

Stone Soup & Christmas Trees A story of Station Papa

Meghan Cronin (NOAA PMEL) with contributions from the **Ocean Climate Stations group at PMEL** (N. Anderson, P. Berk, K. Kohlman, D. Zhang), the **PMEL Carbon Group** (A. Sutton), **UW APL Wave & Acoustics** (J. Thomson, J. Yang), **PMEL Acoustics** (R. Dziak), **PMEL Engineering** (N. Lawrence-Slavas, S. Stalin), **Canadian DFO Line P Program** (M. Robert), and **OOI Papa global node team** (J. Edson, A. Pleuddemann),



Original PIs for Station Papa project in 2007



NOAA PMEL Ocean Climate Station group in 2023

The Mission of OCS (Ocean Climate Stations)

...is to make long time series and high resolution meteorological and oceanic measurements to improve satellite products and forecast models, and to improve our understanding of air-sea interactions and their role within the climate system.

<https://www.pmel.noaa.gov/OCS>





2021
2030
United Nations Decade
of Ocean Science
for Sustainable Development

Observing Air-Sea Interactions Strategy (OASIS)

Decade Programme

Lead Institution

SCOR Working Group #162 for developing OASIS

Contact
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info@airseaobs.org

KEY PARTNERS

- Global Ocean Observing System (GOOS)
- Capacity Development through Surface Ocean and Lower Atmosphere Study (SOLAS) Summer Schools, Ocean Corp and EquiSea
- OceanPredict and Marine Life 2030
- UCAR Center for Ocean Leadership

DECADE CHALLENGES ADDRESSED

CHALLENGE 7: Expand the Global Ocean Observing System

CHALLENGE 8: Create a digital representation of the Ocean

CHALLENGE 9: Skills, knowledge and technology for all

OCEAN BASINS

North Atlantic	Indian
South Atlantic	Arctic
North Pacific	Southern
South Pacific	

 @CroninMF
#airseaobs



Summary

Air-sea exchanges of energy, moisture, and gases drive and modulate the Earth's weather and climate, influencing life, including our own. Air-sea interactions affect the distribution of carbon dioxide between the atmosphere and ocean, how seawater flows and winds blow, and how pollutants floating on the ocean surface move – information critical to policymakers, industry, and civil society. The Observing Air-Sea Interactions Strategy (OASIS) Programme brings together the vast community of researchers, stakeholders, and experts on air-sea interactions to harmonize observational strategies and develop a practical, integrated approach to observing air-sea interactions through capacity development, and leveraging of multi-disciplinary activities. OASIS will work with partners around the world to build a truly global air-sea interactions observing system that will provide transformative observational-based knowledge to fundamentally improve weather, climate, and ocean predictions, and promote healthy oceans, the blue economy, and sustainable food and energy.

Duration: 01/11/2021 - 31/12/2030

Priority Activities (first 2 years)

OASIS Priority Activities are organized within 5 Theme Teams:

- 1) Observing Network Design & Model Improvements
- 2) Partnership & Capacity Strengthening
- 3) UN Decade of Ocean Science Actions
- 4) Best Practice & Interoperability Experiments
- 5) FAIR Data, Models, & OASIS Products

To join one or more of these Theme Teams, please go to airseaobs.org/get-involved

"Earth is a water world and through the OASIS Programme we will work together to better understand, observe and predict how the ocean and atmosphere interact. OASIS will not only improve forecasts of weather and climate fueled by ocean heat and moisture, but also make it possible to track how much carbon dioxide is absorbed by the ocean."

Dr. Meghan Cronin, Oceanographer at NOAA and Co-chair of the Scientific Committee on Ocean Research (SCOR) Working Group #162 for developing an OASIS

