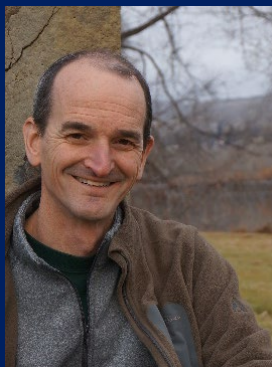


NOAA-Pacific Marine Environmental Lab Engineering

Our mission is to solve technical observing problems to accelerate NOAA's science

- Committed group of ~16:
10 Feds, 3 JISAO, 3 Contractors
- Involved in >90% of the Lab's observations
- Customers: Researchers, Program Managers, NOAA operations, NASA, Industry, Foreign Gov. Partners

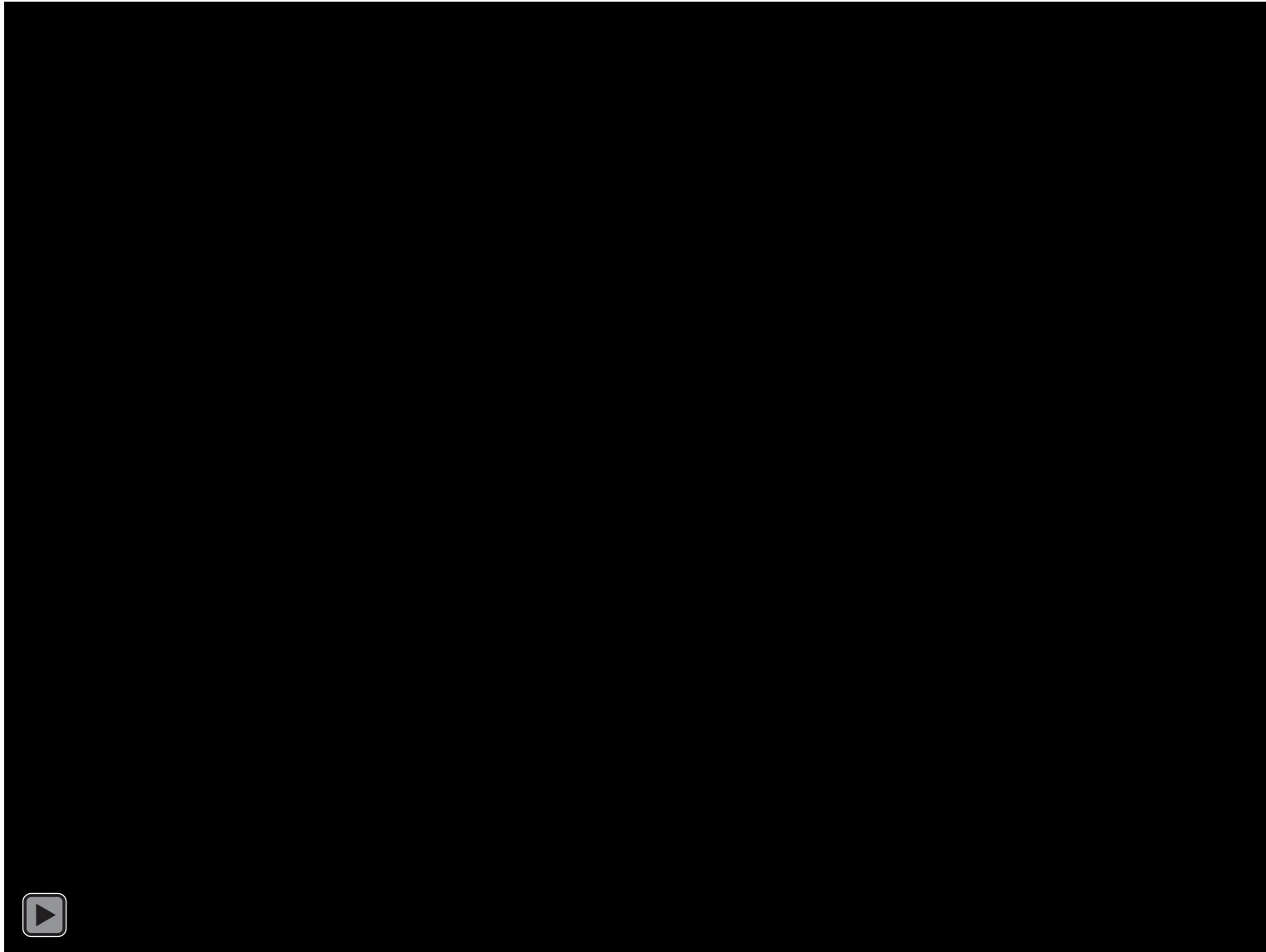


Christian Meinig
Director of Engineering
NOAA-PMEL
Seattle, WA

Functions:

- Engineering
- Electronics Labs
- Machine Shop
- Mooring Shop
- Field Work Support
- Equipment Pool & R/V SP HAYES

PMEL Ocean Observing Systems 2018-'19

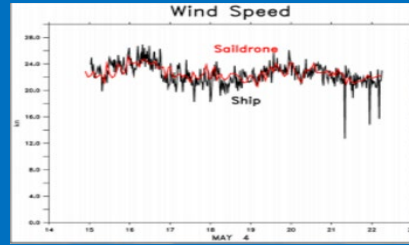


Science Driven Technology Development

Form Partnerships & Establish Feedback Loops



Science Drivers!



Systematic Engineering, Science & Data Development

Platform
Design
and
Sensor
Integration

Operations
and
Field Test
Planning

Automated
Workflow
and Data
Validation

Integrated
Research
Missions

Transition

Engineering Relevance: End-to-End Development

From Innovation to Impact

Evaluate Opportunity

- Science drivers, mission requirements, fund raising?
- Fits OAR Vision?
- Form Partnerships

Develop

- Engineering designs
- Prototypes
- Field testing: local & full ocean depths
- Transition Evaluation

Launch

- Fabrication, integration, deployment
- Scientific evaluation & feedback
- Impacts: *Science & Eng. Publications, Transition to Sustained Research or Operations, Enabling Blue Economy, Protecting Lives & Property*



