pH sensors on profiling floats

1) Measurement
   Strength/Issues
2) Sensor performance
3) Calibration
4) QC (we don't know yet)

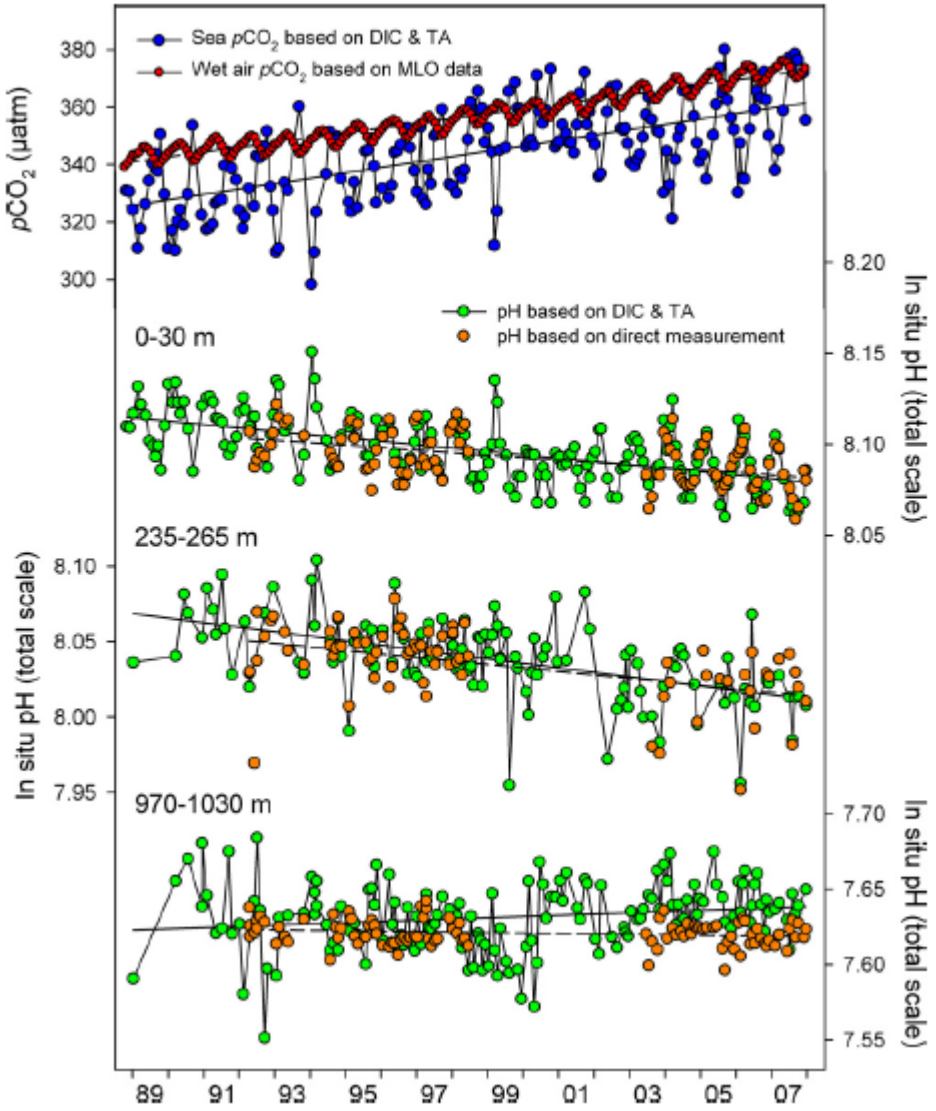
Ken Johnson, Hans Jannasch, Luke Coletti
Monterey Bay Aquarium Research Institute
Steve Riser, Univ. Wash.
Todd Martz, SIO
(Bob Carlson, Jim Connery, Honeywell, Inc.)

