Recent Developments in NOAA's Real-Time Coastal Observing Systems for Safe and Efficient Maritime Transportation

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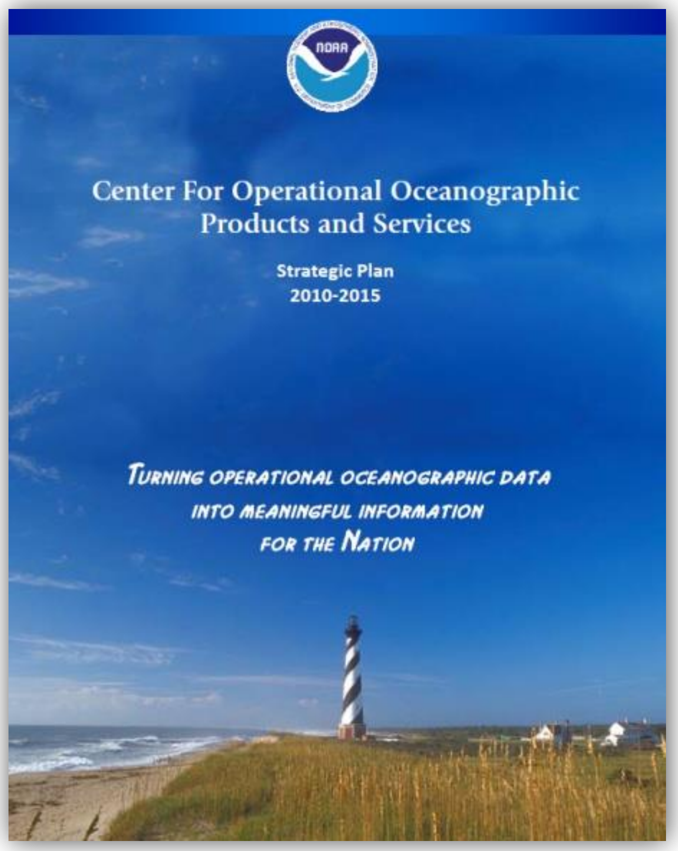
Center for Operational Oceanographic Products and Services (CO-OPS)

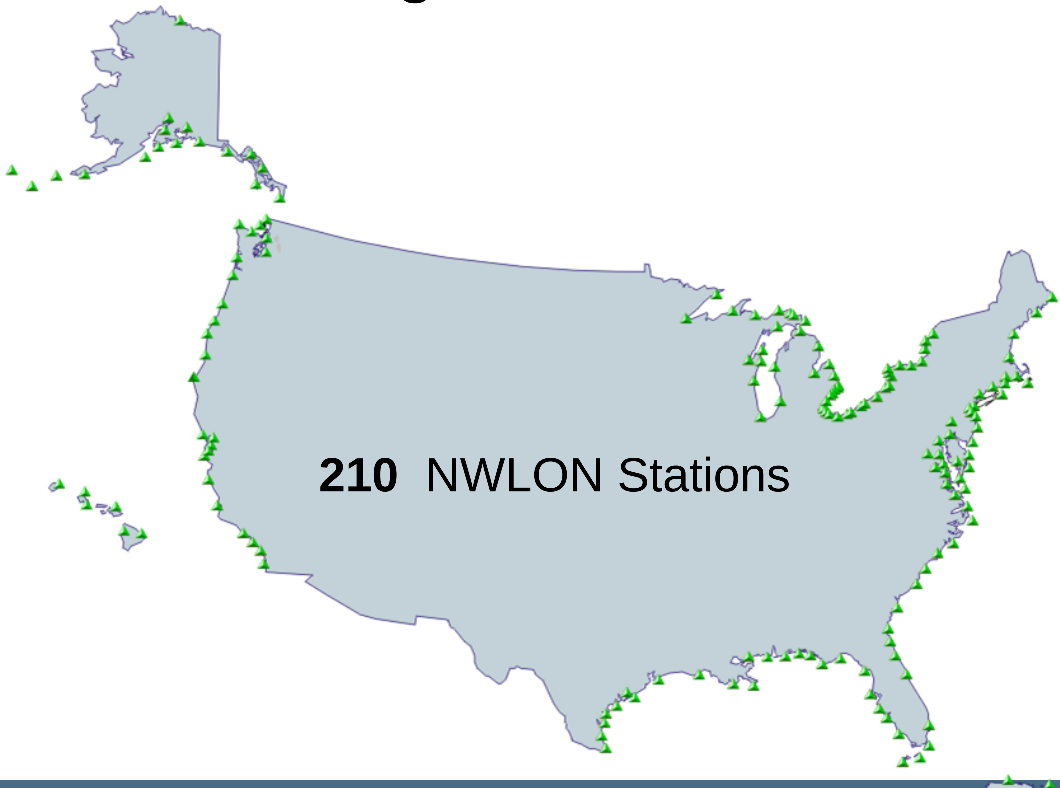
- The authoritative source for accurate, reliable, and timely tides, water levels, currents and other coastal oceanographic information
- Data, products and services support safe and efficient navigation, sound ecosystem stewardship, coastal hazards preparedness and response, and study of climate change
- Foundational geospatial data and tools for a resilient MTS



CO-OPS Observing Systems - NWLON

National Water Level Observation Network (NWLON)

