Measuring Protons with Photons:

A hand-held, spectrophotometric pH Analyzer for Ocean Acidification Research, Community Science and Education

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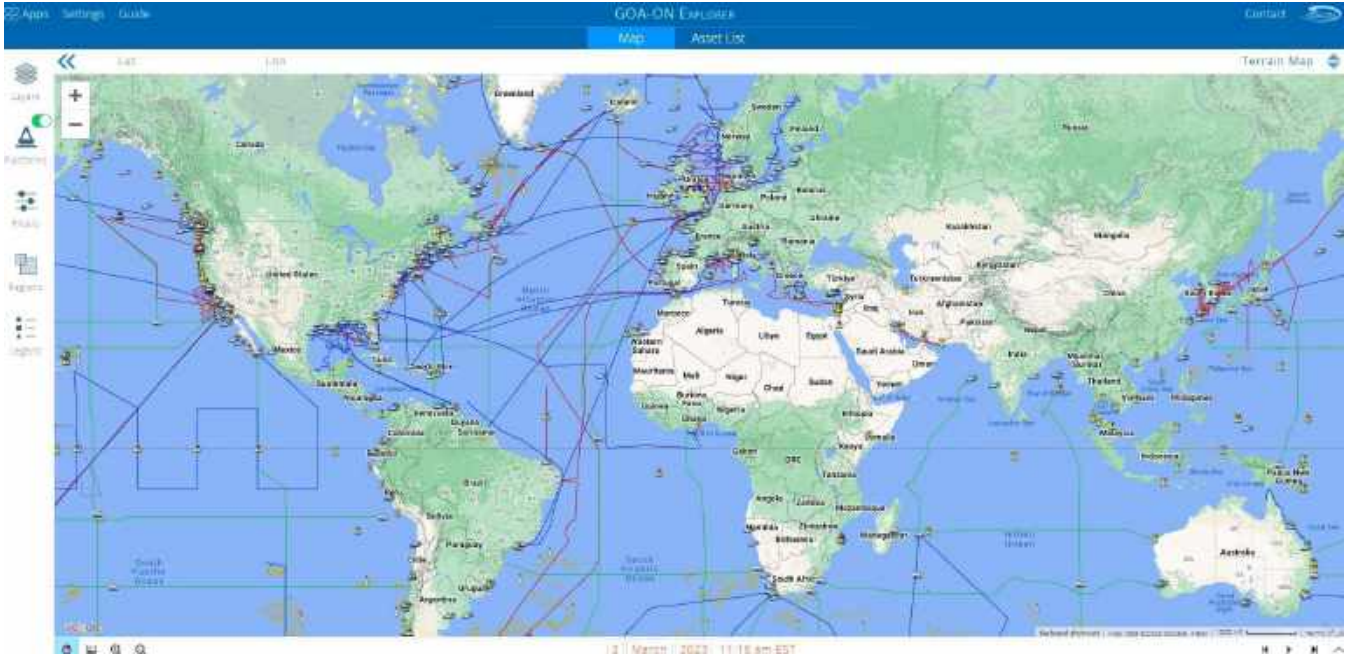
Knauss Fellow in International Policy

In collaboration with: William Pardis, Michael D. DeGrandpre, Reggie Spaulding, James Beck, Jonathan A. Pfeifer, and David M. Long

Imagine communities collecting pH data to contribute to decision making, science, and education



The pHyter

William Pardis

Flathead Valley Community College

Sunburst Sensors
autonomous chemical sensors since 1999

GOA-ON
Global Ocean Acidification Observing Network

GOA-ON WEBINAR SERIES

Measuring Protons with Photons:
a pH Analyzer and community science program to change the relationship between humans and ocean science

Thursday, 18 March 2021 at 11:00 EDT (UTC -4)

Register here: https://attendee.gotowebinar.com/rt/2312052364919044366

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Flathead Valley Community College

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sensors

MDPI

Article

Measuring Protons with Photons: A Hand-Held, Spectrophotometric pH Analyzer for Ocean Acidification Research, Community Science and Education