Physical and biogeochemical modulation of ocean acidification in the central North Pacific

John E. Dore[a,1], Roger Lukas[b], Daniel W. Sadler[b], Matthew J. Church[b], and David M. Karl[b,1]

Acidification signal = -0.0017 pH/year

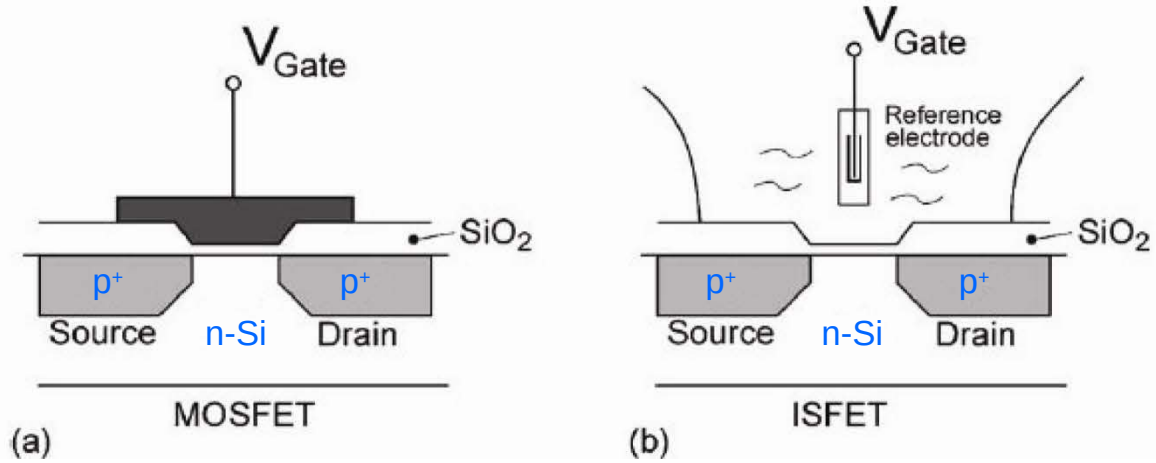
Production/Respiration signal = 0.04 pH/year



Ion Sensitive Field Effect Transistor pH sensor

- Surface potential on exposed FET channel is pH dependent
- Can be made to obey the Nernst equation

$$Si\text{-}O^- + H^+ \leftrightarrow Si\text{-}OH + H^+ \leftrightarrow Si\text{-}OH_2^+$$



