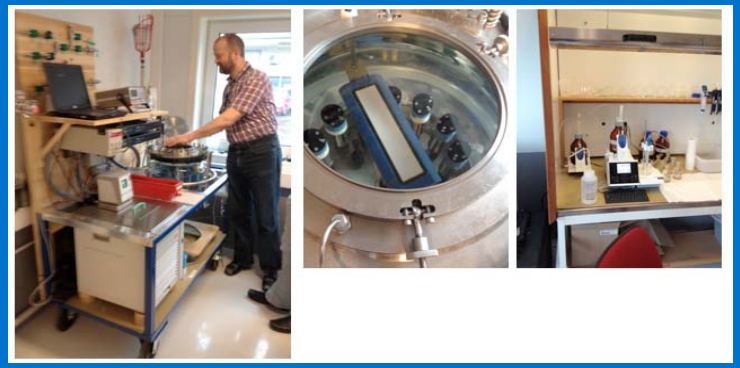
AANDERAA
a xylem brand

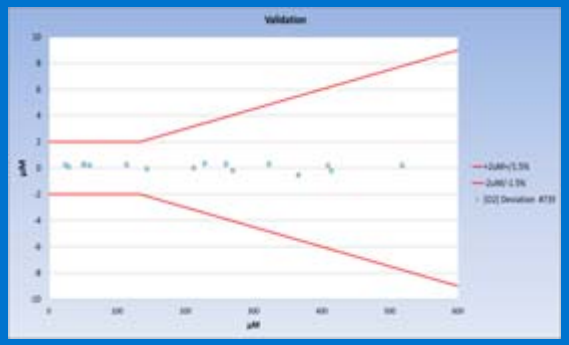
Dr. Anders Tengberg

OI, London, March, 2014

Improve your oxygen optode measurements:

user examples, practical handling and calibrations

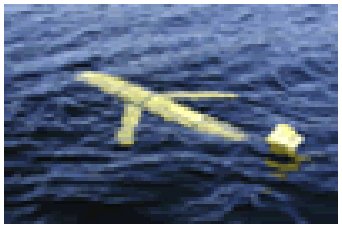




Introduced in 2002. Thousands of Aanderaa Optodes in use from 1-11 000 m depth, from fresh to salt water, from Arctic to Tropical

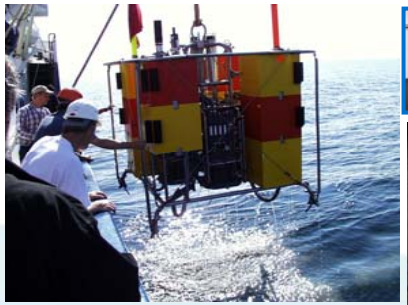













Aqua Optode: Same principles, basic construction & reliability to a lower cost

Multiple output:

- Cond: Cond,Sal,Temp,Sound speed,Raw
- Pres: Pres,Temp,Raw
- Oxygen: O_2,O_2%,Temp,Raw
- Wave & Tide: Wave,Tide,Temp,Raw
- Vented Wave & Tide: Wave, Tide, Pres, Temp, Raw
- Currents: Currents,Temp, Tilt, Signal, Strength,Raw
- CO2: pCO2 (microAtm), Temp, Raw

Communication:

- AiCaP (CAN bus)
- RS232/RS422
- Analog 0-5 V, 4-20 mA
- Aanderaa SR10 (10 bit), will soon be terminated

O_2 with 40 point calibration
Accuracy 1.5 %. 12 000m rated optional

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Improvements in MKII sensors with Framework 3 firmware

MKI (2002)
Main models:
3830 & 3835

- Better electronics
- Better optics (faster foils)
- Red reference LED
- Better temperature compensation
- Better formulas to calculate absolute oxygen (Uchida 2008)
- Multipoint calibrations with pre-treated foils

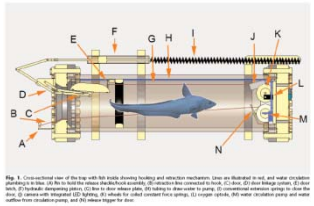
Affordable, High quality, 100 m rated
Aquaoptode 4531 introduced in 2013

MKII (2012)
Main models:
4330, 4831 & 4835

Oxygen Optodes

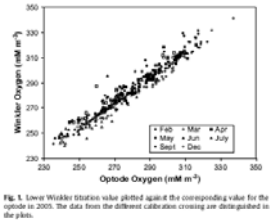
Examples of Scientific Papers

Incubators



Drazen et al (2005), Almroth et al (2012), Wikner et al (2013)

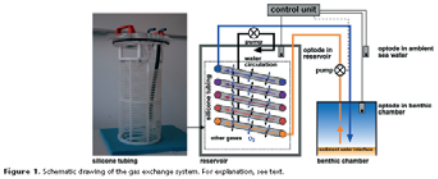
Ferry boxes



Tengberg et al (2006)

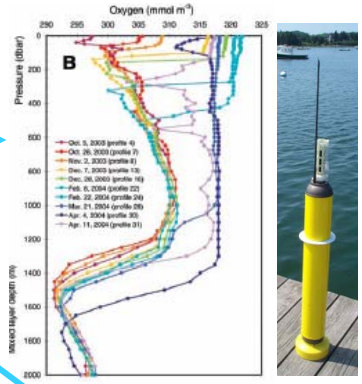
Hydes et al (2009)

Gas Exchange Chamber



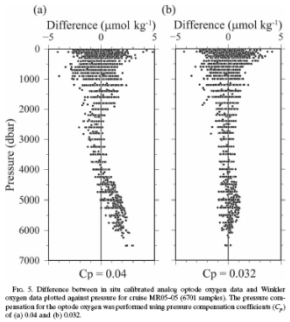
Sommer et al (2008)

Argo floats



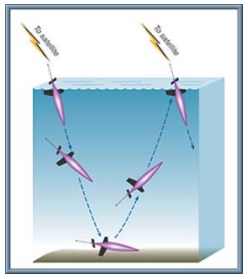
Körtzinger et al (2004, Nature)
Johnson et al (2010, Nature)
Fiedler et al (2013)
Takeshita et al (2013)

Cabled CTD



Uchida et al (2008)

Sea Gliders

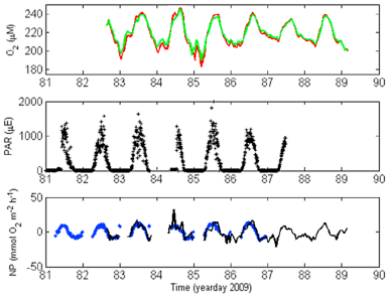


Nicholson et al (2008)

Boys

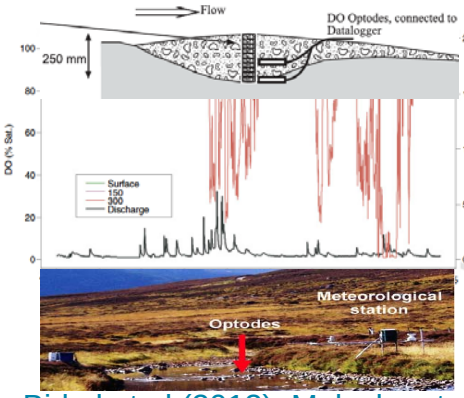
Jannash et al (2008), Bushinsky and Emerson (2013)

Gradients



McGillis et al (2011), Champenois and Borges (2012)

Rivers/Hydrology/Hyporheic

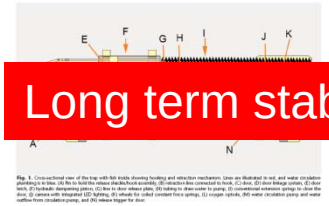


Birkel et al (2013), Malcolm et al (2006, 2008, 2010), Soulsby et al (2008)

Oxygen Optodes

Examples of Scientific Papers

Incubators



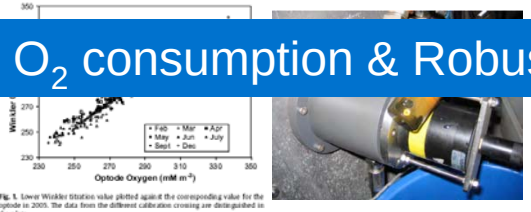
Long term stable

Drazen et al (2005), Almroth et al (2012),
Wikner et al (2013)

Not freezing sensitive

berg et al (2006)

