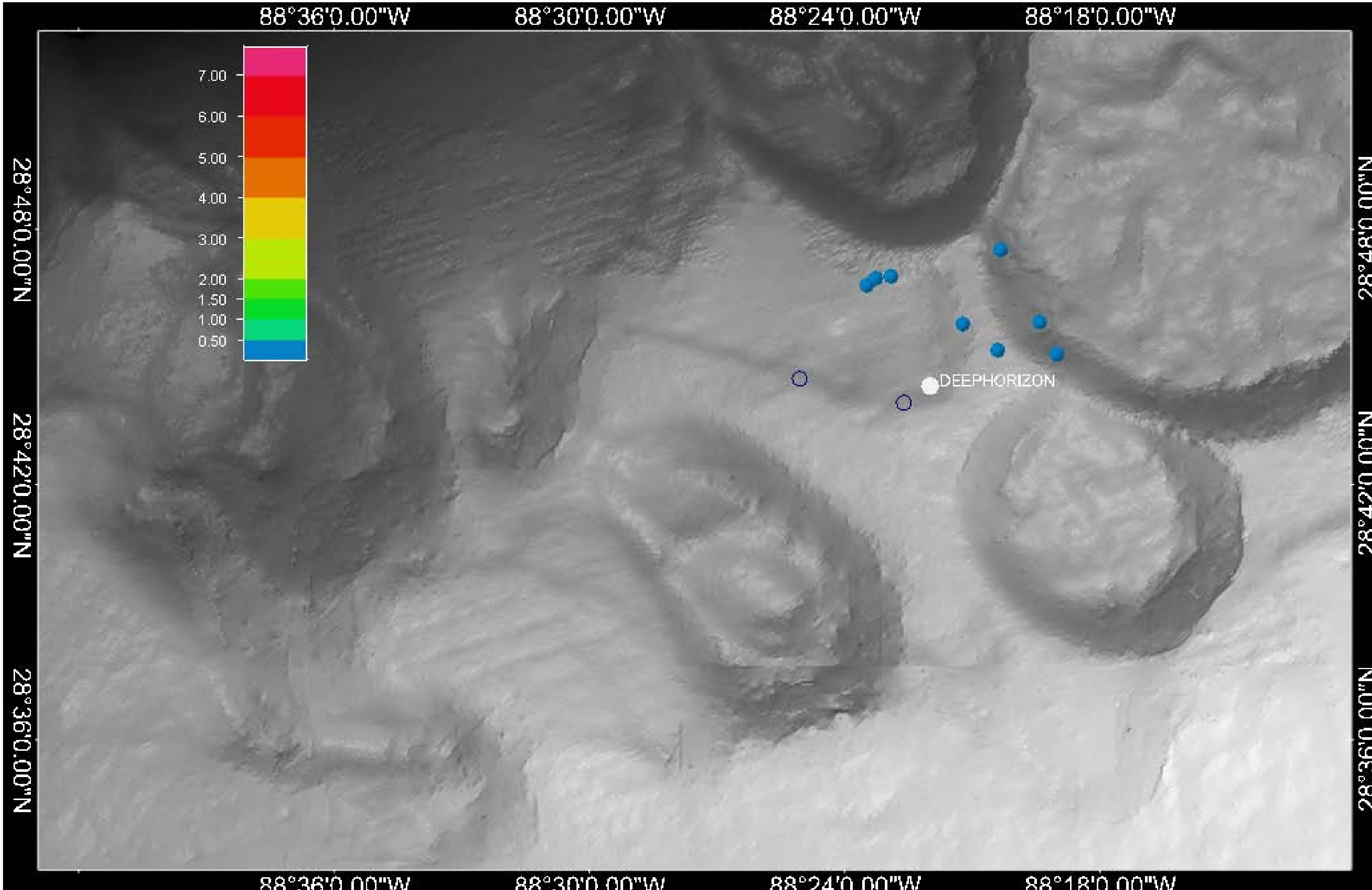


Figure 40: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 16 June 2010

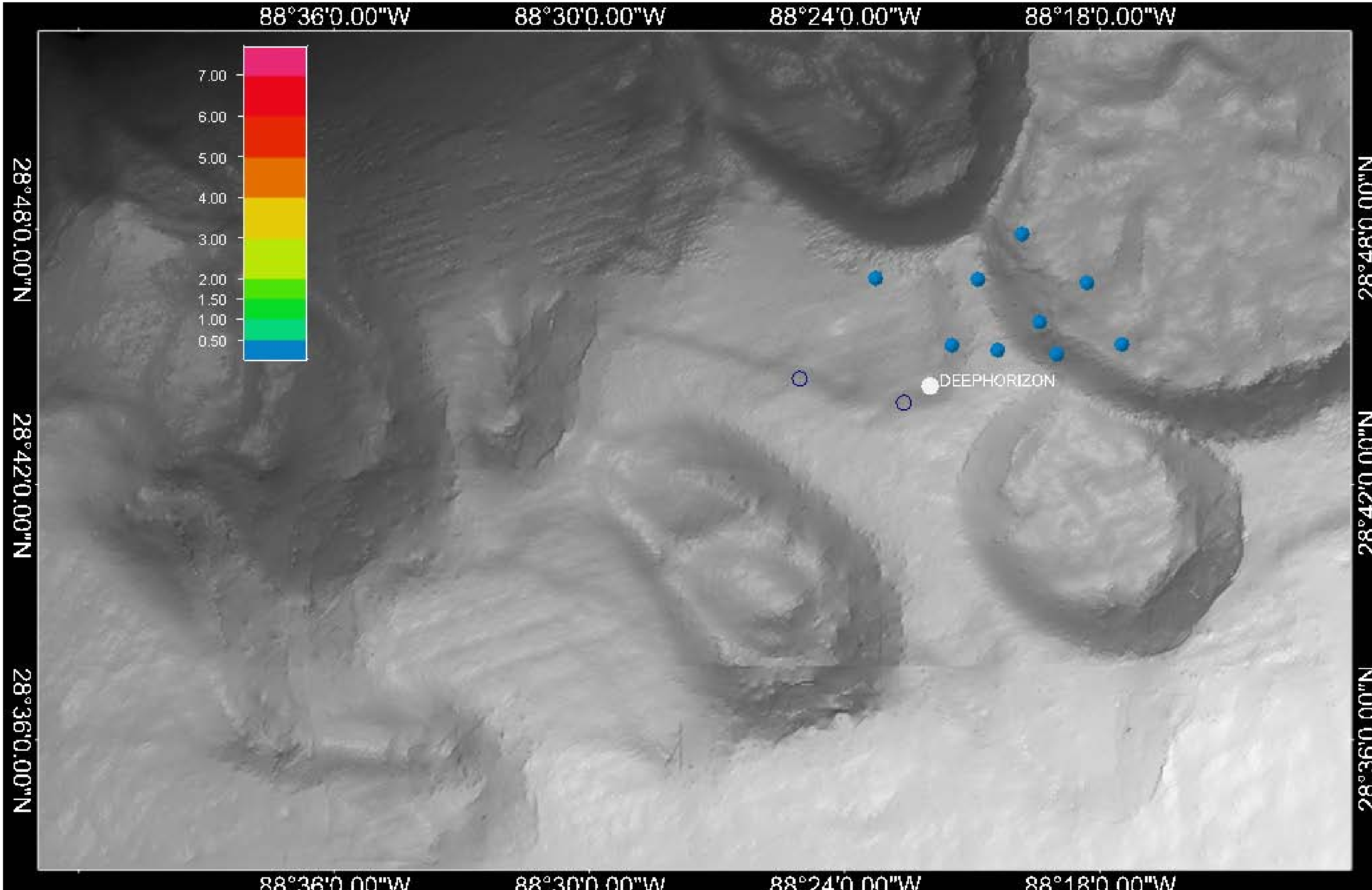


Figure 41: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 17 June 2010

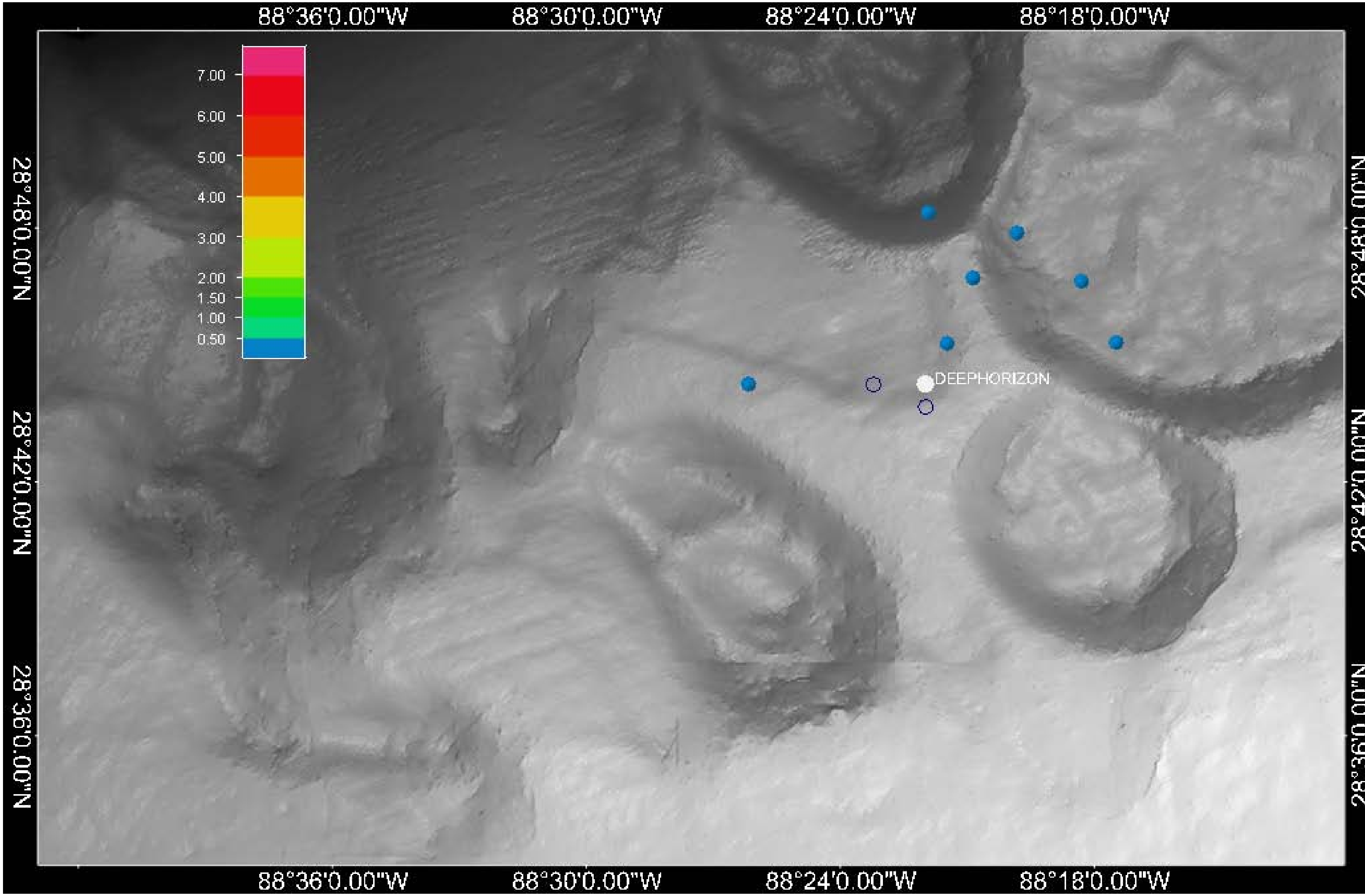


Figure 42: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 18 June 2010

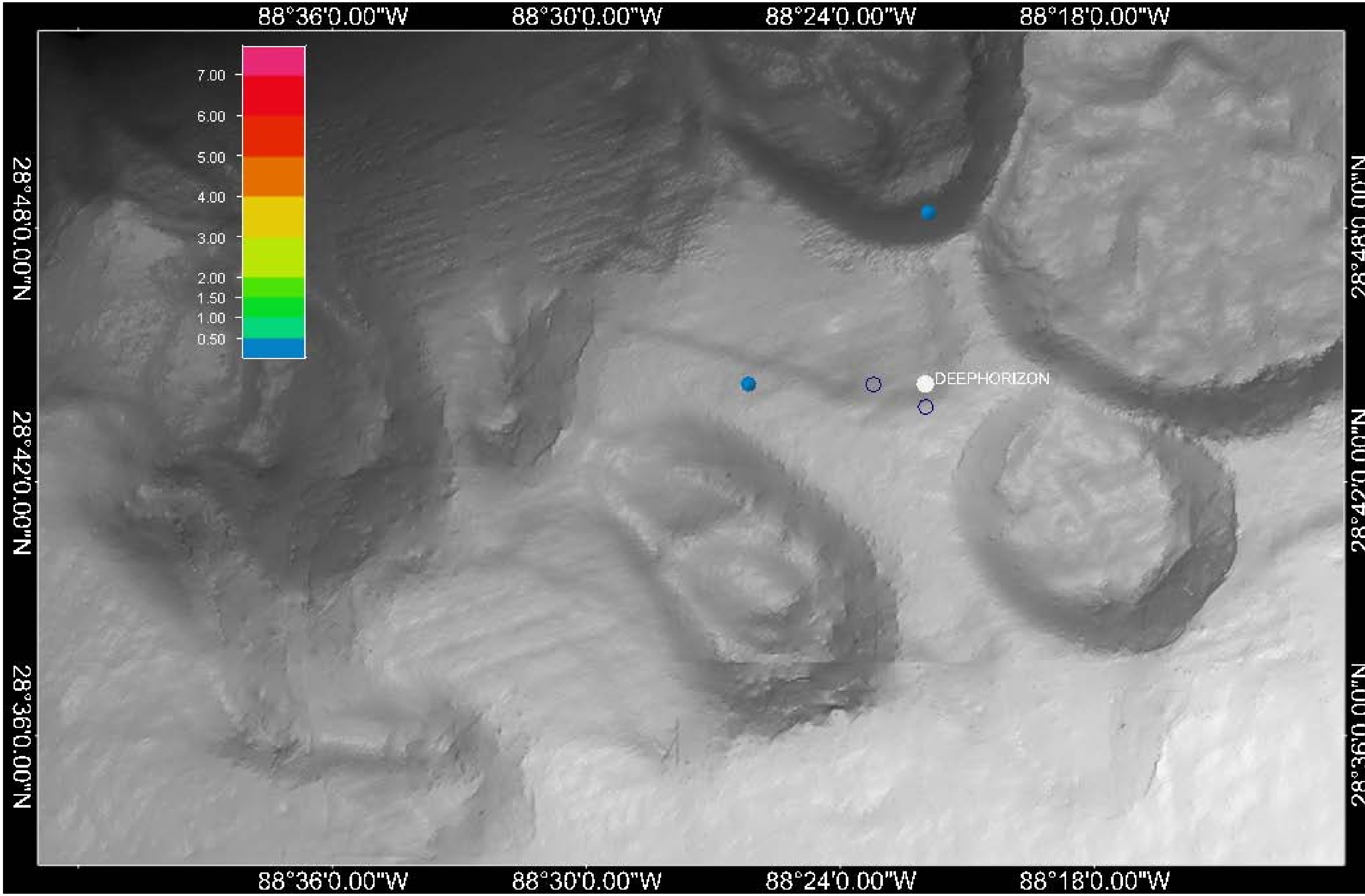


Figure 43: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 19 June 2010

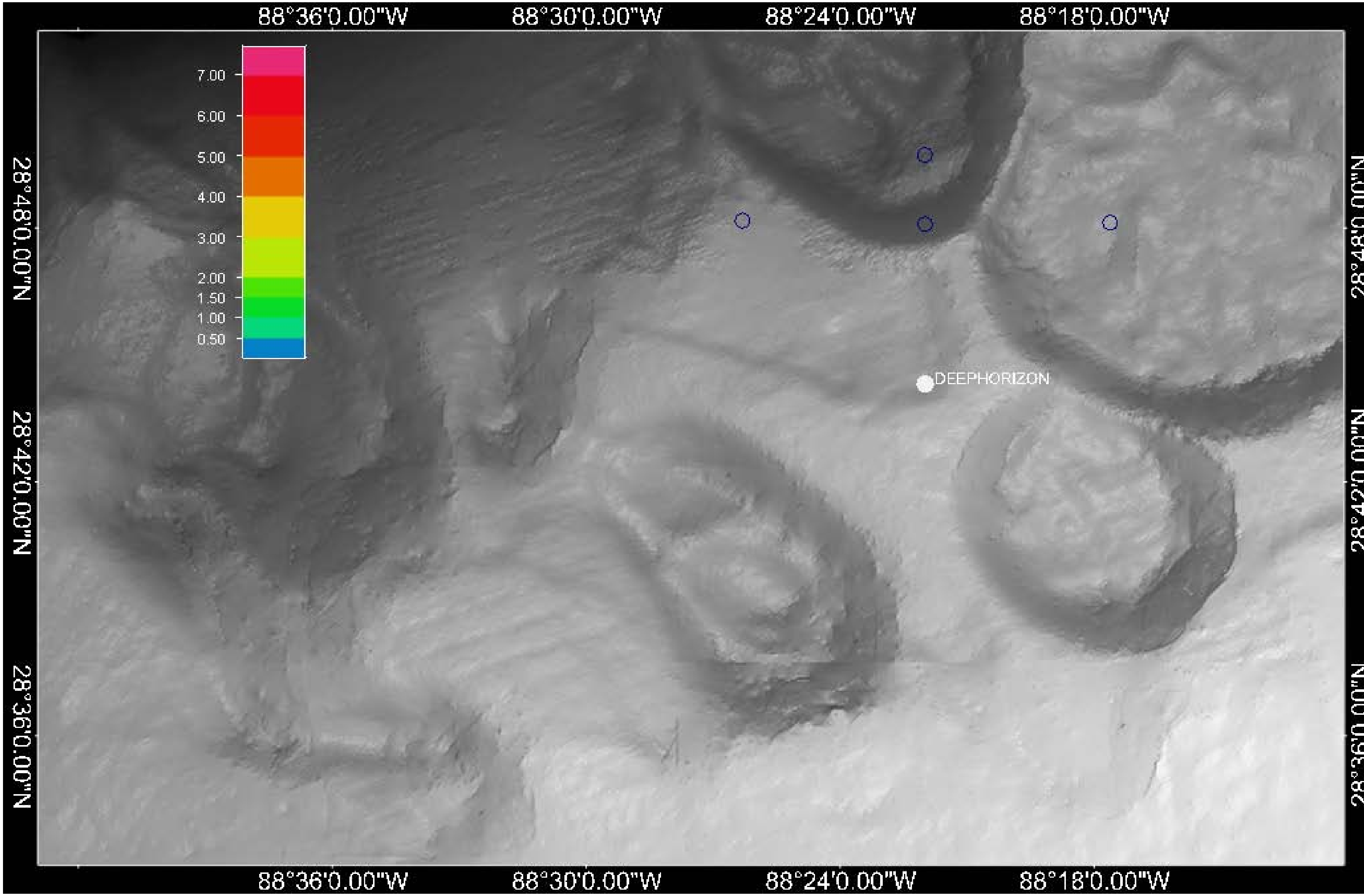


Figure 44: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m from 19 May through 19 June

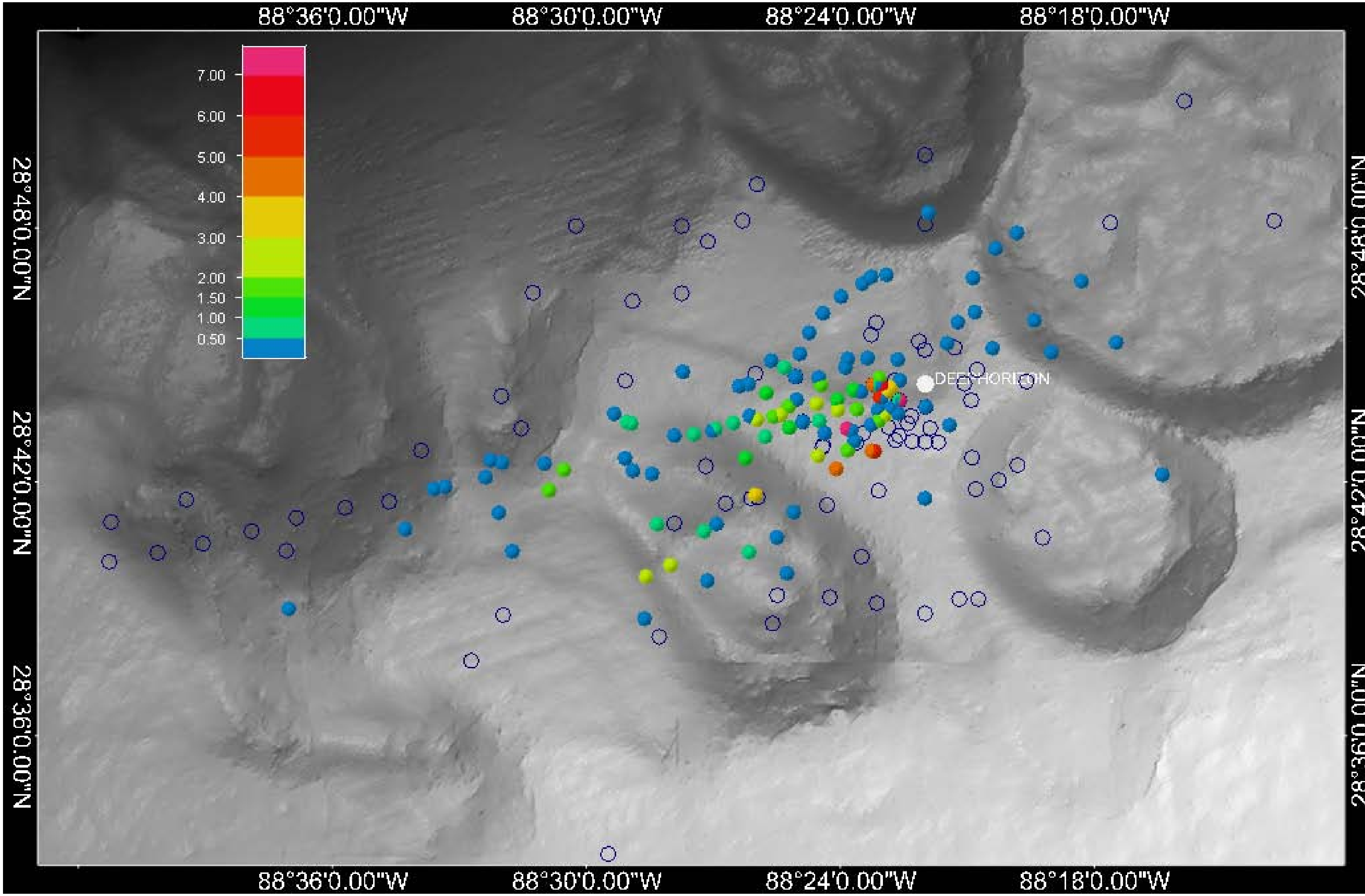


Figure 45: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m from 19 May through 19 June, with far-field R/V *Gordon Gunter* stations

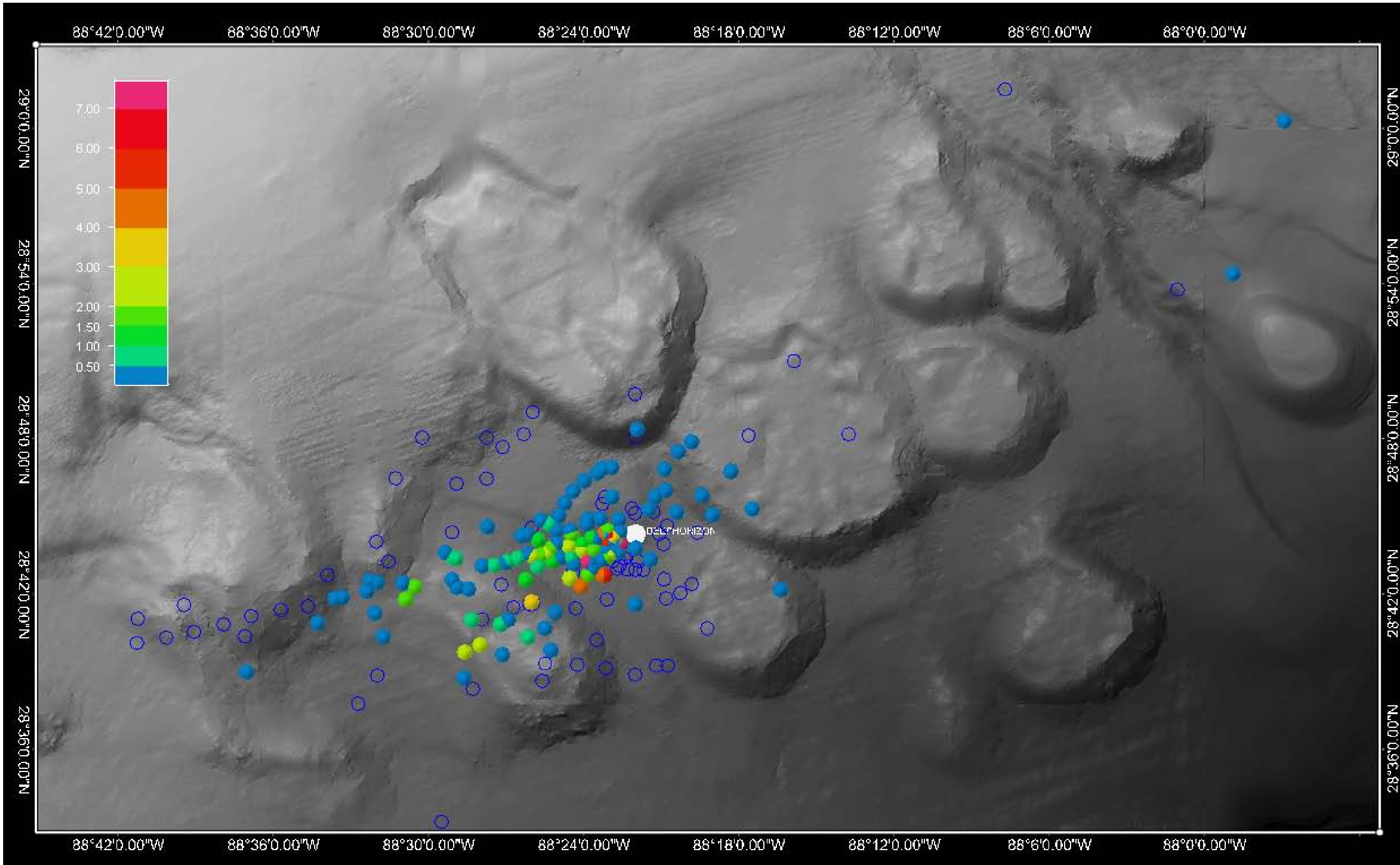
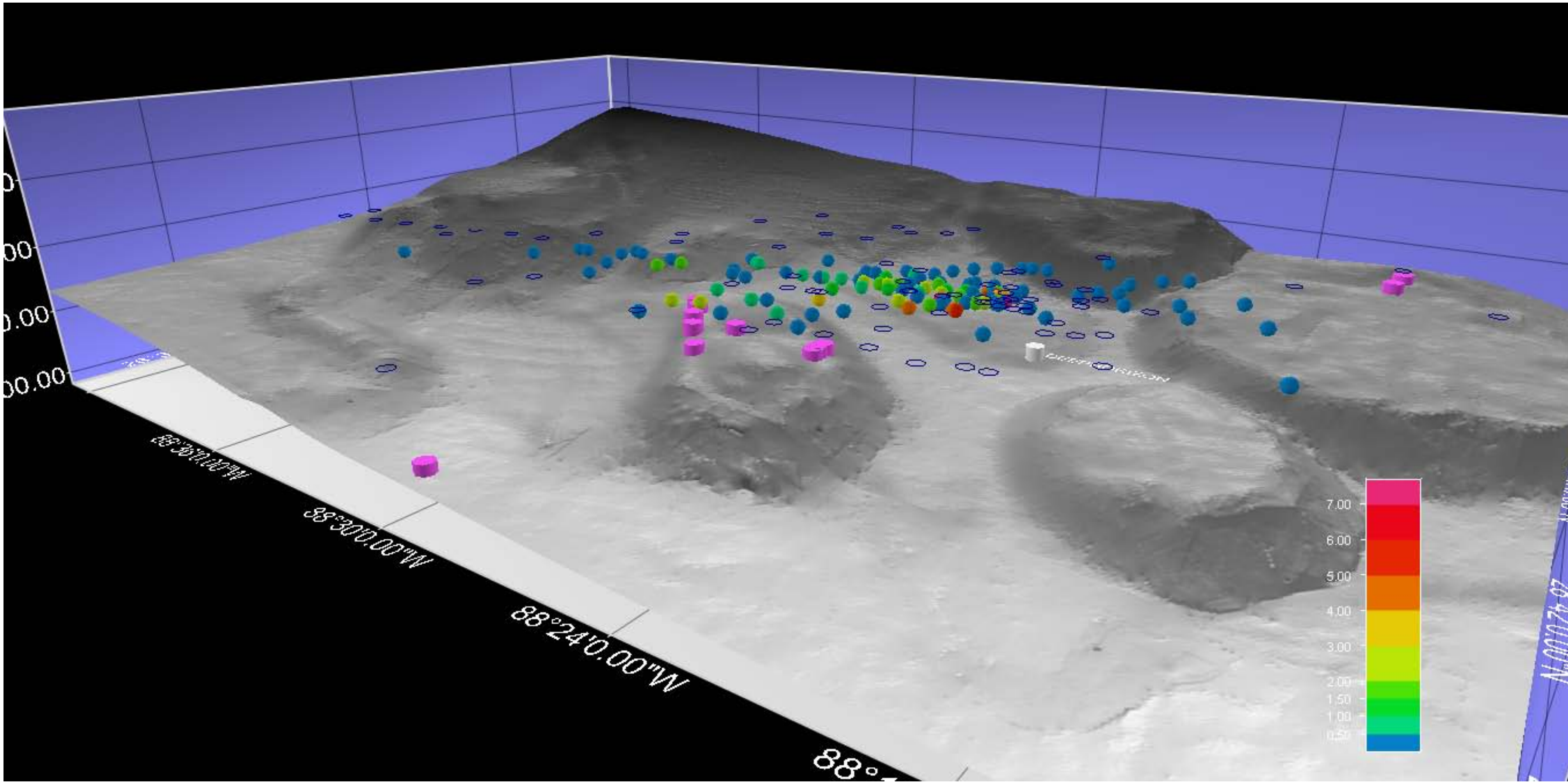
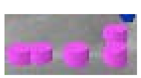


Figure 46: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m from 19 May through 19 June



Seeps 

Appendix A

Instrument Response of an ECO CDOM Fluorometer to MC 252 Oil*

Introduction

An instrument response exercise was developed to determine how the WET Labs' ECO CDOM fluorometer responds to Mississippi Canyon 252 source oil. The objective of the procedure was to provide all research cruises using the ECO CDOM fluorometer with a standardized procedure to derive a coarse estimate of oil and dispersant concentrations in the field based on raw response and the quinine sulfate dihydrate equivalent (QSde) relationship supplied by the manufacturer. The response curves in this report should only be used as a screening tool to provide estimations of oil in water and should not replace conventional quantitative analytical chemistry techniques (e.g., GC/MS).

Procedure

Instrument and Setup

For each of the oil concentrations tested, 60 raw responses (instrument counts) were recorded over the course of 1 minute and the average raw response was calculated for use in the response plots. The instrument setup is shown in Figure 1.

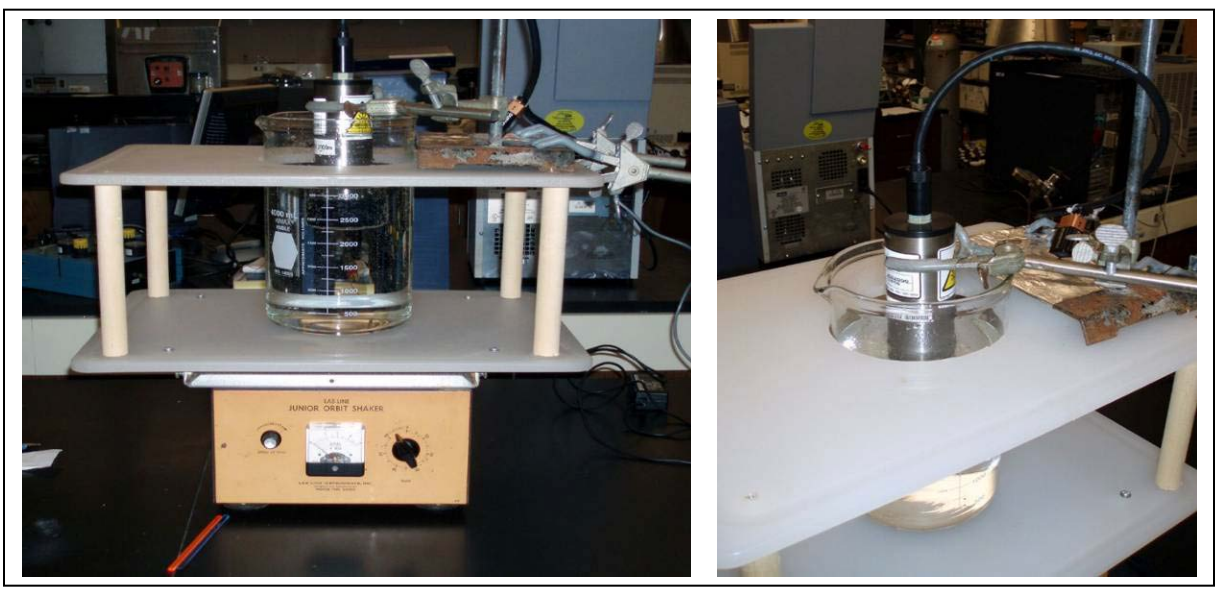


Figure 1. ECO CDOM fluorometer setup for calibration testing.

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*Conducted at Louisiana State University by B. M. Ashton.

Calculations

CDOM calculations were accomplished using the ECO CDOM Fluorometer Characterization Sheet specific to the instrument tested. CDOM was expressed as parts per billion (ppb) quinine sulfate dihydrate equivalent (QSde) and was derived with the following equation:

$$\text{CDOM (QSde)} = \text{Scale Factor} * (\text{Output} - \text{Dark Counts})$$

The dark counts and the scale factor were determined by the manufacturer and the digital values were provided on the characterization sheet.

MC252 Oil + Dispersant Response Procedure

These tests used source oil from the MC252#1 incident and Corexit 9500. Two different dispersant to oil ratios (DOR) were tested—1:25 and 1:2.5. The decision to test two DORs was made to reflect the uncertainty of the actual ratio of dispersant to oil at depth around the wellhead. Oil concentrations ranged from 1 to 50 parts per million (ppm). The responses for oil at 50 ppm were recorded first by using a gas-tight graduated syringe to add oil into 3 L of artificial saltwater containing 30 parts per thousand salt concentration. Dispersant was then added at the specific ratio (1:2.5; 1:25). The orbital shaker was set to 90 revolutions per minute (rpm) and the oil + dispersant solution was allowed to mix on the orbital shaker for 5 minutes prior to data collection. Dilutions of the 50-ppm solution were then performed to obtain oil concentrations of 25, 10, 5, and 1 ppm. All solutions were mixed on the orbital shaker at 90 rpm before data collection began. Again, the final volume for all solutions was 3 L. A blank (artificial seawater without oil or dispersant) was also tested and the average raw response was subtracted out of the oil + dispersant raw responses.

Statistical methods

The responses of the instrument to preparations of crude oil/dispersant mixtures were derived by using the linear regression procedure in Microsoft Excel.

Data/Results

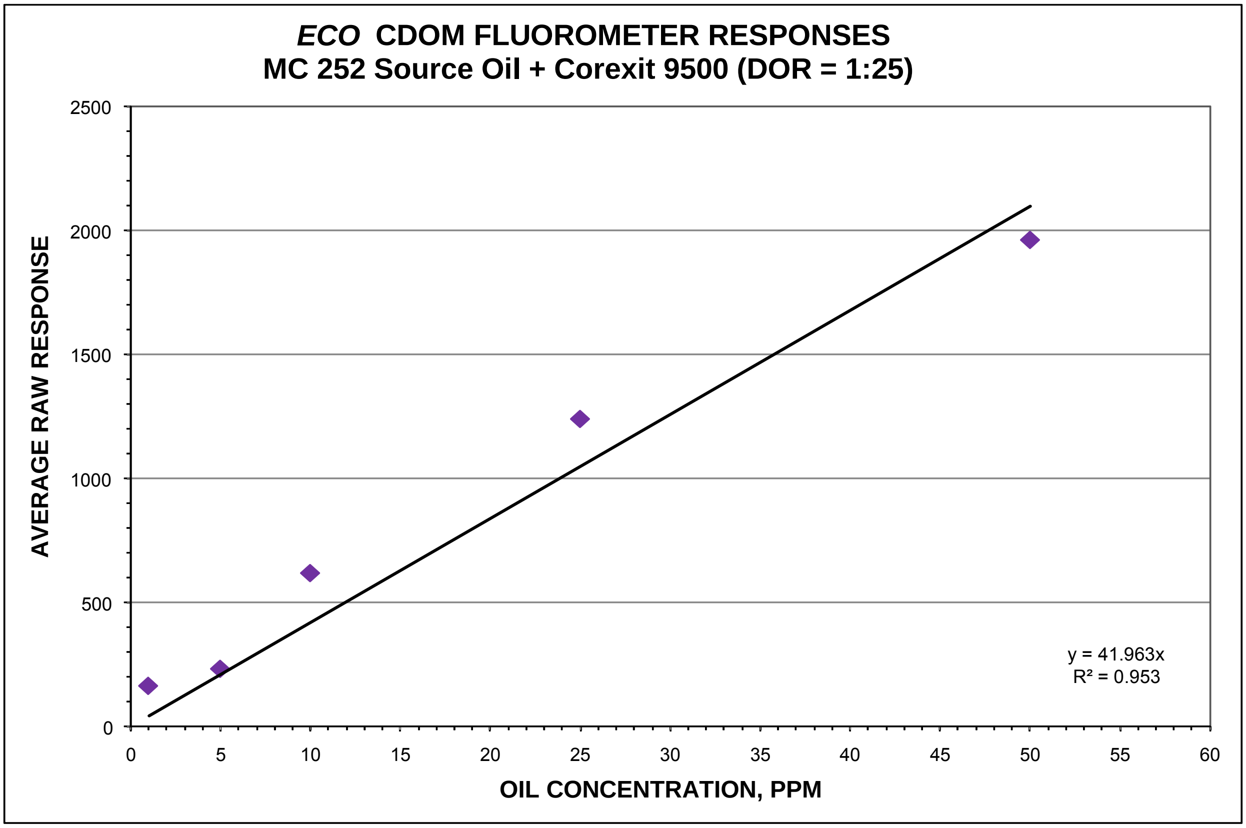
The relationship between the oil extract concentration and fluorescence counts was not strictly linear, although the correlation was highly significant and that amount of variance explained in a linear least-squares regression was large. This was true at 1:25 (Fig. 2) and 1:2.5 (Fig. 3) dispersant-to-oil ratios (DOR). The response of the instrument was significantly different for the two dispersant: oil ratios (1:2.5 and 1:25.0; $P<0.001$) with a quenching of fluorescence as the ratio decreased (more dispersant per oil; Fig. 4).

Conclusions

The information presented here provides an initial estimate of oil + dispersant response curves for the WET Labs CDOM fluorometer. The minimum sensitivity of the instrument is about 1 ppm for oil, and the fluorescence response is affected by the DOR. The values presented in Figures 2–4 could be underestimates because of the low mixing energy used in the preparing the oil + dispersant solutions.

DORs of 1:2.5 are not likely to occur in situ. At an estimated 15,000 barrels of oil per day leak rate, the well releases 630,000 gallons per day, or 26,250 gallons per hour, or 438 gallons per minute. At 8 gallons per minute of dispersant application, assuming perfect contact with the hydrocarbon fluids being released, the DOR is 438 gallons per minute oil/8 gallons per minute dispersant, or 1:55.

Further tests using DORs of 1:25; 1:50; and 1:100 are recommended to understand the relationship between the DOR and fluorescence of source oil from the MC252#1. The JAG is working to refine the initial methods used in this report that will include improvements to preparing oil + dispersant solutions and a broader range of DORs.



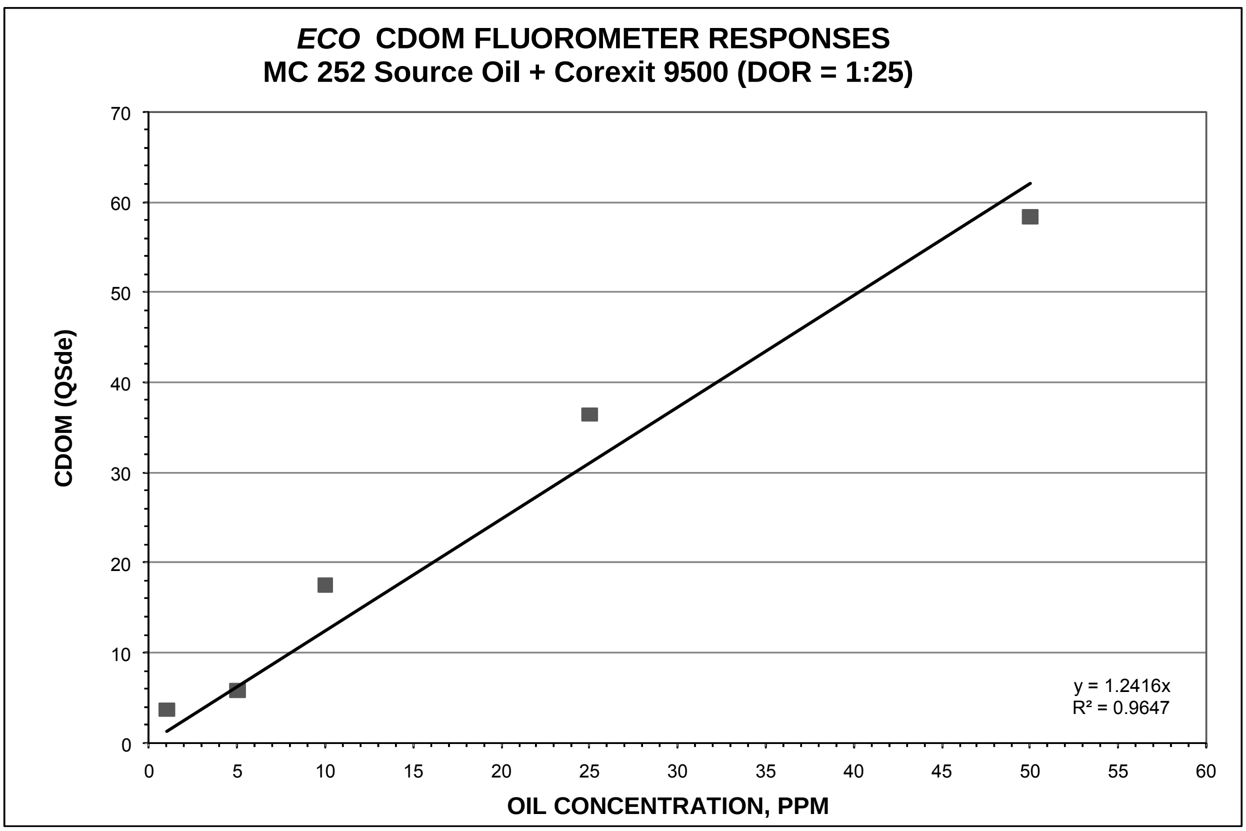
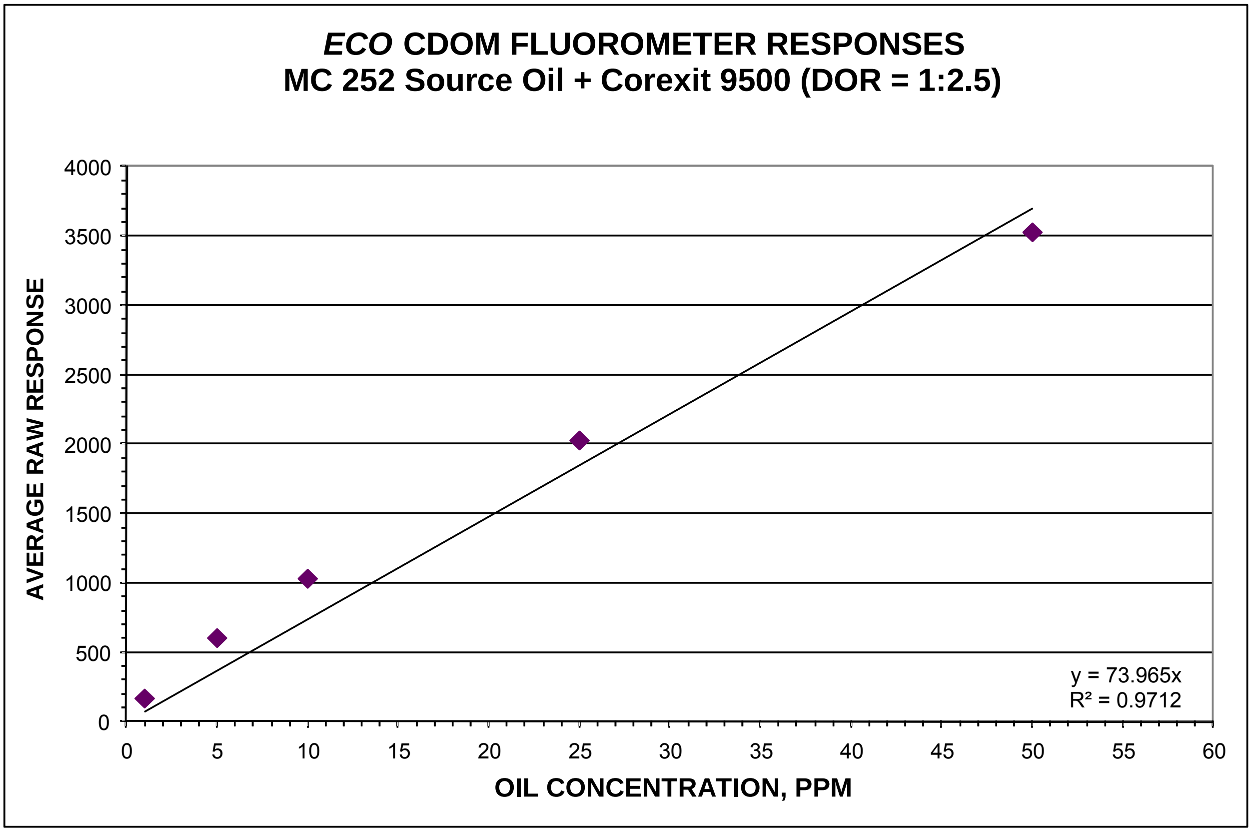


Figure 2. MC 252 + Corexit 9500 (1:25) raw responses (top) and CDOM or QSde (bottom).



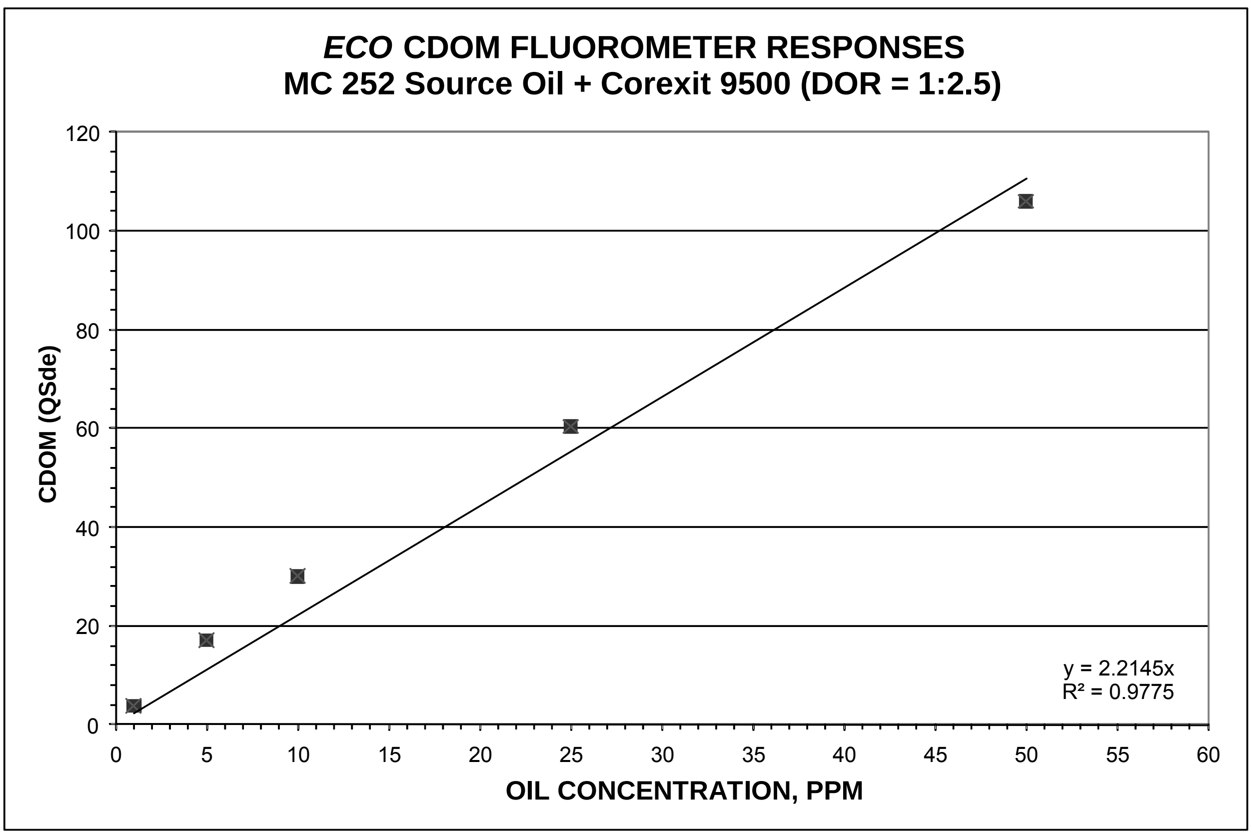


Figure 3. MC 252 + Corexit 9500 (1:2.5) raw responses (top) and CDOM or QSde (bottom).

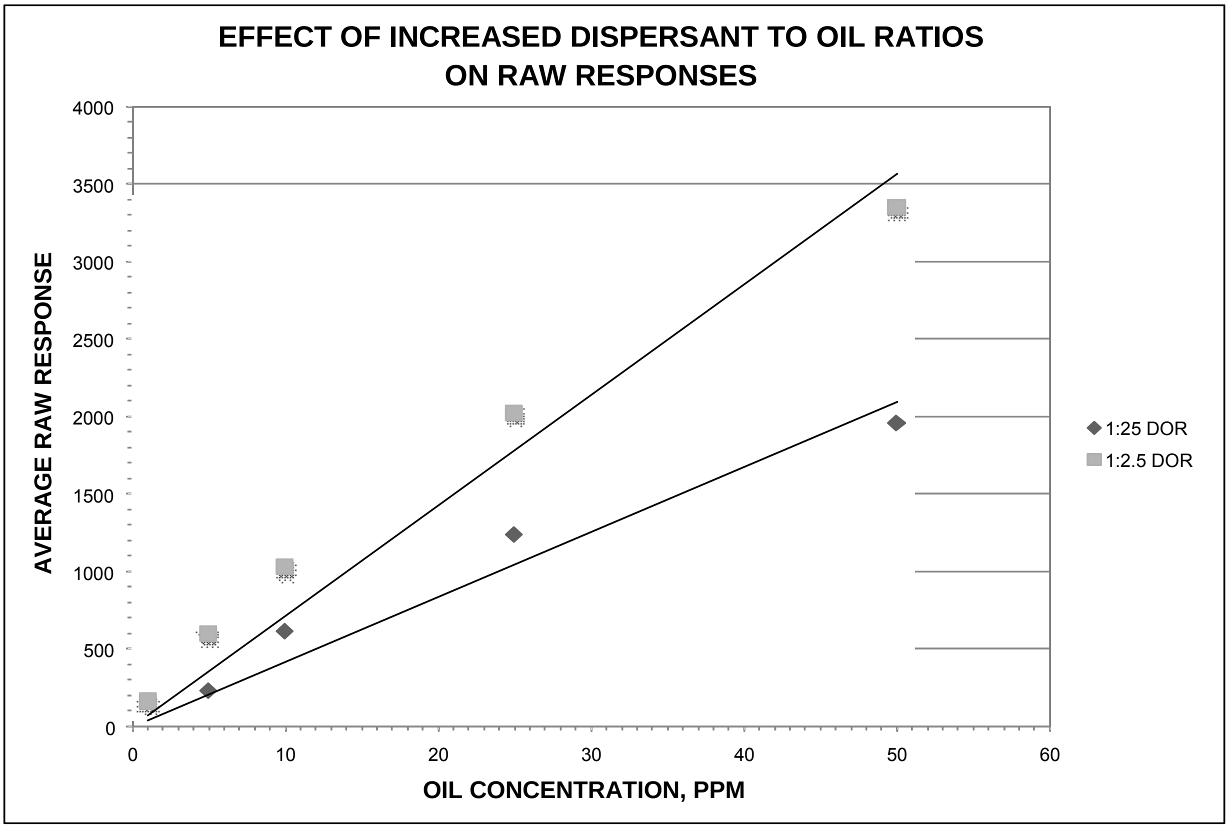


Figure 4. Response of the instrument to different dispersant-to-oil ratios.

Appendix B

Data Processing in Support of the Joint Analysis Group

To provide consistency across different vessels, sensors, and personnel, conductivity-temperature-depth (CTD) data available to the JAG are being reprocessed from raw instrument files. To date, all CTDs being used have been manufactured by Sea-Bird Electronics. Binary data files (hex or dat) and configuration files (con) were obtained for all casts and reprocessed at NODC using Sea-Bird Electronics Data Processing Software version 7.20d released May 27, 2010. Raw files (all scans) were initially plotted and examined visually for instrument response issues. Following that examination, pressure averaged files (1 dbar) for the downcast were created and plotted for a "quick look" review by the JAG members. Separate data files were created for matching CTD observations to water-sample data collected concurrently using Niskin sampling bottles. These "bottle files" contain CTD observations extracted for the known depths of the Niskin bottle samples using both downcast and upcast data from the CTD. Because the water analyses are being done at different labs and require some time to complete, the bottle files are updated over time as laboratory results are received.

Initial Quality Control (QC) of the CTD casts is conducted following a subset of checks outlined in the Global Temperature and Salinity Profile Program (GTSPP) Real-Time Quality Control Manual (UNESCO, 2009). The following automated QC checks are being conducted on the temperature and salinity profiles.

1. Spike
2. Top and Bottom Spike
3. Gradient
4. Density Inversion

QC flags are assigned to the individual temperature and salinity observations following the GTSPP procedures and nomenclature.

The coincident CTD profiles of Colored Dissolved Organic Matter (CDOM) fluorescence and dissolved oxygen have not been quantitatively subjected to QC checks to date. The JAG is examining the instrument response, additional sample verification, and calibration of these sensors relative to hydrocarbons dispersed in the water column.

Methodology for CDOM Normalization. To allow valid comparisons, the following method was applied to normalize the CDOM fluorescence data among all vessels, cruises, and instruments discussed in this report. A least-squares linear fit was determined for each CDOM fluorescence profile between 200 and 900 m. The derived linear fit was extended through the bottom of the cast to serve as the representation of an expected linear profile of CDOM fluorescence in the region (personal communication, Robert Chen, July 6, 2010).

This linear profile was subtracted from the observed profile and all negative values were set to zero. Statistics on the normalized profile were then calculated for depths between 1000 and 1300 m, where the CDOM positive anomalies were observed in the individual casts.

All CTD data are converted to a netCDF format (CF convention) for use by JAG members, as well as additional data assembly into flat files for use by GIS and visualization software, including Fledermaus. Final plots of cast and sample data are being produced for the JAG as requested.

The CTD data and available bottle data are being collated for archiving at NOAA's National Oceanographic Data Center (NODC). All preliminary CTD data are also being preserved at NODC. Profile data will be subjected to additional QC checks as part of ingest into the World Ocean Database at NODC.

