A Sentinel Buoy Information System for Real-time Water Quality Monitoring in Estuarine and Coastal Environments

[1]Andrew Barnard, [2]Ru Morrison, [3]Scott McLean, [4]Brian Smith

[1]WETSAT Inc., PO Box 518, Philomath, OR, 97370, andrew.barnard@wetsat.com
[2]Coastal Observing Center, University of New Hampshire, Durham, NH, 03824, Ru.Morrison@unh.edu
[3]WETSAT Inc., 3481 Marginal Road, Halifax, NS, Canada, B3K 5X8, scott.mclean@wetsat.com
[4]Great Bay NERR, 225 Main Street, Durham, NH, 03824, bsmith@nhfgd.org

Impetus for project

- Overlapping goals for enhanced, real-time monitoring of water quality in Great Bay and nearshore coastal waters.
- University of New Hampshire – Coastal Ocean Observing Center
  - Development and implementation of an ocean observing system for the Western Gulf of Maine ecosystem.
  - Research on the coastal system of interacting riverine, estuarine, nearshore and offshore waters and their ecosystems.
  - Improve spatial and temporal coverage in water quality parameters currently monitored.
- Great Bay National Estuarine Research Reserve– managed by the New Hampshire Fish and Game Department
  - Resource management of the Reserve resources, including seagrass beds, benthic communities, and monitoring of water quality
- Jackson Estuarine Laboratory (UNH) – University of New Hampshire
  - Collecting water quality data since 1960, and for NERRs since 1995

Integrated Ocean Observing System

- Envisioned coastal component designed to detect, assess, and predict the effects of weather, climate, and human activities on the state of the coastal ocean, its ecosystems and living resources and the US economy.
- Improving the coastal resource management through improved monitoring of geophysical, biological and chemical states of the pelagic and benthic environments.

"…contribute to developing ecosystem-based management capabilities by (1) improving remote sensing in nearshore environments by providing more in situ data for calibration and validation and by (2) establishing sentinel and reference stations…"

Ocean.US Report No. 9, draft of "The first U.S. integrated ocean observing system (IOOS) development plan", www.ocean.us

- Early demonstrations of the effectiveness of integration for generating useful products. Facilitate synergy between research and improvement in operational capabilities. Research and pilot projects represent the research and development end of the IOOS.

Core variables identified for IOOS

CORE VARIABLES	Weather & Climate	Marine Operations	Natural Hazards	National Security	Public Health	Healthy Ecosystems	Sustained Resources
Salinity	X	X	X	X	X	X	X
Temperature	X	X		X	X	X	X
Bathymetry	X	X	X	X	X	X	X
Sea Level	X	X	X	X		X	X
Surface waves	X	X	X	X	X	X	X
Surface currents	X	X	X	X	X	X	X
Ice distribution	X	X	X	X			
Contaminants				X	X	X	X
Dissolved Nutrients					X	X	X
Fish species						X	X
Fish abundance						X	X
Zooplankton species					X	X	X
Optical properties				X	X	X	X
Heat flux	X					X	X
Ocean color	X	X			X	X	X
Bottom character	X	X				X	X
Pathogens				X	X	X	X
Dissolved O_2						X	X
Phytoplankton species	X	X		X	X	X	X
Zooplankton abundance						X	X

Key parameters for Water Quality Monitoring:

- Salinity & temperature
- Currents & waves
- Dissolved nutrients
- Optical properties (light, chlorophyll, turbidity and cDOM)
- Dissolved oxygen

