

A Fast Response Capability within NOAA/NOS/CO-OPS

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Abstract—During a maritime emergency, such as an oil spill, it is important to develop an effective response based on sound scientific observations and expertise in order to protect the lives, commerce and environment in the affected area. The National Oceanographic and Atmospheric Administration (NOAA) National Ocean Service's (NOS) Center for Operational Oceanographic Products and Services (CO-OPS), with support from the Emergency Response Division within the Office of Response and Restoration (a.k.a. NOAA Hazmat), has been developing a fast response capability to satisfy this objective. The Quick Response Estuarine Buoy (QREB) has specifically been developed as a rapid-deployment system for the collection of oceanographic and meteorological information at a targeted location in an effort to ensure safe, efficient and environmentally-sound navigation while supporting the environmental needs of Hazmat's response. The QREB is intended to be a self-contained, small moored system that can be easily deployed in coastal waters by a small size vessel. The buoy has a meteorological package and an acoustic Doppler current profiler (ADCP) mounted below its hull. The real time data are communicated through both an IP modem and a GOES satellite antenna for durations up to 30 days. The buoy was deployed during the NOAA Safe Seas 2006 (SS2006) exercise in the Gulf of the Farallones and Monterey Bay National Marine Sanctuaries. Real-time environmental data from the QREB near the site of a simulated oil spill were made available to the Scientific Support Team (SST), Hazmat, the National Weather Service (NWS) and other emergency responders at the Incident Command Post to provide guidance in managing the simulated situation and were also incorporated into the local weather forecasts and used to truth Hazmat's General NOAA Operational Modeling Environment (GNOME) forecasts. Although the Safe Seas drill proved successful, it is evident that improvements are still required for the QREB to become fully operational in response to a real event. Upon successful testing, the QREB will not only be available for event response, but will also be primarily used to collect current velocity data in key navigational areas of the United States in support of the mission of the National Current Observational Program (NCOP) within CO-OPS.

I. INTRODUCTION

During a maritime emergency, such as an oil spill, it is important to develop an effective response based on sound scientific observations and expertise in order to protect the

lives, commerce and environment in the affected area. Under the National Contingency Plan (NCP) for oil and hazardous materials releases (40CFR300), NOAA is charged with providing scientific and data management support to the federal on-scene coordinator (OSC). Responsibility for providing this support is assigned to NOAA Hazmat.

CO-OPS, with support from Hazmat, has been developing a fast response capability to satisfy this objective. The QREB has specifically been developed as a rapid-deployment system for the collection of oceanographic and meteorological information at a targeted location in an effort to ensure safe, efficient and environmentally-sound navigation while supporting the environmental needs of Hazmat's response.

II. BUOY DESIGN AND SPECIFICATIONS

The QREB has been specifically developed as a short-term quick-deployment system for the collection of environmental information at targeted locations in response to an emergency situation. It is intended to be a self-contained, small moored system that can be deployed rapidly in waters up to 100 meters in depth by a small size vessel without the need of a large capacity crane or winch.

The buoy integrated a subsurface current meter with a commercial off-the-shelf (COTS) meteorological package commonly deployed on a CO-OPS tide gauge to provide real-time data for durations up to 30 days (Fig. 1). The meteorological data was compiled by a data collection platform (DCP) and was then transmitted to shore via an IP modem and Geostationary Observational Environmental Satellites (GOES). The current meter was directly connected to an IP modem for shore communications and data transmissions.

A. Buoy Structure

The QREB was composed of a flotation hull, an instrumentation tower mounted atop the hull and a current meter mount with a mooring attachment. The triangular tower housed two electronics enclosures that contained the meteorological data DCP and the current meter IP modem.