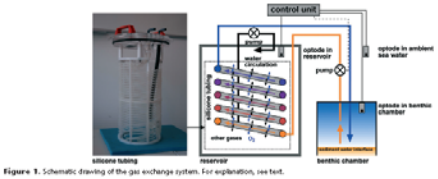
Ferry boxes



No O_2 consumption & Robust

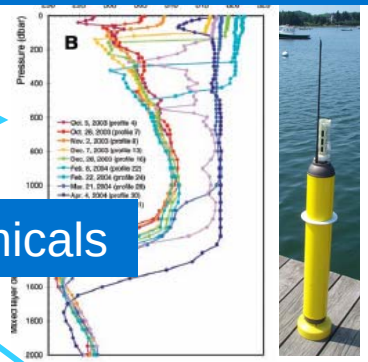
Hydes et al (2009)

Gas Exchange Chamber



Sommer et al (2008)

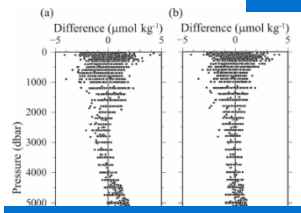
Good for hot water monitoring



Kortzinger et al (2004, Nature)
Johnson et al (2010, Nature)
Fiedler et al (2013)
Takeshita et al (2013)

Cabled CTD

Not sensitive to H_2S and most other chemicals

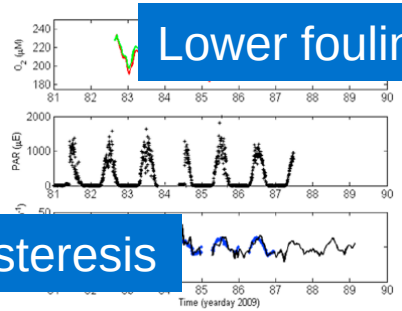


High accuracy & low noise

Uchida et al (2008)

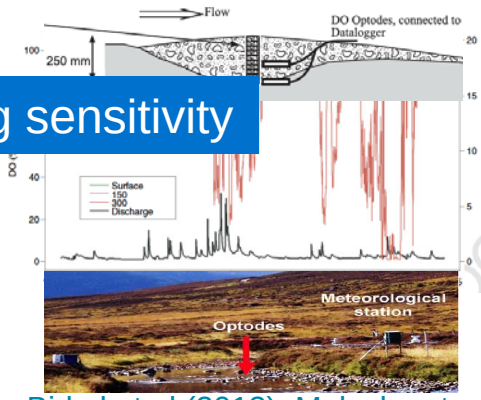
Boys

Gradients



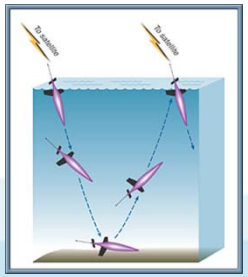
Lower fouling sensitivity

Rivers/Hydrology/Hyporheic



Birkel et al (2013), Malcolm et al (2006, 2008, 2010), Soulsby et al (2008)

Sea Gliders



Nicholson et al (2008)

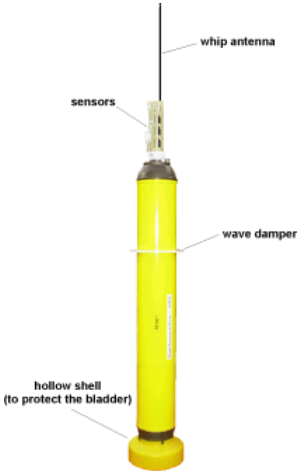
No pressure hysteresis

Emerson (2013)

McGillis et al (2011), Champenois and Borges (2012)

Long term data from 69 Optodes on Argo floats

Yuichiro Takeshita et al., Poster presented at AGU fall meeting, San Francisco, Dec 2010.
Now published in: Takeshita et al. (2013) A climatology-based quality control procedure for profiling float oxygen data. J . Geophysical Res, Vol. 118, 1–11.



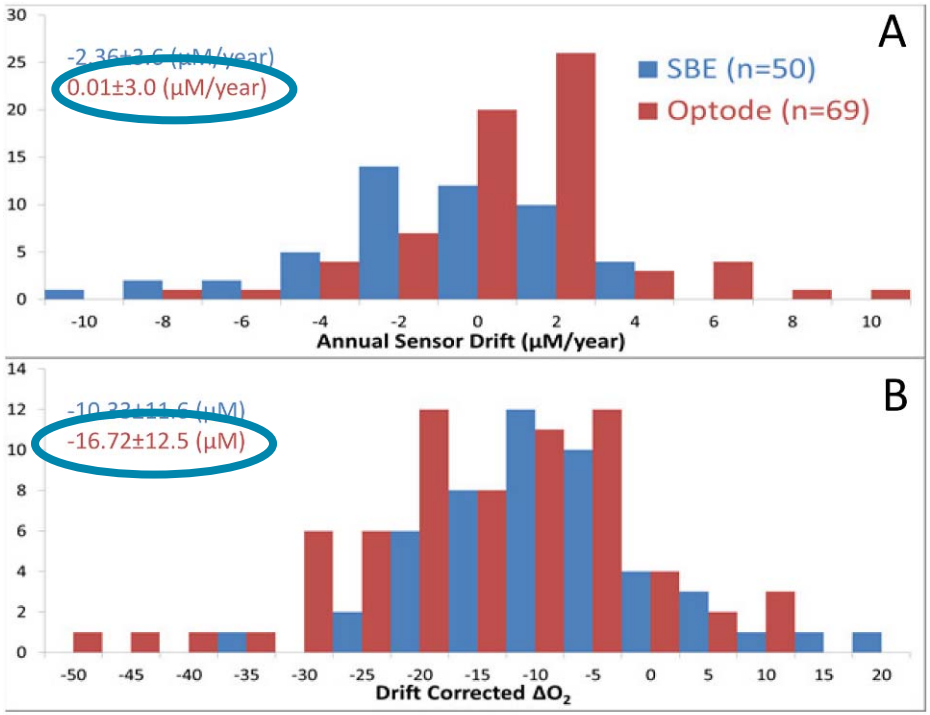
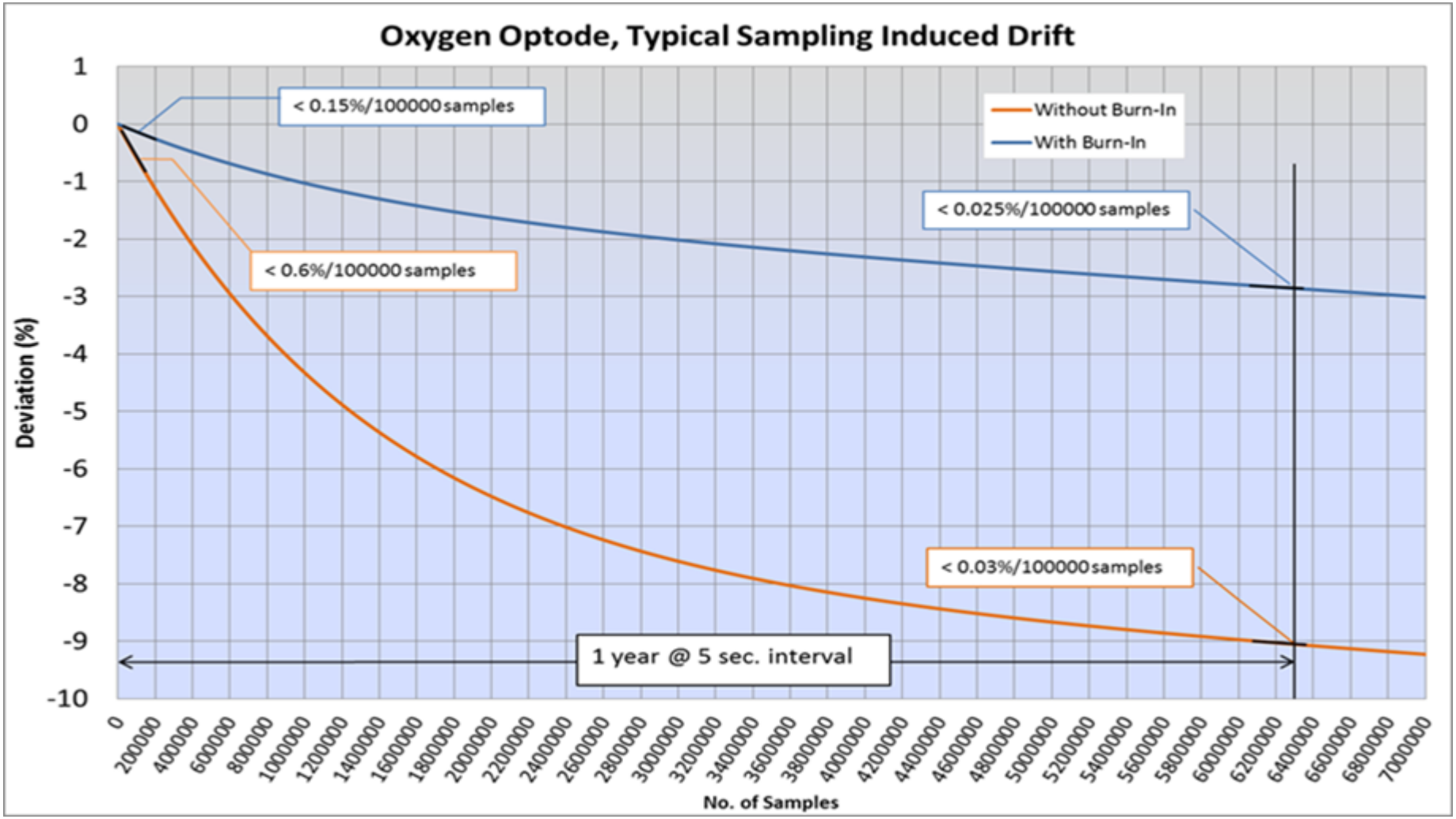


