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Woods Hole Oceanographic Institution

At Sea Test 2 Deployment Cruise
Cruise 475 On Board R/V *Oceanus*
September 22 – 26, 2011
Woods Hole – Woods Hole, MA

By

Robert A. Weller[1], John Lund[1], Keith Von der Heydt[1], Matthew Palanza [1], Steven Lerner[1], Tim Scholz[1], Christian Begler[2], Gregg Siddal[3], Will Ostrom[1], Kris Newhall[1], Paul Bouchard[1], Kathleen McMonagle[1], Eric Jamieson[4], Robert Petitt[1], Jeff O'Brien[1], Gary Cook[4]

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Ocean Observatories Initiative
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

[1] Woods Hole Oceanographic Institution, Woods Hole, MA
[2] Scripps Institution of Oceanography, La Jolla, California
[3] Bedford Institute of Oceanography, Halifax, Nova Scotia, Canada
[4] Raytheon, Portsmouth, RI

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Approved for Distribution:

W. Rockwell Geyer, Chair

Department of Applied Ocean Physics and Engineering

Abstract

The R/V *Oceanus*, on Cruise 475, carried out the deployment of three moorings for the Coastal and Global Scale Nodes (CGSN) Implementing Organization of the NSF Ocean Observatories Initiative. These three moorings are prototypes of the moorings to be used by CGSN at the Pioneer, Endurance, and Global Arrays. *Oceanus* departed from Woods Hole, Massachusetts on September 22, 2011 and steamed south to the location of the mooring deployments on the shelf break. Over three days, September 23-25, *Oceanus* surveyed the bottom at the planned mooring sites, deployed the moorings, and carried out on site verification of the functioning of the moorings and moored hardware. *Oceanus* returned to Woods Hole on September 26, 2011.

Table of Contents

Abstract ii

List of Figures vi

List of Tables xii

I. Introduction 1
- **A. Background and Purpose** 1
- **B. Cruise Chronology** 5
- **C. Weather and Operating Conditions During the Cruise** 8

II. Cruise Preparations 10
- **A. Sensor Evaluation and Burn-in** 10
  - 1. WHOI sensors 10
  - 2. SIO/BIO sensors 23
- **B. CPSM Preparations** 24
  - 1. Lab/bench test 24
  - 2. Well tests - weight, trim tests 47
  - 3. Buoy Spin 48
- **C. CPPM Preparation** 50
  - 1. Lab/bench test 50
  - 2. Well test 52
- **D. Global Hybrid Profiler Mooring (GHPM) Preparations** 59
  - 1. SIO tests 59
  - 2. BIO tests 59
- **E. Staging in Woods Hole** 61
  - 1. SIO/BIO staging at CRL 61
  - 2. WHOI CPSM and CPPM staging 61
- **F. Loading and Deck Layout** 70

III. AST2 Moorings 72
- **A. Overview** 72
- **B. Coastal Pioneer Surface Mooring** 76
  - 1. Buoy Instrumentation 76
  - 2. Subsurface Instrumentation 77
  - 3. Telemetry 78
  - 4. Power Systems 83
  - 5. Data Logging 84
- **C. Coastal Pioneer Profiling Mooring** 85
  - 1. Buoy Instrumentation 85
  - 2. Telemetry 86
  - 3. Power 88
  - 4. Data Logging 90
- **D. Global Hybrid Profiler Mooring** 91
  - 1. GHP Mooring Components Overview 91
  - 2. SIO Instrumentation 92
  - 3. Communication and Telemetry 93

4. Mooring Design and Analysis 97
E. Biofouling Tests 100
Scope 100
Purpose 100
Method 100
Deployment 101
Test Substrates 101
Biofouling Assessment 101
Substrate Retrieval 102
Precautions and Warnings 102
Recovery Precautions 102
IV. Mooring Deployments 105
A. Coastal Pioneer Surface Mooring 105
B. Coastal Pioneer Profiler Mooring 107
C. Global Hybrid Profiler Mooring 109
V. At Sea Test and Verification 111
A. Coastal Pioneer Surface Mooring 111
1. Bulk Meteorology 111
2. At sea electronics verifications 114
3. Other instruments 131
B. Coastal Pioneer Profiler Mooring 136
C. Global Hybrid Profiler Mooring 142
Thanks and Acknowledgments 143
References: 144
Appendix 1: Cruise Participants 145
Appendix 2: Mooring log – Coastal Pioneer Surface Mooring 146
Appendix 3: Mooring Log – Coastal Pioneer Profiler Mooring 150
Appendix 4: Mooring Log – Global Hybrid Profiler Mooring 156
Appendix 5: BULK Met Calibration Documents 160
Appendix 6: MMP Deployment parameters 166
Appendix 7: Long Ranger ADCP configuration file 168
Appendix 8: RBR TWR 2050 Configuration for deployment 170
Appendix 9: CPM Menubar Help 176
Appendix 10: DCL Menubar Help 178
Appendix 11: STC Menubar Help 180
Appendix 12: CPM Error codes 182
Appendix 13: Platcon Electronic Serial Number Locations 184
Appendix 14: Communication Phone numbers and Addresses: 186
Appendix 15: Potential CGSN Optical 187

Appendix 16: ASTM D 6990-05 190
Appendix 17: Trilux 33 Product Datasheet 202
Appendix 18: Trilux 33 Product MSDS 204

List of Figures

Figure 1: Pioneer Array schematic with CSM type circled in red, CPM type circled in green. 2
Figure 2: Endurance Array, Washington line with CSM type circled in red, CPM type circled in green. 2
Figure 3: Global array design, with GHP circled in red. 3
Figure 4: An overview of the location of the moorings deployed on AST2. The CPPM and CPSM were deployed at the site marked 'Coastal" where the water was approximately 520m deep, and the GHP was deployed at the site marked 'Global' where the water was 2480m. 4
Figure 5: Cruise track of *R/V Oceanus* from September 22 to 26, 2011 during the AST2 deployment cruise. Isobaths are every 500m, so the activity for CPSM and CPPM deployments is seen close to the 500m isobaths, while that for the GHP deployment is seen near the 2500m isobath. 6
Figure 6: Overview plots of the underway shipboard data collected during *R/V Oceanus* Cruise 475. 9
Figure 7: Photo of the CPSM halo with bulk met sensor. 12
Figure 8: Plot of air temperature from 3 adjacent systems, Logger L03 = Blue and Logger L06=Green installed on the NTAS-11 Buoy burning in on the test pad. The CPSM Logger (OOIL-001 = Red) was installed near the NTAS=11 Buoy on day 256. Note the good correlation of air temperature data on day 256-257. Prior to day 256 the CPSM buoy logged temperatures in the highbay. 14
Figure 9: Plots of Barometric pressure from three adjacent systems. NTAS-11 buoy with Loggers L03 = Blue and L06= Green compared to OOIL01-001 installed on the CPSM buoy. Note the good correlation of pressure data day 246-257, 2011. 14
Figure 10: Plots of Conductivity from the two systems mounted on the NTAS-11 buoy (Blue and Green) and the CT sensor mounted on the CPSM buoy. The CPSM CT sensor was located in a separate test bucket and correlation is not expected. 15
Figure 11: Plots of Long Wave Radiation from the NTAS-11 systems (Blue and Green) compared to the CPSM sensor (Red). Note the good correlation of data when the CPSM buoy was moved from the Clark South Hghbay on day 256 to the test pad where the system installed on the NTAS-11 buoy were buring in. 15
Figure 12: Precipitation data plot from the CPSM buoy. 16
Figure 13: Plots of Humidity and Relative Humidity from the NTAS-11 Buoy (Blue and Green) compared to the CPSM buoy Red. On day 256 systems were co-located and show good data correlation. 16
Figure 14: Sea Surface Temperature Data from SeaBird microcats (SBE-37). Note instrumnets were not in the same bucket and therfore correlation is not expected. 17

Figure 15: Plots of Short Wave Radiation from the NTAS-11 systems (Blue and Green) compared to the CPSM sensor (Red). Note the good correlation of data when the CPSM buoy was moved from the Clark South Hghbay on day 256 to the test pad where the system installed on the NTAS-11 buoy were buring in. 17
Figure 16: East component of wind from the NTAS-11 systems (Blue and Green) compared to the CPSM sensor (Red). Note the good correlation of data when the CPSM buoy was moved from the Clark South Hghbay on day 256 to the test pad where the system installed on the NTAS-11 buoy were buring in. 18
Figure 17: North component of wind from the NTAS-11 systems (Blue and Green) compared to the CPSM sensor (Red). The CPSM buoy was moved from the Clark South Hghbay on day 256 to the test pad where the system installed on the NTAS-11 buoy were buring in.................. 18
Figure 18: Wind speed from the NTAS-11 systems (Blue and Green) compared to the CPSM sensor (Red). The CPSM buoy was moved from the Clark South Hghbay on day 256 to the test pad where the system installed on the NTAS-11 buoy were buring in. 19
Figure 19: Plot of compass headings during the buoy spin test. Buoy was rotated in 45 degree steps for a complete rotation. Each heading was maintained for a minumum of 15 minutes. 19
Figure 20: End view of the NSIF loaded on *R/V Oceanus*. EM Chain is mechanically electrically connected to the Surface Buoy. Instruments mounted in the frame include: Nortek Point Velocity (twelve o'clock), Fluorometers (three and six o'clock), and CTD (ten o'clock.) 21
Figure 21: NSIF side view. The SeaBird CTD (white) and the DCL pressure housing (silver) are visible. The EM Chain is mounted at the center on the right (top) and the EOM cable is on the left (lower). Data from the instruments are collected in the DCL. 21
Figure 22: Engineer Kathleen McMonagle spins the ADCP frame during a compass calibration... 23
Figure 23: Laptop configured with wifi and RFM to communicate with the buoy. 27
Figure 24: Terminal Emulator screen showing the boot process........................ 29
Figure 25: Command line (DOS) prompt: "ping" to test for network connectivity 30
Figure 26: Secure Shell Configuration. 30
Figure 27: Test and verification of WiFi connection 31
Figure 28: PSC command (no psc currently attached) 32
Figure 29: Wireless network connection location.. 32
Figure 30: Wireless network settings 33
Figure 31: Initial PlatCon set up on bench for Integration, Verification, and Testing 34
Figure 32: PlatCon-PSC I V and T 36

Figure 33: pCO2 DB-9 serial connector dissasembled to confirm serial wiring. 38
Figure 34: "U" transmitted from DCL to laptop 38
Figure 35: "U" transmitted to DCL from laptop 39
Figure 36: Channel 1 demonstrating the loading on the Tx line. 39
Figure 37: Initial DCL-pCO2 connection. 40
Figure 38: Characters only go through when pCO2 not in shutdown. 40
Figure 39: With 1kΩ resistor in series. 41
Figure 40: Laptop connected after 5k resistor installed in R16 41
Figure 41: pCO2 RS-232 transceiver and IRQ2 42
Figure 412: PlatCon, wiring and Telemetry Verification and Test. Platcon (left), buoy junction panel (white), and telemetry modules (right) with covers removed. 43
Figure 43: The surface mooring, em-chain, and NSIF are lowered into the well for testing. 45
Figure 44: Near Surface Instrument Frame CTD Data 46
Figure 45: NSIF Mounted Single Channel Fluorometer Data 46
Figure 46: NSIF Mounted Three Channel Fluorometer Data 47
Figure 427: Surface mooring load cell measuring dry weight (6860 lbs.) prior to loading on the *R/V Oceanus*. 48
Figure 48: Difference between heading and measured heading values plotted 49
Figure 49: Logger/SWND/compass plot shows the 8 steps of 45 degrees during the buoy spin. 50
Figure 50: Photo showing the initial integration test at CRL with the components of the Profiler Mooring laid out on the floor including the 50 ft whale stretch hose, 451m inductive cable with special inductive terminations, jumpers, and custom loop 51
Figure 51: Photo showing profiler inductive cable on the wooden reel, the telemetry test stand in the background and the MMP in its special handling cart. Testing outside Jeff O'Brein's office included testing the platform controller (STC) with the instruments. 52
Figure 52: Photo showing the anchor, SBE37-IM (mounted on the anchor frame) and MMP being 'deployed' lowered by the crane into the WHOI well. 53
Figure 53: SBE37-IM data collected during the well MMP well test. The spike on Friday September 9th represents a quick recovery of the system to check the wire and add an isolation bushing. The system was redeployed into the well until Monday afternoon. 54
Figure 54: SBE37-IM = MC02 pressure data (red) compared with NOAA Woods Hole tide data (blue) offset by 15m (green) shows solid correlation in tidal pressure changes confirming the SBE37-IM was functioning.... 54
Figure 55: Quick plot of MMP CTD data. Colored lines represent individual profiles, Salinity (left), Temperature (center) and Dissolved Oxygen (right). Profile depth ranges (12+ meters) agree with the wire length used in the well set up 55

FIGURE 56: TEMPERATURE VS PROFILES SHOWS THE TEMPERATURE DATA RANGE PLOTTED FOR EACH PROFILE. 55
FIGURE 57: SALINITY VS PROFILE SHOWS THE SALINITY RANGE FOR EACH PROFILE. 56
FIGURE 58: PAR VS DEPTH SHOWS RAW PAR DATA AS A FUNCTION OF DEPTH. THE HIGH NUMBER OF ZERO DATA POINTS IS CAUSED DURING THE 'SENSOR WARM UP' PERIOD OF THE MMP. THE MMP STARTS LOGGING DATA PRIOR TO THE ACTUAL SENSOR BEING TURNED ON AND RECORDS THE VALUES AS A ZERO. 56
FIGURE 59: BBFLT2 FLUOROMETRY DATA (SCATTERING, CHLOROPHYLL MG/L, AND CDOM PPB) PLOTTED AS A FUNCTION OF DEPTH. THIS PLOT SHOW SELECTED PROFILES FROM SEPT 6TH AND 7TH. 57
FIGURE 60: PHOTO SHOWING THE FLOAT TEST PROFILER MOORING IN THE WHOI WELL. THIS TEST ESTABLISHED THAT THE WEIGHT AND BALANCE OF THE BUOY WAS CORRECT ACCORDING TO THE DESIGN. 58
FIGURE 61: BATTERIES WIRED TOGETHER IN THE BOTTOM LAYER 62
FIGURE 62: PHOTO SHOWING THE TEMPORARY PLYWOOD SHELF THAT WAS USED TO ESTABLISH THE LOCATIONS OF THE PLATCON AND PSC TO DETERMINE WIRE HARNESS LENGTHS. 63
FIGURE 63: MIDDLE LAYER HOLDING THE BULK MET DATA LOGGER BACK UP BATTERIES AND ENGINEERING SENSOR BOX. 64
FIGURE 64: PHOTO SHOWING THE TOP LAYER WITH THE COMPLETED PLATCON AND PSC INSTALLED. 65
FIGURE 65: BULK MET JUNCTION PANEL BEING WIRED. 66
FIGURE 66: COMPLETED SURFACE MOORING WELL ON THE BURN IN PAD PRIOR TO THE COMPASS SPIN TEST. 67
FIGURE 67: BUOY WELL BEING INSERTED INTO THE FOAM BUOY. 68
FIGURE 68: SURFACE BUOY ON 'LOW BOY' FLAT-BED BEING DELIVERED TO THE SHIP. 69
FIGURE 69: A FLAT BED TRAILER WAS REQUIRED TO MOVE SEACYCLER FROM CRL TO THE DOCK. 70
FIGURE 70: SEACYCLER BEING LIFTER FROM TRAILER TO LOAD ONTO THE DECK OF R/V OCEANUS. 71
FIGURE 71: DECK LAYOUT OF *R/V OCEANUS*. UPPER PANEL SHOWS DECK, WITHOUT AST2 GEAR. LOWER PANEL SHOWS AST2 GEAR PLACEMENT ON DECK. 71
FIGURE72: COASTAL PIONEER SURFACE MOORING DIAGRAM. 73
FIGURE 73: COASTAL PIONEER PROFILER MOORING AS DEPLOYED IN AST2. 74
FIGURE 74: GLOBAL HYBRID PROFILER MOORING AS DEPLOYED IN AST2. 75
FIGURE 75: PHOTOS SHOWING THE PLIMSOLL ON THE BUOY DURING THE DOCK WELL TEST (LEFT) AND DEPLOYED (RIGHT). THE DECK HEIGHT ABOVE THE WATER LINE IS 32CM AND WAS USED IN THE ABOVE EQUATION TO CORRECT THE HEIGHT OF THE BULK MET SENSORS ABOVE THE SURFACE. 77
FIGURE 76: CPSM TELEMETRY SUITE 79
FIGURE 77: THE CPSM TELEMETRY AS SEEN FROM BELOW THE HALO. 81
FIGURE 78: TWO EMERGENCY BEACONS ARE MOUNTED ON THE BUOY UNDERSIDE. 82
FIGURE 79: FLEET BROADBAND BELOW DECK UNIT (BDU) ENCLOSURE. 82
FIGURE 80: A COMMON ENCLOSURE HOUSES FIVE VERSIONS OF TELEMETRY. 83
FIGURE 81: COASTAL SURFACE BUOY POWER SYSTEM BLOCK DIAGRAM 84
FIGURE 82: CPPM SURFACE BUOY TELEMETRY SUITE. 87

Figure 83: Battery Puck Internal Wiring ... 89
Figure 84: Alkaline Battery Pack used in Coastal Pioneer Profiler Mooring . 89
Figure 85: Emergency beacons located on the CPPM subsurface float. ... 90
Figure 86: AST2 GHPM Block Diagram (3607-00062) ... 94
Figure 87: AST2 GHP Mooring ... 97
Figure 88: Top left: shows calculations of backup bouyancy for each mooring element. Top right: shows tension loads for each element assuming no current. Bottom left: Launch tension loads for each element. Bottom right: acutal load cell data showing tension in the lower load during deployment. ... 99
Figure 89: (a) test samples mounted on the AST2 Surface Buoy, (b) test samples mounted on the AST2 NSIF, (c) location of test samples on the NSIF, (d) location of test samples on the SAT2 BARF, and (e) test samples mounted on the AST2 BARF. ... 103
Figure 90: Track during the deployment of the CPSM. ... 106
Figure 91: Deploy track of the CPPM. ... 108
Figure 92: Deployment of the GHP. The ship was intially set up to steam from the north but was repositioned to steam from the southwest due to a sind shift. ... 109
Figure 93: Overplot of ship and buoy air temperatures. ... 111
Figure 94: Overplot of ship and buoy relative humidities. ... 111
Figure 95: Overplot of ship and buoy incoming shortwave radiation. ... 112
Figure 96: Overplot of ship and buoy barometric pressure. ... 113
Figure 97: Overplot of ship and buoy rain accumulation. ... 113
Figure 98: Overplot of ship and buoy wind speed. ... 114
Figure 99: Overplot of ship and buoy wind direction. ... 114
Figure 100: Shipboard telemetry configuration for AST2 site testing. ... 115
Figure 101: Plot of CPSM load cell tension in pounds vs. time. The gradual increase in tension occurs as the anchor is lowered. When the anchor was released there is a short spike in tension as the anchor falls the short distance to the seabed. ... 116
Figure 102: CPSM Platcon diagram showing dual CPMs and multiple DCLs, as deployed for AST2 ... 117
Figure 103: Photo showing status panel located in the junction box. J-Box panel was made from clear plastic so that status LED lights could be seen. ... 119
Figure 104: CPSM Control Screen ... 122
Figure 105: CPM only Real Time Status Display box ... 123
Figure 106: CPM status box (top table) ... 124
Figure 107: PSC status box ... 125
Figure 108: A hyperlink menu table located above and below the control screens provides links to system files and data plots. ... 126
Figure 109: Table of text files for CPM and DCL. ... 127
Figure 110: PSC plots ... 128
Figure 111: PSC current delivered to CPSM system. ... 129
Figure 112: Close up of wind turbine current generation. ... 129

Figure 113: ASIMET data plots. 130
Figure 114: Figure 13: Motion Pack data 131
Figure 115: Motion Pack Instrument Port Data; This instrument port data shows four separate values; Port state: On or off, the transition to a 50% duty cycle at ~11:00 is clear. 131
Figure 116: Surface mooring status panel. Right most panel lower half shows status of NSIF instrumentation. The eco-dfls and eco-vsfs cells are colored yellow because the sampling schedule (30 minutes at the top of the hour) has them powered down. 132
Figure 117: Zoom in on the 'Data Dir Summary' indicating the file size and last modified time of the file. NSIF instruments cells are green indicating the status is good. 132
Figure 118: Wetlabs DFLS data indicates a malfunctioning sensor. 133
Figure 119: VSFS data shortly after deployment. 133
Figure 120: VSFS data after being deployed for a day. Note the 30 minute sampling pattern on the hour. 134
Figure 121: Aquadopp current data E, N, U in mm/s 134
Figure 122: CTD data just prior to and during the deployment. 135
Figure 123: A 4-hour segment of CTD data after deployment. 135
Figure 124: STC based platform controller for CPPM, combines subset of telemetry and data acquisition elements of CPM and DCL combination 137
Figure 125: Dashboard display for CPPM, taken from the day of the AST2 deployment. 138
Figure 126: Sample plots form the CPPM motion sensor 139
Figure 127: CPPM Profiler CTD data from 09/26/2011 0000Z downcast 140
Figure 128: CPPM Profiler CDOM, DO, PAR and Engineering data from 09/26/2011 0000Z downcast 141
Figure 129: Data example from the SeaBird µCAT CTD at approx. 480m, 09/26/2011 141
Figure 130: First five profiler profiles of Salinity, Temperature and Dissolved Oxeygen (blue) overplotted with the CTD cast (magenta) 142

List of Tables

TABLE 1: TEST REPORT AND QUICK LOOK REPORT REFERENCE DOCUMENT TABLE. 10
TABLE 2: AIR SEA INTERFACE INSTRUMENTS (OR BULK–MET), ABBREVIATED SENSOR NAME AND SERIAL NUMBERS 10
TABLE 3: NSIF INSTRUMENTS MOUNTED IN THE AST2 FRAME AT 7 METERS..................... 20
TABLE 5: PLATCON TEST MATRIX.. 35
TABLE 6: SENSOR CONNECTION AND VERIFICATION TABLE 36
TABLE 7: INITIAL TELEMETRY INTERFACE, VERIFICATION AND TESTING CHECKLIST 42
TABLE 8: INITIAL TELEMETRY INTERFACE, CPM-DCL, AND SENSOR VERIFICATION AND TESTING CHECKLIST 44
TABLE 9: ACTUAL HEADING VALUES 49
TABLE 10: INSTRUMENT HEIGHT (DEPTH) REFERENCED TO THE OCEAN SURFACE. 76
TABLE 11: NSIF INSTRUMENTATION 78
TABLE 12: INSTRUMENTS ON THE PROFILER MOORING 86
TABLE 13: INSTRUMENTS INSTALLED ON THE AST2 GHP MOORING. 92
TABLE 14: AST2 HYBRID PROFILER MOORING SAMPLING STRATEGY ASSUMING A 6-MONTH DEPLOYMENT. 94
TABLE 15: AST2 HYBRID PROFILER MOORING DATA LOGGING AND TELEMETRY OVERVIEW 96
TABLE 16: PIONEER OPTICAL INSTRUMENTS - FIXED... 104
TABLE 17: PIONEER OPTICAL INSTRUMENTS - MOBILE 104
TABLE 18: AST2 OPTICAL INSTRUMENTS - FIXED.. 104
TABLE 19: AST2 OPTICAL INSTRUMENTS – MOBILE 105
TABLE 20: CPSM FUNCTIONALITY. 121

I. Introduction

A. Background and Purpose

The Coastal and Global Scale Nodes (CGSN) of the National Science Foundation's (NSF) Ocean Observatories Initiative (OOI) will deploy two Coastal Arrays, the Pioneer Array off the mid-Atlantic Bight, and the Endurance Array off Oregon and Washington. CGSN will also deploy four Global Arrays at high latitude locations, the Irminger Sea, the Gulf of Alaska, Argentine Basin, and 55°S off Chile. Design work on the moorings to be used in these arrays has been underway at Woods Hole Oceanographic Institution (WHOI) and at Scripps Institution of Oceanography (SIO.)

Prototype testing has played an important role in maturation of CSGN designs. The test deployment named At Sea Test 2 (AST2), conducted off the east coast of the United States, was structured to put in the field prototypes of three mooring types to be used in the CGSN coastal and global arrays. Specifically, AST2 was structured to test the Coastal Surface Mooring to be used at Pioneer and Endurance Arrays, as well as to test the Global Hybrid Profiler mooring to be used at the Global Arrays. The Coastal Surface Mooring type to be tested is circled in red in Figure 1 of the Pioneer Array and Figure 2 of the Washington line of the Endurance Array. In those same figures, the Coastal Profiler Mooring type to be tested is circled in green. Figure 3, a schematic of the Global Array design, has the Global Hybrid Profiler mooring circled in red.

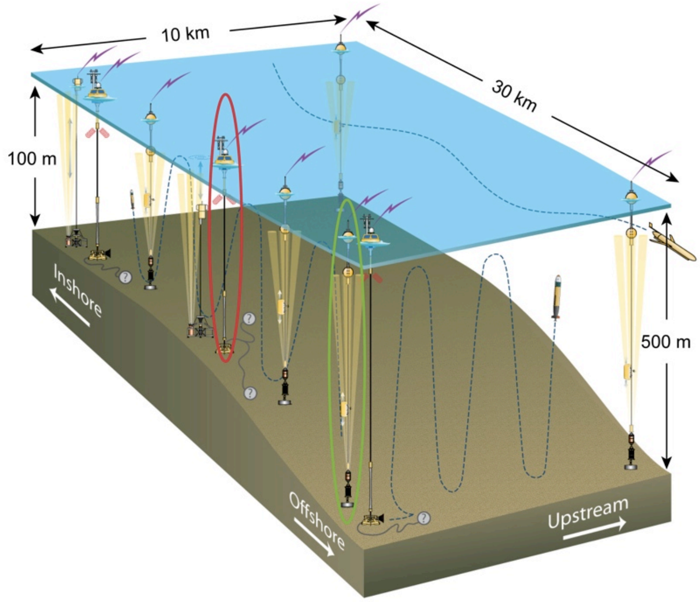


Figure 1: Pioneer Array schematic with CSM type circled in red, CPM type circled in green.

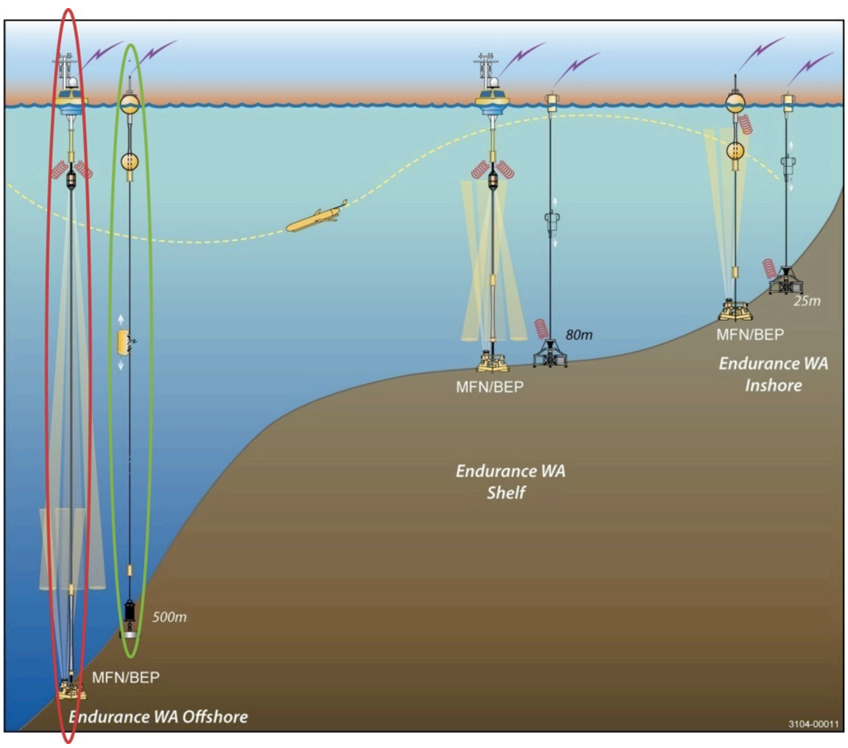


Figure 2: Endurance Array, Washington line with CSM type circled in red, CPM type circled in green.

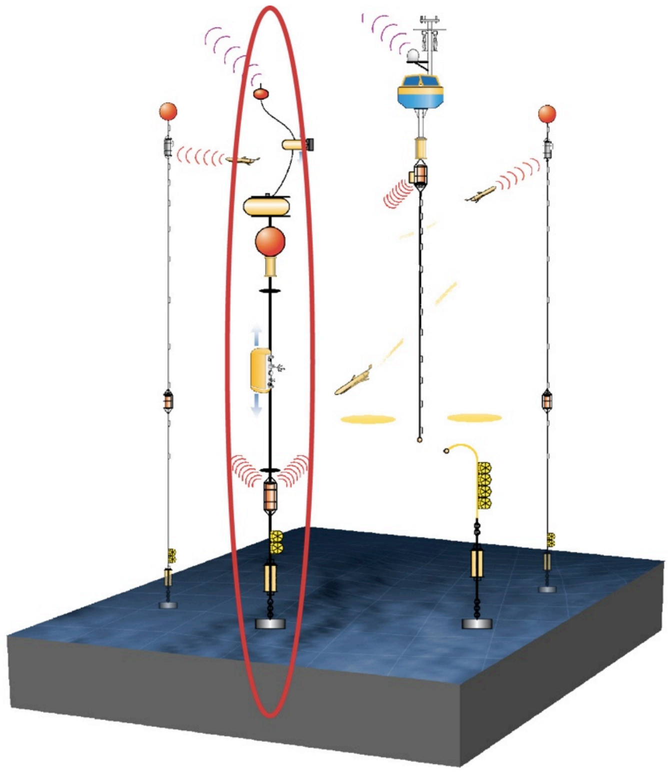


Figure 3: Global array design, with GHP circled in red.

The timing of AST2 was guided by the desire to have the moorings in their deployed locations over the winter, thus allowing them to experience winter wind and wave conditions. The location chosen was the Pioneer Array area and at a site further down the continental shelf. A site close to 500m water depth was chosen for the deployment of the Coastal Surface Mooring and the Coastal Profiler Mooring. A site further south and down the slope in 2,500m of water was chosen for the deployment of the Global Hybrid Profiler prototype mooring. Because of the use of the Pioneer site, the prototype Coastal Surface Mooring was labeled the Coastal Pioneer Surface Mooring or CPSM, and the prototype Coastal Profiler Mooring was labeled the Coastal Pioneer Profiler Mooring or CPPM. The Global Hybrid Profiler mooring was labeled the GHP. Figure 4 shows the locations for the 3 moorings.

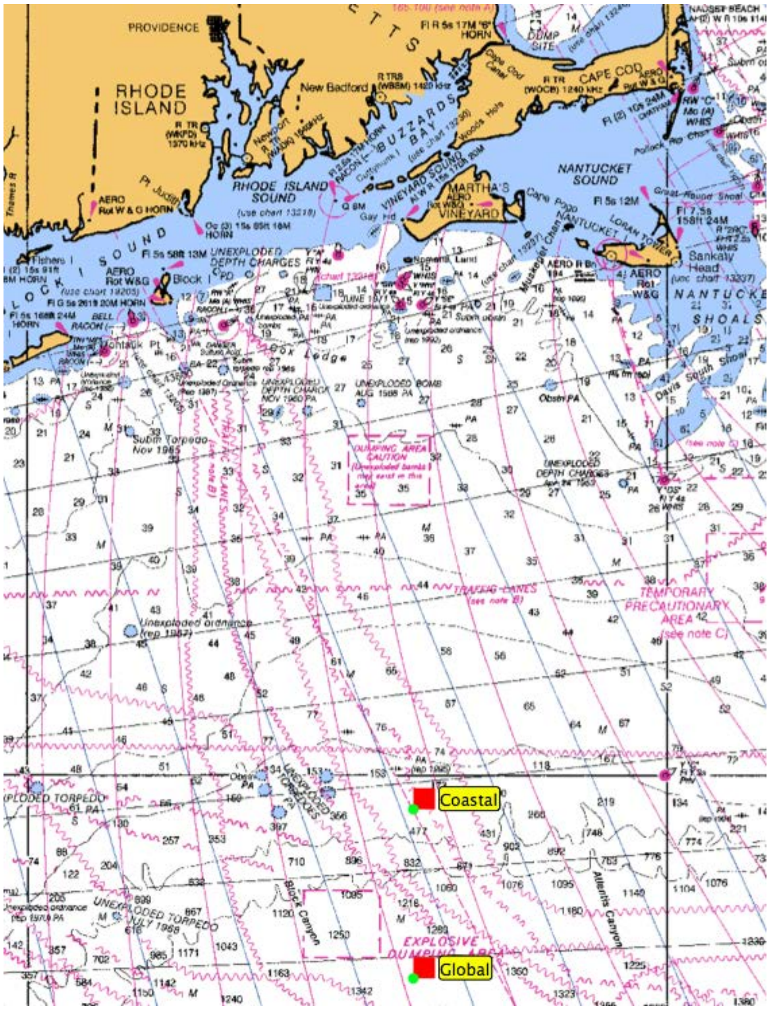


Figure 4: An overview of the location of the moorings deployed on AST2. The CPPM and CPSM were deployed at the site marked 'Coastal" where the water was approximately 520m deep, and the GHP was deployed at the site marked 'Global' where the water was 2480m.

The goals for AST2 are outlined in the AST2 Test Plan (3207-00003, At-Sea Test 2 Development Test (DT) Plan). They are summarized here to explain the goals of AST2 and thus the purpose of this cruise.

At Sea Test 2 had 9 primary goals: 1) Characterize Electro Mechanical EM hose and cable operation and durability at sea, including assessing communications links between the surface buoy and subsurface instruments and EM stretch hose aging and response under typical at-sea conditions; 2) Assessment of power generation/availability for the rechargeable power supply, including measuring wind generator power production under a range of conditions and characterization of the durability of these components at sea and measurement of solar power production in the field; 3) assessment of power consumption of primary power supplies of sensors and profilers under at-sea conditions;

4) documentation of platform controller functionality, telemetry functions, and data acquisition software, including tests of the platform controller and its associated software and telemetry functions in the field, tests of the telemetry system operation, durability, and power consumption, tests of the instrument interfaces, data acquisition hardware and software, and of exemplar instruments in the field, and assessment of connection durability for inductive telemetry links; 5) assessment of the effects of biofouling on sensor performance, including on profiler power consumption and profiler performance; 6) validation of procedures for deployment and recovery of the CGSN moorings; 7) test of the initial implementations of the Operations and Maintenance Center OMC software specific to basic health and status monitoring and control operations; 8) validation of mooring design analysis assumptions and performance through post-recovery data assimilation; and 9) validation of active radar target enhancer power consumption and visibility.

Ship and project scheduling efforts identified *R/V Oceanus* Cruise 475 on September 22-26, 2011 as the cruise for the deployment. An April 2012 cruise on *R/V Knorr* has been identified as the recovery cruise for AST2.

B. Cruise Chronology

The overall plan was to deploy the CPSM first, followed by the CPPM, and finally the GHP. The loading was done to stage the gear to facilitate this plan. The cruise track is shown in Figure 5.

September 19, 20, 21
Loading of the deck gear, moorings, and laboratory equipment began on Monday, September 19. The new Lantec heavy lift winch was installed on the O1 deck, and a TSE mooring winch was installed on the starboard side of the main deck.

September 22
With all the buoys loaded, as well as the components for the GHP and CPPM on deck, the last stage of loading was to pre-assemble and flake out on deck the stretch hose sections of the CPSM. These steps required coordinated use of a shore crane, which was done before sailing on the morning of the 22nd of September.

At 1200 local, *R/V Oceanus* departed, steaming south for the target site for the CPSM and CPPM. Nominally, the plan was to deploy the CPSM and CPPM 1,000m apart, one 500m west of the target location identified in the permit, 39° 55.0’N, 70° 47.5’W.

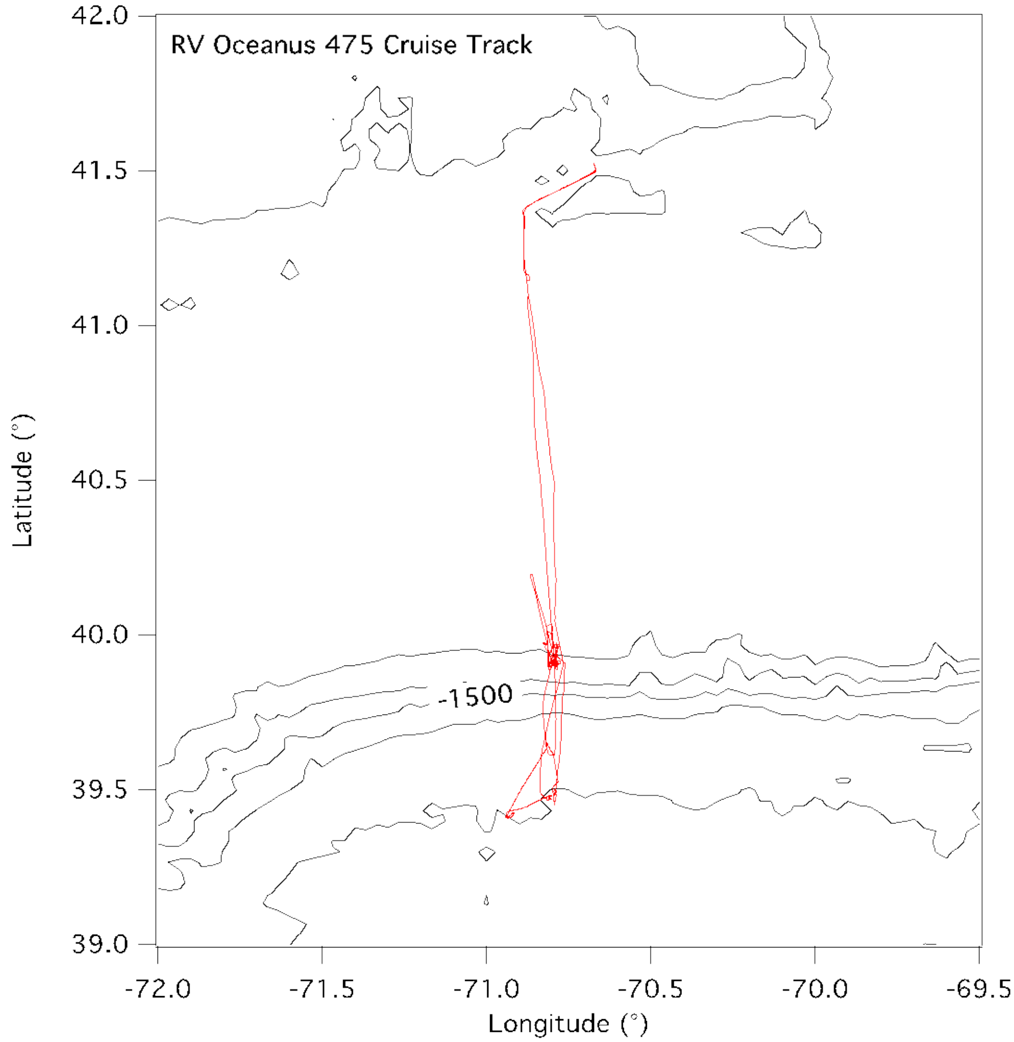


Figure 5: Cruise track of *R/V Oceanus* from September 22 to 26, 2011 during the AST2 deployment cruise. Isobaths are every 500m, so the activity for CPSM and CPPM deployments is seen close to the 500m isobaths, while that for the GHP deployment is seen near the 2500m isobath.

September 23

The target depth sought for the deployment of both CPSM and CPPM was 520m. The ship's Knudsen 12 KHz depth recorder was already corrected for the depth of the transducer. Matthew's Table provided a 4m correction to the depth of the Knudsen display (which uses 1,500 m/s for sound speed) for the local hydrography, so displayed depths of 524m were sought for the two moorings. At 0330 local a small-scale survey was done around the target site to find the two deployment sites, each with 520m of water depth. The wind was out of the south so a deployment course due to south, starting 4 nm north northeast of the target, was planned. At 0730 local the starboard bulwarks were removed and the deployment of the CPSM began with the surface buoy over first.

Deployment of gear continued, leading up to the BARF (Benthic Anchor Recovery Frame) being hung from a release over the stern as the ship was navigated to the target site. The BARF was lowered to within 20m of the bottom, and when the ship was approximately 60m past the target, the BARF was released to fall to the bottom. Following the CPSM deployment, the ship remained stationed nearby for 40 minutes to allow the mooring to settle out. A CTD cast was done, and then Scripps Institution of Oceanography SIO and WHOI acoustic releases were lowered for in the water testing before being employed on the remaining moorings. After the release test, work began on deck to prepare for the CPPM deployment. At 1900 local, work on deck was halted to allow personnel to retire, with the intent of starting the CPPM deployment at 0500 local the following day. At night, *R/V Oceanus* made a 1-hour high speed turn to blow out carbon from the engine exhaust that had accumulated during low speed mooring operations.

September 24
At 0400 local a check of the winds and currents showed the conditions experienced on the 23rd continued, and *R/V Oceanus* was positioned to the north north-east of the CPPM anchor target site to begin deployment. At 0500 local the surface buoy went over and deployment began. Soon after, it was learned that the magnet that shut down CPPM data logging had been reinstalled overnight, with the conclusion that the buoy had been deployed with the data loggers turned off. With the buoy trailing aft of the ship, the ship's small boat was deployed to send personnel (Matt Palanza and Walt Waldorf) out to pull the magnet off and start logging. Once this was done and the small boat recovered, the deployment continued. The deployment finished with the anchor being lowered close to the bottom on the trawl wire with an acoustic release. When the ship steamed 60m past the target, the release was tripped, allowing the anchor to fall to the bottom. With the exception of a period when the ship again ran off station at speed to burn out carbon, the ship stayed on station near the CPPM and CPSM to collect shipboard data for comparison with the moorings.

September 25
At 0330 local, a bathymetry watch began as the ship steamed south toward the nominal target of the GHP. The goal was a deployment in 2,480m of water to accommodate the mooring design. Matthews Tables pointed to a – 16m correction to the depth based on 1,500 m/s sound speed, so an observed depth on the Knudsen of 2,496m was sought. Initial thinking was to again start in the north northeast and steam to the southwest against the wind. SIO personnel suggested a 6 nm distance for the mooring approach, but given there was a 0.3 knot current running to the south and that this was the first deployment of this compound profiler mooring, the decision was made to increase the approach distance to 8 nm.

The instrument and surface floats of the SeaCycler, which had been stored on the O1 deck, were moved to the main deck. During the move, a data cable connecting the floats failed, and the deployment operations were halted. While repairing the data cable, an atmospheric front passed through and winds shifted to come out of the northeast. Ocean currents continued to be towards the southwest. Captain Mello suggested a change in the approach track. The ship was repositioned 8 nm to the southwest to begin the deployment into the wind and current. First, the three components of the SeaCycler were deployed. Then, the remainder of the mooring, including the moored profiler, was deployed. During the deployment, SIO personnel made checks of the inductive connectivity along the mooring. The anchor was lowered on the trawl wire and deployed using an acoustic release. As the ship approached the target water depth, depths were noted and the release was triggered at 2030 local. The ship remained on station, close to the GHP to observe the first several profiles of the SeaCycler and verify its operation.

September 26
R/V Oceanus departed the GHP mooring site at 0200 local, to head back to Woods Hole. The ship docked at the WHOI dock at 1530 local.

C. Weather and Operating Conditions During the Cruise

Favorable conditions were encountered with winds out of the southwest for much of the cruise and some rain. Figure 6 summarizes the surface meteorology as recorded on board *R/V Oceanus.*

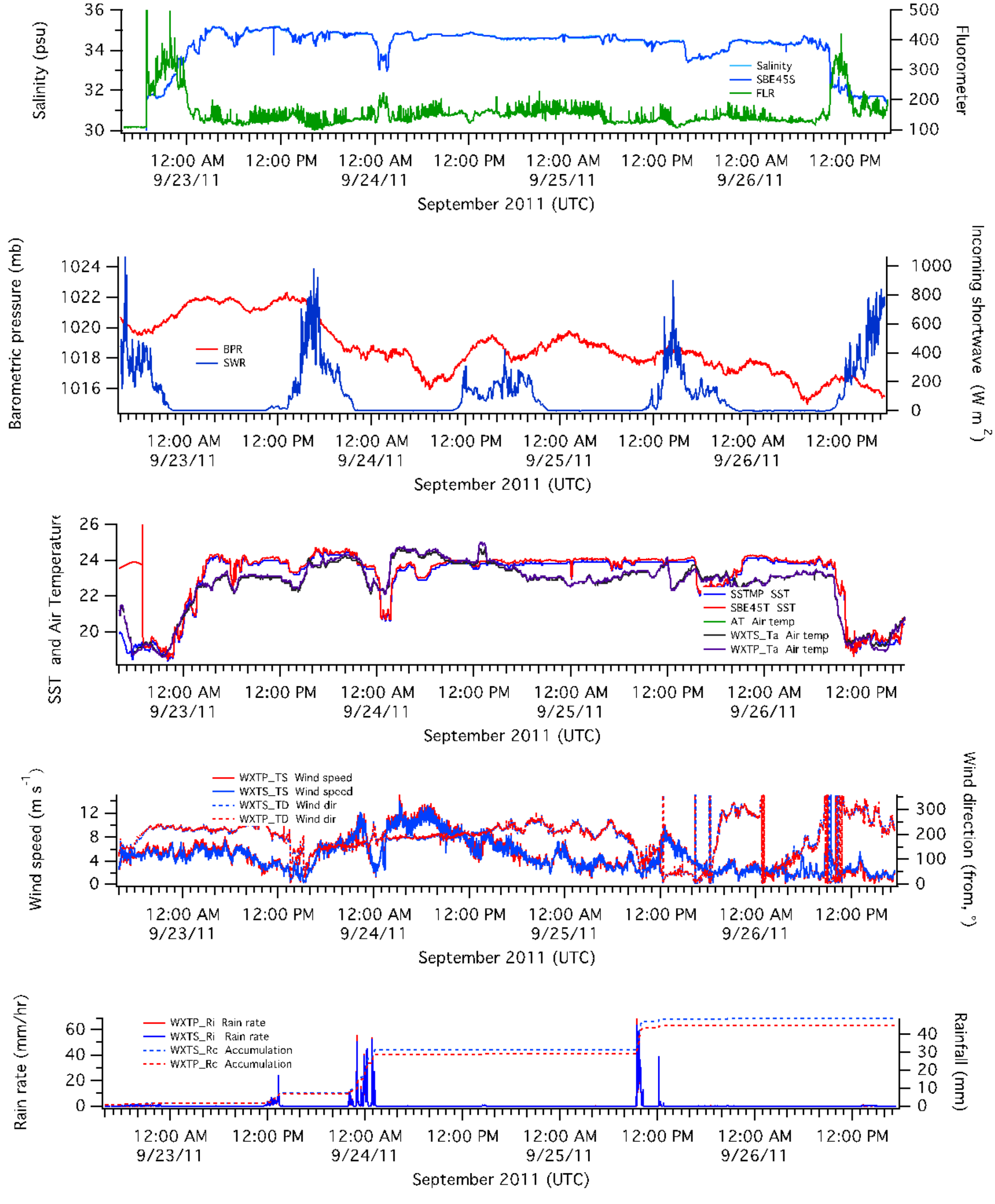


Figure 6: Overview plots of the underway shipboard data collected during *R/V Oceanus* Cruise 475.

II. Cruise Preparations

A. Sensor Evaluation and Burn-in

1. WHOI sensors

Table 1: Test report and quick look report reference document table.

Document number	Title
3207-00015	At Sea Test Instrument Qualification QLR
3207-00016	At Sea Test 2 CPPM Wire Following Profiler Test Report
3207-00022	Coastal Profiler Inductive Loop Riser Integration QLR

General procedure

Instruments were received and inspected, power applied, communication established, and data was collected to confirm they functioned and were not damaged during shipping. Collected data were checked to make sure that they were readable and made sense according to the environment where the instruments were tested.

After sensors were confirmed to work, they were passed along to the software team to write data logger drivers. Continued testing and characterization of instrument states was performed by the software team.

Burn – in

Most sensors were unable to receive an adequate burn-in due to the compressed nature of the buoy assembly and integration. The Bulk Met Package had several days of proper burn-in where the sensors were mounted in the specified locations and were run on the test pad in the vicinity of other similar systems. Plots of concurrent data sets showed good data correlation [Figures 8-18]. Subsurface instrumentation specifically on the NSIF was not burned-in. Rather, they were run fairly extensively during the driver development and system integration.

Bulk Met

Table 2 shows the bulk meteorological, or Air Sea Interface, instrumentation.

Table 2: Air Sea Interface instruments (or Bulk–met), abbreviated sensor name and serial numbers

Sensor	Abbreviation	Serial Number
Barometric Pressure	BPR	228
Humidity / Relative Humidity/ Temperature	HRH /AT	251
Wind speed and direction	WND	220
Precipitation	PRC	224

Short Wave Radiation	SWR	239
Long Wave Radiation	LWR	234
Sea Water Temperature and Conductivity	CT / SST	8028

OOI purchased a Bulk–met system ‘in-a-box’ from Star Engineering. The system included all the meteorological instrument modules and the data logger and cables used in similar systems on Upper Ocean Processes (UOP) moorings. The system is not complete until the modules are calibrated.

The UOP calibration lab run by Jason Smith completed the manufacturing of the modules. Smith calibrated the modules over several months from the initial delivery. The Short and Long Wave Radiation Sensors were mounted next to the standard sensors on the roof of the Clark building and were delayed until June and July in order to get a more direct sunlight angle and hence a better calibration (Appendix 5 Bulk Met calibration documentation).

The Bulk-met data logger was set up by Paul Bouchard and John Lund. The logger was inspected to verify that the jumpers were set correctly. Bouchard recommended that the power Field Effect Transistors FETs for each of the module circuits have a drop of solder added to the long side of the FET tab where it attaches to the board. These have detached from the circuit board in the past and caused problems. The jumper for the sonic wind was cut and a direct power connection was added to supply the sonic wind module power. The 2 GB ScanDisk flash card was replaced with a 256 MB card. The larger card memory is not required for a 1-year deployment and is problematic for the data logger code. The PCMCIA card converter was taped with clear packing tape to insulate the metal case from the lower circuit card. Smith burned the latest firmware into chip and installed it into the logger. Once the modifications were complete, Bouchard powered the logger and set it up, inputting the logger name and setting the defaults.

The bulk met system was one of the first instruments to have the data logger drivers written by Steve Lerner and Michael Eder. An identical system was borrowed from Dr. Tom Farrar (UOP scientist), which allowed the drivers to be written prior to actually receiving the system from Star Engineering. Once the system was running, it was kept running on the bench in order to develop the infrastructure to control and monitor the instruments out at sea. As the OOI Bulk Met system arrived and the modules were calibrated they replaced the UOP loaners that were running on the bench. In retrospect this was advantageous given the final assembly and burn-in of the mooring was compressed to make the ship departure deadline.

The Seabird SBE37 CT Sensor was powered on the bench. Communication was established with the vendor software. Temperature was reported and reflected reasonable room temperature values. Values increased when subjected briefly to warm air from a heat gun. Conductivity values were 0 but the sensor was dry. Internal batteries were not removed from the module since it is ‘controlled’ by the bulk met logger and not directly by the platform controller (PlatCon).

Metrological Sensor Checks

The AST2 tower is outfitted with one complete ASIMET system (Figure 7.) Included in the system are modules which measure Air Temperature (AT), Humidity / Relative Humidity (HRH), Barometric Pressure (BPR), Rain (PRC), Sonic Wind (SWND), Long Wave Radiation (LWR), Short Wave Radiation (SWR) and Sea Surface Temp./Cond. (SST).

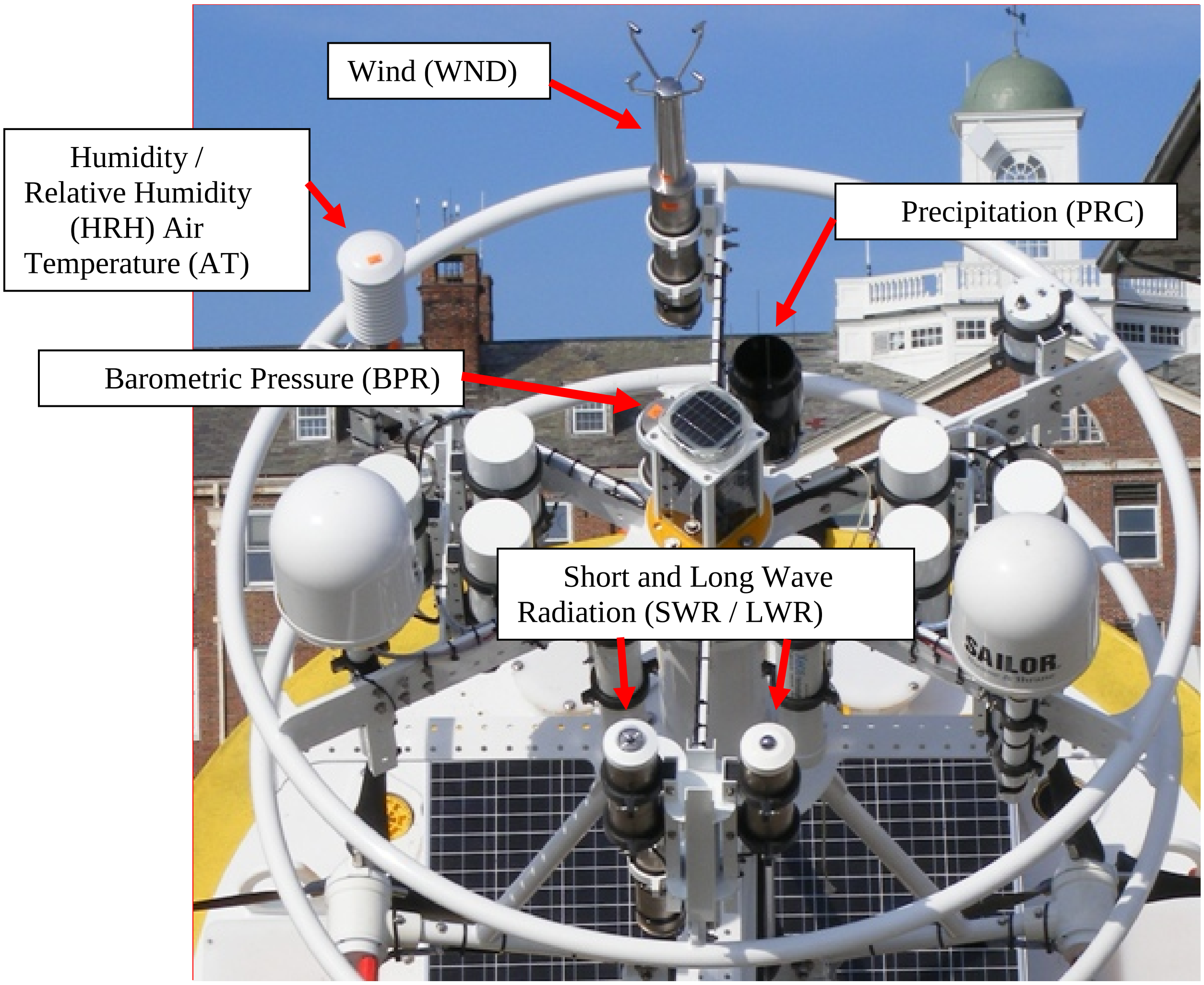


Figure 7: Photo of the CPSM halo with bulk met sensor.

After the modules were mounted on the buoy tower, the buoy was moved outside where it was placed adjacent to the UOP buoy scheduled for the NTAS11 deployment. The NTAS11 buoy also had a similar ASIMET system which was burning in on the pad and served as a good comparison for the CPSM sensors. Data from the NTAS 11 buoys (L-03/L-06) and the AST2 surface buoy (OOIL-001), are shown on the following plots. All three systems were plotted together and compared for performance. The results can be seen in the following plots (Figures 8-18.) Note that the CPSM buoy was moved outside at approximately 14:00 on day 256 as seen on the charts. The data in the plots compare favorably.

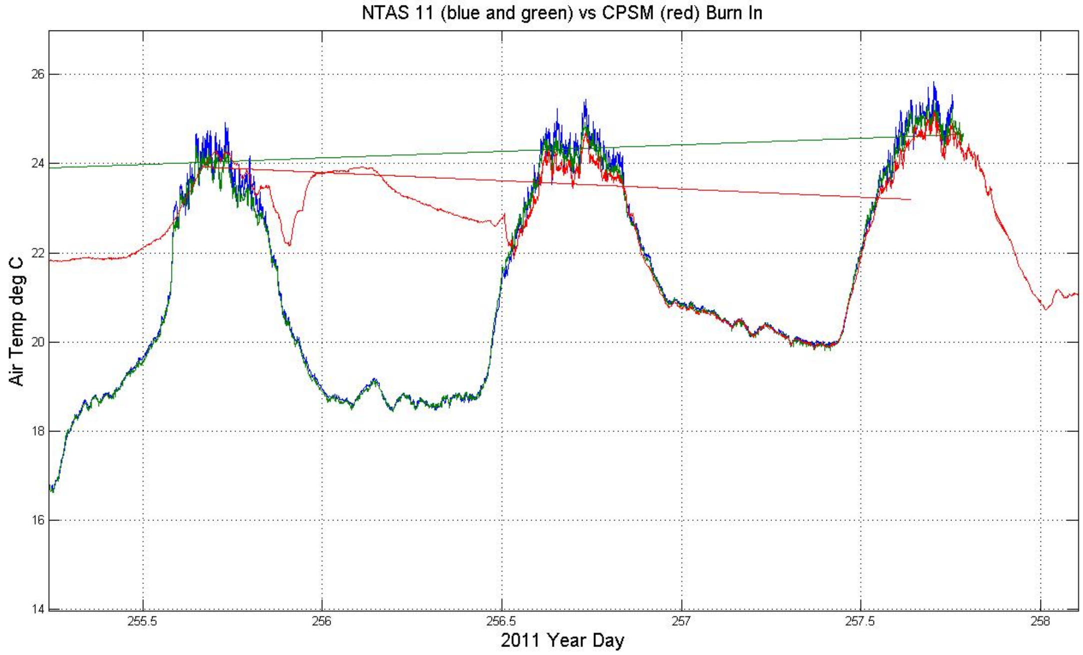


Figure 8: Plot of air temperature from 3 adjacent systems, Logger L03 = Blue and Logger L06=Green installed on the NTAS-11 Buoy burning in on the test pad. The CPSM Logger (OOIL-001 = Red) was installed near the NTAS=11 Buoy on day 256. Note the good correlation of air temperature data on day 256-257. Prior to day 256 the CPSM buoy logged temperatures in the highbay.

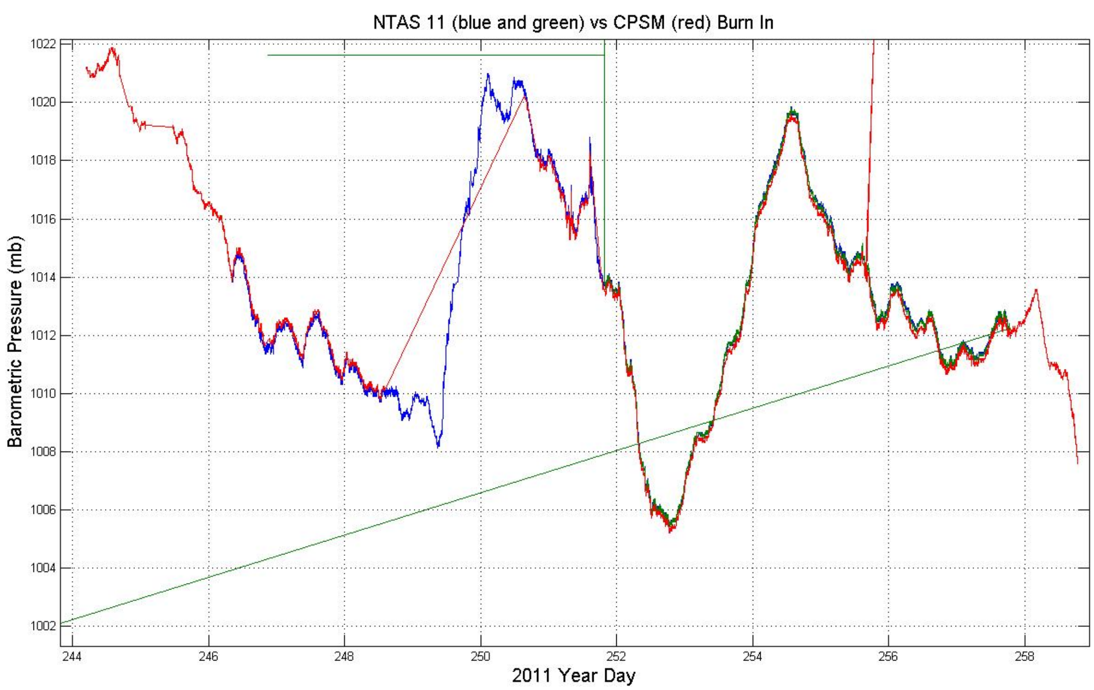


Figure 9: Plots of Barometric pressure from three adjacent systems. NTAS-11 buoy with Loggers L03 = Blue and L06= Green compared to OOIL01-001 installed on the CPSM buoy. Note the good correlation of pressure data day 246-257, 2011.

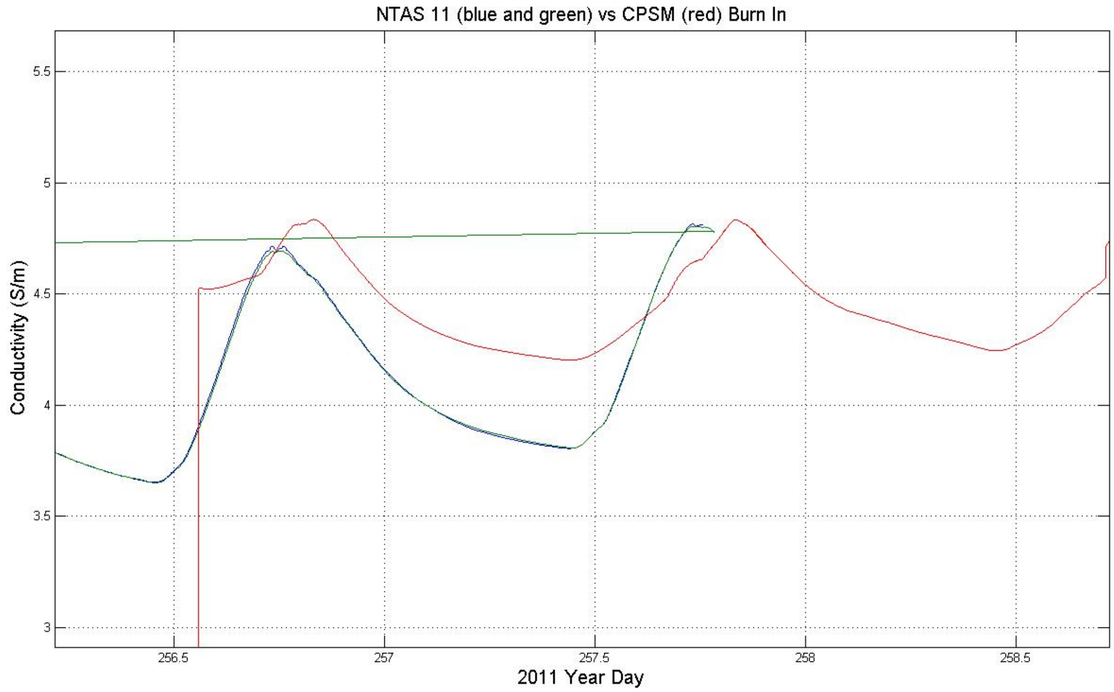


Figure 10: Plots of Conductivity from the two systems mounted on the NTAS-11 buoy (Blue and Green) and the CT sensor mounted on the CPSM buoy. The CPSM CT sensor was located in a separate test bucket and correlation is not expected.

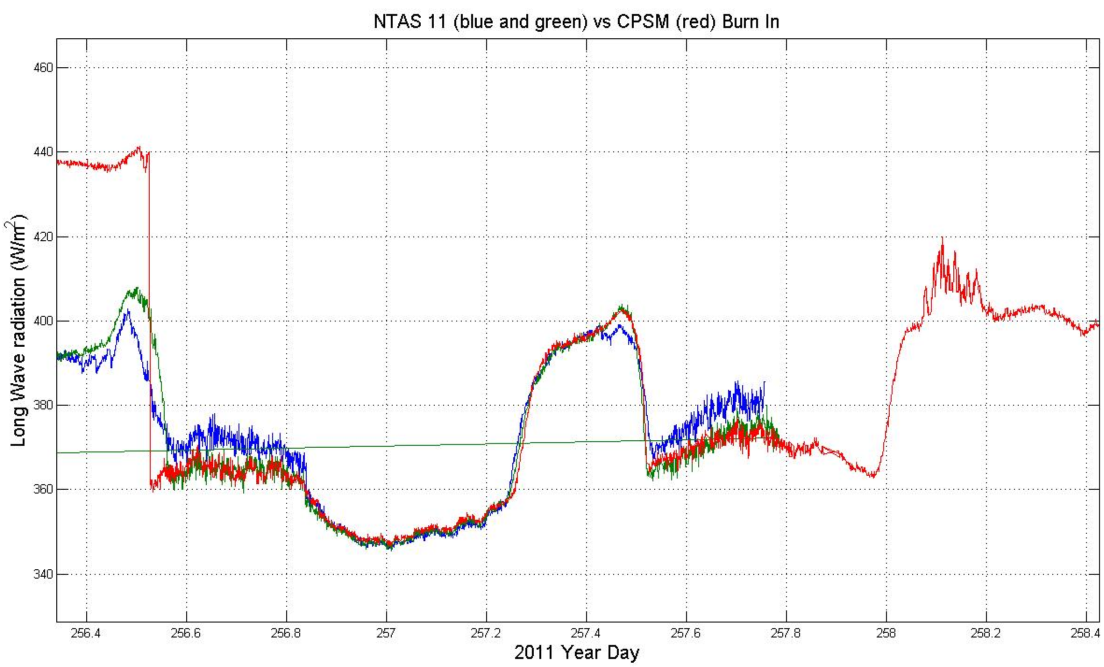


Figure 11: Plots of Long Wave Radiation from the NTAS-11 systems (Blue and Green) compared to the CPSM sensor (Red). Note the good correlation of data when the CPSM buoy was moved from the Clark South Hghbay on day 256 to the test pad where the system installed on the NTAS-11 buoy were buring in.

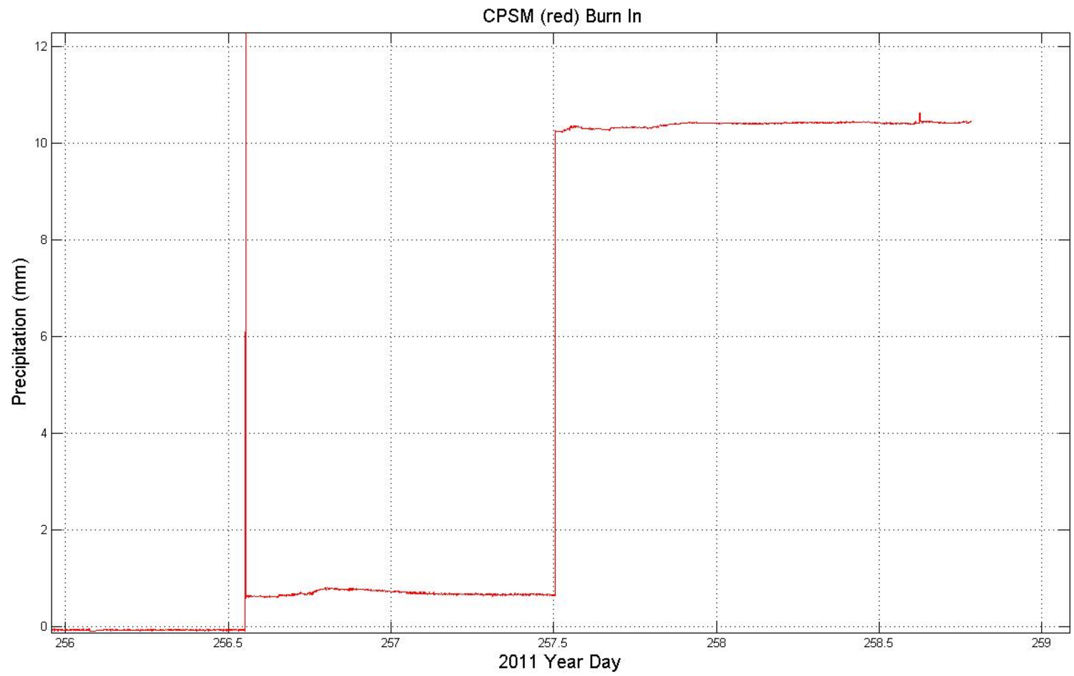


Figure 12: Precipitation data plot from the CPSM buoy.