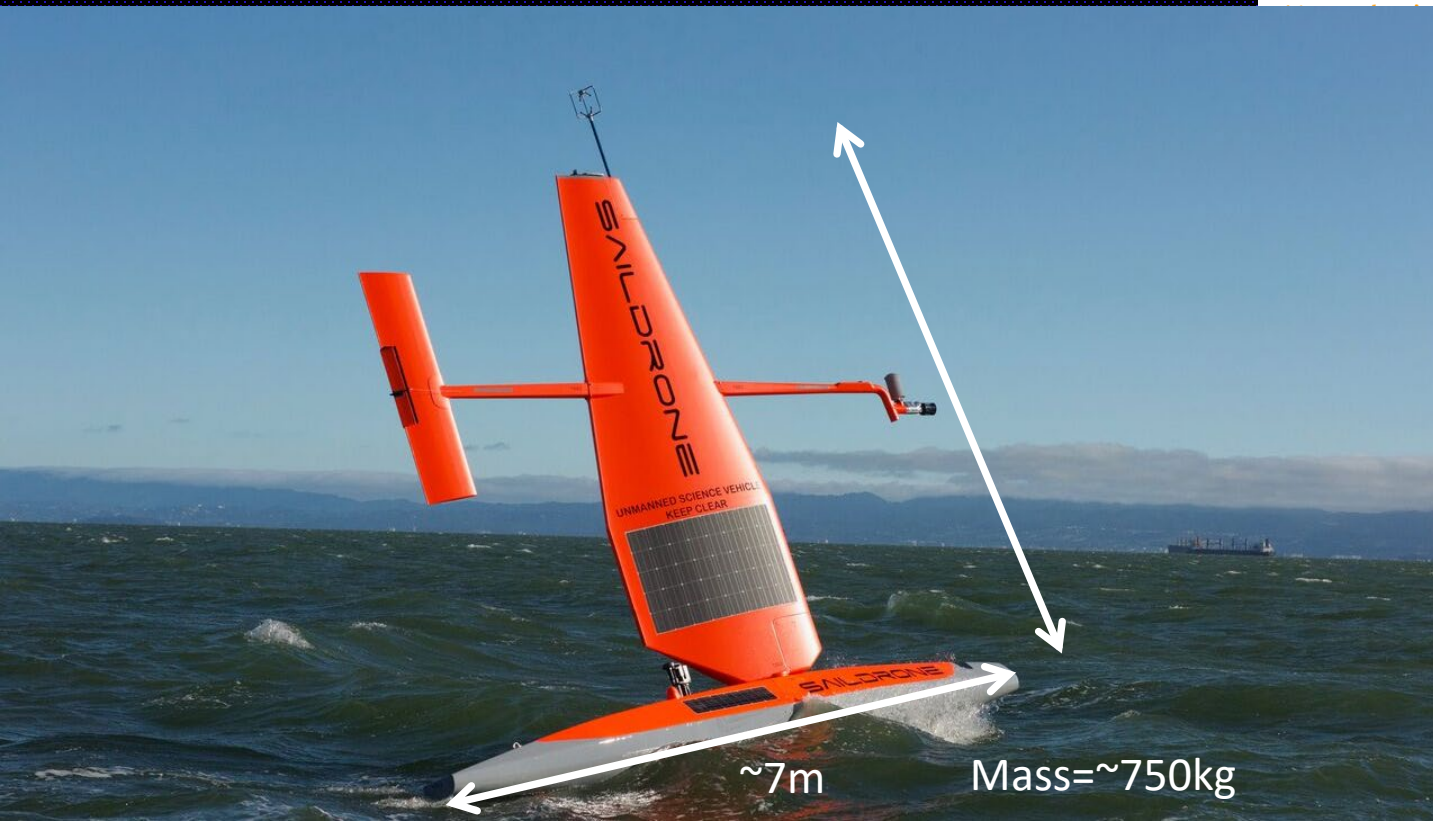
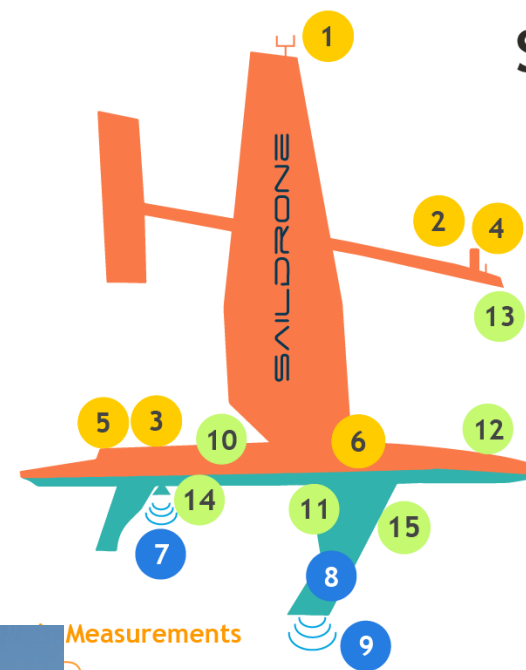
Saildrone-NOAA Co-Development

5 years ~20 sensors

Saildrone Sensor Suite

Specifications

- Length: 7 m
- Height: 4.6 m (above water line)
- Depth: 2 m
- Weight: 545 kg, (fully loaded)
- Speed: Transit - 3 Kt, Max - 8 Kt
- Payload Power: 30W Steady state
- Payload Capacity: 100 kg
- Max deployed duration: 12 months
- Longest voyage: 16,100 km



