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pH (and pCO_2) Sensor Refresh Status

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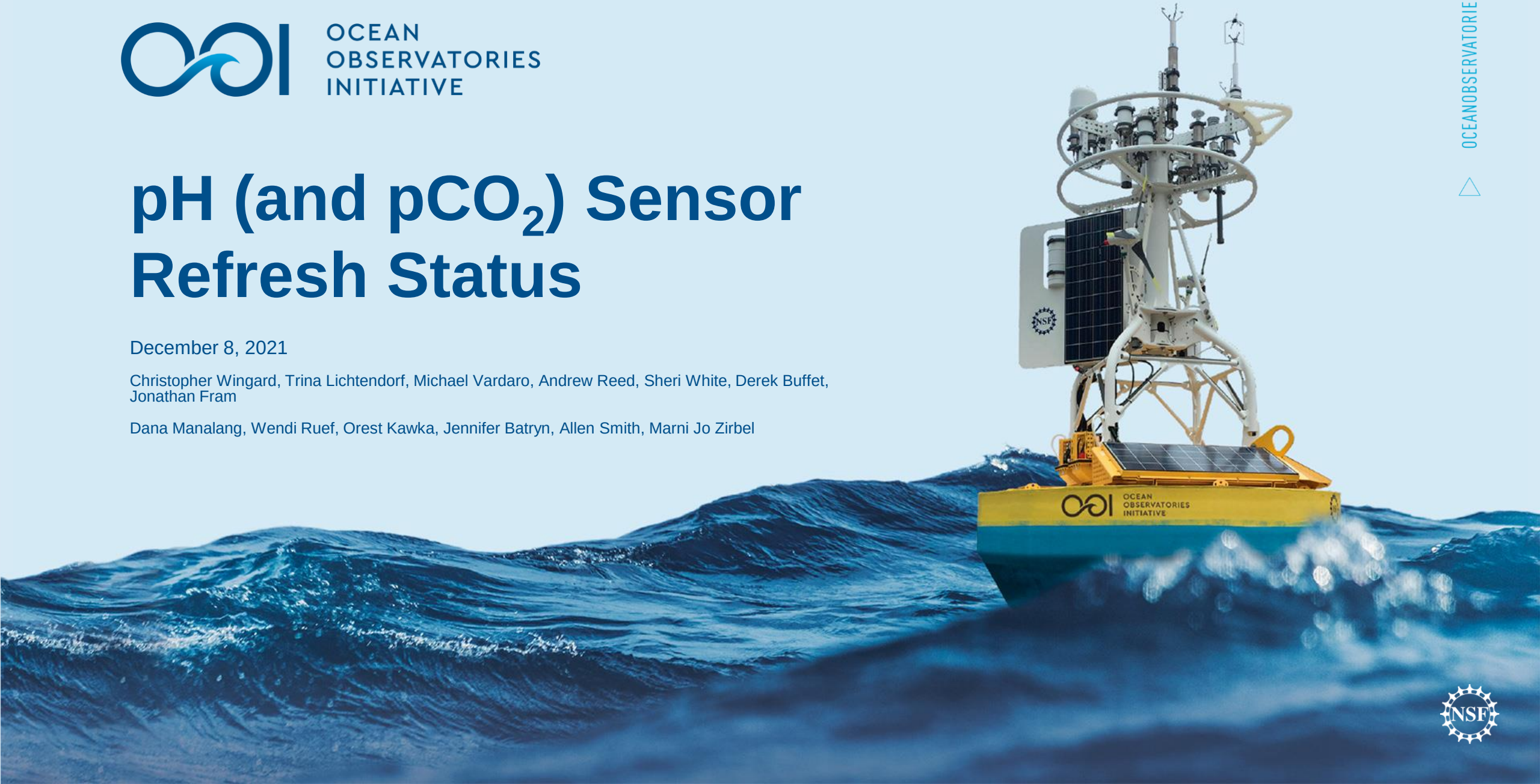