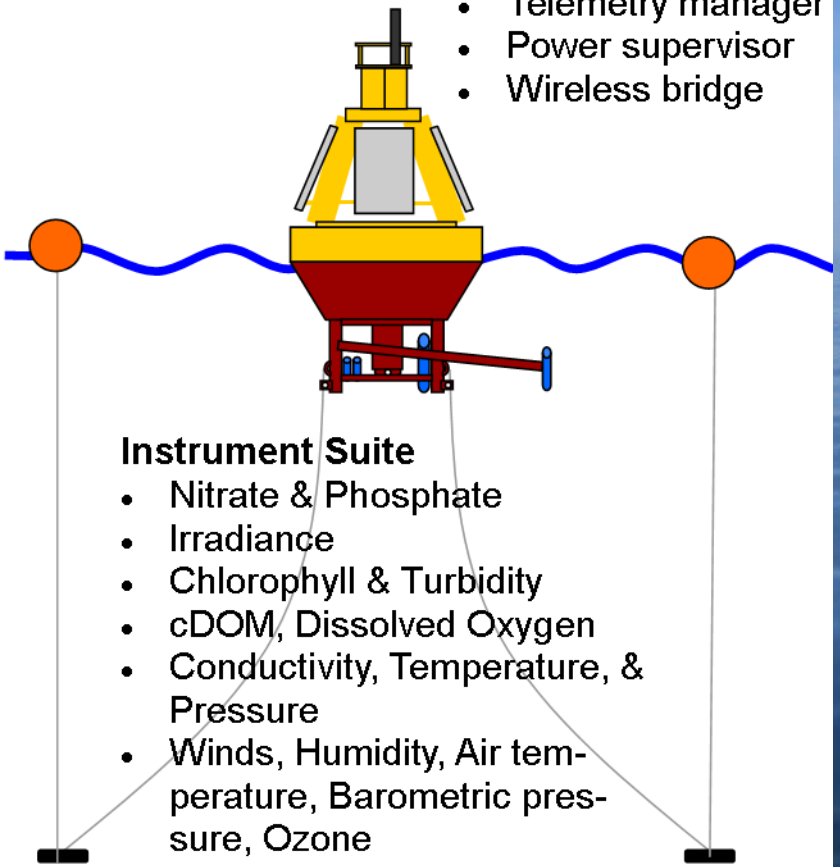
Taken from “The first U.S. integrated ocean observing system (IOOS) development plan”, draft copy, National Ocean Research Leadership Council, Ocean.US Report N0. 9, www.ocean.us.

System configuration

BUOY-SIDE STATION

Buoy Platform
- Solar panel array
- Battery panel
- Charge & load controller

Buoy control system
- Mooring System Manager
- Node manager
- Telemetry manager
- Power supervisor
- Wireless bridge



Instrument Suite
- Nitrate & Phosphate
- Irradiance
- Chlorophyll & Turbidity
- cDOM, Dissolved Oxygen
- Conductivity, Temperature, & Pressure
- Winds, Humidity, Air temperature, Barometric pressure, Ozone

SHORE-SIDE STATION

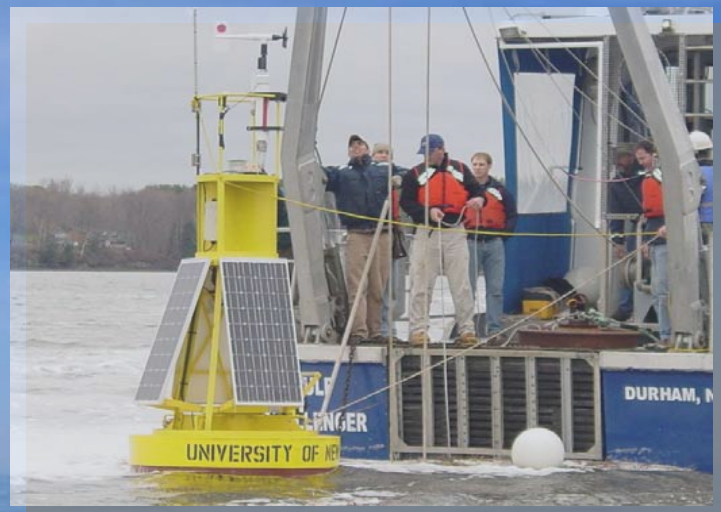
Jackson Estuarine Laboratory, UNH

Telemetry
- Wireless bridge

Shore-side control system
- DACNet RC2
- Telemetry handling
- Sampling scheduling
- Web interface
- Instrument configuration
- XML base metadata