Notes
(1) Techniques for adjusting and normalizing calibration of temperature, salinity, and oxygen profiles between research vessels and cruises relative to canonical profiles (e.g. from World Ocean Database) have been discussed but not implemented to date.
(2) Responsible NODC Divisions: Ocean Climate Laboratory (OC5) and National Coastal Data Development Center (OC6)

Appendix C

Subsurface Monitoring of Dissolved Oxygen at the Deepwater Horizon Site

The National Incident Command (NIC) set up the Joint Analysis Group (JAG) with the goals of analyzing spill-related data, including subsurface oil, dispersant, and oxygen data and to encourage coordinated action among groups. The JAG is examining monitoring and research data collected to study releases from the Deepwater Horizon (DWH) Mississippi Canyon (MC-252) wellhead that could be entrained in subsurface waters. This quick-response data report presents information thought to be useful for shaping ongoing observing efforts. It is time-sensitive due to the need to provide such guidance for at-sea operations in near real time to optimize federal response to this evolving event.

Data from the R/V *Brooks McCall,* R/V *Ocean Veritas*, R/V *Walton Smith*, R/V *Thomas Jefferson*, and R/V *Gordon Gunter,* near the site of the DWH MC-252 wellhead between May 19 and June 19, 2010, sometimes indicate a depression in dissolved oxygen (DO_2) concentration based on measurements from an in situ sensor made at or below 1000-m depth. The observed DO_2 depression—

- could be due to biochemical O_2 demand from oxidation of subsurface oil and gas;
- currently does not show DO_2 to be depressed to levels considered to be hypoxic or to levels of concern for subsea monitoring;
- cannot be reliably interpreted because of a lack of sensor calibration data and possible interference of unknown substances with DO_2 sensors.

Therefore, the JAG advises that Winkler titrations be performed on future cruises to provide a precise measurement of DO_2 levels and calibrate the degree to which in situ sensors reflect actual levels DO_2. The data under consideration are DO_2 measurements obtained using the SBE 43 in situ sensor, the JAG did not address DO_2 measurements that may have been obtained using other ex situ methods, where applicable. However, out of an abundance of caution, the JAG advises using the more precise and accurate Winkler titration.

The DO_2 depression associated with the SBE 43 in situ DO_2 sensor is sometimes coincident with colored dissolved organic matter (CDOM) fluorescence peaks at depths between 1000 and 1300 m that are attributed to oil. See, for example, Figures 1–4. The waters in which the sensors indicate depression of DO_2 are likely to contain dispersed oil from the MC252 #1 well.[8] Oxidation of oil subsurface waters could increase biochemical oxygen demand and lead to a decrease in DO_2 levels.

At this time it is difficult to reliably interpret DO_2 measurements taken during these cruises using the Sea-Bird Electronics SBE 43 DO_2 in situ sensor (the most frequently used

[8] Joint Analysis Group (JAG) Review of R/V *Brooks McCall* Data to Examine Subsurface Oil. June 2010. http://www.noaa.gov/sciencemissions/PDFs/JAG_Report_1_BrooksMcCall_Final_June20.pdf

sensor). There is a possibility that the depression in DO_2 levels is real and is associated with the MC252#1 well release, but confounding factors associated with DO_2 measurement prevent a conclusive determination.

There are several sensor performance characteristics that confound DO_2 data interpretation. The SBE 43 DO_2 sensors are high quality and experience significantly lower drift than previous generations of in situ sensors, but still require independent calibration during use.

A general idea of DO_2 sensor drift can be obtained from the expected DO_2 concentrations near the bottom and surface. Historical (World Ocean Database) and climatological (World Ocean Atlas) spring data show nominal bottom-water values at 1500 m of 4.8±0.1 mL/L (~68±2% saturation) at the study location (Fig. 5). These values, along with expected slight supersaturation measured at the surface of ~101±4 %, can be used to assess systematic deviations and integrity of the DO_2 traces. DO_2 sensor values that are much different from these nominal values at these depths are anomalous, either because of calibration issues of the sensor or biochemical oxygen demand at these depths.

A common analytical method, the Winkler titration, applied to water sampled with the CTD rosette, can provide an accurate measurement of DO_2 levels, likely even in the presence of oil. The JAG recommends that Winkler titrations should be conducted on water samples taken with Niskin bottle casts during the time in situ CTD DO_2 measurements are recorded using electronic sensors. Comparing data from Winkler titrations and in situ electronic sensors will help determine if DO_2 depression below 1000 m are actual changes in DO_2 or artifacts of sensor performance. The comparisons will also address instrument calibration and sensor drift that affect intercruise data comparisons. DO_2 should continue to be monitored in subsurface waters with both in situ sensors and Winkler titrations to understand the potential effects of subsurface oil and gas.

Therefore, as a service to the Unified Command, agency scientists and the broader oceanographic community conducting research in the vicinity of the MC252#1 well incident, the JAG advises that when CTD casts to estimate DO_2 are being made in the oil-spill region, coincident high-quality Winkler titrations be conducted where possible, but in particular where there are fluorometer readings suggestive of the presence of subsurface oil.

Figure 1. Vertical profile showing DO_2 depression coincident with fluorescence peaks between 1100 and 1200 m.

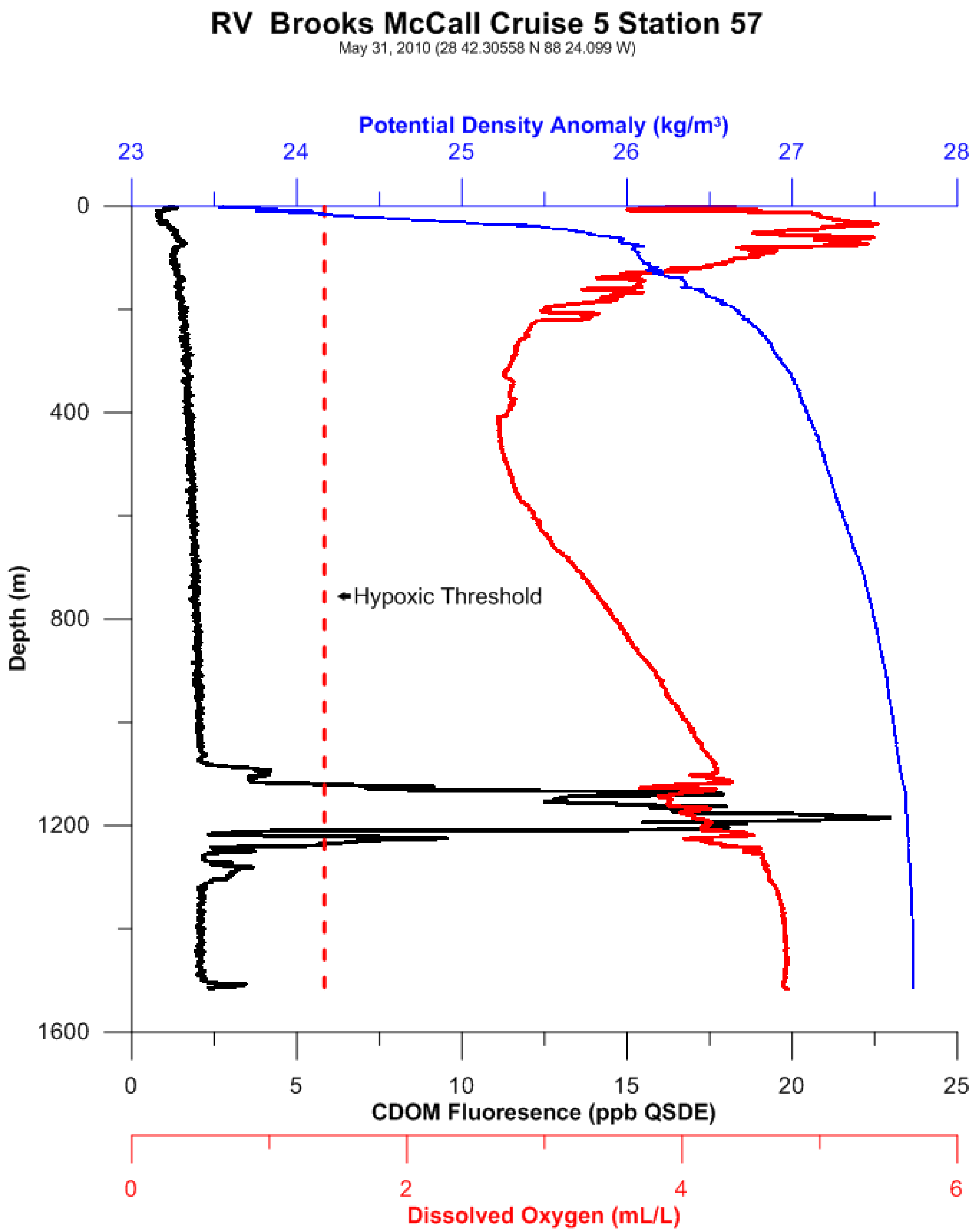


Figure 2. Vertical profile showing DO_2 depression occurring above, below, and coincident with fluorescence peaks between 1050 and 1200 m.

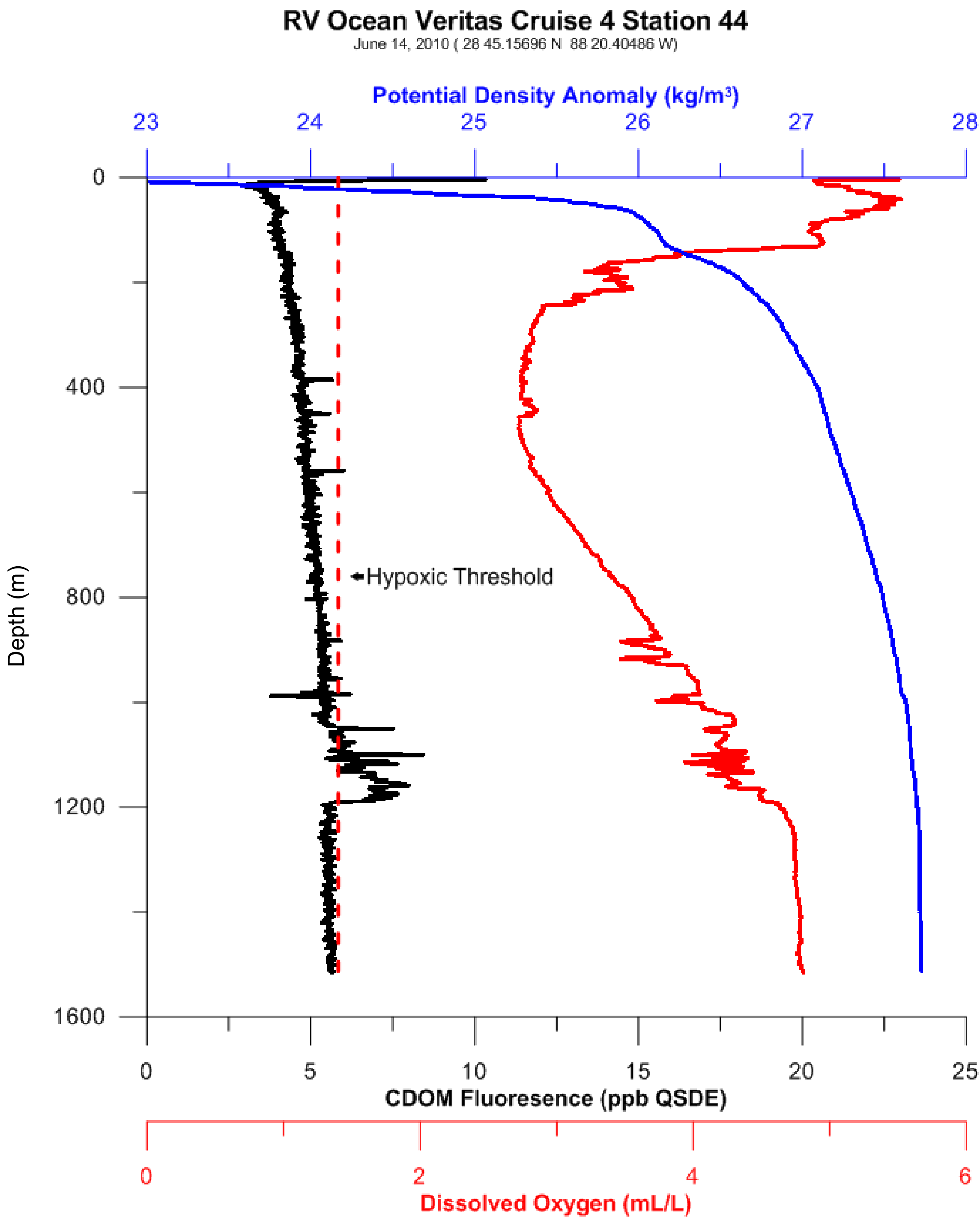


Figure 3. Vertical profile showing two DO_2 depressions, one coincident with fluorescence peaks between 1050 and 1200 m.

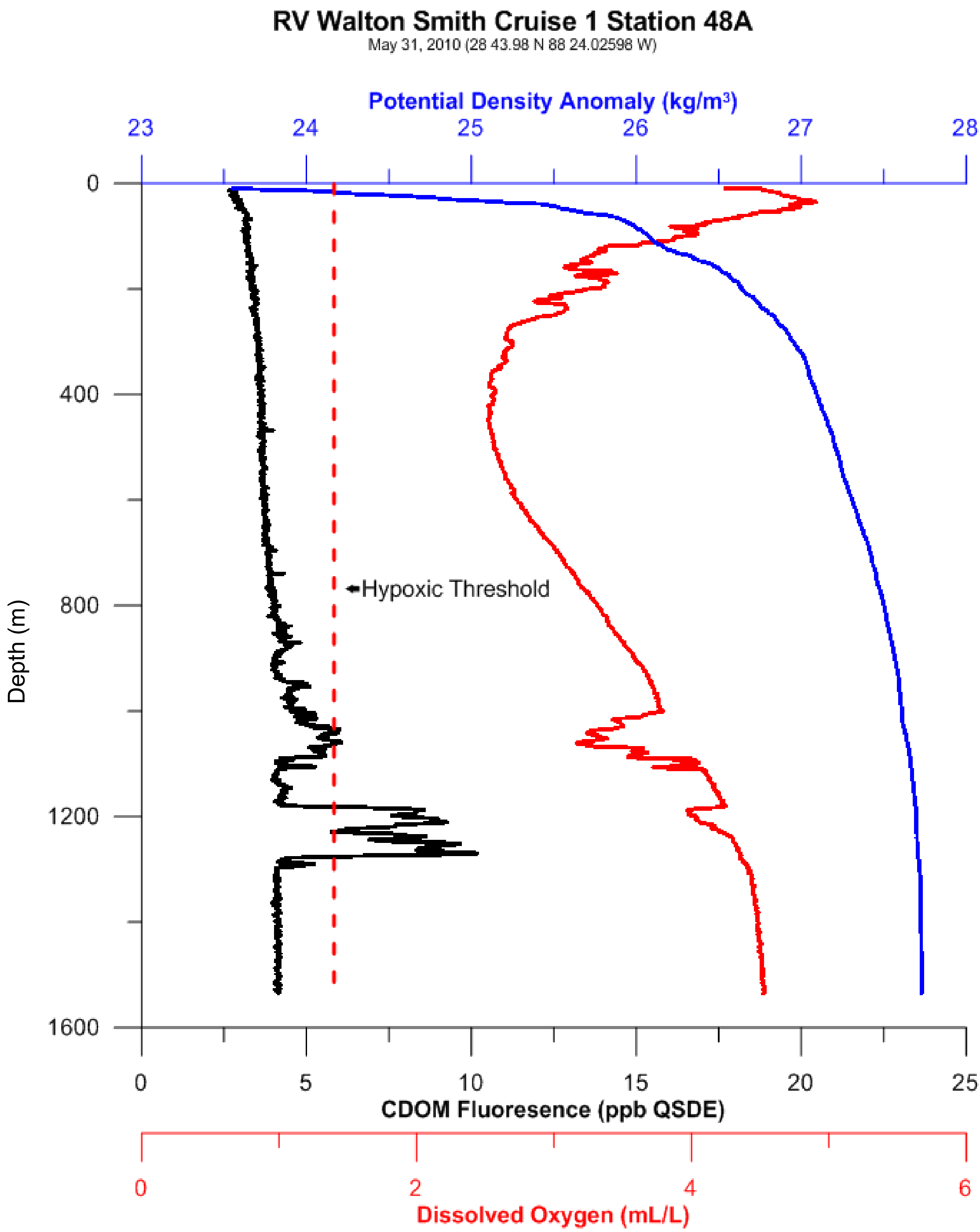


Figure 4. Vertical profile showing large fluorescence peaks between 1100 and 1300 m without a coincident DO2 depression.

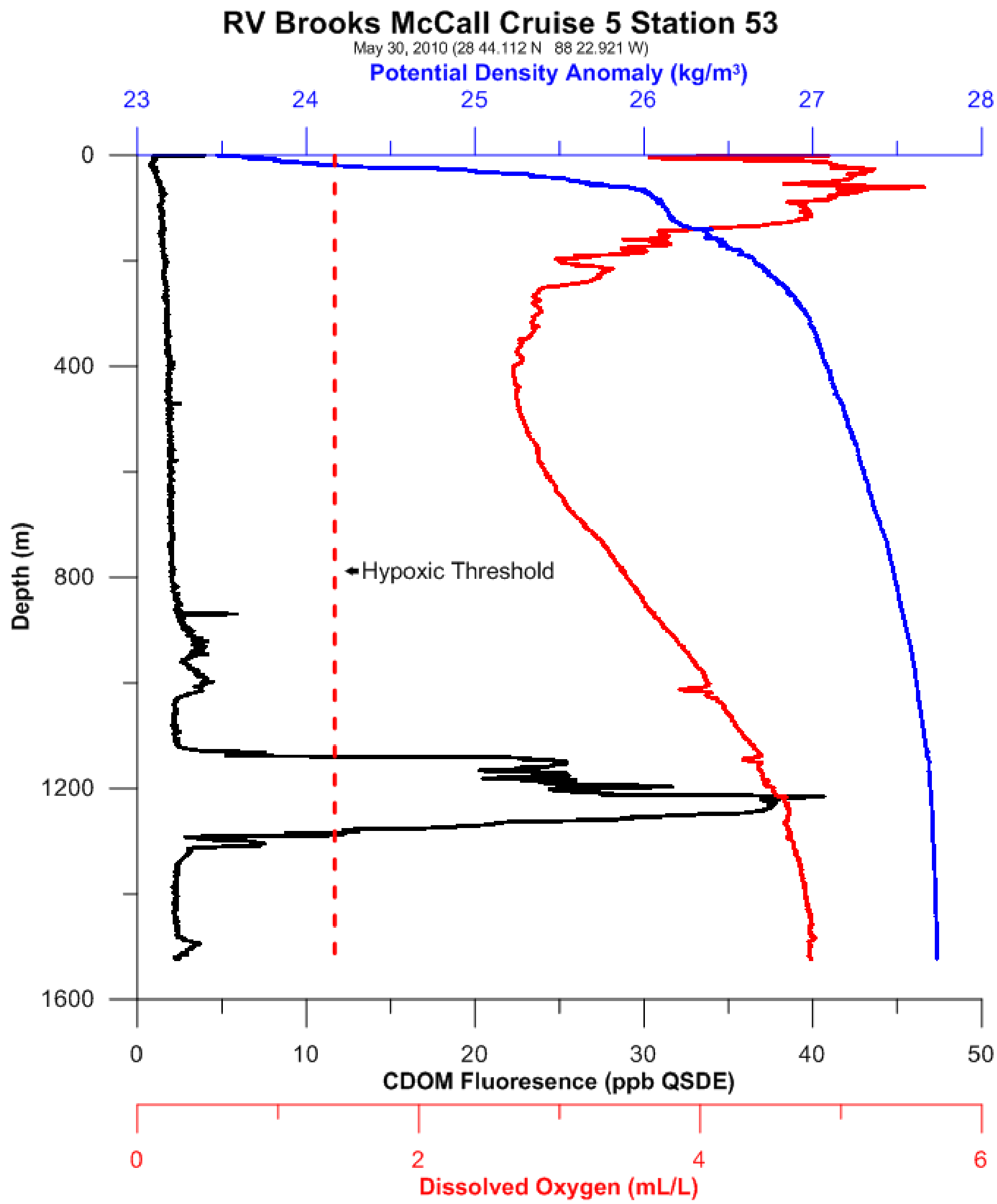
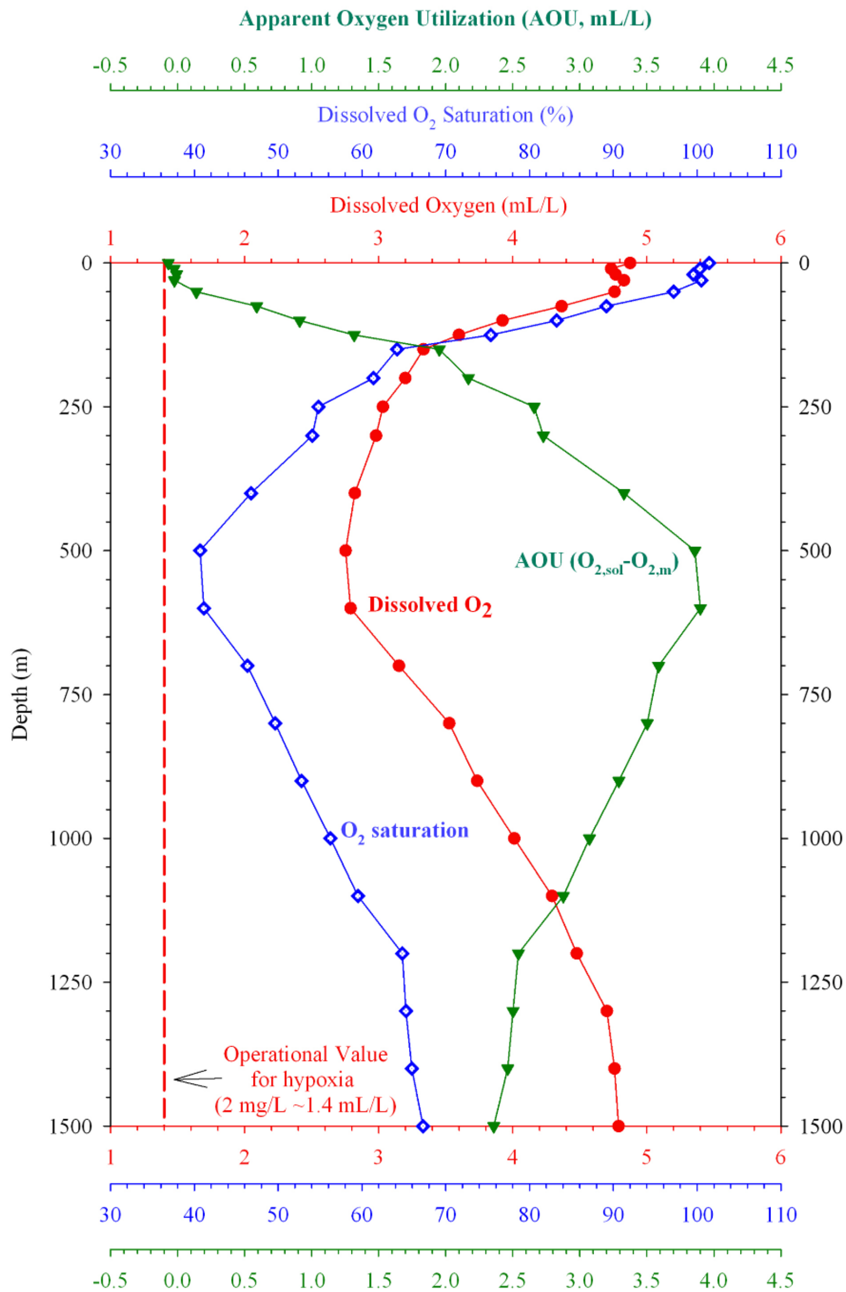


Figure 5. Nominal climatological Spring average values as a function of depth for DO_2, DO_2 saturation, and Apparent Oxygen Utilization (AOU), including the ~1.4 mL/L hypoxia line. This figure may be useful for comparison to past cruises and for future cruises collecting DO2 data near the well.



Spring (April-June) climatological average values for dissolved oxygen, percent oxygen saturation, and Apparent Utilization as a function of depth. Values based on the 1-degree horizontal resolution NODC World Ocean Atlas 2009 near 28.5°N and 88.5°W.

Appendix D

Station Data for Figures 9–47

Vessel	Station ID	Header Date	Header Time	Lat	Lon	CDOM FL Mean	FL Max	FL Norm Mean	FL Norm Max	Fl Norm SDEV
Brooks McCall	2010_0519_BM29	May 19 2010	8:04:21	28 41.2144 N	088 25.4205 W	6.829964452	7.6131	0.01	0.41	0.03
Brooks McCall	2010_0519_BM30	May 19 2010	9:25:20	28 39.6646 N	088 27.1402 W	7.083880731	10.2002	0.15	2.95	0.44
Brooks McCall	2010_0519_BM31	May 19 2010	11:48:54	28 38.6475 N	088 25.6000 W	6.824562791	7.1483	0	0.14	0.02
Brooks McCall	2010_0519_BM32	May 19 2010	14:21:17	28 40.9965 N	088 28.3284 W	7.564862458	15.2789	0.57	8.01	1.2
Brooks McCall	2010_0519_BM33	May 19 2010	16:51:17	28 42.5567 N	088 29.0845 W	7.06777907	8.6849	0.14	1.66	0.36
Brooks McCall	2010_0520_BM34	May 20 2010	7:16:02	28 42.9582 N	088 23.6681 W	6.939151827	9.0142	0.09	1.96	0.35
Brooks McCall	2010_0520_BM35	May 20 2010	10:10:22	28 43.7307 N	088 22.8185 W	6.848571761	7.6735	0.01	0.79	0.07
Brooks McCall	2010_0520_BM36	May 20 2010	12:45:02	28 43.9215 N	088 22.6054 W	8.03588505	19.9445	1.13	12.94	2.62
Brooks McCall	2010_0520_BM37	May 20 2010	15:12:07	28 43.7743 N	088 21.9818 W	6.953918937	11.9276	0.09	4.87	0.52
Brooks McCall	2010_0521_BM38	May 21 2010	7:20:29	28 43.9217 N	088 22.6036 W	7.953419269	19.3628	1.07	12.28	2.84
Brooks McCall	2010_0521_BM39	May 21 2010	10:29:29	28 44.3222 N	088 21.0677 W	6.838570764	7.1416	0	0.15	0.01
Brooks McCall	2010_0521_BM40	May 21 2010	13:05:20	28 45.1212 N	088 22.0066 W	6.798496678	7.04	0	0.15	0.01
Brooks McCall	2010_0521_BM41	May 21 2010	15:47:07	28 44.3006 N	088 23.2182 W	11.35025382	24.2762	4.09	16.64	4.44
Brooks McCall	2010_0523_BM42	May 23 2010	14:49:30	28 43.9207 N	088 22.6064 W	11.51847674	20.5612	4.77	13.77	3.84
Brooks McCall	2010_0523_BM43	May 23 2010	18:22:21	28 44.3012 N	088 23.2146 W	7.84627309	14.9575	1	7.64	2.01
Brooks McCall	2010_0523_BM44	May 24 2010	12:03:13	28 44.1076 N	088 22.9129 W	11.30136744	20.6031	3.84	12.79	3.41
Brooks McCall	2010_0524_BM45	May 24 2010	12:03:13	28 44.2867 N	088 24.4573 W	8.01620897	18.4842	1.87	12.17	3.03
Brooks McCall	2010_0524_BM46	May 24 2010	14:32:26	28 43.6973 N	088 24.0589 W	8.520097342	16.3432	2.22	9.8	2.38
Brooks McCall	2010_0524_BM47	May 24 2010	17:11:58	28 43.1470 N	088 23.4647 W	5.937888372	6.2157	0	0.08	0.01
Brooks McCall	2010_0524_BM48	May 24 2010	19:51:20	28 44.1035 N	088 25.7520 W	7.631943189	13.1953	1.36	6.66	1.85
Brooks McCall	2010_0525_BM49	May 25 2010	11:32:58	28 43.2834 N	088 25.2046 W	7.794633223	14.9854	1.47	8.43	1.88
Brooks McCall	2010_0525_BM50	May 25 2010	14:01:37	28 43.0693 N	088 25.7752 W	7.196474086	12.813	0.91	6.32	1.45
Brooks McCall	2010_0525_BM51	May 25 2010	16:41:56	28 44.2595 N	088 26.3932 W	6.751290033	13.9528	0.45	7.36	1.31
Brooks McCall	2010_0525_BM52	May 25 2010	19:22:22	28 43.9204 N	088 22.6072 W	6.275893688	9.0058	0.03	2.34	0.23
Walton Smith	2010_0526_WS01B	May 26 2010	18:03:56	28 42.8600 N	088 24.4000 W	3.057023588	3.1072	0	0	0
Walton Smith	2010_0526_WS01C	May 26 2010	19:56:47	28 42.8200 N	088 24.4200 W	4.089388889	4.2267	0	0	0
Walton Smith	2010_0526_WS02A	May 26 2010	21:17:37	28 43.8400 N	088 24.5600 W	6.486192359	11.9288	2.2	8.93	2.16
Walton Smith	2010_0526_WS03A	May 27 2010	2:13:26	28 44.4600 N	088 24.5100 W	4.30547309	7.4022	0.08	2.67	0.33
Walton Smith	2010_0527_WS04A	May 27 2010	4:23:06	28 43.4400 N	088 24.5000 W	5.10703887	7.5286	0.84	3.16	0.81
Walton Smith	2010_0527_WS05A	May 27 2010	5:47:14	28 43.7800 N	088 25.2200 W	6.194843854	12.9195	1.83	8.42	1.6
Walton Smith	2010_0527_WS06A	May 27 2010	6:55:10	28 43.5400 N	088 25.5800 W	6.007847841	14.459	1.68	10.04	2.1
Walton Smith	2010_0527_WS07A	May 27 2010	7:58:28	28 43.4700 N	088 25.9700 W	6.3061299	13.7074	2.02	9.32	1.9
Walton Smith	2010_0527_WS08A	May 27 2010	9:11:06	28 43.3900 N	088 26.5300 W	5.118532558	6.5924	0.8	2.16	0.6
Walton Smith	2010_0527_WS09A	May 27 2010	10:22:24	28 43.2500 N	088 26.9500 W	5.159144186	7.1284	0.9	2.78	0.61
Walton Smith	2010_0527_WS10A	May 27 2010	11:23:51	28 43.1200 N	088 27.4600 W	4.814453821	6.0086	0.58	1.75	0.57
Walton Smith	2010_0527_WS11A	May 27 2010	12:29:20	28 43.0900 N	088 27.9200 W	4.577590033	5.9204	0.34	1.66	0.44
Walton Smith	2010_0527_WS12A	May 27 2010	13:43:52	28 43.4100 N	088 29.0400 W	5.025023588	7.6687	0.82	3.37	0.88
Walton Smith	2010_0527_WS12B	May 27 2010	15:34:46	28 43.3800 N	088 28.9400 W	4.813209967	6.3889	0.57	2.16	0.67
Walton Smith	2010_0527_WS14A	May 27 2010	23:57:01	28 42.4300 N	088 30.9900 W	4.299415615	6.1729	0.14	1.88	0.29
Walton Smith	2010_0527_WS15A	May 28 2010	1:20:38	28 42.1100 N	088 32.3800 W	4.565805316	6.5769	0.32	2.31	0.57
Walton Smith	2010_0527_WS16A	May 28 2010	2:50:59	28 41.8300 N	088 33.6000 W	4.619191362	6.542	0.41	2.28	0.66
Walton Smith	2010_0528_WS17A	May 28 2010	4:24:16	28 41.5300 N	088 34.6600 W	4.588695455	6.4481	0	0	0
Walton Smith	2010_0528_WS18A	May 28 2010	5:30:54	28 41.3900 N	088 35.7000 W	4.157364286	4.3802	0	0	0
Walton Smith	2010_0528_WS19A	May 28 2010	6:40:15	28 41.1500 N	088 36.8500 W	4.118194118	4.2355	0	0	0
Walton Smith	2010_0528_WS20A	May 28 2010	7:45:08	28 40.8300 N	088 37.9100 W	4.125188095	4.2693	0	0	0

Walton Smith	2010_0528_WS21A	May 28 2010	8:44:09	28 40.5400 N	088 39.0600 W	4.129588636	4.2298	0	0	0
Walton Smith	2010_0528_WS22A	May 28 2010	9:43:41	28 40.3200 N	088 40.1300 W	4.1374864	4.274	0	0	0
Walton Smith	2010_0528_WS23A	May 28 2010	10:53:01	28 40.1100 N	088 41.2700 W	4.166520884	4.301	0	0	0
Walton Smith	2010_0528_WS24A	May 28 2010	12:08:16	28 41.0500 N	088 41.2300 W	4.154363522	4.2833	0	0	0
Walton Smith	2010_0528_WS25A	May 28 2010	14:22:27	28 41.5800 N	088 39.4500 W	4.106966667	4.116	0	0	0
Walton Smith	2010_0528_WS27A	May 28 2010	17:02:38	28 42.7400 N	088 33.9000 W	4.245762275	5.554	0	0	0
Walton Smith	2010_0528_WS28A	May 28 2010	18:35:34	28 43.2600 N	088 31.5400 W	4.477639247	8.8704	0	0	0
Walton Smith	2010_0528_WS29A	May 28 2010	21:28:39	28 43.6100 N	088 29.3400 W	4.348644186	6.2435	0.21	2.09	0.4
Gordon Gunter	2010_0529_003	May 29 2010	10:22:02	29 00.2800 N	087 56.9100 W	2.631322591	2.8732	0.01	0.15	0.03
Gordon Gunter	2010_0529_004	May 29 2010	20:41:35	28 53.7600 N	088 01.0400 W	2.60289701	2.7868	0	0.04	0
Gordon Gunter	2010_0530_006	May 30 2010	10:36:13	28 54.3800 N	087 58.9000 W	2.436643522	2.6665	0.02	0.14	0.03
Gordon Gunter	2010_0530_007	May 30 2010	13:17:51	29 01.5000 N	088 07.7100 W	2.554769318	2.7236	0	0	0
Gordon Gunter	2010_0530_008	May 31 2010	1:44:27	28 48.1700 N	088 13.7500 W	2.418013311	2.6476	0	0	0
Walton Smith	2010_0530_WS30A	May 30 2010	6:29:28	28 45.7600 N	088 23.1600 W	4.100398671	4.2159	0	0.06	0
Walton Smith	2010_0530_WS31A	May 30 2010	7:53:38	28 46.0100 N	088 20.8200 W	4.179586711	5.0732	0.03	0.68	0.1
Walton Smith	2010_0530_WS32A	May 30 2010	9:32:17	28 44.3700 N	088 19.6000 W	4.112250166	4.2187	0	0.1	0.01
Walton Smith	2010_0530_WS33A	May 30 2010	11:03:55	28 42.5700 N	088 20.8900 W	4.119251163	4.2573	0	0.07	0.01
Walton Smith	2010_0530_WS34A	May 30 2010	12:37:21	28 42.7300 N	088 23.2500 W	8.507237874	22.1734	4.3	17.92	5.68
Walton Smith	2010_0530_WS34B	May 30 2010	17:56:47	28 42.7200 N	088 23.1900 W	9.50212093	30.1214	5.3	25.88	8.06
Walton Smith	2010_0530_WS35A	May 30 2010	14:10:44	28 41.4500 N	088 24.3100 W	4.123040199	4.2516	0	0.04	0
Walton Smith	2010_0530_WS36A	May 30 2010	15:56:20	28 42.6100 N	088 24.5300 W	6.787296678	15.8992	2.67	11.7	3.66
Walton Smith	2010_0530_WS37A	May 30 2010	19:50:07	28 42.5600 N	088 26.2400 W	5.316656146	11.2154	1.1	6.96	1.29
Walton Smith	2010_0530_WS38A	May 30 2010	21:30:24	28 42.7400 N	088 23.8300 W	5.899008638	14.4255	1.72	10.14	2.51
Walton Smith	2010_0530_WS39A	May 30 2010	23:10:40	28 42.1900 N	088 28.4500 W	4.649753156	9.4481	0.46	5.2	1.04
Walton Smith	2010_0530_WS40A	May 31 2010	0:47:05	28 41.2700 N	088 32.0700 W	4.44527608	5.3342	0.22	1.07	0.31
Walton Smith	2010_0530_WS41A	May 31 2010	2:12:41	28 40.8800 N	088 34.2800 W	4.304580731	4.7901	0.06	0.49	0.1
Walton Smith	2010_0530_WS42A	May 31 2010	3:42:12	28 40.3700 N	088 37.0900 W	4.346308553	4.8351	0	0	0
Gordon Gunter	2010_0531_009	May 31 2010	11:40:14	28 39.2300 N	088 20.7400 W	2.503833887	2.7645	0	0.09	0.01
Gordon Gunter	2010_0531_010	May 31 2010	15:56:20	28 51.0000 N	088 15.8700 W	2.378705848	2.5612	0	0	0
Walton Smith	2010_0531_WS43A	May 31 2010	4:55:13	28 39.0000 N	088 37.0300 W	4.534001329	19.5479	0.33	15.24	1.02
Walton Smith	2010_0531_WS44A	May 31 2010	6:44:14	28 37.7700 N	088 32.7200 W	4.140822924	4.2812	0	0.05	0.01
Walton Smith	2010_0531_WS45A	May 31 2010	14:10:55	28 41.0200 N	088 27.9200 W	4.100462126	4.4133	0	0.15	0.02
Walton Smith	2010_0531_WS46A	May 31 2010	15:22:32	28 41.6900 N	088 26.0100 W	7.264697674	16.5513	3.07	12.29	3.3
Walton Smith	2010_0531_WS46B	May 31 2010	17:17:32	28 41.6300 N	088 25.9500 W	7.032615947	16.491	0	0	0
Walton Smith	2010_0531_WS47A	May 31 2010	18:42:34	28 43.2500 N	088 23.8400 W	11.58480033	34.3973	7.4	30.17	8.89
Walton Smith	2010_0531_WS48A	May 31 2010	20:50:16	28 43.9400 N	088 24.0700 W	5.812987375	10.1784	1.46	5.64	1.63
Walton Smith	2010_0531_WS49A	May 31 2010	22:52:35	28 43.3500 N	088 23.2700 W	4.307207309	5.2145	0.18	1.04	0.27
Walton Smith	2010_0531_WS50A	Jun 01 2010	0:27:14	28 42.9800 N	088 22.7000 W	4.07771196	4.2677	0	0.07	0.01
Walton Smith	2010_0531_WS51A	Jun 01 2010	2:02:22	28 43.2900 N	088 22.8600 W	4.096161462	4.2657	0	0.08	0.01
Gordon Gunter	2010_0601_012	Jun 01 2010	12:26:49	28 49.0300 N	088 25.9700 W	2.416433766	2.765	0	0	0
Gordon Gunter	2010_0601_013	Jun 01 2010	14:32:32	28 47.6800 N	088 27.1300 W	2.346773754	2.55	0	0.09	0.01
Gordon Gunter	2010_0601_014	Jun 01 2010	16:05:10	28 46.2700 N	088 28.9100 W	2.322658804	2.555	0	0.08	0.01
Gordon Gunter	2010_0601_015	Jun 01 2010	17:53:58	28 44.3900 N	088 29.0800 W	2.409312625	2.6613	0	0.05	0
Gordon Gunter	2010_0601_016	Jun 01 2010	19:26:09	28 42.2600 N	088 28.9000 W	2.418854153	2.6693	0.01	0.28	0.04
Gordon Gunter	2010_0601_017	Jun 01 2010	21:11:24	28 40.8300 N	088 27.2200 W	3.010716279	6.3154	0.59	3.84	0.85
Gordon Gunter	2010_0601_018	Jun 01 2010	22:54:15	28 39.3200 N	088 25.4900 W	2.429631229	2.7865	0	0.08	0.01
Gordon Gunter	2010_0602_019	Jun 02 2010	2:33:28	28 40.0300 N	088 28.0100 W	4.946916944	15.2046	2.39	12.63	3.54
Gordon Gunter	2010_0602_020	Jun 02 2010	4:05:20	28 39.7600 N	088 28.5900 W	4.809525249	15.5754	2.29	13.03	3.48
Gordon Gunter	2010_0602_021	Jun 02 2010	11:58:27	28 33.2000 N	088 29.4800 W	2.361023256	2.6229	0	0.12	0.01
Gordon Gunter	2010_0602_022	Jun 02 2010	13:51:03	28 38.8500 N	088 31.9700 W	2.459307309	2.6596	0	0.14	0.02
Gordon Gunter	2010_0602_023	Jun 02 2010	19:31:02	28 39.1300 N	088 23.1400 W	2.389507973	2.6447	0	0.1	0.01
Gordon Gunter	2010_0602_024	Jun 02 2010	20:49:17	28 39.2300 N	088 21.1900 W	2.493981063	2.6828	0	0.11	0.01
Gordon Gunter	2010_0602_025	Jun 02 2010	22:37:21	28 40.6800 N	088 19.2200 W	2.516131894	2.9336	0	0.1	0.01

Gordon Gunter	2010_0603_026	Jun 03 2010	0:18:28	28 42.1700 N	088 16.3900 W	2.446229568	2.6706	0.01	0.13	0.02
Gordon Gunter	2010_0603_027	Jun 03 2010	14:32:42	28 42.0400 N	088 20.2600 W	2.314434551	2.639	0	0.25	0.02
Gordon Gunter	2010_0603_028	Jun 03 2010	20:21:07	28 42.3700 N	088 27.1800 W	3.412941958	8.6236	0	0	0
Gordon Gunter	2010_0603_029	Jun 03 2010	21:48:02	28 41.6100 N	088 26.1100 W	2.430304983	2.673	0	0.14	0.01
Walton Smith	2010_0603_WS52A	Jun 01 2010	3:34:42	28 43.2700 N	088 21.8800 W	4.108017608	4.2498	0.00	0.20	0.03
Walton Smith	2010_0603_WS53A	Jun 01 2010	5:04:35	28 44.0000 N	088 23.0600 W	9.232265781	32.9492	5.02	28.68	8.31
Walton Smith	2010_0603_WS54A	Jun 01 2010	9:54:05	28 43.7100 N	088 23.6100 W	6.040119601	26.5089	1.84	22.26	4.71
Walton Smith	2010_0603_WS55A	Jun 01 2010	15:27:13	28 43.1500 N	088 24.3700 W	4.417100997	5.9865	0.26	1.81	0.39
Walton Smith	2010_0603_WS56A	Jun 01 2010	17:44:56	28 42.9200 N	088 23.6200 W	3.939371429	4.3194	0.00	0.07	0.01
Walton Smith	2010_0603_WS57A	Jun 01 2010	19:30:40	28 44.1700 N	088 23.6900 W	4.499051827	16.8872	1.12	13.48	2.17
Walton Smith	2010_0603_WS58A	Jun 01 2010	21:39:00	28 44.2300 N	088 22.9700 W	10.17442957	23.6388	6.81	20.24	6.06
Walton Smith	2010_0603_WS59A	Jun 01 2010	23:58:42	28 44.2300 N	088 22.7900 W	6.574113621	20.4782	3.28	17.19	4.02
Gordon Gunter	2010_0604_030	Jun 04 2010	0:39:46	28 40.6900 N	088 25.5000 W	2.463419601	2.681	0.01	0.15	0.03
Walton Smith	2010_0604_WS06B	Jun 04 2010	18:13:44	28 43.5800 N	088 25.4100 W	6.090612292	20.391	2.04	16.17	4.18
Walton Smith	2010_0604_WS08B	Jun 04 2010	20:23:48	28 43.5600 N	088 26.1400 W	4.269253156	5.6042	0.15	1.38	0.27
Walton Smith	2010_0604_WS58B	Jun 04 2010	22:16:20	28 44.2980 N	088 23.0900 W	4.411036213	7.4406	0.26	3.15	0.75
Walton Smith	2010_0604_WS60A	Jun 04 2010	4:13:47	28 44.4500 N	088 23.0800 W	5.739931561	13.3791	1.58	9.11	2.70
Walton Smith	2010_0604_WS61A	Jun 04 2010	6:45:19	28 44.9000 N	088 23.8300 W	4.197354817	7.589	0.10	3.34	0.45
Walton Smith	2010_0604_WS62A	Jun 04 2010	8:19:58	28 44.6000 N	088 27.7200 W	4.239550166	5.1185	0.09	0.89	0.18
Walton Smith	2010_0604_WS63A	Jun 04 2010	9:51:32	28 44.0300 N	088 32.0100 W	4.076548855	4.2175	0.00	0.00	0.00
Walton Smith	2010_0604_WS66A	Jun 04 2010	12:55:56	28 40.3600 N	088 31.7500 W	4.106357475	4.3957	0.02	0.28	0.05
Walton Smith	2010_0604_WS67A	Jun 04 2010	14:58:54	28 44.5600 N	088 26.0100 W	4.083569435	4.2249	0.00	0.07	0.01
Brooks McCall	2010_0605_B65	Jun 05 2010	16:01:17	28 43.9215 N	088 22.6036 W	2.111090698	2.5545	0	0.26	0.01
Brooks McCall	2010_0605_B66	Jun 05 2010	19:02:40	28 43.7745 N	088 21.9852 W	2.343030897	5.3288	0.12	2.74	0.39
Brooks McCall	2010_0605_B67	Jun 05 2010	22:03:12	28 41.6061 N	088 22.0006 W	2.335534219	4.0711	0.2	1.86	0.43
Walton Smith	2010_0605_WS16B	Jun 06 2010	0:15:53	28 41.8800 N	088 33.3400 W	4.220210963	4.7581	0.14	0.58	0.14
Walton Smith	2010_0605_WS47B	Jun 05 2010	21:48:13	28 43.2100 N	088 23.7400 W	4.002390365	4.3838	0.01	0.20	0.03
Walton Smith	2010_0605_WS53B	Jun 05 2010	1:42:08	28 43.9900 N	088 23.0200 W	4.345090365	8.9587	0.18	4.64	0.68
Walton Smith	2010_0605_WS59B	Jun 05 2010	0:19:24	28 44.4000 N	088 22.7100 W	4.137060797	4.242	0.00	0.05	0.00
Walton Smith	2010_0605_WS68B	Jun 05 2010	3:12:36	28 44.9900 N	088 22.7500 W	3.964233555	4.2275	NaN	NaN	NaN
Walton Smith	2010_0605_WS69A	Jun 05 2010	4:47:11	28 45.3200 N	088 22.1400 W	4.089928571	4.2177	0.00	0.02	0.00
Walton Smith	2010_0605_WS70A	Jun 05 2010	6:01:37	28 45.1700 N	088 21.3000 W	4.113915282	4.2393	0.00	0.08	0.01
Walton Smith	2010_0605_WS71C	Jun 05 2010	8:55:37	28 44.6500 N	088 20.7700 W	4.082380731	4.2255	0.00	0.03	0.00
Walton Smith	2010_0605_WS72A	Jun 05 2010	10:20:57	28 43.9300 N	088 20.9100 W	4.096170432	4.4375	0.00	0.15	0.01
Walton Smith	2010_0605_WS73A	Jun 05 2010	11:50:07	28 43.3400 N	088 21.4200 W	4.073985382	6.7279	0.15	2.59	0.35
Walton Smith	2010_0605_WS75A	Jun 05 2010	14:21:59	28 43.5700 N	088 22.9500 W	6.199482392	13.0913	2.06	8.91	2.74
Walton Smith	2010_0605_WS76A	Jun 05 2010	18:21:05	28 43.6200 N	088 22.6400 W	4.277319269	7.86	0.18	3.65	0.48
Walton Smith	2010_0605_WS77A	Jun 05 2010	20:13:41	28 43.7000 N	088 23.1100 W	4.04450897	4.3889	0.01	0.18	0.03
Walton Smith	2010_0605_WS78A	Jun 06 2010	2:16:31	28 46.4700 N	088 31.2600 W	4.043242614	4.5125	0.00	0.00	0.00
Brooks McCall	2010_0606_B68	Jun 06 2010	11:28:57	28 38.8912 N	088 22.0004 W	2.012393355	2.1959	0	0.15	0.01
Brooks McCall	2010_0606_B69	Jun 06 2010	14:24:44	28 41.8280 N	088 20.8028 W	2.060371096	2.295	0	0.19	0.02
Brooks McCall	2010_0606_B70	Jun 06 2010	17:06:25	28 42.3909 N	088 19.8166 W	2.052867774	2.2427	0	0.09	0.01
Brooks McCall	2010_0607_B72	Jun 07 2010	11:22:05	28 44.8898 N	088 22.6453 W	2.062535216	2.1965	0.01	0.15	0.02
Brooks McCall	2010_0607_B73	Jun 07 2010	14:46:01	28 43.3788 N	088 22.4087 W	2.11746113	2.2813	0	0	0
Brooks McCall	2010_0607_B74	Jun 07 2010	19:33:22	28 41.2859 N	088 25.0981 W	2.299719934	5.5936	0.16	3.36	0.56
Brooks McCall	2010_0611_B75	Jun 11 2010	11:32:58	28 43.4173 N	088 24.8892 W	2.076894352	2.2335	0	0.08	0.01
Brooks McCall	2010_0611_B76	Jun 11 2010	14:28:26	28 43.9413 N	088 25.0327 W	2.213077741	3.8115	0.1	1.62	0.27
Brooks McCall	2010_0611_B77	Jun 11 2010	17:12:20	28 44.4850 N	088 25.0558 W	2.426652492	6.5335	0.31	4.32	0.9
Brooks McCall	2010_0611_B78	Jun 11 2010	19:44:37	28 45.0238 N	088 24.9595 W	2.260188704	4.2506	0.14	2.02	0.45
Brooks McCall	2010_0612_B79	Jun 12 2010	11:31:15	28 45.5260 N	088 24.7355 W	2.129522924	2.9454	0.02	0.71	0.1
Brooks McCall	2010_0612_B80	Jun 12 2010	14:00:30	28 44.9244 N	088 23.3606 W	2.198853488	3.73	0.07	1.51	0.28
Brooks McCall	2010_0612_B81	Jun 12 2010	16:31:02	28 44.1297 N	088 23.5120 W	2.329156811	4.1711	0.19	1.92	0.46
Brooks McCall	2010_0612_B82	Jun 12 2010	19:12:10	28 44.3993 N	088 22.5938 W	2.231786711	3.0997	0.09	0.87	0.2

Brooks McCall	2010_0613_B83	Jun 13 2010	11:30:43	28 44.8622 N	088 25.6319 W	2.181012292	2.7734	0.05	0.57	0.11
Brooks McCall	2010_0613_B84	Jun 13 2010	13:57:39	28 45.9856 N	088 24.4089 W	2.300137542	3.9418	0.15	1.71	0.32
Brooks McCall	2010_0613_B85	Jun 13 2010	16:26:57	28 46.3761 N	088 23.9815 W	2.337018937	3.7785	0.18	1.55	0.36
Brooks McCall	2010_0613_B86	Jun 13 2010	18:48:11	28 46.6827 N	088 23.4792 W	2.279554817	3.928	0.13	1.71	0.31
Brooks McCall	2010_0613_B87	Jun 13 2010	21:20:07	28 46.8954 N	088 22.9116 W	2.280794352	3.8867	0.11	1.63	0.29
Brooks McCall	2010_0617_B88	Jun 17 2010	8:36:59	28 43.7693 N	088 21.9814 W	2.11386113	2.2861	0	0.06	0.01
Brooks McCall	2010_0617_B89	Jun 17 2010	11:59:00	28 44.2988 N	088 23.2181 W	2.12317309	2.3361	0	0.17	0.02
Brooks McCall	2010_0617_B90	Jun 17 2010	14:50:00	28 44.3107 N	088 26.1668 W	2.153948173	2.7219	0.01	0.51	0.04
Brooks McCall	2010_0618_B94	Jun 18 2010	19:34:00	28 48.0908 N	088 21.9959 W	2.148826087	2.3321	0	0	0
Brooks McCall	2010_0619_B95	Jun 19 2010	11:34:00	28 48.1242 N	088 17.6232 W	2.166599609	2.5915	0	0	0
Brooks McCall	2010_0619_B96	Jun 19 2010	13:53:00	28 49.7251 N	088 22.0012 W	2.126498276	2.328	0	0	0
Brooks McCall	2010_0619_B97	Jun 19 2010	16:11:00	28 48.1725 N	088 26.3090 W	2.129557931	2.3295	0	0	0
Brooks McCall	2010_0619_B98	Jun 19 2010	18:31:00	28 46.6830 N	088 23.4787 W	2.194843522	2.775	0.03	0.54	0.07
Brooks McCall	2010_0619_B99	Jun 19 2010	20:51:00	28 45.7538 N	088 22.8956 W	2.162710299	2.3996	0.01	0.18	0.03
Ocean Veritas	2010-0527-OV003	May 27 2010	21:50:00	28 39.9613 N	088 45.4083 W	5.917116129	6.1583	NaN	NaN	NaN
Ocean Veritas	2010-0527-OV004	May 28 2010	3:40:00	28 40.6030 N	088 21.7713 W	5.946860797	6.3245	NaN	NaN	NaN
Ocean Veritas	2010-0527-OV005	May 28 2010	12:17:00	28 48.1383 N	088 21.9628 W	5.965790909	6.1102	NaN	NaN	NaN
Ocean Veritas	2010-0527-OV006	May 28 2010	16:03:00	28 43.0367 N	088 23.1170 W	5.949817276	6.1758	NaN	NaN	NaN
Ocean Veritas	2010-0527-OV007	May 28 2010	21:17:00	28 48.4517 N	087 58.1978 W	6.015407973	6.3889	NaN	NaN	NaN
Ocean Veritas	2010-0527-OV008	May 28 2010	23:00:00	28 40.7992 N	087 58.0330 W	5.993047841	6.2782	NaN	NaN	NaN
Ocean Veritas	2010-0527-OV009	May 29 2010	23:00:00	28 44.4597 N	088 10.1288 W	5.995765781	6.359	NaN	NaN	NaN
Ocean Veritas	2010-0527-OV010	May 29 2010	16:09:00	28 43.8165 N	088 25.0123 W	8.96519898	17.2375	NaN	NaN	NaN
Ocean Veritas	2010-0527-OV011	May 29 2010	0:31:00	28 43.9207 N	088 22.6073 W	18.92341362	72.6662	NaN	NaN	NaN
Ocean Veritas	2010-0527-OV013	Jun 02 2010	7:22:00	28 48.1186 N	088 23.5114 W	5.747467816	5.9747	NaN	NaN	NaN
Ocean Veritas	2010-0527-OV015	Jun 03 2010	0:07:00	28 44.4048 N	088 23.4955 W	6.245491362	19.8994	NaN	NaN	NaN
Ocean Veritas	2010-0527-OV016	Jun 03 2010	1:48:00	28 44.4048 N	088 23.4955 W	6.186549302	15.151	NaN	NaN	NaN
Ocean Veritas	2010-0527-OV021	Jun 04 2010	12:12:00	28 42.3900 N	088 20.8740 W	6.492500332	17.2532	NaN	NaN	NaN
Ocean Veritas	2010-0527-OV023	Jun 04 2010	15:20:00	28 40.4760 N	088 19.7880 W	5.589409302	5.9355	NaN	NaN	NaN
Ocean Veritas	2010-0527-OV024	Jun 04 2010	17:29:00	28 40.5461 N	088 20.8334 W	5.646490033	7.3855	NaN	NaN	NaN
Ocean Veritas	2010-0527-OV025	Jun 04 2010	20:55:00	28 41.3648 N	088 21.6766 W	5.889649502	7.4405	NaN	NaN	NaN
Ocean Veritas	2010-0527-OV026	Jun 04 2010	22:50:00	28 42.4374 N	088 21.6569 W	6.186636877	9.6444	NaN	NaN	NaN
Brooks McCall	2010-0530-B53	May 30 2010	15:24:29	28 44.1050 N	088 22.9128 W	14.71750432	40.6728	NaN	NaN	NaN
Brooks McCall	2010-0530-B54	May 30 2010	18:22:12	28 43.9210 N	088 22.6013 W	9.896017608	33.8787	7.71	31.62	8.69
Brooks McCall	2010-0530-B55	May 30 2010	20:54:05	28 45.4808 N	088 23.2736 W	1.814025581	2.2591	0	0.09	0.01
Brooks McCall	2010-0530-B56	May 31 2010	12:06:18	28 43.4128 N	088 24.8927 W	2.069391362	2.2933	0.01	0.19	0.03
Brooks McCall	2010-0530-B57	May 31 2010	14:41:51	28 42.3056 N	088 24.0990 W	6.831405648	22.9548	4.65	20.74	6.27
Brooks McCall	2010-0530-B58	May 31 2010	17:15:59	28 40.3394 N	088 26.1561 W	2.948828904	18.0236	0.8	15.77	2.66
Brooks McCall	2010-0530-B59	May 31 2010	19:32:53	28 38.3357 N	088 28.2771 W	2.106811296	2.2471	0	0.07	0.01
Brooks McCall	2010-0530-B60	Jun 01 2010	11:31:48	28 43.5545 N	088 22.3220 W	2.095001661	2.274	0	0.01	0
Brooks McCall	2010-0530-B61	Jun 01 2010	14:14:06	28 41.7907 N	088 23.0989 W	2.108053156	2.2952	0	0.05	0
Brooks McCall	2010-0530-B62	Jun 01 2010	16:42:46	28 39.2716 N	088 24.2470 W	2.091047841	2.3534	0	0.04	0
Brooks McCall	2010-0530-B63	Jun 01 2010	19:09:33	28 39.8388 N	088 25.2636 W	2.162800332	2.7203	0.01	0.38	0.04
Brooks McCall	2010-0530-B64	Jun 01 2010	21:33:19	28 41.0036 N	088 26.9227 W	2.302525581	4.9476	0.12	2.68	0.42
Thomas Jefferson	2010-0603-TJ03	Jun 04 2010	13:14:38	28 41.4900 N	088 26.7120 W	3.018514027	3.2327	0.00	0.11	0.01
Thomas Jefferson	2010-0603-TJ06	Jun 04 2010	23:36:00	28 38.7600 N	088 28.6296 W	3.016862871	3.2481	0.01	0.21	0.03
Thomas Jefferson	2010-0603-TJ07	Jun 05 2010	2:27:42	28 41.8000 N	088 30.8796 W	5.053254419	10.1165	1.98	7.00	2.40
Thomas Jefferson	2010-0603-TJ08	Jun 05 2010	13:33:09	28 42.2820 N	088 30.5298 W	5.067390667	10.479	1.99	7.31	2.54
Thomas Jefferson	2010-0603-TJ09	Jun 05 2010	19:30:56	28 42.4500 N	088 31.9900 W	3.05941195	3.8615	0.03	0.79	0.10
Thomas Jefferson	2010-0603-TJ10	Jun 05 2010	22:35:21	28 42.5100 N	088 32.2620 W	3.034836073	3.2342	0.01	0.16	0.02

Thomas Jefferson	2010-0603-TJ11	Jun 06 2010	12:18:02	28 43.2100 N	088 27.0198 W	3.020103687	3.2008	0.01	0.15	0.02
Ocean Veritas	2010-0608-OV027	Jun 08 2010	8:04:00	28 48.0477 N	088 30.2429 W	5.547048936	5.9889	0	0	0
Ocean Veritas	2010-0608-OV028	Jun 08 2010	10:56:00	28 48.0450 N	088 27.7474 W	5.553113278	5.8673	0	0	0
Ocean Veritas	2010-0608-OV029	Jun 08 2010	13:32:00	28 46.4569 N	088 27.7474 W	5.542554485	5.8634	0	0.11	0.01
Ocean Veritas	2010-0608-OV030	Jun 08 2010	16:33:00	28 40.2314 N	088 23.4974 W	5.460165116	5.8391	0	0.31	0.02
Ocean Veritas	2010-0608-OV031	Jun 08 2010	19:30:00	28 42.9401 N	088 21.9965 W	5.510852492	5.7866	0	0.12	0.01
Ocean Veritas	2010-0608-OV032	Jun 09 2010	7:12:00	28 42.9318 N	088 21.6856 W	5.507632558	5.8448	0	0.13	0.01
Ocean Veritas	2010-0608-OV033	Jun 09 2010	14:14:00	28 42.9521 N	088 22.3014 W	5.516349502	5.8292	0	0.25	0.02
Ocean Veritas	2010-0608-OV034	Jun 09 2010	12:12:00	28 43.0934 N	088 22.6167 W	5.501806977	5.8199	0	0.03	0
Ocean Veritas	2010-0608-OV035	Jun 09 2010	19:12:00	28 43.4399 N	088 23.0990 W	7.405921927	15.4483	1.82	9.72	3.02
Ocean Veritas	2010-0608-OV036	Jun 10 2010	13:04:00	28 43.9206 N	088 22.6074 W	6.217490033	13.6584	0.74	8.08	1.83
Ocean Veritas	2010-0608-OV039	Jun 10 2010	19:46:00	28 44.7000 N	088 23.8800 W	5.783944186	6.9765	0.02	0.76	0.11
Ocean Veritas	2010-0608-OV040	Jun 10 2010	21:46:00	28 44.7000 N	088 25.3200 W	6.327903322	10.3402	0.51	4.43	1.04
Ocean Veritas	2010-0608-OV042	Jun 14 2010	13:35:00	28 47.5128 N	088 20.3356 W	5.665740199	6.349	0.06	0.70	0.12
Ocean Veritas	2010-0608-OV043	Jun 14 2010	16:15:00	28 45.7717 N	088 21.2248 W	6.155468439	9.3687	0.39	3.77	0.73
Ocean Veritas	2010-0608-OV044	Jun 14 2010	18:33:00	28 45.1570 N	088 20.4049 W	5.972753156	8.4596	0.23	2.80	0.49
Ocean Veritas	2010-0608-OV045	Jun 14 2010	20:54:00	28 45.8174 N	088 19.4173 W	5.717619601	7.9532	0.24	2.30	0.56
Ocean Veritas	2010-0608-OV046	Jun 14 2010	22:45:00	28 45.0631 N	088 19.0166 W	5.769888372	7.6727	0.13	1.96	0.31
Ocean Veritas	2010-0608-OV047	Jun 15 2010	12:08:00	28 44.4850 N	088 25.0558 W	5.288967442	5.8247	0.00	0.12	0.01
Ocean Veritas	2010-0608-OV048	Jun 15 2010	15:03:00	28 43.9206 N	088 22.6074 W	5.557002326	5.9358	0.00	0.17	0.02
Ocean Veritas	2010-0608-OV049	Jun 15 2010	17:26:00	28 46.8452 N	088 23.2708 W	5.490817276	6.1719	0.04	0.71	0.10
Ocean Veritas	2010-0608-OV050	Jun 15 2010	19:17:00	28 46.8208 N	088 20.8685 W	5.677998671	7.556	0.10	1.94	0.28
Ocean Veritas	2010-0608-OV051	Jun 15 2010	21:07:00	28 45.2709 N	088 21.4796 W	5.775003987	8.3704	0.12	2.67	0.37
Ocean Veritas	2010-0608-OV052	Jun 16 2010	12:45:00	28 45.2941 N	088 17.4807 W	5.712753716	7.3628	0.15	1.75	0.34
Ocean Veritas	2010-0608-OV053	Jun 16 2010	14:43:00	28 46.7414 N	088 18.3054 W	6.081570161	8.5584	0.45	2.75	0.81
Ocean Veritas	2010-0608-OV054	Jun 16 2010	16:27:00	28 47.8833 N	088 19.8259 W	6.081189041	8.8209	0.44	3.08	0.70
Ocean Veritas	2010-0608-OV055	Jun 16 2010	18:17:00	28 48.3641 N	088 21.9200 W	6.038464912	8.877	0.46	3.23	0.80
Max						18.92341362	72.6662			
Min						1.814025581	2.1959			

Appendix E
Joint Analysis Group: Report 2 Data Supplement: June 20 to July 13

The JAG report published on July 23, 2010,[1] reported on data collected between May 19 and June 19.