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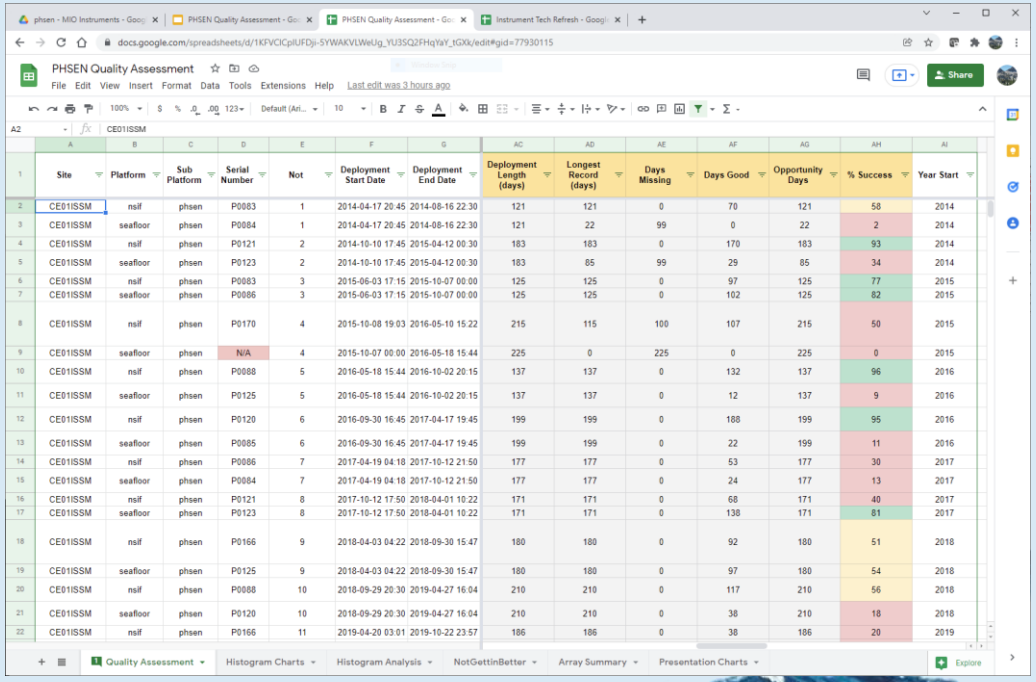
Background

- MIO Instrument Team compiled a list of common instruments, ranking based on data quality, reliability, ease of use, safety, vendor quality, obsolescence, and available alternatives (2017-2019)
- pH sensor (Sunburst Sensors SAMI-pH, PHSEN) was identified as an unreliable sensor. Primary issues were data quality and reliability/vendor quality (flooding, ground faults, battery performance, survivability)
- Rankings were based on experience of the MIO Instrument and Data Team members. Though based on expert opinions, the rankings were anecdotal to a degree
- Beginning in 2019, undertook an effort to develop quantifiable metrics of instrument performance
- Goal was to use the instrument data itself to grade performance (unbiased)
- Secondary goal was to develop a framework and workflow for future reviews

OOI 2.0 – Instrument Tech Refresh		Prioritization									
			1 = good, 2 = adequate, 3 = bad					1 = not anytime soon, 2 = next few years, 3 = now		1 = none, 2 = one, 3 = more than one	
Instrument Class	Model	Vendor	Data Quality	Relia-bility	Ease of Use	Safety	Vendor Quality	Obsolescence	Alternative from same vendor	COTS Alternatives	Alternative within OOI?	Sum
CAMDS		Kongsberg	2	3	3	2	3	3		2	No	18
PHSEN	SAMI-pH	Sunburst	2	2	3	3	3	1	No	3	No	17
PCO2W	SAMI-CO2	Sunburst	2	2	2	3	3	1	No	3	No	16
VEL3D-B	MAVS	Nobska Scientific	2	2	2	1	3	1	No	3	Yes	14
OPTAA	AC-S	WET Labs	2	3	3	1	2	1	No	1	No	13
DOFST	SBE43	Sea-Bird	2	2	2	1	1	1	Yes	3	No	12
ZPLSC/G	AZFP	ASL	2	2	1	1	2	1	No	2	Yes	11
WAVSS	Tri-Axys	Axys Technologies	1	1	2	1	1	3	No	2	No	11
PARAD	QSP	Biospherical	1	1	1	1	1	3	No	3	Yes	11
VEL3D	Aquadopp2	Nortek	2	1	1	1	1	2	Yes	3	Yes	11
VEL3D	Vector	Nortek	1	2	2	1	1	1	Yes	3	Yes	11
VELPT	Aquadopp	Nortek	1	2	2	1	1	1	No	3	No	11
PRESF	SBE26plus	Sea-Bird	1	1	1	1	1	3	No	3	No	11
ADCP	WorkHorse	Teledyne RDI	1	2	1	1	2	1	Yes	3	No	11
FDCHP	DCFS	WHOI	1	3	2	1	2	1	No	1	No	11