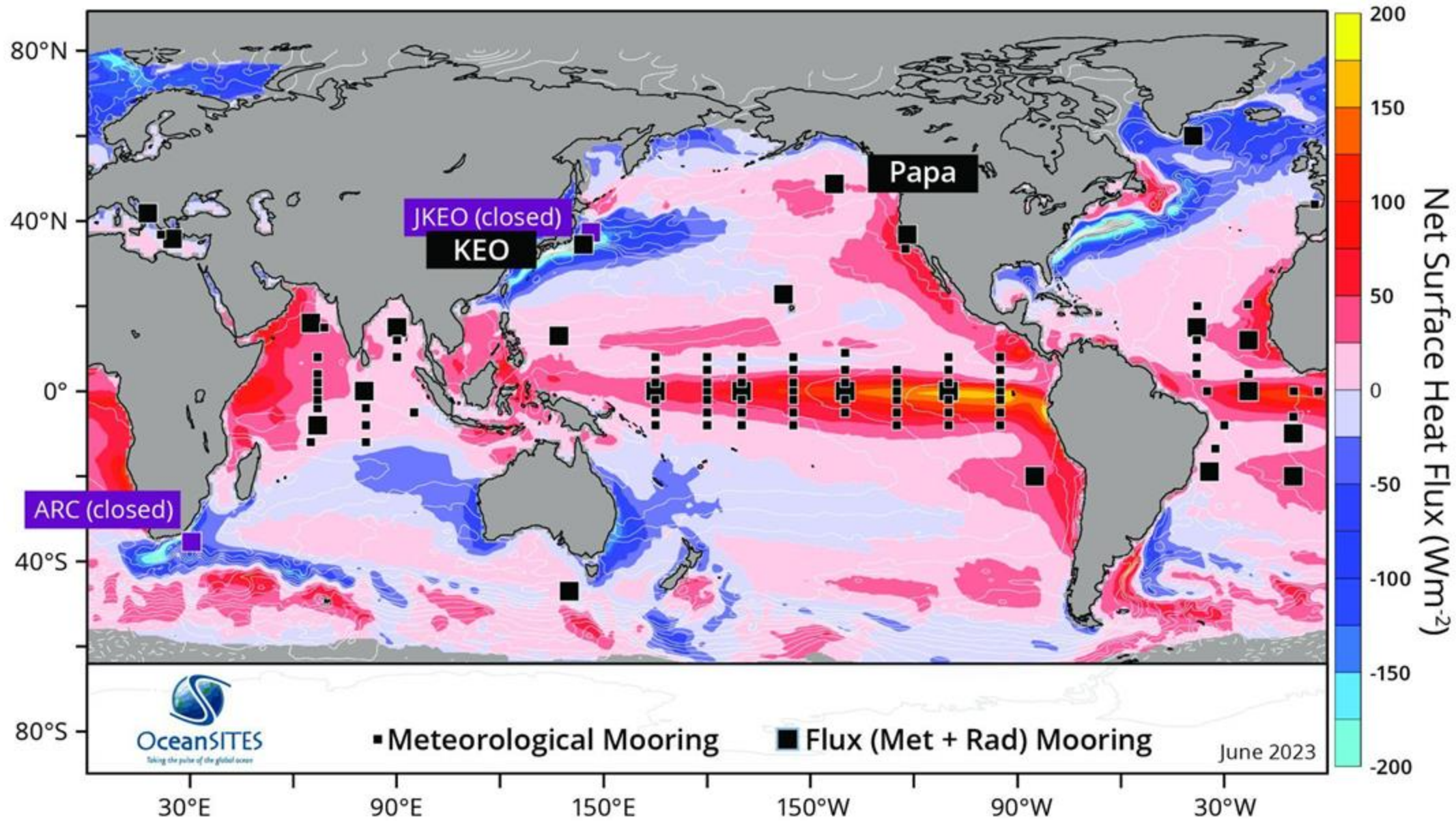
airseaobs.org

The Mission of OASIS

(Observing Air-Sea Interactions Strategy)

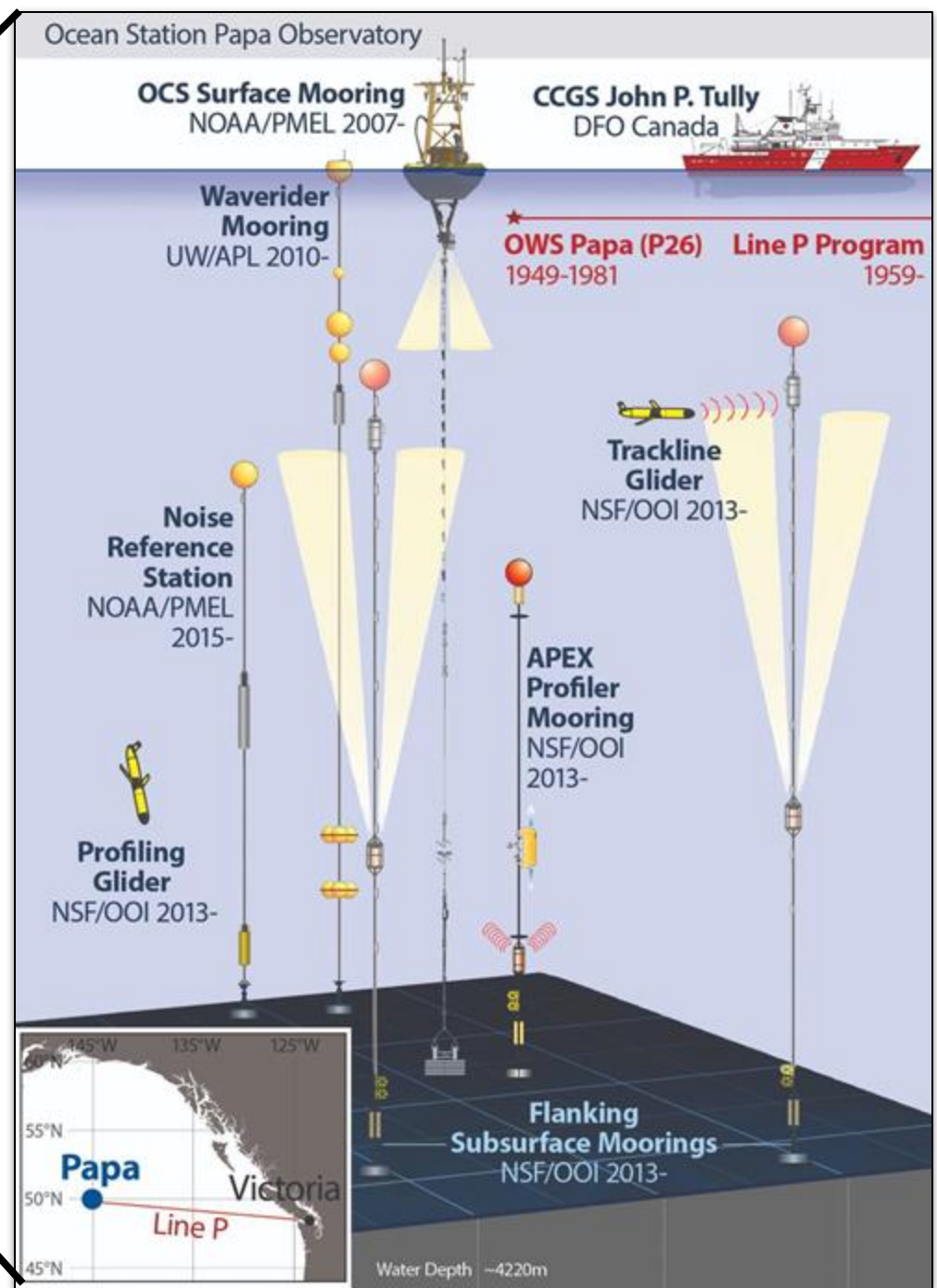
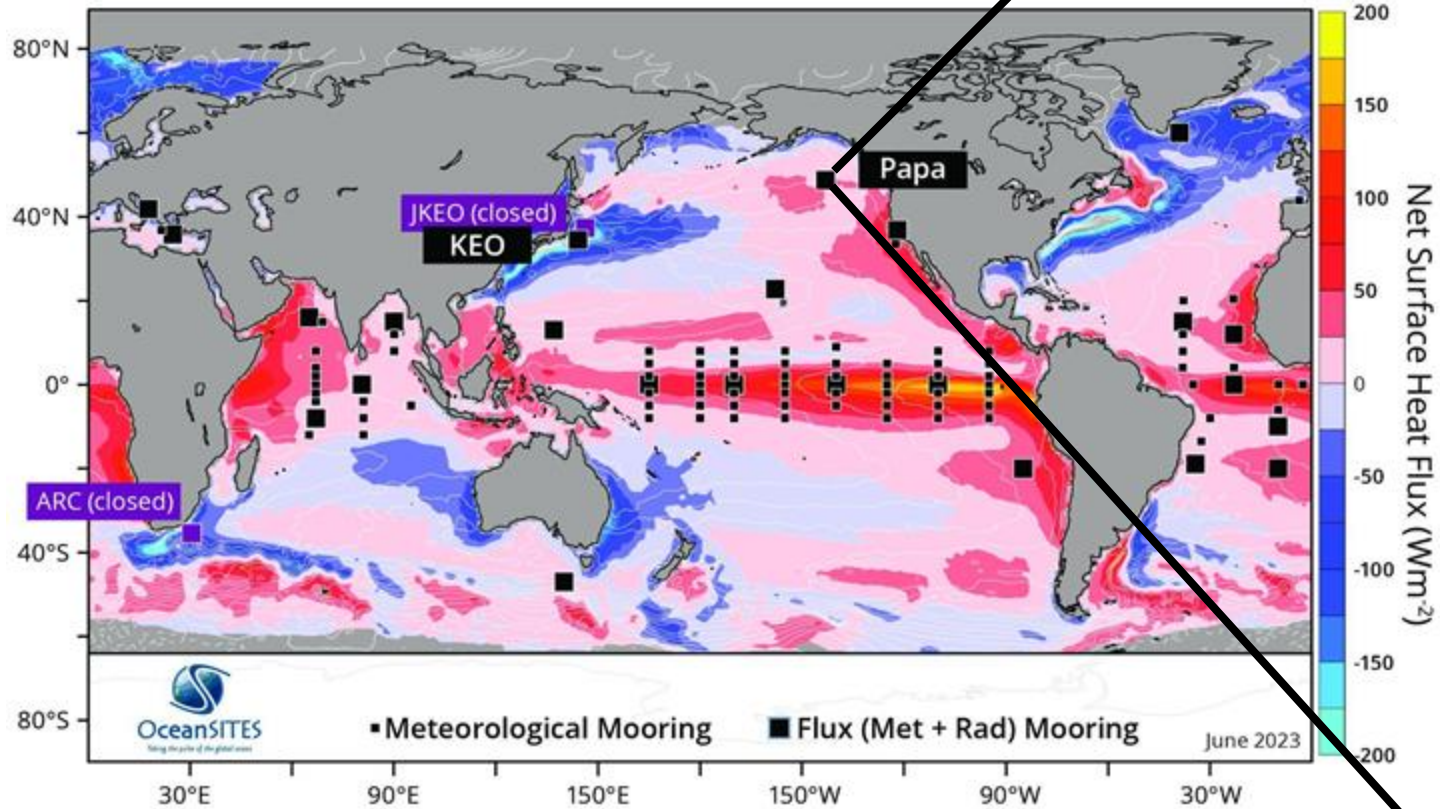
...is to develop a practical, integrated approach to observing air-sea exchanges associated with the Energy, Water, Carbon and Life Cycles