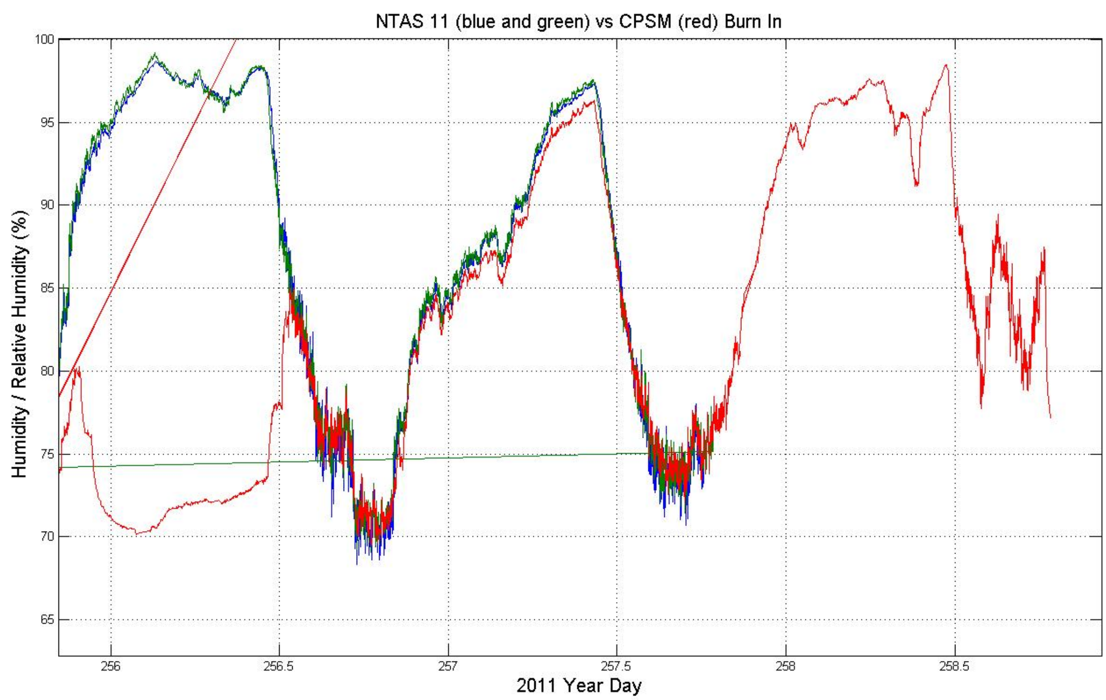


Figure 13: Plots of Humidity and Relative Humidity from the NTAS-11 Buoy (Blue and Green) compared to the CPSM buoy Red. On day 256 systems were co-located and show good data correlation.

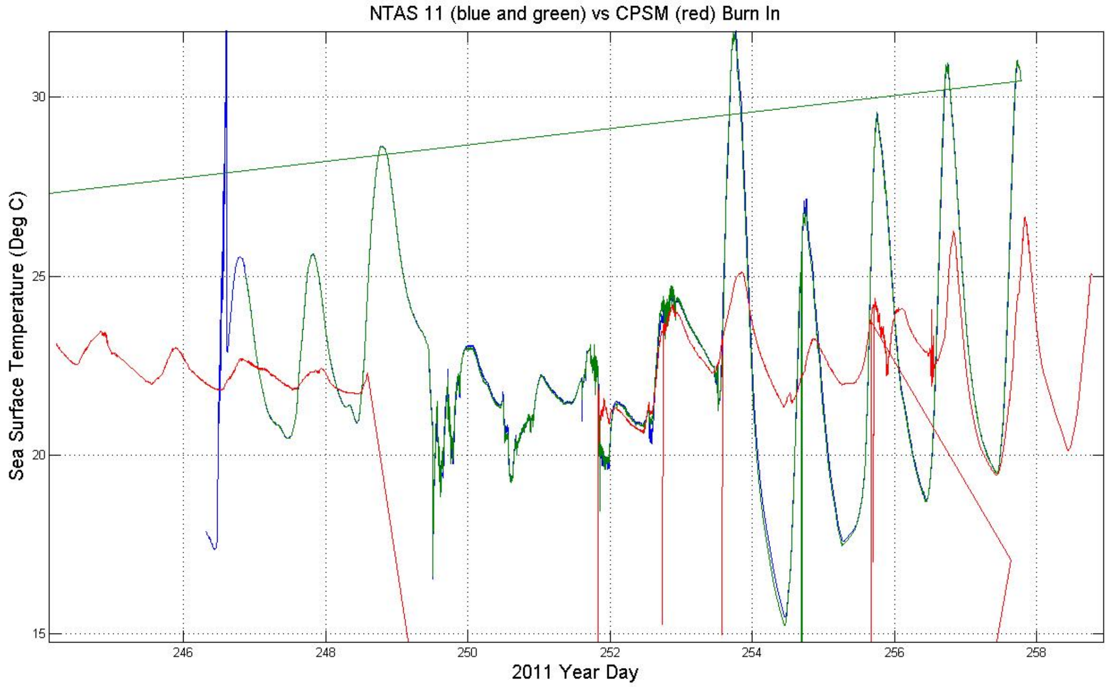


Figure 14: Sea Surface Temperature Data from SeaBird microcats (SBE-37). Note instrumnets were not in the same bucket and therfore correlation is not expected.

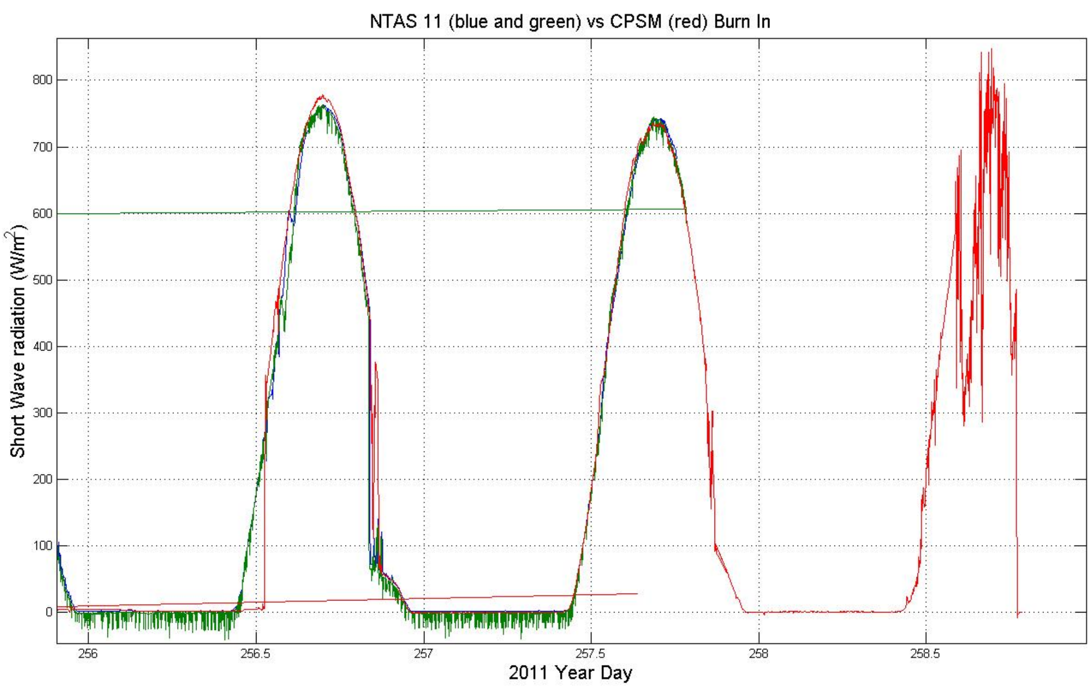


Figure 15: Plots of Short Wave Radiation from the NTAS-11 systems (Blue and Green) compared to the CPSM sensor (Red). Note the good correlation of data when the CPSM buoy was moved from the Clark South Hghbay on day 256 to the test pad where the system installed on the NTAS-11 buoy were buring in.

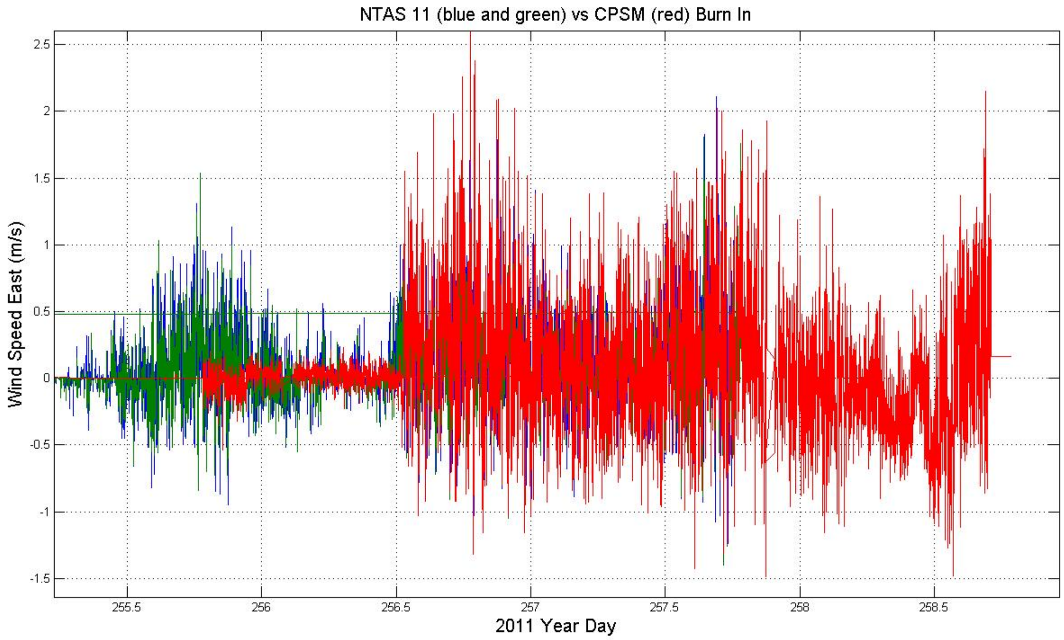


Figure 16: East component of wind from the NTAS-11 systems (Blue and Green) compared to the CPSM sensor (Red). Note the good correlation of data when the CPSM buoy was moved from the Clark South Hghbay on day 256 to the test pad where the system installed on the NTAS-11 buoy were buring in.

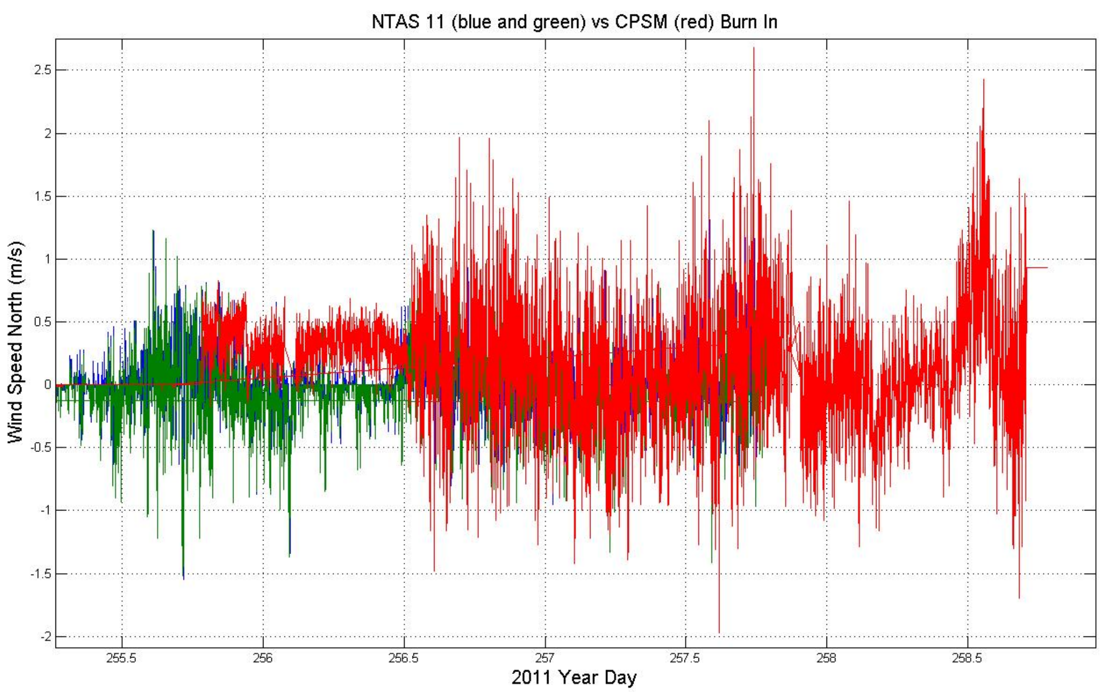


Figure 17: North component of wind from the NTAS-11 systems (Blue and Green) compared to the CPSM sensor (Red). The CPSM buoy was moved from the Clark South Hghbay on day 256 to the test pad where the system installed on the NTAS-11 buoy were buring in.

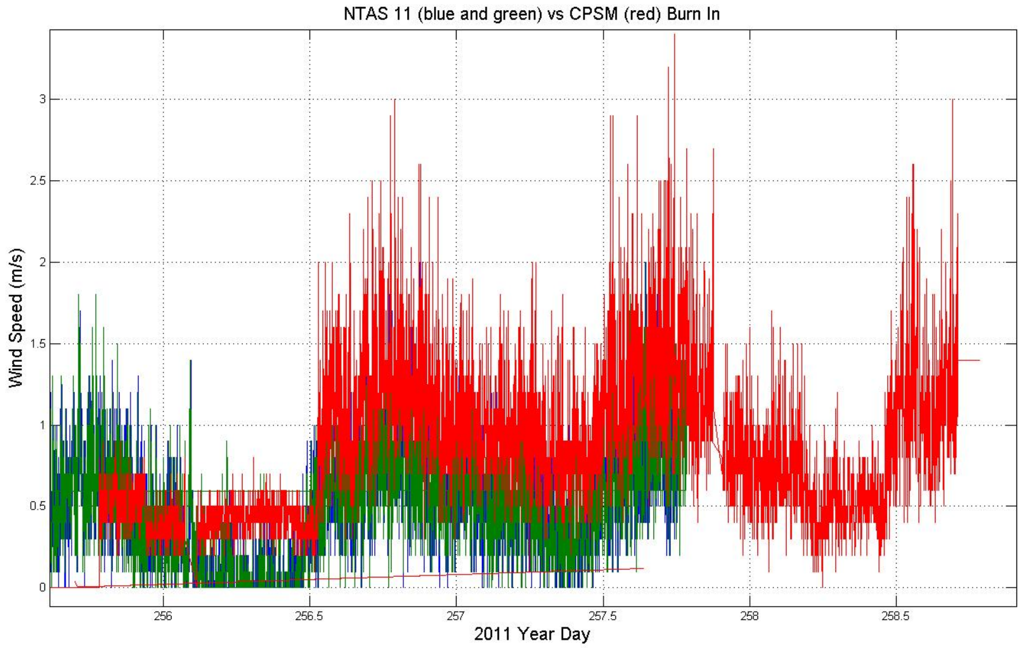


Figure 18: Wind speed from the NTAS-11 systems (Blue and Green) compared to the CPSM sensor (Red). The CPSM buoy was moved from the Clark South Hghbay on day 256 to the test pad where the system installed on the NTAS-11 buoy was buring in.

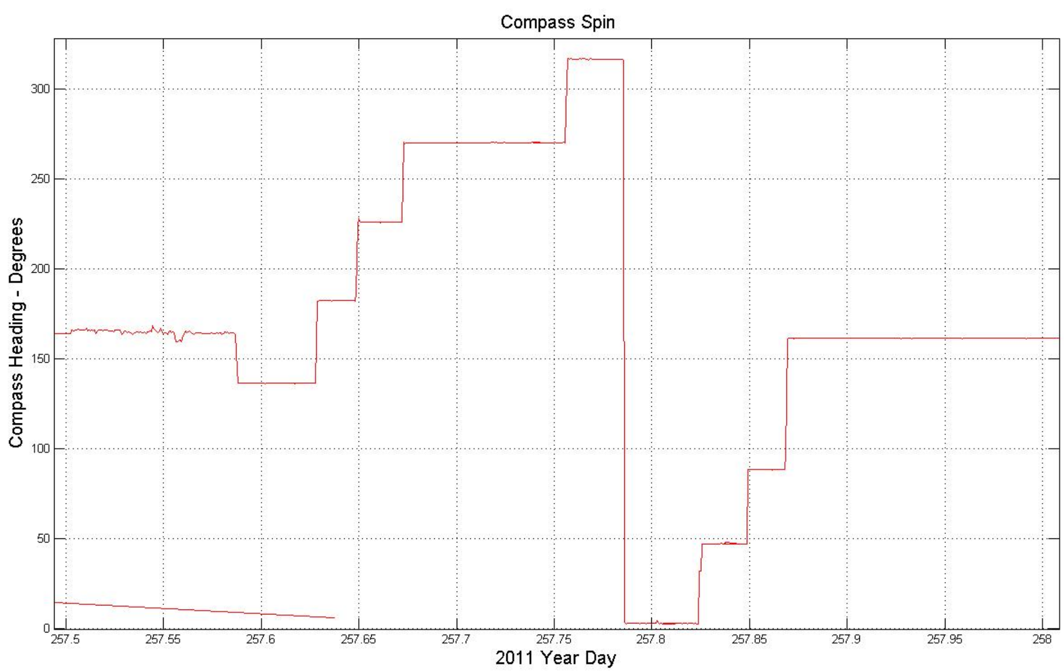


Figure 19: Plot of compass headings during the buoy spin test. Buoy was rotated in 45 degree steps for a complete rotation. Each heading was maintained for a minumum of 15 minutes.

Near Surface Instrument Frame (NSIF)

The NSIF resides at the bottom of the EM chain (see figure 72 mooring diagram). For the AST2 experiment this is approximately 7 meters below the surface. The frame is a cylindrical aluminum frame with a six spoke pattern for mounting a variety of instruments (figure 20.) For the AST2 deployment the frame held four sensors and a high pressure DCL enclosure (figure 21.) The table below lists the sensors.

Table 3: NSIF instruments mounted in the AST2 frame at 7 meters.

Qty.	Item	Part Number	Serial Number
1	Fluorometer WETLABS ECO DFL	WetLabs DFLS	69
1	Volume Scattering WETLABS ECO VSF	WetLabs VSFS	050B
1	Point Velocity VELPT	NORTEK AQUADOPP SYMMETRIC	P23833-9
1	CTDBP SERIES C	1336-00001-00003 Sea-Bird 16plusV2	6841

Figure 20: End view of the NSIF loaded on *R/V Oceanus*. EM Chain is mechanically electrically connected to the Surface Buoy. Instruments mounted in the frame include: Nortek Point Velocity (twelve o'clock), Fluorometers (three and six o'clock), and CTD (ten o'clock.)

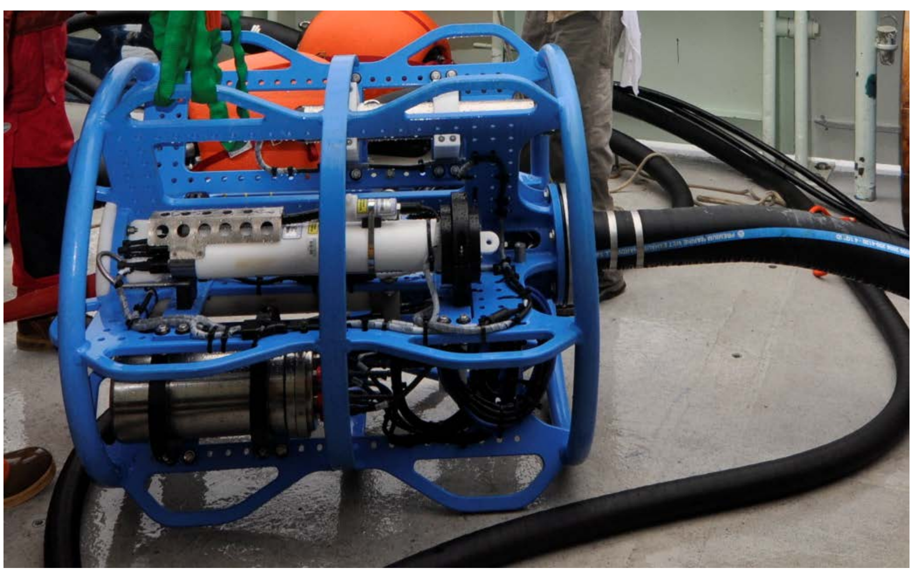


Figure 21: NSIF side view. The SeaBird CTD (white) and the DCL pressure housing (silver) are visible. The EM Chain is mounted at the center on the right (top) and the EOM cable is on the left (lower). Data from the instruments are collected in the DCL.

Optical Instruments
The fluorometers were borrowed from Chris Wingard at Oregon State University (OSU). These instruments will provide a qualitative measure of biofouling during the AST2 deployment. The Volume Scattering Functions VSFs had the copper shutter and wiper removed. Part of the AST2 experiment will assess the effectiveness of shuttered vs. non shuttered instruments. The Biofouling experiment is explained in more detail later in this report (Section III.E.) Instrument preparation included making a cable to communicate and power the instruments. Functionality was verified and they were handed to the software team to write drivers. During the driver testing, the VSFS failed. The shutter spun continuously and the instrument failed to make any measurements. The instrument was returned to WET Labs for repair. The failure was due to a worn and dirty shutter coupler, caused by anodizing wearing off inside the shutter drive components. The age of the instrument contributed to the shutter failure. WET Labs repaired the driver components and returned the instrument in working order.

VELPT
The Nortek velocity sensor was borrowed from the WHOI instrument pool. It was a brand new instrument and had never been deployed. Functionality was checked and the batteries were removed so that the Plat Con could reset the instrument if needed. The instrument, power adapter, and communication cable were transferred to the software team for driver development. Clamps and brackets to mount the VELPT in the NSIF were some of the last parts to be fabricated. Engineers were cautioned to be sure that the instrument was mounted in the frame so that the acoustic beams did not interfere with either the frame of the riser.

When the mooring was dipped into the well during the buoyancy water line test, the NSIF instruments were powered and recording. Data during the test confirmed that the VELP tilt and roll sensors were functioning. The instrument transitioned from horizontal to vertical. It was also observed that echo intensity of the beams was approximately equal. A high echo amplitude in one beam would have been indicative of interference with the frame or EM Chain.

CTD
The SeaBird SBE16 pumped CTD was the first instrument to go through the OOI QCT procedure [Reference 3207-00015]. Communication using both the software provided by SeaBird, as well as command line control using ProComm, was tested. The CTD was tested using the suggested procedure and testing steps listed in the manual. Both a wet and dry test was conducted. The wet test was conducted in the CRL test tank. Salinity and temperature were checked and functioning. The CTD was lowered approximately 1 meter in the tank and the pressure sensor changed accordingly.

Profiler Mooring
The majority of the profiler mooring instruments are part of the MMP. The configuration and testing of the MMP instruments is covered in section II.C. The SBE37-IM was powered and tested. The initial testing steps and results are described in the QCT report [Ref 3207-00016, 3207-00022].

The 75 KHz Long Ranger was configured as an upward looking ADCP. The setup file was created using the deployment planning software that comes with the instrument. The ADCP will collect a profile of velocities that includes the surface. Bin sizes and spacing, as well as sampling intervals, were selected by OOI project scientist Dr. Al Plueddemann (Appendix 7.) A compass calibration was performed on the ADCP with the SBE37-IM and ADCP mounted into the frame.

Figure 22: Engineer Kathleen McMonagle spins the ADCP frame during a compass calibration.

2. SIO/BIO sensors

2.1 Global Surface Piercing Profiler (GSPP)

The GSPP Instrument Float contained a conductivity, temperature, depth (pressure) sensor (CTD) (SBE 52-MP), a dissolved oxygen sensor (SBE 43-F) and a PCO2 instrument (ProOceanus PSI PC02). The analysis of the data from a previous GSPP deployment showed that the oxygen sensor calibration was outdated. The Oxygen sensor was removed from the SBE 52-MP and returned to the Seabird factory for calibration. The SBE 43-F sensor was replaced by the vendor. During the burn-in phase at WHOI, the BIO team discovered a high peak current drain at startup by the PCO2 instrument and its SBE 5T pump, that triggered the over current protection circuit on the GSPP instrument float controller. This issue was fixed in the lab by implementing a soft start (Pulse Width Modulated - PWM) within the GSPP instrument float controller.

2.2 Load Cell

Two load cells are installed on the GHPM, a disk type load cell below the 64" sphere and an inline mounted load cell below the load cage. Both load cells were pressure tested and calibrated with weights to 5,200 lbs.

2.3 Wire Following Profiler (WFP)

The WFP on the GHPM carries a CTD (SBE 52-MP), an Optode Dissolved Oxygen Sensor (AANDERAA 3830), a Fluorometer and Turbidity sensor (WETLABS FLBBRTD), and an Acoustic Current Meter (NOBSKA MAVS). The Optode Oxygen Sensor was calibrated by SIO using a 2 point calibration. The CTD and Fluorometer were tested with samples from the SIO seawater supply system and compared to values from other calibrated instruments to confirm the calibrations. Full operation of the WFP and the sensor data were evaluated during functional tests in the SIO test tank.

B. CPSM Preparations

1. Lab/bench test

The buoy power system include natural power collection sources, a custom Power System Controller (PSC) circuit card assembly (CCA) with custom firmware, and eight, 12VDC rechargeable AGM batteries arranged in four strings of two series batteries that comprise the 24VDC main power bus. The natural power sources included four PV panels, two mounted on the well hatch cover and two mounted on either side of the buoy wind vane. Additional power sources include two modified 350W rated wind turbines mounted above the hatch and below the mast halo on the port and starboard side of the buoy. The power system also includes the provision for external charging of the batteries in a lab or shipboard environment.

Lab and bench testing of power system components was focused on hardware testing of the PSC CCA, as well as functional testing of the PSC custom firmware in a development test set-up referred to as the Power Bench Test (PBT).

Prior to PBT of the PSC/firmware, Design Verification Testing (DVT) was executed on both the rev1 and rev2 versions of PSC hardware[1]. Special testing of the PV boost circuit heat sink performance under high power conditions was also performed.[2] Special CPM integration testing was performed in the Bigelow CPM lab to confirm PSC-CPM interfaces.[3]

[1] Reference: Quick Look Report 3309-00052.
[2] Reference: Quick Look Report 3309-00051
[3] Reference: Quick Look Report 3166-10151

The core of the PBT PSC/firmware checkout is documented in detail as noted in the footnote below.[4] However, a very high level summary of this testing is provided below for context.

The PBT was set up in early August following several weeks of functional checkout and repair of the four PSC CCA assets produced in support of AST2. As part of this checkout/repair effort, it was discovered that ringing overshoot due to PV circuit galvanic isolation switching transients on the 24VDC battery bus were causing component damage due to peak voltages exceeded the 45V limit of regulators and other components. Once this was understood, the application of bulk capacitance to the 24VDC bus as well as Transzorb protection of the bus and zener protection on the regulator outputs was added as a rework to the boards to prevent further damage.

The PBT firmware evaluation began in earnest on 11-August-2011 and proceeded until just a few days prior to deployment; however, the Quick Look Report was issued on 18-August-2011 and does not document the testing that proceeded beyond this date. In fact, the PBT continues as this is written as an accelerated life test on the AGM batteries in conjunction with PSC battery charging logic. Initially, the PBT focus was on documenting basic functionality of the PSC firmware logic, Coulomb counting, and charge termination logic under different conditions. The last firmware update was installed on 1-September-2011, and the firmware has not changed since this date. Since 1-September-2011, the PBT focus has shifted from confirming basic functionality of the firmware to a focus on accelerated life testing of the batteries under PSC recharging control, and more than 57 battery cycles of varying depth of discharge (DOD) have been executed. As a comparison, during the same period of time, the AST2 batteries have been cycled only 7 times, and most of these were shallow, 10% DOD cycles. The details of this on-going test in the form of meta-data for each of the cycles are documented in the footnote below.[5]

In addition to PBT testing on the PSC/firmware, the PBT set-up was also used for testing on the wind turbines after electrical modification of the turbines. Turbines were modified and then connected to the PSC; motive force to turn the turbines was supplied using a hand-held drill. This is described in detail in the reference below.[6]

No special bench testing is documented for the PV panels. Testing on these units was deferred until buoy integration.

Power System Buoy-Level Integration and Test at Clark South

The buoy-level integration and testing effort began with installation of the AGM batteries in the bottom of the buoy together with their harnessing on 19-July-2011 at Clark South. Basic continuity checks were made before fuses were installed at the battery terminals. On 21-July-2011, a rev1 PSC mounted in the standard PSC enclosure was used as a

[4] Reference: Quick Look Report 3309-00050.
[5] Reference: "PBT Cycle Meta-data.xls"
[6] Reference: "Wind Turbine Electrical Mod Notes.doc"

temporary surrogate PSC for power distribution purposes, and the PSC-Platcon cabling was continuity checked and verified. The batteries and PSC then sat idle in the buoy well until 6-September-2011 when the surrogate PSC was replaced by a fully functional and bench tested rev2 PSC with final tactical firmware. The batteries open circuit voltage (OCV) was then tested with all the batteries reading 12.76V. Per the supplier, this voltage was just below the 12.8V criteria indicative of a full charge, so the batteries were then charged over a two day period via the external charging port to bring them to full charge.

The Platcon was integrated with the PSC on 7-September-2011 without incident. This date was also the last time that the batteries were charged using shore power. The connecting cable between the PSC and Platcon had been modified to include a 9 pin Sub-D connector "tap" on the RS232 communications from PSC to Platcon, allowing non-intrusive constant monitoring of the power system engineering status data. Also on 7-September-2011, the four PV panels were functionally tested "end-end" in the power system using a 1000W halogen lighting rig to illuminate each panel from close range. Each panel produced 5 to 10W of power during these tests with the halogen lighting rig.

On 8-September-2011, the two wind turbines were functionally tested end-end in the power system using the same hand drill technique that was used in the bench test, but their mechanical integration was delayed due to lack of mechanical parts.

On Tuesday, 13-September-2011, the buoy was moved to the outdoor burn-in pad at Clark South. While there was no wind, we were able to verify operation of all the PV panels under real solar power. It was interesting to note that the large vertical PV panel facing away from the sun and looking at "blue sky" put out a constant 12W of power for much of the day. Significant recharging/load mitigation occurred from this point forward until deployment using PV power. This battery "Cycle 0", and all the subsequent battery cycles up until the present time are documented in the reference below.[7]

The modified wind turbines used on the buoy were not actually operated under wind power until after the buoy was deployed.

Platform Controller

This section describes how the Platform Control (PlatCon) design engineers use real time data from the buoy systems in order to monitor and evaluate the performance and health of the OOI AST-2 CPSM and CPPM electrical systems.

Test Chronology:
6/1/2011:
Initial PlatCon Integration, Verification and Testing:

[7] Reference: "AST2 Cycle Meta-Data.xlsx"

The following section describes how to communicate with a PlatCon in order to safely bring up the various electrical components of a CSM buoy and verify the proper operation of the following:

- PlatCon
- PSC
- RFM
- WiFi
- GPS
- ISU
- SBD
- FBB
- Scientific and engineering sensors

Communication Setup:
PlatCon: All devices mechanically and electrically connected.
Remote Pilot:

- Laptop: equipped with:
    - Radio Frequency Modem (RFM) Master on a serial port or USB to serial converter
    - Terminal Emulation Program (e.g: ProCommm)
    - SSH Program (e.g: Putty)
    - WiFi
        - Set laptop to private network address: 192.168.0.150

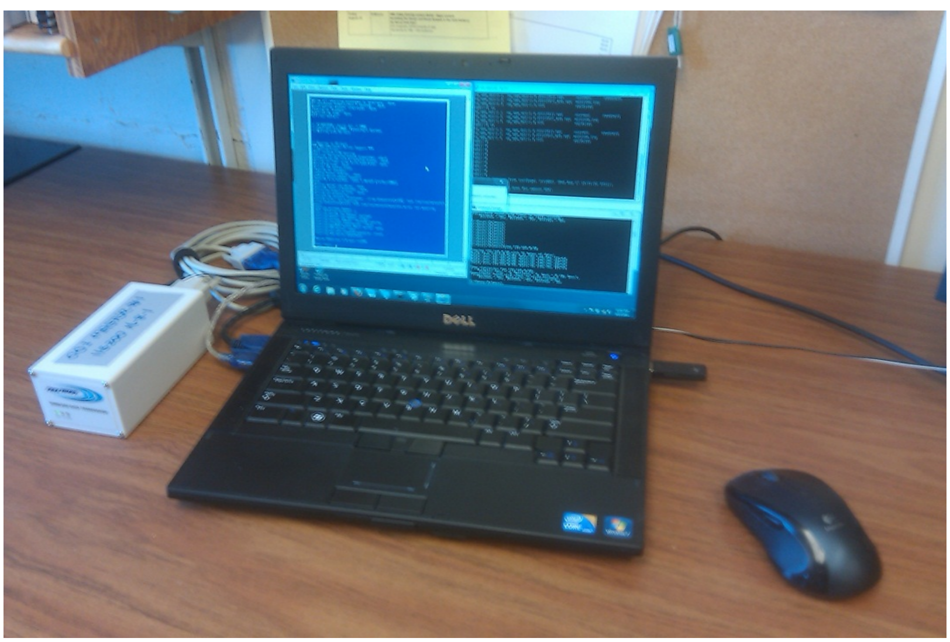


Figure 23: Laptop configured with wifi and RFM to communicate with the buoy.

Test Procedure:

Background: The initial Integration and Verification Test is intended to test and verify power and bi-directional communication of the above listed systems.

Due to the autonomous nature of the Platform Controller, the Computational Element of the CPM automatically starts a series of processes as listed below:

ce003:~# cd current
ce003:~/current# ./start –s

Currently Running the Following CGSN Components:

```
root  1138 0.0 0.4 1456  588 ?  S   00:00 0:00 bin/logger
root  1141 0.3 0.6 1540  792 ?  S   00:00 0:00 bin/status -I C_STATUS
root  1144 0.0 0.5 1484  648 ?  S   00:00 0:00 bin/gps_sys -I C_GPS -l2
root  1147 0.0 1.1 1468 1440 ?  SL  00:00 0:00 bin/pps -I C_PPS
root  1150 0.0 0.4 1480  624 ?  S   00:00 0:00 bin/supervisor
root  1153 0.0 0.4 1472  616 ?  S   00:00 0:00 bin/power_sys
root  1156 0.0 0.4 1456  584 ?  S   00:00 0:00 bin/telem_sys
root  1159 1.2 2.6 5484 3328 ?  S   00:00 0:02 bin/main_fb250.pl
root  1162 0.0 0.5 1508  640 ?  S   00:00 0:00 bin/iridium
root  1165 0.0 0.2 1296  268 ?  S   00:00 0:00 bin/watchdog
root  1168 1.8 2.8 5744 3676 ?  S   00:00 0:03 bin/cpm_control.pl
```

Some of these processes will be left running, others with be turned off in order to manually control the device. Since these devices have been previously powered and tested with the current wiring harness, all processes can be left running

Initial Communication Procedure:
The automated initial boot process will, by default, test and verify operation of the RFM and Wi-Fi power and bi-directional communication.

1. Power on the PlatCon by applying power to the PSC.
2. CPM console will be available on the laptop terminal.
    a. The CE boot process can be monitored on the terminal emulator.
3. At the login prompt, log in as “root” and use the default password.

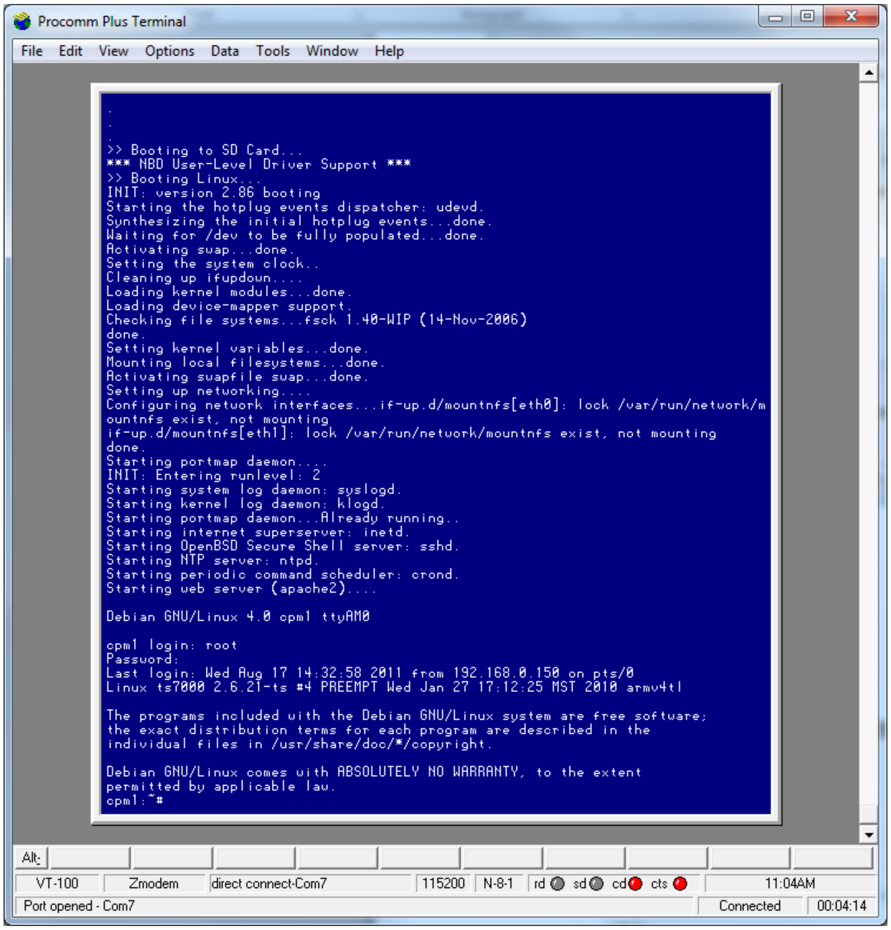


Figure 24: Terminal Emulator screen showing the boot process.

4. WiFi will come on simultaneously.
   a. After the CE boot process is complete, connect to WiFi if it didn't do so automatically.
   b. Once a connection to the private network has been established, connectivity can be tested:

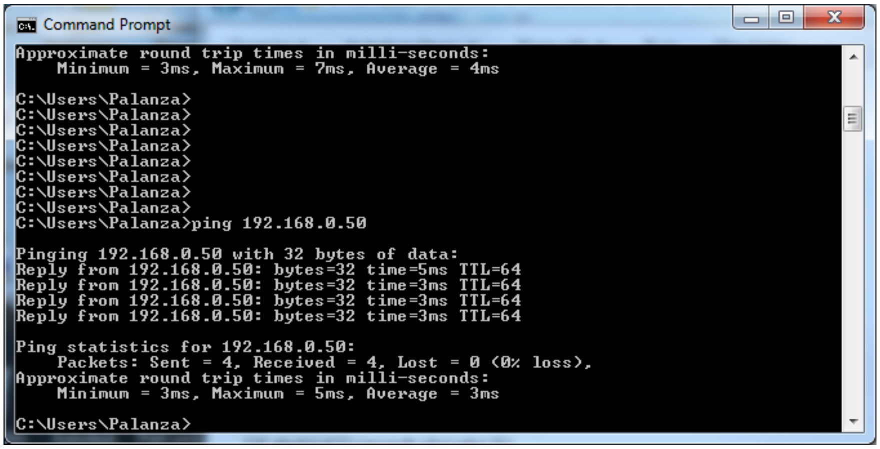


Figure 25: Command line (DOS) prompt: “ping” to test for network connectivity

5. Start a secure shell session (SSH) to the primary CPM CE; 192.168.0.50

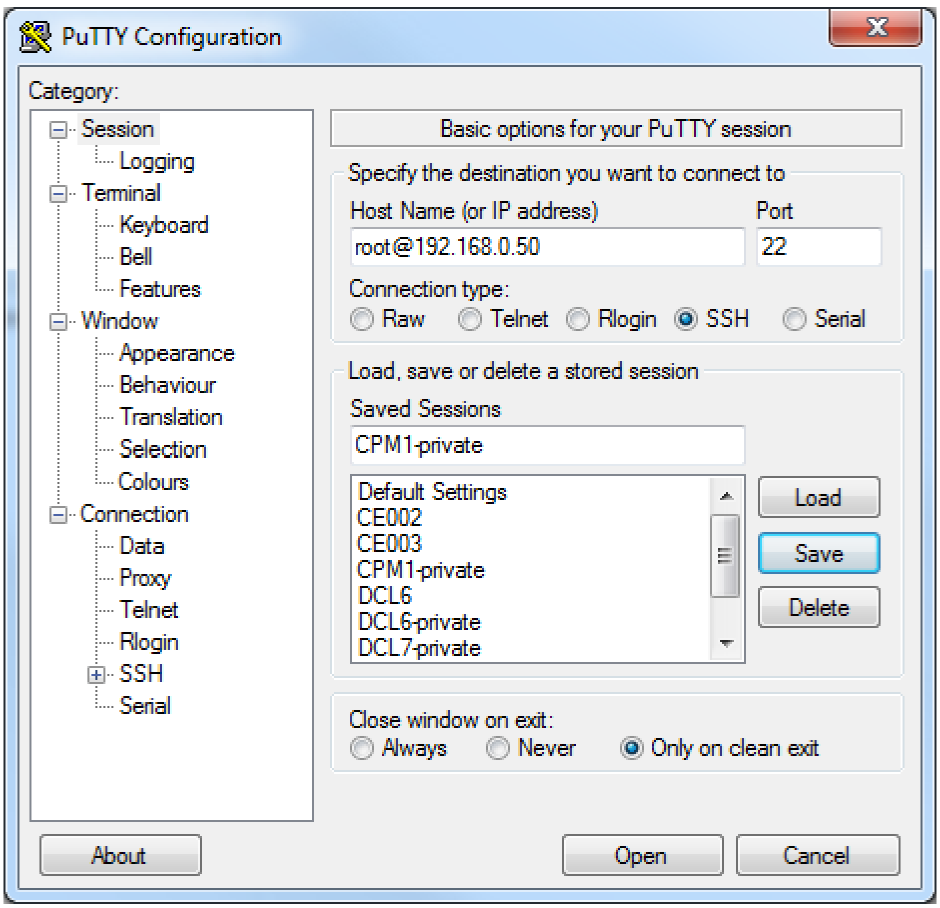


Figure 26: Secure Shell Configuration.

6. Login to CPM1:

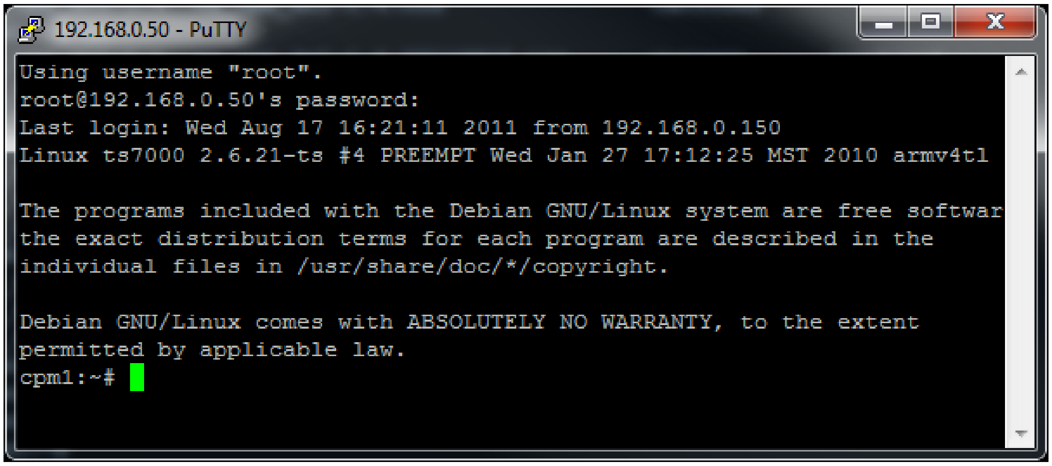


Figure 27: Test and verification of WiFi connection

7. Test and verification of ISU interface
   a. Start a duplicate SSH session to CPM1
   b. cd current //change to "current" directory
   c. ./stop iridium // stops the iridium process
   d. minicom irid // opens a pre-configured minicom session (dev/ttts10, 19200 Baud, hardware flow control)
   e. bin/ucmd // from second ssh (in "current" directory), sends CE commands to MPIC
   f. _pwron irid //
   g. Minicom irid session, ISU should respond "OK" to at <enter>
8. Test and Verification of GPS interface
   a. ./stop gps_sys // from the current directory
   b. Minicom gps // opens a pre-configured minicom session; dev/ttts2, 4800 baud, no flow control
   c. GPS data should be streaming…
      i. Send a config string by manually entering string.
9. Test and verification of PSC interface
   a. bin/ucmd // allows manual interface to automated CPM/DCL processes
   b. _psc get_id // verifies CPM/PSC communication

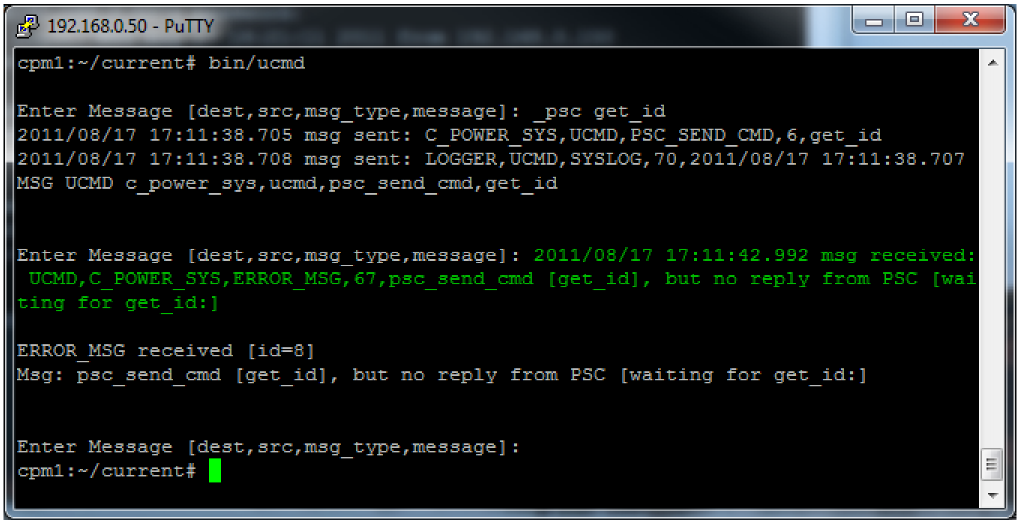


Figure 28: PSC command (no psc currently attached)

10. Configuring a laptop for the PlatCon private network:

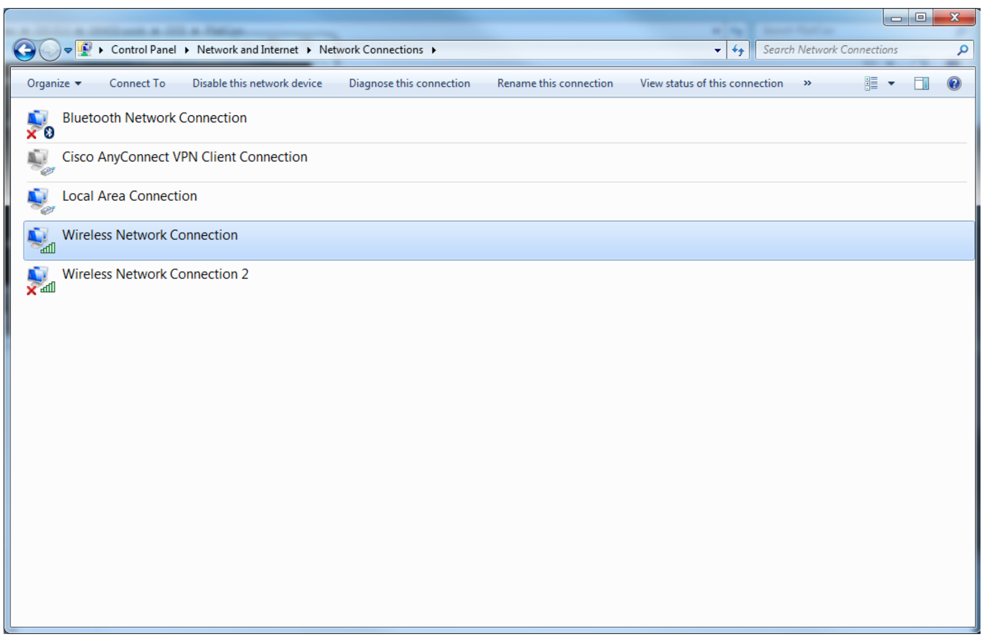


Figure 29: Wireless network connection location

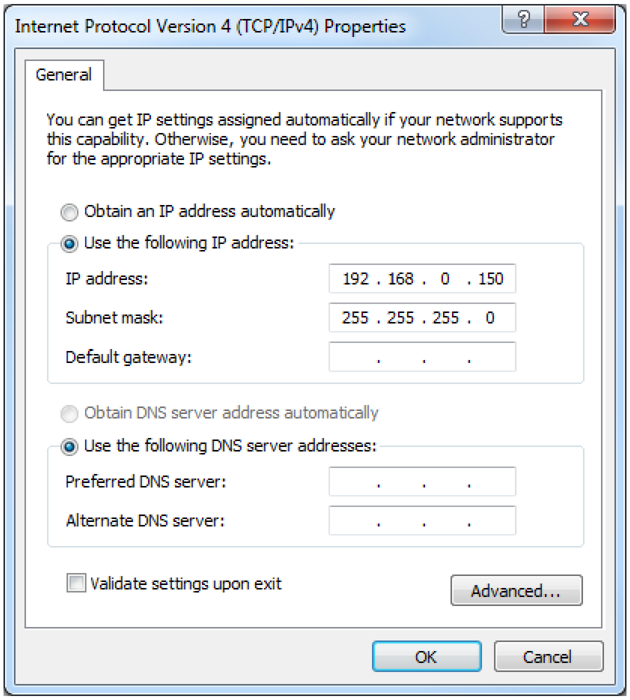


Figure 30: Wireless network settings

8/4/2011:
PlatCon-Sensor Integration, Verification and testing:

A Platform Controller (PlatCon) consisting of two CPMs, two DCLs, 9 slot backplane, and Moxsa Ethernet switch, as assembled for lab bench testing. Preliminary external telemetry devices were attached as well as dummy loads for power supply testing. Figure 31 below shows the bench setup.

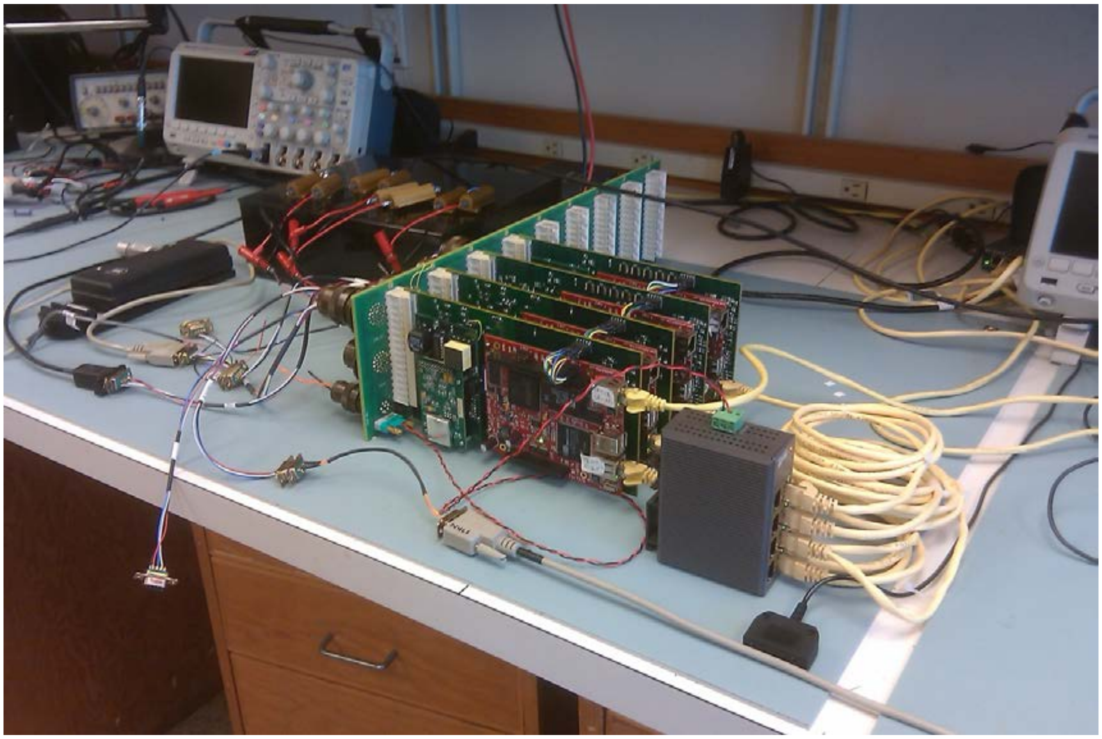


Figure 31: Initial PlatCon set up on bench for Integration, Verification, and Testing

All serial channels are nominally tested. Telemetry devices were plugged in and made to work; ISU, SBD, Freewave (RFM), GPS, and Wi-Fi. Initially, science sensors were simulated with serial connections to other computer serial ports and power connected to dummy loads. Table 5 below lists tested devices.

Table 5: PlatCon Test Matrix

PlatCon Test Table	**RFM Console**	**Wi-Fi**	**ISU**	**SBD**	**GPS**		
CPM1	Verified	Verified	Verified	Verified	Verified		
CPM2	Verified	Verified	Verified	Verified	Verified		
	Console	**Instrument Port 1**	**Instrument Port 2**	**Instrument Port 3**	**Instrument Port 4**	**Instrument Port 5**	**Instrument Port 6**
DCL1	Verified	Verified	Verified	Verified	Verified	Verified	Verified
DCL7	Verified	Verified	Verified	Verified	Verified	Verified	Verified

8/3/2011:
Initial PlatCon and Power System Control (PSC) interface:
Prior to full sub-system integration, the PlatCon was interfaced to a PSC development board and a bench power supply. A bench power supply was connected to the PSC as a substitute for the battery connection. The PlatCon-PSC cable built for the CPSM was connected to the PSC and left unconnected at the PlatCon. The PlatCon-PSC cable had been previously tested for proper connectivity. The PSC was powered and the open end of the cable was tested for proper voltage levels and passed. The PSC was powered down. The PlatCon-PSC connection was made, the PSC was powered up, which in turn powered up the PlatCon. An initial problem was discovered; the PlatCon was holding the PSC in reset. The PSC reset line from the PlatCon was inverted from the required logic. A quick re-program of the control firmware to invert control polarity fixed this. After a restart, normal operation was established. The PSC delivered power and status messages to the PlatCon, and the capability for the PlatCon to override the PSC settings was confirmed. The PSC and PlatCon were left connected for the duration of integration to allow for as much burn-in time as possible.

Figure 32: PlatCon-PSC I V and T

8/4/2011:
PlatCon-Sensor Integration, Verification and testing:

The sensors listed below were first connected with temporary serial and power cables to verify proper serial communication and power delivery. This allowed for the operation of automated data collection.

Table 6: Sensor Connection and Verification Table

	Instrument Port 1	**Instrument Port 2**	**Instrument Port 3**	**Instrument Port 4**	**Instrument Port 5**
DCL1	3DM-GX3	Metbk	Loadcell	Verified-N/C	RTE
DCL7	ADCP	SBE16	DFLS	VSFS3	N/C

The actual buoy wiring harness was substituted for the temporary wiring once it became available. The process was repeated, and the sensors were left connected for data collection.

Initial work with the Battelle pCO2 yielded the following:

Problem: The Battelle pCO2 sensor serial interface does not work with the DCL serial interface. In initial testing, the pCO2 seems to load the transmission line of the DTE (master) device.

Test Procedure:
1. Establish and record “standard” RS-232 transmission voltage levels with two known, working devices.
2. Connect pCO2 to a laptop to establish the working, but non-standard RS-232 voltage levels.
3. Connect pCO2 to our Data Logger (DCL) in order to establish the RS-232 voltage levels.

Hypothesis:
The Receive Data line on the pCO2 Sensor is sinking current. There is enough current drive on a PC serial port to overcome this, but this is a non-standard condition. There is not enough current drive on our DCL.

Try some series resistance on the pCO2 Transmission and DCL Receive line.
Note: did confirm that there are no extraneous wires (such as a ground connection) in the pCO2 serial connector:

Figure 33: pCO2 DB-9 serial connector dissasembled to confirm serial wiring.

Test Results:

1. Normal serial communications established between a laptop serial port and our DCL serial port.

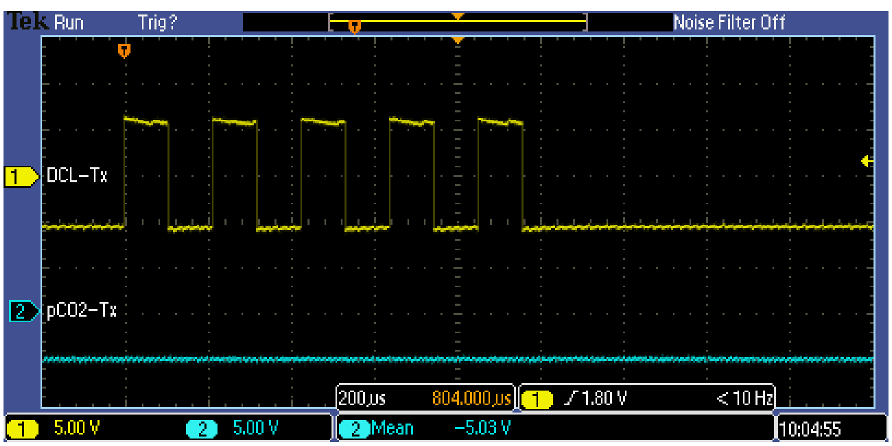


Figure 34: “U” transmitted from DCL to laptop

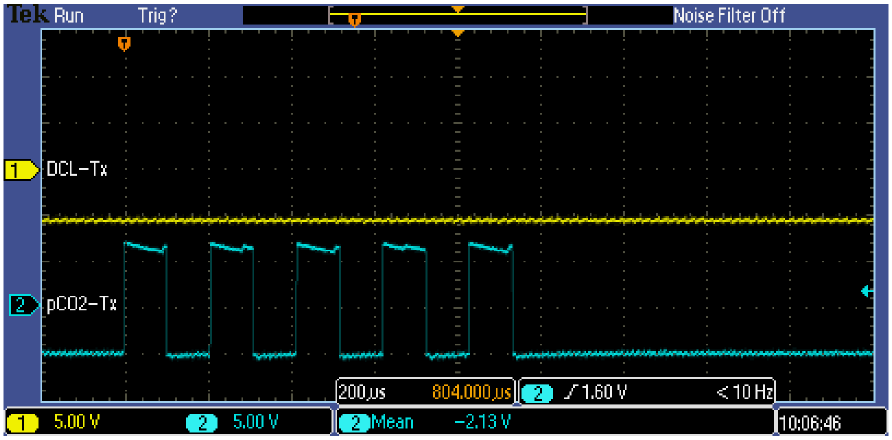


Figure 35: "U" transmitted to DCL from laptop

Result Test 1:
Confirmation that DCL RS-232 port is operating normally.

2. Laptop connected to pCO2. Laptop Tx line, labeled DCL-Tx, is showing a negative swing of -3V versus -6V in previous test. Positive voltage swing is now +5V versus +6V. The -3V is on the edge of a valid voltage level for the RS-232 standard.

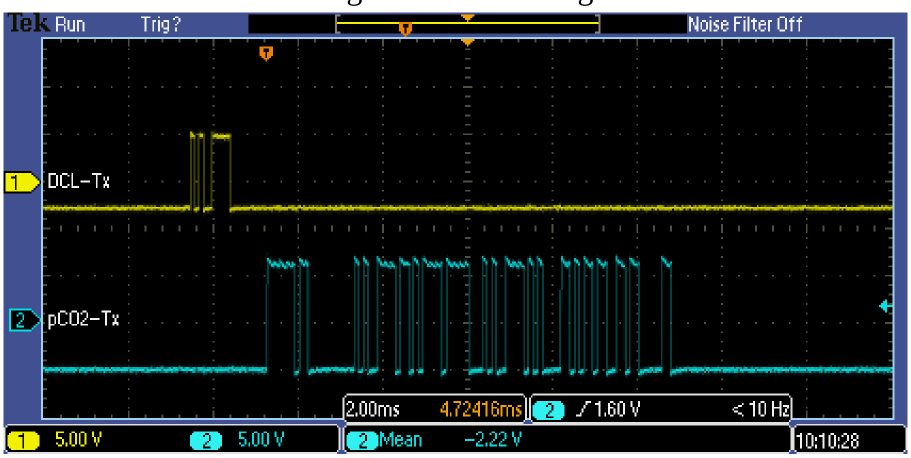


Figure 36: Channel 1 demonstrating the loading on the Tx line.

Result Test 2:
Confirmation that pCO2 sensor has a low impedance input on the Receive line.

3. DCL connected to the pCO2. This configuration seems to have created a situation where the PCO2 receive line is switching between a low-impedance to a "less low-impedance". This switching is very regular at ~5Hz. The negative voltage swing is pulled to -3V as in the laptop connection, and there is no positive voltage swing. The pCO2's response is the prompt polling across a terminal screen.

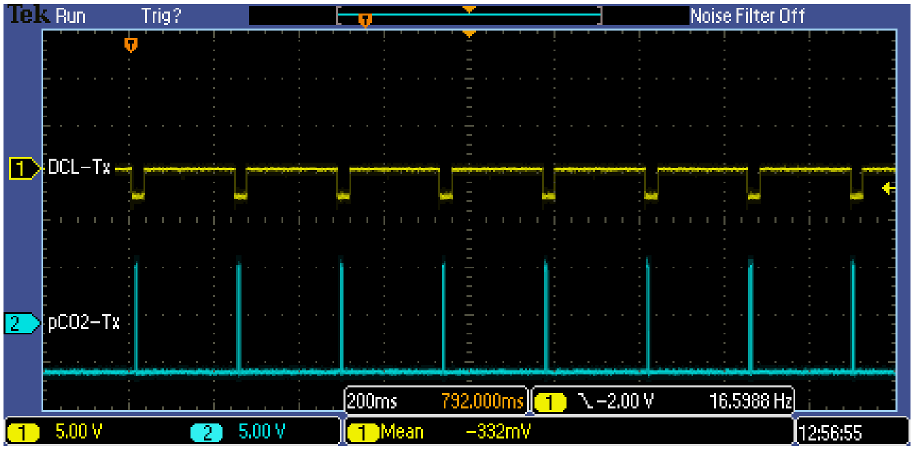


Figure 37: Initial DCL-pCO2 connection.

A user typing at the terminal prompt may get some characters across while in the negative voltage swing, but there is no stable bi-directional communication on this serial channel.

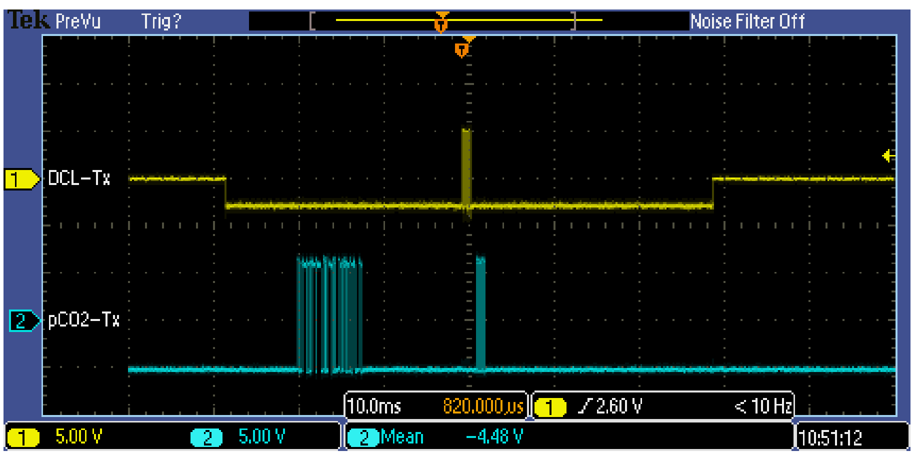


Figure 38: Characters only go through when pCO2 not in shutdown.

Result Test 3:
The DCL channel does not have Transmit current drive to overcome the Receive current sinking.

Short Term Solution:
Limit the current on the Tx line with series resistance. A first attempt with a 1kΩ resistor was successful in making the DCL-pCO2 interface act the same as the Laptop-pCO2 interface.

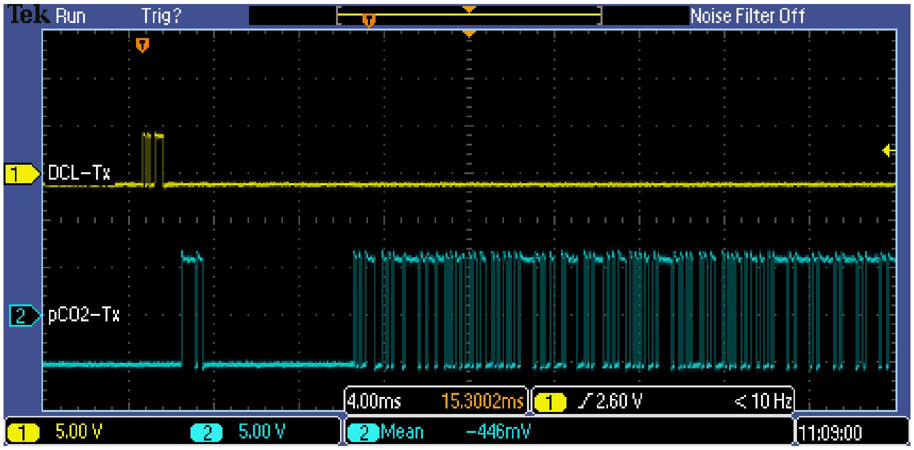


Figure 39: With 1kΩ resistor in series.

The next test used a 4.7k resistor in series. At this level of series resistance, transmission was intermittent and had no effect on the DCL-Tx voltage levels (they are the same as test 1 and 1kΩ) (figure 40.)

Battelle Response:
Jac Fought from Battelle sent the following schematic capture shown in figure 41.

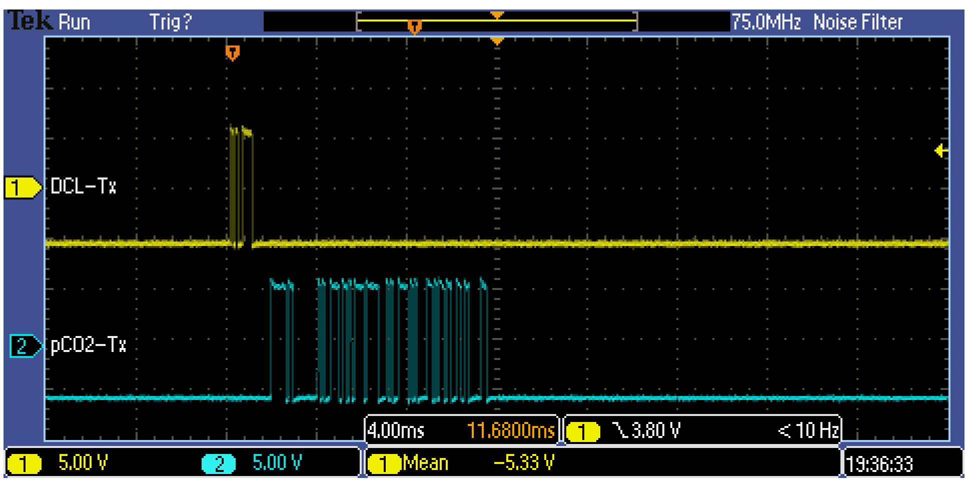


Figure 40: Laptop connected after 5k resistor installed in R16

The apparent problem is JP11 connecting an RS-232 signal to a diode clamp, D6 through R16, a 100Ω resistor.

After bringing this to Battelle's attention; their request is that we replace R16 with a 5kΩ to 10kΩ resistor. JP11 is required as part of a software IRQ.

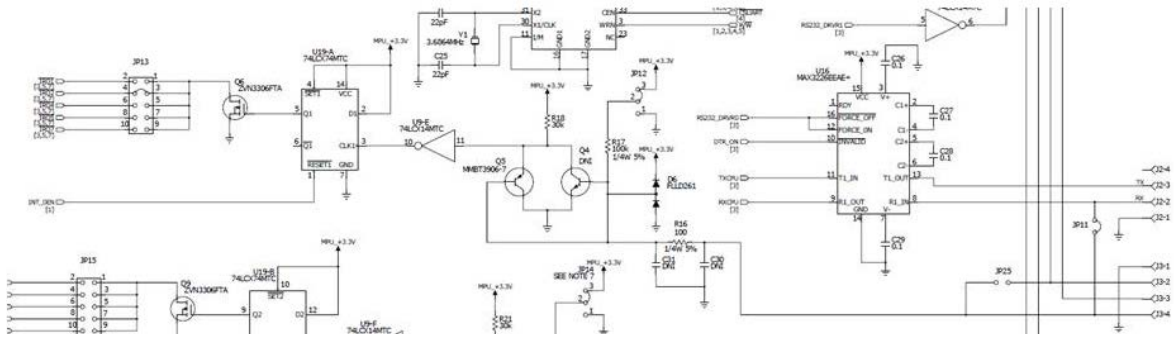


Figure 41: pCO2 RS-232 transceiver and IRQ2

After solving the communication issue with the pCO2 sensor, further problems still existed with powering the reactive loads of the sensor. The large inrush currents of relays and pump motor caused the sensor power supply to motorboat, i.e: to cycle through a voltage drop, current limit and attempt to restart repeatedly. A hardware solution was tried; a modified version of the telemetry surge suppressing board was used, but was not able to prevent the brownout condition. At this time, any further pCO2 sensor integration was put on hold.

