

## Aanderaa Oxygen Optodes

## **Best Practices for Maintaining High Data Quality**

This document gives recommendations on field adjustments of oxygen optodes.

Done correctly a one or two-point adjustment of an optode will give it almost the same accuracy as when it was factory calibrated. By following these procedures end-users should be able to maintain high accuracy and documented data quality themselves.

Below two different methods are suggested.

Adjustment of saturation calibration in air-bubbled water: The example given is from the Swedish <u>Aquanet project</u> in which about 100 Aquaoptode (model 4531) were used at five field stations for five months in targeted mesocosm studies.

Aanderaa optodes are stable and normally becomes better over time. Do not change foils unless mechanically damaged. During the initial months of storage/use a Foil maturation process occurs resulting in lower readings by several %. The maximum observed maturation induced drift on more than 1000 sensor has been 8 % for sensors with non-factory prematured WTW foils (model: 4835, 4531 and 5730 Steinsvik) and 6 % for sensors with factory pre-matured PSt3 foils (model: 4330, 4831, 5331 hadal). During/between field deployments there are possibilities for end users to post-adjust the sensors either by a one-point air-saturation adjustment or by taking reference samples (e.g. water samples and Winkler titration) and/or using a well-calibrated sensor in parallel. If done correctly such an adjustment should result in an absolute accuracy of around 1 % for multipoint calibrated sensors (model: 4330, 4831, 5331 and 5730) and 3 % for two-point calibrated (model: 4835, 4531), see below for more information about factory calibrations. The drift will decrease over time so that during the second year it is not likely to be more than 1-2 %. After this it should be less than 0.5 % per year, unless the foil is mechanically damaged.

<u>Saturation adjustment</u>: After the first year of Aquanet experiments, 16 optodes from one of the sites were immersed into an open tank filled with air-bubbled freshwater and left there to record for several days (Fig. 1). It is important that the aquarium pump takes in air from an

open atmosphere outside, not from inside the room/laboratory where  $O_2$  levels will be affected by the on-going activities and/or the ventilation. To verify that optodes are in saturated water you can take them up from the water and hold them just above the surface for a few minutes. There should then be no change in the saturation readings.

Fig. 1: Sixteen (16) optodes immersed into air-bubbled freshwater for post-deployment calibration check.





Fig. 2: Saturation readings from 16 optodes in air-bubbled freshwater (lower panel) and variations in local air-pressure (blue curve) and the calculated related air saturation levels compensated for the height above sea level (red curve) during an 8-day period. It should be noted that there is a 0.1-0.5 % difference when air-pressure changes from low-to-high compared to when it changes from high-to-low. The reason for this is an adaptation delay in the water mass in the tank. The smaller and better stirred/bubbled the water volume around the sensors is, the faster the water will reach equilibrium when air-pressure and/or temperature change(s).

The 16 optodes read between 4.1-6.5 % low and should be individually compensated by multiplying the readings by a factor of 1.041 for the sensor that reads the highest and 1.065 for the sensor that reads the lowest.

Adjustment of saturation calibration in air: The method suggested above gives high quality one-point adjustments but can be time consuming. A simpler field method, inspired by in-air calibrations on Argo floats and gliders (Bittig & Körtzinger, 2014; Johnson *et al.*, 2015; Nicholson & Feen, 2017; Bittig *et al.*, 2018) could be used during measurement campaigns but could render lower quality if the optode foil is not wet or the temperature at the foil is different from the one at the temperature sensor.

Simply let the optode(s) log outside in free air for several hours before and after the deployments and note the average air-pressure.

Preferably the recordings should be done during the night when air is normally moister and temperature is lower and more stable.

At sea level at standard air pressure (101.3 kPa = 1 Atm = 14.69 psi) the sensors should show 100 % if wet and 102 % if completely dry and at an air pressure of 100 kPa it should show (1.3/101.3)\*100 = 1.3 % lower.



The example below is from a <u>SeaGuard</u> instrument (measuring currents, mooring movements, particles,  $O_2$ , temp, salinity and depth) that is in continuous deployment in the Mediterranean Sea (<u>E2-M3A observatory</u>) at 1250 m depth. The instrument was logged in air before and after every deployment (Fig. 3). It was found that the oxygen optode was showing 9 % too low but that it did not drift over the 4-year deployment period that is reported on here. Also, pressure data from the deep water rated pressure sensor indicated that there was no drift since it was tracking with air-pressure in-between deployments.



Fig. 3: Simple field quality control letting the instrument log in air. The example shows quality control of the pressure sensor and the oxygen optode mounted on the SeaGuard.

<u>Adjustment of zero (0) readings:</u> To maintain high accuracy when using sensor in low oxygen environments also the zero calibration can be checked but normally its drift is minimal.

The sensor then has to be immersed into an environment with zero oxygen until the readings stabilize at low, close to 0 %. Please observe that plastic sensors and containers will take longer to reach low levels because plastics absorb or dissolve oxygen that can contaminate the surroundings. Methods that can be used include that the sensors could be put into a plastic bag filled with e.g.  $N_2$  gas or immersed into zero oxygen water where oxygen was removed chemically (e.g. sodium sulphite,  $Na_2SO_3$ ), biologically (put yeast and sugar in body warm water and all  $O_2$  will be consumed). Also boiling or bubbling water with e.g.  $N_2$  gas will create low  $O_2$  water but it is difficult to be sure that its  $O_2$  concentration is absolutely zero.

If a 0 % O<sub>2</sub> check is done this compensation could also be added/subtracted. If the sensor reads e.g. +0.2  $\mu$ M in N<sub>2</sub>gas/anoxic water -0.2  $\mu$ M should be subtracted from the data. To facilitate calculations we have made an Excel sheet that also gives the text strings to be

transferred to the sensor in case a terminal emulator software program is used (see instructions below).

**Correcting sensor readings:** There are two ways to correct the readings: **A. Externally**: By applying the correction factor(s) as a post-compensation or in real time by the software that logs and presents the incoming data. **B. Internally**: By serially (RS232) connecting the sensors to a PC and change the factor internally. This factor can be changed by using the dedicated Aanderaa software (RT collector) or by sending commands from a terminal emulator software program (e.g. Tera Term, HyperTerminal). Instructions for how to do both are given below in appendix 1 and 2.

**<u>Recommendations</u>**: It is recommended to do an air saturation quality check of oxygen optodes before and after long deployments.

Please keep records of how sensors mature over time. It will help detect when a sensor starts to behave abnormally.

Sensors should be cleaned before storage and stored with black caps on including some tap water, or with a piece of wet cotton taped against the foil. If sensors are stored dry the foil will dry out which could lead to 1-2 % lower readings. The sensor then needs to be placed in water to hydrate at least 24 h prior to starting filed measurements again. The storage temperature is not important.

<u>Antifouling:</u> Biological fouling is a major impediment for long-term monitoring in shallow water. For antifouling protection of e.g. Aanderaa sensors different solutions have been successfully applied including:

- 1. <u>Zebratech</u> wipers have been protecting Aanderaa Turbidity, O<sub>2</sub>, and pCO<sub>2</sub> sensors/optodes (Fig. 4). With a SeaGuard/SeaGuardII/SmartGuard one of the analog channels can be used to activate a wiper or <u>UV leds</u>. The "warm-up time for the sensor" is used to turn on the wiper/UV for a desired time period. You should set it up with a delay so that it is not wiping/shining sensors when the measurements are done.
- 2. Copper tape (e.g. 3M 1181) or Copper/Nickel (last much longer) are easy antifouling solution (Fig. 4). When applying the tape please be careful so that there is no contact between the tape and other metal parts. Then the tape will loose its antifouling properties.
- 3. <u>UV leds</u> in combination with copper tape (Fig. 4) have turned out to be efficient for long (year) deployments on costal observatories. The downside of UV LEDs is that they consume relatively high amounts of power. Please contact Aanderaa to get more detailed recommendations.
- 4. Electro-chlorination has been successfully applied to Aanderaa and other manufacturers sensors in multiple applications conducted by <u>IFREMER</u>.
- 5. Ongoing trials: Aanderaa is continuously searching for and testing new combinations of antifouling methods. The focus is on non-toxic methods like fiber/hair cloth and "shark skin" film.

Please contact us to obtain more detailed recommendations and information.





Figure 4, Left: Wiper protecting of a  $pCO_2$  optode against fouling, wiping is activated by one of the four SeaGuard analog ports. Middle left: multi-parameter instrument with copper tape on some parts after 2 months in an area with high biofouling. The copper tape last for about 1 year and nothing grows on it. Middle right: Close-up of the Turbidity and  $O_2$  optode both measured correctly for 1 and 2 months respectively. Right: Conductivity and  $O_2$  optode on SeaGuard were successfully bio fouling protected by UV-LED's during the active season.

#### **References:**

- Bittig H. & A. Körtzinger (2015) Tackling Oxygen Optode Drift: Near-Surface and In-Air Oxygen Optode Measurements on a Float Provide an Accurate in Situ Reference. Journal of Atmospheric and Oceanic Technology, **32**, 1536-1543.
- Bittig H.C., A. Körtzinger, C. Neill, E. van Ooijen, J.N. Plant, J. Hahn, K.S. Johnson, B. Yang & S.R. Emerson (2017) Oxygen Optode Sensors: Principle, Characterization, Calibration and Application in the Ocean. Frontiers in Marine Science, in press.
- Johnson K.S, J.N. Plant, S. Riser & D. Gilbert (2015) Air Oxygen Calibration of Oxygen Optodes on a Profiling Float Array. Journal of Atmospheric and Oceanic Technology, 32, 2160-2172.
- Nicholson D.P. & M.L. Feen (2017) Air calibration of an oxygen optode on an underwater glider. 15.5, 495–502.



#### Aanderaa optode models and their calibrations

<u>Common features</u>: Very well characterized (+150 scientific papers). Extreme stability. High quality temperature sensor. Red reference LED. Stern-Volmer Uchida formulas. Output calibrated values in  $\mu$ M, % saturation and raw data. Dynamic Range: 0-300 % (higher range at request). Calibration range: 0-120 % (higher range at request, special calibrations have been provided for 0-500 %). Response time (63 % in water) standard foil t<sub>63</sub><25 s and fast foil t<sub>63</sub>< 8 s (only for model 4330, 4831 and 5331). Resolution/Precision better than 0.1  $\mu$ M.



