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REPORT

Near surface oceanographic measurements using the SailBuoy

Test deployment off Grand Canaria

Client

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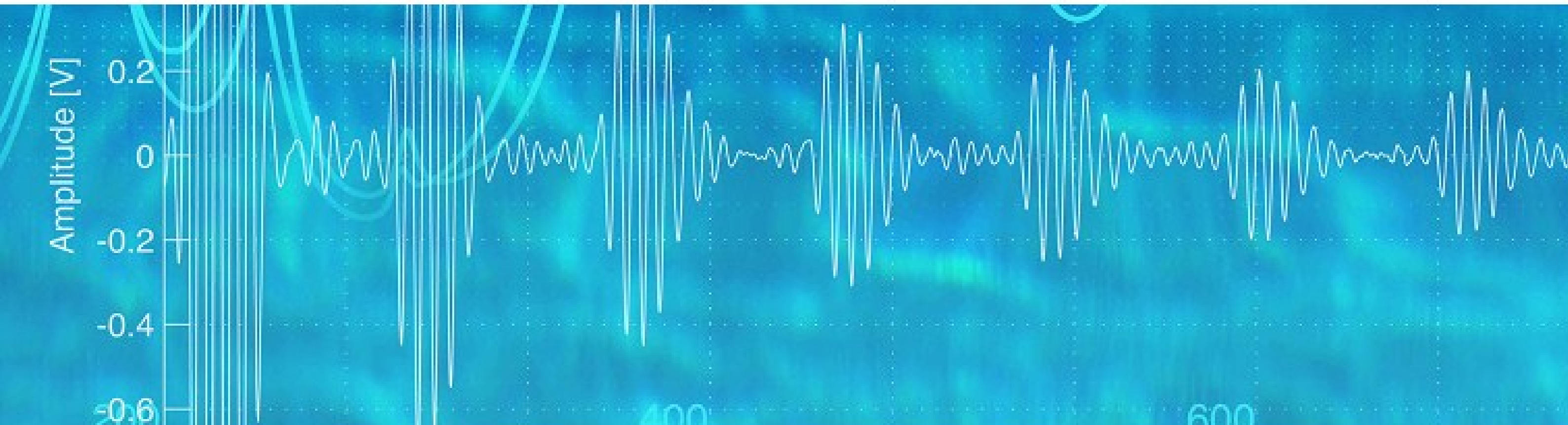

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Title

Near surface oceanographic measurements using the SailBuoy

Extract

In this document, the preliminary data are reported from a deployment of SailBuoy conducted in winter 2012, off Grand Canaria. The SailBuoy was equipped with conductivity-temperature sensors and an oxygen optode.

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Table of Contents

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1 Introduction

The SailBuoy, developed by Christian Michelsen Research (CMR) Instrumentation, is an unmanned ocean vessel capable of travelling the oceans for extended periods of time (see http://www.sailbuoy.no). It navigates autonomously, controlled by 2-way communication through the Iridium satellite system, transmitting data in real time underway. The SailBuoy can be fitted with various sensors to be used for a wide variety of ocean applications. A detailed report on the navigation performance and characteristics are the SailBuoy can be found in Fer & Peddie [1].

In this document, the data are presented from a deployment of SailBuoy SB02 off Grand Canaria (Canary Islands, Spain) (Figure 1). The deployment has been conducted in collaboration with the Oceanic Platform of the Canary Islands (PLOCAN). For this deployment, SB02 was equipped with Neil Brown conductivity-temperature sensors and an Aanderaa Instruments oxygen optode. The deployment is summarized in Section 2 together with the sensors used. The data set is presented and discussed subsequently in Section 3.