8/14/2011:
PlatCon-Telemetry Integration, Verification and testing:

The CPSM wiring harnesses that were built in the buoy well were brought to the lab and used for verification. The harnesses were connected to the PlatCon with CPM1 designated as the primary controller. The telemetry ports were sequentially powered on and tested for proper voltage levels and polarities. Telemetry ports were powered down, connections to the telemetry devices were made, and devices were sequentially powered on. The same process was repeated with CPM2 as the primary controller. Since the RFM and Wi-Fi units are Line of Sight (LOS), a full closed loop communication test was completed within the confines of the lab space.

Table 7: Initial Telemetry Interface, Verification and Testing Checklist

	RFM Console	**Wi-Fi**	**ISU**	**SBD**	**GPS**
CPM1	Verified	Verified	Verified	Verified	Verified
CPM2	Verified	Verified	Verified	Verified	Verified

Figure 412: PlatCon, wiring and Telemetry Verification and Test. Platcon (left), buoy junction panel (white), and telemetry modules (right) with covers removed.

8/17/2011
Remote DCL Adapter Sensor Integration, Verification and testing:

A remote DCL Adapter (RDA) was installed to the PlatCon. The harness from the buoy well was used to connect the PlatCon to the remote DCL connector on the Junction Box (J Box). A temporary wiring harness from the J Box to the remote DCL housing was built to emulate the EM chain. This setup tested the RDA board in a DCL backplane slot, the isolated power supply powering the remote DCL, the single slot backplane board used in the DCL housing and the ability to power and communicate with sensors mounted on the NSIF. Full functionality was verified and the DCL was left in the remote configuration with sensors attached to allow for as much software run time as possible.

9/7/2011
Full Buoy Integration and Burn In:

Clark High Bay: In preparation for initial power up, the PlatCon box was installed in the instrument well with CPM1 set up as primary controller. PlatCon was connected to the telemetry suite and surface sensors. The status box (mounted in the J Box) was connected with the magnet for the magnetic switch installed to prevent the CPM's from turning on. Connection to Power System Controller was made and the magnet was removed; the PlatCon initialized normally.

Table 8: Initial Telemetry Interface, CPM-DCL, and Sensor Verification and Testing Checklist

	RFM Console	**Wi-Fi**	**ISU**	**SBD**	**GPS**	**PSC Interface**
CPM1	Verified	Verified	Verified	Verified	Verified	Verified
CPM2	N/A	N/A	N/A	N/A	N/A	N/A

	Console	**Instrument Port 1**	**Instrument Port 2**	**Instrument Port 3**	**Instrument Port 4**	**Instrument Port 5**
DCL1	Verified	Verified	Verified	Verified	N/C	Verified
DCL7	N/C	N/C	N/C	N/C	N/C	N/C

Initial testing verified bi-directional serial communication with telemetry devices. Secondary testing verified but was not a closed loop test.

DCL7 in NSIF installation testing:
The CPSM surface buoy was powered on. The EM chain section was attached to the instrument well junction box. The NSIF end of the EM chain was left disconnected.

1. The power to the remote DCL was manually turned on, and verified to be correct voltage and polarity.
2. Remote DCL power was manually turned off
3. Remote DCL was plugged into EM chain termination and manually turned back on.
4. Serial communications to the remote DCL console were verified to be properly working.
5. Ethernet connection was verified to be properly working.
6. From the remote DCL, individual sensor power was turned on and verified to be correct voltage and polarities.
7. All sensor power was turned off and sensors were connected.
8. Individual sensors were powered on and data logging was verified to be operating normally.

9/21/2011:
Well Test:

CPSM assembled down to the Near Surface Instrument Frame (NSIF). The wiring was completed as per drawing number 3718-00065 (note: extension in drawing number 3718-00086-00001 was not needed and not used.) The mooring was lifted by crane and was in the well from 18:00 to 21:00 (UTC) (figure 43.)

Figure 43: The surface mooring, em-chain, and NSIF are lowered into the well for testing.

The Platform Controller was powered and operating normally during the lift, while in the well and was left on continuously since. Figures 44-46 show plots of the buoy immersed in the well.

Figure 44: Near Surface Instrument Frame CTD Data

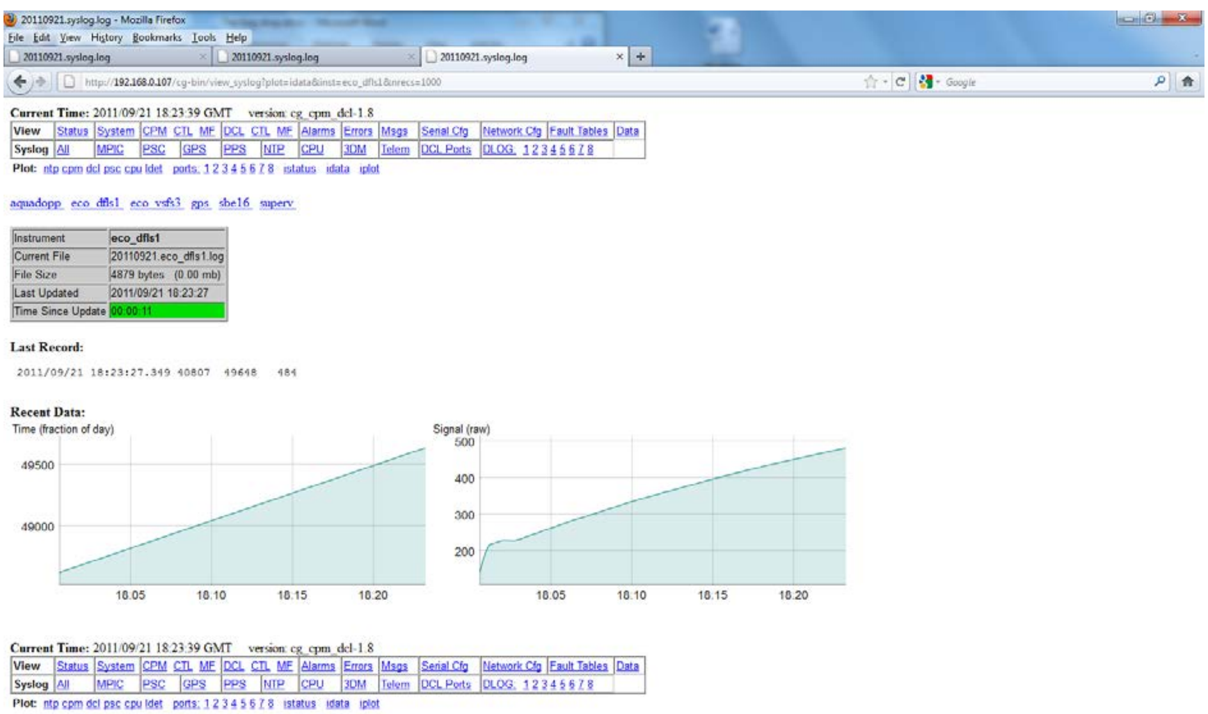


Figure 45: NSIF Mounted Single Channel Fluorometer Data
Note: This instrument does not seem to have reasonable output. This is later verified with deployment data that is simply a linearly increasing number.

Figure 46: NSIF Mounted Three Channel Fluorometer Data

2. Well tests - weight, trim tests

Well testing of the surface and submersible buoys was performed Sept 21, 2011 at the WHOI dock. The purpose of the test was to verify that the buoys floated vertically and verify that the waterline was appropriately located. 1230 lbs of steel ballast was attached to the bottom frame at the bow of the well to trim out the mass of the sensor tower.

The em-chain and NSIF were attached to the buoy. The crane lifted the assembly and put it into the large well in the WHOI dock (Figure 43 above). An inclinometer mounted to the tower oscillated between 0 and 3 degrees of tilt (bow up) when the buoy, em-chain, and NSIF were in the water. It should be noted that the PCO2 sensor was not installed in the outer edge of the floatation at the bow of the buoy. The large mass of the instrument would have provided the necessary moment arm to restore the buoy to the proper trim.

Similarly the profiler buoy was floated in the well. The float characteristics and waterline location of the buoy were as expected (Figure 60.)

Prior to loading the buoys on the ship dry weights were measured using a load cell in-line with the lifting straps and the crane hook. The surface buoy dry weight was 6860 lbs. (Figure 47.) The profiler mooring dry weight was 1280 lbs.

Figure 427: Surface mooring load cell measuring dry weight (6860 lbs.) prior to loading on the *R/V Oceanus*.

3. Buoy Spin

As part of the checks and burn in, a buoy spin is performed to check the performance of the sonic wind module compass. The AST2 buoy spin was performed on the buoy burn in pad which has been magnetically surveyed and found to have little to no variation across the area. A reference point in the distance was chosen to point the buoy during each data point. The buoy was rotated in 45 degree increments. At each point, the buoy data logger was allowed to record for a minimum of 15 minutes. The data loggers were stopped and put into a test mode to see the wind variables. A heading value was acquired, the logger was stopped and sampling restarted. Next, the buoy was spun clockwise 45 degrees and the process repeated. Eight different headings were checked through a full 360 degree rotation. After all 8 points were taken, the buoy was allowed to sit for a period of time. The final step included, stopping the logger, downloading the measured heading data, to compare to the rotated buoy headings. Typically, less than +/- 5 degrees difference in readings is considered good. The maximum difference observed was 2.6 degrees. Table 9 and figures 48-49 below show the results from the buoy spin.

Table 9: Actual Heading Values

Heading	OOIL01	Difference
0	2.60	2.60
45	46.90	1.90
90	88.40	-1.60
135	136.20	1.20
180	182.50	2.50
225	225.90	0.90
270	270.00	0.00
315	316.50	1.50

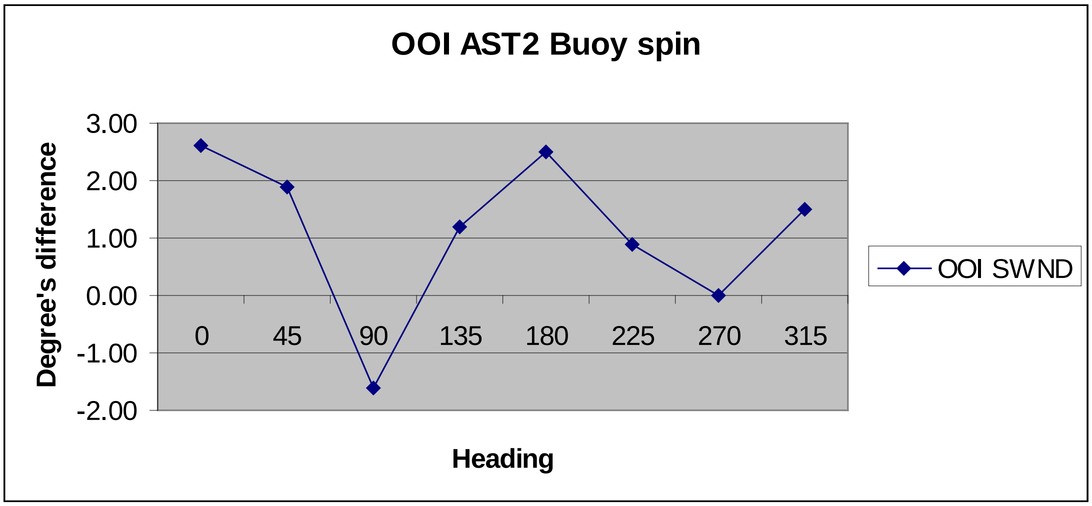


Figure 48: Difference between heading and measured heading values plotted

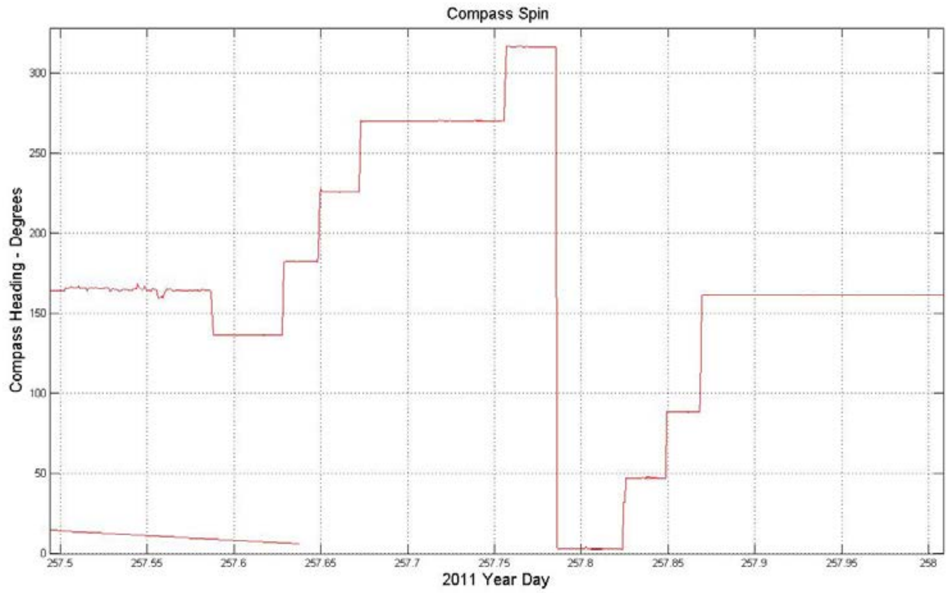


Figure 49: Logger/SWND/compass plot shows the 8 steps of 45 degrees during the buoy spin.

C. CPPM Preparation

The prototype Coastal Profiler Mooring (identified as the Coastal Pioneer Profiler Mooring or CPPM) was prepared in three main integration phases. These phases included a bench test to confirm inductive communication performance, testing with the Sensor/Telemetry Controller (STC) and telemetry devices, and finally a well test to simulate a full field deployment.

1. Lab/bench test

The McLane Moored Profiler (MMP), Seabird SBE37-IM CTD, and 451m EM cable and special inductive terminations were interconnected in the Coastal Research Laboratory (CRL) and connected via inductive modem to Jeff O'Brien's laptop. O'Brien ran his software on the laptop and retrieved both the profile data stored in the MMP and data stored in the CTD.

Figure 50: Photo showing the initial integration test at CRL with the components of the Profiler Mooring laid out on the floor including the 50 ft whale stretch hose, 451m inductive cable with special inductive terminations, jumpers, and custom loop

STC and telemetry testing

The second phase of integration testing included a test of the platform controller (STC) with the telemetry devices. The STC circuit card assembly was assembled onto the submersible buoy well end cap with the inductive modem and SubConn bulkhead cables. The end cap was then connected to the telemetry devices, EM chain, whale stretch hose, 451m cable with special inductive terminations and custom loop cable. The McLane Moored Profiler (MMP) and Seabird SBE37-IM CTD were assembled on the inductive riser near the dock outside Jeff O'Brien's lab (figure 51).

O'Brien ran the STC software to collect both profile data stored in the MMP and data stored in the CTD at an accelerated 30 minute duty cycle. Communication with the STC was accomplished using the telemetry devices. Error checking was conducted on the telemetered data files through the comparison of files before and after file transfer. The results of this testing showed that no errors were introduced to the files through the telemetry devices. Software corrections were made and retested over a period of several weeks.

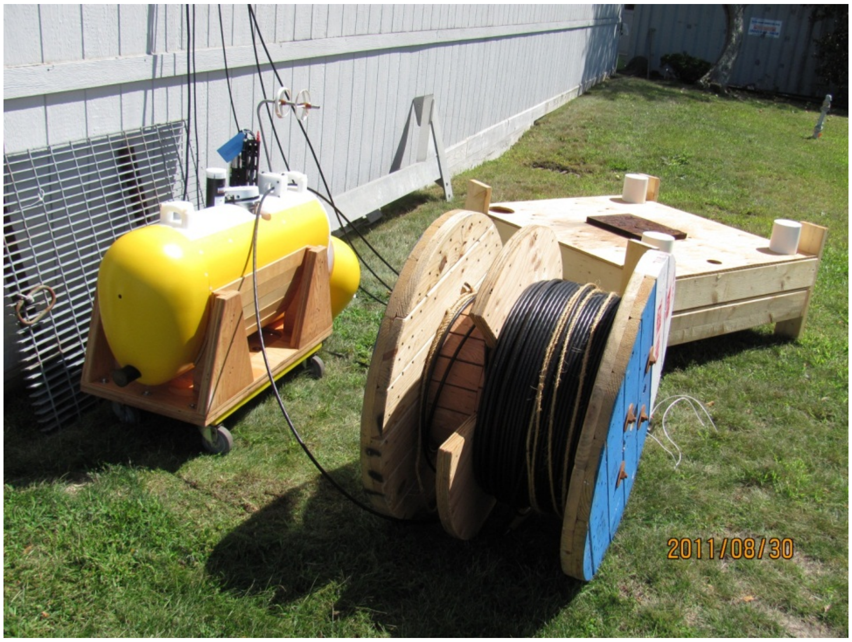


Figure 51: Photo showing profiler inductive cable on the wooden reel, the telemetry test stand in the background and the MMP in its special handling cart. Testing outside Jeff O'Brein's office included testing the platform controller (STC) with the instruments.

2. Well test

The final integration test 'deployed' the components of the CPPM in the WHOI well to simulate a full field deployment and verify that all the components were functioning. The STC end cap assembly, riser components, MMP profiler, and CTD were brought to the large well at the WHOI dock. The end section or the inductive cable was attached to a 300 lb. anchor. The SBE37-IM was attached to the anchor and connected into the inductive cable using the custom loop back cable. The profiler was attached to the cable and scheduled to execute a single 10m profile every 30 minutes. Once all components were attached the crane lifted them into the well (figure 52) and they were secured to the I-beam. O'Brien again ran the software and monitored performance between September 6^{th} and 12^{th}. The MMP was visually observed traversing the wire. Data from the MMP and CTD was collected and transmitted via satellite telemetry to the temporary server.

Figure 52: Photo showing the anchor, SBE37-IM (mounted on the anchor frame) and MMP being 'deployed' lowered by the crane into the WHOI well.

The MMP records three individual files A*, C*, E*, where the A* denotes acoustic current data from the MAVS instrument, C* denotes files logged by the SeaBird CTD, and E* files which contain the MMP engineering data. Also contained in the engineering data are the PAR and Fluorometer sensor data. Data files are named using the profile number (*) followed by either a .dat or .hex extension indicating raw data. Unpacked data are converted from binary to ASCII using the McLane data unpacker executable or in the case of the MAVS an unpacker provided by Nobska, the manufacturer of the MAVS.

Data from the dock tests were downloaded from the MMP inductively and transmitted to the server using the satellite communication devices. Data were unpacked using the Windows executable unpacker file supplied by McLane to process binary MMP data to ASCII. Selected profiles were plotted and shown in the following figures 53-59 to verify the MMP sensors were collecting reasonable data.

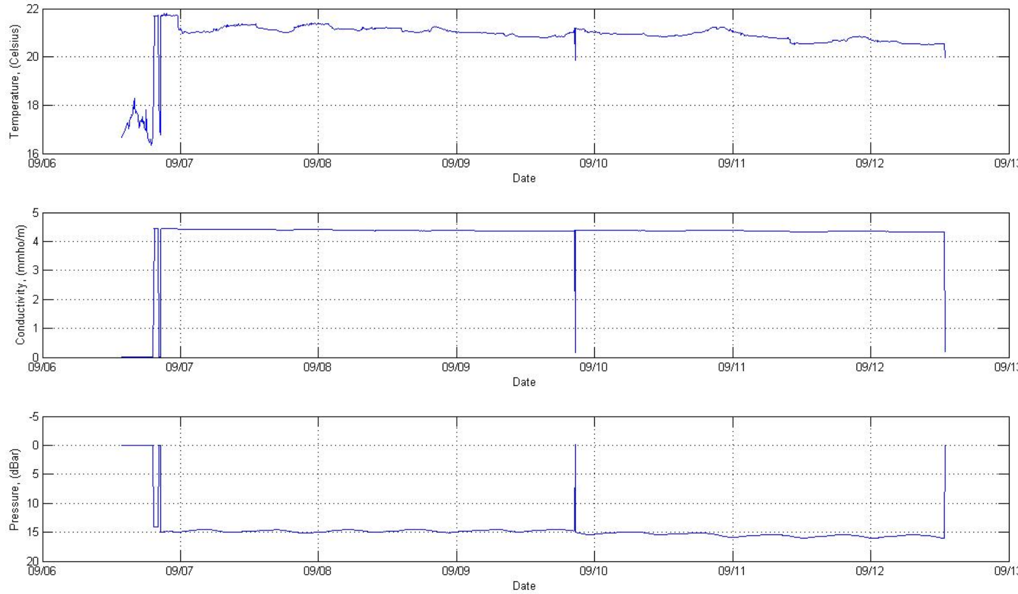


Figure 53: SBE37-IM data collected during the well MMP well test. The spike on Friday September 9th represents a quick recovery of the system to check the wire and add an isolation bushing. The system was redeployed into the well until Monday afternoon.

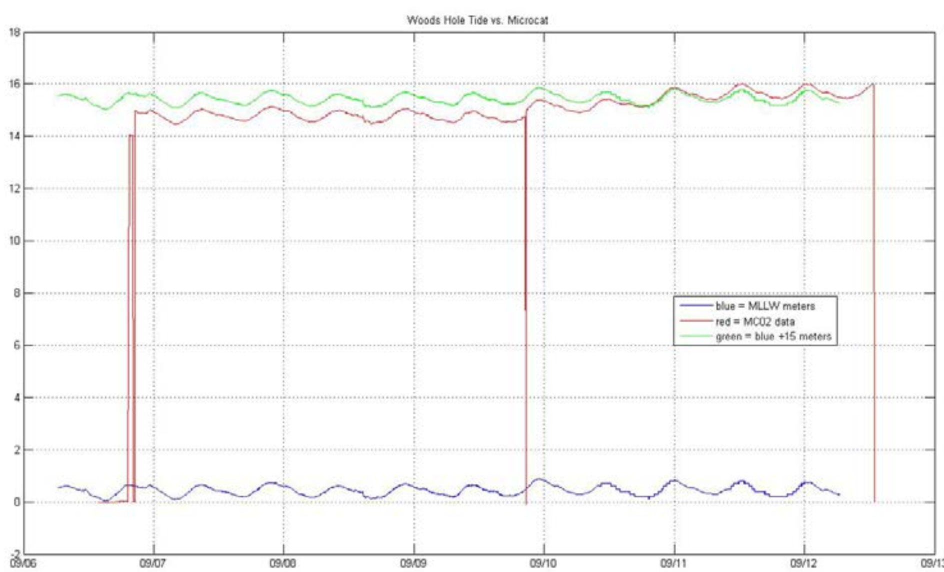


Figure 54: SBE37-IM = MC02 pressure data (red) compared with NOAA Woods Hole tide data (blue) offset by 15m (green) shows solid correlation in tidal pressure changes confirming the SBE37-IM was functioning.

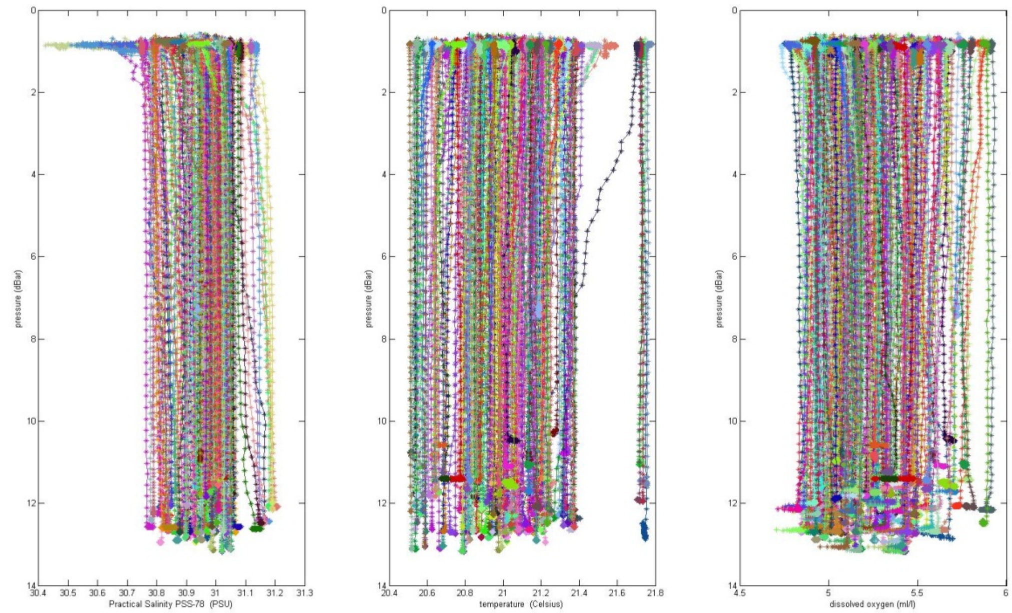


Figure 55: Quick plot of MMP CTD data. Colored lines represent individual profiles, Salinity (left), Temperature (center) and Dissolved Oxygen (right). Profile depth ranges (12+ meters) agree with the wire length used in the well set up.

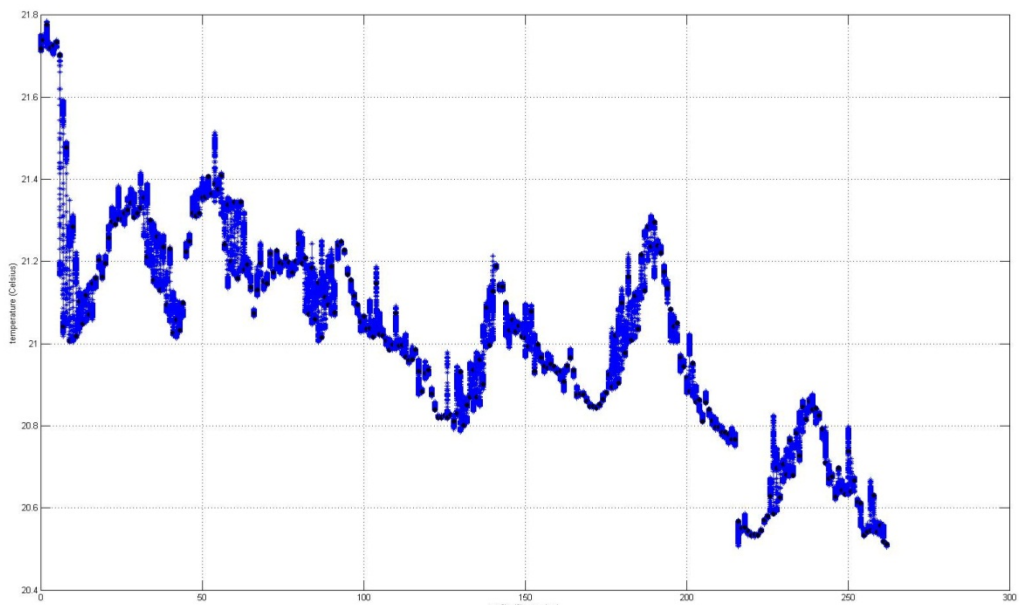


Figure 56: Temperature vs Profiles shows the temperature data range plotted for each profile.

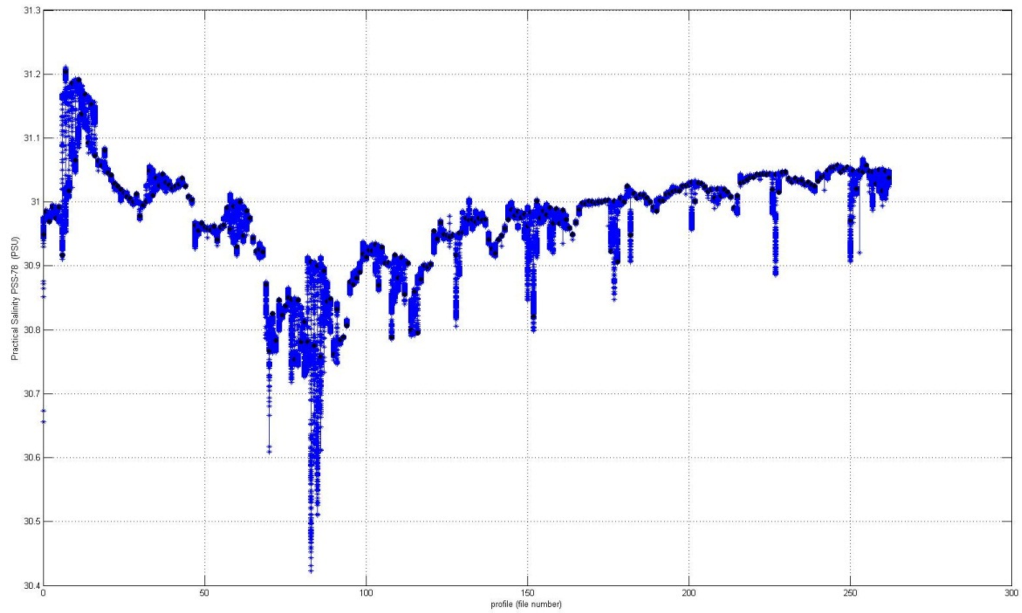


Figure 57: Salinity vs Profile shows the salinity range for each profile.

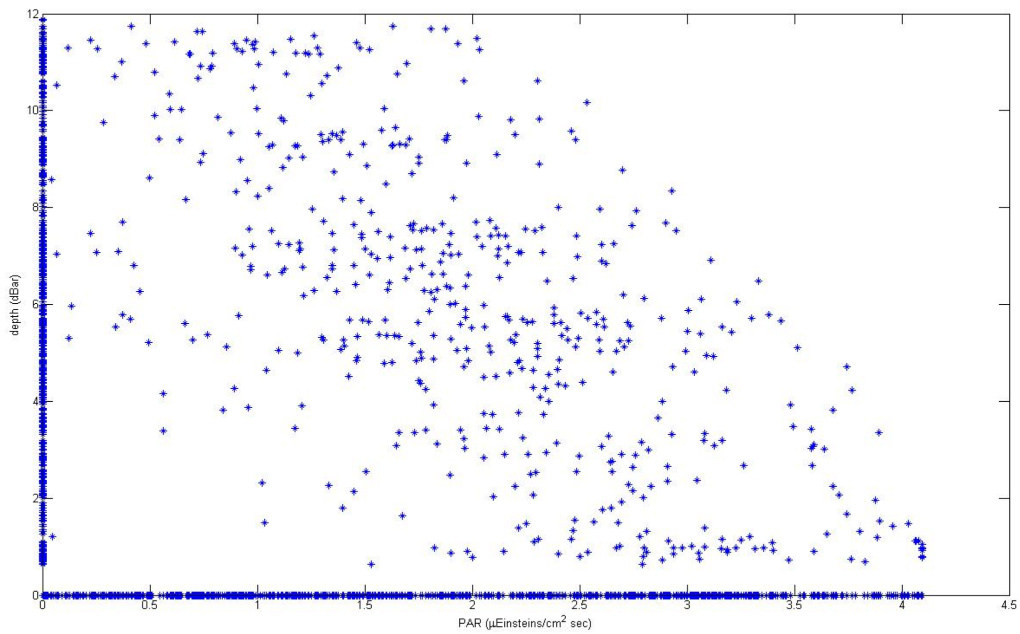


Figure 58: Par vs Depth shows raw par data as a function of depth. The high number of zero data points is caused during the 'sensor warm up' period of the MMP. The MMP starts logging data prior to the actual sensor being turned on and records the values as a zero.

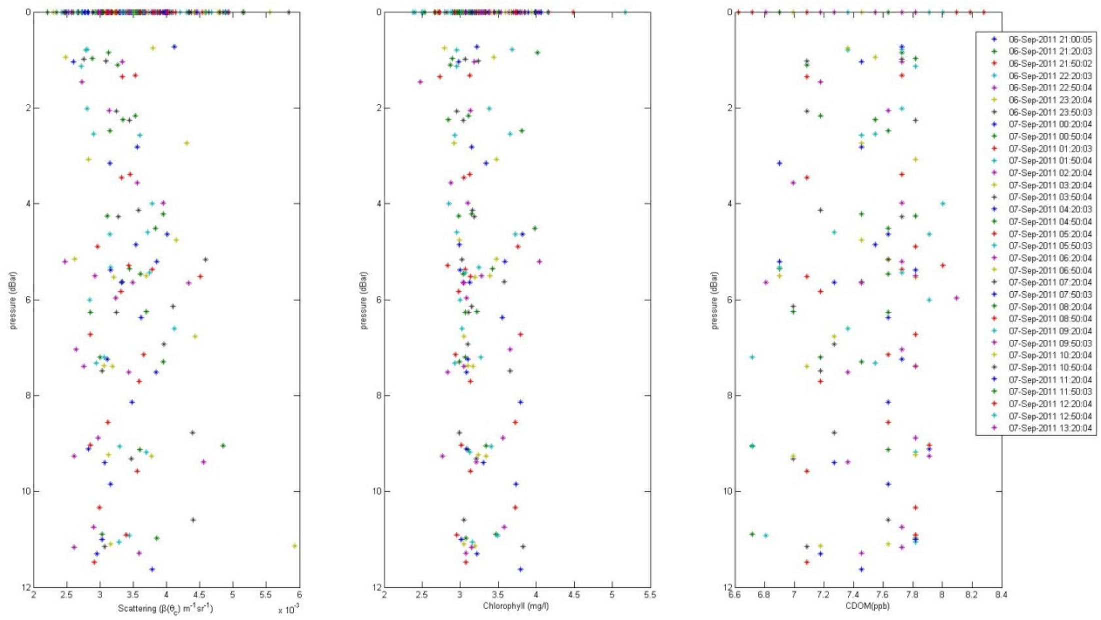


Figure 59: BBFLT2 Fluorometry data (Scattering, Chlorophyll mg/l, and CDOM ppb) plotted as a function of depth. This plot show selected profiles from Sept 6th and 7th.

Once the profiler was recovered from the well test O'Brien continued testing the full system and monitored the performance of the MMP and CTD (in air) on the dock outside Bigelow.

Prior to loading the ship the complete CPPM buoy was weighed in air and floated in the well to establish check the waterline. The Buoy weighed 1280 lbs. in air and floated at the expected level (figure 60.)

Figure 60: Photo showing the float test Profiler Mooring in the WHOI well. This test established that the weight and balance of the buoy was correct according to the design.

MAVS

The MMP unpacker software does not include the code to unpack data from the MAVS instrument. At the time of the well test the data from the Nobska MAVS were not able to be processed. Profiles collected during the well test were sent to Todd Morrison (vice president of Nobska). Unfortunately, Morrison was travelling in Mexico and unable to respond to email. At the time of the well test all that could be verified was that the MAVS file on the MMP matched the MAVS file on the surface controller and the MAVS file that was transmitted home via iridium.

After the ship departed, O'Brien collected more documentation and MatLab files to start writing command line program in C that could be compiled and run on the Linux servers and be integrated with Steve Lerner's web interface. The code automatically processed the data and posted it into the appropriate folder on the server.

Analysis of the processed data looked incorrect and data were resent to Morrison for a second opinion. Morrison confirmed that the velocity measurements and to some degree the compass values were intermittently bad. McLane was contacted to get a copy of test tank data. Tim Shanahan sent the raw data to O'Brien and processed the McLane tank data. The tank data was found to be corrupted indicating the problem existed prior to the

MMP delivery. Morrison looked at the tank and the well data and does not know what is causing the issue. He has offered to troubleshoot the issue when the profiler is recovered.

It should also be noted that the Scripps profiler on the hybrid profiler is suffering from a similar yet lesser issue with its MAVS unit.

D. Global Hybrid Profiler Mooring (GHPM) Preparations

1. SIO tests

The assembly and test of the GHPM and its components started in July 2011 at SIO as outlined in the Integration and Test Plan (ITP) plan, Document #3166-30000. All controllers, instruments, acoustic modems, acoustic release and beacons were tested individually. Mechanical parts were inspected and the wet weights of major components were measured: the 64" sphere assembly, U-joint, EM chain with coupler, upper acoustic release assembly, wire with inductive termination, load cage with/without instrumentation. The inductive communication between SIO controller, WFP and current meter was verified during a test of the WFP in a 10m tank for approximately three days. The inductive communication test failed on the 2000m section of wire which was spooled on a reel due to electromagnetic interferences created by the coil of wire. This test failure has been observed in previous tests with the wire on the reel. The wire was not removed from the reel due to the length.

2. BIO tests

The SeaCycler Mechanism Float (Winch) was shipped from SIO to WHOI with the main controller electronics and associated pressure case removed from the system. This allowed the winch to be shipped on a flatbed truck without subjecting the electronics to "back-driven" voltage surges caused by motor rotation during transportation. This also provided an opportunity to fully inspect the drive motor and all of the associated control electronics before it was re-installed into the winch at WHOI.

The four battery cases were also shipped independent from the winch. This was done to alleviate any excess winch bearing and journal wear that might have been experienced because of extra weight during transportation.

Prior to re-installing the control electronics, bench tests were conducted on the controller to verify motor control and all monitoring circuitry. Basic telemetry tests were done to confirm the communication link between the SeaCycler Mechanism Float and the SeaCycler Instrument Float. Inductive communications tests were conducted on the bench between the SIO Controller and the SeaCycler winch electronics, using Seabird test couplers. This was the first opportunity to test the inductive link with "real hardware" and some minor firmware modifications were implemented as a result of this testing.

The four battery cases were tested using a "dummy" load to ensure the integrity of all packs. The cases were installed into the winch, with each case cabled and tested as a "stand alone" pack. This approach was implemented to ensure that any one of the four battery cases could power the SeaCycler winch, independent of the others.

The control electronics were installed in the winch and full system tests were performed. These tests were conducted before the profiling cable was threaded through the fair leads, which allowed the motor control system to power the drum through its full translation from the "docked" position to the "all cable out" position and back again. During these tests, all operating parameters were verified including: motor start/stop, brake (both dynamic and static) operation and monitoring, power consumption and monitoring, motor and drum rotation monitoring, dock detection, over-current detection, pendulum counter-balance monitoring and wireless telemetry operation.

After all of the functional winch tests had been conducted and verified, the profiling and winch cables were threaded through the fair leads, and the Instrument Float and Inductive Coupler were connected. Additional tests were conducted to verify the operation of the inductive link between the SeaCycler winch and the SIO controller. It was during these tests that the Seabird Inductive Modem Module (IMM) in the SeaCycler winch control electronics failed. The electronics case was removed and the IMM was replaced with a spare supplied by SIO. The follow-on testing of the inductive link was successful after the replacement. The original IMM was sent back to Seabird for evaluation in order to determine the cause of the failure.

A series of tests were conducted on the SeaCycler Instrument Float, including: communications between the Instrument Float and the winch, communications between the Instrument Float and the Comm Float, functional and communications tests between the Instrument Float and the three onboard instruments (CTD, PCO2 and Acoustic Modem). It was during these tests that an intermittent power-up issue was detected on the PCO2 sensor. There was an excessive inrush current into the Seabird pump which was not detected during the bench tests conducted at BIO. This caused the over-current protection circuit in the SeaCycler Instrument Float control electronics to trip. After assessing the issue, a firmware "soft start" was implemented in the SeaCycler control electronics in an attempt to resolve the issue. These tests were all conducted at room temperature. Post deployment data shows the "fix" was marginal, as subsequent field results have shown that the solution was only partially effective in colder water temperatures.

The Comm Float was initially tested independent of the winch and instrument floats. The Comm Float has a user interface with built-in functions for testing GPS, Freewave and Iridium functionality. The Comm Float was set up outside the CRL building, powered up with an external battery pack and connected to a laptop computer. The GPS was powered up and left on until it had acquired its new Almanac and Epheremis data. Also, the technician verified that the GPS was sending stable position readings. A number of power off/on cycles were conducted to establish the new "warm" time to first fix. Freewave communication was tested by transmitting a number of Comm Float generated, constant pattern files to a laptop computer at CRL, running BIO's STS software. The patterns were compared at the receiving computer for data integrity. Test commands were also sent through the STS interface, back to the Comm Float during this exercise. Similar tests were conducted using the Iridium modem, however these files were received (and emailed back) from the STS receiving equipment at BIO.

The Comm Float was connected to the Instrument Float, and full system communications tests were conducted. These tests included complete communication path transfers to/from the SIO Controller and the Mechanism Float; to/from the Mechanism Float and the Instrument Float; to/from all instruments and the Instrument Float; to/from the Mechanism Float and the Comm Float; and to/from the Comm Float and the STS receiving computer. Most of these tests used Freewave as the primary communication medium; however a few Iridium sessions were conducted as well.

E. Staging in Woods Hole

1. SIO/BIO staging at CRL

Staging for the Hybrid Profiler Mooring was conducted in the high bay of the Coastal Research Laboratory. Shipments from BIO and SIO were shipped there directly. Final integration and testing were performed in the high bay. Final packing for the cruise was organized in CRL prior to loading the ship.

2. WHOI CPSM and CPPM staging

The CPSM mechanical assembly was started in in the Coastal Research Lab and was transitioned to the Clark high bay for final assembly and integration. The buoy and staging for the AST2 deployment cruise also took place in the high bays of Clark South and CRL. Because this was a WHOI-to-WHOI and did not require shipping containers, cruise packing could take place in individual labs and material brought to the ship as it was set up.

The CPPM completed integration testing next to the trailers on the WHOI dock near Jeff O'Brien's office. The buoy and components of the mooring riser were located on the dock prior to loading the ship. These parts were loaded directly to the ship.

CPSM Buoy Assembly
Well Assembly:
The AST2 surface buoy well consists of three layers, the bottom or battery layer, the middle deck or logger/telemetry layer, and the top deck or controller layer. The layers were assembled and wired from the bottom up. The buoy well assembly also included wiring four separate junction box panels with bulkhead connectors and cabling.

Battery layer:
The deep cycle marine battery harnesses were pre-made with connections on the battery ends only. Approximately 12 ft. of wire was left unconnected so that the wire path could be determined and cut to length. The batteries were mounted in a battery tray and the cables were connected to the batteries with the fuses removed to avoid shorting the open ends. The populated battery tray was then installed and secured on the bottom deck of the well. The cables from the batteries were routed and secured to the well side walls.

Each of the four separate power channels was checked at its respective end. The remaining terminations were made after estimating the lengths to the PSC (power system controller) and the junction box panel. Once all terminations were completed, final continuity testing was performed, and the bottom deck was considered finished.

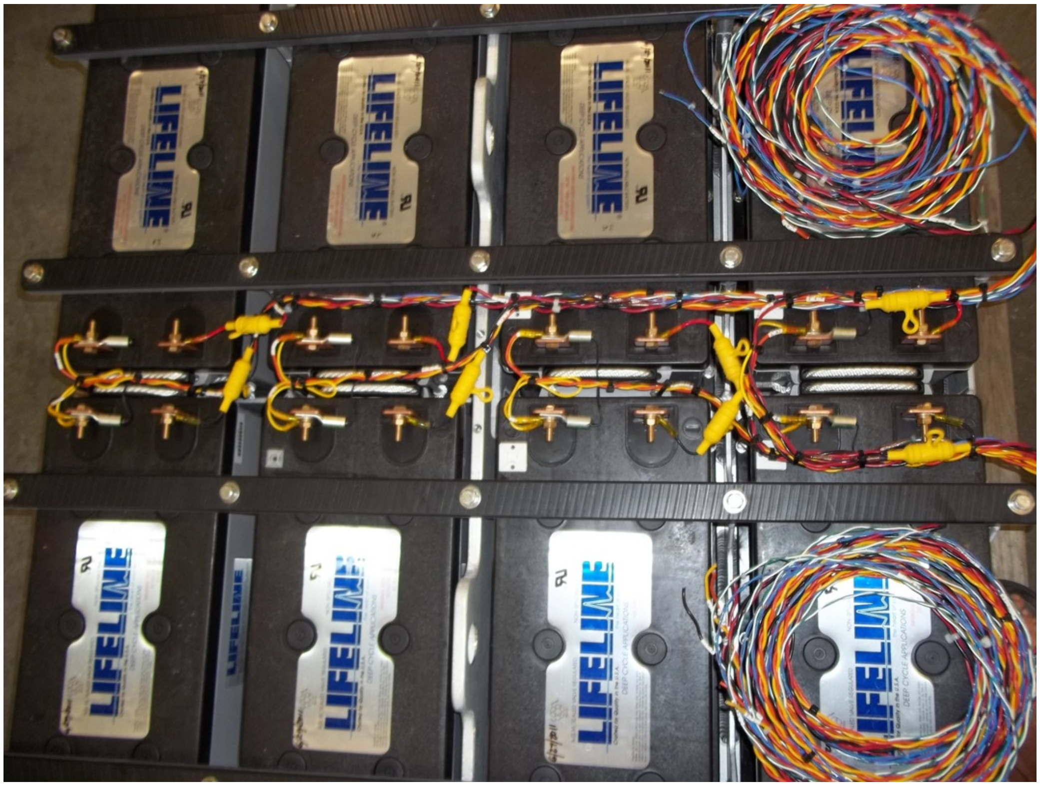


Figure 61: Batteries wired together in the bottom layer

Once the bottom deck was completed, a temporary top shelf was installed. The PSC and the PlatCon were located on the shelf to measure the cable lengths. Connectors were attached to 10 ft cable leads and temporarily run to their final destinations including the junction boxes.

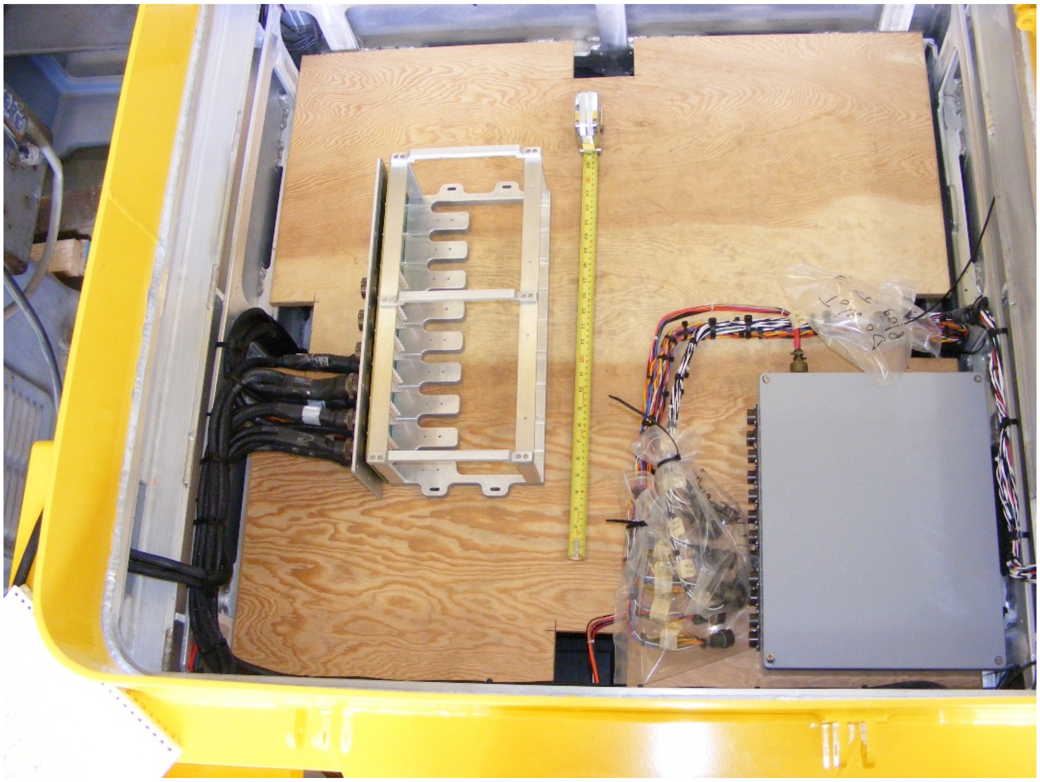


Figure 62: Photo showing the temporary plywood shelf that was used to establish the locations of the platcon and PSC to determine wire harness lengths.

The PSC and PlatCon were removed and the cabling moved aside to allow for access to the middle layer.

MET Logger/Telemetry layer:
The middle deck was secured and populated after the moving the top layer cabling aside and removing the top deck (figure 63). Electronic boxes and backup batteries were secured to the deck. Cables to the J-Boxes were run to their designated destinations. The harnesses from the top deck to the middle deck were then terminated and secured with the rest of the interior cabling.

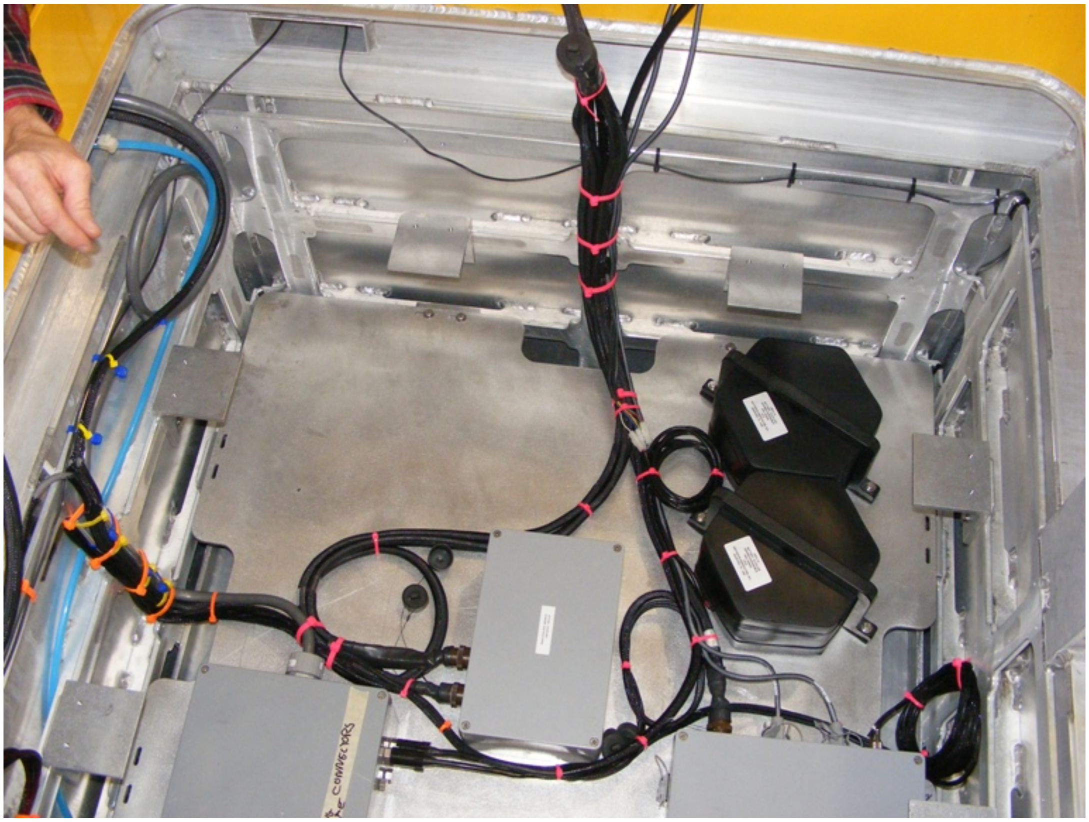


Figure 63: Middle layer holding the bulk met data logger back up batteries and engineering sensor box.

The final step required the top deck to be installed and the PSC and PlatCon mounted and secured (figure 64).

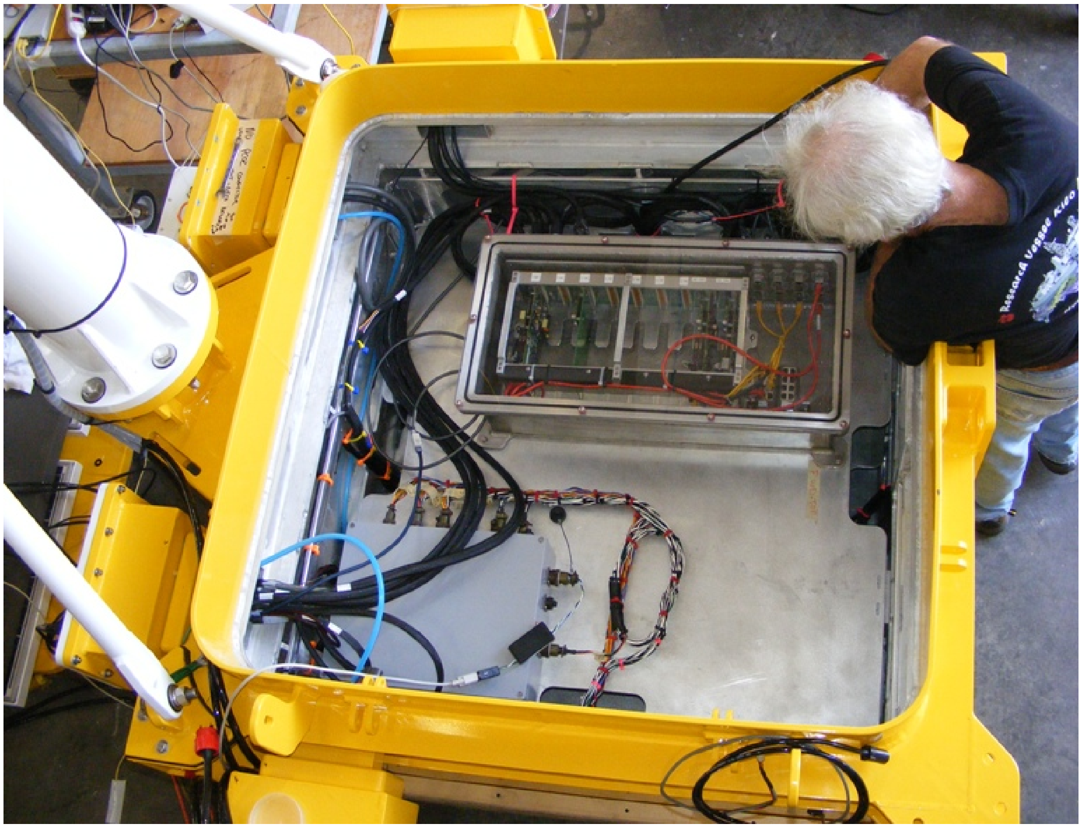


Figure 64: Photo showing the top layer with the completed Platcon and PSC installed.

Junction box panels:
There are four panels with bulkhead connectors, which allow pass-through from the outside of the buoy to inside the well. Some wiring was terminated with inline splicing and some with removable connectors. Connections were wired with service loops for access to the back-side of the panels for service (figure 65). After all wires were connected, the interior cabling was secured for deployment. Tie wraps, spiral wrap, and neoprene strips were used to secure the cables and to prevent chaffing of the wires.

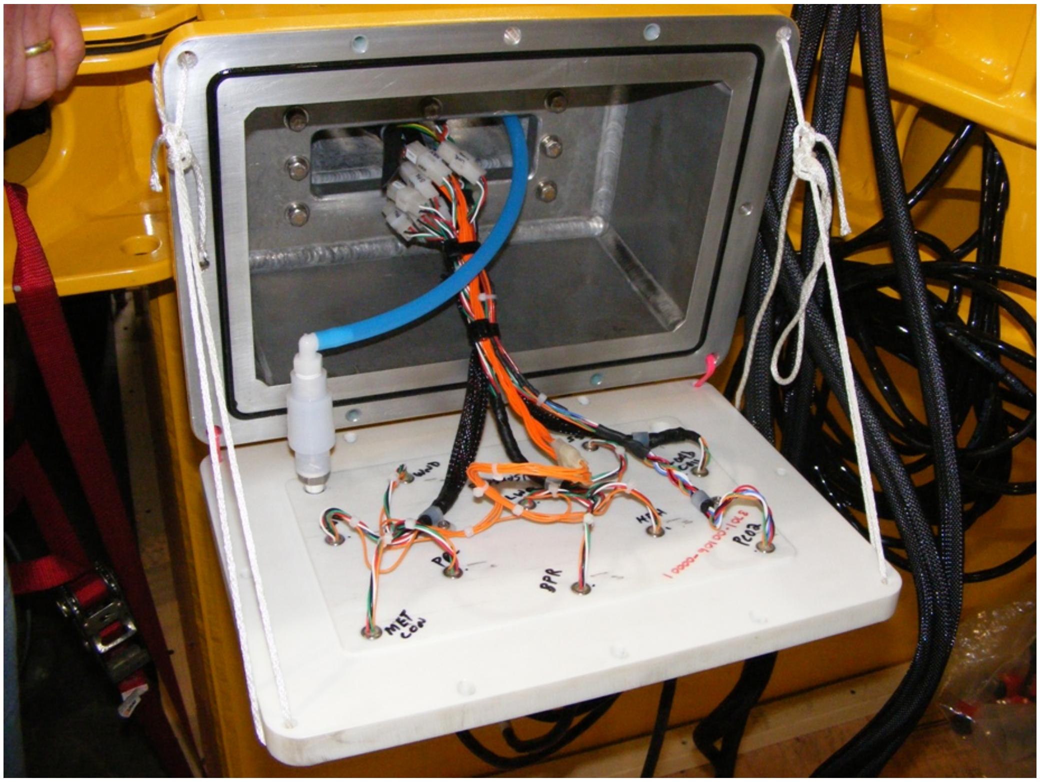


Figure 65: Bulk met junction panel being wired.

Once the CPSM buoy well was completed in the Clark South High Bay, it was moved to the burn-in pad adjacent to the Clark South High Bay (figure 66). Burn in testing consisted of continuous running of all systems using full telemetry and with scientific instruments placed in water barrels next to the buoy.

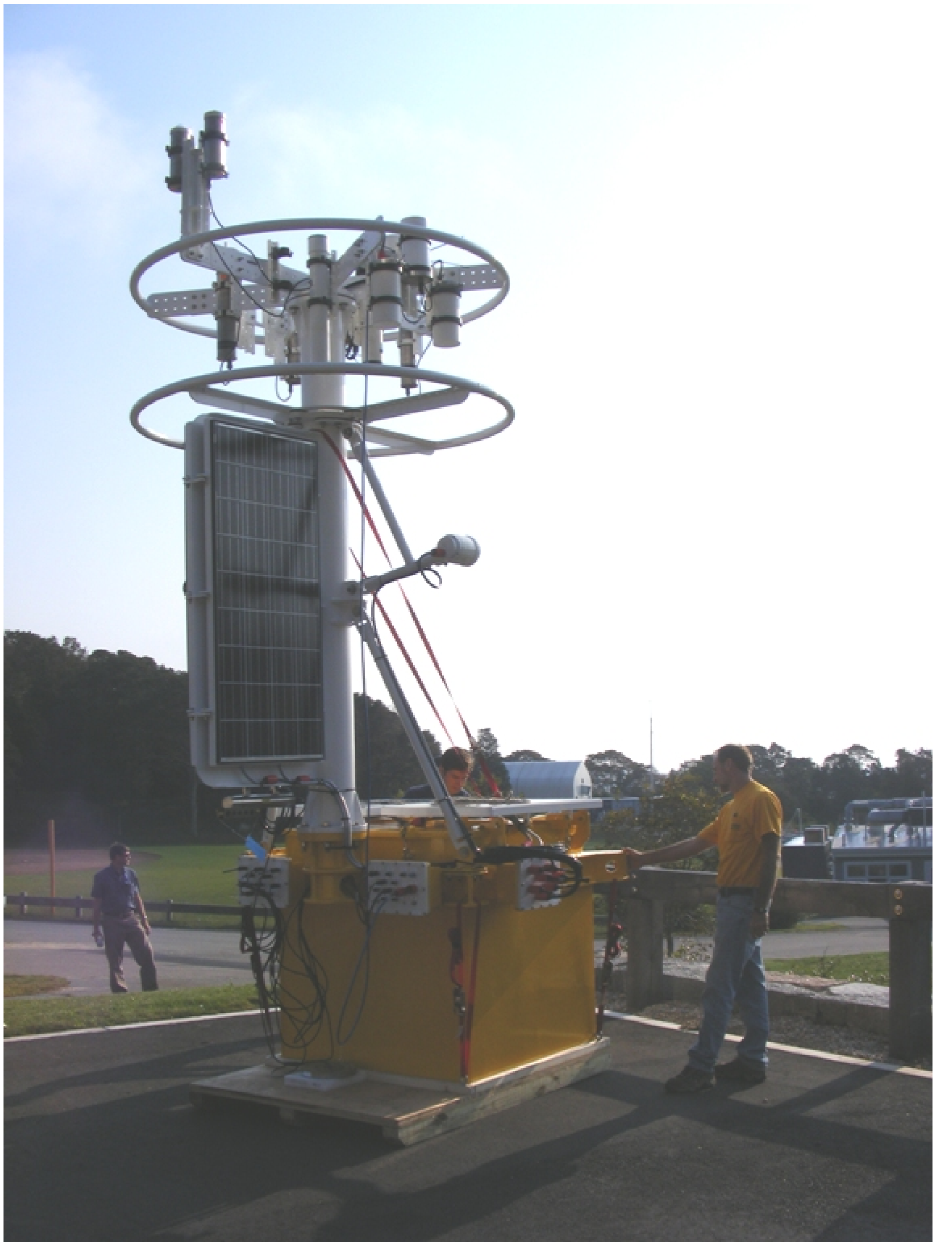


Figure 66: Completed surface mooring well on the burn in pad prior to the compass spin test.

After burn-in, the buoy well was inserted into the flotation foam and the assembly of the buoy was completed (figure 67). The assembled buoy was moved down to the dock for well tests and loading on the ship (figure 68).

Figure 67: Buoy well being inserted into the foam buoy.

Figure 68: Surface buoy on 'low boy' flat-bed being delivered to the ship.

The CPPM was built up in the village. This allowed testing in the WHOI dock well and facilitated loading on the ship.

F. Loading and Deck Layout

Loading took place on Sept. 20-23, 2011. The AST2 surface buoy, hybrid profiler winch assembly were transported from the Coastal Research Center via a double drop commercial trailer. This trailer style shown in Figure 69 was required, due to over road restriction of large size components.

Figure 69: A flat bed trailer was required to move SeaCycler from CRL to the dock.

Figure 71, illustrates the completed deck load of *the R/V Oceanus* prior to departure. The loading process began with loading the 01 deck level first. Main deck loading followed and was loaded from the out board port rail to the inboard starboard rail.

The hybrid profiler was transferred from the double drop trailer shown in Figure 70 to the ship directly from the trailer using the ship's crane.

Figure 70: SeaCycler being lifter from trailer to load onto the deck of R/V Oceanus.

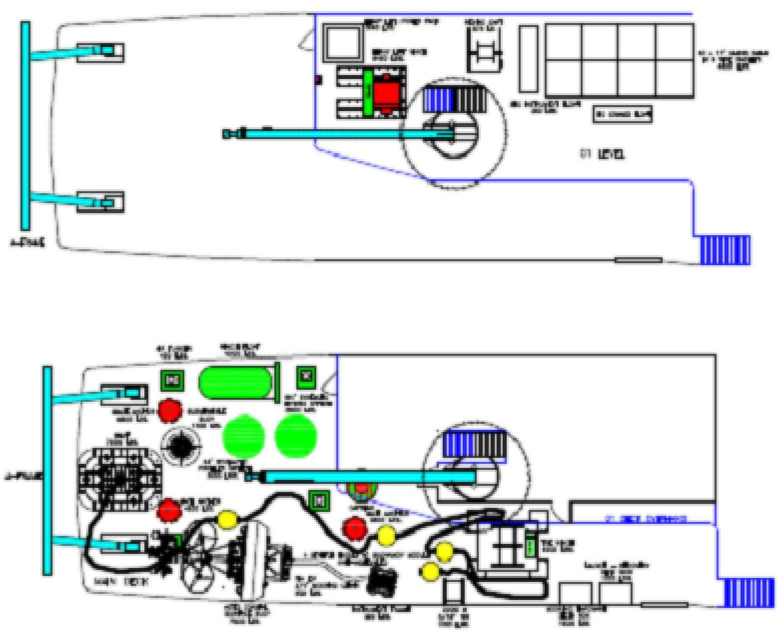


Figure 71: Deck layout of *R/V Oceanus*. Upper panel shows deck, without AST2 gear. Lower panel shows AST2 gear placement on deck.

Seven science personnel were detailed with the task of loading and securing the cruise science equipment. Two nine-hour days were required to complete this task with approximately 5 hours to pre-stage the AST2 surface mooring for deployment on the day of departure.

III. AST2 Moorings

A. Overview

The three moorings deployed in AST2 are prototypes of the mooring types to be deployed by CGSN. The Coastal Pioneer Surface (CPSM) as deployed is shown in Figure 72; it is a CGSN surface buoy attached by stretch hose to a Benthic Anchor Recovery Frame (BARF). The Coastal Pioneer Profiler Mooring (CPPM) as deployed in AST2 is shown in Figure 73; it has a submersible surface buoy for telemetry above a taut mooring that support a wire-crawling profiler. The Global Hybrid Profiler (GHP) mooring as deployed in AST2 is shown in Figure 74; it has a SeaCycler upper ocean winched profiler in the top section and a crawler profiler in a taut wire lower section.

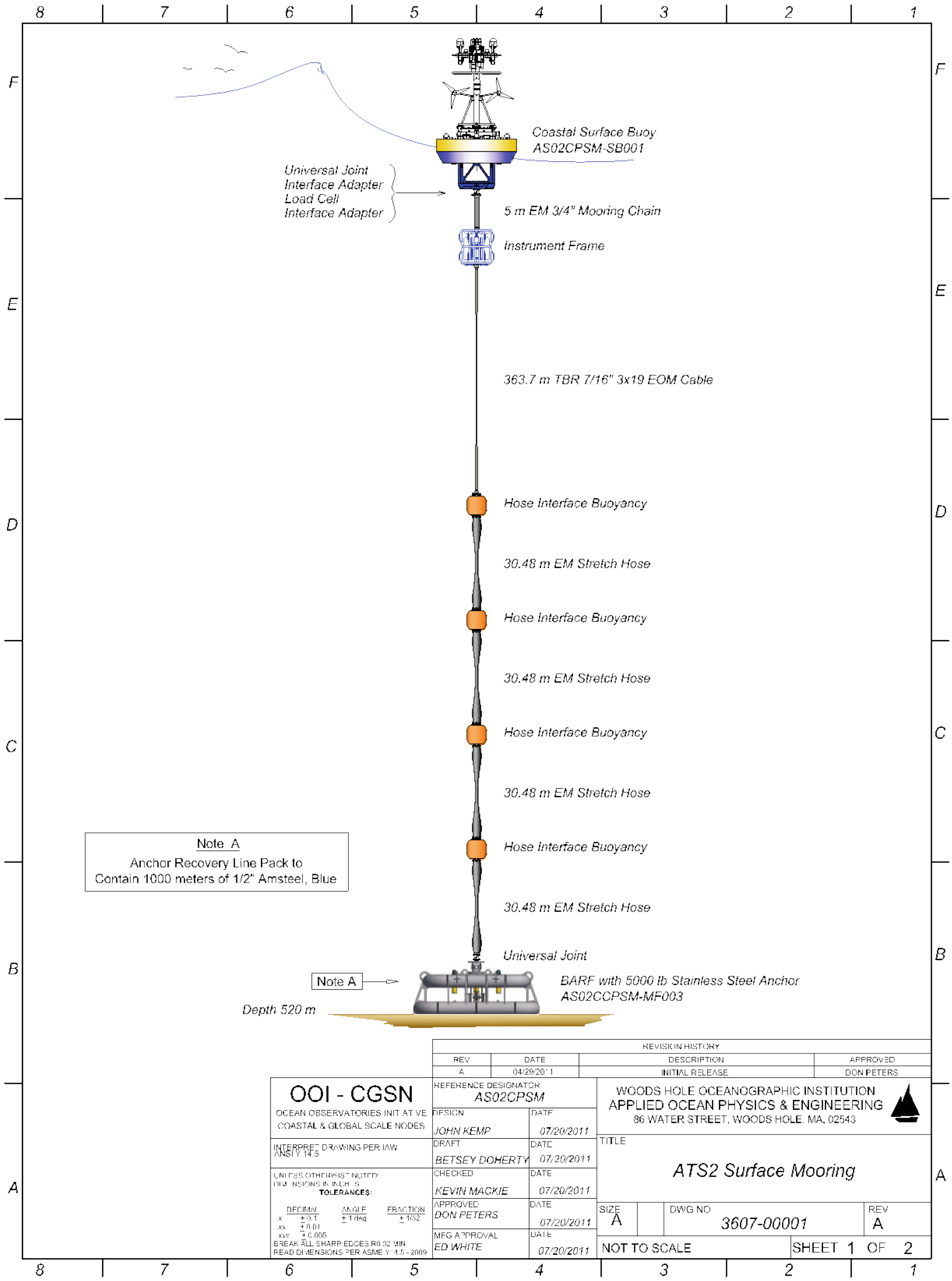


Figure72: Coastal Pioneer Surface Mooring diagram.

