# Stretching the scales of Ocean Observing: *Biogeochemistry from the Saildrone ASV*


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OCB Summer Workshop 2017

ITAE Innovative Technology for Arctic Exploration

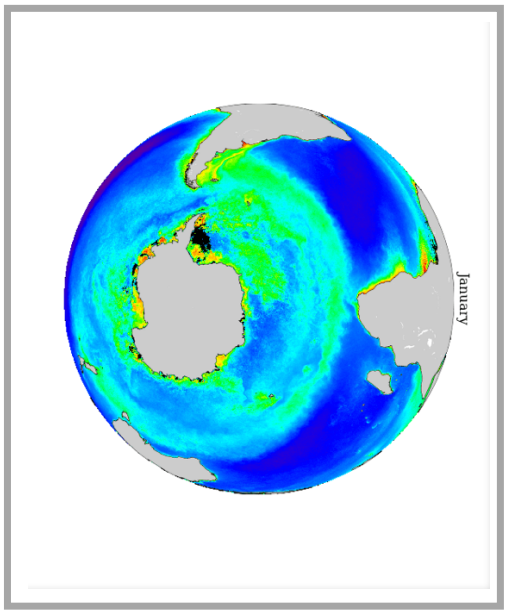
NOAA PMEL JISAO SAILDRONE


Given infinite
time and infinite
resources...

# We need multiple scales for imperfect models:

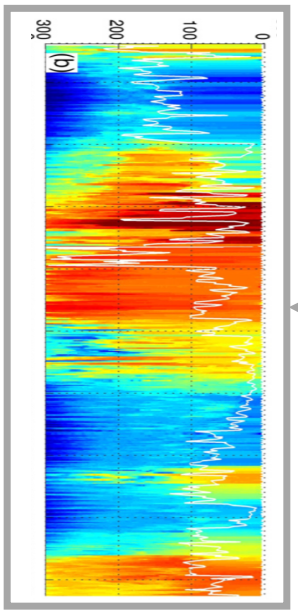
*Fine resolution, simultaneous multi-sphere observations are needed to understand the full system and variability*