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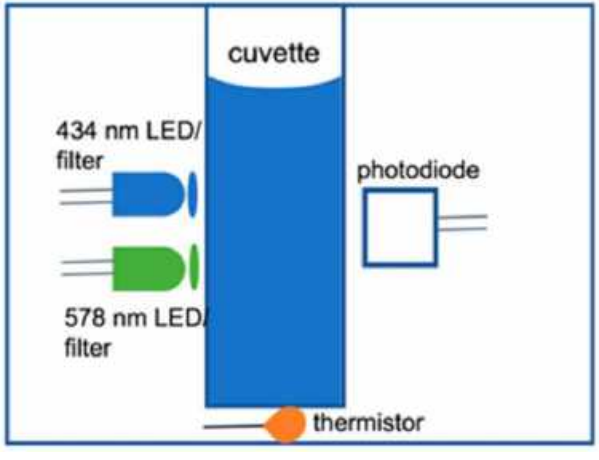
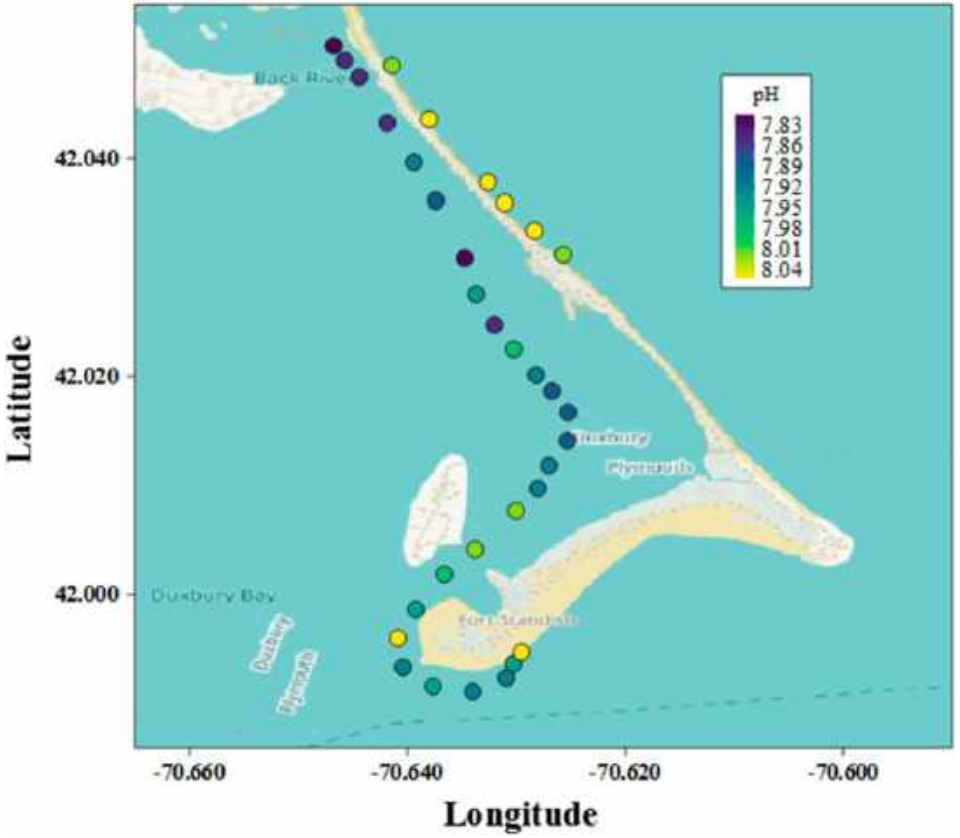
pHyter is a hand-held, affordable, field-durable, easy-to-use pH instrument