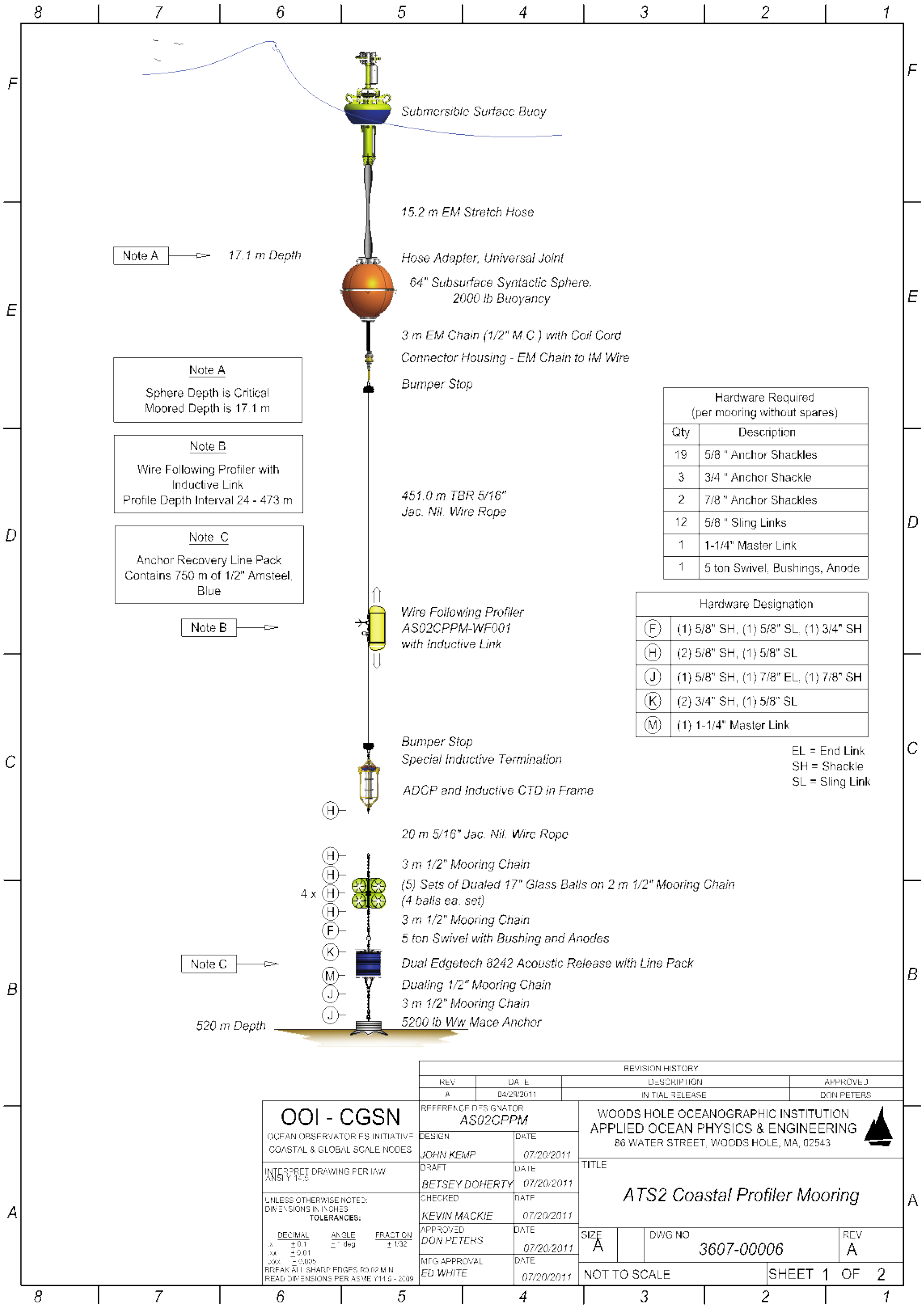


Figure 73: Coastal Pioneer Profiler Mooring as deployed in AST2.

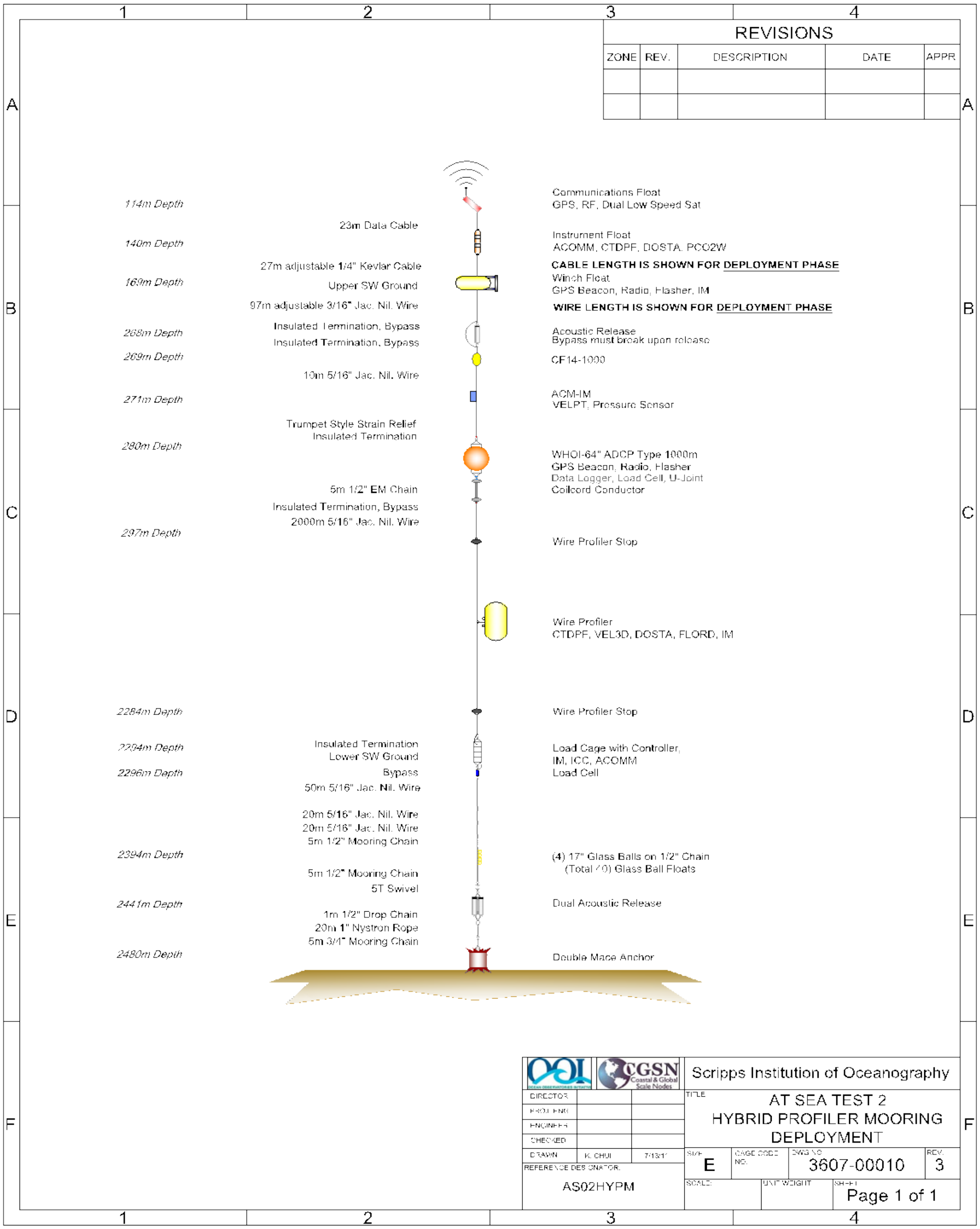


Figure 74: Global Hybrid Profiler mooring as deployed in AST2.

B. Coastal Pioneer Surface Mooring

1. Buoy Instrumentation

The Surface mooring instrumentation included a combination of scientific and engineering sensors designed to collect environmental data sets or data that describes how the buoy responded to the environment. The Surface mooring instrumentation included instruments mounted on surface buoy and instruments located in a special Near Surface Instrument Frame (NSIF) located on the mooring riser below the buoy.

Surface science instrumentation consisted mostly of the bulk meteorological sensors mounted in the buoy halo. The table below shows the modules and reports module height above the water. The height is calculated with the following equation:

Height above water = Waterline to deck + deck to halo + height above halo

In the case of the CT sensor the water line is subtracted from the distance to the deck.

Table 10: Instrument height (depth) referenced to the ocean surface.

Sensor	Distance from Sea Surface
Precipitation (PRC)	353 cm
Humidity / Relative Humidity (HRH)	362 cm
Sonic Wind (SWND)	378 cm
Short Wave Radiation (SWR)	402 cm
Long Wave Radiation (LWR)	402 cm
Barometric Pressure (BPR)	347.5 cm
Sea water Conductivity / Temperature (CT)	-111 cm

Figure 75: Photos showing the plimsoll on the buoy during the dock well test (left) and deployed (right). The deck height above the water line is 32cm and was used in the above equation to correct the height of the bulk met sensors above the surface.

2. Subsurface Instrumentation

Except for the bulk met CT sensor mounted to the bottom frame of the surface buoy, the subsurface science instrumentation was mounted in the NSIF. This cylindrical frame has six mounting plates in a spoke pattern. The hole pattern on the plots allows for a maximum number of mounting configurations. The frame is attached to the 5-meter EM Chain below the buoy. Four sensors listed in Table 11 below and a DCL were mounted to the NSIF.

Table 11: NSIF instrumentation

Fluorometer WETLABS ECO DFL	WetLabs DFLS	69
Volume Scattering WETLABS ECO VSF	WetLabs VSFS	050B
Point Velocity VELPT	NORTEK AQUADOPP SYMMETRIC	P23833-9
CTDBP SERIES C	1336-00001-00003 Sea-Bird 16plusV2	6841

Engineering sensors include a load cell and a 3 dimensional accelerometer (3dmg). The load cell is at the bottom of the buoy attached to the universal and measures the tension in the mooring riser components. The motion pack is located nearly in the center of the well in the engineering sensor box (figure 63) and describes the 3 dimensional accelerations which are used to calculate the heading, pitch, and roll of the surface buoy. The buoy motion and the mooring tension will be used in the dynamic analysis of the mooring response to the environmental forcing.

3. Telemetry

The telemetry deployed on the CPSM consists of a fully redundant suite of transceivers and receivers which provided data links via satellite systems and local radios. In addition to these data links are the locator beacons and emergency beacons which are stand-alone backup systems. Also, not technically a telemetry device, the mooring includes an active radar transceiver to give the buoy an increased radar signature.

The CPSM surface buoy halo is show in Figure 76 with the telemetry modules labeled.

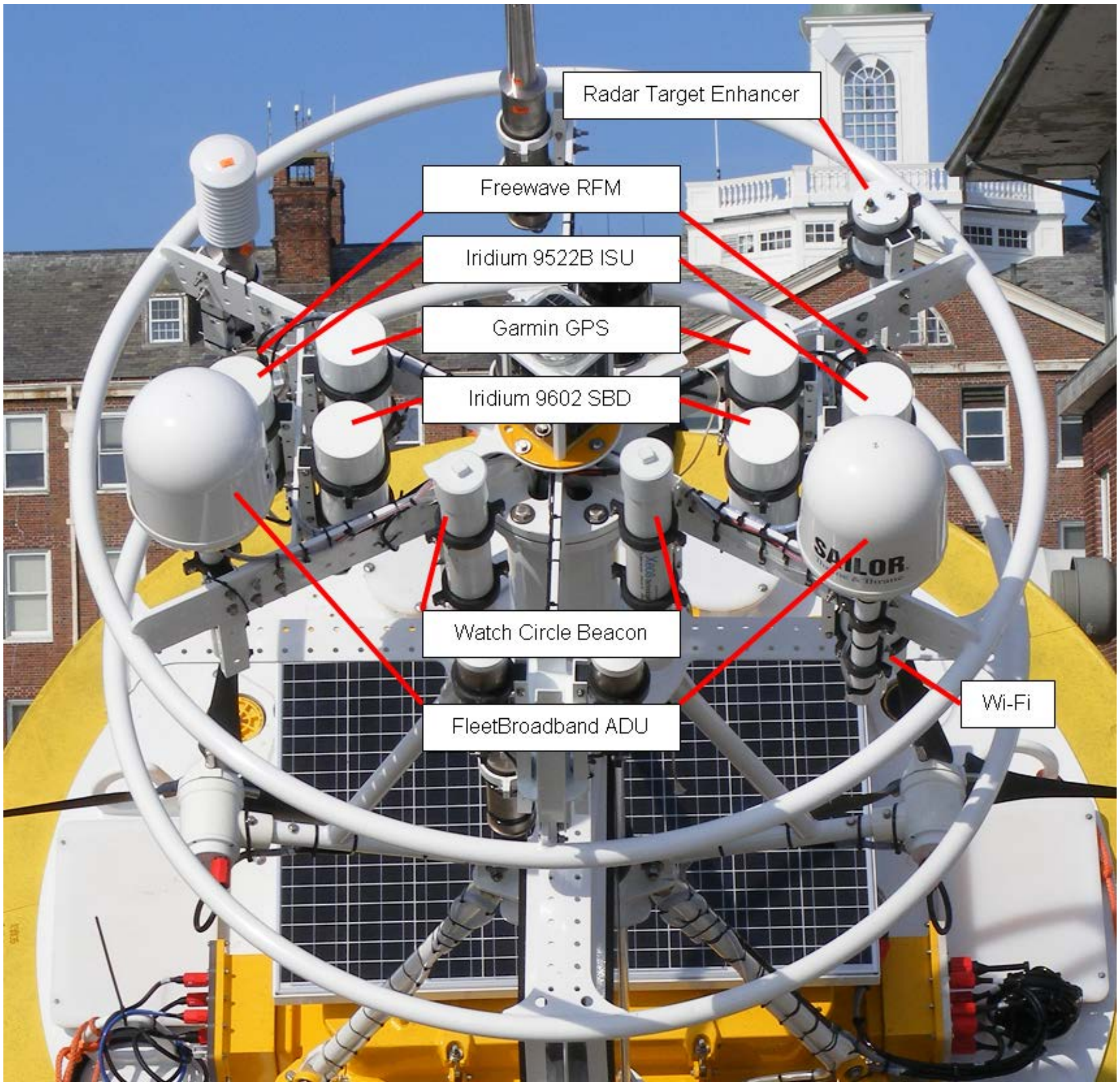


Figure 76: CPSM Telemetry Suite

The telemetry hardware shown in Figure 76 includes:

- Two each Fleet Broadband (FBB) 250 ADU. The FBB 250 is an Inmarsat satellite based Ethernet modem that is the primary data link between the mooring controllers and shore. The FBB 250 consists of an Above Deck Unit (ADU) which houses a tracking antenna and GPS receiver coupled to a Below Deck Unit (BDU) housed within the well. The BDU is described in greater detail in a subsequent section. The ADU has been hardened for the buoy application with additional sealing and a modified drain vent.

- Two each Iridium 9522B ISU. The ISU is an Iridium satellite based serial modem that is the secondary data link between the mooring and shore. The ISU are enclosed within a common telemetry housing that will be described in a subsequent section.
- Two each Iridium 9602 SBD. The 9602 is an Iridium satellite based Short Burst Data (SBD) link that is a primary link between the buoy watchdog system and shore. The SBD are enclosed within the common telemetry housing.
- Two each Garmin GPS. The GPS is providing position and timing information to the buoy and one of the units is enabled at all times. The GPS are enclosed in the common telemetry housing.
- Two each Freewave RFM. The Freewave transceiver is a line-of-sight RF Modem (RFM) which provides a serial data link between the buoy controller console ports and matching master transceivers for pre-deployment and post-deployment local (shipboard) operations. The RFM are enclosed in the common telemetry housing.
- One each Ubiquiti Wi-Fi. The Wi-Fi is a line-of-sight wireless transceiver which provides WLAN connectivity between the buoy LAN and ship or shore based WLAN equipment for pre-deployment and post-deployment local (shipboard) operations. The Wi-Fi is enclosed in the common telemetry housing.
- Two each Xeos MELO watch circle beacons. The MELO is COTS hardware manufactured by Xeos Technologies. Each beacon is self-powered and includes a GPS and Iridium SBD transceiver operating under local processor control. The watch circle software is remotely configured for watch circle center position, watch circle diameter, and normal and alarm timing. Should the buoy travel outside of the watch circle the beacons enter alarm mode and in conjunction with shore based software will alert designated personnel via e-mail.
- One each Radar Target Enhancer (RTE). The RTE is an X-band and S-band transceiver which detects radar pulses and re-transmits the pulse with minimal latency. The transmitted pulse has greater signal strength than a pulse that would be reflected from a passive radar reflector. The interrogating vessel will receive a signal which gives the buoy an enhanced radar cross-section and improves its visibility.

The CPSM is shown from below in Figure 77. In this figure it can be seen that the Wi-Fi, Freewave RFM, and Radar Target Enhancer are mounted upside down on the halo. The Wi-Fi- and RFM have an annular beam pattern with connectivity that benefits from this orientation and resulting in less shadowing on the satellite based telemetry, which want as clear a view of the sky as possible. The RTE is mounted in this orientation to minimize its impact on the halo mounted instruments and to help protect it from damage.

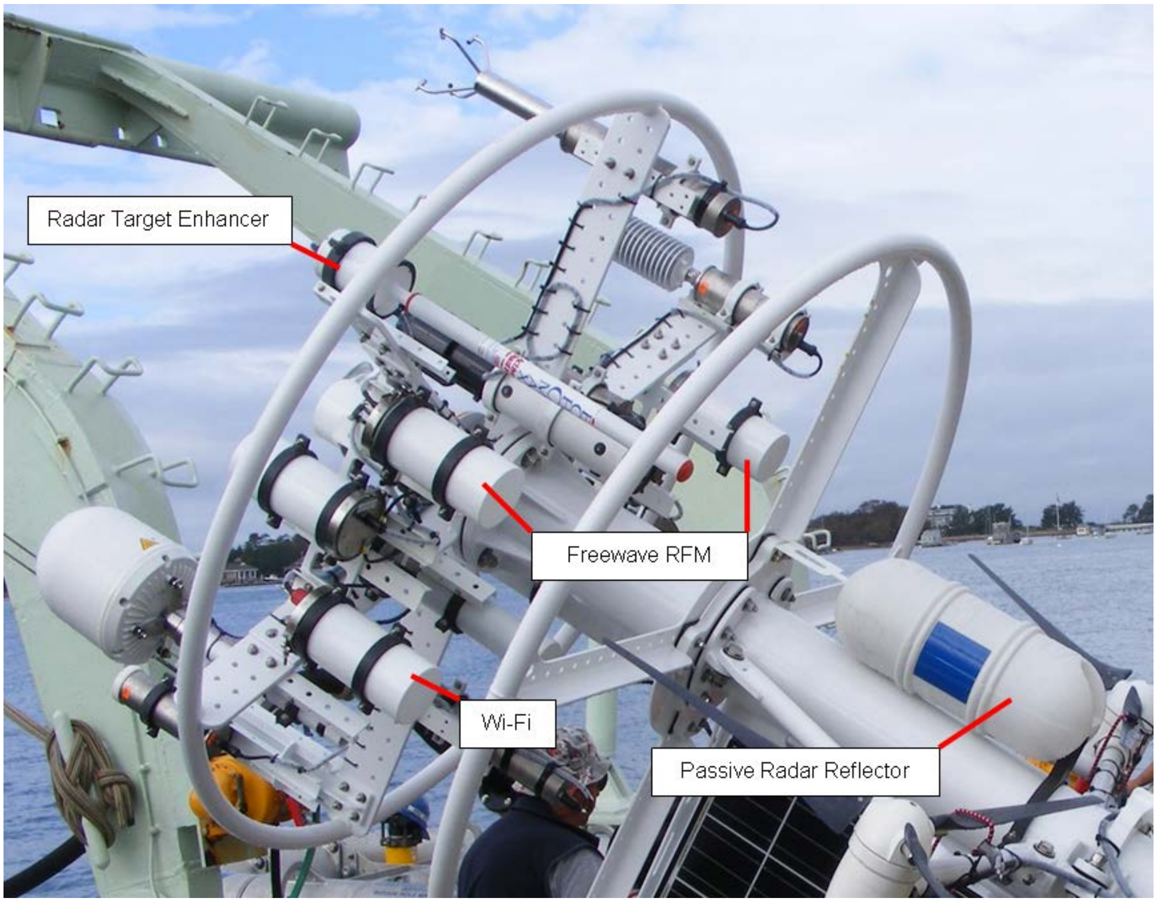


Figure 77: The CPSM telemetry as seen from below the halo.

The CPSM surface buoy was deployed with two emergency beacons mounted on its underside, referred to as “turtle” beacons, shown Figure 78. The first beacon is a COTS LED flasher manufactured by Xeos Technologies that is configured to remain off while upside down, under water, or in the presence of daylight. The LED flasher is self-powered and has battery capacity to flash continuously for 60 Days. The KILO beacon is COTS hardware manufactured by Xeos Technologies that has similar capabilities as the MELO beacon mounted on the buoy halo. It includes a GPS and Iridium SBD transceiver under local processor control. The KILO is self-powered and is configured to remain off while either upside down or in the presence of water. These same two beacons are also mounted on the BARF as an aid to recovery.

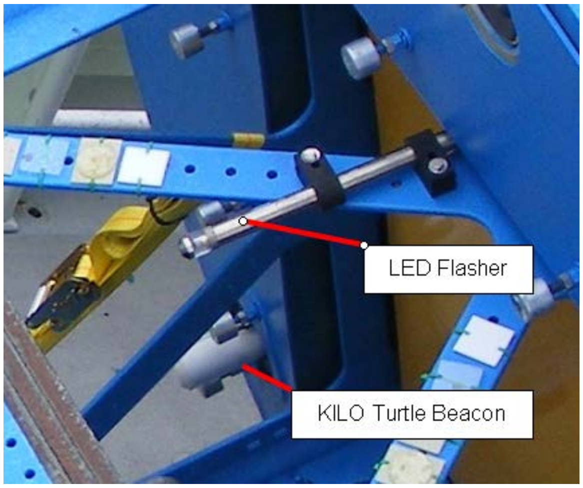


Figure 78: Two emergency beacons are mounted on the buoy underside.

Mounted within the well of the CPSM surface mooring is the housing that contains the two Fleet Broadband below Deck Units (BDU). This is shown in Figure 79. The housing and all of its connectors are IP68 rated and the BDU have full electrical isolation, where an RF ground is provided for connection to seawater.

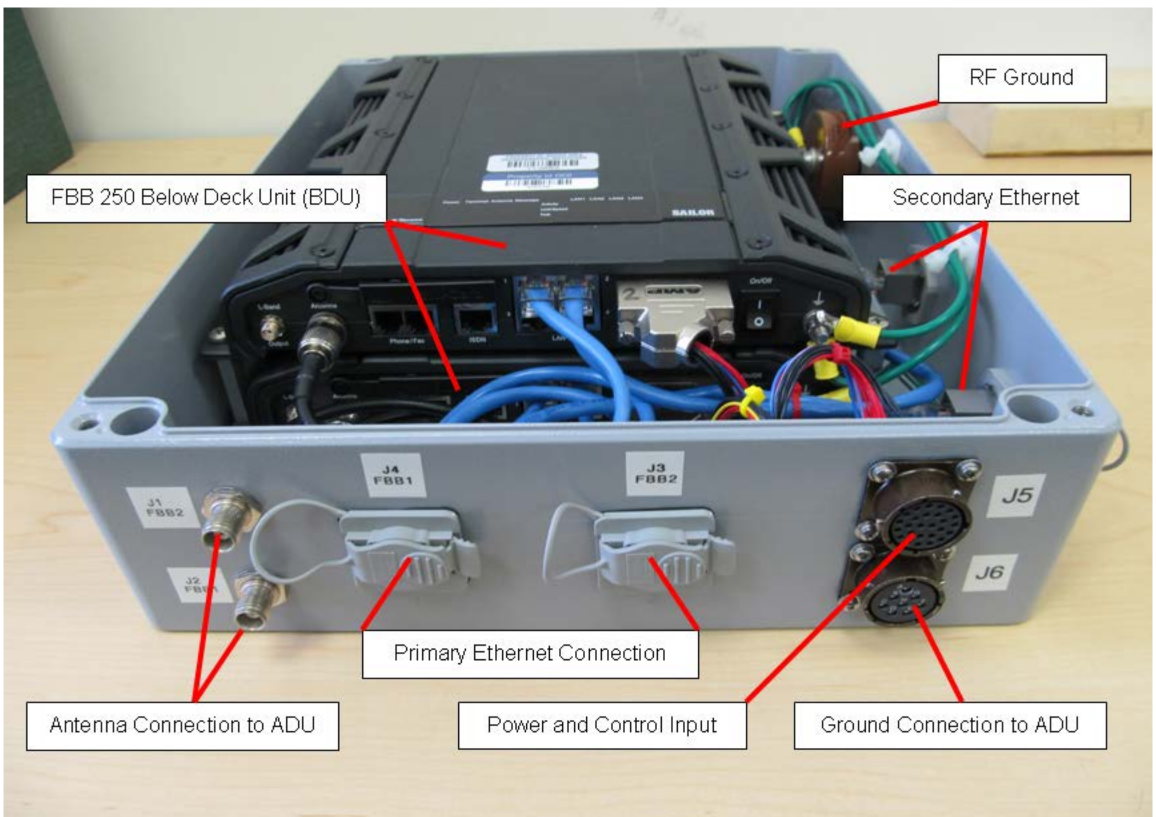


Figure 79: Fleet Broadband Below Deck Unit (BDU) Enclosure.

Nine telemetry devices mounted on the CPSM halo are housed in a common telemetry enclosure, shown in Figure 80. The common enclosure is used across all CGSN moorings, including the CPSM and CPPM deployed for AST2. This enclosure is rated for 100m immersion and includes all telemetry hardware such that the interface to controlling hardware is power and data alone, avoiding the need for high priced underwater rated RF connectors. The enclosed hardware is fully electrically isolated and includes an isolated RF ground connection.

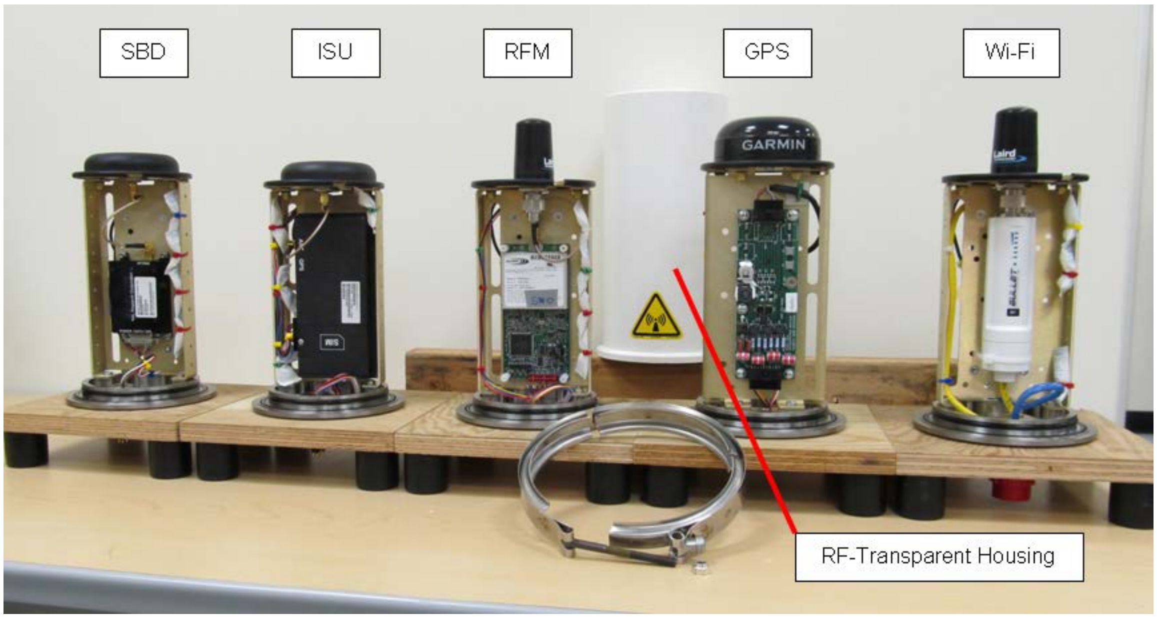


Figure 80: A common enclosure houses five versions of telemetry.

4. Power Systems

Coastal Pioneer Surface Mooring

The Coastal Surface Buoy power system block diagram, shown in Figure 81, includes natural power collection sources, a WHOI-developed Power System Controller (PSC) unit with custom firmware, and eight, 12VDC, rechargeable, 4D size AGM batteries arranged in four strings of two series batteries providing a 24VDC main power bus and a capacity of 20 kW-hr. There are two sources of natural power - an array of four PV panels and a pair of horizontal axis wind turbines. Two Kyocera 85W PV panels are mounted on the well hatch cover and two Kyocera 135W panels are mounted on either side of the buoy wind vane. The wind turbines, manufactured by Superwind GmbH, are rated at 350W each and are mounted below the mast halo on the port and starboard sides of the buoy. The COTS wind turbines are modified by WHOI to enhance mechanical robustness and to incorporate a blade-braking safety feature. The rechargeable battery bank is located in the lowest layer of the buoy well. The PSC is mounted high in the well to an aluminum plate with provisions for heat sinking to the hull. Connections to the power generators exterior to the well are brought out to a j-box access plate for convenient cable routing. The power system j-box also includes a port for battery charging from an external source in a lab or shipboard environment.

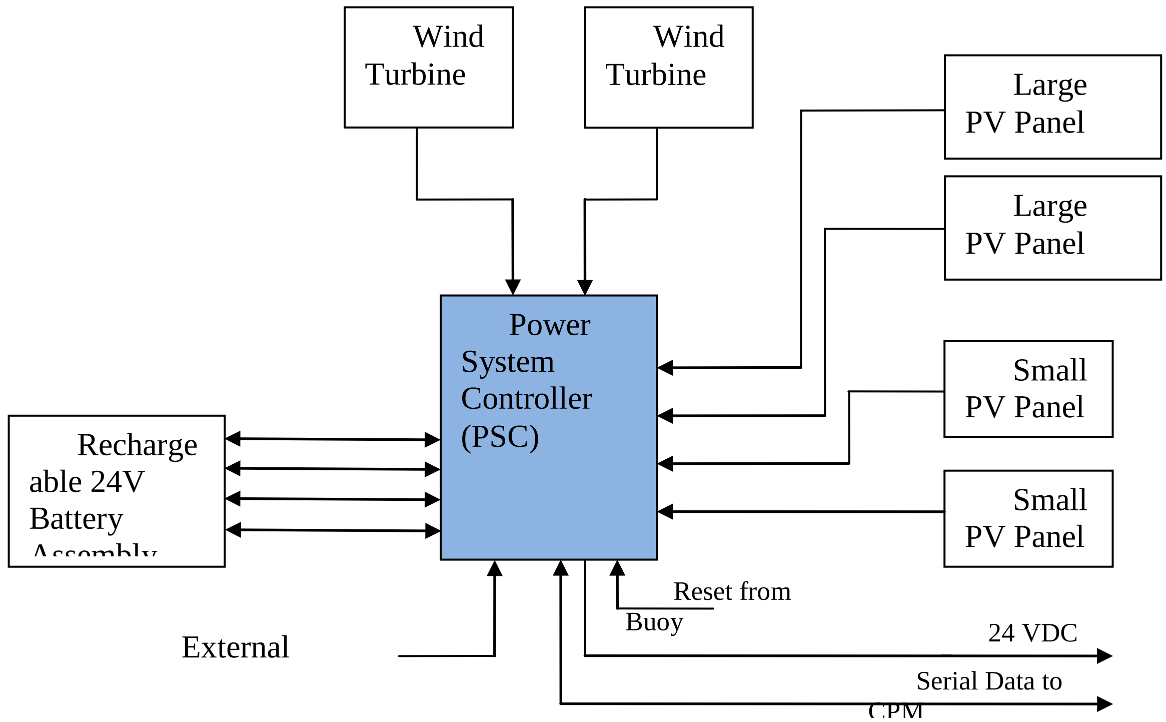


Figure 81: Coastal Surface Buoy power system block diagram

During normal operation, the PSC manages charging of the battery bank by enabling or disabling the power generating devices. A typical charging cycle begins with a fully charged battery and power generators disabled (PV panel outputs disconnected and Wind turbine outputs disconnected and shorted). As the buoy electronic loads deplete the battery bank the PSC monitors power usage and reports status to the Platform Controller. When the battery state-of-charge reaches 90% the power generators are enabled and power is harvested as it becomes available. The generators remain in an enabled state until the PSC determines that the battery bank has reached a fully charged state as indicated by a coulomb counting algorithm and measurement of the battery terminal voltage. When the battery bank is fully recharged the generators are disabled and the next charging cycle begins.

5. Data Logging

Data from the buoys are logged in several locations. In general the Buoy STC or DCL records the engineering data, status data about the platform controller, buoy location, and communication statistics, in addition to the scientific data. Data transmitted to the shore side OMC represent another location data are recorded. These data are transmitted and parsed to make the various plots and status tables on the OMC website (http://cgsn-omc.whoi.edu/oms)

In addition to the data logged on the DCL some of the science sensors log data internally. The seven modules of bulk met system each record raw data internally on flashcard internal to the module. Data from all the modules is logged and time stamped on the stand-alone Bulkmet data logger which connects to the DCL.

The Nortek point velocity sensor and the Sea Bird Pumped CTD mounted in the NSIF record data internally. The two Wet Labs optical instruments are not capable of logging data internally.

The engineering sensors (load cell, radar reflector, and motion pack) do not record data internally. The DCL records these data and transmits them to the OMC using the Fleet Broad Band communication.

C. Coastal Pioneer Profiling Mooring

1. Buoy Instrumentation

The profiler mooring instrumentation consists of a Seabird SBE37-IM purchased by the OOI program and a Teledyne RDI 75 KHz Longranger ADCP borrowed from Dan Torres in the Physical Oceanography Department. The remainder of the sensors is part of the McLane Moored Profiler MMP which was purchased as a one-off-buy for the AST2 deployment.

The 75 KHz Long Ranger ADCP and the SBE37-IM were mounted in Inductive ADCP frame connected to the bottom of the 451m inductive cable that the MMP crawls. The ADCP was borrowed from Dan Torres and was configured to be upward looking. The ADCP is not capable of inductive communications and will log data internally to be downloaded after recovery. The SBE37-IM was mounted in the frame with the ADCP and connected to the inductive line using a custom loop-back cable.

Two self-logging RBR tide wave sensors were attached as engineering sensors (Appendix 8). One RBR is attached to the bottom of the submersible buoy and will hopefully capture any instances when the buoy is submerged. The second RBR sensor was mounted to the 64 inch sphere will record the sphere depth and should be able to describe the wave and tide condition at the surface.

Table 12: Instruments on the Profiler Mooring

Qty.	Item	Part Number	Serial Number
1	75kHz Longranger ADCP	Teledyne WHLS75-I-2-UG14	ML1271 4-01
1	Wave/Tide Meter	RBR TWR -2050	21589
1	CTDMO Series G	Sea-Bird 37-IM	8523
1	Wire Following Profiler	McLane MMP-7	ML1271 4-01
1	CTD	Sea-Bird 52MP	0093
1	DO (Dissolved Oxygen)	Sea-Bird 43F	0239
1	MAVS Acoustic Current Meter	Nobska MAVS40p0.c	10300
1	PAR	Biospherical QCP-2300	70357
1	Fluorometer	Wet Labs BBFL2	830
1	Wave/Tide Meter	RBR TWR -2050	21590

2. Telemetry

The telemetry deployed on the CPSM consists of a fully redundant suite of transceivers and receivers which provided data links via satellite systems and local radios. In addition to these data links are the locator beacons and emergency beacons which are stand-alone backup systems. Also, not technically a telemetry device, the mooring includes an active radar transceiver to give the buoy an increased radar signature.

The CPSM surface buoy halo is show in Figure 82 below.

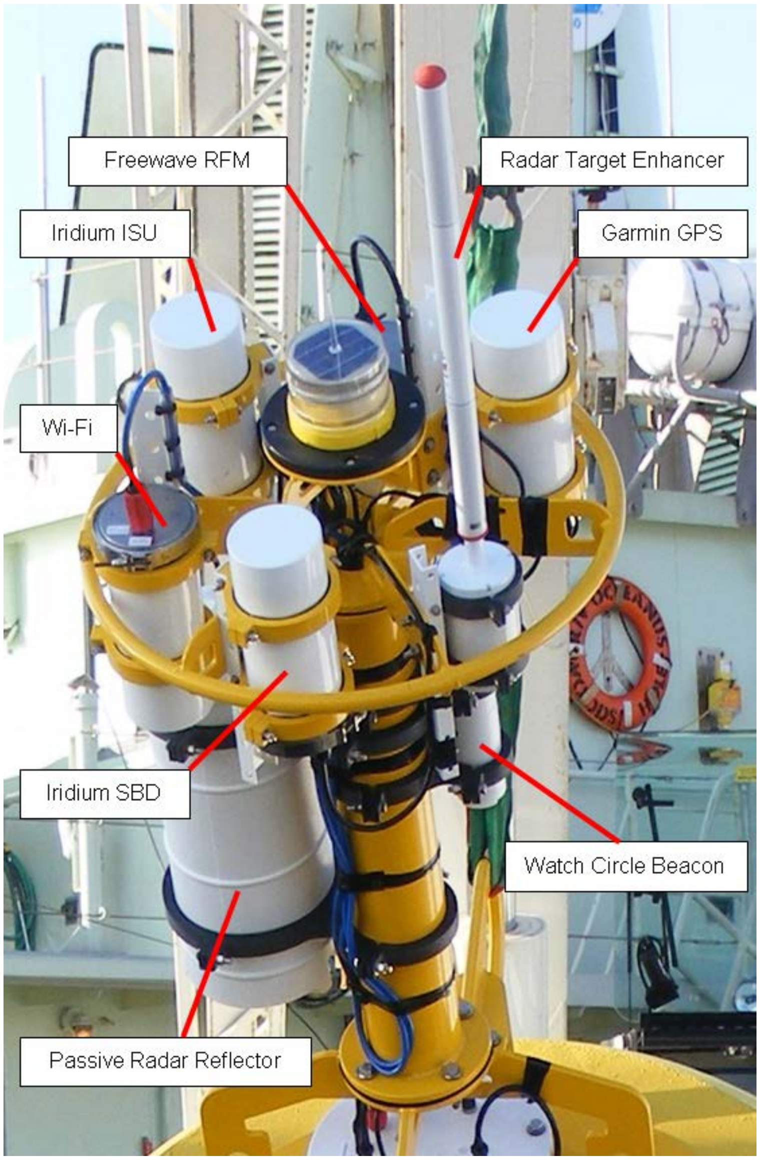


Figure 82: CPPM surface buoy telemetry suite.

The telemetry hardware shown includes:

- One each Iridium 9522B ISU. The ISU is an Iridium satellite based serial modem that is the primary data link between the mooring controller and shore. The ISU is enclosed within a common telemetry enclosure.
- One each Iridium 9602 SBD. The 9602 is an Iridium satellite based Short Burst Data (SBD) link that is the primary link between the buoy watchdog system and shore. The SBD is enclosed within the common telemetry housing.
- One each Garmin GPS. The GPS is providing position and timing information to the buoy and one of the units is enabled at all times. The GPS is enclosed in the common telemetry housing.

- One each Freewave RFM. The Freewave transceiver is a line-of-sight RF Modem (RFM) which provides a serial data link between the buoy controller console port and matching master transceiver for pre-deployment and post-deployment local (shipboard) operations. The RFM is enclosed in the common telemetry housing.
- One each Ubiquiti Wi-Fi. The Wi-Fi is a line-of-sight wireless transceiver which provides WLAN connectivity between the buoy controller and ship or shore based WLAN equipment for pre-deployment and post-deployment local (shipboard) operations. The Wi-Fi is enclosed in the common telemetry housing.
- One each Xeos KILO watch circle beacons. The KILO is COTS hardware manufactured by Xeos Technologies. The beacon is self-powered and includes a GPS and Iridium SBD transceiver operating under local processor control. The watch circle software is remotely configured for watch circle center position, watch circle diameter, and normal and alarm timing. Should the buoy travel outside of the watch circle the beacon enters alarm mode and in conjunction with shore based software will alert designated personnel via e-mail.
- One each Radar Target Enhancer (RTE). The RTE is an X-band and S-band transceiver which detects radar pulses and re-transmits the pulse with minimal latency. The transmitted pulse has greater signal strength than a pulse that would be reflected from a passive radar reflector. The interrogating vessel will receive a signal which gives the buoy an enhanced radar cross-section and improves its visibility. The RTE was not deployed as it was damaged during transit to site.

The CPPM subsurface float was deployed with two emergency beacons mounted to it shown in Figure 85. The first beacon is a COTS LED flasher manufactured by Xeos Technologies that is configured to remain off if it is upside down, under water, or in the presence of daylight. The LED flasher is self-powered and has battery capacity to flash continuously for 60 Days. The KILO beacon is COTS hardware manufactured by Xeos Technologies that has similar capabilities as the MELO beacon mounted on the buoy halo. It includes a GPS and Iridium SBD transceiver under local processor control. The KILO is self-powered and is configured to remain off while either upside down or in the presence of seawater.

3. Power

The Coastal Pioneer Profiler Mooring is powered by an Alkaline Battery pack assembly modified from the Alkaline Battery Chassis made by EOM Offshore LLC. This modified battery pack is located in the payload well of the Profiler Mooring surface buoy.

The original Alkaline Battery Chassis from EOM Offshore consists of ten Alkaline Battery pucks (PN: MAI-150640) connected in parallel. Each Alkaline Battery puck is made of six parallel strings of twelve Alkaline Battery cells connected in series. Each battery string in the puck has a series blocking diode as illustrated in Figure 82. Each puck is capable of delivering 72 Ah of energy.

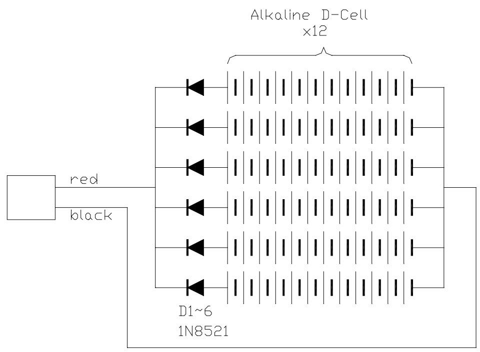


Figure 83: Battery Puck Internal Wiring

The Alkaline Battery pucks were configured into two packs for use in the Coastal Pioneer Profiler Mooring. One consists of 4 pucks diode-isolated and wired in parallel for powering the Coastal Pioneer Profiler Mooring electronics and telemetry. The second one consists of 2 pucks diode-isolated wired in parallel to power the radar transponder. Each pack is fitted with a 5A fast blow fuse to protect the battery pack from accidental load short circuit.

Figure 84: Alkaline Battery Pack used in Coastal Pioneer Profiler Mooring

Each battery pack is terminated with either 2-pin or 4-pin Molex connector. Power monitoring and control is performed by the Profiler Mooring STC and power data is reported to shore via satellite telemetry links.

Figure 85: Emergency beacons located on the CPPM subsurface float.

4. Data Logging

Data from the buoys are logged in several locations. In general, the Buoy STC records the engineering data, status data about the platform controller, buoy location, and communication statistics, in addition to the scientific data. Data transmitted to the shore side OMC represent another location data are recorded. These data are transmitted and parsed to make the various plots and status tables on the OMC website (http://cgsn-omc.whoi.edu/oms).

The RADAR Target Enhancer was connected to a HOBO data logger to record power statistics for the RTE. These data were not logged by the STC and were not transmitted to shore. The data will be available when the mooring is recovered.

Science data are logged in several places on the profiler mooring. The majority of the science instruments are part of the profiler. The profiler logs each sensor in one of the three log files that it records. Acoustic current data is logged in A* files, CTD data in C* files, and engineering data in E* files where the * denotes the profile number and file extension. Additionally, the current data from the MAVS is logged in it raw binary format on the MAVS instrument and similarly the CTD logs raw CTD data and Dissolved Oxygen data it in the CTD memory. The Engineering data includes the engineering data such as battery voltage, pressure, and motor current for the profiler. The engineering file also includes the science sensors which do not log data internally. These data include the PAR and the Wet Labs BBFL2 (Scattering, Chlorophyll, and CDOM signals). The science data from the profiler are transmitted via an inductive link to the STC where it logged on the buoy. Data from the ADCP and the SBE37 – IM are logged internally on the instruments. The ADCP data is available only after recovery. The SBE37 data is transmitted via the inductive cable and is logged on the STC and transmitted to the OMC with the other data sets. On the OMC there is software to unpack and view data from the platform.

D. Global Hybrid Profiler Mooring

1. GHP Mooring Components Overview

The AST2 Global Hybrid Profiler Mooring configuration includes a Global surface-piercing profiler prototype (GSPP - SeaCycler) and a production wire-following profiler (WFP). The instrument suite is a subset of the Global infrastructure.

The SeaCycler has been developed and manufactured at BIO. The SeaCycler has a mechanism float in a nominal depth of 150m. It contains an underwater winching system to allow instrument float profiling to the surface. While the instrument float is rising to the surface, the mechanism float winds down with a ratio 1:5 to balance the energy. About 440m of profiling cable can be paid out. A small communication float is tethered with 23m of cable to the instrument float. At the surface, the communication float can establish a 2-way communication to shore using an Iridium satellite link or to a nearby vessel through Freewave.

A current meter with pressure sensor is clamped on the lower end of the mechanism float wire to monitor currents, wire spin and depth during deployment for the validation of the mooring dynamic simulations.

An acoustic release is installed at the lower wire termination of the mechanism float cable to allow the SeaCycler to be recovered separate from the remainder of the mooring.

A 64 inch syntactic sphere is located about 270m depth underneath to maintain vertical tension on the mooring which minimizes the subduction even in extreme current events. A GPS beacon, radio beacon and flasher are installed on the sphere for emergency location and as recovery aids. A disk type load cell is located underneath the sphere to validate the mooring design analysis.

A universal-joint and EM-chain below the sphere provide bend relief during deployment and recovery. A wire following profiler (WFP) underneath the sphere profiles through the mid- water column along a continuous section of 2000m wire.

The SIO controller and an acoustic modem are installed in a load cage at the lower end of the 2,000m wire. A second load cell below the load cage provides the capability to verify the mooring design analysis.

The lower part of the mooring consists of about 100m of wire rope in several shots to be adjusted for the water depth. Forty 17 inch glass flotation spheres are included for backup buoyancy. A dual acoustic release has been implemented to support recovery operations. Nystron rope (20m) is used above the anchor (wet-weight of 5,500 lbs.) to provide shock absorption during the anchor launch.

2. SIO Instrumentation

Table 13 shows the instruments installed on the AST2 GHP mooring.

Table 13: Instruments installed on the AST2 GHP mooring.

AST2 GHPM Instrumentation					
Depth	***Platform***	***Instrument***	***SN/ID***	***Variables***	***Comments***
120m - 0m	GSPP Comm Float	FreeWave Modem	NA	NA	
		Iridium Modem	NA	NA	
140m - 0m	GSPP Instr Float	SBE52MP	SN#0012	P, T, C	
		SBE43F	SN#43F0228	Ox	
		ProOceanus PSI PC02	SN#25-046	pCO2	
		Controller	NA	NA	
		Benthos ATM 885	SN#44389 Acoustic ID#03	NA	
		Aquadopp DW IM	Hardware ID#9372 HeadID#3022 Inductive ID#22	U, V, W, P, T	not part of real time data telemetry
		Sable GPS Beacon	IMEI#300034012383240	NA	
150m - 230m	GSPP Mech Float	Controller with IMM	NA	NA	
		Sable GPS Beacon	IMEI#300034012483540	NA	
260m	Mech Float Wire	Aquadopp DW IM	Hardware ID#6239 Head ID #3028 Inductive ID#28	U, V, W, P, T	
265m	Upper Acoustic Release Assembly	ORE 8242XS	SN#34637	NA	
270m	64" Sphere	Sensing Systems Ring Tension Load Cell 11105-3	SN#001	F	not part of real time data telemetry
		Develogic Mini Logger	SN#4001	NA	
		XMB-7500 RF Beacon	SN#144	NA	
		XMF-7500 LED Beacon	SN#153	NA	
		Sable Iridium GPS Beacon	IMEI#300034012385240	NA	
2270m - 300m	WFP	McLane MMP with IMM	SN#ML12774-01	NA	
		SBE52MP	SN#97	P, T, C	
		Nobska MAVS41P0	SN#10301	U, V, W	not part of real time data telemetry
		Aanderaa Optode 3830	SN#1427	Ox, T	
		Wetlabs FLBBRTD	SN#2350	Chl, Turb	
2285m	Load Cage	Sensing Systems Tension Link Load Cell 10692-3	SN#001	F	
		SIO Controller with IMM	SN#01	NA	

AST2 GHPM Instrumentation					
Depth	***Platform***	***Instrument***	***SN/ID***	***Variables***	***Comments***
		SIO Controller Persistor CF-2	SN#10896	NA	
		Benthos ATM 887	SN#52983 Acoustic ID#04	NA	
2430m	Dual Acoustic Release	ORE 8242XS	SN#34635	NA	
		ORE 8242XS	SN#34636	NA	

3. Communication and Telemetry

A closed inductive loop is maintained from the GSPP mechanism float to the load cage with the SIO controller. Bypass cables are installed between each termination of the mooring wire sections. The SIO controller interfaces via inductive communication to the WFP and GSPP. The SIO controller transfers the profile data from the WFP to the GSPP for transmission to shore. The acoustic modem connected to the SIO controller provides a capability to perform acoustic data transmission with other platforms that have an acoustic modem.

The SIO Controller retrieves profile data from the WFP after the WFP has finished a profile. The WFP initiates the data transfer to the SIO controller. The SIO controller also polls the data from the current meter below the GSPP. Upon request by the GSPP, the SIO controller forwards a subset of the WFP data, current meter data, controller status data and load cell data to the GSPP. The GSPP communication float transmits the data received from the SIO controller, GSPP profile and engineering data to shore upon reaching the surface. The communication path allows commands to be sent from shore to the SIO controller via the GSPP as illustrated in the block diagram below.

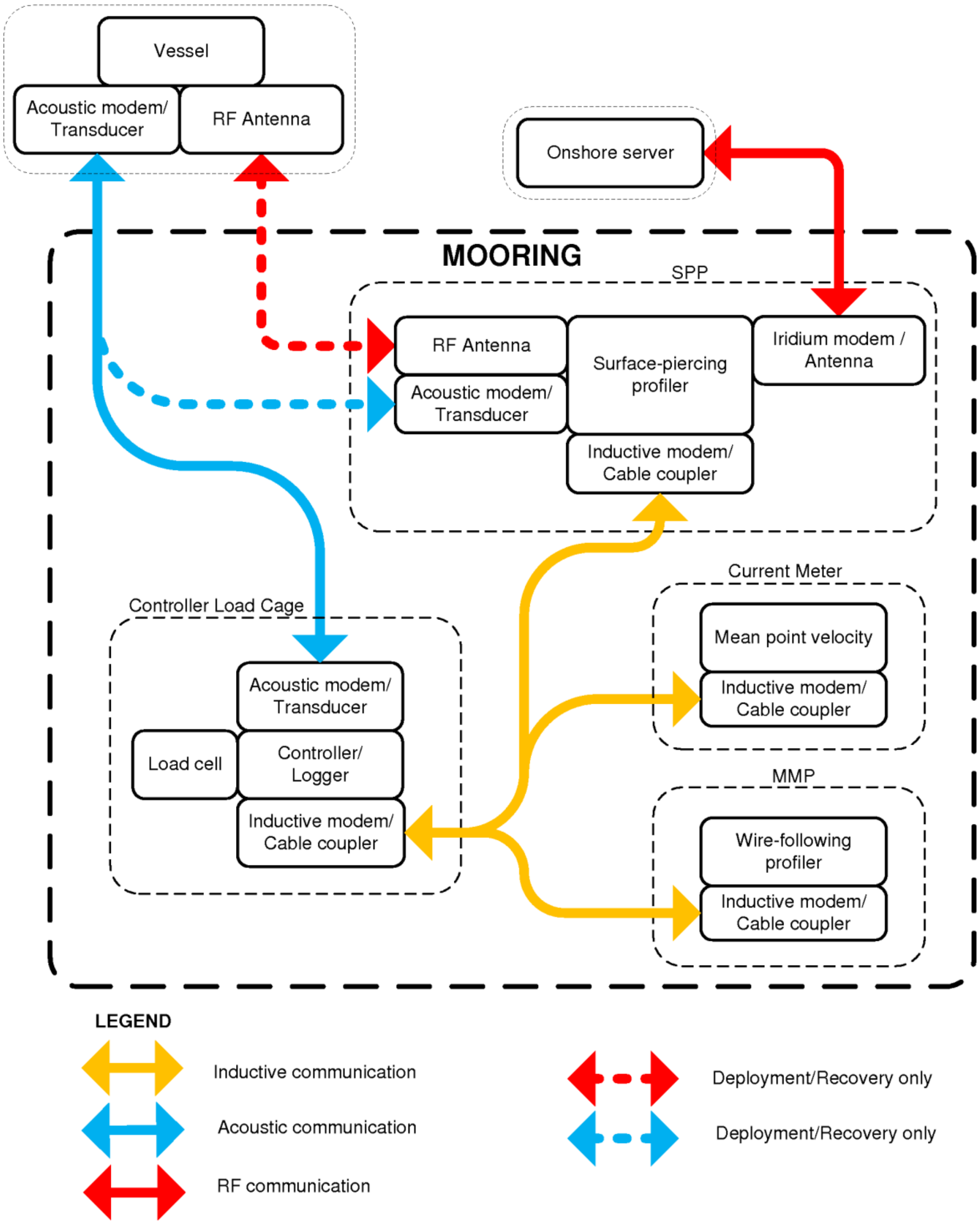


Figure 86: AST2 GHPM Block Diagram (3607-00062)

The AST2 Hybrid Profiler Mooring Sampling Strategy is shown below which assumes a 6 month deployment:

Table 14: AST2 Hybrid Profiler Mooring sampling strategy assuming a 6-month deployment.

Controller or Instrument/Sensor: Model	Nominal Depth or Profiling range/ Speed / Duration	Profiling interval or Sampling Interval / Sampling Duration / Frequency		Comments
		initial	operational	
GSPP Instrument Float Ref: 3310-00005	150m to surface 0.33 m/s 7.5min, max. 20min (depending how much cable needs to be spooled out to reach surface in presence of currents)	4 or more cycles/day (up and down cast)	1, 2 or 4 cycles/day to be adjusted to maintain operability over deployment period	200,000m endurance, 650 cycles (up and down cast) in calm conditions over 150m, near surface stop for satellite communication. 4 cycles per day can be maintained if only 180m of cable needs to be spooled out. If more, then fewer profiles.
CTDPF: SBE52MP DOSTA: SBE43F		1Hz	1Hz	Up-Cast
PCO2W: ProOceanus		5 samples/profile	5 samples/profile	Down-Cast with stops
VELPT: Aquadopp		2min / 10s / avg.	2min / 10s / avg.	
VELPT: Aquadopp	260m	10min / 10s / avg.	10min / 10s / avg.	
Mini Logger: Upper Load Cell	270m	60s / 60s / 5Hz Deployment, est. 24h	60min / 60s / 10Hz	Initial phase over the span of the anchor launch period
WFP Ref: 3310-00003	2270m to 300m 0.25m/s 2.25h	3 profiles/day	3 profiles/day	Est. 500 profiles over 2000m on 360Ah Battery and low current drag on the profiler, 350 profiles with high current drag. Requirement is 2 profiles per day, but manual claims 1Mm so will run batteries down to verify.
CTDPF: SBE52MP		1Hz	1Hz	
VEL3D: Nobska MAVS		1Hz	1Hz	
DOSTA: Optode		15s interval (3.75m)	15s interval (3.75m)	
FLORD: Wetlabs		15s interval (3.75m)	15s interval (3.75m)	
Eng/Stop-check		15s interval (3.75m)	15s interval (3.75m)	
SIO Controller	2285m	continuously, est. 6h	60min	Initial phase over the span of the anchor launch period
Status		60s / 1s / 1Hz	60min / 1s / 1Hz	
Lower Load Cell		60s / 60s / 5Hz	60min / 60s / 5Hz	

Table 15: AST2 Hybrid Profiler Mooring Data Logging and Telemetry Overview

Controller / depth / sampling intervall	Instrument / Sensor	retrieve data from	send data to
GSPP 150m to surface, 1, 2 or 4 cycles/day	CTDPF DOSTA PCO2W Eng. Data	SIO Controller (inductive) - VELPT@270M - WFP data - SIO Controller Status - Lower Load Cell *SSP initiates communication.* *Data will be stored temporarily in communication module for transmission.*	Vessel or Shore (FreeWave, Iridium) - CTDPF, DOSTA, PCO2W, 10 KBytes/profile - Eng. Data, 30 KBytes/profile - VELPT@270M - WFP data - SIO Controller Status - Lower Load Cell *GSPP initiates communication.* *Est. 100 kBytes/day is a rough estimation, depending from profiling time and other parameter.*
	VELPT		*Instrument internal storage only.*
VELPT 260m, 10min	3D Velocity Temperature Pressure Heading, Pitch, Roll		SIO Controller (inductive), 176 bytes/rec *SIO Controller initiates communication.*
Mini Logger	Upper Load Cell		*Controller internal storage only.*
WFP 2270m to 300m, 3 profiles/day	CTDPF DOSTA FLORD Eng. Data		SIO Controller (inductive), 125 KB/profile *WFP initiates communication.*
	VEL3D		*Instrument internal storage only.*
SIO Controller 2285m, 60min	Status data Lower Load Cell	VELPT@270m (inductive) WFP (inductive) *WFP initiates communication.* *Data will be stored on SIO Controller.*	GSPP (inductive), 45 KB/day - VELPT@270M - WFP data, low sampled by factor 10 - SIO Controller Status, 64 Bytes/rec - Lower Load Cell, 1850 Bytes/rec, transmit only 1 record per day *GSPP initiates communication.* Acoustic Modem (serial), 4.5 KB/day - VELPT@270M - SIO Controller Status - Lower Load Cell (not for initial phase) *SIO Controller initiates communication, sends a single record to modem every 12 hours due to memory limitation*
Acoustic Modem 2300m		SIO Controller (serial) - VELPT@270M - SIO Controller Status - Lower Load Cell *SIO Controller initiates communication.* *Data will be stored in Modem.*	Remote Modem (acoustic), on Vessel, Glider, ROV etc. - VELPT@270M - SIO Controller Status - Lower Load Cell *Remote modem initiates communication.*

4. Mooring Design and Analysis

The AST2 GHP mooring design follows the OOI CGSN mooring design standards. (Document #: 3307-00003), which provided guidance for backup buoyancy, nominal static loads, safe anchor weight and launch tension.

The mooring diagram as the mooring was deployed is shown below. An electromechanical swivel is installed at the lower termination of the GSPP mechanism float to minimize twist in the mechanism float wire.

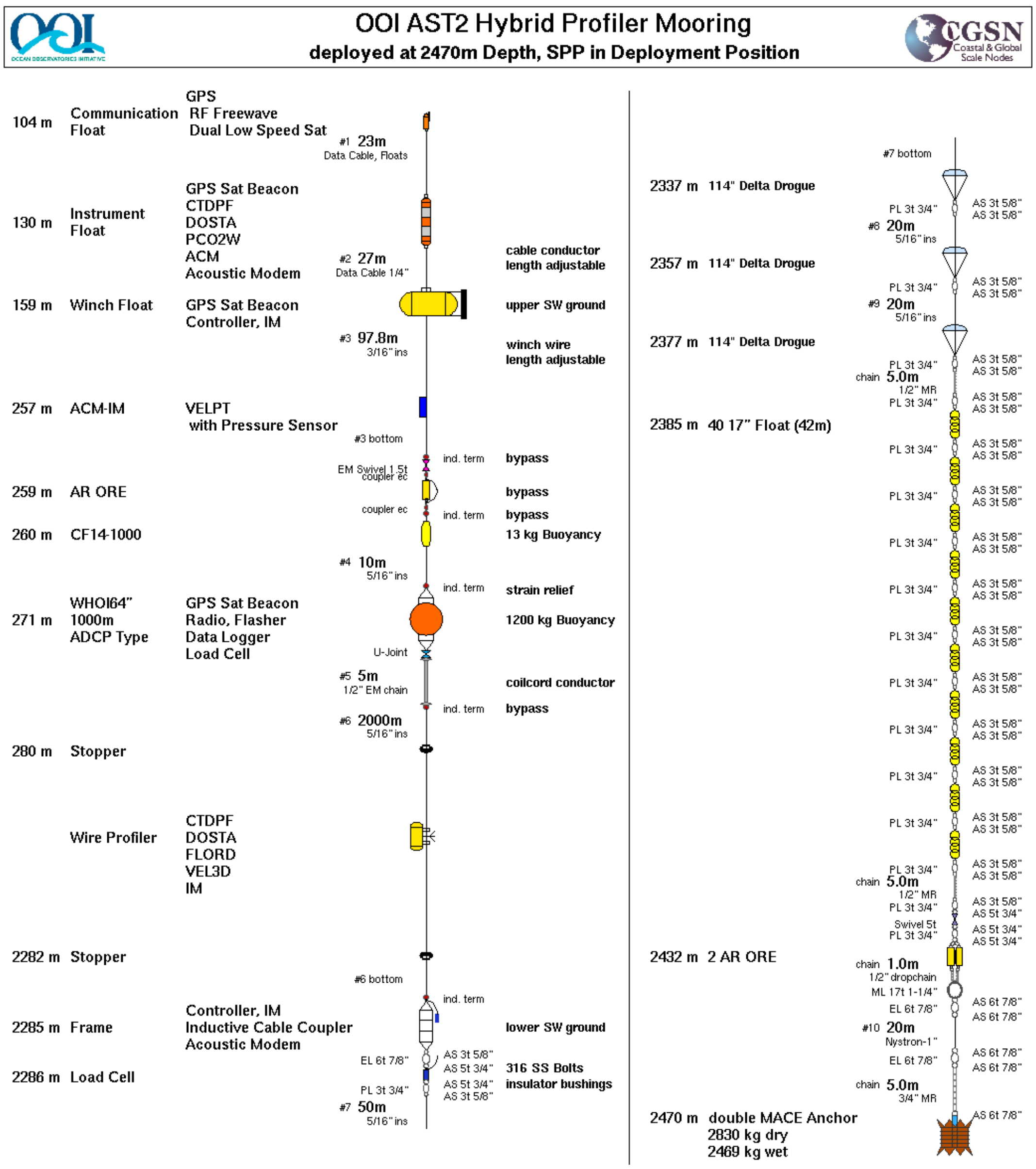


Figure 87: AST2 GHP Mooring

The GSSP is limited to a launch speed of 1m/s. To ensure this limit is not exceeded, three 114 inch Delta Drogues where added at the connections between wire segments below the load cage to provide additional drag during anchor launch. Without these drogues, the launch speed is estimated to be at the limit of 1m/s. The observed AST2 launch tension on the load cell below the load cage (decimated data transmitted through the GSPP) agrees with the simulated steady state launch tension shown below in Figure 88.

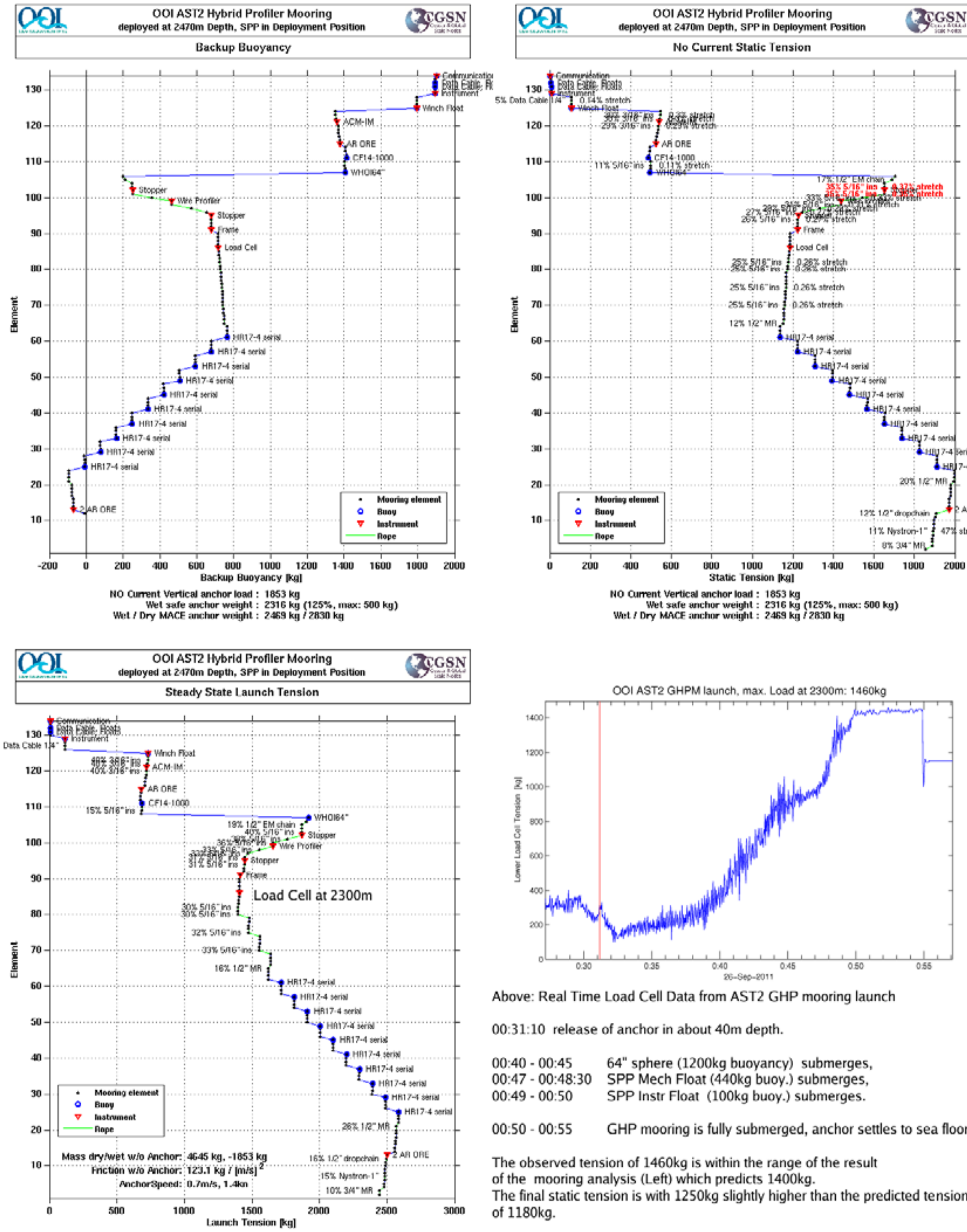


Figure 88: Top left: shows calculations of backup bouyancy for each mooring element. Top right: shows tension loads for each element assuming no current. Bottom left: Launch tension loads for each element. Bottom right: acutal load cell data showing tension in the lower load during deployment.

E. Biofouling Tests

Scope

This test plan applies to Test Objective 5 of the At Sea Test 2 Developmental Test Plan (reference 3207-0003.) This objective is to assess the effects of biofouling on sensor performance for the CPPM, CPSM, and HYPM.

Purpose

Two tests were deployed on AST2: a comparison study between two similar instruments and a test to generate a biofouling benchmark for optical instruments on the Pioneer Array. The first test is described in full in this section. The second is detailed over the remainder of this report.

Test 1

The first test utilized two similar WetLabs optical instruments a Volume Scattering Function Meter (VSFS) and Digital Fluorometer (DFLS). Each of these instruments comes equipped with a copper shutter with neoprene wiper. The wiper was removed from the VFSF instrument so that functionality and biofouling growth could be compared between the two instruments. Both instruments were deployed looking up near the top of the NSIF. This arrangement was selected to maximize biofouling growth and minimize variation between the instruments. Both instruments were configured to sample at the same schedule. A failure was discovered in the DFLS post AST2 deployment. At the time of this report this instrument is not working. Upon retrieval, the state of the optical surfaces will be assessed to evaluate the efficacy of the wiper mechanism for inhibiting biological growth over the period of AST2 and the necessity/expected fouling if the wiper were not present.

These instruments are on the order of 10 years old, so functionality of them was a known risk. Borrowing an instrument from a vendor would interfere with the procurement process; therefore the instruments were selected as the best option for deployment on AST2.

Test 2

The purpose of the second test is to quantify biofouling growth on exemplar test surfaces representing optical instruments over the deployment period of AST2. Results from these tests will benefit OOI by providing data to inform decisions concerning biofouling mitigation strategies and failure modes for fixed and mobile optical instruments.

Method

To evaluate biofouling growth on optical surfaces, characteristic optical surface materials shall be deployed on the AST2 surface mooring (CPSM) and/or profiler mooring (CPPM) to allow biofouling growth over the duration of AST2. Upon recovery of the AST2 Moorings, the biofouling communities on the test substrates will be visually assessed and ranked per ASTM D 6990-05, Standard Practice for Evaluating Biofouling Resistance and Physical Performance of Marine Coating Systems (Appendix 16) to provide comparative data which may inform decisions about biofouling mitigation strategies and failure modes for fixed and mobile optical instruments.