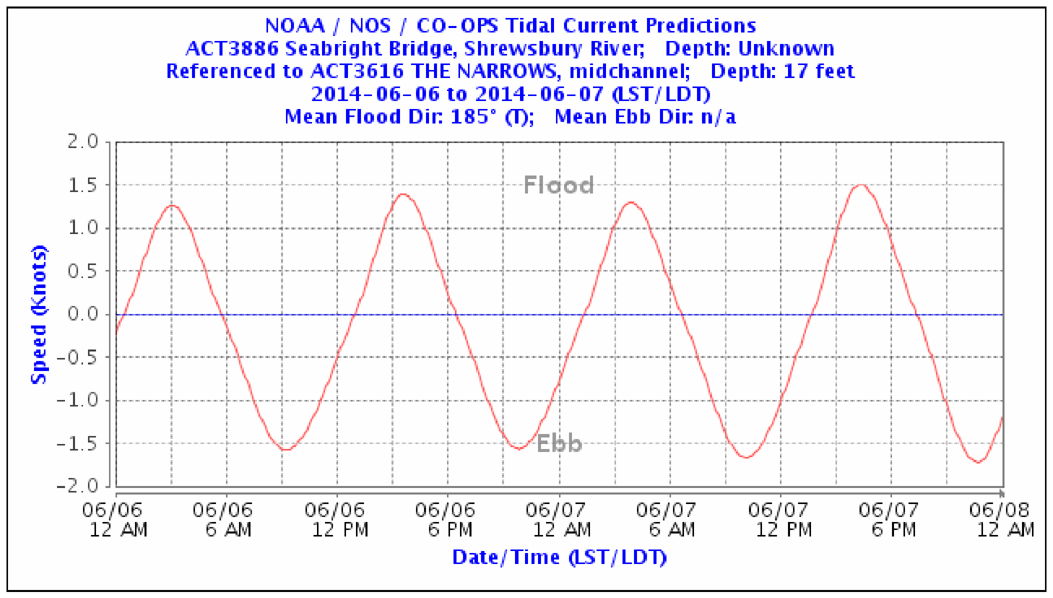
- Water level, air and water temperature, wind speed/direction, barometric pressure
- Long- and short-term stations



CO-OPS Observing Systems - NCOP

National Current Observation Program

- Collect, analyze, and distribute current observations
- Generate products and information to maintain and update the Nation's Tidal Current Tables

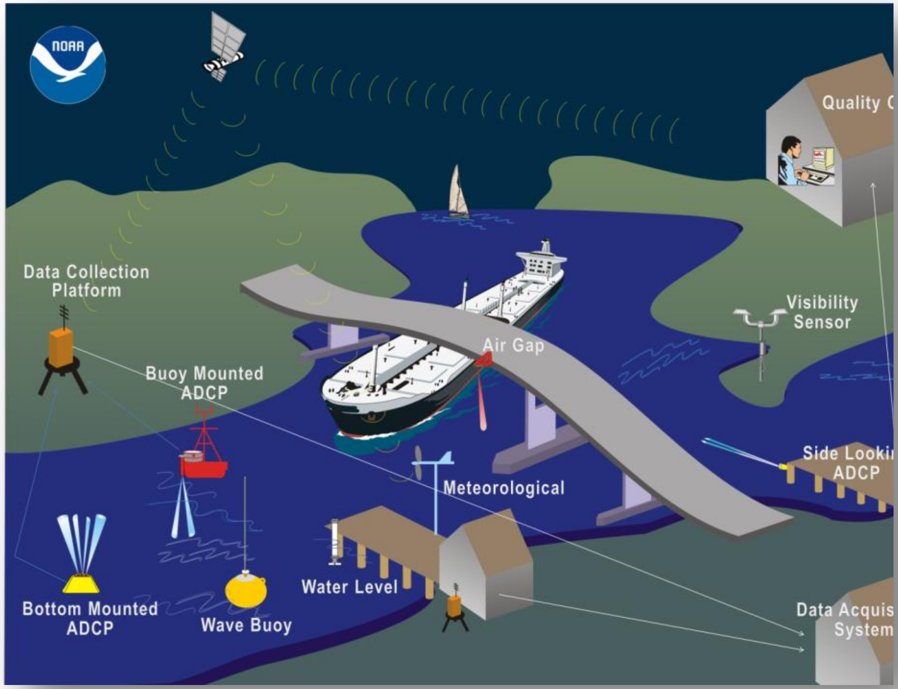


CO-OPS Observing Systems – PORTS®

Physical Oceanographic Real-Time Systems

Measures and disseminates real-time observations, forecasts, and predictions:

- Water levels
- Currents
- Salinity
- Air gap
- Meteorological parameters
- Visibility
- Waves



Physical Oceanographic Real-Time System®

PORTS®

Network Enhancements - New Sensor Technology

Air-Gap Bridge Clearance

Improving Air-Gap Measurement Systems

- PORTS® Air Gap established in 2005 used CWFM radar
- Water level system developments leveraged to identify a new, low power, pulse MW radar
- Significantly reduced cost and power requirements of system – improved data interface
- Laser range sensor for enhanced quality control

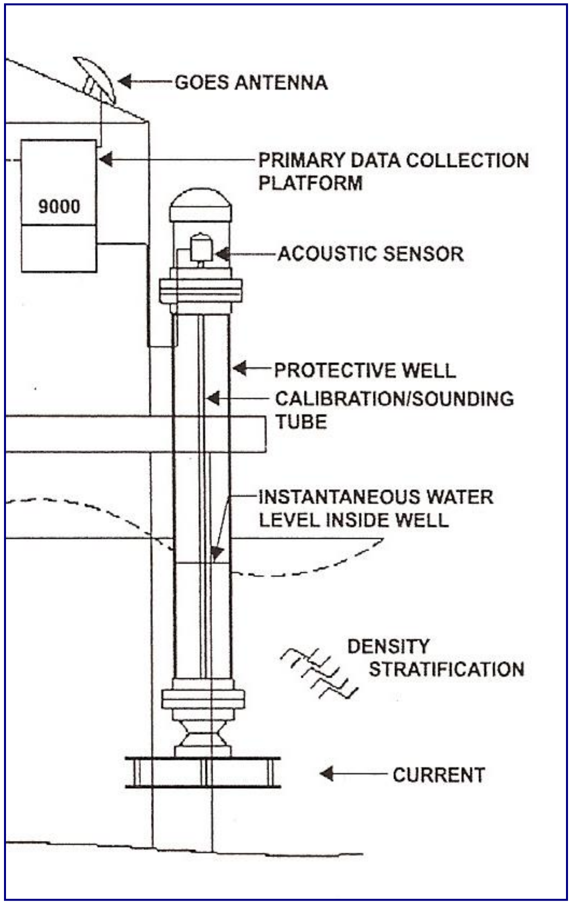
Early Air Gap in LA PORTS

New, low power, pulse radar system, Charleston PORTS, 2012

Network Enhancements - New Sensor Technology

Microwave Radar Water Level Sensors (MWWL)