Fig. 4: Aanderaa offers five optode models: **A**. <u>5730</u>: 40-point calibrated, WTW foils\*, flush mounted, aquaculture cameras, serial output. For OEM sales, restriction apply, please contact us. **B**. <u>4531</u>: 2-point calibrated, WTW foils\*, 100 m rated, various connector options, shallow water/aquaculture, serial+analog (V/mA, 2 channels) output. **C**. <u>4835</u>: 2-point calibrated, WTW foils\*, 300 m rated, coastal, serial+AiCaP\*\* output. **D**. <u>4330</u>: 40-point calibrated, pre-matured PreSens foils\*\*\*, 3000/6000/12 000 m rated, high accuracy/deep water, serial+AiCaP\*\* **E**. <u>4831</u>: 40-point calibrated, pre-matured PreSens foils\*\*\*, 3000/6000/12 000 m rated, high accuracy/deep water, serial+AiCaP\*\* **E**. <u>4831</u>: 40-point calibrated, pre-matured PreSens foils\*\*\*, 3000/6000/12 000 m rated, high accuracy/deep water/3d party platforms, 8-pin SubCon connector, serial+analog (V/mA) output.

\* WTW FDO 701: <u>WTW</u> is a Xylem company that offers high quality instrumentation for laboratory and wastewater application. Their  $O_2$  optode foils are stable and exceptionally robust against the mechanical wear that often occurs in shallow water application.

\*\* AiCaP: AiCaP: is a modified CAN bus based master-slave communication protocol standard available on most of Aanderaa's smart sensors. AiCaP makes plug-and-play connection, to as many (+40) sensors, possible when connected to an Aanderaa logger or Hub directly and remotely using a single seven wire cable. This is practical in all multi-parameter applications e.g. <u>strings</u>, buoys, ferry boxes, <u>autonomous platforms</u>.

\*\*\* *PreSens PSt3* foils: used on our high accuracy/deep water optodes. These foils are stable and very well characterized for oceanographic use in more than 20 scientific papers (see Bittig et al., 2018 for a recent summary). Used on Aanderaa optodes in thousands of applications since 2002. To minimize initial drift the foils are pre-matured before doing the 40-point calibration, which today is standard for 4330 and 4831. A fast responding version is available ( $t_{63}$ < 8 s). The fast foils were upgraded from July 8, 2018 (model 4330 s/n 2994)



and April 5, 2018 (model 4831, s/n 737) with foils that has the same low noise level as the standard foils and it is less sensitive to direct incoming sunlight (compared to the previous version fast foils).

It should be emphasized that the foils used on Aanderaa oxygen optodes become more stable over time. The longest operating optodes were delivered in 2002 and most of these still use the original foils. Therefore foils should <u>not</u> be changed unless they are mechanically damaged. By following the recommendations in this Best Practice document it is possible for end users to keep sensors operational for many years at a high level of accuracy without the necessity for overhaul and calibration by Aanderaa.

<u>**Two-point calibrations:**</u> The two-point calibrations (Accuracy  $\pm 5\%$  or  $\pm 8 \mu$ M) are based on a common characterization of a production batch (normally 100) of sensing foils with an additional two-point adjustment for every optode. The two-point calibrated sensors, 4531 and 4835 (see above) are calibrated at 10°C for 100% saturation, and at room temperature (22°C) for the 0% point. For referencing at 100 % saturation three (3) 40-point calibrated optodes (absolute accuracy better than  $\pm 1$ %) are used. The calibration of these is back traceable to regular checks in one of our multipoint calibrations tanks, which are regularly verified by water samples analyzed by Winkler titration.

<u>Multipoint calibrations:</u> For application demanding higher accuracy ( $\pm$ 1.0 % or  $\pm$ 2 µM) an individual multipoint calibration was optional for the 5730, 4330, 4831 and 5331 optodes from 2012. Since January 1, 2018 it is automatically included without extra cost for all deepwater 4330, 4831 and 5331 models that use PreSens foils. The foil pre-maturation process is standard before calibration. This process removes the initial drift in new foils and brings them to a state where the drift is typically 0.025% per 100,000 measurements.

Fig 5 Left: One of three multipoint calibration systems in operation at Aanderaa. Middle: Detail of multiple sensors inside the temperature regulated bath. Right: Regular control of the 3 reference optodes is done with Winkler titration using an automatic titration system from SI Analytics (a Xylem company).





After pre-maturation the optodes are placed in one of the specially designed automatically controlled temperature-regulated baths where the oxygen saturation is changed by diffusing different mixtures of  $O_2$  and  $N_2$  into the water. The gas mixture is controlled by use of high accuracy Mass Flow Controllers. The water is stirred vigorously to provide homogeneity and oxygen concentration is measured by three reference optodes that are fully calibrated (40

Aanderaa has participated, with good results, in an international inter-comparison in which the performance of different leading oxygen calibration laboratories (in Australia, France, Germany, USA, Japan and Norway) were evaluated. These laboratories are mainly focusing on high accuracy calibrations of oxygen optodes for Argo floats and gliders. If of interest please <u>contact us</u> for more information about this work.

points) by water sampling and Winkler titration one time per year. For continuous control

water samples are also taken every month and analyzed by Winkler titration.

Based on the calibration data seven coefficients (c0 to c6) in the modified Stern-Volmer formula derived by Uchida et al, 2008 [17] are calculated:

$$[O_2] = \frac{\left(\frac{P_0}{P_c} - 1\right)}{K_{SV}}$$

and:

 $K_{SV} = c_0 + c_1 t + c_1 t^2$  $P_0 = c_3 + c_4 t$  $P_c = c_5 + c_6 P_r$ 

where t is temperature (°C) and Pr is the raw phase shift reading (TCPhase)

After the calibration sequence the performance of all sensors are verified in 20 points covering the complete calibration range. For an example see Fig. 6, below.



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Fig. 6: <u>A</u>: Targeted calibration points for a standard 40-point calibration. Please note that optodes are more sensitive at lower concentrations. <u>B</u>: 3D plot of residuals during the 40-point calibration. <u>C</u>: Residuals at the 20-point check that is done directly after the calibration. A full calibration with check is automatic and takes 48 h.

Our experience from delivering thousands of optodes over more than 15 years is that optical oxygen sensors are non-linear both in response to oxygen and to temperature. In addition their sensing foils, optics and electronics can differ. It is therefore our strong opinion that individual multipoint calibrations are necessary to achieve the highest accuracy through the lifetime of the sensor. In Bittig et al (2018) similar recommendations are also given: Depending on the kind of optode calibration, handling and usage scenario, accuracy of O<sub>2</sub> measurements can vary considerably (from 1 hPa to more than 20 hPa, see Fig. 11, in Bittigs paper, for PSt3 foil optodes). To achieve highest accuracy, each sensor requires an individual multi-point calibration in T-and O<sub>2</sub>-space at least once during its lifetime. Foil batch calibrations fail to achieve such high accuracy.

#### Be Aware of How Different Manufacturers Give Specifications:

Different manufacturers specify the performance of their sensors differently. It is worth taking this into account when comparing sensor specifications.

When Aanderaa states an absolute accuracy of e.g. ( $\pm 1$  % or  $\pm 2 \mu M$ ), we mean the accuracy of the sensor in the field over the entire range of oxygen concentrations and temperatures. Another manufacturer might mean the laboratory accuracy just after calibration or in some cases how well the sensor returns to the exact same point as it was calibrated in right after it was calibrated. If specified in this way, our accuracy would be approximately  $\pm 0.5$  %.

When Aanderaa states a 63 % response time of 25 s for the non-transparent foil and 8 s for the faster responding transparent foil, we mean the response time in water at 20°C. Other manufacturers give the response time of their sensors in air. If we were to specify in this way our 63 % response time would be approximately 6 s for the non-transparent foils and 3 s for transparent foils.

Our philosophy is to give specifications, which reflects the field performance of our sensors. We are convinced that this way of specifying is more valuable for the end user.



## Scientific papers using Aanderaa optodes

(Only first authors listed, full references in list, updated July 2018.)

Commercially available oxygen optodes for oceanographic application were introduced by Aanderaa in 2002. The proven long-term stability (years) and reliability of these sensors have revolutionized oxygen measurements and several thousand are in use in applications ranging from streams (Birkel 2013) and buried in the river bed (Malcolm 2006,2009,2010, Vieweg 2013) to the deepest trenches (12 000 m) on earth, from aquaculture (Thomas, 2017) to wastewater, from polar ice (Mowlem 2013, Bagshaw 2016) to earthquake areas (Oguri 2016). This document gives examples of published scientific investigations in which Aanderaa optodes have played a central role.

The basic technique and an evaluation of its functioning in aquatic environments were presented in Tengberg (2006), Bittig (2014,2015A,2018). Other studies include use on autonomous floats Joos (2003), Körtzinger (2004,2005,2008), Kihm (2010), Koelling (2017), Johnson (2009,2010,2015), Alkire (2012), Bittig (2015B,2017), Bushinsky (2016), Fiedler (2013), Takeshita (2013), D'Asaro (2013), Nikolov (2015), Plant (2016), Wolf (2018), Sarma (2018) on gliders (Nicholoson 2008,2017, Karstensen 2015, Pizarro 2016, DeYoung 2018, Queste 2018) on Autonomous Underwater Vehicles (Clark 2013), animal-borne (Baileul 2015), autonomous sail buoy (Ghani 2014), long-term monitoring in coastal environments with high bio-fouling (Martini 2007), on crab pots (Shearman 2012), on coastal buoys (Jannasch 2008, Johnson 2010, Bushinsky 2013), on Ferry box systems (Hydes 2008, 2009, Hartman 2014), on cabled CTD instruments for profiling down to 6000 m including suggestions for improved calibrations, pressure effect and compensation for slow response (Uchida 2008) and in chemical sensor networks (Johnson et al 2007). In the Hypox project multiple optodes were used on multiple platforms to study Hypoxia (Friedrich 2013). Lo Bue (2011) pointed at potential artifacts in oxygen readings in environments with low currents. It has been found that the lower readings are caused by oxygen consumption occurring when metals are corroding (e.g. one sacrificial Zn anode with a weight of 130 g can consume all oxygen in 700 I of water). In Bittig et al. (2012) a seagoing multipoint Winkler free optode calibration system is described and used. McNeil (2014) suggested calibration methods based on physical properties of the sensing foil. Drazen (2005) presented a novel technique to measure respiration rates of deep sea fish and Sommer (2008) described an automatic system to regulate oxygen levels and to measure sediment-water fluxes during in-situ sediment incubation at vent sites. Wikner (2013) measured respiration rates of oligotrophic waters and pointed out potential artifacts from oxygen dissolved in plastic incubators and Rabouille (2009) benthic O<sub>2</sub> consumption. Also Pakhomova (2007), Almroth (2009,2012), Viktorsson (2013), Cathalot (2012), Caprais (2010), Noffke (2016), Niemisto (2018), Sommer (2009,2016,2017) used the same type of optodes on autonomous landers to perform sediment-water incubations on natural and fish farm affected sediments and with and without the introduction of sediment resuspension. In Wesslander (2011) the dynamics and coupling of carbon dioxide (CO<sub>2</sub>) and oxygen weres investigated in coastal Baltic Sea waters and McGillis (2011) described a novel method to assess the productivity of coral reefs using boundary layer and enclosure methods. Champenois (2012) studied variations in community metabolism rates of a Posidonia oceanica seagrass meadow by continuous measurements of oxygen at three different levels during three years. Viktorsson (2012) used yearlong oxygen measurements at several Gulf of Finland locations to calibrate a 3D model for prediction of bottom water oxygen dynamics and the subsequent coupling of low oxygen conditions to release of sediment bound phosphorous. In Atamanchuk (2014,2015A,2015B) and Peeters (2016)  $pCO_2$  optodes were described and used in parallel with  $O_2$  optodes to study biogeochemical processes in fjords, lakes and at Carbon Capture and Storage. Glud (2016) studied nutrient turn-over and mineralization in a Scottish loch and Hamme (2015)  $O_2$ and N<sub>2</sub> dynamics in the Saanich inlet.