<https://airseaobs.org/get-involved>



Cronin et al. (2023) Figure 1

Ocean Station Papa Observatory



Cronin et al. (2023) Figure 1 & 3

Ocean Station Papa Observatory

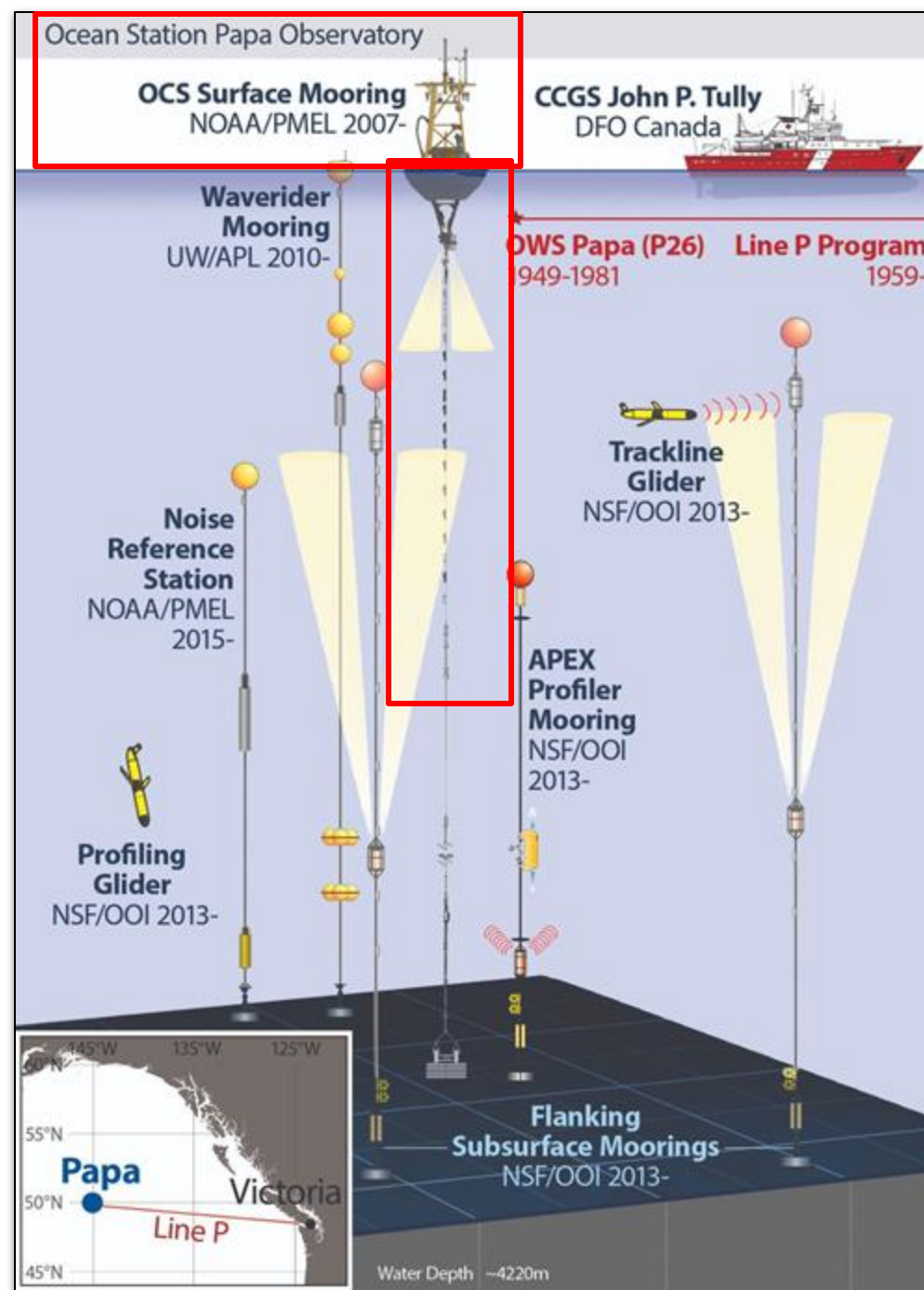
NOAA PMEL's Ocean Climate Station (2007-)
with CO₂ system and Ocean Acidification sensor suite