ELSEVIER

Sensors and Actuators B 88 (2003) 1–20

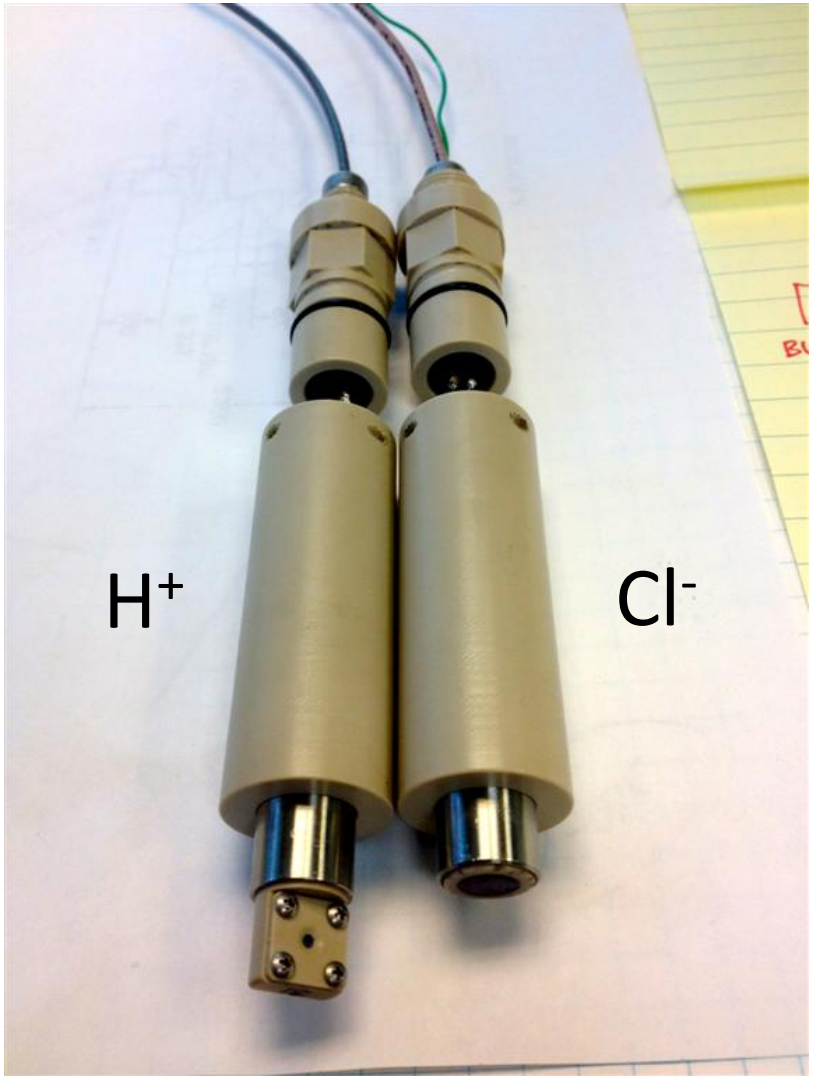
SENSORS AND ACTUATORS B CHEMICAL

www.elsevier.com/locate/sensorb

Thirty years of ISFETOLOGY
What happened in the past 30 years and what may happen in the next 30 years☆

P. Bergveld

Really two sensors, one for H^+, one for Cl^-, sensor response is proportional to (H^+) x (Cl^-)



$Vrs = k_0 + k_2 \times T + k_3 \times P + k_4 \times P^2 +$

$k_5 \times P^3 + k_6 \times P^4 + k_7 \times P \times T +$

Thermodynamic fn (T, S, P) +

$R \times T/F \ln ((H^+) \times (Cl^-))$ (Nernst Eqn.)

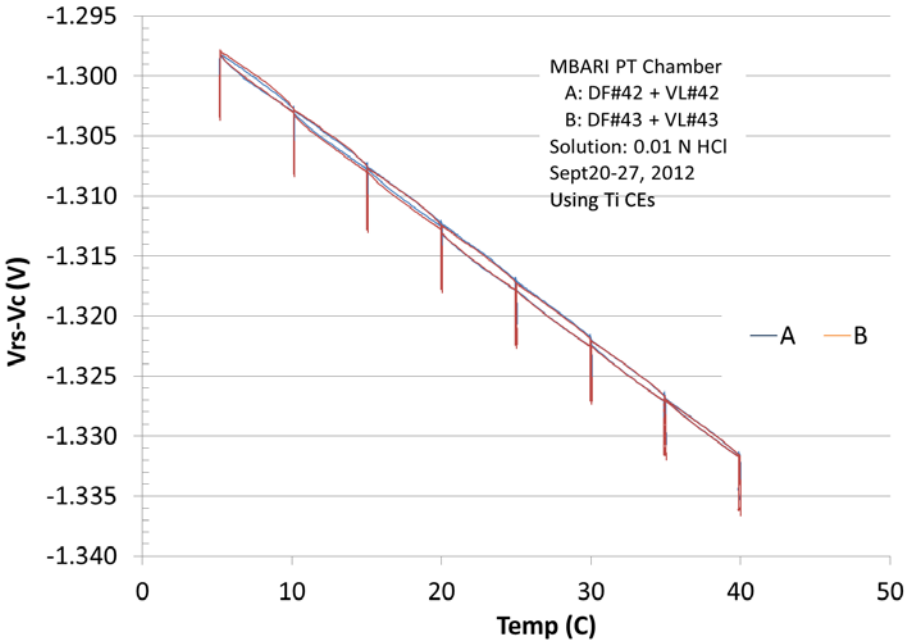
Weakness – Pressure response complicated (but stable). Next version should fix that.