This supplement extends those data to July 13.

Some station data in this supplement did not meet quality control methods as described in Appendix B of the July 23 report. Those data are not plotted in figures 25-28, 37-40, 43-45, 75, 77, 80, 81.

Values not plotted are noted in the data tables in Appendix D and at the end of this report.

The figures in this supplement should be interpreted in the context of the July 23, 2010, JAG report that can be found at http://ecowatch.ncddc.noaa.gov/JAG/reports.html.

[1] Deepwater Horizon National Incident Command Joint Analysis Group. "Review of Preliminary Data to Examine Subsurface Oil in the Vicinity of MC252#1-May 19 to June 19, 2010.

The JAG acknowledges and thanks Dr. Samantha Joye (University of Georgia) and the scientists and crew on the R/V *Walton Smith* for contributing their CTD derived data for inclusion in JAG analysis and reporting, and encourages other academic and private partners to do so as well. The JAG also thanks the National Science Foundation for supporting this effort and encouraging collaboration with the JAG.

Joint Analysis Group (JAG)

Report 2 Data Supplement: June 20 to July 13

- Figures 1–24 show the locations where each vessels collected data by week with details for 5, 20, and 50 kms.
- Figure 25 shows the mean CDOM fluorescence between 1000 m and 1300 m as a function of distance from the wellhead.
- Figure 26 shows the maximum CDOM fluorescence between 1000 m and 1300 m as function of distance from the wellhead.
- Figures 27 and 28 show changes in the mean and maximum fluorescence according to sampling date.
- Figures 29 to 84 show the daily location of mean CDOM fluorescence measurements between 1000-1300 m.
- Figures 85 shows mean fluorescence values for all stations within 20km of the wellhead, which excludes distant stations.
- Figure 86 is a perspective view of data shown in Figure 85 along with the locations of natural seeps recently mapped in the area.

Figure E1: Subsurface Monitoring Stations within 5 km of the Wellhead 19–25 May

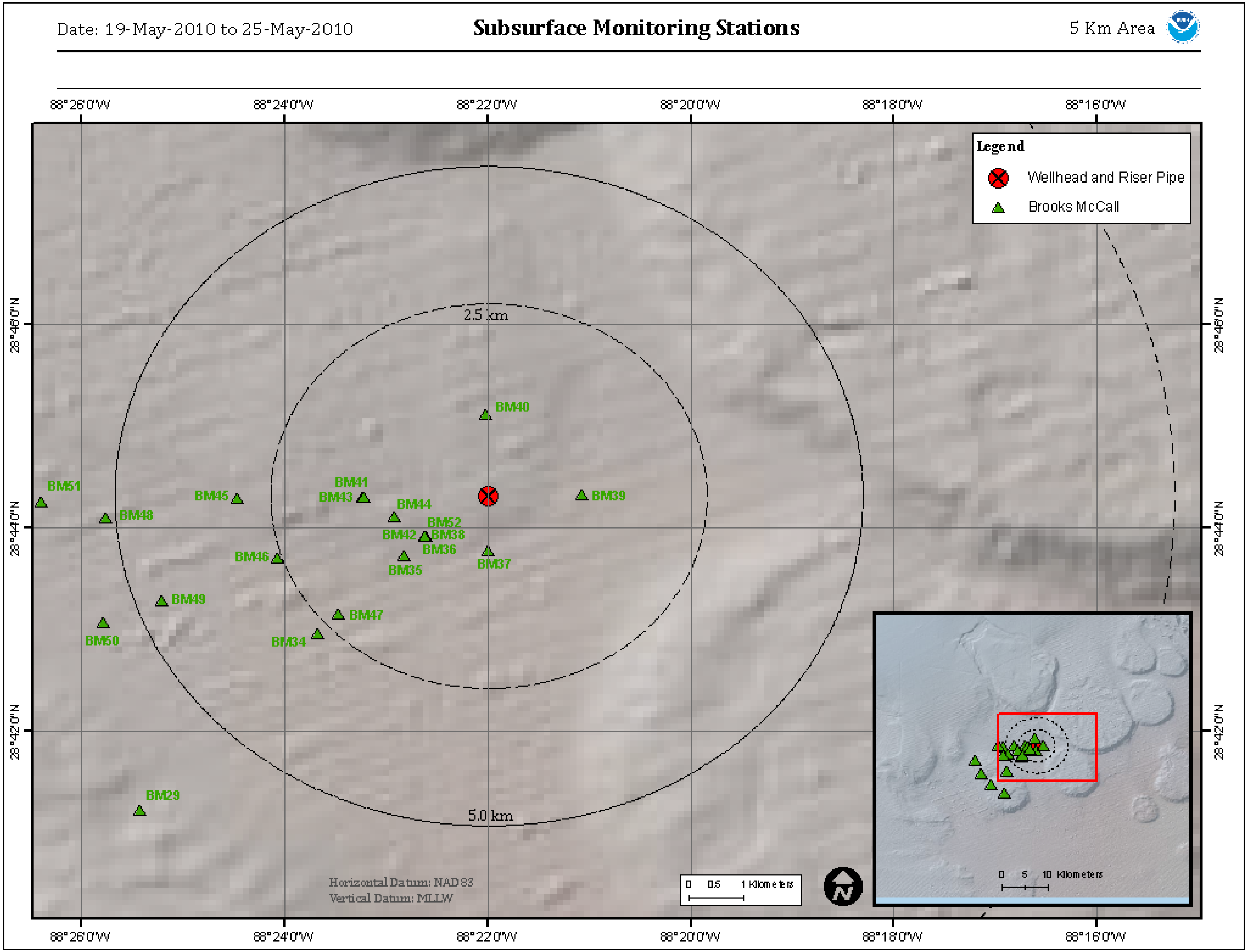


Figure E2: Subsurface Monitoring Stations within 20 km of the Wellhead 19–25 May

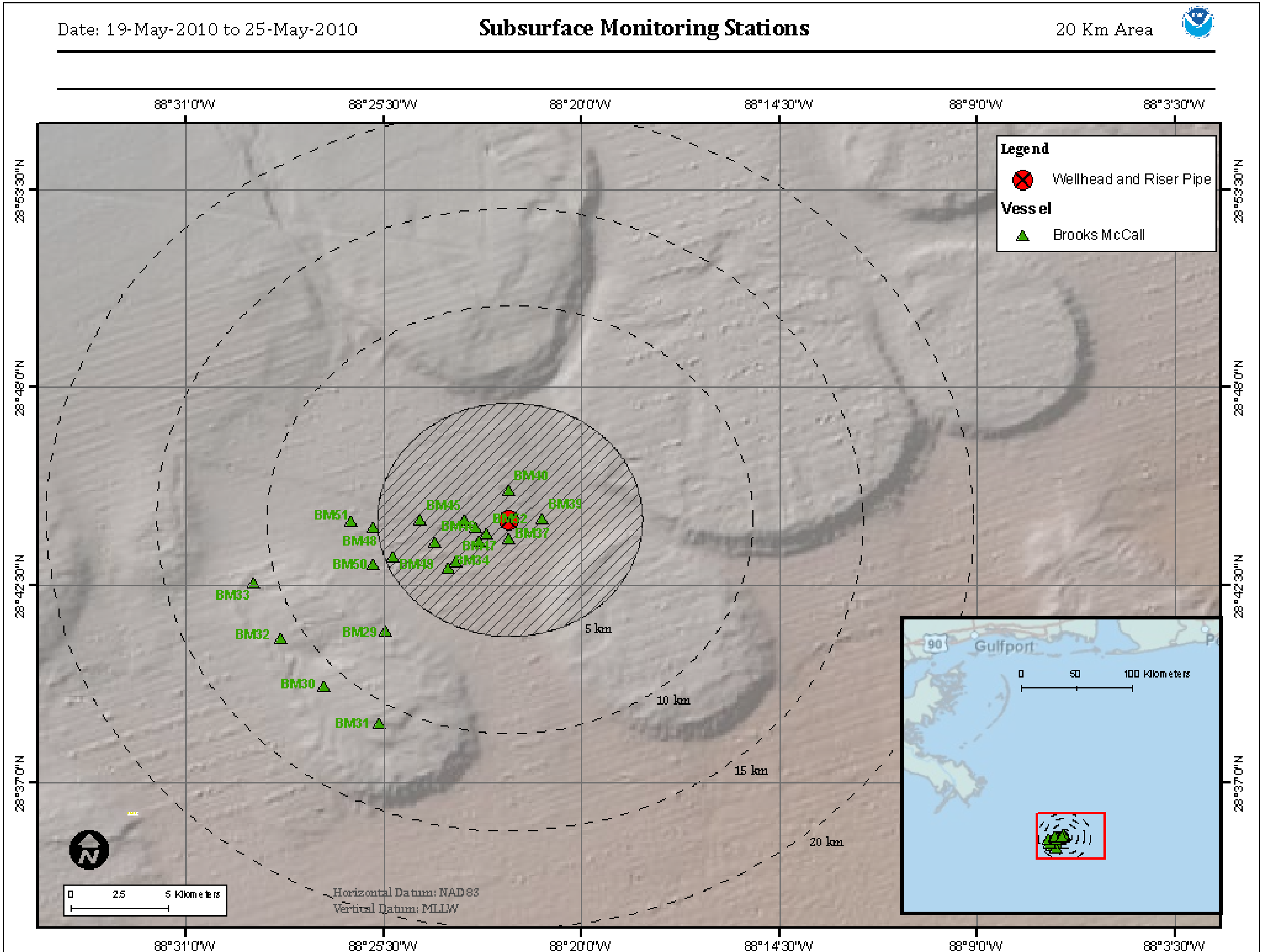


Figure E3: Subsurface Monitoring Stations within 50 km of the Wellhead 19–25 May

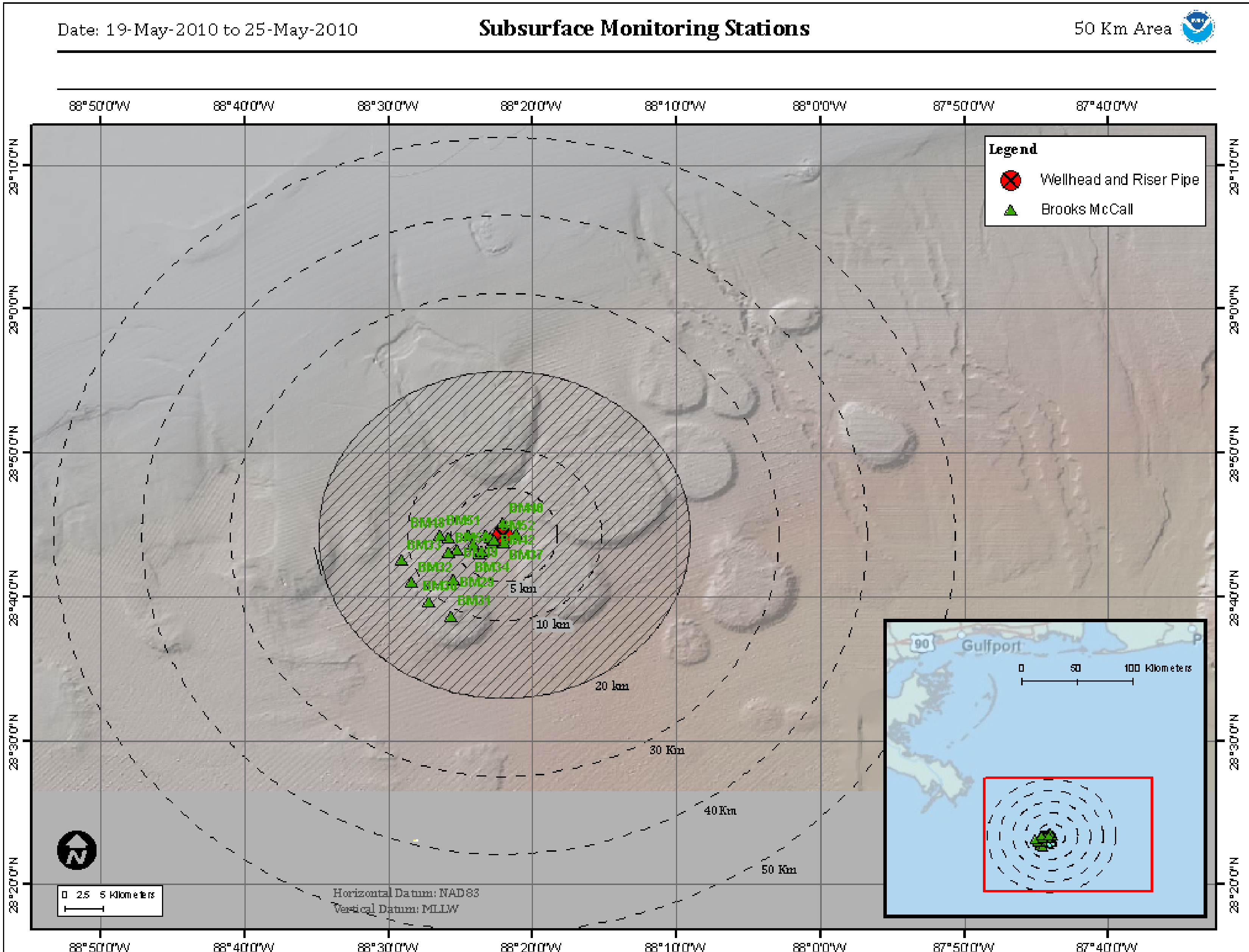


Figure E4: Subsurface Monitoring Stations within 5 km of the Wellhead 26 May–01 June

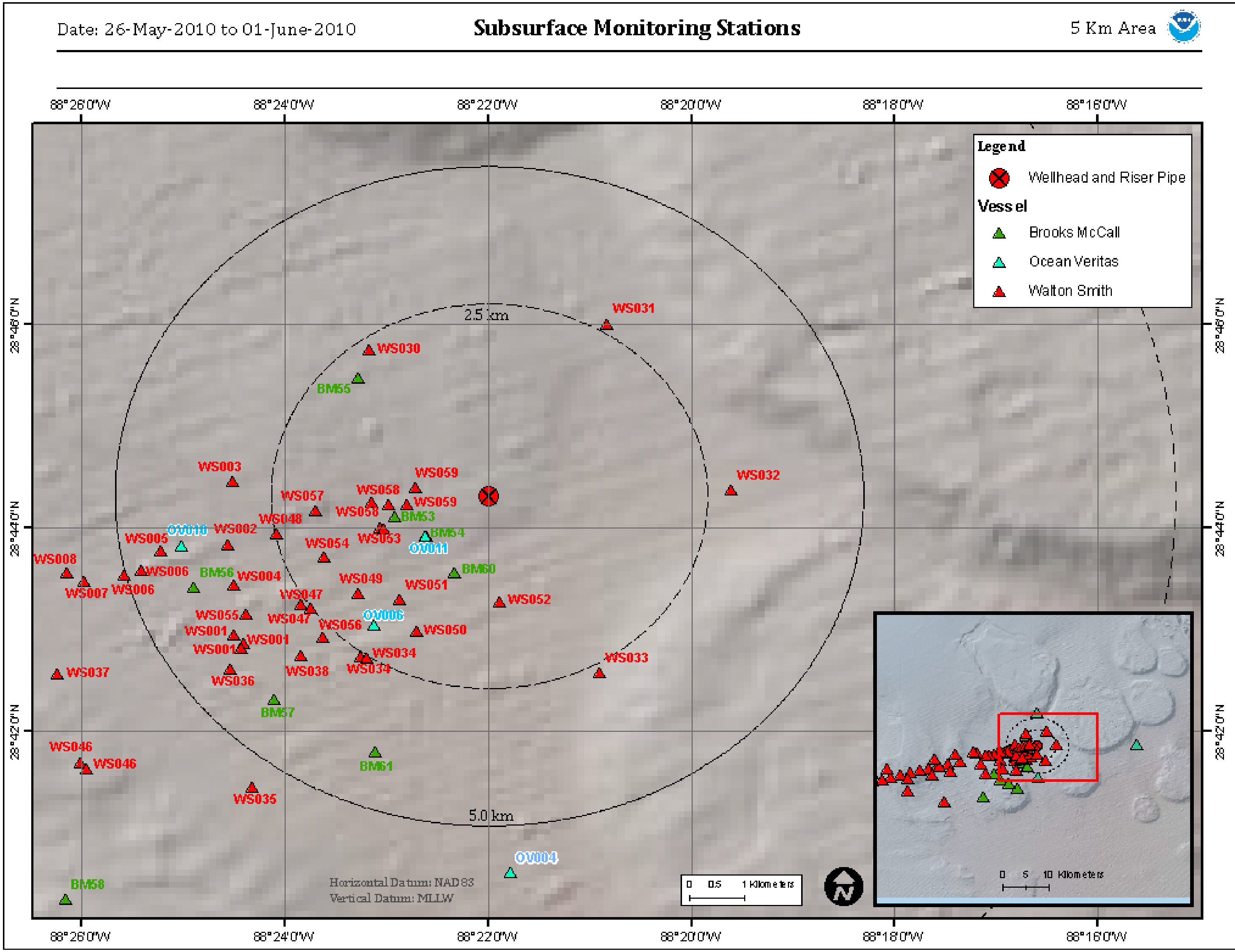


Figure E5: Subsurface Monitoring Stations within 20 km of the Wellhead 26 May–01 June

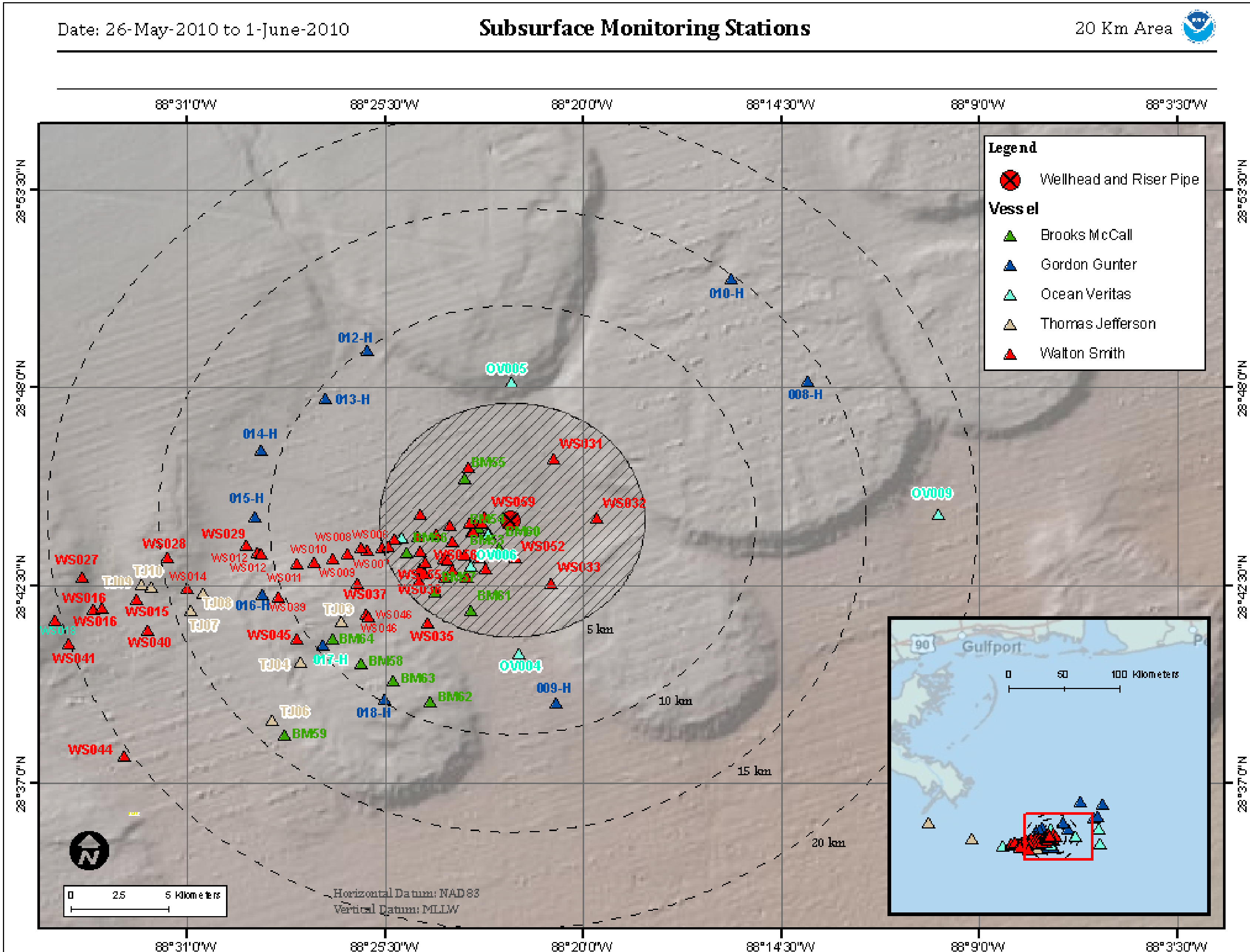


Figure E6: Subsurface Monitoring Stations within 50 km of the Wellhead 26 May–01 June

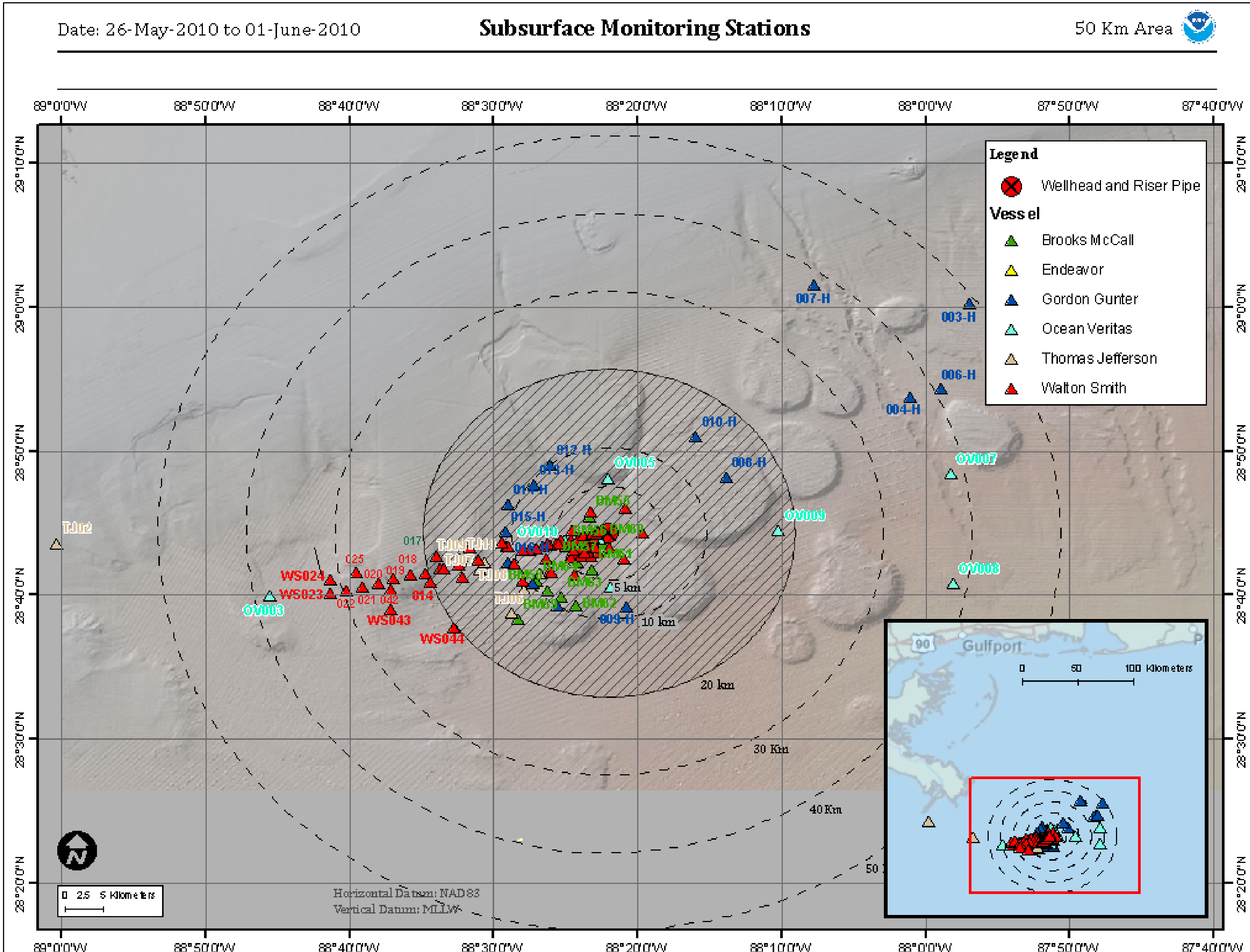


Figure E7: Subsurface Monitoring Stations within 5 km of the Wellhead 02–08 June

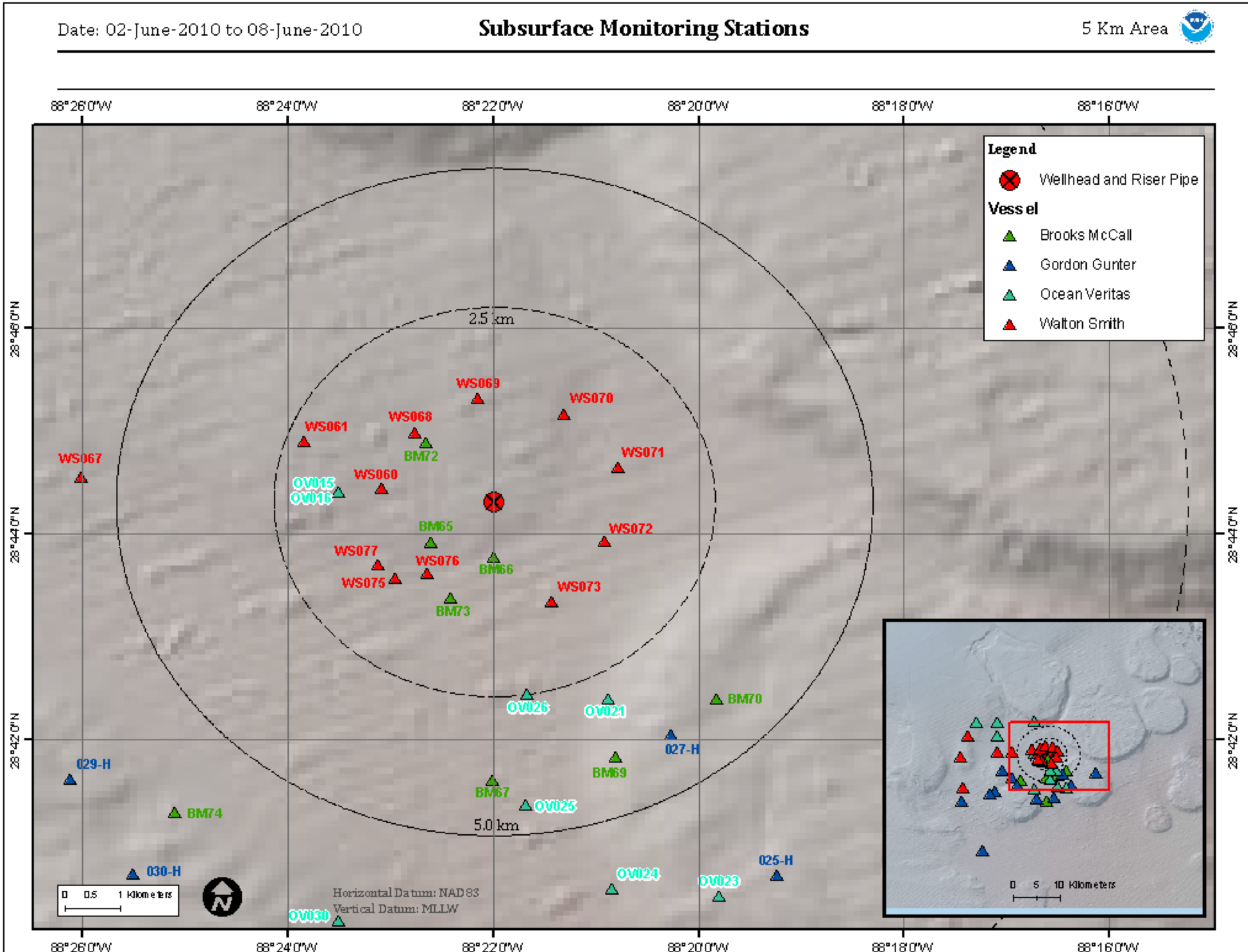


Figure E8: Subsurface Monitoring Stations within 20 km of the Wellhead 02–08 June

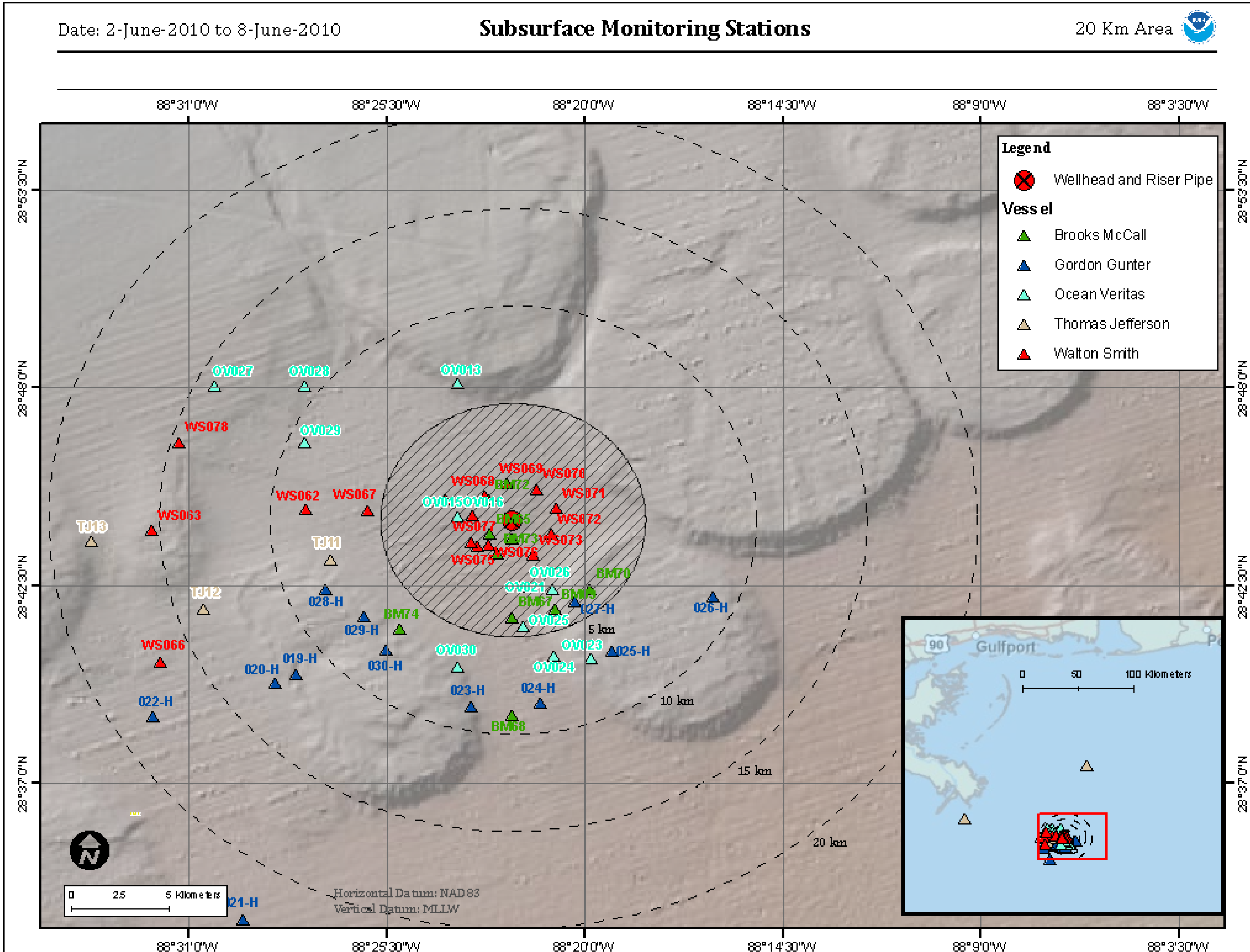


Figure E9: Subsurface Monitoring Stations within 50 km of the Wellhead 02–08 June

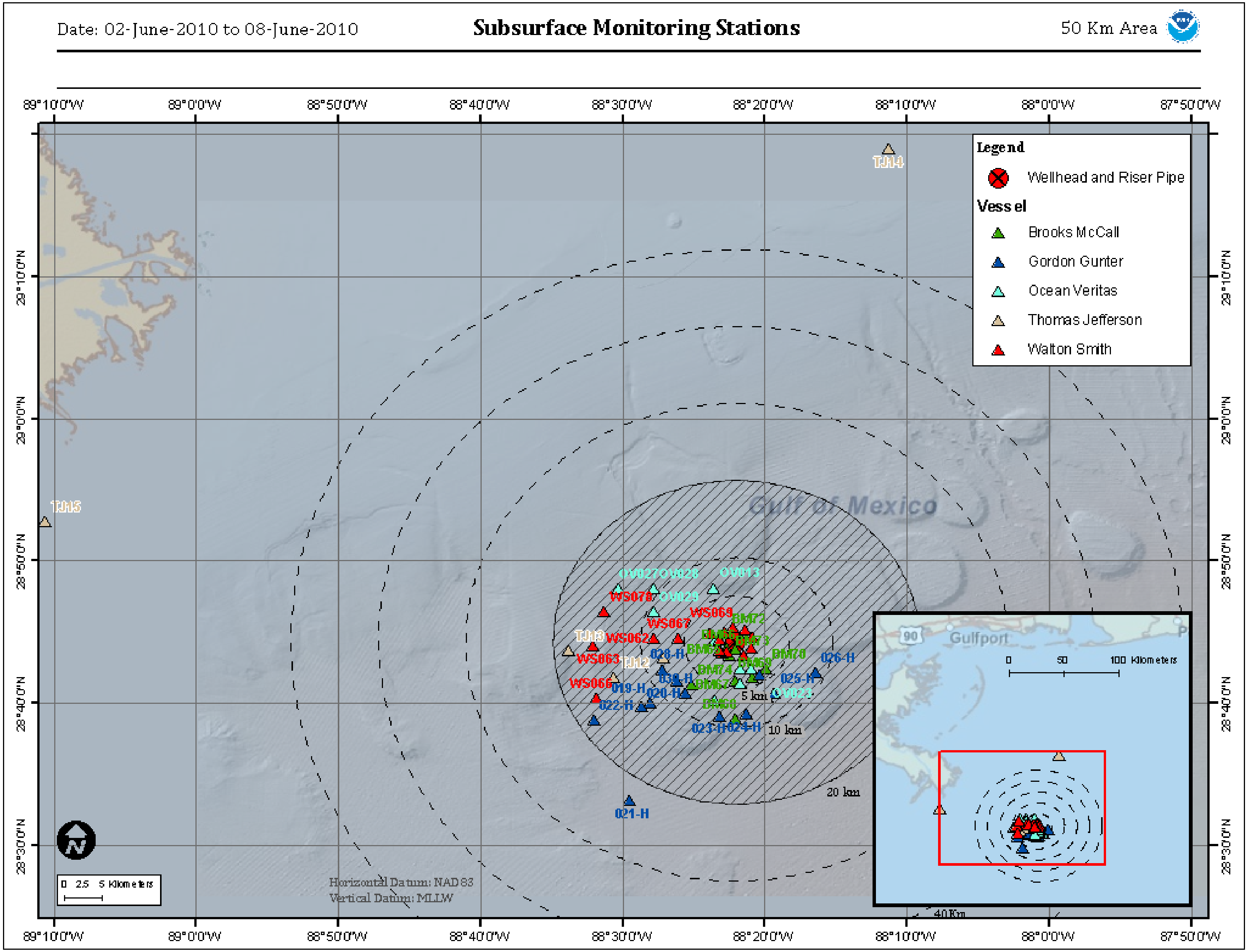


Figure E10: Subsurface Monitoring Stations within 5 km of the Wellhead 09–15 June

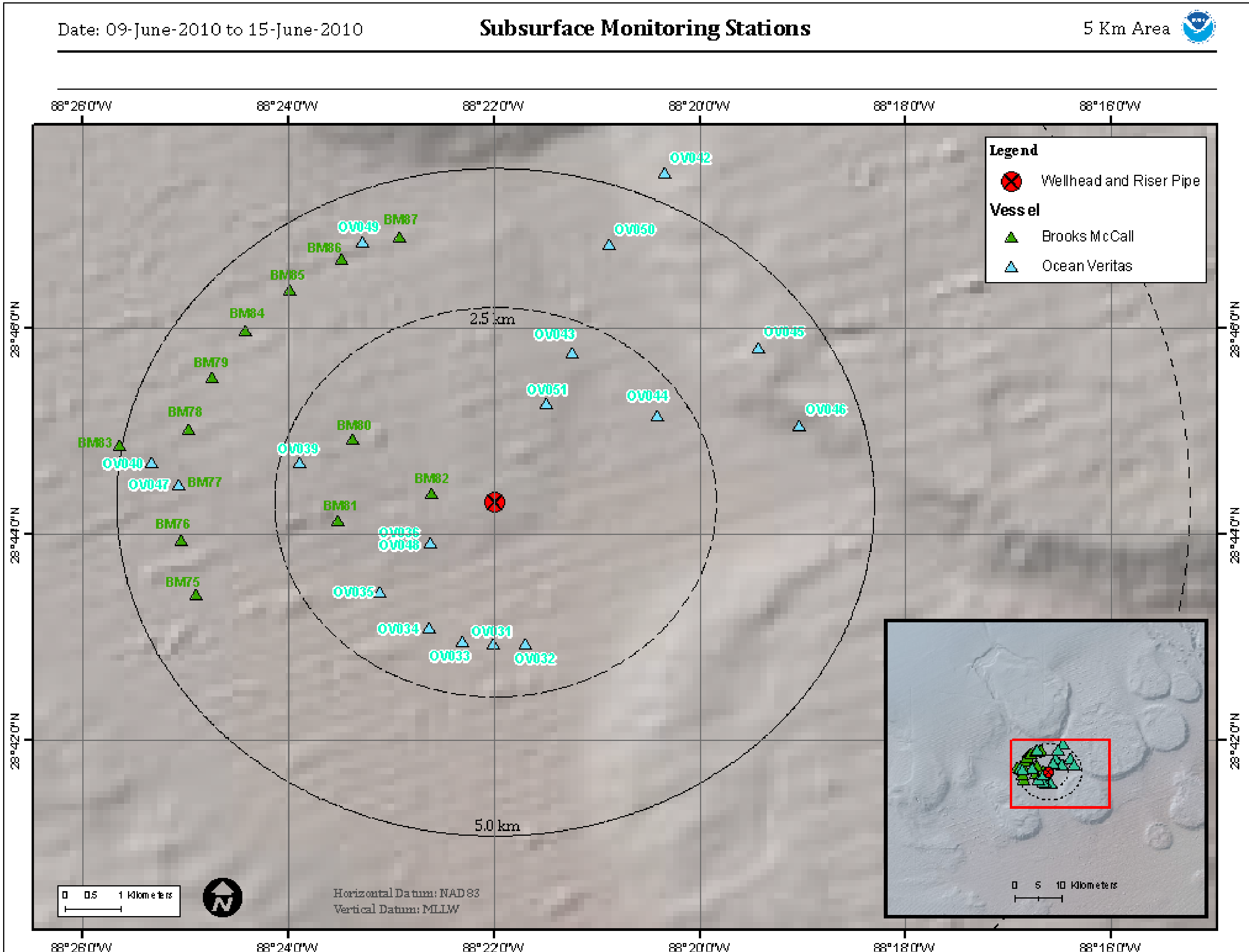


Figure E11: Subsurface Monitoring Stations within 20 km of the Wellhead 09–15 June

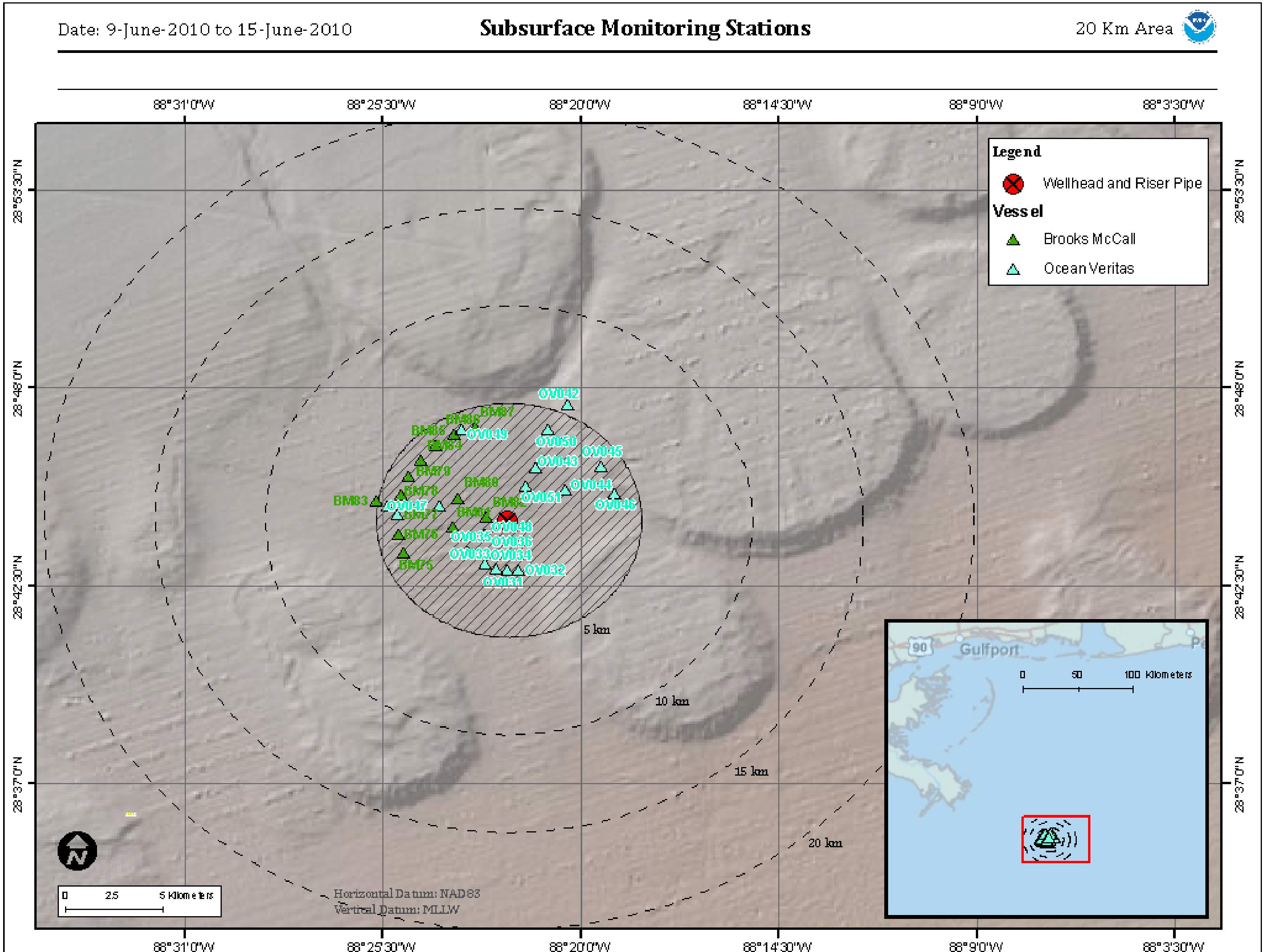


Figure E12:: Subsurface Monitoring Stations within 50 km of the Wellhead 09–15 June

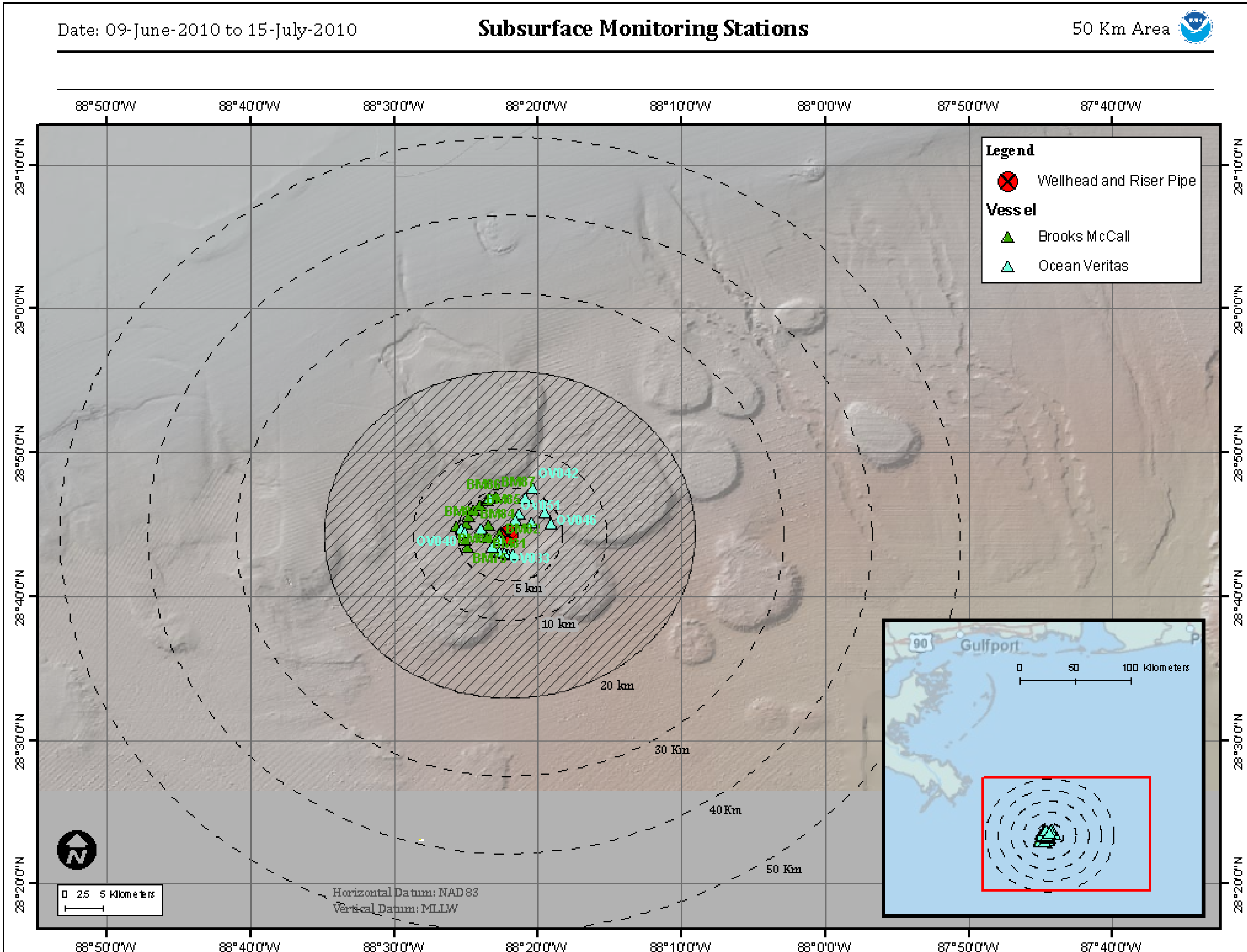


Figure E13: Subsurface Monitoring Stations within 5 km of the Wellhead 16–22 June