NOAA PMEL's **Ocean Climate Station** group



Adrienne Sutton
(Carbon Group)





OCS Website: www.pmel.noaa.gov/ocs/Papa/

All data are freely available and collaborations with OCS are encouraged.

Please let us know about any publication using this data. We will add it to the bibliography!

Ocean Climate Stations
Pacific Marine Environmental Laboratory

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
UNITED STATES DEPARTMENT OF COMMERCE

Search OCS

Home About Us Research **Data** Technology Publications Media

Data

Data Overview
Mooring Data
Computed Fluxes
Partners Data
Data Links
Data Reports

Related

Sensor Specifica...
Sensors used on OCS moorings are listed in the following table, along with th

Sampling Rates
Data from OCS moorings are obtained from three different data collection syst

Measurement Heig...
The tables below describe the nominal heights of meteorological measurements,

Flux Documentati...
Documentation for Calculations of Air-Sea Flux

Mooring Data

KEO (32.3°N, 144.6°E) **Papa (50.1°N, 144.9°W)** ARC (38.5°S, 30°E)

Time Series Profiles Separate Plots Overlay De-Select Variables

Shortwave Radiation Wind Speed Sea Surface Temperature Zonal Current Heat Content
 Longwave Radiation Scalar Wind Speed Temperature Profile Meridional Current Longitude
 Rain Rate Wind Direction Sea Surface Salinity Current Vector Latitude
 Air Temperature Zonal Wind Salinity Profile Zonal ADCP Meridional ADCP
 Relative Humidity Meridional Wind Sea Surface Density Meridional ADCP
 Barometric Pressure Wind Vectors Density Profile Deep SVP

2007 JUN 8 2024 FEB 25 Daily

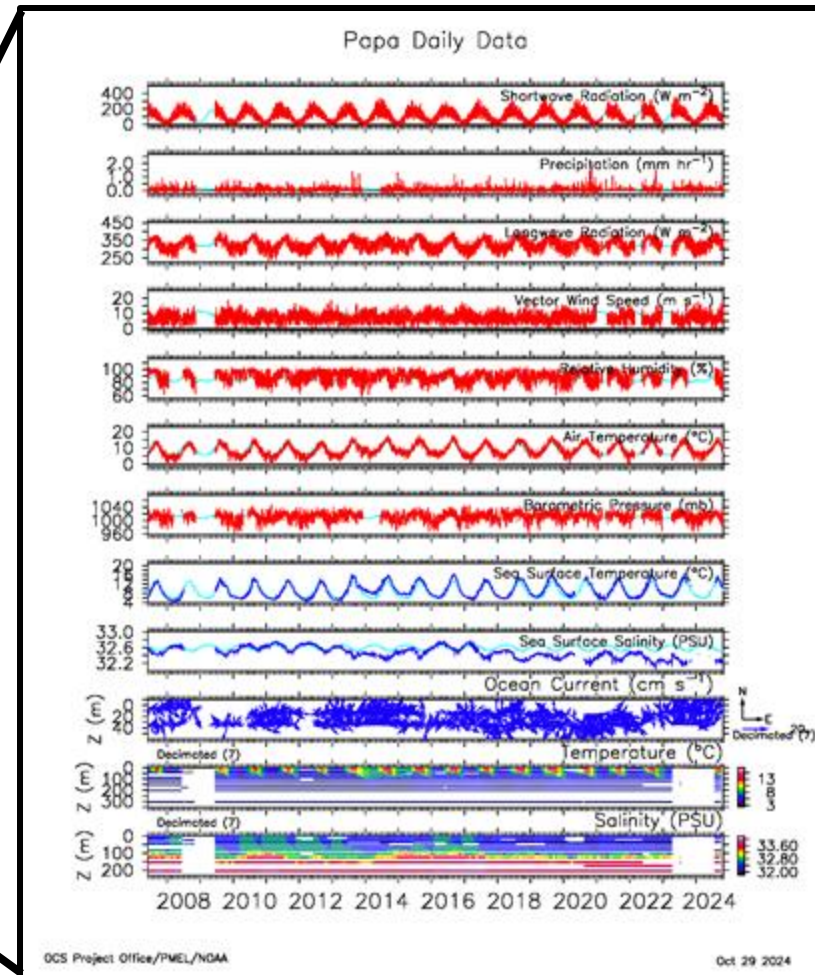
ASCII Compression

Clear Deliver **Display**

Instructions

To view plots or download data from the KEO, Papa and ARC moorings: Click a blue site button to select the mooring, and use the menus to define the time period of interest, and sample rate. Choose observations to display by clicking checkboxes. A gray box indicates that data are unavailable. Availability of observations changes as you change the time range and data frequency. Click the purple Display button to view plots. To deliver data, choose the file type (ASCII or netCDF) and the compression, and then click the red Deliver button. Light blue lines on plots are climatological averages.

Note: Please do not use your browsers 'Back' button. To clear selections click the orange Clear button.



