Examining the Calibration Stability of Sea-Bird's Oxygen Sensor Technology: Drift < 1 umol/kg per year

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Figure 1

The SBE 43F oxygen sensor is an optimized Clark electrode integrated into the exhaust stream of the SBE 41 CTD mounted to an APEX float (NOPP float s/n 0894, WMO ID 4900093) (figure 1).

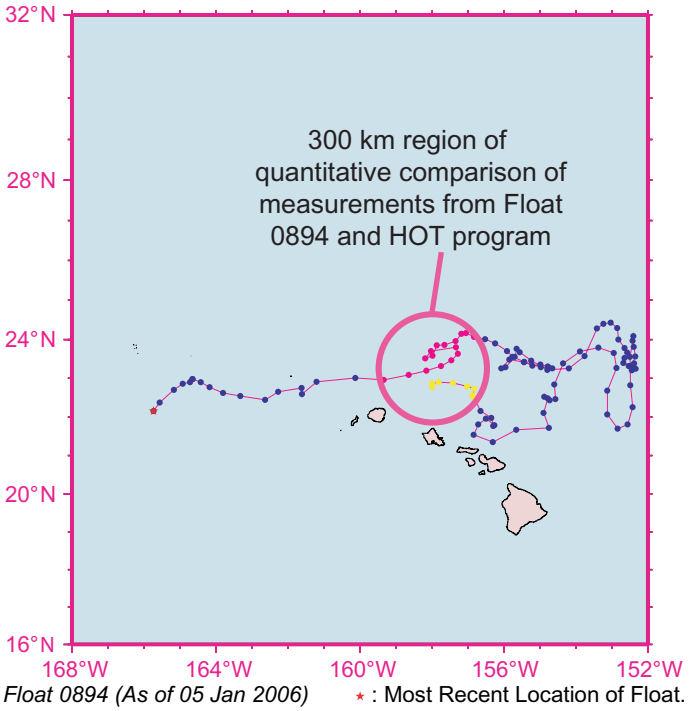
Calibration drift of this Clark design scales with total oxygen consumed. The CTD plumbing shape and flow control allow the sensor to go anoxic between profiles, minimizing consumed oxygen and calibration drift. Antifouling and contaminant prevention systems minimize drift from these sources as well. This float implementation affords an evaluation of the SBE 43 sensor's fundamental stability.

Calibration stability is evaluated two ways: against Winkler-titrated water samples from the surface mixed layer and deeper density surfaces at the HOT-ALOHA long-term monitoring station, and by the degree of repeatability of the T-Oxygen relationship in deep water.

Float 0894 was deployed at the HOT-ALOHA site. Its Lagrangian drift trajectory returned past the site 33 months later, affording two periods to evaluate sensor drift against concurrent HOT measurements. We focused on float profiles within a ~150 km circle of HOT, presuming meteorologic uniformity in surface oxygen saturation and similarity of water-mass conditions on deeper density surfaces (figure 2).

The composite of TS and T-Oxygen curves from all 112 Float 0894 profiles exhibit tight oxygen repeatability at the 2.5° C isotherm until the sensor stopped operating at profile 99 (figure 3).