The biofouling test was an un-funded objective of AST2. Apparatus design was conducted to minimize schedule and cost impact using spare material where available. Designs were approved by John Kemp and Jim Dunn at the Coastal Research Lab to ensure that mooring performance was not compromised.

Deployment

The AST2 deployment occurred with a minimum set of test substrates to provide a biofouling benchmark for the deployment. Samples were fixed at the AST2 CPSM surface buoy, Near Surface Instrument Frame (NSIF), and the Benthic Anchor Recovery Frame (BARF). Figure 89 shows the test substrates in these locations.

Additional test substrates were available on the AST2 cruise. Instructions were given to cruise members to fix additional test substrates to the mooring if time permitted to: A) determine locations were substrates would not interfere with or negatively impact the mooring operations and/or durability and B) attach substrates without creating a schedule impact on mooring operations. It was the opinion of the cruise team that additional test substrates could not be included on the mooring.

Test Substrates

The characteristic optical surface materials acrylic, epoxy, glass, and Teflon, were selected as test substrates to represent exemplar and example materials. Since the AST2 deployment region is within the region of the Pioneer Array, potential optical instrument materials were down-selected to only those instruments which may be present on the Pioneer Mooring Array. See Table 16 and Table 17 for a list of optical instruments on Pioneer and AST2 moorings and mobile assets and Table 18 and Table 19 for a list of exemplar and example optical instruments with optical surface materials.

The test substrates were deployed as 2 inch square samples. Each deployment location includes three replicate samples per characteristic material (12 samples in total). Samples were individually tie wrapped to the mounting locations.

Edge effects from near-by anti-foulant have an impact on biofouling growth. Samples on the AST2 CPSM surface buoy and NSIF were mounted over Trilux 33, antifouling paint. Samples on the AST2 BARF were mounted on an inert surface. A preferable test apparatus would have duplicate samples mounted over anti-foulant and inert control surfaces (24 samples total). Due to the compacted nature of the AST2 the structures for creating these surfaces were removed from the test plan.

Biofouling Assessment

Upon recovery of the moorings, biofouling growth shall be assessed and ranked using the ASTM D 6990-05, Standard Practice for Evaluating Biofouling Resistance and Physical Performance of Marine Coating Systems (Appendix 16). This method provides a repeatable method for rating biofouling growth on a substrate. This evaluation may be performed onboard the ship immediately after recovery of the samples, or from photographs shore-side depending on resource availability during recovery operations. If the ASTM method will be performed from images, the photographer should take a clear, mega-pixel resolution image of each sample individually and record the sample location, and image number generated by the camera. These images should be taken ASAP after retrieval of the test substrates. A test data worksheet containing instructions will be provided for the recovery cruise.

Substrate Retrieval

To be determined based from input from the biofouling research community at WHOI. Samples may be offered to other researchers.

Precautions and Warnings

Marine operators should follow all precautions and warnings for any antifouling coating. The product data sheet and MSDS for Trilux 33 is included in the Appendix 18.

Recovery Precautions

Care must be taken to preserve biofouling communities on the samples during mooring recovery. Wherever possible, crew should take the necessary precautions to prevent the test substrates to come in contact with any objects that may damage the fouling communities. Additionally, wherever possible, care should be taken to prevent unnecessary “washing” of the test substrates as they are lifted from the water.

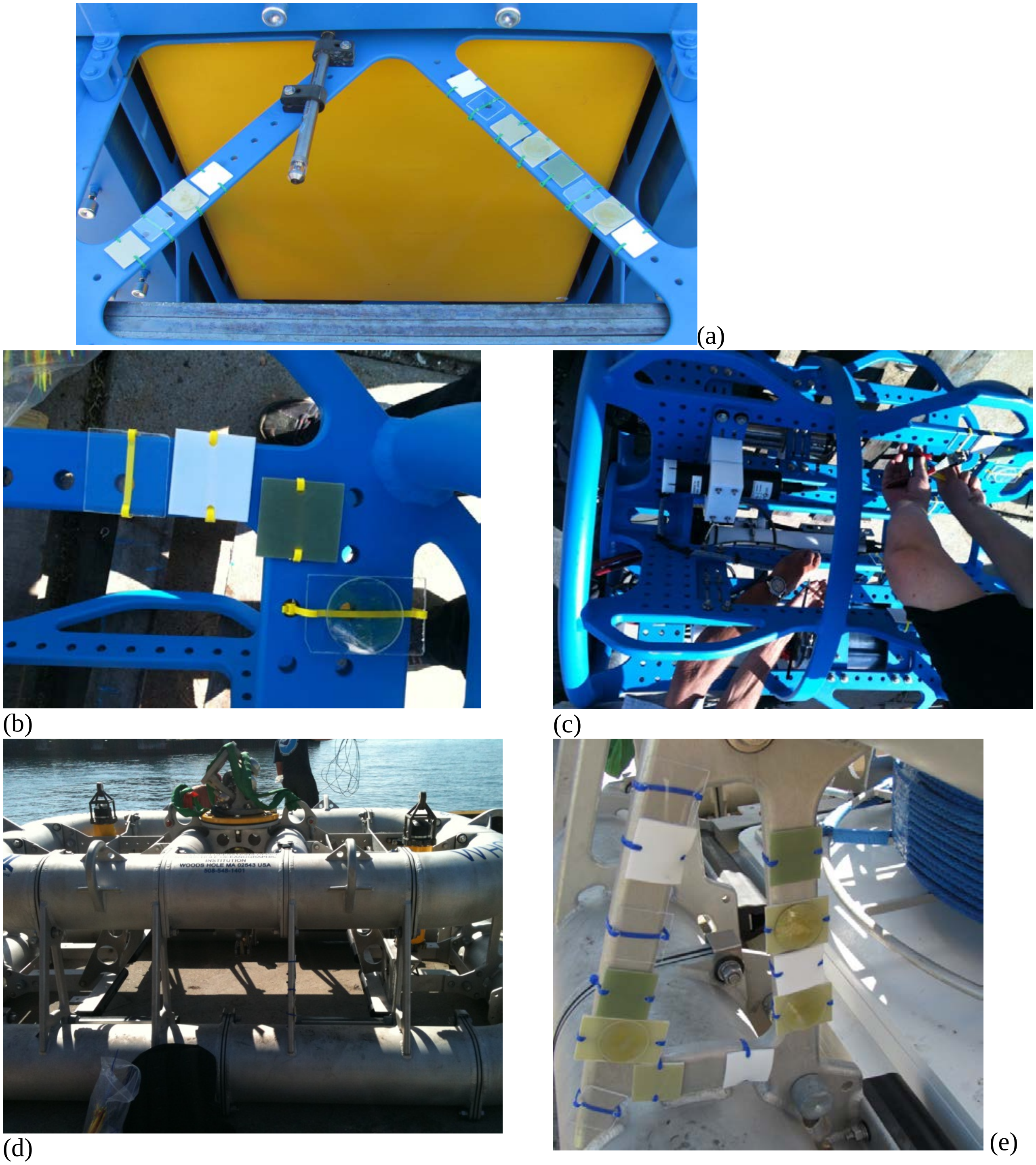


Figure 89: (a) test samples mounted on the AST2 Surface Buoy, (b) test samples mounted on the AST2 NSIF, (c) location of test samples on the NSIF, (d) location of test samples on the SAT2 BARF, and (e) test samples mounted on the AST2 BARF.

Table 16: Pioneer Optical Instruments - Fixed

Code	Deploy Depth (m)
SPKIR	5
FLORT	5
OPTAA	5
OPTAA	130
OPTAA	210
OPTAA	520

Table 17: Pioneer Optical Instruments - Mobile

Code	Deploy Depth (m)	Range (m)	Notes
SPKIR	210	0-210	Pioneer Central P1 Surface-Piercing Profiler
FLORT	210	0-210	Pioneer Central P1 Surface-Piercing Profiler
PARAD	210	0-210	Pioneer Central P1 Surface-Piercing Profiler
OPTAA	210	0-210	Pioneer Central P1 Surface-Piercing Profiler
SPKIR	130	0-130	Pioneer Inshore P3 Surface-Piercing Profiler Mooring
FLORT	130	0-130	Pioneer Inshore P3 Surface-Piercing Profiler Mooring/Pioneer Upstream Inshore Wire-Following Profiler Mooring
PARAD	130	0-130	Pioneer Inshore P3 Surface-Piercing Profiler Mooring/Pioneer Upstream Inshore Wire-Following Profiler Mooring
OP TAA	130	0-130	Pioneer Inshore P3 Surface-Piercing Profiler Mooring
FLORT	520	20-520	Pioneer Offshore Wire-Following Profiler Mooring/Pioneer Upstream Offshore Wire-Following Profiler Mooring
PARAD	520	20-520	Pioneer Offshore Wire-Following Profiler Mooring/Pioneer Upstream Offshore Wire-Following Profiler Mooring
FLORT	360	20-360	Pioneer Central Offshore Wire-Following Profiler Mooring
PARAD	360	20-360	Pioneer Central Offshore Wire-Following Profiler Mooring
FLORT	1000	0-1000	Glider
PARAD	1000	0-1000	Glider

Table 18: AST2 Optical Instruments - Fixed

Code	Deploy Depth (m)
VSFS	5
DFLS	5

Table 19: AST2 Optical Instruments – Mobile

Code	Deploy Depth (m)	Range (m)	Notes
PARAD	500	20-500	AST2 Coastal Profiler Mooring
FLORT	500	20-500	AST2 Coastal Profiler Mooring
FLORD	500		AST2 Global Hybrid Profiler Mooring

IV. Mooring Deployments

A. Coastal Pioneer Surface Mooring

The surface buoy load cell, universal joint, ballast, hose connection and electrical connections and dressings were completed on the dock/ship before sailing. The CPSM was to be deployed first: all stretch hoses and Hose-Interface-Buoyancy (HIB) modules were assembled (bolted, double nutted and Loctite); all electrical connections were made. However, upon deployment, it was determined that the top hose had a male connector which couldn't mate with the bottom E/M chain male connector (full assembly and/or gender jumpers are needed in the future).

R/V Oceanus was on station surveying the bottom early on September 23. With the wind out of the south, a 3 nm approach from the north was chosen and executed (Figure 90).

Figure 90: Track during the deployment of the CPSM.

Setup of the deck began at 0500 to begin the mooring deployment after breakfast: lines and cleats were placed on and around the buoy to control the forward/aft movement as well as swing and all tag lines were rigged. We deployed the surface buoy and slipped the E/M chain, near surface instrument frame & E/M wire using tag lines, TSE (winch) and the ship's crane. The frame and E/M chain were pre hung against the starboard rail (and were slipped prior to the water line before the buoy was deployed).

The surface buoy was picked up then lowered into the water using the ship's crane; tension was applied to all slip lines in order to prevent buoy movement. The quick release was pulled thus allowing the buoy to drift aft. Each hose was slipped using the HIB and 3/8" spectra from the winch, passing the line through each stainless steel slip bale, lowered by the TSE. Once the line was roughly 200 feet in the water, the next HIB was stopped off using the stopper line; this procedure was repeated four times until the last HIB was in the water. The last hose was slipped to the BARF (which was tied back) and the lowering strong-back/release was hooked to the lowering bale. The heavy lift winch (HLW) picked the BARF off the deck and was lowered to 500m. The buoy barely moved as the anchor hit the bottom with the BARF at 500m. The release point was chosen based on the previous survey of the bottom and the desire to place the mooring in 520 m of water. The ship steamed south, moving slowly into deeper water. The depth of the Knudsen was watched, and the acoustic release was triggered just past the target depth.

Upon deployment, the WHOI team confirmed all power and communications working well. Release tests and a CTD followed.

Release Test:

- #34817 – 312 meters
  - Enabled @ 1851
  - Released then ranged (@312m)
  - Disabled then ranged (no response)
- #34815 – 312 meters
  - Enabled @ 1854
  - Released then ranged (@314m)
  - Disabled then ranged (no response)

Notes: the releases responded on first command with successful and clear communications.

B. Coastal Pioneer Profiler Mooring

The wind shifted to out of the southwest, so a 3 nm approach from the northeast was used for the deployment (Figure 91). The deck was prepared at 0500 by moving the buoy and sphere in place; all electrical connections until the 400+ meter IM cable were connected and dressed for deployment.

The submersible buoy was deployed first using the ship's crane which allowed the stretch hose to fall into the water and drift aft. One person handled the hose at the starboard quarter to make sure the hoses didn't get hung up; the sphere was already attached to the HLW in between the A-frame and ready for deployment.

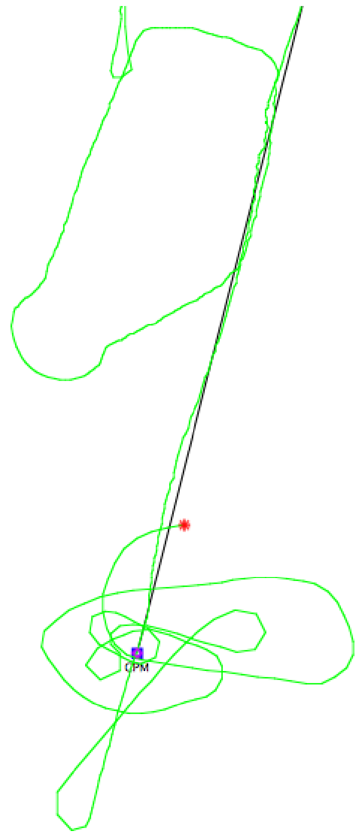


Figure 91: Deploy track of the CPPM.

The sphere was picked up with the heavy lift winch (with quick release on the top bale) and also with the crane (on the bottom bale) until the 3m EM chain was clear of the transom; the crane was disconnected then the sphere released; the buoy and sphere were allowed to drift aft thus putting slight tension on the 5/16 inch IM wire rope. A Gifford block was hung using the spectra tag line wound around the ship's capstan; the block height was adjusted by hauling in or paying out the capstan at any given time. The MMP top bumper was also attached to the wire rope. Two-thirds of the IM cable was deployed then the MMP was brought out on deck from the main science lab. Using a section of 3/8" VLS (Yalex) a bowline was tied to the Gifford block and the bitter end was reeved through the line section on the bottom of the MMP. When the block was raised, the spectra line checked until the A-frame was outboard of the transom; the MMP was slipped into the water once clear.

The remaining IM wire rope was deployed until the winch leader shackle was on the stern where it was stopped off. The ADCP was shackled in line and the bottom MMP bumper attached – both were slipped out by attaching the quick release on the bottom pear ring of the ADCP. Note the bottom bumper had the tire assembly removed from the wire clamp so the bumper would not damage the MAVS on the MMP during recovery. After a small shot of wire rope was deployed the glass floatation was put into the water. The line pack was shackled in line and slipped to the anchor which was pre-rigged with the lowering strong-back to the HLW. The anchor was lowered into the water until reaching a depth of 505m (or until the subservice sphere was breaking the surface of the water). The anchor was dropped by triggering the acoustic release. Once deployed, the subsurface buoy dipped below the water surface then resurfaced less than 35 seconds later (or once the anchor hit the bottom and the hose was allowed to stretch and settle). Upon deployment, the WHOI team confirmed that the profiler had profiled on schedule and sent data using the IM circuit

C. Global Hybrid Profiler Mooring

The ship initially set up for the deployment to the north, but during the preparations, an atmospheric front passed through and with the wind out of the northeast the decision was made to reposition and steam from the southwest to the northeast for the deployment (Figure 92).

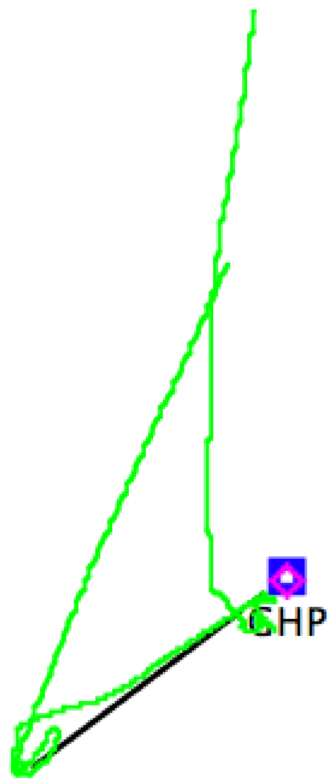


Figure 92: Deployment of the GHP. The ship was intially set up to steam from the north but was repositioned to steam from the southwest due to a sind shift.

The deployment team was on deck at 0500 to organize the deck and move key components of the deployment into place: sea-cycler and sphere were moved to the starboard quarter and lashed. The E/M chain was connected and rigged to hang over the side. The profiler and surface float were both lifted and/or carried to the stern where each cable was reeved around the A-frame in order to accommodate deployment; both were hooked up electrically. The sea-cycler was hooked to the ship's crane and tag lines were prepared.

It was decided that the sea-cycler would be deployed first and towed behind the boat using 3/8” spectra tied to a stern deck cleat; the two profilers would then be deployed and allowed to drift aft.

The Heavy Lift Winch (HLW) was rigged with a quick release in the A-frame; the smaller surface profiler was lowered into the water by hand over the port quarter. The profiler was lifted off the deck and slipped/lowered to the water and both instruments slowly drifted aft past the sea-cycler and were towed slowly (ship’s SOG was kept at 1.0 knot). The 3/16 inch yellow profiler wire was figure-eighted prior to putting the profiler(s) in; this was now deployed by hand using a hand-over-hand method until the taught on the top of the 64 inch sphere (which was still lashed to the deck). The sphere was slung with the quick release and deployed as the 3/16 inch wire was slowly handled and allowed to drift aft. As the sphere drifted behind the boat the 2000m of 5/16 inch wire rope (pre-wound on the TSE) was payed out at a slow rate in order to ensure proper tension. The Gifford Block was rigged into the A-frame and positioned with the capstan to keep the wire off the deck at a good angle.

Once the wire was payed out, the last instrument frame was attached and the IM connections made; the frame was lifted overboard and deployed. Forty sets of glass floatation were deployed next: three sets of four balls (12 ea.) were shackled together and deployed. Using a stopper line, the last set was stopped off while the next sets of 12 were connected. Finally, the 20m section of blue synthetic line was added and slipped to the anchor already placed and secured at the stern. Once the section of line was slipped to the anchor (using a double ended stopper with two bowlines to the TSE) the acoustic release strong-back was lifted and secured over the anchor

The anchor was lifted over the stern and placed into the water using the trawl winch. At a depth of 20-30 meters the release command was sent thus deploying the mooring. Once deployed, the SIO and BIO team tested and confirmed that the profiler was profiling on schedule and the IM circuit was working.

The biggest change for the SeaCycler compared to previous missions was the method of deployment. This was the first opportunity to attempt a stern deployment and it worked extremely well. The MechFloat was deployed first and towed behind the ship using its tow point while the remaining profiling components were prepared on deck. The CommFloat was deployed next and allowed to trail aft followed by the InstFloat. Once all three components were aligned behind the ship and prevented from tangling, the tow line was slipped and tension was taken up on the mooring Take-Up cable leading from below the MechFloat.

Having good sea conditions and working with experienced mooring technicians helped a lot, but regardless, it is recommended this procedure should be adopted on all future deployments as the preferred method.

V. At Sea Test and Verification

A. Coastal Pioneer Surface Mooring

1. Bulk Meteorology

R/V Oceanus collected surface meteorology from a number of sensors on her mast (port and starboard sets of sensors in some cases), and these data provide a basis for in the field assessment of the bulk meteorological package installed on the CPSM. After the cruise over plots were made of buoy data time series and the shipboard data.

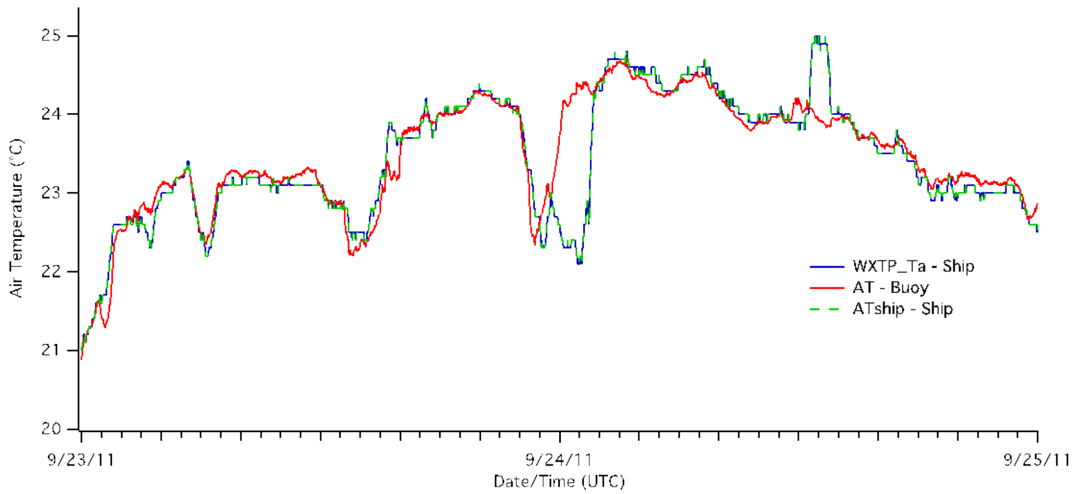


Figure 93: Overplot of ship and buoy air temperatures.

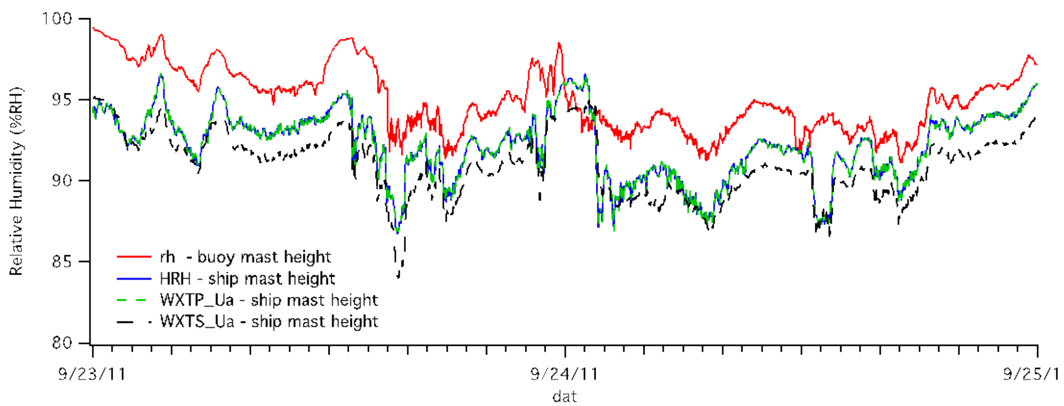


Figure 94: Overplot of ship and buoy relative humidities.

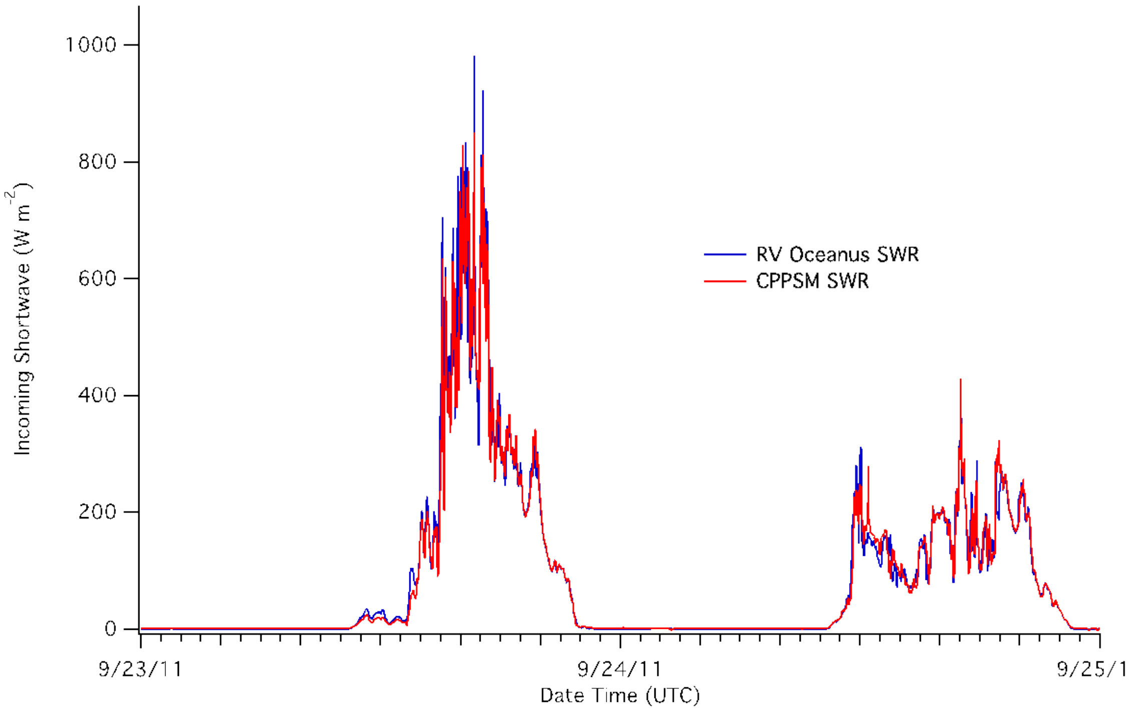


Figure 95: Overplot of ship and buoy incoming shortwave radiation.

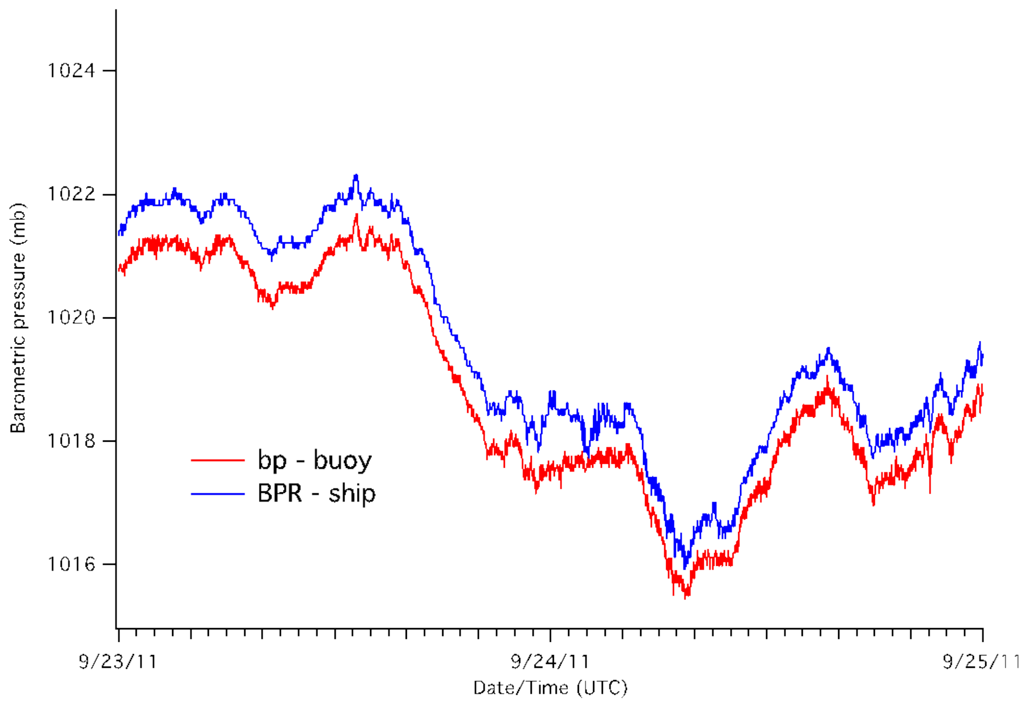


Figure 96: Overplot of ship and buoy barometric pressure.

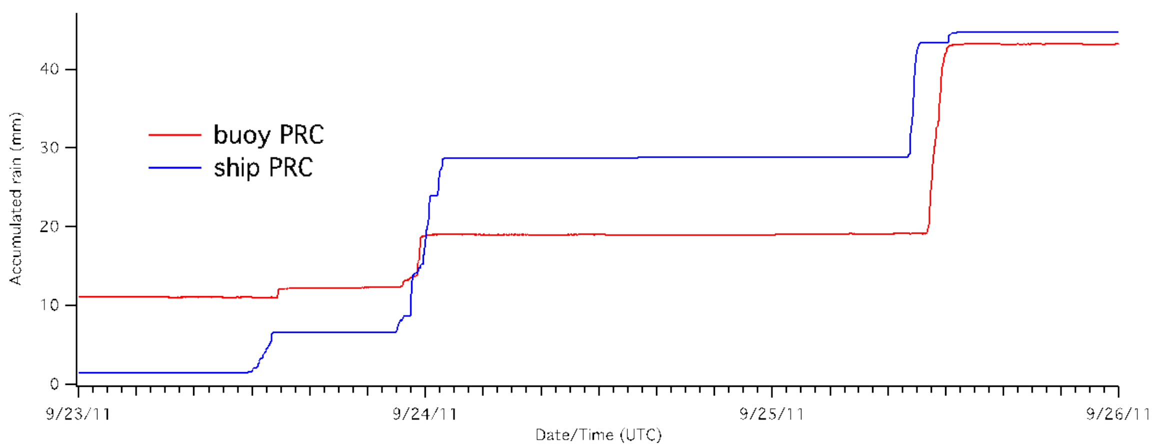


Figure 97: Overplot of ship and buoy rain accumulation.

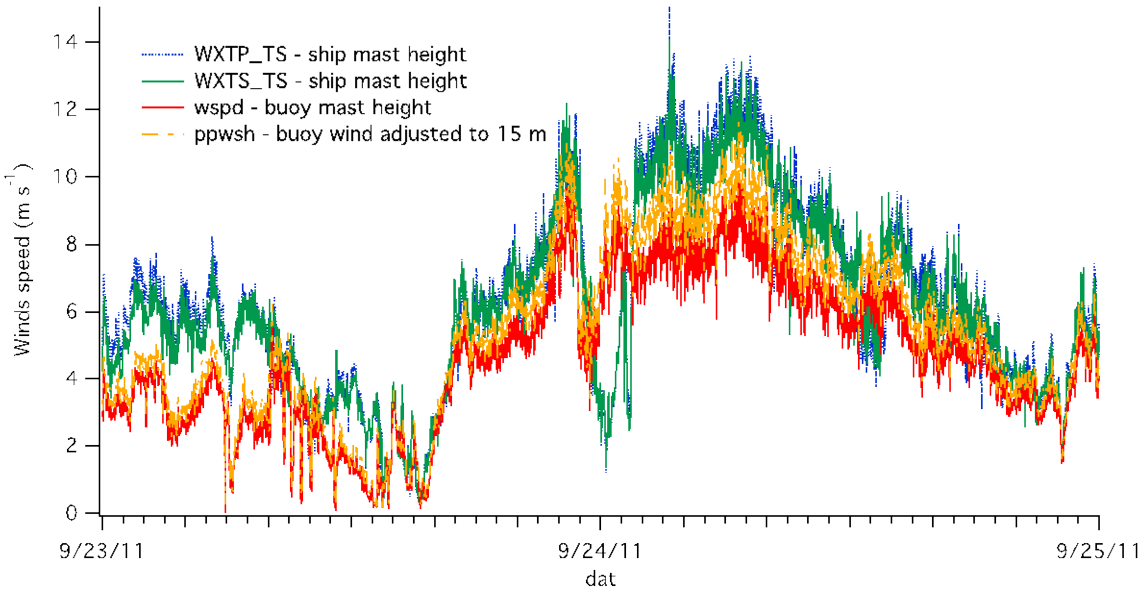


Figure 98: Overplot of ship and buoy wind speed.

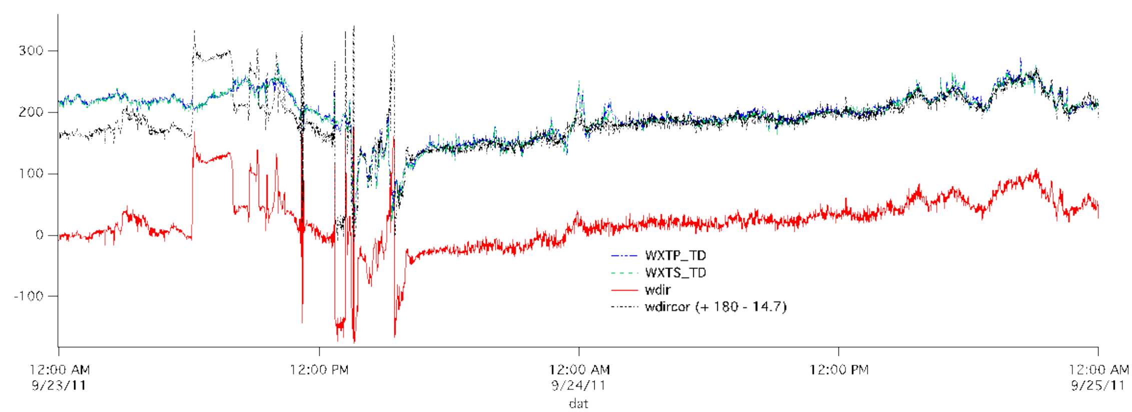


Figure 99: Overplot of ship and buoy wind direction.

2. At sea electronics verifications

The Coastal Pioneer Surface Mooring (CPSM) and the Coastal Pioneer Profiler Mooring (CPPM) were loaded aboard the R/V Oceanus in a nominal operating state at 3 and 4 hour cycles respectively. The Profiler was not attached to the CPPM hence it was not in fact awakened from Profiler activity. Prior to departure, the CPPM was connected to an external power supply to conserve the energy of its alkaline primary battery. Both platforms were in communication with shipboard WiFi and radio modems (RFM) and sending baseline status via SBD Iridium transceivers throughout the transit period. Once the CPSM was deployed, the CPPM was disconnected from external power. As there was concern for the amount of battery power on the CPPM, the shutdown magnet was installed to minimize the power drawn from the alkaline battery pack until deployment

A mooring communications control center was established in the 01 level lab benches near the SSSG systems. Given the communication resources aboard Oceanus, it was possible to have real-time IP connections to shore as if we were indeed controlling the platforms from ashore. Being on site, we simultaneously had the local radio links to both platforms. A set of 4 Freewave radio modems and a Bullet WiFi had been installed on the crosstree above the bridge. The cables from these transceivers were routed down to the 01 lab area where laptops where configured for the different communications connections. Figure 100 shows the communication paths as configured aboard ship.

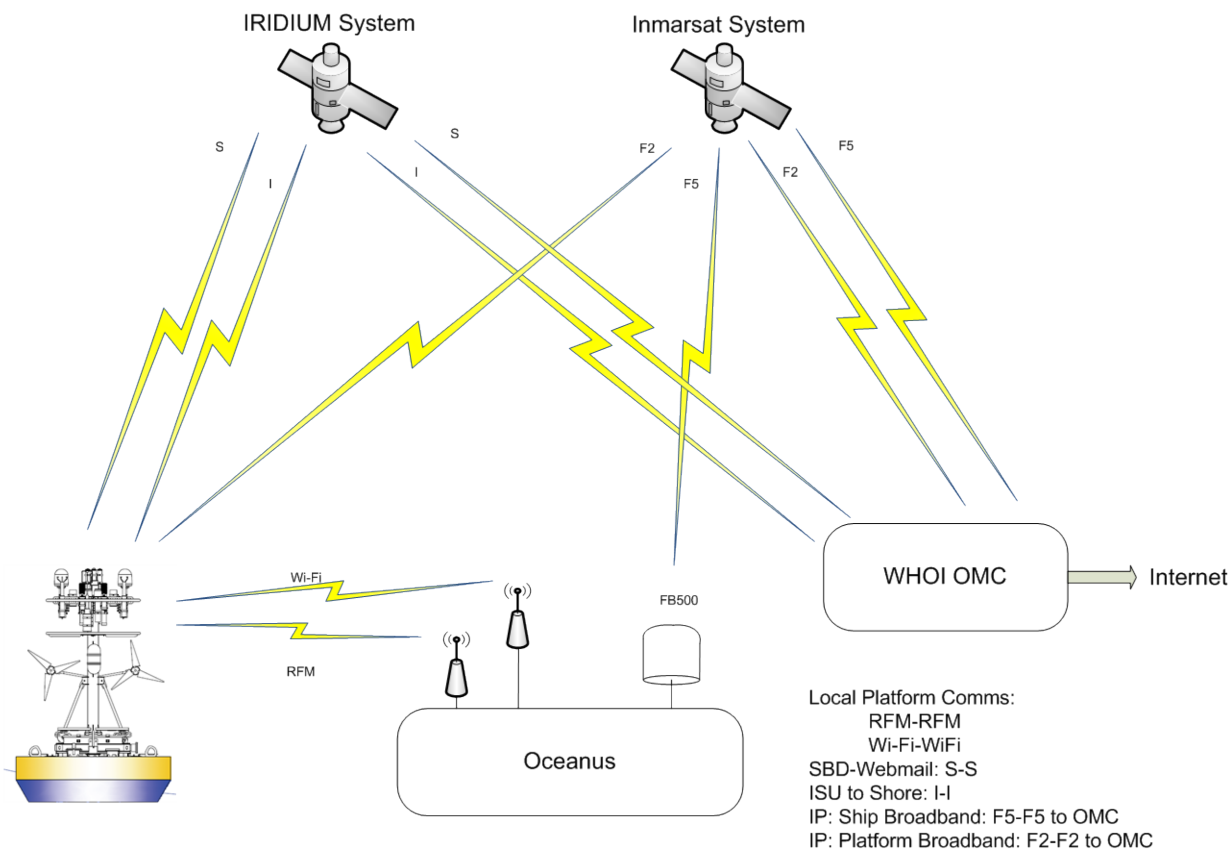


Figure 100: Shipboard telemetry configuration for AST2 site testing.

1. Communication through the ships' network by enabling an IP connection to shore (actually, dedicated use of the ships FB500 communicator) provided the ability to effectively connect to the CPSM Fleet Broadband 250 communicator as if we were working ashore from the OMC. For instance, the path for use of the 100-200 kbps link from CPSM to ship was F2 > WHOI OMC > F5.

2. The platform status web pages assembled at the WHOI OMC could be viewed using the F5 link from the ship (also the High Seas link from the ship)

3. RFM serial and WiFi IP links allowed direct local connection to either of the platforms. The serial links were to the CPM and STC Linux consoles on the CPSM and the CPPM. The WiFi links provided local IP "login" access to the CPSM and CPPM Linux systems.

4. Both platforms' Short Burst Data (SBD) messaging capability was exercised and monitored thru access to "webmail.whoi.edu" from / to the SBD server located at Carlson Lane (cgsn-sbd@whoi.edu). Inbound (mobile originated) messages can be up to 340 bytes and outbound (mobile terminated) messages can be up to 270 bytes. SBD messaging is used by the Platcon Supervisor for event notification and regular terse status transmissions. Asynchronous activity requests can be sent to the Supervisor from shore.

A. Coastal Pioneer Surface Mooring (CPSM)

On the morning of 9/23, the CPSM was deployed with no change to its nominal operating status throughout the procedure. The wind turbines were shut down for safety reasons. The 6000 lb. anchor was lowered to within 10m of the bottom and acoustically released. Figure 101 shows the load cell transient at that time. The primary CPM, DCL in the #1 slot of the buoy well "PlatCon" housing and the DCL on the NSIF have to date continued to operate.

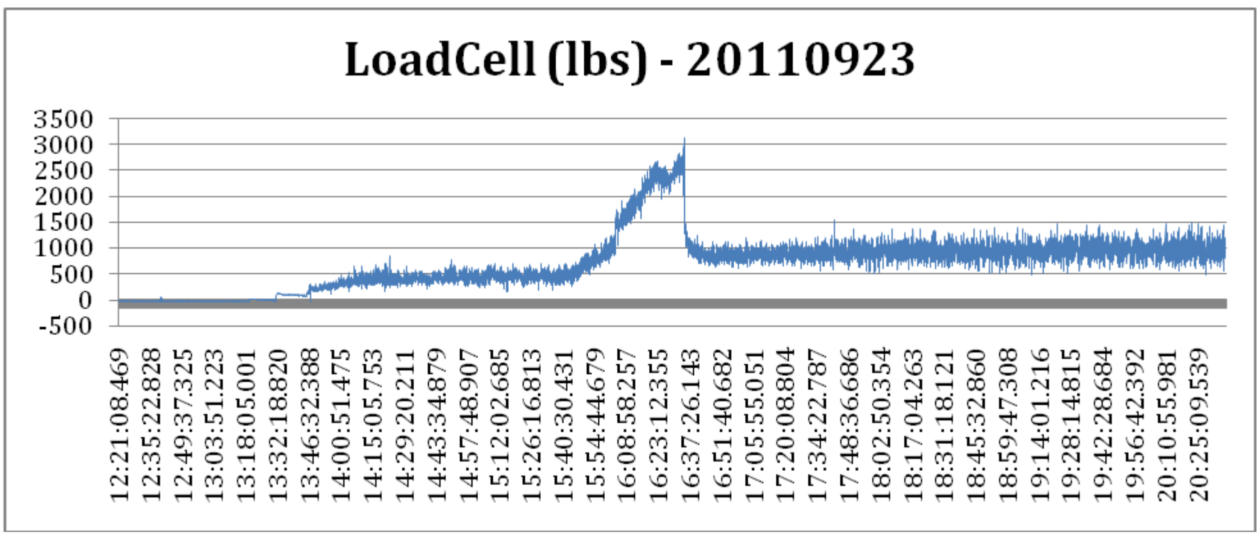


Figure 101: Plot of CPSM load cell tension in pounds vs. time. The gradual increase in tension occurs as the anchor is lowered. When the anchor was released there is a short spike in tension as the anchor falls the short distance to the seabed.

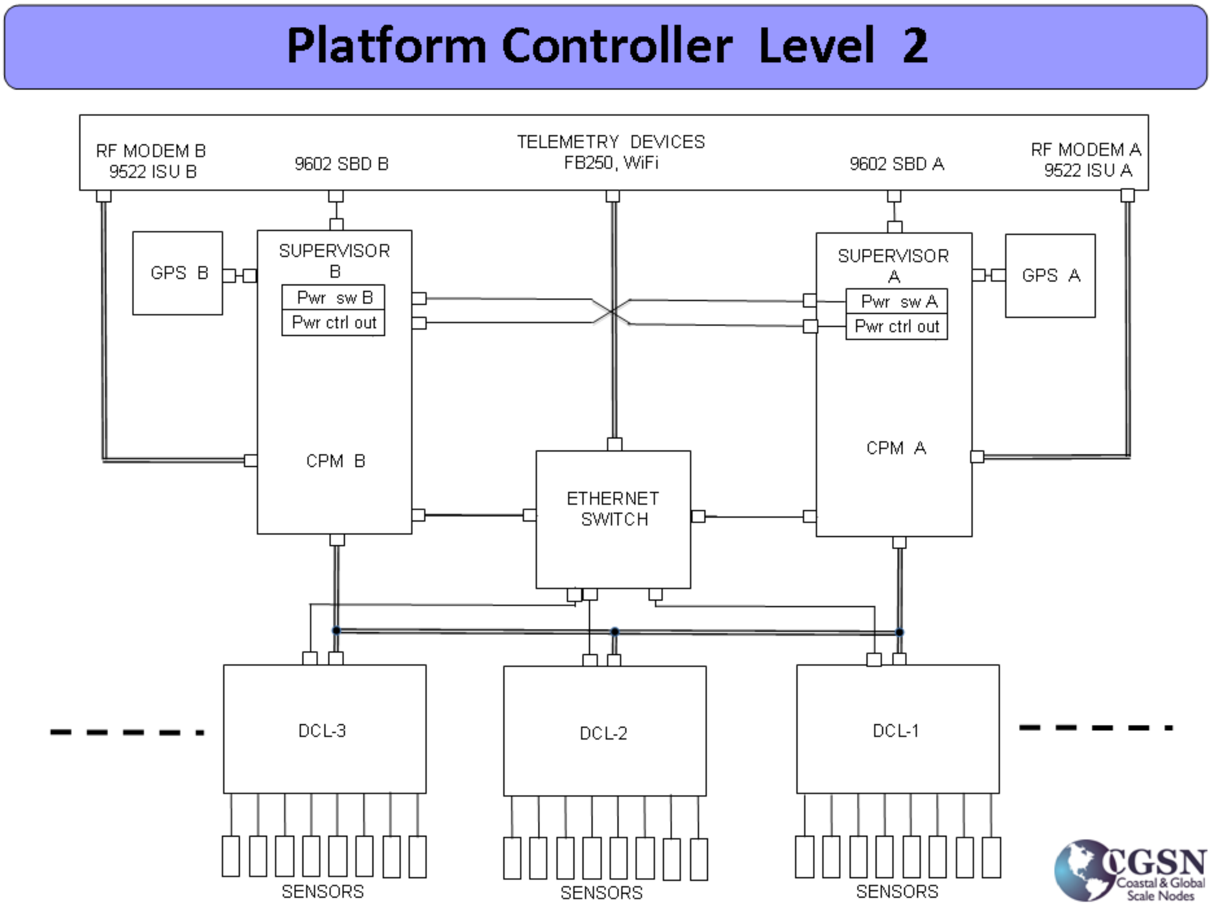


Figure 102: CPSM Platcon diagram showing dual CPMs and multiple DCLs, as deployed for AST2

Once deployed, the PSC wind turbines were enabled. There was little if any wind at the time. The CPSM system continued to maintain its schedule of CPM status and data updates every 3 hours with the pleasant addition of data from surface and near surface instrument frame (NSIF) sensors. PlatCon Supervisor SBD status updates continued on the hour with the Supervisor checking for outbound messages (from shore) every 20 minutes.

The surface sensor payload on the CPSM is:

1. Motion monitoring package with triaxial gyro, accelerometer and magnetometer plus temperature sensors
2. 8000 lb. load cell mounted between the buoy and the urethane chain link to the NSIF
3. ASI Bulk Met package including sensors for vector wind, sea surface temperature and conductivity, barometric pressure, relative humidity, rain gauge, long and short wave radiometers.

4. Radar Target Enhancer (RTE); current was monitored to provide information as to vessel encounters.

The NSIF sensor payload includes:
1. AquaDopp ADCP
2. SBE 16 CTD
3. Single channel fluorometer
4. 3 channel fluorometer

Verification of CPSM operation consisted of these activities
1. Monitoring and assess data acquired, compare locally offloaded copy with what was transferred to the OMC on the 3-hourly schedule
2. Monitor PSC status and PlatCon power reported during the different operations occurring aboard the platform
3. Exercise the telemetry capabilities of the platform including Fleet Broadband (FBB), radio modem (RFM), WiFi, Iridium Subscriber Unit (ISU), and SBD links. Of interest was some sense of the range at which the RFM and WiFi telemetry was effective.
4. Monitor engineering and general operational status of the platform throughout the cruise both locally and while at the HYPM site and on the return trip
5. Note operational anomalies and assess need for changes/corrections to hardware and software

CPSM Platcon Electronics
DCL Rev 1, CPM Rev 2 and RDA Rev 1 modules were deployed in the Surface PlatCon. The Ethernet switch was an EDS-208 (plastic housing). The module component list with associated serial numbers and network configuration is in Appendix 13.

The CPSM PlatCon (diagram in Figure 102) is configured with dual CPM's for redundancy. The CPM in use is the PRIMARY unit, selected by a jumper on the CPM board. The Supervisor on the backup CPM is always alive and similarly to the Supervisor on the PRIMARY CPM, regularly sends a terse status message via its SBD transceiver with baseline power and state of platform information.

There is a viewport on one of the CPSM junction boxes (figure 103), showing a set of 4 LEDs for each CPM as a baseline diagnostic indication of CPSM status. Green indicates that the main power bus is hot which means that the PSC is connected and providing power to the PlatCon 24v power bus. This is the system OFF state before the PlatCon is activated by removing a magnet from the viewport. Once the magnet is removed, the blue LED for each CPM should commence to blink, indicating that the Supervisor is active and generating a status string at the blink rate that is made available to the CE. Shortly after the appearance of blue, the white LED on the active CPM should be on indicating that power has been applied to the CE. Less than a minute later, the red LED should turn on indicating that the CE Linux OS has booted and started to prosecute its mission.

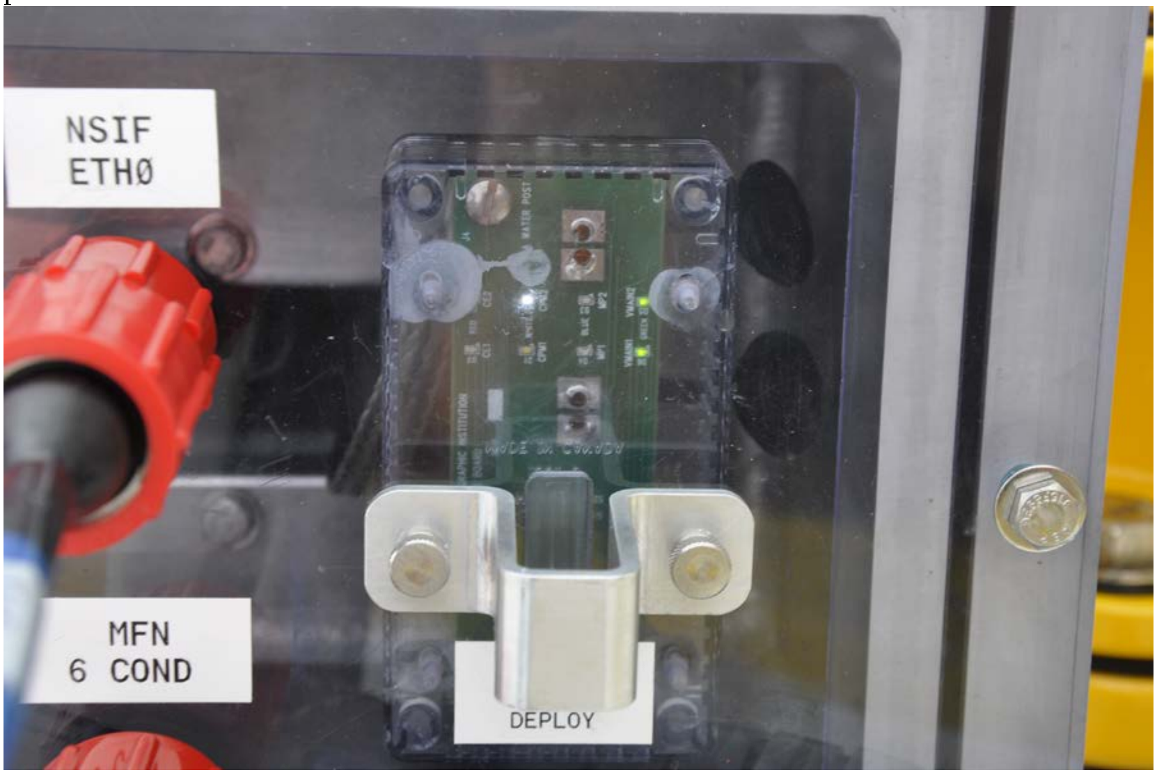


Figure 103: Photo showing status panel located in the junction box. J-Box panel was made from clear plastic so that status LED lights could be seen.

Telemetry Testing

When power is applied to a CPM by its Supervisor, the RFM (115.2kbaud) and Wi-Fi are by default enabled which allows local monitoring of the CE boot process. In the absence of use, both are shutdown within 5 minutes otherwise both remain powered. These devices, particularly the WiFi were in constant use during the time spent on station at the deployment site. Most often the ship maintained a distance of 1 – 2km from the CPSM and both communication links were of high quality. Of course the main factors determining quality of these links are shipboard antenna height, use of low gain (3 dB) omnidirectional antennas to limit pointing errors, and power settings for the transceivers. For the standard ISM bands in the 902-928 MHz and 2.4 GHz regions, the EIRP is limited to 4W. While nobody is generally checking on open water, that is perfectly adequate for our purposes. On an occasion when the ship steamed away from the 2 WHOI platforms, RFM and WiFi reception remained useful to a range of about 6 nm although a higher sea state would reduce that range.

At no time was there evidence that any of the satellite based telemetry systems were compromised in any way. One of the parameters to which we hope to gain insight during the AST2 is the robustness of the mechanically steered FBB-250 antennas. The CPSM is equipped with 2 FBB units both of which can be used by either CPM. We use them alternately at 3-hourly epochs not only to demonstrate that we are able but to exercise both FBB units. In general, SBD messaging incurred latencies of less than 3 minutes, often percolating through the SBD system in much less time. We have yet to experience a missed message. While the ISU iridium link was never used for data during the cruise, the ability to use it on a "login" basis to the CPM CE Linux was confirmed. Once logged in to the CE, the terminal emulator utility "Minicom" was used to gain access to either of the 2 DCLs.

CPSM: Science and Engineering Data Integrity Tests

Two Linux computers ashore comprising an OMC facility were configured to receive and contribute inbound CPSM and CPPM data to a web accessible displays that we could view from the ship using the shipboard satcom systems. These facilities had been preconfigured to show status information gleaned from the platforms at 3 hour intervals, representing the mission scheduler basic interval. Detailed plots of sensor time series were accessible as well, again as if we were ashore. This allowed confirmation that the same data we could extract from the platforms locally was in fact arriving ashore. A sampling of these displays follows that were taken from screen grabs during the cruise (Figures 104-129). These browser accessible displays have been augmented since the cruise and can be viewed at http://sunfish.whoi.edu/omc-bin/oms_main.pl. This is essentially the tool that allowed us to confirm expected operation of the deployed platforms. The following section includes examples of what was observable shortly after deployment of the CPSM and CPPM moorings.

There are quick-look Real Time Status Displays (dashboards) for the CPSM and CPPM systems in which engineering and scientific sensor data are presented in human readable form (Figures 103-104.) Dashboards present data in two ways. The initial web-based interface displays text in fields, some of which are color coded in order to represent the state of a specific sensor. From this front page clicks on hyperlinks will bring up more detail. These links either bring up more text explaining the field or plot sensor values over time to evaluate longer term trends. This data is not meant to be a full QA/QC test of scientific instruments, but does allow for a quick and easy evaluation of "reasonableness". These dashboards, thru local telemetry provided the basis of platform assessment following the AST2 deployments in the small amount of time allotted to observation while on site. Subsequently, the same information was accessible thru shipboard telemetry links to confirm that the same information was reaching the OMC servers ashore.

Further performance evaluation of the systems can be accomplished by reviewing the system log files which record all events under system control. These log files allow for the reconstruction of any series of events made by the platform controllers or data loggers. For example, the timing of a satellite communication call is recorded in the system log file and keywords can be used to filter out relevant information.

Procedure:

**Note: The following examples are from the AST-2 CPSM and CPPM deployment unless otherwise noted.*

Figure 104 below was observed in real time by logging on to the private network of the buoy platforms, or from the shore side OMC server after the information has been transmitted to shore. Note - The DCLs deployed for AST2 are Rev 1 boards on which sensor ports 7 & 8 are not functional. This has no impact on AST2 since there are only 4 sensors on DCL7 and NSIF DCL1.

The test table below shows the pertinent CPSM functionality that had to be confirmed in short order after deployment. In most cases, for instance of telemetry devices, it was fairly clear whether a device was working. Expected GPS operation was recognized by the reception of valid fixes and by small observed jitter in PPS arrival near the expected time which is continuously checked.

Table 20: CPSM functionality.

PlatCon Tests	**RFM Console**	**Wi-Fi**	**ISU**	**SBD**	**GPS**	**PSC Interface**
CPM1	x	x	x	x	x	x
CPM2						

	Console	**Channel 1**	**Channel 2**	**Channel 3**	**Channel 4**	**Channel 5**	**Channel 6**
DCL1	x	AquaDopp	CTD	1 ch fluo	3 ch fluo		
DCL7	x	MOPAK	MetBK	Loadcell		RTE	

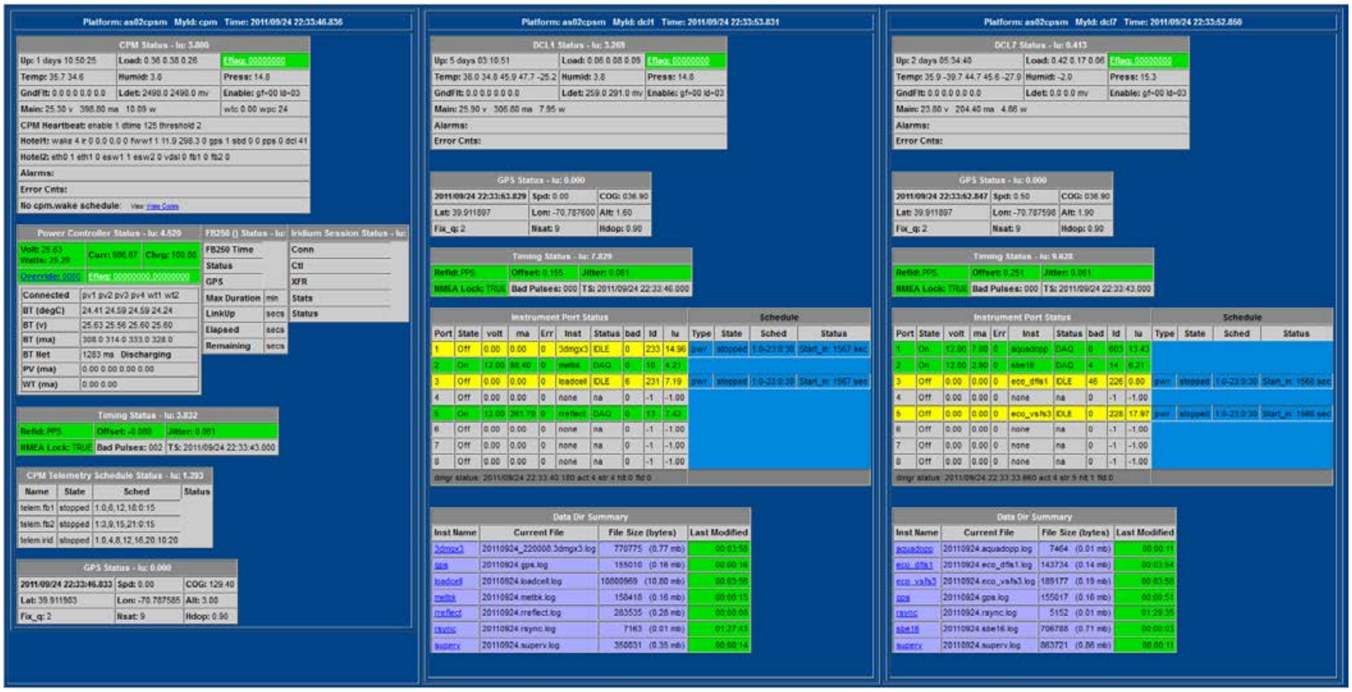


Figure 104: CPSM Control Screen

Figure 104 is the CPSM dashboard as it was configured during the AST2 deployment. It displays the status of the active Communication and Power Manager as well as any active Data Concentrator Loggers. Green coloring is indicative of a properly functioning active process or device. Yellow coloring is indicative of a scheduled inactive, waiting to start process or device and gray represents either inactive facilities or the most recently updated state of a device parameter. Red constitutes and alarm or error condition. Since the deployment, this display has been augmented but the information shown enabled CPSM operational assessment following deployment. We observed no red flags on this initial display. Each table in the 3 major sections contains specific functions that were closely monitored. Once it becomes clear what is where, this top level view is a very effective tool for assessing system health. The first section on the left is CPM status. The middle and right sections are specific to DCL1, in the PlatCon well housing, and DCL7, in the Near Surface Instrument Frame (NSIF) respectively. Figure 105 below is a closer look at the CPM status screen.

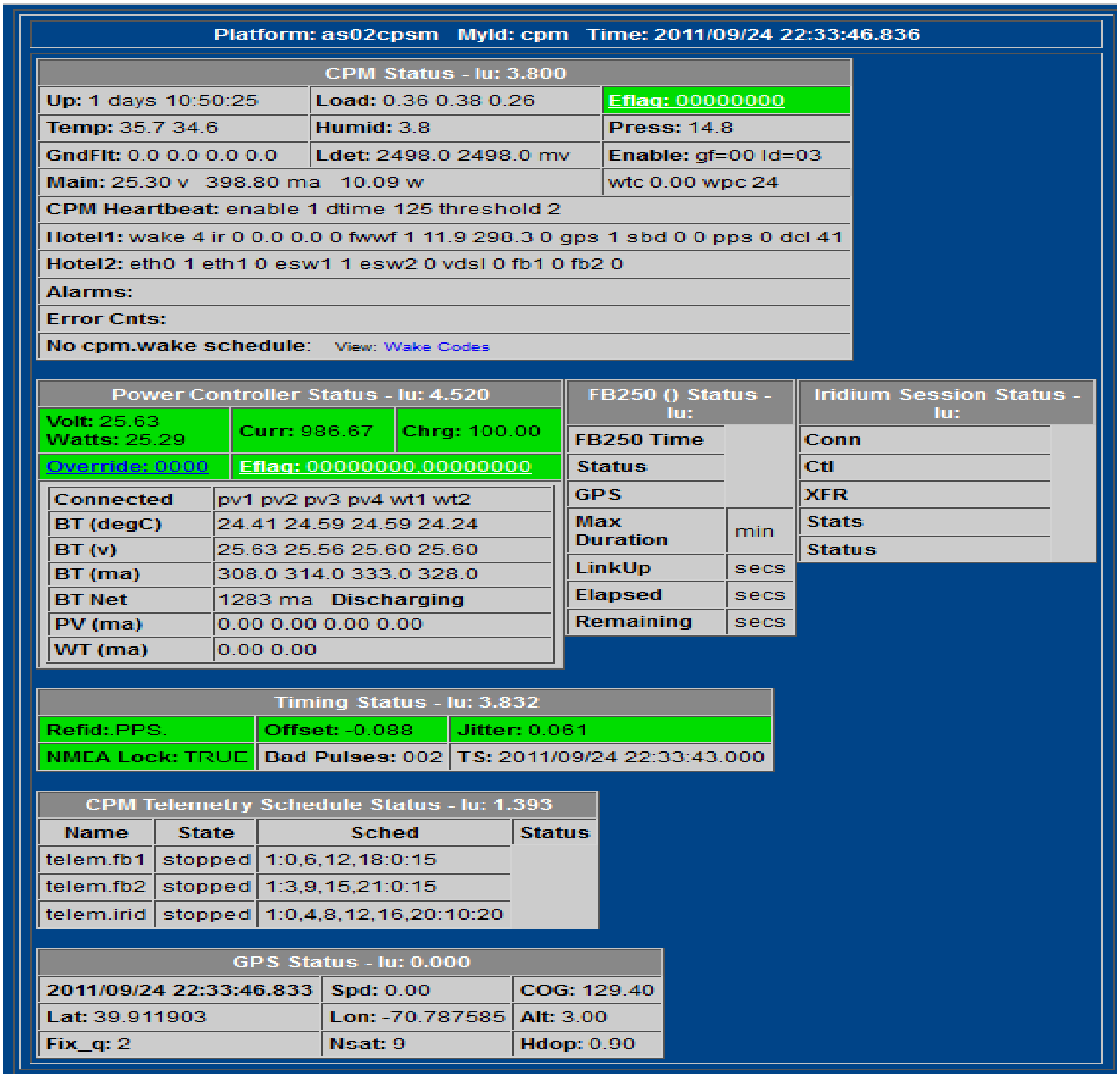


Figure 105: CPM only Real Time Status Display box

The CPM status view is made up of seven different tables:

- CPM status: Information from the Computational Element (CE) and the Supervisor
- PSC Status: Information from the Power System Controller
- FB250 status: high speed satcom transmission statistics
- Iridium status: Transmission statistics
- Timing status: GPS/PPS/timing statistics
- CPM telemetry schedule: FB250/Iridium status and schedule
- GPS Status: Information from GPS strings

During deployment, certain fields were monitored closely. Among the important ones are the CPS and PSC Status boxes. Furthermore, close attention should be given to certain fields within those boxes shown in Figure 106.

CPM Status - lu: 1.720		
Up: 1 days 10:52:38	**Load:** 0.34 0.38 0.27	Eflag: 00000000
Temp: 35.7 34.6	**Humid:** 3.8	**Press:** 14.8
GndFlt: 0.0 0.0 0.0 0.0	**Ldet:** 2498.0 2498.0 mv	**Enable:** gf=00 ld=03
Main: 25.30 v 400.40 ma 10.13 w		wtc 0.00 wpc 24
CPM Heartbeat: enable 1 dtime 125 threshold 2		
Hotel1: wake 4 ir 0 0.0 0.0 0 fwwf 1 11.9 259.3 0 gps 1 sbd 0 0 pps 0 dcl 41		
Hotel2: eth0 1 eth1 0 esw1 1 esw2 0 vdsl 0 fb1 0 fb2 0		
Alarms:		
Error Cnts:		
No cpm.wake schedule: View: Wake Codes		

Figure 106: CPM status box (top table)

The CPM status box displays CE and Master PIC information. Below is a brief description of the available information:

- CPU uptime: Time since last CE reboot
- CPU load
- Master PIC error flag display with hyperlink decoder
- Temperature sensor values in C: Temperature inside the PlatCon control housing
- Humidity sensor value in %rh: Humidity inside the PlatCon control housing
- Atmospheric pressure in psi: Inside the PlatCon housing
- Sea Water Fault Detect values (mA)
- Leak Detect values (mV)
- Enable table for Sea Water Fault Detect and Leak Detect
- Main Bus Voltage and Current measurement, Power calculated from these measured values.
- WTC= Wake Timer Count; countdown timer to sleep
- Wake Power Count; number of CPU/CE power cycles
- CPM heartbeat settings: The MasterPIC monitors CE health by a string sent to it by the CE
- Hotel1/Hotel2: Telemetry and communication device status and power consumption for Iridium, RFM and Wi-Fi
- Alarms: From the CE, error list in an appendix
- Error Cnts: Statistics of any reported errors.
- CPM Wake Schedule: Wake list in Appendix 12 Table 2

Of the above listed fields, particular attention should be paid to the **Temp:** and **Main:** fields. These fields do not have any automated response for values that may be outside safe parameters. Nominal values for these are: 24V, 200-1200mA depending on which telemetry devices are enabled. Power is calculated from the measured voltage and current. Secondly, error flags from the Supervisor are attention getters.

This field will turn red in the Eflag: 00000000 presence of an error. And, in addition, the field will link to a description of the error code. Similarly, the **Alarms:** field will display any errors issued by the CE.

The Power Controller Status box is a status from the PSC as seen below in figure 107.

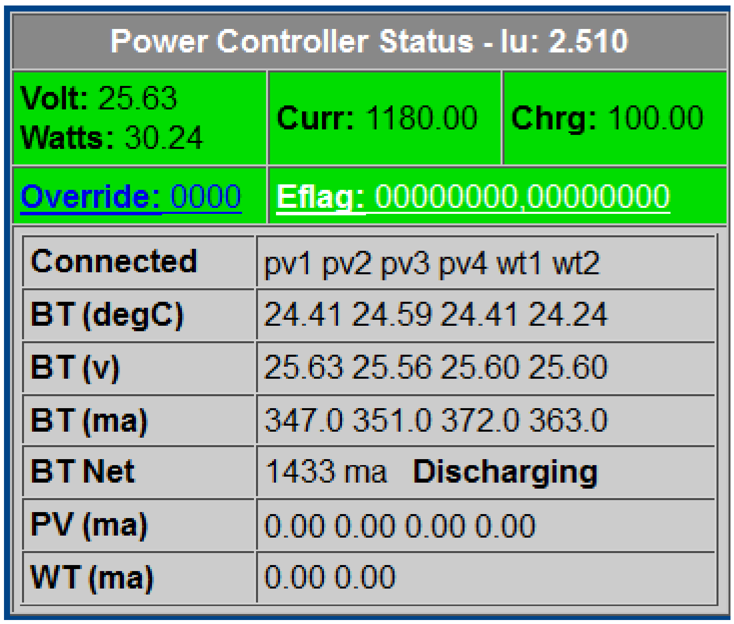


Figure 107: PSC status box

This status display is generated from the string of values supplied by the Power System Controller (PSC). At a glance it can be seen that the bus voltage is 25.63V, the CPSM system is using 30W (at this snapshot in time) the state of charge is at 100% as well as what devices are connected and their current values.

The plotting of data, and links to system log files, are found in a top menu as seen in Figure 108 below. There are practical limitations to the amount of data that can be plotted on the CPM's and DCL's, but they are generally sufficient for verification of operation.

Current Time: 2011/09/25 04:58:40 GMT   version: cg_cpm_dcl-1.11

View	Status	System	CPM CTL MF	Alarms	Errors	Msgs	Serial Cfg	Network Cfg	Fault Tables	Data
Syslog	All	MPIC	PSC	GPS	PPS	NTP	CPU	FB250	Irid	View dcl_syslog

Plot: ntp cpm psc cpu ldet idata iplot

Figure 108: A hyperlink menu table located above and below the control screens provides links to system files and data plots.

System Files:
The CPM and DCL's are configured through the use of text files. All events are recorded in a system log file. These can be viewed, and filtered by selecting the test in the Figure 108 table. Descriptions of all links in CPM, DCL and STC sections are included in the Appendices 9, 10, and 11.