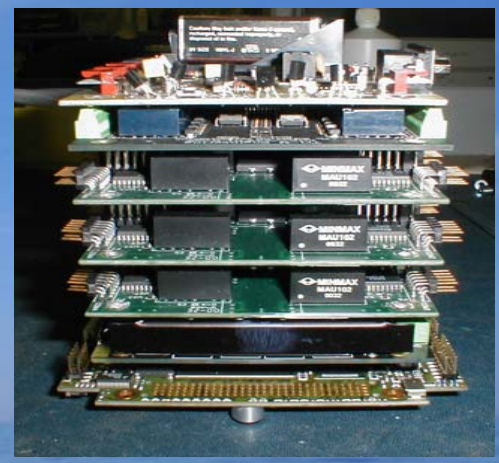
Buoy System

- Mooring Systems Inc Guardian 2000 buoy
- 1.9 m Aluminum superstructure
  - solar panels, radar reflector
  - sensor and data system mounting
- Small compact system for shallow water deployment and servicing from small vessels.
- Three 80 W solar panels
- 250 AH battery panel
- Satlantic Charge & Load Controller
  - Charges battery panel from solar panel
  - Voltage and temperature monitoring
- Bi-moored deployment design



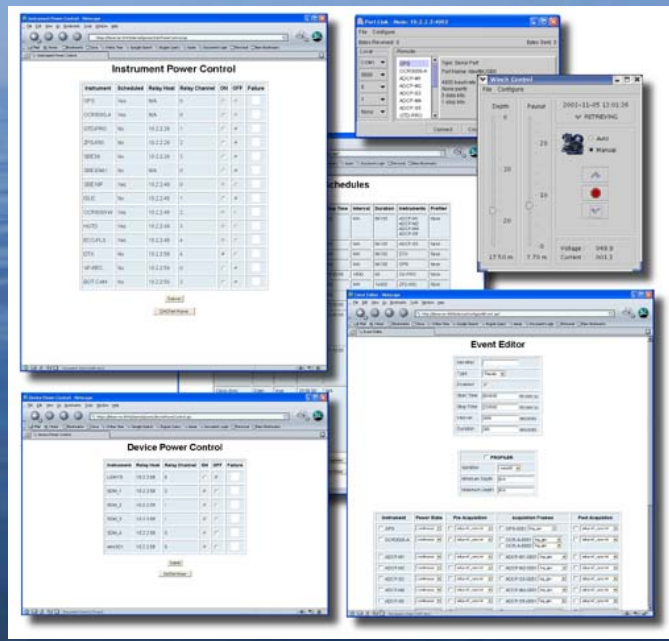
Buoy Data System

- Satlantic Mooring System Manager (MSM)
- PC104 computer running Linux
- Mounted in water resistant enclosure
- 12 serial data ports, 16 power channels
- Scalable: additional serial/power ports
- 1 GB hard drive for data storage
- Node Manager Software: 3 operating modes
  - Acquisition: runs scheduled program, manages data and power resources
  - Telemetry: connects with shore side server for data uploads and schedule maintenance.
  - Maintenance: Allow user to remotely access file system and buoy resources for system maintenance or system testing over TCP.