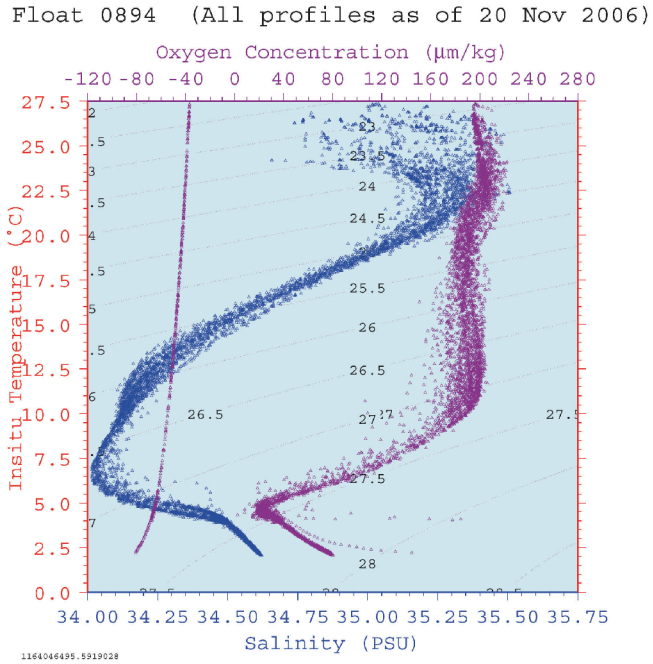
Figure 2



Float 0894 (As of 05 Jan 2006) ⋆ : Most Recent Location of Float.

1136492546.0054580

Figure 3



http://flux.ocean.washington.edu/argo/homographs/TP/0894.html

COMPARISON OF HOT-ALOHA AND FLOAT OXYGEN MEASUREMENTS

Figure 4:
Near-surface percent oxygen saturation measured by water samples (Winkler method) at HOT-ALOHA station (blue dots) and nearby float 0894 (purple stars). Lines represent a least-squares-fit to the data during periods when the float was in the vicinity of the HOT-ALOHA station (represented by circles in the shaded regions). The float data during these periods were corrected for a calibration offset caused by electrolyte consumption due to the sensor's 9-month exposure to air prior to the float deployment (August 2002). Sensors are now stored in an anoxic environment prior to deployment to prevent offsets.

Difference in the linear trends in oxygen measured by HOT vs. the float is approximately 0.3% over 33 months.

This amounts to an SBE 43F drift rate of less than 1 umol/kg during 33 months of operation.

Figures 5 and 6:
Similar analysis was conducted on deep oxygen data collected at HOT and by the float. Oxygen time series along constant potential density surfaces in the deep ocean near 1000 db and 1800 db indicate small drifts of less than 2 umol/kg during 33 months of operation.

Evaluating the trend in oxygen drift was conducted along constant potential density surfaces to remove internal wave variability and to account for the Eulerian character of the HOT data. This more careful approach to analyzing the deep density and oxygen values reveals a 10 umol/kg range in Eulerian HOT oxygen values near 1000 db. The Lagrangian float data exhibit a smaller range of oxygen values (4-6 umol/kg), presumably because the float was tracking a specific water mass.

This quantitative assessment corroborates the surface analysis, notwithstanding the sparse data and observed natural oxygen variability on the deep density surfaces.

LEGEND

- = HOT-ALOHA station
- = Float 0894
- = HOT-ALOHA station when Float 0894 in vicinity
- = Float 0894 when in vicinity of HOT-ALOHA station