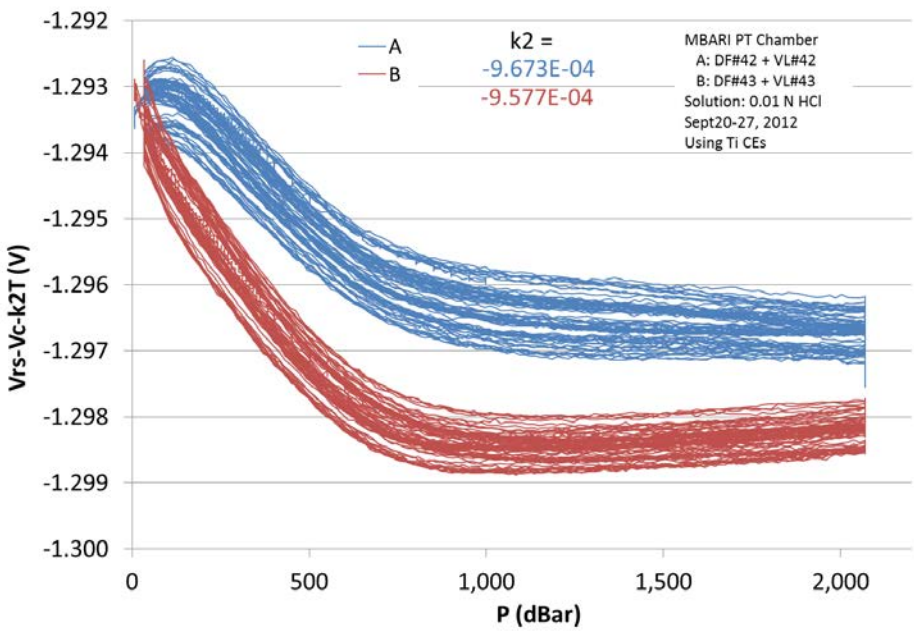
- The thermodynamics are not fully settled.
- Requires 18 bit A/D (minimum, 20 better)

Calibration

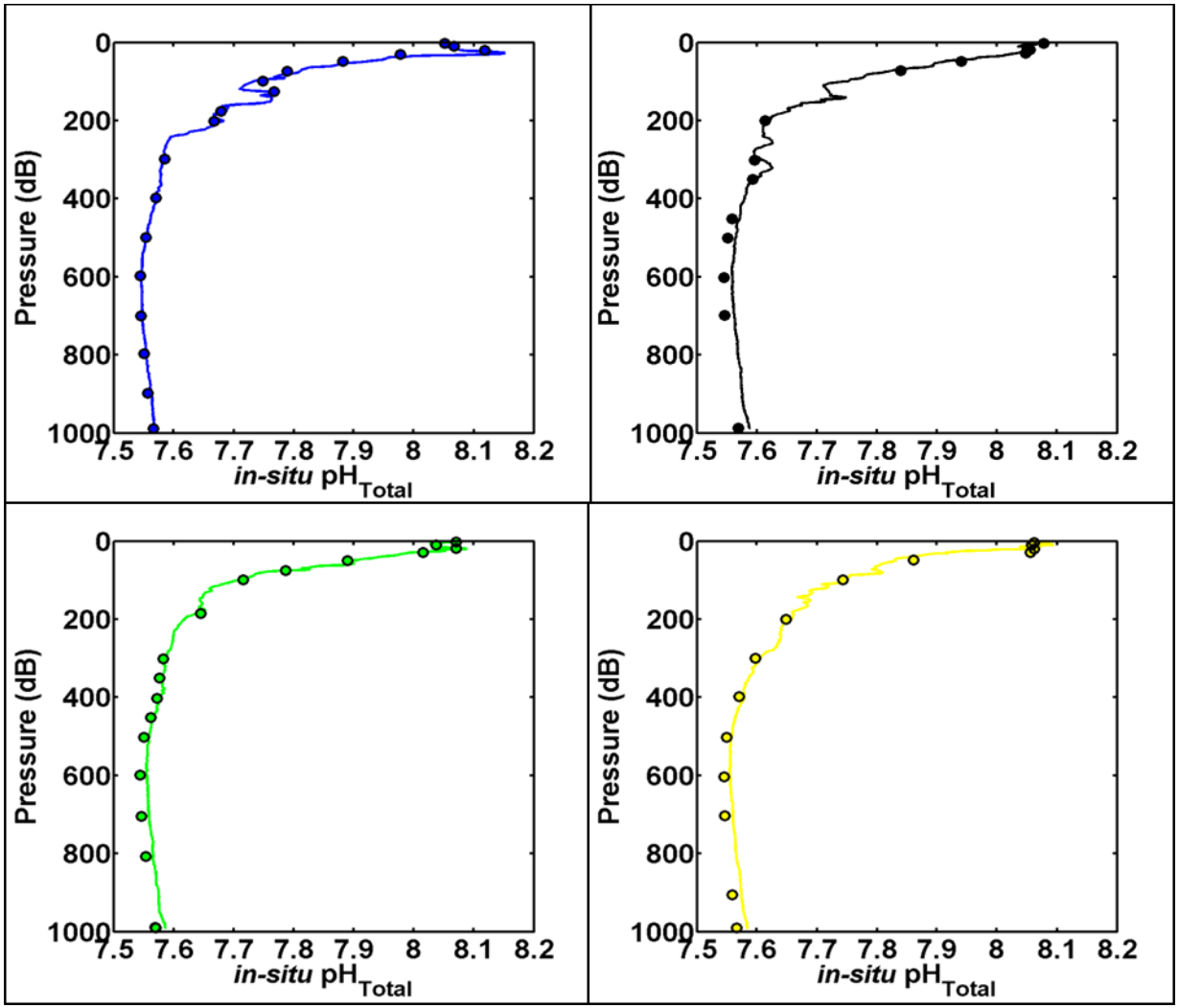
Strength – Sensor has a perfect Nernstian response. You can calibrate in HCl (hydrochloric acid) and get the right pH in seawater – linear over 8 orders of magnitude.

