NEXT GENERATION OCEAN OBSERVING SYSTEMS, PART 1: PLATFORMS

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1.0 INTRODUCTION

Oceanography is an observational science that is driven and guided by data collected from ships, moorings and island based instruments, satellites and aircraft, Autonomous Underwater Vehicles, (AUVs) and freely drifting platforms, etc. Oceanographers contribute to global-scale climate-change studies that require sharing the data collected by an individual or group of investigators with others in near-real time. The distribution of data is required, because global change studies require more data than can be collected by one individual or group of investigators. The near real-time requirement is necessary to get the data to studies and predictive models in reasonable time. The older but more standard oceanographic technique of deploying instrumentation with internal recording then recovering the instrumentation to get the data a year or two later is not adequate for predictive modeling efforts. This distribution requirement and the large quantities of data that modern instruments are capable of collecting place new requirements on data base management, archiving and documentation.

There is still a need for the continuous, long-term time-series observations at fixed positions made by moored platforms in spite of the new technology developments in satellite and AUV remote sensing, and more traditional shipboard based observations. The problem facing environmental sciences (including oceanography) is sampling in horizontal space (Latitude and Longitude), depth (or height) and time. No on observing system or approach has the ability to do it all. Just as we got a great improvement in data quantity and understanding of oceanographic processes when we went from individual bottles and reversing thermometers to electronic profilers, we are now getting increased understanding of the spatial variations at the sea surface from satellite imagery. However, the satellite observations need to be extended down into the oceans, and need to be more continuous in time. It is the combination of all of the possible (and new techniques) that will be required to obtain all the data required.

The data that can be collected can now be supplied in near real-time to support climate change research, weather forecasting and predictive programs (both near-term as well as long-term predictions), environmental monitoring and assimilative modeling efforts. The concept of sharing their data is a new way of operation for many oceanographers who have been used to collecting their data and then spending some time of exclusive access before publishing and distributing their data and results. The demands of applied problems require the involvement of many people who share their data, and provide it to other investigators.

To provide the required time-series data from moored platforms at specific locations, (1) improved buoys and mooring technologies need to be developed, tested and utilized, (2) new sensors and data systems with intelligent sampling and processing capability need to be developed and incorporated into moorings, and (3) world-wide, two-way high-speed satellite telemetry systems need to be developed to return the data in near-real time. Besides providing data to the research, modeling and predicative efforts, a two-way link would allow control of the remote platforms from shore to optimize system capabilities.

Working toward this goal in support of scientific studies in continental shelf regions, several

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moored buoy systems have been developed and utilized during the past 15 years. Newer buoys provide lower maintenance systems that can be moored for longer duration. The mooring system utilizes non-metallic strength members (Kevlar, Spectra, etc.) with electrical conductors for power and data telemetry. These moorings are also using compliant tether technology to provide improved observational capabilities. The technologies being utilized in these newer mooring systems can also be used in freely drifting systems, which utilize the same sensors, data and power system, and same telemetry links.

Figure 1. A new steel buoy system (Irish, et al, 1999). The large foam flotation collar is seen as the basic buoy hull. Above the solar panels the tower holds meteorological sensors, the radar reflector, the guard light and an ARGOS locator beacon antenna. The satellite transmitting and receiving antennas are mounted highest on the tower. A GPS receiving antenna for position is also included.

2.0 IMPROVED BUOYS

Many early oceanographic research buoys were made from NAVY surplus steel submarine net floats to which towers and bases were added. A number of these are still in active use showing the long life that can be obtained with steel buoys. However, the maintenance on these buoys is relatively high. To provide newer buoys, WHOI has constructed steel and aluminum buoys with foam flotation collars (see Figure 1). The steel, hot dipped galvanized and painted, has survived for several years with little maintenance. The aluminum buoys used 5400 series aluminum for lighter weight and low corrosion after some problems with the 6061 series aluminum corroding in the ocean environment. On both the steel and aluminum buoys, the buoy's tower is made from aluminum for lower weight and buoy stability. Both steel and aluminum buoys with foam flotation have proven successful through the last five years on Georges Bank as part of GLOBEC, and in other applications in coastal and mid-ocean regions. For pictures and discussion of the GLOBEC buoys and moorings, see <http://kelvin.whoi.edu>, and for pictures of the steel buoy in Figure 1 during construction, see <http://www.wavix.com>.

An instrumentation well is located in the center of the buoy surrounded by foam. It provides space for the batteries, solar panel regulators, power distribution system, the data processing and storage system, and telemetry systems. Water tight connectors pass power and signals between the sensors and data system.

Buoyancy is provided by a Surlyn foam flotation collar supplied by the Gilman Corporation. The Surlyn foam is formed with a standard yellow pigment to indicate a research buoy and not an aid to navigation. During the five years deployed on Georges Bank the yellow has faded slightly, but held up better than painted steel buoys. There was no noticeable loss of flotation due to water absorption or foam shrinking. The foam has proven reliable and although it shows some signs of being hit, gouged, and other rough usage, it is not really damaged. It survives being hit better than a steel buoy that will chip and then rust. The foam buoy is also easier to handle as it can be "snugged" up to the ship on recovery without damage to the buoy or ship while recovery lines are attached. Surprisingly, the foam has also reduced buoy maintenance efforts because it does not bio-foul as severely as steel guard buoys deployed nearby. The buoys are easily cleaned by a pressure washer and then repainted below the water line with standard antifouling paint before deployment. We routinely do no other maintenance for several years. On the other hand, the steel buoys require scraping, priming, and regular painting each time they are deployed (about once per year).