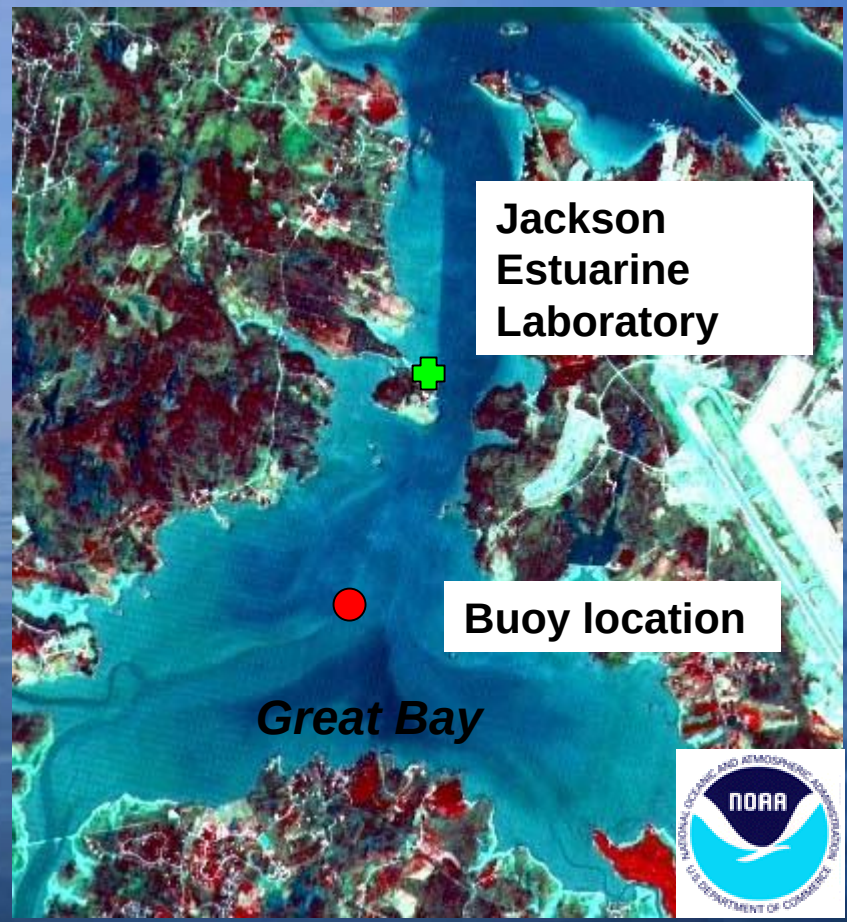
Shore-side Data System

- Satlantic Data Acquisiton and Control Network (DACNet) software
- Installed on Linux computer system
- Web browser operator interface
- XML based metadata
- Station Manager module
  - Provide the shore based system operator with real-time remote control
  - Scheduling and monitoring of instruments and systems on the buoy
  - Direct connection to individual serial instruments
- The Telemetry Manager
  - executes scheduled data acquisition from the buoy
  - uploads new configuration and schedules to the buoy's MSM system.



Telemetry

- Wireless network bridge using 802.11 protocols
- Cisco BR350: up to 11 Mbits/s
- Telemetry range buoy to shore: ~2.2 km
- Buoy:
  - 5.2 dBi omni-directional antenna mounted on top of buoy
  - Cisco wireless bridge mounted in water-tight enclosure
  - Connected to the MSM via a wet-pluggable Ethernet cable.
- Shore station:
  - Wireless bridge inside Jackson Estuarine Laboratory
  - 21 dBi 60cm parabolic dish antenna mounted on top of JEL



Above Water Instrumentation

- Meteorological - WeatherPAK 2000 Coastal Environmental Systems
  - Winds
    - 0-60 m/s, 0.1 m/s res.
  - Compass
    - 360^{o}, 0.1^{o} res.
  - Barometric pressure
    - 500-1200 hPa, 1 hPa res.
  - Relative humidity
    - 0-100% range, 1% res.
  - Air Temperature
    - -30 to 60^{o} C, 0.1^{o} C res.
- Atmospheric – University of New Hampshire Ozone prototype sensor

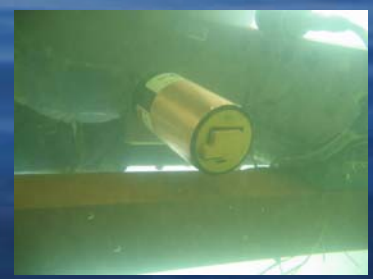
In Water Instrumentation

- CTD – Sea-Bird Electronics SBE37-SIP
  - Conductivity: 0-7 S/m, 0.00001 S/m res.
  - Temperature: -5 to 35° C, 0.0001° C res.
  - Pressure: 0-100m, 0.002% full scale res.

