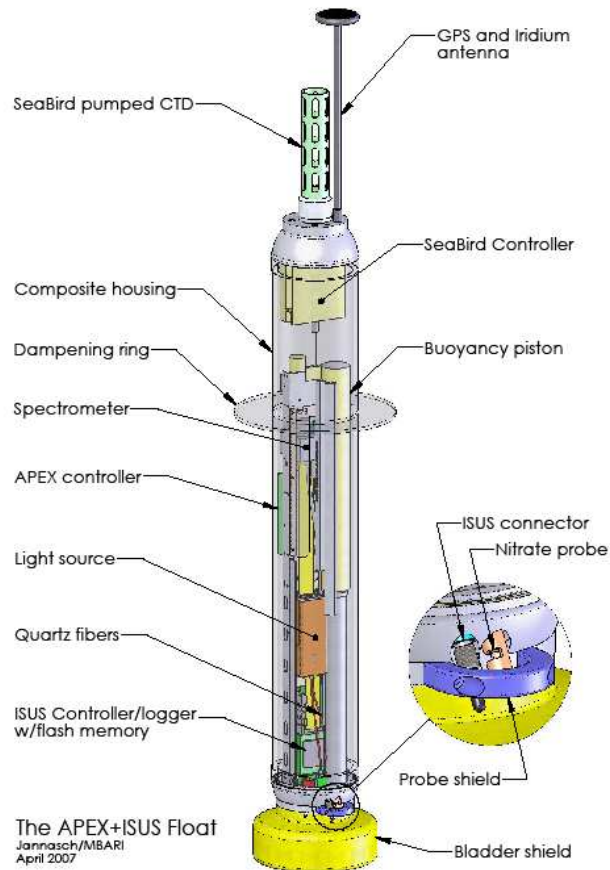


# ISUS/SUNA Nitrate Sensors in Apex Profiling Floats



Ken Johnson  
MBARI  
&  
Steve Riser  
UW



Dana  
Swift

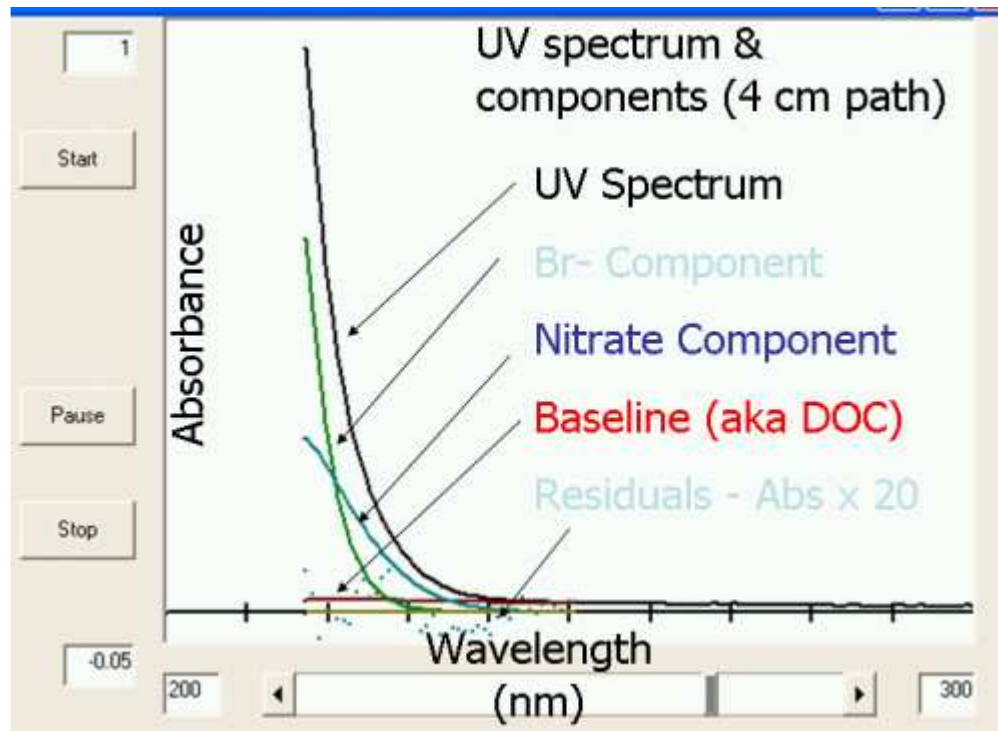
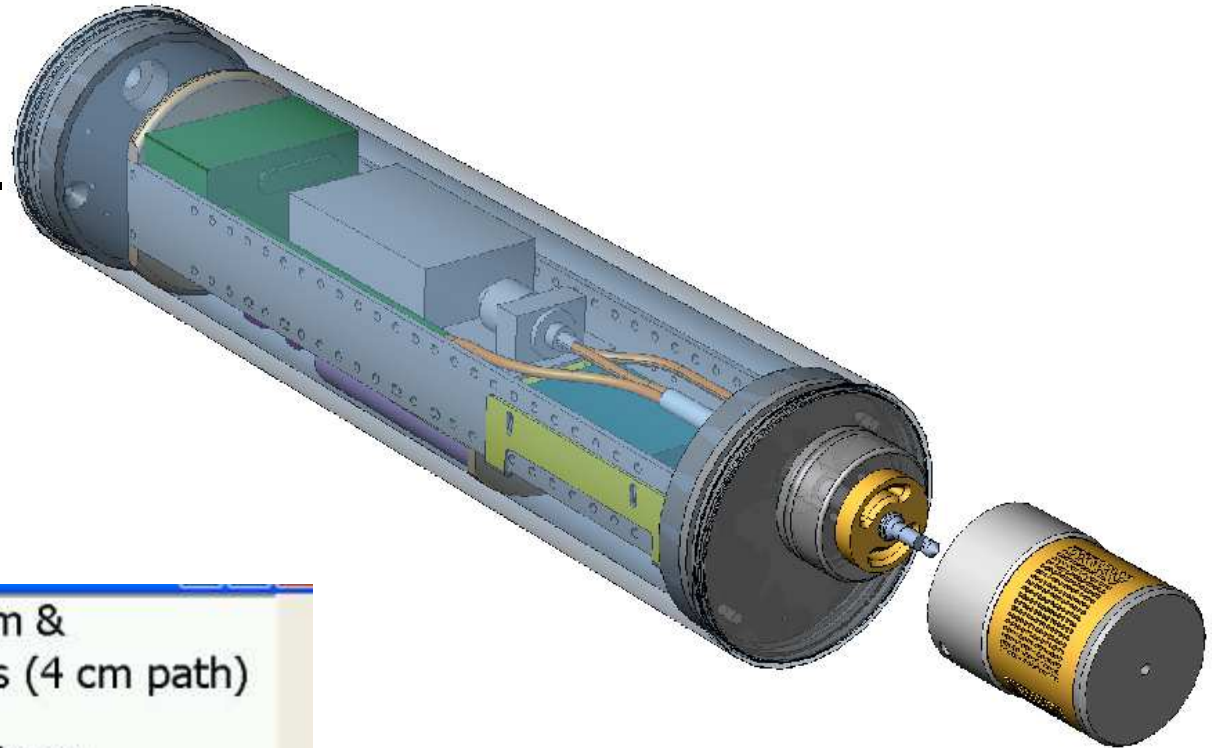
Luke  
Coletti

