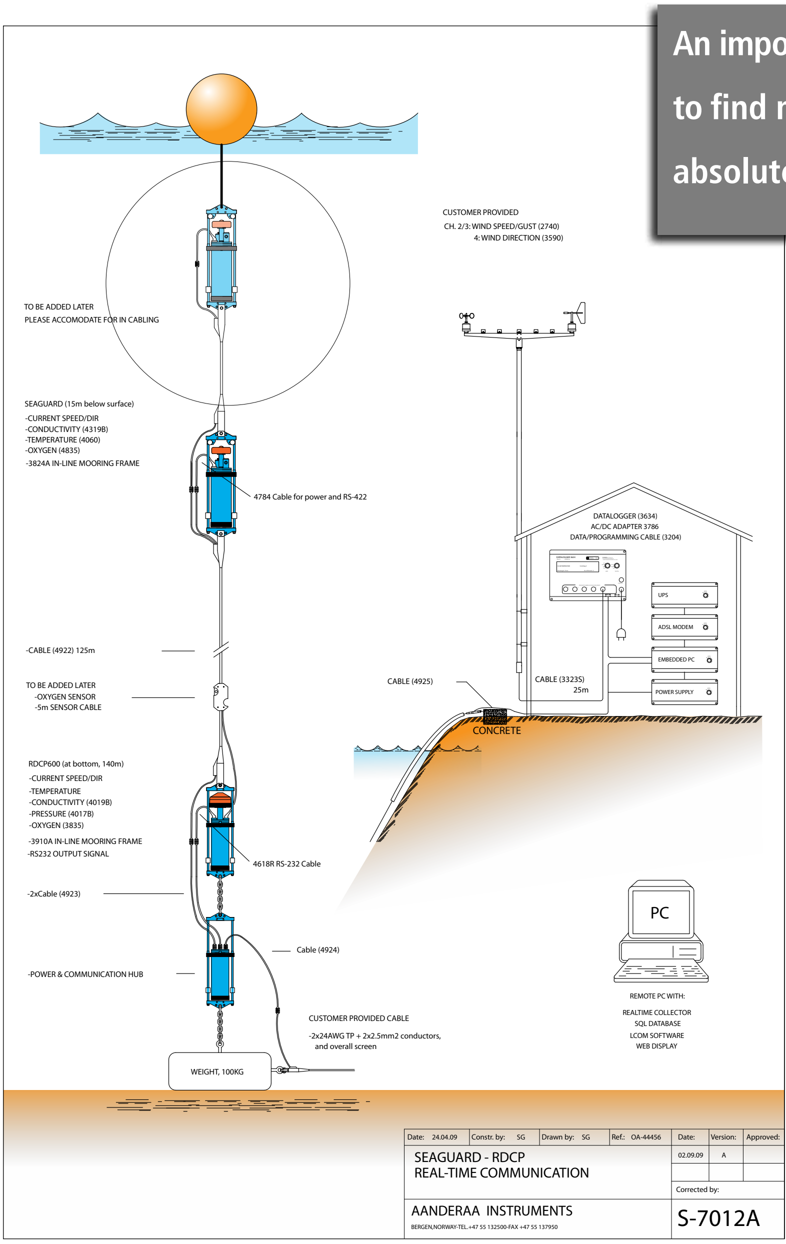
EU–HYPOX project aims to improve oxygen monitoring and understanding of the importance of hypoxia

by: Anders Tengberg

Most aquatic life depends on oxygen. It is, thus, an alarming finding that the occurrence of hypoxic (low oxygen) conditions is increasing worldwide. This is mainly thought to be a consequence of anthropogenic eutrophication (nutrient input) and climate change. The intention of the ongoing EU-project HYPOX (http://www.hypox.net/) is to improve the capacity to monitor and predict oxygen depletion, by e.g. implementing reliable long-term sensors to different platforms for in-situ monitoring.

AADI was involved in the HYPOX project at the beginning and has provided instrumentation and technical advice for installations for several partners of the consortium. Furthermore, AADI cooperates with HYPOX partners on issues of sensor calibration improvements and provided equipment on loan for workshops and field campaigns.