**BGC response + growth term**



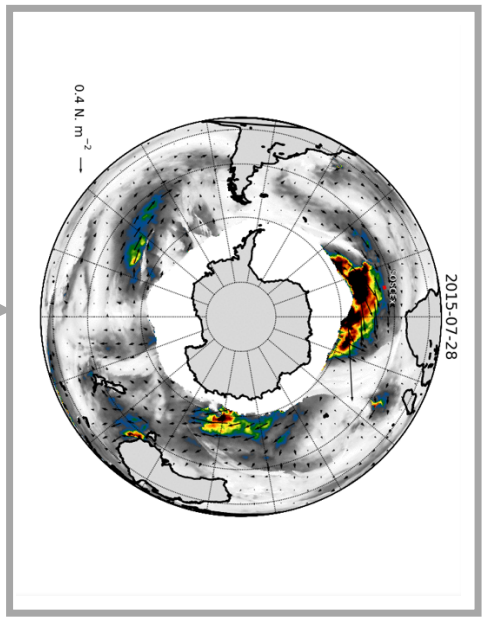

**BIOGEOCHEM**

**Submesoscale ocean**



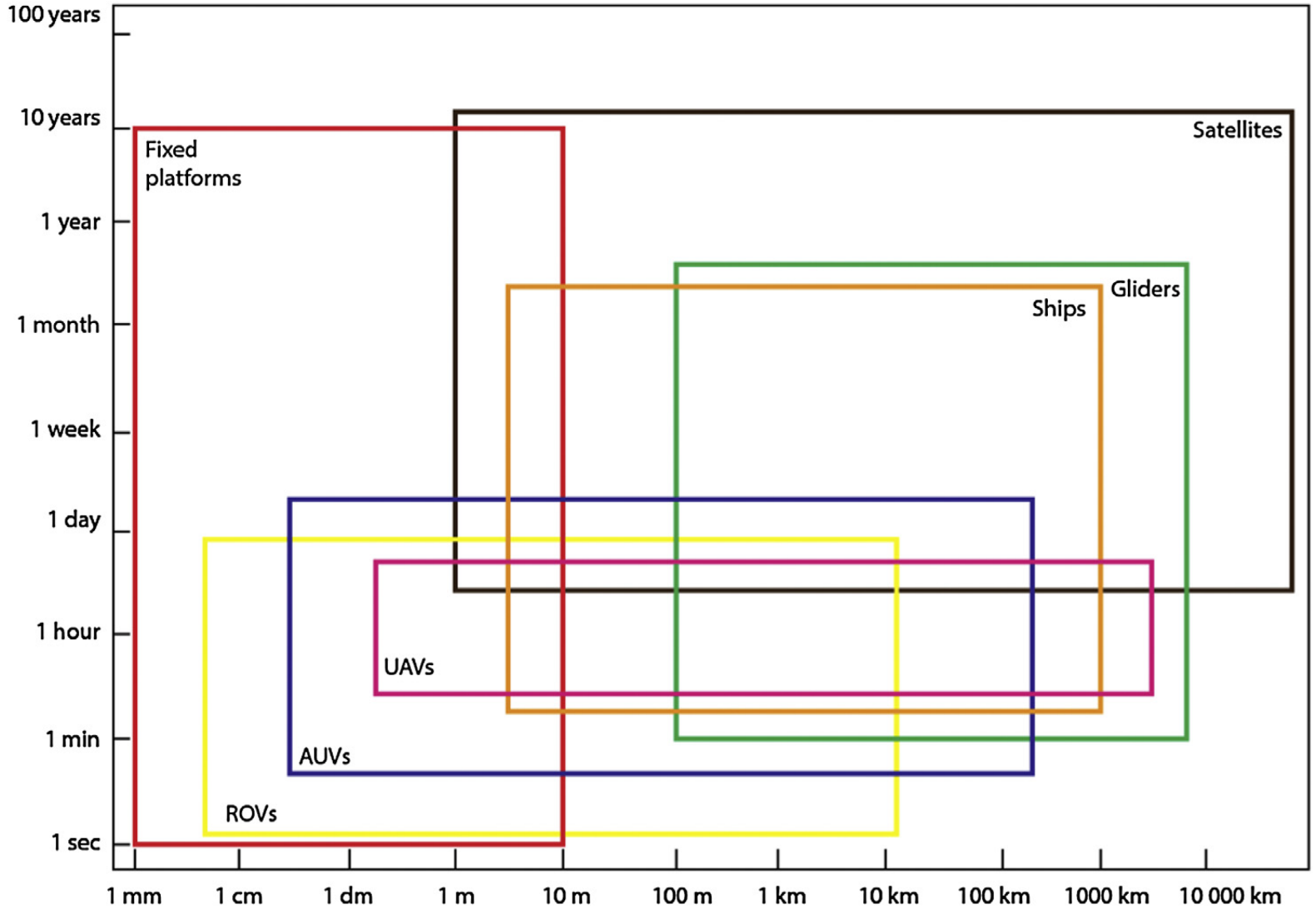

**OCEAN**

**Winds – high frequency**



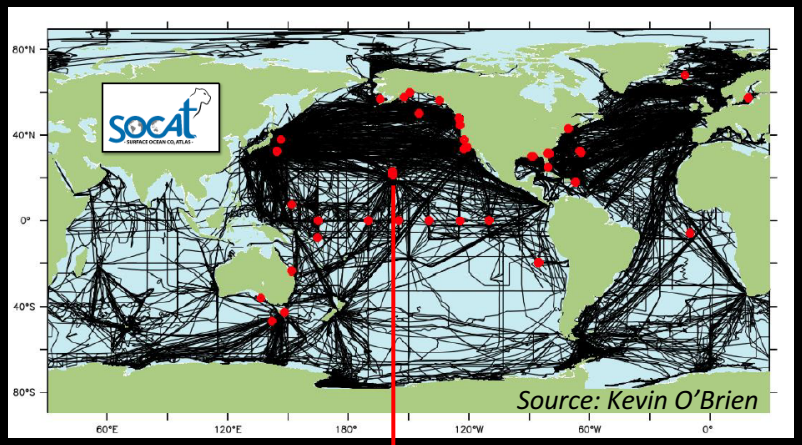

**ATMOSPHERE**

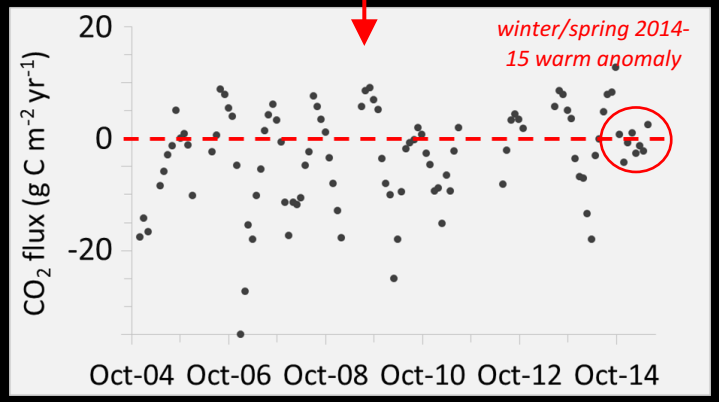
# What we have:




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

# The observing network works:

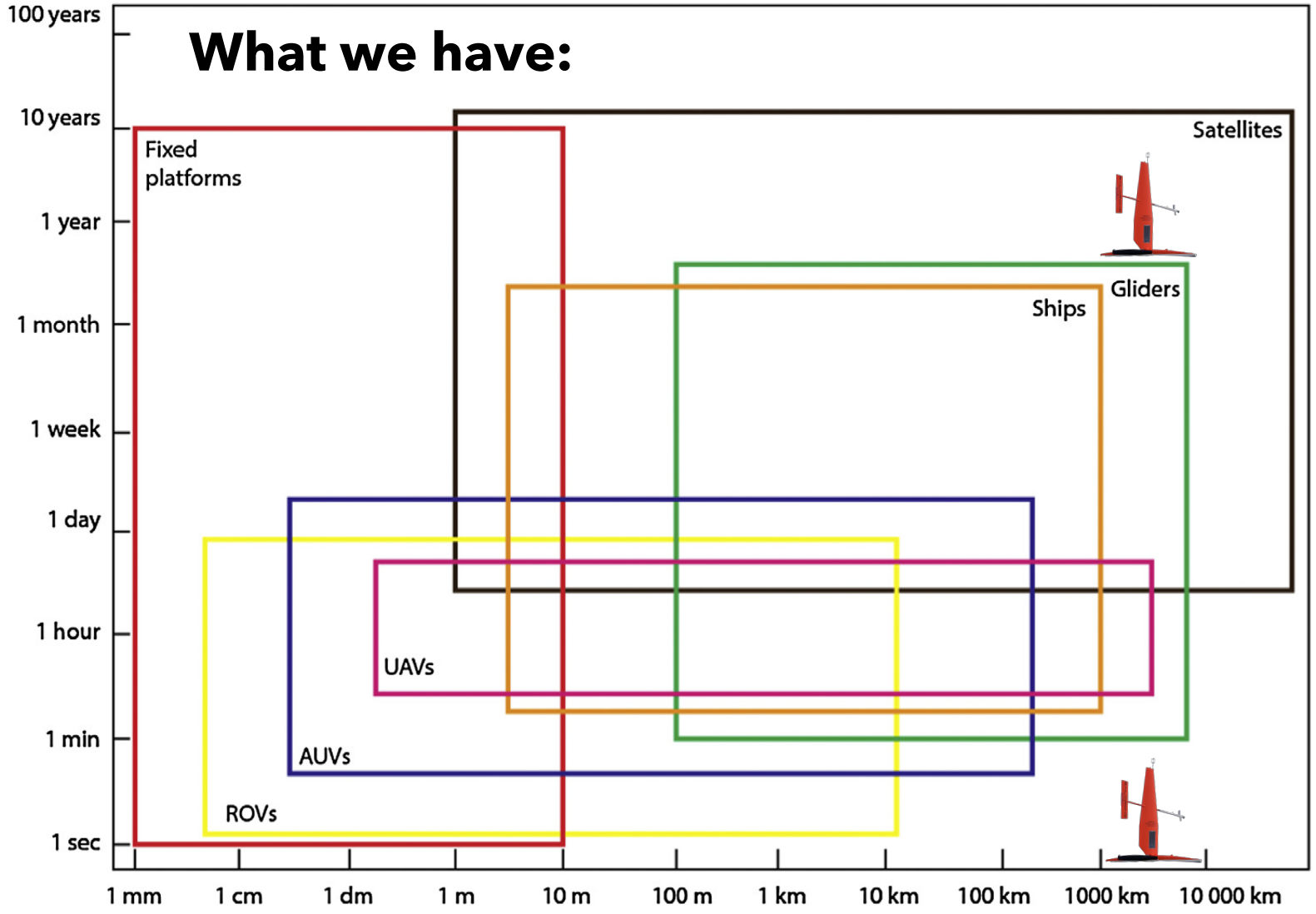



*Source: Sutton et al. in review*

- Moorings and ship-based underway measurements both provide climate-quality measurements
- Over the last 15 years, air-sea $CO_2$ flux uncertainty has been reduced by 50%
- New fixed time series resolve sub-seasonal variability and processes

# Resolving Issues of Scaling




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

# BUILD

# CONNECT

# EXPLORE

OceanSITES

TPOS 2020

ARCTIC PROGRAM

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SAILDRONE
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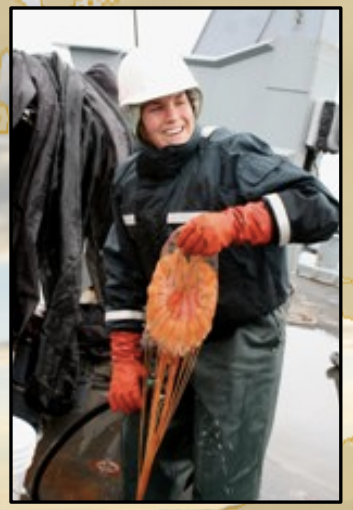
Saildrone Advantage:
Fast – Big – Durable
NOAA
PMEL

# Speed and Endurance

**2 boats ◆ 97 days**
**7600 km ◆ 46 kt winds**
**Up to 7 kt speed**



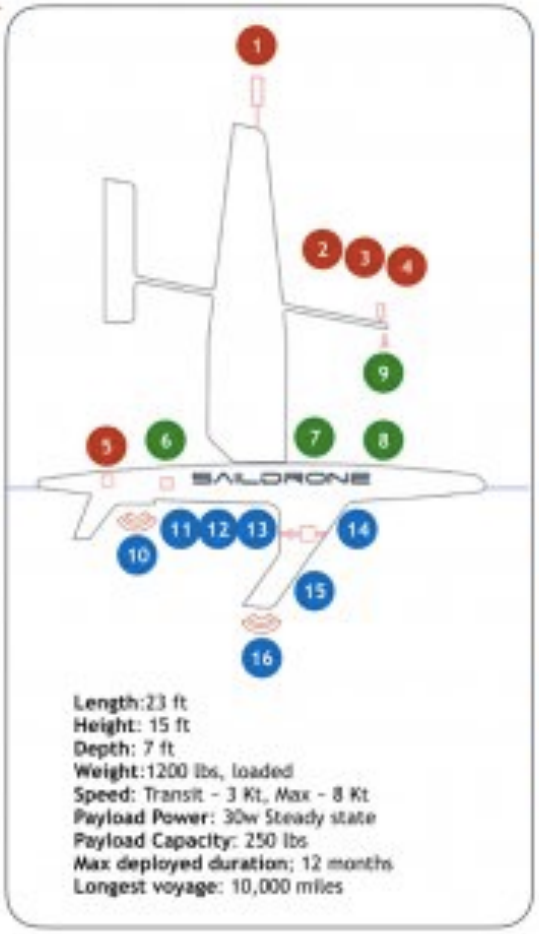
# SAILDRONE GEN 4 SPECIFICATIONS AND SENSOR SUITE

## Atmospheric Measurements

- Wind Speed, Wind Direction → 1 — Anemometer @ +4.5m — Gill Windmaster 3D ultrasonic 20H
- Sunlight → 2 — Sunshine Pyranometer @ +2.2m — Delta-T Devices SPN1
- Sunlight → 3 — Pyranometer @ +2.2m — Eppley PSP & PIR
- Air Temperature, Humidity → 4 — Meteorological Probe @ +2.2m — Rotronic HC2 - S3 with rad shield
- Air Pressure → 5 — Digital Barometer @ +0.2m — Vaisala BAROCAP PTB210

## Oceanic Surface Measurements

- Wave Height & Period → 6 — Dual GPS & IMU — Vectornav / KVH
- $pCO_2$ → 7 — $CO_2$ System @ +0.3m — PMEL ASVCO$_2$
- Magnetic Field → 8 — Magnetometer @ 0m — Barrington MAG 648
- Skin Temperature → 9 — SST IR Pyrometer @ +2.2m — Heitronics KT15 II




**Length:** 23 ft
**Height:** 15 ft
**Depth:** 7 ft
**Weight:** 1200 lbs, loaded
**Speed:** Transit - 3 Kt, Max - 8 Kt
**Payload Power:** 30w Steady state
**Payload Capacity:** 250 lbs
**Max deployed duration:** 12 months
**Longest voyage:** 10,000 miles