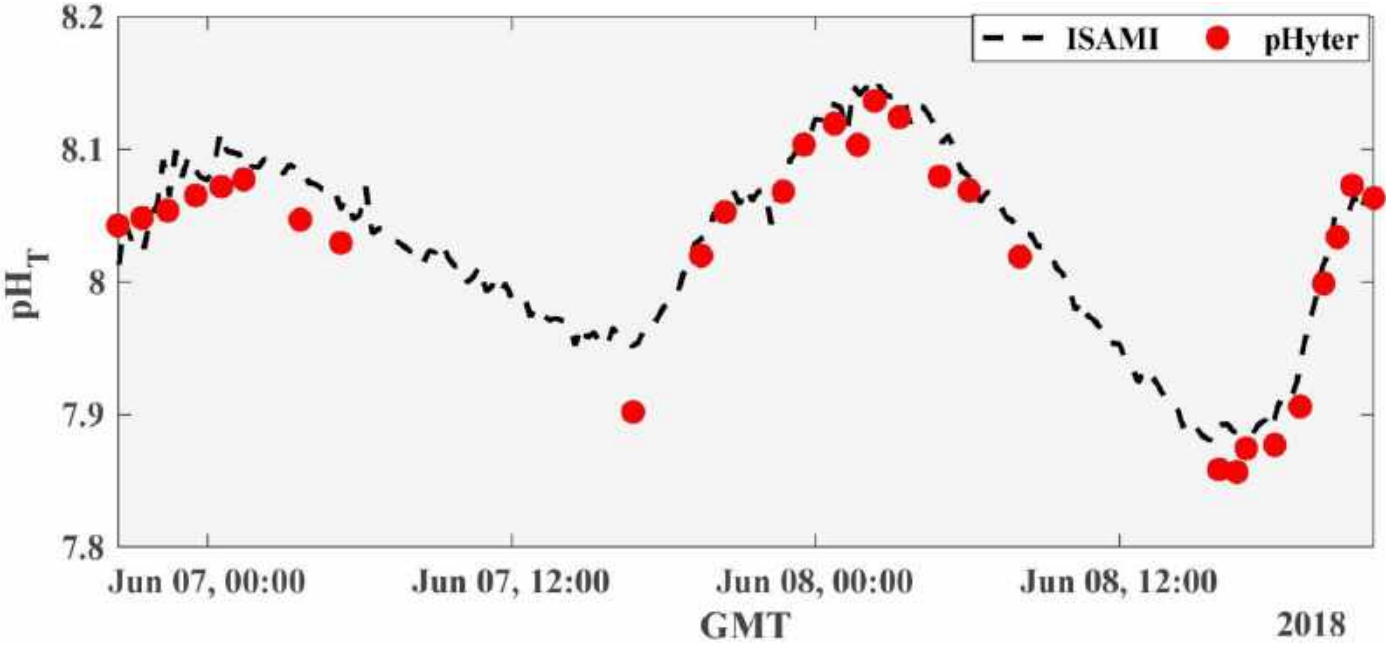
- Controlled through **smartphone app** with data in under 1 minute
- pH measurements are **spec-based with indicator dye**
- Accuracy **comparable** to uncertainties in benchtop **spectrophotometric pH measurements** (+/- 0.046)
- Designed for **community-based science** and used with minimal training
- Ideal for **spatial and temporal sampling**, while highlighting small-scale variations across large regions



pHyter can be used to spatially survey pH



pH measurements by the pHyter and iSAMI



National Marine Sanctuaries Team Developed Ocean Acidification Plankton Monitoring curriculum and pilot program

- Adopted by Ocean Guardian School
- Earned students from Quileute Tribal School in La Push, Washington “Get Dirty!” Ambassadors by Nickelodeon