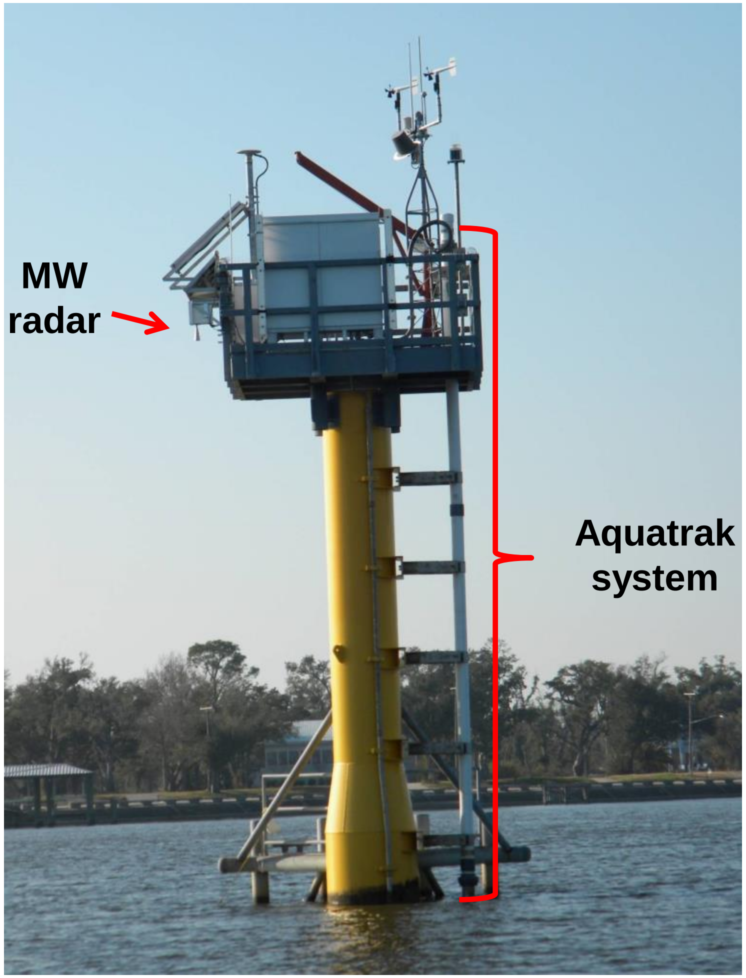
Aquatrak ®
acoustic sensor



Waterlog ®
microwave radar

- No contact with water
- Reduced size & hardware
- Low maintenance, low cost
- Longer life span
- No temperature dependence

NWLON 'Sentinel' station, St. Louis Bay, MS



Microwave Water Level Sensor

Initial test plan 2008

NOAA Technical Report NOS CO-OPS 052
Ocean Systems Test and Evaluation Program

Microwave Water Level Sensor Operational Capability Test and Evaluation Plan

Silver Spring, Maryland
October 2009

First phase of test results 2011

NOAA Technical Report NOS CO-OPS 061
Ocean Systems Test and Evaluation Program

Test and Evaluation Report

Limited Acceptance of the Design Analysis WaterLog® H-3611i Microwave Radar Water Level Sensor

Silver Spring, Maryland
March 2011

First step to transition to operations

Field Installation Guide

Field Installation Procedures for Design Analysis WaterLog® H3611i Microwave Radar Water Level Sensor Using the Sutron Data Collection Platform

Version 1.0

January 2013

Center for Operational Oceanographic Products and Services
Engineering Division

Microwave Water Level Transition to Operations (MWWL TOP)

WaterLog H-3611 Test Plan

Part II: Sensor Response to Dynamic Water Levels

Revision History		
Date	Editor	Reason
January 11, 2013	RMH	Initial draft
January 17, 2013	JP	Additions & revisions
January 23, 2013	RMH	Additions & revisions
January 24, 2013	JP	Revisions

Plan for phase II testing (high wave energy)

Microwave Water Level Phase II Analysis

Joseph Park *

*NOAA

National Ocean Service, Center for Operational Products and Services

Water level data from acoustic and microwave ranging sensors covering a period of 19 months at coastal tide stations on both the Atlantic and Pacific coasts are analyzed. Physical mechanisms are identified that contribute to errors in the acoustic system, primarily from undiagnosed temperature gradients and wave-induced water level draw-down. Water level comparison between the acoustic and microwave systems reveal that the majority of differences are accounted for by errors in the acoustic system. It is demonstrated that resonance of the protective well of the acoustic system can distort the spectral variance of water levels and that the microwave sensor captures water level variability with higher fidelity than the acoustic system when waves are present. Although the microwave system has limitations such as signal scattering and sidelobe interference, when temperature or wave forcings are present the microwave sensor is a more accurate water level gauge than the acoustic system.

Aquatrak | Microwave | Water Level Error

Introduction

orifice are known to draw-down or pile up water inside the well introducing another potential error [6].

From a logistical perspective, installation and maintenance of the protective well requires nontrivial infrastructure and yearly servicing including dive operations, and there is potential for the well to be damaged from flotsam or vessel impacts.