For example; by clicking Serial Cfg the following text file is displayed. This information lists any possible sensor, telemetry system and DCL that may be connected to the CPM and DCL's, and the information about the connection. Much of the information in these files is displayed as fields on the Real Time Status Display in 104.

```
======================   CPM SERIAL Config ==========================
 #########################################################
 ################  CGSN OOI SYSTEM FILE ##################
 ##############  Serial Configuration file ###############
 #### (DO NOT EDIT THIS FILE IF YOU DO NOT KNOW HOW) #####
 #########################################################
 #
 #########################################################
 # FFC VERSION
 #########################################################
 #
 # Syntax: space separated fields, comments begin with #
 # Note:   Do *not* modify port name
 #
 #Name        port,baud,parity,nbits,stop,flowctl  debug_level
 #------------------ SYSTEM FUNCTIONS --------------------
 Freewave     /dev/ttyAM0  115200 N 8 1 0   MSG
 Supervisor   /dev/ttts0    38400 N 8 1 0   MSG
 GPS          /dev/ttts2     4800 N 8 1 0   MSG
 PwrSys       /dev/ttts3   115200 N 8 1 0   MSG
 Irid9522B    /dev/ttts10    9600 N 8 1 2   MSG
 #------------------- DCL Console Ports ------------------
 DCLCon1      /dev/ttyAM1    9600 N 8 1 0   MSG
 DCLCon2      /dev/ttts1     9600 N 8 1 0   MSG
 DCLCon3      /dev/ttts4     9600 N 8 1 0   MSG
 DCLCon4      /dev/ttts5     9600 N 8 1 0   MSG
 DCLCon5      /dev/ttts6     9600 N 8 1 0   MSG
 DCLCon6      /dev/ttts7     9600 N 8 1 0   MSG
 DCLCon7      /dev/ttts9     9600 N 8 1 0   MSG
 #----------------- Not Connected/Unavailable ------------
 N/C          /dev/ttts8     9600 N 8 1 0   MSG
 N/C          /dev/ttts11    9600 N 8 1 0   MSG
 #########################################################


======================   DCL1 SERIAL Config ==========================
 #########################################################
 ################  CGSN OOI SYSTEM FILE ##################
 ##############  Serial Configuration file ###############
 #### (DO NOT EDIT THIS FILE IF YOU DO NOT KNOW HOW) #####
```

```
##########################################################
#
# Syntax: space separated fields, comments begin with #
# Note:   Do *not* modify port name or dlog_id
#
#Name         port,baud,parity,nbits,stop,flowctl  debug_level [dlog_id dlog_proc
params]
#------------------ SYSTEM FUNCTIONS --------------------
Console       /dev/ttyAM0  115200 N 8 1 0   MSG
Supervisor    /dev/ttts0    38400 N 8 1 0   MSG
GPS           /dev/ttts2     4800 N 8 1 0   MSG
#------------------ Instrument Port Mappings ------------
3dmgx3        /dev/ttyAM1  115200 N 8 1 0   MSG   DLOGP1  bin/dl_3dmgx -a 3
metbk         /dev/ttts1     9600 N 8 1 0   MSG   DLOGP2  bin/dl_metbk
loadcell      /dev/ttts4     9600 N 8 1 0   MSG   DLOGP3  bin/dl_loadcell -f 200
pco2          /dev/ttts5     9600 N 8 1 0   MSG   DLOGP4  bin/dl_pco2
rreflect      /dev/ttts6     9600 N 8 1 0   MSG   DLOGP5  bin/dl_rreflect
Inst6         /dev/ttts7     9600 N 8 1 0   MSG   DLOGP6
Inst7         /dev/ttts9     9600 N 8 1 0   MSG   DLOGP7
Inst8         /dev/ttts10    9600 N 8 1 0   MSG   DLOGP8
#----------------- Not Connected/Unavailable ------------
#N/C           /dev/ttts3     9600 N 8 1 0   MSG
#N/C           /dev/ttts8     9600 N 8 1 0   MSG
#N/C           /dev/ttts11    9600 N 8 1 0   MSG
##########################################################



======================   DCL7 SERIAL Config ==========================
##########################################################
##############  CGSN OOI SYSTEM FILE ###################
###############  Serial Configuration file ################
#### (DO NOT EDIT THIS FILE IF YOU DO NOT KNOW HOW) #####
##########################################################
#
# Syntax: space separated fields, comments begin with #
# Note:   Do *not* modify port name or dlog_id
#
#Name         port,baud,parity,nbits,stop,flowctl  debug_level [dlog_id dlog_proc
params]
#------------------ SYSTEM FUNCTIONS --------------------
Console       /dev/ttyAM0  115200 N 8 1 0   MSG
Supervisor    /dev/ttts0    38400 N 8 1 0   MSG
GPS           /dev/ttts2     4800 N 8 1 0   MSG
#------------------ Instrument Port Mappings ------------
aquadopp      /dev/ttyAM1    9600 N 8 1 0   MSG   DLOGP1  bin/dl_aquadopp
sbe16         /dev/ttts1     9600 N 8 1 0   MSG   DLOGP2  bin/dl_sbe16
eco_dfls1     /dev/ttts4     9600 N 8 1 0   MSG   DLOGP3  bin/dl_florvsf -a 1
Inst4         /dev/ttts5     9600 N 8 1 0   MSG   DLOGP4
eco_vsfs3     /dev/ttts6     9600 N 8 1 0   MSG   DLOGP5  bin/dl_florvsf -a 3
Inst6         /dev/ttts7     9600 N 8 1 0   MSG   DLOGP6
Inst7         /dev/ttts9     9600 N 8 1 0   MSG   DLOGP7
Inst8         /dev/ttts10    9600 N 8 1 0   MSG   DLOGP8
#----------------- Not Connected/Unavailable ------------
#N/C          /dev/ttts3     9600 N 8 1 0   MSG
#N/C          /dev/ttts8     9600 N 8 1 0   MSG
#N/C          /dev/ttts11    9600 N 8 1 0   MSG
##########################################################
```

Figure 109: Table of text files for CPM and DCL.

Plots:

The row of links below the table in Figure 108 can be utilized to generate respective data plots. These can be and were used for quick verification and correlation of science and engineering data. By clicking the PSC link, the plots in Figure 110 are displayed.

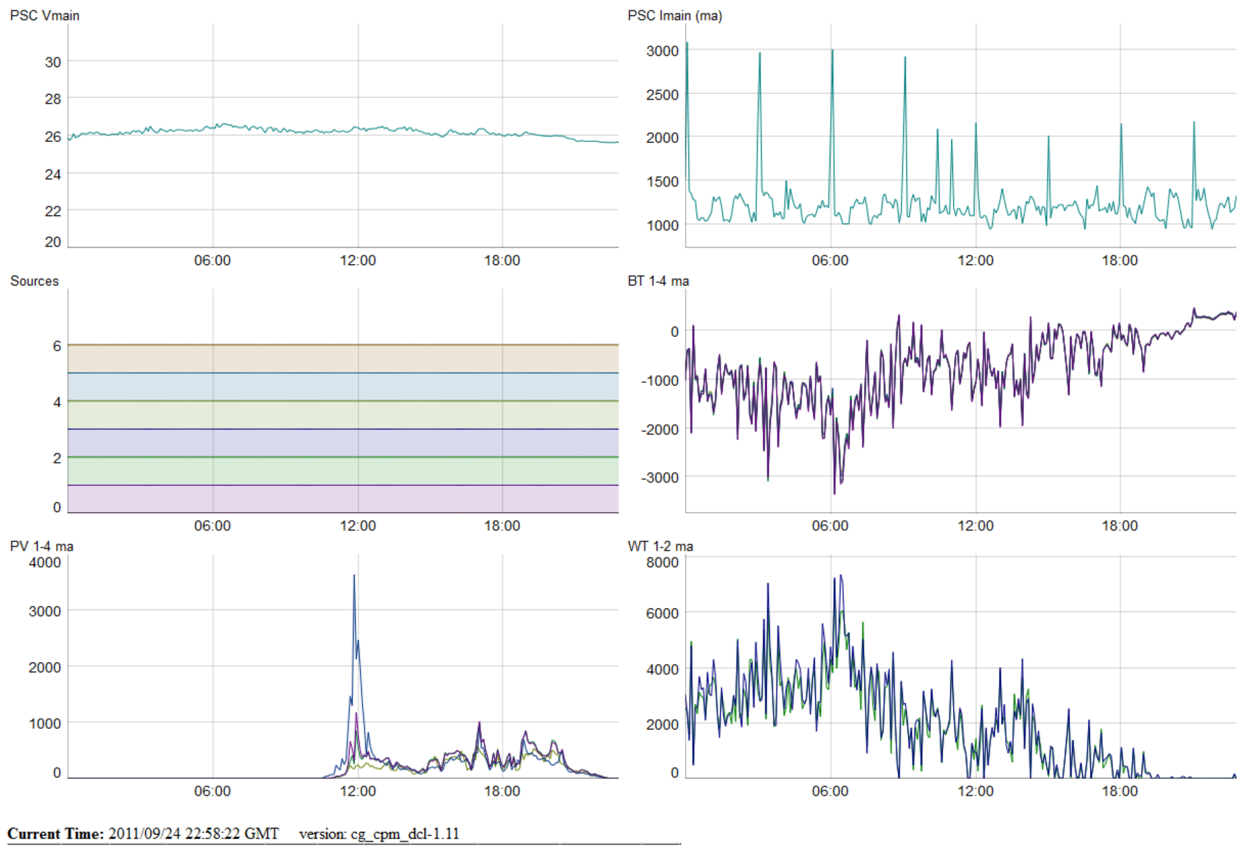


Figure 110: PSC plots

This quick view shows multiple variables over time.

- PSC Vmain: bus voltage
- PSC Imain: Current delivered to CPSM
- Sources: On/off states of the four PV panels and the 2 wind turbines
- BT: Current in or out of the individual batteries, negative current (-ma) = discharging
- PV: Current out of the four PV panels
- WT: Current out of the 2 wind turbines

Some observations noted in the above plots are; the regular intervals of current spikes in the PSC Imain plot and the decrease in power generation from the wind turbines in WT 1-2 plot.

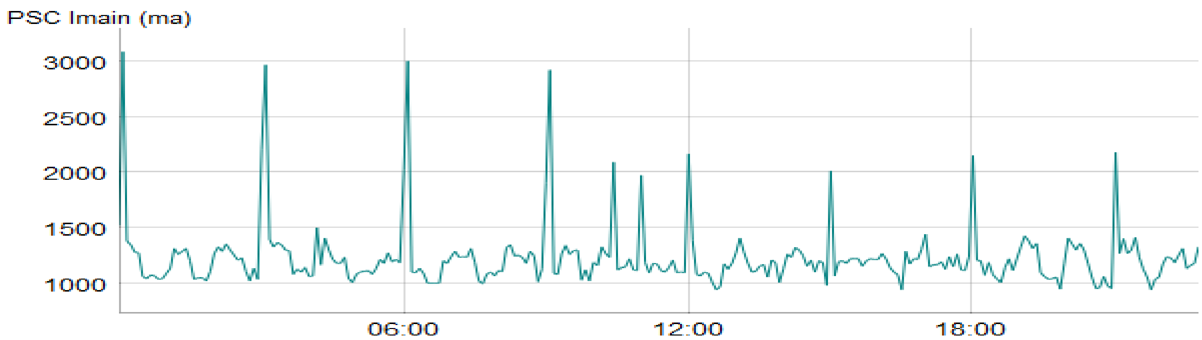


Figure 111: PSC current delivered to CPSM system.

From the current plot in Figure 111, the current spikes can be associated with the time stamps of the Fleet Broadband transmissions in the syslog. Lines such as:

```
2011/09/26 06:04:45.743 MSG C_FB250 FB250 fb1 link is UP
```

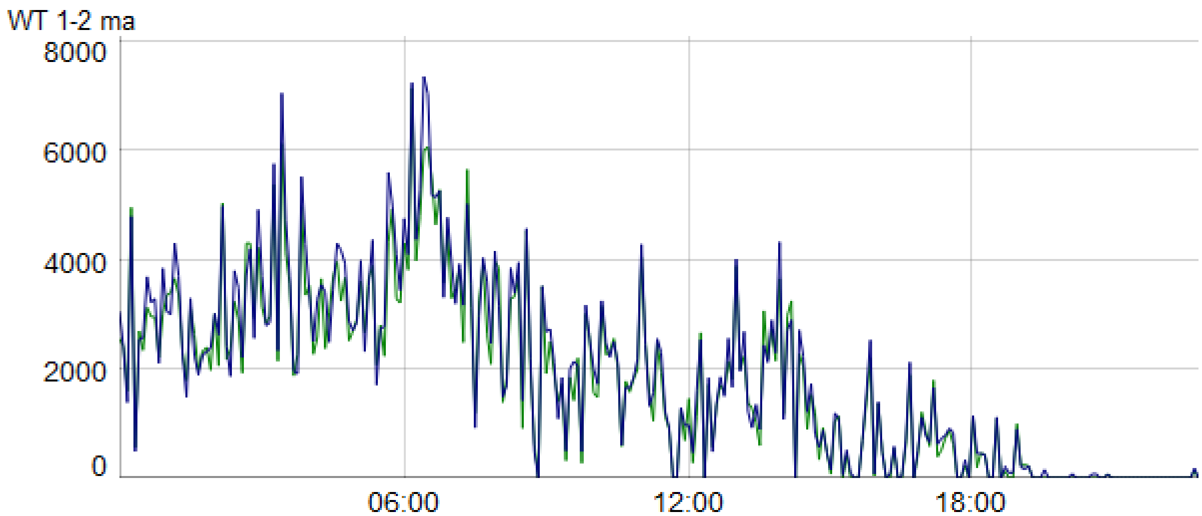


Figure 112: Close up of wind turbine current generation.

In Figure 111, Green and Blue denote WT1 and WT2. Note when looking at these plots on the website one has the ability to mouse over the curves which provides text values of the time and value. One can also zoom in and out of the plot to analyze points of interest.

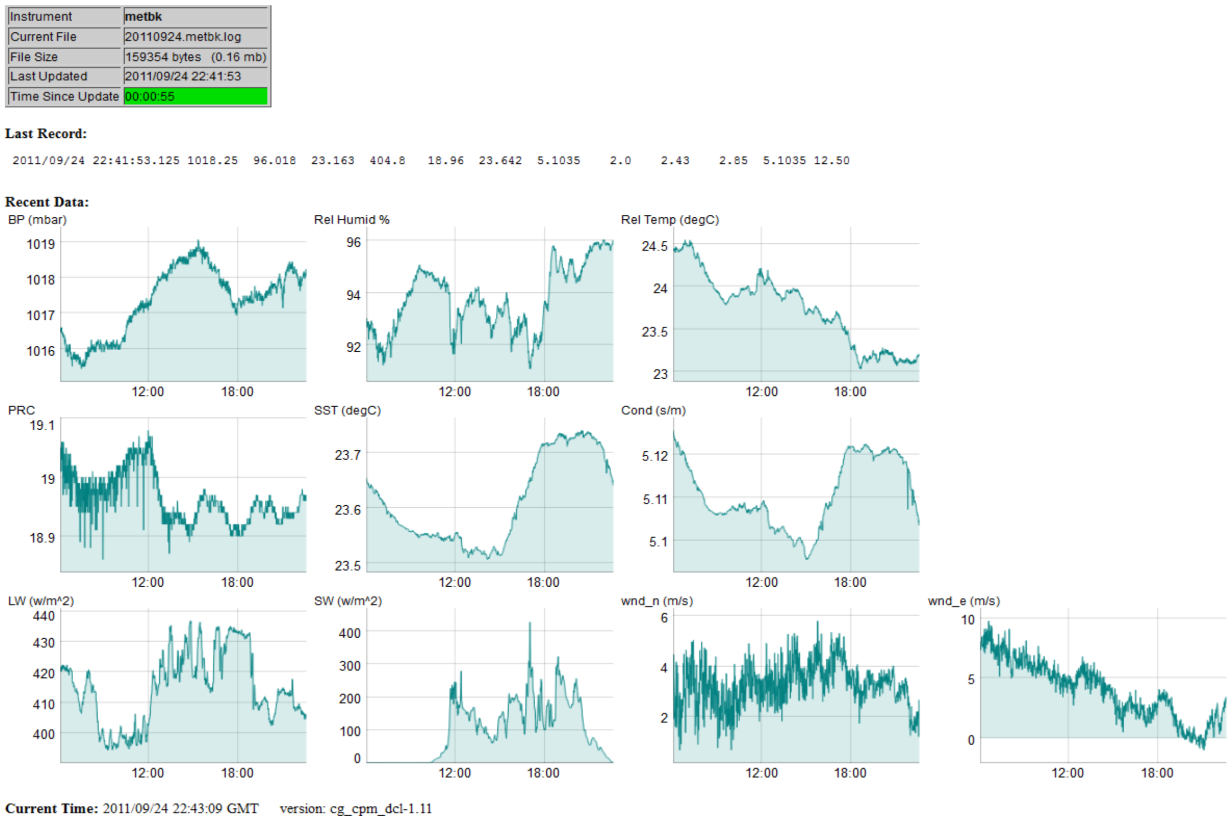


Figure 113: ASIMET data plots.

Further correlation across the CPSM platform allowed verification of proper external device function. For example, wind speed in the two lower right hand plots of Figure 113 show a diminishing wind speed which correlates with the reduced wind turbine power generation plot in Figure 112.

In addition to recording and plotting the data from a sensor, the CPM's and DCL's record engineering data about the instrument port itself. This is used to verify proper operation of the port and the instrument. Such time series of engineering data creates a capability to troubleshoot a remote system.

For example: Figure 114 below is the 3DM-GX3 motion pack data plot. Figure 115 is the instrument port data plot.

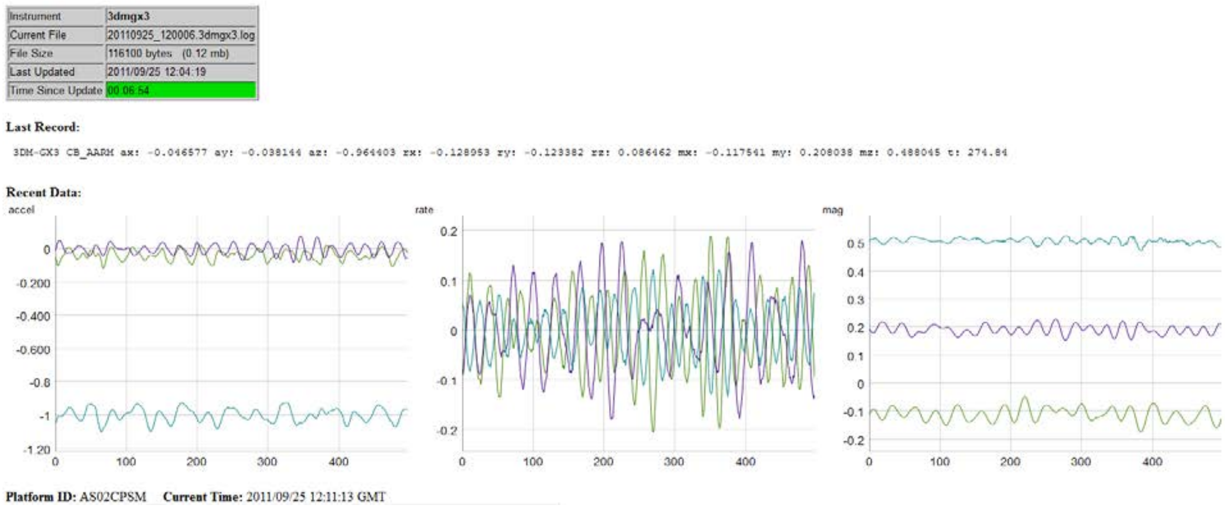


Figure 114: Figure 13: Motion Pack data

One can “mouse over” the plots and get further specific information about the individual data plots.

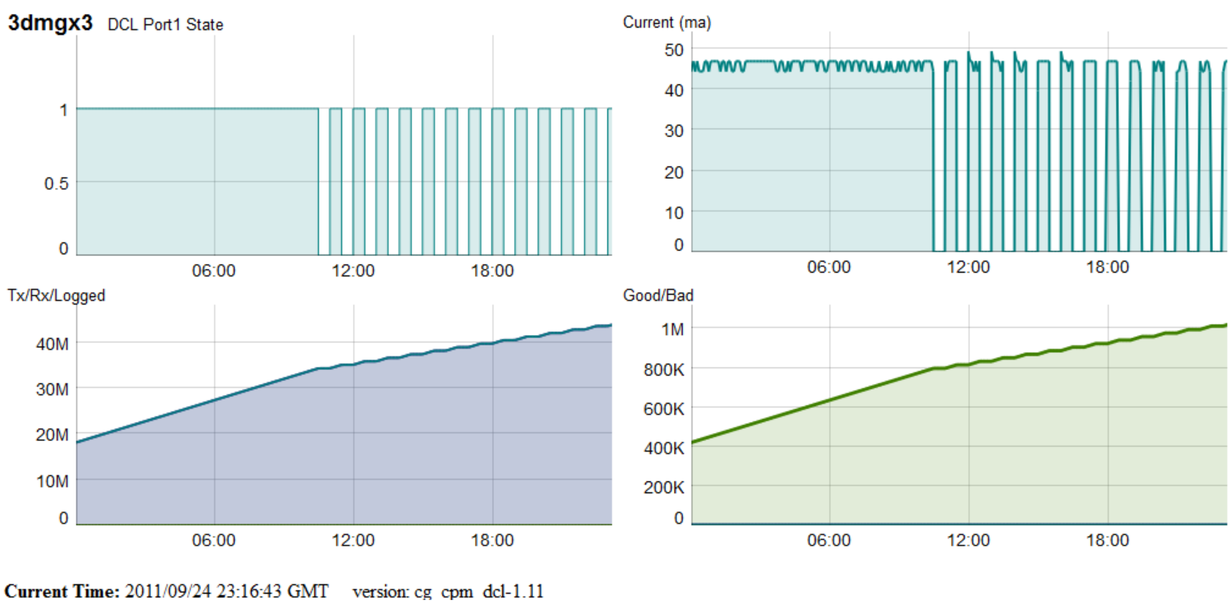


Figure 115: Motion Pack Instrument Port Data; This instrument port data shows four separate values; Port state: On or off, the transition to a 50% duty cycle at ~11:00 is clear.

3. Other instruments

The surface mooring science instruments mounted in the Near Surface Instrument Frame included a Seabird pumped CTD, Nortek Aquadopp, and two Wetlabs optical instruments (VSFS and DFLS). The Nortek Aquadopp and CTD provide physical oceanographic measurements of currents and density respectively. Heading, Pitch, and roll data are included in the Nortek data stream and will be useful in characterizing the motion of the NSIF. The Wetlabs optical instruments are part of the Biofouling experiment.

The 'Data Dir Summary' panel of the status window and the screen shots of the NSIF instrumentation after deployment were used to verify the instruments and data collection were working. The CPSM status panel with green colored instrument cells (figure 116) indicates that the instruments were collecting and transmitting the data through the entire mooring back to shore. Figures 118-123 show NSIF real time data. Unfortunately, the Wetlabs DFLS sensor was not functioning as indicated by the saw-tooth pattern seen in the raw of the signal Figure 118).

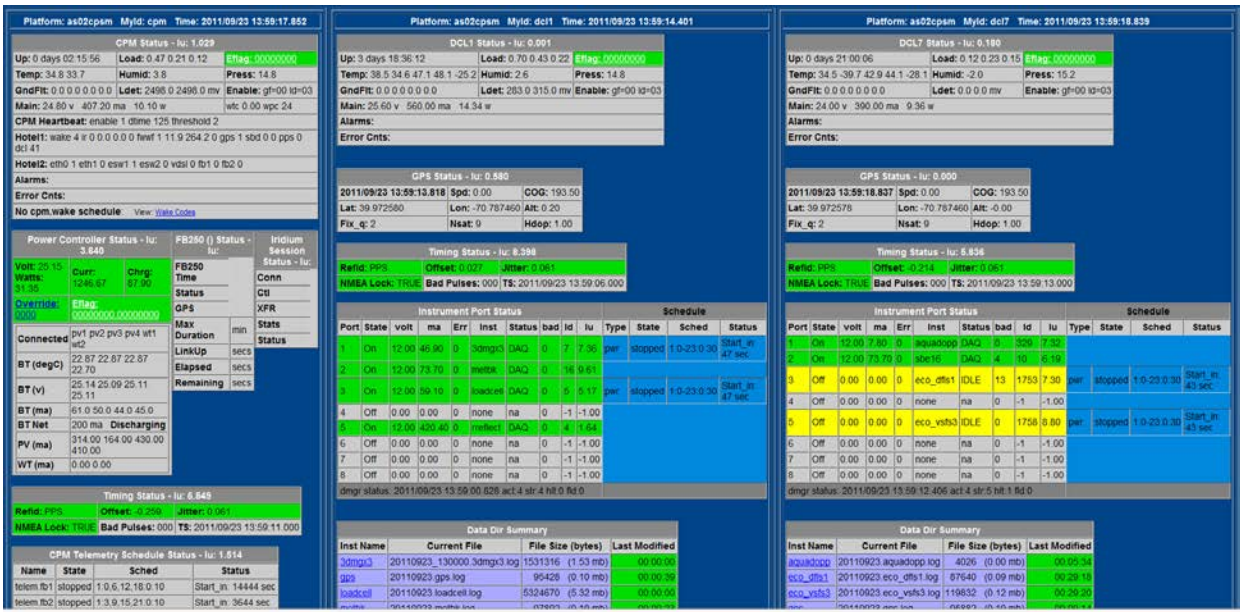
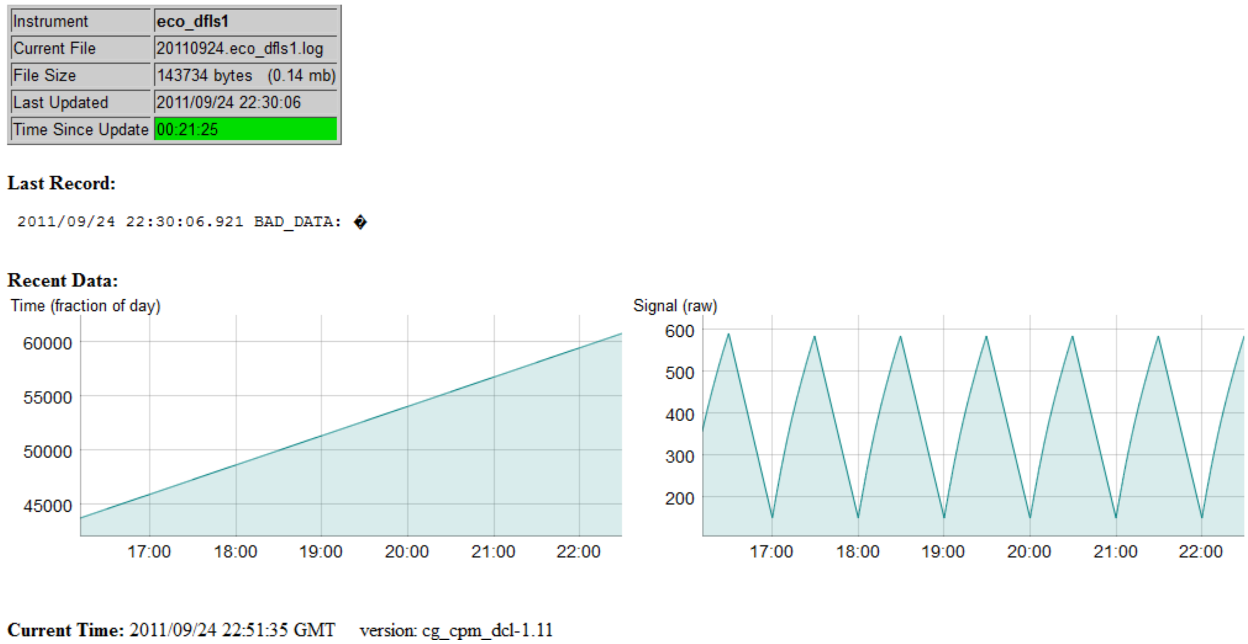


Figure 116: Surface mooring status panel. Right most panel lower half shows status of NSIF instrumentation. The eco-dfls and eco-vsfs cells are colored yellow because the sampling schedule (30 minutes at the top of the hour) has them powered down.

Data Dir Summary			
Inst Name	Current File	File Size (bytes)	Last Modified
3dmgx3	20110923_130000.3dmgx3.log	1531316 (1.53 mb)	00:00:00
gps	20110923.gps.log	95428 (0.10 mb)	00:00:39
loadcell	20110923.loadcell.log	5324670 (5.32 mb)	00:00:00
metbk	20110923.metbk.log	97892 (0.10 mb)	00:00:23
rreflect	20110923.rreflect.log	16905 (0.02 mb)	00:00:01
rsync	20110923.rsync.log	2869 (0.00 mb)	01:54:37
superv	20110923.superv.log	213024 (0.21 mb)	00:00:13

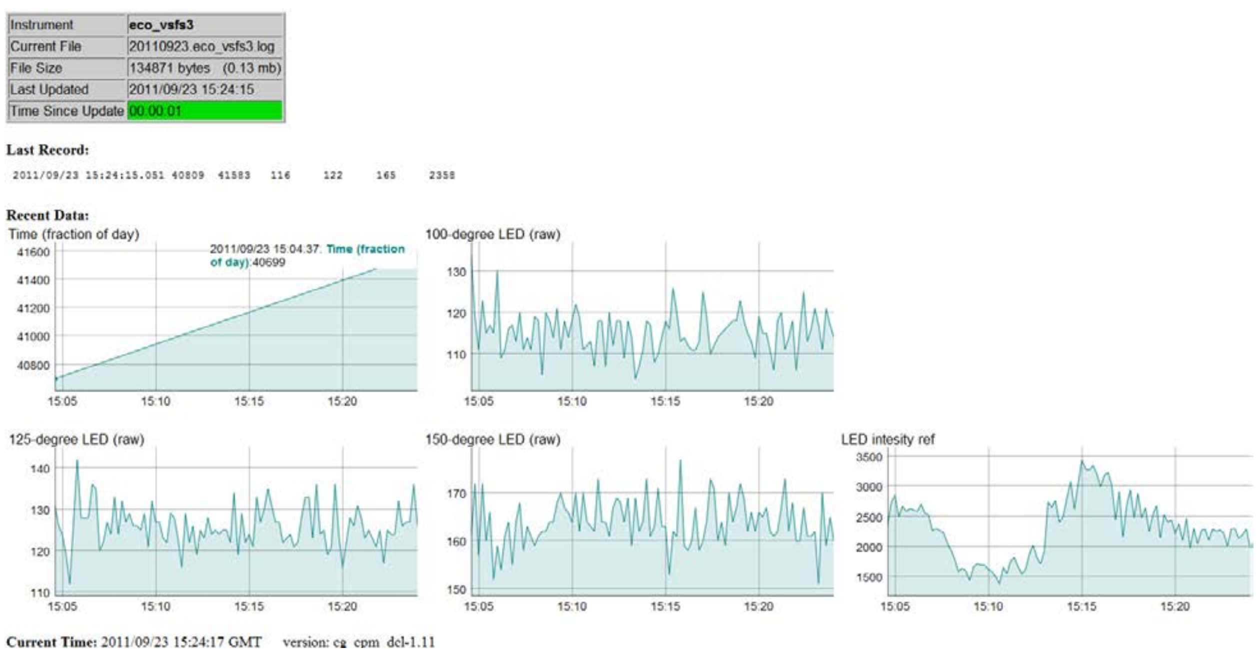
Data Dir Summary			
Inst Name	Current File	File Size (bytes)	Last Modified
aquadopp	20110923.aquadopp.log	4026 (0.00 mb)	00:05:34
eco_dfls1	20110923.eco_dfls1.log	87640 (0.09 mb)	00:29:18
eco_vsfs3	20110923.eco_vsfs3.log	119832 (0.12 mb)	00:29:20
gps	20110923.gps.log	95882 (0.10 mb)	00:00:14
rsync	20110923.rsync.log	2647 (0.00 mb)	01:55:38
sbe16	20110923.sbe16.log	416839 (0.42 mb)	00:00:06
superv	20110923.superv.log	532526 (0.53 mb)	00:00:02

Figure 117: Zoom in on the 'Data Dir Summary' indicating the file size and last modified time of the file. NSIF instruments cells are green indicating the status is good.



Instrument	eco_dfls1
Current File	20110924.eco_dfls1.log
File Size	143734 bytes (0.14 mb)
Last Updated	2011/09/24 22:30:06
Time Since Update	00:21:25

Figure 118: Wetlabs DFLS data indicates a malfunctioning sensor.



Instrument	eco_vsfs3
Current File	20110923.eco_vsfs3.log
File Size	134871 bytes (0.13 mb)
Last Updated	2011/09/23 15:24:15
Time Since Update	00:00:01

Figure 119: VSFS data shortly after deployment.

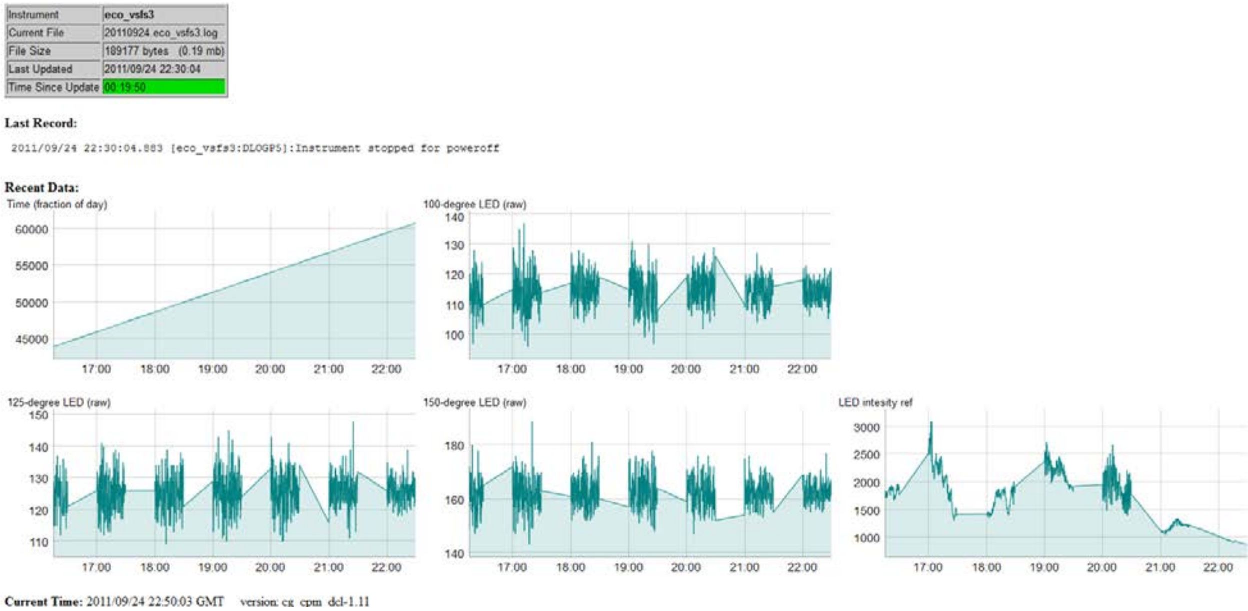


Figure 120: VSFS data after being deployed for a day. Note the 30 minute sampling pattern on the hour.

Figure 121: Aquadopp current data E, N, U in mm/s

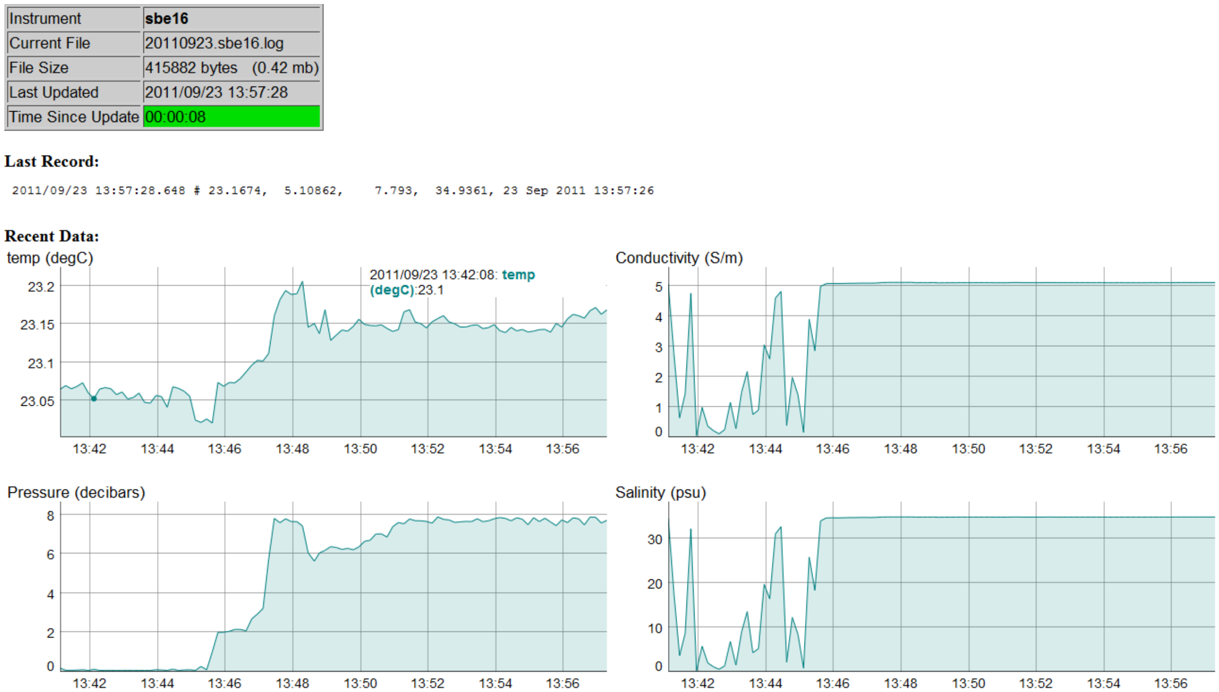


Figure 122: CTD data just prior to and during the deployment.

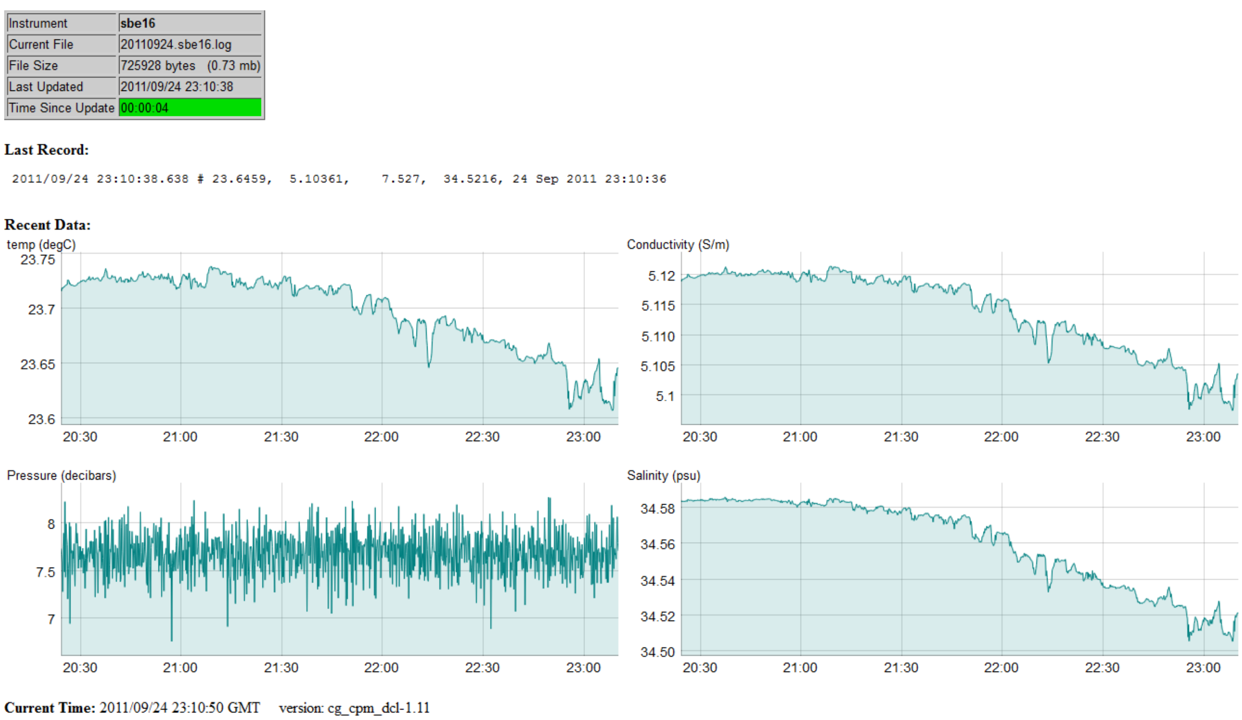


Figure 123: A 4-hour segment of CTD data after deployment.

B. Coastal Pioneer Profiler Mooring

On the morning of 24 Sept. the CPPM was deployed. Midway thru the deployment it was discovered that the STC shutdown magnet had not been removed. Deployment operations were halted until the small boat could be launched so the shutdown magnet on the surface buoy could be removed to enable the system. Fortunately, the most difficult part of this procedure was the successful start of the outboard. After the CPPM was enabled the deployment was completed. Upon deployment of the anchor, the surface buoy submerged briefly as was expected because of the short scope. It was anticipated that the Profiler would commence its first downcast at 2000Z, taking about 30 min to make the cast and another 8 min or so to transfer the data from the instruments to the Profiler controller memory.

Just before 2038Z, the CPPM STC was awakened by the Profiler and requested that the first data be transferred over the inductive link to the STC. The GPS was powered allowing the CE RTC to be resynchronized, motion sensor data was acquired (@10Hz for 5 minutes), the ISU was powered, dial-up connection made and status message and current data was sent to the OMC. Four hours later, the wakeup sequence was repeated and the first upcast data were transferred to the STC. Battery power is conserved by minimizing the time that the CE must be powered and by disabling any of its unused resources such as Ethernet interfaces. This is done by running all STC CE tasks in parallel which keeps the STC duty cycle in this case to about 12.5%.

Figure 124 shows the simpler architecture of the STC compared to the combination of CPM(s) and DCL(s). The tradeoff is 5 sensor channels rather than 8, reduced serial protocol capability, and no Fleet Broadband telemetry. The motivation for the STC design is that some CGSN platforms are essentially an inductive link connection to a wire crawling profiler and 1 or 2 additional instruments on the surface with a similarly intermittent sampling strategy leaving the platcon asleep much of the time. Note the power saving stems mainly from the platcon’s very low duty cycle on the Linux based CE.

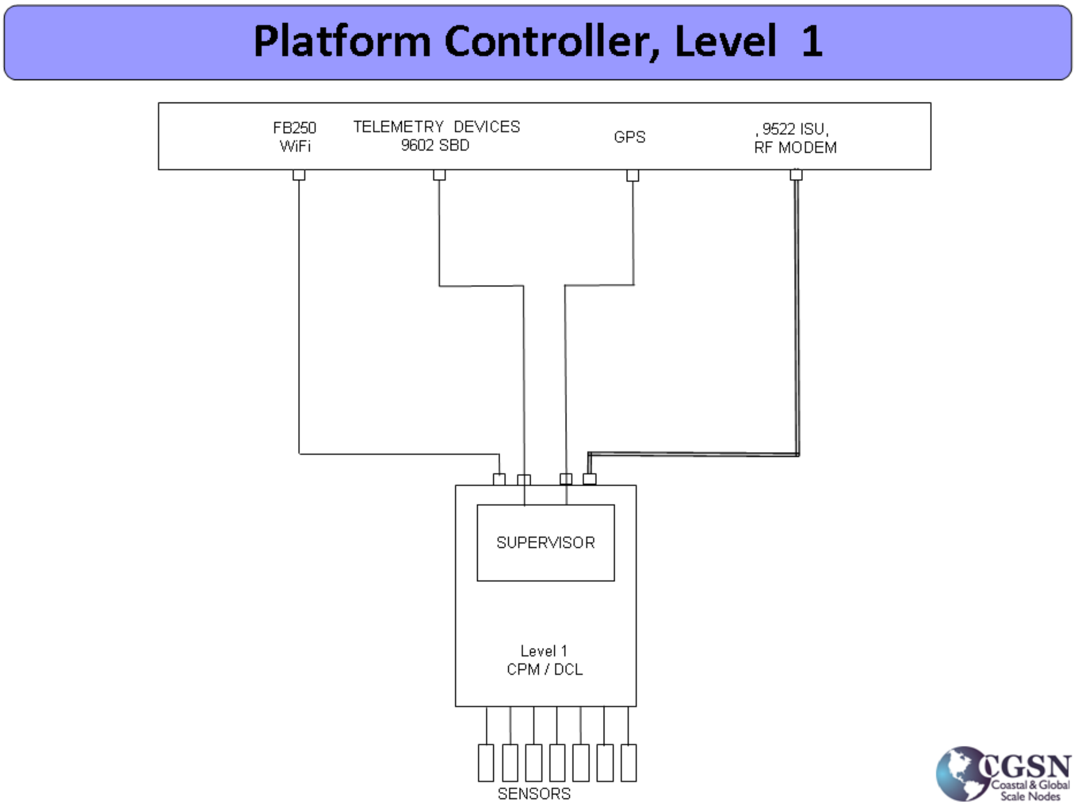


Figure 124: STC based platform controller for CPPM, combines subset of telemetry and data acquisition elements of CPM and DCL combination

The AST2 CPPM mission is configured for 6 one-way profiles per day with IMM data transfers to the STC based platcon every 4 hours starting at 0000Z. At the start of each of these epochs, the Profiler awakens according to its schedule and does a one – way profile over the approximately 450m water column. At .25m/s, it takes about 30min to make this trip. Upon completion of the profile, the data from all the instruments within the profiler, are transferred to the controller and prepared for transmission to the surface using inductive telemetry thru the steel mooring cable with water return.

Figure 125 is a view of the CPPM dashboard from the OMC taken shortly after the CPPM was deployed on 24 Sept.

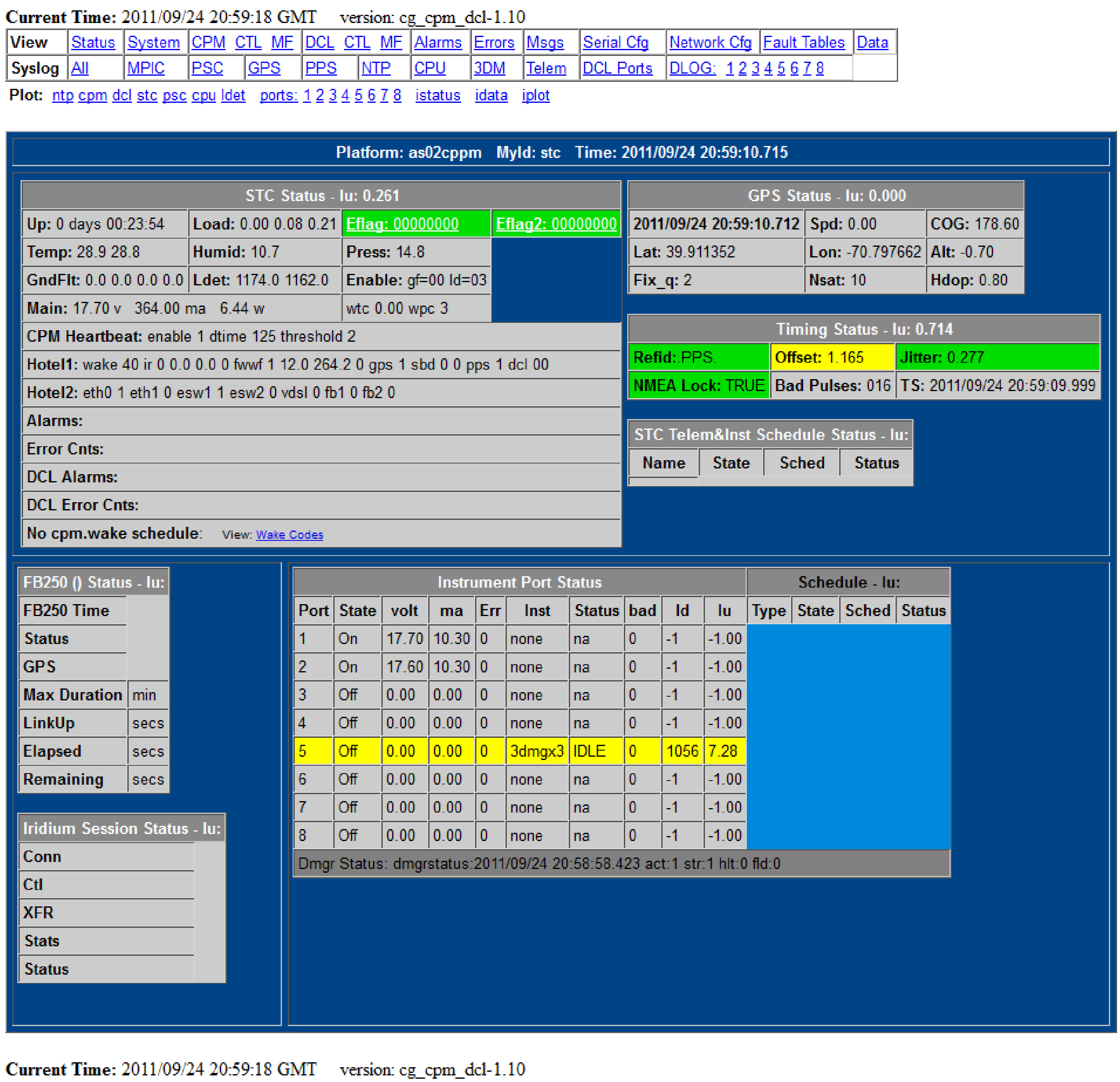


Figure 125: Dashboard display for CPPM, taken from the day of the AST2 deployment.

As with the CPSM dashboard, green coloring is indicative of a properly functioning active process or device. Yellow coloring is indicative of a scheduled inactive, waiting to start process or device and gray represents either inactive facilities or the most recently updated state of a device parameter. Red constitutes and alarm or error condition.

The CPPM dashboard represents the instrument and engineering data similarly to the CPSM however there is less to observe. The STC status and schedule sections are essentially identical to the CPM section of the CPSM as are the GPS timing and instrument port sections. The FB250 status section is not applicable.

Verification of proper operation after the AST2 deployment was based on assessments taken from dashboard information as with the CPSM. We show similar plots to demonstrate what can be observed and what we used to confirm, in the short time allowed, that the CPPM platform appeared to be substantially operational prior to departing the site. The first, Figure 126, is an early series of plots from the Microstrain 3DM-GX3 motion package. While the angular rates are comparable to those from the CPSM, the character of the magnetometer plots is different which initially we assumed was due to the free rotation of the CPPM platform whereas the CPSM has a large effective wind vane to stabilize its rotation response. In addition, it is apparent that the Z-axis of one platform is the opposite of the other, but the characters are similar.

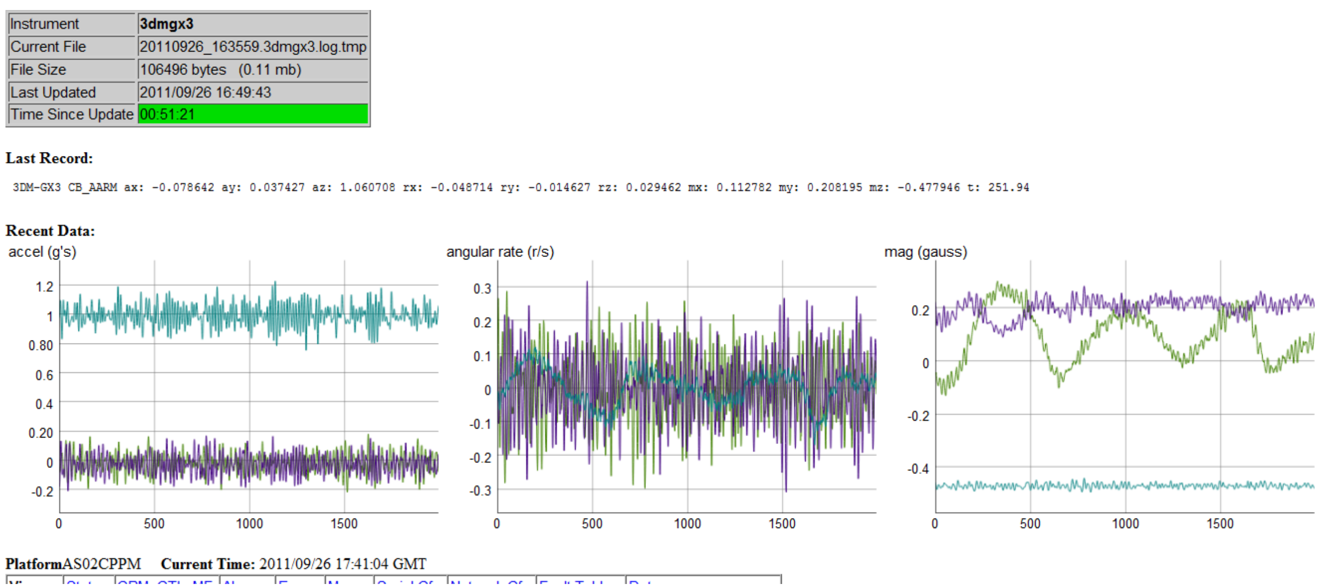


Figure 126: Sample plots form the CPPM motion sensor

The CPPM was equipped with an RTE when it was moved aboard the ship however it was damaged in the process hence it was removed prior to launch. The primary sensor system was the McLane profiler equipped with a CTD, MAVS-4, DO, PAR and CDOM-triplet sensor suite. In addition there was a Seabird µCAT below the lower Profiler stop ~470m. The MAVS data is problematic and it is unclear just what the problem might be.

Shortly after the conclusion of each 4 hourly sampling epoch, the CPPM dashboard page could be viewed using the shipboard satcom link to the OMC. Figure 127, from Sept 26, less than 2 days after deployment, shows an example of the CTD data from a downcast. The essential indication is that the CTD data appeared to be reasonable. Figure 128 is a screen shot of the CDOM, PAR and DO sensors and the motor current and battery voltage data from the same cast. Here again, the data are plausible leading us to contend that the Profiler was functional as well as the CPPM STC and its Iridium telemetry. The lithium battery pack voltage and motor current are what one would expect from previous experience with similarly equipped McLane Profilers. Figure 129 is a set of data plots acquired from the SeaBird µCAT and transmitted over the inductive modem link during the same epoch. All of these plots are raw data.

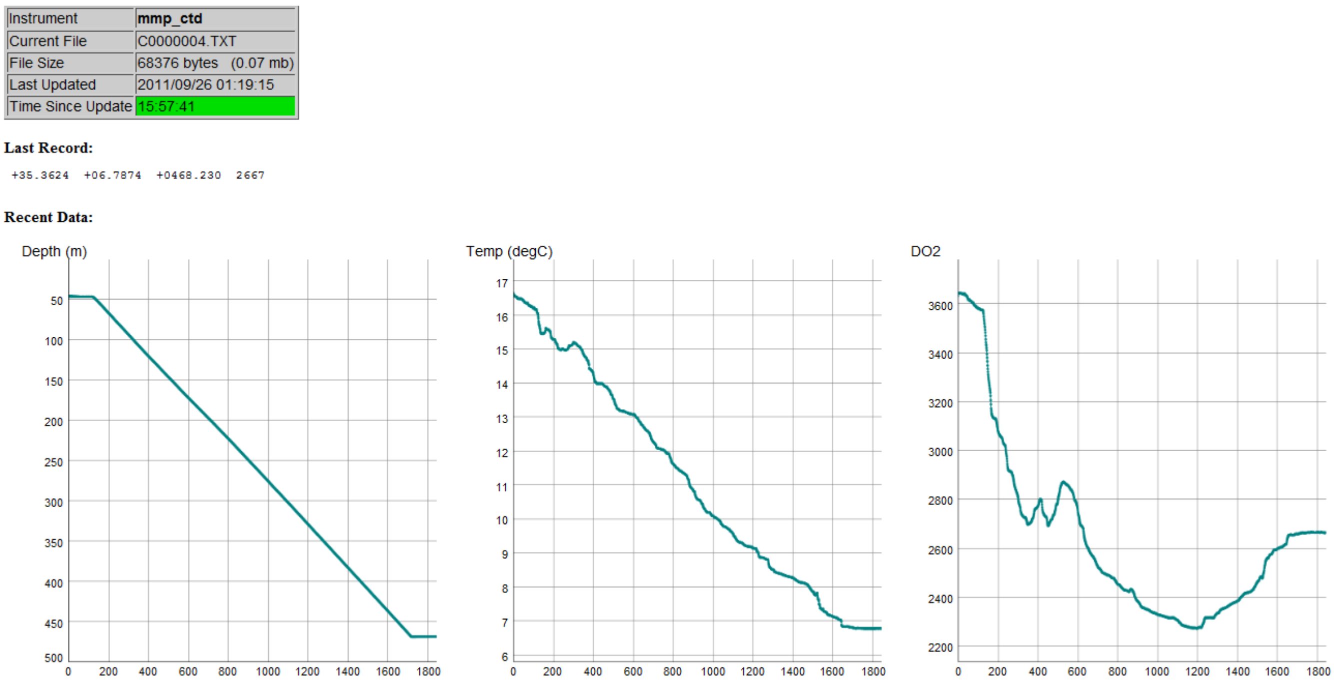


Figure 127: CPPM Profiler CTD data from 09/26/2011 0000Z downcast

Instrument	**mmp_eng**
Current File	E0000004.TXT
File Size	20184 bytes (0.02 mb)
Last Updated	2011/09/26 01:19:36
Time Since Update	00:42:13

Last Record:

```
09 25 2011 08 26 43    191    10.8    467.120        0.00      304      52      82
```

Recent Data:

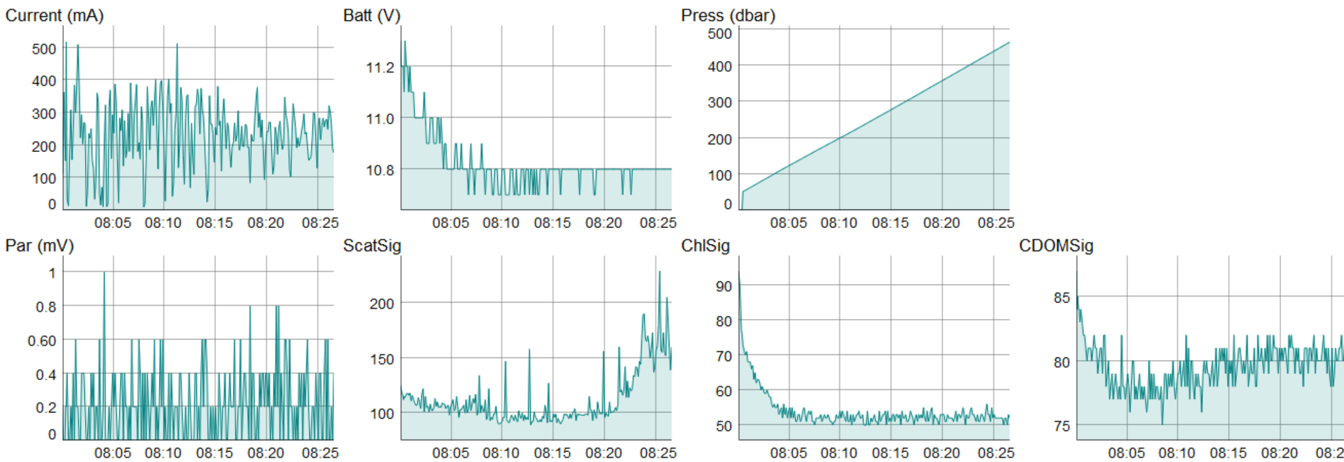


Figure 128: CPPM Profiler CDOM, DO, PAR and Engineering data from 09/26/2011 0000Z downcast

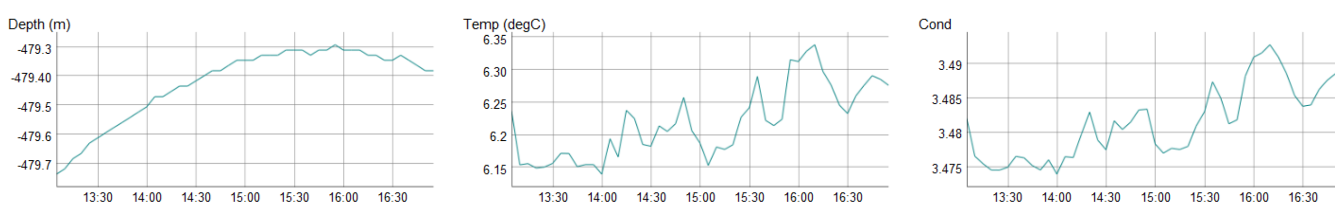
The times shown in the upper left of these figures are the time stamp (GMT) applied to the data files when they are created aboard the platcon.

Instrument	**mcat**
Current File	MC02_20110925_165703.DAT.txt
File Size	2662 bytes (0.00 mb)
Last Updated	2011/09/26 00:24:18
Time Since Update	17:18:38

Last Record:

```
#//End Data
```

Recent Data:



PlatformAS02CPPM **Current Time:** 2011/09/26 17:42:56 GMT

Figure 129: Data example from the SeaBird µCAT CTD at approx. 480m, 09/26/2011

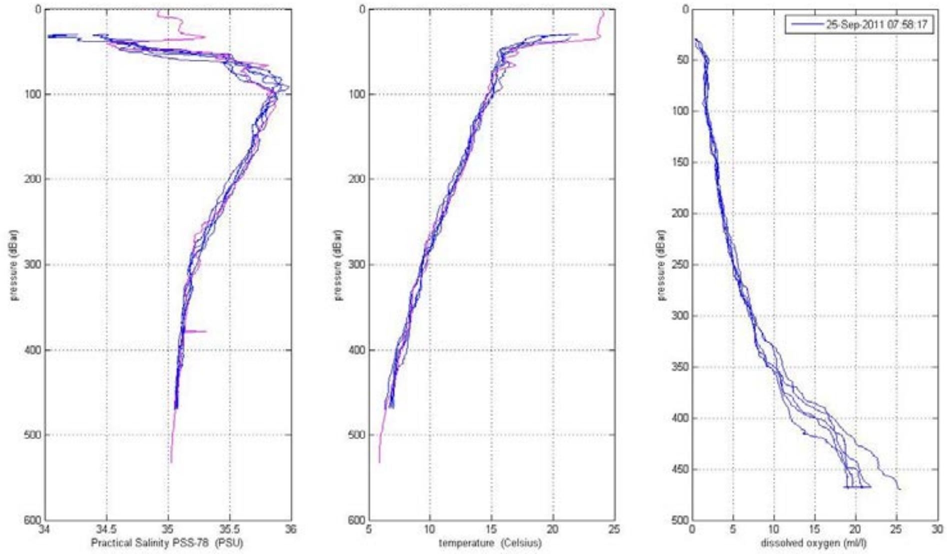


Figure 130: First five profiler profiles of Salinity, Temperature and Dissolved Oxeygen (blue) overplotted with the CTD cast (magenta)

C. Global Hybrid Profiler Mooring

After loading the GHP mooring components and instrumentation onboard the *R/V Oceanus*, the instruments and controllers functionality were tested. A comprehensive data acquisition and communication test with the GSPP, current meter, WFP and SIO controller was conducted as outlined in the AST2 Developmental Test (DT) Plan (Document #3207-00003, TC-001 and TC-002).

During the mooring deployment, inductive communication tests were conducted on all inductive bypass connections. These tests have been proven useful during the AST2 deployment since a bad inductive bypass connection was detected and corrected below the upper acoustic release assembly and above the 64 inch sphere.

At the end of the mooring deployment, acoustic sessions were initiated with an on-vessel acoustic modem to communicate with the GSPP and to initiate a profile. Upon reaching the surface, the GSPP Comm float initiated a Freewave session with another Freewave modem installed on the vessel. After two partially successful Freewave sessions (most of the data were transmitted, but bad transmission conditions prevented the session to be completed), the vessel departed the deployment site for a return to WHOI. The GSPP Comm float continued to communicate through Iridium.

An Acoustic communication to the modem in the lower load cage connected to the SIO controller could not be established. This is an issue which the SIO team has previously experienced on other deep modem deployments. On past deployments, the acoustic link from the vessel could not be established but a glider could retrieve data from the deep modem well while communicating at a depth of a few hundred meters. The limited cruise deployment time did not allow for further investigation of this issue but will be evaluated in detail prior to the next deployment.

The SeaCycler is operating satisfactorily and at the end of the deployment cruise had already completed (8) profiles (2.2 Km total distance) with (29) files transferred to shore. Eleven of these files were collected from the SIO Controller which shows that the Inductive Modem communication link to lower instruments on the mooring is working.

The mooring is in 2,474m of water with the Instrument Float parked at 142m and profiling to a 5m depth. The surfacing depth will be adjusted from shore to bring it closer to the surface once engineering tests are complete. Note that the Communication Float is located 23m above the Instrument Float and therefore it’s not necessary to completely surface the Instrument Float for good communication.

The average power consumption for the completed profiles is 17.2 W-Hrs per round-trip, which is exactly what has been observed at the beginning of previous deployments. The system consistently starts new missions with lower efficiency and then improves with the increased performance of the mechanism float wire management system and the internal lubrication system. Profile Number 6 used 15.1 W-Hrs (compared to the 16.2 W-Hrs/round-trip average) indicating that the system is running well and starting to settle out. These numbers indicate that we should be able to complete 500 to 600 profiles during the deployment depending on water temperatures, wave loading and mooring knock over.

The energy-conserving buoyancy balance between the moving floats is well adjusted to optimize profiler escape from surface waves. In other words, it takes slightly less power to retract the profiler rather than to ascend it towards the surface.

The deployment has also confirmed that the Deployment Brake Extender has dropped out and the new Cable Snuggers are functioning properly. The Mechanism Float (containing the winch) was towed for about 6 hours before the anchor was dropped, so the Snuggers were thoroughly exercised. Wave height during the deployment was about a 1.5m gentle swell.

Thanks and Acknowledgments

Preparation for the AST2 deployment cruise involved many people across the WHOI and SIO CGSN teams and institutions. Facilities, shop, and other support staff provided key help. The officers and crew of *R/V Oceanus* are thanked for their excellent support and participation in the AST2 deployment. The CGSN effort of the OOI is funded by the National Science Foundation through a sub award from the Consortium for Ocean Leadership.

References:

OOI CGSN Documents by number:

1. 3166-10151 PCS Rev 2 Beanchtop Integration with Backplan CMP
2. 3166-30000 AST2 Hybrid Profiler Mooring I&T Plan
3. 3207-00003 At-Sea Test 2 Development Test (DT) Plan
4. 3207-00015 AST2 Instrument Qualification Test Report
5. 3207-00016 AST2 CPPM Wire Following Profiler Test Report, QLR
6. 3207-00022 Coastal Profiler Inductive Loop Riser Integration, QLR
7. 3307-00003 Standard Engineering Details
8. 3309-00050 Power Bench Test Quick Look Report
9. 3309-00051 PSC PV Heat-Sink Temperature Rise
10. 3309-00052 Power System Controller Revision 1 Initial Test
11. 3207-00032 AST2 Cycle Meta-Data.xlsx
12. 3207-00033 PBT Cycle Meta-Data.xls

ASTMD 6990-05
Wind Turbine Electrical Mods

Appendix 1: Cruise Participants

1.	Robert Weller	WHOI	rweller@whoi.edu	Ch. Scientist
2.	John Kemp	WHOI	jkemp@whoi.edu	Exped. leader
3.	Kris Newhall	WHOI	knewhall@whoi.edu	
4.	Jim Ryder	WHOI	jryder@whoi.edu	
5.	John Lund	WHOI	jlund@whoi.edu	
6.	Matt Palanza	WHOI	mpalanza@whoi.edu	
7.	Keith Von Der Heydt	WHOI	kvonderheydt@whoi.edu	
8.	Christian Begler	SIO	cbegler@ucsd.edu	
9.	Gabriela Chavez	SIO	gchavez@ucsd.edu	
10.	Romaine Heux	SIO	rheux@ucsd.edu	
11.	Brian Beanlands	BIO	brian.beanlands@dfo-mpo.gc.ca	
12.	Greg Siddal	BIO	greg.siddall@dfo-mpo.gc.ca	
13.	Walt Waldorf	OSU	waldorf@coas.oregonstate.edu	
14.	Steve Lerner	WHOI	slerner@whoi.edu	

Appendix 2: Mooring log – Coastal Pioneer Surface Mooring

Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. ASTZ MOORED STATION NO. CPSM

Launch (anchor over)

Date (day-mon-yr) 2? SEPT 2011 Time 16:34:30 UTC

Deployed by JOHN KEMP Recorder/Observer JOHN LUND

Ship and Cruise No. RV Oceanus 475 Intended Duration 7 MONTHS ≈ APRIL 2012

Depth Recorder Reading 526.4 m Correction Source MATHEW TABLES

Depth Correction −4 meters m

Corrected Water Depth 522.4 m Magnetic Variation (E/W) ______

Anchor Drop Lat. (N/S) 39°54.500 Lon. (E/W) 070° 47.154

Surveyed Pos. Lat. (N/S) ______ Lon. (E/W) ______

Argos Platform ID No. NA Additional Argos Info on pages 2 and 3

Acoustic Release Model ORE 8242XS Tested to @ WHOI Dock m

Release No. 1 (sn) 34578 Release No. 2 (sn) 34580

Interrogate Freq. 11 Interrogate Freq. 11

Reply Freq. 12 Reply Freq. 12

Enable A 122077 Enable A 122163

Disable 122106 Disable 122201

Release 134241 Release 134313

Recovery (release fired)

Date (day-mon-yr) ______ Time ______ UTC

Latitude (N/S) ______ Longitude (E/W) ______

Recovered by ______ Recorder/Observer ______

Ship and Cruise No. ______ Actual duration ______ days

Distance from waterline to buoy deck 32 cm

1

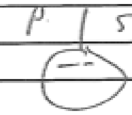
ARRAY NAME AND NO. AS12 **MOORED STATION NO.** CPSM

Surface Components

Buoy Type discus **Color(s) Hull Tower** White, solar panels, wind turbines

Buoy Markings yellow, blue bottom paint; WHOI NSF OOI
If Found Adrift contact WHOI CGSN operations office ....