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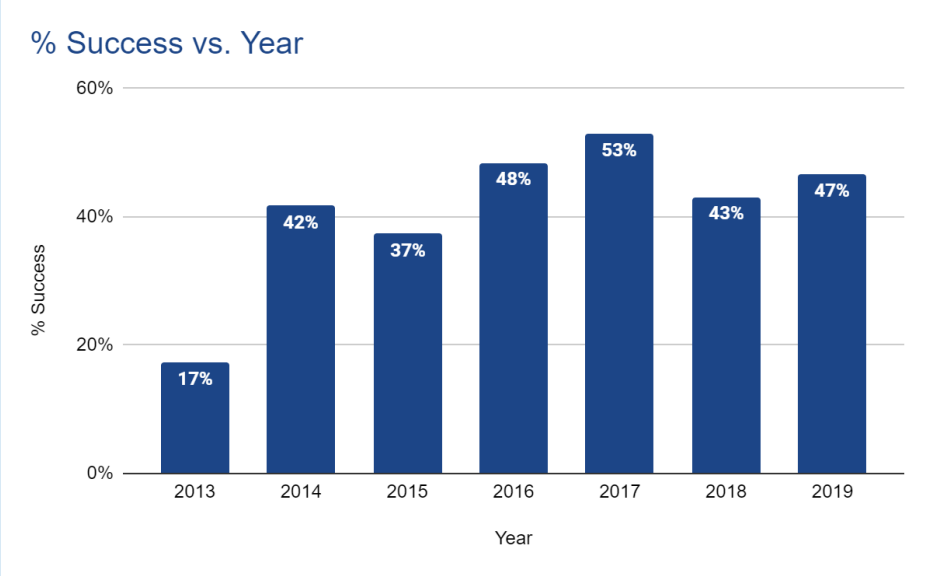
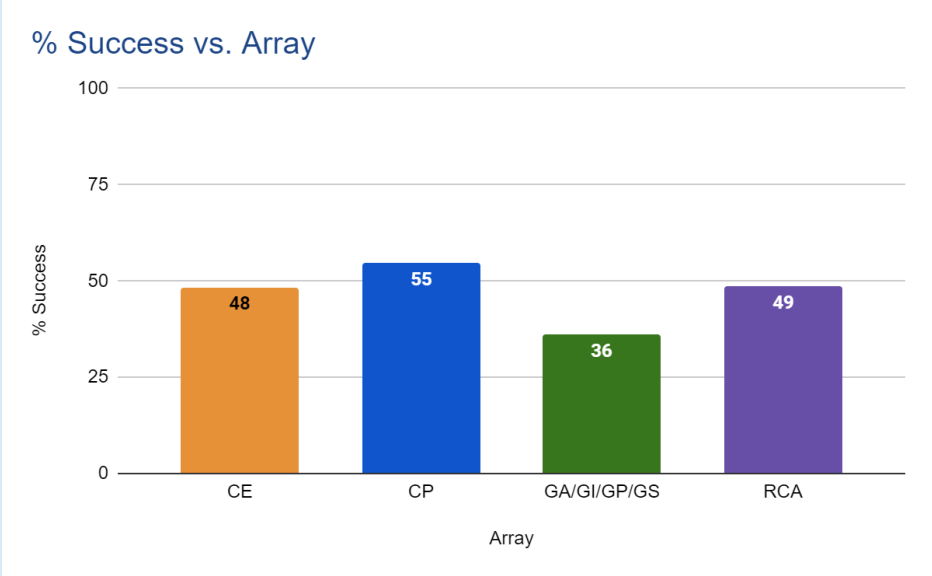
Initial Assessment

- Using data collected from deployments ending Fall 2019 (all arrays and data delivery methods, N = 254)
- % Success = Days of Good Data / Opportunity Days = 44%
  - Days of Good Data = % good data * days of longest record
    - % good data = vendor supplied automated tests of data quality (raw signal levels and computed pH)
  - Opportunity Days = days instrument could have operated given the opportunity (excludes days the data logger failed rather than the instrument). Usually, number of days in a deployment
- % Data Collected = Days of Collected Data / Opportunity Days = 71%
- See included PHSEN Quality Assessment slides for more detailed information