- Dissolved oxygen – Aanderaa Oxygen optode 3835
  - 0-500 μM, < 1μM res.

- Downwelling irradiance – Satlantic HyperOCR
  - bandwidth range 350-800 nm, 10 nm spectral resolution
  - 0-13.5 μW cm^{-2} nm^{-1}, 1.5 x 10^{-3} μW cm^{-2} nm^{-1} res.

- Nitrate – Satlantic ISUS V2
  - range 0.5 to 2000 uM, 2 uM accuracy
- Chlorophyll & Turbidity – WET Labs FLNTUS
  - Chl: 0 – 50 μg/L, 0.012 μg/L res.
  - NTU: 0 – 25 NTU, 0.01 NTU res.



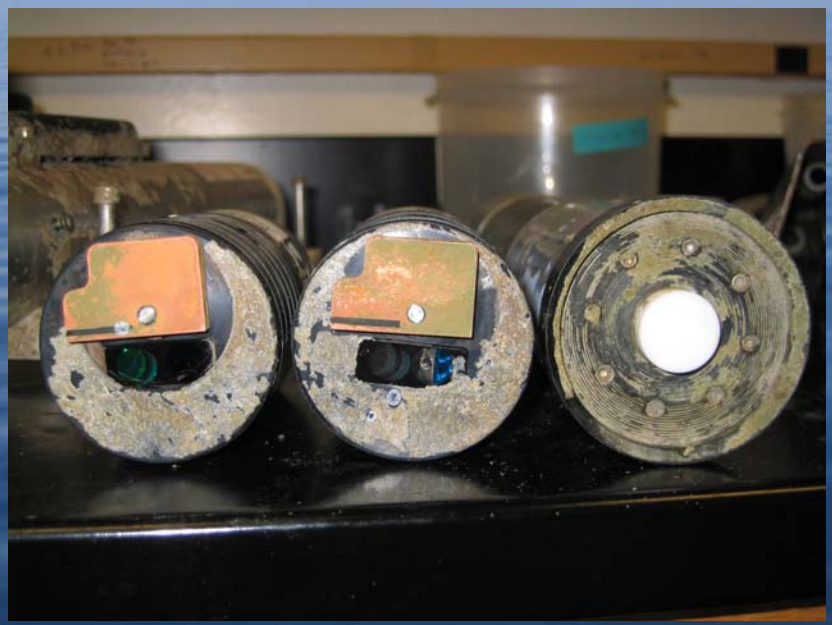
- cDOM – WET Labs FLCDS
  - 0.25 to 300 ppb (QSE), 0.25 ppb res.
- Prototype Phosphate sensor – WET Labs CYCL-P