Hans  
Jannasch

NOPP



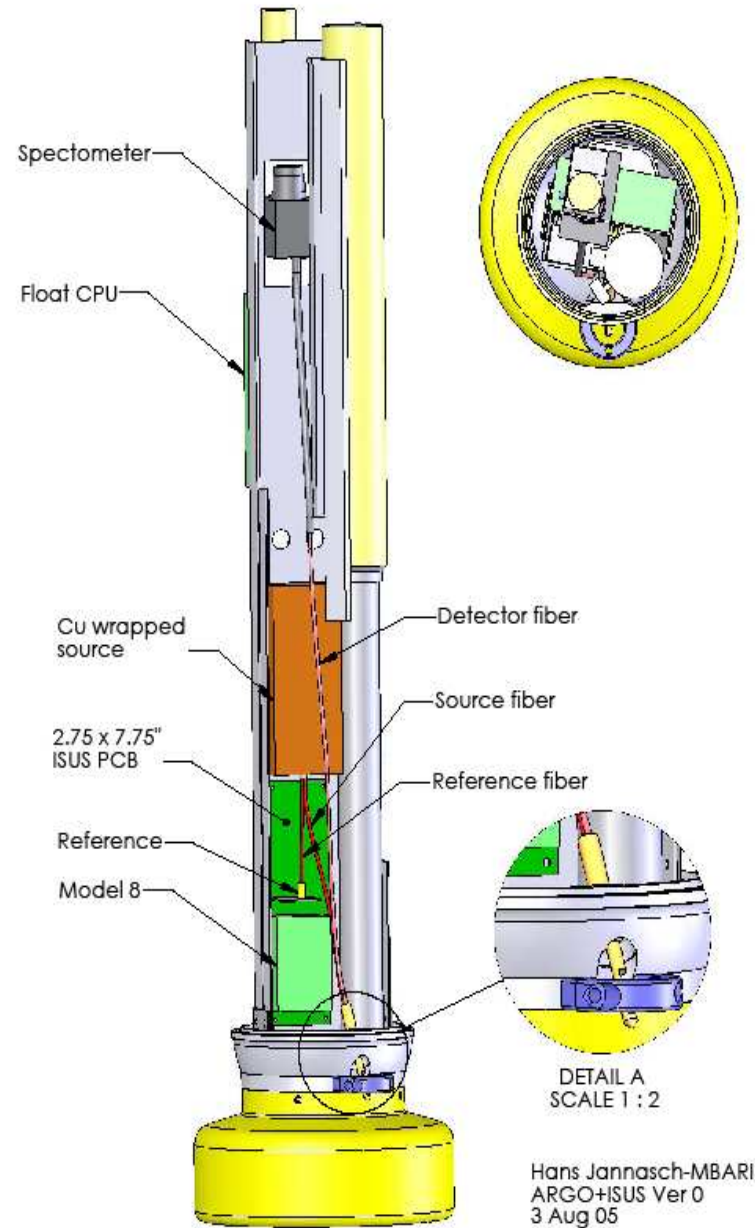
MBARI In Situ  
Ultraviolet Spectro-  
photometer (ISUS).  
Now commercially  
available from  
Satlantic.



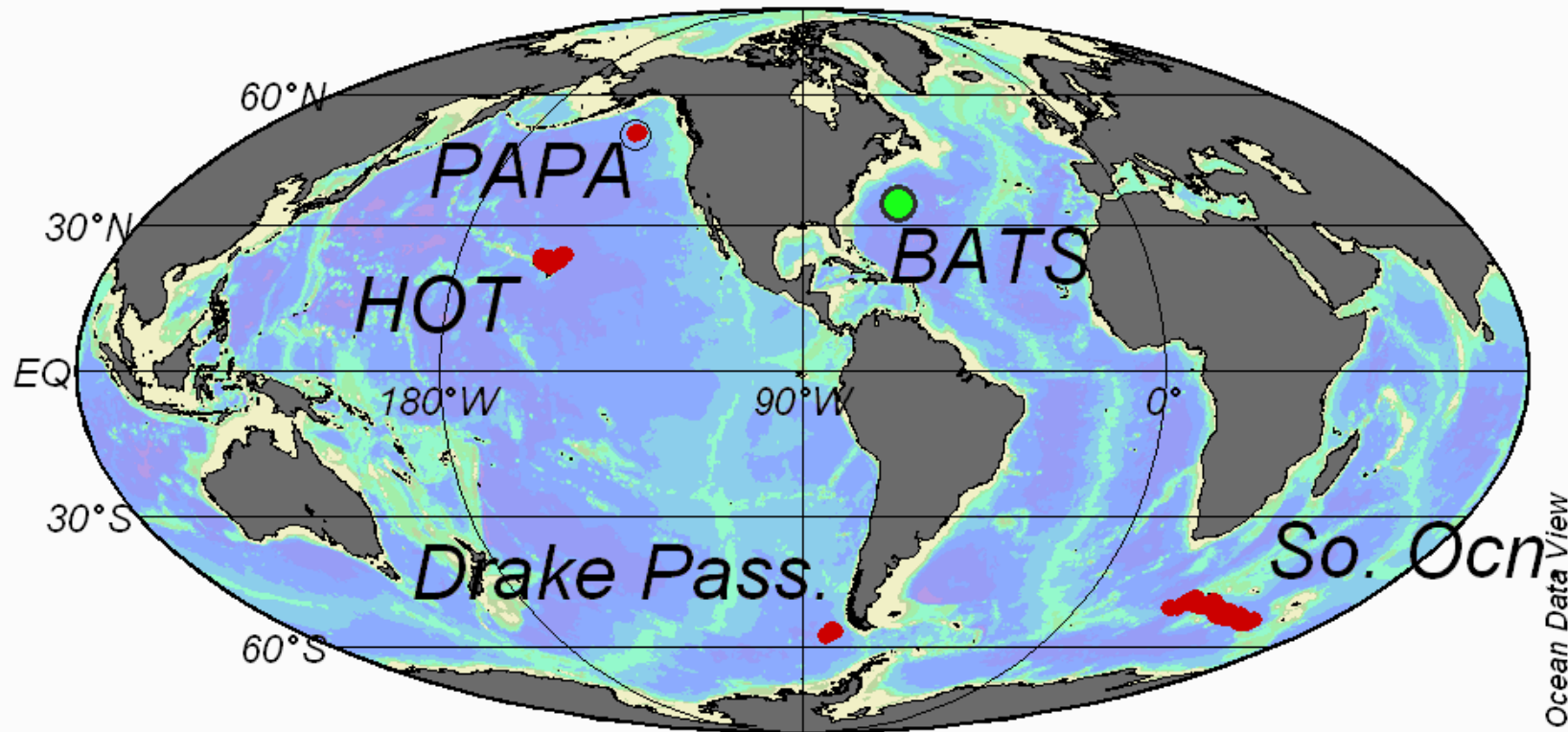
Nitrate measured directly  
using UV absorption  
spectrum from 217 to 240  
nm (Johnson & Coletti,  
Deep-Sea Res. I, 49, 1291  
2002).

# ISUS integrated into APEX float.

- 44 joule/ $\text{NO}_3^-$  measurement
- 60  $\text{NO}_3^-$  meas./profile to 1000 m
- Detection limit  $\sim 0.5 \mu\text{M}$
- Float endurance 260 profiles to 1000 m.  $\sim 4$  year life at 5 day cycle time.
- Requires Iridium comms. & Li batteries

