Application of Subsea Wireless Technology to Environmental Monitoring

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***Abstract*— This paper will look at how wireless technology is being used to support and enable real time environmental monitoring techniques. The relative benefits of wired versus non wired systems will be considered and this will be illustrated with a real life example from a wireless environmental monitoring application.**

Of particular interest will be the Chesapeake Bay Interpretive Buoy System where wireless communication capability was designed into a surface buoy. Environmental monitoring data was transmitted wirelessly between a seabed sensor and a surface buoy using subsea wireless technology.

The Chesapeake Bay Interpretive Buoy System (CBIBS) program, operated by the NOAA Chesapeake Bay Office in Annapolis, MD, has a network of buoys to continuously monitor oceanographic and meteorological conditions in the Chesapeake Bay, the largest estuary in the United States. Data from the buoys, such as wind speed, temperature, and wave height could be used to inform and educate local users, who include mariners, kayakers and schools who can use the data to get a better understanding of their local marine environment and also provide long term trend data the about changes in the bay.

The specific example for the presentation was located at Dominion Gooses Reef, one of twenty artificial reef sites in the Chesapeake Bay area. Construction materials from a local project were relocated to the bay, To create a new habitat for the area's oyster population that has been devastated by decades of overharvest.

Keywords—seatooth, wireless, radio, buoy technology, water quality, Chesapeake bay

I. INTRODUCTION

The Chesapeake Bay Interpretive Buoy System (CBIBS) program operated by the US National Oceanographic Atmospheric Administration (NOAA) Chesapeake Bay Office in Annapolis, has a network of smart buoys continuously monitoring oceanographic and meteorological conditions in the Chesapeake Bay, the largest estuary in the United States [1].

Underwater wireless capability from WFS was integrated with AXYS Technologies buoy as part of a 4 year contract with NOAA for the ongoing monitoring of the bay.

The objective was to allow real - time water quality data to be transmitted wirelessly between seabed sensors and the surface buoy. The first subsurface transmitting buoy is located over Dominion Gooses Reef, one of twenty artificial reef sites in the Chesapeake Bay area covering 362 acres in the middle bay. Data from all the buoys in the bay, such as wind speed, temperature, and wave height, is used to inform and educate local users, who include mariners, kayakers and schools, to get a better understanding of their local marine environment and also provide long-term trend data the about changes in the bay.

FIGURE 1: Axys Technologies Watchkeeper Buoy

II. Gooses Reef Buoy

Both the reef itself and the buoy system are sponsored by the Maryland Artificial Reef Initiative and the Dominion Foundation (one of the USA's largest producers of energy) in a project to repopulate the oyster for which the Chesapeake area has been famous for generations. Construction materials from the old Woodrow Wilson Bridge in Washington, D.C. were recycled to build new reefs in the Bay [2].

The aim is to create a new habitat for the area's oyster population that has been devastated by decades of overharvest. Since the late 19th century, the eastern oyster has contributed millions of dollars to the region's economy as well as contributing to the health of the bay itself (an adult oyster can filter up to 50 gallons of water per day [3]). Approximately 75 tons of shell and about 25 bushels of oysters on the reef, with the goal of providing the new ecosystem a jump start. The oysters and shell were spread over a select portion of the 80-acre, man-made reef. Later in the spring the reef was seeded with juvenile oysters, called oyster spat [4].

FIGURE 2: Eastern Oysters. Image credit to Tom Pelton/CBF Staff.

The Gooses Reef buoy was the first to collect bottom water quality data. The data collected by the other smart buoys in the bay was meteorological, near-surface quality/temperature, wave height, current measurements

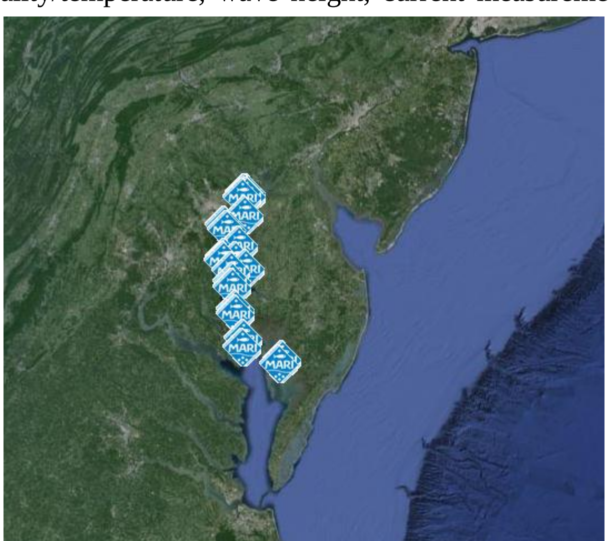

FIGURE 3: Google Map of Current MARI Reef Locations

and positioning. To monitor the conditions specifically pertinent to the oysters, the data needed to come from the bay floor. Even a moored buoy will drift from its station with the currents in the bay, so a cabled solution would be expensive to install and would potentially incur high maintenance costs if the cable were damaged.