Measurements

- 1 Anemometer @ +5.0m
Gill WindMaster 3D Ultrasonic 20Hz
- 2 Sunshine Pyranometer @ +2.5m
Delta-T Devices SPN1
- 3 Pyrgeometer +0.7m
Eppley PIR
- 4 Meteorological Probe @+2.4m
Rotronic HC2 - S3 with rad shield
- 5 Digital Barometer @ +0.3m
Vaisala BAROCAP® PTB210
- 6 CO₂ System @ +0.5m
PMEL ASVCO₂

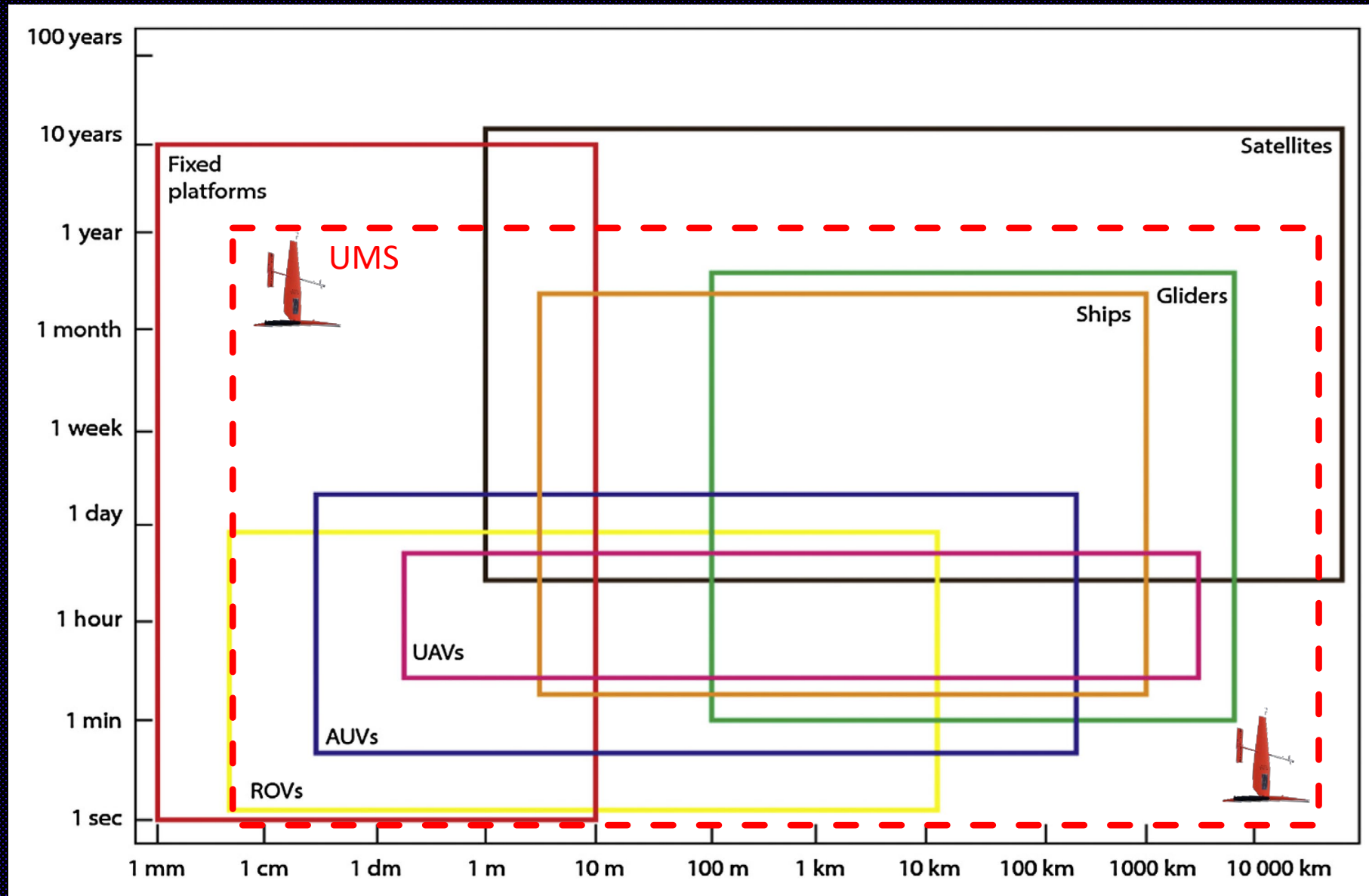
Surface Measurements

- 7 ADCP @ -0.3m
Teledyne RDI 300 kHz Workhorse Sentinel
- 8 Passive Acoustic Recorder @ -1.3m
Greenridge Sciences Inc. Acousonde
- 9 Scientific Echosounder @ -1.8m
SIMRAD WMINI
Multi-beam Sonar @ -1.8m
Norbit iWBMS

Oceanic Surface Measurements

- Wave Height & Period 10 Dual GPS & IMU
Vectornav / KVH
- Seawater pCO₂ & pH
- Dissolved Oxygen
- Water Temperature
- Salinity
- 11 CO₂ System
PMEL ASVCO₂ @ -0.5m
Honeywell Durafet @ -0.5m
Aanderaa Optode @ -0.5m
Sea-Bird Scientific SBE PRAWLER @ -0.6m
- Magnetic Field 12 Magnetometer
Barrington MAG 648
- Skin Temperature 13 SST IR Pyrometer @ +2.2m
Heitronics KT15 II
- Chla
- CDOM Concentration 14 Fluorometer and Backscatter @ -0.2m
Sea-Bird Scientific WET Labs Eco Triplet
- Red Backscatter
- Water Temperature
- Salinity 15 Thermosalinograph CTD @ -0.6m
Teledyne RDI Citadel TS-NH

Saldrone Development: Why Bother?



Nilssen et al (2015) based on Haury et al (1978)

Drivers: Partnership Opportunities in Marine Technology?