## Literature cited

- Almroth, E., Tengberg, A., Andersson, J. H., Pakhomova, S., & Hall, P. O. J. (2009). Effects of resuspension on benthic fluxes of oxygen, nutrients, dissolved inorganic carbon, iron and manganese in the gulf of Finland, Baltic Sea. *Continental Shelf Research, 29*(5-6), 807-818. doi:10.1016/j.csr.2008.12.011
- Almroth-Rosell, E., Tengberg, A., Andersson, S., Apler, A., & Hall, P. O. J. (2012). Effects of simulated natural and massive resuspension on benthic oxygen, nutrient and dissolved inorganic carbon fluxes in loch creran, scotland. *Journal of Sea Research*, 72, 38-48. doi:10.1016/j.seares.2012.04.012
- Asaro, E. A., & Mcneil, C. (2013). Calibration and stability of oxygen sensors on autonomous floats. *Journal of Atmospheric and Oceanic Technology, 30*(8), 1896-1906. doi:10.1175/JTECH-D-12-00222.1
- Atamanchuk, D., Kononets, M., Thomas, P. J., Hovdenes, J., Tengberg, A., & Hall, P. O. J. (2015). Continuous long-term observations of the carbonate system dynamics in the water column of a temperate fjord. *Journal of Marine Systems, 148*, 272-284. doi:10.1016/j.jmarsys.2015.03.002
- 5. Atamanchuk, D., Tengberg, A., Aleynik, D., Fietzek, P., Shitashima, K., Lichtschlag, A., . . Stahl, H. (2015). Detection of CO2 leakage from a simulated sub-seabed storage site using three different types of pCO2sensors. *International Journal of Greenhouse Gas Control, 38*, 121-134. doi:10.1016/j.ijggc.2014.10.021
- Atamanchuk, D., Tengberg, A., Thomas, P. J., Hovdenes, J., Apostolidis, A., Huber, C., & Hall, P. O. (2014). Performance of a lifetime-based optode for measuring partial pressure of carbon dioxide in natural waters. *Limnology and Oceanography: Methods, 12*(FEB), 63-73. doi:10.4319/lom.2014.12.63
- Bagshaw, E. A., Beaton, A., Wadham, J. L., Mowlem, M., Hawkings, J. R., & Tranter, M. (2016). Chemical sensors for in situ data collection in the cryosphere. *TrAC -Trends in Analytical Chemistry, 82*, 348-357. doi:10.1016/j.trac.2016.06.016
- Bailleul, F., Vacquie-Garcia, J., & Guinet, C. (2015). Dissolved oxygen sensor in animal-borne instruments: An innovation for monitoring the health of oceans and investigating the functioning of marine ecosystems. *PLoS ONE,10*(7) doi:10.1371/journal.pone.0132681
- Birkel C., C. Soulsby, I. Malcolm and D.Tetzlaff (2013) Modeling the dynamics of metabolism in montane streams using continuous dissolved oxygen measurements. Water Resources Research, 49, 1–16.
- 10. Bittig, H. C., Fiedler, B., Fietzek, P., & Körtzinger, A. (2015). Pressure response of aanderaa and sea-bird oxygen optodes. *Journal of Atmospheric and Oceanic Technology*, *3*2(12), 2305-2317. doi:10.1175/JTECH-D-15-0108.1
- 11. Bittig, H. C., Fiedler, B., Scholz, R., Krahmann, G., & Körtzinger, A. (2014). Time response of oxygen optodes on profiling platforms and its dependence on flow speed and temperature. *Limnology and Oceanography: Methods*, *12*(AUG), 617-636. doi:10.4319/lom.2014.12.617
- Bittig, H. C., Fiedler, B., Steinhoff, T., & Körtzinger, A. (2012). A novel electrochemical calibration setup for oxygen sensors and its use for the stability assessment of aanderaa optodes. *Limnology and Oceanography: Methods*, *10*(NOVEMBER), 921-933. doi:10.4319/lom.2012.10.921
- 13. Bittig, H. C., & Körtzinger, A. (2015). Tackling oxygen optode drift: Near-surface and in-air oxygen optode measurements on a float provide an accurate in situ reference. *Journal of Atmospheric and Oceanic Technology, 32*(8), 1536-1543. doi:10.1175/JTECH-D-14-00162.1
- 14. Bittig, H. C., & Körtzinger, A. (2017). Technical note: Update on response times, inair measurements, and in situ drift for oxygen optodes on profiling platforms. *Ocean Science, 13*(1), 1-11. doi:10.5194/os-13-1-2017
- 15. Bittig HC, Körtzinger A, Neill C, van Ooijen E, Plant JN, Hahn J, Johnson KS, Yang B and Emerson SR (2018). Oxygen Optode Sensors: Principle, Characterization,



Calibration and Application in the Ocean. *Front. Mar. Sci.* **4**:429. doi: 10.3389/fmars.2017.00429

- Bushinsky, S. M., & Emerson, S. (2013). A method for in-situ calibration of aanderaa oxygen sensors on surface moorings. *Marine Chemistry*, 155, 22-28. doi:10.1016/j.marchem.2013.05.001
- Bushinsky, S. M., Emerson, S. R., Riser, S. C., & Swift, D. D. (2016). Accurate oxygen measurements on modified argo floats using in situ air calibrations. *Limnology and Oceanography: Methods, 14*(8), 491-505. doi:10.1002/lom3.10107
- Cathalot C., B. Lansard, P.O.J. Hall, A. Tengberg, E. Almroth-Rosell, A. Apler, L. Calder, E. Bell and C. Rabouille (2012) Spatial and Temporal Variability of Benthic Respiration in a Scottish Sea Loch Impacted by Fish Farming: A Combination of In Situ Techniques. Aquatic Geochemistry, 18:515–541.
- Caprais, J. -., Lanteri, N., Crassous, P., Noel, P., Bignon, L., Rousseaux, P., ... Khripounoff, A. (2010). A new CALMAR benthic chamber operating by submersible: First application in the cold-seep environment of napoli mud volcano (mediterranean sea). *Limnology and Oceanography: Methods, 8*(JUNE), 304-312. doi:10.4319/lom.2010.8.304
- 20. Champenois, W., & Borges, A. V. (2012). Seasonal and interannual variations of community metabolism rates of a posidonia oceanica seagrass meadow. *Limnology and Oceanography*, *57*(1), 347-361. doi:10.4319/lo.2012.57.1.0347
- Clark, C. M., Hancke, K., Xydes, A., Hall, K., Schreiber, F., Klemme, J., . . . Moline, M. (2013). Estimation of volumetric oxygen concentration in a marine environment with an autonomous underwater vehicle. *Journal of Field Robotics*, *30*(1), 1-16. doi:10.1002/rob.21421
- 22. Drazen J. C., L. E. Bird and J. P. Barry (2005) Development of a hyperbaric traprespirometer for the capture and maintenance of live deep-sea organisms. Limnology and Oceanography Methods 3: 488-498.
- Felisberto, P., Jesus, S. M., Zabel, F., Santos, R., Silva, J., Gobert, S., . . . Borges, A. V. (2015). Acoustic monitoring of O2 production of a seagrass meadow. *Journal of Experimental Marine Biology and Ecology, 464*, 75-87. doi:10.1016/j.jembe.2014.12.013
- 24. Fiedler, B., Fietzek, P., Vieira, N., Silva, P., Bittig, H. C., & Körtzinger, A. (2013). In situ CO2 and O2 measurements on a profiling float. *Journal of Atmospheric and Oceanic Technology*, *30*(1), 112-126. doi:10.1175/JTECH-D-12-00043.1
- Friedrich, J., Janssen, F., Aleynik, D., Bange, H. W., Boltacheva, N., Çagatay, M. N., . . . Wenzhöfer, F. (2014). Investigating hypoxia in aquatic environments: Diverse approaches to addressing a complex phenomenon. *Biogeosciences*, *11*(4), 1215-1259. doi:10.5194/bg-11-1215-2014
- 26. Ghani, M. H., Hole, L. R., Fer, I., Kourafalou, V. H., Wienders, N., Kang, H., . . . Peddie, D. (2014). The sailBuoy remotely-controlled unmanned vessel: Measurements of near surface temperature, salinity and oxygen concentration in the northern gulf of mexico. *Methods in Oceanography, 10*, 104-121. doi:10.1016/j.mio.2014.08.001
- Glud, R. N., Berg, P., Stahl, H., Hume, A., Larsen, M., Eyre, B. D., & Cook, P. L. M. (2016). Benthic carbon mineralization and nutrient turnover in a Scottish sea loch: An integrative in situ study. *Aquatic Geochemistry*, 22(5-6), 443-467. doi:10.1007/s10498-016-9300-8
- Hamme, R. C., Berry, J. E., Klymak, J. M., & Denman, K. L. (2015). In situ O2 and N2 measurements detect deep-water renewal dynamics in seasonally-anoxic Saanich inlet. *Continental Shelf Research*, *106*, 107-117. doi:10.1016/j.csr.2015.06.012
- 29. Hull, T., Greenwood, N., Kaiser, J., & Johnson, M. (2016). Uncertainty and sensitivity in optode-based shelf-sea net community production estimates. *Biogeosciences*, *13*(4), 943-959. doi:10.5194/bg-13-943-2016