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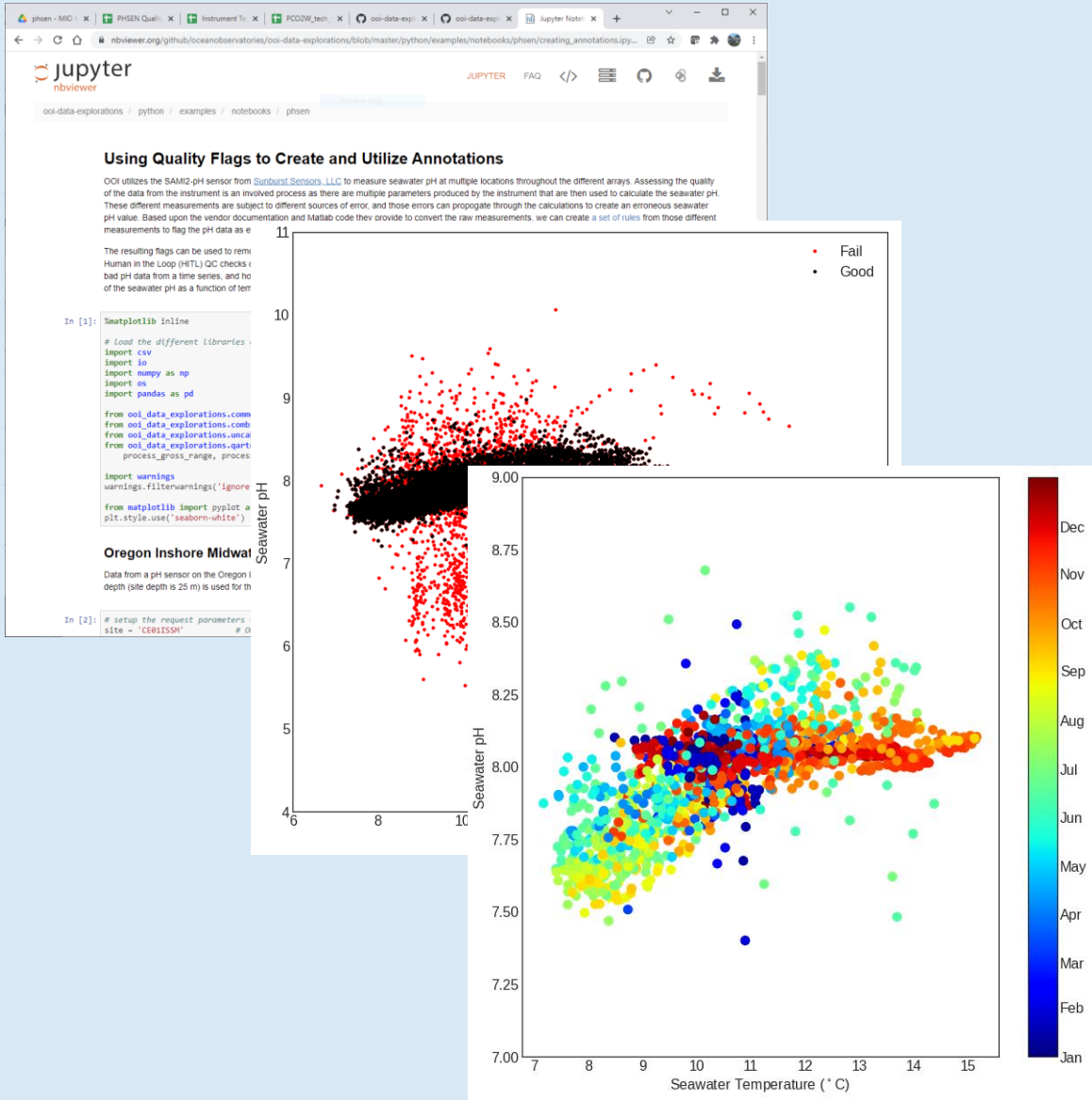
Lessons Learned

- Missing datasets identified and ingested.
- Process forced a deeper review of the vendor's Matlab code (especially their recently updated code versus older version from 2014 used by OOI).
- From that review, developed a more stream-lined set of Matlab functions to parse and process SAMI-pH data, and from there python code to automate creation of QARTOD-style quality flags of the pH data.
- Quality flags can be used to identify blocks of bad data and to create initial annotations for HITL reviews of the data.
- Those automated tests, in addition to existing annotations, have been incorporated into workflows used to generate the QARTOD Gross Range and Climatology test limits.
- Adapted structure of pH quality flags for the SAMI-pCO2 data.



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Progress and Path Forward

- COMPLETED TASKS
  - Prioritized instrumentation for tech refresh
  - Updated Common Instrument Specification (1336-00000)
  - Drafted Instrument Tech Refresh Process Document (1100-00007; approved September 2020)
  - Quality assessment of PHSEN data (N = 254)
  - Identified potential pH instrument vendors
  - Evaluate PHSEN requirements
  - Drafted RFI document
  - Issue RFI
  - Assess RFI responses
- NEXT STEPS
  - ***Analysis of Alternatives***
  - Generate recommendation plan (Q3)
  - *Issue RFQ*
  - *Generate ECR for implementation of procurement*
  - *Procure & Test*