GET DIRTY! AMBASSADOR EXPEDITION FROM QUILEUTE TRIBAL SCHOOL

NATIONAL MARINE SANCTUARIES

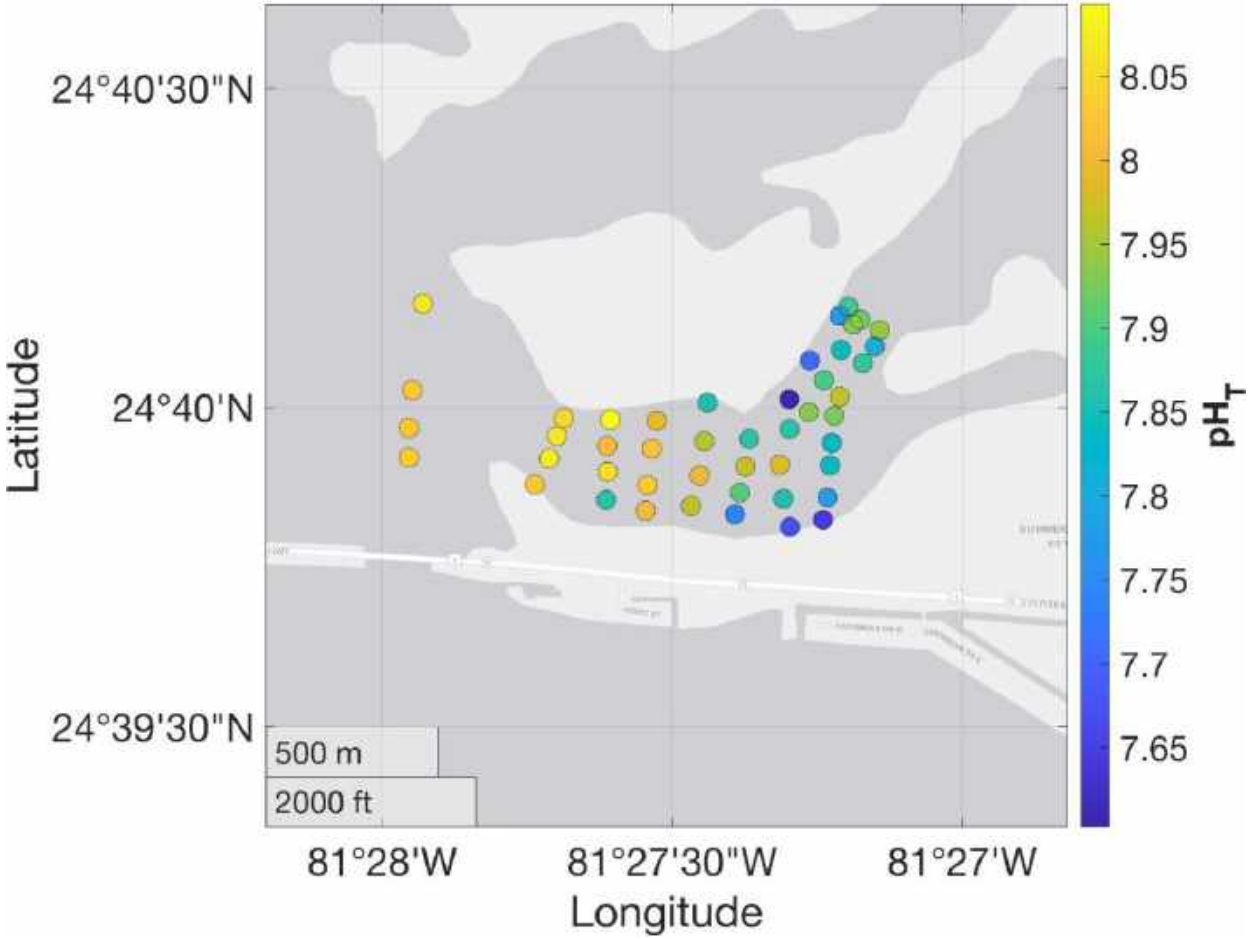
NOAA

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

Funded by NOAA OA Education Mini-Grant

Jacqueline Laverdure, Nicole Harris, Christine VanDeen (Olympic Coast National Marine Sanctuaries)

Students mapped pH with the pHyter in the mangroves



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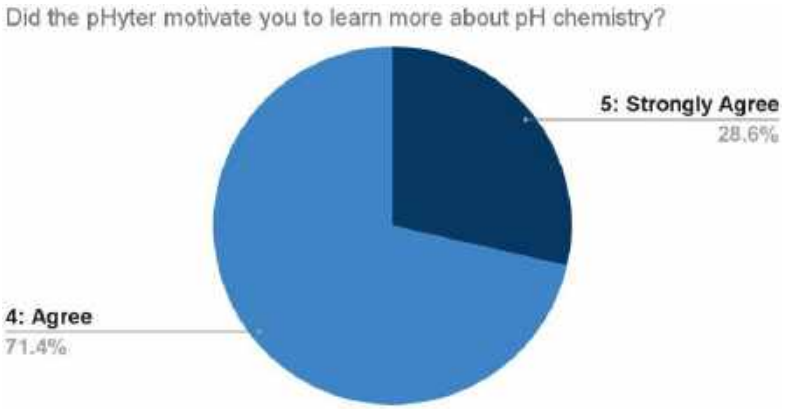
The pHyter is a great teaching utensil