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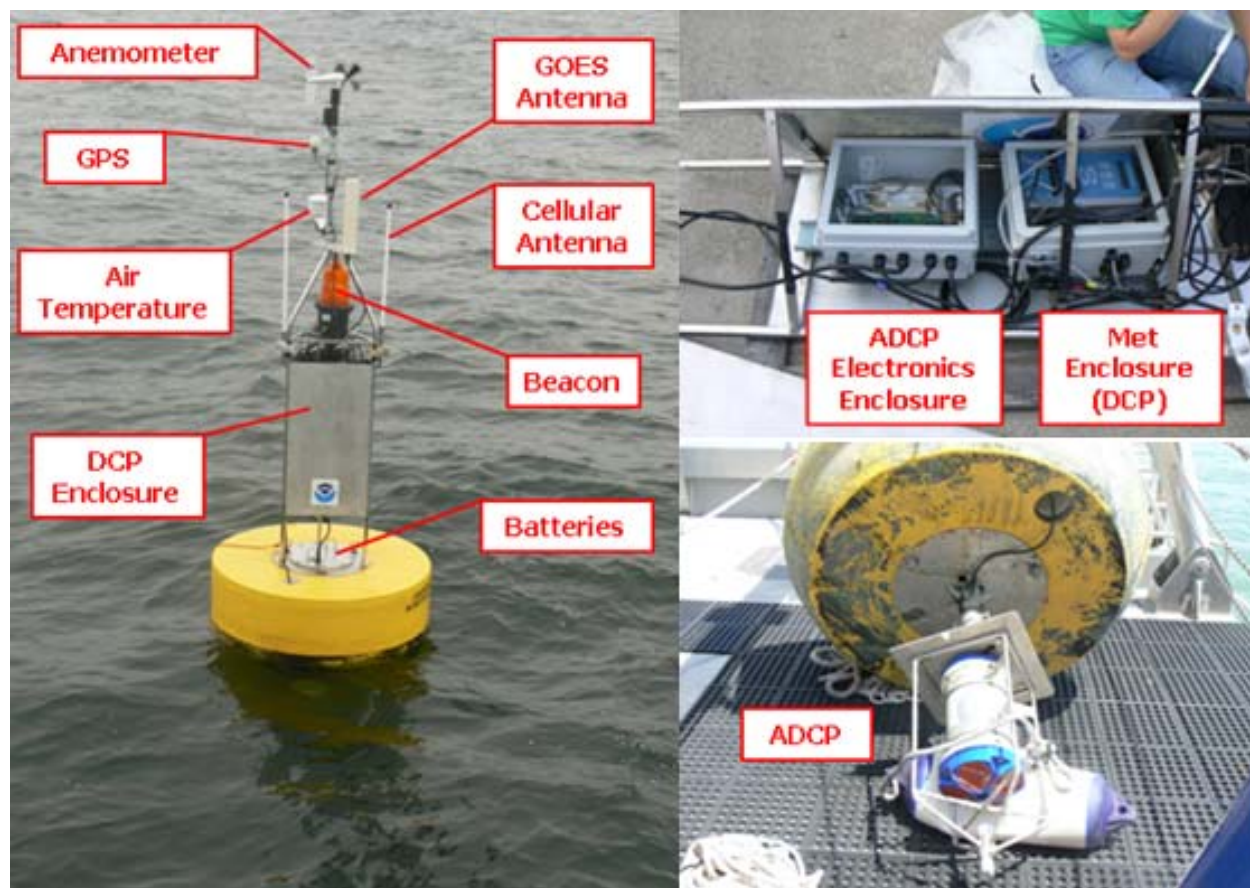


Figure 1. QREB components as deployed at the Safe Seas 2006 exercise.

The meteorological sensors were also clamped to the tower. The buoy hull, manufactured by Endeco/YSI, was 91cm (36 in.) in diameter and was made of ionomer foam. Two 12V lead-acid batteries were stored within a drilled out enclosure in the center of the hull, which were used to power all of the electrical components except the current meter. The ADCP was secured to the bottom of the hull by a bracket mount. A pyramid anchor was attached to the bracket by an anchor line consisting of heavy chain and rope. An additional line attached to a pennant anchor and marked by a surface buoy was tied to the pyramid anchor to aid in recovery. The buoy and tower weighed 650 lbs., the current meter bracket weighed 100 lbs., and the anchoring system weighed an additional 600 lbs. Most of the anchor line was deployed before the buoy was placed in the water to alleviate the amount of stress placed on the small capacity winch used for the deployment.

B. Anemometer

An R.M. Young (model 5103) Wind Monitor was mounted on top of the instrumentation tower (2.7m (9 ft) above the water surface) to measure the wind speed and wind gust. Since the anemometer was adapted from the stationary tide station, the compass could not account for the buoy spin. Thus, the wind direction could not be measured accurately and was not reported.

C. Barometer and Temperature Probe

A Sutron Accubar 5600-0120-1 Barometer was mounted within the tower (1.2m (4 ft) above the water surface) to monitor changes in the atmospheric pressure. A Campbell Scientific 107 Temperature Probe was externally clamped to the tower (2.4m (8 ft) above the water surface). The thermistor was housed inside a radiation shield.