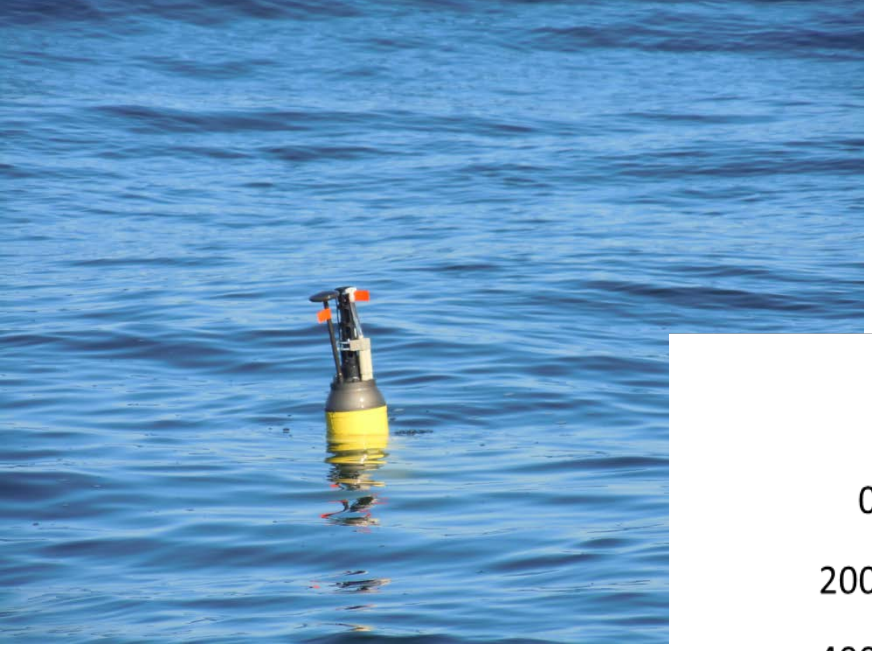
Weakness – each sensor has a different pressure response and must be calibrated at high P.