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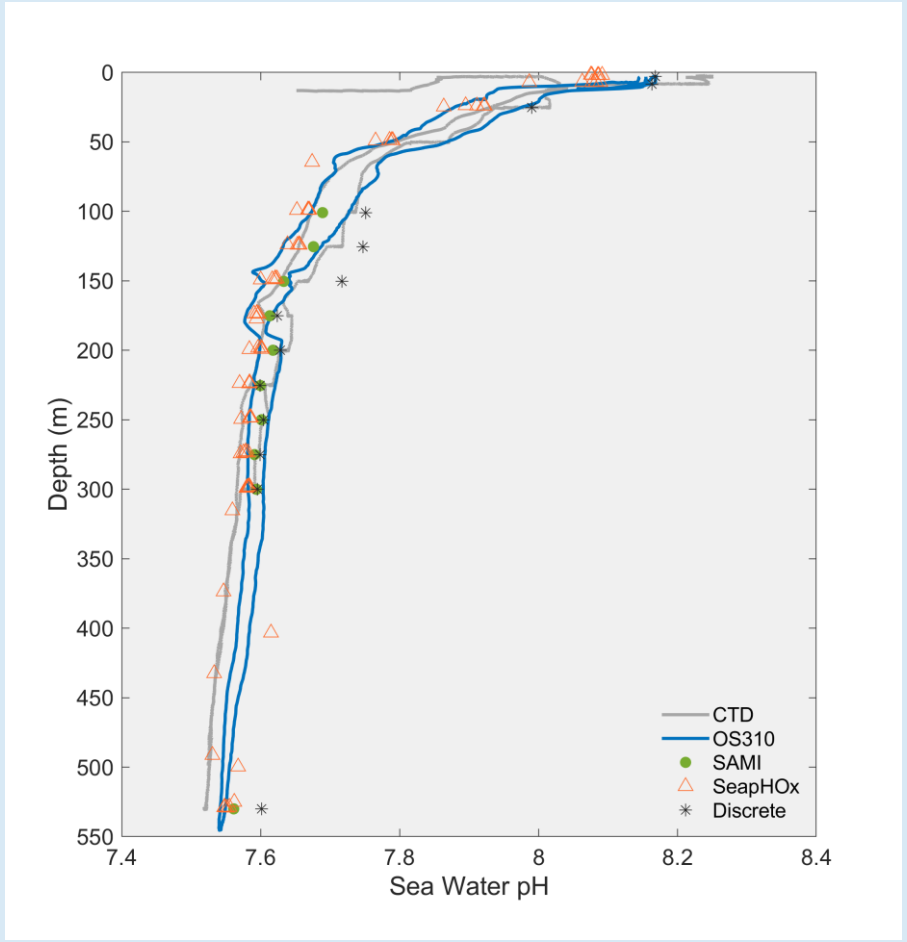
Analysis of Alternatives

- Benchtop testing of the sensors by RCA and EA staff
- Integration and burn-in testing by EA staff
- Side-by-side comparisons of the sensors:
  - The shipboard CTD rosette, with collection of water samples at multiple depths
  - Long term deployment (Fall 2021 to Spring 2022) on the midwater platform (7 m, NSIF) of the Oregon Shelf Surface Mooring (CE02SHSM); periodic water sampling
- *Results presented are necessarily brief. We are engaged in an active test. A formal review with a Recommendation Plan will need to be completed upon conclusion of the test (Q3)*

Vendor	Instrument	
Sunburst Sensors http://www.sunburstsensors.com/index.html	SAMI-pH Ocean pH Sensor	
Idronaut https://www.idronaut.it/	Ocean Seven 310 Multiparameter CTD (OS310)	
Sea-Bird Scientific https://www.seabird.com/	Deep SeapHOx V2 Ocean CT(D)-pH-DO Sensor	

Shipboard CTD Cast

- 2021-09-14, Cast #06 (Washington Offshore)
  - Ship's CTD included an SBE 27 pH/O.R.P (Redox) Sensor calibrated 2020-12-01.
  - OS310 configured to sample at 1 Hz (fastest rate possible). Sampling started immediately after powering on via magnetic switch. Down and upcast.
  - SAMI-pH configured to sample every 5 minutes (every 4 minutes is the fastest rate possible) with sampling delayed (timed to start when CTD was near the bottom of the cast). Upcast only.
  - SeapHOx configured to sample every minute (*fastest rate possible?*) with sampling delayed (timed to start when CTD was near the bottom of the cast). Upcast only.
  - Water samples collected during upcast at 530, 300, 275, 250, 225, 200, 175, 150, 125, 100, 50, 25, 7, and 2 m
  - Water sampling results posted to Alfresco 2021-11-10
- Issues and results
  - Vendor documentation was confusing and determining the correct settings to use was not straight-forward
  - Only able to complete 1 cast, rather than the 2 that were originally planned
  - Excellent agreement between all sensors and the discrete samples ***with a caveat!***