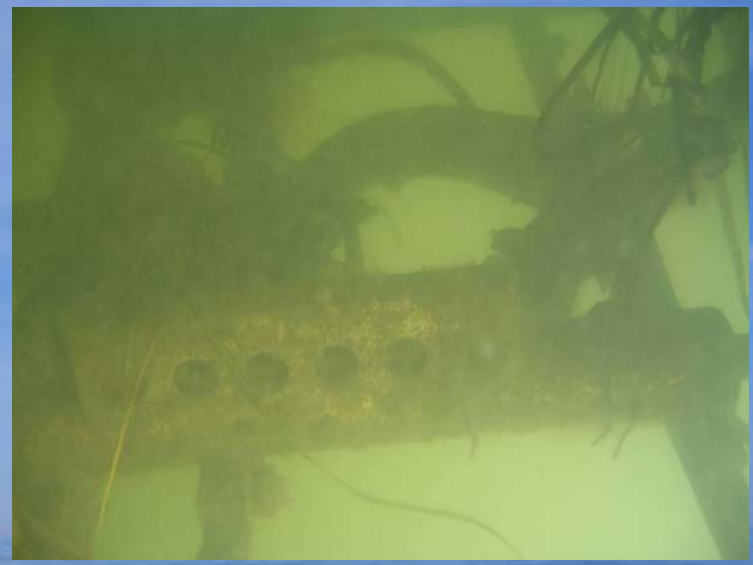
Timeline Deployments

- Built and constructed winter 2004 to 2005
- Components delivered April 2005
- First Deployment – April 28
- First Recovery – August 9
- Second Deployment – August 26
- Recovery – before ice
- Diver servicing operations: maintenance, deployment/recovery, cleaning
- Schedule: sampling every 30 minutes for most sensors