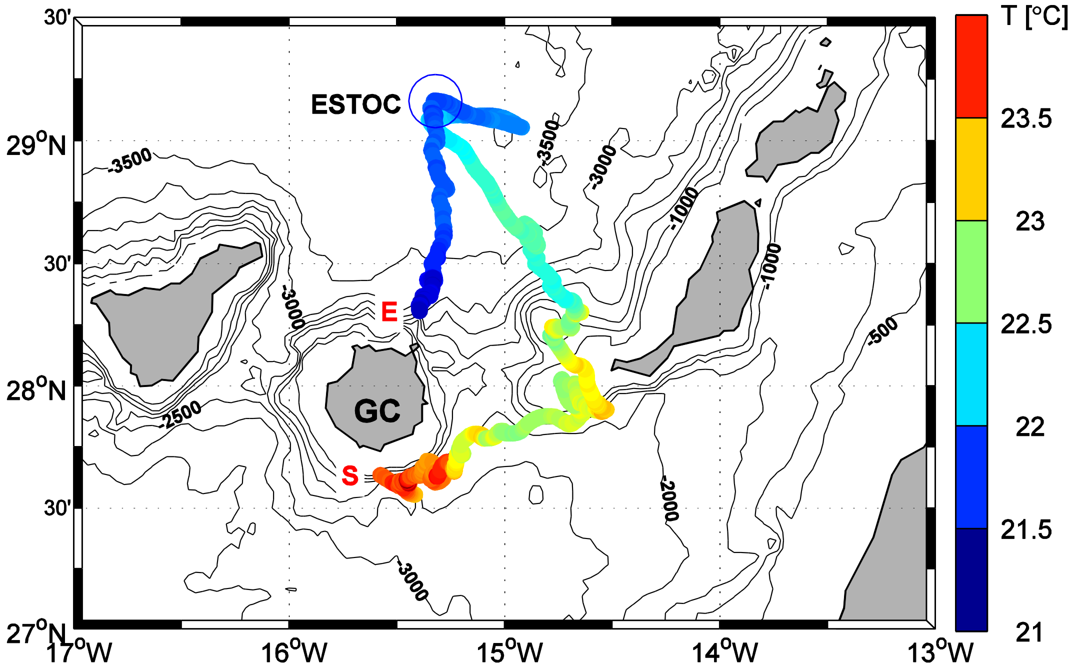

Figure 1. Map showing the track covered by the SailBuoy SB02 during the mission off Gran Canaria (GC) in November 2012. Each GPS fix is color-coded for the surface temperature. Isobaths (black) are drawn at 250 m intervals. The start (S) and end (E) of the mission are marked. The circle labeled ESTOC marks the location of the European Station for Time-series in the OCean (ESTOC).

2 Deployment

The SailBuoy utilized in this trial is SB02. SB02 was equipped with a conductivity-temperature sensor (Section 2.1) and an oxygen optode (Section 2.2) which are described below. The main goal of the mission was to sail to the European Station for Time-series in the OCean (ESTOC) site, and demonstrate its navigation and near-surface oceanographic sampling capabilities. ESTOC is an internationally recognized ocean site, and has recently improved its sampling program with unmanned, autonomous underwater and surface vehicles technology.

The deployment was made from a light boat on 13 November 2012, 12:00 UTC, and the mission started at 15:00. During the mission, data are relayed at 30 minute intervals, whereas in recovery mode prior to and after the mission, the position is sent at 10 minute intervals. The recovery mode ensures frequent update on GPS fixes of the SailBuoy. The mission was completed on 5 December 07:30 and the SailBuoy recovered on 11:20 from a small boat. The deployment and recovery was conducted in collaboration with PLOCAN in Grand Canaria (Figure 2).


Deployment


Recovery

Figure 2. Deployment and recovery of the SailBuoy.

2.1 Conductivity-Temperature Sensor

A glider conductivity-temperature (CT) sensor manufactured by Neil Brown Ocean Sensors, Inc. was interfaced to SB02. The CT sensor is a low-drag, fast response unit, composed of a 4-electrode conductivity cell, and a stable thermistor. The CT sensor was chosen due to its rugged design, low drag, and resistance to fouling, key to successful deployments on a SailBuoy. No pump is required and the electronics are free of thermal drifts. The serial port outputs data as temperature and conductivity at a 5 Hz sample rate. The fin-cell is mounted to the hull of SB02 (see Figure 3). DC power at 12 VDC is supplied to the CT board. A DC/DC converter then generates the ±5 VDC required by the board electronics. The board draws about 30 mA independent of the sample rate. The thermistor temperature sensor is calibrated by the manufacturer in a high stability temperature-controlled bath.

Figure 3. CT sensor mounted on the SailBuoy.