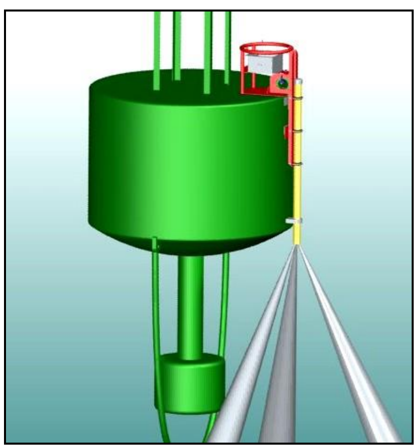
Wave Height Dependence. As surface wave amplitude increases there is an observed increase in water level standard deviation (σ), although the relationship has been viewed primarily as a source of error in the water level measurement [6, 7]. However, as part of the TOPEX/Poseidon validation experiments a direct relationship between significant wave height ($H_{1/3}$) and standard deviation was established [8, 9]. It was concluded that standard deviation of the NOAA water level estimate is a good first-order measure of significant wave height with the proviso that the protective well and low

First report of phase II testing (high wave energy)

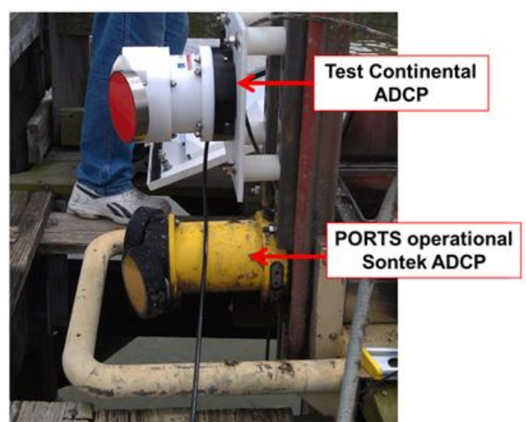
Network Enhancements - New Sensor Technology

New and Improved Current Measurement Technology

- Continue to test new ADCPs for use in both ATON buoy and land based systems – getting parameters observed where most needed by users
- Recent expiration of ADCP broadband patent results in broader range of COTS available acoustic currents and waves sensors
- More multi-frequency ADCP systems available for better spatial coverage




ATON ADCP system



New and improved side looker ADCPs


Bottom mounted ADCP

Network Enhancements - New Sensor Technology

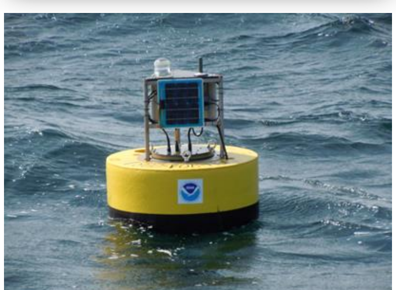
Real-Time Wave Measurement Systems

- Many PORTS® users have expressed significant interest in the addition of wave data and 2009 IOOS National Wave Plan – identifies significant gaps in wave observation coverage

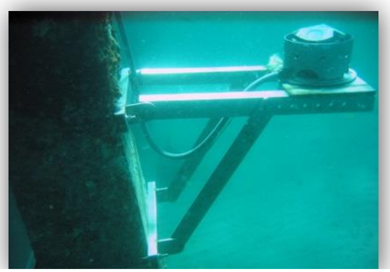
- CO-OPS collaborates with Scripps Institute of Oceanography Coastal Data Information Program (CDIP) to identify existing CDIP wave buoys within PORTS® regions

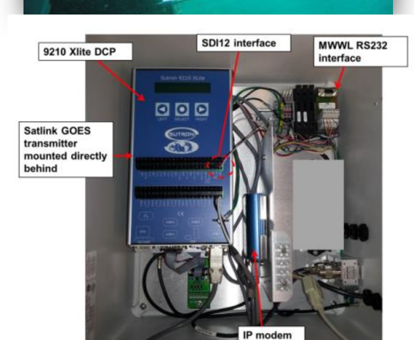
- CO-OPS is developing and testing real-time wave systems for use in regions where wave info is strongly desired; both subsurface acoustic and surface MWWL sensors

OFFSHORE SYSTEM
bottom mount + comms buoy

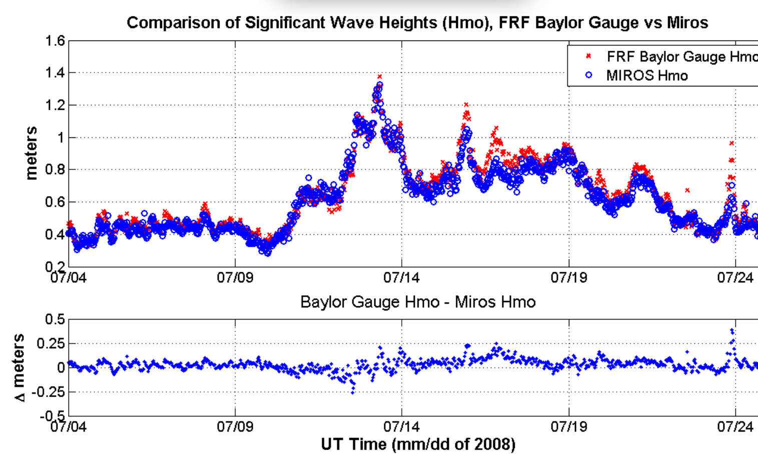


SHORE BASED SYSTEM 1
pier mounted, cabled sensor





SHORE BASED SYSTEM 2
MW radar water level sensors



Network Enhancements – Data Communications

Improved Real-Time Capability for PORTS Currents Stations

- Integration of ADCP and standard NOS Data Collection Platform (ADCPX) - enables redundant communications, remote control, and onsite data logging
- ADCP data transmitted real-time via GOES with wireless IP as backup
- Enables easy integration of additional ocean and met sensors at current stations