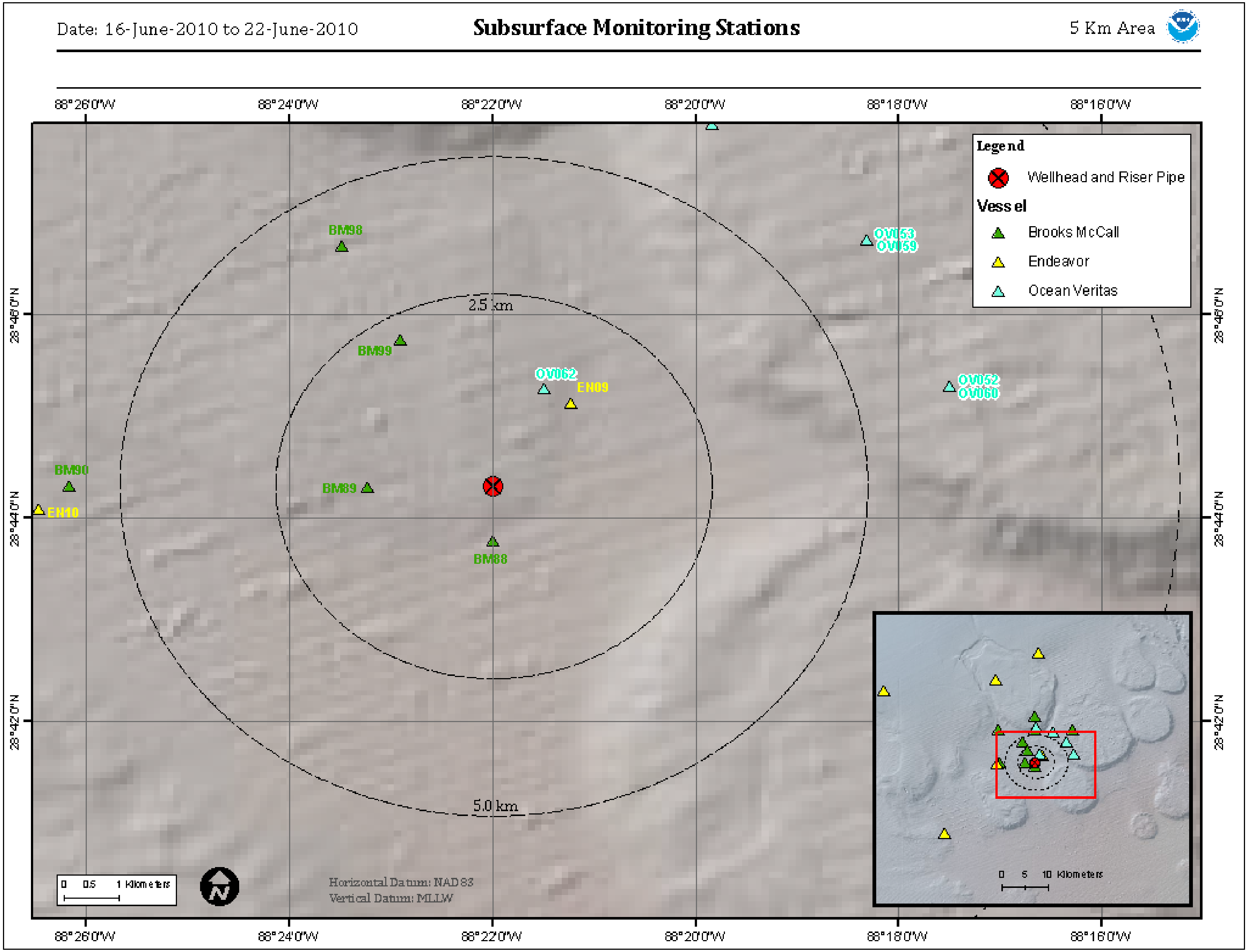


Figure E14: Subsurface Monitoring Stations within 20 km of the Wellhead 16–22 June

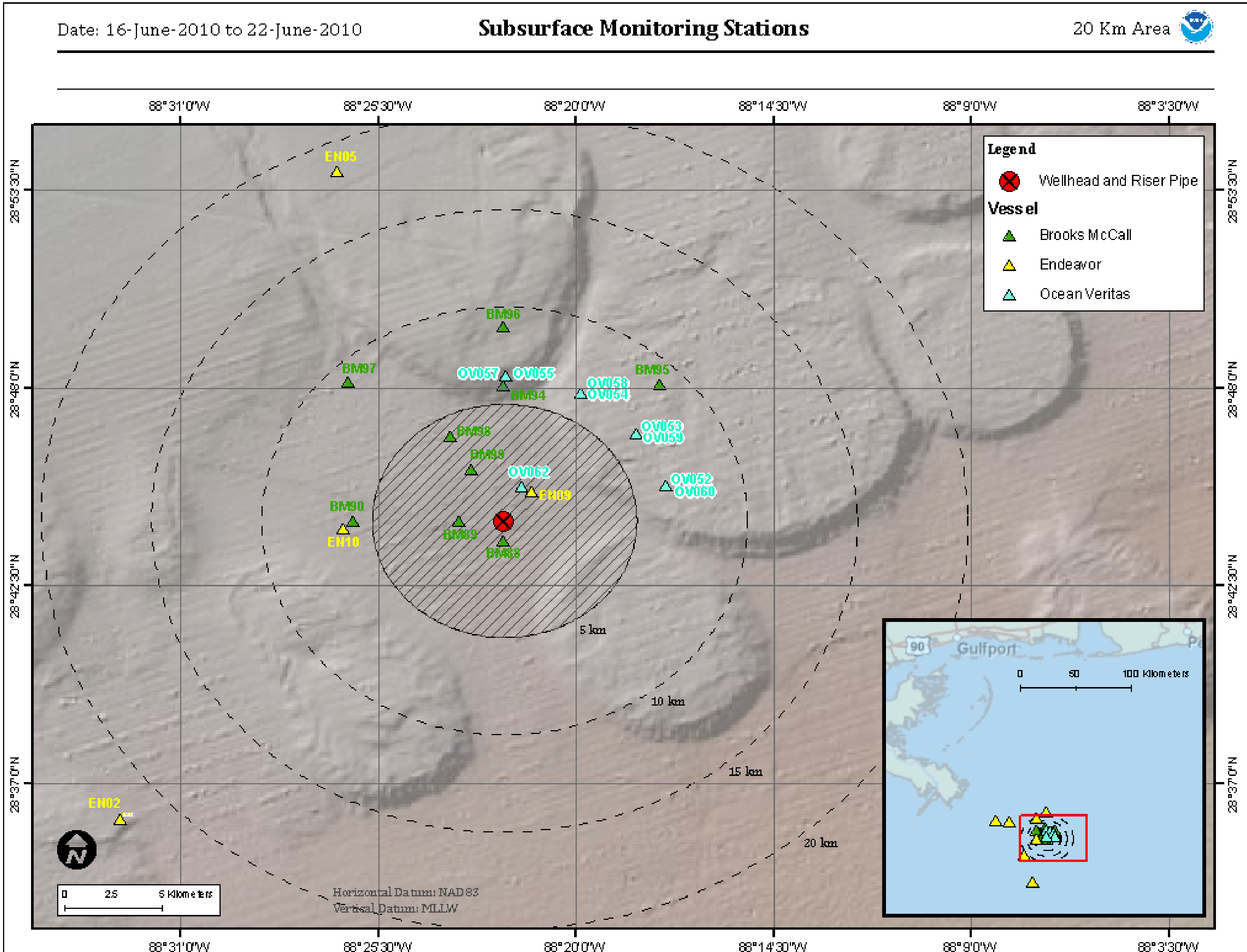


Figure E15: Subsurface Monitoring Stations within 50 km of the Wellhead 16–22 June

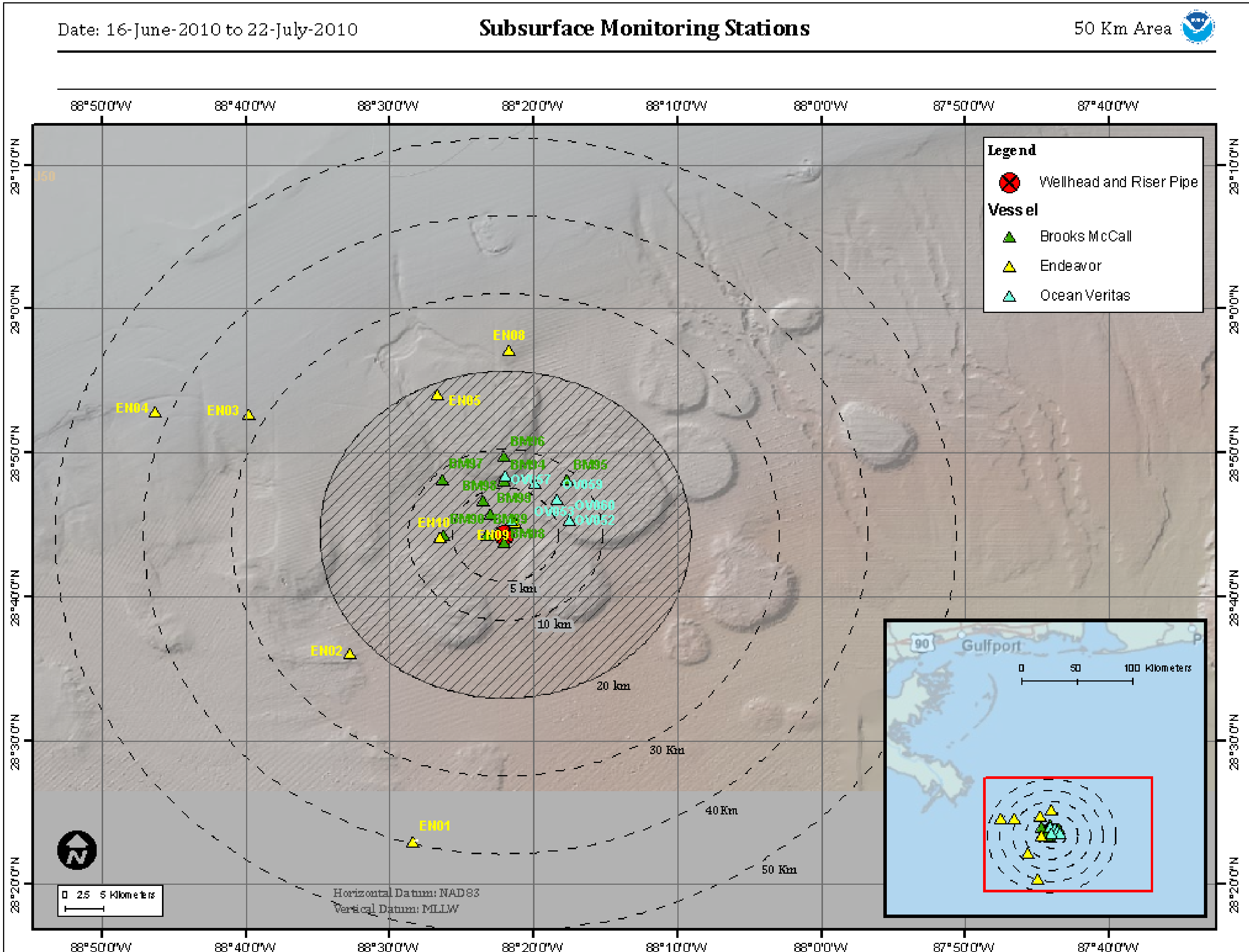


Figure E16: Subsurface Monitoring Stations within 5 km of the Wellhead 23–29 June

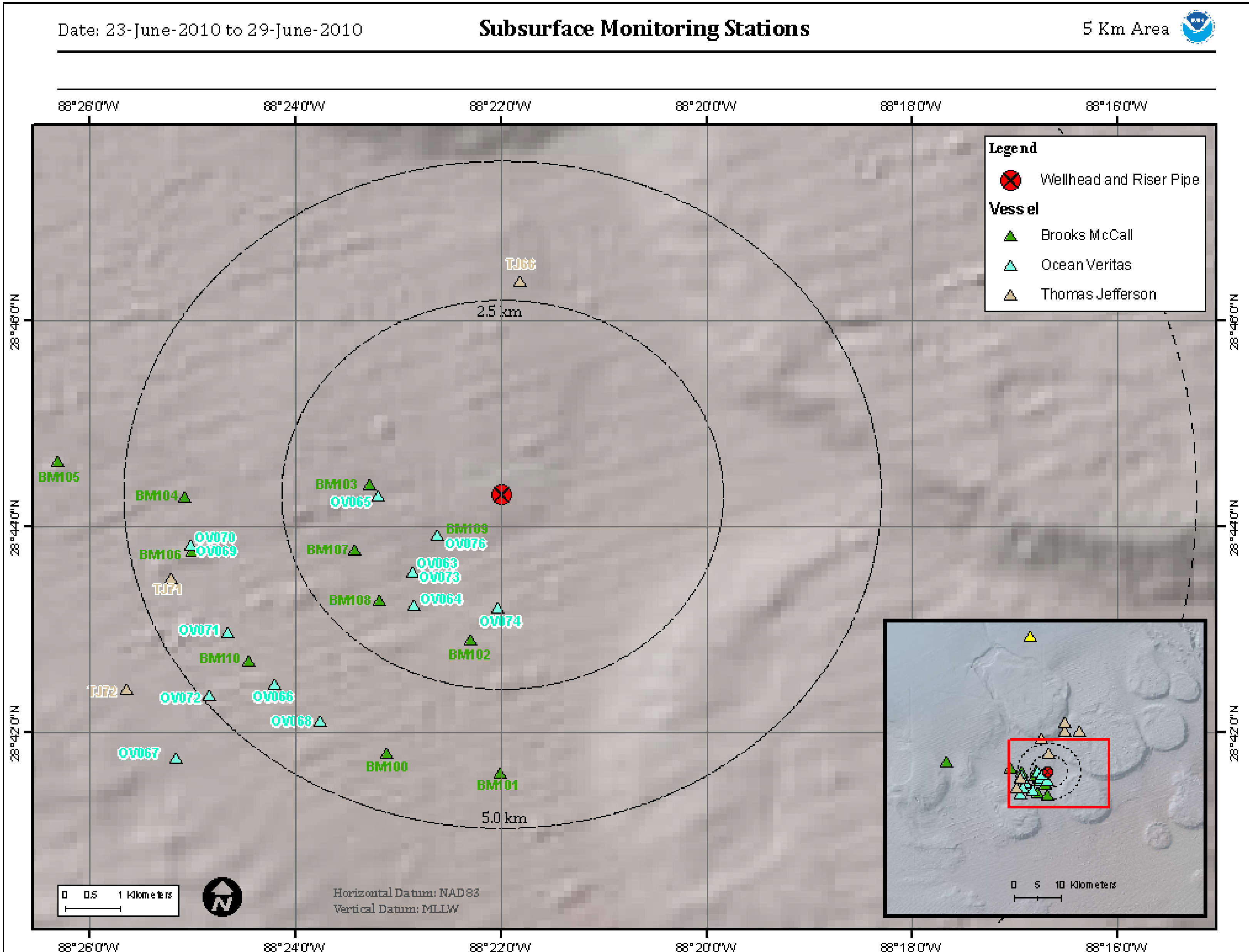


Figure E17: Subsurface Monitoring Stations within 20 km of the Wellhead 23–29 June

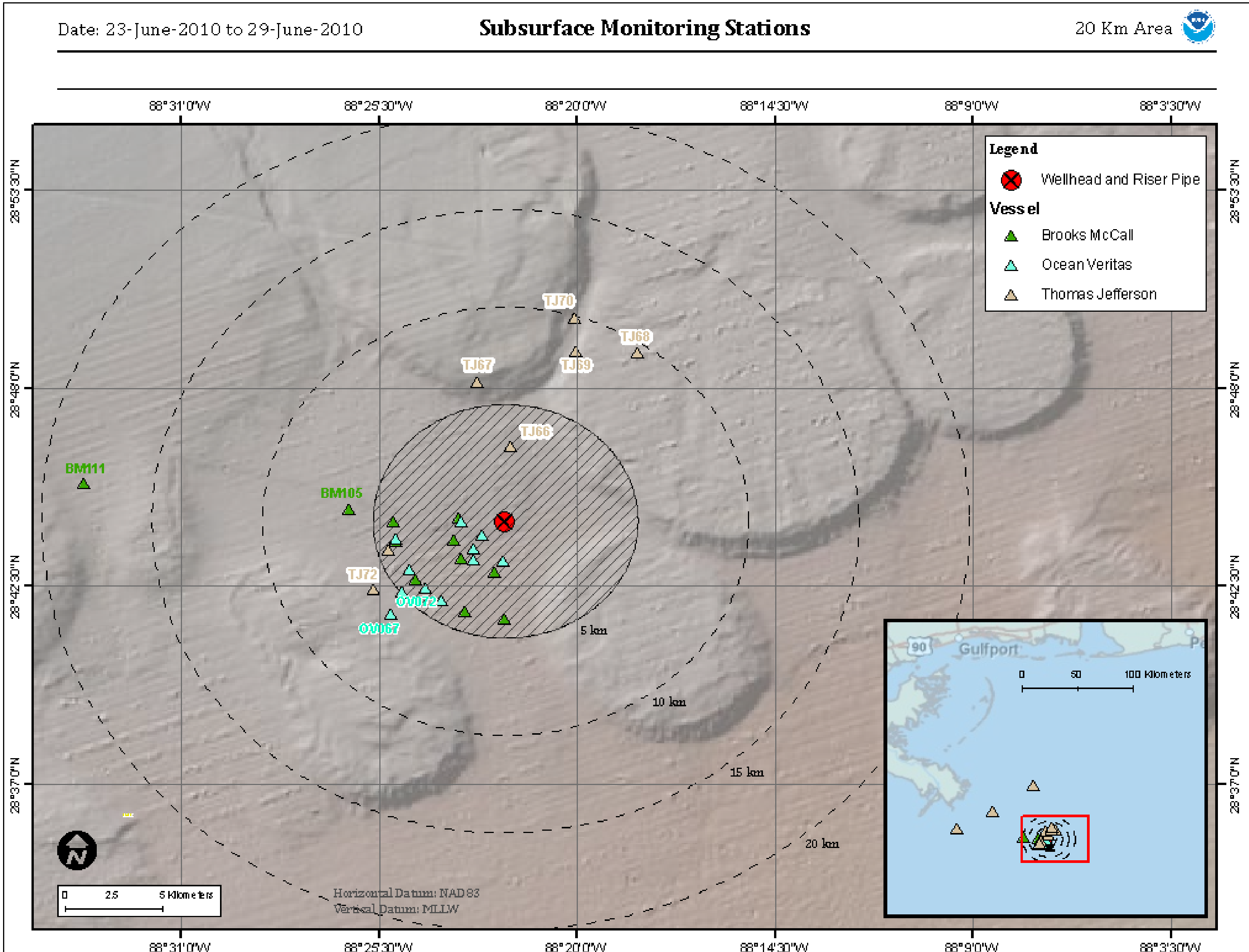


Figure E18: Subsurface Monitoring Stations within 50 km of the Wellhead 23–29 June

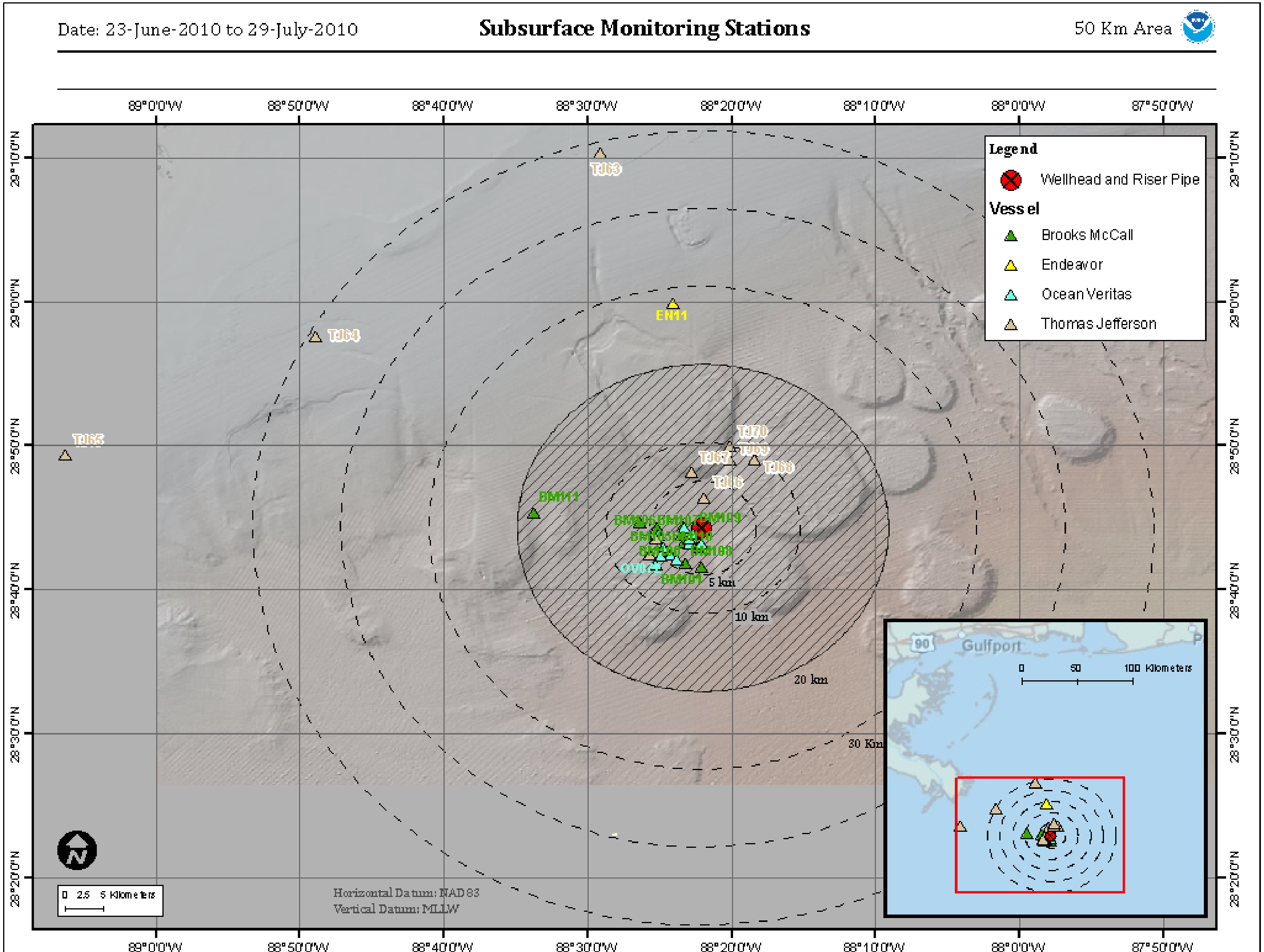


Figure E19: Subsurface Monitoring Stations within 5 km of the Wellhead 30 June–06 July

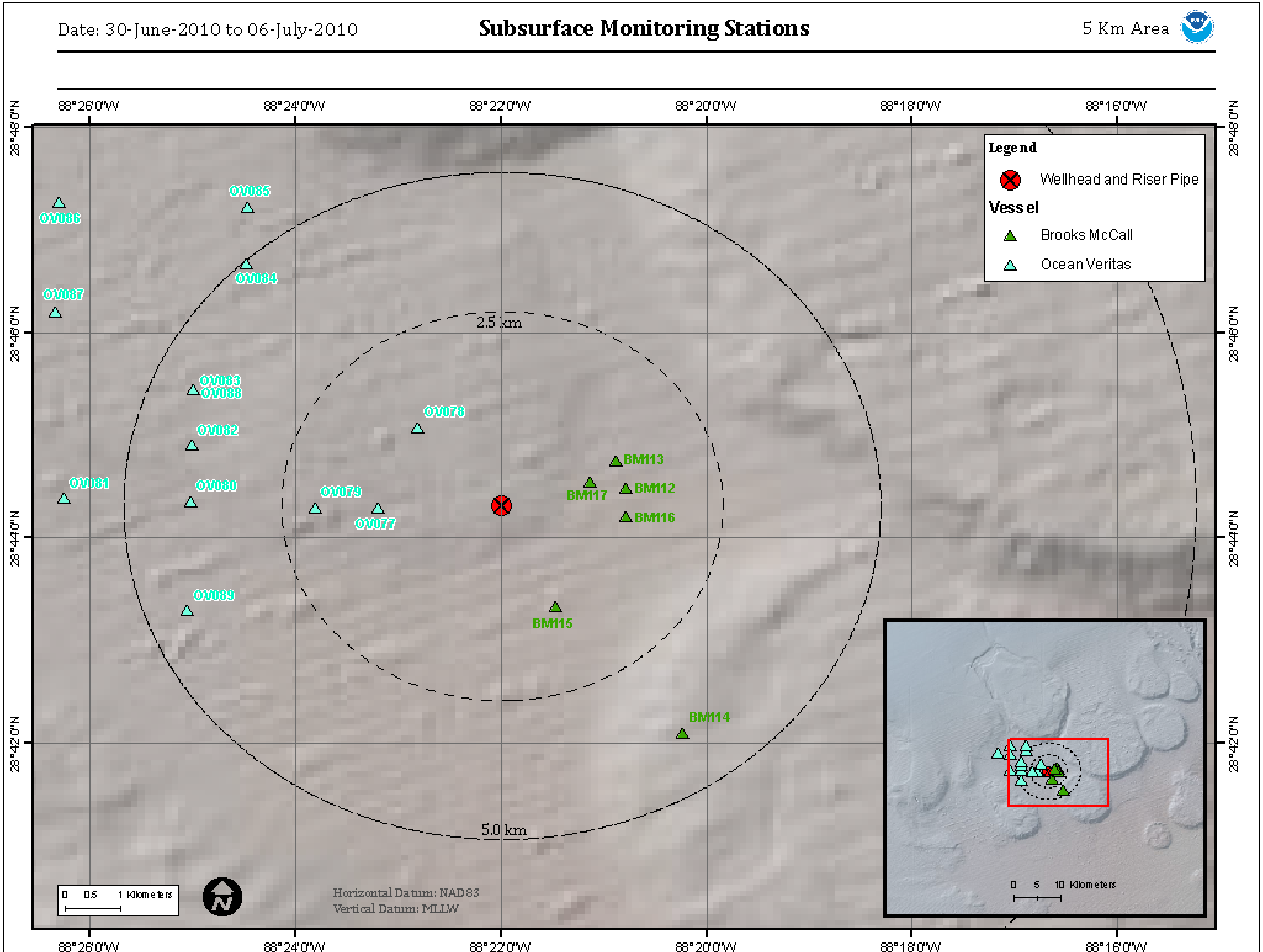


Figure E20: Subsurface Monitoring Stations within 20 km of the Wellhead 30 June–01 July

Date: 30-June-2010 to 06-July-2010

Subsurface Monitoring Stations

20 Km Area

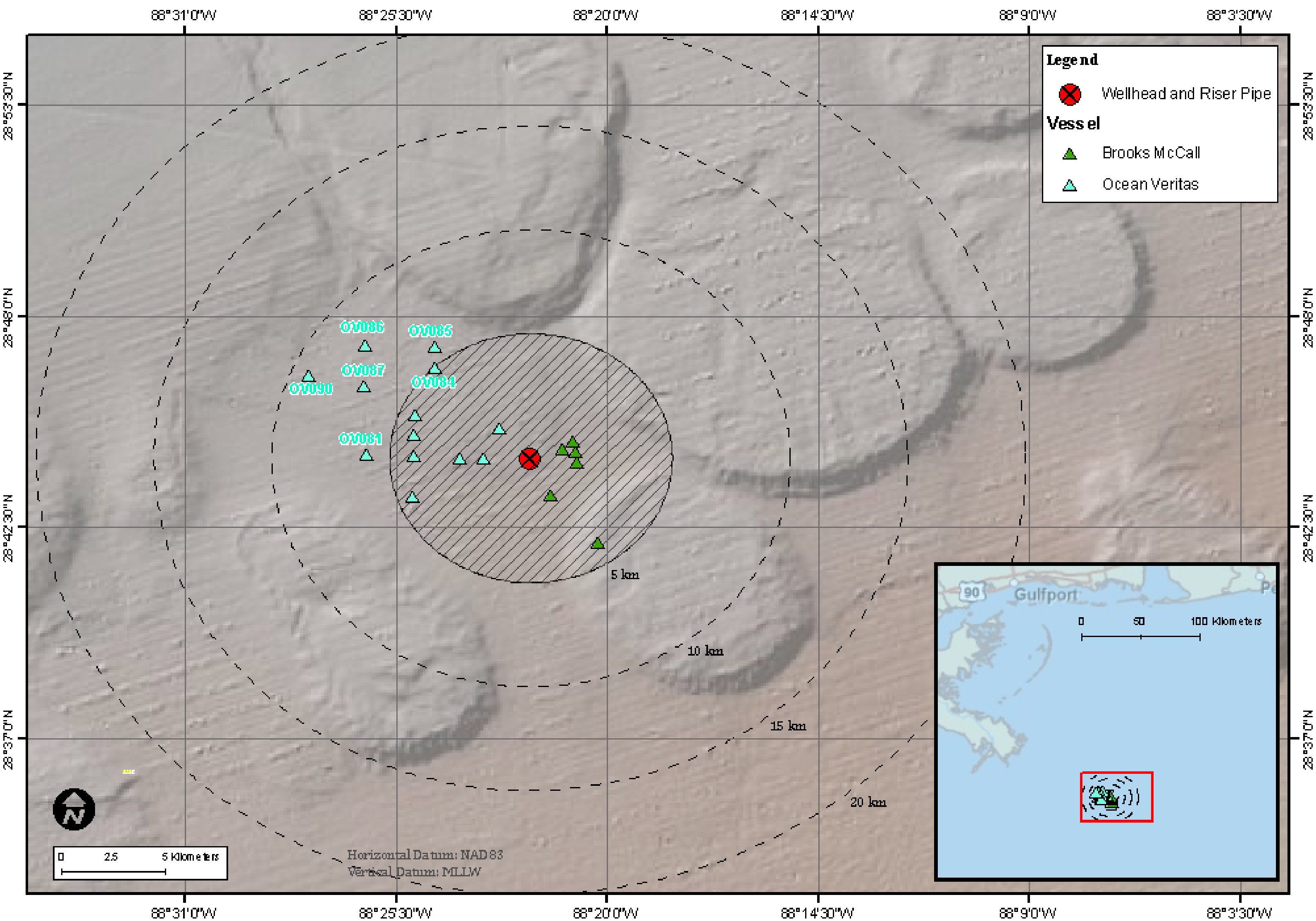


Figure E21: Subsurface Monitoring Stations within 50 km of the Wellhead 30 June – 06 July

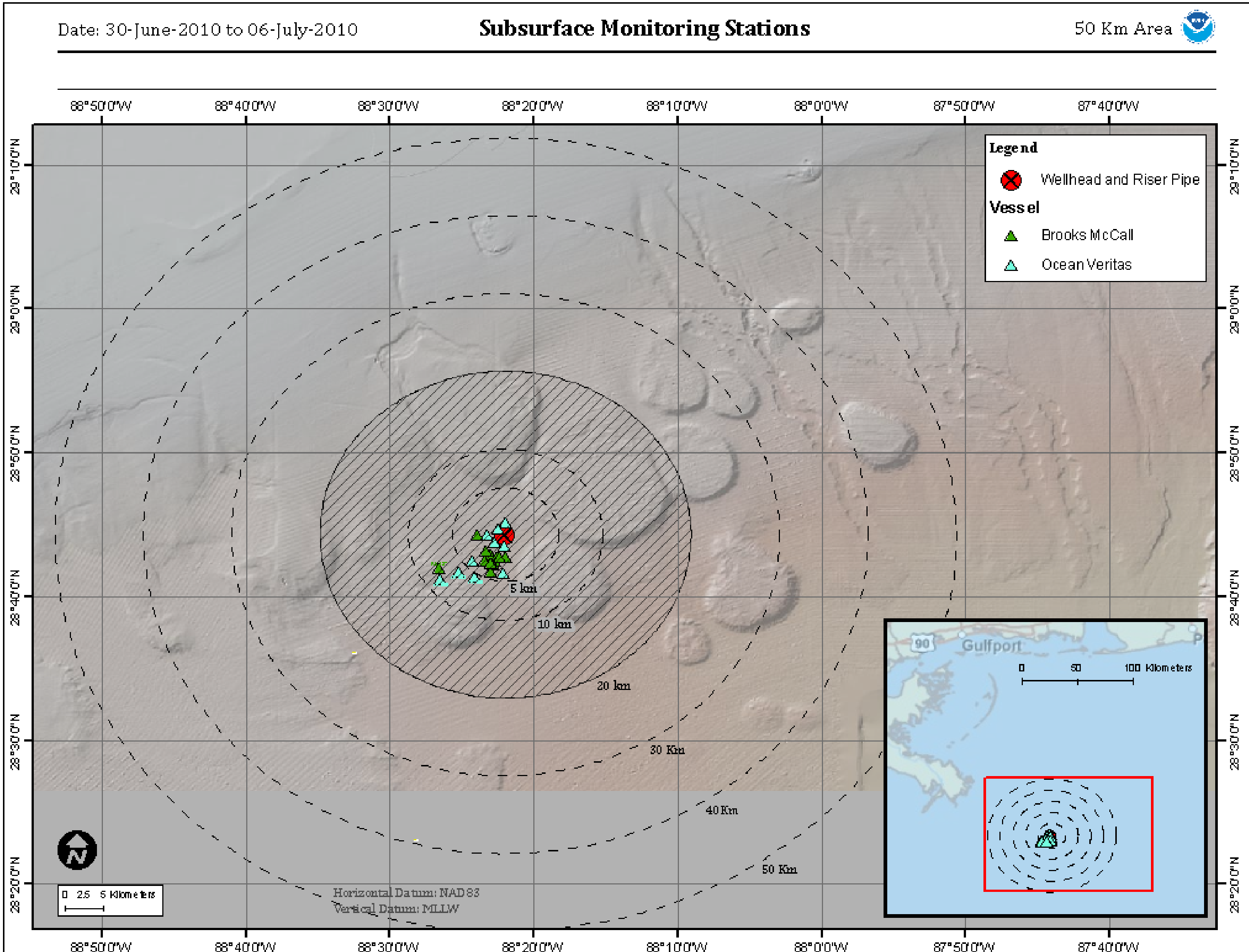


Figure E22: Subsurface Monitoring Stations within 5 km of the Wellhead 06–13 July

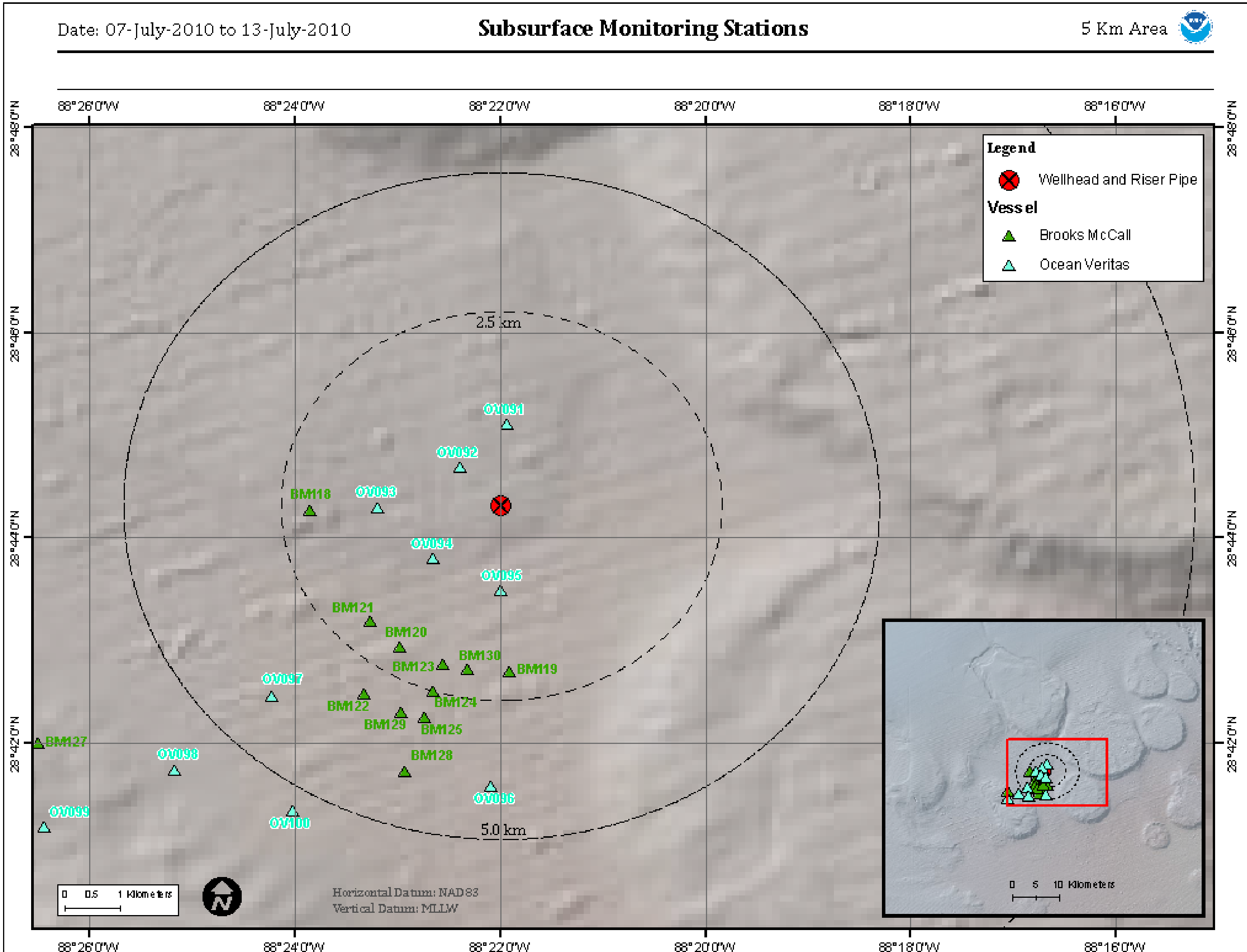


Figure E23: Subsurface Monitoring Stations within 20 km of the Wellhead 06–13 July

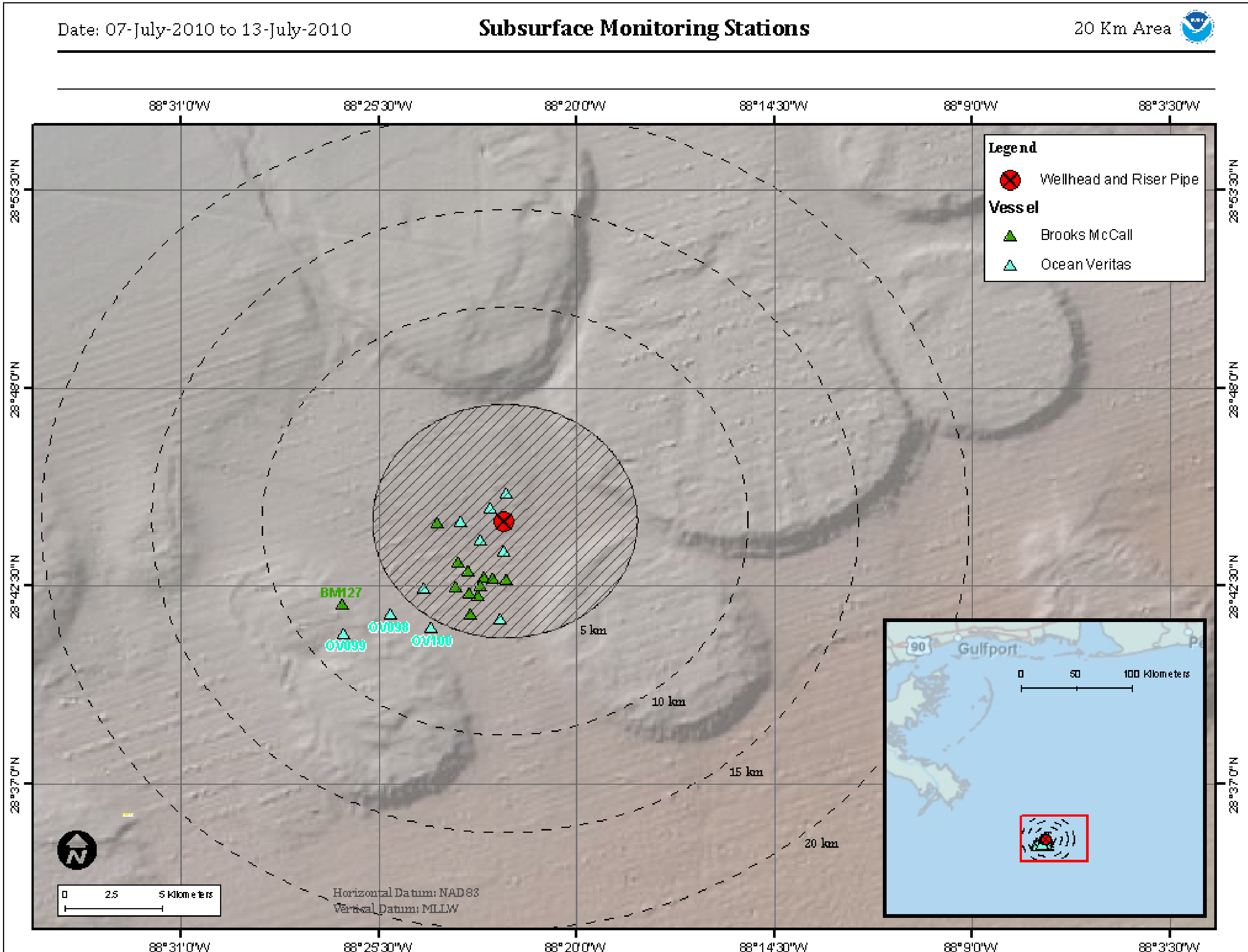


Figure E24: Subsurface Monitoring Stations within 50 km of the Wellhead 06–13 July

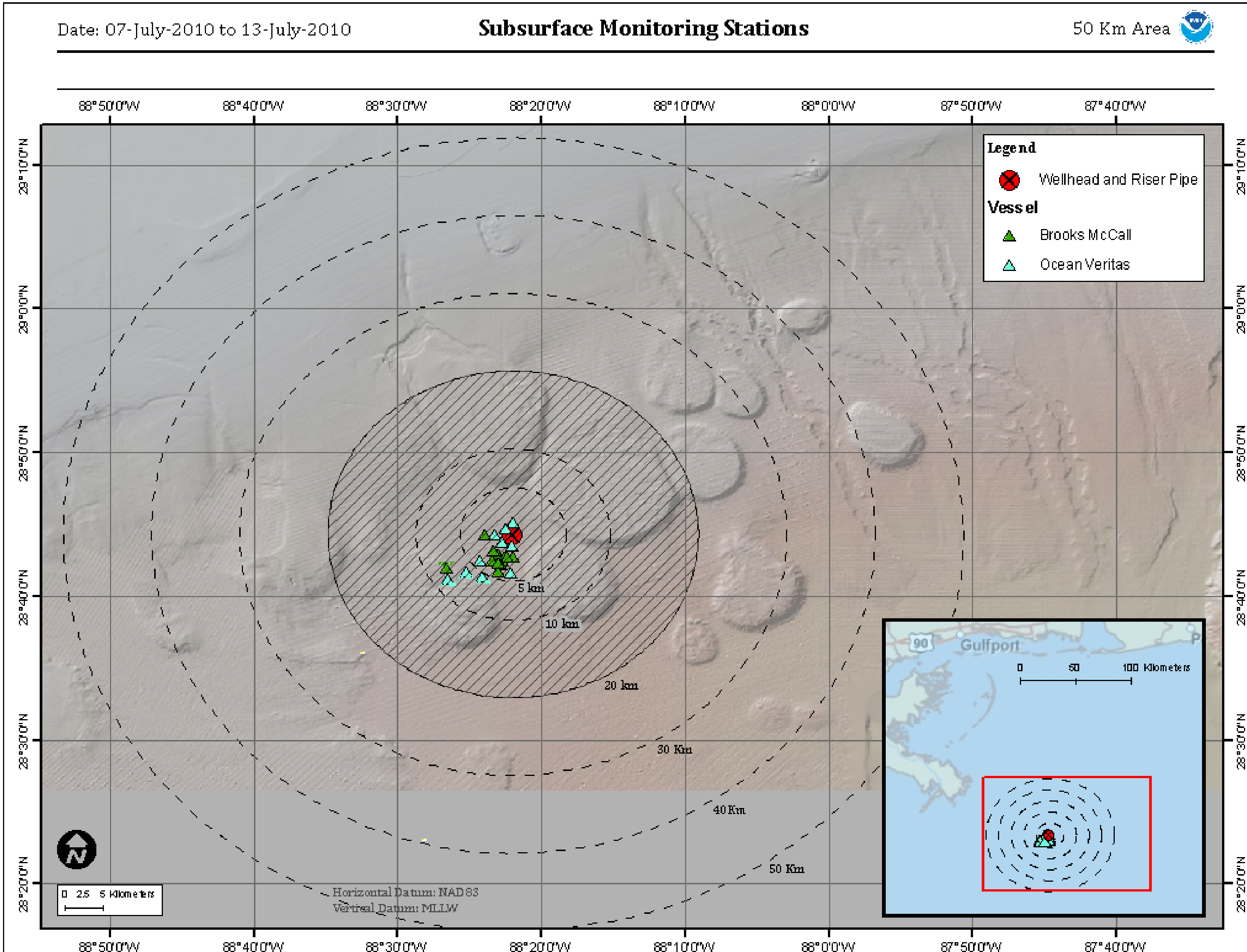


Figure E25: Mean Fluorescence (ppb QSDE) vs. Distance from the Wellhead (May 19–July 13)

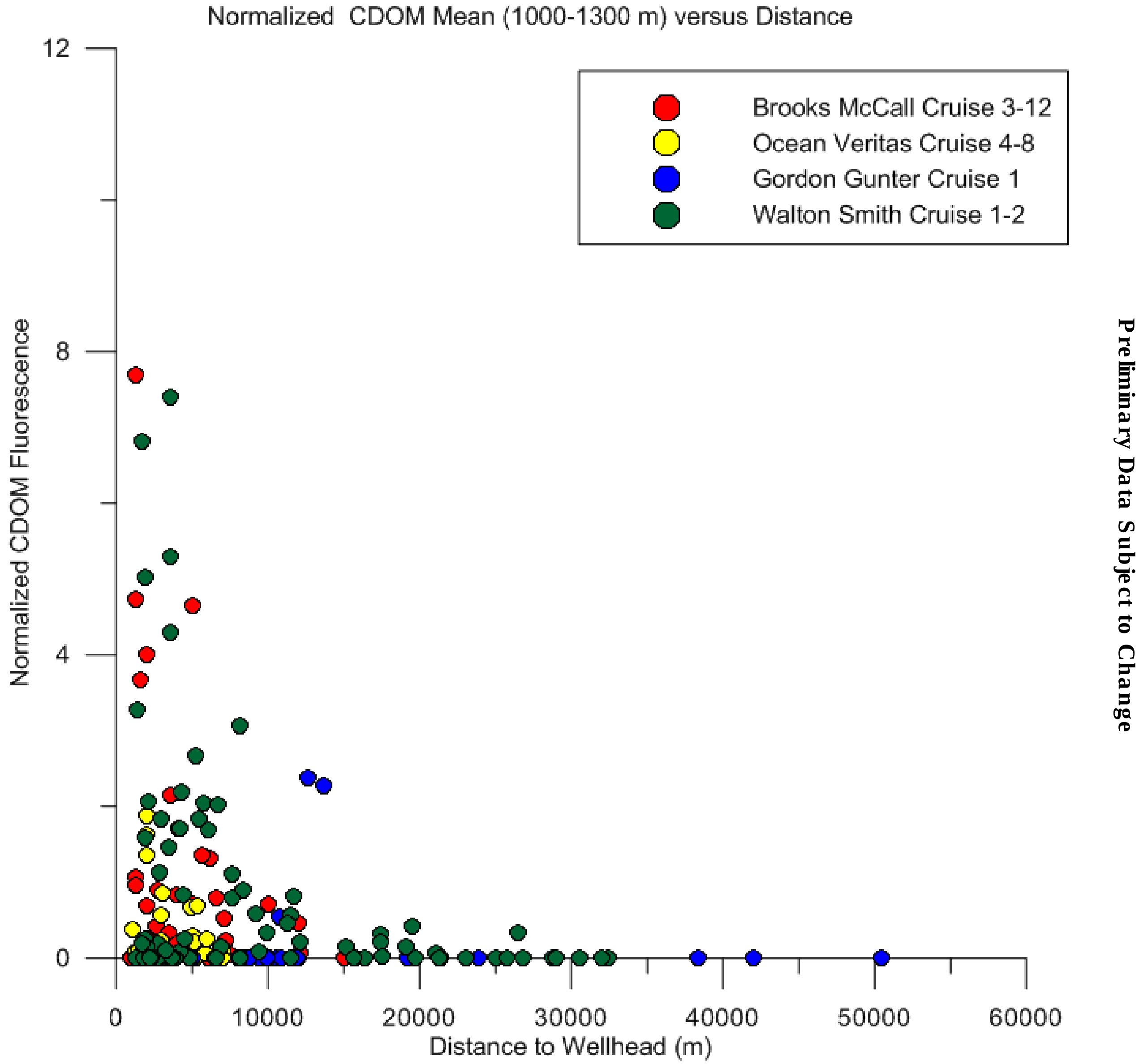


Figure E26: Maximum Fluorescence (ppb QSDE) vs. Distance from the Wellhead (May 19–July 13)

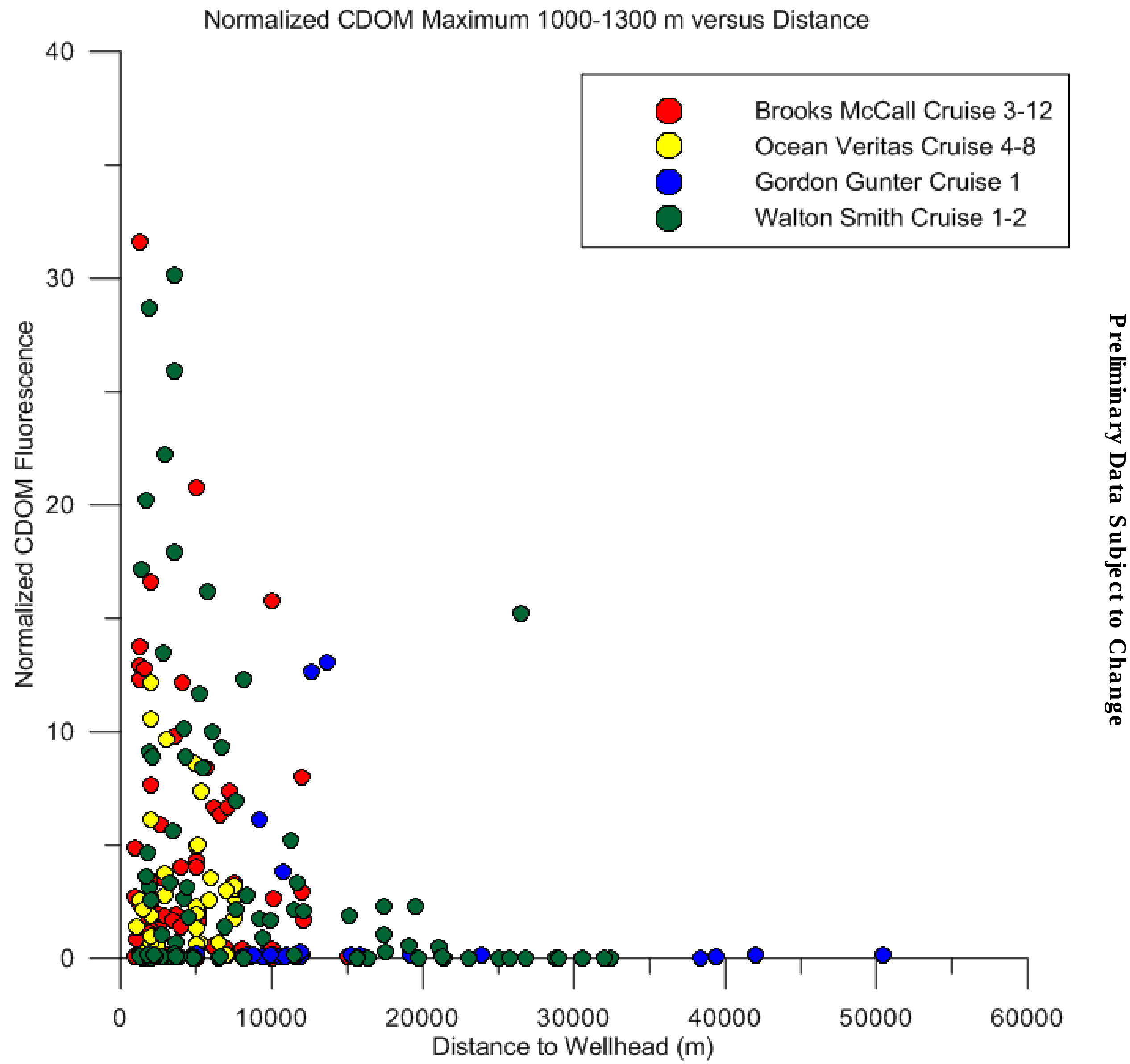
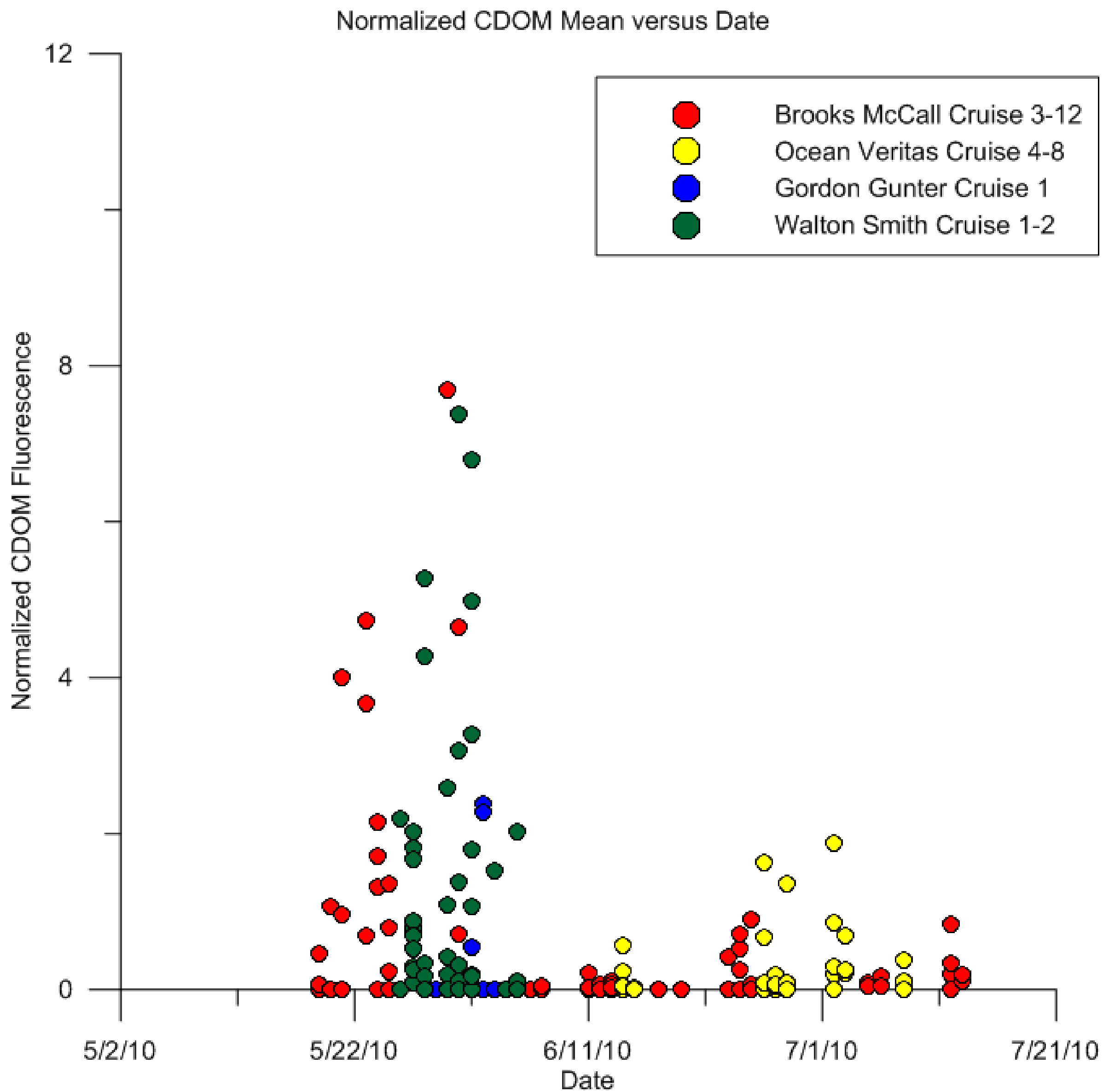


Figure E27: Mean Fluorescence (ppb QSDE) vs. Time of Observation (May 19–July 13)



Preliminary Data Subject to Change

Figure E28: Maximum Fluorescence (ppb QSDE) vs. Time of Observation (May 19-July 13)

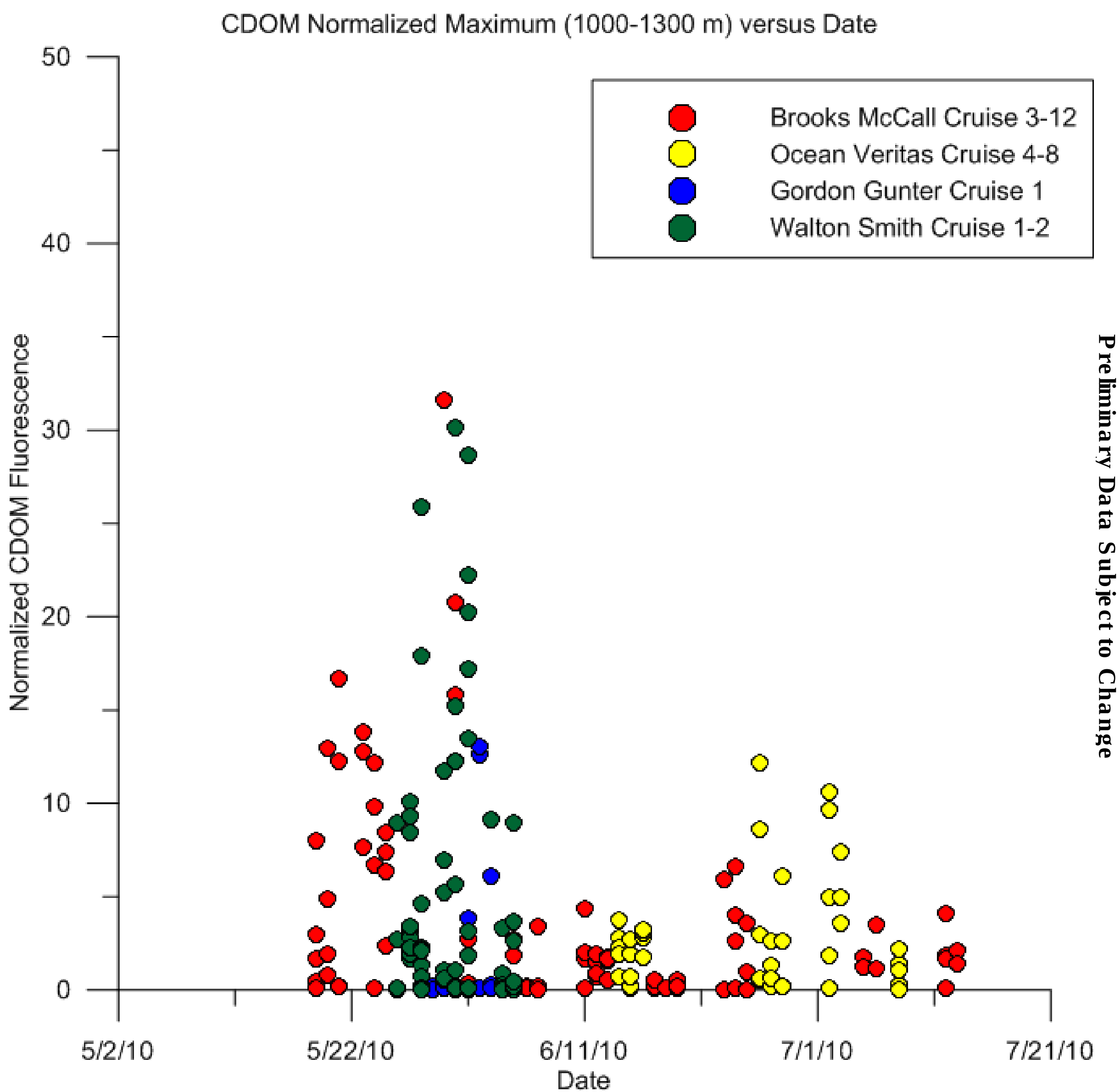


Figure E29: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 19 May 2010.