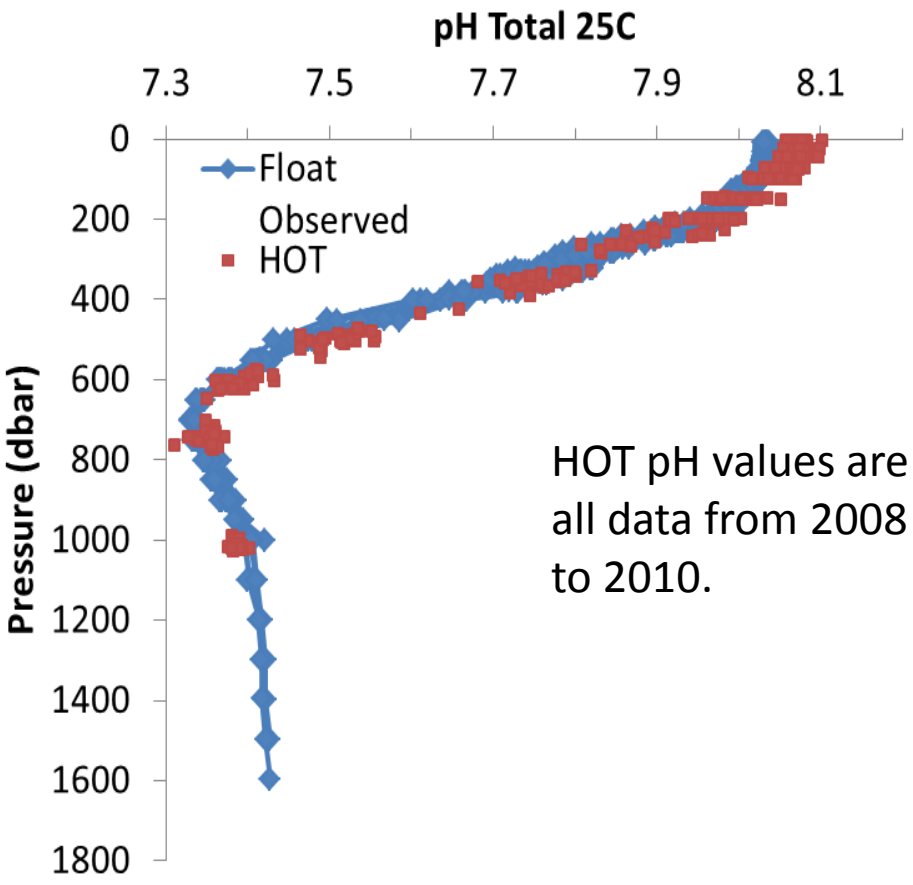


Sensor on a CTD Rosette vs. shipboard pH obs (which get corrected to in situ conditions, some uncertainty). Data collected by Todd Martz/Yui Takeshita, SIO





Deep-Sea Durafet pH sensor built at Honeywell & MBARI, tested by SIO, integrated to float by UW, deployed by HOT

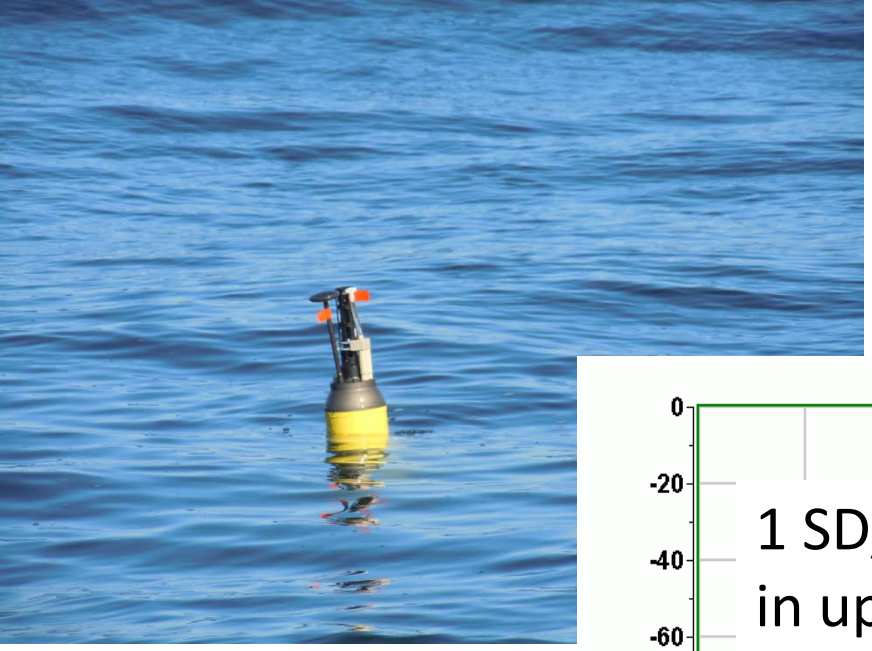


HOT pH values are all data from 2008 to 2010.