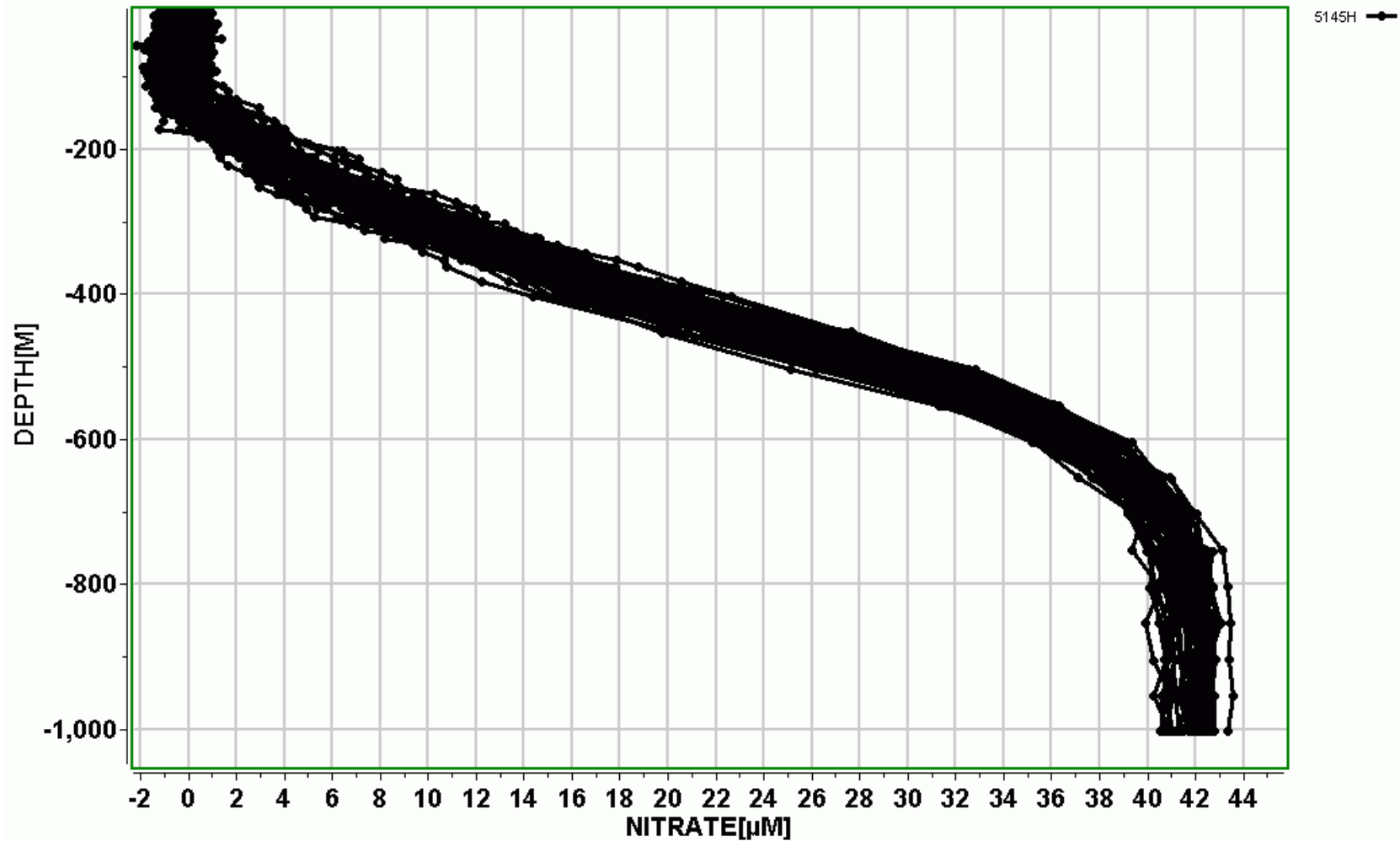


- 4 Apex/ISUS floats deployed, all operating
  - >3 years accumulated operating time
- 1 in transit for June deployment at BATS
- 35+ funded – will create arrays at time series stns.

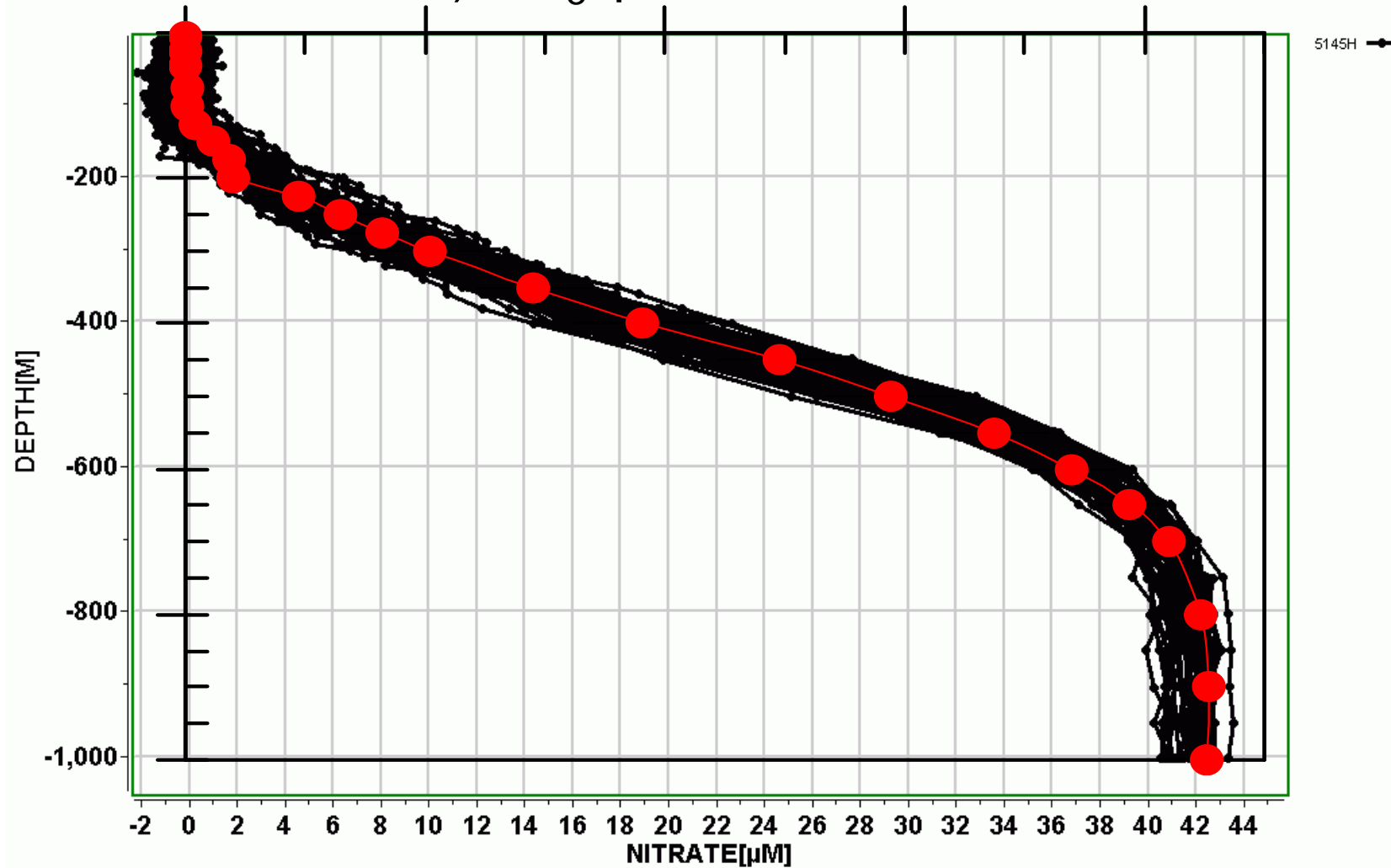


MBARI, Univ. of Washington, Webb Research, Satlantic

Float 5145 near Hawaii Ocean Time-series (HOT).  
Now 480 days since deployment in Dec. 2007.



Red dots are HOT mean (last 2 years of available data)  $\text{NO}_3^-$  profile.