Figure 2. Histogram of sensor drift (A) and the Drift Corrected Average Deep ΔO_2 (B) for the two different types of oxygen sensors. The mean±std. dev. is labeled on the plot with its corresponding color.

- Conclusion: Optodes stable but gave lower values
- Reason: Foils bleach in ambient light (especially fluorescent) and if sampling is done at high frequency

When storing sensors use black protection cap!

Optode drift in relation to number of measurements and pre-treatment (with burn-in) or not



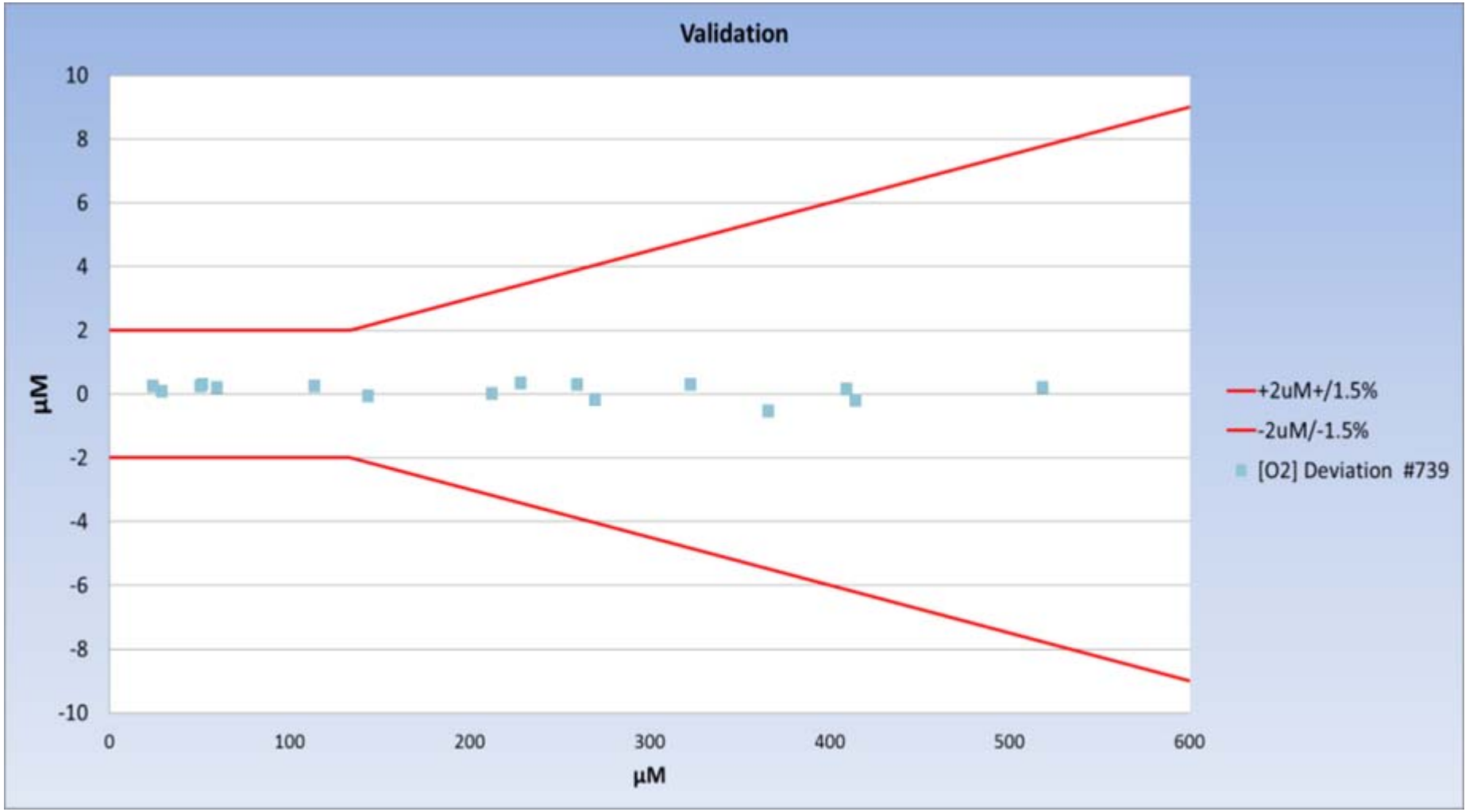
All Multipoint calibrated Foils are Pre-matured ► Better Accuracy
► Better Stability Drift < 0.15 µM/100,000 samples
If not mechanically damaged foils get better over time

Multipoint Calibration System

- Gas injection by use of mass flow controllers
- Automatic System 40 point calibration & 20 point subsequent verification
- Operational since August 2012
- 3 parallel reference optodes in system
- Automatic Winkler system from SI Analytics for frequent verification
- International inter-comparison of calibration facilities
- Absolute accuracy better than 1.5%/±2.5 µM