- The pHyter:
  - Motivated students to learn more about pH
  - Was easier to use than the benchtop spec
- The students:
  - Felt competent using the pHyter on their own after a few times and teaching their peers
  - Enjoyed using the pHyter



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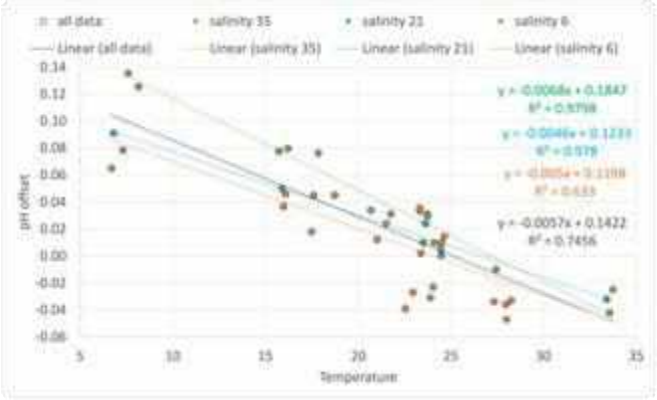
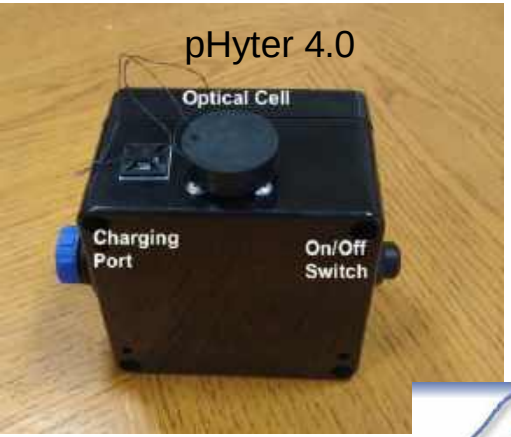
Additional Interested Partners

- Community Science
  - Buzzards Bay Coalition, National Phytoplankton Monitoring Network, Surfrider Foundation
- Education and Outreach
  - Cabrillo College, Chesapeake Bay Governor's School for Marine and Environmental Science, Flathead Valley Community College, Quileute Tribal School, Ocean Guardian School, Montana American Indians Math and Science, Sea Education Association, University of North Carolina Wilmington, Woods Hole Oceanographic Institution
- Governmental Agencies
  - US Environmental Protection Agency (EPA), US National Oceanic and Atmospheric Administration (NOAA)
- International Networks
  - OA Alliance, GOA-ON
- Local Industries
  - Aquaculture, fishers
- Non-governmental organizations
  - The Ocean Foundation

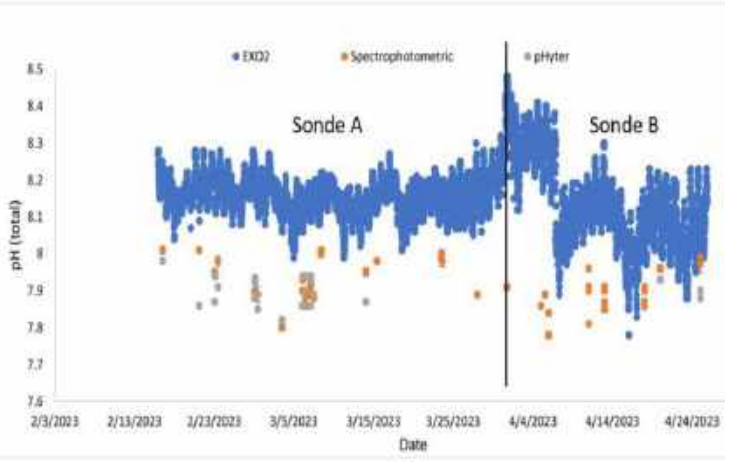
pHyter progress and approach by Sunburst

pHyter 3.0
-Ip66 box
-rechargeable Li battery
-IP68 USB charging port
-square cell (difficult to glue/seal)
-Particle Argon & Feather boards
plus custom PCB (lots of soldering)
-thermistor glued to **outside** of cell
(temperature dependence of error)





pHyter 4.0 improvements
-Ip68 box
-round cell, O-ring seal
-thermistor glued to **inside** of cell
-IP68 on/off switch