Network Enhancements – Data Communications

Iridium Satellite Communications

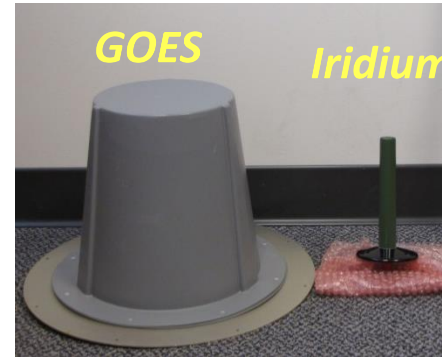
- **CO-OPS recently established DISA service – low cost**

- **Iridium Benefits**
  - *Small size, low power*
  - *Flexibility in transmit time and configuration*
  - *Global coverage*
  - *Potential to increase transmission frequency*

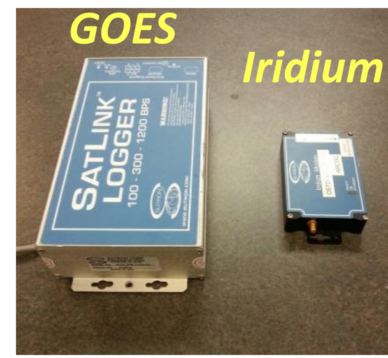
Current operational use

- *NWLON stations outside of GOES (Guam)*
- *Hydro support systems for Pacific NW*

Antennas



Transmitters

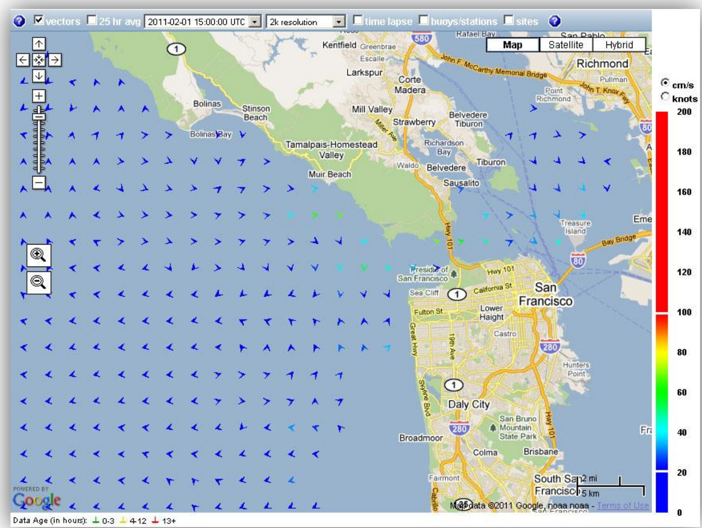


Portable Tide Gauge for Hydro Support in AK

Network Enhancements – Data Integration

High Frequency Radar Product Integration

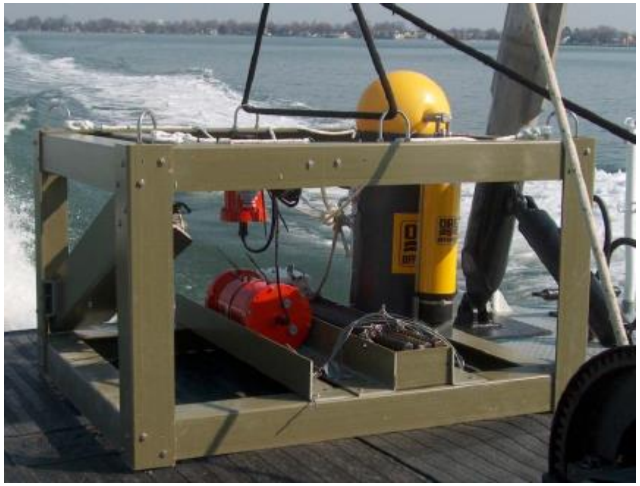
- IOOS Regional Associations operate network of High Frequency (HF) Radar
- New surface currents web product for MTS users released in May 2014
- Displays near real-time surface current observations and surface tidal current predictions
- Two locations: San Francisco Bay and Chesapeake Bay