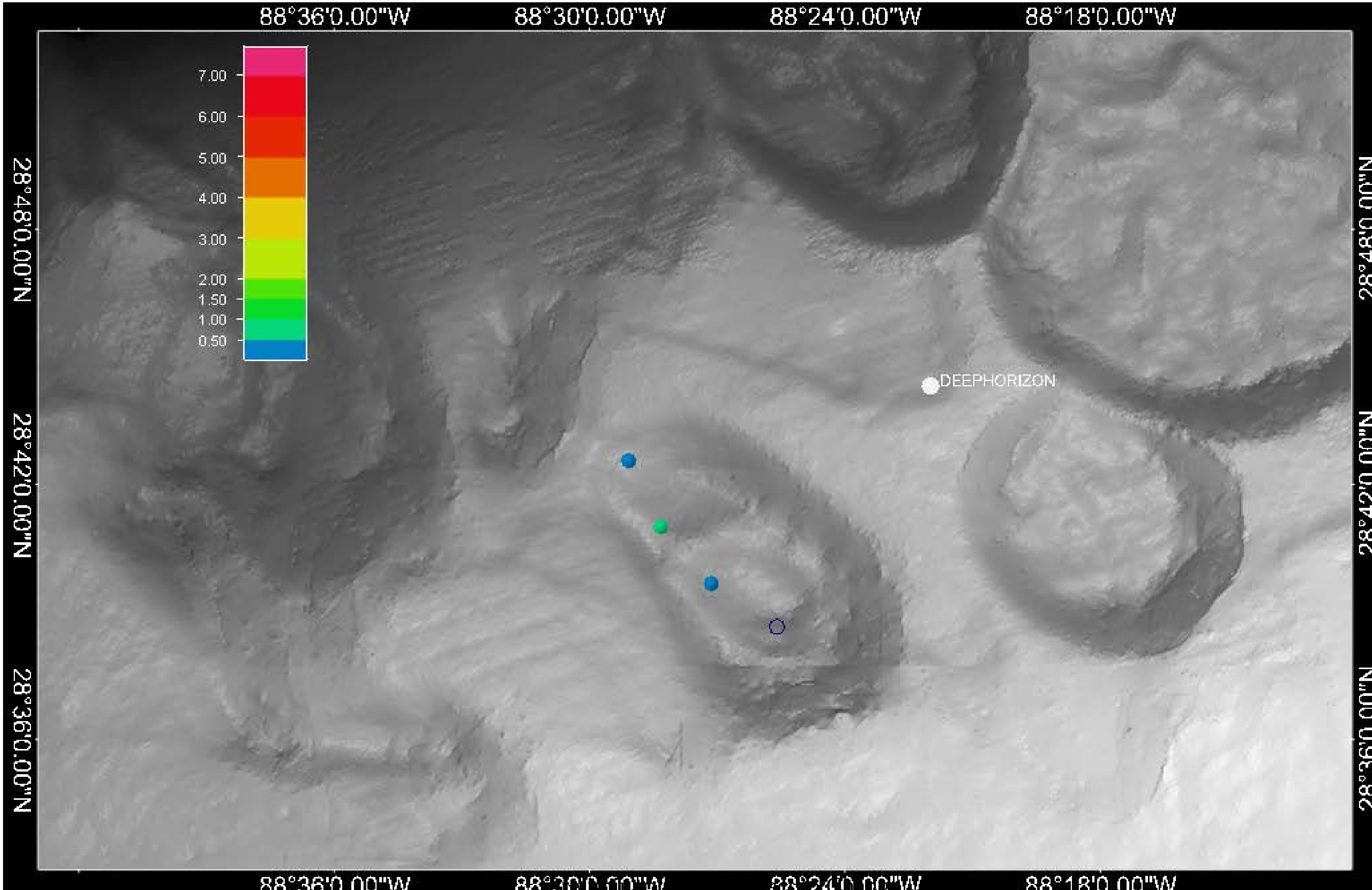
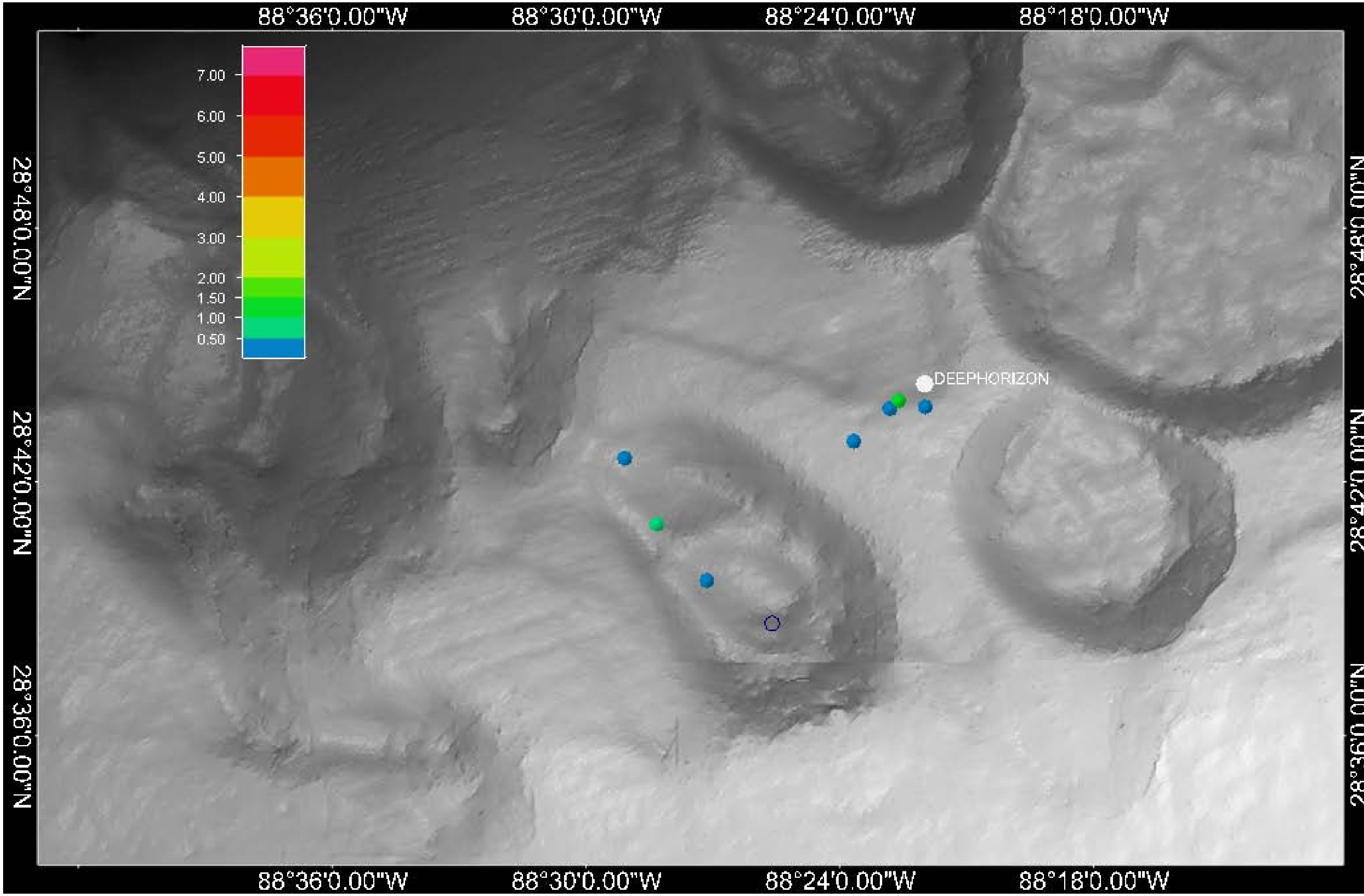


Figure E30: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 20 May 2010.