First pH float deployed at Hawaii Ocean Time-Series. Precision ~0.002 pH, accuracy ~0.02 (0.005 on Rosette)

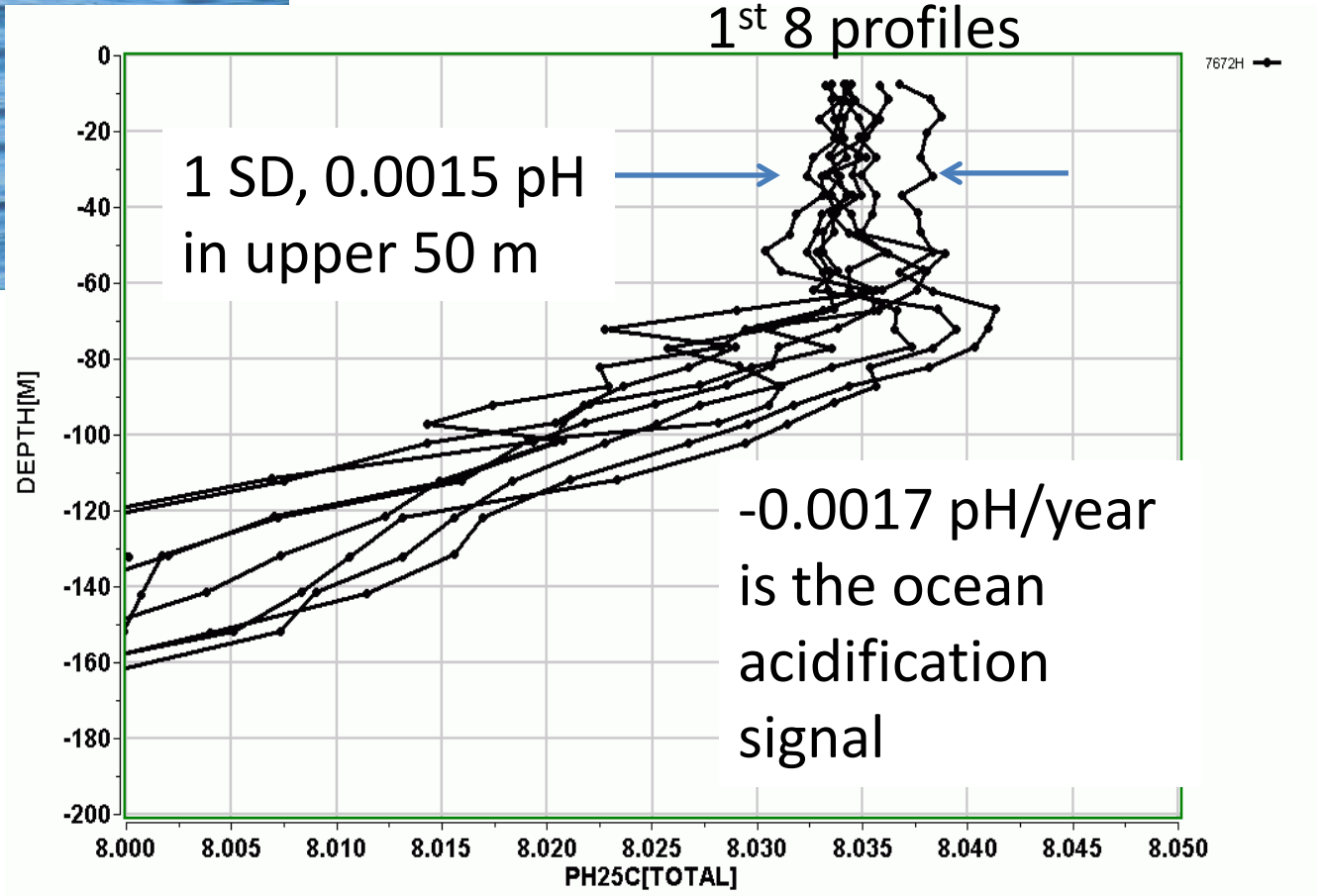
C|SOBOM

Funding from NOPP and Packard Foundation



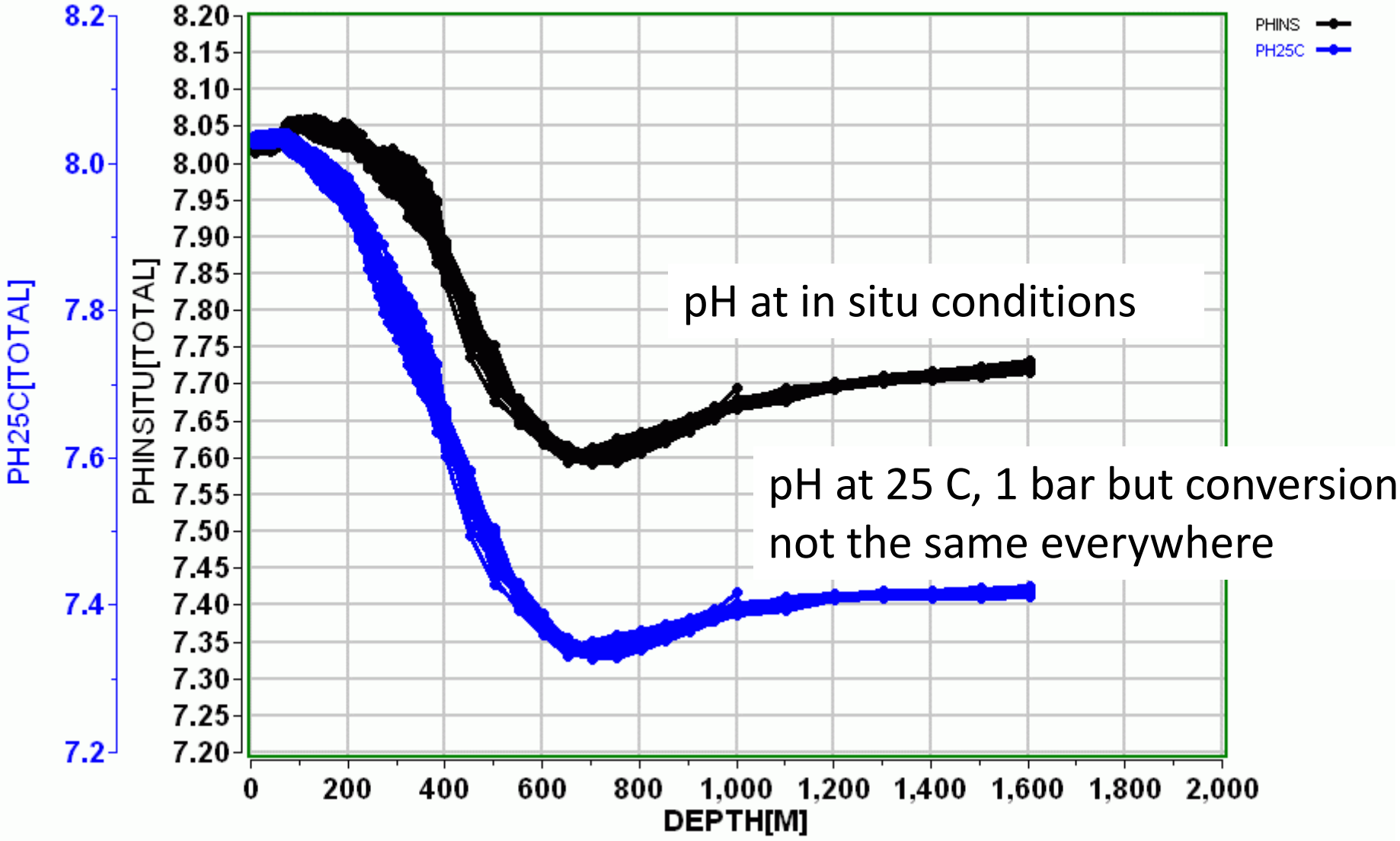
Deep-Sea Durafet pH sensor built at Honeywell & MBARI, tested by SIO, integrated to float by UW, deployed by HOT

First pH float deployed at Hawaii Ocean Time-Series. Precision ~0.002 pH, accuracy ~0.02 (0.005 on Rosette)



C|SOBOM

First 23 profiles from float 7672



At least 4 scales on which pH can be reported

Free $$pH_F = -\log([H^+]/m^0)$$

NBS $$pH = -\log(a_{H+}) = -\log(m_{H+}\gamma_{H+}/m^0)$$

Total $$pH_T = -\log(([H^+] + [HSO_4^-])/m^0)$$

Seawater $$pH_{SWS} = -\log(([H^+] + [HSO_4^-] + [HF])/m^0)$$

Marion, G.M., et al., pH of seawater, Mar. Chem. (2011), doi:10.1016/j.marchem.2011.04.002