http://tidesandcurrents.noaa.gov/hfradar/

Future Network Enhancements

Real-Time Offshore Water Level System for the Arctic



Tides under the Ice: Measuring Water Levels at Barrow, Alaska 2008-2010

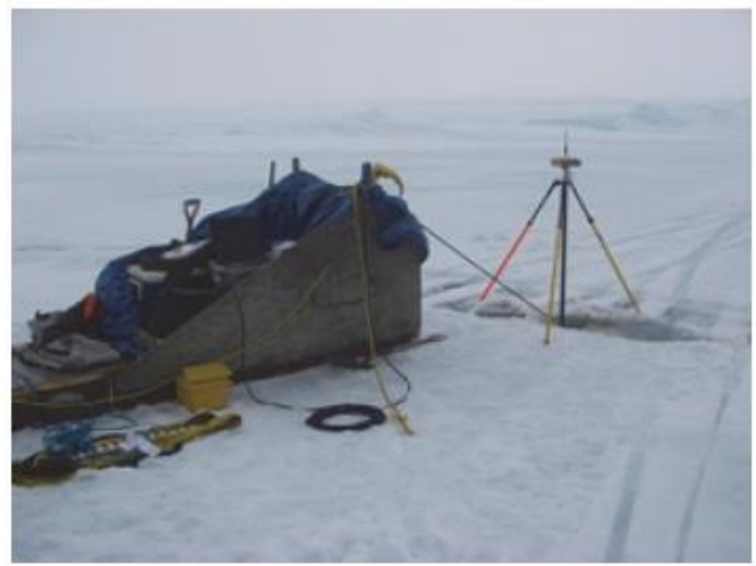


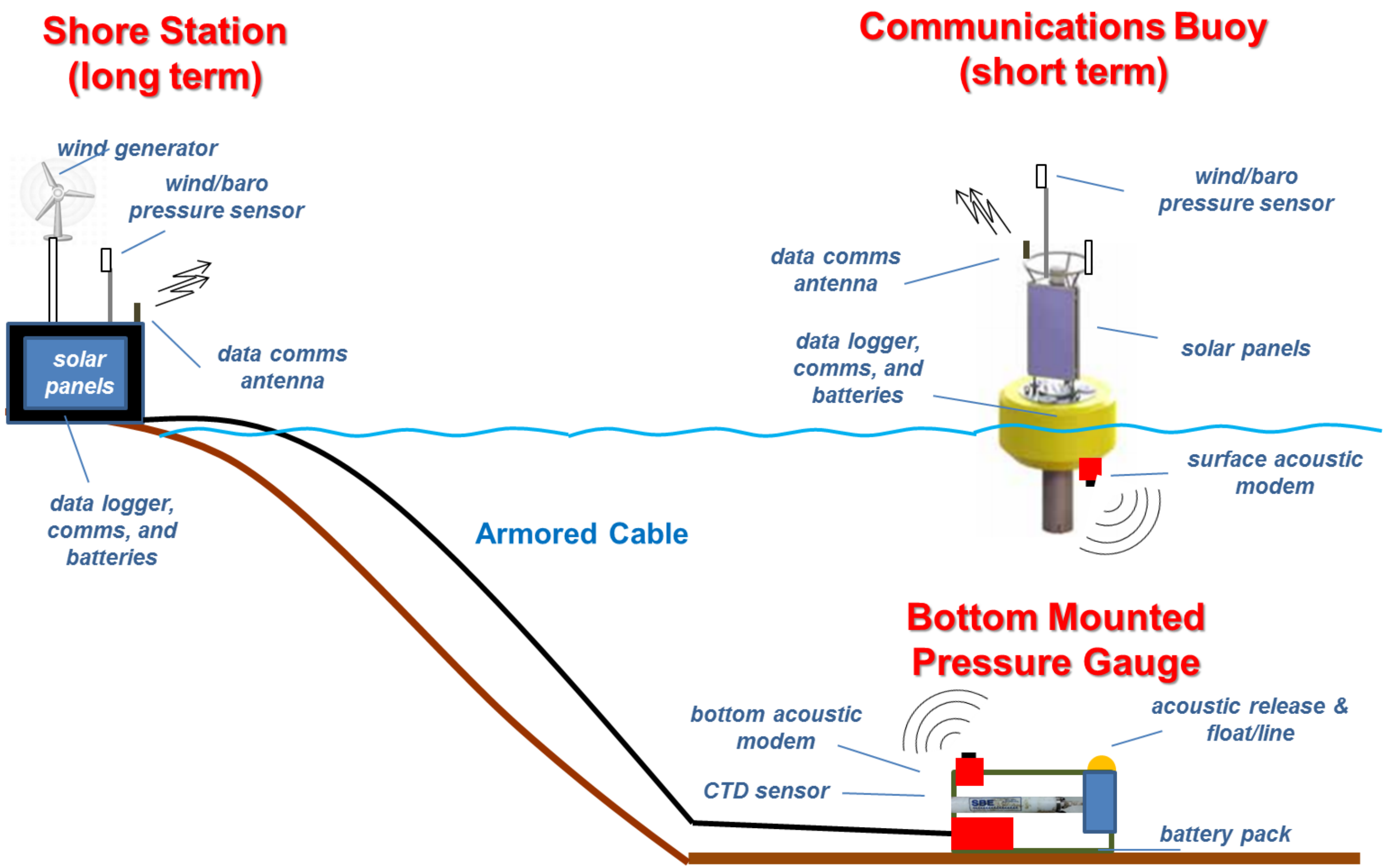
Figure 13a. Downloading tide data through the ice.

Future Network Enhancements

Real-Time Offshore Water Level System for the Arctic

Two real-time system designs now under development (to be field tested Aug'14)

1. ***Bottom Mount + Communications Buoy and acoustic link (short term)***
2. ***Bottom Mount + Share Station with cabled connection (long term)***



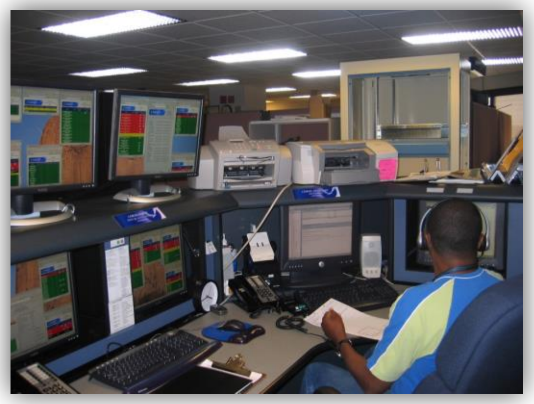
Conclusions

- Geospatial information infrastructure (data and tools) is foundational for a resilient MTS.
  - Saves lives and property as coastal hazards approach
  - Informs long term resiliency planning for near and long term hazards
- Innovative infusion of technology to continually evolve observing systems is essential to control costs, improve data utility, and address emerging needs.
  - Station reliability essential; redundancy, hardening, etc.
- Gaps: More observations needed on a cost effective basis.
  - Models can play a key complementary role
  - Salinity sensors that require less frequent cleaning
  - Data integration (IOOS, IOCM)
- Significant geospatial information gaps in arctic region.
  - Traditional technologies don't work in such a remote, challenging environment