Preliminary Data Subject to Change

Figure E31: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 21 May 2010

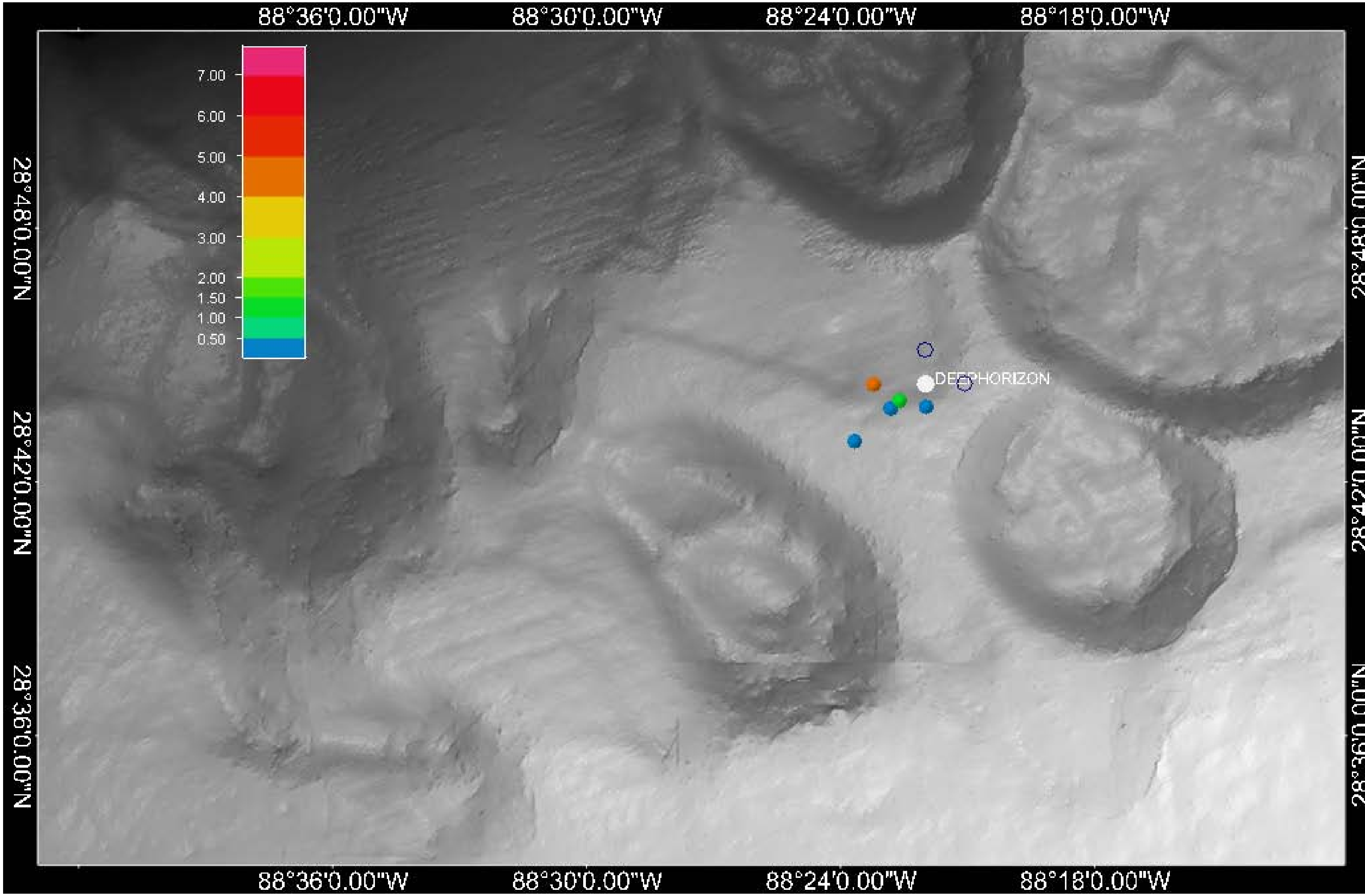


Figure E32: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 22 May 2010

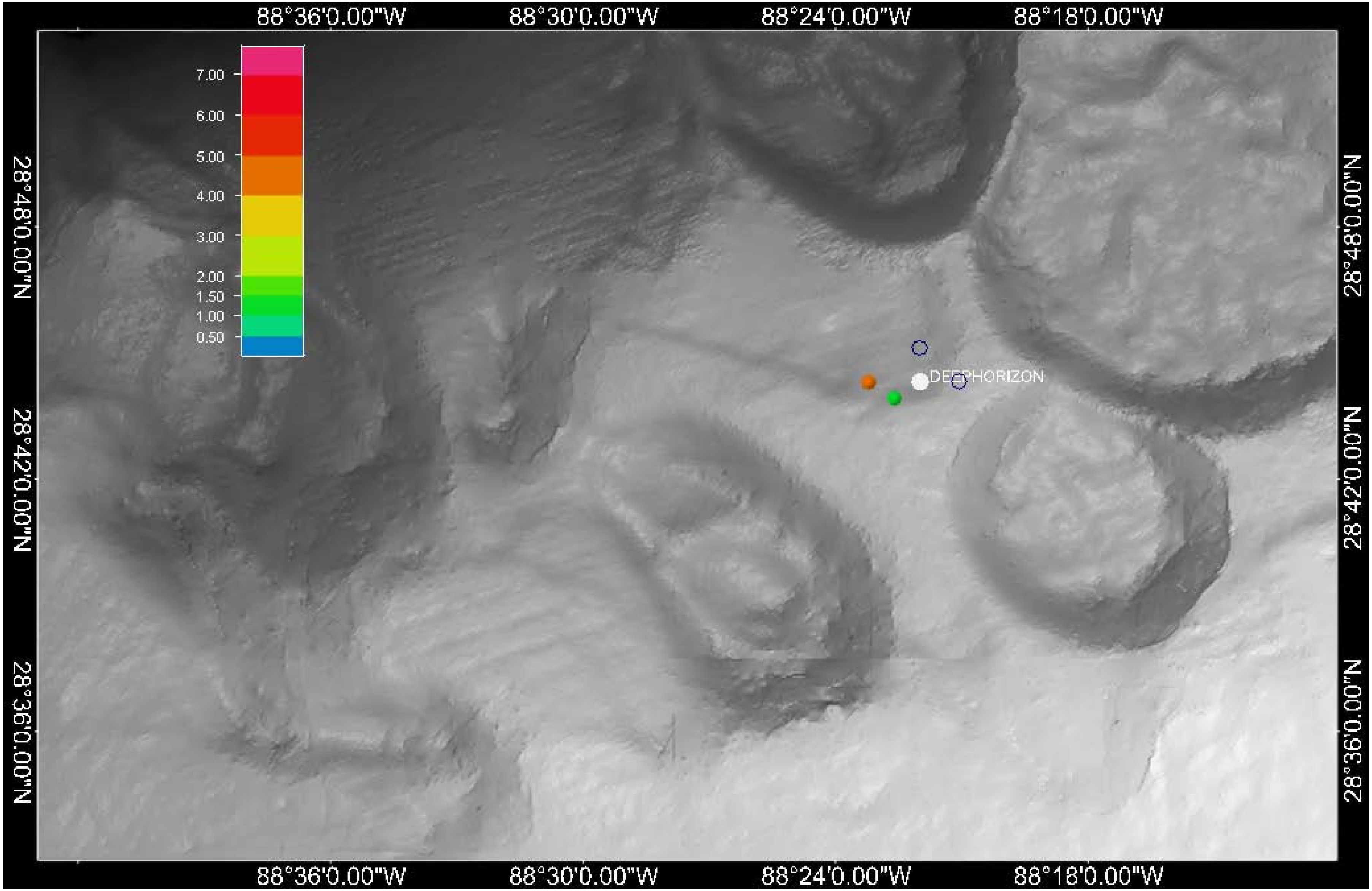


Figure E33: Mean Fluorescence ppb (QSDE) between 1000and 1300 m on 23 May 2010

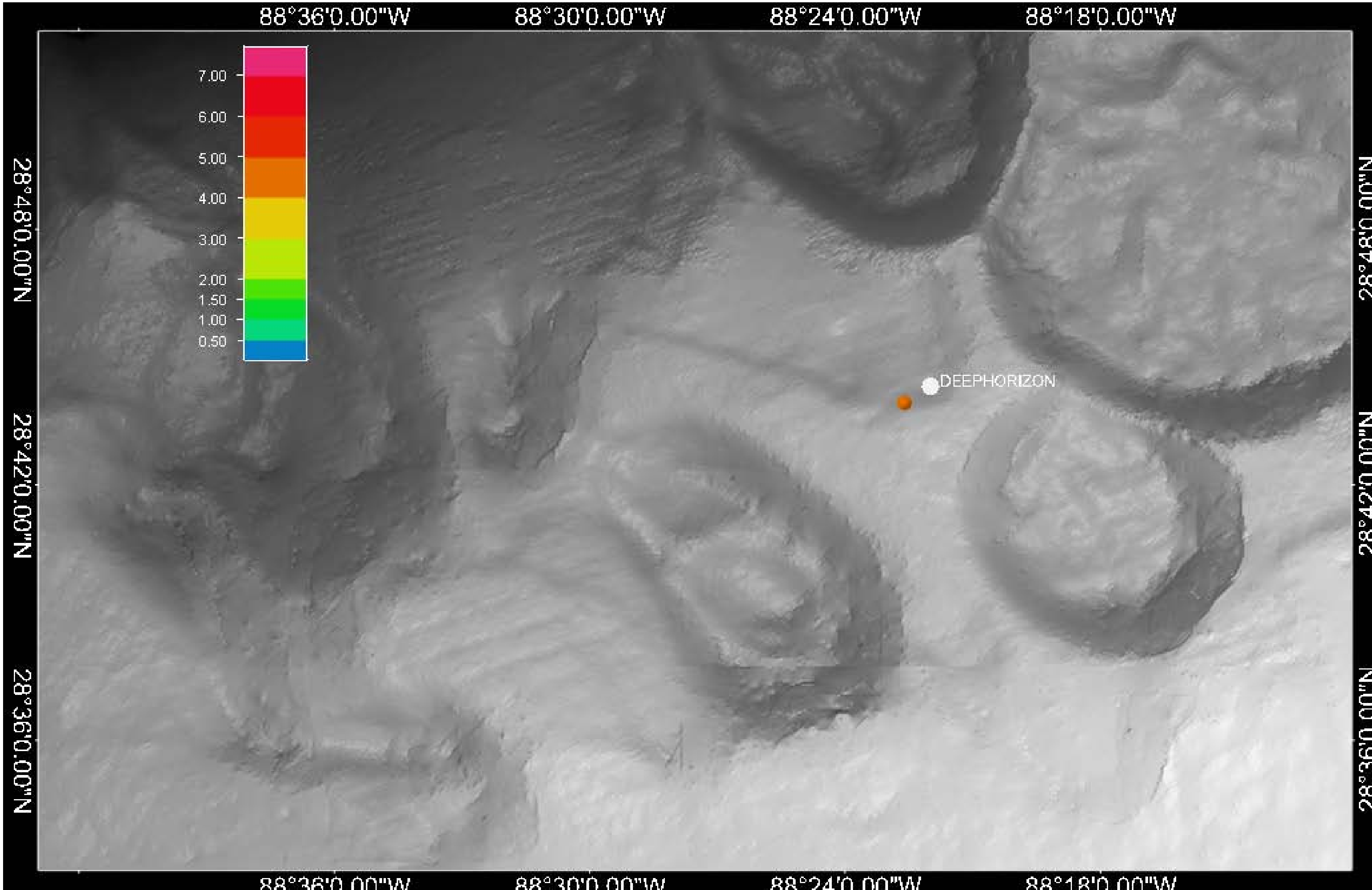


Figure E34: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 24 May 2010

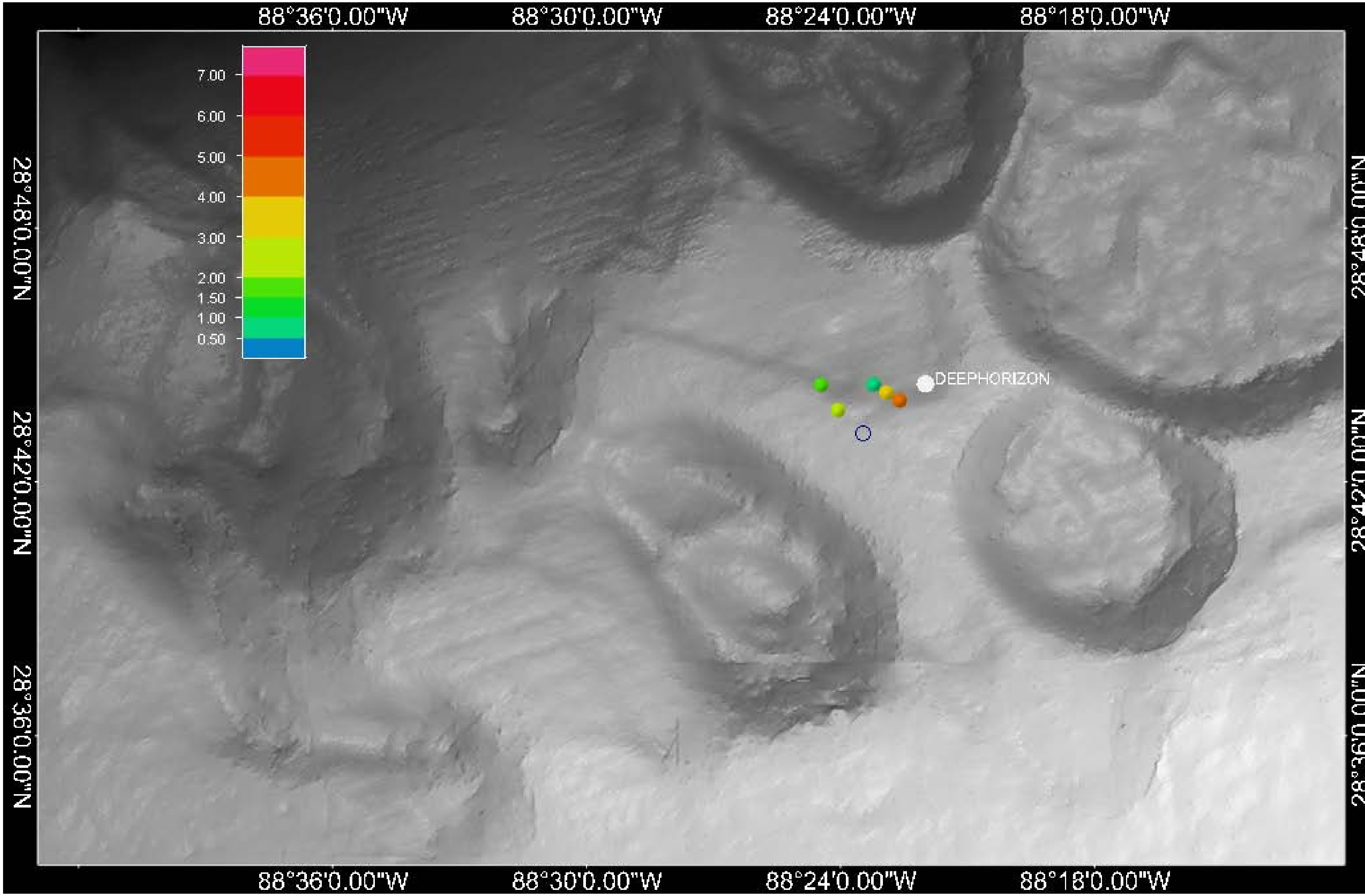


Figure E35: Mean Fluorescence ppb (QSDE) between 1000 and1300 m on 25 May 2010

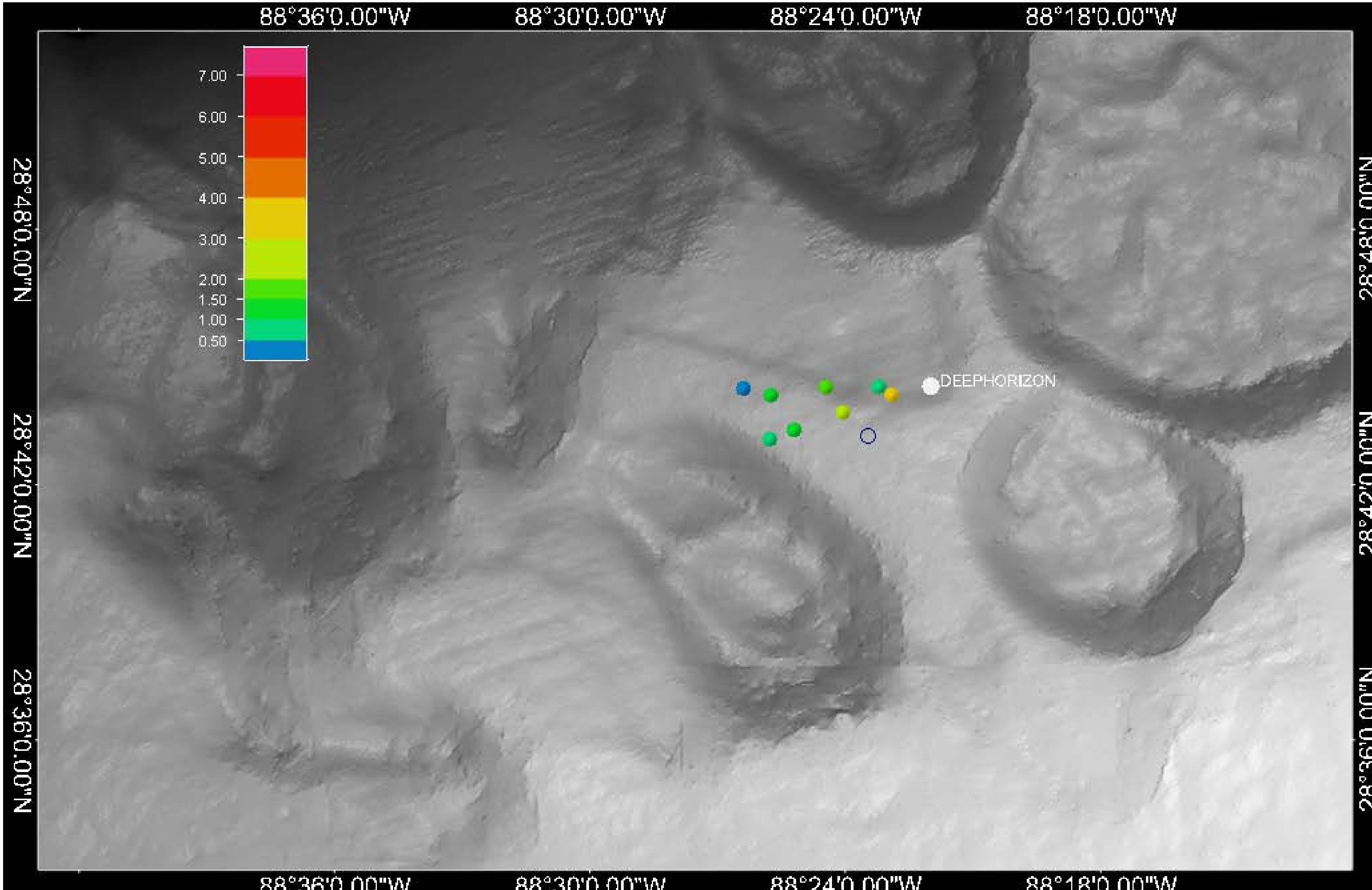


Figure E36: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 26 May 2010

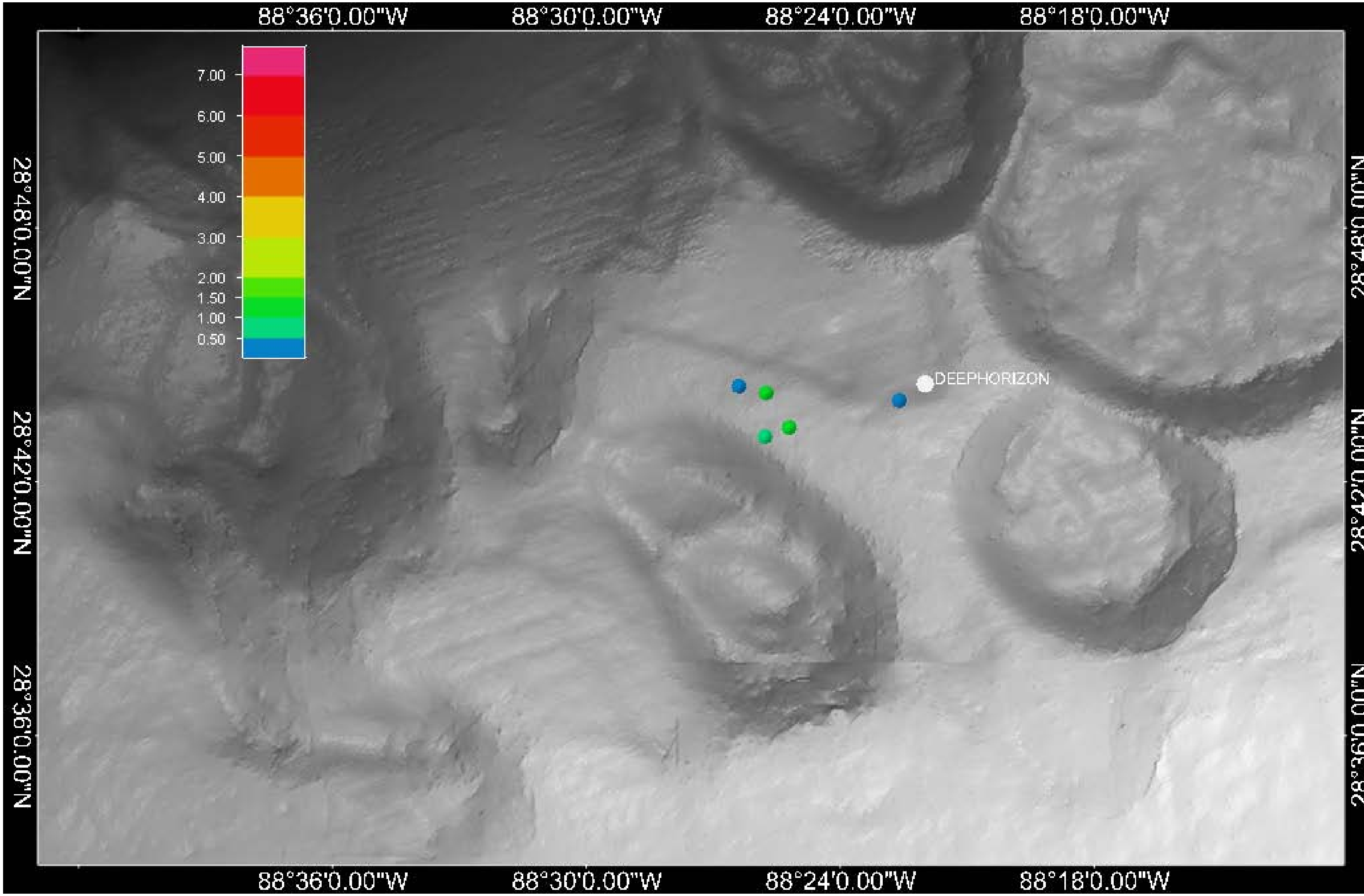


Figure E37: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 27 May 2010

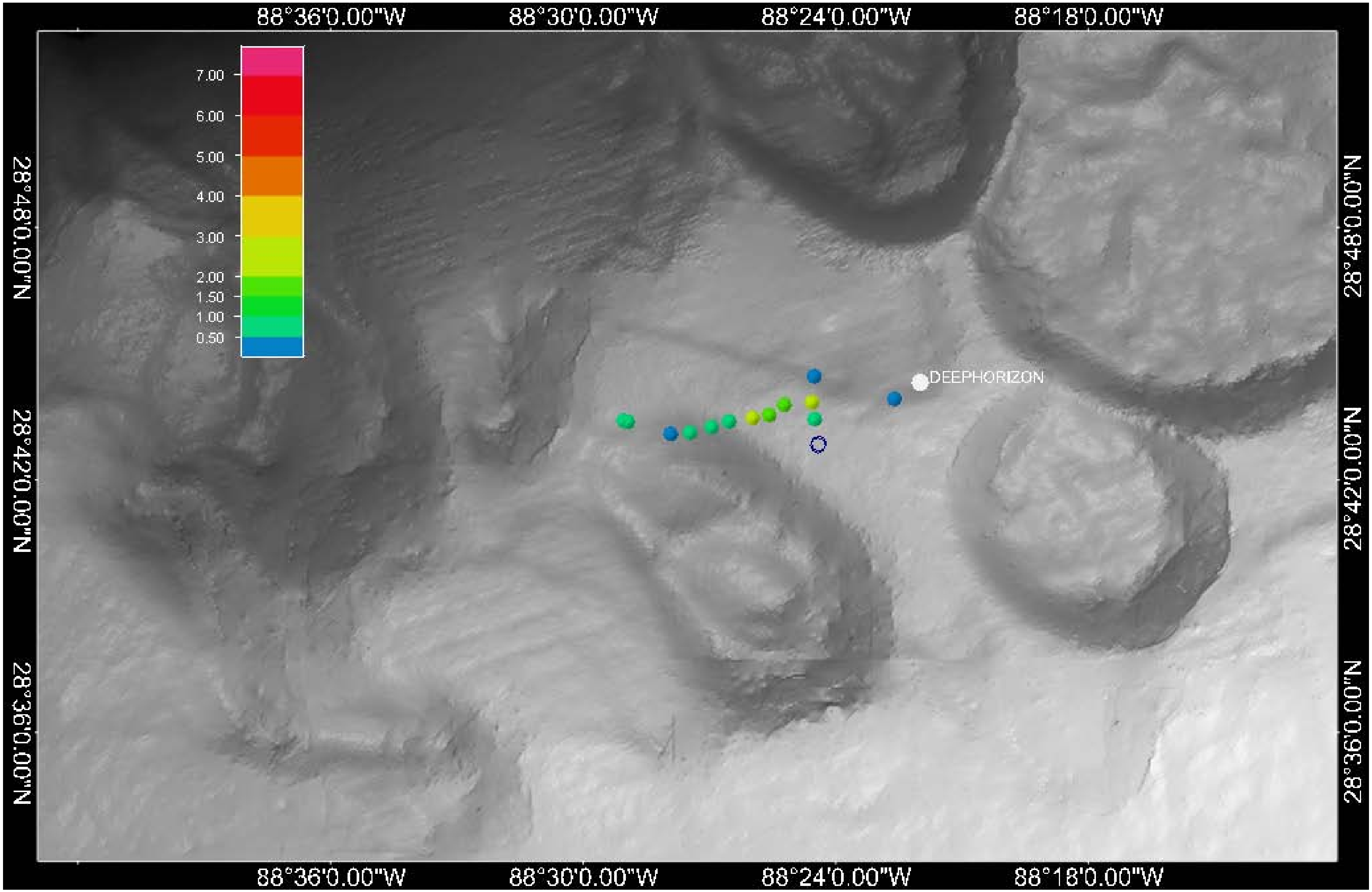


Figure E38: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 28 May 2010

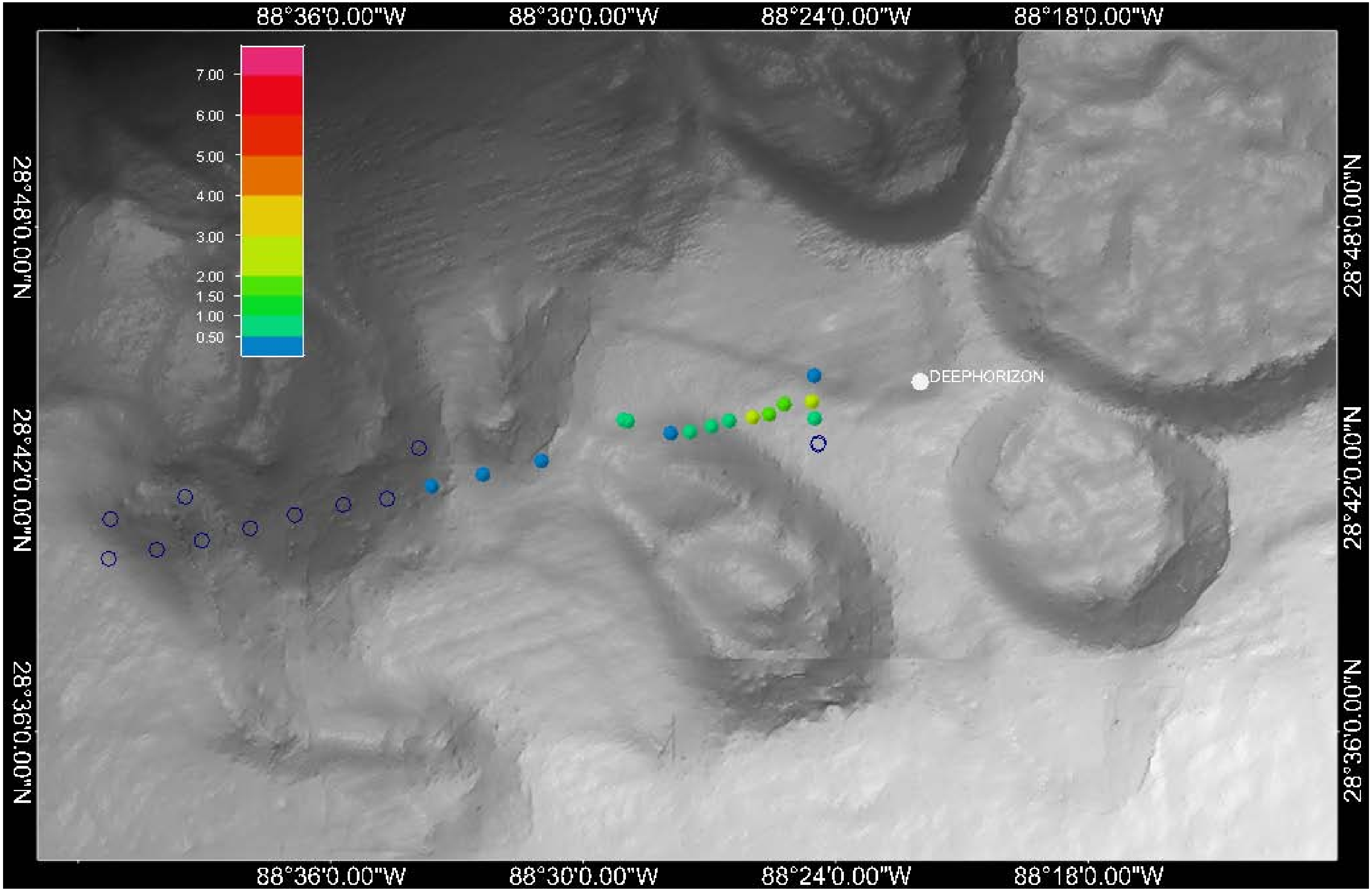


Figure E39: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 29 May 2010

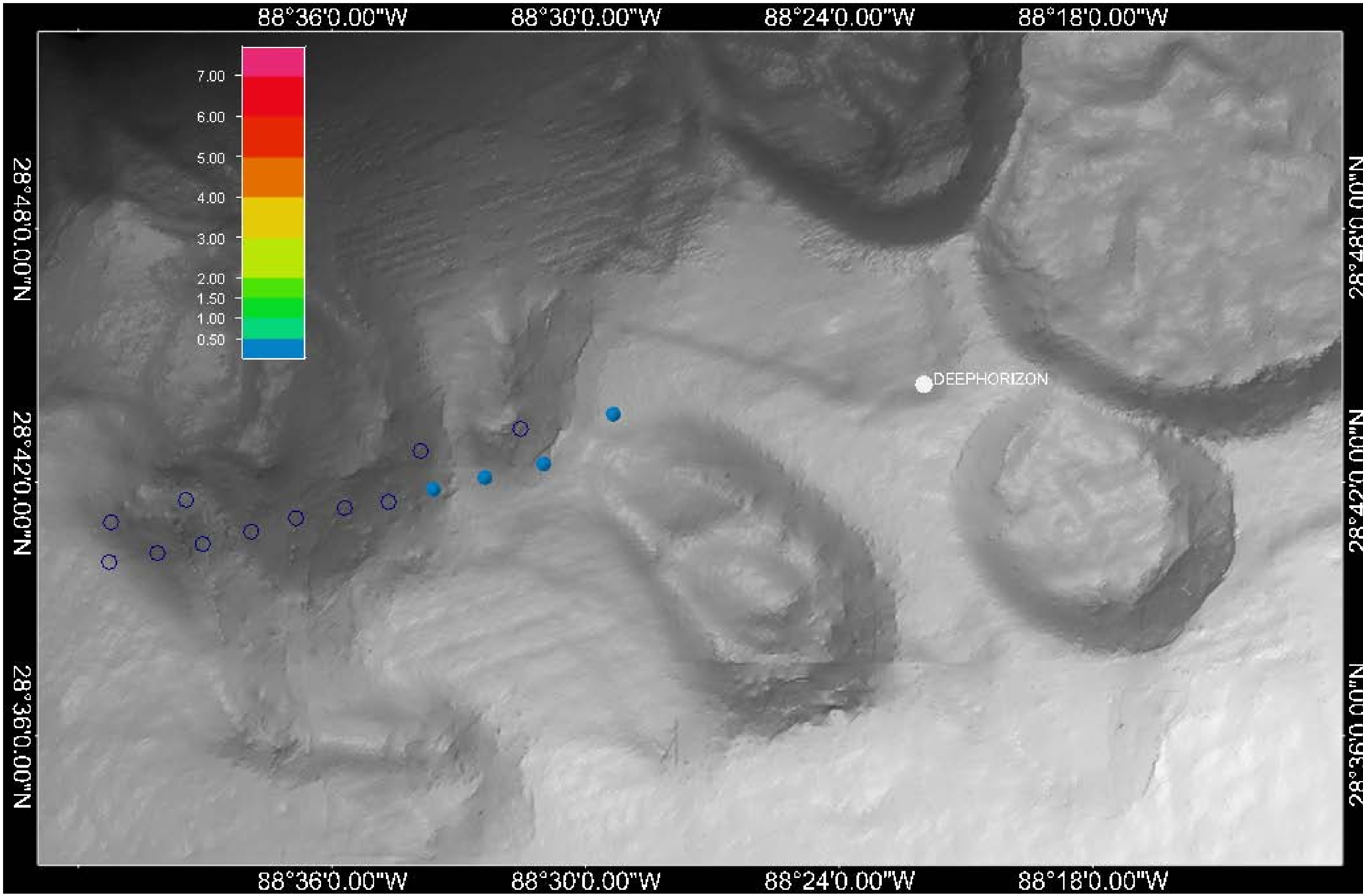


Figure E40: Mean Fluorescence ppb (QSDE), between 1000 and 1300 m on 30 May 2010

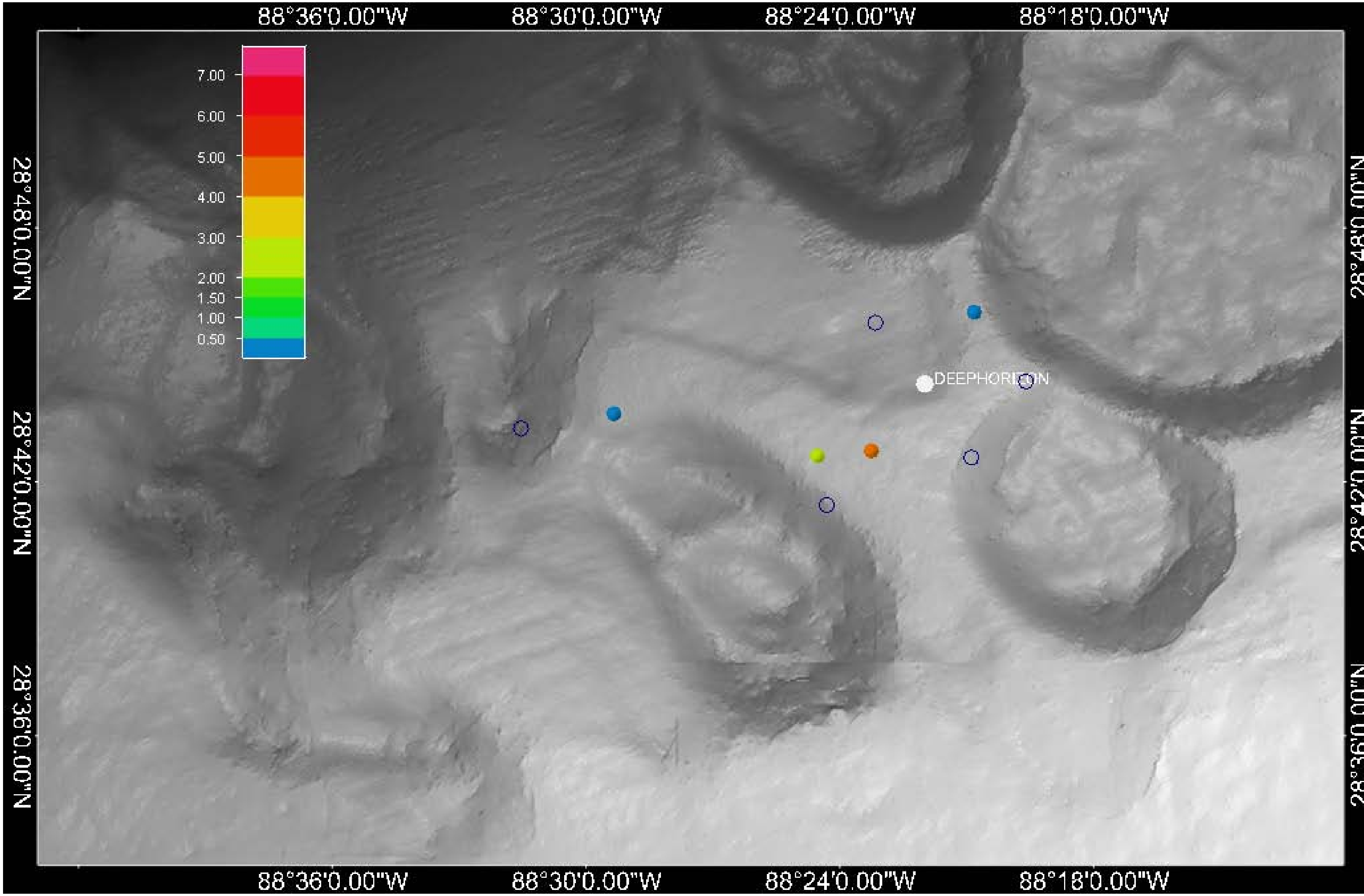


Figure E41: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 31 May 2010

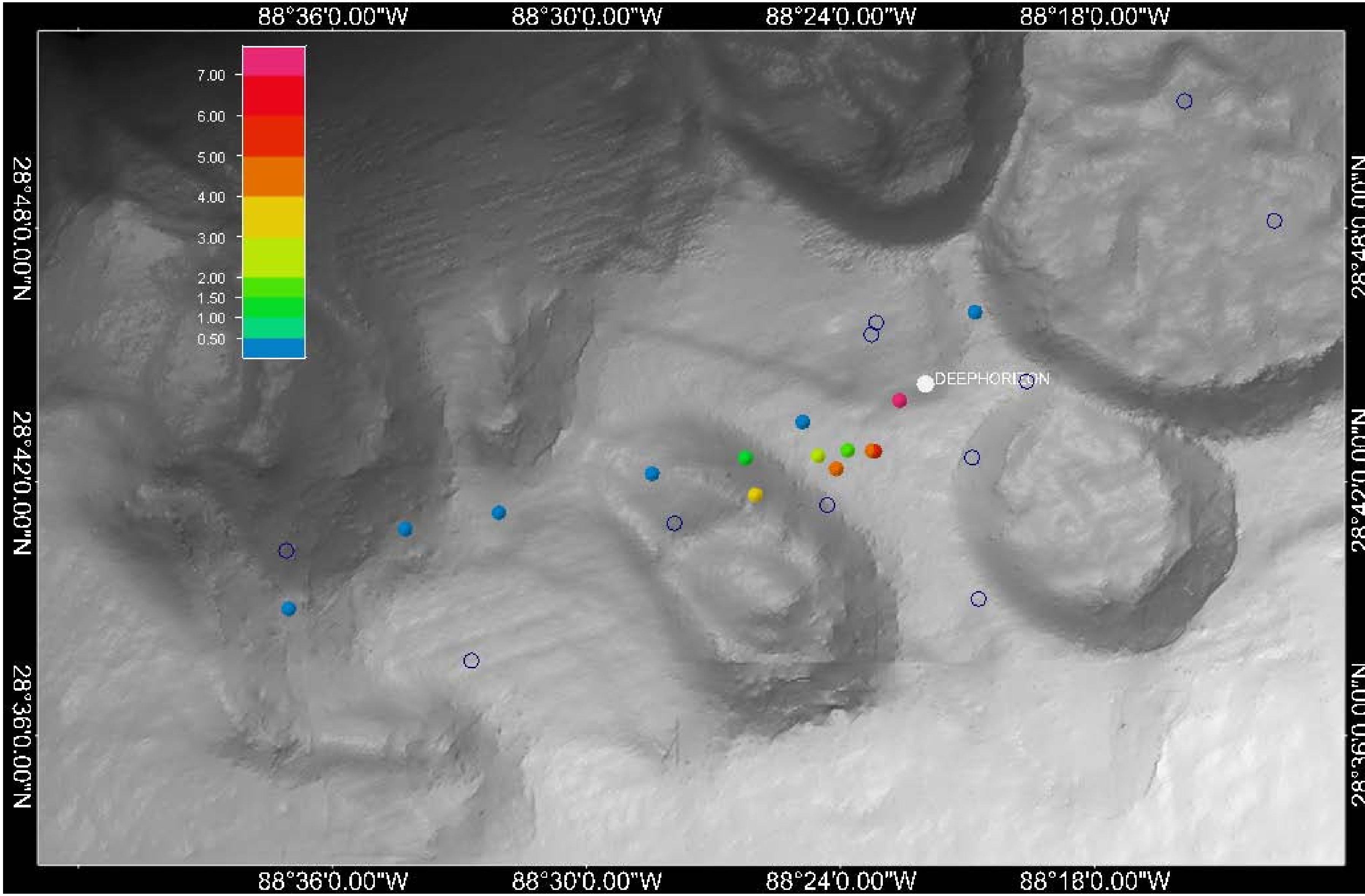


Figure E42: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 01 June 2010

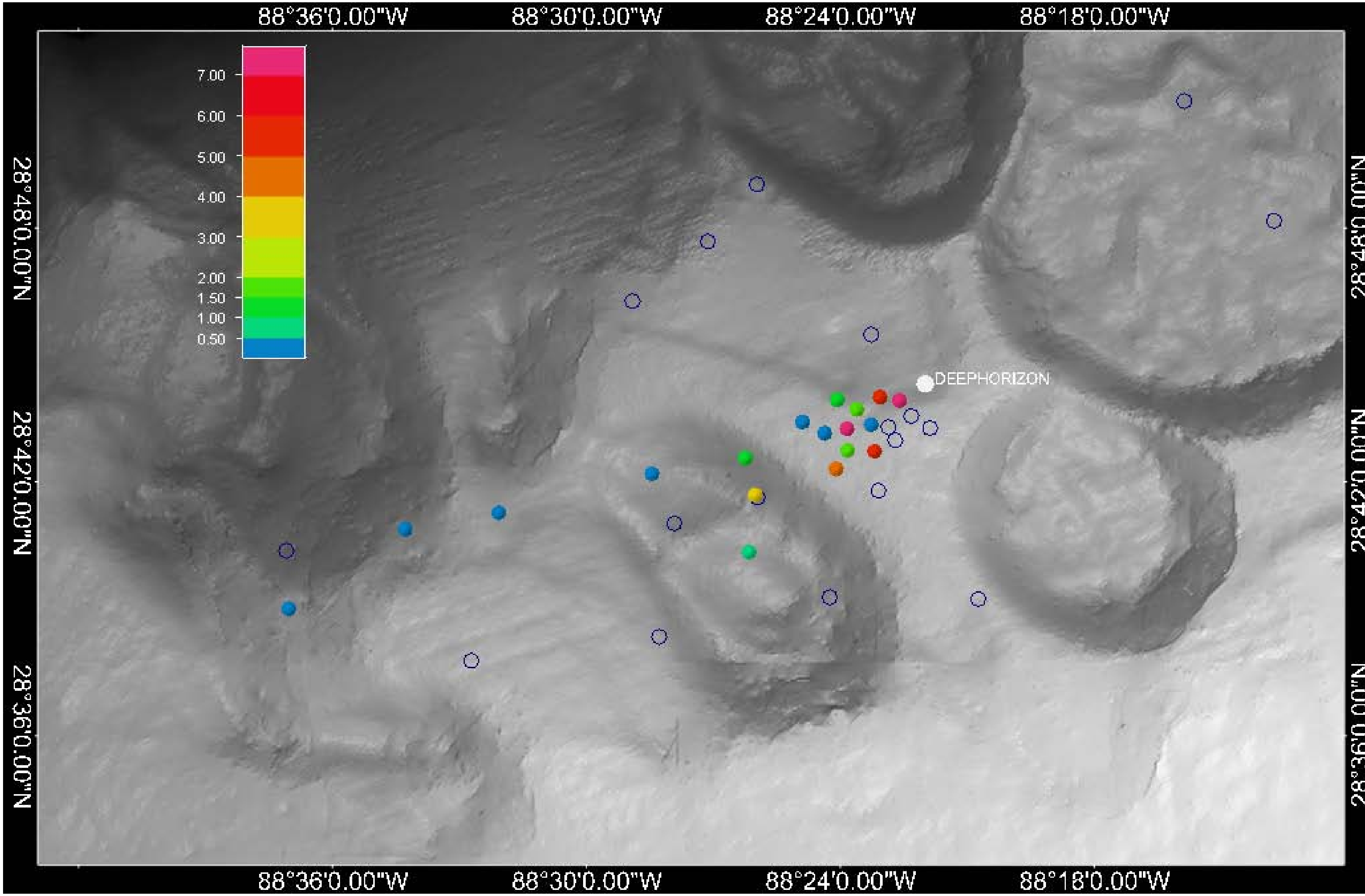


Figure E43: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 02 June 2010

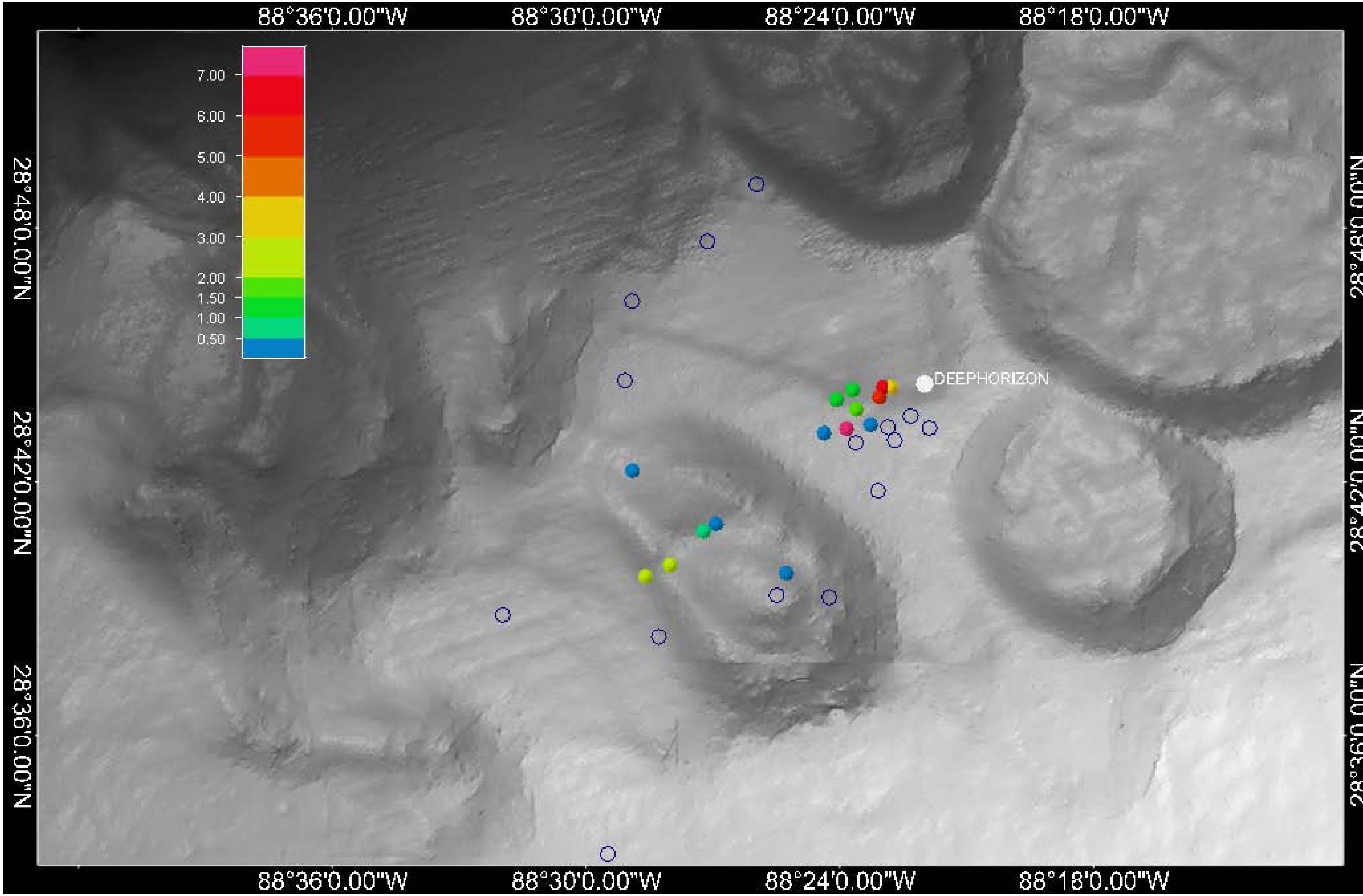


Figure E44: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 03 June 2010

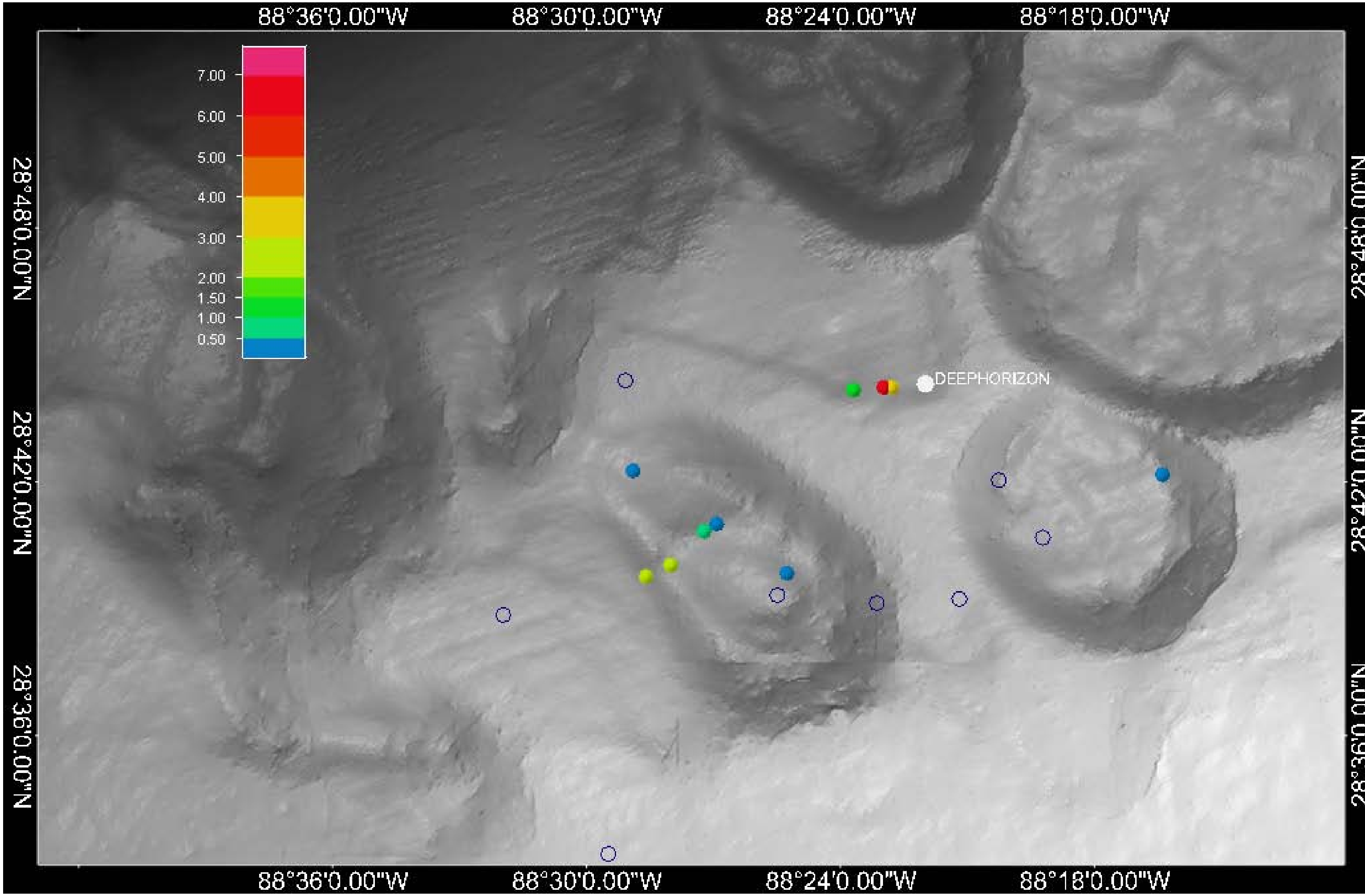


Figure E45: Mean Fluorescence ppb (QSDE) between 100 and 1300 m on 04 June 2010

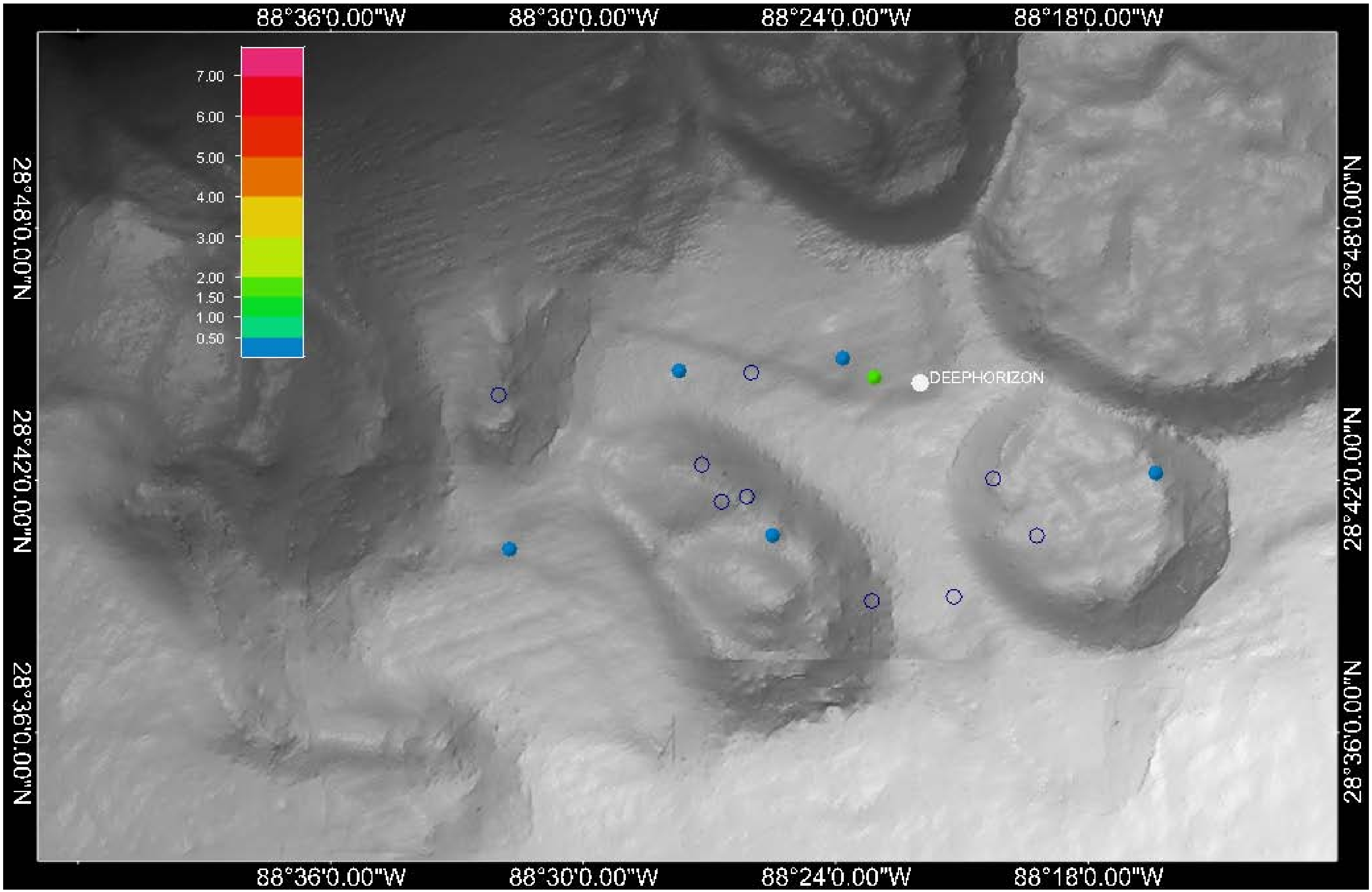