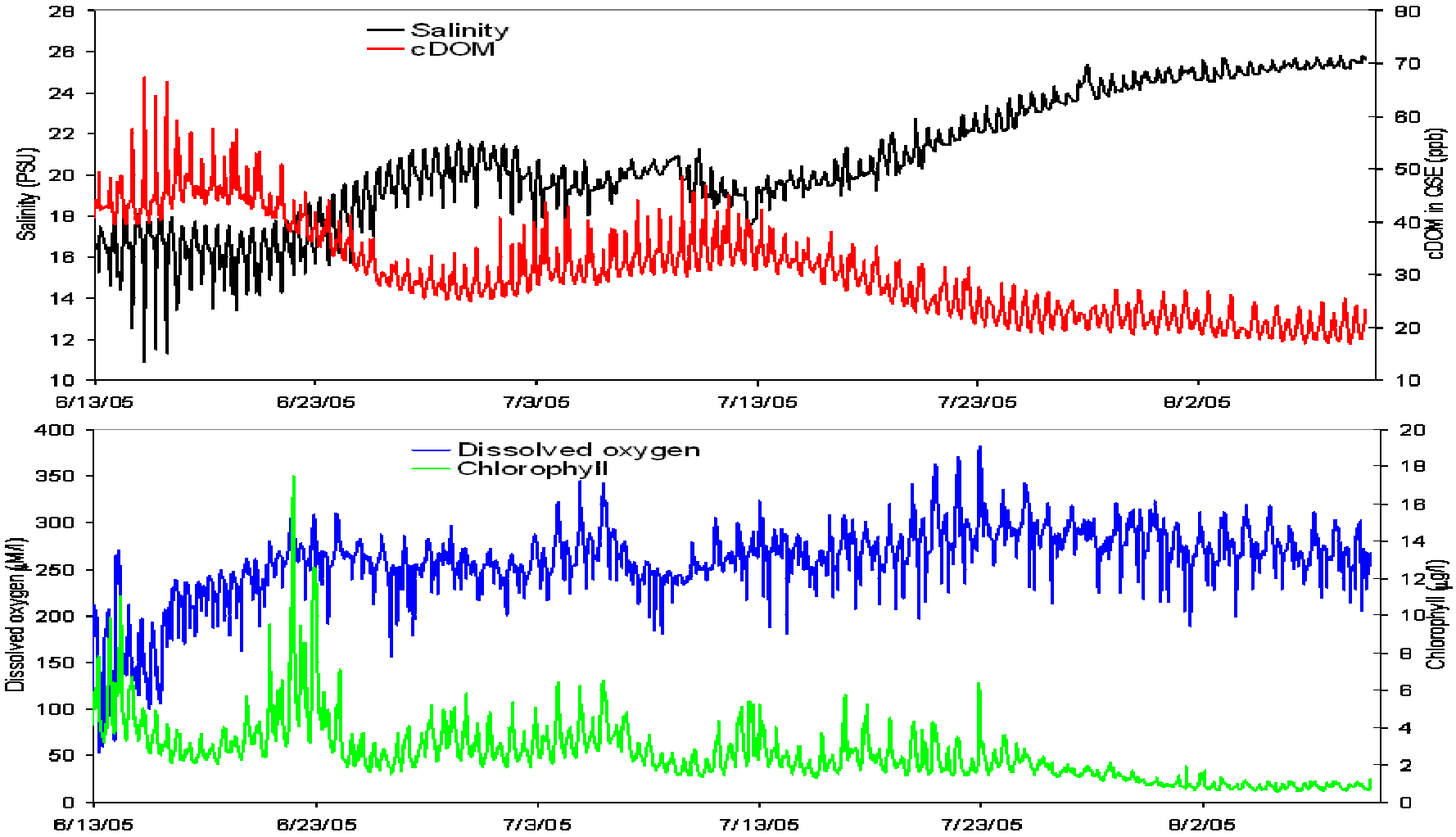
Anti-biofouling results

- First deployment -104 days
- Even with anti-fouling devices, some periodic cleaning necessary





Data from first deployment



Coastal Buoy - Netscape

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http://www.cooa-dev.sr.unh.edu/buoydata/buoy.jsp

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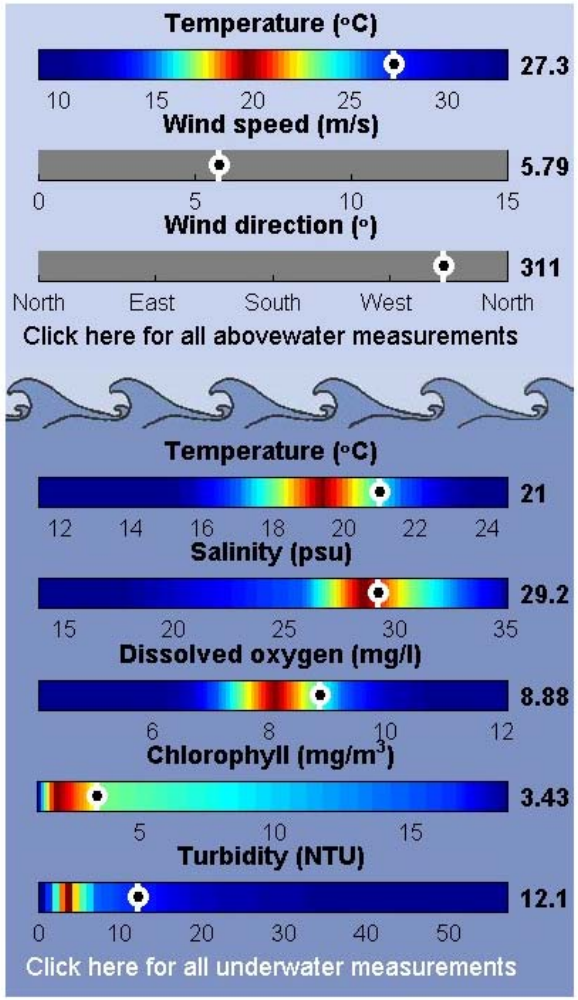
Great Bay Coastal Buoy

Recent observations at the Buoy (12-Sep-2005 17:00 UTC):



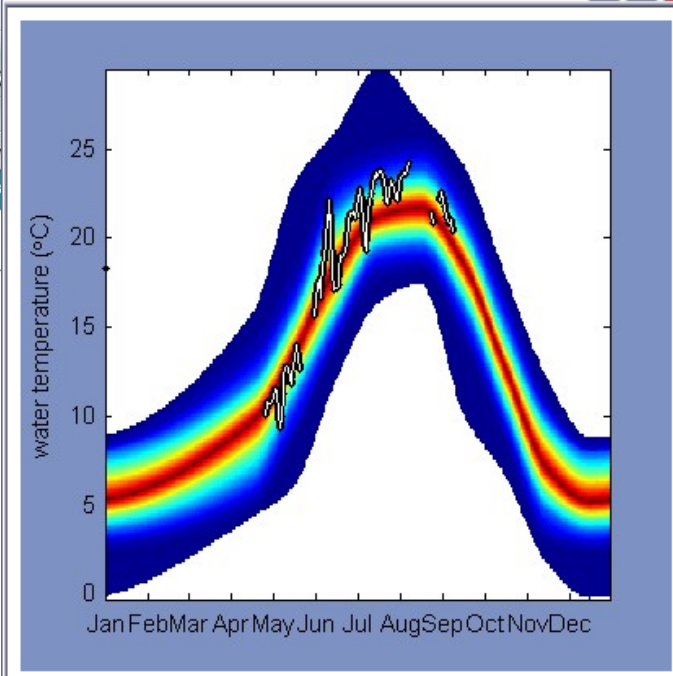
The **Great Bay Coastal Buoy** is located at 43.0716 degrees N and 70.8678 degrees W, near Portsmouth, NH. The buoy records a suite of measurements and these observations are updated regularly. The most recent observations are presented in the graph on the left; click the bar chart for each parameter to compare these current conditions to a 13 year historical average.