Backup Slides

CO-OPS Observing System

Features of Typical Long Term Measurement Station



Measurement Systems

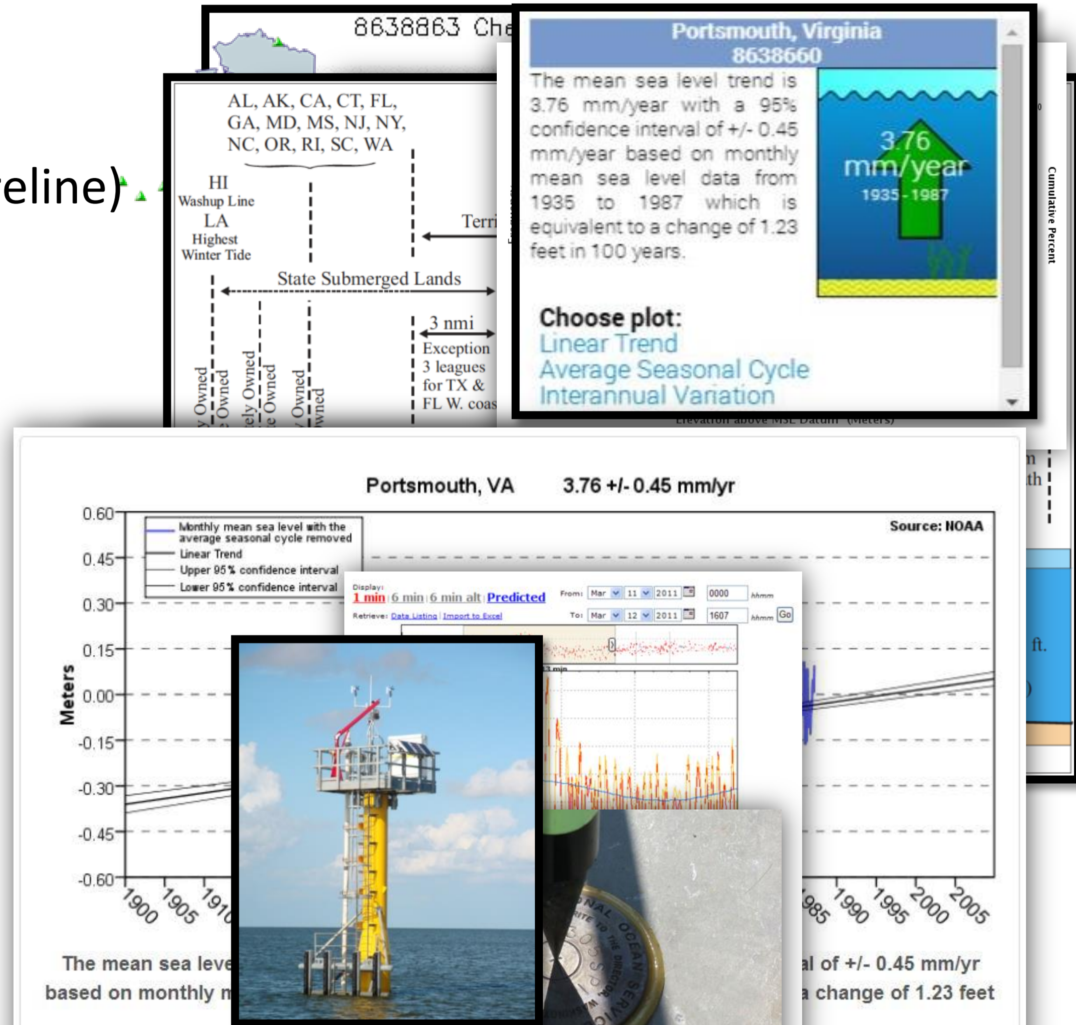
- Primary and backup water level systems (NWLON)
- Geodetic connection (NWLON)
- Data collection platform with onsite storage
- Multiple real-time communications (GOES, Iridium, Wireless IP, phone).
- 6 min sample rate and real-time transmission
- Field power

Data Management

- Continuous Quality control
  - *Automated flags*
  - *CORMS (24/7)*
  - *Routine processing QC and stability reviews*
- Product generation, dissemination, and data archival

CO-OPS Observing Systems - NWLON

- ✓ Vertical control / tidal datums
- ✓ Marine boundaries (charts, shoreline)
- ✓ Sea level trends
- ✓ Predictions
- ✓ Real-time data (navigation, storm surge, tsunami)
- ✓ Statistical tools
- ✓ Hydrodynamic models
- ✓ Coastal habitat restoration
- ✓ Research and education
- ✓ Local and national applications



NOAA Sentinel of the Coast Station

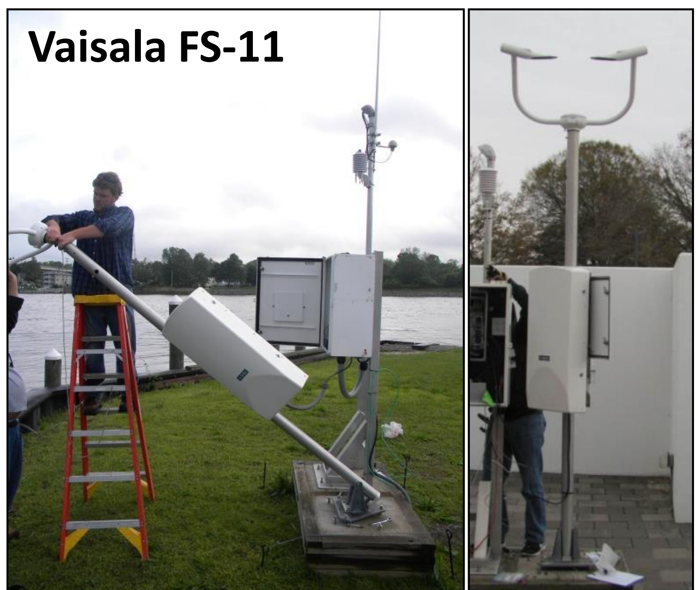
Network Enhancements - New Sensor Technology

Visibility Measurement Systems

Continued Development and Test of Optical Visibility Sensors

- CO-OPS partners with USACE and USCG to test and evaluate visibility sensors
- First PORTS® visibility systems established in 2010 (Mobile Bay, AL) ; Vaisala FS-11
- Smaller, low cost, low power version of sensor (PWD20) recently tested and approved
- PWD20 will allow installation at remote sites, increased coverage of measurements.