2.2 Oxygen Optode

The Oxygen Optode AS4835, manufactured by Aanderaa Data Instruments (AADI), was fitted to SB02. The optode is designed for measuring the dissolved O_2 concentration in shallow water and samples the O_2 concentration and air saturation at a resolution of 1 microM and 0.4%, respectively. The output format is RS-232. The average current drain is 0.16 +48mA/S where S is sampling interval in second. Its dimensions are Ø36 x 86 mm and weighs 118 g. The optode was mounted to the hull, to the opposite side of the CT sensor (not shown).

2.3 Sampling and data reduction

The conductivity and temperature are sampled at 5 Hz for 8 seconds at the start of each sampling period. The batch of 40 data points for both temperature and conductivity are averaged after ignoring any outliers exceeding ±1 standard deviation to remove the effects of possible spikes and erratic readings at the surface layer. A single reading from the oxygen optode is returned. The resulting data are relayed with the GPS fix and time stamp together with diagnostic data.

3 Results

The complete track of the mission off Grand Canaria is shown in Figure 1, overlain on the bathymetric contours and color-coded for the measured temperature. The substantial cooling in the later part of the deployment is due to bio-fouling of the sensor as discussed later.

Following the deployment, the wind ceased, leading to a reduction on the navigation performance of the SB02. This endangered the instrument since the site has heavy ship traffic. During the mission, another four episodes of weak wind occurred. The periods of weak wind are marked on the track of the vessel shown in Figure 4. Following the onset of wind, SB02 sailed northeast toward the given waypoint. With the forecast of ceasing winds, the operator has decided to maintain the vessel in a traffic free environment close to the southern tip of the island northeast of Grand Canaria. On its way to the ESTOC buoy site (marked blue in Figure 4), two more episodes of weak winds occurred. Upon reaching the ESTOC site, SB02 maintained position for approximately 16 hours, followed by a short zonal section. SB02 then returned to the ESTOC site, maintained position for another 5 hours before proceeding southward to Grand Canaria.

Data are extracted between 13 November 2012, 15:00 and 5 December 2012, 07:30:00 UTC. In total 1028 data points, at typically 30 minute intervals are recovered. The extent of the track coverage is approximately 140 km zonally and 220 km meridionally.

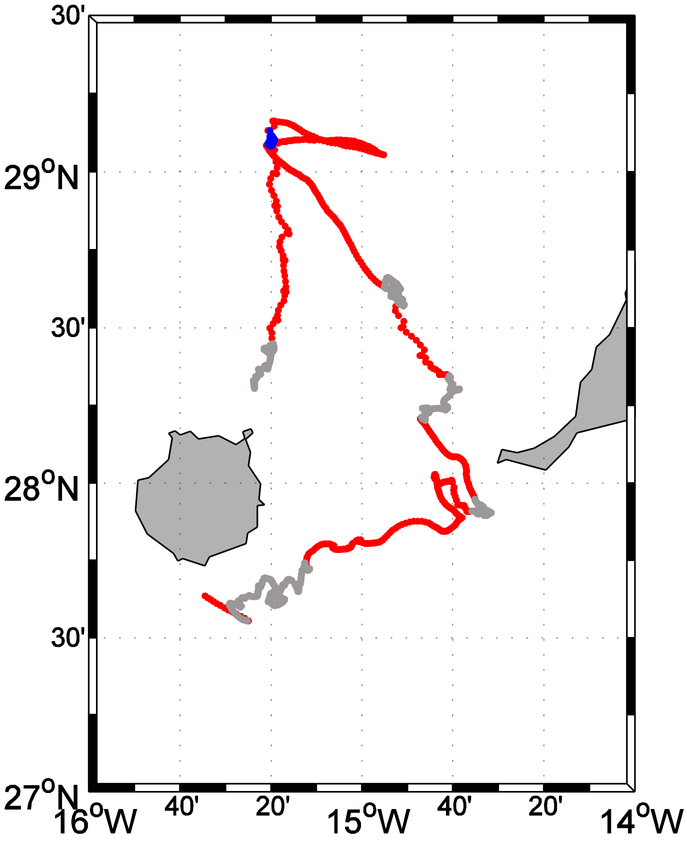

Figure 4. The track of SB02 (red) with the low wind portions (gray) and station keeping at the ESTOC site (blue) marked.