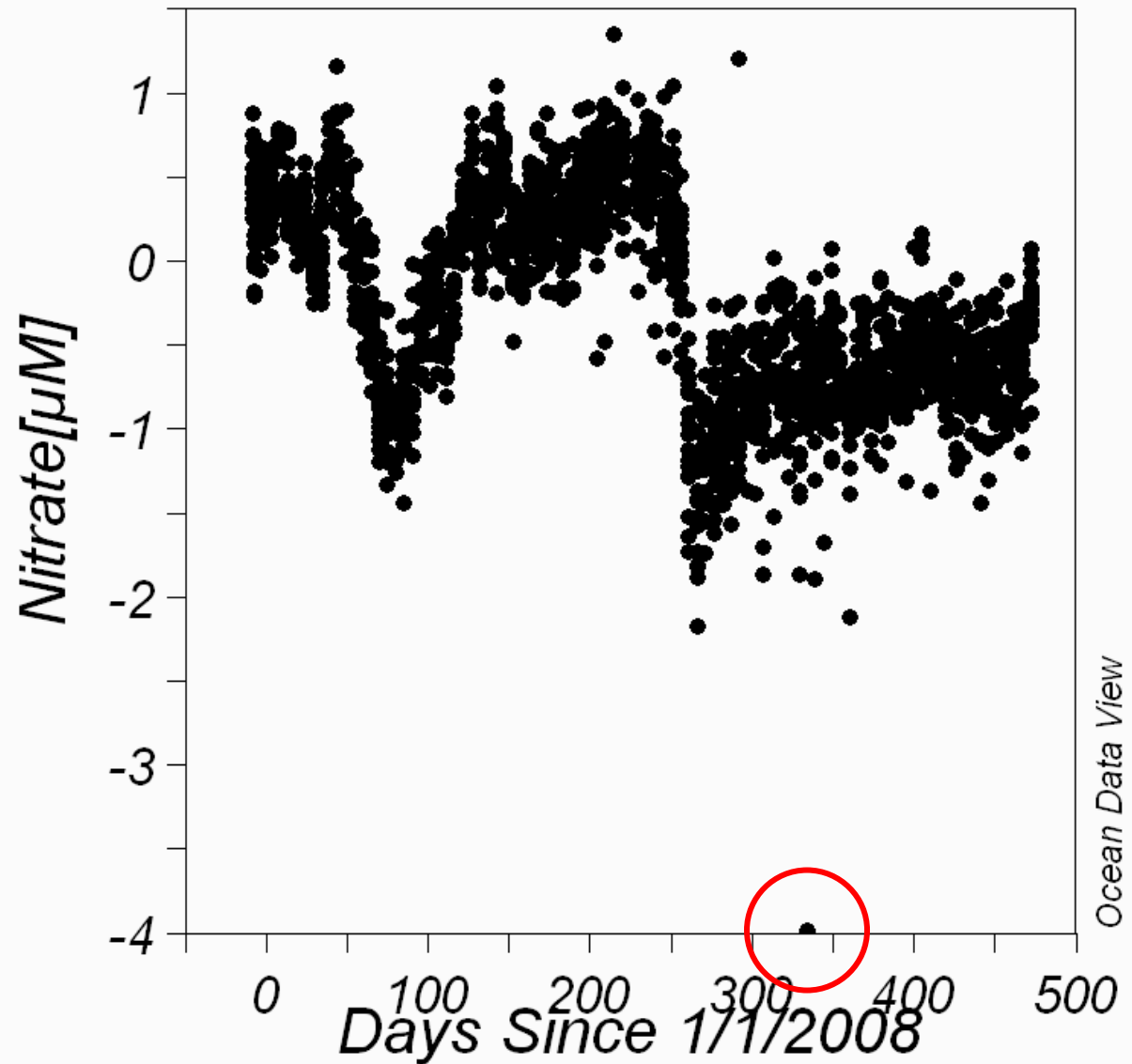


All HOT float  $\text{NO}_3^-$  values at 0 to 100 m over 480 days. As transmitted by float

$-0.2 \pm 0.6 \mu\text{M}$  (1 SD,  $N=1862$ )

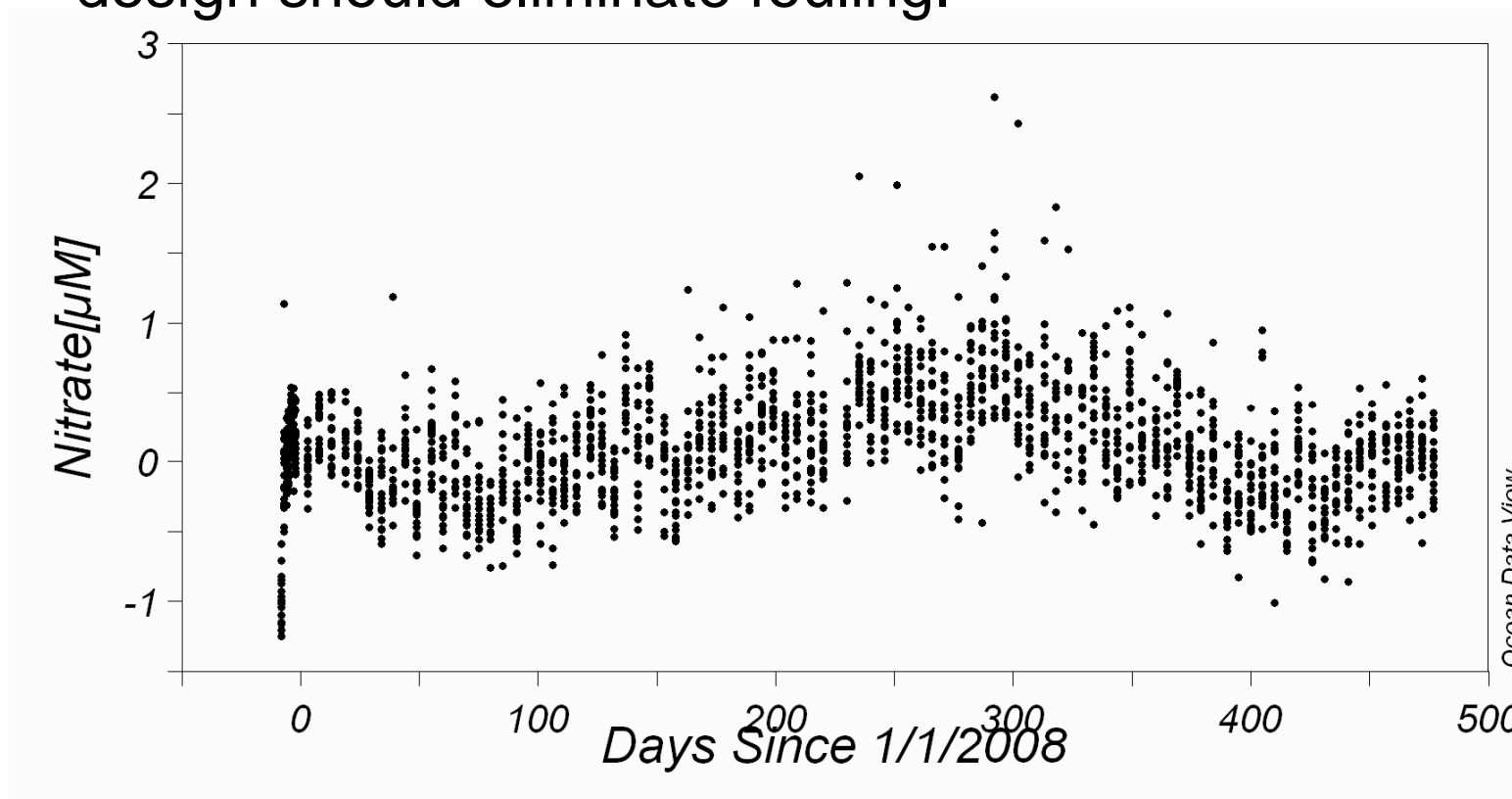
Clearly not random – intermittent fouling.

This is the WORST case so far for stability.



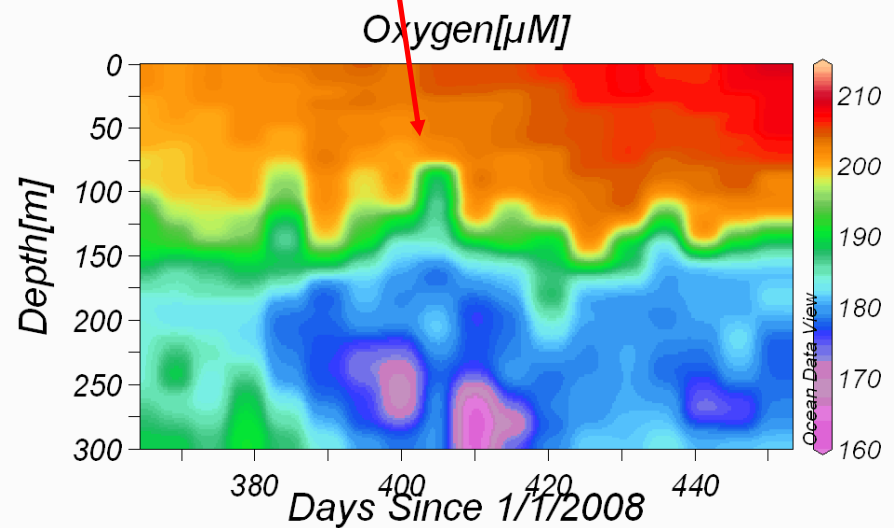
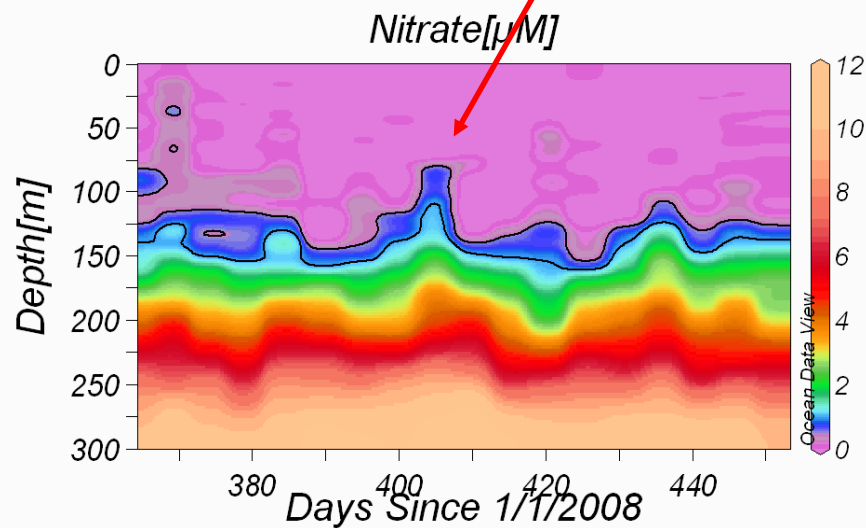
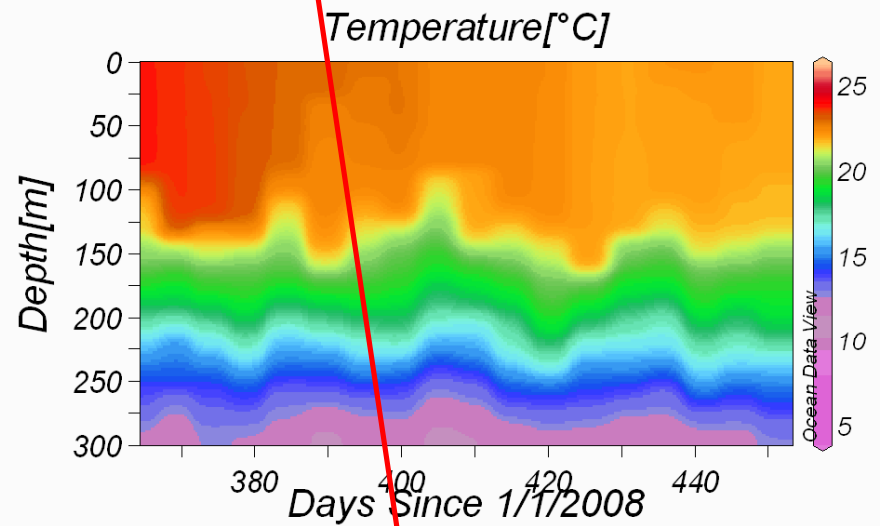
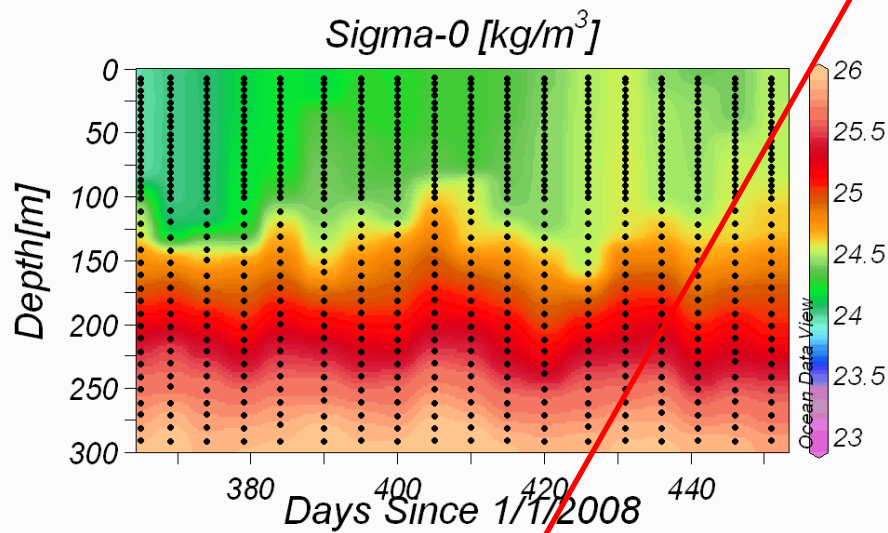
Because all data transmitted, revised algorithm development possible - HOT data with improved calculation.