Multipoint calibration only for MkII: 4330 & 4831

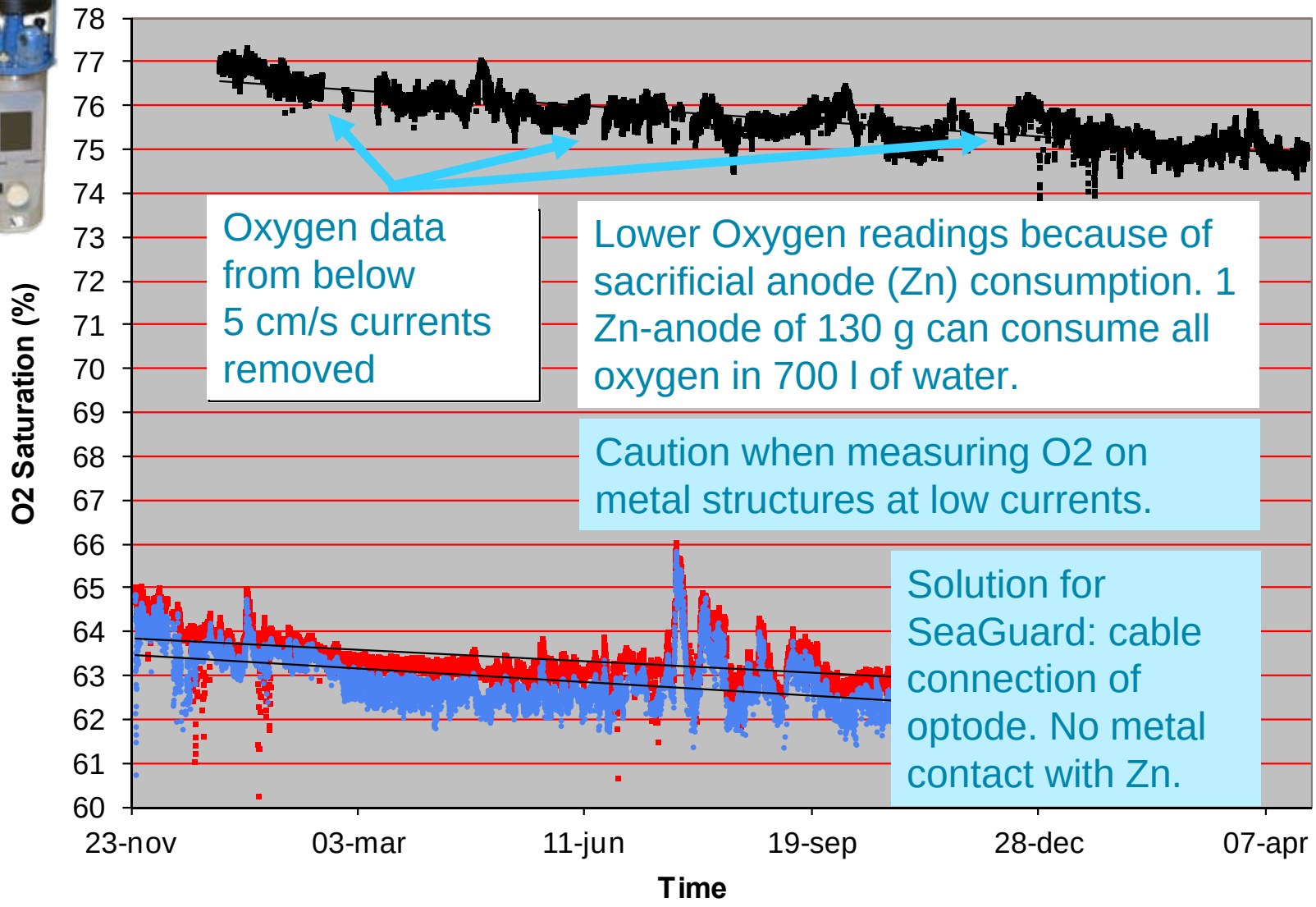
Validation



Accuracy over entire range of O_2 and Temp: ±2.5 µM or ±1.5%. Field resolution: ±0.2µM

Multipoint Calibration + red LED referencing gives the highest accuracy

Oxygen at 4000 m



Oxygen data from below 5 cm/s currents removed

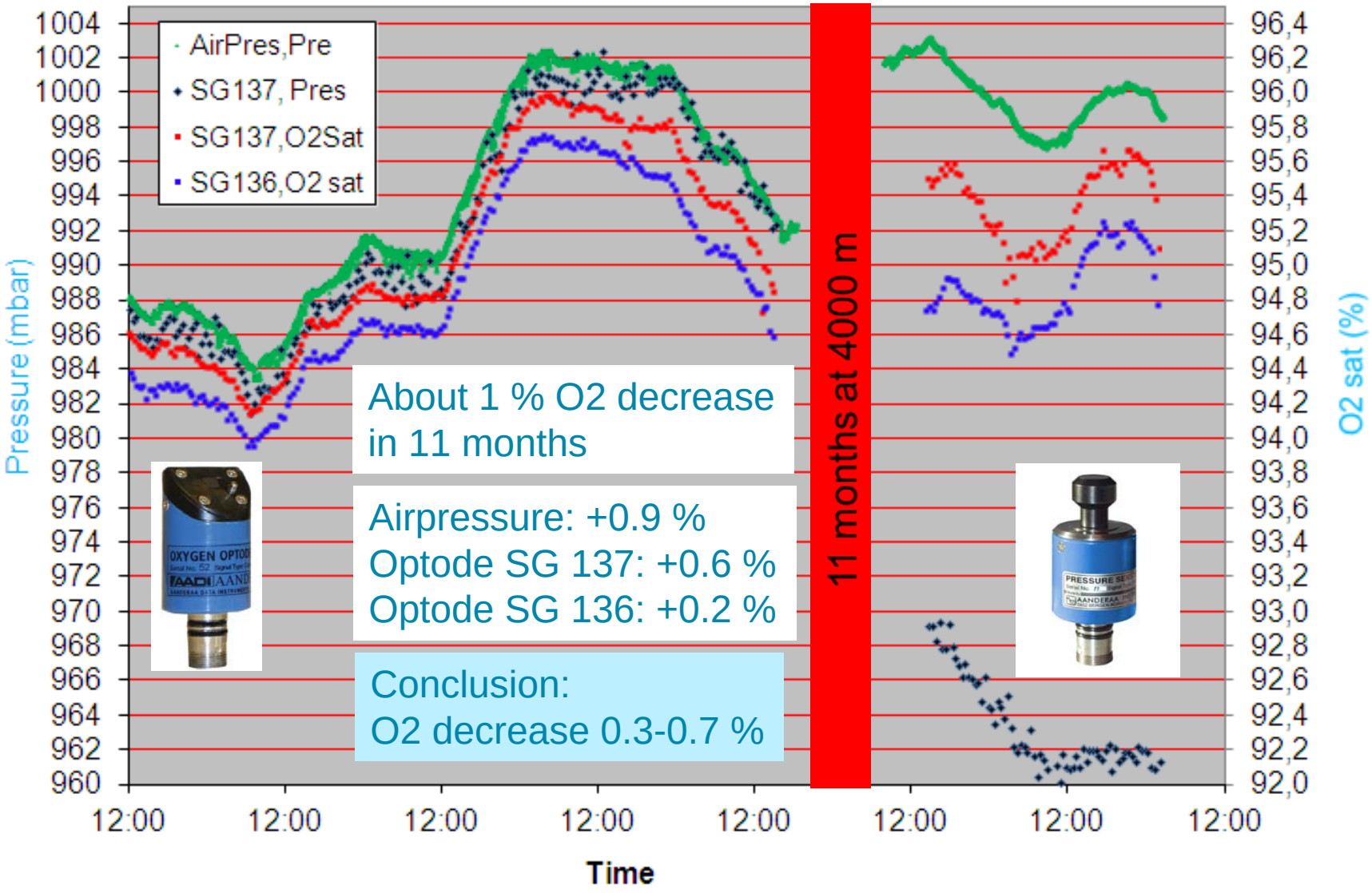
Lower Oxygen readings because of sacrificial anode (Zn) consumption. 1 Zn-anode of 130 g can consume all oxygen in 700 l of water.

Caution when measuring O2 on metal structures at low currents.

Solution for SeaGuard: cable connection of optode. No metal contact with Zn.

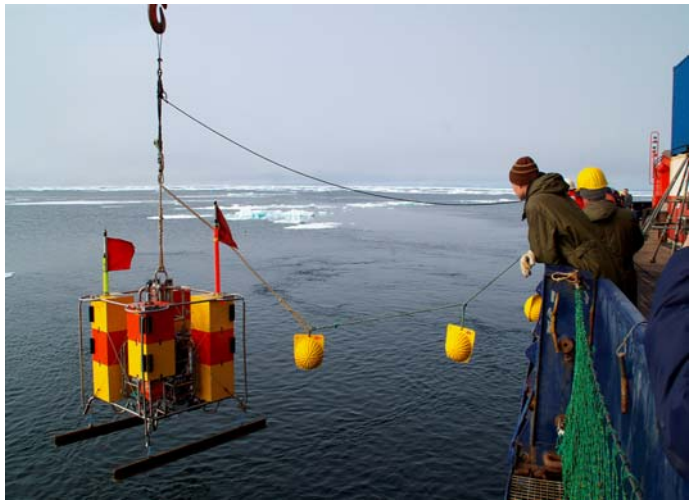
Lo Bue N. et al. (2011) Anomalies of oxygen measurements performed with Aanderaa optodes. J of Operational Oceanography. Volume 4 No. 118, 1–11.