D. Current Meter

A 300kHz Teledyne RD Instruments (RDI) Workhorse Sentinel ADCP was mounted to the buoy hull to measure the vertical profile of current speed and direction. The RDI ADCP was set to poll mode and directly connected to an IP modem. The current meter was programmed to sample at 1Hz and the data was ensemble-averaged every 6 minutes. CO-OPS polled the ADCP via the IP modem every 6 minutes and the data was subsequently transmitted to shore.

E. Data Collection Platform

A Sutron 9210 XLite DCP was used to collect all of the meteorological data. All sensors sampled at 1Hz. The DCP averaged the data, compiled it into a pseudo-binary message and transmitted the message via GOES every 6 minutes. In addition, the ASCII message was saved on the DCP which could then be polled via an IP modem.

F. IP Modem

Two Airlink Raven CDMA modems were incorporated into the QREB. One was used to initiate communications and poll data from the DCP storing the meteorological data. System resets or maintenance on the DCP could be initiated through the IP modem. The second one was directly connected to the RDI ADCP to poll the 6-minute-averaged data. The modem offered two-way communication, allowing for data transmissions to shore and system configuration commands from shore. Although communications were able to be established through the IP modems, they are limited in range since they need to be placed in proximity to a cellular telephone tower. Strong gain IP modem antennas were installed on the buoy to boost the signal to allow them to function if deployed within a fringe location.

G. GOES Transmitter

A Satlink2 Logger-Transmitter (Sutron model no. SL2-G312-1) was mounted on the buoy tower to allow for the data transmission of the collected meteorological information. An omni-directional antenna was attached to the tower to allow for buoy spin. Data was automatically transmitted through GOES utilizing a 5-second window. The standard CO-OPS encoding process was used to minimize the data message length (80 bytes). Therefore, even though the GOES transmitter was connected to a GPS antenna to ensure the scheduled transmission would occur at the proper time based on the GPS time, the GPS location could not be incorporated into the data message.

III. FIELD TEST VERIFICATION

A field test was conducted to verify the operation of the buoy components. Also, a bottom-mounted ADCP was placed near the buoy to substantiate the current velocity data measured by the buoy-mounted ADCP and account for the effect of buoy drift. The test was carried out over a 12-day period. All of the buoy components functioned properly.

Time series comparisons of the velocity components were made at all depths, as represented in Fig. 2. Good agreement was observed at all depths, with correlation coefficients ranging from 0.88 to 0.95 for the east (u) velocity and from 0.97 to 0.99 for the north (v) velocity. It should be noted that the tidal motion of the buoy was taken into account to determine the corresponding depth cell from the stationary bottom-mounted ADCP. Since the buoy passed the field test, it was deemed operational for the Safe Seas 2006 exercise.

IV. NOAA SAFE SEAS 2006 EXERCISE

The Safe Seas 2006 exercise was conceived by NOAA to improve the quality of scientific and data management support during a disaster response, such as a large oil spill. The primary goals of SS2006 were to 1) demonstrate human and technological capabilities, integrating across programs for the common goal of protecting marine and coastal resources; 2) develop individual skills in program management, coordination, contingency planning, emergency response, and

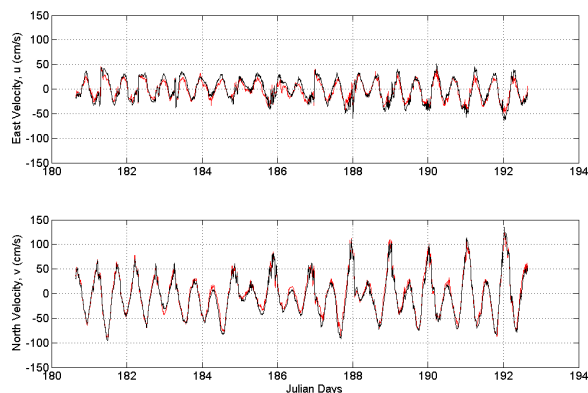


Figure 2. Comparison of east (u) and north (v) velocities between QREB (black) and bottom-mounted ADCP (red) at a depth of 2.9m (9.5 ft) below the surface. Correlation coefficients of 0.95 and 0.98 were attained for the east and north velocities at this depth.

health and safety; and 3) build relationships across the public and private sector that foster long-term collaboration to protect the environment.