Test Bed at USACE FRF, Duck, NC



Vaisala FS-11

Vaisala PWD-20

Network Enhancements - New Sensor Technology

Microwave Radar Water Level Sensors (MWWL)

Since 2011, CO-OPS has transitioned MWWL sensors to operations in 3 different applications:

1. *Existing long-term NWLON stations.*
2. *Temporary stations supporting hydrographic survey and VDatum*
3. *Newly constructed or rebuilt stations (NWLON and PORTS)*

Since 2011, MWWL sensors have been installed at:

- *More than 20 short term stations (hydrographic and VDatum support)*
- *6 existing long term NWLON stations for 1 year overlap*
- *6 new long term stations*

10-20 NWLON stations per year planned to receive MWWL upgrade ; 3 year cycle per station.

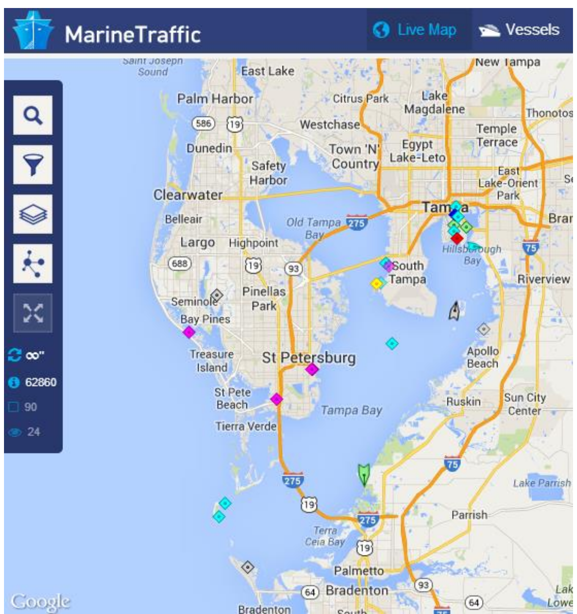
- *Year 1- Equipment purchase, recon and design*
- *Year 2 – Installation of MWWL sensor and collection of 1 yr overlapping data record*
- *3rd year – Removal of legacy primary sensor and components (well)*

Network Enhancements – Data Communications

PORTS® Data Transmitted over AIS

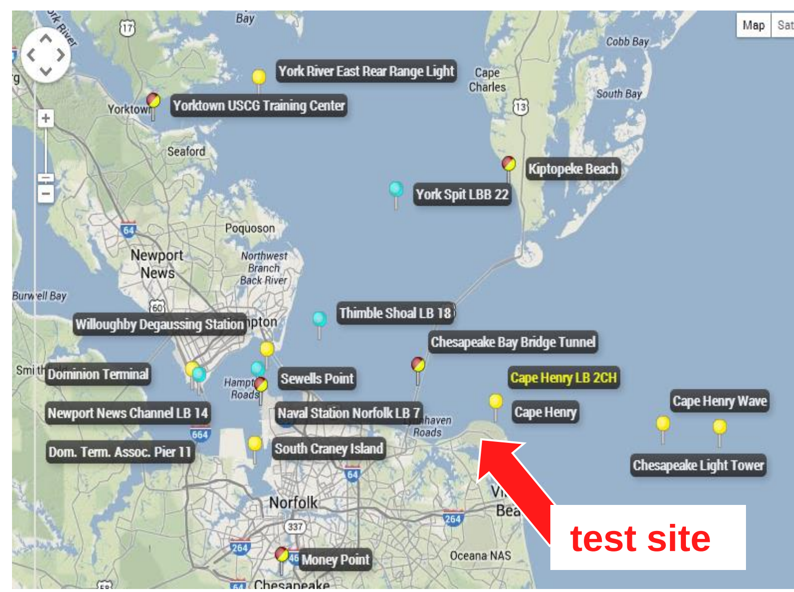
- CO-OPS worked with USCG to implement software required to send ocean/met data from main PORTS® database to AIS systems in Tampa Bay PORTS
- Currently developing standalone AIS system that CO-OPS can install along with PORTS measurement systems.
- PORTS/AIS system test planned for Cape Henry Light, VA (S Chesapeake Bay PORTS).

Tampa Bay, FL Vessel Tracking



Cape Henry Light

South Chesapeake Bay PORTS®



Summary

CO-OPS continues to develop and maintain over 300 long-term, real-time oceanographic and meteorological measurement stations across all of the Nation's coastlines.

CO-OPS invests in the continued research, development, test, and evaluation of new sensors and measurement system components to improve data quality and operating efficiency.

Recent developments and enhancements to CO-OPS' network include:

- Transition to MW radar water level sensors
  - lower cost, size, power, maintenance requirements
  - higher accuracy, resolution (waves), and lifespan
- Continued development and testing of new current sensors to reduce cost and improve accuracy and reliability or PORTS systems.
- Development of multiple wave measurement systems, both acoustic and MW radar.
- Expanding data communication capabilities through use of Iridium Satellite and AIS.

With anticipated increase in maritime traffic in high latitudes, one major focus on future network enhancements is developing a real-time offshore water level systems for the Artic.

- Prototype systems demonstrated in Barrow, AK.
- Next generation system with real-time communications to be tested Aug'14 .