mean  $\pm$  1 SD =  $0.11 \pm 0.4 \mu\text{M}$ . Pretty good, but 2X improvement theoretically possible. New Apex/ISUS design should eliminate fouling.

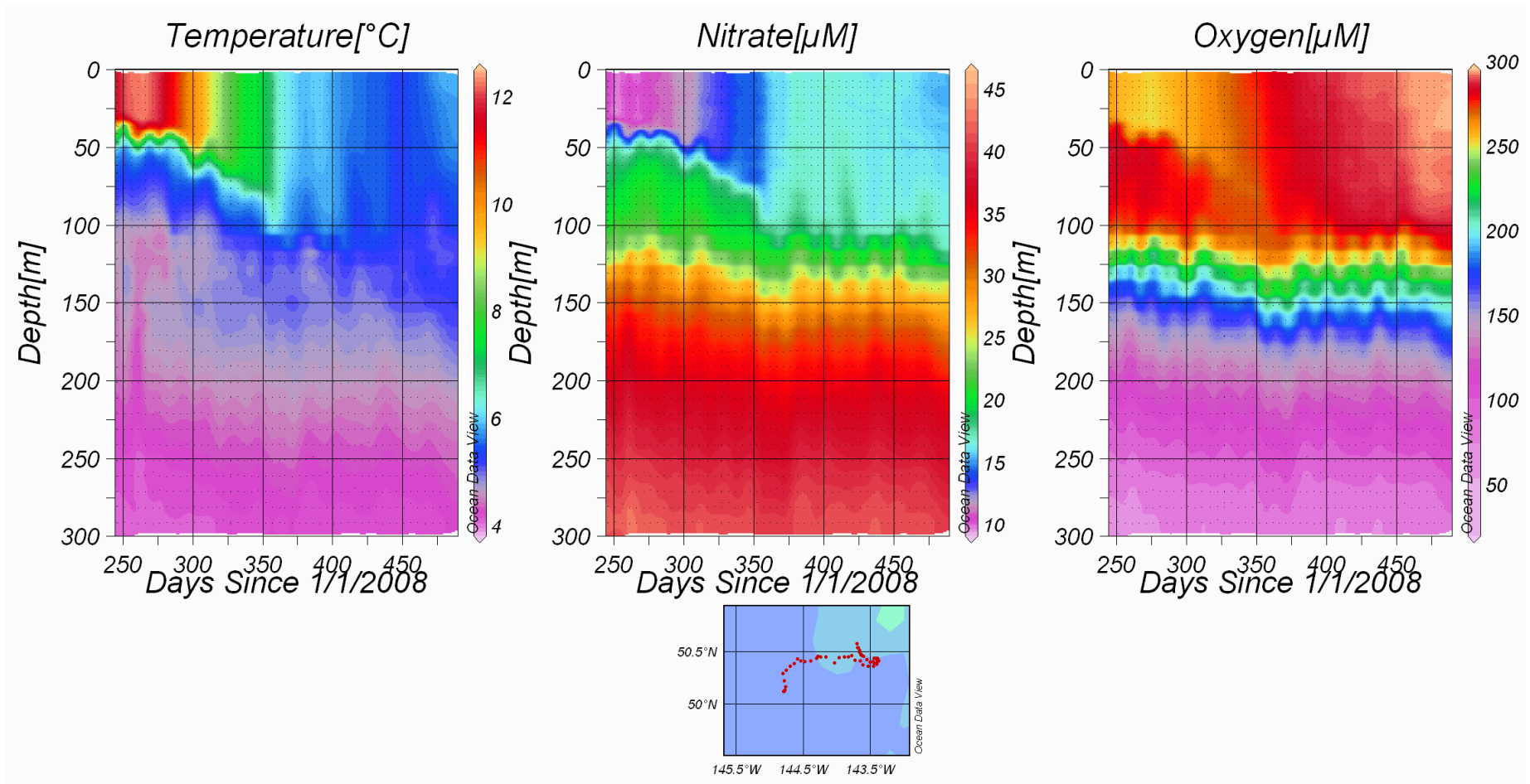




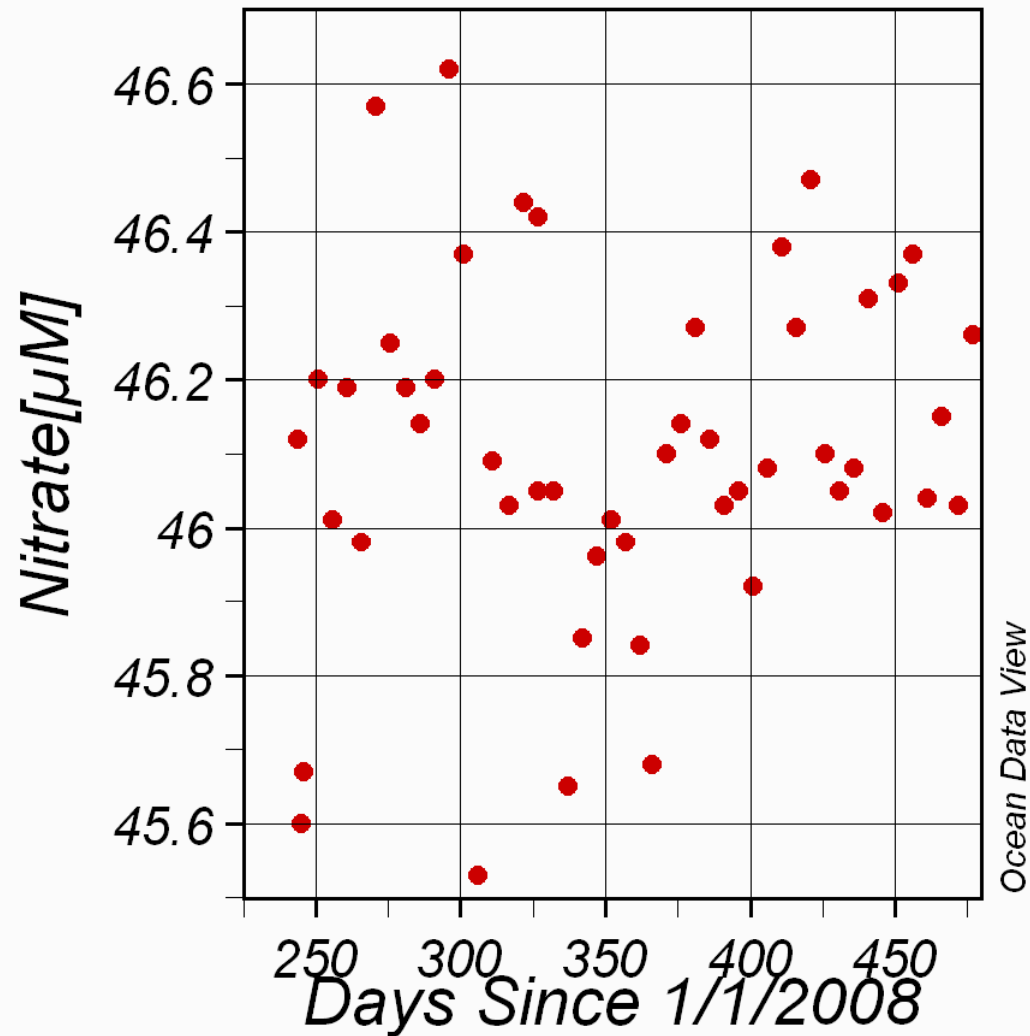
Upper 100 m has nitrate  $< 0.05 \mu\text{M}$  most (all?) of the time.  
Contour line at  $0.5$  &  $1 \mu\text{M NO}_3^-$ . Is  $\text{NO}_3^-$  at  $75 \text{ m}$  real?  