The horizontal speed of the vessel is calculated from the centered-first differencing of the complex position vector inferred from the GPS fixes as in Fer and Peddie [1]. Out of a total of 1028 data points, only 418 were when the wind was relatively stronger (red markers on Figure 4). The statistics of the speed using this approximately 40% subset of the data gives minimum and maximum values of 5 cm s^{-1} and 135 cm s^{-1}, respectively. The average speed is 70 cm s^{-1}, with a standard deviation of 27 cm s^{-1}. The median is 68 cm s^{-1}. Out of this chosen portion of data, only 12 data points (about 3%) had speed less than 20 cm s^{-1}, whereas almost 50% exceed 70 cm s^{-1}, i.e. the distribution was skewed toward larger speeds.

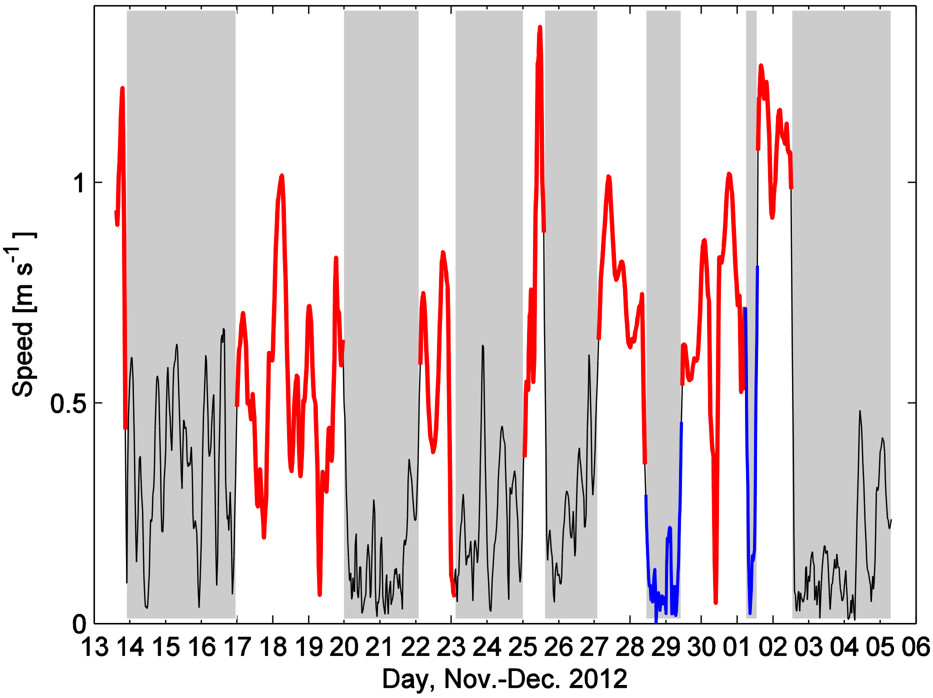

Figure 5. Vessel speed inferred from GPS fixes. No smoothing is applied. Gray portions mark the periods with weak wind and the the portion marked blue are when the vessel was station keeping at ESTOC site.

The time-series of measured near-surface temperature, conductivity and derived salinity are shown in Figure 6. After 27 November 2012 12:00 UTC the measurements indicate a significant drift in temperature and conductivity measurements. This is induced by bio-fouling, also evidenced by the biology covering the sensors photographed after recovery (Figure 7). The sensors, however, returned 14 days of near-surface data of high quality. This is achieved without applying any anti-bio-fouling material on the sensors. For the future deployments, the performance is expected to increase after applying anti-fouling paint.

During the 14 days period the surface temperature was 22.81 ± 0.37 °C (± one standard deviation). The corresponding surface salinity was 36.8 ± 0.1 on the practical salinity scale. The temperature record shows finestructure with numerous fronts with order 0.4°C anomaly, compensated in density with salinity anomalies. This can be seen on the composite temperature-salinity diagram (color-coded for dissolved oxygen concentration for reference) where the data points typically lie along isopycnals (Figure 8).