III. SUBSEA WIRELESS SOLUTION

Enabling the water quality sensor with wireless capability and allowing it to talk to a drifting (moored) buoy, up to 30m away and use it as a relay for communications was the answer. The smart buoy was an Axys WatchKeeper™ 1.7 metre diameter rugged navigation buoy with a low maintenance hull. The WatchKeeper™ is powered by a configurable and expandable sensor I/O platform specifically designed for marine applications [5].

FIGURE 4: The topside WFS modem was mounted internal to the buoy hull, below the battery pack near the waterline deemed to be a safe location from fouling/corrosion.

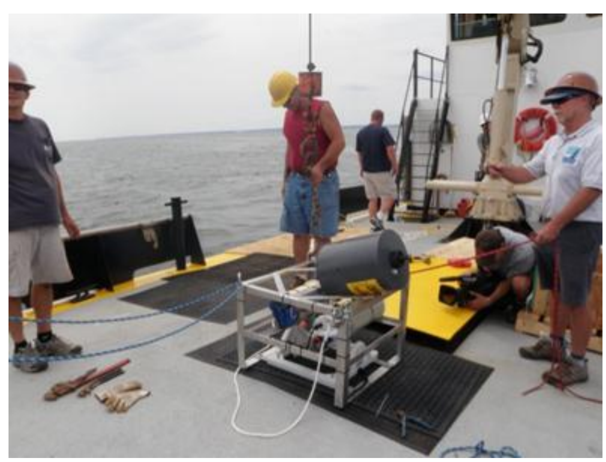

FIGURE 5: The second modem can be seen here built into the seabed frame with the water quality sensor.

The sensor is mounted on the bay floor at 11m depth; about 100m from the artificial reef. The sensor logs the water quality data and converts it to a digital stream. This digital stream of data is transmitted wirelessly using the subsea wireless communications link to the buoy where the data is received and relayed to the shore based receiving station using CDMA telemetry where it is analysed to ensure optimum conditions are maintained.

This snapshot of data shows anoxic conditions from summer 2010 and low oxygen water (associated with a high salinity intrusion). NOAA is working with researchers and winds and currents data from the buoy to investigate this [6].

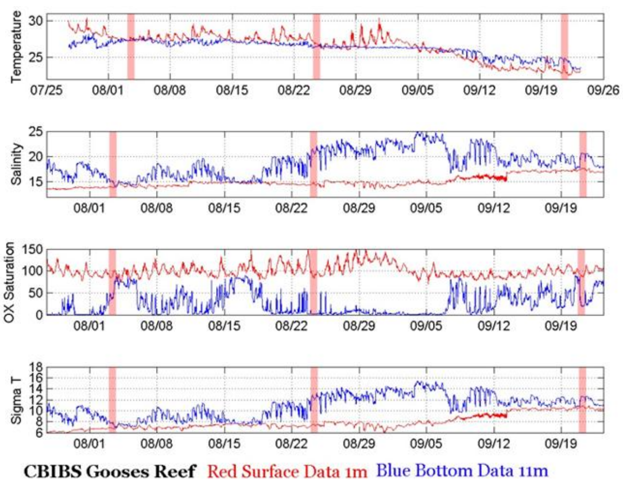

FIGURE 6: CBIBS DATA

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CDMA is "code division multiple access", a channel access method used by some radio communication technologies. CDMA is multiple access, where several transmitters can send information concurrently over one communication channel. Spread-spectrum technology allows several users to share a band of frequencies with a special coding scheme (where each transmitter has its own code). CDMA is used as the access method in many mobile phone standards such as cdmaOne, CDMA2000 (the 3G evolution of cdmaOne), and WCDMA (the 3G standard used by GSM carriers) [7].

Use of subsea wireless instruments in projects such as this, can help to lower the costs of installation and maintenance of a water based environmental monitoring system. A wireless system is more robust against the elements, the tides and currents, and without cabling, ensures no interruption in critical data reporting. In addition to this, the data can be harvested from sensors in real time, enabling speedy response if a change is reported. Standard subsea connectors are replaced with wireless connectors for fast download of data from sensors and data loggers without physical connection or having to recover the sensor to the surface. Without a hard wiring sensors can also be deployed quickly and in areas that would normally be hard to monitor.

