Cable-Free Automatic Profiling Buoy

Real-Time Oceanographic Profiles From Low-Maintenance Buoy

By Monica S. Kolding • Bård Sagstad

The underwater universe of the oceans has always been a challenge to observe and monitor, particularly with remotely operated fixed floating installations for vertical profiles. Most environmental parameters such as light, temperature, oxygen and salinity vary significantly and often abruptly with depth, making high-resolution depth curves one of the most important diagnostic indicators for hydrological dynamic processes and environmental conditions of the water column.

With the globally increased focus on the marine biosphere as a source of food and the physical role of the oceans in regulating climate, the need for such data is rapidly rising. Aquatic resource managers and the growing aquaculture industry use environmental data to understand the interactions between biotic communities and their abiotic surroundings, as well as routine monitoring of ambient water quality.

Marine and climate researchers use the same data to better map and understand the oceanographic circulation systems, and to calibrate dynamic models for future predictions and scenarios.

Floating APB5 buoy near Bergen, Norway, with solar panels, wind generators and embedded Web server.

Standard hydrological data are normally acquired by CTD sensors, with auxiliary measuring instruments for dissolved oxygen, turbidity and fluorescence, for example. The data collection, however, is normally ship-dependent and manually operated, and, hence, expensive and time-consuming. Remotely controlled automatic profiling with real-time results has, therefore, long been an attractive goal in marine technology. There are, however, numerous obstacles in achieving practical solutions, and foremost among these are communication, energy demand and maintenance.

Cable Connections, Biofouling Challenges

Up until present, communication and data transfer between the sensor and the recipient, as well as energy supply, has been heavily dependent on electrical cable connections. All existing advanced scientific CTD probes require manual reading or cable-dependent data transfer between the instrument and the recipient. For automatic profiling, this results in relatively long and heavy cables and vulnerable, fatigue-prone connectors, such as slip rings. This is because an oscillating body hanging from a winch drum cannot have a fixed socket connection without twisting the cable. In addition, the weight and corresponding energy demand for hoisting become substantial.

An important but often overlooked problem of sensitive and reliable data collection from submerged instruments is biofouling, i.e., the settlement and growth of sessile aquatic

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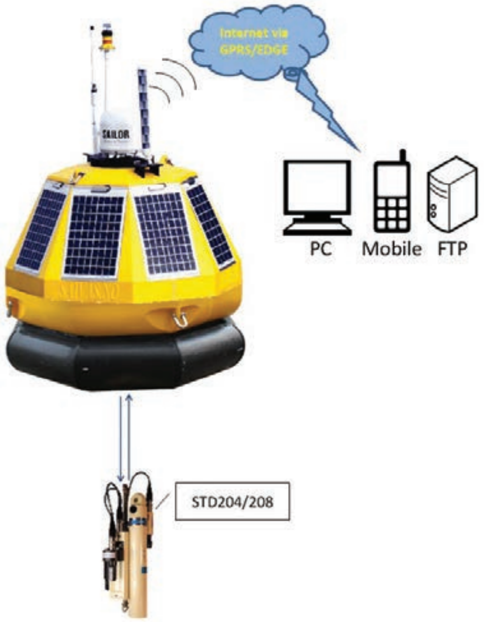


APB5 buoy with STD204/208 probe and wireless data transfer by the Internet via GPRS (general packet radio service) or EDGE (enhanced data rates for global evolution).

organisms on exposed surfaces. In many marine environments, such biological processes are fast, and require frequent cleaning and maintenance.

In short, the technical problems of automatic profiling from unmanned stations with restricted energy supplies have been too complicated to solve adequately from small, easily manageable and inexpensive offshore installations. However, SAIV AS's (Laksevag, Norway) APB5 buoy, which has a wireless short-distance radio-transmitted interface between the profiling probe and transmitting data server, as well as extremely low energy demand allowing long-time battery operation, represents a breakthrough in solving these obstacles.