## Oceanic Sub-Surface Measurements

- Ocean Currents → 10 — ADCP @ -0.2m — Teledyne RDI Workhorse 300 kHz
- Chla, CDOM Concentration, Red Backscatter → 11 — Fluorometer @ -0.2m — Sea-bird Scientific WET labs Eco Triplet
- Dissolved Oxygen → 12 — Oxygen Optode @ -0.5m — Aanderaa 4831
- $pCO_2$ → 13 — $CO_2$ System @ -0.5m — PMEL ASVCO$_2$, Sea-Bird Scientific SBE Prawler, Honeywell Durafet
- Water Temperature, Salinity → 14 — Thermosalinograph @ -0.5m — Teledyne RDI Citadel TS-NH
- Marine Mammal Presence → 15 — Passive Acoustic Recorder — Greenridge Sciences Inc. Acousonde
- Fish Biomass, Bathymetry → 16 — WBAT @ -2.5m — SIMRAD EK 80; Multi-beam Sonar @ -2.5m — Norbit iWBMS

WIRED

The Drone That Will Sail Itself Around the World

SAILDRONE

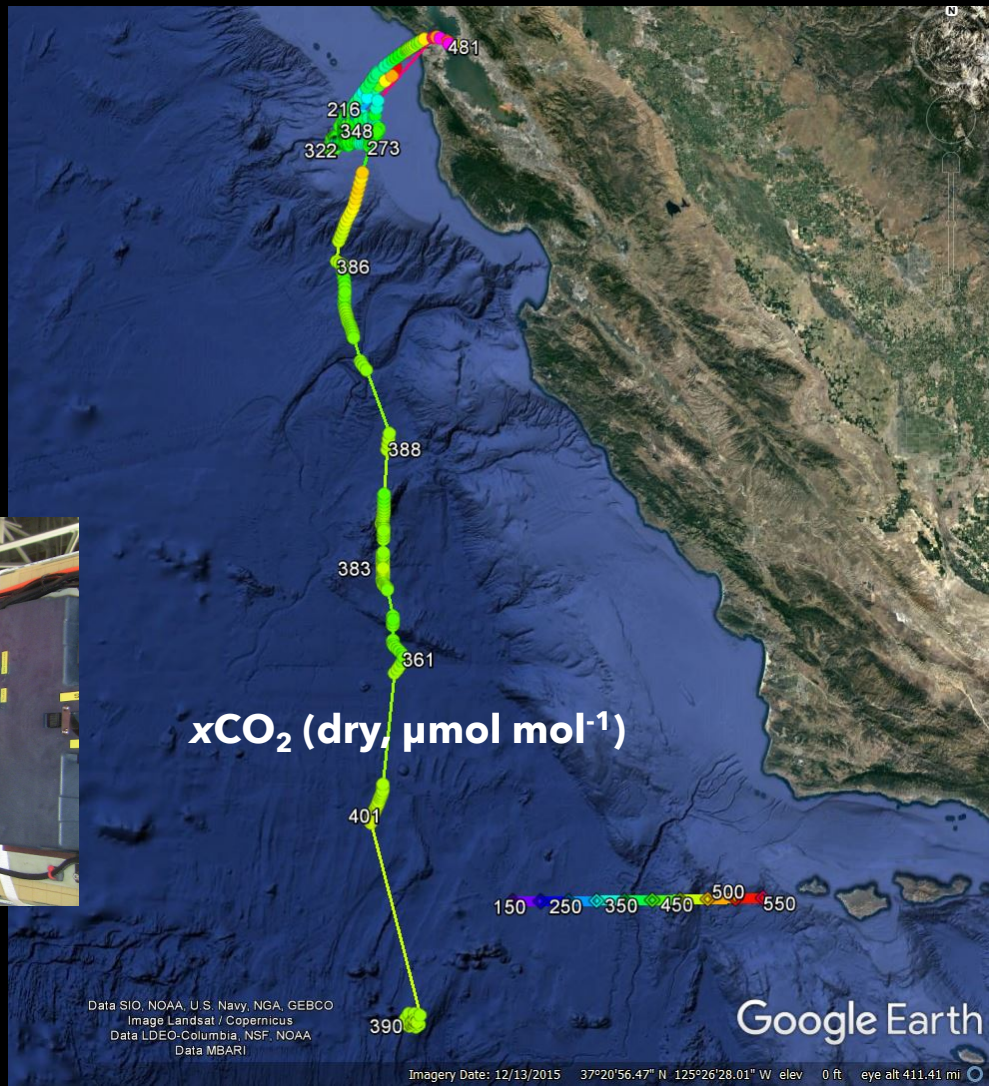
Inc. disruptors 2017