An important task within the Hypox project is to find methods to improve and maintain the absolute accuracy of the oxygen measurements



The long-term stability and robustness of the AADI optodes makes these sensors particularly well suited for this project but until now there was a lack of a broad experience from long term (months/years) exposure in low oxygen (suboxic/anoxic) environments which is now being acquired.

HYPOX target site Loch Etive is a relatively pristine marine environment without major influence from human activities (e.g. agriculture and urban agglomerations). Facing the facts of climate change it is highly likely that this will have negative effects on the oxygen conditions in the Loch. Increasing surface temperatures and increased precipitation will potentially enhance water column stratification and reduce the exchange of deep isolated water bodies. Additional input of terrestrial organic matter due to an increased river runoff as well as higher surface water temperatures will increase the biological oxygen demand and decrease oxygen solubility. Thus, predicted climate changes may very well increase the duration and severity of hypoxia in Loch Etive, a fjord that already is classed as one of the most sensitive Loch's in Scotland in terms of oxygen depletion.

A turn-key on-line system was delivered to the Scottish Marine Association in Oban (SAMS) and installed in Loch Etive during the autumn

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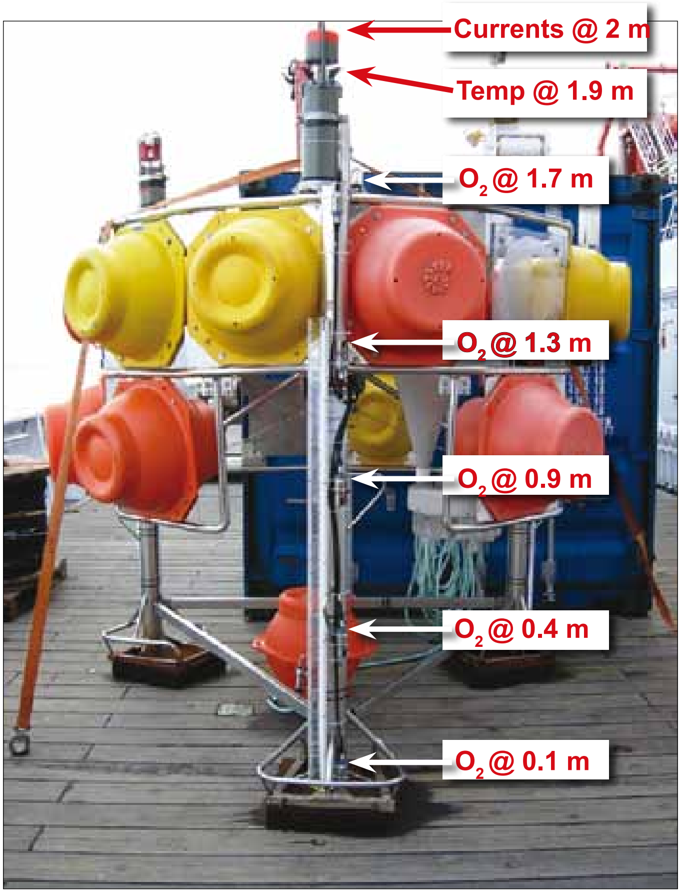

Fig. 2: AWI long-term oxygen lander on deck for yearly service and data download.

Fig. 3: UGOT Seaguard with 20 m string on-deck before deployment. Measures: Currents at one level, Water level, Cond/Sal/Temp at 4 levels, O_2/Temp at 3 levels. There is empty space for 11 additional sensors. The autonomy of the system is about 1 year using internal batteries and set to record data at 20 min intervals.

of 2009. Major components in this system include one SEAGUARD® single point current meter with auxiliary sensors, one profiling current meter RDCP 600 with auxiliary sensors, an underwater communication hub (from http://www.develogic.de/), a shore cable, a shore based station to receive and retransmit the data and the necessary software (RT-collector and GeoView) to present and store data in real time (for details see Fig. 1).