Figure 4

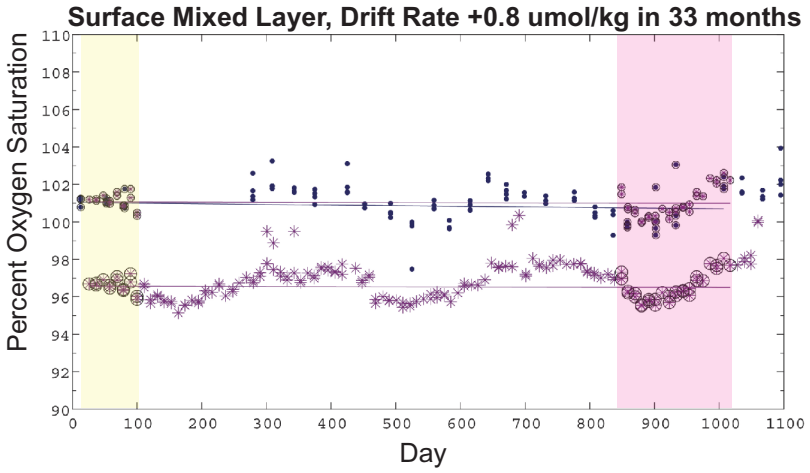


Figure 5

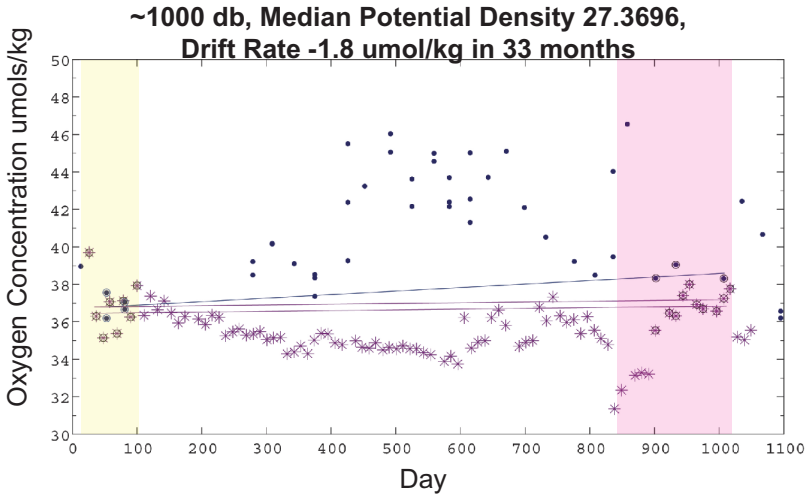
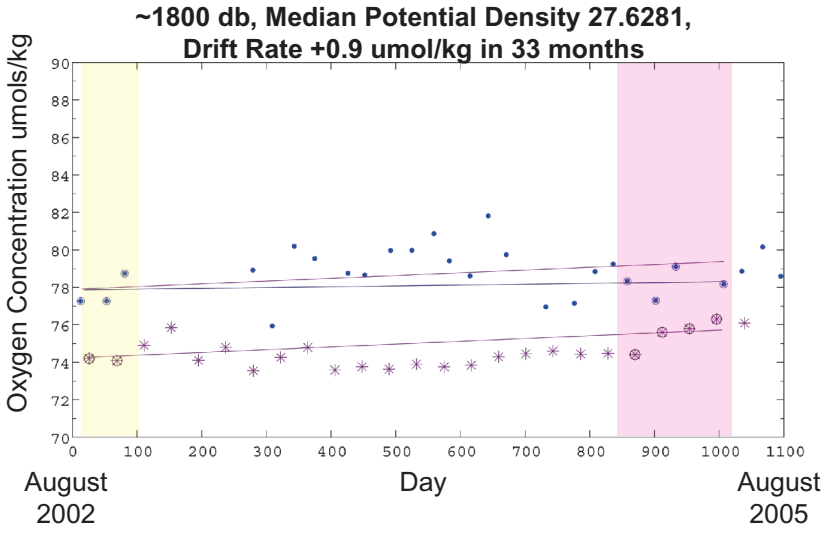