Sunburst Sensors
autonomous chemical sensors since 1999

Future directions for the pHyter from Sunburst

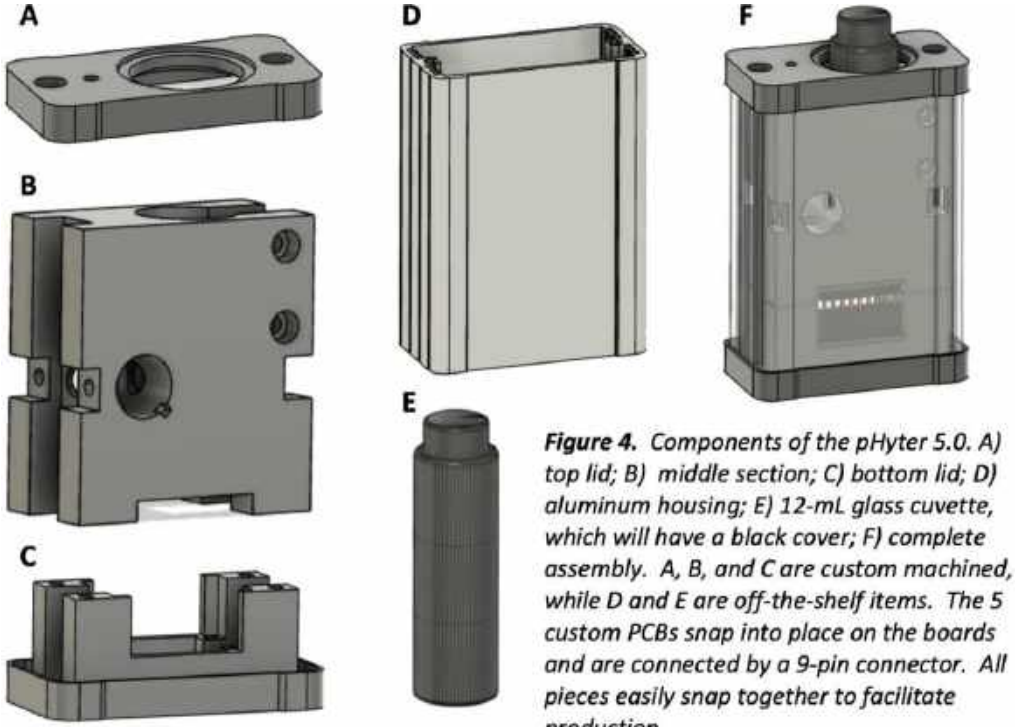


Figure 4. *Components of the pHyter 5.0. A) top lid; B) middle section; C) bottom lid; D) aluminum housing; E) 12-mL glass cuvette, which will have a black cover; F) complete assembly. A, B, and C are custom machined, while D and E are off-the-shelf items. The 5 custom PCBs snap into place on the boards and are connected by a 9-pin connector. All pieces easily snap together to facilitate production.*

pHyter 5.0

-custom machined parts snap together like Legos
-custom PCBs snap into machined parts and are connected by a cable (very little soldering)
-the thermistor is glued to the inside of the glass cell
-has indicating on/off switch
-app has charge-state indicator
-not thoroughly tested yet

Currently in development

-pHyterPro-TA (total alkalinity)
-pHyter-Chl-a (chlorophyll a)
-pHyter-FDOM (fluorescent dissolved organic matter)
-website/data portal where pHyter data can be uploaded and visualized on mapping and graphing pages

Additional development efforts for the pHyter

David Long

Jonathan Pfeifer

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Our Ocean. Our Planet. Our Future.®

Future of the pHyter

Provide communities, such as **Indigenous nations**, with opportunities in science and **education**