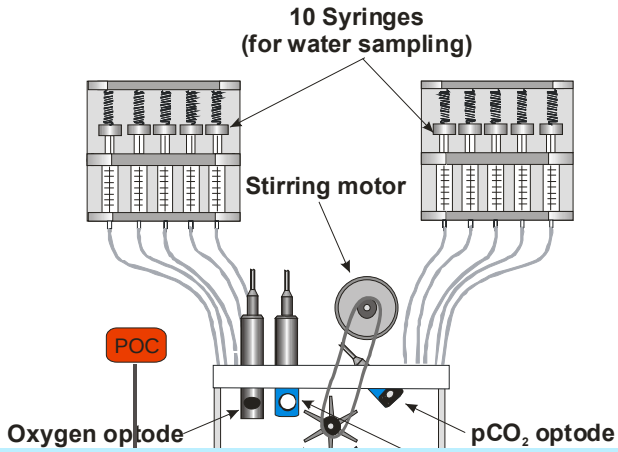
Pre & Post Deployment data. Air Pressure Ship + SG Pressure + Oxygen Saturation before and after deployment on two Seaguards



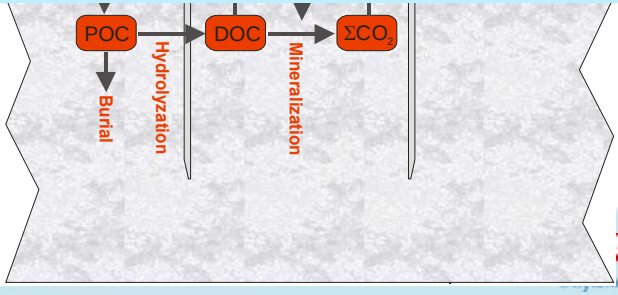
Gothenburg Autonomous Bottom Landers for Sediment-Water Incubations. Deployed ~300 times from 5-5600 m water depth

RCM Blue
in action measuring
above sediment
incubation system

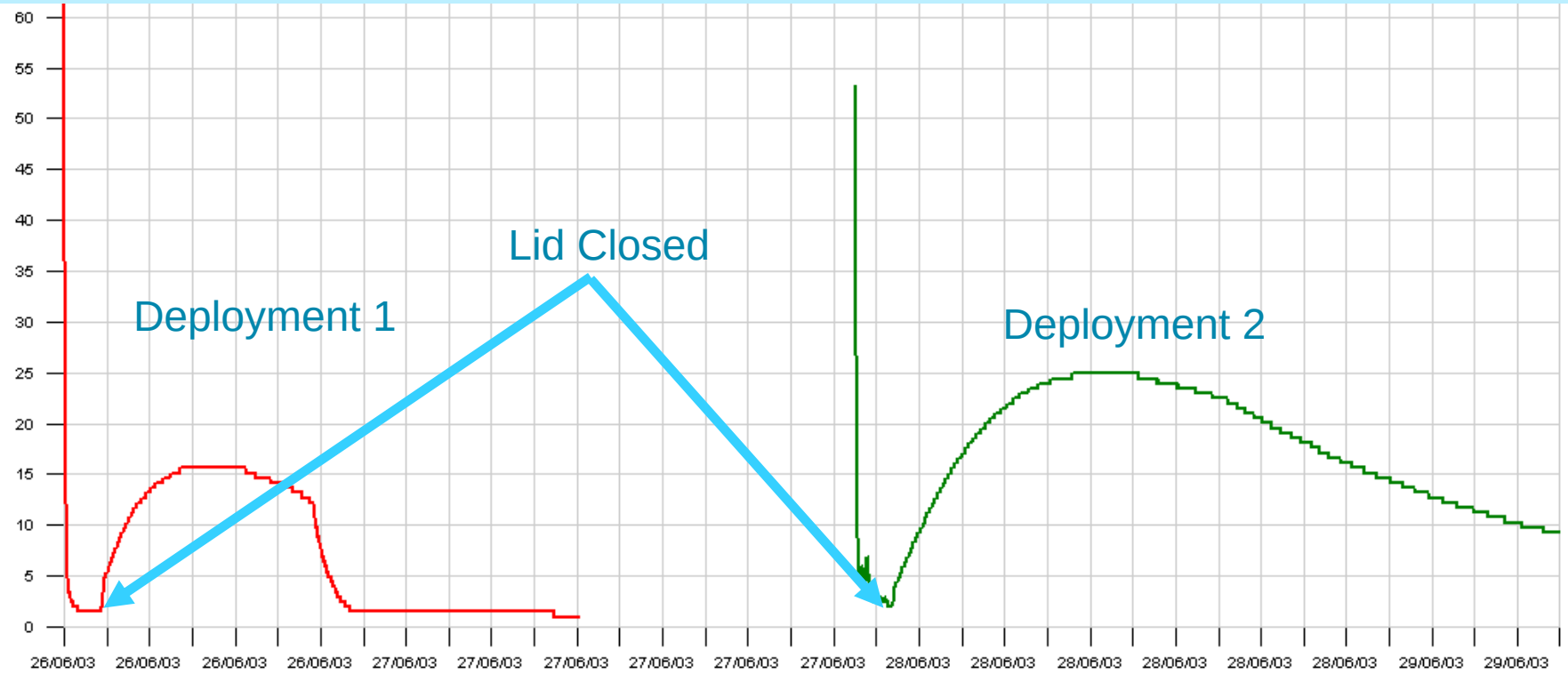


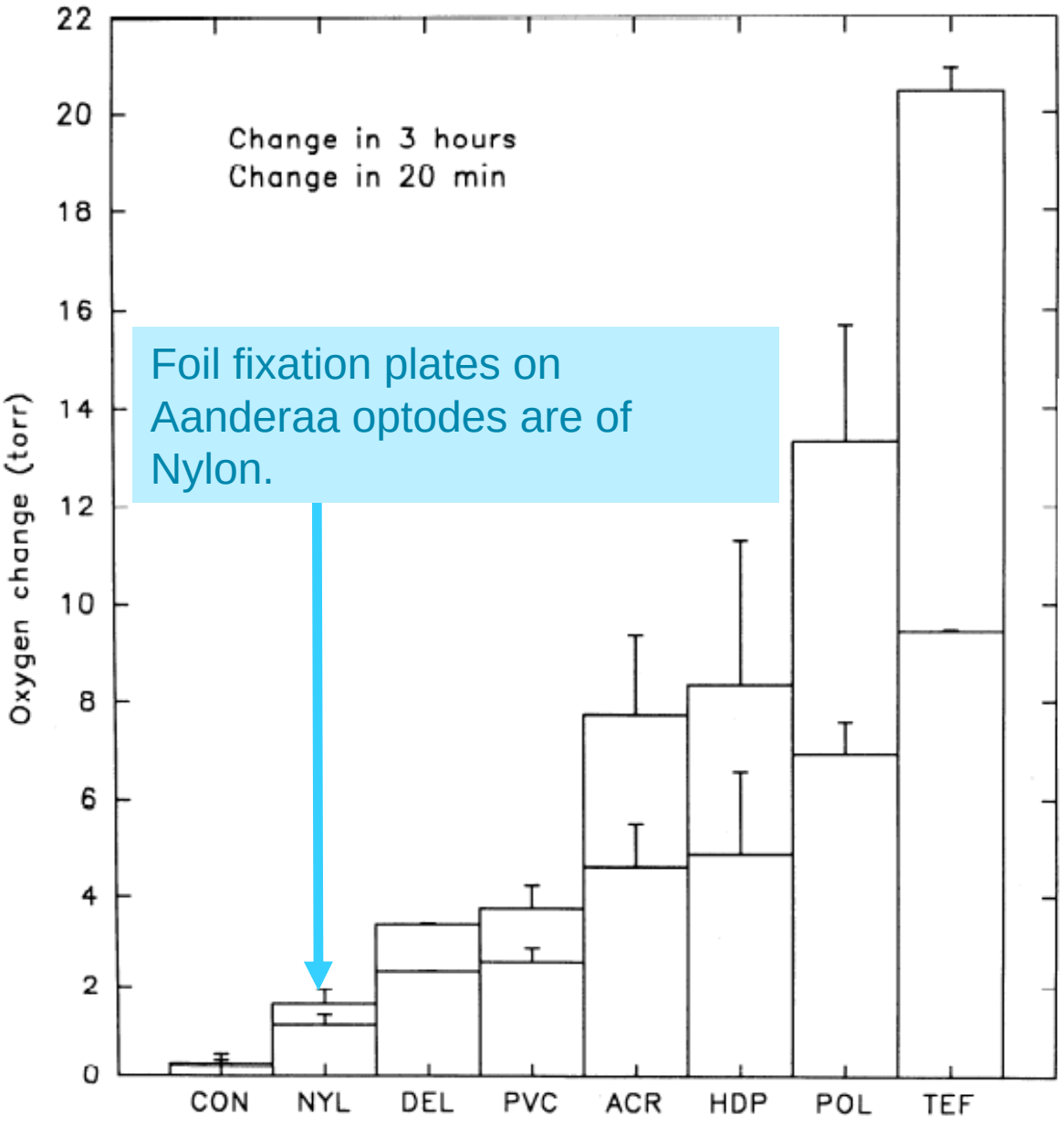


Incubation Chambers in Polycarbonate



Plastic/Polycarbonate incubators dissolve high amounts of oxygen. Have to ventilated for hours prior to incubation in Hypoxic environments → Artifacts