The Most Exciting Drones Aren't in the Air--They're in the Ocean

# Adapting Carbon Sensors

## Autonomous Surface Vehicle $CO_2$ ($ASVCO_2$) system

Photos courtesy of: Saildrone, Inc. and Noah Lawrence-Slavas

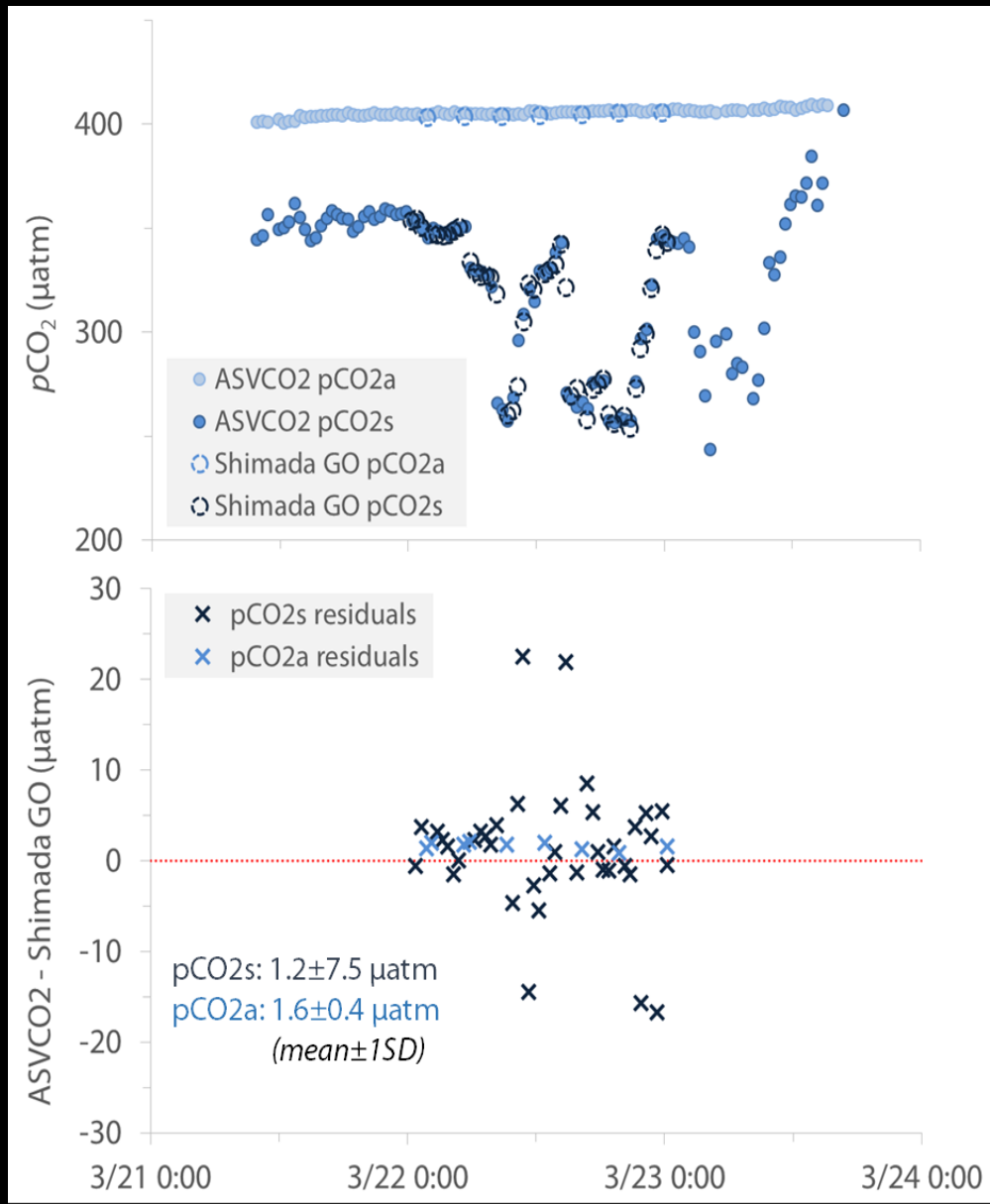


# Saildrone ASVCO2 Field Test

Saildrone ASVCO2 vs. R/V *Shimada* General Oceanics underway $pCO_2$ system

Field test on coastal CA shelf in highly variable seawater $pCO_2$ conditions

Preliminary results from lab and field testing suggest ASVCO2 measurement errors are comparable to MAPCO2 systems deployed on buoys (< 2 µatm)



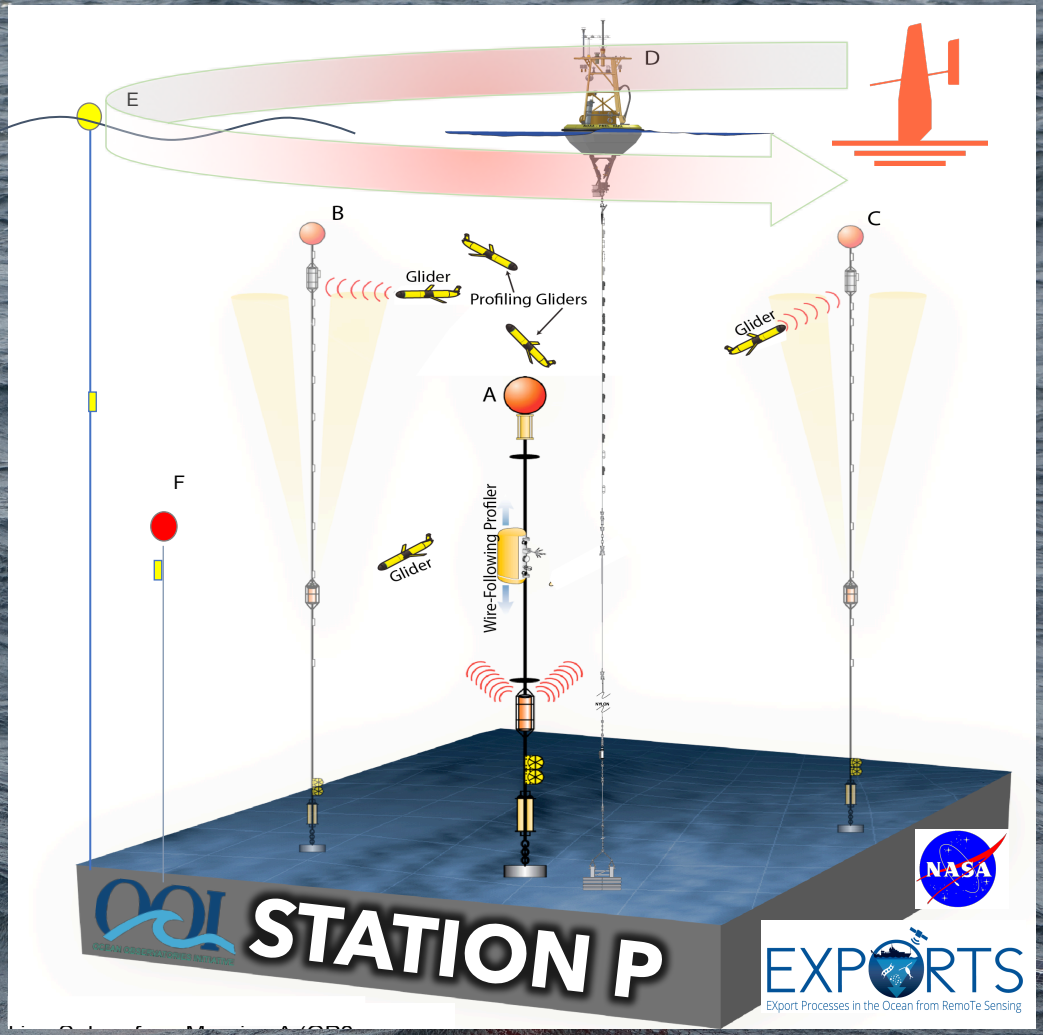
BUILD CONNECT EXPLORE

# Saildrone deployments create new mission capabilities for NOAA.

# BUILD CONNECT EXPLORE

**EXPORTS Goal: To predict the export and fate of ocean Net Primary Production (NPP) from satellite and other observations.**