- Hydes, D. J., Hartman, M. C., Bargeron, C. P., Campbell, J. M., Curé, M. S., & Woolf, D. K. (2008). A study of gas exchange during the transition from deep winter mixing to spring bloom in the Bay of Biscay measured by continuous observation from a ship of opportunity. *Journal of Operational Oceanography*, *1*(2), 41-50. doi:10.1080/1755876X.2008.11020102
- Hydes, D. J., Hartman, M. C., Kaiser, J., & Campbell, J. M. (2009). Measurement of dissolved oxygen using optodes in a FerryBox system. *Estuarine, Coastal and Shelf Science, 83*(4), 485-490. doi:10.1016/j.ecss.2009.04.014
- 32. Jannasch, H. W., Coletti, L. J., Johnson, K. S., Fitzwater, S. E., Needoba, J. A., & Plant, J. N. (2008). The land/ocean biogeochemical observatory: A robust networked mooring system for continuously monitoring complex biogeochemical cycles in estuaries. *Limnology and Oceanography: Methods, 6*(JUL), 263-276.
- Johnson, K. S. (2010). Simultaneous measurements of nitrate, oxygen, and carbon dioxide on oceanographic moorings: Observing the redfield ratio in real time. *Limnology and Oceanography*, 55(2), 615-627. doi:10.4319/lo.2009.55.2.0615
- Johnson, K. S., Berelson, W. M., Boss, E. S., Chase, Z., Claustre, H., Emerson, S. R., . . . Riser, S. C. (2009). Observing biogeochemical cycles at global scales with profiling floats and gliders: Prospects for a global array. *Oceanography, 22*(SPL.ISS. 3), 216-225. doi:10.5670/oceanog.2009.81
- 35. Johnson, K. S., Needoba, J. A., Riser, S. C., & Showers, W. J. (2007). Chemical sensor networks for the aquatic environment. *Chemical Reviews*, *107*(2), 623-640. doi:10.1021/cr050354e
- 36. Johnson, K. S., Plant, J. N., Riser, S. C., & Gilbert, D. (2015). Air oxygen calibration of oxygen optodes on a profiling float array. *Journal of Atmospheric and Oceanic Technology*, *32*(11), 2160-2172. doi:10.1175/JTECH-D-15-0101.1
- Johnson, K. S., Riser, S. C., & Karl, D. M. (2010). Nitrate supply from deep to nearsurface waters of the north pacific subtropical gyre. *Nature*, *465*(7301), 1062-1065. doi:10.1038/nature09170
- Karstensen, J., Fiedler, B., Schütte, F., Brandt, P., Körtzinger, A., Fischer, G., ... Wallace, D. (2015). Open ocean dead zones in the tropical North Atlantic Ocean. *Biogeosciences*, *12*(8), 2597-2605. doi:10.5194/bg-12-2597-2015
- 39. Kihm, C., & Körtzinger, A. (2010). Air-sea gas transfer velocity for oxygen derived from float data. *Journal of Geophysical Research: Oceans, 115*(12) doi:10.1029/2009JC006077
- Koelling, J., Wallace, D. W. R., Send, U., & Karstensen, J. (2017). Intense oceanic uptake of oxygen during 2014–2015 winter convection in the Labrador Sea. *Geophysical Research Letters*, 44(15), 7855-7864. doi:10.1002/2017GL073933
- Körtzinger, A., J. Schimanski, and U. Send (2005) High-quality oxygen measurements from profiling floats: A promising new technique. J. Atmos. Ocean. Techn., 22: 302-308.
- 42. Körtzinger, A., J. Schimanski, U. Send, and D.W.R. Wallace (2004). The ocean takes a deep breath. Science, 306: 1337.
- Körtzinger, A., Send, U., Wallace, D. W. R., Karstensen, J., & de Grandpre, M. (2008). Seasonal cycle of O2 and pCO2 in the central Labrador Sea: Atmospheric, biological, and physical implications. *Global Biogeochemical Cycles*,22(1) doi:10.1029/2007GB003029
- 44. Lo Bue, N., Vangriesheim, A., Khripounoff, A., & Soltwedel, T. (2011). Anomalies of oxygen measurements performed with Aanderaa optodes. *Journal of Operational Oceanography*, *4*(2), 29-39. doi:10.1080/1755876X.2011.11020125
- Malcolm I.A., C.A. Middlemas, C. Soulsby, S.J. Middlemas and A.F. Youngson (2010) Hyporheic zone processes in a canalised agricultural stream: implications for salmonid embryo survival. Fundam. Appl. Limnol., Arch. Hydrobiol. Vol. 176/4, 319– 336.
- 46. Malcolm I.A, C. Soulsby and A.F. Youngson (2006) High-frequency logging technologies reveal state-dependent hyporheic process dynamics: implications for



hydroecological studies. Hydrological Processes, 20, 615-622.

- 47. Malcolm I.A, C. Soulsby, A.F. Youngson and D. Tetzlaf (2009) Fine scale variability of hyporheic hydrochemistry in salmon spawning gravels with contrasting groundwater-surface water interactions. Hydrogeology Journal, 17, 161-174.
- 48. Mantikci, M., Hansen, J. L. S., & Markager, S. (2017). Photosynthesis enhanced dark respiration in three marine phytoplankton species. *Journal of Experimental Marine Biology and Ecology, 497*, 188-196. doi:10.1016/j.jembe.2017.09.015
- Martini, M., Butman, B., & Mickelson, M. J. (2007). Long-term performance of aanderaa optodes and sea-bird SBE-43 dissolved-oxygen sensors bottom mounted at 32 m in Massachusetts bay. *Journal of Atmospheric and Oceanic Technology, 24*(11), 1924-1935. doi:10.1175/JTECH2078.1
- McGillis W. R., C. Langdon, B. Loose, K. K. Yates and Jorge Corredor (2011) Productivity of a coral reef using boundary layer and enclosure methods. Geophysical Research Letters, Volume 38: L03611.
- 51. McNeil, C. L., & D'Asaro, E. A. (2014). A calibration equation for oxygen optodes based on physical properties of the sensing foil. *Limnology and Oceanography: Methods, 12*(MAR), 139-154. doi:10.4319/lom.2014.12.139
- 52. Moreau, S., Kaartokallio, H., Vancoppenolle, M., Zhou, J., Kotovitch, M., Dieckmann, G. S., . . . Delille, B. (2015). Assessing the O<sub>2</sub> budget under sea ice: An experimental and modelling approach: Assessing the O budget under sea ice. *Elementa*, *3* doi:10.12952/journal.elementa.000080
- 53. Mowlem, M. C., Tsaloglou, M. -., Waugh, E. M., Floquet, C. F. A., Saw, K., Fowler, L., . . . Woodward, J. (2013). Probe technology for the direct measurement and sampling of Ellsworth subglacial lake. *Antarctic subglacial aquatic environments* (pp. 159-186) doi:10.1002/9781118670354.ch10
- Nicholson, D. P., & Feen, M. L. (2017). Air calibration of an oxygen optode on an underwater glider. *Limnology and Oceanography: Methods, 15*(5), 495-502. doi:10.1002/lom3.10177
- 55. Nicholson D., S. Emerson and C. C. Eriksen (2008) Net community production in the deep euphotic zone of the subtropical North Pacific gyre from glider surveys. Limnology and Oceanography, 53: 2226–2236.
- 56. Niemisto J., M. Kononets, N. Ekeroth, P. Tallberg, A.Tengberg, P.O.J. Hall (2018) Benthic fluxes of oxygen and inorganic nutrients in the archipelago of Gulf of Finland, Baltic Sea – Effects of sediment resuspension measured in situ. Journal of Sea Research, 135, 95–106
- 57. Nikolov, N., & Pandelova, A. L. (2015). Calculation of oxygen concentration in the Black Sea using data from argo automatic profiling floats. *Bulgarian Chemical Communications, 47*, 350-355.
- Noffke, A., Sommer, S., Dale, A. W., Hall, P. O. J., & Pfannkuche, O. (2016). Benthic nutrient fluxes in the eastern Gotland basin (Baltic Sea) with particular focus on microbial mat ecosystems. *Journal of Marine Systems*, *158*, 1-12. doi:10.1016/j.jmarsys.2016.01.007
- 59. Oguri, K., Furushima, Y., Toyofuku, T., Kasaya, T., Wakita, M., Watanabe, S., . . . Kitazato, H. (2016). Long-term monitoring of bottom environments of the continental slope off otsuchi bay, northeastern japan. *Journal of Oceanography*, *72*(1), 151-166. doi:10.1007/s10872-015-0330-4
- Pakhomova, S. V., Hall, P. O. J., Kononets, M. Y., Rozanov, A. G., Tengberg, A., & Vershinin, A. V. (2007). Fluxes of iron and manganese across the sediment-water interface under various redox conditions. *Marine Chemistry*, *107*(3), 319-331. doi:10.1016/j.marchem.2007.06.001
- Peeters, F., Atamanchuk, D., Tengberg, A., Encinas-Fernández, J., & Hofmann, H. (2016). Lake metabolism: Comparison of lake metabolic rates estimated from a diel CO2-and the common diel O2- technique. *PLoS ONE*, *11*(12) doi:10.1371/journal.pone.0168393
- 62. Plant, J. N., Johnson, K. S., Sakamoto, C. M., Jannasch, H. W., Coletti, L. J., Riser,



S. C., & Swift, D. D. (2016). Net community production at ocean station papa observed with nitrate and oxygen sensors on profiling floats. *Global Biogeochemical Cycles, 30*(6), 859-879. doi:10.1002/2015GB005349