- Fill gaps in observing tech
- Enables new science discoveries
- Provide value to stakeholders:
 - dissemination and transition

INNOVATIVE TECHNOLOGIES TO ADVANCE OCEAN OBSERVATION

AUTHORS

Ms. Heather McRae Tabisola 1, 3 Dr. Jessica Cross 2, 3
Mr. Christian Meinig 2, 3 Dr. Calvin Mordy 1, 3

1 University of Washington, Joint Institute for the Study of Atmosphere and Ocean
2 National Oceanic and Atmospheric Administration
3 NOAA Pacific Marine Environmental Laboratory, Seattle, WA

SMART OBSERVATIONAL INTELLIGENCE SOLUTIONS

The Innovative Technology for Arctic Exploration program at NOAA's Pacific Marine Environmental Laboratory conceptualizes and builds effective research equipment for the assessment of the Arctic environment and ecosystem. Development and field tests of technologies to advance ocean observation included ITAE's big four in the summer of 2017.

ACCOMPLISHMENTS

Connected over 30 partners in academia, government, & industry, with more than 500 days of data collection, ~40,000 km of remote territory traveled, and 3,600 dives.

PUSHING OBSERVATIONAL BOUNDARIES

- ▶ First to transit through Bering Strait
- ▶ First to travel 7 NM from sea ice edge
- ▶ First to make Arctic Basin observations
- ▶ FARTHEST NORTH an ASV has traversed

ECOSYSTEMS UP CLOSE Collecting SEAL'S-EYE-VIEW video

MAKING NEW DISCOVERIES Oculus dives show turbulent "CHIMNEYS"