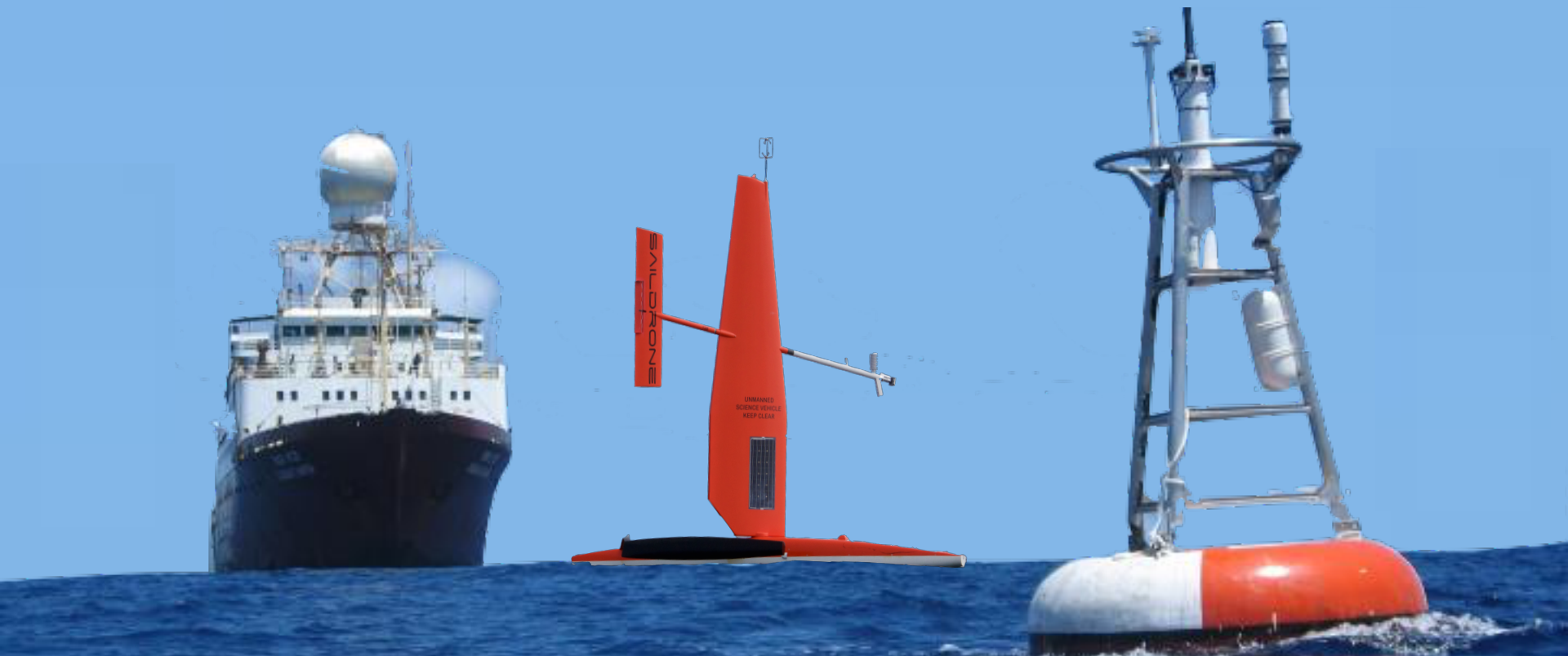
- **Saildrone + ADCP + ASVCO2: How does vertical velocity impact NPP?**