IV. SUBSEA WIRELESS ROV SOLUTION

A seabed to surface solution is not the only method of retrieving data for environmental analysis. In other applications where transmitting to the surface is not viable or achievable, wireless technology can be readily implemented with sensors and data loggers to deliver operational updates to decision makers on such variables as rainfall and water level rise, or levels of pollution in a body of water.

Sensors can be wireless enabled to transmit data through water to a mini ROV system (also wireless enabled), and the data sent up topside through the vehicle tether. The submerged sensor can measure any number of parameters (turbidity, pH, DO (dissolved oxygen), conductivity, temperature, differential & absolute pressure (depth), salinity) data from all of which can be transmitted and picked up by the ROV.

Sensors that have been enabled with wireless technology for applications in the environmental arena include: a YSI sonde, an Aanderaa Seaguard CTD, a Nortek AWAC and a Sontek ADCP. Using wireless power technology, underwater sensors can also be recharged without recovery to allow extended environmental monitoring programs.

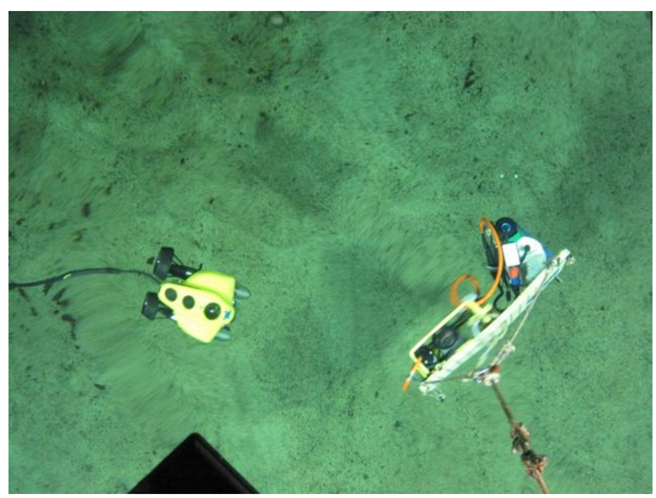

FIGURE 7: A Mini ROV interrogating and wirelessly harvesting data from a subsea sensor

The subsea wireless technology used in the CBIBS project is Seatooth®, WFS Technologies flagship subsea wireless platform. The company is a founding member of SWIG (the Subsea Wireless Group), an industry initiative focusing on the development of open standards for wireless communications underwater. The aim is to create a standard similar to Bluetooth, the wireless technology standard for exchanging data over short distances in air, and support interoperability between subsea wireless systems.

V. CONCLUSION

The range that can be achieved by a subsea wireless system is limited in water, especially salt water as can be seen in this graph below. However as shown in the Chesapeake Bay CBIBS project, although limited, wireless subsea technology proves itself as the most practical tool for transmitting data in this type of environmental application both for the value it brings as a solution and for the benefits the technology offers over other methods.

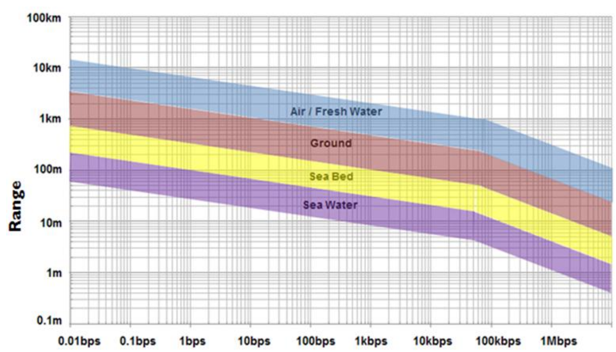

FIGURE 8: Seatooth®, *range vs bandwidth*

A Maryland Department of Natural Resources study released in 2011 showed higher levels of oyster reproduction and a lower mortality rate for the Chesapeake Bay oyster [8].

REFERENCES

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[5] AXYS buoys for NOAA's Chesapeake Bay Interpretive Buoy System (CBIBS) case study