Quileute Tribal School

Makah Indian Reservation

Increase **OA monitoring capacity** and **build international collaborations**

Pacific Islanders training in Fiji

Chile

Enable countries to meet **UN mandate to submit data to global pH databases**

Sustainable Development Goal 14.3.1 Data Portal and GOA-ON Data Explorer

Acknowledgements

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IDEAL
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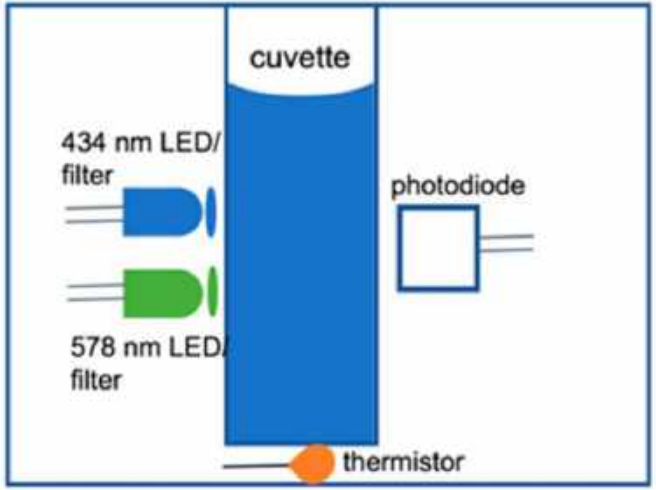
- Lisa Uttal
- Jennifer Mintz
- Brady Clarke
- Michael Acquafredda

Sunburst Sensors
- James Beck
- Reggie Spaulding

WHOI
- William Pardis
- Jonathan Pfeifer

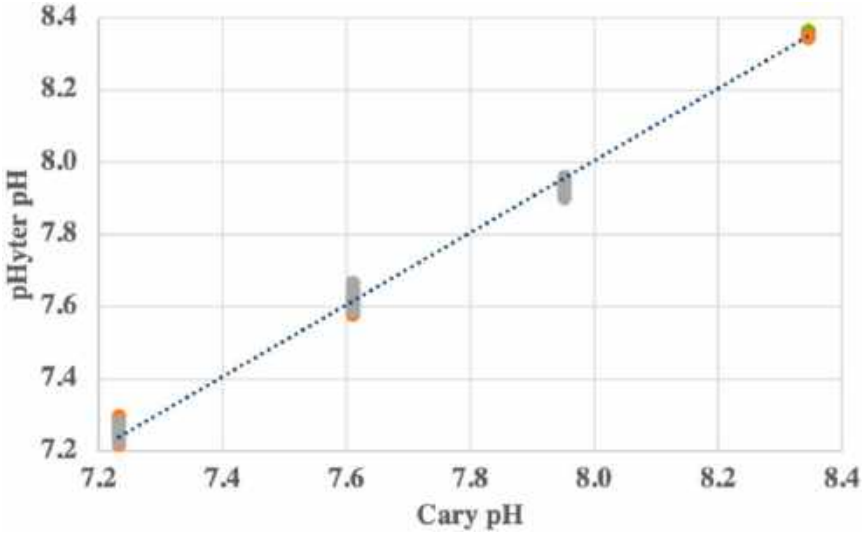
pHyter Quick Facts

- **Accuracy**: +/- 0.046
- **Method**: Spec with meta-Cresol Purple
- **Size**: 5.1 cmW x 3.8 cm L x 2.5 cm H
- **Weight**: 200g
- **Operation**: Smartphone App
- **Price**: ~$500
- **Measurement time**: ~1-3 minutes



Accuracy was tested with CRM and against Cary Spec

- **Accuracy is +/- 0.046**
- **Accuracy is not as good as most reliable benchtop instruments**
- **Accuracy is on par with other errors**
  - **Inter-laboratory differences +/- 0.02**
  - **Dye impurities +/- 0.008**
  - **Dye perturbation +/- 0.001-0.05**



Temperature (C)	Tris pH	pHyter 1	pHyter 2	pHyter 3	pHyter 4	pHyter 5	Average Offset	Standard Deviation
24.74 ± 0.09	8.107 ± 0.003	8.130	8.120	8.120	8.120	8.110	+0.013	±0.007
22.09 ± 0.35	8.190 ± 0.011	8.230	8.220	8.230	8.200	8.190	+0.024	±0.010
27.72 ± 0.19	8.016 ± 0.006	8.030	8.189	8.010	8.013	N/A	+0.046 (+0.002)	±0.086 (0.011)