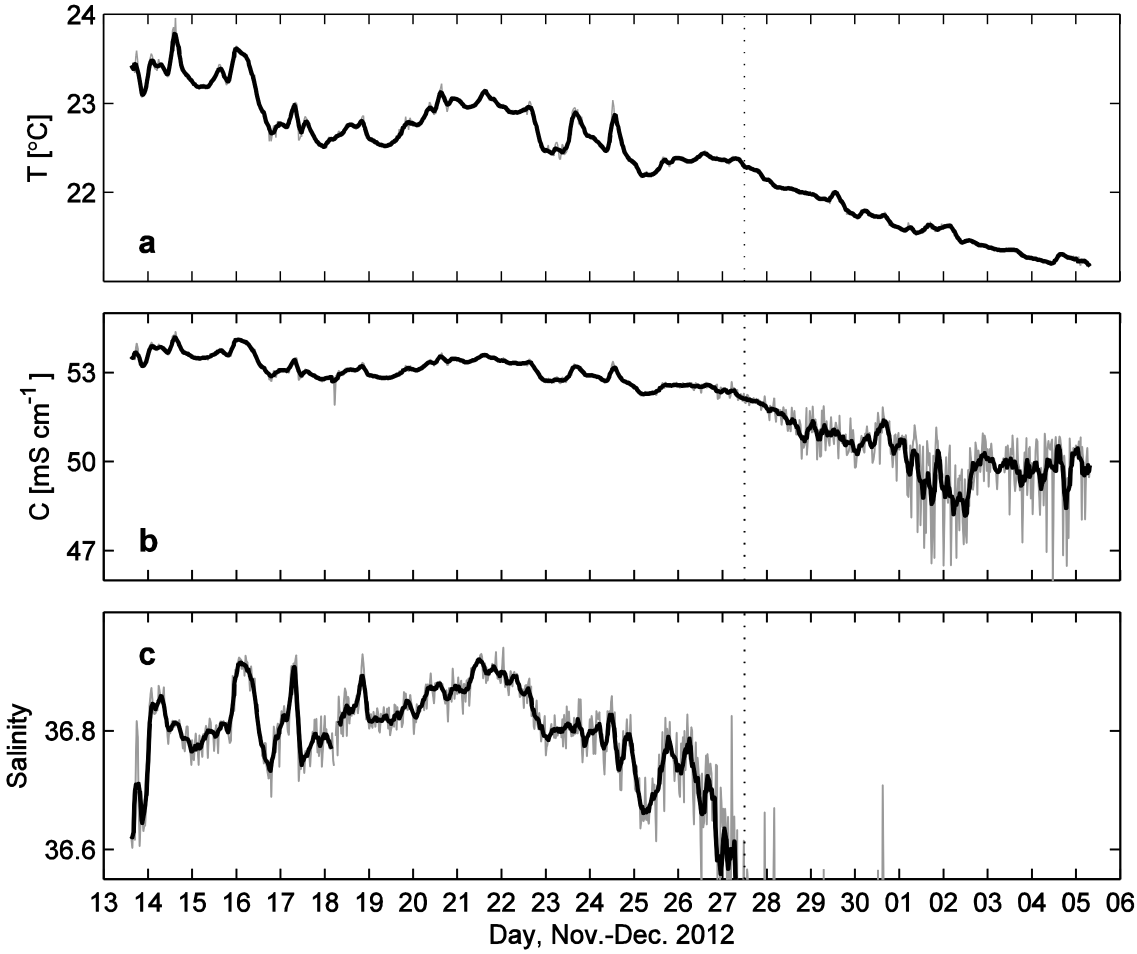

Figure 6. Time series of a) temperature, b) conductivity, and c) salinity measured by the CT sensor. Thick black trace is 3-hour smoothed data. The vertical dashed lines mark the time when the CT sensor starts a significant drift due to bio-fouling.

Figure 7. Close-up pictures of the (left) CT-sensor and (right) optode taken after recovery, showing the biology.

