San Francisco Bayweb 2009

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Summary
San Francisco Bayweb is an underwater wireless communications network delivering near-real-time data from unattended oceanographic sensors deployed on the seabed. Our poster describes 2 pilot Bayweb networks deployed during 2009.

Background
National economy and security depend on commerce through our seaports. The goal of SF Bayweb is to field a wireless underwater sensor and communications network within such a port. The Navy successfully demonstrated Seaweb networking in the Port of Long Beach, CA in 2008 with benign environmental conditions. The San Francisco Bay offers a more challenging environment with heavy shipping traffic, strong currents, and significant sediment transport. At SF Bayweb, a Seaweb communications network delivers environmental sensor data in near-real-time from the subsurface domain to a shore-based server. These ocean data serve the oceanographic community while simultaneously supporting analysis of Bayweb communications performance. SF Bayweb 2009 is a pilot demonstration of a scaleable network architecture, with the longer-term goal of fielding larger more complex networks, more sophisticated oceanographic and surveillance sensors, and integration with above-water sensors and systems.

SF Bayweb 2009 occurred in the vicinity of Angel Island, in the San Francisco Bay. Two Acoustic Doppler Current Profiler (ADCP) sensors were deployed to measure currents in this area. A Seaweb network composed of up to 7 telesonar repeater nodes and 1 Racom gateway node was intended to telemeter the environmental measurement data from the undersea sensors to a gateway node. The gateway node provided the link between the land site (via cellular telephone modem) and the underwater domain (via telesonar modem). The gateway node was a USCG buoy, modified with a Seaweb Racom kit.

Objectives
The objectives for SF Bayweb 2009 were:

- Adapt US Navy Seaweb technology involving commercial telesonar modems, digital acoustic through-water communications, and open-systems interface (OSI) networking.
- Configure 2 oceanographic current sensor nodes for moored deployment on a shifting seabed.
- Obtain periodic (every 10 minutes) measurements of current profiles (i.e., current vector as a function of water depth) in a major maritime port environment characterized by strong currents.
- Include up to 7 telesonar repeater nodes deployed on the seabed as part of the Seaweb network linking the sensor nodes with a gateway node.
• Outfit an operational USCG navigation buoy as a radio/acoustic communications (Racom) gateway node.
• Use a cellular telephone modem for communications between the gateway node and an ashore server.
• Advance the Seaweb capability for automated ad hoc discovery and initialization of network routes.
• Provide near-real-time data dissemination via an internet web site.
• Advance technologies and methods with applicability at other maritime locales for the purpose of serving a broad user community.

Participants
The following organizations participated in SF Bayweb 2009:
• Naval Postgraduate School, Monterey, CA
• SPAWAR Systems Center Pacific, San Diego, CA
• US Coast Guard, 11th District, Yerba Buena, CA
• SFSU Romberg Tiburon Center for Environmental Studies, Tiburon, CA
• UC Berkeley, Berkeley, CA
• Central and Northern California Ocean Observing System (CeNCOOS), Moss Landing, CA
• Monterey Bay Aquarium Research Institute (MBARI), Moss Landing, CA
• UC Davis Bodega Marine Lab, Bodega, CA

Experiment Site

Figure 1. SF Bayweb 2009 operations area.
**Results**

**Networking.** Underwater networking at the SF Bayweb experiments was hindered by a collection of unexpected software bugs inadvertently introduced into the Seaweb firmware by contractor Teledyne Benthos, Inc. during development of their commercial firmware. Symptoms included rebooting of the modem DSP, loss of network-layer routing tables, and other unexpected behaviors. Navy engineers used the SF Bayweb deployments as an opportunity to troubleshoot the affected Seaweb networking functions. These systematic debugging operations involved the introduction of test points into the network in the form of a telesonar modem deck box with cabled transducer hanging over the side of the research vessel. Longer term testing also made use of the Racom gateway buoy, permitting engineers to exercise the network from remote locations including SPAWAR Systems Center Pacific (San Diego, CA) and Teledyne Benthos, Inc. (Falmouth, MA). Although networked telemetry at SF Bayweb was unsuccessful, the debugging operations resulted in a repaired version of Seaweb software that permitted successful Seaweb operations at subsequent 2009 sea trials in Italy and Florida. Hence, the SF Bayweb experiments provided critical testing that circumvented failure at those more significant Naval demonstrations. Because SF Bayweb network operations were significantly impaired by these software bugs, the usual Seaweb network analysis was not performed.

**Acoustic communications.** The debugging operations did serve to characterize the Raccoon Strait acoustic conditions as noisy and variable. Future operations requiring a convenient location with adverse acoustic conditions would do well to return to this test site.

**USCG Racom gateway buoy.** Installation of the US Navy Racom kit onto an operational USCG buoy was successful. The gateway provided reliable communications between the underwater network and an AirLink cellular telephone modem. Remote access to the gateway node was via an IP address.

**ADCP sensor deployed on a near-seabed StableMoor buoy.** Two units were deployed in each of the two Bayweb experiments. While the deployments were tricky, boat handling and rigging procedures were refined such that the installation of these unique sensors became routine. The sensors successfully measured current vectors as a function of depth. Although these data were not telemetered in near-real-time, the data were internally recorded and

**Conclusions**

Most of the components of an oceanographic sensor network well suited for San Francisco Bay were developed and demonstrated. Networked communications were thwarted by software issues that have since been resolved. SF Bayweb experiences indicate that such a network is indeed feasible. It is recommended that the equipment developed for these 2009 experiments be redeployed in San Francisco Bay at a future opportunity.

**References**