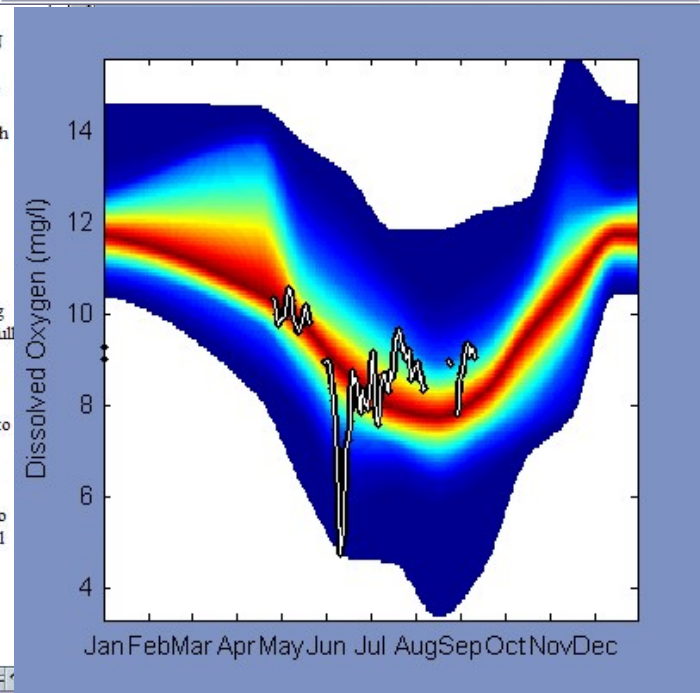
The Buoy This Week:

The buoy was redployed on Friday August 26, after a little rest and some hardware upgrades to allow further light measurements to be made. Unfortunately it stopped working the day after but was revived on the Monday and put into full working order on the last day of August. The figures to the left are (in theory) being updated on a regular basis but we need Ken-the-Programer to sort out some entropy issues (don't ask me exactly what that means - the files don't seem to transfer how they should is all I know).
Bill-the-other-Programer will shortly be adding the time and position information and then we might have a working observing system. Ru-the-boss-and-programer also needs to get his act into gear and finish generating all the plots in real time!!

Watch the video of the buoy recovery !

Netscape





Summary

- Brought together academia, resource managers, and industry to develop a scalable, nearshore buoy system
- High quality, high resolution measurements of a full suite of water quality and physical parameters
- Able to characterize coastal ecosystem components utilizing recently developed sensor and anti-fouling technology.
- Providing a test bed for new prototype sensors
- Providing real-time telemetry to shore using the latest wireless technology
- Implemented a shore-based data management system
- Generation of useable products through modeling and synthesis and consultation with interested partner groups (coastal management and education).

Future work

- Additional sensors:
  - Currents and Waves – Nortek Acoustic Wave and Current profiler (AWAC)
  - Light attenuation measurements – WET Labs C-Star, downwelling irradiance
- Upgrade to latest version of DACNet software
- Continued testing of prototype sensors (ozone and phosphate)
- Continued development of data products
- Web site improvements

Acknowledgements

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  - Ian Walsh, Alex Derr, WET Labs, Inc.