- 63. Rabouille, C., Caprais, J. -., Lansard, B., Crassous, P., Dedieu, K., Reyss, J. L., & Khripounoff, A. (2009). Organic matter budget in the southeast atlantic continental margin close to the congo canyon: In situ measurements of sediment oxygen consumption. *Deep-Sea Research Part II: Topical Studies in Oceanography, 56*(23), 2223-2238. doi:10.1016/j.dsr2.2009.04.005Sarma,
- 64. Sarma, V. V. S. S., & Udaya Bhaskar, T. V. S. (2018). Ventilation of oxygen to oxygen minimum zone due to anticyclonic eddies in the Bay of Bengal. Journal of Geophysical Research: Biogeosciences, 123. <u>https://doi.org/</u> 10.1029/2018JG004447
- 65. Sommer, S., Clemens, D., Yücel, M., Pfannkuche, O., Hall, P. O. J., Almroth-Rosell, E., . . . Dale, A. W. (2017). Major bottom water ventilation events do not significantly reduce basin-wide benthic N and P release in the eastern gotland basin (Baltic Sea). *Frontiers in Marine Science, 4*(FEB) doi:10.3389/fmars.2017.00018
- 66. Sommer, S., Gier, J., Treude, T., Lomnitz, U., Dengler, M., Cardich, J., & Dale, A. W. (2016). Depletion of oxygen, nitrate and nitrite in the Peruvian oxygen minimum zone cause an imbalance of benthic nitrogen fluxes. *Deep-Sea Research Part I: Oceanographic Research Papers, 112*, 113-122. doi:10.1016/j.dsr.2016.03.001
- 67. Sommer, S., Türk, M., Kriwanek, S., & Pfannkuche, O. (2008). Gas exchange system for extended in situ benthic chamber flux measurements under controlled oxygen conditions: First application-sea bed methane emission measurements at captain arutyunov mud volcano. *Limnology and Oceanography: Methods, 6*(1), 23-33. doi:10.4319/lom.2008.6.23
- Sommer, S., Linke, P., Pfannkuche, O., Schleicher, T. , Deimling, J. Schneiderv, Reitz, A., Haeckel, M., Flögel, S., Hensen, C. (2009). Seabed methane emissions and the habitat of FrenulateTubeworms on the captain Arutyunov mudvolcano (gulf of Cadiz). Mar.Ecol.Prog.Ser. 382, 69–86. <u>http://dx.doi.org/10.3354/meps07956</u>.
- Takeshita, Y., Martz, T. R., Johnson, K. S., Plant, J. N., Gilbert, D., Riser, S. C., . . . Tilbrook, B. (2013). A climatology-based quality control procedure for profiling float oxygen data. *Journal of Geophysical Research: Oceans, 118*(10), 5640-5650. doi:10.1002/jgrc.20399
- 70. Tengberg A., J. Hovdenes, J. H. Andersson, O. Brocandel, R. Diaz, D. Hebert, T. Arnerich, C. Huber, A. Körtzinger, A. Khripounoff, F. Rey, C. Rönning, S. Sommer and A. Stangelmayer (2006). Evaluation of a life time based optode to measure oxygen in aquatic systems. Limnology and Oceanography, Methods, 4: 7-17.
- Thomas, P. J., Atamanchuk, D., Hovdenes, J., & Tengberg, A. (2017). The use of novel optode sensor technologies for monitoring dissolved carbon dioxide and ammonia concentrations under live haul conditions. *Aquacultural Engineering*, 77, 89-96. doi:10.1016/j.aquaeng.2017.02.004
- Uchida, H., Kawano, T., Kaneko, I., & Fukasawa, M. (2008). In situ calibration of optode-based oxygen sensors. *Journal of Atmospheric and Oceanic Technology, 25*(12), 2271-2281. doi:10.1175/2008JTECHO549.1
- 73. Vieweg, M., Trauth, N., Fleckenstein, J. H., & Schmidt, C. (2013). Robust optodebased method for measuring in situ oxygen profiles in gravelly streambeds. *Environmental Science and Technology*, 47(17), 9858-9865. doi:10.1021/es401040w
- 74. Viktorsson, L., Almroth-Rosell, E., Tengberg, A., Vankevich, R., Neelov, I., Isaev, A., . . . Hall, P. O. J. (2012). Benthic phosphorus dynamics in the Gulf of Finland, Baltic Sea. *Aquatic Geochemistry*, *18*(6), 543-564. doi:10.1007/s10498-011-9155-y
- Viktorsson, L., Ekeroth, N., Nilsson, M., Kononets, M., & Hall, P. O. J. (2013). Phosphorus recycling in sediments of the central Baltic Sea. *Biogeosciences*, *10*(6), 3901-3916. doi:10.5194/bg-10-3901-2013
- 76. Wesslander, K., Hall, P., Hjalmarsson, S., Lefevre, D., Omstedt, A., Rutgersson, A., .



. . Tengberg, A. (2011). Observed carbon dioxide and oxygen dynamics in a Baltic Sea coastal region. *Journal of Marine Systems, 86*(1-2), 1-9. doi:10.1016/j.jmarsys.2011.01.001

77. Wikner, J., Panigrahi, S., Nydahl, A., Lundberg, E., Båmstedt, U., & Tengberg, A. (2013). Precise continuous measurements of pelagic respiration in coastal waters with oxygen optodes. *Limnology and Oceanography: Methods*, *11*(JAN), 1-15. doi:10.4319/lom.2013.11.1



<u>Testimonials of Aanderaa optode stability:</u> Aanderaa oxygen optodes have been used in numerous scientific studies published in peer-reviewed journals (see appendix 1 below for full references). Some of these studies focused on details in the performance of the Aanderaa optodes (see references and citations above):

- Joos et al (2003): "Initial field tests have shown exceptional sensitivity and excellent stability (A. Körtzinger and D.W. R.Wallace, University of Kiel, unpublished data, 2002). The new technology seems well suited to deployment on long-term in-situ moorings, profiling floats, and other autonomous platforms."
- Körtzinger et al (2004): "The initial results from the first six months of operation are presented. Data are compared with a small hydrographic oxygen survey of the deployment site. They are further examined for measurement quality, including precision, accuracy, and drift aspects. The first 28 profiles obtained are of high quality and show no detectable sensor drift."
- Nicholoson et al. (2008): "The optode sensor showed no sign of drift when compared to Winkler measurements over the nine months of deployment. Seaglider 021, equipped with the same optode sensor, was stable from its initial February deployment through the end of its second deployment in November, without requiring any recalibration between deployments (data not shown). The optode on glider 020 showed similar stability over its shorter deployment."
- Jannasch et al. (2008): "Oxygen optode (Aanderaa, 3930). Similar to nitrate, oxygen concentrations within estuaries can vary widely (0 to 400 µM O2). We have found the optode to be resistant to fouling as previously suggested (Tengberg et al. 2006) and to be extremely stable. Sensors were calibrated prior to deployment using the factory-suggested, two-point calibration. There was no noticeable drift in instrument accuracy before and after deployment".
- Hydes et al. (2009): "The optodes maintained good stability with no evidence of instrumental drift during the course of a year. Over the observed concentration range (230–330 mMm<sup>-3</sup>) the optode data were approximately 2% low in both years. By fitting the optode data to the Winkler data the median difference between the optode and Winkler measurements is reduced to less than 1 mMm<sup>-3</sup> (0.3%) in both years." Comment: Measurements were done every 30 s. Sensors were operated one year at a time, which equals more than 1 Million samples.
- Johnson et al. (2010): "The oxygen sensor shows no evidence of drift, but it seems to have a small accuracy bias (≤10 µmol/l), as reported for earlier applications of Aanderaa Optode sensors on profiling floats and gliders." The deployment period was more than 600 days.
- Champenois and Borges (2012) "The comparison of O<sub>2</sub> measured by optodes and by Winkler titration allowed us to determine the accuracy of O<sub>2</sub> measurements by optodes, which was better than ±2.0 mmol kg<sup>-1</sup>. The accuracy was not significantly different among the three O<sub>2</sub> optodes and remained stable during the study period. The precision of O<sub>2</sub> measurements by the O<sub>2</sub> optodes was better than ±0.1 mmol kg<sup>-1</sup>, based upon the standard deviation on the mean of 30 measurements during 30 s, which is the standard configuration of measurements used." Comment: The deployment period was more than 1100 days. Sensors were logged hourly which equals approximately 26,000 samples.
- Johnson et al. (2015): "Aanderaa optode sensors for dissolved oxygen show remarkable stability when deployed on profiling floats, but these sensors suffer from poor calibration because of an apparent drift during storage (storage drift). Comment: In this paper results from 47 floats were presented and methods for in air calibration on Argo floats suggested.

## Appendix 1: Enter a foil adjustment into the sensor using Real-Time Collector

Serially connect sensor to computer and power (one USB connector on the 3855 cable is to give power, 5-14 V, to the sensor) and start Real-Time Collector. Please observe that the quality of USB to Serial convertors is variable. Some work well and some are unreliable/do not work at all. From investigations we have found that KEYSPAN convertors work reliably on different computers with different operating systems.



If you have no Aanderaa Smart Sensor connection established since before: press "New" in the lower left corner.

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Connection Name		Data Format	
Connection Name	Smart Sensor connection	AADI Real-Time Format	
		Legacy AADI & Custom Data Fe	ormats
Port Settings		Choose a legacy AADI data for	matora
Serial Port		custom defined data format. Th must be configured before use.	ne format
Port Name	COM3	AADI Deck Unit 3127	
Baud Rate	9600	Configure	
System Informatio	n	Advanced Settings	
System Informatio	n	Advanced Settings	
S <b>ystem Informatio</b> .ocation Geographical Position	n	Advanced Settings	
System Informatio .ocation Seographical Position /ertical Position	n	Advanced Settings	
System Informatio Location Geographical Position Vertical Position Owner	n	Advanced Settings	

On "Port Settings" select "Serial Port" from drop down menu. Select the correct baud rate (default is 9600 when sensor is delivered) and the correct COM port (see Port mapping in Windows). Name the connection and use AADI Real-Time Format. Then click "OK".