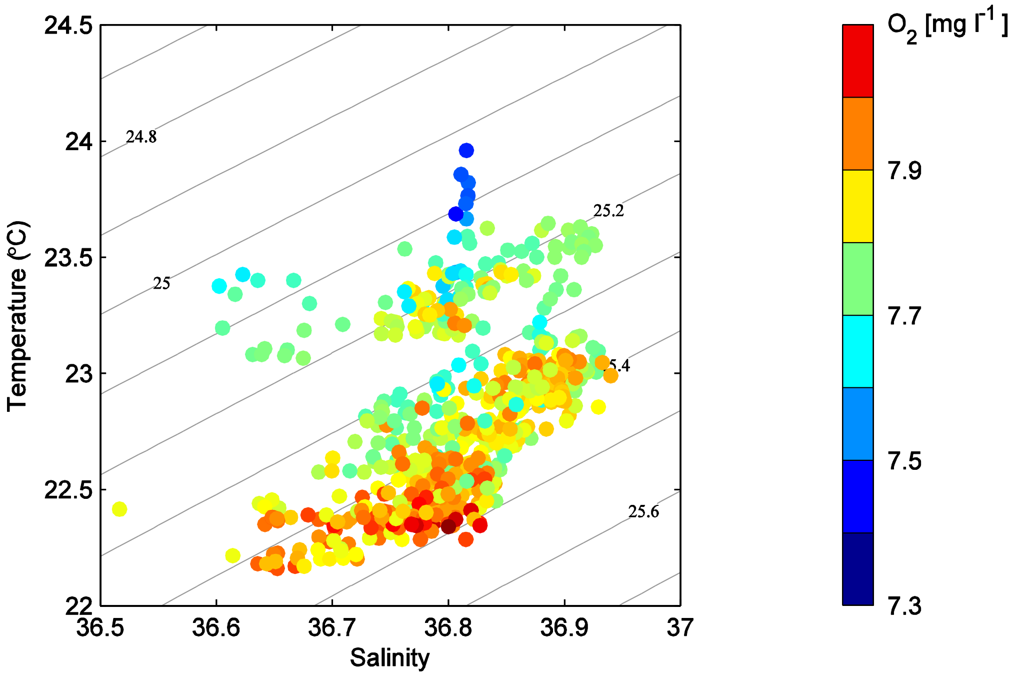

Figure 8. Temperature-salinity diagram of the data collected until 27 November 2012, color-coded for the dissolved oxygen concentration. Isolines are the potential density anomaly (σ_θ) referenced to the surface pressure.

The time-series of oxygen concentration show a pronounced diurnal cycle of about 0.1-0.2 mg l^{-1} peak-to-peak amplitude overlain on a weak increasing trend, presumably associated with a drift in the sensor (Figure 9). The amplitude of the oscillations is suppressed following 27 November, accompanied with an increase in the background drift, suggesting bio-fouling, i.e. the sensitivity of the sensor is reduced. While the reduction in sensitivity is also observed in the air saturation, there drift in the measurements is relatively weaker.