Figure E46: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 05 June 2010

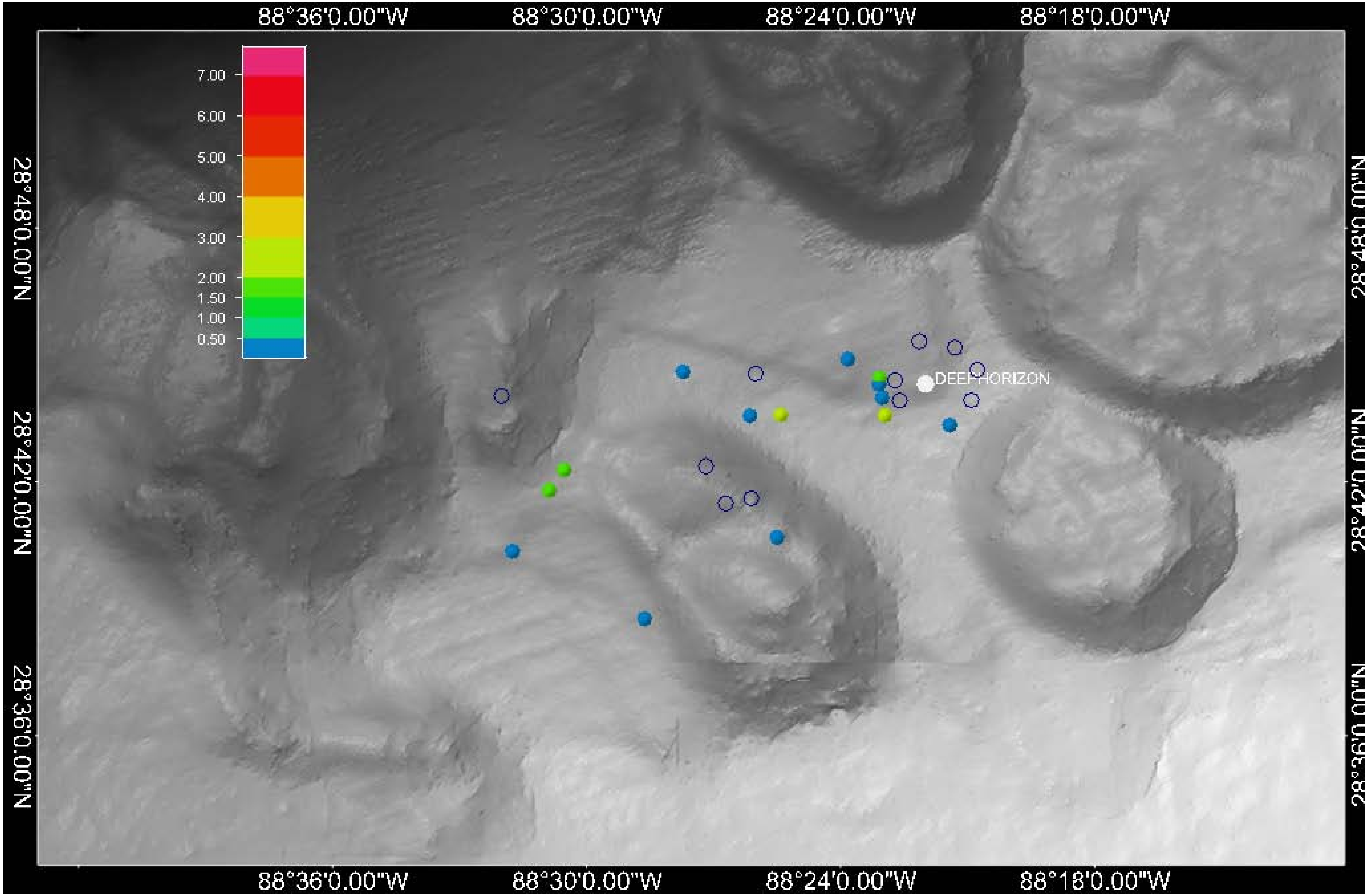


Figure E47: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 06 June 2010

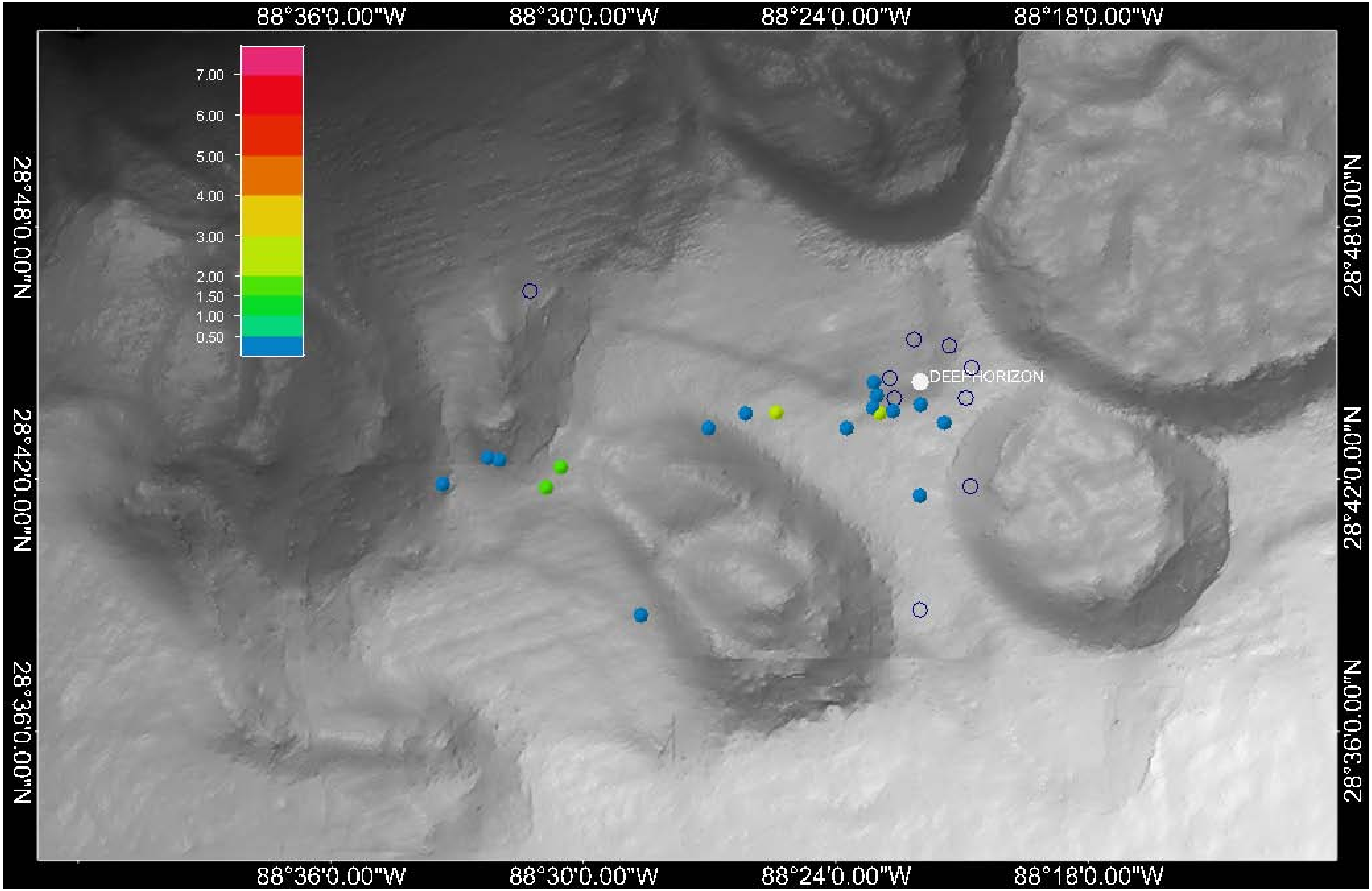


Figure E48: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 07 June 2010

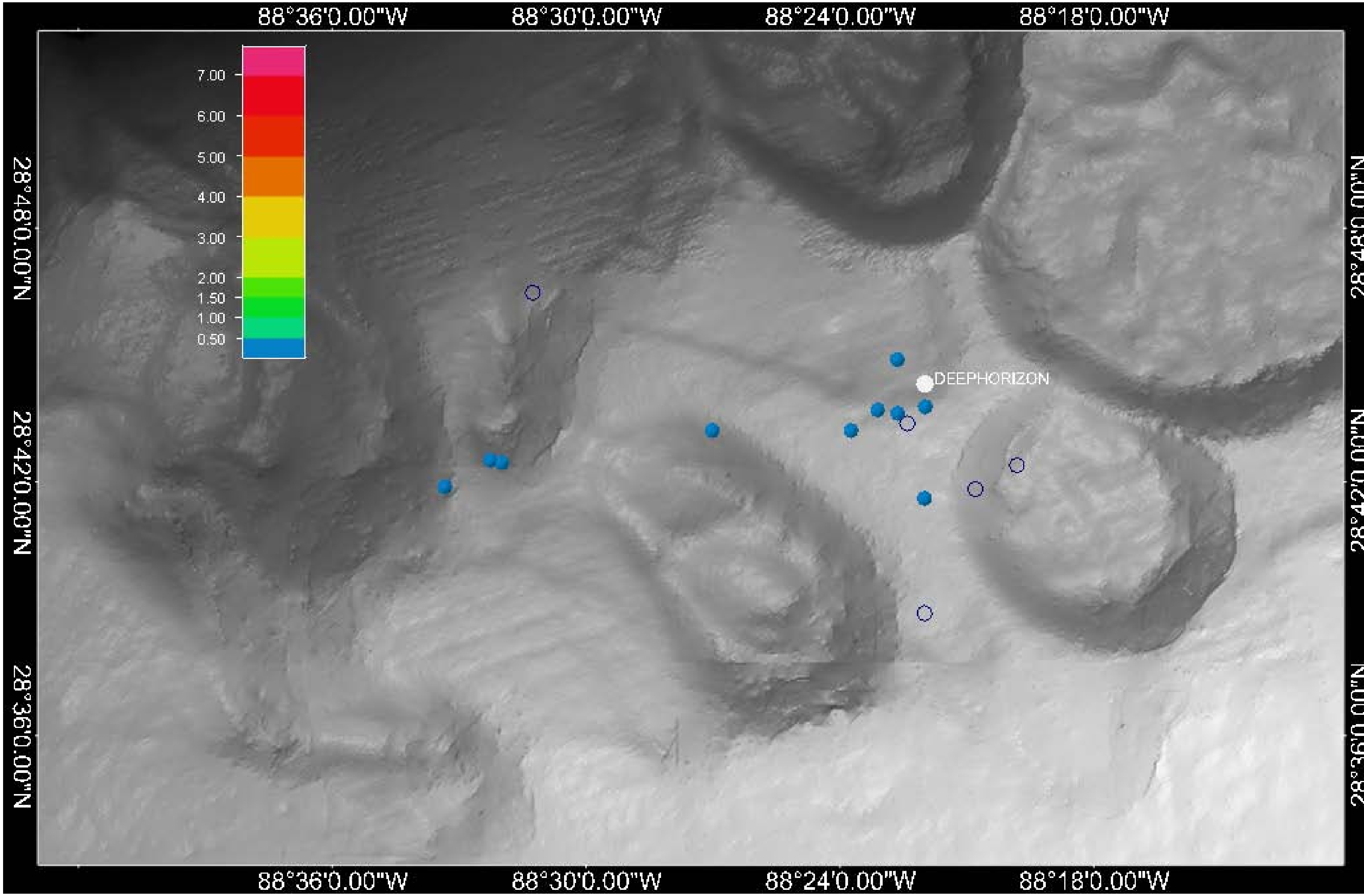


Figure E49: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 08 June 2010

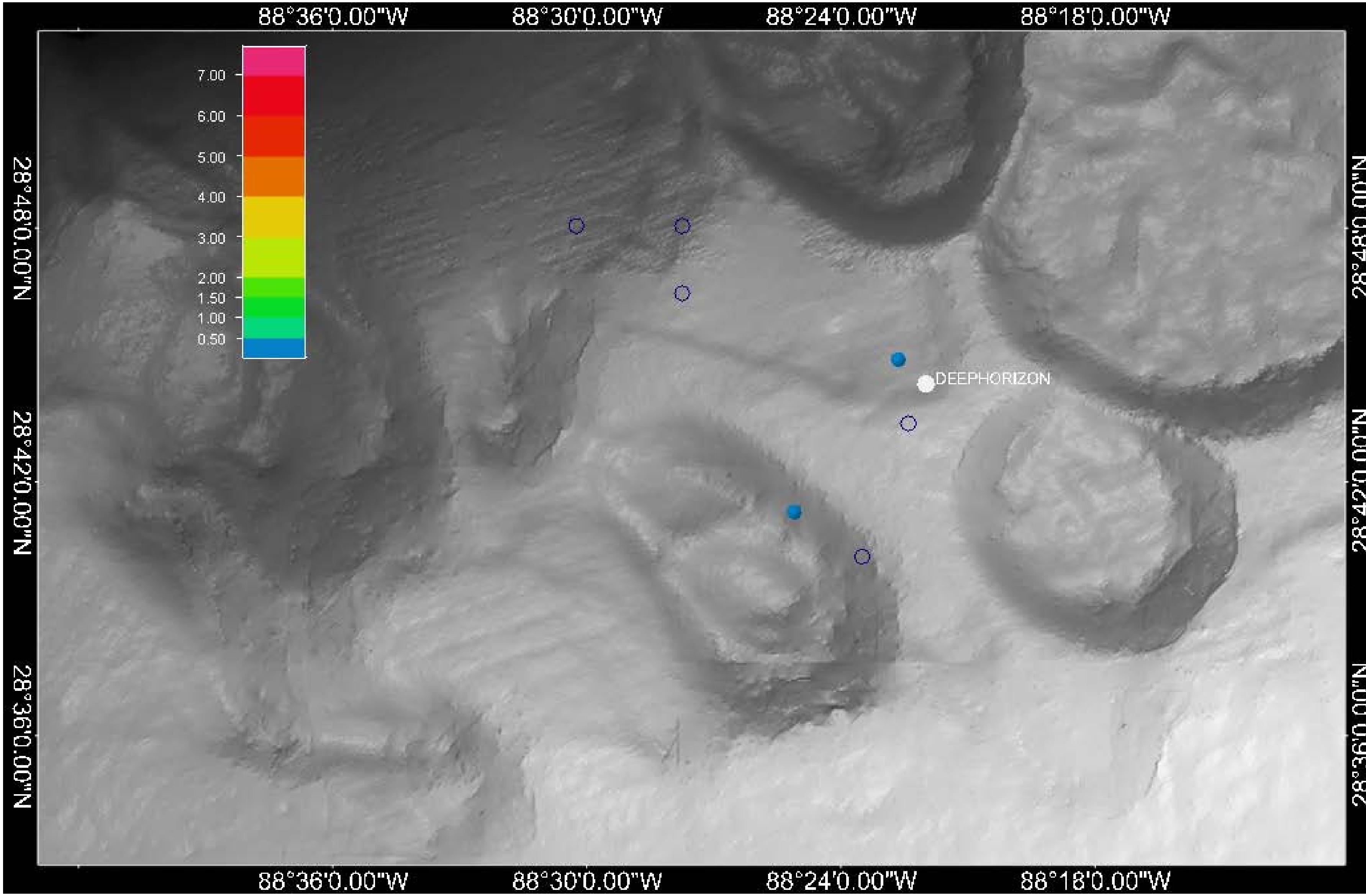


Figure E50: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 09 June 2010

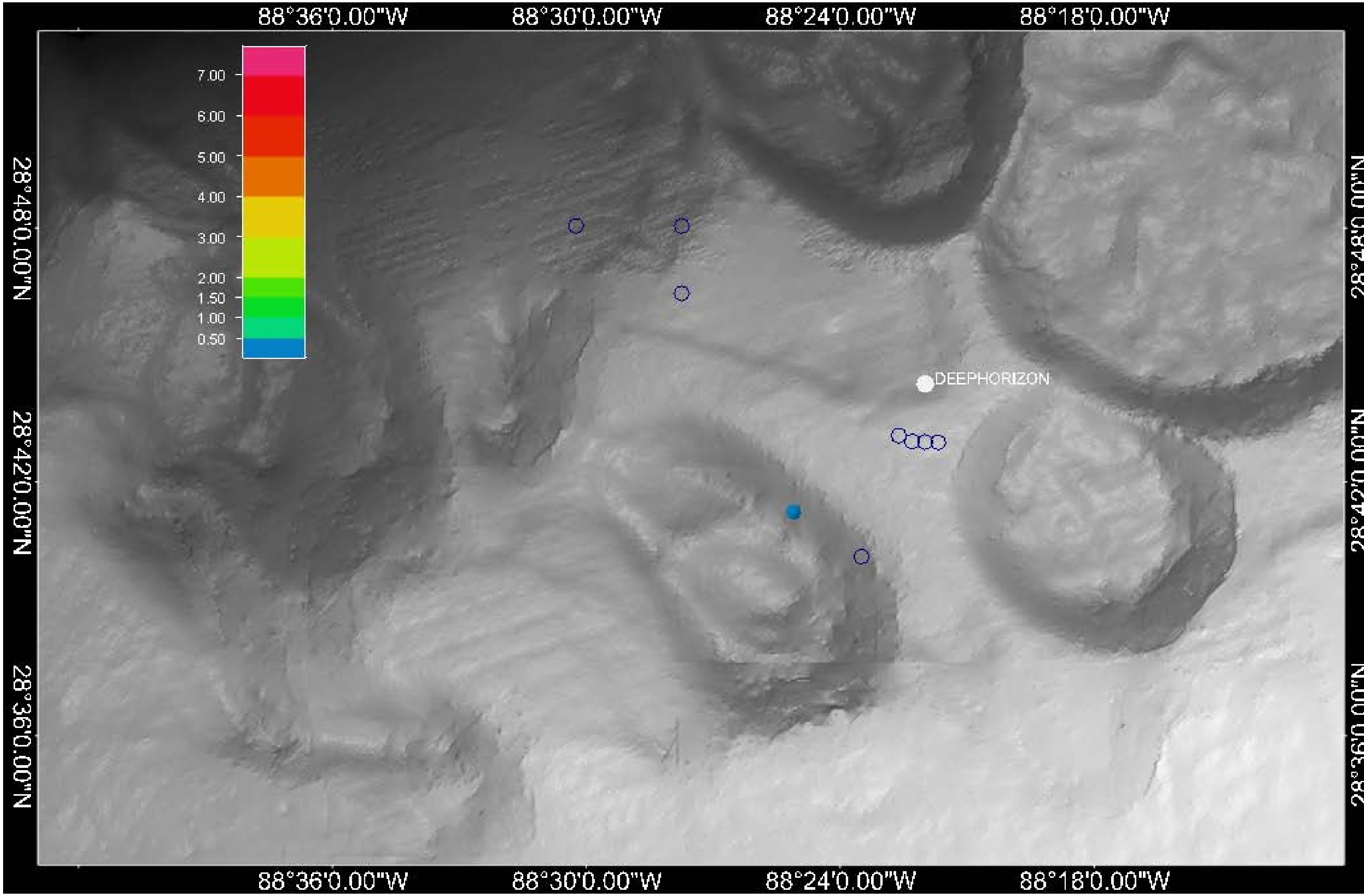


Figure E51: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 10 June 2010

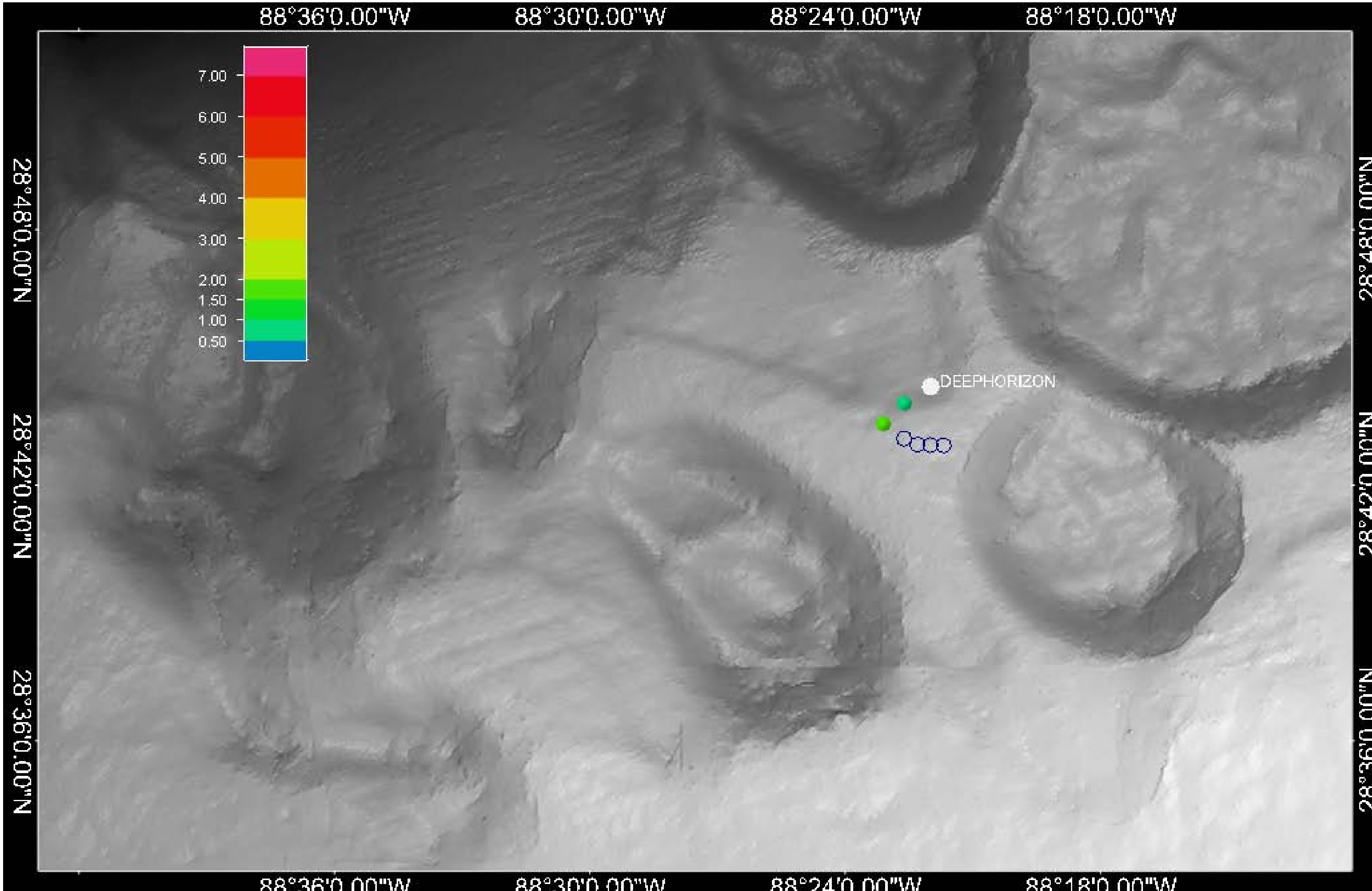


Figure E52: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 11 June 2010

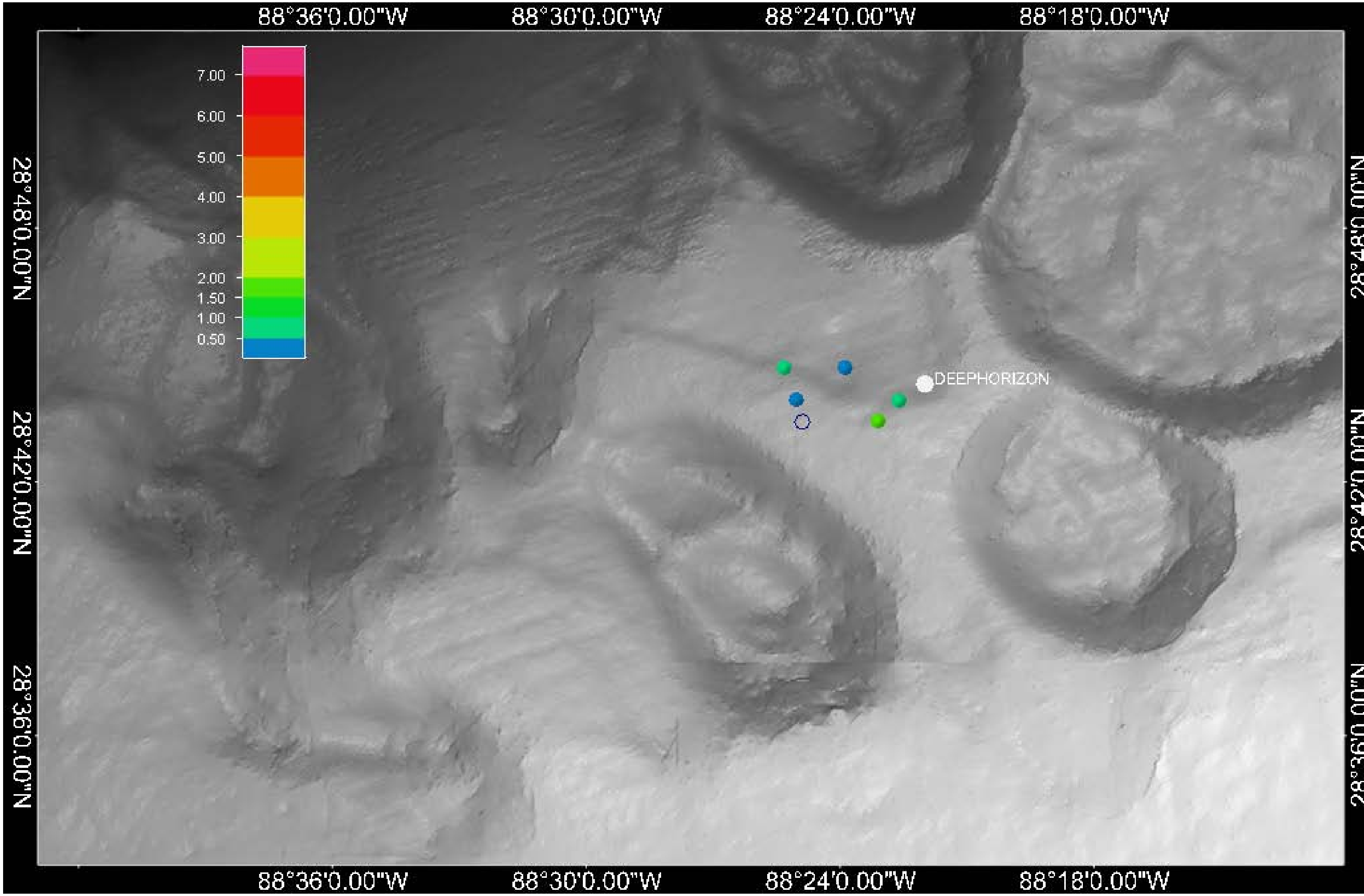


Figure E53: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 12 June 2010

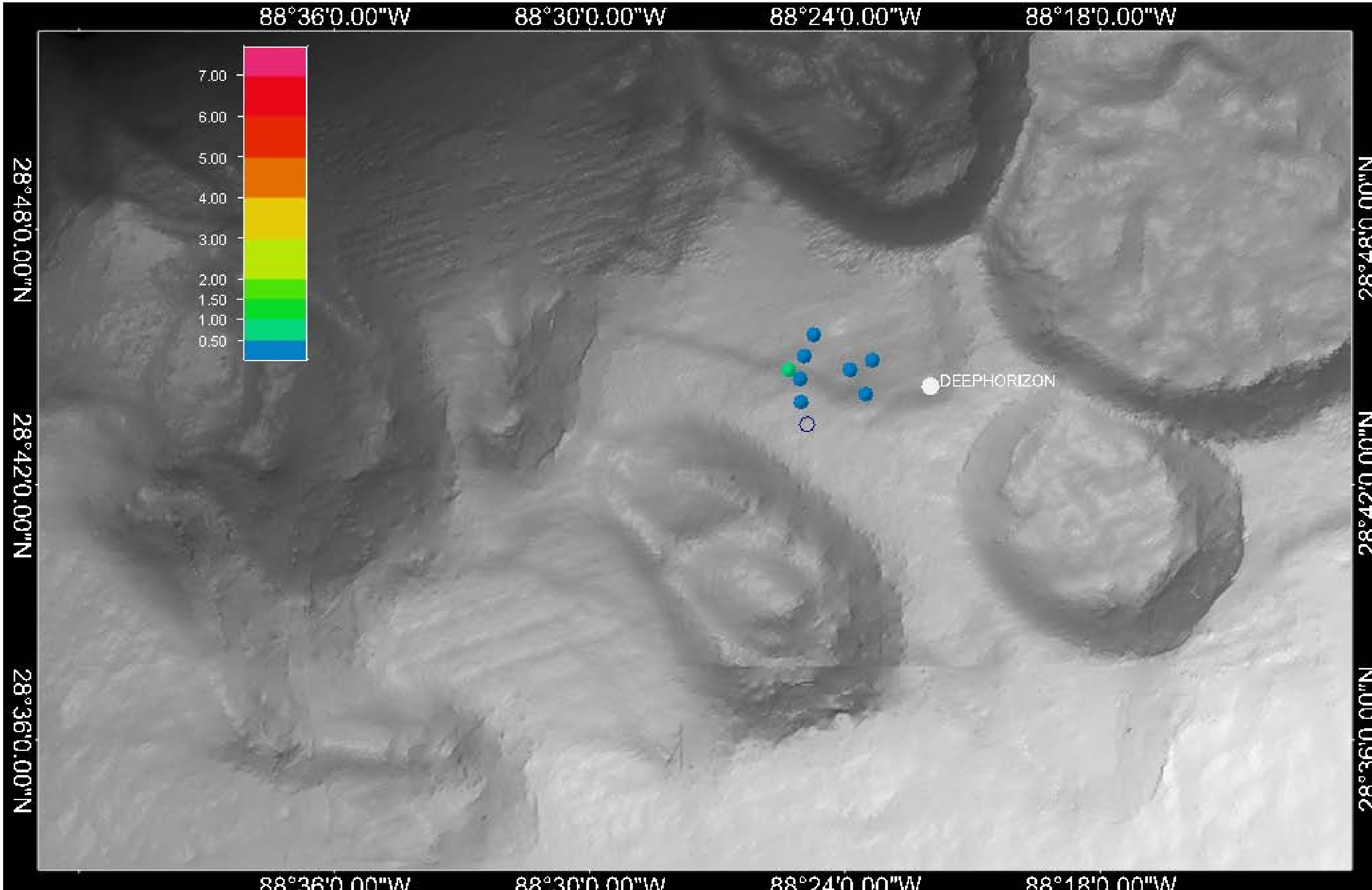


Figure E54: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 13 June 2010

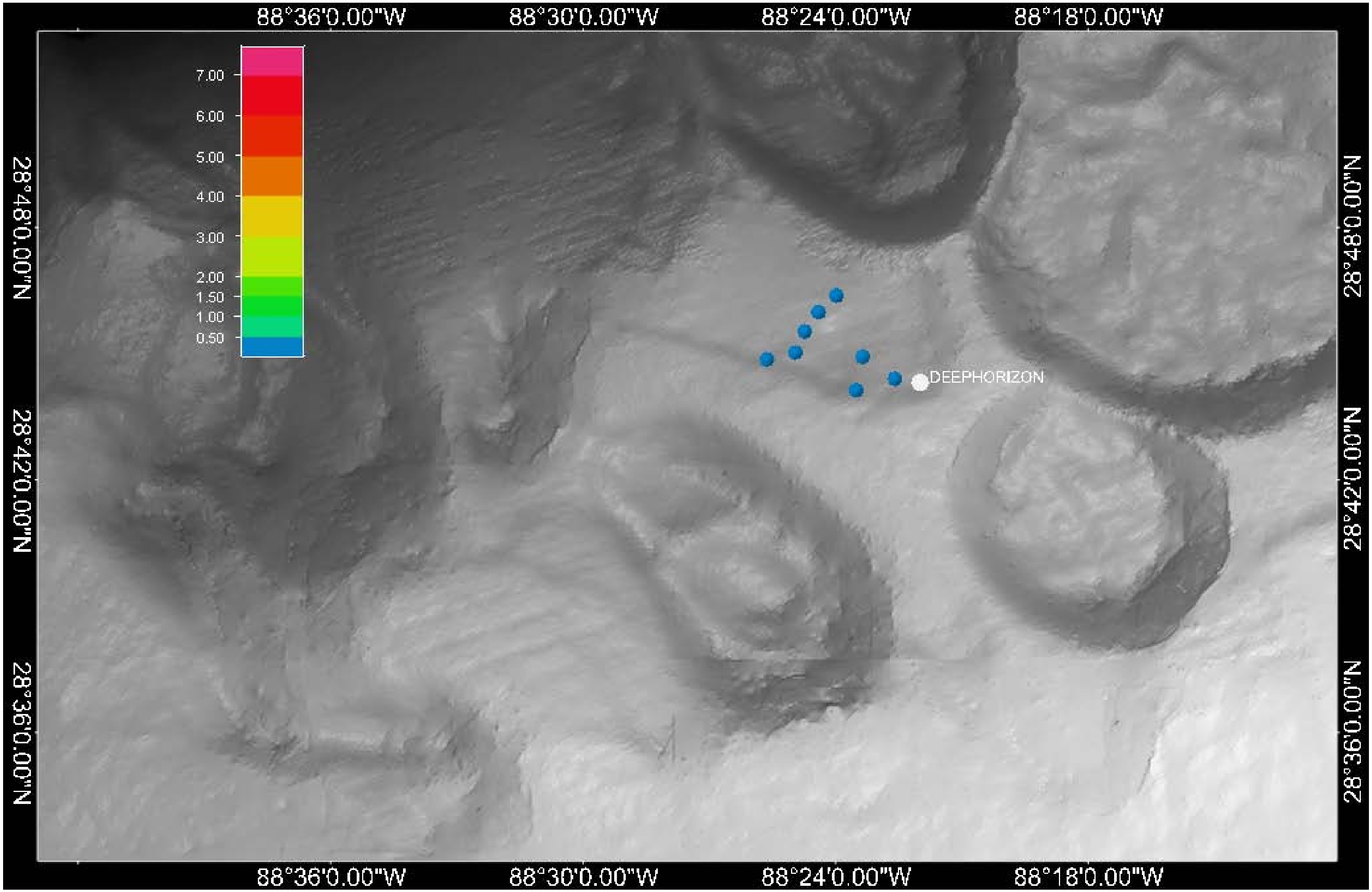


Figure E55: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 14 June 2010

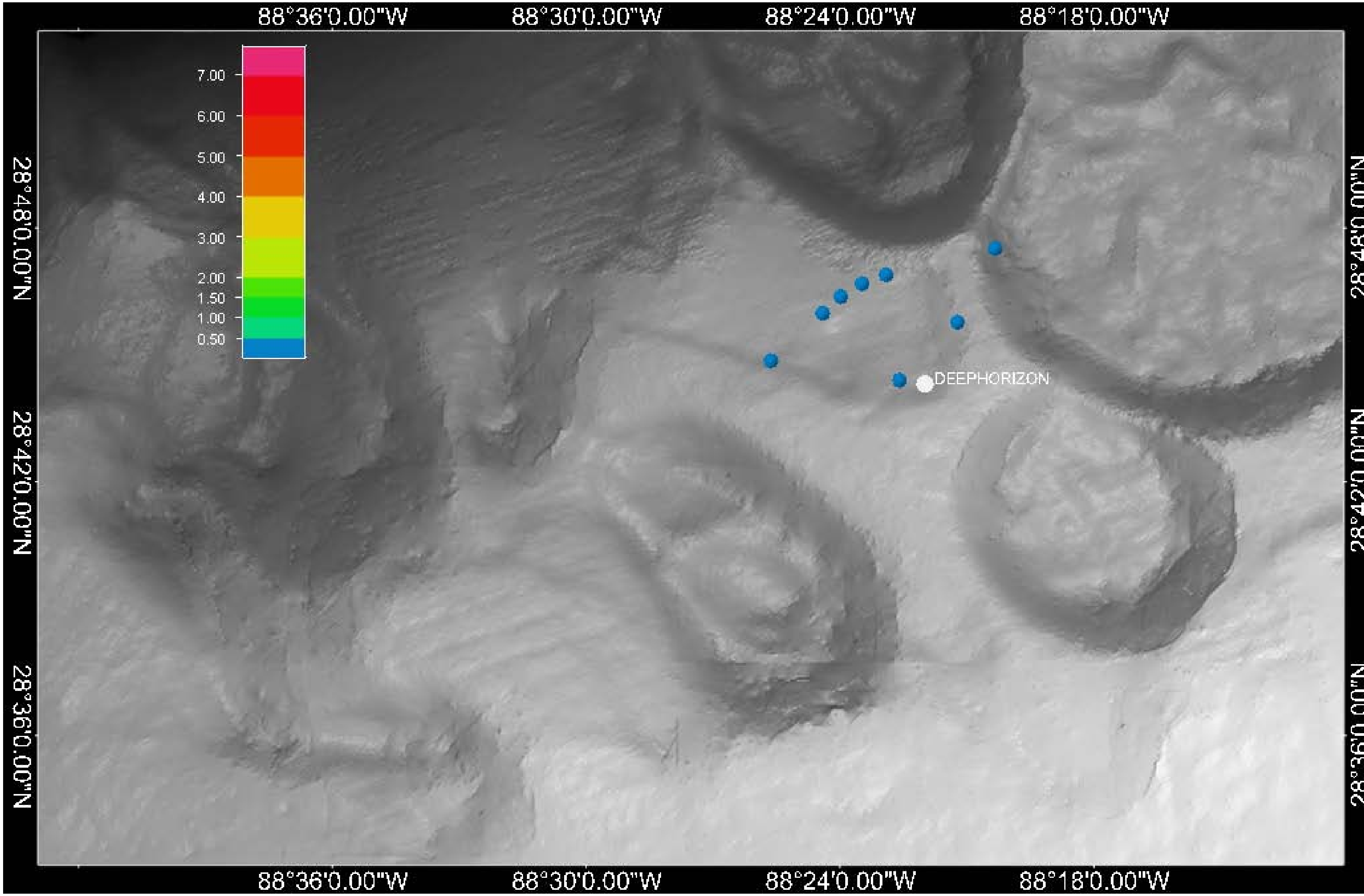


Figure E56: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 15 June 2010

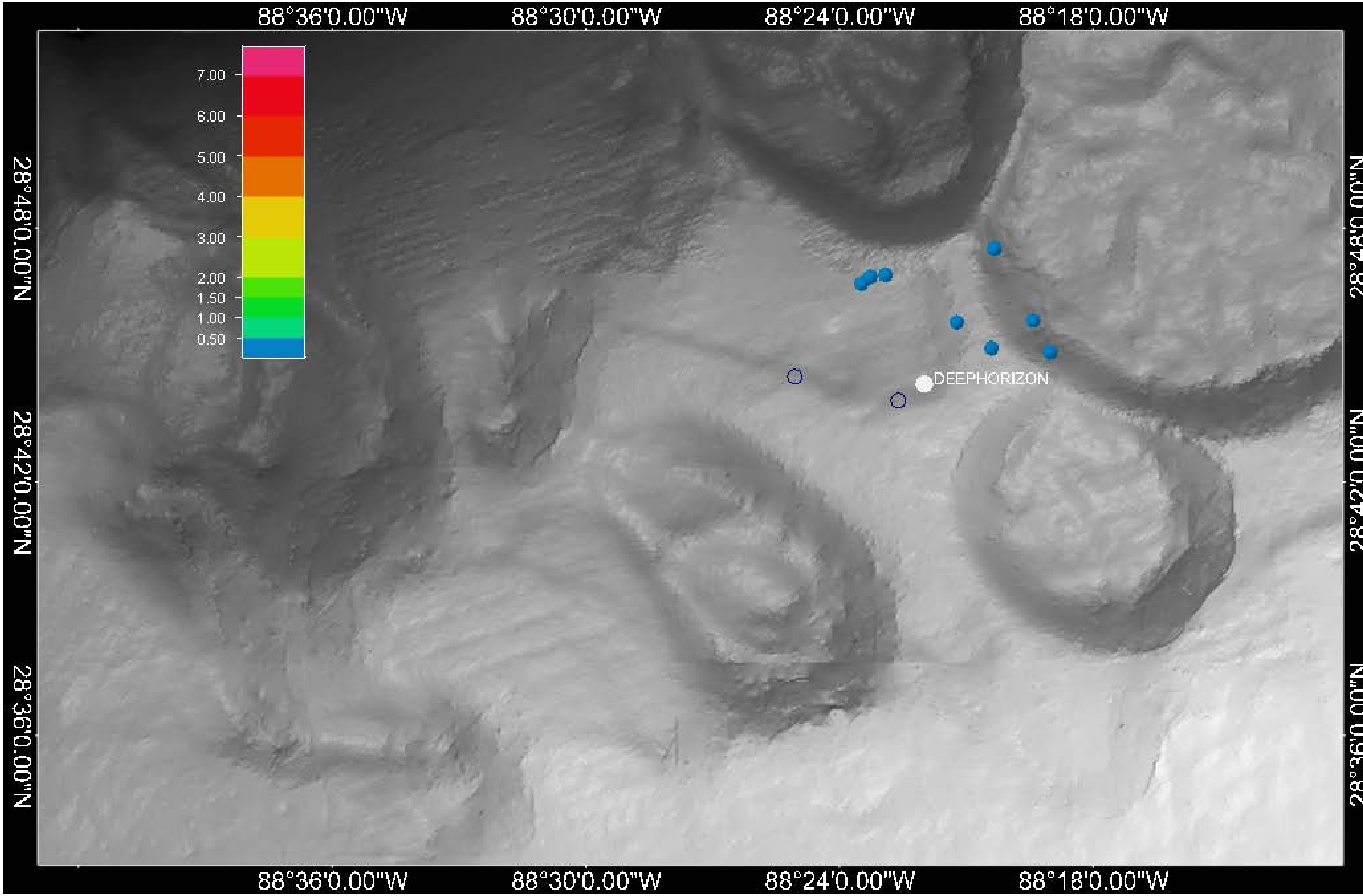


Figure E57: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 16 June 2010

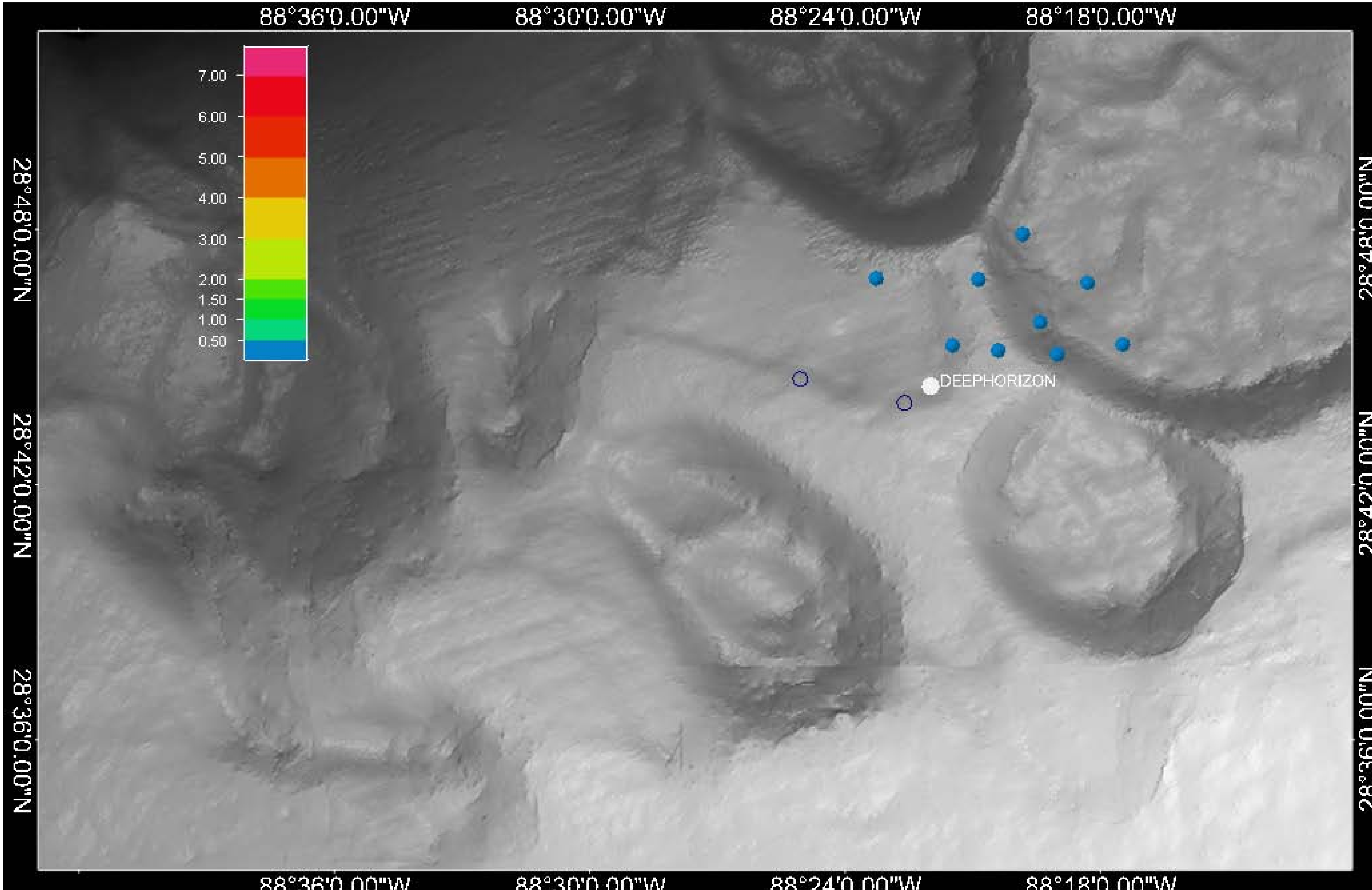


Figure E58: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 17 June 2010

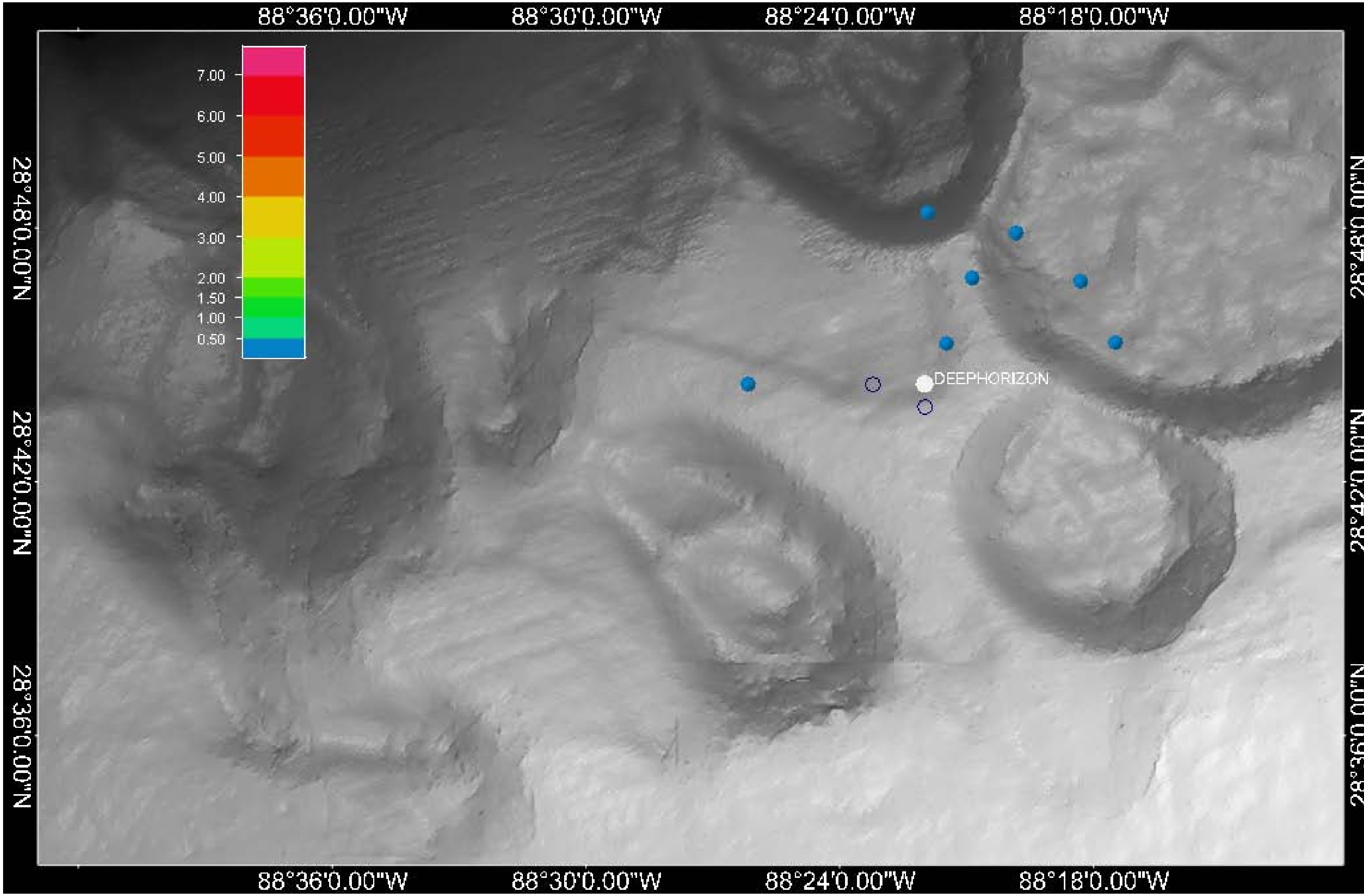


Figure E59: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 18 June 2010

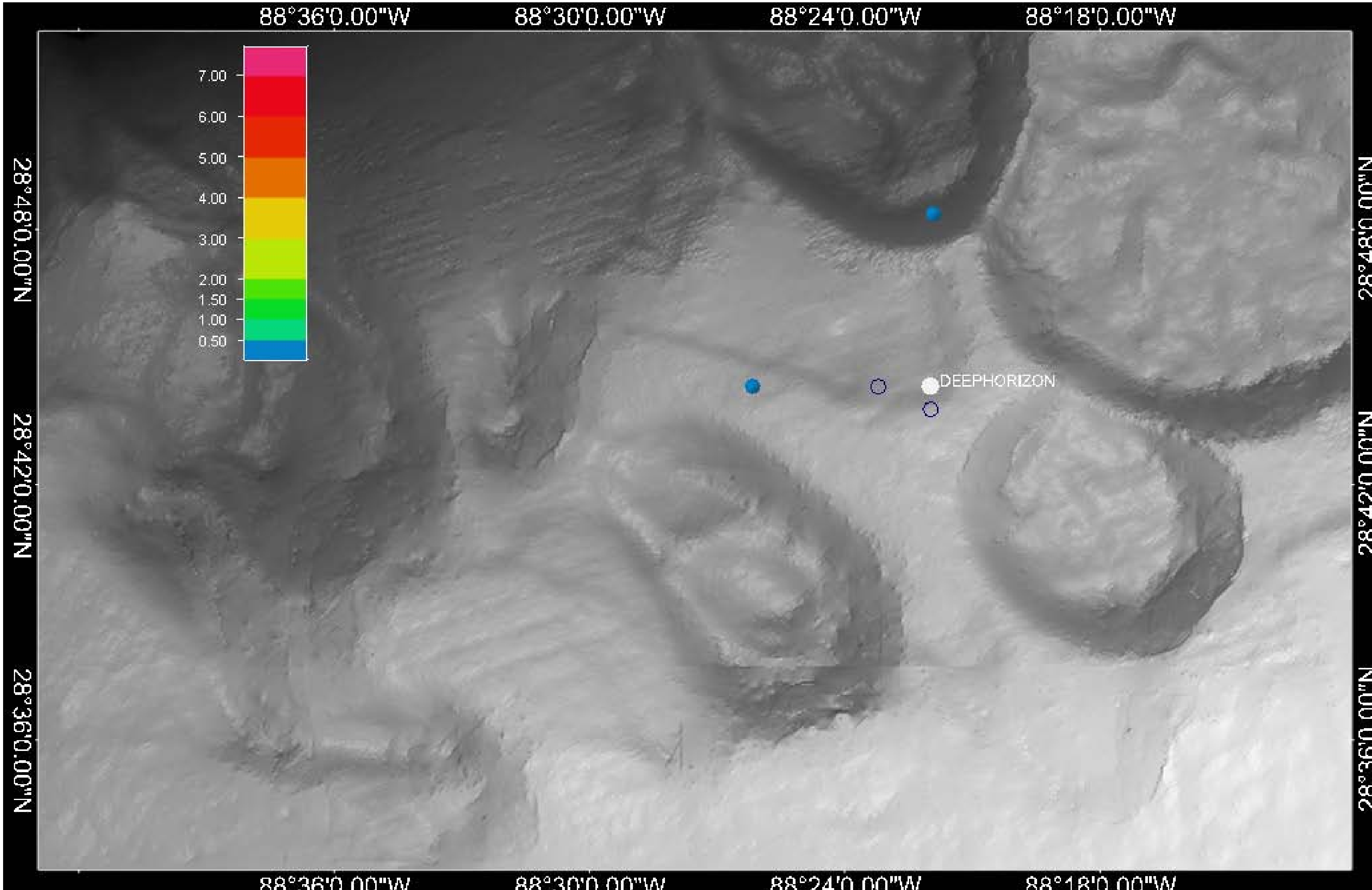


Figure E60: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 19 June 2010

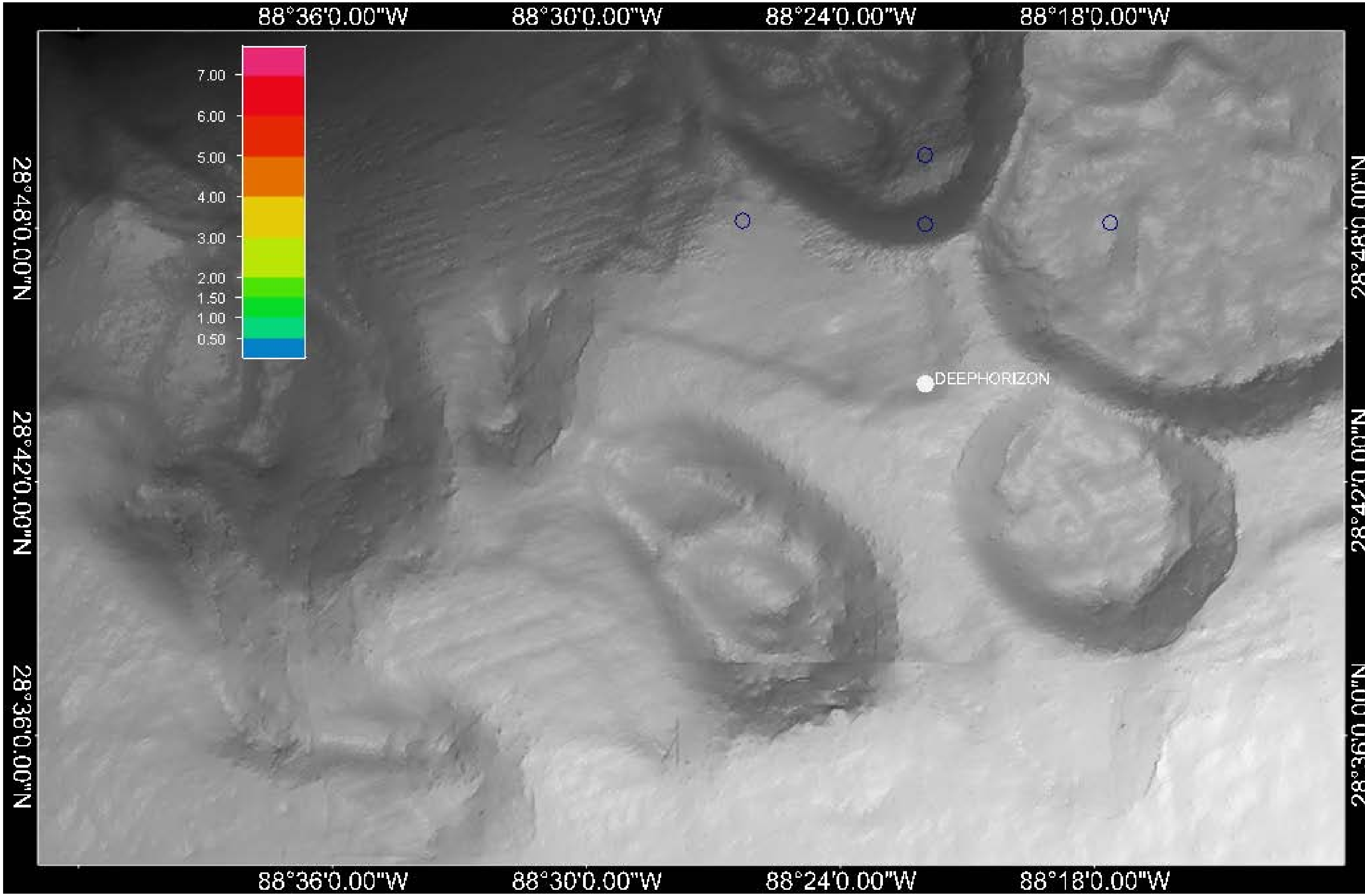


Figure E61: Mean Fluorescence ppb (QSDE) between 1000 and -1300 m on 20 June 2010