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	Port	Status	Smart Sensor connectio	n	
Optode 3830	COM1	0	Connection Details	Statistics	
Optode 4835	COM5	- 0	Port Status Closed	Records received	6
Smartguard IP	10.10.10.10:61234	0	Connection Status Not connected	Records lost	0
RCM Blue #10	RCM Blue (COM46)	0	Name COM3	Bytes received	10.52 KB
Smart sensor	COM3	0	Baud Rate 9600	Bytes sent	56 bytes
RCM Blue#11	RCM Blue (COM49)	0	Data Format AADI Real Time	Peret	
Smart guard India	COM1	0	Connected Clients 0	Reset	
RCM Blue no 19	RCM Blue (COM36)	0			
RCM Blue nr 16	RCM Blue (COM36)	0	DeviceInformation	Data Visualizati	on
Smart sensor 2	COMS	0	ID	To to	
Seaguard sn 2550	COM5	0	Description	1 pp	<b>_</b>
optode	COM1	0	More info Advanced +		
Seaguard	COM5	0	Notifications		
RCM Blue serial	COM5	0	There are no unread device notificat	tions.	View All.
Smartguard Romantika	USB	0			100000
Seaguard nr 165	COM5	0			
RCM Blue serial conect	COM6	0			
Smartguard Austevoll	USB	0			
cyclops	COM1	0			
SeaGuardII	USB	0			
	COM3	0		1	Control Docal

Connect any Aanderaa Smart Sensor (Pres/Wave/Tide/Temp, Doppler Current/Temp, Doppler Current Profiling/ Temp, O2/Temp, pCO2/Temp, Cond/Sal/Temp, Temp, Motus) to COM port and Power and press "Open Port"

Connection	Port	Status	Smart Sensor connection		
Optode 3830	COM1	0	Connection Details	Statistics	
Optode 4835	COM5	0	Port Status Open	Records received	24
Smartguard IP	10.10.10.10:61234	0	Connection Status Connected	Records lost	0
RCM Blue #10	RCM Blue (COM46)	0	Name COM3	Bytes received	39.27 KB
Smart sensor	COM3	0	Baud Rate 9600	Bytes sent	84 bytes
RCM Blue#11	RCM Blue (COM49)	0	Data Format AADI Real Time	Barat	0.0,000
Smart guard India	COM1	- 0	Connected Clients 0	Keser	
RCM Blue no 19	RCM Blue (COM36)	0			
RCM Blue nr 16	RCM Blue (COM36)	0	Device Information	Data Visualizati	on
Smart sensor 2	COM5	- 0 -	ID 4648A-21	1	
Seaguard sn 2550	COM5	0	Description Wave And Tide Sensor		
optode	COM1	0	More info Advanced +		
Seaguard	COM5	- 0	Notifications		
RCM Blue serial	COM5	0	There are no unread device notification:	5.	View All
Smartguard Romantika	USB	0			Denvinn
Seaguard nr 165	COM5	0			
RCM Blue serial conect	COM6	0			
Smartguard Austevoll	USB	0			
cyclops	COM1	0			
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Smart Sensor connection	СОМЗ	•	Class Bast Settings	Connection Long	Control Danol

FTP Server: Stopped

Established connection gives green light and shows which sensor is connected (many sensors and instruments can be connected simultaneously, see list for some examples, we have connected, collected data and presented results in real-time from +70 sensors ). Click "Control Panel" to enter the settings.



Connection Port Status   Optode 3830 COM1   Optode 4835 COM5   Smart Sensor Connection Connection Details   Smart Sensor Statistics   Recorder Panel Ip Device Configuration   Big Device Configuration Debug   Recorder Status 0   Recorder Status 292,51 KB   423 bytes   Recorder Status   Recorder Status   Recorder Status   Record number: 436 (2015-09-22 07:09:35)   Start Delayed   Start Delayed   Start Delayed   Start Sensor   Start Sensor   Start Sensor   Start Sensor   Start Delayed   Start Sensor   Start Sensor   Start Sensor   Start Delayed   Start Sensor   Start Sensor   Start Delayed   Start Delayed   Start Sensor   Start Recorder   Start Recorder   Start Sensor   Start Delayed   Start Sensor   Start Delayed   Start Pelayed   Start Sensor   Start Recorder   Start Recorder   Start Recorder   Start Recorder   Start Recorder   Start Recorder   Start Delayed   Start Recorder   Star	AADIReal-T	ime Collector ebug Help					-	-			
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Smartguard Control Panel - Smart Sensor connection   RCM Blue #1 Smart Sensor Device Configuration Debug   Recorder Status Recorder Status 423 bytes   Recording Refresh Status 423 bytes   RCM Blue #1 Start time: N/A Last record number: 436 (2015-09-22 07:09:35)   Smart senso Start Options   Seaguard Start Options   © Fixed Interval   © Start Corder   © Fixed Interval   © Start Recorder     New Ready	Optode 4835		COM5	Θ	Port Status Open	Records rece	ived 190				
ACM Blue #2 Image: Recorder Panel Image: Device Configuration Debug # 292,51 KB   Smart senso Recorder Status Recorder Status # 23 bytes   Recording Refresh Status # 23 bytes   Record number: 436 (2015-09-22 07:09:35) # ation   Smart senso Start Options   Seaguard in Seaguard in Seaguard in Seaguard in 	Smartguard	Control Panel - Smart Sensor connection X 0									
Smart senso       Recorder Status       423 bytes         Smart guard       Recording       Refresh Status         RCM Blue no       Start time: N/A       Last record number: 436 (2015-09-22 07:09:35)         Smart senso       Start Options       Image: Control Pareline in the initian settings are changed         Seaguard nr       Start Delayed       2015-09-22 minitian initian settings are changed         Smart senso       Start Options       Image: Control Panel         Start Options       Start Options       Image: Control Panel         Seaguard nr       Script       Image: Control Panel         Start Recorder       Stap Recorder       Flash recorder node if timing settings are changed         New       Ready       Ready	RCM Blue #1	Recorder Pa	nel 将 Device Configu	ration Deb	ua		d 292.51 KB				
ACM Blue#1 Recorder Status   Smart guad Recording   RCM Blue no   ACM Blue no   Smart senso   Smart senso   Start Options   Start Options   Start Delayed   2015-09-22 v   07:07:55 *   Timing   Image: Start Recorder   Smart guad   Image: Start Recorder   Start Coptions   Start Delayed   2015-09-22 v   07:07:55 *   XCM Blue se   Smart guad   Image: Start Recorder   Image: Recorder <th>Smart senso</th> <th colspan="9">d23 bytes</th>	Smart senso	d23 bytes									
Smart guard Recording Refresh Status   ACM Blue in Start time: N/A   ACM Blue in Start coord number: 436 (2015-09-22 07:09:35)   Smart senso Start Options   Seaguard in Start Dplayed   Start Delayed 2015-09-22 v 07:07:55 +   CM Blue se Start Loelayed   Smartguard Start Loelayed   Seaguard in Fixed Interval   Start Recorder Stap Recorder   Start Stap Recorder Flash recorder node if timing settings are changed	RCM Blue#1	Recorder Stat	tus								
ACM Blue na   ACM Blue na   ACM Blue na   Smart senso   Seaguard sn   Start Options   Image: Start Now   Seaguard na   Start Delayed 2015-09-22 Im 07:07:55 Imm   Smartguard   Image: Start Now   Seaguard na   Image: Start Recorder   Image: Start	Smart guard	Recording			<u>R</u> efresh Status						
ACM Blue nr   Smart senso   Seaguard so   Seaguard so   Seaguard so   Start Options   Seaguard so   Start Now   Seaguard nr   Start Recorder	RCM Blue no	Start time: N/A									
Smart senso   Start Options	RCM Blue nr	Last record number: 436 (2015-09-22 07:09:35)									
Seaguard sn Start Options   optode Start Now   Seaguard Start Delayed   2015-09-22 07 107 :55   XCM Blue se Timing   Smartguard Fixed Interval   Seaguard nr Fixed Interval   Script Script   Smartguard Start Recorder   Start Recorder Flash recorder node if timing settings are changed   New Ready	Smart senso										
optode	Seaguard sn	n Start Options									
Seaguard       Start Delayed       2015-09-22       07:07:55       Image: Control Panel         ACM Blue se       Timing       Image: Control Panel       Image: Control Panel         Seaguard nr       Script       Image: Control Panel       Image: Control Panel         SeaGuardII       Start Recorder       Flash recorder node if timing settings are changed       Image: Control Panel         New       Ready       Ready       Image: Control Panel       Image: Control Panel	optode	Start Now									
ACM Blue se   Smartguard   Seaguard nr   Seaguard nr   Script   Smartguard   Start Recorder   Start Recorder   Start Recorder   Start Recorder   Ready	Seaguard	Start Delay	ed 2015-09-22 🔽	07:07:55	÷.						
Smartguard   Seaguard nr <ul> <li>Fixed Interval</li> <li>Script</li> </ul> Smartguard   Smartguard   Script   Smartguard   Start Recorder   Start Recorder   Start Recorder   Start Recorder     Flash recorder node if timing settings are changed     Smart Senso     New     Ready     Timing	RCM Blue se	Winster.					View All				
Seaguard nr <ul> <li>Fixed Interval</li> <li>Secolution</li> <li>Script</li> <li>Start Recorder</li> <li>Stop Recorder</li> <li>Flash recorder node if timing settings are changed</li> <li>Start Recorder</li> <li>Stop Recorder</li> <li>Flash recorder node if timing settings are changed</li> <li>SeaGuard II</li> <li>Smart Senso</li> <li>New</li> <li>Ready</li> <li>Control Panel</li> <li>Image: Control Panel</li> <li>Ima</li></ul>	Smartguard	Timing									
RCM Blue se   Smartguard   syclops   SeaGuardII   Smart Senso     New   Ready   Ready	Seaguard nr	Fixed Interv	al 2 sec 💌								
Smartguard   syclops   SeaGuardII   Smart Senso     New   Ready     Flash recorder node if timing settings are changed     start Recorder   Stop Recorder   Flash recorder node if timing settings are changed     start Recorder     Stop Recorder     Flash recorder node if timing settings are changed     start Recorder     Start Recorder     Start Recorder     Flash recorder node if timing settings are changed     start Recorder     Start Recorder     Start Recorder     Start Recorder     Start Recorder     Flash recorder node if timing settings are changed     start Recorder	RCM Blue se	Script									
Spyclops     Start Recorder     Stop Recorder     Flash recorder node if timing settings are changed       Smart Senso     Fill     Fill       New     Ready     Fill	Smartguard			-							
SeaGuardII Smart Senso New Ready Control Panel	cyclops	<u>S</u> tart Record	er Stop Recorder	Flash rec	order node if timing settings are changed						
Smart Senso     S Control Panel       New     Ready	SeaGuardII										
New Ready	Smart Senso						S Control Panel				
New Ready									_		
Ready	<u>N</u> ew	Baady					1				
		Reduy					]		_		

If sensor is running click "Stop Recorder" and then "Device Configuration" in selection at top of opened window.