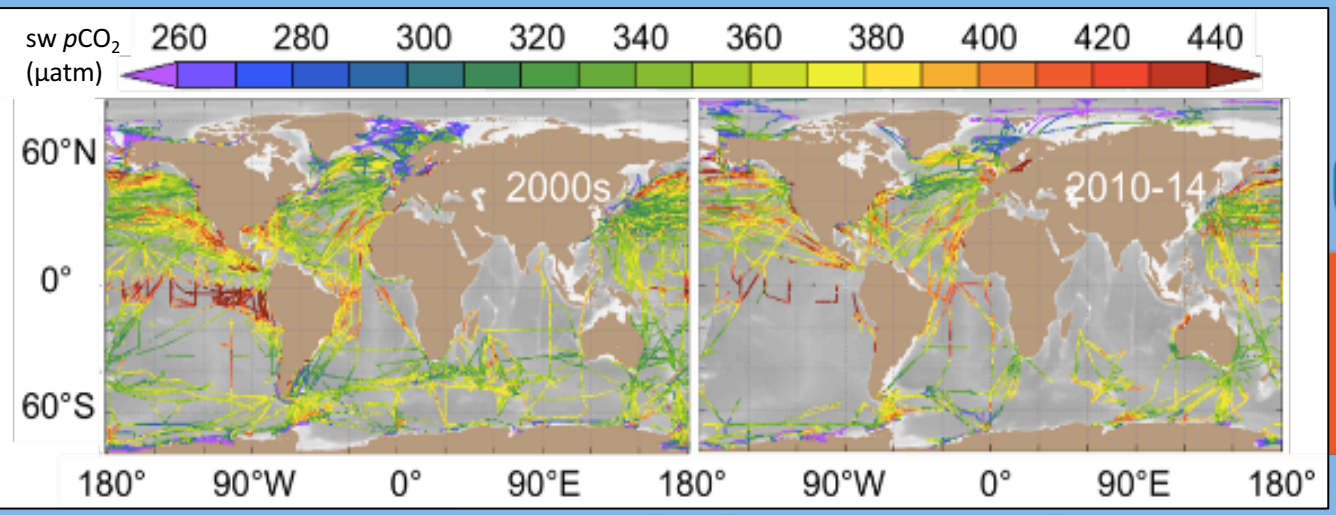


# TPOS 2020

Tropical Pacific Observing System

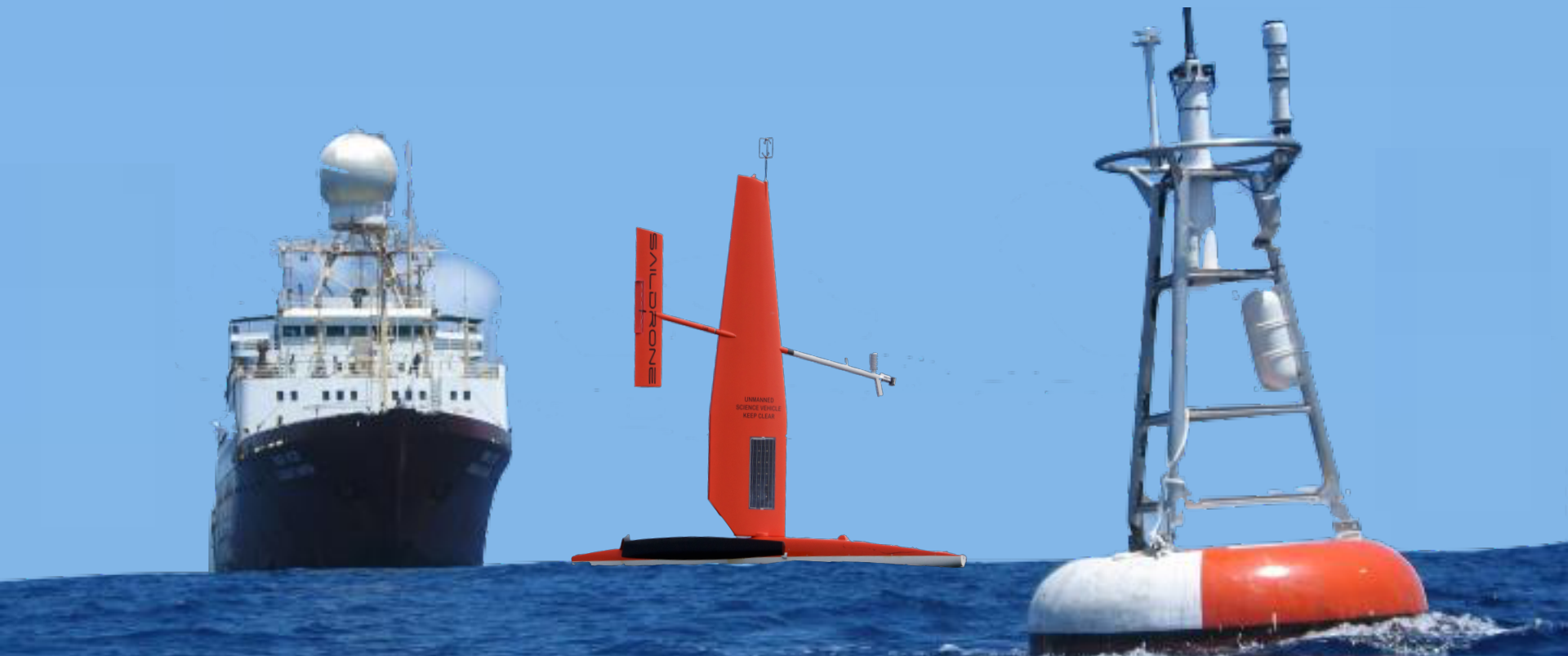
**BUILD** **CONNECT** **EXPLORE**






# Tropical Pacific Observing System 2020

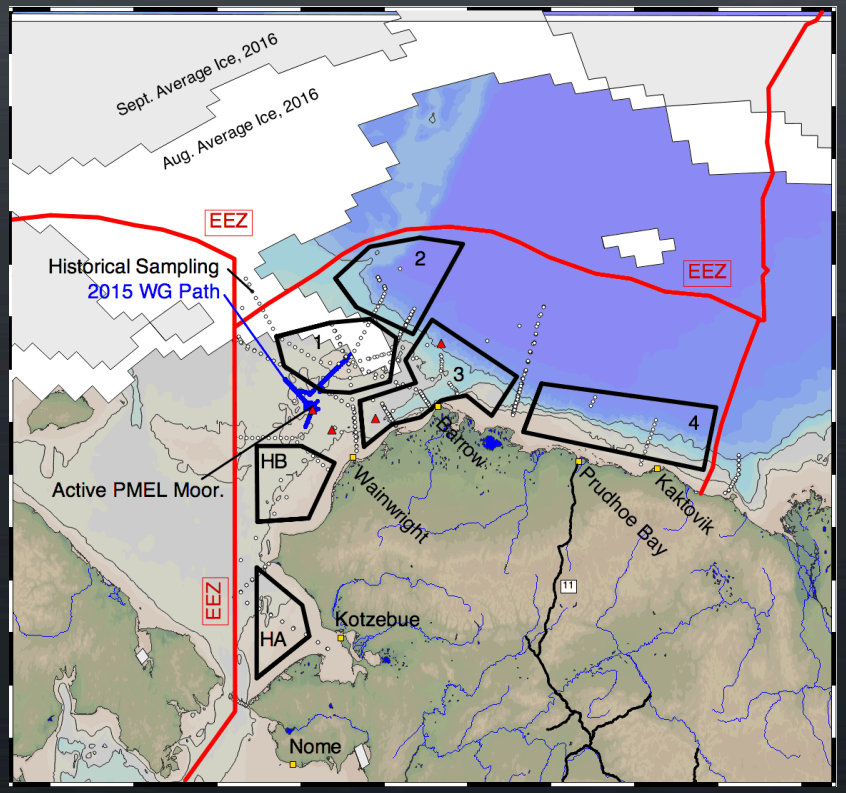
## BUILD CONNECT EXPLORE



ARCTIC PROGRAM

OAP
NOAA OCEAN ACIDIFICATION PROGRAM

# TACTICAL DEPLOYMENT




## BUILD CONNECT EXPLORE

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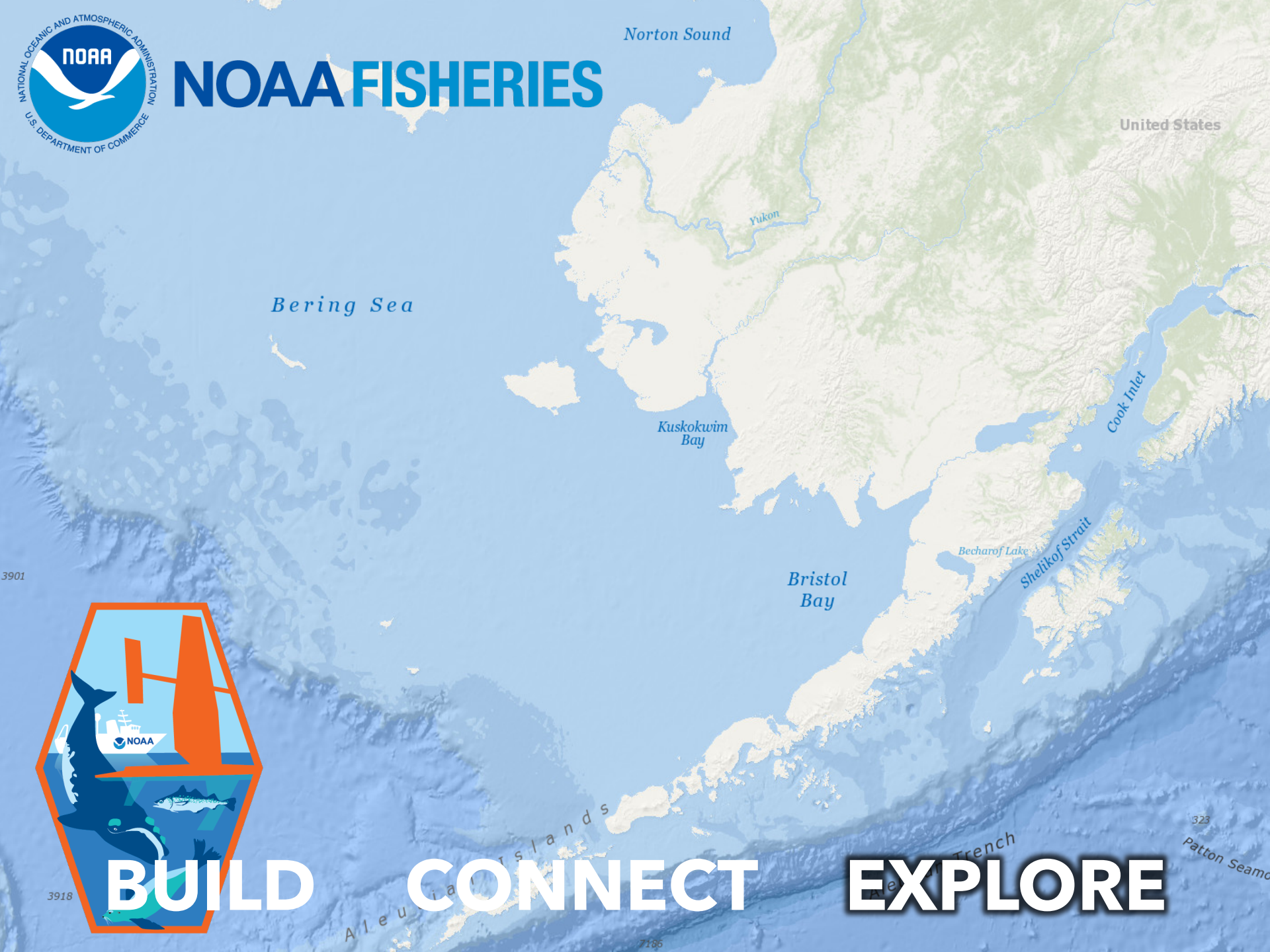
# NOAA FISHERIES


## BUILD CONNECT EXPLORE


NOAA FISHERIES
Norton Sound
United States
Yukon
Bering Sea
Kuskokwim Bay
Cook Inlet
Becharof Lake
Shelikof Strait
Bristol Bay
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NOAA FISHERIES

BUILD CONNECT EXPLORE

NOAA FISHERIES

Norton Sound

Yukon

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Aleutian Islands

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SAILDRONE

**Sandlin Seguin** ▸ **Jessica Cross**
5 mins ·

As a scientist who has also sent unmanned probes into arctic waters, I assume that when these results came in, you ran down the hall with a ream of dot matrix paper trailing behind you shouting for all your colleagues to hear "Boaty McBoatface is back!" while they cheered. If any part of my story isn't true, please don't tell me.


**Boaty McBoatface Makes Its Triumphant Return, Hauling 'Unprecedented Data'**

The curiously named submersible wrapped up its inaugural voyage last week. And, as the British Antarctic Survey noted Wednesday, Boaty acquitted itself well on...

NPR.ORG

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## Future Projects:

- ***Export Fluxes***
- ***Ocean Acidification***
- ***Subsurface!***

OCB Ocean Carbon & Biogeochemistry

*Collister et al- LiDAR for particles*
*Mawji et al- Microfluidic carbonate*

ITAE Innovative Technology for Arctic Exploration

NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

PMEL Pacific Marine Environmental Laboratory

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