ACHIEVING NOAA MISSIONS

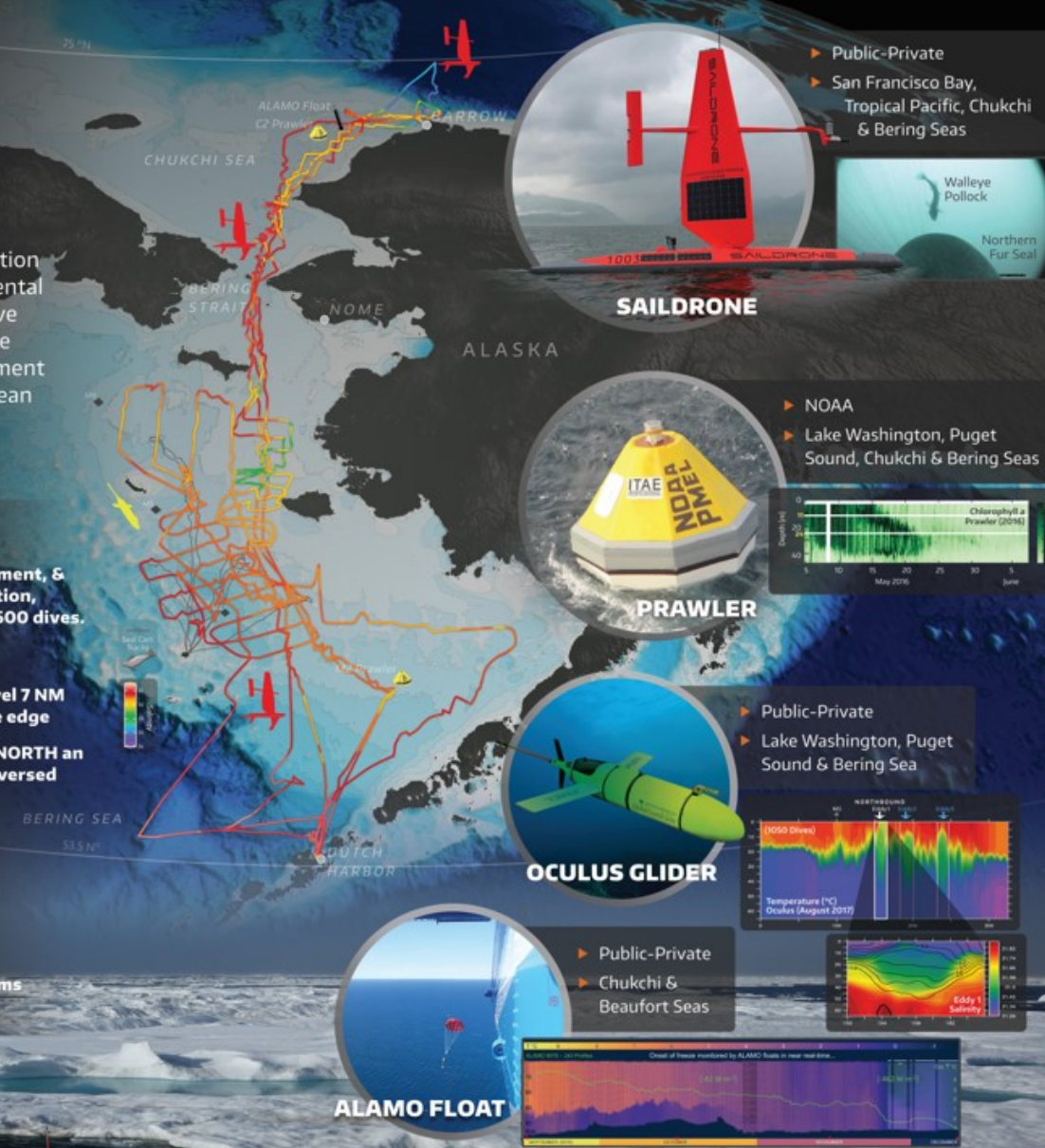
- ▶ **BUILT** and expanded operational capacity
- ▶ **CONNECTED** sustained arctic observing systems
- ▶ **EXPLORED** new scientific frontiers



FUNDING:
Funding to PMEL and UW provided by NOAA Research, June 2014- current.