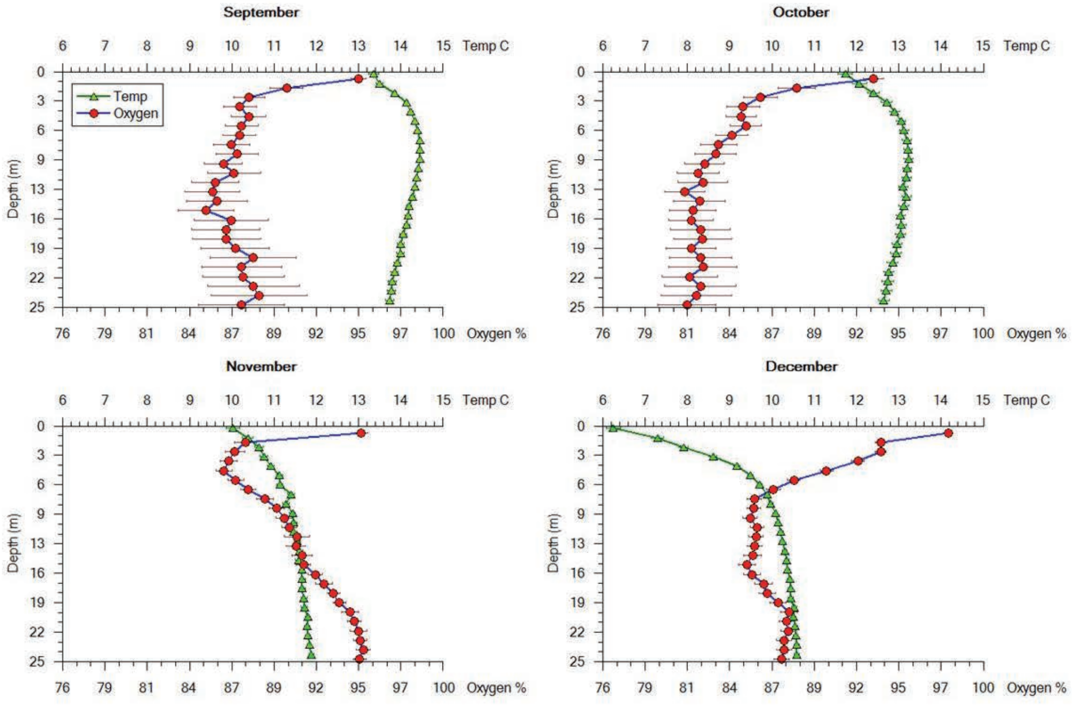
Buoy Development

The buoy has a height of 130 centimeters, a diameter of 150 centimeters and weighs 200 kilograms. Constant exposure to seawater and extreme weather events, such as storms, make high demands on the endurance and stability of the buoy. Its body is made entirely of rotational molded foam-filled polyethylene, and all bolts, nuts and tackle are stainless, acid-free steel. The buoy is designed to prevent sinking and capsizing even under extreme events. All external cable connections are sealed or joined by SAIV AS's deepwater sockets, which are widely used on ROVs.

SAIV AS has for the past 20 years gradually developed and improved its portable, compact CTD probe, STD204/208. In contrast to many other similar probes on the market, the STD204/208 will store all relevant calibration coefficients, and continuously process and deliver the measured data directly in physical units.

Recently, the model was further developed to support wireless data transfer via shortwave radio, while still maintaining extremely low energy requirements. This feature enabled the possibility of developing an automatic self-sustained profiling buoy without the previous obstacles described above.

Most importantly, the wireless communication solved all the conventional cable problems. Secondly, the low energy requirements make the probe operable on batteries for hourly profiling for at least a year without replacement. Lastly, the airborne data transfer in between profiling that requires the probe to be hoisted out of the water has unexpectedly and inadvertently proven to be effective for antifouling. Thus, as the probe is kept suspended above the surface inside the buoy when not profiling, the equipment



Monthly average temperature and oxygen profiles (means with 95 percent confidence limits) in 1-meter depth intervals from inside a salmon aquaculture holding pen September to December 2011.

is practically maintenance-free in between routine annual service. An additional bonus is the possibility to calibrate the oxygen probe automatically from the atmospheric oxygen concentration.

The probe, weighing approximately 6 to 8 kilograms in air depending on the amount of auxiliary equipment, hangs from a 4-millimeter nylon rope with up to 150 meters range on the winch. The lightness of the dynamic parts (probe and rope) makes the winching itself—which is the most energy-demanding operation—relatively low-consuming, so it can be sustained by mounted solar panels or miniature wind turbines on the buoy.

The data as well as remote control commands are transmitted from the buoy to the user via the Internet. The embedded server is accessible via the HTTP protocol, FTP, SMS or Wi-Fi. If network coverage is unavailable, satellite communication can be provided. The modern network-based communication makes the buoy and data transfer accessible in real time through standard PC, tablet and mobile-phone equipment. One to several users can access the buoy independently from any location over the Internet.

All commands, such as start, stop, frequency, range and depth intervals of profiling, as well as diagnostic routines, are performed through online menus, and the return and downloading of incoming data is equally simple. The server in the buoy will store and keep incoming data in between downloading and can store data for up to two years. Malfunctioning will be instantly reported, in which case, the buoy will automatically go into hibernation.

Results From Field Tests

The buoy was tested by prototypes in two separate coastal locations in Norway for more than two years of continued bihourly profile operations in all kinds of weather. One site was a commercial salmon farm near Bergen, Norway, where the equipment was mounted inside a floating holding pen rearing Atlantic salmon, and the other site was a permanent hydrographic monitoring station in the Høgsfjorden fjord near Stavanger, Norway, which has been operating continuously since June 2010.

The data from the salmon cage, which began being gathered in September 2011, are processed by a dedicated software application called the Welfaremeter, developed by the Institute of Marine Research in Bergen, Norway. This application, which continuously stores and analyzes the incoming data using a database, gives a real-time evaluation of the environmental conditions in the cage as either very good, good or potentially harmful for the fish. The results are graphically displayed and updated on a Web page so that a farmer has instant control of his fish cages via PC, tablet or mobile phone.

The data from the Høgsfjorden buoy, being collected by EWOS Innovation, a Norwegian commercial aquaculture feed company, is used primarily to monitor the surface layers of low-salinity water stemming from freshwater runoff. The data are being used to investigate the dynamics between salmon sea-lice infestation and salinity gradients of the water column.

Future Potential

This APB5 buoy is the first generation in an envisioned series of internationally cooperating measuring platforms based on the present product. SAIV AS has received inquiries for possible positioning of the equipment on floating ice in the Arctic as part of ongoing climate research programs. The buoy can be extended to support acoustic Doppler current meters and atmospheric weather stations.

The company also foresees a huge and growing interest from the aquaculture industry, where intensive offshore rearing in larger sea cages combined with increased user demands for healthy conditions for both the fish and the ambient environment will require high-resolution monitoring of reliable real-time data.

Furthermore, the buoy can be used for any activities requiring continued water quality monitoring, such as filling, mining or drilling. ■

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