Contemporaneous with  $\text{O}_2$ ,  $T$ ,  $\sigma$ . Likely real.



# Float 5143 at Ocean Station PAPA

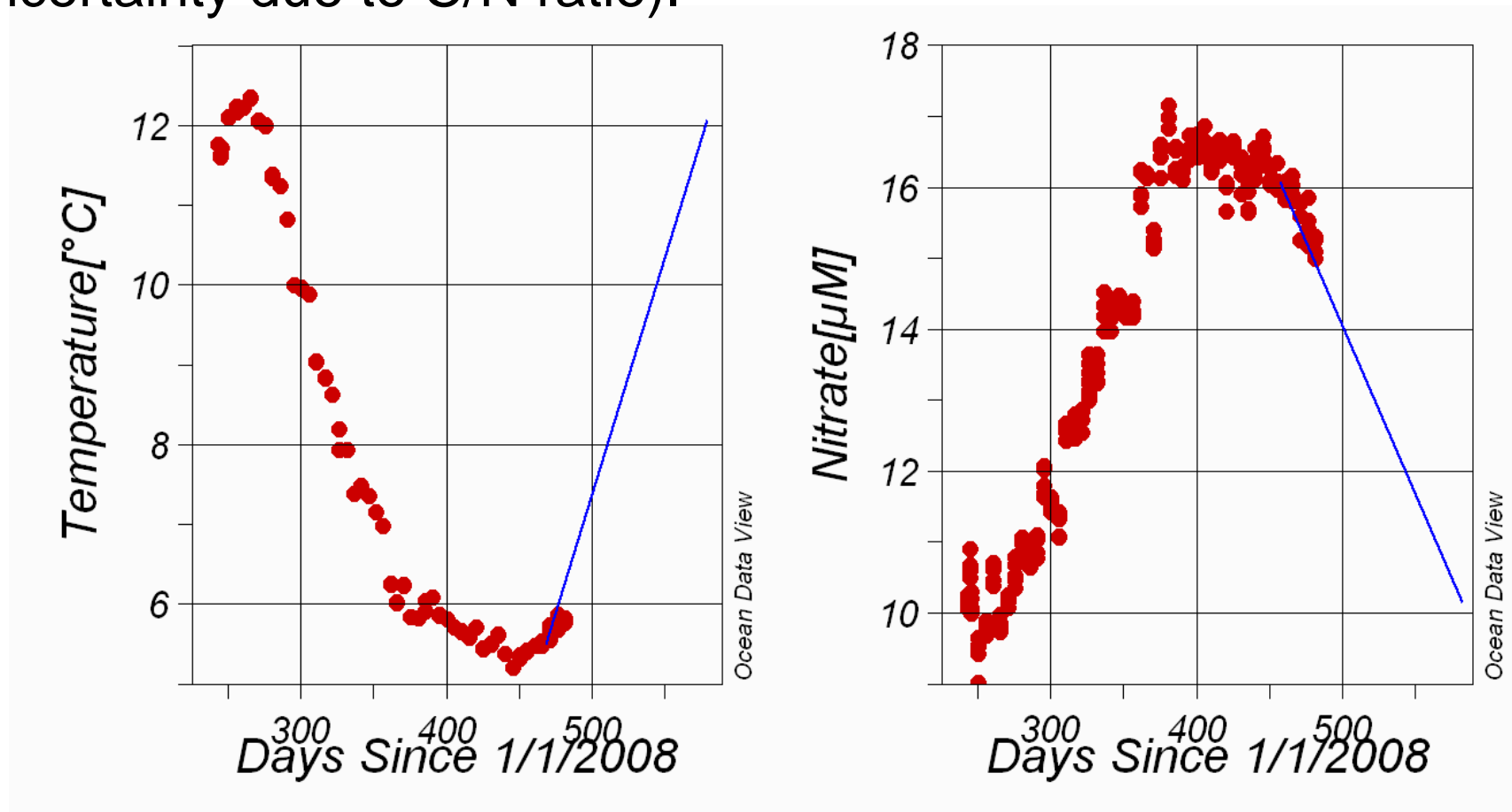


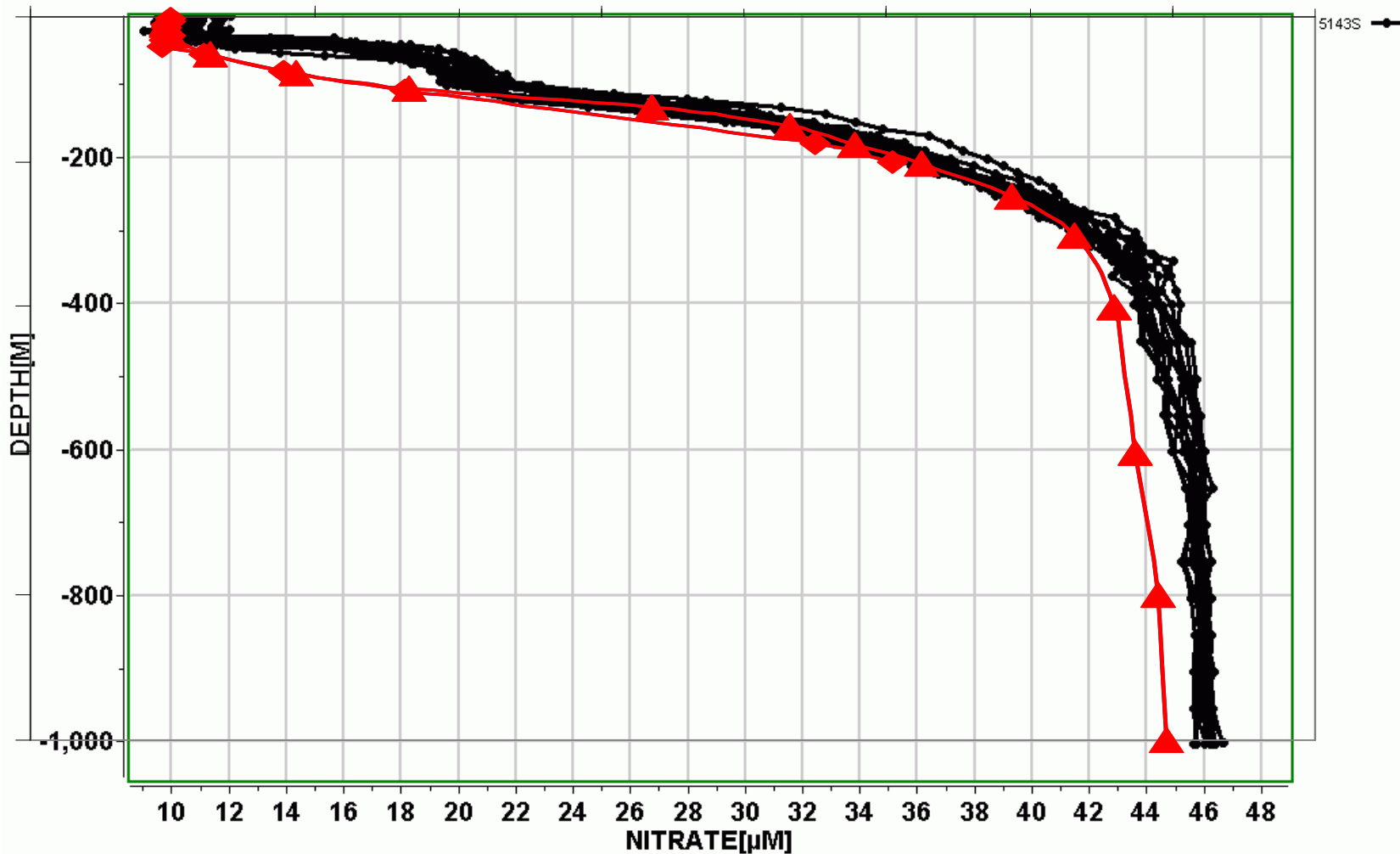
Stn PAPA  $\text{NO}_3^- = 46.1 \pm 0.2 \mu\text{M}$  at 1000 m. No adjustments. About the best one can expect. Detection limit 2 or 3 X 1 SD = 0.4 to 0.6  $\mu\text{M}$ .