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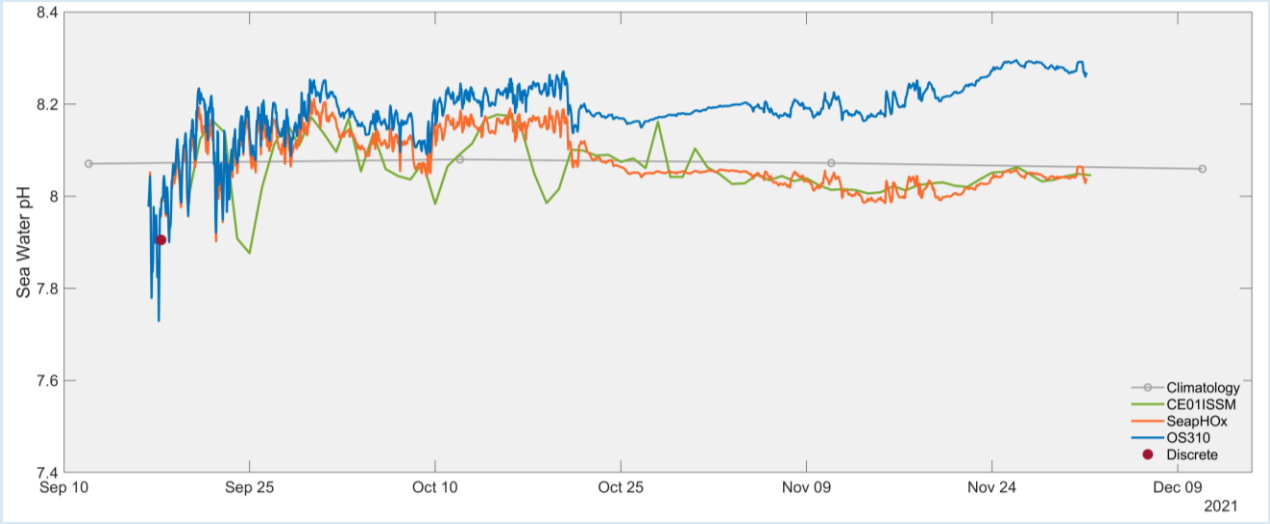
Long Term Deployment

- 2021-09-16 through 2022-04 (Oregon Shelf)
  - OS310 configured to collect 5 samples every 15 minutes
  - SAMI-pH configured to collect 1 sample every hour per OOI sampling plan (reagent limited)
  - SeapHOx configured to collect 1 sample every 15 minutes
  - Discrete samples collected at beginning of deployment with plans to collect more over the course of deployment (during glider and CSPP cruises, as weather allows)
  - Water sampling results posted to Alfresco 2021-11-10
- Issues and results to date
  - SAMI-pH fouled immediately after deployment. Data shown is from the Oregon Inshore Surface Mooring (CE01ISSM) midwater platform
  - OS310 was offset by +0.2455 from the SeapHOx (based on difference between the sensors averaged over the first 48 hours of the deployment). OS310 data shown has the offset subtracted. ***The same offset was applied to the CTD cast data (caveat)***
  - Noticeable linear drift (r^2 = 0.9688) in the OS310 data compared to the other instruments



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pCO_2 Sensor Refresh Status

- COMPLETED TASKS
  - Prioritized instrumentation for tech refresh
  - Updated Common Instrument Specification (1336-00000)
  - Drafted Instrument Tech Refresh Process Document (1100-00007; approved September 2020)
- NEXT STEPS
  - ***Quality assessment of PCO2W data (N = 182)***
  - Identified potential pCO_2 instrument vendors
  - Drafted RFI document
  - Evaluate PCO2W requirements
  - Issue RFI
  - Assess RFI responses
  - Analysis of Alternatives
  - Issue RFQ
  - Generate recommendation plan
  - Generate ECR for implementation of procurement
  - Procure & Test