~2,300 (est.) Papa mooring data downloads from OCS website in FY24

12 peer-reviewed science papers published since 2023

Ocean Station Papa Observatory

Ocean Weather Station Papa (1949-1981)

Canadian DFO Line P Program (1956-)



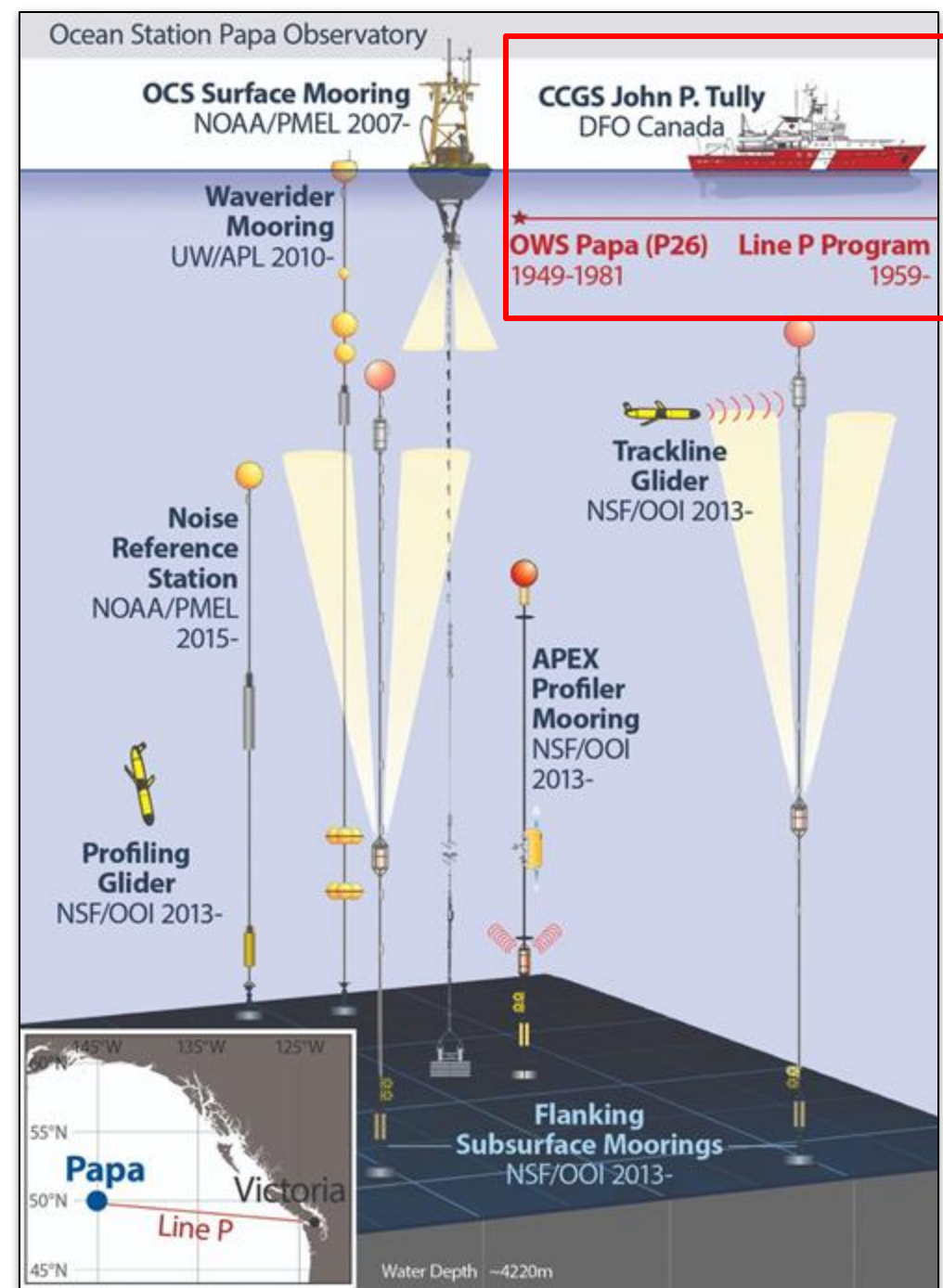
Ocean Weather Ship Papa at 50N, 145W (1949-1981)



Canadian DFO Pacific Oceanographic Group in 1962



The CCGS John P. Tully in May 2003 embarking on trip to Ocean Station Papa



Ocean Station Papa Observatory

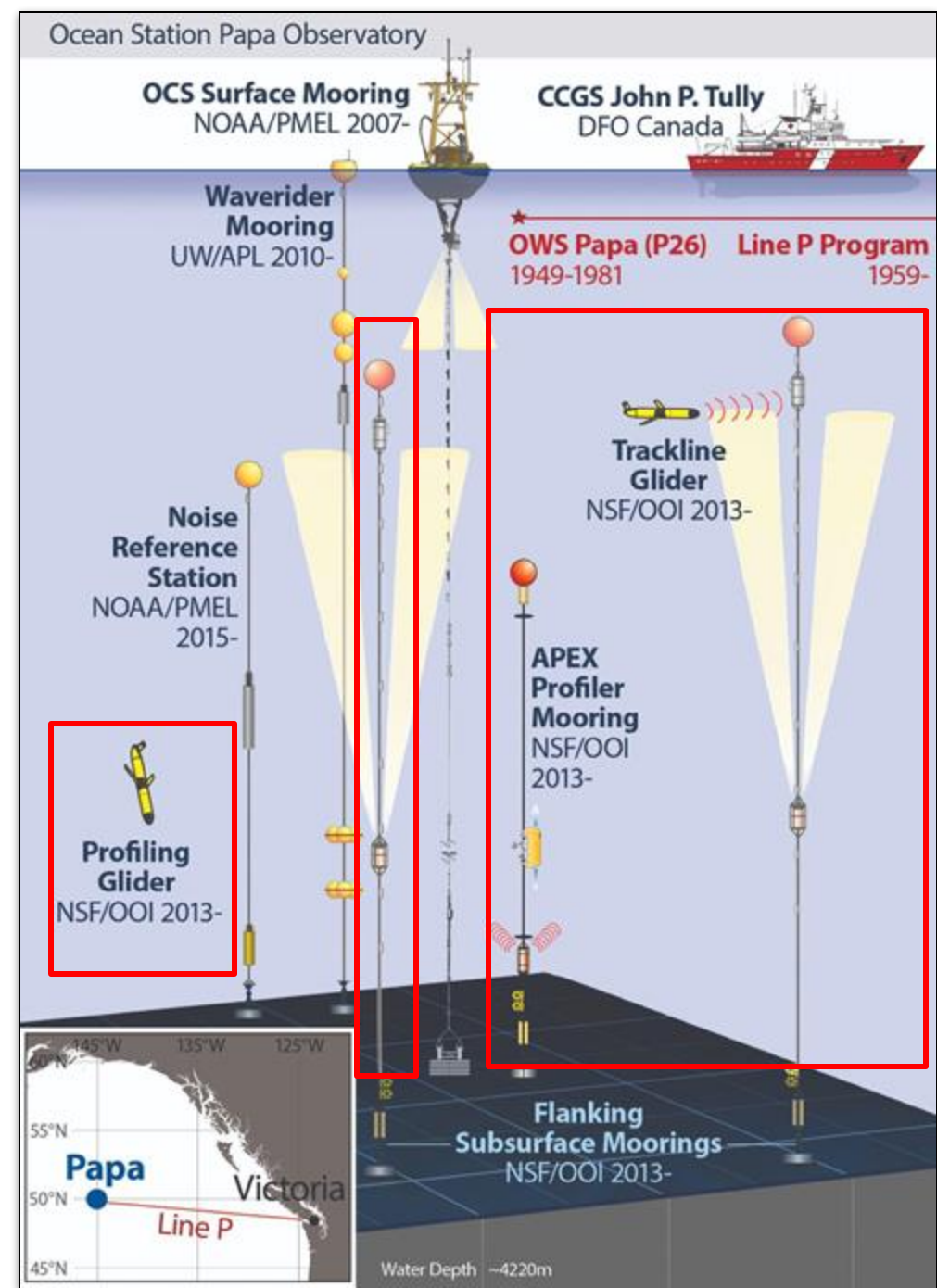
NSF Ocean Observatories Initiative (OOI) (2013-)