More than 400 people from local, state and federal agencies participated in the drill, making this the largest emergency response drill to date. The National Marine Sanctuary Program and the Office of Response and Restoration coordinated NOAA's response, which involved 150 participants. Personnel from the Regional Associations of the Integrated Ocean Observing System (IOOS), the U.S. Coast Guard, the U.S. Department of the Interior, the State of California's Department of Fish and Game and the Office of Spill Prevention and Response, and Harley Marine Services also took part in the exercise.

The Safe Seas 2006 oil spill response exercise took place on August 9-10, 2006 in the Gulf of the Farallones and Monterey Bay National Marine Sanctuaries off the coast of San Francisco, CA. The scenario centered around the hypothetical collision of the M/V Blue Harp, a bulk freight cargo ship inbound from Long Beach, with the Dottie, an oil tank barge outbound for Los Angeles. The Dottie was being pulled by an outbound tugboat at the time of the collision. Following the collision, the M/V Blue Harp continued to transit north a short distance before anchoring offshore of Bolinas Bay, leaking oil as it traveled. The Dottie sank south of the collision site such that its bow remained at the surface and its stern rested on the bottom, dispersing oil at all depths.

As part of the drill, CO-OPS deployed the buoy near the site of the sunken Dottie in approximately 31m (100 feet) of water. The buoy reported real-time meteorological and oceanographic information, such as current speed and direction, wind speed, wind gust, air temperature and barometric pressure, every 6 minutes. The vertical resolution of the velocity profile was 1m. The data were displayed on the CO-OPS extranet and the nowCOAST portal (Fig. 3). The display integrated the NOAA Physical Oceanographic Real-Time System (PORTS) program water level prediction and

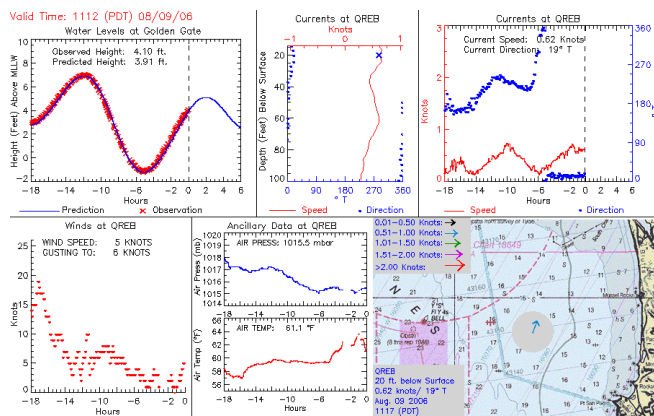


Figure 3. Example of the data display utilized during the Safe Seas 2006 exercise. Note that the winds were weak and the current 6m (20 ft) below the surface was to the northeast.

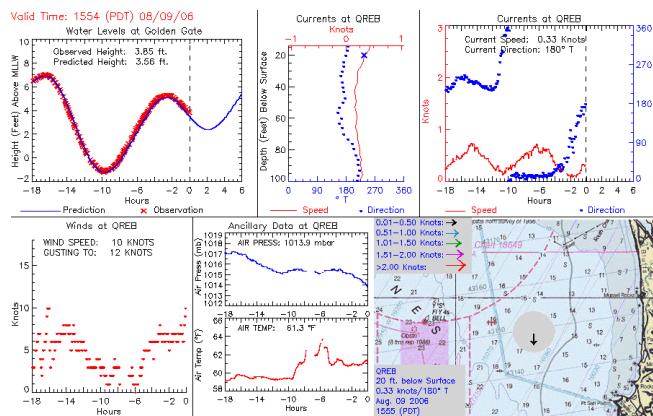


Figure 4. Data display approximately 5 hours later. Note that the winds had increased and the current 6m (20 ft) below the surface had changed direction and was now headed south.

tide gauge data from San Francisco Bay near the Golden Gate Bridge with the real-time information from the buoy. The data were made available to the Scientific Support Team (SST), Hazmat, NWS and other emergency responders at the Incident Command Post (ICP) to truth Hazmat's GNOME trajectory model forecasts and to provide guidance in managing the simulated situation. Salvage representatives of Resolve Marine Group used the vertical velocity profile data provided by the QREB to guide their removal operations of the sunken barge Dottie.