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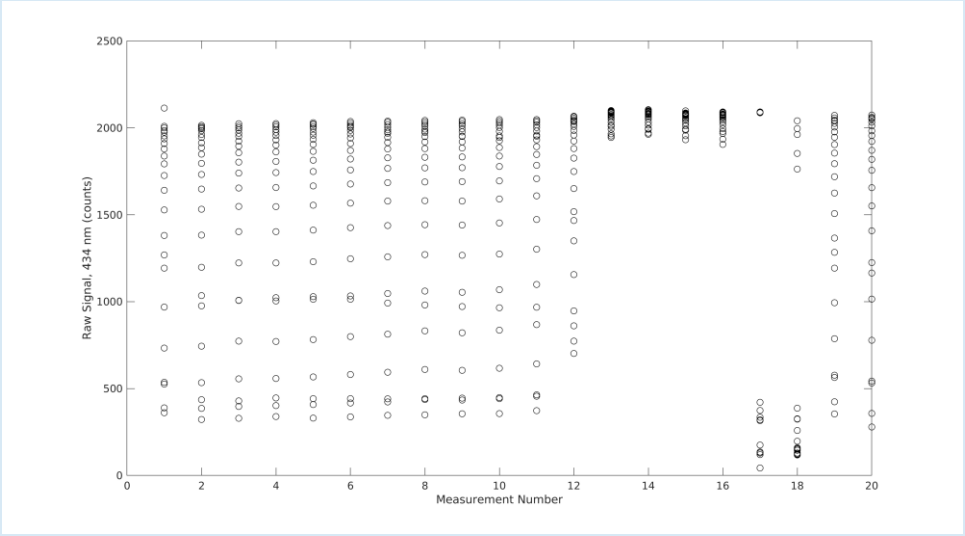
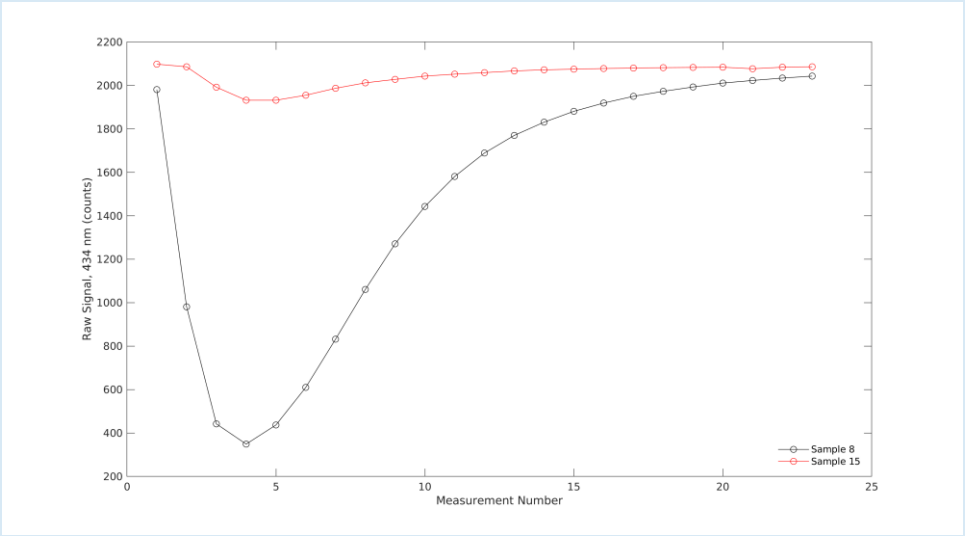
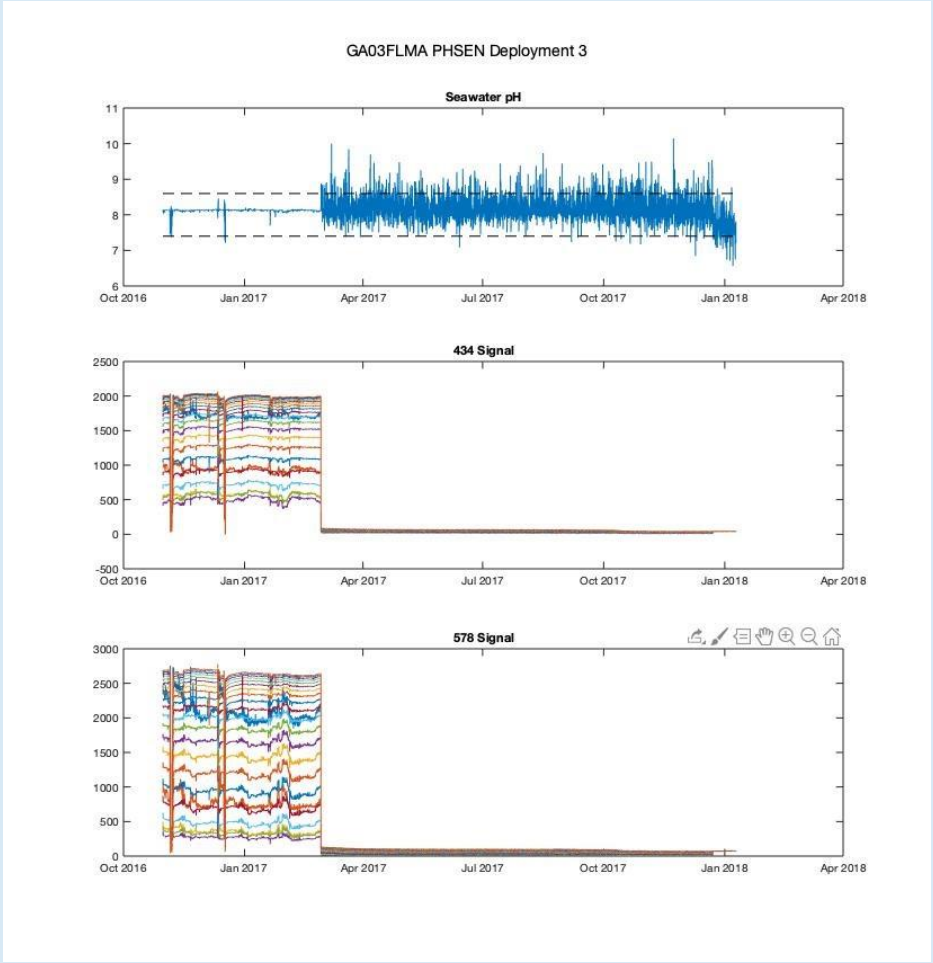
Assessing pH Data Quality