Preparation for Station Papa deployment.
Credit: Paul Chua © WHOI.



R/V Sikuliaq returning to Seward Alaska
after successful Station Papa operations.
Credit: Rebecca Travis © WHOI.



Ocean Station Papa Observatory

NOAA PMEL's Noise Reference Station (2015-)

UW APL Passive Acoustic Listening Device (2007-)

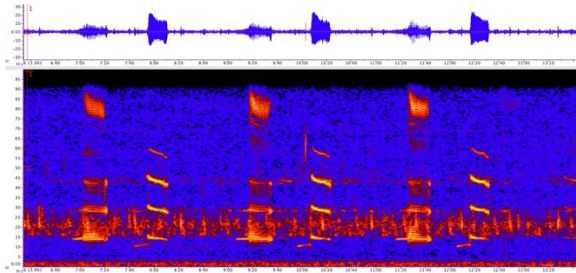


Bob Dziak (NOAA
PMEL Acoustic Group)

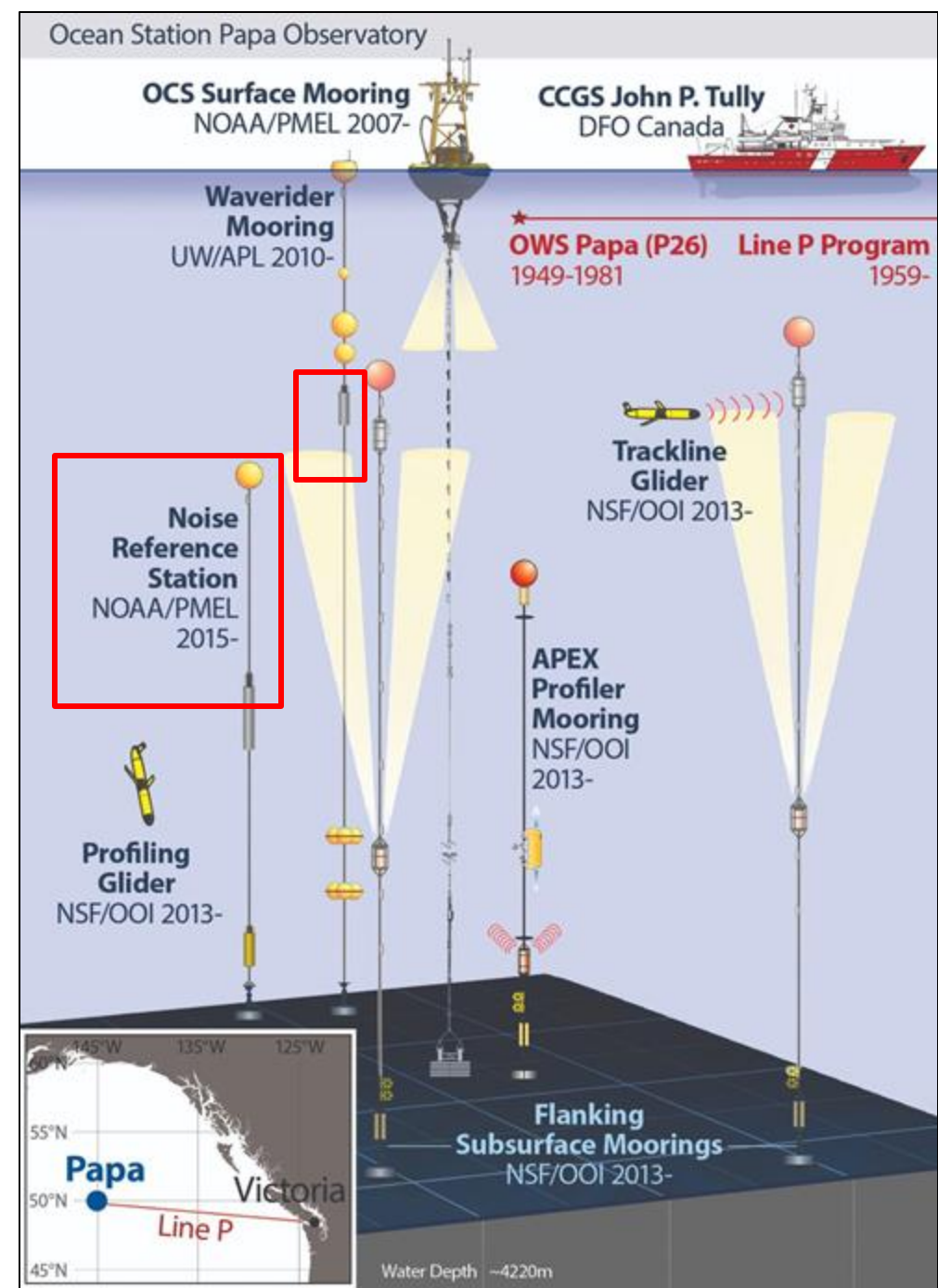


Jie Yang (UW APL)

Blue whale are heard every month of the year at Station P, but peak in summer. Image NOAA Fisheries. Sounds file courtesy Bob Dziak.