Figure 6

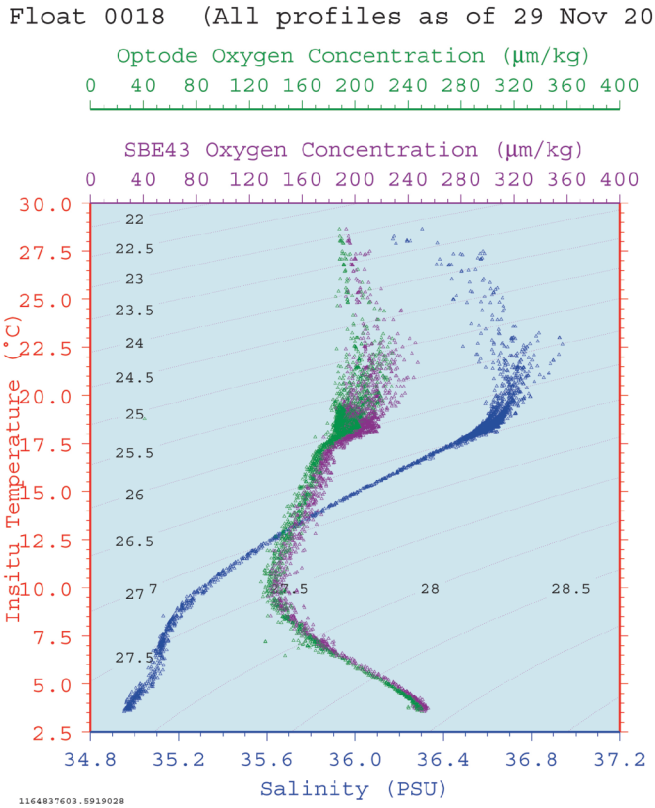


APEX FLOATS EQUIPPED WITH SBE 43I AND AANDERAA OPTODE OXYGEN SENSORS

Profile data from two other floats are summarized in composite plots of TS and T-Oxygen curves (figures 7 and 8). Data exhibit oxygen variability in the upper water column but a tight repeatability on deep density and isotherm surfaces. Sensor calibration drift does not exceed the difference in repeatability, and some fraction of this is natural oxygen variability on density surfaces, as seen in figures 5 and 6.

Figure 7. North Atlantic Float 0018, 127 profiles, 1.92 years

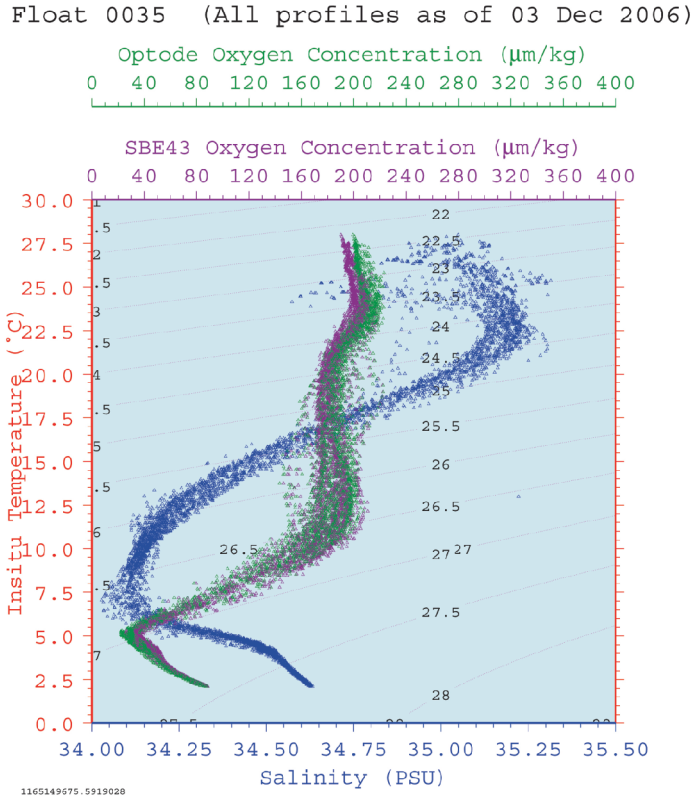
The Sea-Bird (magenta) and Aanderaa (green) oxygen sensors exhibit very similar stability on deep, cold isotherms.



http://flux.ocean.washington.edu/argo/homographs/TP/0018.html

Figure 8. North Pacific Float 0035, 99 profiles, 1.51 years

The tightly repeatable Sea-Bird oxygen sensor data plots underneath the Optode T-Oxygen curves in deep water.



http://flux.ocean.washington.edu/argo/homographs/TP/0035.html

CONCLUSIONS

- Less than 1 umol/kg drift in 33 months is observed between the near-surface oxygen saturation values measured by NOPP Float 0894 and water samples from the HOT-ALOHA station.
- Less than 2 umol/kg drift in 33 months is observed along constant density surfaces in the deep ocean.
- **These results suggest the expected drift in Sea-Bird oxygen sensors is less than 1 umol/kg per year!**

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