Effects of climate changes are first seen in Polar Regions, especially in Arctic ice margins. To detect and track the impact of environmental changes and their effect on deep-sea biodiversity, the Alfred Wegener Institute for Polar and Marine Research (AWI) has established the observatory "HAUSGARTEN" at a water depth of 2500 m. As part of the HYPOX project oxygen is measured at 5 different levels (from 0.1-1.7 m) above the seafloor using one of the autonomous AWI landers (see Fig. 2). The gradient measurements have been done with 2 hours intervals from 2007-2009 using an RCM 11 current meter to which 5 oxygen optodes are connected. Short term (weeks/months) variations are surprisingly high, depending on current directions, and there are interesting longer trends in the data (not presented here).

On the Swedish west coast in the Havstens/Koljö fjord system a SEAGUARD® string logger with a 20 m long sensor string was deployed by the University of Gothenburg (UGOT) in November 2009 (Fig. 3) as part of the HYPOX project. One intention of these measurements is to assess when and how frequently exchanges in the fjord system occur. The field data are used to improve an environmental model which has been established for the area. With a well functioning model that can mimic the present different future scenarios will be simulated. In Fig. 4 data from measurements every 30 minutes are presented and compared with results from a nearby sampling station included in the national Swedish monitoring program operated by the Swedish Meteorological and Hydrological Institute (SMHI). The intention of the monitoring program is to do monthly ship monitoring. Due to severe ice conditions in the winter of 2009-2010 there is a 4 month gap in the ship data. As can be seen in the figure sensor and monitoring results track fairly well (please observe that measurements and sampling are not done at the exact same locations and depths). The variability of all parameters is large and monthly data can not resolve temporal variations at this, and probably most other coastal sites. Monthly ship data are however very useful to check the quality rendered by in-situ sensors.

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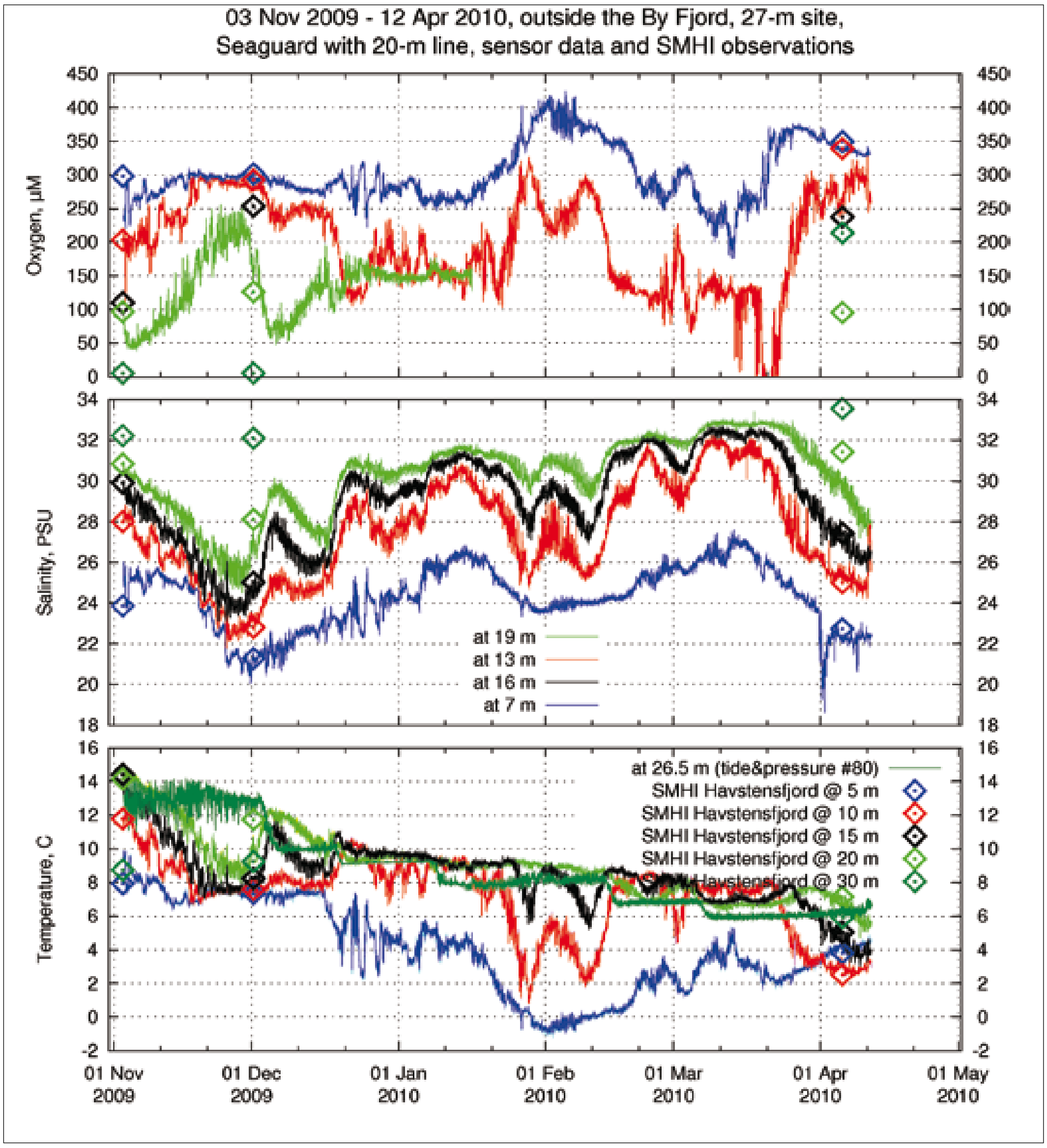