The buoy was given a Standard Hydrometeorological Exchange Format identifier (SHEF ID) by NOAA's National Data Buoy Center (NDBC) which allowed the data to be included in the NDBC data stream. This enabled the data to be displayed on the NWS Advanced Weather Interactive Processing System (AWIPS) where it was available to the local NWS Weather Forecast Office (WFO) in Monterey and the Incident Meteorologist (IMET) on-scene at the ICP to develop the local forecast and guidance.

As the exercise progressed, it was shown that the intensity of the wind directly influenced the direction of the coastal current. Tides off the coast of California are predominantly semidiurnal [1]. Typically, the seasonal winds are generally from the north [2] which was verified by offshore NDBC buoys during the exercise. The tidal currents on the shelf where the buoy was deployed are weak, but there exists a strong, nonlinear subtidal component [3]. It has been observed that the currents on the shelf tend to move poleward when the wind speeds are low, as seen in Fig. 3. The observed currents from the buoy tended to rotate equatorward as the winds intensified (Fig. 4). Thus, the equatorward shelf currents were probably a response to the increased equatorward winds. A better spatial picture of the evolution in the current circulation identified by the buoy was illustrated by the High Frequency Surface Current Mapper data from the Central and Northern California Ocean Observing System (CENCOOS) and the GNOME forecasts.

V. FUTURE WORK

Although the Safe Seas drill proved successful, it is evident that improvements are still required for the QREB to become fully operational. The first improvement is to improve the accuracy of the wind direction parameter. Wind direction information was not included in the buoy's data transmission due to high errors. Thus, offshore NDBC buoys were used to verify the wind direction as the exercise transpired. To eliminate this dependence and discount the possibility of spatial variability, a procedure to calibrate the anemometer compass (manufactured by Honeywell) needs to be developed to improve the accuracy for incorporation into the data message. The calibration must account for the buoy spin as well as interference from metal and electronics found on the buoy. Experimental testing using an ultrasonic anemometer will also be occurring. The ultrasonic anemometer offers several advantages over a mechanical wind sensor, including less maintenance due to no moving parts, greater accuracy and more durability.

During the drill, IP modems were used for two-way communication between the buoy and shore and for ADCP data transmissions to CO-OPS. If the exercise had taken place in a more remote area or farther offshore, the data would not have been able to be communicated. For this reason, it is necessary to employ an alternative communication method which has blanket coverage. CO-OPS plans to conduct field testing with the Iridium Satellite Communication System as a possible solution to its data transmission needs. Iridium provides stable global coverage, requires less power and offers two-way communication. Iridium's Short Burst Data (SBD) capability uses the same format as the GOES transmission, but offers larger message capability so more data can be transmitted in addition to the meteorological data. Iridium also allows shore-initiated communications with the buoy through the dial-in data option. This improvement would significantly expand the coverage area where the QREB could be deployed. These capabilities justify the higher costs

associated with Iridium, especially when the QREB could be used for an emergency response.

Ongoing experimental efforts continue at CO-OPS to improve the operation of the buoy. Different current meters and configurations will be tested in an effort to collect reliable water velocity data closer to the surface. Lithium batteries will be placed in the buoy to ensure longer operation in the field. Other enhancements include integration and hardening of the data collection platform, the addition of a solar-powered beacon and inclusion of the GPS message. Two separate DCPs were used to collect and disseminate the data. Work will be done to integrate the DCPs so data from all sensors will be stored on a single Sutron DCP. Furthermore, conditions during the drill were fairly calm, but encasing the integrated DCP and associated electronics in a ruggedized, waterproof housing will enable the buoy to function during rougher conditions. The beacon would drain less power from the batteries and extend the length of the deployment. Inclusion of the GPS message would safeguard against losing the buoy if it were to break from its mooring.

Once these enhancements have been completed, component field testing will be required and a battery capacity test will be needed to determine the optimal length of deployment before

it will need servicing. The QREB will continue to be developed as part of the mission of the National Current Observation Program (NCOP) within CO-OPS. Thus, the QREB will not only be available for a long-term event response, but will also be primarily used to collect current velocity data in key navigational areas of the United States in support of the mission of NCOP. Following successful field testing and operational acceptance, additional buoys will be developed as more funding becomes available.

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The successful performance of the QREB is a reflection of the hard work of many individuals within CO-OPS, including personnel from the Product and Services, Research and Development and Information Systems Divisions and the Ocean System Testing and Evaluation Program.

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