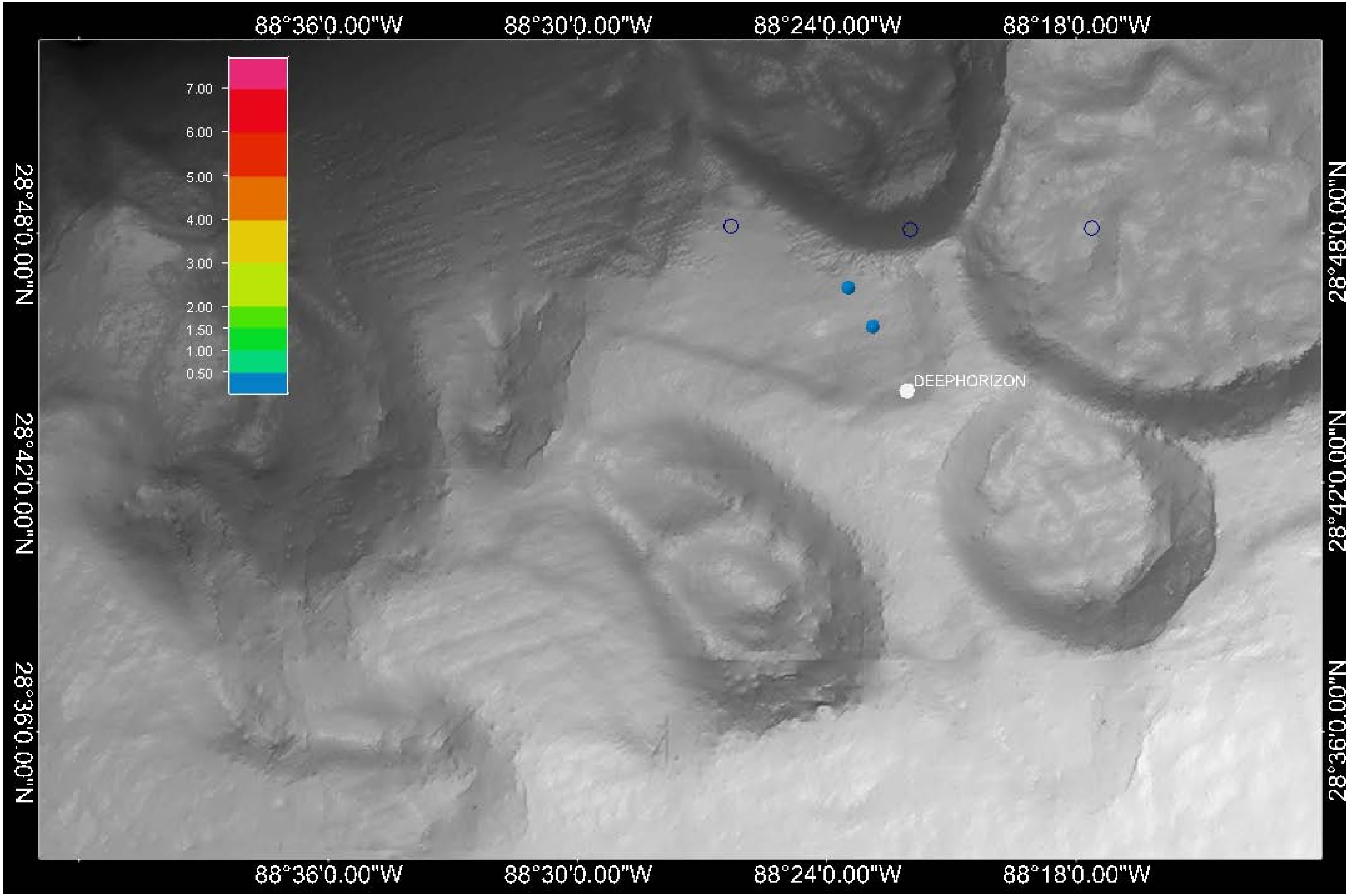


Figure E62: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 21 June 2010

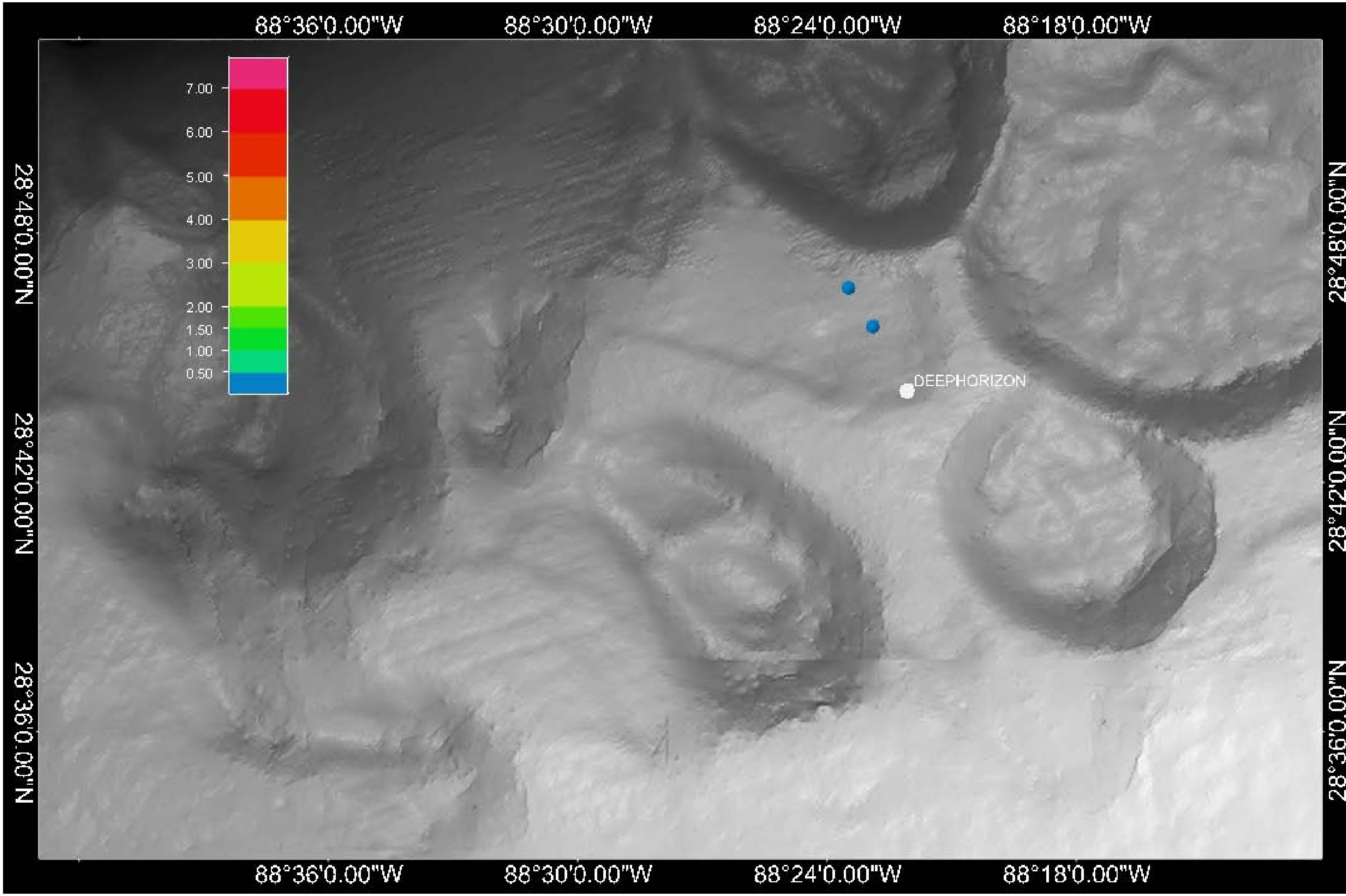


Figure E63: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 22 June 2010

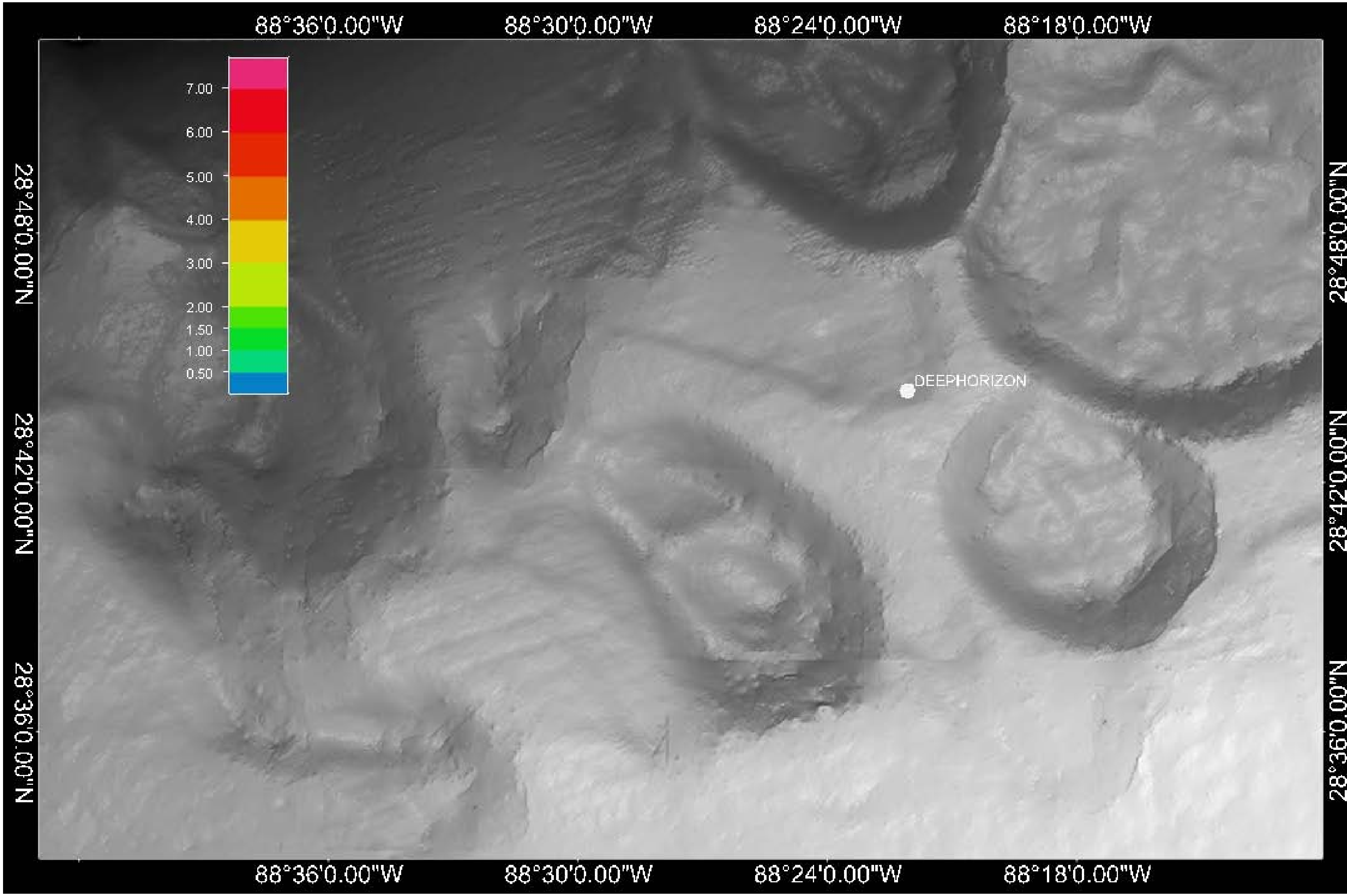


Figure E64: Mean Fluorescence ppb (QSDE) between 1000 and 1300m on 23 June 2010

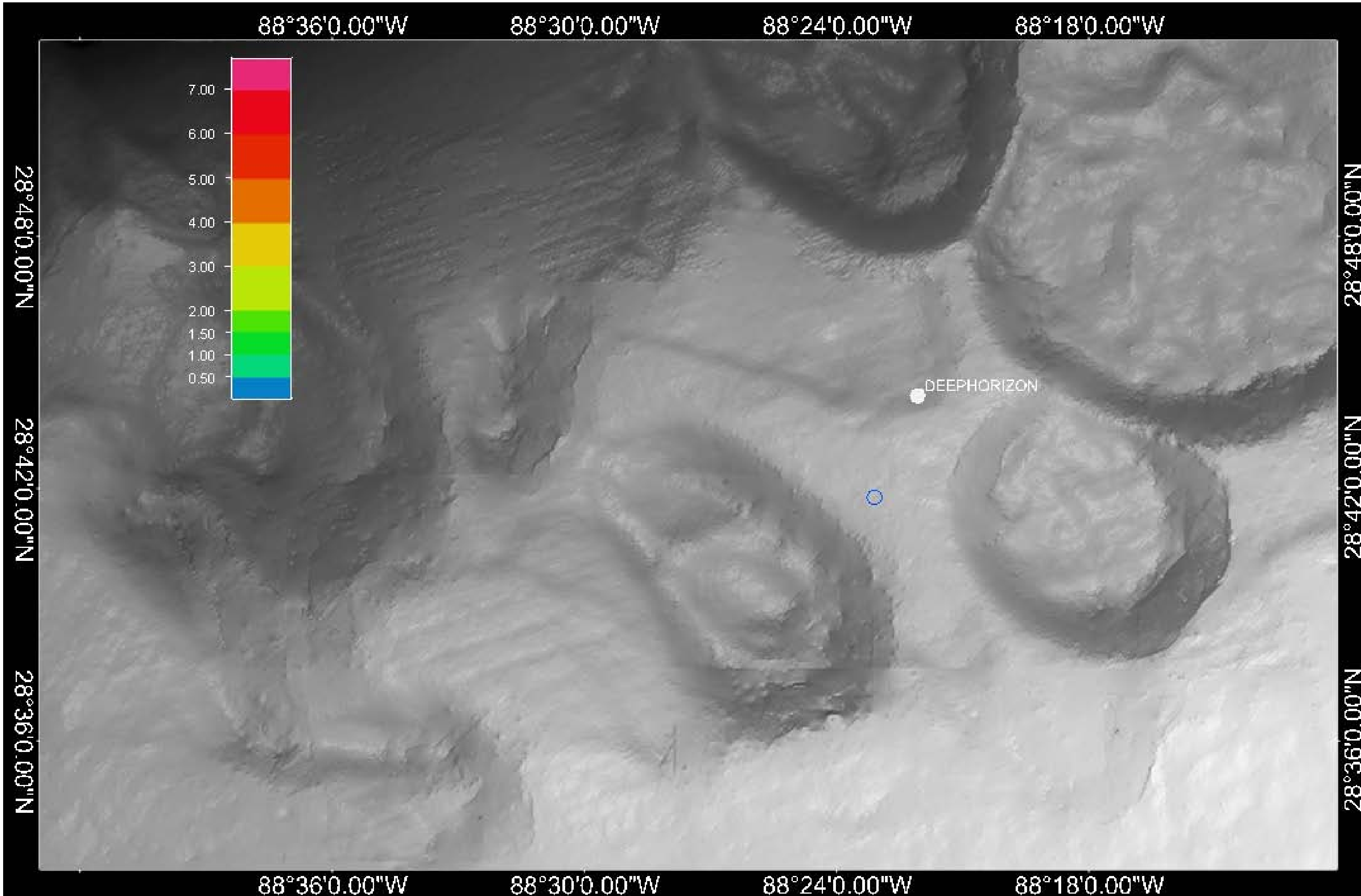


Figure E65: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 24 June 2010

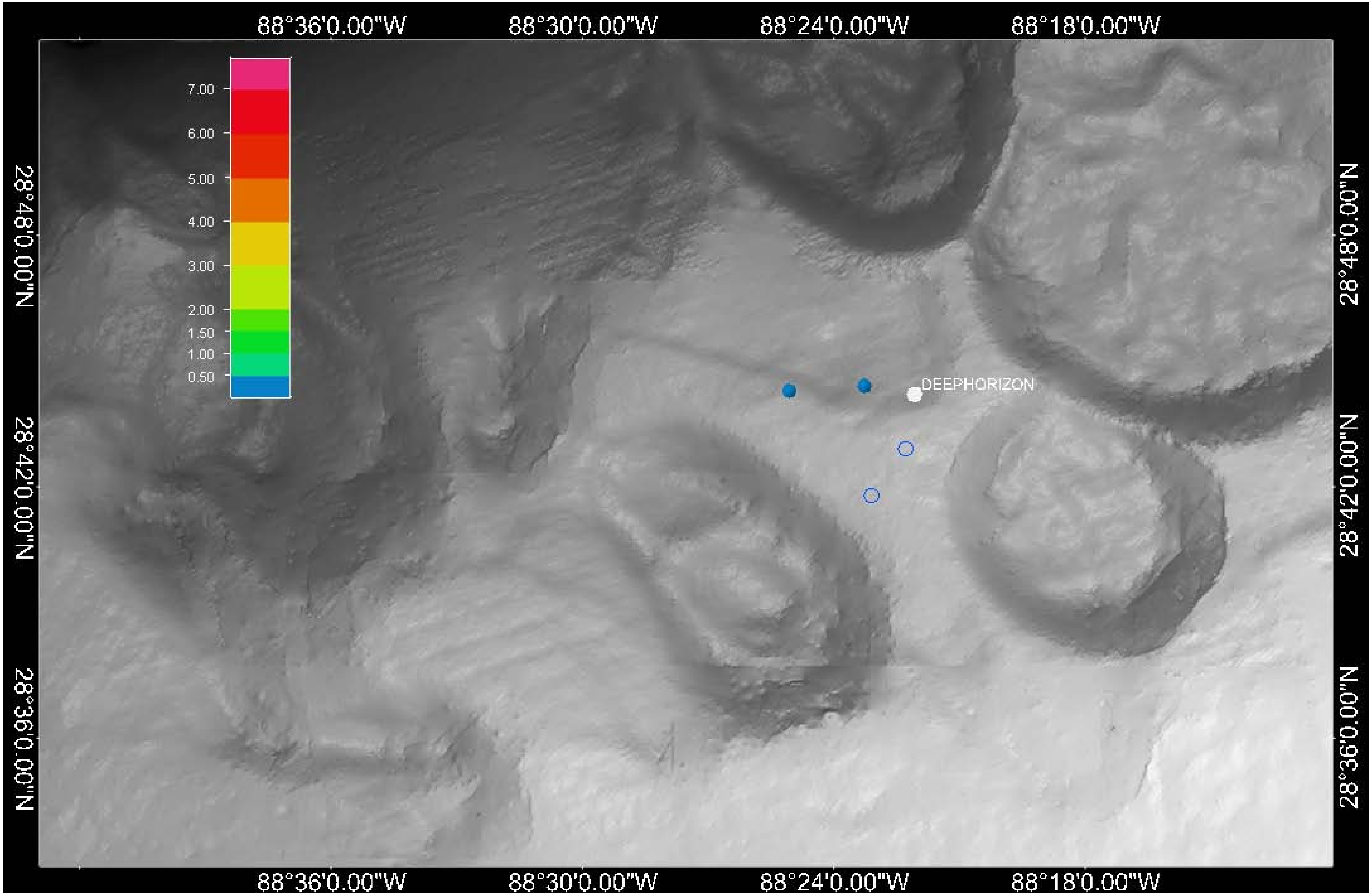


Figure E66: Mean Fluorescence ppb (QSDE) between 1000-1300m on 25 June 2010

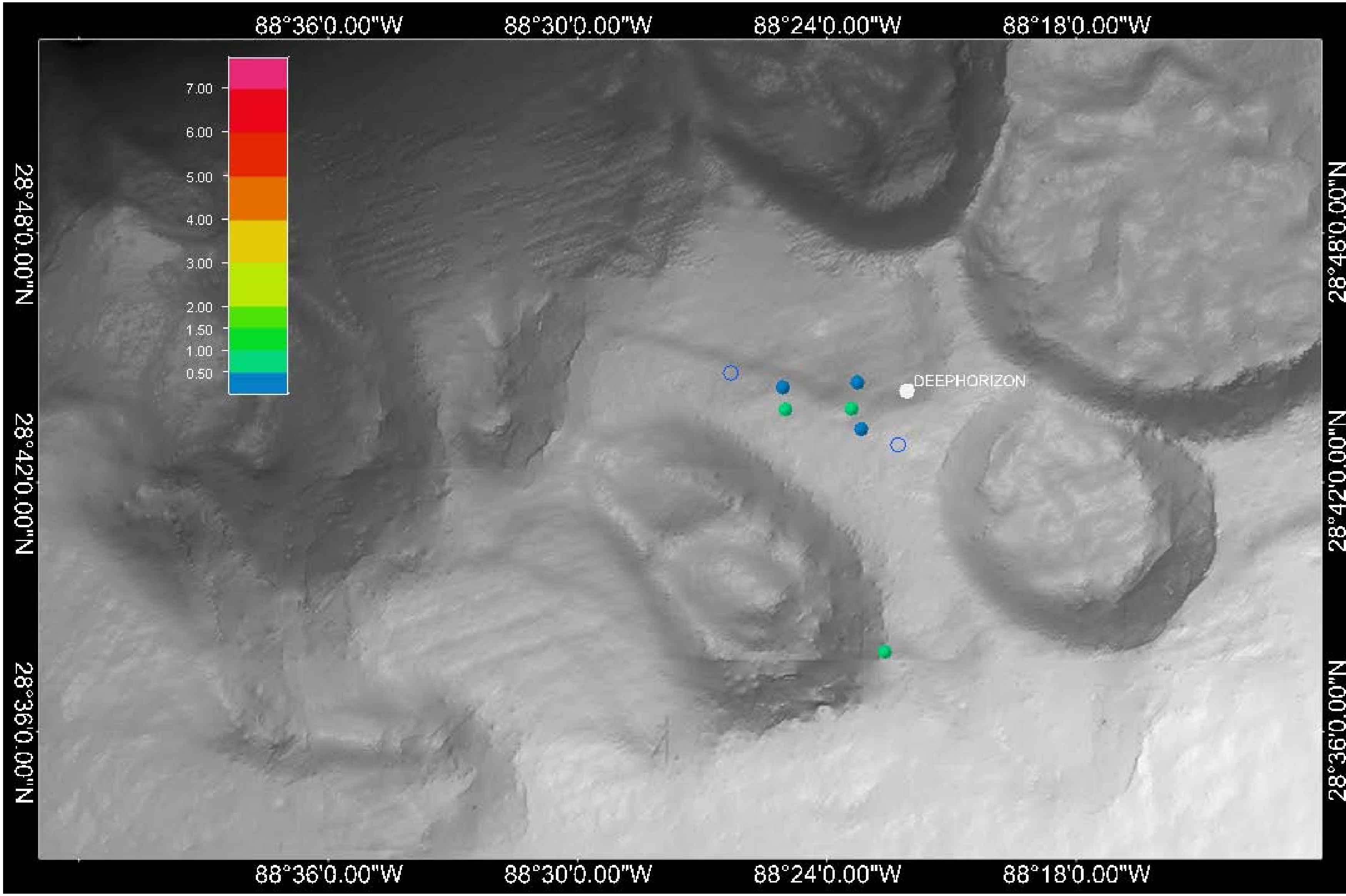


Figure E67: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 26 June 2010

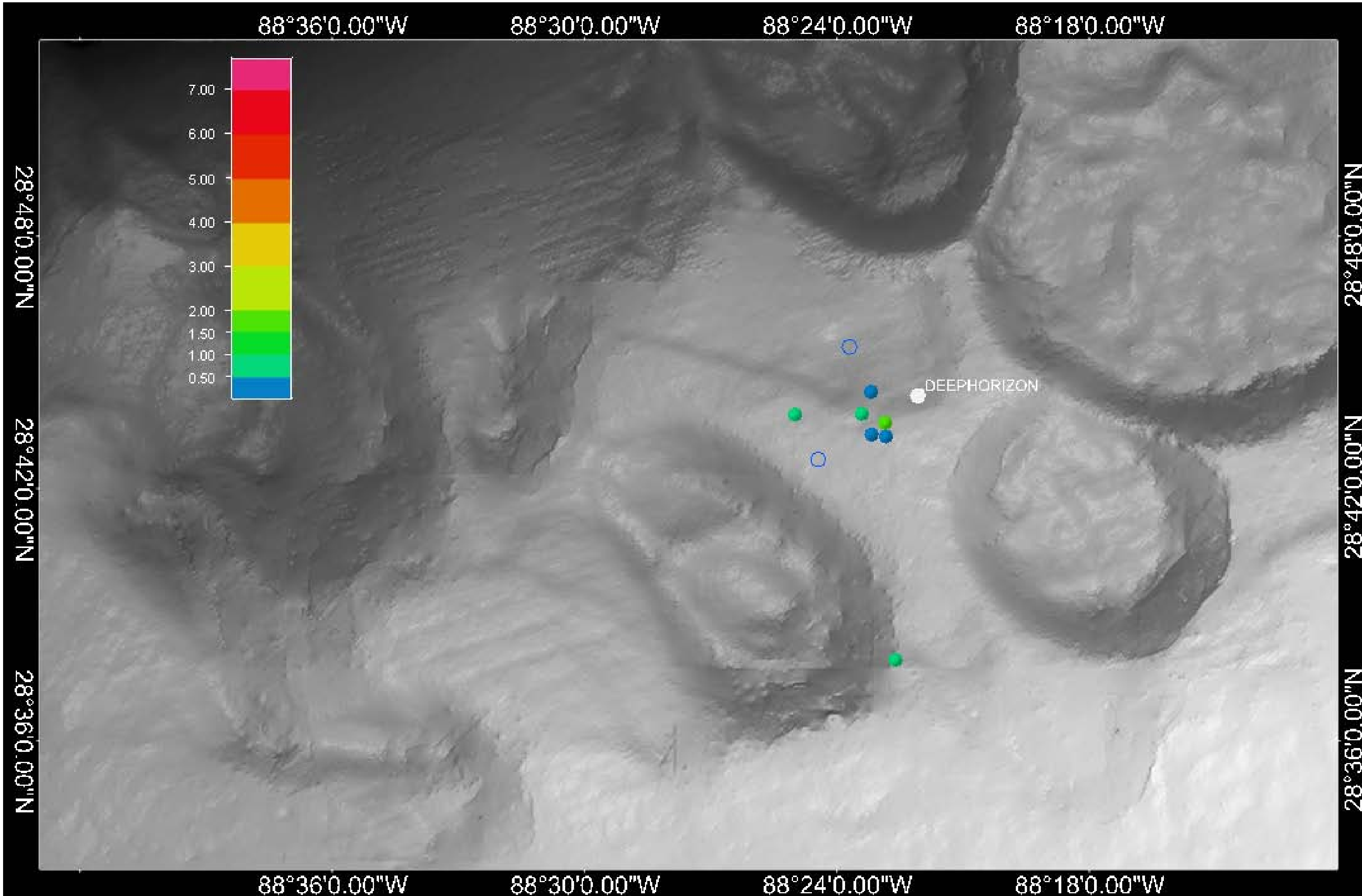


Figure E68: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 27 June 2010

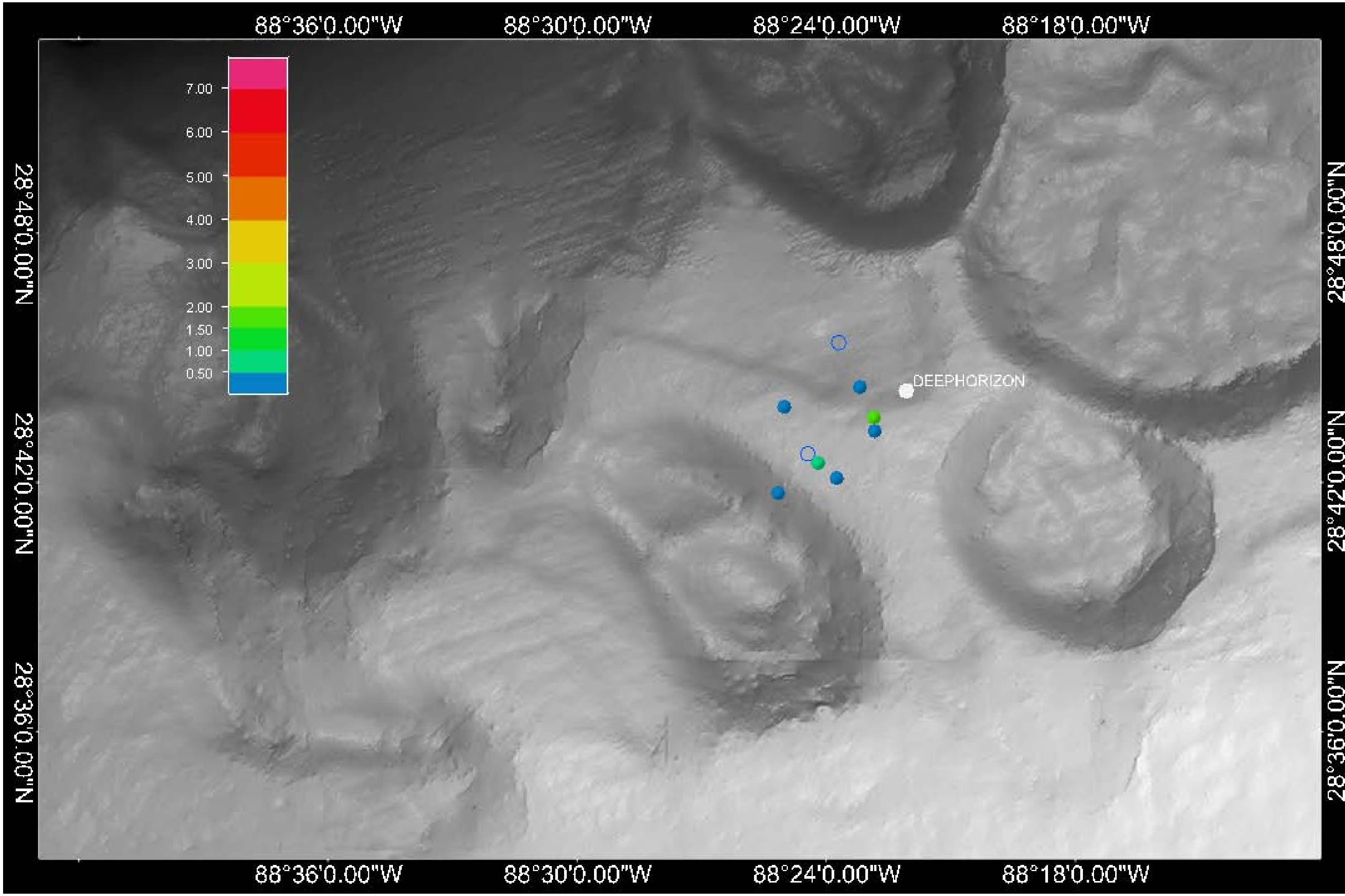


Figure E69: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 28 June 2010

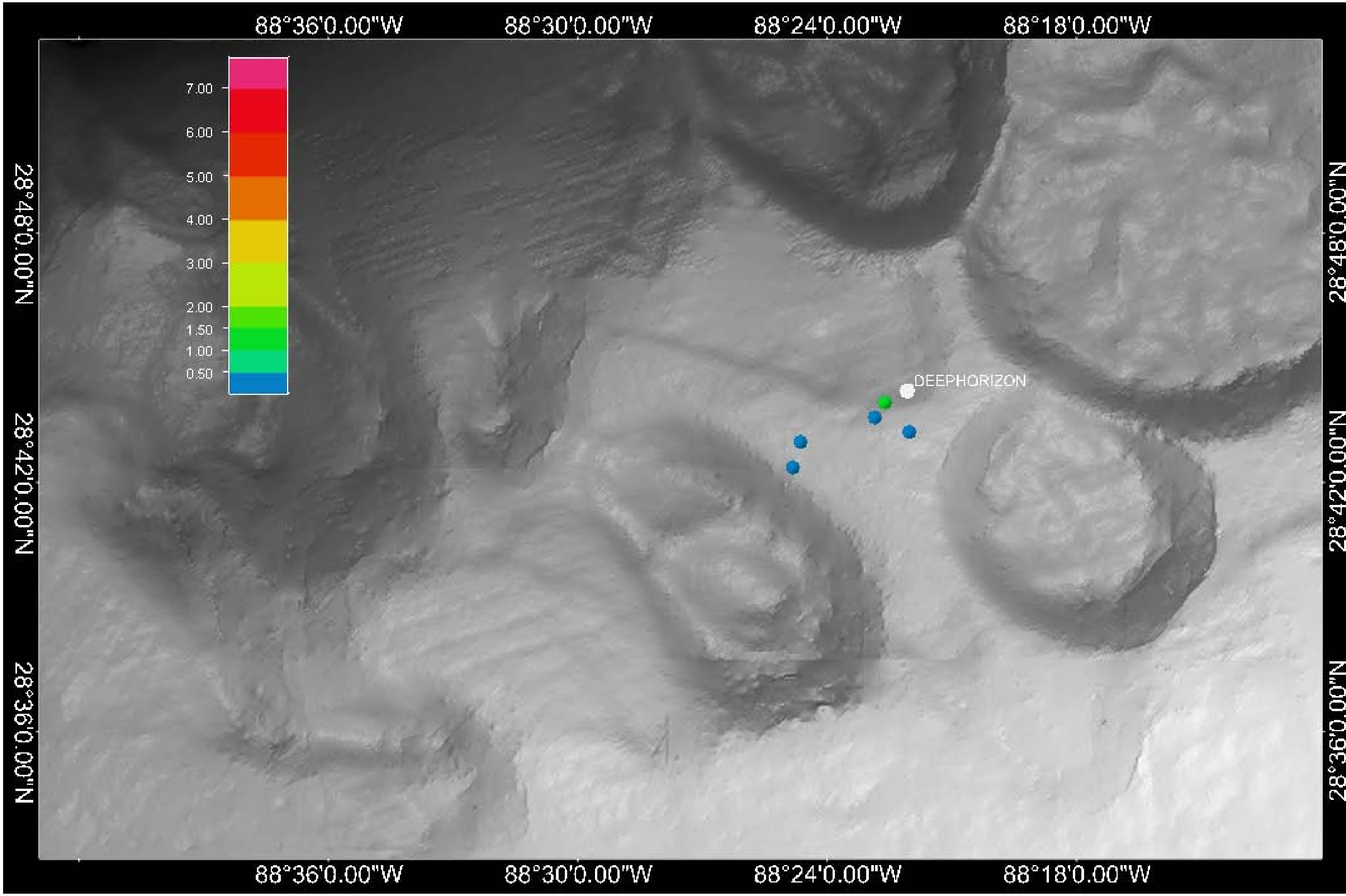


Figure E70: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 29 June 2010

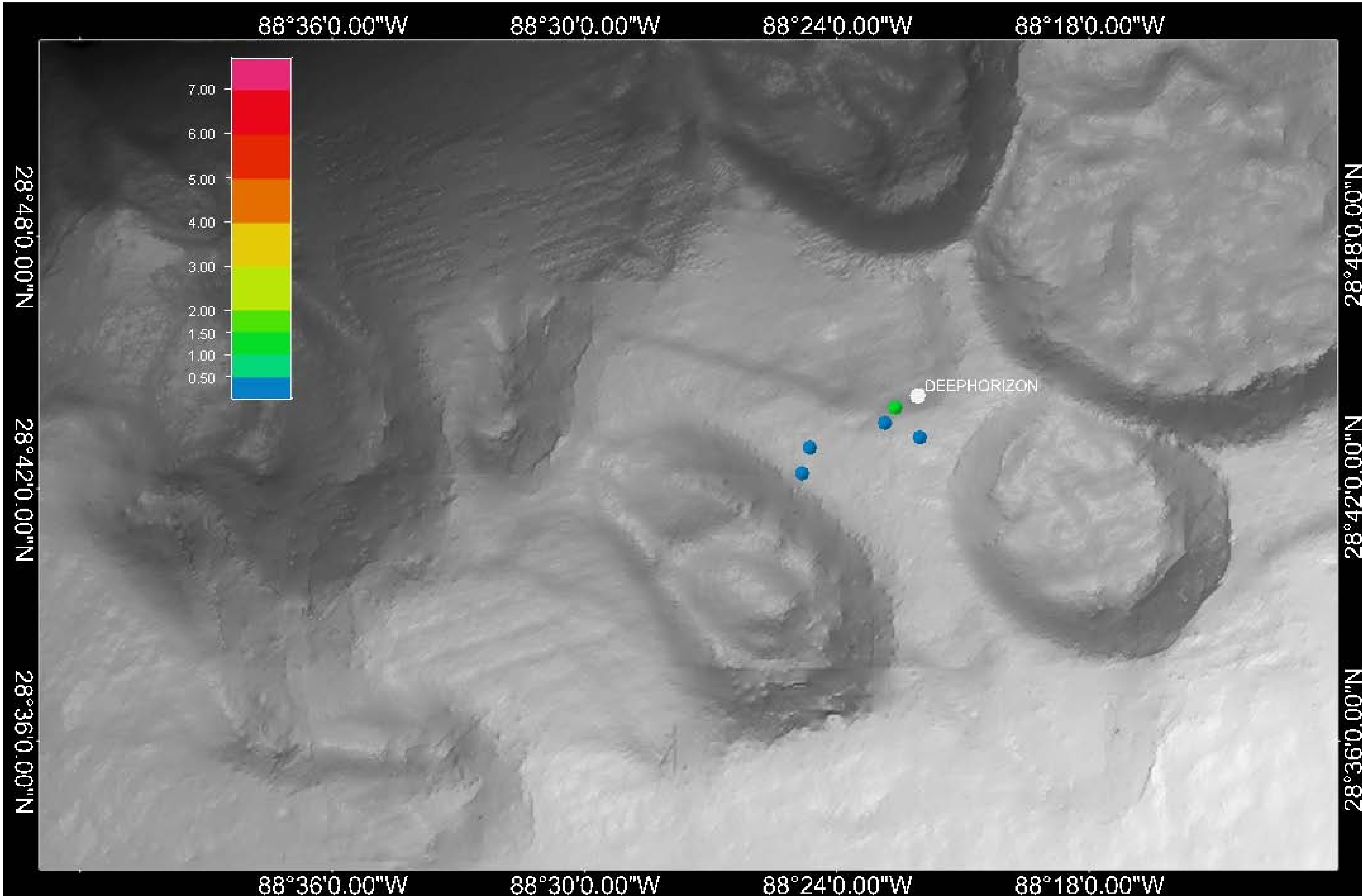


Figure E71: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 30 June 2010

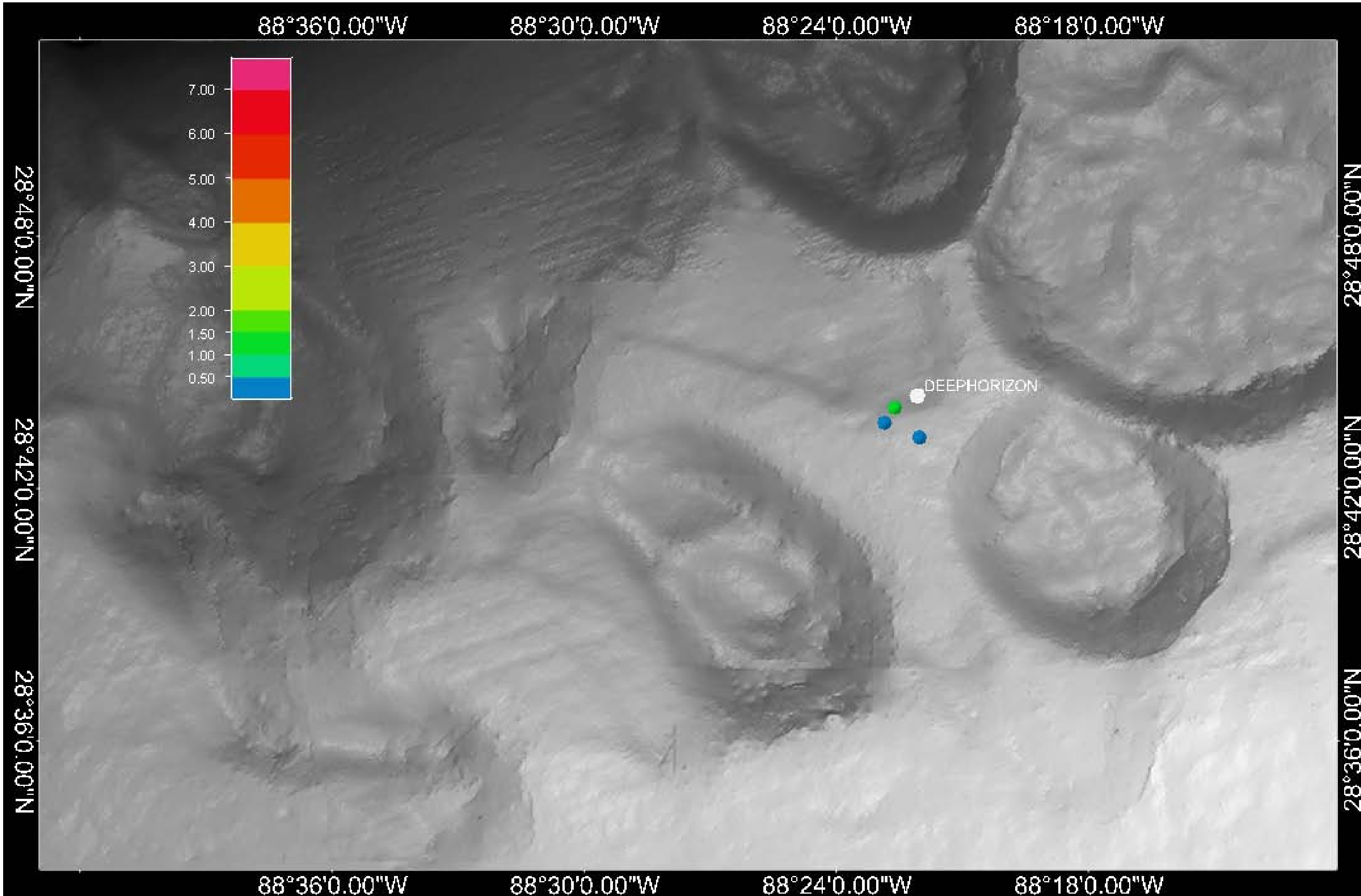


Figure E72: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 01 July 2010

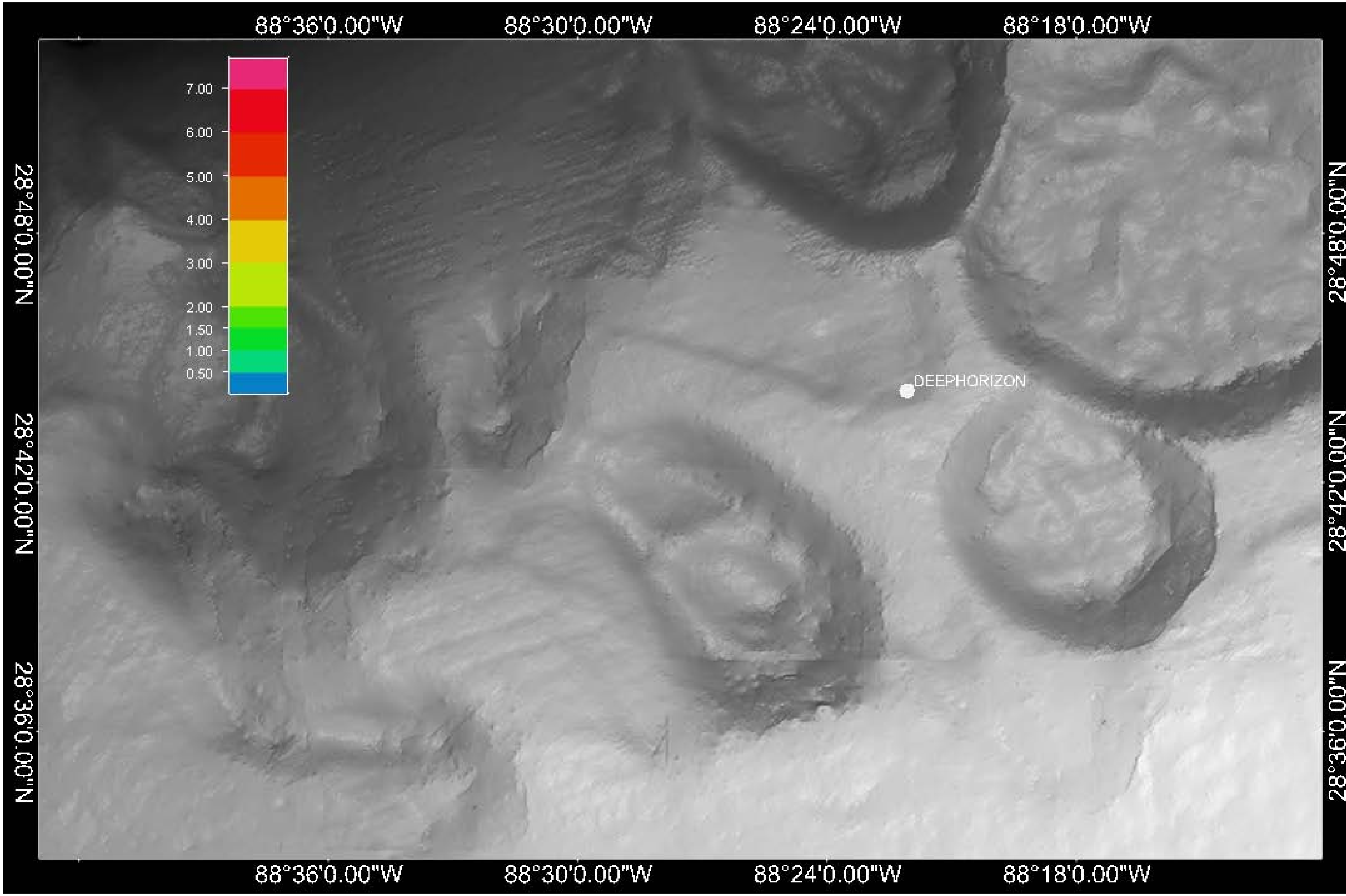


Figure E73: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 02 July 2010

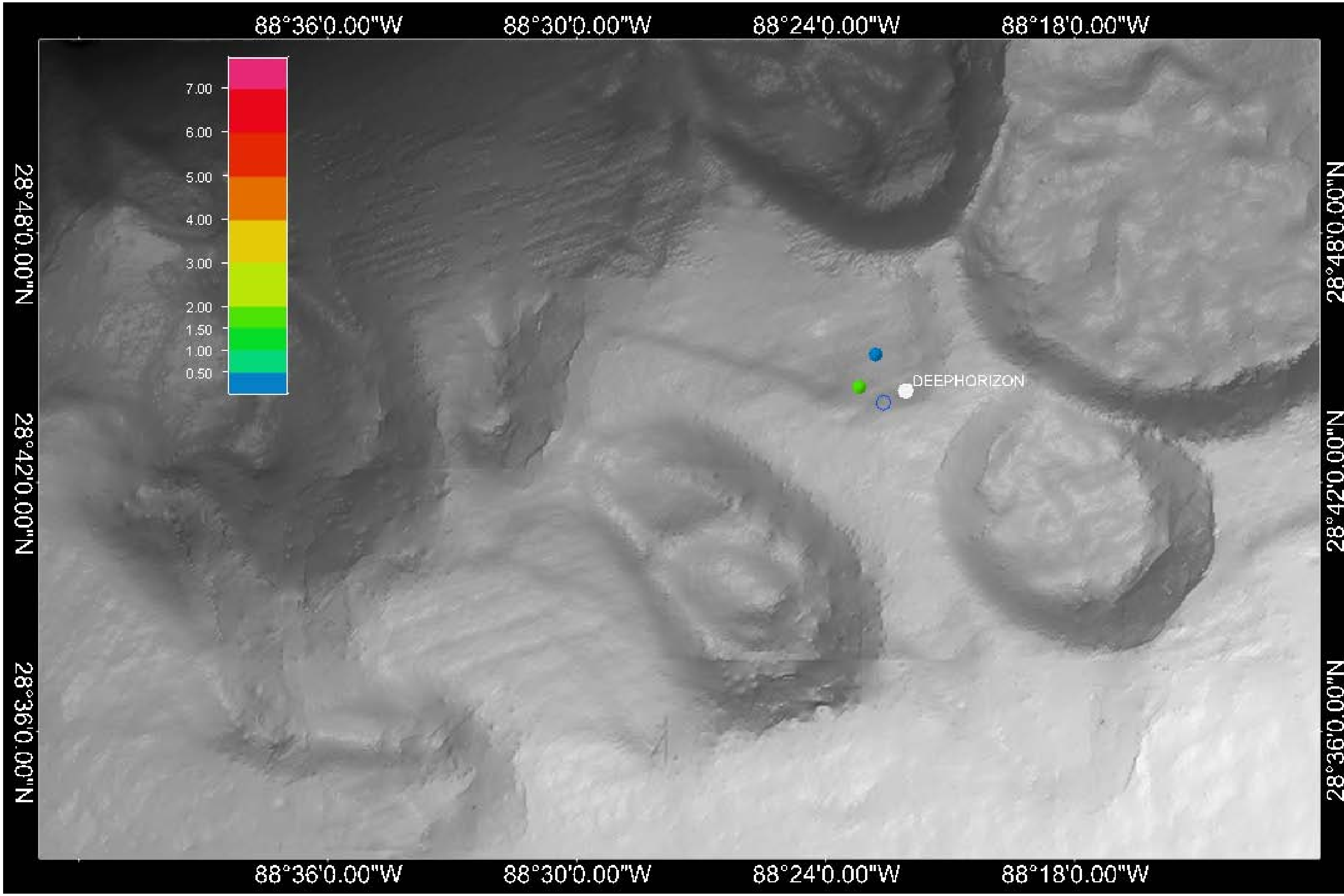


Figure E74: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 03 July 2010

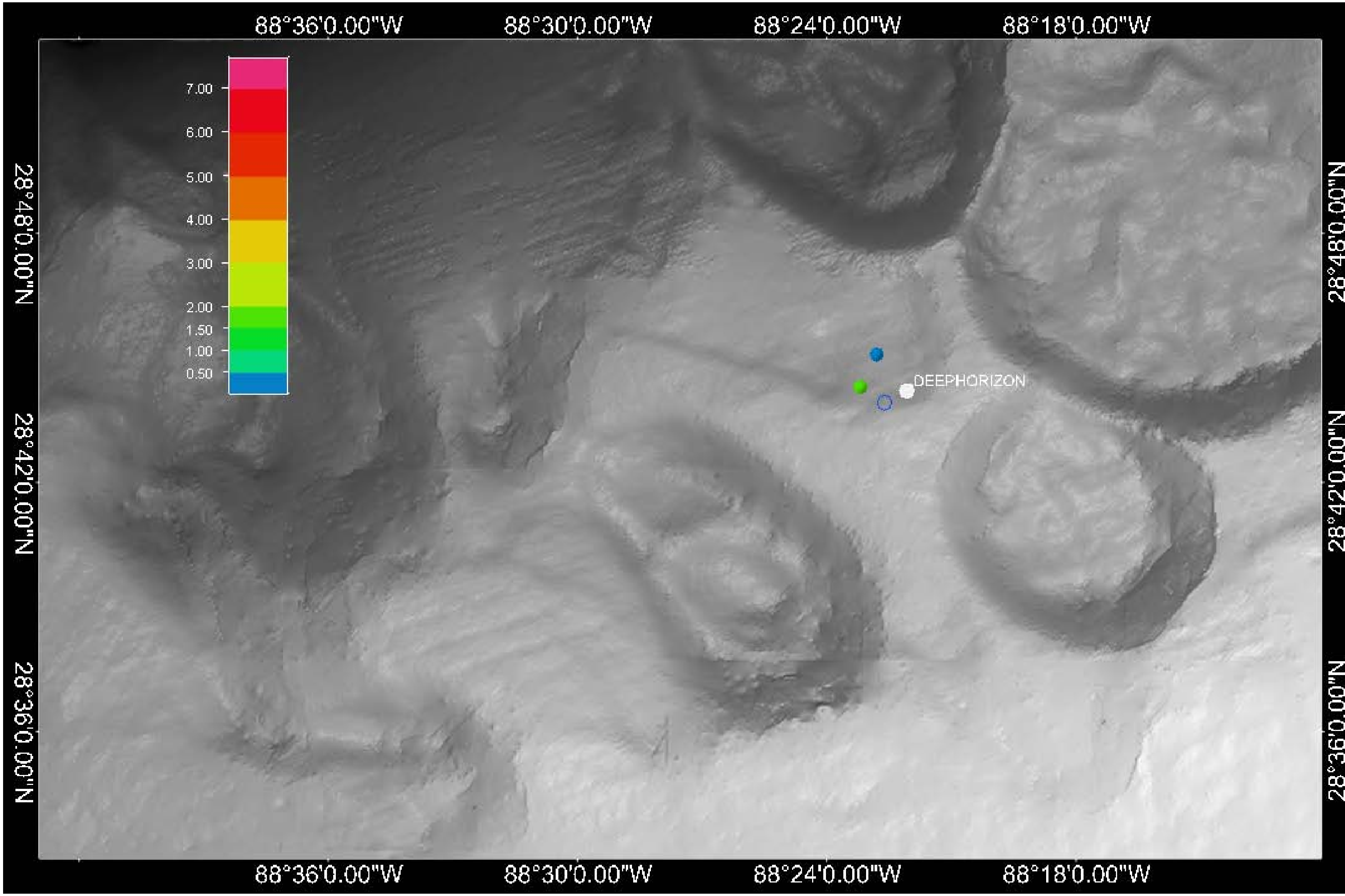


Figure E75: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 04 July 2010

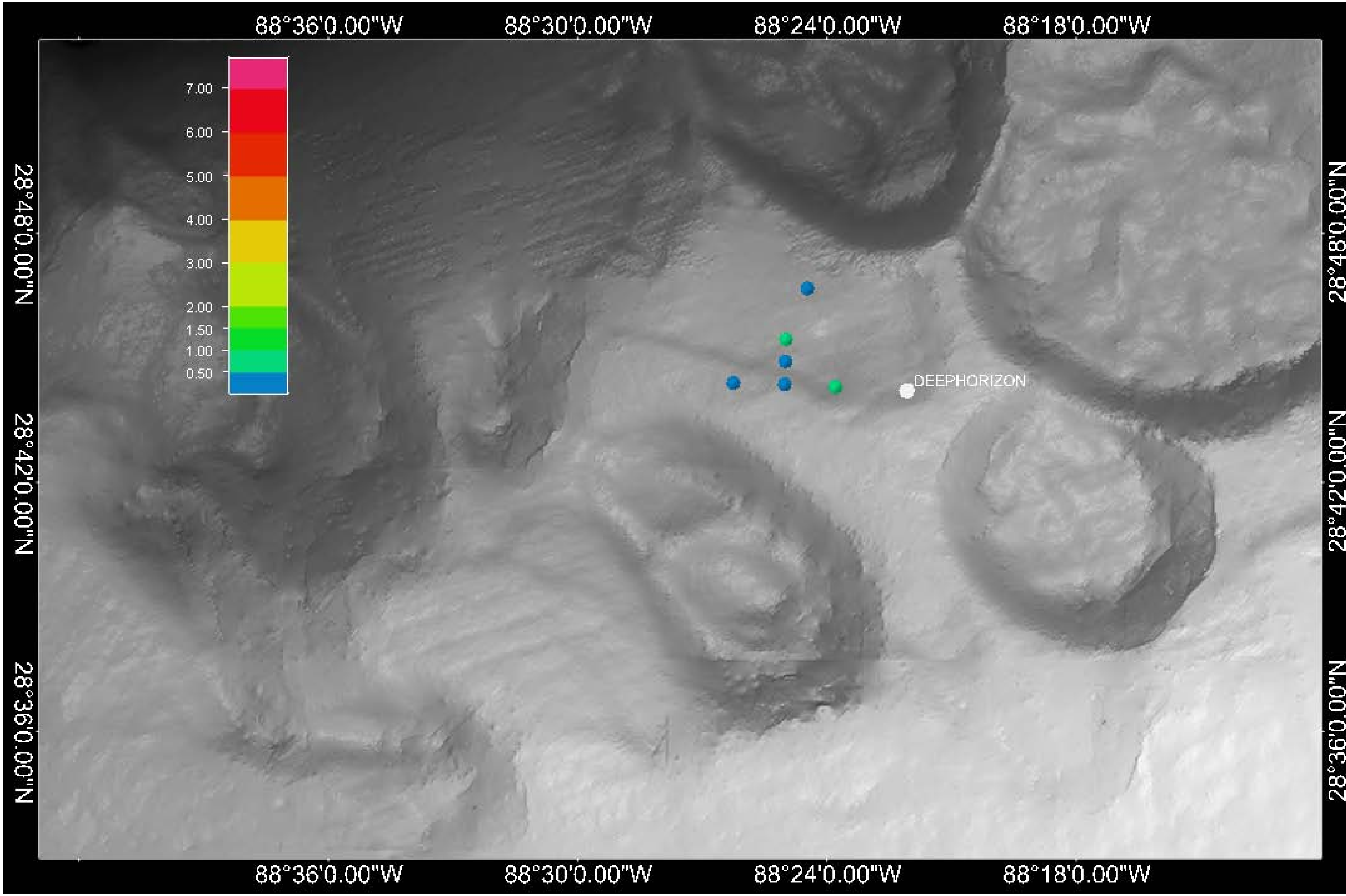


Figure E76: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 05 July 2010

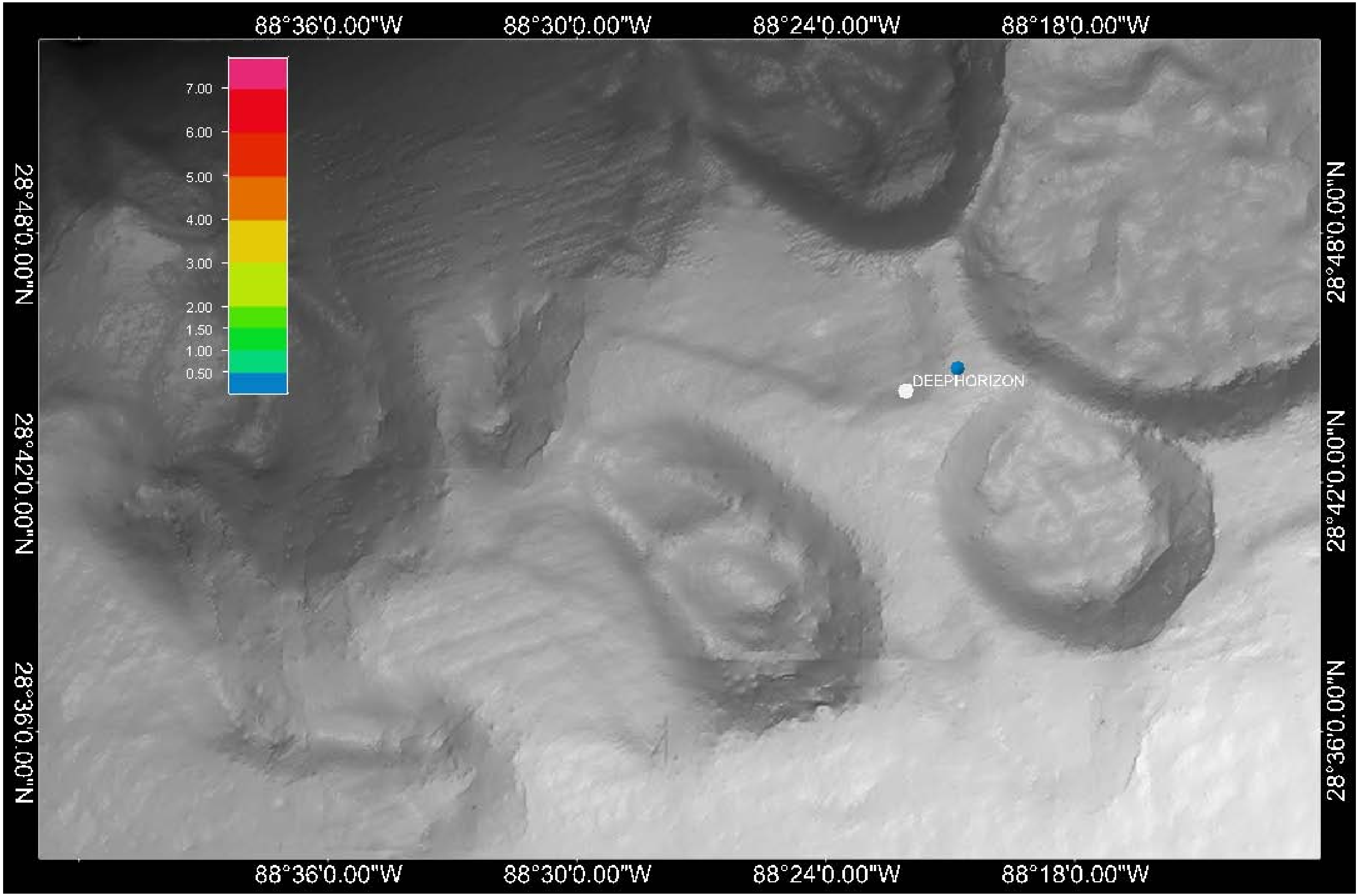


Figure E77: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 06 July 2010

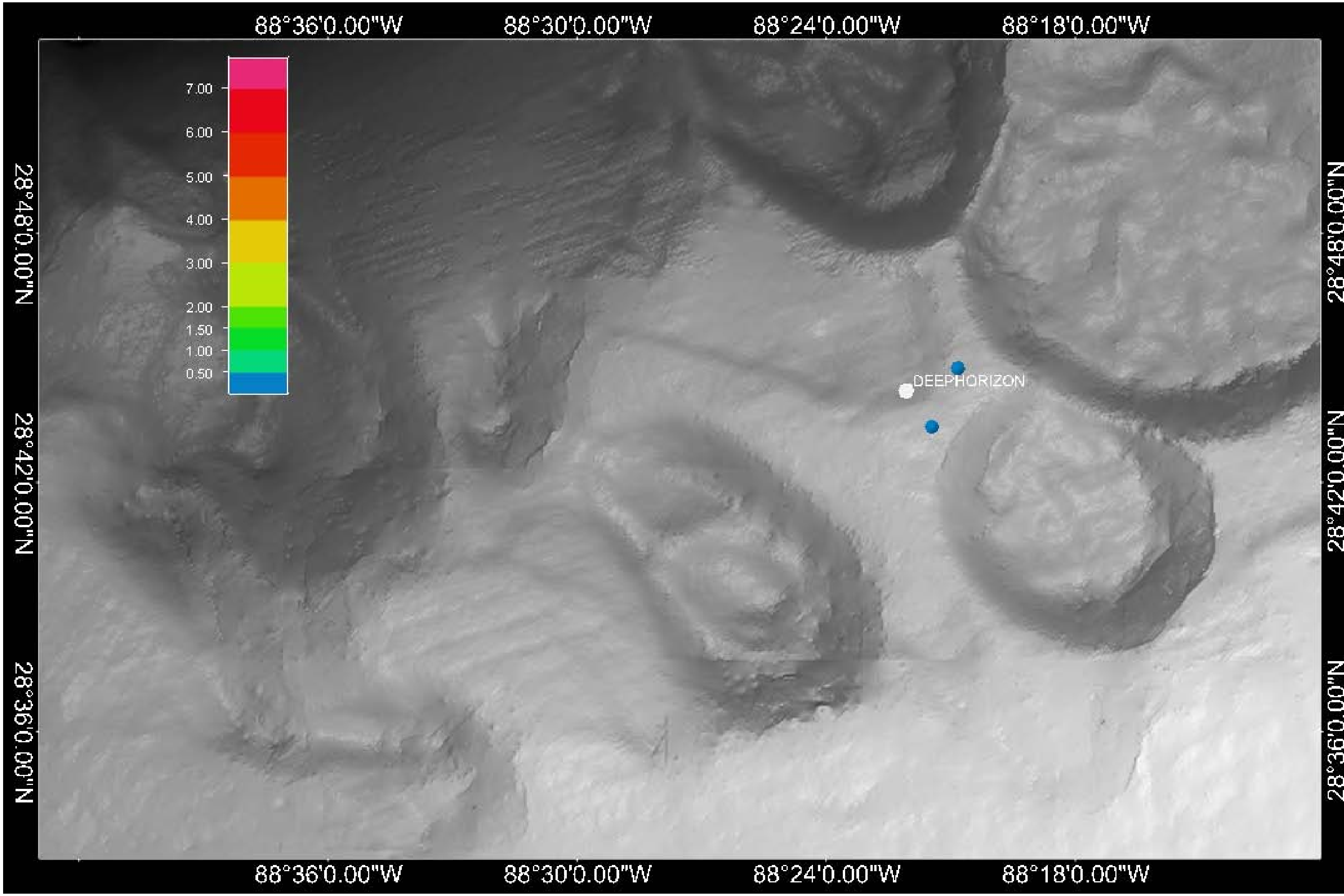


Figure E78: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 07 July 2010

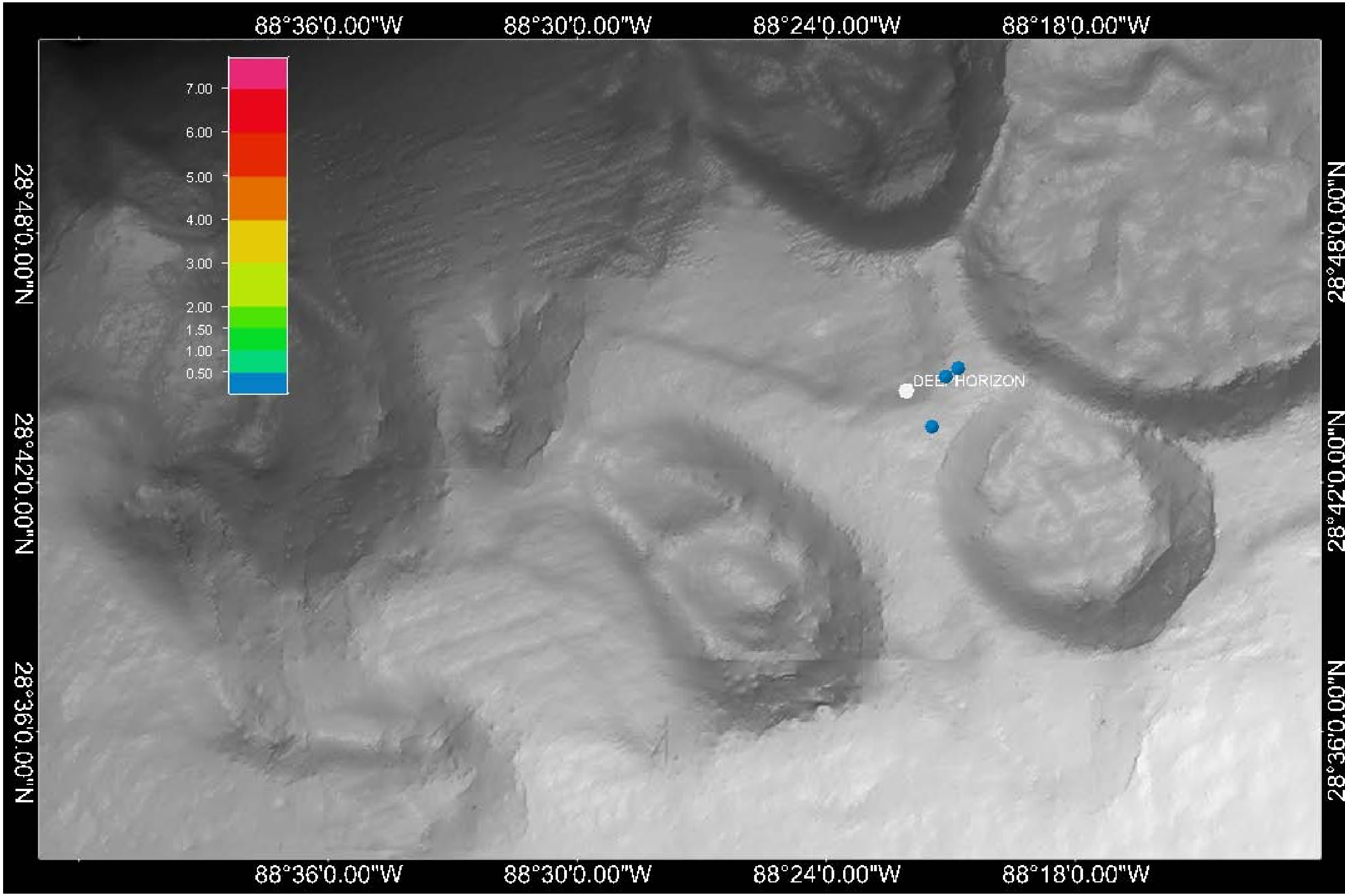


Figure E79: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 08 July 2010

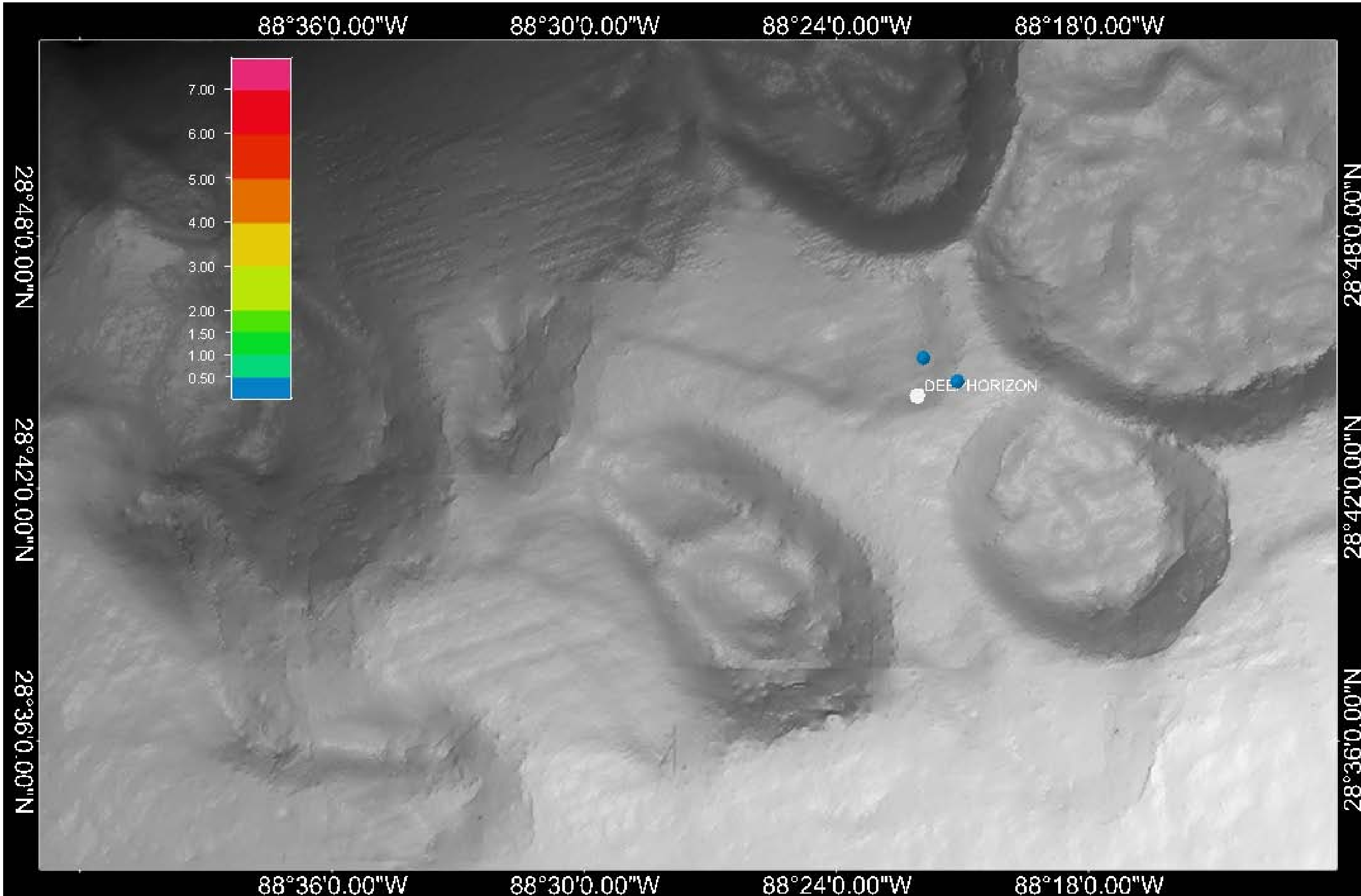


Figure E80: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 09 July 2010

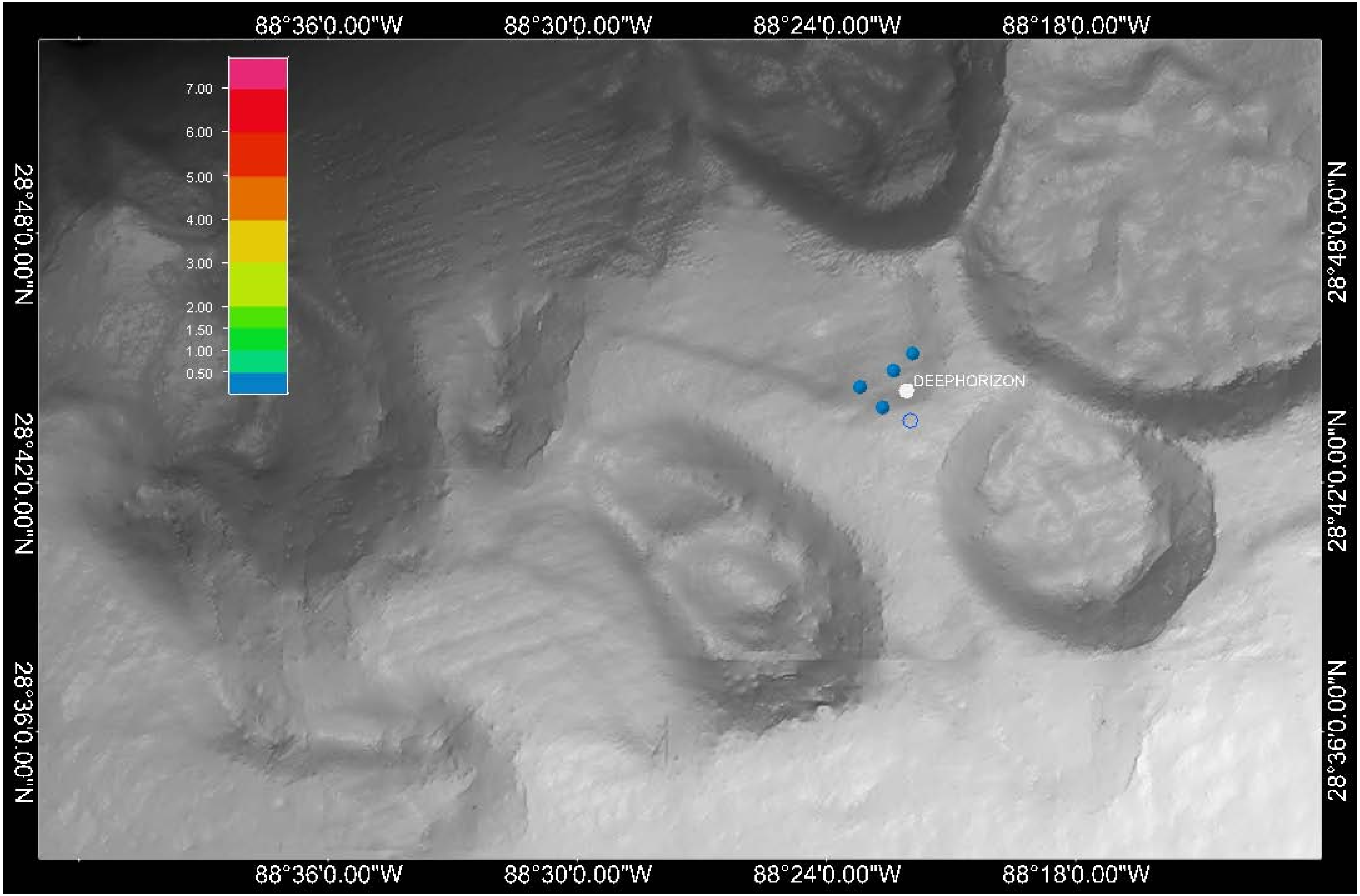


Figure E81: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 10 July 2010

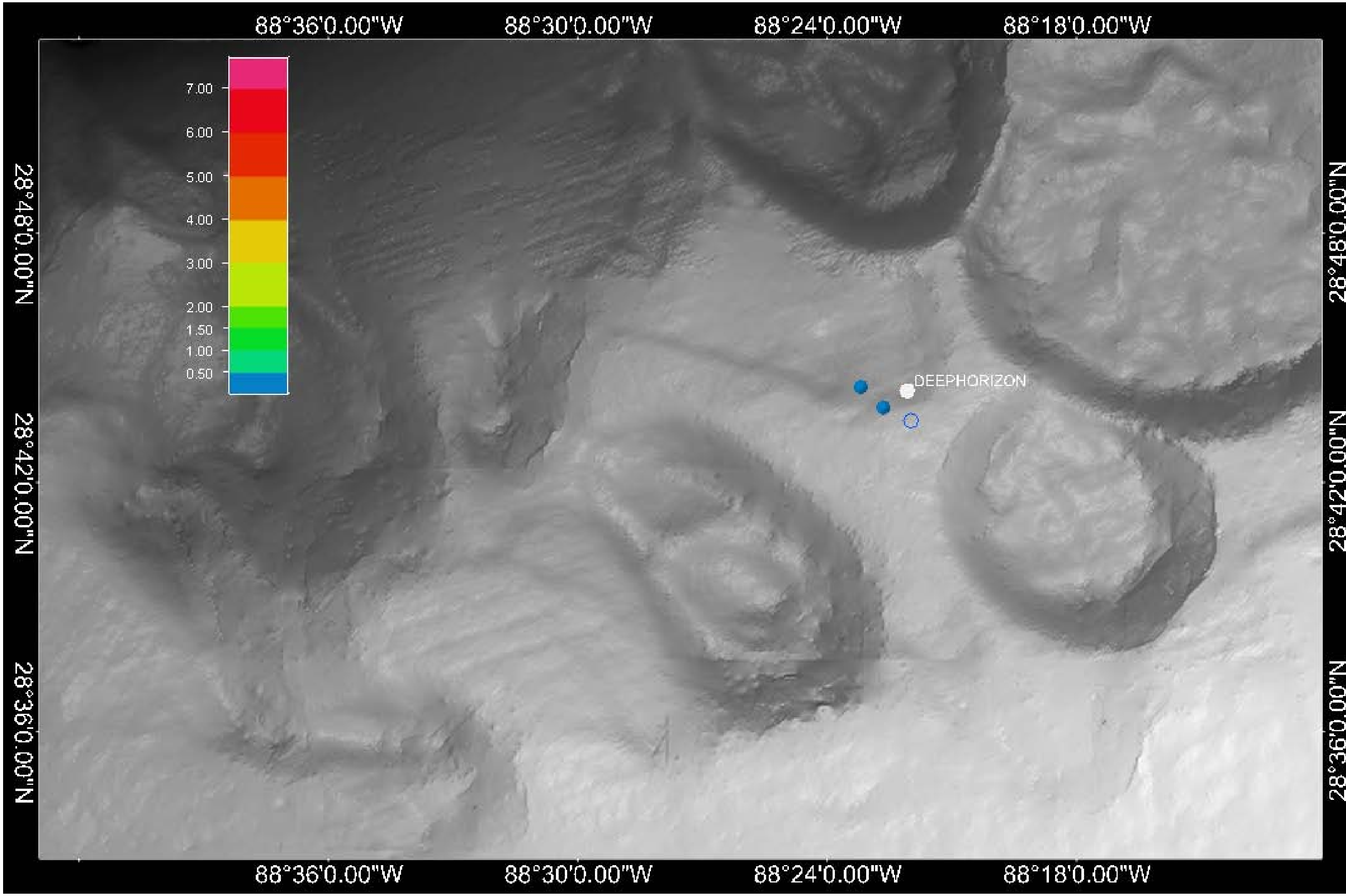


Figure E82: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 11 July 2010

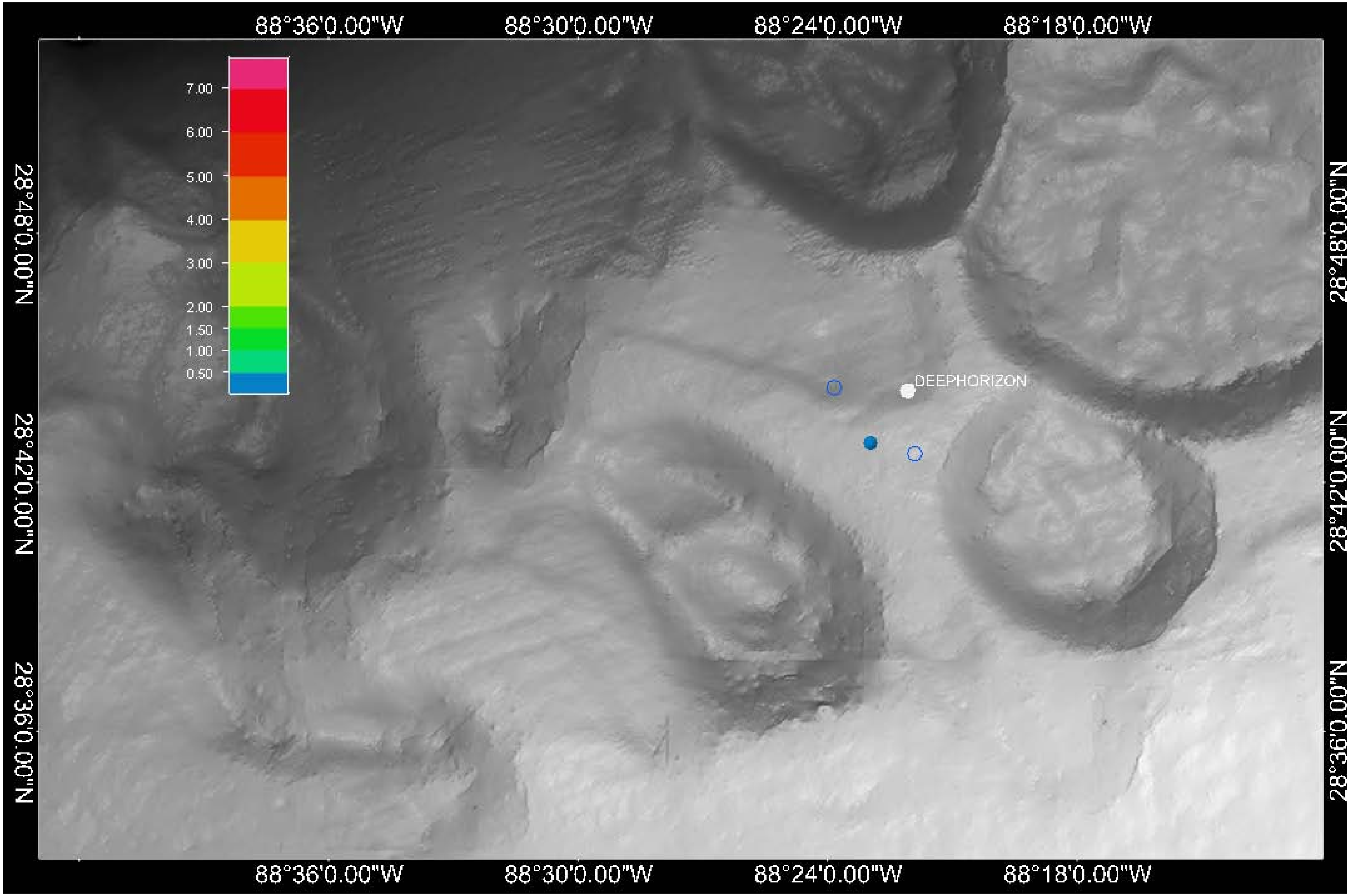


Figure E83: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 12 July 2010

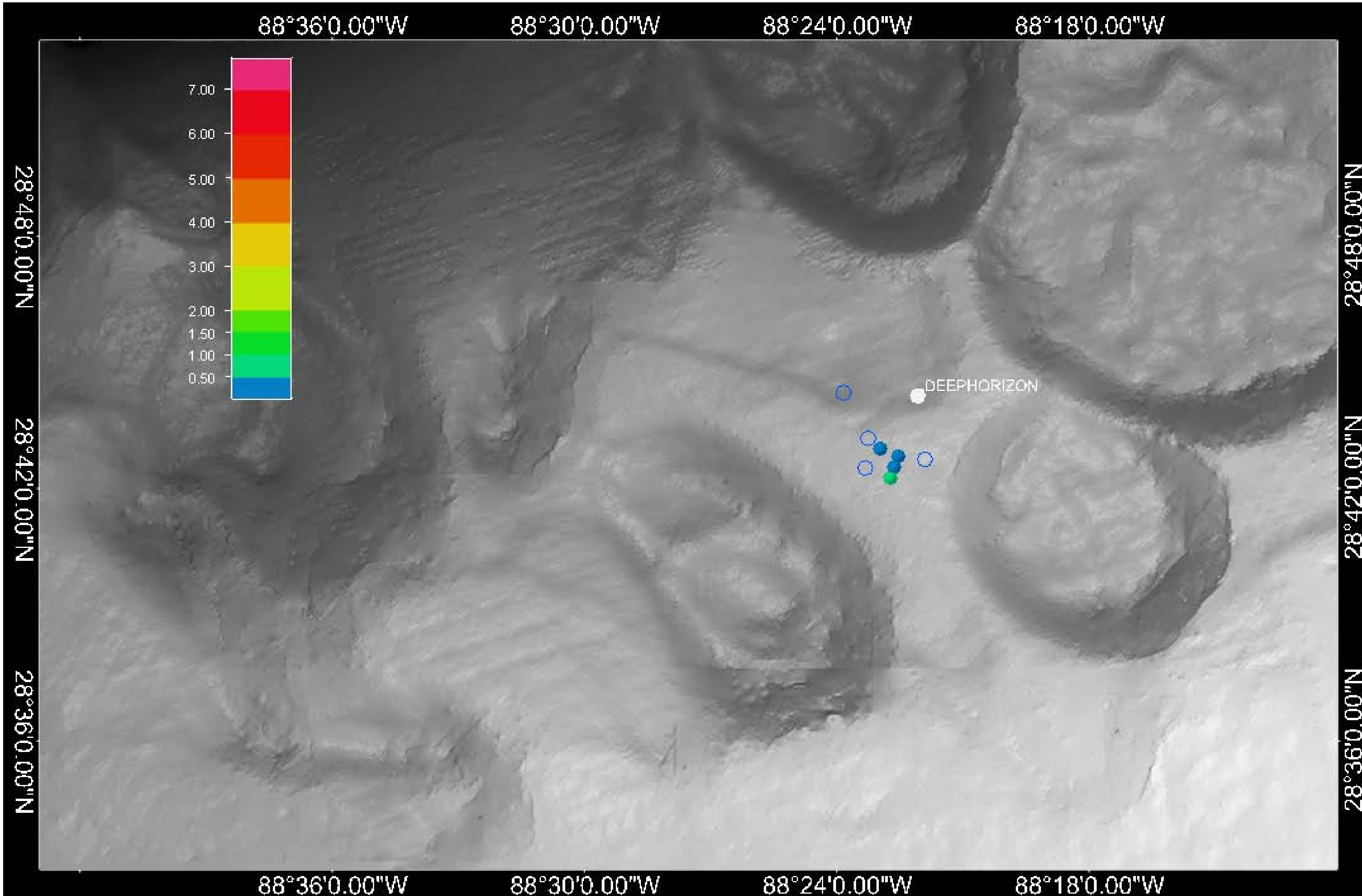


Figure E84: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m on 13 July 2010

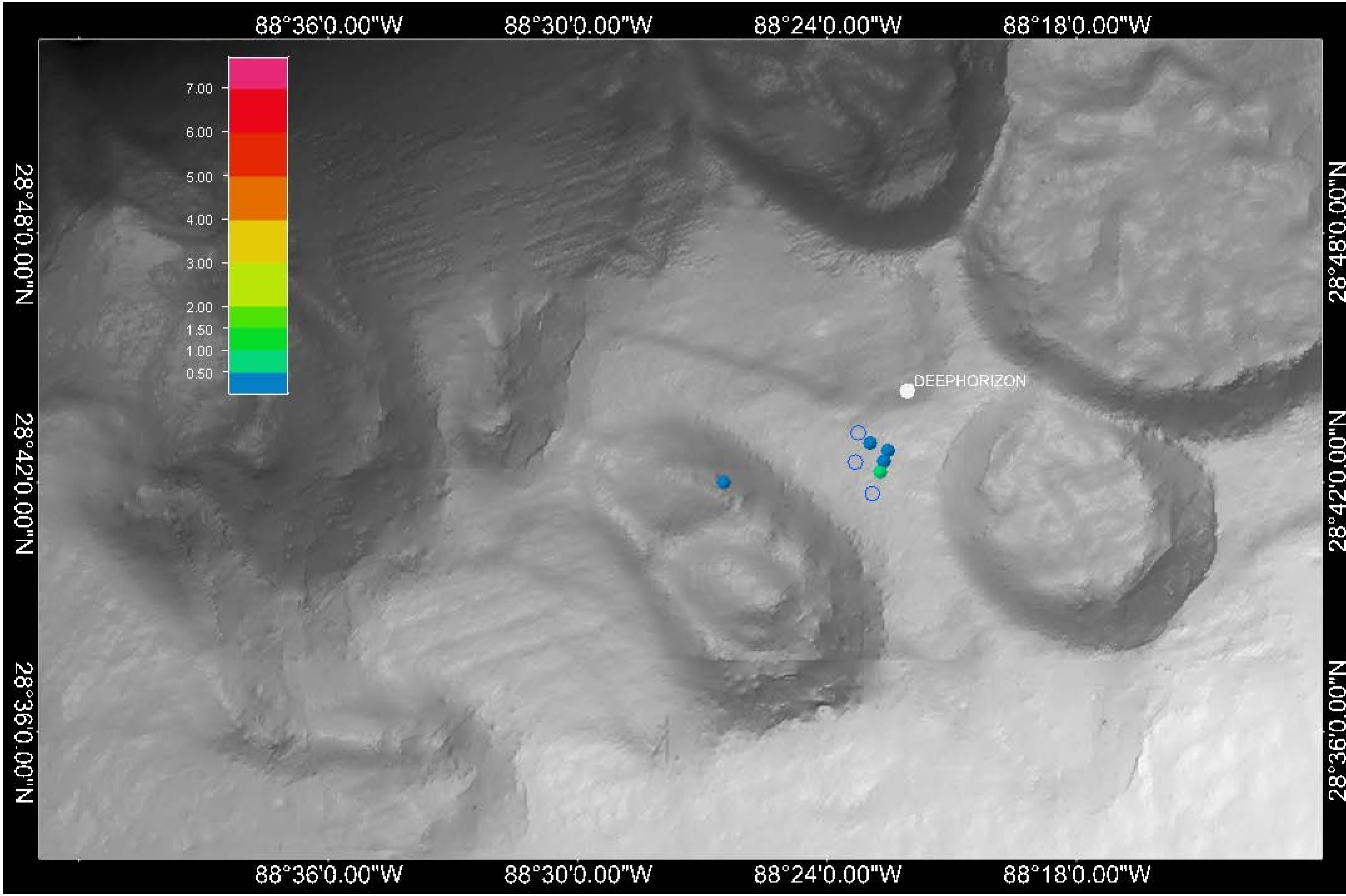


Figure E85: Mean Fluorescence ppb (QSDE) between1000 and 1300 m from 19 May through 13 July

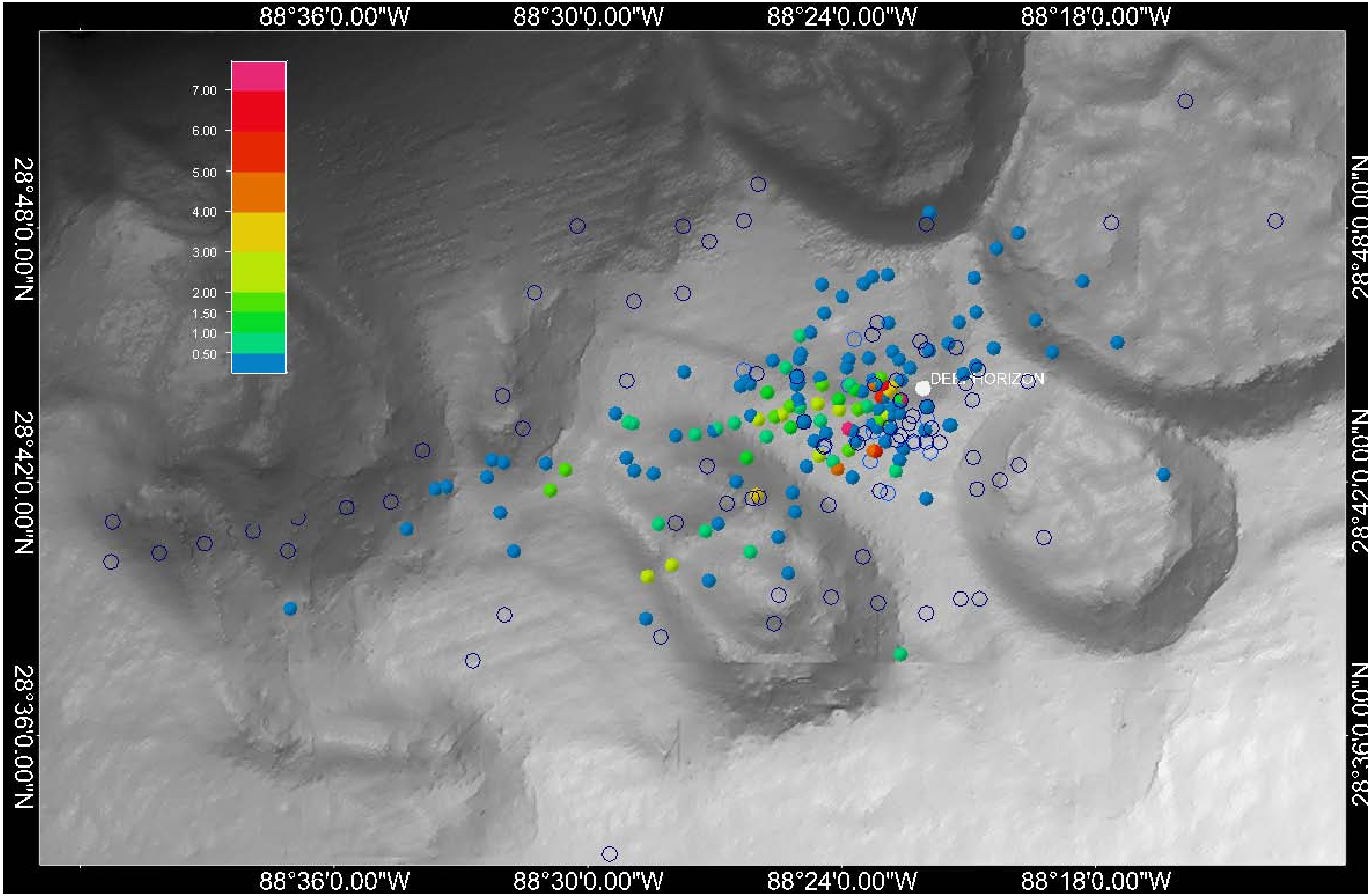
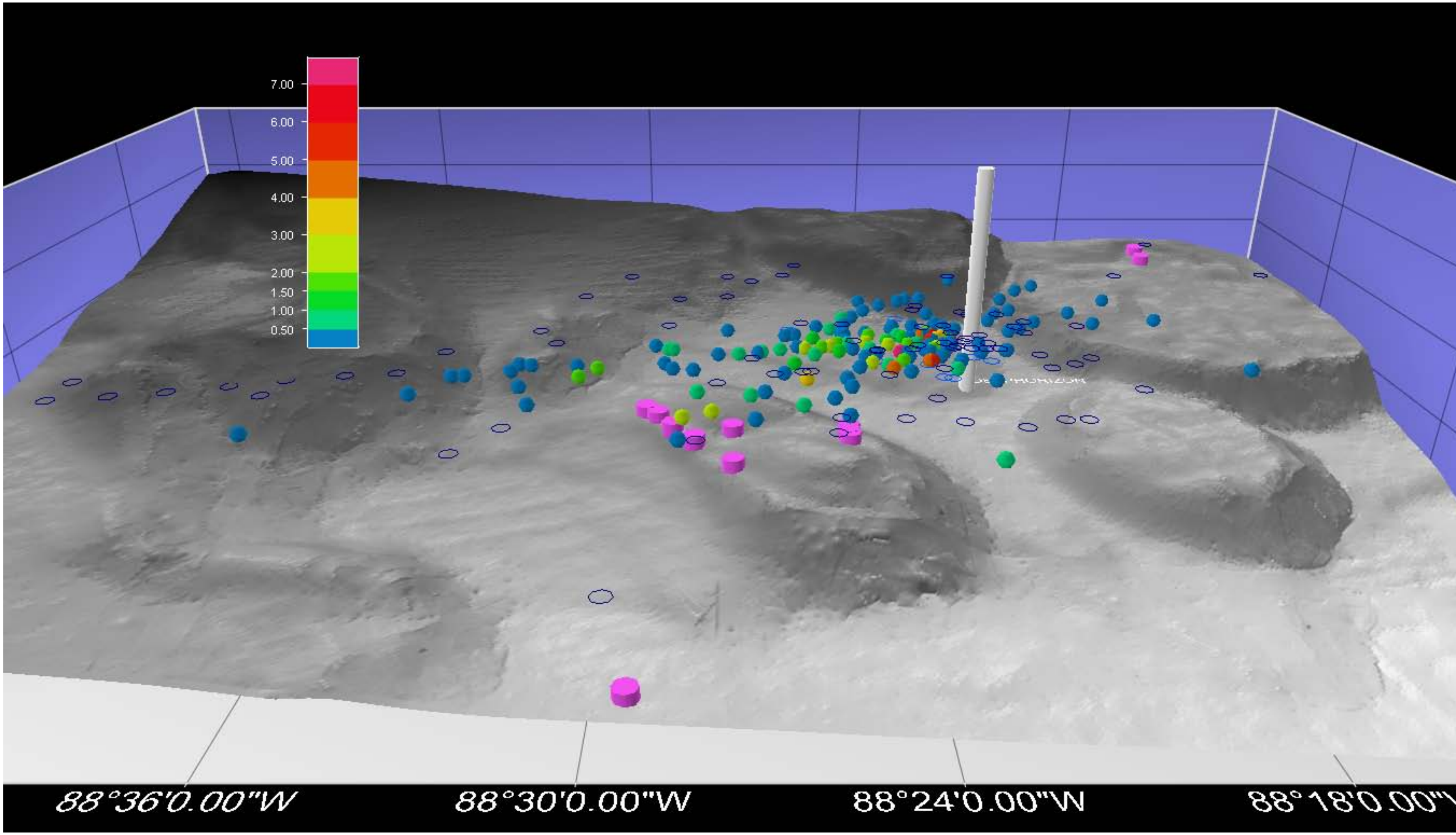
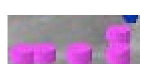


Figure E86: Mean Fluorescence ppb (QSDE) between 1000 and 1300 m from 19 May through 13 July



Seeps 

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