Fig. 4: Examples of Oxygen, Salinity and Temperature measurements obtained with a Seaguard with 20 m string. Dots in the plots represent ship monitoring data from a nearby station collected by SMHI.

An important aspect within the HYPOX project is to investigate the absolute accuracy of oxygen measurements for low concentrations and long-term studies. With this in mind an optode calibration workshop was performed by HYPOX researchers and AADI staff at the Max Planck Institute (MPI) in Bremen in December 2009. During three days 13 optodes were run in a temperature regulated gas tight calibration vessel (Fig. 5). Three of the sensors were previously Winkler multipoint calibrated 4330 MkII optodes that served as references. Calibration runs at different temperatures (2-35ºC) in cooling/heating cycles and six oxygen concentrations between 0-220 µM were used to investigate and improve the performance of the optodes. These results demonstrated the superiority of the MkII (4330) optodes in maintaining constant oxygen readings at all temperatures which can be explained by the more elaborate quenching-oxygen-temperature formulas that are included in the 4330 sensors. In addition the optics is improved in the newer sensors. The older 3830 MkI sensors were generally readings lower than the reference optodes and at the highest oxygen concentration (220 µM)

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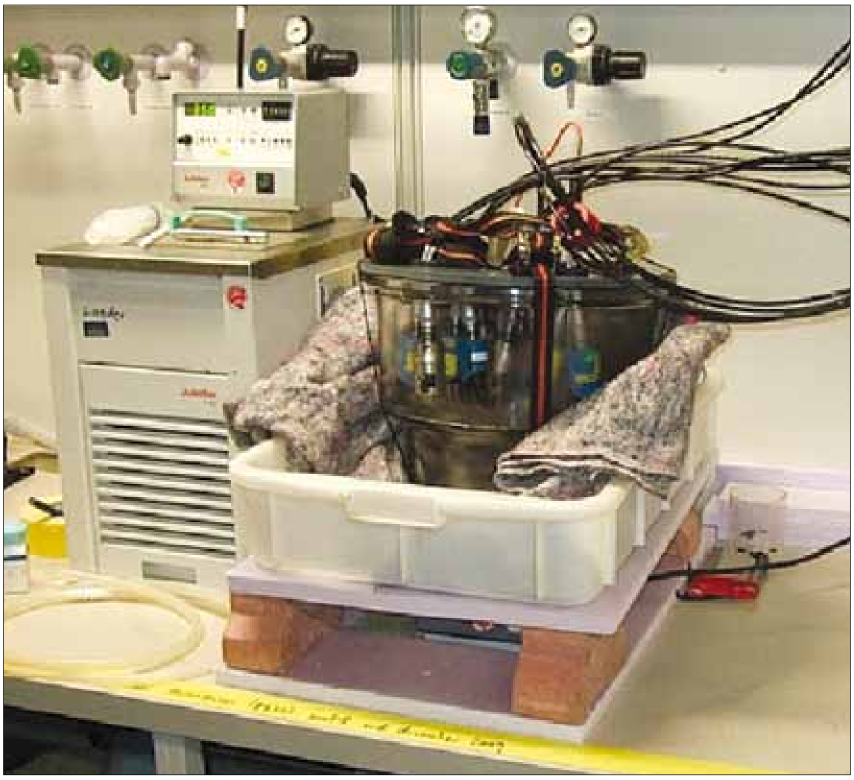