Stn PAPA Temp. and  $\text{NO}_3^-$  in upper 30 m. Spring bloom, as evidenced by  $\text{NO}_3^-$  draw down, just starting.

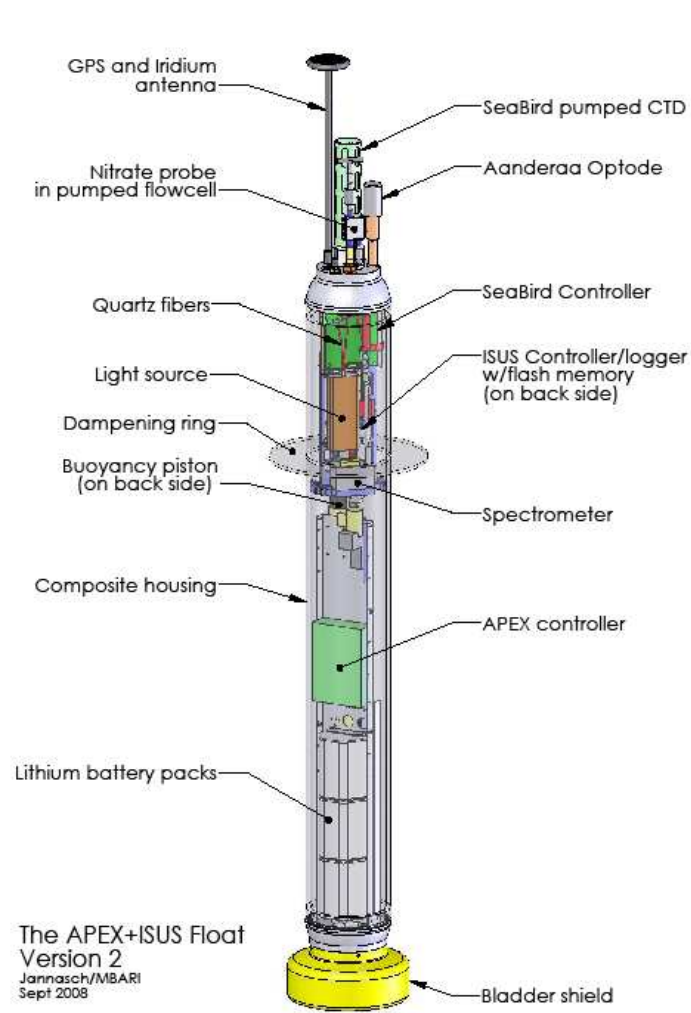
Data merged with a model would be a super tracer of primary production – no uncertainty due to gas exchange (but uncertainty due to C/N ratio).



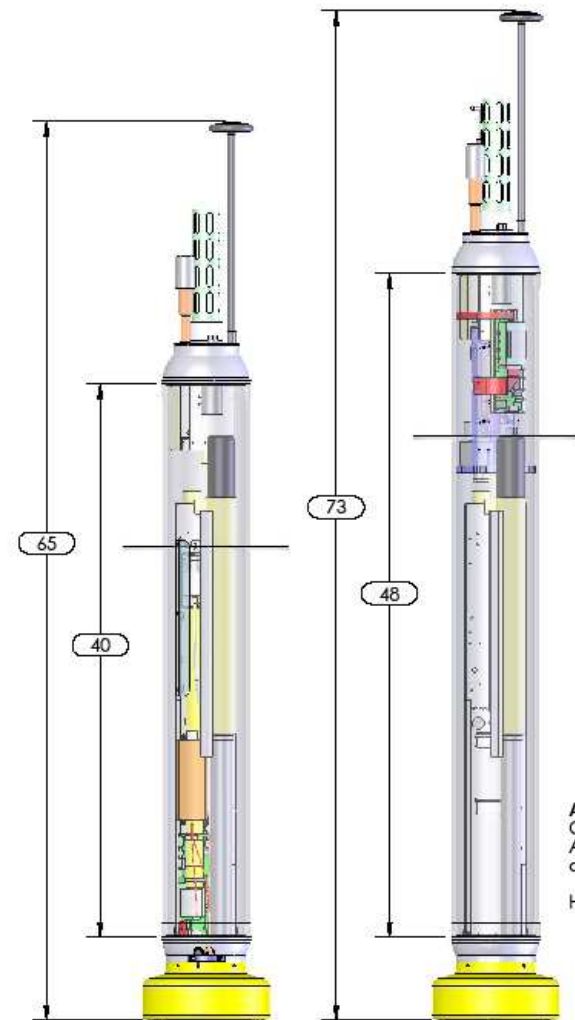


Ocean Station Papa. Compared to most recent profiles from OSP web site, we're too high by  $\sim 1 \mu\text{M}$  over whole profile. Good precision, accuracy can still be improved.

Apex/ISUS version 2. Extended pressure hull by 8" (Float #6 and on) to make ISUS easier to install. Now hangs under upper end cap as integrated unit. Moves UV optics into CTD pumped stream at top of float.



The APEX+ISUS Float Version 2  
 Jannasch/MBARI  
 Sept 2008



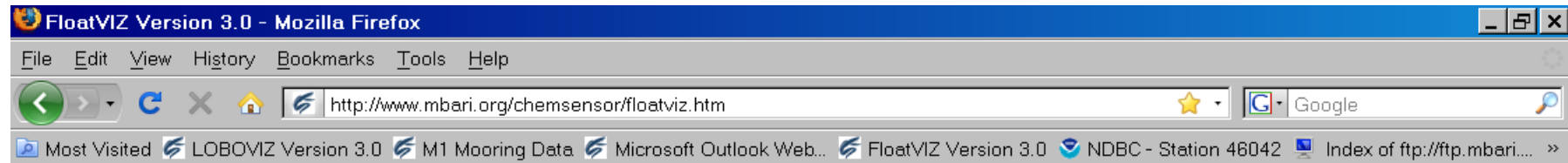
APEX+ISUS Version 2  
 Concept for integrating APEX with ISUS mounted on the top endcap  
 Hans Jannasch 9/24/08

We will also be testing new Satlantic SUNA (Submersible UV Nitrate Analyzer) as external nitrate sensor option on ~6 floats. Will incorporate latest MBARI algorithm.



NOPP funding with Satlantic and Webb Research to make ISUS or SUNA (or both) a standard sensor option on profiling floats.