Connection	Port	Status	Smart Sensor connection		
Optode 3830	COM1	0	Connection Details	Statistics	
Optode 4835	COM5	0	Port Status Open	Records rece	ived 258
smartguard Control	Panel - Smart Sensor conne	ection		- = X	0
CM Blue #1 DB Rec	order Panel	onfiguration	ebua		d 396,04 KB
imart senso					756 bytes
CM Blue#1: Devi	ce Configuration				
Smart guard senso	evice configuration contains r. The settings are grouped	into three categori	device, as well as for each connected es.		
CM Blue no	t Current Configuration	Toolude Use	Maintenance		and an
CM Blue nr	e current comigar beornin	in thouse use	rmaintenance		zation
Smart senso					
Seaguard sn	Deployment Set	-	Custom surview		
optode all	Edit	er Maintenance			
Seaguard	P	assword: ****			
RCM Blue se	9		K		View All
Smartguard	System Configu		ation to file		
Seaguard nr	Edit		Save Include optiona	attributes	
RCM Blue se					
Smartguard			1000		
cyclops	User Maintenance				
SeaGuardII	Bedit Passwor	d protected.			
Consult Conser					

If access to all settings is of interest tick "User Maintenance" click "Get Current Configuration" and fill out Password which is 1000 for all sensors. Then click "Ok".



Vetede 3930		Port	Status	Smart Sensor connection				
Optode 3830	6	COM1	0	Connection Details	Statistics			
Optode 4835		COM5	Θ	Port Status Open	Records receive	d 258		
Smartguard	Control Panel - S	Smart Sensor connec	tion		_ = X	0		
RCM Blue #1	Recorder Pa	nel R Device Co	figuration	abus	4	403.89 KB		
Smart senso	Necoluci Pa				-	1 22 KB		
RCM Blue#1	Device Cor	figuration				1,22 10		
Smart guard	The device co	nfiguration contains a attings are grouped in	all settings for the	device, as well as for each connected				
RCM Blue no		te for the grouped in	an an ac categorie					
RCM Blue nr	Get Current Configuration M Include User Maintenance							
Smart senso	The device co	nfiguration was last r	nodified at 2015-0	9-22 07:14:56.				
Seaguard sn		informant Cattings		Sustan avancian	-	C UD		
optode	-FFFF	provinent settings		system over view				
Seaguard		Edit		Off View				
RCM Blue se				0		Cast all		
Smartguard	Sy	stem Configuration	(	Save configuration to file		Tien Witte		
Seaguard nr		Edit		Save I Include optiona	lattributes			
RCM Blue se	4			include options	attributes			
and the second strike product a balance								
Smartguard	Us	er Maintenance						
Smartguard cyclops		Edia Descured	protected.					
Smartguard cyclops SeaGuardII		Edit Password						
Smartguard cyclops SeaGuardII Smart Senso		Password				Control Danal		

To access most common settings click "System Configuration" (normally enough). For more advanced settings click "User Maintenance" (caution in changing things here).

Connection		Port		Status	Smart Sen	sor connectio	n			
Optode 3830		COM	Ê.	0	Connection Details		Statistics	Statistics		
Optode 4835		COMS	£	O Port 5		Open	Records receive	ands received 258		
Smartguard Cont	ol Panel - S	Smart Se	ensor connection				- = ×	0		
CM Blue #1 m	ecorder Pa	nel II	Device Config	aration De	hun		d	403.89	KB	
imart senso							f	1.22 K	в	
CM Blue#1: De	vice Cor	nfigura	tion							
imart guard Th	e device co isor. The se	ettinos 5	System Configurat	ion					1	
CM Blue no	Cat Curran	+C	Wana And Tid		••				1	
CM Blue nr	Gercurre	in Com	Wave And Tid	e Sensor #/	648A, Version 8)			21		
mart senso	e device co	nhgun	Serial No: 21					4	and the second	
eaguard sn	De	ploye	Mode			AADI Real-	-Time 🔹	-	( d. b)	
ptode		8.64	Enable Sleep			AiCaP				
eaguard C	TITE	Culture					sor Terminal			
CM Blue se			Terminal Prot	0001		Smart Sensor Terminal FW2			w All	
martguard	Sy	stem	Property			Value				
eaguard nr	T F	Edit	Enable Poli	ed Mode		0				
CM Blue se			Enable Tex	t						
Smartguard			<ul> <li>Enable Dec</li> </ul>	malformat		M				
yclops	Us	ier Ma	Measurement							
eaGuardII	S 🕞	Edit	Property			Value				
imart Senso	_		C Enable High	h Sample Rat	te .				Papel	
1.5	10. P	- 1	CEnable Ten	operature		1			Fautoria	
New	2.17	-	C Enable Rav	rdata		2				
Rea	Ŋ		C Enable Tide							
			C Tidal Avera	ige Period		40 s			FTP Server: Stopp	
and the second second		-	C Enable War	re						
		-	Number of	Samples		1024	~	-	Contraction of the	

Access to needed deployment settings in "System Configuration" (normally enough). AADI Real-Time (xml) to be used with RT-Collector, Smart Sensor Terminal (ASCII) with standard terminal program. AiCaP is a CAN bus based protocol which is used for plug-and-play connection to Aanderaa instruments (e.g. SeaGuard, SmartGuard)



onnection	Port	Status	Smart senso	r (				
ptode 3830	COM1	Θ	Connection Deta	ils.	Statistics			
ptode 4835	COMS	0	Port Status	Open Records received		35		
martguard IP	10.10.10.10:61234	0	Connection Status	Connected	Records lost	0		
CM -1 -1-			11		ed	124.03 KE		
Control Panel - Smart	10 control				2 2 2 2	5,56 KB		
CN III Recorder Panel	Provice Configu	ration De	bug					
Device Configu	ration							
CN The device configur	Transmission and	4	a 11. a a	A., A., A.,				
Ch sensor. The setting	s User maintenance					10		
Get Current Con	Optode Sensor	4330#591						
oa The device configur	Serial No: 593	ir (4330, ver L	sion 6)			02	(a.ac)	
optc	FoilD			1023E			1.00	
ea JHH	FoilCoefA			-3.604788E-	06;-6.843659E-06			
CN Edit.	FoilCoefB			-7.934825E-	07:3.792412E+03	ew	All	
me	FoilPolyDeg	egT		1;0;0;0;1;2;	0;1;2;3;0;1;2;3;			
ea System	FoilPolyDeg	0		4;5;4;3;3;3;	2;2;2;2;1;1;1;1;			
CN T Edit	SVUFoilCoe	1		1.000000E+0	00;1.000000E+00	Edit Array	Data	
	ConcCoef			-2.000000E-	01;1.052000E+00	-		
	NamAirPres	s (hPa)		1.013250E+0	03	Index	Value	
User M	NomAirMix	(hPa)		2.094600E-0	1	0	-0.2	
Edit.	CalDataSat	(Deg)		2.7013358+0	01;2.726602E+01	1	1.052	
	CalDataAPr	ess (hPa)		1.013250E+0	00	1.0		
2012	CalDataZer	o (Deg)		6.1749318+0	01;2.190072E+01			
-	Sample Setting	35						
Ready	Property			Value		1		
	Enable Red	Reference						
	C DedDeferre	and taken and		-		-		

In some cases user maintenance is useful, consult manual before changing settings. The example shows a drift adjustment of a two-point calibrated oxygen optode that read 5.2 % to low at 100 % air saturation (air-bubbled water, 1013 hPa air-pressure) and 0.2 uM to high at 0 oxygen. The ConcCoef is adjusted (double click to edit) so that 0.2 uM is subtracted from incoming values and then they are multiplied with 1.052 (+5.2 %).

🔏 AADI Real-T	ime Collector					-	. =	x	
File Tools D	ebug Help								
Connection		Port	Status	Smart Sensor connection				٦	
Optode 3830		COM1	0	Connection Details	Statistics				
Optode 4835		COM5	0	Port Status Open	Records rece	uved 258			
Smartguard	d Control Panel - Smart Sensor connection _ E X 0								
RCM Blue #1	Recorder Pa	nel 报 Device Configur	ation Deb	uq		d 403,89 KB			
Smart senso				-		1,22 KB			
RCM Blue#1	Recorder Stat	us							
Smart guard	Stopped			<u>R</u> efresh Status					
RCM Blue no	10 zation								
RCM Blue nr									
Smart senso	nso 🚦 🙆 📄								
Seaguard sn	Start Options								
optode	Start Now								
Seaguard	Start Delay	ed 2015-09-22 💽	07:07:55	A V					
RCM Blue se	Timing					View All			
Smartguard	Eined Teters								
Seaguard nr	Fixed Interv	2 500							
RCM Blue se	Script	5 sec	¥						
Smartguard	Start Record	er 20 sec der	Z Flash rec	order node if timing settings are changed					
Cyclops	30 sec								
SeaGuardII		1 min 2 min							
Smart Senso		3 min 💌				s Control <u>P</u> anel			
<u>N</u> ew	Ready								
(						J FTP Serve	r: Stopp	per	

When finished go to "Recorder Panel" and select the "Fixed interval" that you want and then "Start Recorder". Then close menu to go back to main menu.



If sensor is set to "AADI Real-Time" (see above) go to main menu and select most suitable option for "Data Visualization" (Graph or Table). If Graph select what parameters to be presented. Right click on graph to enter into graph settings.

44	Connection Settings			
AADI Real-Time Coll	Connection Name		Data Format	_ = ×
File Tools Debug F	Connection Name	Smart Sensor connection	AADI Real-Time Format	
Connection			Legacy AADI & Custom Data Formats	
Optode 3830	Port Settings		Choose a legacy AADI data format or a	
Optode 4835	Serial Port	•	custom defined data format. The format must be configured before use.	81
Smartguard IP	Port Name	СОМЗ	AADI Deck Unit 3127	r (
RCM Blue #10	Baud Rate	9600	Configure	43,08 KB
Smart sensor	Connect subscription	llu en analization startur	- <u>-</u>	75 KB
RCM Blue#11	Connect automatica	iny on application startup		
Smart guard India				
RCM Blue no 19				
RCM Blue nr 16				
Smart sensor 2				
Seaguard sn 2550				- d'h.
optode	-			
Seaguard	System Information		Advanced Settings	
RCM Blue serial	Location		<u>A</u> dvanced Settings	View All
Smartguard Romanti	<b>Geographical Position</b>			The second secon
Seaguard nr 165	Vertical Position			
RCM Blue serial cone	Owner			
Smartguard Austevo	o di la			
cyclops	Reference		<u>QK</u> <u>C</u> ancel	
SeaGuardII				
Smart Sensor connec	tion COM3	•	<u>Open Port</u> <u>S</u> ettings Connection <u>Logs</u>	Control <u>P</u> anel
<u>R</u> emo	ove			
				FTP Server: Stopped

To log data in xml or txt close communication "Close Port" and click on "Settings". Select "Advanced Settings".