Surface Instrumentation

Item	ID #	Height*	Comments
PRC	224	78 cm	
HCH	251	87 cm	
SWnd	220	103 cm	
SWR	239	127 cm	
LWR	234	127 cm	
BPR	228	72.5 cm	
Port			
RFM	0001		879-7424
GPS	0001		
SPD	0003		300234010445320
ISU	0001		8816-9248-9556
IMEA			300025010116940
Fleet Broad Band		120 cm	
XEOS	IME1	92 cm	300034012197236
Starboard			
RFM	0003		879-7838
ISU	0003		8816-9248-9557
SPD-IMA	0001	371209003 00001	300234010627270
GPS	0003		1A3010262
WIFI	0001		AS2CPSM
Fleet BB		120 cm	
Xeos	IME1		300034013906090
Wind Turbine		172 cm	

*~~Height above buoy deck~~ in centimeters

* Height above halo
halo to deck = 243 cm

ARRAY NAME AND NO. AST 2 **MOORED STATION NO.** CPSM

Subsurface Instrumentation on Buoy and Bridle

Item	ID #	Depth†	Comments
Xeos Kib			366234010510850
SST	8028	-143 cm	
Biofouling test panels on buoy frame			
Instrument Frame			
Wetlabs	OFLS	SN 069	
Wetlabs	VSFS	SN 050B	
Nortek	Aquadopp	SN P23833-9	
SBE	16plus V2	SN 6841	
Sc			

†Depth below buoy deck in centimeters

3

ARRAY NAME AND NO. AST2 MOORED STATION NO. CPSM

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
1		surface buoy	0		13:47		MET, xmitters 0700z flasher-activated (?) ✓ 9/22
2	5m	3/4" EM			13:47		turbine shock cords (?) ✓
3		Inst Frame			13:32 gmt		remove fluorometer
4	363.7	EOM cable	~13:50 →		14:31		covers (?) ✓ 0703z 9/22
5		HIB			14:31		plug in CTD pump (?) ✓
6	30.48	EM Hose	(067)		14:39		CTD Plugged in @ 12:47z
7		HIB			14:39		Steve Lerner shut down DCL
8	30.48	EM hose	(064)		14:45		Ert → PUMP DRY!
9		HIB			14:45		Steve turned pump on
10	30.48	EM hose	(068)		14:53		w/ crane ~ 15 min dry
11		HIB			14:53		
12	30.48	EM hose	(069)		15:37		
13		BART			15:37		flasher-activated (?) ✓ 0700z 9/22
14							releases #1 34578
15							#2 34580
16							
17							14:40 1.1 knots thru the
18							water
19							@ 15:05 → 1:36 minutes to
20							drop site (drag)
21							
22							13:39 ~ 2 40 min to drop
23							16:05 anchor @ 350 m
24							
25							

4

Appendix 3: Mooring Log – Coastal Pioneer Profiler Mooring

Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. AST2 **MOORED STATION NO.** CPPM

Launch (anchor over)

Date (day-mon-yr) 23 SEPT 2011	Time 16:14 UTC
Deployed by JOHN KEMP	Recorder/Observer JOHN LUND
Ship and Cruise No. R/V Oceanus 475	Intended Duration ~7 MONTHS APRIL 2012
Depth Recorder Reading 526.1 m	Correction Source MATHEW'S TABLES
Depth Correction −4 m	
Corrected Water Depth ______ m	Magnetic Variation (E/W) ______
Anchor Drop Lat. (N/S) 39° 54.570	Lon. (E/W) 70° 47.887
Surveyed Pos. Lat. (N/S) ______	Lon. (E/W) ______
Argos Platform ID No. ______	Additional Argos Info on pages 2 and 3
Acoustic Release Model 8242XS	Tested to 300 m
Release No. 1 (sn) 34815	Release No. 2 (sn) 34817
Interrogate Freq. 11 KHz	Interrogate Freq. 11 KHz
Reply Freq. 12 KHz	Reply Freq. 12 KHz
Enable 163500 (A) 0 (B)	Enable 163607 (A) 0 (B)
Disable 163523	Disable 163624
Release 146255	Release 146307

Recovery (release fired)

Date (day-mon-yr) ______	Time ______ UTC
Latitude (N/S) ______	Longitude (E/W) ______
Recovered by ______	Recorder/Observer ______
Ship and Cruise No. ______	Actual duration ______ days
Distance from waterline to buoy deck ______	

1

ARRAY NAME AND NO. AST2 MOORED STATION NO. CPFM

Surface Components

Buoy Type fsa Color(s) Hull Tower yellow

Buoy Markings yellow top / blue boot

Surface Instrumentation

Item	ID #	Height*	Comments
WIFI	3712-00106		
SBD	3712 00163	SN 0002	300234010062670
RFM	SN 0002	3712-00104-	00001 8879-7597
GPS	SN 0001	3712-00105-	00001 1A 3010266
XEOS			300234010511850
RF Enhancer	SN 0329		
Iridium ISU	SN 0002	IMEI 3000	250 1011 2890
		SIM 89881	6922 4000 687110

*Height above buoy deck in centimeters

2

ARRAY NAME AND NO. AST2 MOORED STATION NO. CPPM

Subsurface Instrumentation on Buoy and Bridle			
Item	**ID #**	**Depth†**	**Comments**
TWR 2050	21589	- 1.8 m	
Just Frame			
SBE 37	37IM 64183	8523	SN 8523
RDI	SN 15481	~480 m	75kHz
64" sphere		~18 m	
TWR 2050	21590	~18 m	
Xeos			300234 0105 29920
MMP	SN ML12714-01		
SBE-52MP	SN 0093		
SBE-43F	SN 0209		
MAVS	SN 10300		MAVS40P0.C
BBFL2	SN 830		
†Depth below buoy deck in centimeters			

3

ARRAY NAME AND NO. ASTZ MOORED STATION NO. CPPM

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
1		buoy	0		09:18		submersible surface buoy
2	15.2	EM stabilizer			09:34		plug in inductive link?
3			17.1 m	TWR 21590			TWR on 64" sphere
4		64" sphere		CG 55B 0002	09:34		flasher ordered 9/22
5	3m	EM chain			09:34		
6		upper bumper	24 m		09:34		
7	451 m	MMP on wire		ML12714-01	14:19		wire following profiler
8		lower bumper	473 m		15:00		
9		ADCP			15:00		
10		SBE 37IM		8523	15:00		Note: MMP dive Ø
11	20m	5/16 wire		11128-4	15:05		would be 20 UTC
12	3m	1/2 chain			15:05		4pm local -
13		4 ball set			15:06		adjust ~~[illegible]~~
14		4 ball set			15:09		
15		4 ball set			15:09		Magnet not removed!
16		4 ball set			15:10		on buoy → buoy in
17		4 ball set			15:10		H_2O ∴ → small boat →
18	3m	1/2 chain			15:19		ground for redeploy
19		5 ton swivel			X		ON TRACK @ 2:03GMT 5.4km
20		dual release		34817 34815	15:23		with line pack 34815
21	3m	1/2 chain			15:26		
22		5200 lb mcm anchor			15:26		
23							MMP profile dive Ø = ~~1900~~
24							18:00
25							

(11128-1 (m157))

4

ARRAY NAME AND NO.________ MOORED STATION NO.________

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
26							
27							
28							
29							
30							
31							
32							
33							
34							
35							
36							
37							
38							
39							
40							
41							
42							
43							
44							
45							
46							
47							
48							
49							
50							

pages 5-7
are blank

5

ARRAY NAME AND NO._________ MOORED STATION NO._________

Date/Time	Comments
15:50	SPHERE UNDER WATER
	SEND RELEASE CODE @ 80M PAST TARGET
	DEPTH @ TARGET

8 09G0135

Appendix 4: Mooring Log – Global Hybrid Profiler Mooring

Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. AST2 MOORED STATION NO. HYPM

Launch (anchor over)

Date (day-mon-yr) 25-09-2011 start — Time 26-09-2011 00:31:10 release UTC

Deployed by Kemp/Begler/Siddall — Recorder/Observer G. Chavez

Ship and Cruise No. Oceanus 475 — Intended Duration April 2012

Depth Recorder Reading 2484 m — Correction Source Matthews Tables

Depth Correction (minus) 16 m

Corrected Water Depth 2468 m — Magnetic Variation (E/W)

Anchor Drop Lat. (N/S) 39° 28.782' — Lon. (E/W) 70° 48.840

Surveyed Pos. Lat. (N/S) — Lon. (E/W)

Argos Platform ID No. — Additional Argos Info on pages 2 and 3

Acoustic Release Model ORE 8242XS — Tested to 480 m

Release No. 1 (sn) 34637 (at 269 m.) — Release No. 2 (sn) 34635 / 34636 (pair at bottom)

Interrogate Freq. 11 kHz — Interrogate Freq. 11 kHz / 11 kHz

Reply Freq. 12 kHz — Reply Freq. 12 kHz / 12 kHz

Enable 140126 — Enable 140032 / 140074

Disable 140143 — Disable 140057 / 140105

Release 135675 — Release 135633 / 135656

Recovery (release fired)

Date (day-mon-yr) — Time UTC

Latitude (N/S) — Longitude (E/W)

Recovered by — Recorder/Observer

Ship and Cruise No. — Actual duration days

Distance from waterline to buoy deck

1

ARRAY NAME AND NO. AST2 **MOORED STATION NO.** HYPM

39°23.336'N 70°56.298'W 7.8nm to site

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
							All BEACONS ACTIVE. ✓
1		COMM-FLOAT			18:57		23m. cable to the inst. float
2		INSTRUMENT FLOAT			19:00		27m. to the winch
3		WINCH FLOAT			18:37		47.8m of 3/16" wire
4		Aquadopp DH-6239		6239	(19:43)		@ bottom of yellow wire
5		EM Swivel 15t			(19:45)		Pulled back in at 19:55 due to —
6		Coupler			(19:45)		ind. comm. was tested down @ the chain at 19:59 and it works.
7		(1) acoustic release #34037		34037	(19:45)		There was some issue with the ... Christian solved it. Back in the water @ 20:05
8		Coupler			(19:45)		inductive comm worked 19:15
9		CF19-1000			(19:45)		
10	10	5/16" wire ind. term.		#11174-1			
11		61" float with load cage and instruments			20:28		Beacon @ 156.875 MHz
12	5	EM chain			20:19 (end of chain)		ind comm. does not work 19:52; 19:59 works after bringing back hypm & fixing it. Bypass in the water @ 20:04 and ind comm. still works.
13	2000	5/16" wire ind. term. #11156-2		#11156-2	23:02		Finished spooling out & stopped for stopper & load cage.
14	on wire:	wire profiler stopper					About 2 m. below the EM chain.
15	on wire:	wire profiler w. instruments			20:49		Fluoro cap removed – all plugged. Placed after ~800m of wire were spooled out
16	on wire:	wire profiler stopper			23:30		immediately above the load cage
17		Load cage w lower stop around			23:30		23:19 ind. comm. test worked.
18		Shackle-Ring-Shackle	(S-R-S) ✓				END LINK
19		Load cell 10692-3 #001	✓	10692-3 #001	23:30		
20		S-R-S	✓				
21	50	5/16" wire #11122-8		#11122-8	23:30–23:34		
22		Parachute			23:35		
23		S-R-S	✓				
24	20	5/16" wire		#11122-10	23:37		
25		Parachute			23:38		

4

ARRAY NAME AND NO. ASI2 MOORED STATION NO. HYPM

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
26		S-R-S	✓				
27	20	5/16" wire		#11122-11	23:39		
28		Parachute			23:43		
29		S-R-S	✓				
30	5	Chain			23:48		
31		S-R-S	✓				Some S-R-S at first
32		4 glassballs	✓		23:48		went with nuts
33		S-R-S	✓				just finger-tight
34		4 glassballs	✓		23:48		until it was noticed
35		S-R-S	✓				and all were tightened
36		4 glassballs	✓		23:52		with a wrench after
37		S-R-S	✓				that.
38		4 glassballs	✓		23:52		
39		S-R-S	✓				
40		4 glassballs	✓		23:53		
41		S-R-S	✓				
42		4 glassballs	✓		23:57		
43		S-R-S	✓				
44		4 glassballs	✓		23:57		
45		S-R-S	✓				
46		4 glassballs	✓		23:57		
47		S-R-S	✓				
48		4 glassballs			00:00		
49		S-R-S	✓				
50		4 glassballs			00:01		

(pages 2-3 are blank)

5

ARRAY NAME AND NO. ASI2 **MOORED STATION NO.** HYPM

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
51		S-R-S	✓				
52	5	chain	✓		00:11		
53		S-R-S	✓				
54		Swivel 5/8	✓		00:11		
55		S-R-S	✓				
56		Acoustic release pair #34635 and #34636			00:11		
57	1	1/2" dropchain	✓				
58		Master Link	✓				
59		S-R-S	✓				END LINK
60	20	Nystron 1"					1 hr. to go till deployment site.
61		S-R-S	✓				END LINK
62	5	Chain	✓				
63		shackle	✓				
64		Parachute					no parachute, lowering with
65		double NACE anchor	✓				~~[illegible]~~ trawl lift winch.
66							to about 34 m. and
67							dropped (released)
68							
69							
70							
71							
72							
73							
74							
75							

6

Appendix 5: BULK Met Calibration Documents

BPR

Output of fitbpr.m (2/03/2005) 2011-02-01 14:59:19
Least squares linear fit

S/N BPR228 CAL: 2011-02-01 PIN: DHI PPC2+ S/N358
Sensor S/N: DXD006291 Sensor cal: 00-00-0000

INPUT DATA: Means and SDs of 10 points per nominal BPin

BPin Mean	SD	PIMET Mean	SD	Diff
980.00	0.01	980.50	0.00	0.50
989.99	0.01	990.49	0.03	0.49
1000.00	0.00	1000.44	0.02	0.44
1010.00	0.00	1010.49	0.02	0.49
1020.00	0.00	1020.42	0.00	0.42
1030.00	0.01	1030.42	0.00	0.42
1040.00	0.01	1040.35	0.00	0.35
1030.00	0.01	1030.42	0.00	0.42
1020.00	0.01	1020.42	0.00	0.42
1010.00	0.01	1010.43	0.00	0.43
1000.00	0.01	1000.36	0.00	0.36
990.00	0.00	990.43	0.00	0.43
980.00	0.00	980.43	0.00	0.43

FIT STATISTICS

BP = -1.658 + 1.00122 * PIMET kPa

DXD constants: -0.024 1.00122

Pdhi	Pimet	PCALC	P-PC
980.00	980.50	980.04	0.04
989.99	990.49	990.03	0.04
1000.00	1000.44	1000.00	-0.00
1010.00	1010.49	1010.06	0.06
1020.00	1020.42	1020.00	0.00
1030.00	1030.42	1030.02	0.02
1040.00	1040.35	1039.96	-0.04
1030.00	1030.42	1030.02	0.02
1020.00	1020.42	1020.00	0.00
1010.00	1010.43	1010.00	0.00
1000.00	1000.36	999.92	-0.08
990.00	990.43	989.98	-0.02
980.00	980.43	979.97	-0.04

BPSD = 0.04
Number of data points = 13

Calibration history

Date	A	B
2011-02-01	-1.658	1.00122

HRH

Output of fithrh.m 2011-04-26 15:59:21
Least squares linear fit

HRH251 CAL: 2011-04-21
RH S/N: R33690 RHIN: Thunder Scientific chamber

INPUT DATA: Means and SDs of 10 points per nominal Vin

RHIN MEAN	STD	N MEAN	STD	MOD RH	MOD-IN
20.00	0.00	35383.6	1.1	20.99	0.99
25.00	0.00	36039.4	1.1	26.11	1.11
30.00	0.01	36677.4	2.5	31.09	1.08
34.98	0.00	37300.0	2.5	35.94	0.96
40.00	0.01	38008.8	1.9	41.47	1.47
45.01	0.01	38688.4	2.3	46.77	1.76
50.00	0.01	39352.4	0.9	51.95	1.94
55.00	0.00	40009.8	1.6	57.08	2.08
60.01	0.00	40662.8	1.6	62.17	2.16
65.01	0.00	41316.4	0.9	67.27	2.26
70.00	0.00	41970.8	1.5	72.37	2.37
74.99	0.01	42626.6	2.3	77.49	2.50
80.01	0.01	43294.4	1.7	82.70	2.69
85.00	0.01	43957.2	2.2	87.87	2.86
90.02	0.00	44637.6	2.3	93.17	3.15
95.03	0.01	45332.2	2.4	98.59	3.56

FIT STATISTICS

RH = -247.06 + 0.0075521 * N

RH = -255.76 + 0.0079860 * N + -5.37903e-009 * N^2

RH = -174.60 + 0.0019110 * N + 1.45667e-007 * N^2 + -1.24754e-012 * N^3

RH	N	RHlin	RH-RHC	RH2nd	RH-RHC	RH3rd	RH-RHC
20.00	35383.6	20.16	-0.16	20.08	-0.08	20.13	-0.13
25.00	36039.4	25.11	-0.11	25.06	-0.06	25.07	-0.07
30.00	36677.4	29.93	0.07	29.91	0.09	29.89	0.11
34.98	37300.0	34.63	0.35	34.63	0.35	34.60	0.38

40.00	38008.8	39.98	0.01	40.01	-0.01	39.97	0.02
45.01	38688.4	45.12	-0.11	45.15	-0.15	45.12	-0.12
50.00	39352.4	50.13	-0.13	50.18	-0.17	50.16	-0.15
55.00	40009.8	55.10	-0.10	55.15	-0.15	55.14	-0.14
60.01	40662.8	60.03	-0.02	60.08	-0.07	60.08	-0.07
65.01	41316.4	64.96	0.05	65.01	0.00	65.03	-0.02
70.00	41970.8	69.91	0.09	69.94	0.06	69.97	0.03
74.99	42626.6	74.86	0.13	74.88	0.11	74.91	0.08
80.01	43294.4	79.90	0.11	79.90	0.11	79.93	0.08
85.00	43957.2	84.91	0.10	84.89	0.12	84.90	0.10
90.02	44637.6	90.05	-0.03	90.00	0.02	89.99	0.03
95.03	45332.2	95.29	-0.26	95.21	-0.18	95.16	-0.13

RHSTD = 0.15 0.14 0.14
Number of data points = 16

DATE/N	36813	38097	39381	40665	41949	43233	44517	45800
2011-04-21	30.94	40.67	50.39	60.09	69.78	79.44	89.09	98.71

HRH-Temp

Output of fithrht.m 2011-03-10 16:34
Least squares linear fit

HRH251 CAL: 2011-03-10
Rotronic S/N: R53369 AT std: SBE35

INPUT DATA: Means and SDs of 10 points per nominal Vin

ATIN	STD	N	STD	ATMOD	DIFF
0.10	0.00	38060.0	0.7	0.45	0.35
5.01	0.00	38702.0	0.7	5.26	0.25
10.01	0.00	39366.0	1.2	10.24	0.23
15.00	0.00	40027.8	1.3	15.21	0.21
20.00	0.00	40692.4	0.5	20.19	0.19
25.00	0.00	41359.8	1.3	25.20	0.20
30.01	0.00	42029.6	0.9	30.22	0.21
35.01	0.00	42700.4	0.9	35.25	0.24

FIT STATISTICS

AT = -286.02 + 0.0075194 * N

AT	N	ATCALC	AT-ATC
0.10	38060.0	0.17	-0.07
5.01	38702.0	5.00	0.01
10.01	39366.0	9.99	0.02
15.00	40027.8	14.97	0.03
20.00	40692.4	19.96	0.04

25.00	41359.8	24.98	0.02
30.01	42029.6	30.02	-0.01
35.01	42700.4	35.06	-0.05

ATSTD = 0.04
Number of data points = 8

DATE/N	38630	39285	39900	40600	41260	41920	42600
2011-03-10	4.45	9.38	14.00	19.27	24.23	29.19	34.31

PRC

OUTPUT OF FITPRC.FOR (10/8/99) 15:48:40 EST 01/28/0111
LEAST SQUARES LINEAR FIT

PRC S/N: PRC224 CAL: 01-28-2011 RMY S/N: 1793

INPUT DATA

WL(mm)	N	STD
.0	32878.0	.9
5.0	34098.0	.3
15.0	36513.3	.2
25.0	39008.8	.4
35.0	41547.5	.2
45.0	44164.0	.3
50.0	45467.7	1.0
.0	32867.0	.6
10.0	35344.6	.4
20.0	37755.6	.1
30.0	40286.4	.2
40.0	42876.6	.1
50.0	45471.9	.0
.0	32862.1	1.0

FIT STATISTICS

WL = -130.4 + .39755E-02 * N

WL(mm)	N	WLCALC	WL-WLC(mm)
.0	32878.0	.3	-.26
5.0	34098.0	5.1	-.11
15.0	36513.3	14.7	.29
25.0	39008.8	24.6	.37
35.0	41547.5	34.7	.28
45.0	44164.0	45.1	-.12
50.0	45467.7	50.3	-.31
.0	32867.0	.2	-.21
10.0	35344.6	10.1	-.06
20.0	37755.6	19.6	.35
30.0	40286.4	29.7	.29

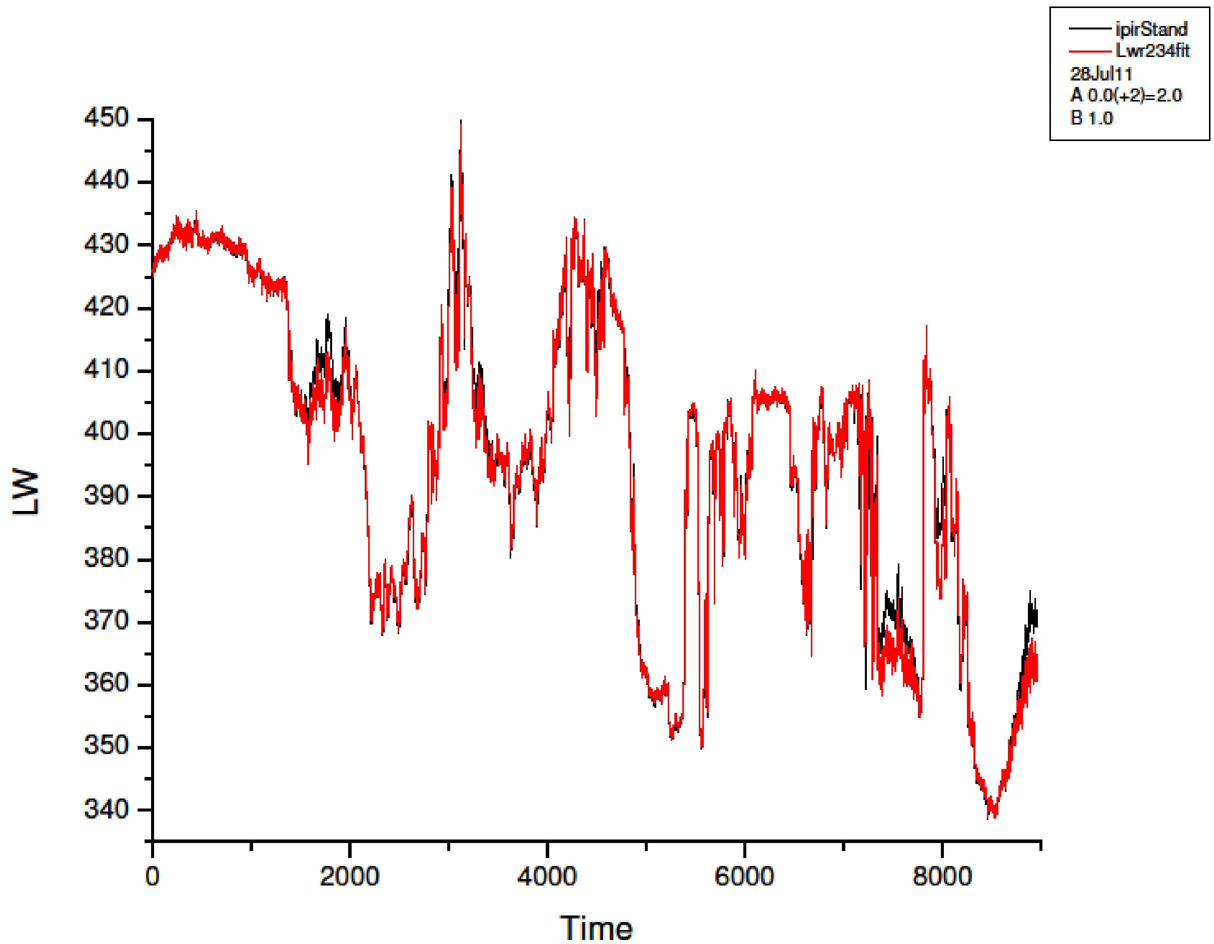
40.0	42876.6	40.0	-.01
50.0	45471.9	50.3	-.32
.0	32862.1	.2	-.19

WLMSTD = .25 (mm)
Number of data points = 14

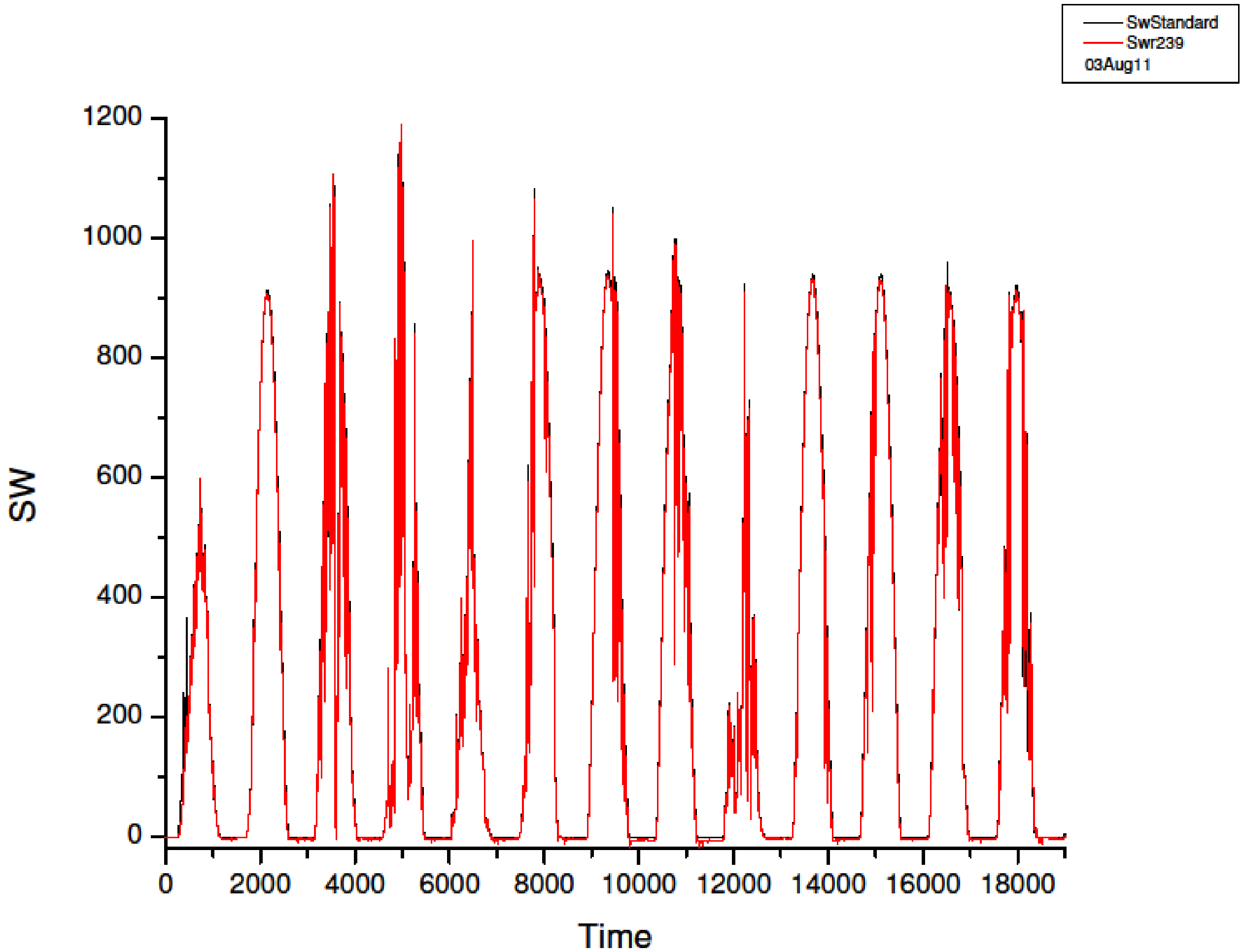
Standard outputs using cal equation

Date/WL	32935.	35500.	38005.	40480.	42980.	45400.
01-28-2011	.48	10.68	20.64	30.48	40.42	50.04

LWR



SWR


SwStandard
Swr239
03Aug11
1200
1000
800
600
400
200
0
SW
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
Time

Appendix 6: MMP Deployment parameters

```
DEPLOYMENT PARAMETERS
_____________________

Serial Number          ML12714-01
Mooring ID             001

Scheduled start              09/24/2011 18:00:00
Profile start interval 000 04:00:00 [DDD HH:MM:SS]
Reference date/time          09/24/2011 00:00:00
Burst interval         010 00:00:00 [DDD HH:MM:SS]
Profiles per burst             Disabled
Paired profiles                Disabled
Profiles / file set                   1
Shallow pressure                   31.0 [dbar]
Deep pressure                     467.0 [dbar]
Shallow error                      40.0 [dbar]
Deep error                         40.0 [dbar]
Profile time limit             00:51:20 [HH:MM:SS]
Stop check interval                   4 [sec]
Transmission duration                15 [min]


SYSTEM CONFIGURATION
____________________

Nominal Battery Life       240 Ah
Inductive Telemetry        ENABLED
Acoustic Transponder       disabled
Inductive Charger Modem    disabled
FSI EM          CTD        disabled
SeaBird 41CP    CTD        disabled
SeaBird 52MP    CTD        ENABLED
RBR Logger      CTD        disabled
FSI 2D          ACM        disabled
Nobska MAVS3    ACM        ENABLED
Teledyne RDI    DVS        disabled
NortekAquaDopp DVS         disabled
SeaPoint       Fluorometer  disabled
               AutoGain     YES
               Current Gain n/a
               Sample/avg = 5
Wetlabs        Fluorometer  disabled
               Sample/avg =    5
SeaPoint       Turbidity    disabled
               AutoGain     YES
               Current Gain n/a
               Sample/avg = 5
Aanderaa       Optode       disabled
Wetlabs        BBFL2        ENABLED
```

```
SatlanticSUNA Nitrate      disabled
        Frames/Stopcheck = 2
BioSuite      Triplet/PAR  disabled
Wetlabs       FLNTU        disabled
Biospherical  Par          ENABLED
              Sample/avg = 5
File Deletion              disabled with profiles stored = 60
```

INTERNAL PARAMETERS

```
FullSpeed                     0.250 [dbar/sec]
PR_Threshold                  0.045 [dbar/sec]
PR_TimeThreshold              180 [sec]
sensor_warmup                 120 [sec]
sensor_warmdown               120 [sec]
PR_Threshold for Charger      0.045 [dbar/sec]
PR_TimeThreshold for Charger  30 [sec]
InfiniteDeployment            ENABLED
```

```
Firmware version          431
Countdown delay           00:00:30 [HH:MM:SS]
Deployment delay          00:00:30
Profile zero start        18:00:00
Profiles Commanded        1000
Acoustic telemetry        0
Telemetry depth           500.000
Telemetry duration        00:15:00
Files per file set        3
Fluorometer range         500.000
```

Appendix 7: Long Ranger ADCP configuration file

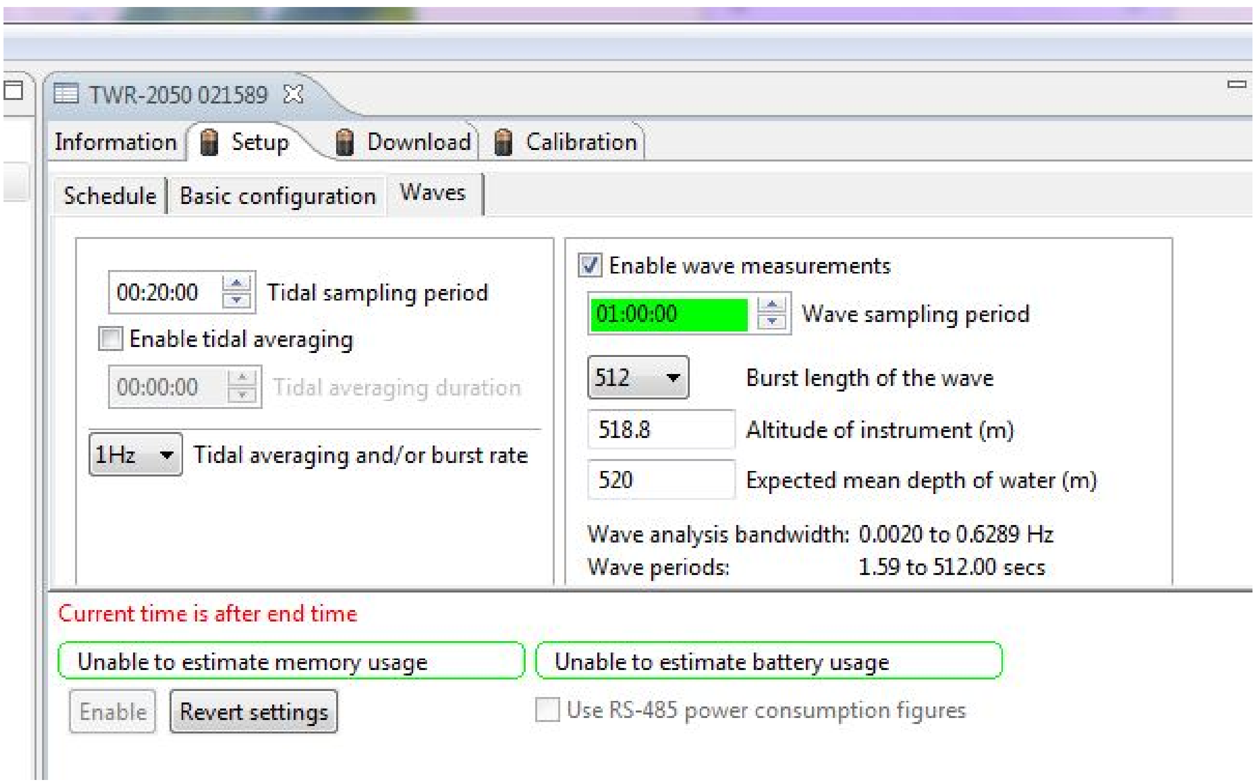
```
   ;PlanADCP output for AST2 LongRanger ADCP. Assumes 4 alkaline
packs.
   ;ADCP uplooking from 475 m per 3607-00007 mooring design.
   ;
   CR1
   CQ255
   CF11101
   EA0
   EB0
   ED0
   ES35
   EX11111
   EZ1111101
   WA50
   WB1
   WD111100000
   WF704
   WN62
   WP70
   WS800
   WV175
   TE01:00:00.00
   TP00:02.50
   CK
   CS
   ;
   ;Instrument          = Workhorse Long Ranger
   ;Frequency           = 76800
   ;Water Profile       = YES
   ;Bottom Track        = NO
   ;High Res. Modes     = NO
   ;High Rate Pinging   = NO
   ;Shallow Bottom Mode= NO
   ;Wave Gauge          = NO
   ;Lowered ADCP        = NO
   ;Ice Track           = NO
   ;Surface Track       = NO
   ;Beam angle          = 20
   ;Temperature         = 10.00
   ;Deployment hours    = 5040.00
   ;Battery packs       = 4
   ;Automatic TP        = NO
   ;Memory size [MB]    = 256
   ;Saved Screen        = 2
   ;
   ;Consequences generated by PlanADCP version 2.05:
   ;First cell range    = 16.62 m
```

```
;Last cell range    = 504.62 m
;Max range          = 515.66 m
;Standard deviation = 1.75 cm/s
;Ensemble size      = 1394 bytes
;Storage required   = 6.70 MB (7025760 bytes)
;Power usage        = 1705.08 Wh
;Battery usage      = 3.8
;
; WARNINGS AND CAUTIONS:
; Advanced settings have been changed.
```

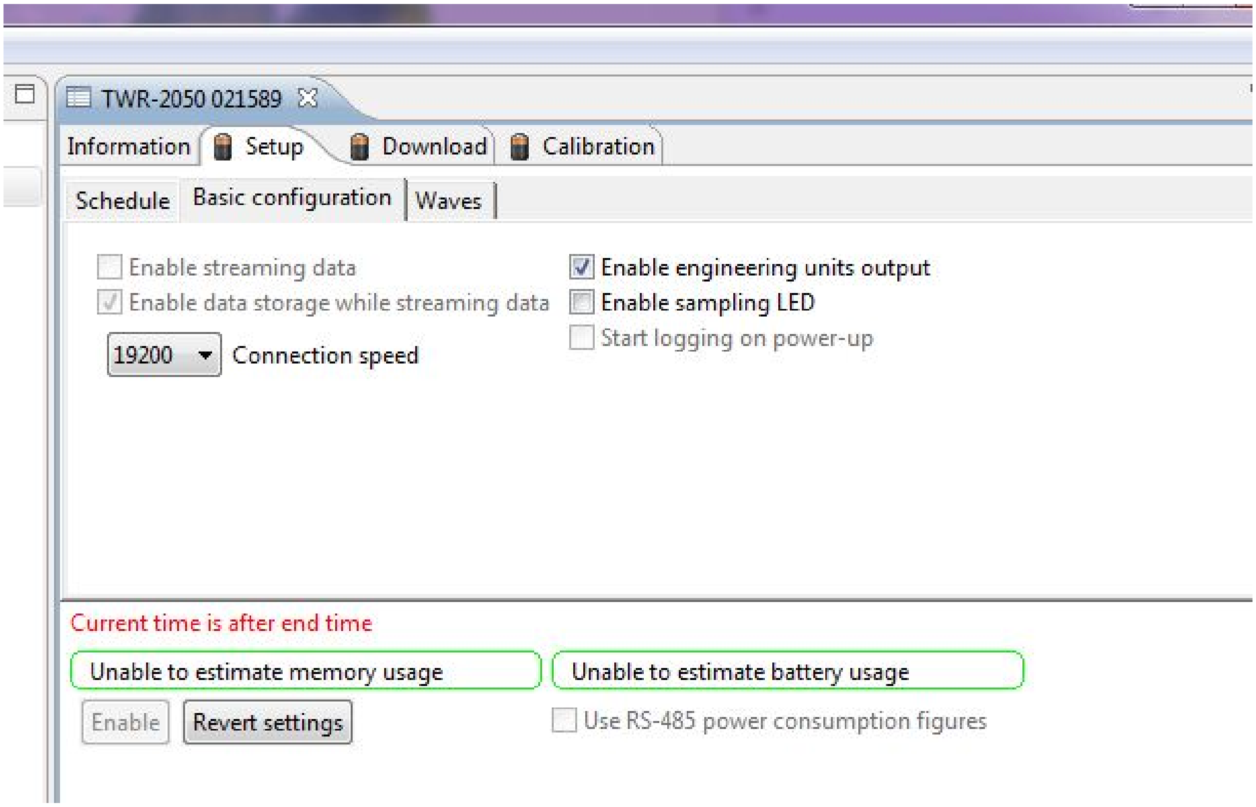
Appendix 8: RBR TWR 2050 Configuration for deployment

These are Kathleen McMonagle's notes.

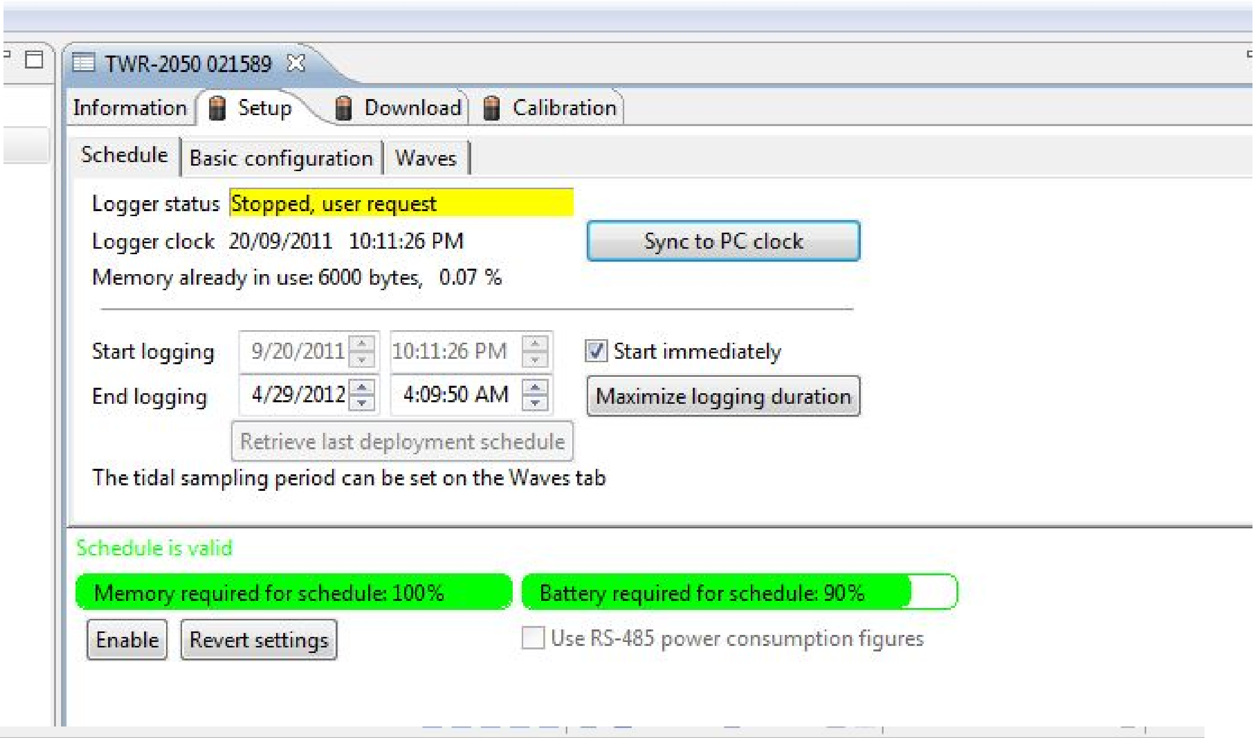
Serial No. 21589
Deployment Location – AS02CPPM Surface buoy ~4 ft (1.2 m) from the water line.
Mean water depth: 520 m
Altitude (height of instrument above the benthos): 518.8 m
Battery Voltage: 5.983 VDC
Calibration values checked against vendor provided cal sheets.

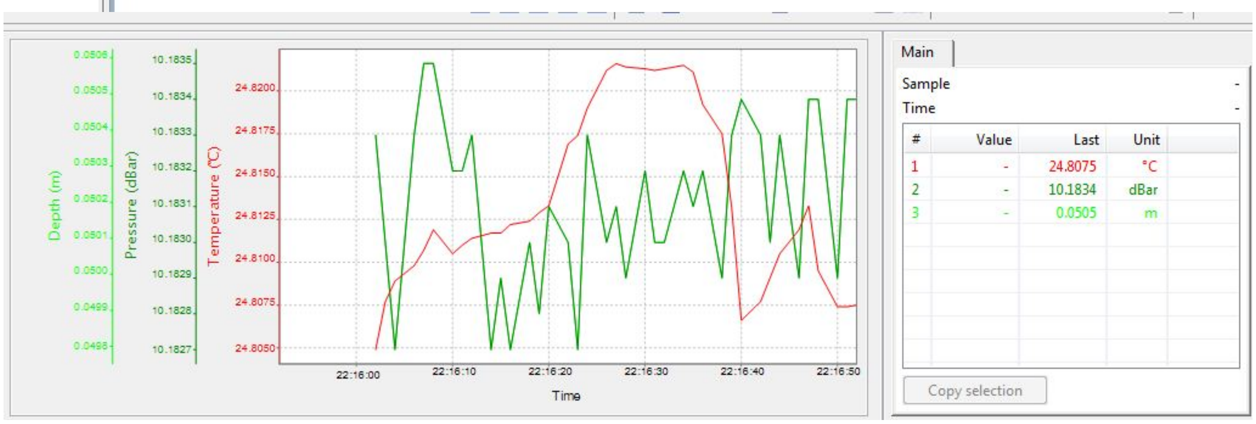


Waves configuration.

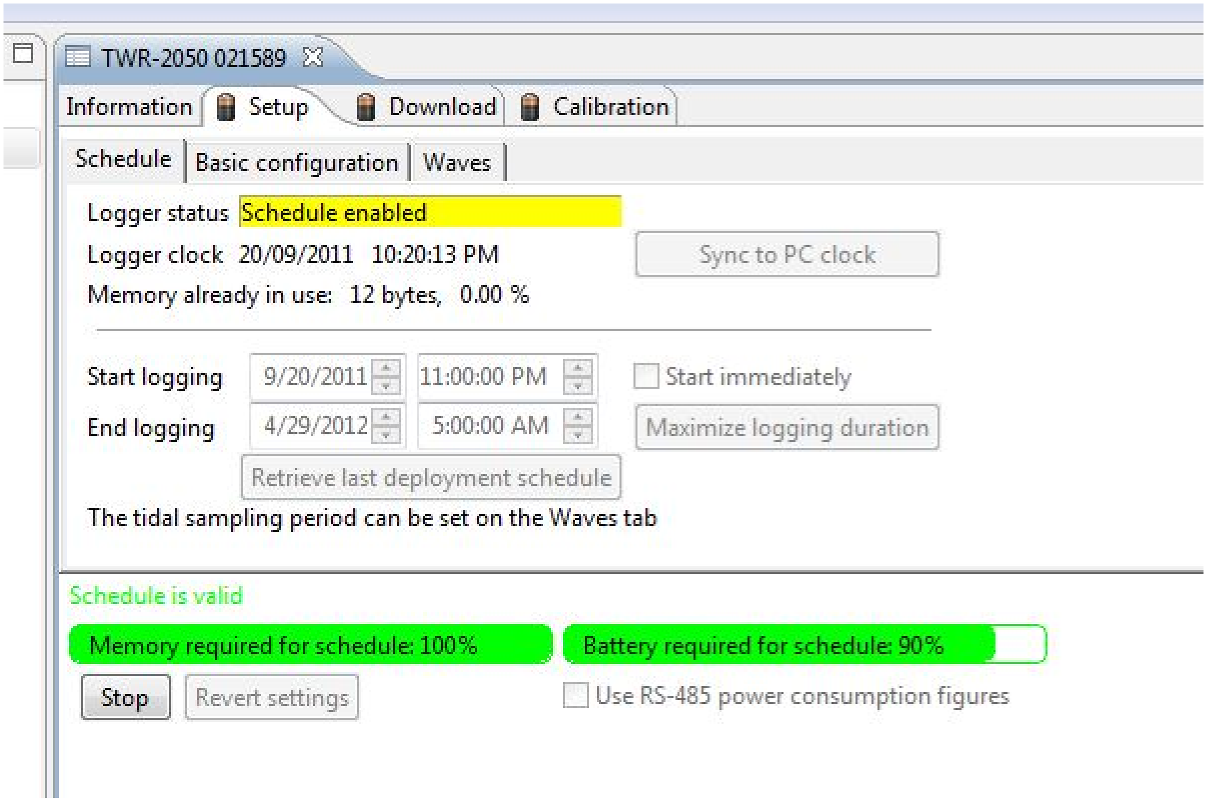


Enable engineering units.


TWR-2050 021589
Information
Setup
Download
Calibration
Schedule
Basic configuration
Waves
Logger status
Stopped, user request
Logger clock 20/09/2011 10:11:26 PM
Sync to PC clock
Memory already in use: 6000 bytes, 0.07 %
Start logging
9/20/2011
10:11:26 PM
Start immediately
End logging
4/29/2012
4:09:50 AM
Maximize logging duration
Retrieve last deployment schedule
The tidal sampling period can be set on the Waves tab
Schedule is valid
Memory required for schedule: 100%
Battery required for schedule: 90%
Enable
Revert settings
Use RS-485 power consumption figures

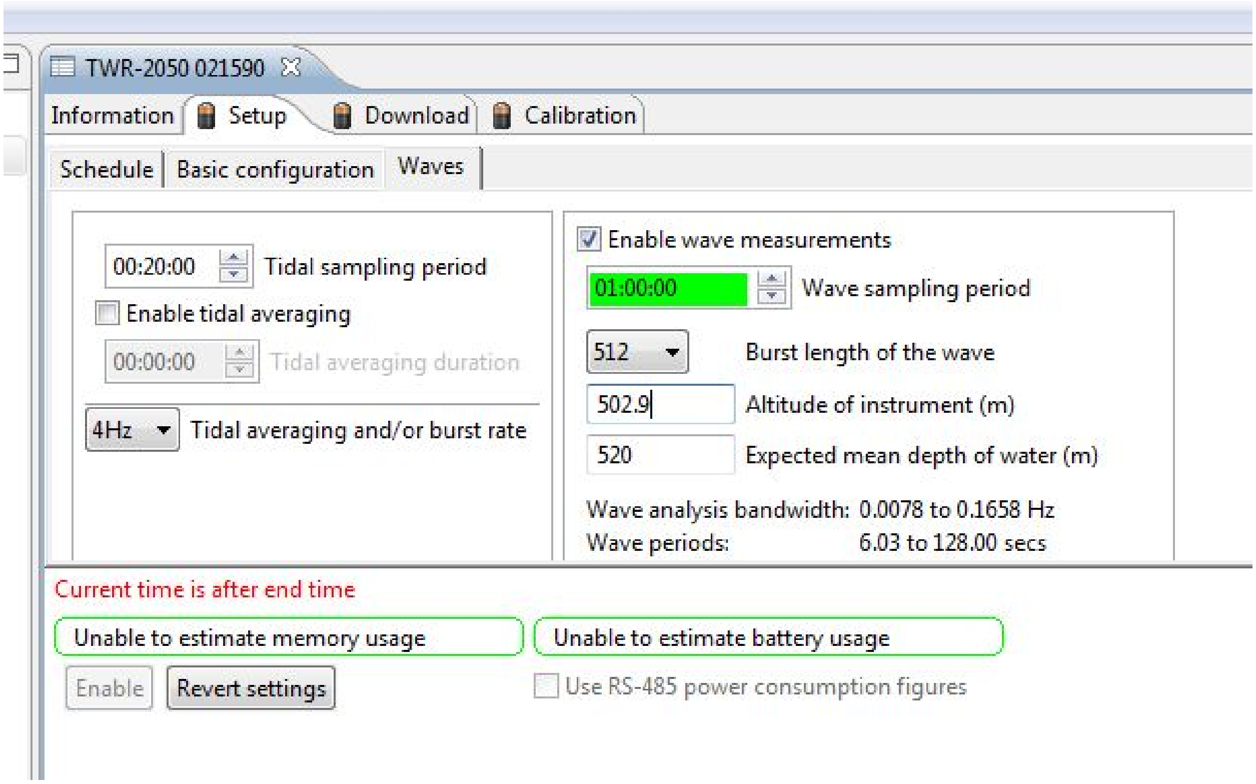

Depth (m)
Pressure (dBar)
Temperature (C)
Time
Main
Sample
Time
#
Value
Last
Unit
1
24.8075
°C
2
10.1834
dBar
3
0.0505
m
Copy selection

Data check.

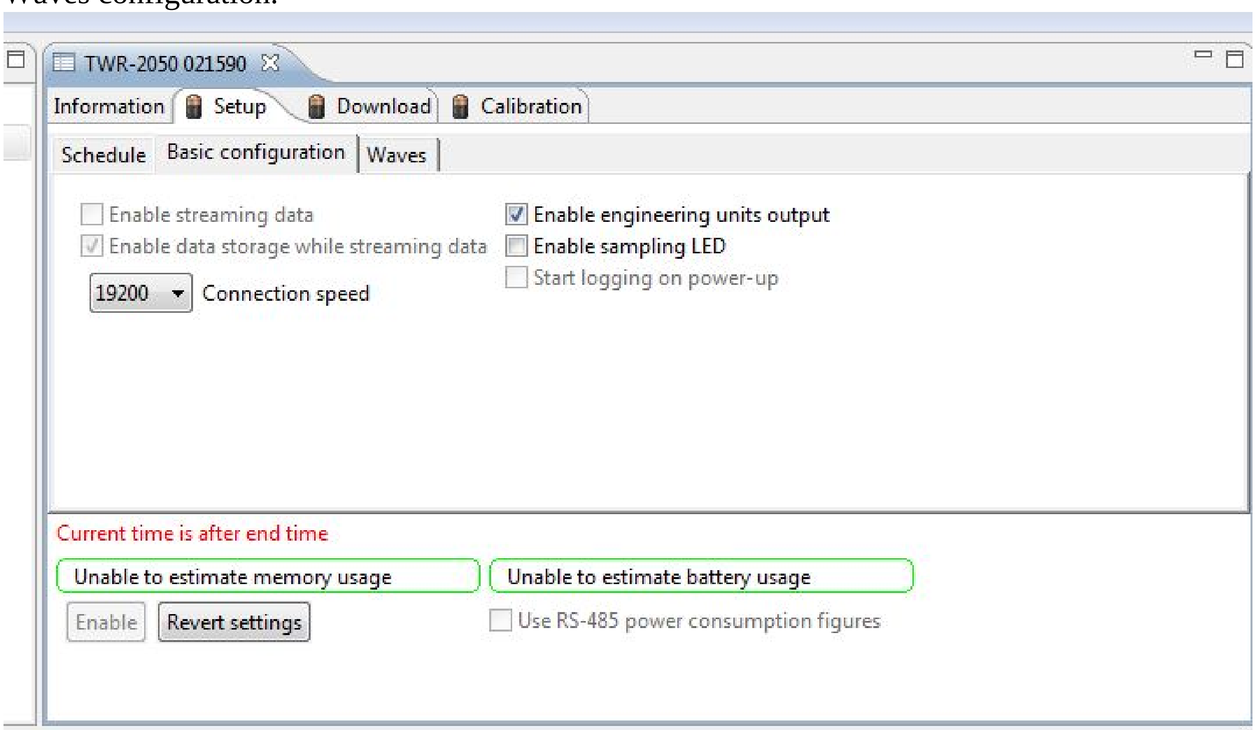


Deploy.

Serial No. 21590
Deployment Location – AS02CPPM 64 inch sphere at 17.1m depth.
Mean water depth: 520m
Altitude (height of instrument above the benthos): 502.9m
Battery Voltage: 5.985 VDC
Calibration values checked against vendor provided cal sheets.



Waves configuration.



Enable engineering units.

Check data.

21590 was deployed on the same schedule as 21589 (no screen grab for 21589).

Notes:
The time can only be set by syncing the time to the computer. The computer was set to UTC time and synced to time.microsoft.com. The computer time was less than 1 second behind the UTC time obtained from time.gov.

Appendix 9: CPM Menubar Help

================
CPM Menubar Help
================

On Platform: http://192.168.0.51/cg-bin/view_syslog
On Shore: http://cgsn-omc.whoi.edu/oms and click-on 'Detail Status' under specific platform section

Note: Plots are interactive. Drag an area on the plot to zoom-in, double-click on the plot to zoom-out.

View Status: Displays graphical system status for CPM and all associated DCLs
System: Displays summary of CE system - eg; cpu load, disk space, CGSN processes
CPM CTL MF Displays CPM realtime status file, cpm controller log file, and cpm mission file
Alarms: Displays any active alarms
Errors: Displays any active alarms
Msgs: Displays message counts from processes
Serial Cfg Displays CPM and all associated DCLs serial port configurations
Network Cfg Displays CGSN processes networking table
Fault Tables Displays Faults tables for CPM, DCL, and PSC
**DFmt Displays data formats for data logged by CPM and all associated DCLs
Data Dir Displays data directory hierarchy for platform

Syslog All Displays current syslog file. Append &d=YYYYMMDD to URL to view another day
MPIC Displays CPM MPIC messages from syslog file
PSC Displays PSC messages from syslog file showing PSC status
GPS Displays GPS messages from syslog file showing GPS status
PPS Displays PPS messages from syslog file showing PPS status
NTP Displays NTP messages from syslog file showing ntp sync status
CPU Displays CPU messages from syslog file showing cpu load and memory usage
FB250 Displays FB250 messages from syslog file showing FB250 status
Irid Displays Irid messages from syslog file showing Irid status
*SBD Displays summary of SBD messages received on-shore for current platform.
View_dcl_syslog

Plot ntp Realtime plot of current NTP sync statistics
cpm Realtime plot of current CPM voltage, current, temp, humidity, press, and leak detect data

dcl1 Realtime plot of current DCL1 voltage, current, temp, humidity, press, and leak detect data
dcl7 Realtime plot of current DCL7 voltage, current, temp, humidity, press, and leak detect data
psc Realtime plot of current PSC voltage, current, battery charge, sources connected, pv_mA, wt_mA, bt_mA
cpu Realtime plot of current CPM cpu load and memory statistics
+ldet Realtime plot of current CPM leak detect - deprecated, use plot cpm.
DCL1: ports Realtime plot that summarizes all port states (on/off), and port currents (mA)
idata Realtime table that summarizes instrument data directories, current file, size, and time since updated
iplot Realtime table that summarizes last instrument file along with plots of instrument data - select instrument from list
DCL7: ports Realtime plot that summarizes all port states (on/off), and port currents (mA)
idata Realtime table that summarizes instrument data directories, current file, size, and time since updated
iplot Realtime table that summarizes last instrument file along with plots of instrument data - select instrument from list
*Watch Circle Realtime google map plot depicting anchor position and pre-defined red watch circle. Recent GPS locations are then plotted (red tracks indicated the most-recent positions, blue tracks are prior days of data).

*Not available on embedded platform controller at-sea
**Not currently available on embedded platform, but will be
+To be deprecated

Appendix 10: DCL Menubar Help

================
DCL Menubar Help
================
On Platform: http://192.168.0.101/cg-bin/view_syslog
On Shore: http://cgsn-omc.whoi.edu/oms and click-on 'Detail Status' under specific platform section,
then click-on 'View dcl syslog`

Note: Plots are interactive. Drag an area on the plot to zoom-in, double-click on the plot to zoom-out.

View Status: Displays graphical system status for CPM and all associated DCLs
System: Displays summary of CE system - eg; cpu load, disk space, CGSN processes
CPM CTL MF Displays CPM realtime status file, cpm controller log file, and cpm mission file
DCL CTL MF Displays DCL realtime status file, cpm controller log file, and cpm mission file
Alarms: Displays any active alarms
Errors: Displays any active alarms
Msgs: Displays message counts from processes
Serial Cfg Displays CPM and all associated DCLs serial port configurations
Network Cfg Displays CGSN processes networking table
Fault Tables Displays Faults tables for CPM, DCL, and PSC
**DFmt Displays data formats for data logged by CPM and all associated DCLs
Data Dir Displays data directory hierarchy for platform

Syslog All Displays current syslog file. Append &d=YYYYMMDD to URL to view another day
MPIC Displays DCL MPIC messages from syslog file
+PSC Displays PSC messages from syslog file showing PSC status (should be deprecated)
GPS Displays GPS messages from syslog file showing GPS status
PPS Displays PPS messages from syslog file showing PPS status
NTP Displays NTP messages from syslog file showing ntp sync status
CPU Displays CPU messages from syslog file showing cpu load and memory usage
+3DM Displays sparse sampling of 3DM data for sanity checking (deprecated, use plot instrument data)
+Telem Displays Telem messages from syslog file (deprecate, no telemetry on DCL)

+DCL Ports Displays DCL MPIC messages from syslog file (deprecate, use MPIC)
DLOG: 1-8 Displays datalogger status for all ports or individual port specified

Plot ntp Realtime plot of current NTP sync statistics
+cpm Deprecate, DCL
dcl Realtime plot of current DCL voltage, current, temp, humidity, press, and leak detect data
+psc Deprecate, DCL
cpu Realtime plot of current CPM cpu load and memory statistics
+ldet Realtime plot of current CPM leak detect - deprecated, use plot cpm.
ports Realtime plot that summarizes all port states (on/off), and port currents (mA)
Port 1-8 Realtime plot for specified port, shows state (on/off), and port current (mA)
istatus Realtime table that summarizes instrument port status (state, volt, current, err, climit, protocol, status, last update, schedule, etc.)
idata Realtime table that summarizes instrument data directories, current file, size, and time since updated
iplot Realtime table that summarizes last instrument file along with plots of instrument data - select instrument from list

*Not available on embedded platform controller at-sea
**Not currently available on embedded platform, but will be
+To be deprecated

Appendix 11: STC Menubar Help

================
STC Menubar Help
================

On Platform: http://192.168.0.51/cg-bin/view_syslog
On Shore: http://cgsn-omc.whoi.edu/oms and click-on 'Detail Status' under specific platform section
Note: Plots are interactive. Drag an area on the plot to zoom-in, double-click on the plot to zoom-out.

View Status: Displays graphical system status for STC
System: Displays summary of CE system - eg; cpu load, disk space, CGSN processes
CPM CTL MF MMP
Displays CPM (STC) realtime status file, stc controller log file, cpm/stc mission file, mmp mission file
Alarms: Displays any active alarms
Errors: Displays any active alarms
Msgs: Displays message counts from processes
Serial Cfg Displays CPM and all associated DCLs serial port configurations
Network Cfg Displays CGSN processes networking table
Fault Tables Displays Faults tables for CPM, DCL, and PSC
Profiles Displays summary of mmp profiles
Idata Realtime table that summarizes instrument data directories, current file, size, and time since updated
**DFmt Displays data formats for data logged by CPM and all associated DCLs
Data Dir Displays data directory hierarchy for platform

Syslog All Displays current syslog file. Append &d=YYYYMMDD to URL to view another day
MPIC Displays STC MPIC messages from syslog file
GPS Displays GPS messages from syslog file showing GPS status
PPS Displays PPS messages from syslog file showing PPS status
NTP Displays NTP messages from syslog file showing ntp sync status
CPU Displays CPU messages from syslog file showing cpu load and memory usage
+3DM Displays sparse sampling of 3DM data for sanity checking (deprecated, use plot instrument data)
Telem Displays Telem messages from syslog file
Irid Displays Irid messages from syslog file showing Irid status
*SBD Displays summary of SBD messages received on-shore for current platform.

DLOG: 1-8 Displays datalogger status for all ports or individual port specified

Plot stc Realtime plot of current STC voltage, current, temp, humidity, press, and leak detect data

instrument data
Realtime table that summarizes last instrument file along with plots of instrument data - select instrument from list

*Watch Circle Realtime google map plot depicting anchor position and pre-defined red watch circle. Recent GPS locations are then plotted (red tracks indicated the most-recent positions, blue tracks are prior days of data).

*Not available on embedded platform controller at-sea
**Not currently available on embedded platform, but will be
+To be deprecated

Appendix 12: CPM Error codes

```
======================  CPM Fault Table  ==========================
#
# MP error codes v0.04 (4/01/11)
#
# History:
#     Date      Who    Description
#    --------   ---    ----------------------------------
#   04/11/2011  SL/MB  v0.04
#   04/11/2011  SL/MB  Added 0x40000000 Channel PIC over current
#=======================================================

0x00000000 No errors
0x00000001 SBD Hardware Failure
0x00000002 SBD Antenna Fault
0x00000004 SBD No Comms
0x00000008 SBD Timeout Exceeded
0x00000010 SBD Bad Message Received
0x00000020 Main_V Out of Range
0x00000040 Main_C Out of Range
0x00000080 BBatt_V Out of Range
0x00000100 BBatt_C Out of Range
0x00000200 Seascan PPS Fault
0x00000400 GPS PPS Fault
0x00000800 Wake from Unknown Source
0x00001000 No PSC Data
0x00002000 PSC Main_V and Main_V disagree
0x00004000 PSC Main_C and Main_C disagree
0x00008000 No CPM Heartbeat
0x00010000 Heartbeat Threshold Exceeded, power-cycling CPM
0x00020000 Gflt_SBD_Pos
0x00040000 Gflt_SBD_Gnd
0x00080000 Gflt_GPS_Pos
0x00100000 Gflt_GPS_Gnd
0x00200000 Gflt_Main_Pos
0x00400000 Gflt_Main_Gnd
0x00800000 Gflt_9522_fw_Pos
0x01000000 Gflt_9522_fw_Gnd
0x02000000 Leak Det1 Exceeded Limit
0x04000000 Leak Det2 Exceeded Limit
0x08000000 I2C Communication Error
0x10000000 UART Communication Error
0x20000000 CPM dead - recommend switchover...
0x40000000 Channel PIC over current
```

Table 1: CPM Error Codes

Wake Bits	Description
1	Cold start
2	Alarm wakeup from CE
3	Wakeup from SBd
4	Wakeup from DCL
5	MPIC Watchdog
6	PSC Error
7	Wakeup from IMM
8	HBEAT error

Table 2: CPM Wake Codes

Appendix 13: Platcon Electronic Serial Number Locations

Serial numbers and addresses associated with AST2 Platcon electronics

CPM 1 (CPM slot #1) PORT side of the buoy facing the vertical wind vane

CPM s/n 0023 CE 0004 Super 0005 Seascan 1651
RFM s/n 0003 879-7838
SBD s/n 0001 300234010627270
GPS s/n 0003 1A3010262
ISU s/n 0003 8816-9248-xxxx
eth0 00:D0:69:43:xx:xx IP 192.168.xxx.xxx Bcast 192.168.xxx.255 Mask 255.255.255.0
WIFI SSID AS02CPSM

CPM 2 (CPM slot #2) STBD side of the buoy facing the vertical wind vane

CPM s/n 0024 CE 0001 Super 0006 Seascan 1572
RFM s/n 0001 879-7424
SBD s/n 0003 300234010446400
GPS s/n 0001
ISU s/n 0001 8816-9248-xxxx
eth0 00:D0:69:43:xx:xx IP 192.168.xxx.50 Bcast 192.168.xxx.255 Mask 255.255.255.0
WIFI SSID AS02CPSM

RDA s/n 0002 LPR 0002 (slot 7)

DCL1 (slot 1 at opposite end of chassis from CPMs)

DCL s/n 0002 CE 0084 LPR 0005
eth0 00:D0:69:43:xx:xx IP 192.168.xxx.xxx Bcast 192.168.xxx.255 Mask 255.255.255.0

NSIF

DCL s/n 0001 CE 0061 LPR 0004 1BP-0002
eth0 00:D0:69:43:xx:xx IP 192.168.xxx.xxx Bcast 192.168.xxx.255 Mask 255.255.255.0

SPAREs

DCL s/n 0004 CE 0071 LPR 0001
DCL s/n 0003 CE 0007 LPR 0005 eth0 00:D0:69:43:xx:xx eth1 00:D0:69:43:xx:xx

STC

STC: CGSN-STC-0002
CE: CGSN-CEL-0063

BP:	CGSN-1BP-0001	
SUPERboard	004	
Seascan	1652	
SD card:	Sandisk SDHC 4GB class 4	"ce000org" handwritten on SD
USB	flashdrive NOT used	
RFM	879-7597	
SBD	300234010626270	
GPS	s/n 0001 1A3010266	
ISU	8816-9248-xxxx	
eth0	IP 192.168.xxx.xxx	Bcast 192.168.xxx.255
Mask 255.255.255.0		
WIFI SSID	AS02CPPM	
SBE IMM:	SN 70001275	
SBE IMM	Adapter board 41546	

Appendix 14: Communication Phone numbers and Addresses:

Freewave Masters on boat; Buoy Freewaves have all except 879-7597 in callbooks

842-3310 (mounted)
842-3427 connects to CPPM 879-7597 on Buoy
842-2689 connects to CPM1
924-7669 connects to CPM2 879-7424 on Buoy

Irid Shore Phone Numbers

irid.phone1 = 001508289xxxx # voip phone number blake seaglass
irid.phone2 = 0088160000xxxx # rudics phone number carlson cgsn-rudics.whoi.edu
irid.phone3 = 001508540xxxx # backup analog number carlson cgsn-rudics1.whoi.edu
carlson test bed room 111 analog phone lines long distance carrier: mci
(508) 540-xxxx
(508) 540-xxxx
(508) 540-xxxx

Fleet Broadband 250

FB1 - IP Address: 216.86.xxx.xxx
Antenna bootloader version: 1.0
Antenna software version: 1.30
Antenna serial number: 80242466
IMEI number:
Unit serial number: 10433039

FB2 - IP Address: 216.86.xxx.xxx
Antenna bootloader version: 1.0
Antenna software version: 1.10
Antenna serial number: 80357962
IMEI number:
Unit serial number: 09436624

SBD email cgsn-sbd@whoi.edu webmail.whoi.edu
To send a message:
Destination: data@sbd.iridium.com
Subject: IMEI#
Attachment: data.sbd (regular ASCII text file containing message - must not be CRLF terminated

Appendix 15: Potential CGSN Optical

Potential CGSN Optical Instruments					
Code	**Manufacturer**	**Instrument**	**Material**	**Notes**	**Source**
Fluorometer (AST2)	WET Labs	VSFS (Turbidity)/DFLS	ABS Plastic/Optically Clear Epoxy - delrin housing		In-house
FLORD	WET Labs	ECO-BB2F	ABS Plastic/Optically Clear Epoxy	Exemplar Model	CGSN-EarlyInstruments.xls
FLORT	WET Labs	Eco-Puck Triplet	ABS Plastic/Optically Clear Epoxy	Exemplar Model for Gliders	CGSN-EarlyInstruments.xls Open_Ocean_Glider_LowFreqSense_List.docx
PARAD	Bioshperical Instruments	QSP-2000 Series	Teflon	Exemplar Model for AUVS&Gliders	CGSN-EarlyInstruments.xls
Fluorometer	Turner Designs	CYCLOPS-7 (Fluorometer)	Stainless/Titanium /Plastic Housing - optics unknown		CGSN-EarlyInstruments.xls
Fluorometer	Turner Designs	PhytoFlash (Fluorometer)			CGSN-EarlyInstruments.xls
Fluorometer	Turner Designs	C3 (Fluorometer)	"All Plastic housing" (delrin) - optics unknown		CGSN-EarlyInstruments.xls
Fluorometer	Seaapoint Sensors		ABS Plastic Housing		http://www.whoi.edu/page/live.do?pid=53376
SPKIR	SATLANTIC	OCR-504			http://www.whoi.edu/page/live.do?pid=53377

SPKIR	SATLANTIC	OCR-507			http://www.whoi.edu/page/live.do?pid=53377
PARAD	SATLANTIC	PAR Series			http://www.whoi.edu/page/live.do?pid=53378
PARAD	LiCor	Li-192	Acrylic		CGSN-EarlyInstruments.xls
PARAD	LiCor	Li-193	Acrylic		CGSN-EarlyInstruments.xls
OPTAA	WET Labs	ac-9	Optics Internal? (glass?)		CGSN Core Sensor Design
CAMDS	DEEPSEA Power & Light	Wide-i SeaCam®	Glass		CGSN Core Sensor Design
CAMDS	DEEPSEA Power & Light	Multi-SeaCam®	Sapphire		CGSN Core Sensor Design
CAMDS	DEEPSEA Power & Light	LED Multi-SeaCam®	Sapphire		CGSN Core Sensor Design (Shown in Doc)
CAMDS	DEEPSEA Power & Light	Super SeaCam® 5000	Glass		CGSN Core Sensor Design
CAMDS	DEEPSEA Power & Light	SeeSnake® Camera	Sapphire		CGSN Core Sensor Design
CAMDS	DEEPSEA Power & Light	SeaLite® Sphere	Sapphire		CGSN Core Sensor Design
CAMDS	DEEPSEA Power & Light	LED Matrix-1 SeaLite®	Sapphire		CGSN Core Sensor Design
CAMDS	DEEPSEA Power & Light	LED Matrix-3 SeaLite®	Sapphire		CGSN Core Sensor Design
CAMDS	DEEPSEA Power & Light	LED Matrix-3R SeaLite®	Sapphire		CGSN Core Sensor Design
CAMDS	DEEPSEA Power & Light	LED Multi-SeaLite® Matrix™	Acrylic		CGSN Core Sensor Design
CAMDS	Deep Sea Systems	DCP-700	Plexiglas		CGSN Core Sensor Design
CAMDS	ROS	Navigator	Acrylic		CGSN Core Sensor Design
CAMDS	ROS	Viper	Acrylic		CGSN Core Sensor Design

CAMHD	ROS	Mantis HD	Glass		CGSN Core Sensor Design
CAMHD	ROS	PTZ-1000 HD SYSTEM	Acrylics		CGSN Core Sensor Design
CAMDS	ROS	Inspector	Acryllic		CGSN Core Sensor Design
CAMDS	ROS	CE-X-18 HAZARDOUS ENVIRONME NT CAMERA	Acryllic		CGSN Core Sensor Design
CAMDS	ROS	CE-X-36 HAZARDOUS ENVIRONME NT CAMERA	Acryllic		CGSN Core Sensor Design
CAMDS	ROS	ROVer	Quartz		

Appendix 16: ASTM D 6990-05

Designation: D 6990 – 05

Standard Practice for Evaluating Biofouling Resistance and Physical Performance of Marine Coating Systems[1]

This standard is issued under the fixed designation D 6990; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This method establishes a practice for evaluating degree of biofouling settlement on and physical performance of marine coating systems when panels coated with such coating systems are subjected to immersion conditions in a marine environment. Guidance for preparation or exposure and handling of test specimens can be found in related ASTM standards as noted below (see Section 2).