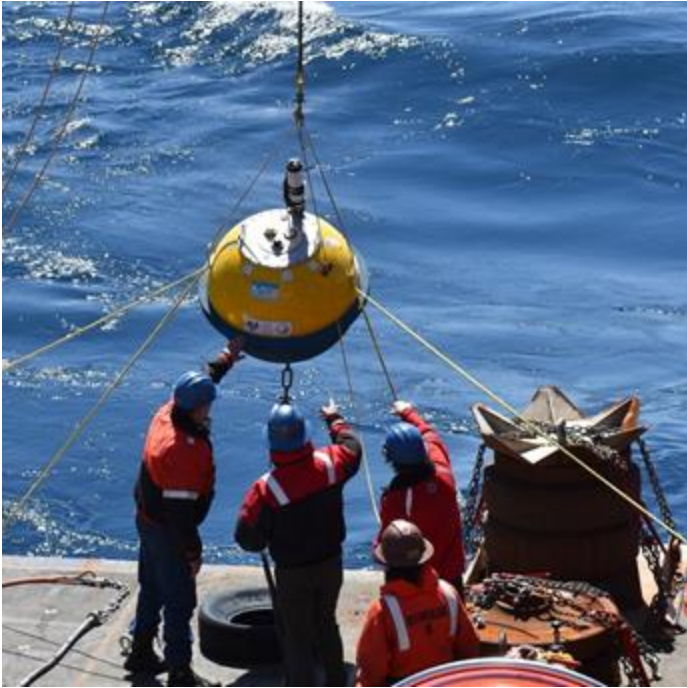


Environmental sounds are being used to monitor wind, rain and impacts of wave breaking by UW APL.



Ocean Station Papa Observatory

UW APL Waverider Mooring (2010-)



Waverider mooring deployment. Photos UW APL.

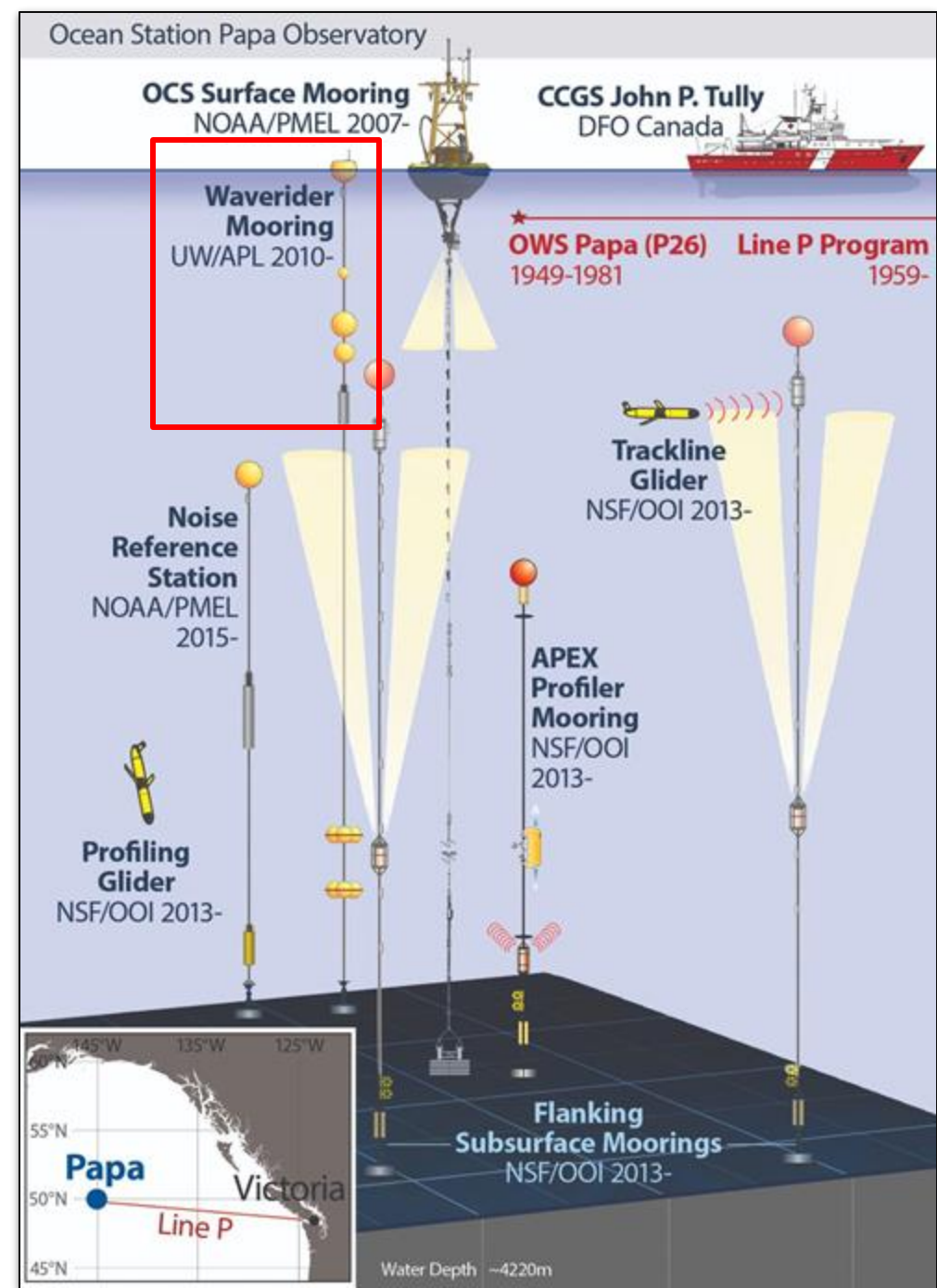


Jim Thomson
(UW APL)