Committed to real time data distribution. Plots and numeric data available in real time at [www.mbari.org/chemsensor/floatviz.htm](http://www.mbari.org/chemsensor/floatviz.htm)



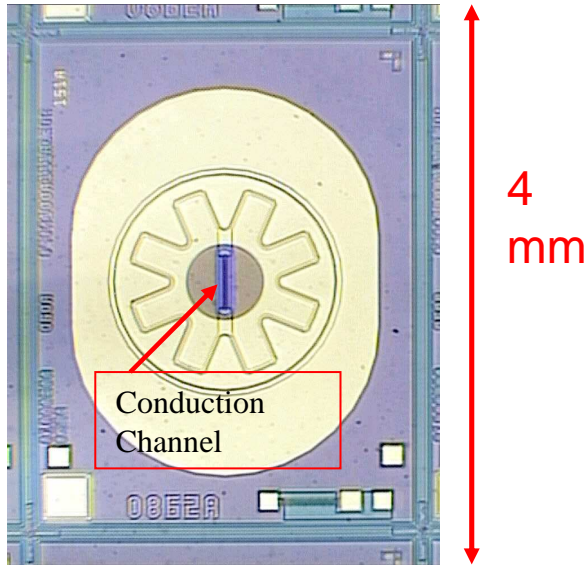
## FloatViz 3.0 - Apex/ISUS Data Visualization

### An ISUS nitrate sensor in a Webb Research Apex profiling float

[Quick Instructions](#)
[Float list and link to complete Ascii data files](#)
[Apex/ISUS description page](#)

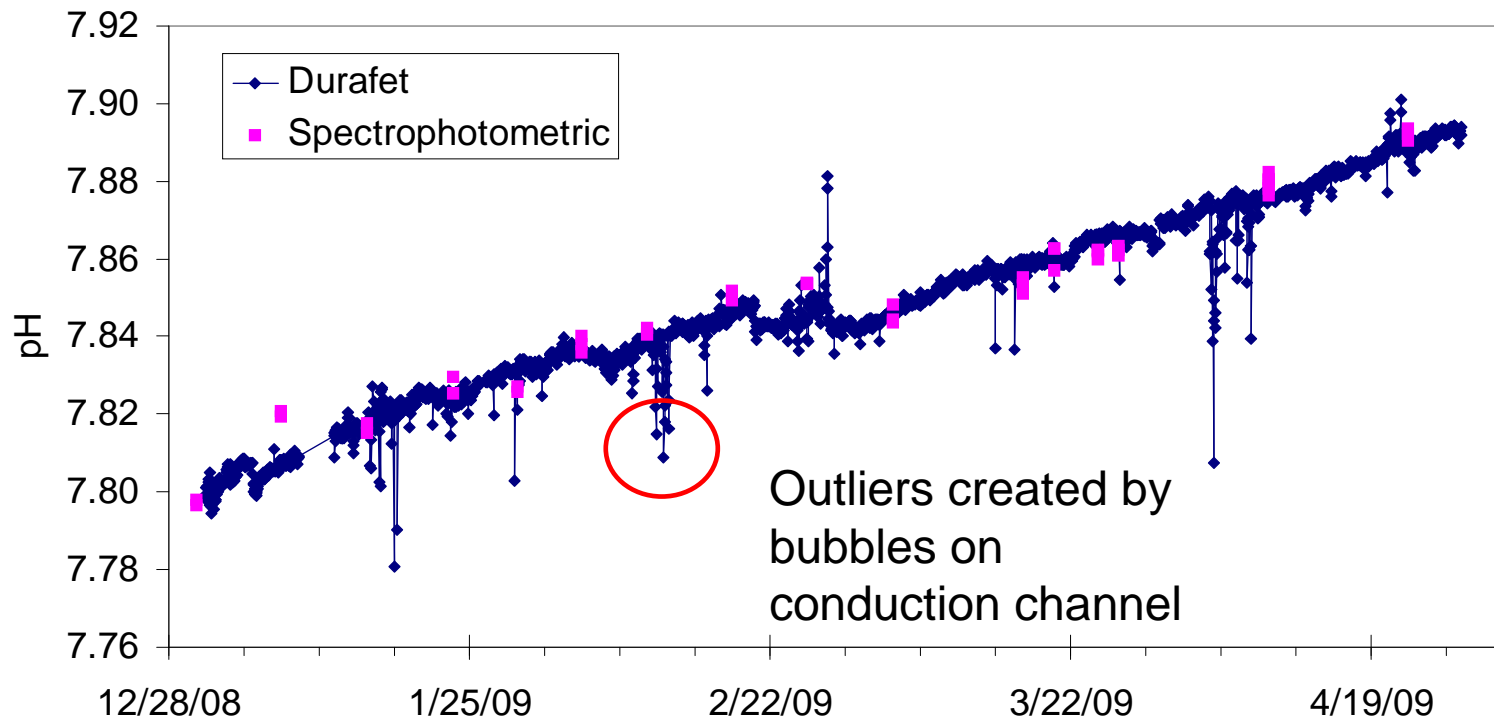
|  | Select Float(s)  | Select one X variable   | Select Y variable(s)   |   |
|--|--|---|--|---|
| How many graphs?<br><input type="button" value="One"/> <input type="button" value="Two"/> <input type="button" value="Three"/>   | Graph 1<br>5145MtyBay<br><b>5145Hawaii</b><br>5146SoOcn<br>5143StnP<br>5426DrakePass | Nitrate[ $\mu$ M]<br>Depth[m]<br>Salinity<br>Temperature[ $^{\circ}$ C]<br>DensityAnomaly<br>Oxygen[ $\mu$ M] | Nitrate[ $\mu$ M]<br><b>Depth[m]</b><br>Salinity<br>Temperature[ $^{\circ}$ C]<br>DensityAnomaly<br>Oxygen[ $\mu$ M] | <input checked="" type="checkbox"/> On<br><input type="checkbox"/> Off<br>Autoscale X & Y axis:   |
| Data Quality:<br><input type="button" value="All Data"/><br><input checked="" type="button" value="Good and Quest"/><br><input type="button" value="Good Only"/>   | Graph 2<br>5145MtyBay<br><b>5145Hawaii</b><br>5146SoOcn<br>5143StnP<br>5426DrakePass | Nitrate[ $\mu$ M]<br>Depth[m]<br>Salinity<br>Temperature[ $^{\circ}$ C]<br>DensityAnomaly<br>Oxygen[ $\mu$ M] | Nitrate[ $\mu$ M]<br><b>Depth[m]</b><br>Salinity<br>Temperature[ $^{\circ}$ C]<br>DensityAnomaly<br>Oxygen[ $\mu$ M] | Enter Ranges if Autoscale is Off (Min & max ranges default to 0 and 200 if Autoscale off and box is empty. Depth ranges are entered as negative values on Y axis and as positive values on X axis.)<br>X Min: <input type="text"/><br>X Max: <input type="text"/><br>Y Min: <input type="text"/><br>Y Max: <input type="text"/> |
| What dates?<br><input checked="" type="button" value="All Dates available"/><br><input type="button" value="Week Ending on End Date"/><br><input type="button" value="Month Ending on End Date"/><br><input type="button" value="Specify Start/End Date"/> | Graph 3<br>5145MtyBay<br><b>5145Hawaii</b><br>5146SoOcn<br>5143StnP<br>5426DrakePass | Nitrate[ $\mu$ M]<br>Depth[m]<br>Salinity<br>Temperature[ $^{\circ}$ C]<br>DensityAnomaly<br>Oxygen[ $\mu$ M] | Nitrate[ $\mu$ M]<br><b>Depth[m]</b><br>Salinity<br>Temperature[ $^{\circ}$ C]<br>DensityAnomaly<br>Oxygen[ $\mu$ M] | <input checked="" type="checkbox"/> On<br><input type="checkbox"/> Off<br>Y Stack: (In a single graph, multiple Y variables or multiple stations are stacked vertically if it is On)  |
| Change dates: (MM/DD/YYYY)<br>Start Date: <input type="text" value="09/17/2007"/><br>End Date: <input type="text" value="04/21/2009"/>   |  |   |  | Output Type:<br><input checked="" type="button" value="Plot"/> <input type="button" value="Text File"/> <input type="button" value="SEND"/>   |





## Honeywell Durafet Ion Sensitive Field Effect Transistor pH sensor – a potential float/glider sensor

- Long-term stability – months at  $\pm 0.006$  pH in seawater
- High temperature stability – weeks of cycling 5 to 35°C in equimolar buffers (pH=pK(T)) show  $>0.01$  pH stability
- Pressure tolerance is now limiting factor. Re-engineering packaging to be pressure tolerant – possible, but not easy.
- Low power ( $\mu$ Ws), low weight (grams), fast ( $<1$  s)



MBARI  
Seawater  
Test Tank –  
Std. dev. of  
difference  
from Spec.  
pH values is  
0.006 over  
3+ months  
(pH going up  
as tank  
outgases  
CO<sub>2</sub>)