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FIGURES

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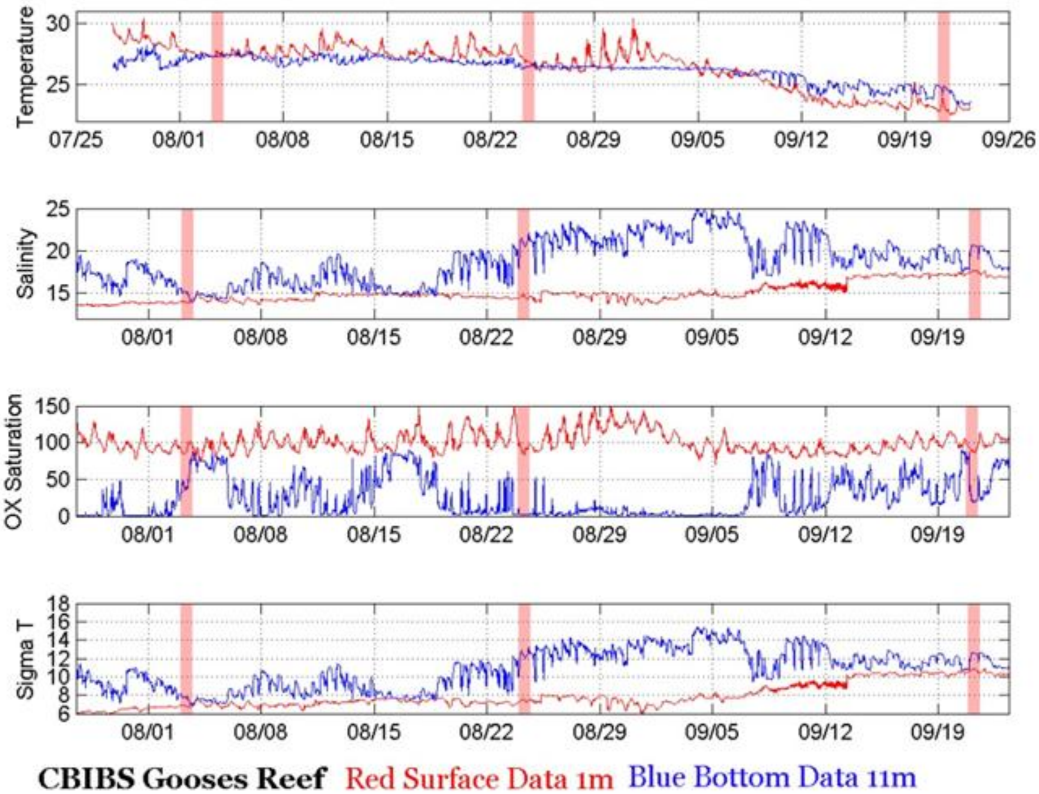

FIGURE 6: CBIBS DATA

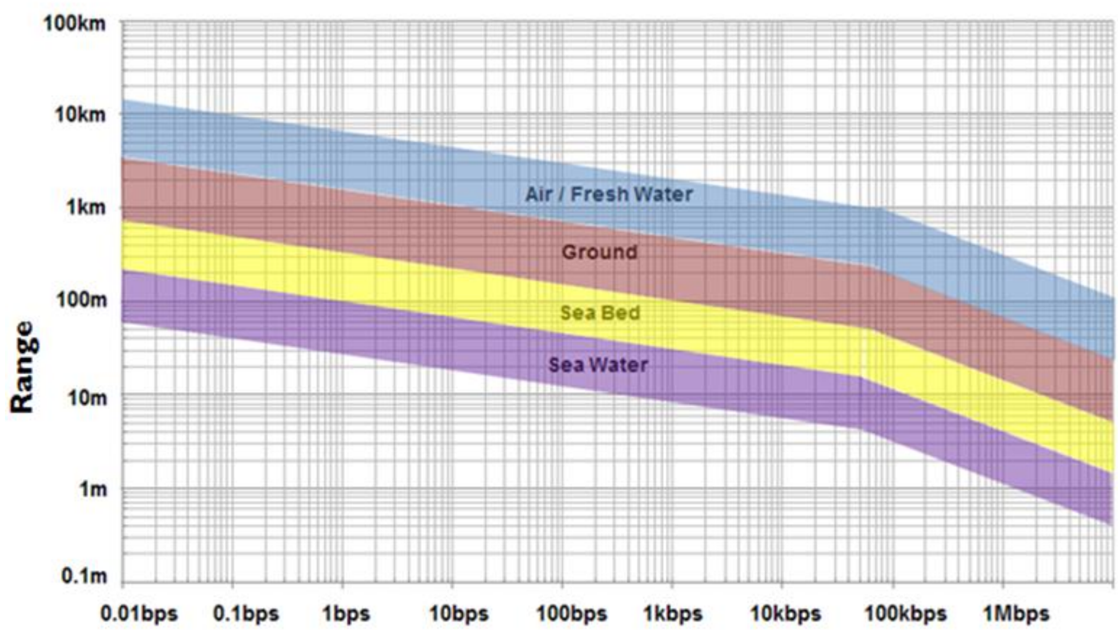

FIGURE 8: Seatooth®, *range vs bandwidth*