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In "Advanced Connection Settings" select "File Output" click "Collect data to file" and select File Format (xml or txt) and location. The name of the stored file will be the same as the name of the connection. Click "Apply" + "OK". Then open the port again, incoming data will be stored to the specified file.

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# Appendix 2: Enter a foil adjustment into the sensor using terminal software

Different types of freely available software exist to communicate and change settings in sensors that use serial communication. One example is Tera Term. Below you will find step by step how to enter, communicate and change settings of Aanderaa smart sensors using the Tera Term software. For another terminal software the procedures should be similar.

Serially connect sensor to computer and power (one USB on 3855 cable is to power the sensor with 5-14 V) and Start Tera Term. Please observe that the quality of USB to Serial convertors is variable. Some work well and some are unreliable/do not work at all. From investigations we have found that KEYSPAN convertors work reliably on different computers with different operating systems.

Tera Term - [disconnect	ed] VT Jow Help	A w	×	
٥				
	Tera Term: Ne	w connectio	n	X
	○ тср/ір	Host: Service:	192.168.1.3 History Telnet SSH Other	TCP port#: 22 SSH version: SSH2 v Protocol: UNSPEC v
and the second	⊙ Serial	Port	COM3: Keys	pan USB Serial Port (CON 💙
1 📁		ОК	Cancel	Help

Select "Serial Port" and the correct COM port (see Port mapping in Windows). Then click "OK".



🐸 COM3:9600baud - Tera Term VT				X
File Edit Setup Control Window Help	Tera Term: Serial port	setup	<u> </u>	
0	Port:	сомз 🗠	ΟΚ	*
	Baud rate:	9600 💌		
	Data:	8 bit 💌	Cancel	
	Parity:	none 💌		
	Stop:	1 bit 💌	Help	
	Flow control:	Xon/Xoff 🔽		
	Transmit delay	/char 0 m	sec/line	

Select "Serial Port" under "Setup" and set up the COM port as shown above. The default setting of the smart sensors when delivered is a Baud rate of 9600. Click "OK".

🗵 COM3:9600baud - Tera Term VT	
File Edit Setup Control Window Help	
Tera Term: Terminal setup         Terminal size         IBZ       X         Y       Z4         Y       Term size         Auto window resize       Transmit: CR+         Terminal ID:       VT100         Y       Local echo         Answerback:       Auto switch	Cancel Help h (VT<->TEK)

Select "Terminal" under "Setup" and set up with Carriage Return (CR) + Line Feed (LF) and Local echo as shown above. Click " OK".

ŝ	🖳 COM3:9600baud - Tera Term VT														×					
ł	ie	Edit	Setup	Control	Window	Help														
Z																			ļ	^
s	tartuş	pInfo	4330	591	Hode	AiCaP	CANID	0×180EF900	AiCaP	Version	٥	R\$232	Protocol	Version	3	Conf i	g Version	6		
Т	rying	to co	nnect to	CANbus	netuork															
h																				
Γ																				
																				~
	Dis-	-con	nect a	and Re	e-conne	ct pov	ver. Th	ne sensor	will tel	l you ir	n whi	ch out	put mo	ode it i	s set	up (tł	ne optio	ons a	are:	

Dis-connect and Re-connect power. The sensor will tell you in which output mode it is set-up (the options are: AiCap, Smart Sensor Terminal, AADI Real-Time, Analog Output). You can type "help" or consult manual to see available commands/settings. You can type "get all" to see all coefficients and settings of the connected sensor. The commands are not case sensitive but you must respect if there is/is not a space in-between characters.



😕 COM3:9600baud - Tera Term VT	
File Edit Setup Control Window Help	
set passkey(1000) 🗍	^
#	
set mode(smart sensor terminal)	
#	
save	
#	
reset	
	*

Change the output to serial communication (with text) by typing the following commands: 1. set passkey(1000) + CR (Carriage Return)  $\rightarrow$  wait for return of #; 2. set mode(smart sensor terminal) + CR  $\rightarrow$  wait for return of #; 3. save + CR  $\rightarrow$  wait for return of #; type reset or disconnect and reconnect power. The sensor will start presenting data at the pre-set interval.

CON3:9	sooba	ud - Te	era Term VT														
File Edit Se	hip C	Introl	Window Help														1000
V -200.9																	in.
NERLIRENENT	63	591	Officience net applicable	262.904 #irSaturation[2]	101.134 Terperature(Deg.C1	24.578 CalPhace(Dep)	29.310 1	CPhanel Depl	28.479 CSRPhil	egl 35.76	C29Philleg1	7.272	C1RepLeVI	106.1	C29ep[ril]	710.8	RauTempEn
VERSUREMENT	433	581	02Concent net Josifa#1	262.314 AurSaturation[2]	381.334 Terpenature(Deg.C1	24.576 CalPhace(Dep)	28.310 1	CPhanelDepl	28.473 (3896.0	ng) 35.74	C28PhOlogi	7.272	CSHop[#V]	1065.2	C2/ep[xil]	710.7	RauTerplin
PERMAENENT	4130	591	02Concent nut confut0	262,570 Hirbaturation(2)	101-154 Terperature(Dep.CI	24.575 CalPhace(Deg)	28.300 1	(Phanel Dep)	28.475 (3896.0	egi 35.74	C39560eg1	7,272	Clifep1el/I	1965.1	(29kepTell)	710.5	RaiTerpla
VERSTREMENT 7	431	581	02Concent net sovilu#0	262.069 Rinflaturation(2)	101.134 Terperature(Deg.01	24.575 CalPhanelDepl	20.313 1	(Phace/Dep)	28.405 (38950)	1 (S.)0	C3Rhiby)	7,271	Cthp[rV]	1965,1	(29kp[xil)	730.3	RauTerplin
FERRET	433	91	Official ter traceoutly	263.039 Rinflaturet Jon(2)	101.154 Terperature(Deg.C1	24.562 CalPhanelDeg)	29.311	CPhacel Depl	28.474 C389510	eg] 35.74	C39hibeg1	7.272	C18xp1xVI	1965.1	C2NepLeif1	710.2	RauTerpla
NEACOREMENT V 500.2	4130	581	02Concent net ion Luffi	263.135 RurSeturet Isol 23	101.106 Terperature(Deg.C1	24.559 CalPhace(Dep)	21.300	(Phanel Dep)	21.471 (38%)	191 IS.74	C395(Deg)	7.271	C\$hip[eV]	196.1	C2NepLeil1	710.1	ReaTempla
HORIZEMENT	4330	585	(Concent rat ion aft)	4													*

The example above is for oxygen measurements with full text including raw data

L C	OM3:	9600b	aud -	Tera Ter	m VT	
File	Edit	Setup	Contro	l Window	Help	
4330	591	263.	.458 101	.344 24.577	,	
4330	591	262.	.095 101	.015 24.681	l	
4330	591	262.	425 101	.140 24.680	I	
4330	591	262.	.220 101	.059 24.679	1	
4330	591	262.	.520 101	.175 24.679	1	
4330	591	262.	.298 101	.090 24.679	1	
4330	591	262.	.362 101	.111 24.677	,	
4330	591	262.	.452 101	.143 24.676	i	
4330	591	262.	.515 101	.170 24.677	,	
4330	591	262.	509 101	.170 24.678	1	
4330	591	262.	378 101	.118 24.678	)	

The example above is for oxygen measurements (Oxygen in  $\mu$ M, Oxygen in % saturation and Temperature), with the text removed and without raw data. To change to this type of text string type the following commands: 1. set passkey(1000) + CR (Carriage Return)  $\rightarrow$  wait for return of #; 2. set enable text(no) + CR  $\rightarrow$  wait for return of #; 3. set enable rawdata(no) + CR  $\rightarrow$  wait for return of #; 4. save + CR  $\rightarrow$  wait for return of #; type reset or disconnect and reconnect power. The sensor will start presenting data at the pre-set interval.



Get actual Air Pressure (hPa) <sup>1)</sup>		995								
Connect Optode to PC with terminal program <sup>2)</sup>										
Enter result from Optode <sup>3)</sup>	Saturation:	95,00%	Expected Air Saturation (based on air pressure) 98,22%							
Get current offset and slope coeffici	ents by sending th	e following commands to the Optode:								
Enter current coefficient values:		Set Passkey(1) Get ConcCoef ConcCoef <sub>a</sub> ConcCoef <sub>1</sub> -0,2 1	New Coefficients ConcCoef <sub>0</sub> ConcCoef <sub>1</sub> -0,2 1,0339							
Save updated offset and slope coeff	icients by sending	the following commands to the Optod	e:							
		Set Passkey(1000) Set ConcCoef(-0,2, 1,0339) Save								
Check that the new readings from th Notes	ne Optode corresp	ond to expeced Air Saturation level:	98,22%							
<ol> <li>Preferably without correction with repect to heigth above sea level</li> <li>For instance Tera Term, Baudrate 9600,1 stop bit, XON/XOFF Handshake, Terminal Setup\New Line\Transmit: CR+LF</li> <li>The optode foil should preferably be soaked for 24 hours prior to the adjustment</li> </ol>										

The example above shows a drift adjustment calculation using an Excel sheet available from Aanderaa of a twopoint calibrated oxygen optode that read 3.4 % to low at 98.2 % air saturation (air-bubbled water, 995 hPa airpressure) and 0.2 uM to high at 0 oxygen. The ConcCoef is adjusted so that -0.2 uM (ConCoef<sub>0</sub>) is subtracted from incoming values and then they are then multiplied with 1.0339 (+3.4 %, ConcCoef<sub>1</sub>).

M C	OM3:9	600baud - Te	ra Term VT							Ē	
File	Edit S	etup Control \	Mindow Help	-							
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All commands and data can be logged. Click on "File" and select "Log". Type a name for the log file and select "Option". If Timestamp is crossed off the time will be taken from the computer.