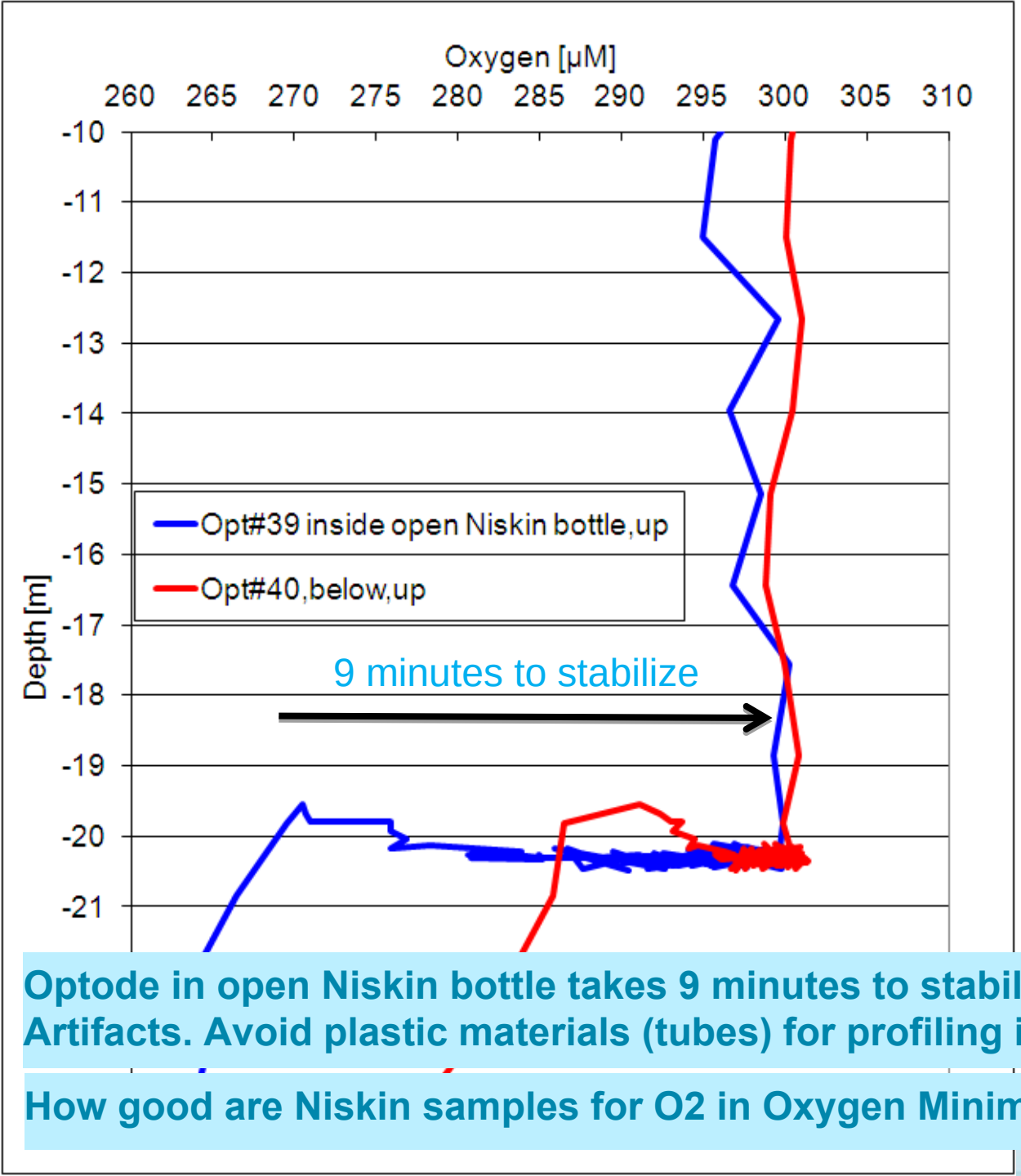




Foil fixation plates on Aanderaa optodes are of Nylon.

Stevens, E. Don (1992) Use of plastic materials in oxygen-measuring systems. Journal of Applied Physiology, 72(2): 801-804.

Plastic Materials have “memory” effects on O2. Plastic materials should be avoided for profiling and if high accuracy/precision is needed.



Optode in open Niskin bottle takes 9 minutes to stabilize. Plastic materials → Artifacts. Avoid plastic materials (tubes) for profiling in sharp gradients.

How good are Niskin samples for O2 in Oxygen Minimum Zones (OMZ)?

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Dr. Anders Tengberg

OI, London, March, 2014

Improve your oxygen optode measurements:

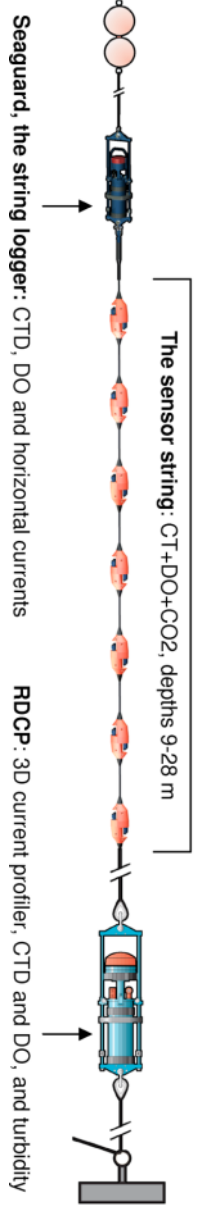
user examples, practical handling and calibrations