To minimize the tilting motion of the buoy in the wave field, the lower portion of the foam is cut with two chines so the bottom of the floatation collar approximates a sphere. Therefore, the waves can apply no tilting moment to the buoy, and, with the elastic tether elements in the mooring (see below), provide a more stable platform for scientific observations, especially meteorology.

Solar charged batteries supply system and sensor power, allowing a deployment to continue as long as the sensors are working well. Primary data storage is by telemetry to shore. Present telemetry options include ARGOS (polar orbiting) and GOES (Geostationary Satellite). The ARGOS satellite offers the benefit of low power and platform positioning worldwide (as the satellite is able to measure Doppler shift and calculate position), but provides only limited data capability. GOES offers an increased data telemetry capability, but at higher power. Recent developments in LEO (Low Earth Orbiting) satellites (see companion paper below) should provide two-way, high-bandwidth telemetry to revolutionize telemetry options. These systems are now becoming operational (Wavix, 1999 and <http://www.wavix.com>). Telemetry from remote moored platforms deployed for long periods is critical for modern scientific studies. The data needs to be supplied in reasonable time to predictive weather and climate changes modeling efforts.

Data system technology that is applicable to moored instrumentation is also growing rapidly. Notebook computer developments have given us the processing and hard disk storage space found in desktop computers, and provided computation power that is capable of being deployed in oceanographic applications and powered for long time from batteries. On buoys with solar power, these systems provide capabilities not previously available in A/D conversion, in situ digital signal processing, large, robust data storage capabilities at low cost, and offer the potential for two way telemetry to control sampling programs, and update software for more optimum performance of the remote platform (Shaumeyer et al., 1998).

3.0 COMPLIANT ELASTIC TETHER MOORING TECHNOLOGY

To improve the mooring system, we have been using compliant elastic elements (e.g. six 1 inch diameter rubber bands) to reduce movement (and hence wear) on mooring components and reduce shock loading due to movement in high seas to prolong mooring life. The reduced shock loading and lower mooring tensions also allow lighter weight, lower cost mooring hardware to be successfully utilized (Paul et al., 1999). The elastic elements also provide a more constant tension downward on the bottom of the buoy that reduces buoy motion for improved scientific observations. A typical configuration used for instrument testing (Figure 2), is similar to systems deployed in the Gulf of Maine (Irish, 1992), Massachusetts Bay (Irish et al., 1992), and in GLOBEC (Irish and Kery, 1996 and Irish, 1997). The main difference of the new mooring for the NASA ocean observing buoy is that sensors will be located below the elastic tether that need to be connected to the buoy's data system. This is accomplished with a coil-cord assembly that carries power down and signal up around one of the elastic elements (Paul and Irish, 1998).

4.0 DRIFTING PLATFORMS

The same technology in platform materials, sensors and data and telemetry systems can also provide scientifically useful data when incorporated in drifting and station-keeping platforms. A freely drifting system will be smaller and lower cost because of no need for the mooring (or the additional flotation required by the mooring system). In deep ocean regions with low currents, a drifting system could provide valuable meteorological and water property time-series in the upper ocean. The position of the observations would be located geographically through GPS (Global Positioning System). With additional solar and wind power, it also appears feasible to have a station keeping buoy that could remain in a general location, except in western boundary currents, and provide useful meteorological and oceanographic information.

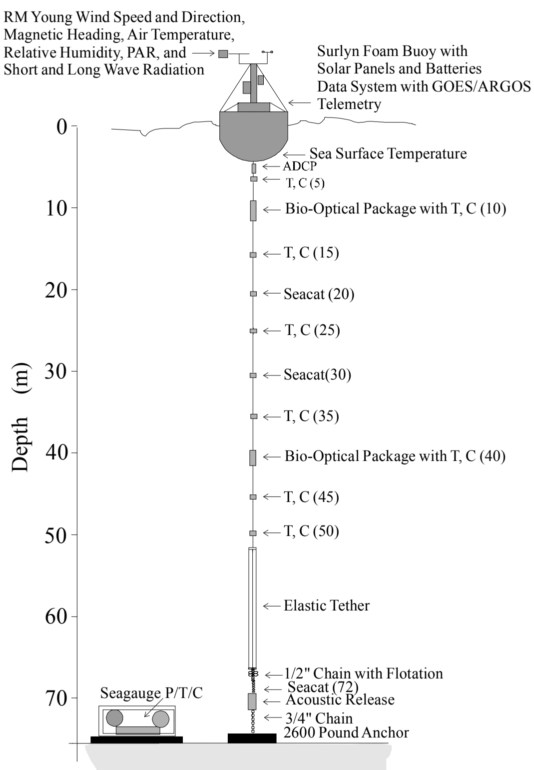

Figure. 2. A schematic of the mooring configuration used for five years (with 6 month servicing) on the southern flank of Georges Bank as part of GLOBEC.

4.0 CONCLUSION

The requirements for global scale scientific studies, climate change studies, and improved weather forecasting are for longer time series from critical locations worldwide. Improvements in buoy and mooring design should allow us to meet these requirements. However, coastal studies are becoming more critical, and our mooring technology is not able to cope with these needs. Continuing studies on mooring technology should be conducted to allow us to meet the long-term time series requirements of future programs.

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