Fig. 5: Gas tight and temperature regulated calibration vessel set up at MPI

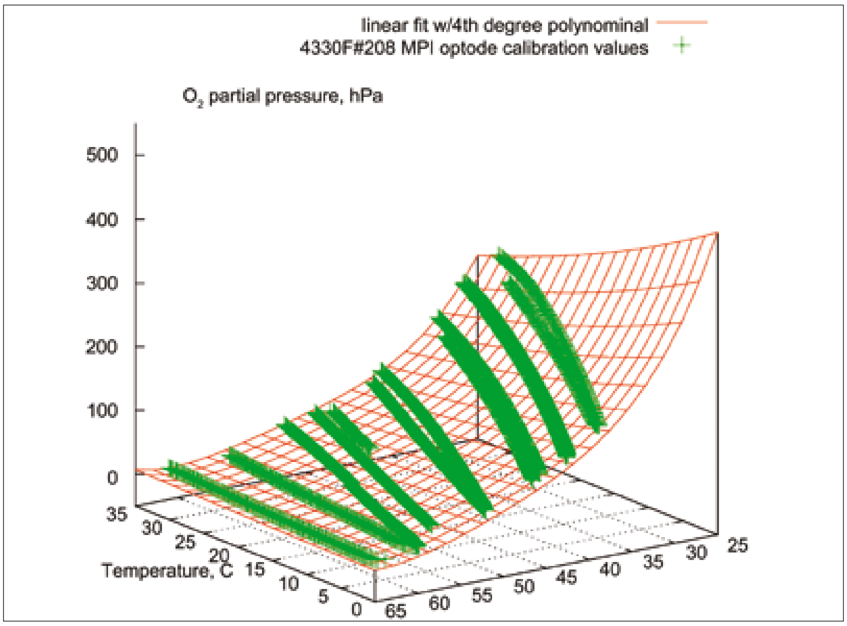

Fig. 6: Example of oxygen concentrations and temperatures covered in the MPI calibrations exercise with calibrated data from one of the participating optodes shown in green.

the deviation could be as large as 30 µM at certain temperatures. These deviations may be attributed to two artefacts. The first is that the temperature compensation formulas applied in the older optodes are not optimal in compensating the oxygen readings at all temperatures. The second is that when foils are new there appears to be an initial foil curing effect created by exposure in lamp light which can lead to some % lower oxygen readings. It is therefore recommended to store sensors and foils dark in-between deployments.

Three 4330F optodes with transparent fast responding foils participated in the calibration runs. These were within the factory given specifications (±5% or ±8µM whichever is greater) but they were reading lower than the references and the noise level was higher. Because the transparent foils are less robust and sensitive to bleaching in sun light it is recommended to check the saturation accuracy of optodes with these foils mounted more frequently.

The calibration exercise provided information which makes it possible to improve the absolute accuracy of all participating sensors down to a couple of µM (Fig. 6) without the need for frequent Winkler referencing. Given that raw data are stored in the field for the older MkI optodes, the information obtained in the calibration workshop can be used to improve absolute performance of older sensors by post processing of the measurements.

During an upcoming field campaign UGOT will use results from the calibration workshop to improve the accuracy of two 3830 MkI optodes to obtain high resolution gradient measurements close to the seafloor.

Based on the experiences gained from the calibration exercise MPI is improving their existing calibration equipment and AADI is building up a new advanced calibration facility for O_2 and CO_2.