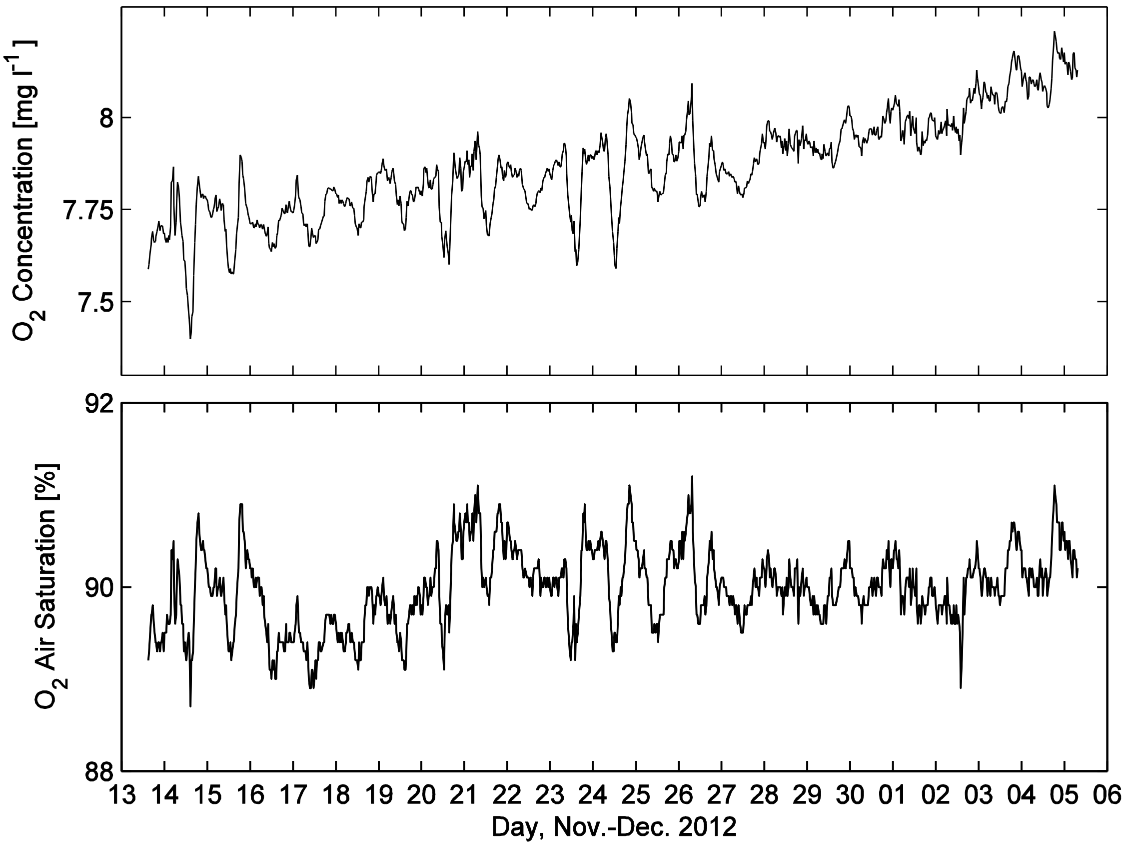

Figure 9. Time series of the dissolved oxygen concentration and the oxygen air saturation measured by the AADI optode.

4 Summary

SailBuoy SB02, fitted with a Neil Brown conductivity-temperature sensor and an Aanderaa Instruments oxygen optode, was deployed off Grand Canaria, Spain, in 13 November 2012. The mission duration was 22 days and the extent of the track coverage was approximately 140 km zonally and 220 km meridionally.

During the mission, several episodes of calm weather occurred which reduced the navigation performance of the vessel. With the onset of wind, however, SB02 sailed satisfactorily with an average (± one standard deviation) speed of 70 (± 27) cm s^{-1}.

Two weeks into the deployment, the measurements indicate a significant drift in temperature and conductivity induced by substantial bio-fouling. This pilot study was conducted without anti-fouling material on the sensors, and the performance of the sensors is expected to improve if anti-fouling paint is applied. During the 14 days period with high quality near surface measurements, the temperature and salinity were 22.81 (± 0.37) °C and 36.8 (± 0.1), respectively. Temperature fronts, with order 0.4 °C anomaly, compensated in density with salinity anomalies, were observed. The time-series of oxygen concentration showed a pronounced diurnal cycle of about 0.1-0.2 mg l^{-1} peak-to-peak amplitude overlain on a weak increasing trend, presumably due to a drift in the sensor. After two weeks, similar to the onset of bio-fouling inferred for the conductivity-temperature sensors, the amplitude of the oscillations is suppressed suggesting a reduction in the optode’s sensitivity and hence bio-fouling.

5 Conclusion

A conductivity-temperature sensor manufactured by Neil Brown Ocean Sensors Inc., and an Aanderaa Instruments oxygen optode were successfully interfaced to the CMR-SailBuoy. During the 22 days deployment in the waters off Grand Canaria, Spain, high quality near surface measurements were obtained in the first two weeks. Both the conductivity-temperature sensor and the optode indicate significant bio-fouling after approximately 14 days. It is expected that this period can be extended by at least 50% if anti-fouling paint is applied. The navigation performance of the vessel is significantly reduced in calm conditions, and it is recommended to avoid deployments in calm days close to shore or at sites with heavy ship traffic.

6 References

[1] Fer, I., and D. Peddie (2012), Navigation performance of the SailBuoy. Bergen - Scotland mission, 12 pp, Christian Michelsen Research AS, Bergen.