1.2 This practice and related exposure methodologies are designed as tools for the relative assessment of coating performance, and in no way are to be used as an absolute indicator of long-term performance under all conditions and in all environments. There can be high variability among and within exposure sites with respect to water quality and population or species of fouling organisms, and coating performance may vary with these and other properties.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* A specific hazard statement is given in Section 6.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

Recommended ASTM Methods and Practices for evaluation of antifouling coatings via panel exposure under a variety of exposure conditions:

- D 3623 Test Method for Testing Antifouling Panels in Shallow Submergence
- D 4938 Test Method for Erosion Testing of Antifouling Paints Using High Velocity Water
- D 4939 Test Method for Subjecting Marine Antifouling Coatings to Biofouling and Fluid Shear Forces in Natural Seawater
- D 5479 Practice for Testing Biofouling Resistance of Marine Coatings Partially Immersed
- D 5618 Test Method for Measurement of Barnacle Adhesion Strength in Shear

2.2 *ASTM Standards for Reference Only:*[2]

The following ASTM standards may provide the reader with useful information on evaluating physical performance of marine coating systems. The method references are provided only for the convenience of the reader. The reader is not required to specifically apply these methods to the ratings and reporting assigned under this method, but is encouraged to utilize the descriptions, definitions, and pictures provided in the methods to assist in understanding coating physical performance.

- D 16 Terminology for Paint, Related Coatings, Materials, and Applications
- D 660 Test Method for Evaluating Degree of Checking of Exterior Paints
- D 661 Test Method for Evaluating Degree of Cracking of Exterior Paints
- D 662 Test Method for Evaluating Degree of Erosion of Exterior Paints
- D 714 Test Method for Evaluating Degree of Blistering of Paints
- D 772 Test Method for Evaluating Degree of Flaking (Scaling) of Exterior Paints
- D 4538 Terminology Relating to Protective Coating and Lining Work for Power Generation Facilities

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *biofilm, n*—matrix-enclosed populations of microorganisms adherent to each other or to surfaces, or both, or interfaces.

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[1] This practice is under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.45 on Marine Coatings.

Current edition approved Jan. 1, 2005. Published January 2005. Originally approved in 2003. Last previous edition approved in 2003 as D 6990 – 03.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.1.2 *biofouling adhesion*, *n*—qualitative or quantitative force required for the successful and complete removal of marine fouling attached to the antifouling coating surface (for example, reference Test Method D 5618 for barnacles).

3.1.3 *corrosion eruptions*, *n*—build up of oxides, exiting through protective paint film.

3.1.4 *damage*, *n*—limited destruction of portions of paint film due to impact with a foreign article.

3.1.5 *digging*, *n*—a term used to describe hard fouling macroorganisms that are growing "into" the coating. That is, where its calcareous shell penetrates/breaks through the coating surface causing physical damage to the coating.

3.1.6 *macroorganism*, *n*—organisms large enough to be seen with the naked eye. In this context, these organisms would be noted when growing on submerged surfaces.

3.1.7 *microorganism*, *n*—organisms too small to be seen with the naked eye. These generally include bacteria, protozoa, fungi and microalgae. Sometimes also called "slime."

3.1.8 *peeling*, *n*—the phenomenon manifested in paint films where a portion of a film, when pulled, can be removed in strips or relatively large intact pieces, or both.

3.1.9 *silt*, *n*—sedimentary material consisting especially of mineral particles intermediate in size between those of sand and clay.

3.1.10 *TRIBsoftness*, *adv*—the phenomenon manifested by paints in transferring some of its pigmentation to a foreign item or substance, upon encountering friction on its surface.

3.1.11 *wearing*, *n*—gradual loss of the paint film caused by use or exposure to the environment.

4. Summary of Practice

4.1 Test specimens or panels are coated with marine coating systems and exposed to marine immersion conditions for a specified amount of time and under specific sets of conditions as agreed upon by the producer and user. See 2.1 for published ASTM standard methods and practices that provide guidance for exposure of coating systems.

4.2 Coating systems are evaluated in terms of fouling rating which describes percent of coverage of the coating system by biofouling organisms, and physical deterioration rating which describes the percentage area of the coating system affected by physical coating failure(s). These data are useful in assessing and comparing effectiveness of antifouling coating systems.

5. Significance and Use

5.1 This practice is designed to provide guidance to a panel inspector for quantitative and consistent evaluation of coating performance from test panels coated with marine antifouling coating systems. The practice assesses performance of coating systems based on both antifouling and physical properties.

5.2 The user is cautioned that the results are representative for the specific region and time of year in which the specimens are immersed. It shall be noted that interpretation of results will depend on the geographical location where the test is conducted, whether the coated specimens are exposed either totally or partially immersed, under static or dynamic conditions, and position and orientation.

5.3 Simultaneous testing of a proven standard antifouling coating system (known to minimize fouling accumulation, for example, containing biocide or active agent(s) to prevent fouling settlement/growth) in the specific marine environment shall be included as a reference to assist in interpretation of results. In addition, a negative control (inert surface susceptible to heavy fouling) shall be included on a regular basis. For the exposure to be valid, the surface of the negative control should show heavy fouling relative to the standard system(s).

5.4 Marine coating systems that produce positive results relevant to the standard system(s) show potential for use in protecting underwater marine structures.

5.5 The format can be utilized independent of exposure protocol and coating type, and provides the end user with a consistent practice and format for reporting of performance rating.

6. Safety Precautions

6.1 **Warning**—Certain marine coating systems contain toxic materials (biocides) that may cause skin and eye irritation on contact as well as adverse physiological effects if ingested or inhaled. In the preparation, application, and general handling of panels coated with various types of marine paints, the use of appropriate protective clothing and equipment is required consistent with local, state, federal government regulations and recognized industrial and technical standards.

7. Procedure—Evaluation of Fouling Present on Test Surface

7.1 Controls should be exposed and assessed at the same time as the test materials. More information about the use of control materials in weathering tests can be found in Guide G 141. (See also 5.3 above.)

7.2 Retrieve test panels and any negative controls and reference coatings from immersion site. Note and record the visual percentage coverage by biofilm or silt, or both, or lack thereof in accordance with the guidelines provided below.

7.3 Prior to inspection, it is recommended that panels be rinsed in order to remove silt (may interfere with observation of attached forms) and unattached forms. Alternatives such as either gentle agitation of the panels or not rinsing the panels may be done but must be specified in the final reports. (Then, check reporting section to make sure this information is required.) Whichever preparation is chosen, it must be documented and performed on all panels equally and at each inspection. If rinsed, the test panel surface is to be wetted using low-pressure water (for example, household pressures from ⅜ to ½ in. garden hose are sufficient) in the form of a gentle shower spray or non-forceful flow to allow for a reliable inspection of what is attached to the coating/panel. Nozzles that cause water to be forcefully applied to the panel shall not be used. **Warning**—Risk in rinsing panels is that subsequent biofouling attachment may be affected. Alternatively, panels may be gently agitated in water to remove loose/unattached bacterial biofilm or silt deposits, or both. **Warning**—Risk in not rinsing panels is that silt or slime, or both, may interfere with assessment of biofouling attachment on complete panel surface.

7.4 Test panels shall not be allowed to dry during the entire inspection period. A holding tank is useful for accomplishing this.

7.4.1 Rinse water and holding tank water, shall be taken from the immersion site.

7.4.2 Efforts shall be made to minimize the length of time panels remain removed from the normal immersion site, and to not touch the coated surfaces.

7.5 Populations and types of organisms will vary by test site. Some examples of biofouling microorganisms include barnacles, oysters, mussels, bryozoans (arborescent and encrusting), hydroids, tubeworms, tunicates, sponges, and various types of algae. Each type of fouling organism directly attached to the test surface shall be reported by (*1*) the estimated percentage of the panel area covered by all of the same type of biofouling (for example, colonial forms), (*2*) the frequency (number of individuals for the larger and solitary organisms; for example, barnacles, mussels, oysters, tube worms, and some tunicates), and (*3*) the range of size for the individual organisms (for larger, solitary organisms). See Appendix X1 for guidance on estimating percent cover and Fig. X2.1 for a suggested sample antifouling inspection report form.

7.5.1 Mak a note of any fouling organisms found to be growing into the paint film, also referred to as "digging."

7.5.2 Note that percentage cover of algae and arborescent bryozoans shall be based on the area covered by the "hold fast" and not the area covered by the "strands" or colony. The type of algae (for example, brown, red, green) shall also be recorded if known.

7.5.3 Only attachment of primary biofouling settlement (that is, biofouling attached directly to the coating system) shall be recorded. Notes on secondary fouling (biofouling attached to other fouling organisms) can be made if desired, but shall not factor into the generation of a "fouling rating."

7.5.4 Percent cover by gammarid amphipods shall be reported as a footnote in Fig. X2.1, but shall NOT factor into the generation of a "fouling rating."

7.5.5 *Partial Immersion Test Panels Only*—Panels exposed in accordance with Practice D 5479 are partially immersed. The non-immersed area will be subject to splash and may show some fouling attachment, but the area is not included in the determination of a fouling rating. Therefore, the fouling rating is calculated based on the fully immersed surface area, counting the immersed surface area as 100 %.

7.5.5.1 In addition, antifouling performance of coating systems is often different in the immediate waterline vicinity. Therefore, an estimate of coverage along the first two immersed inches (50 mm) of the test panel shall also be made and can then be contrasted with the overall coverage. Fouling occurring in the "above the waterline" area, if any, is not considered when generating a "fouling rating."

7.6 Discount biofouling attachment within 13 mm (½ in.) from all edges of the test panel.

8. Procedure—Evaluation of Physical Deterioration/ Performance of Test Surface

8.1 Prior to the original exposure, inspect all test panels for possible physical deterioration. Record findings. Continue observation of predetermined damage during future inspections. See Fig. X2.2 for a suggested sample physical performance inspection report form.

8.2 Evaluate individual physical performance failure, qualitatively and quantitatively, for each test specimen. Observations of erosion, wearing, blistering, alligatoring, checking, cracking, chipping, peeling, flaking, and damage shall be made. For additional information and guidance for evaluating any of the previous physical deteriorations, refer to Sections 2 and 3. Record the percent surface area affected by each physical parameter.

8.2.1 Observations of physical deterioration shall be performed for each coat visible to the inspector (for example, topcoat, intermediate, primer). The percent surface area affected by each physical parameter shall be estimated based on the visible area of each coat.

8.3 Discount any physical failures within 13 mm (½ in.) from all edges of the test panel.

8.4 Observations of physical deterioration cannot be performed on panel surface areas covered by hard fouling. At the time of inspection do not count this area in the generation of the physical deterioration rating (PDR); see also 11.2. At the end of the panel test period, a final evaluation of physical deterioration rating can be performed after removal of hard fouling in order to determine whether physical deterioration has occurred under areas that had been covered by hard fouling.

9. Procedure—Evaluation of "Softness" of Marine Coating System

9.1 Evaluation of "softness" is intended for marine coating systems (excluding silicone coating systems), and is an indicator of a coating's pigment erosion characteristics. It is measured on a subjective scale of 10 to 0 (see 9.2.1), dependent on the amount of pigment transferred from the coating to a cotton swab.

9.2 After rinsing the test panels (see 7.2), rub a wet cotton swab, exactly 10 strokes in a back and forth motion, over the wet test surface. The cotton swab is held at one of its ends with the thumb and index finger. The cotton swab is positioned at 45° to the coating surface and sufficient pressure is applied so that the cotton swab stem just starts to bend. The strokes shall be made continuously in a back and forth motion, in the same linear pattern, approximately 50 to 65 mm (2 to 2½ in.) in length. Use of proper protective equipment, such as gloves, is recommended.

9.2.1 Softness shall be evaluated on the following subjective scale, where:

10 = no pigment transferred to a cotton swab,
8 = trace amount of pigment transferred to a cotton swab,
6 = slight amount of pigment transferred to a cotton swab,
4 = moderate amount of pigment transferred to a cotton swab,
2 = severe amount of pigment transferred to a cotton swab, and
0 = complete removal of pigment transferred to a cotton swab.

9.3 Softness measurements can be performed anywhere 13 mm (½ in.) or more away from all edges of the test panel. In the case of partially immersed panels, avoid taking measurements in the area affected by partial immersion.

9.4 When a large change in "softness" is observed in any subsequent inspection cycle, the inspector will take a second or even third softness grading at a different location of the test panel to ascertain a true, consistent, or, possibly, averaged value.

9.5 The appropriate layer of paint film (that is, topcoat, intermediate coat, or primer coat) on which softness testing was performed shall be recorded and noted in the report.

10. Interferences

10.1 The presence of "loose" detritus or bacterial slimes, or both, which include microorganism attachment and silt settlement, shall be reported based on the estimated percentage of the panel area covered excluding: (*a*) percentage of panel area covered by macrofouling, and (*b*) percentage of panel area where the antifouling film is no longer present due to previous physical failure.

10.1.1 "Loose forms" of fouling settlement shall be reported using only the more predominant of the two, silt or bacterial, present on the surface. In addition, the severity or accumulation on top of the surface shall be designated as light, medium, or heavy.

10.1.2 In practice, it is impossible to ascertain total silt or bacterial slime coverage until this "loose" film has been rinsed off, exposing the existing paint surface or low height macrofouling forms, or both, which may have been obscured by the "loose forms."

10.2 When evaluating the type and percentage coverage of microfouling organisms, be sure to distinguish between the fouling adherent to the surface and the unattached fouling. Neither fouling attached to other fouling, nor unattached fouling shall be included in the fouling rating.

11. Calculations

11.1 Grading for antifouling performance of the marine coating system—generation of a fouling rating (FR). The range of FRs is from 0 to 100.

11.1.1 The fouling rating for a coating system free of adherent biofouling settlement shall be recorded as 100.

11.1.2 The fouling rating for a paint film free of macrofouling settlement but partially or totally covered by microfouling growth (adherent slime) shall be recorded as 99, irrespective of the percent area covered by the "adherent slime."

11.1.3 Upon settlement of macrofouling forms, the total sum of percentage of area covered by macrofouling shall be deducted from 100. The fouling rating, then, essentially reflects non-fouled area.

11.2 Grading of physical performance of the marine coating system—generation of a physical deterioration rating (PDR). The range of PDRs is 0 to 100.

11.2.1 The physical deterioration rating for a coating system free of physical deterioration shall be recorded as 100.

11.2.2 Separate physical deterioration ratings are applied to each layer of intact coating.

11.2.3 Upon determining physical deterioration(s), the sum of all reported percentages of deterioration will be deducted from 100, and the result will reflect the physical deterioration rating of the remaining intact film for each coat.

11.2.4 Topcoat, intermediate, and primer of the marine coating system shall be graded independently from one another. The lowest rating shall be taken as the PDR for the paint system.

11.3 To calculate the percentage coverage by "loose forms," note what percentage of the panel area is free of bacteria or silt. Upon rinsing the surface, the sums of percentages covered by macrofouling, plus percentages of missing paint film plus area free of "loose forms" coverage, deducted from 100 will provide the amount covered by bacteria or silt, or both.

12. Inspection Report

12.1 Appendix X2 provides sample comprehensive inspection reports. Required general information includes:

12.1.1 Testing Facility name, address, phone number, body of water in which panels were immersed,

12.1.2 Name of customer for whom test is being conducted,

12.1.3 Size and shape of test substrate,

12.1.4 Material out of which substrate was made,

12.1.5 Type of exposure (reference associated ASTM method numbers as appropriate). Include orientation of panel, and depth of exposure,

12.1.6 Initial date of immersion and total number of months of exposure at time of latest inspection cycle,

12.1.7 Identification of panel series,

12.1.8 Individual panel identification,

12.1.8.1 In the event that a specific test panel is to have more than a single surface inspected, the descriptive location (for example, front, back) shall be shown immediately following the identification of the specific test panel.

12.1.9 Date of inspection,

12.1.10 Inspector's name or initials, and

12.1.11 Original color of marine coating on panel (prior to test exposure) and color at time of each inspection.

12.2 Required information concerning coating performance includes:

12.2.1 *Antifouling Performance Ratings* (refer to Fig. X2.1):

12.2.1.1 Report fouling rating and biofilm/silt fouling as described in Sections 7-11, including percent cover information for each type of macroorganism and algae.

12.2.1.2 The inspector shall report percent cover of all macroorganisms occurring at the test site, and shall not limit their reporting to those listed in the sample report provided in Fig. X2.1. All organisms from a particular genus may be reported together. For example, percent cover by barnacles may include more than one species of barnacle.

12.2.2 *Physical Deterioration Ratings* (refer to Fig. X2.2):

12.2.2.1 Report physical deterioration ratings as described in Sections 8-11 for each layer of exposed paint.

12.2.3 *Softness of the Marine Coating* (refer to Fig. X2.2):

12.2.3.1 Report softness rating as described in Sections 9-11 for each layer of exposed paint.

12.3 *Optional Information in Report*:

12.3.1 Additional information may be included in the report dependent upon the needs of the producer and user. Optional variables could include, but are not limited to:

12.3.1.1 Color photos of each panel at each inspection are strongly recommended. Additional recommendation includes labeling each panel with, at a minimum, the test site, coating name/code name, date of exposure, and date of inspection.

12.3.1.2 Recommendations for frequency of panel inspection or photographs, or both.

12.3.1.3 Range of water temperature, salinity and pH at the test site (reporting period to be determined between evaluator and producer).

12.3.1.4 A record of average occurrence of fouling at the test site on a monthly basis over one year.

12.3.1.5 Orientation of rack/panel(s) to sun and tide.

12.3.1.6 Comments on color change.

12.4 *Additional Guidance*:

12.4.1 Providing cumulative performance data reports on a quarterly basis is suggested.

12.4.2 It is desirable to devise a reporting format where, for a given panel, cumulative periodic inspections can be viewed simultaneously and in chronological order.

13. Keywords

13.1 antifouling coating; antifouling performance; biofouling; coating physical performance; fouling rate; physical performance; evaluation; film physical performance

APPENDIXES

(Nonmandatory Information)

X1. EXTENT DIAGRAMS

X1.1 Each 12 by 36 segment represents a test specimen or panel coated with an antifouling coating system and immersed in a marine environment. The percentage listed below each diagram indicates the total area covered by the shaded area. The shaded area is representative of biofouling coverage.

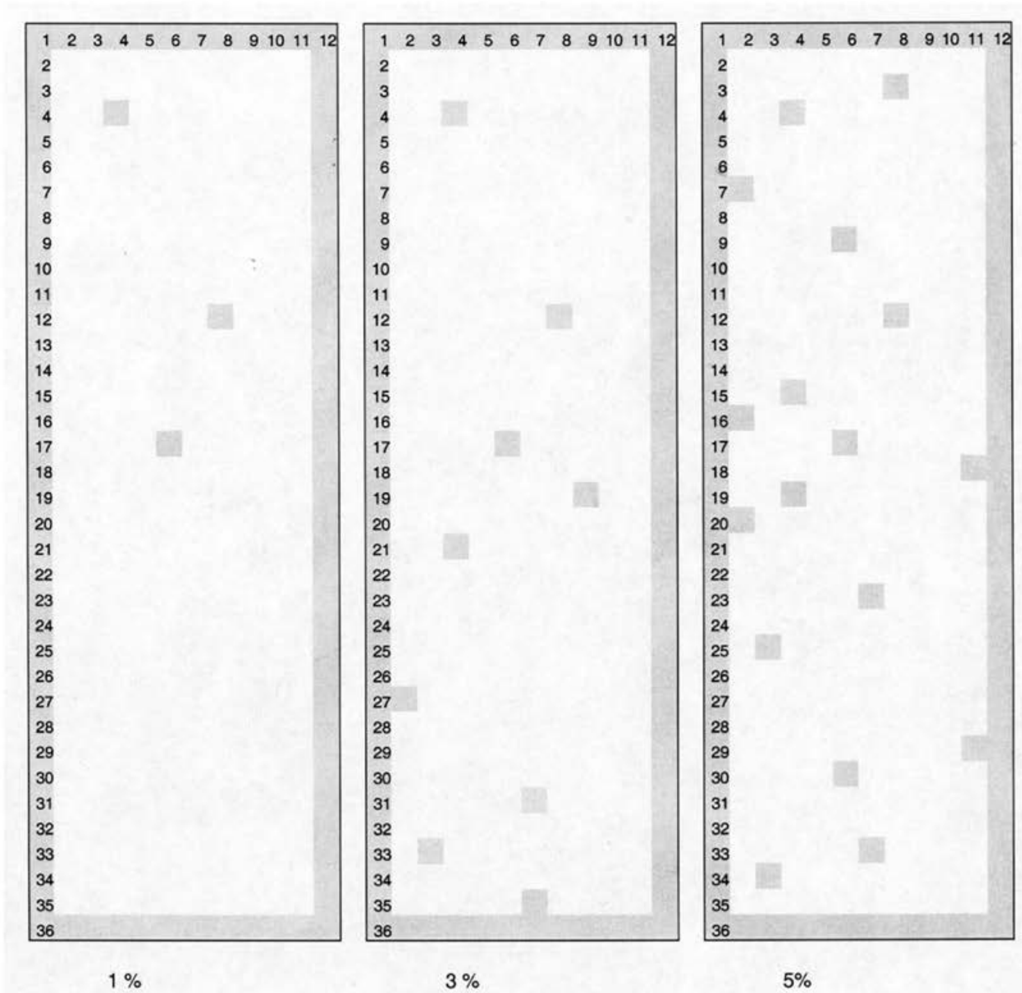
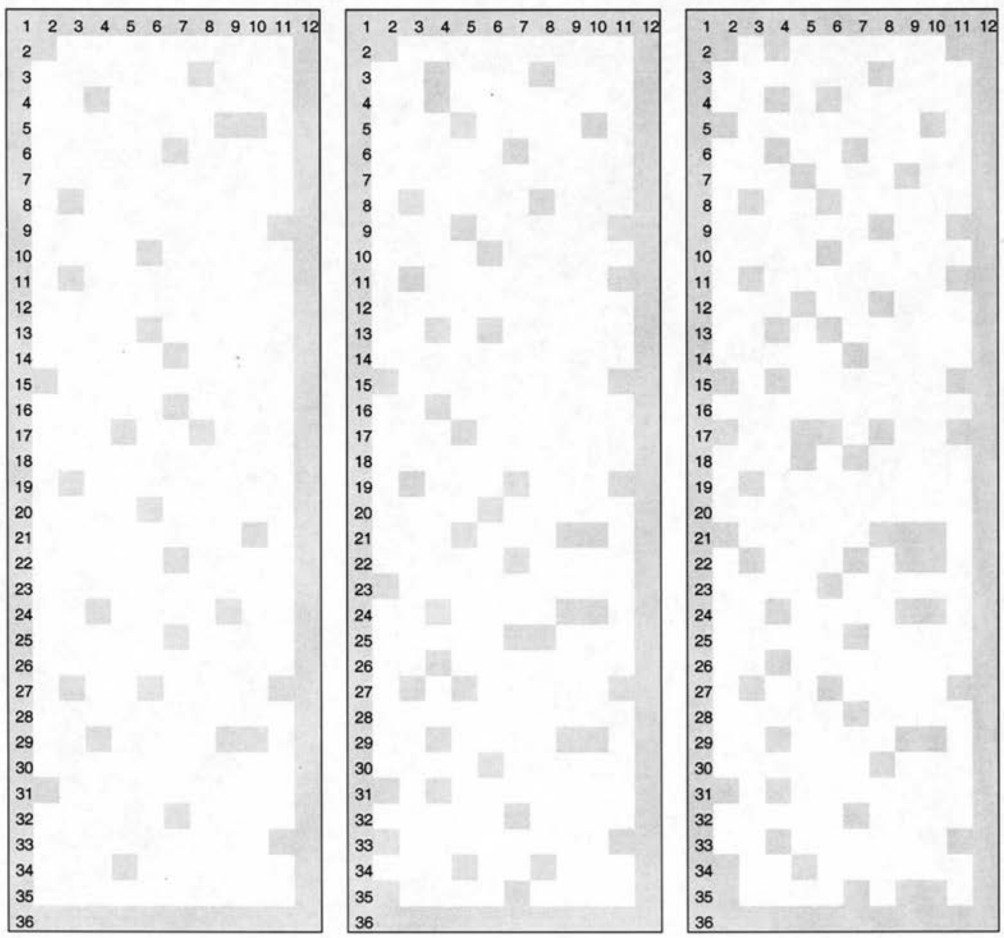


FIG. X1.1



10% 15 % 20%

FIG. X1.2

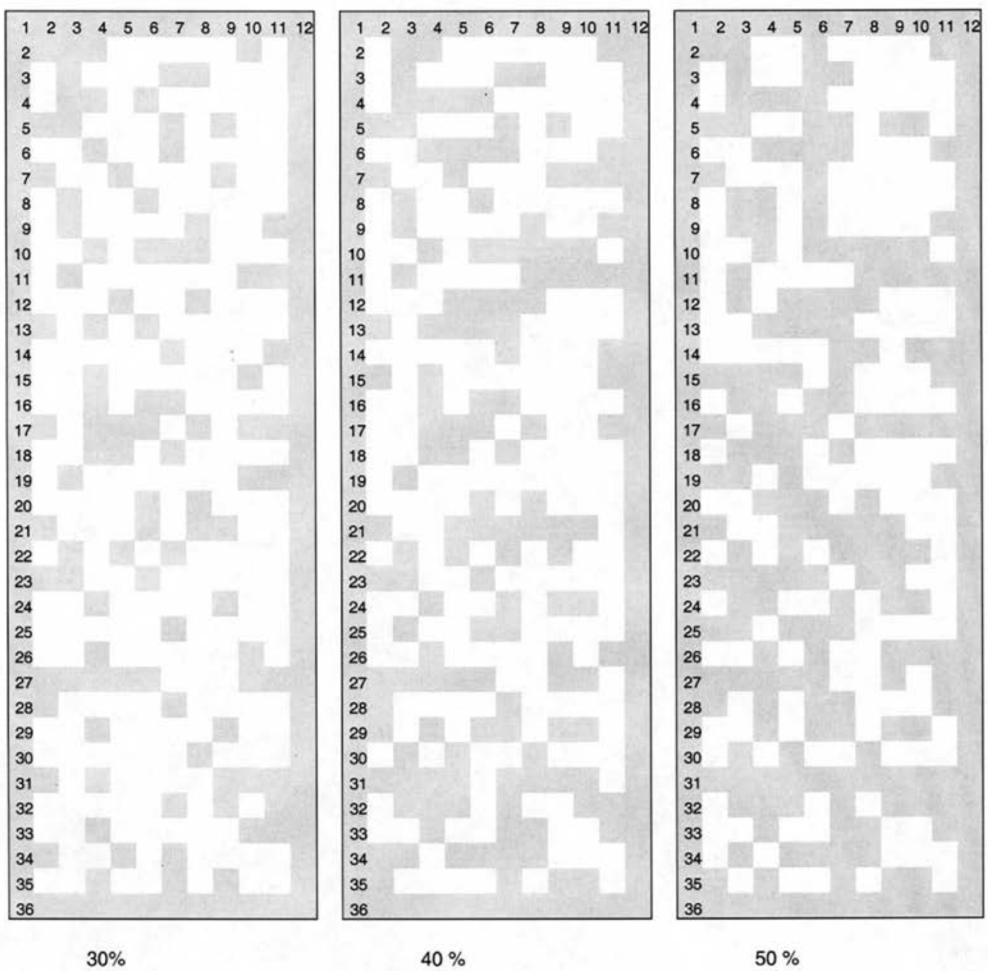
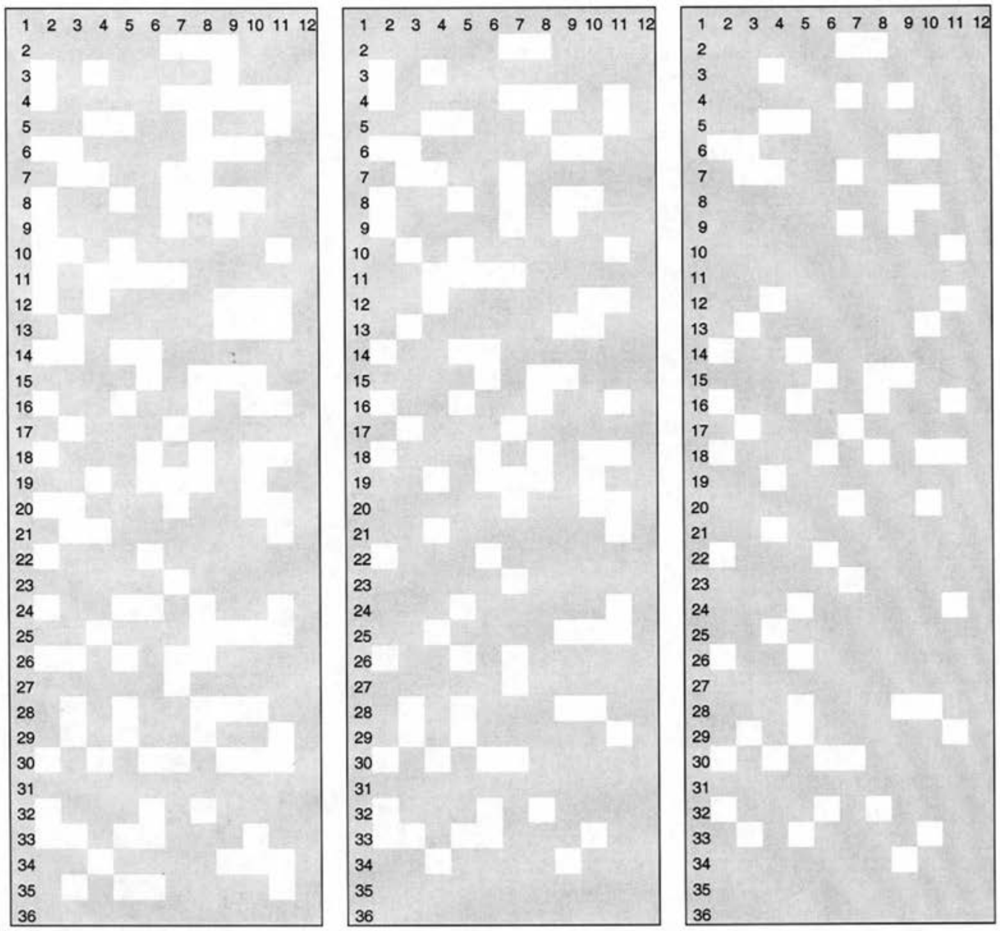


FIG. X1.3



60 % 70 % 80 %

FIG. X1.4

X2. REPORT FORMS

NAME OF MARINE EXPOSURE TESTING FACILITY
ADDRESS INFORMATION, PHONE, AND OTHER CONTACTS

TEST CONDUCTED FOR "NAME OF COATING PRODUCER, CLIENT" **IN** BODY OF WATER, LOCATION, STATE

Series ID: (Series Number)
Substrate: (Fiberglass or Metal)
Panel Size and Shape: (6 × 18 in., Flat, Rectangular)
Type of Exposure: (Submerged or Waterline; Practice D 5479)
Type of Supporting Rack: (Submerged or Floating)

Date of Initial Exposure: (mm/dd/yy)
Scheduled Duration of Exposure: (## of Months)
Inspection Schedule: (Monthly, Quarterly, Semiannually)
Date of Inspection: (mm/dd/yy) Inspector: (Initials)
Total Exposure Time to Date: (## of Months)

ESTIMATE OF ANTIFOULING PERFORMANCE

PANEL NUMBER	FOULING RATING (FR)	BARNACLES			OYSTERS/MUSSELS			TUBEWORMS			BRYOZOANS		HY-DROIDS	TUNI-CATES	GAM-MARID AMPHI-POD	SPONGES	ALGAE				BIO-FILM	SILT
		% Cover	No. of Indvs	Size Range	% Cover	No. of Indvs	Size Range	% Cover	No. of Indvs	Size Range	Encrust-ing	Arbores-cent	% Cover	% Cover	% Cover*	% Cover	Waterline		Submerged		% Cover	% Cover
											% cover	% cover					Algal Type	% Cover	Algal Type	% Cover		

LEGEND

Fouling Rating (FR): 100 = Perfect (0 % failure); 99 = 1 % failure; 90 = 10 % failure; ... 0 = Complete Failure (100 % failure).
Size Range: All measurement in millimetres.
Algal Type: G= Green, R = Red, B = Brown, C = Coral Algae.
Abbreviations: S = Barnacle Seed; P = Tubeworm Pinpoint; L = Loose; ML = Mainly Loose; T = Tight; E = present on Edge (s); W = present at Waterline; AW = present Above Waterline; MW = present Mainly at Waterline.

NOTES

1) At time of inspection all panels are rinsed and kept wet with water from test site.
2) Panel edges (½ in.) and mounting holes are not considered during the fouling ratings.
3) Silt rating performed before the water rinse.
4) *A unique damage or performance to panel(s) may be noted here.*
5) *Percent cover amphipod is reported, but NOT considered in overall fouling rating.

FIG. X2.1 Estimate of Antifouling Performance

NAME OF MARINE EXPOSURE TESTING FACILITY
ADDRESS INFORMATION, PHONE, AND OTHER CONTACTS

TEST CONDUCTED FOR "NAME OF COATING PRODUCER, CLIENT" **IN** BODY OF WATER, LOCATION, STATE

Series ID: (Series Number)
Substrate: (e.g., Fiberglass or Metal)
Panel Size and Shape: (e.g., length × width mm, Flat, Rectangular)
Type of Exposure: (e.g., ASTM method # or brief description)

Date of Initial Exposure: (mm/dd/yy)
Date of Inspection: (mm/dd/yy)
Total Exposure Time to Date: (## of Months)
Inspector: (name(s))

ESTIMATE OF FILM PHYSICAL PERFORMANCE

PANEL NUMBER	Original Panel Color	Present Panel Color	DAMAGE		Wearing % Cover	Blistering % Cover	Corrosion % Cover	Peeling % Cover	Chipping % Cover	Flaking % Cover	Checking % Cover	Cracking % Cover	Alligatoring % Cover	Softness Rating (10-0)	**PHYSICAL DETERIORATION RATING (PDR)**		
			Type	% Cover											Top Coat A.F.	Inter coat Tie	Primer A.C.

LEGEND

Physical Deterioration Rating (PDR): 100 = 0 % fouling; 99 = 1 % fouling; 90 = 10 % failure; ... 10 = 90 % fouling; 0 = 100 % fouling).
Softness Rating: 10 = No pigment transfer; 8 = Trace amount; 6 = Slight amount; 4 = Moderate amount; 2 = Severe amount; 0 = Complete Removal of pigment.

NOTES

1) At time of inspection all panels are rinsed and kept wet with water from test site.
2) Panel edges (13 mm) and mounting holes are not considered in the film physical ratings.
3) *A unique damage to or performance of panel(s) may be noted here.*
4) Each physical performance rating applies to the antifouling (A.F.), tie, and anticorrosive (A.C.) costs.

FIG. X2.2 Estimate of Film Physical Performance

X3. COATING PERFORMANCE INSPECTION PROTOCOLS

X3.1 Portions of the currently published Test Method D 3623 provide guidance for rating coating system performance during antifouling coating panel testing. The panel inspection protocol has been lifted from Test Method D 3623, modified, and is now published as a separate method – Practice D 6990. In the near future, the ASTM Marine Coatings subcommittee will ballot changes to Test Method D 3623 (removing the inspection protocol). Changes will also be made to Test Methods D 4938, D 4939, D 5618, and Practice D 5479. Essentially, these methods will now refer to Practice D 6990 for coating performance inspection protocols (panel testing).

Appendix 17: Trilux 33 Product Datasheet

Trilux 33*
Antifouling
TBT Free Antifouling Paint for Aluminum

Interlux. yachtpaint.com

PRODUCT DESCRIPTION

* Specially formulated to be the safest and most effective product for use on aluminum boats, outdrives and outboards. It can also be applied to fiberglass, wood and other underwater metals.
* Highly effective antifouling protection from a new, improved version of Biolux® Technology for improved control of slime and algae growth.
* Slow polishing system makes it suitable for fast, active craft as polish-through at high speeds is avoided.
* Available in bright white, and a range of bright colors with long lasting color stability.
* Replaces Trilux and Micron 33.
* For use below the waterline in fresh, salt and brackish waters.

PRODUCT INFORMATION

Colour	YBA060-Blue, YBA061-Green, YBA062-Red, YBA063-Black, YBA068-White
Finish	Low sheen
Specific Gravity	1.6
Volume Solids	50%
Typical Shelf Life	2 yrs
VOC (As Supplied)	390 g/lt
Unit Size	1 US Pint (White and Black only) , 1 US Quart , 1 US Gallon , 3 US Gallon (blue & black only)

DRYING/OVERCOATING INFORMATION

	Drying			
	41°F (5°C)	50°F (10°C)	73°F (23°C)	95°F (35°C)
Touch Dry [ISO]	8 hrs	6 hrs	3 hrs	2 hrs
Immersion	36 hrs	30 hrs	12 hrs	10 hrs

	Overcoating Substrate Temperature							
	41°F (5°C)		50°F (10°C)		73°F (23°C)		95°F (35°C)	
Overcoated By	Min	Max	Min	Max	Min	Max	Min	Max
Trilux 33*	24 hrs	ext	20 hrs	ext	6 hrs	ext	4 hrs	ext

APPLICATION AND USE

Preparation	**BARE ALUMINUM** Sand with medium grade (grit) emery cloth to a bright metal finish. Wipe clean. Apply one very thin coat of Viny-Lux Primewash 353/354. Prime with Interprotect 2000E/2001E. On sandblasted aluminum the Viny-Lux Primewash 353/354 can be omitted if priming with Interprotect the same day as blasting. **FACTORY FINISHED ALUMINUM** Prime with Primocon. **BARE FIBERGLASS** Begin by scrubbing well using soap and water and a stiff brush. Rinse with fresh water. Wipe a small area with a clean rag that has been wetted with Fiberglass Solvent Wash 202. While the surface is still wet, wipe with a clean, dry rag. Continue this process until the entire surface has been cleaned. No Sand System - Apply one thin, continuous coat of Interlux Fiberglass No-Sand Primer. Sanding System - Sand with 80 grade (grit) paper. Remove sanding residue. Wipe with Fiberglass Solvent Wash 202. **BARE WOOD** Sand with 80 grade (grit) paper. Clean with Special Thinner 216. Apply first coat reduced 10% with Special Thinner 216. Fill seams, if necessary, with Seam Compound Brown 30. **EPOXY COATED WOOD** Begin by scrubbing well using soap and water and a stiff brush. Rinse with fresh water. Sand with 120 to 180 grade (grit) paper. Remove sanding residue. Wipe with Fiberglass Solvent Wash 202. Prime with Interprotect 2000E/2001E. **PREVIOUSLY PAINTED SURFACES** **with Trilux 33*** **or Trilux with Biolux** Sand with 80 grade (grit) paper. **OTHER ANTIFOULINGS** Sand surface, wipe clean. Prime with Primocon. Remove antifouling paint in poor condition with Interstrip Semi-Paste 299E.
Method	At least 2 coats should be applied.
Hints	**Thinner** Bare Wood - Special Thinner 216. **Thinning** Spray - Special Thinner 216.

Please refer to your local representative or visit www.yachtpaint.com for further information.

AkzoNobel

Ref:3425 Issue Date:6/8/2010

Trilux 33*
Antifouling
TBT Free Antifouling Paint for Aluminum

Interlux. yachtpaint.com

	Cleaner Bare Fiberglass - Fiberglass Solvent Wash 202. Bare Wood - Special Thinner 216. **Airless Spray** Pressure: 170-204 bar/2500-3000 psi. Tip Size: 0.53 mm/21 thou. **Conventional Spray** Pressure Pot: Pressure: 3.44-4.47 bar/50-65 psi (gun pressure); 10-15 psi (pot pressure). Tip Size: 1.8-2.2 mm/70-85 thou. **Other** Spraying of antifouling paints is prohibited in Canada. To prevent premature failure, ensure correct amount of paint is applied using the coverage as a guide.
Some Important Points	Product temperature should be minimum 10°C/50°F and maximum 29°C/85°F. Ambient temperature should be minimum 10°C/50°F and maximum 35°C/95°F. Substrate temperature should be minimum 10°C/50°F and maximum 29°C/85°F.
Compatibility/Substrates	Apply to clean, dry, properly prepared surfaces only. Surface must be dry and clean, and free from grease, detaching paint etc. Do not apply Trilux 33* directly to aluminum. All metal surfaces must be primed with Interprotect 2000E/2001E or Primocon. Do not apply to tin-based paint such as Micron® 33, 44 or Tri-Lux® II T.
Number of Coats	2Bare Wood: 3 coats (first thinned)
Coverage	(Theoretical) - 443.7 ft²/gal by brush
Recommended DFT	2 mils dry
Recommended WFT	3.6 mils wet
Application Methods	Airless Spray, Brush, Conventional Spray, Roller(Pressure Pot) . Spray application is recommended only for Professional Applicators that have all the proper safety equipment including a full-face shield.

TRANSPORTATION,STORAGE AND SAFETY INFORMATION

Storage	**TRANSPORTATION:** Trilux 33* should be kept in securely closed containers during transport and storage. **STORAGE:** Exposure to air and extremes of temperature should be avoided. For the full shelf life of Trilux 33* to be realised ensure that between use the container is firmly closed and the temperature is between 5°C/40°F and 35°C/95°F. Keep out of direct sunlight.
Safety	DISPOSAL: Container Disposal: Triple Rinse (or equivalent). Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill or by other procedures approved by state or local authorities. Pesticide Disposal: Open dumping is prohibited. Pesticide, spray mixture or rinsate that cannot be used or chemically reprocessed should be disposed of according to procedures approved by Federal, state, or local disposal authorities. GENERAL: Read the label safety section for Health and Safety Information, also available from our Technical Help Line. Contains biocides. Antifoulings should only be wet sanded. Never dry sand or burn-off old antifoulings. Spraying of antifouling paints is prohibited in Canada.
IMPORTANT NOTES	*The performance of any marine paint or coating depends on many factors outside the control of International Paint LLC., including surface preparation, proper application, and environmental conditions. Therefore, International Paint LLC. cannot guarantee this product's suitability for your particular purpose or application. IMPLIED WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE AND/OR MERCHANTABILITY ARE EXCEEDED. International Paint Inc. SHALL NOT, UNDER ANY CIRCUMSTANCES, BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES. By purchase of this product, the buyer agrees that the sole exclusive remedy, if any, is limited to the refund of the purchase price or replacement of the product at International Paint LLC. option.*

Please refer to your local representative or visit www.yachtpaint.com for further information.

Ref:3425 Issue Date:6/8/2010

Appendix 18: Trilux 33 Product MSDS

YBA060_A7

MATERIAL SAFETY DATA SHEET

Sales Order: {SalesOrd}

TRILUX 33 BLUE

MSDS Revision No: A7 – 1
MSDS Revision Date: 08/09/2008

Akzo Nobel Coatings
Interlux Yacht Finishes
2270 Morris Avenue
P. O. Box 386
Union, NJ 07083

EMERGENCY NUMBERS:

(800) 424–9300	CHEMTREC (USA)
(703) 527–3887	CHEMTREC (Intl)
(800) 854–6813	Poison Control Center
CUSTOMER SERVICE:	(Non–Emergency)
(800) 589–1267	International Paint
(800) 631–7481	Interlux

1. GENERAL INFORMATION

Product Identity: TRILUX 33 BLUE

Bulk Sales Reference No: YBA060

IMPORTANT: Read this MSDS before handling or disposing of this product, and provide this information to the employee, customers, and users of this product. PLEASE NOTE THE MSDS REVISION NUMBER AT THE TOP OF THIS PAGE. If the MSDS Revision Number posted at the top of this page does not match the MSDS Revision Number on the product label, please contact Customer Service at the phone number included above for the correct MSDS. This product is covered by the OSHA Hazard Communication Standard and this document has been prepared in accordance with requirements of this standard.

NOTICE: OSHA hazardous chemicals are listed in Section 2 if present at 1% or more. Carcinogens and extraordinarily/special hazardous chemicals are listed in Section 2 if present at .1% or more. Additional regulatory information for specific chemical categories is included in Section 15.

2. HAZARDOUS INGREDIENT INFORMATION

CAS No.	Ingredient Name & %	Source	Exposure Data
000100–41–4	Benzene, ethyl– 1.0 – 10% by Weight	OSHA:	100 ppm TWA; 435 mg/m3 TWA125 ppm STEL; 545 mg/m3 STEL
		ACGIH:	100 ppm TWA125 ppm STEL
		NIOSH:	100 ppm TWA; 435 mg/m3 TWA125 ppm STEL; 545 mg/m3 STEL800 ppm IDLH (10% LEL)
		Supplier:	No Established Limit
		OHSA, CAN:	100 ppm TWAEV; 435 mg/m3 TWAEV125 ppm STEV; 540 mg/m3 STEV
		Mexico:	100 ppm TWA; 435 mg/m3 TWA125 ppm STEL; 545 mg/m3 STEL
		Brazil:	78 ppm TWA; 340 mg/m3 TWA
		Source	Health Data
		NIOSH:	Eye skin
		Source	Carcinogen Data
		OSHA:	Select Carcinogen: Yes
		NTP:	Known Carcinogen: No; Suspected Carcinogen: No
		IARC:	Group 1: No; Group 2A: No; Group 2b: Yes; Group 3: No; Group 4: No

CAS No.	Ingredient Name & %	Source	Exposure Data
001111–67–7	Thiocyanic acid, copper(1+) salt 10 – 25% by Weight	OSHA:	No Established Limit
		ACGIH:	No Established Limit
		NIOSH:	No Established Limit
		Supplier:	No Established Limit
		OHSA, CAN:	No Established Limit
		Mexico:	No Established Limit
		Brazil:	No Established Limit
		Source	Health Data
		NIOSH:	No Established Limit
		Source	Carcinogen Data
		OSHA:	Select Carcinogen: No
		NTP:	Known Carcinogen: No; Suspected Carcinogen: No

YBA060_A7

		IARC:	Group 1: No; Group 2A: No; Group 2b: No; Group 3: No; Group 4: No

CAS No.	Ingredient Name & %	Source	Exposure Data
001314-13-2	Zinc oxide 10 - 25% by Weight	OSHA:	5 mg/m3 TWA (fume); 15 mg/m3 TWA (total dust); 5 mg/m3 TWA (respirable fraction)10 mg/m3 STEL (fume)
		ACGIH:	2 mg/m3 TWA (respirable fraction)10 mg/m3 STEL (respirable fraction)
		NIOSH:	5 mg/m3 TWA (dust and fume)10 mg/m3 STEL (fume)15 mg/m3 Ceiling (dust)500 mg/m3 IDLH
		Supplier:	No Established Limit
		OHSA, CAN:	2 mg/m3 TWAEV (respirable)10 mg/m3 STEV (respirable)
		Mexico:	5 mg/m3 TWA (fume); 10 mg/m3 TWA (dust)10 mg/m3 STEL (fume)
		Brazil:	No Established Limit
		Source	Health Data
		NIOSH:	Metal fume fever
		Source	Carcinogen Data
		OSHA:	Select Carcinogen: No
		NTP:	Known Carcinogen: No; Suspected Carcinogen: No
		IARC:	Group 1: No; Group 2A: No; Group 2b: No; Group 3: No; Group 4: No

CAS No.	Ingredient Name & %	Source	Exposure Data
001330-20-7	Xylenes (o-, m-, p- isomers) 10 - 25% by Weight	OSHA:	100 ppm TWA; 435 mg/m3 TWA150 ppm STEL; 655 mg/m3 STEL
		ACGIH:	100 ppm TWA150 ppm STEL
		NIOSH:	No Established Limit
		Supplier:	No Established Limit
		OHSA, CAN:	100 ppm TWAEV; 435 mg/m3 TWAEV150 ppm STEV; 650 mg/m3 STEV
		Mexico:	100 ppm TWA; 435 mg/m3 TWA150 ppm STEL; 655 mg/m3 STEL
		Brazil:	78 ppm TWA; 340 mg/m3 TWA
		Source	Health Data
		NIOSH:	Central nervous system depressant; respiratory and eye irritation
		Source	Carcinogen Data
		OSHA:	Select Carcinogen: No
		NTP:	Known Carcinogen: No; Suspected Carcinogen: No
		IARC:	Group 1: No; Group 2A: No; Group 2b: No; Group 3: Yes; Group 4: No

CAS No.	Ingredient Name & %	Source	Exposure Data
008047-99-2	ETHYLTOLUENESULFONAMIDE 1.0 - 10% by Weight	OSHA:	No Established Limit
		ACGIH:	No Established Limit
		NIOSH:	No Established Limit
		Supplier:	No Established Limit
		OHSA, CAN:	No Established Limit
		Mexico:	No Established Limit
		Brazil:	No Established Limit
		Source	Health Data
		NIOSH:	No Established Limit
		Source	Carcinogen Data
		OSHA:	Select Carcinogen: No
		NTP:	Known Carcinogen: No; Suspected Carcinogen: No
		IARC:	Group 1: No; Group 2A: No; Group 2b: No; Group 3: No; Group 4: No

CAS No.	Ingredient Name & %	Source	Exposure Data

YBA060_A7

CAS No.	Ingredient Name & %	Source	Exposure Data
008050-09-7	Rosin 10 – 25% by Weight	OSHA:	No Established Limit
		ACGIH:	No Established Limit
		NIOSH:	No Established Limit
		Supplier:	No Established Limit
		OHSA, CAN:	No Established Limit
		Mexico:	0.1 mg/m3 TWA (as Formaldehyde)
		Brazil:	No Established Limit
		Source	Health Data
		NIOSH:	No Established Limit
		Source	Carcinogen Data
		OSHA:	Select Carcinogen: No
		NTP:	Known Carcinogen: No; Suspected Carcinogen: No
		IARC:	Group 1: No; Group 2A: No; Group 2b: No; Group 3: No; Group 4: No

CAS No.	Ingredient Name & %	Source	Exposure Data
013463-41-7	Zinc pyrithione 1.0 – 10% by Weight	OSHA:	No Established Limit
		ACGIH:	No Established Limit
		NIOSH:	No Established Limit
		Supplier:	No Established Limit
		OHSA, CAN:	No Established Limit
		Mexico:	No Established Limit
		Brazil:	No Established Limit
		Source	Health Data
		NIOSH:	No Established Limit
		Source	Carcinogen Data
		OSHA:	Select Carcinogen: No
		NTP:	Known Carcinogen: No; Suspected Carcinogen: No
		IARC:	Group 1: No; Group 2A: No; Group 2b: No; Group 3: No; Group 4: No

CAS No.	Ingredient Name & %	Source	Exposure Data
013463-67-7	Titanium dioxide 1.0 – 10% by Weight	OSHA:	15 mg/m3 TWA (total dust)
		ACGIH:	10 mg/m3 TWA
		NIOSH:	5000 mg/m3 IDLH
		Supplier:	No Established Limit
		OHSA, CAN:	10 mg/m3 TWAEV (total dust)
		Mexico:	10 mg/m3 TWA (as Ti)20 mg/m3 STEL (as Ti)
		Brazil:	No Established Limit
		Source	Health Data
		NIOSH:	Lung tumors in animals
		Source	Carcinogen Data
		OSHA:	Select Carcinogen: Yes
		NTP:	Known Carcinogen: No; Suspected Carcinogen: No
		IARC:	Group 1: No; Group 2A: No; Group 2b: Yes; Group 3: No; Group 4: No

3. HAZARD IDENTIFICATION

Overview:	NOTICE: Reports have associated repeated and prolonged occupational overexposure to solvents with permanent brain and nervous system damage. Intentional misuse by deliberately concentrating and inhaling the contents may be harmful or fatal. Avoid contact with eyes, skin and clothing.
Inhalation:	Harmful if inhaled. May cause lung injury. Causes nose and throat irritation. Vapors may affect the brain or nervous system causing dizziness, headache or nausea.
Eyes:	Causes severe eye irritation. Avoid contact with eyes.
Skin:	Causes skin irritation. May cause delayed skin irritation. May be harmful if absorbed through the skin.

YBA060_A7

Ingestion:	Harmful if swallowed. May cause abdominal pain, nausea, vomiting, diarrhea, or drowsiness.		
Chronic Effects:	Possible cancer hazard. Contains an ingredient which may cause cancer based on animal data (See Section 2 and Section 15 for each ingredient). Risk of cancer depends on duration and level of exposure.		
HMIS Rating:	Health: Unknown	Flammability: Unknown	Reactivity: Unknown

4. FIRST AID MEASURES

General:	Remove contaminated clothing and shoes. Get medical attention immediately. Wash clothing before reuse. Thoroughly clean or destroy contaminated shoes.
Inhalation:	If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.
Eyes:	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention immediately.
Skin:	In case of contact, immediately flush skin with soap and plenty of water. Get medical attention immediately.
Ingestion:	If swallowed, immediately contact Poison Control Center at 1−800−854−6813. DO NOT induce vomiting unless instructed to do so by medical personnel. Never give anything by mouth to an unconscious person.

5. PROTECTIVE EQUIPMENT AND CONTROL MEASURES

Respiratory:	Select equipment to provide protection from the ingredients listed in Section 2 of this document. Ensure fresh air entry during application and drying. If you experience eye watering, headache or dizziness or if air monitoring demonstrates dust, vapor, or mist levels are above applicable limits, wear an appropriate, properly fitted respirator (NIOSH approved) during and after application. Follow respirator manufacturer's directions for respirator use. FOR USERS OF 3M RESPIRATORY PROTECTION ONLY: For information and assistance on 3M occupational health and safety products, call OH&ESD Technical Service toll free in U.S.A. 1−800−243−4630, in Canada call 1−800−267−4414. Please do not contact these numbers regarding other manufacturer's respiratory protection products. 3M does not endorse the accuracy of the information contained in this Material Safety Data Sheet.
Eyes:	Avoid contact with eyes. Protective equipment should be selected to provide protection from exposure to the chemicals listed in Section 2 of this document. Depending on the site−specific conditions of use, safety glasses, chemical goggles, and/or head and face protection may be required to prevent contact. The equipment must be thoroughly cleaned, or discarded after each use.
Skin/Hand:	Protective equipment should be selected to provide protection from exposure to the chemicals listed in Section 2 of this document. Depending on the site−specific conditions of use, protective gloves, apron, boots, head and face protection may be required to prevent contact. The equipment must be thoroughly cleaned, or discarded after each use.
Engineering Controls:	Prevent build−up of vapors by opening all windows and doors to achieve cross−ventilation.
Other Work Practices:	Emergency eye wash fountains and safety showers should be available in the immediate vicinity of any potential exposure. Use good personal hygiene practices. Wash hands before eating, drinking, using toilet facilities, etc. Promptly remove soiled clothing and wash clothing thoroughly before reuse. Shower after work using plenty of soap and water.

6. FIRE AND EXPLOSION INFORMATION

Flash Point:	F: 80 C: 27
Lower Explosive Limit (LEL):	1 (%vol in air) at Normal Atmospheric Temp and Pressure
Fire and Explosion Hazards:	Flammable liquid and vapor. FLAMMABLE/COMBUSTIBLE MATERIALS: Will be easily ignited by heat, sparks or flames. Vapors may form explosive mixtures with air. Vapors may travel to source of ignition and flash back. Most vapors are heavier than air. They will spread along ground and collect in low or confined areas (sewers, basements, tanks) creating a vapor explosion hazard. Runoff to sewers may create fire or explosion hazard. Containers may explode when heated.
Fire Fighting Procedures:	Also Reference Emergency Response Guide Number: Not Determined

7. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Liquid
pH:	No Established Limit
Specific Gravity:	1.567283
Boiling Point (F):	279

YBA060_A7

Vapor Density:	Heavier than air
VOC Content (lbs):	Refer to the Technical Data Sheet for this product.
Evaporation Rate:	Slower than ether

8. STABILITY AND REACTIVITY DATA

General:	This product is stable and hazardous polymerization will not occur. Not sensitive to mechanical impact. Excessive heat and fumes generation can occur if improperly handled.
Incompatible Materials:	Strong oxidizing agents.
Hazardous Decompostion:	May produce hazardous fumes when heated to decomposition as in welding. Fumes may produce Carbon Dioxide and Carbon Monoxide.

9. HANDLING AND STORAGE

Storage Temperature:	Store between 40–100F (4–38C).
Handling and Storage Precautions:	Keep away from heat, sparks and flame. Do not smoke. Extinguish all flames and pilot lights, and turn off stoves, heaters, electric motors and other sources of ignition during use and until all vapors are gone. Vapors may cause flash fire or ignite explosively. Prevent build–up of vapors by opening all windows and doors to achieve cross–ventilation. Avoid contact with eyes and clothing. Avoid prolonged or repeated contact with skin. Close container after each use. Wash thoroughly after handling.

10. TOXICOLOGICAL DATA

General:	NOTICE: Reports have associated repeated and prolonged occupational overexposure to solvents with permanent brain and nervous system damage. Intentional misuse by deliberately concentrating and inhaling the contents may be harmful or fatal. No additional information provided for this product. See Section 2 for chemical specific data.

11. ECOLOGICAL DATA

General:	No additional information provided for this product. See Section 2 for chemical specific data.

12. ACCIDENTAL RELEASE MEASURES

Spill Response Procedures:	ELIMINATE ALL IGNITION SOURCES (no smoking, flares, sparks or flames in immediate area). Use only non–sparking equipment to handle spilled material and absorbent. Do not touch or walk through spilled material. Stop leak if you can do so without risk. Prevent entry into waterways, sewers, basements or confined areas. A vapor suppressing foam may be used to reduce vapors. Absorb or cover with dry earth, sand, or other non–combustible material and transfer to containers. Use non–sparking tools to collect absorbed material.
Public Safety:	CALL CHEMTREC at (800)–424–9300 for emergency response. Isolate spill or leak area immediately for at least 25 to 50 meters (80 to 160 feet) in all directions. Keep unauthorized personnel away. Stay upwind. Keep out of low areas. Ventilate closed spaces before entering. LARGE SPILLS: Consider initial downwind evacuation for at least 300 meters (1000 feet). Also, Reference Emergency Response Guide Number: Not Determined

13. DISPOSAL CONSIDERATION

Waste Disposal:	Dispose of in accordance with local, state and federal regulations. (Also reference RCRA information in Section 15 if listed).

14. TRANSPORTATION INFORMATION

DOT (Domestic Surface Transportation)		IMO / IMDG (Ocean Transportation)	
DOT Proper Shipping Name: CONSUMER COMMODITY, ORM–D		IMDG Proper Shipping Name: Paint	
DOT Hazard Class:	NR	IMDG Hazard Class:	Flammable Liquid, 3

YBA060_A7

UN / NA Number:	Not Regulated	UN Number:	UN 1263
DOT Packing Group:	Not Regulated	IMDG Packing Group:	III
CERCLA/DOT RQ:	37 gal. / 487 lbs.	System Reference Code: 181	

15. REGULATORY INFORMATION

Regulatory Overview:	The regulatory data in Section 15 is not intended to be all–inclusive, only selected regulations are represented. All ingredients of this product are listed on the TSCA (Toxic Substance Control Act) Inventory or are not required to be listed on the TSCA Inventory. **Note:** Any chemical ingredients listed in Section 15, that do not also appear in Section 2, are contained in the product at a concentration below the applicable OSHA threshold level of 1% or 0.1%.
WHMIS Classification:	No Established Limit
Regulatory List	Product Ingredients on List
DOT Marine Pollutants (10%): (No Product Ingredients Listed)	
DOT Severe Marine Pollutants (1%): (No Product Ingredients Listed)	
EPCRA 311/312 Chemicals and RQs (>.1%) :	
000100–41–4	Benzene, ethyl– : 1000 lb final RQ; 454 kg final RQ
000080–62–6	Methyl methacrylate : 1000 lb final RQ; 454 kg final RQ
001330–20–7	Xylenes (o–, m–, p– isomers) : 100 lb final RQ; 45.4 kg final RQ
EPCRA 302 Extremely Hazardous (>.1%) : (No Product Ingredients Listed)	
EPCRA 313 Toxic Chemicals (>.1%) :	
000100–41–4	Benzene, ethyl–
000080–62–6	Methyl methacrylate
001330–20–7	Xylenes (o–, m–, p– isomers)
Mass RTK Substances (>1%) :	
000100–41–4	Benzene, ethyl–
013463–67–7	Titanium dioxide
001330–20–7	Xylenes (o–, m–, p– isomers)
001314–13–2	Zinc oxide
Mass Extraordinarily Haz Sub (>.01%) : (No Product Ingredients Listed)	
Penn RTK Substances (>1%) :	
000100–41–4	Benzene, ethyl–
013463–67–7	Titanium dioxide
001330–20–7	Xylenes (o–, m–, p– isomers)
001314–13–2	Zinc oxide
Penn Special Hazardous Substances (>.01%) : (No Product Ingredients Listed)	
Rhode Island Hazardous Substances (>.1%) :	
000100–41–4	Benzene, ethyl–
000080–62–6	Methyl methacrylate
013463–67–7	Titanium dioxide
001330–20–7	Xylenes (o–, m–, p– isomers)
001314–13–2	Zinc oxide
RCRA Status (%):	
007440–43–9	Cadmium : .00113
007439–92–1	Lead : .01351
N.J. RTK Substances (>1%) :	

000100–41–4	Benzene, ethyl–
013463–67–7	Titanium dioxide
001330–20–7	Xylenes (o–, m–, p– isomers)
001314–13–2	Zinc oxide
N.J. Special Hazardous Substances (>.01%) :	
000100–41–4	Benzene, ethyl–
007439–92–1	Lead
000080–62–6	Methyl methacrylate
001330–20–7	Xylenes (o–, m–, p– isomers)
N.J. Env. Hazardous Substances (>.1%) :	
000100–41–4	Benzene, ethyl–
000080–62–6	Methyl methacrylate
001330–20–7	Xylenes (o–, m–, p– isomers)
Proposition 65 – Carcinogens (>0%):	
007440–43–9	Cadmium
000100–41–4	Benzene, ethyl–
007439–92–1	Lead
014808–60–7	Quartz
Proposition 65 – Female Repro Toxins (>0%):	
007439–92–1	Lead
Proposition 65 – Male Repro Toxins (>0%):	
007440–43–9	Cadmium
007439–92–1	Lead
Proposition 65 – Developmental Toxins (>0%):	
007440–43–9	Cadmium
007439–92–1	Lead

16. OTHER INFORMATION

The information and recommendations contained herein are based upon data believed to be correct. However, no guarantee or warranty of any kind, expressed or implied, is made with respect to the information contained herein. We accept no responsibility and disclaim all liability for any harmful effects which may be caused by exposure to our products. Customers/users of this product must comply with all applicable health and safety laws, regulations, and orders.

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IMPORTANT NOTE The information in this data sheet is not intended to be exhaustive and is based on the present state of our knowledge and on current laws: any person using the product for any purpose other than that specifically recommended in the technical data sheet without first obtaining written confirmation from us as to the suitability of the product for the intended purpose does so at his own risk. It is always the responsibility of the user to take all necessary steps to fulfill the demands set out in the local rules and legislation. Always read the Material Data Sheet and the Technical Data Sheet for this product if available. All advice we give or any statement made about the product by us (whether in this data sheet or otherwise) is correct to the best of our knowledge but we have no control over the quality or the condition of the substrate or the many factors affecting the use and application of the product. Therefore, unless we specifically agree in writing otherwise, we do not accept any liability whatsoever for the performance of the product or for any loss or damage arising out of the use of the product. All products supplied and technical advice given are subject to our standard terms and conditions of sale. You should request a copy of this document and review it carefully. The information contained in this data sheet is subject to modification from time to time in the light of experience and our policy of continuous development. It is the user's responsibility to verify that this data sheet is current prior to using the product.

Head Office

International Paint, LLC, 6001 Antoine Drive, Houston, Texas 77091. http://www.international–pc.com or http://www.international–marine.com

End Of Document

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16. Abstract (Limit: 200 words)

The R/V Oceanus, on Cruise 475, carried out the deployment of three moorings for the Coastal and Global Scale Nodes (CGSN) Implementing Organization of the NSF Ocean Observatories Initiative. These three moorings are prototypes of the moorings to be used by CGSN at the Pioneer, Endurance, and Global Arrays. Oceanus departed from Woods Hole, Massachusetts on September 22, 2011 and steamed south to the location of the mooring deployments on the shelf break. Over three days, September 23-25, Oceanus surbeyed the bottom at the planned mooring sites, deployed the moorings, and carried out on site verification of the functioning of the moorings and moored hardwrd. Oceanus returned to Woods Hole on September 26, 2011.

17. Document Analysis a. Descriptors

moorings
real-time system
OOI CGSN AST2

b. Identifiers/Open-Ended Terms

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