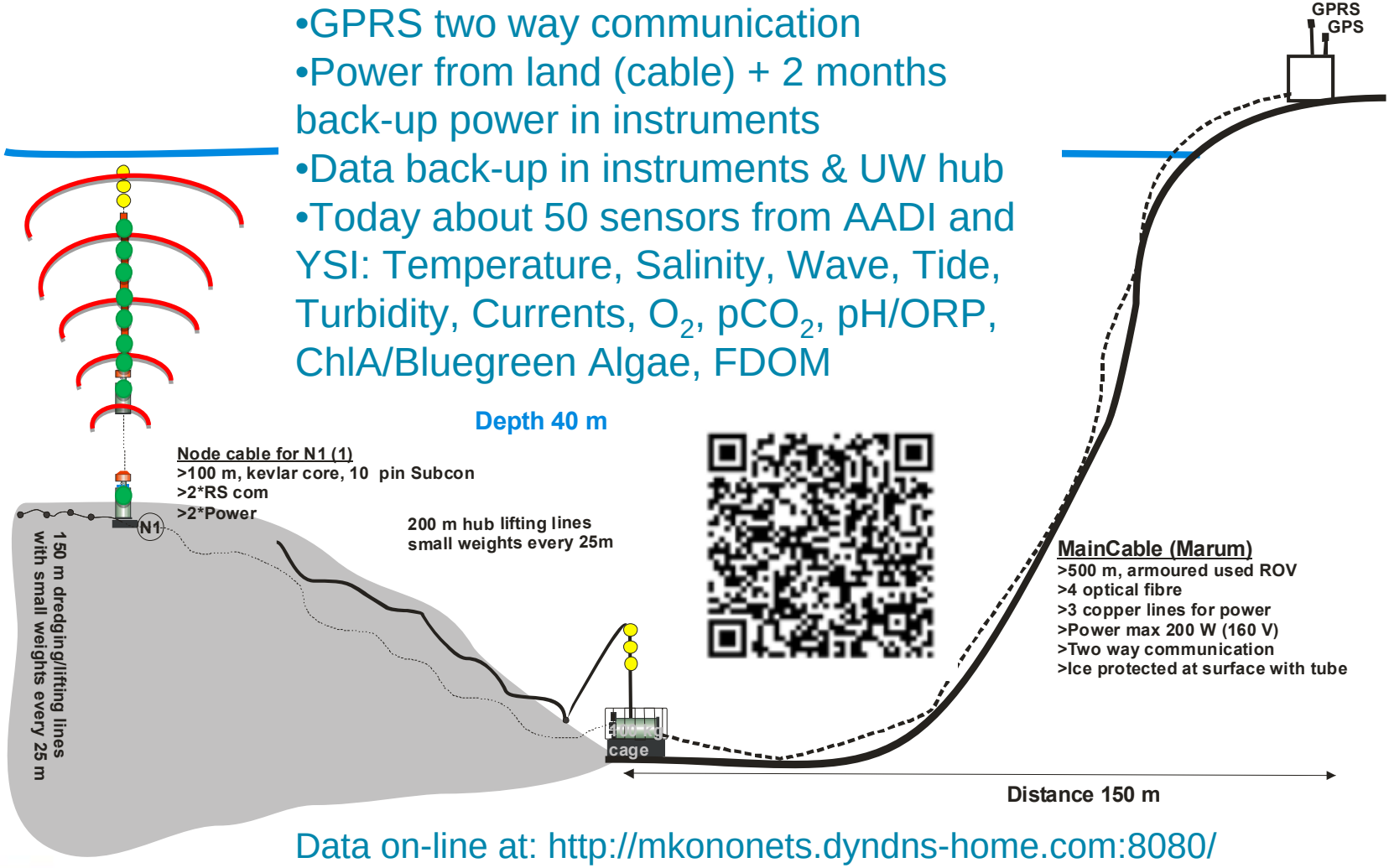
Conclusions

- In-situ monitoring + quality control + modeling ➔ 3 essential components of understanding aquatic environments
- Optodes are robust, accurate, stable, flexible and have low power consumption
- Proven long-term stability + 5 years
- Used in a wide variety of applications, about 50 scientific publications
- Simple field methods can improve the absolute accuracy to ± 3 %
- Multipoint calibrations improve the absolute accuracy to ± 1.5 %
- Sacrificial anodes can induce artifacts
- Plastic materials have O2 memory effects, should be avoided

Koljoe fjord observatory: structure

- Real time 2-30 min interval
- GPRS two way communication
- Power from land (cable) + 2 months back-up power in instruments
- Data back-up in instruments & UW hub
- Today about 50 sensors from AADI and YSI: Temperature, Salinity, Wave, Tide, Turbidity, Currents, O_2, pCO_2, pH/ORP, ChlA/Bluegreen Algae, FDOM

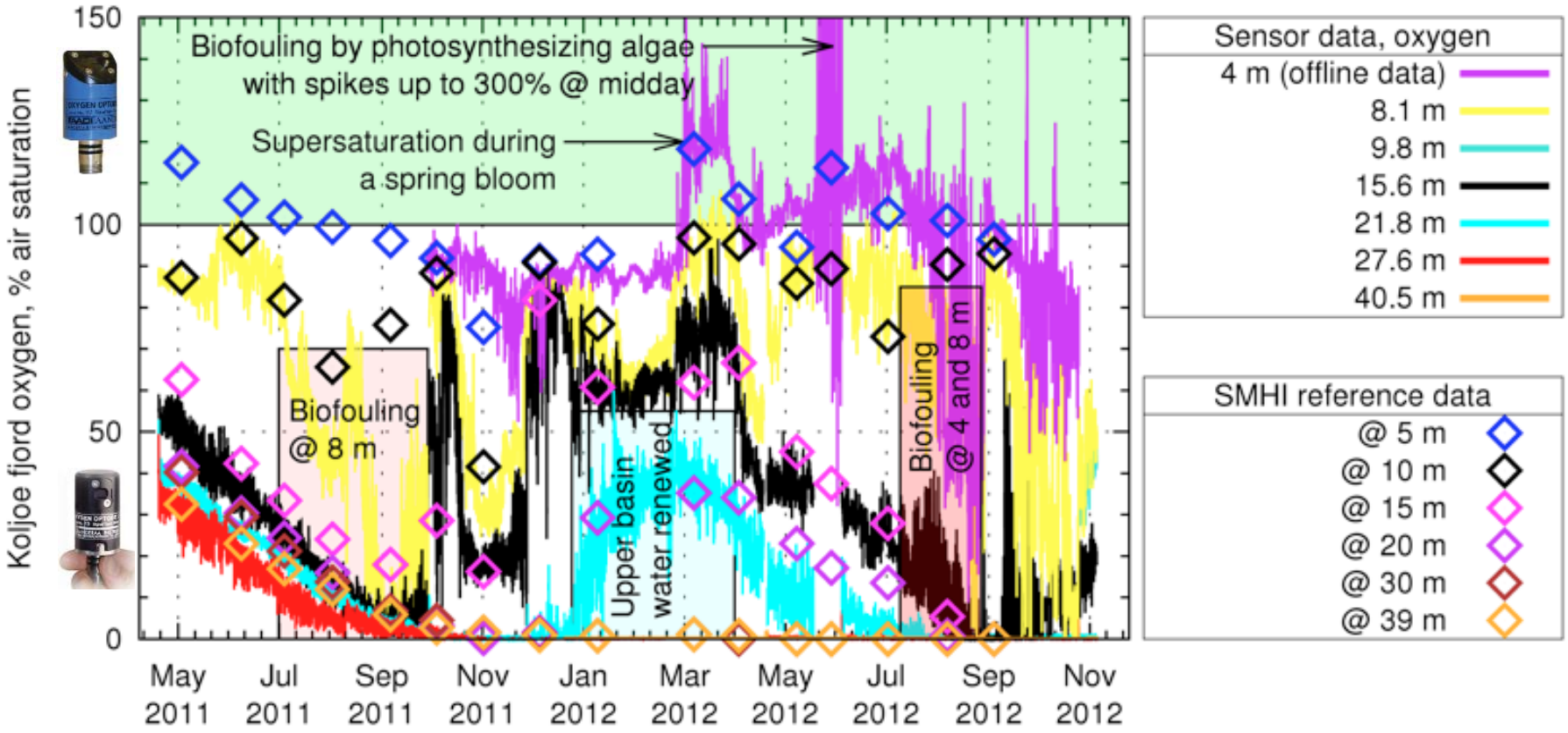




Data on-line at: http://mkononets.dyndns-home.com:8080/

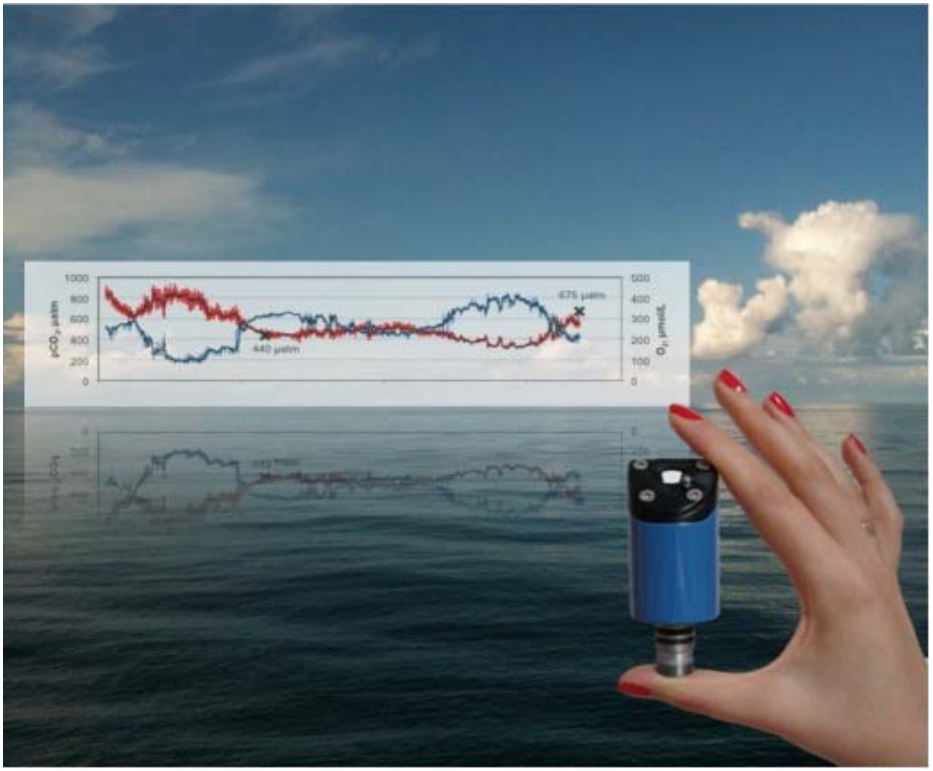

RDCP
Seaguard
String with
sensors

Examples of data: 18 months oxygen recordings, with monthly reference data from SMHI



- Oxygen measured at 7 levels. Variable conditions with up to 70% saturation changes in some hours. Deep water oxygen depleted with time. When below 40% saturation winkler titration overestimates oxygen levels.
- Fouling effects sensor readings after 1.5-3 months in the summer season.
- After cleaning, sensors read correctly again and no calibration is needed.