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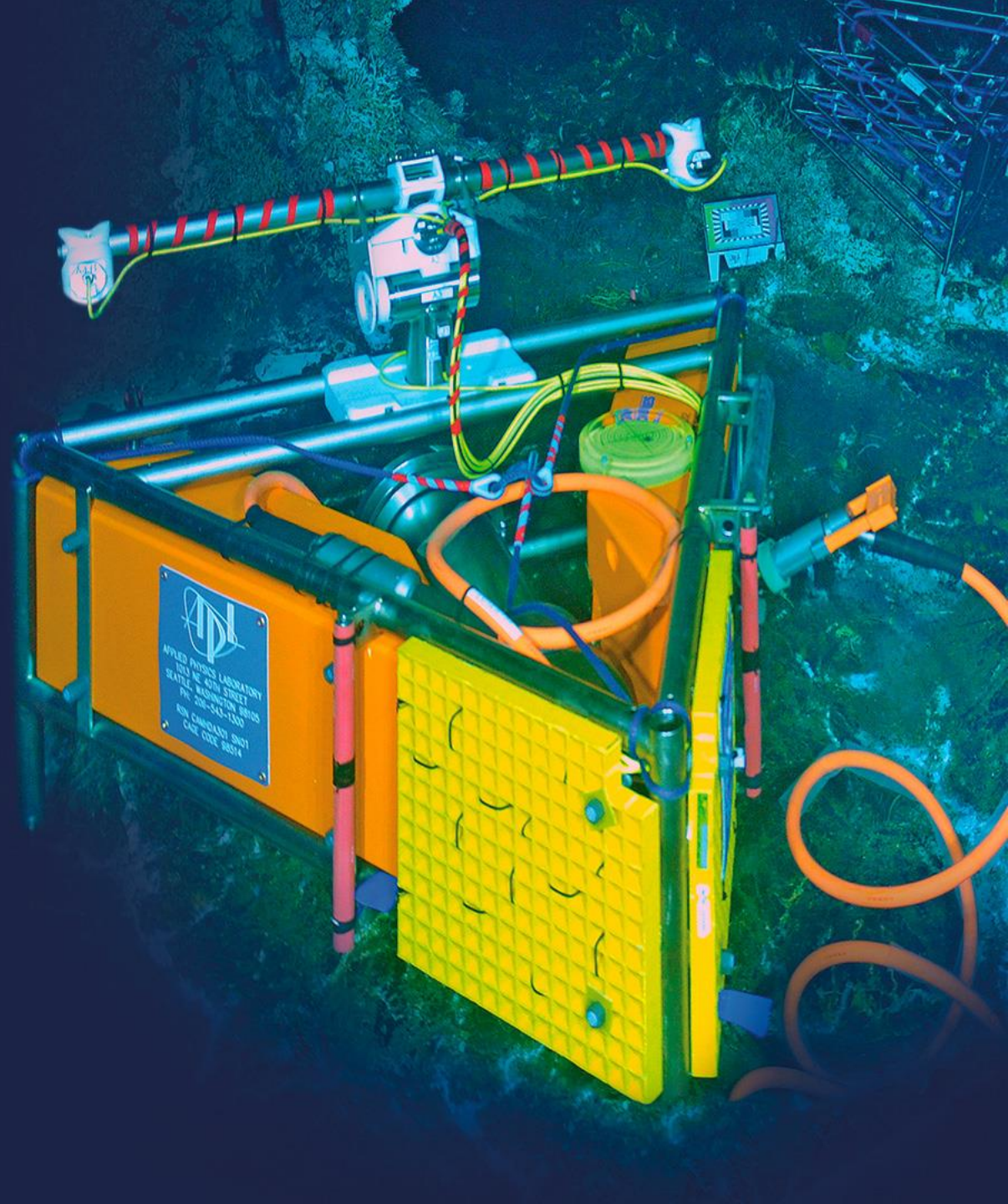
Questions?