ACKNOWLEDGEMENTS:

This work would not have been achieved without the dedication and commitment of many personnel from NOAA Research, NOAA Fisheries, and NOAA Cooperative Institute, the University of Washington Joint Institute for the Study of Atmosphere and Ocean. From the drawing board to the field, these successful field missions are made possible through dedicated administration, engineers, researchers, communications teams, private partnerships, and the officers and crews of NOAA Ship Oscar Dyson and the USCO Cutter Healy.



www.pmel.noaa.gov/itae/ www.youtube.com/NOAAPMEL www.instagram.com/noaa/



Common Components

New Capability



Seaglider
<1000m

Deepglider
<6000m

Oculus
<200m

ITAE Development Supports *every* NOAA Line Office

OMAO UxS	NMFS Fisheries	NOS Charting	OAR Climate / Oceans	NWS Weather	NESDIS Satellites
<p>OMAO in process of defining a new Unmanned Systems Operations Program at NOAA. PMEL has been asked to contribute.</p>	<p>NMFS uses both our platforms and sensors:</p> <ul style="list-style-type: none"> -- Conservation / Recovery / Protected species / Endangered species (C. Kuhn) -- Fisheries stocks (A. De Robertis) 	<p>NOS has updated charts based on SD sounding and has outfitted a SD with multibeam sonar</p>	<p>OUR PRIMARY CUSTOMER!</p> <p>OAR Programs using ITAE developments:</p> <ul style="list-style-type: none"> • CPO/ARP • OAP • TPO • OER <p>NOAA labs using ITAE developments:</p> <ul style="list-style-type: none"> • PMEL • ESRL • AOML 	<p>Surface ocean data currently transferred to the GTS</p>	<p>2019 mission has enhanced satellite SST products as its primary mission goal (MISST / GHRST)</p>

Over the past 5 years, we've collaborated with every NOAA LO

Partnerships

Each is unique



research

Industry



operations

Research Cover

Rapid Scaling
Matching Resources
Top Software Talent
SME
Lobbying Power

Access to global network
Structured Approach
Deep Partner Reachback
Defined Stakeholders
High Risk Tolerance
Functions Based

Shared Vision
Rapid Co-Development
Built-in Transitions
Long Term Data Needs
Broad Stakeholders

Federal Mandates
Operational Needs
Community Standards
Data Needs
Long Time-Horizon
Defined Stakeholders

Overlap is a Powerful Multiplier for Innovation

Southern Ocean Carbon 2019



Video taken from SD 1020's onboard camera showing the extreme conditions in the Southern Ocean during the 2019 Antarctic Circumnavigation.

pmel.NOAA.gov



ASVC₂
Autonomous Surface Vehicle CO₂ Sensor



External Collaborations

Industry

Research Institutes/Academia

Public Agencies/Tribes

HYDROID
 A KONGSBERG COMPANY
 Advanced Marine Robots You Can Rely On

SAIC
 From Science to Solutions

KONGSBERG

SAILDRONE

Google

LIQUID ROBOTICS
 A Boeing Company

McLANE
 RESEARCH LABORATORIES, INC.

PAROSCIENTIFIC, INC.
 Digiquartz® Pressure Instrumentation

SEQUOIA
 Products and Research for Environmental Science

SBE Sea-Bird
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SEA-BIRD SCIENTIFIC

DNV-GL

Battelle
 The Business of Innovation

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 Everywhere you look

wework

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 Monterey Bay Aquarium
 Research Institute

University of Victoria

CSIRO

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Jupiter
 Research Foundation

SEAGLIDER FABRICATION CENTER

Pacific Northwest NATIONAL LABORATORY

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MAKAH INDIAN NATION
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W. BUERK CENTER
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blue
 WASHINGTON MARITIME

WORLD METEOROLOGICAL ORGANIZATION

jcommops

SEATTLE AQUARIUM

Port of Seattle

STATE OF WASHINGTON
 Department of Commerce
 Innovation is in our nature.