Development and use of an optical pCO_2 sensor in marine studies



PhD thesis presentation

Dariia Atamanchuk

Department of Chemistry and Molecular Biology,
Marine Chemistry
Faculty of Natural Sciences
University of Gothenburg
Gothenburg, Sweden

25 October 2013

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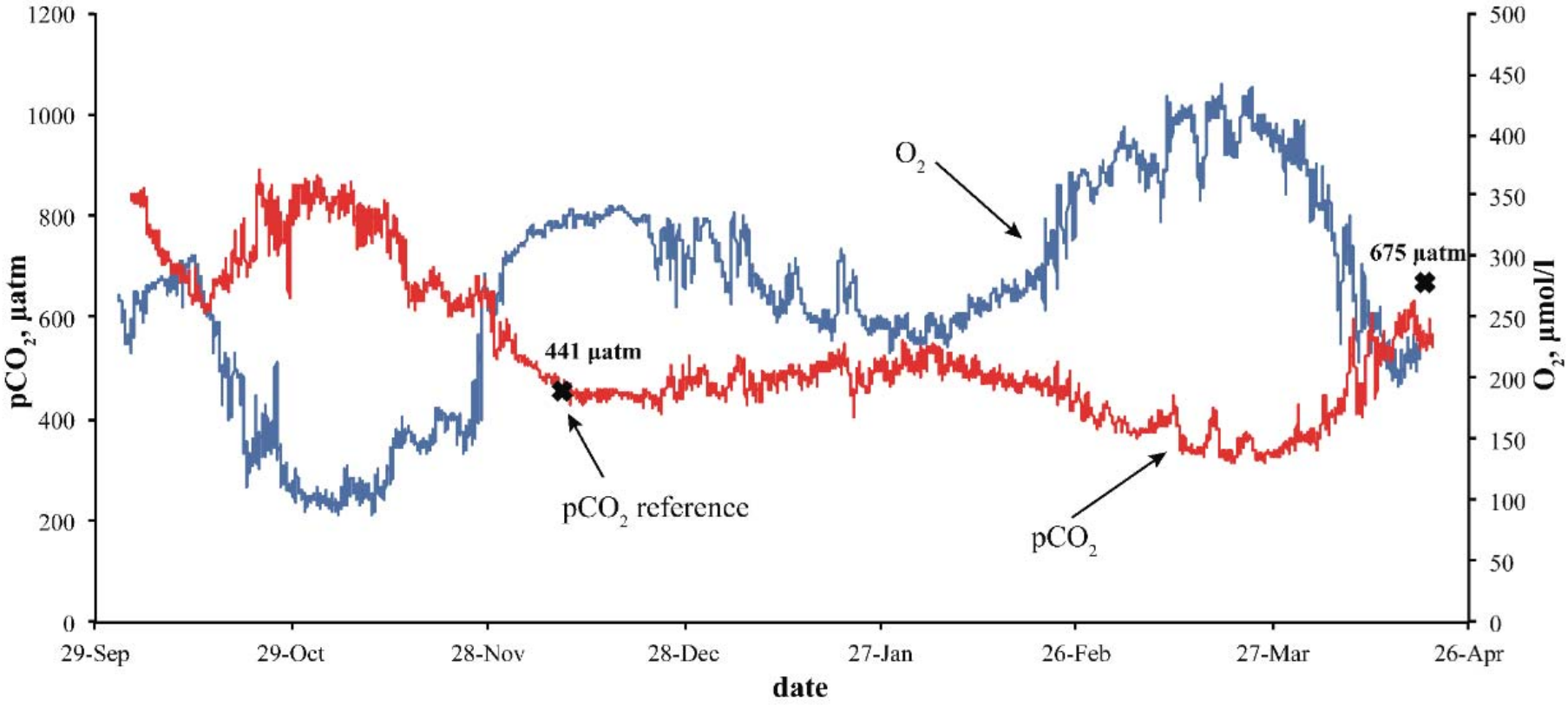
Koljoe Fjord cabled observatory
pCO_2 sensor and O_2 optode at the depth of 12.6 m
7 months time-series, 30 min measuring interval



AANDERAA
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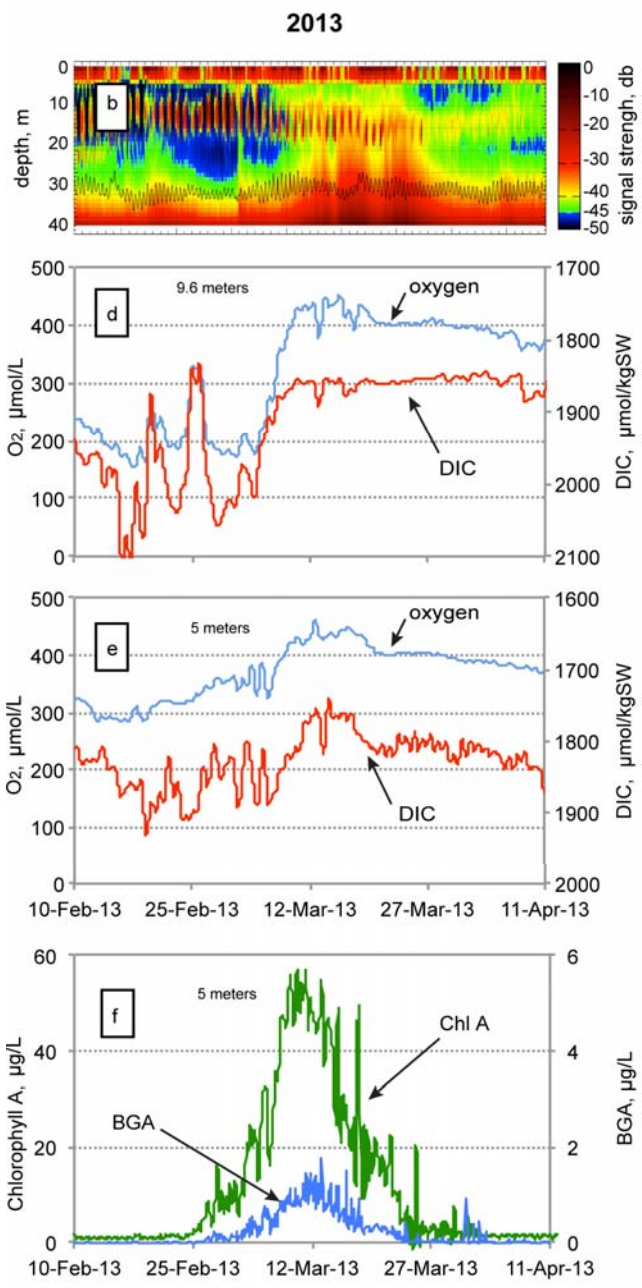
Koljoe Fjord cabled observatory
pCO_2 sensor and O_2 optode at the depth of 12.6 m
7 months time-series, 30 min measuring interval

Salinity derived Alkalinity

Redfield scaled plots. Atamanchuk et al. (2013)

Combining Seaguard and EXO2



YSI a xylem brand

AANDERAA a xylem brand

AANDERAA Ambeon MSI

MS ROMANTIKA
TALLINK

Choose date 09-03-2014

Choose parameter Temperature [°C]

Sattelite overlay: -

View: datatable

graph

SHIP'S LAST POSITION
- 1,1..1,9 °C
- 1,9..2,6 °C
- 2,6..3,3 °C
- 3,3..4 °C
- 4..4,7 °C

http://on-line.msi.ttu.ee/lvferry3/?ts=1394316000&param=salinity

MS ROMANTIKA

Time. 09-03-2014 23:52
Latitude: 57° 41.8382'
Longitude: 21° 58.6255'
Temperature: 1.82 °C
Conductivity: 6.39 mS/cm
Salinity: 6.33 psu
O2 Conc: 425.35 uM
O2 Air Satur: 96.92 %
Chlorophyll-a: 6.86 ug/l
Turbidity: 0.77 FTU
Phycocyanin: 3.29 ug/l
pCO2: 620.18 uatm
CalPhase: 32.74 deg
Signal strength: -59 dBm
Current GSM/GPRS provider: 24701
Battery voltage: 14.3 V

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SmartGuard: Compact Ferry Box System called SOOGuard

http://on-line.msi.ttu.ee/lvferry2/?param=air_sat