CDIP Monitoring and Prediction of Waves and Shoreline Change

186 - OCEAN STATION PAPA Status: ACTIVE

Date (UTC)	Hs (m)	Tp (s)	Dir (deg)	Ts (s)	SWT (m)
2023-05-01 23:30	7.25	6.25	257	5.87	47.5
2023-05-01 23:00	7.55	6.87	257	5.88	47.5
2023-05-01 22:30	7.84	7.69	272	5.93	47.5
2023-05-01 22:00	7.58	6.87	261	5.82	47.5
2023-05-01 21:30	7.25	7.69	274	5.75	47.5
2023-05-01 21:00	7.51	7.68	276	5.88	47.5
2023-05-01 20:30	7.25	7.69	275	6.08	47.5
2023-05-01 20:00	7.09	5.88	267	5.95	47.5
2023-05-01 19:30	7.26	7.14	270	6.11	47.3
2023-05-01 19:00	7.22	9.09	278	5.86	47.3
2023-05-01 18:30	7.22	7.69	268	6.05	47.3
2023-05-01 18:00	6.96	6.25	265	5.89	47.3
2023-05-01 17:30	6.82	9.09	270	6.20	47.3
2023-05-01 17:00	6.89	6.87	267	6.16	47.3
2023-05-01 16:30	6.50	10.53	265	6.20	47.3
2023-05-01 16:00	6.89	7.14	267	6.21	47.3
2023-05-01 15:30	6.73	9.09	267	6.18	47.3
2023-05-01 15:00	6.79	9.09	277	6.27	47.3
2023-05-01 14:30	6.46	8.88	277	6.23	47.3
2023-05-01 14:00	6.33	9.09	274	6.18	47.3
2023-05-01 13:30	6.46	8.88	272	6.62	47.3
2023-05-01 13:00	6.33	9.09	277	6.18	47.3
2023-05-01 12:30	6.40	10.53	275	6.24	47.3
2023-05-01 12:00	6.36	8.33	282	6.53	47.3
2023-05-01 11:30	6.04	9.09	278	6.28	47.5
2023-05-01 11:00	6.10	10.53	272	6.31	47.5

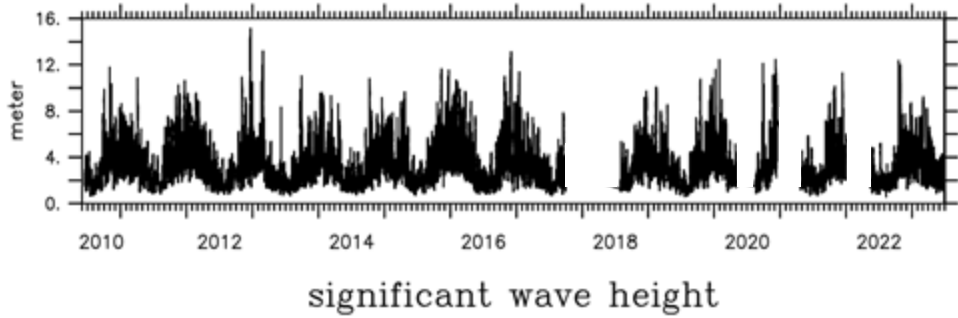


Ocean Station Papa Observatory

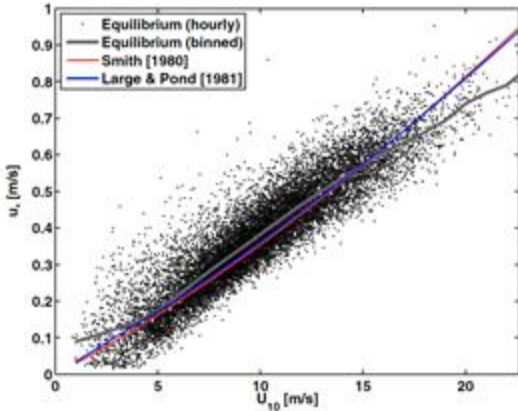
UW APL Waverider Mooring (2010-)



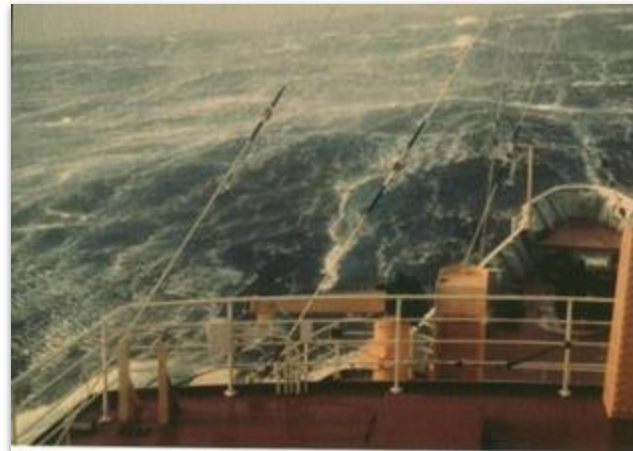
Jim Thomson
(UW APL)



Wind*, est. from Waves



Winds Measured by Buoy



BEAUFORT FORCE 10
WIND SPEED: 48-55 KNOTS

SEA: WAVE HEIGHT 9-12.5M (29-41FT), VERY HIGH WAVES WITH LONG OVERHANGING CRESTS, THE RESULTING FOAM, IN GREAT PATCHES, IS BLOWN IN DENSE WHITE STREAKS ALONG WIND DIRECTION. ON THE WHOLE, SEA SURFACE TAKES A WHITE APPEARANCE, TUMBLING OF THE SEA IS HEAVY AND SHOCK-LIKE, VISIBILITY AFFECTED.

An old idea backed by modern data

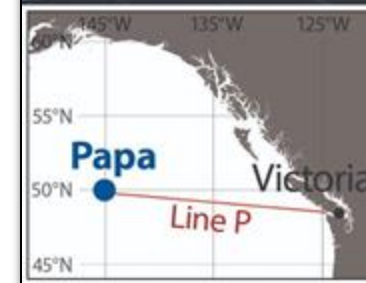
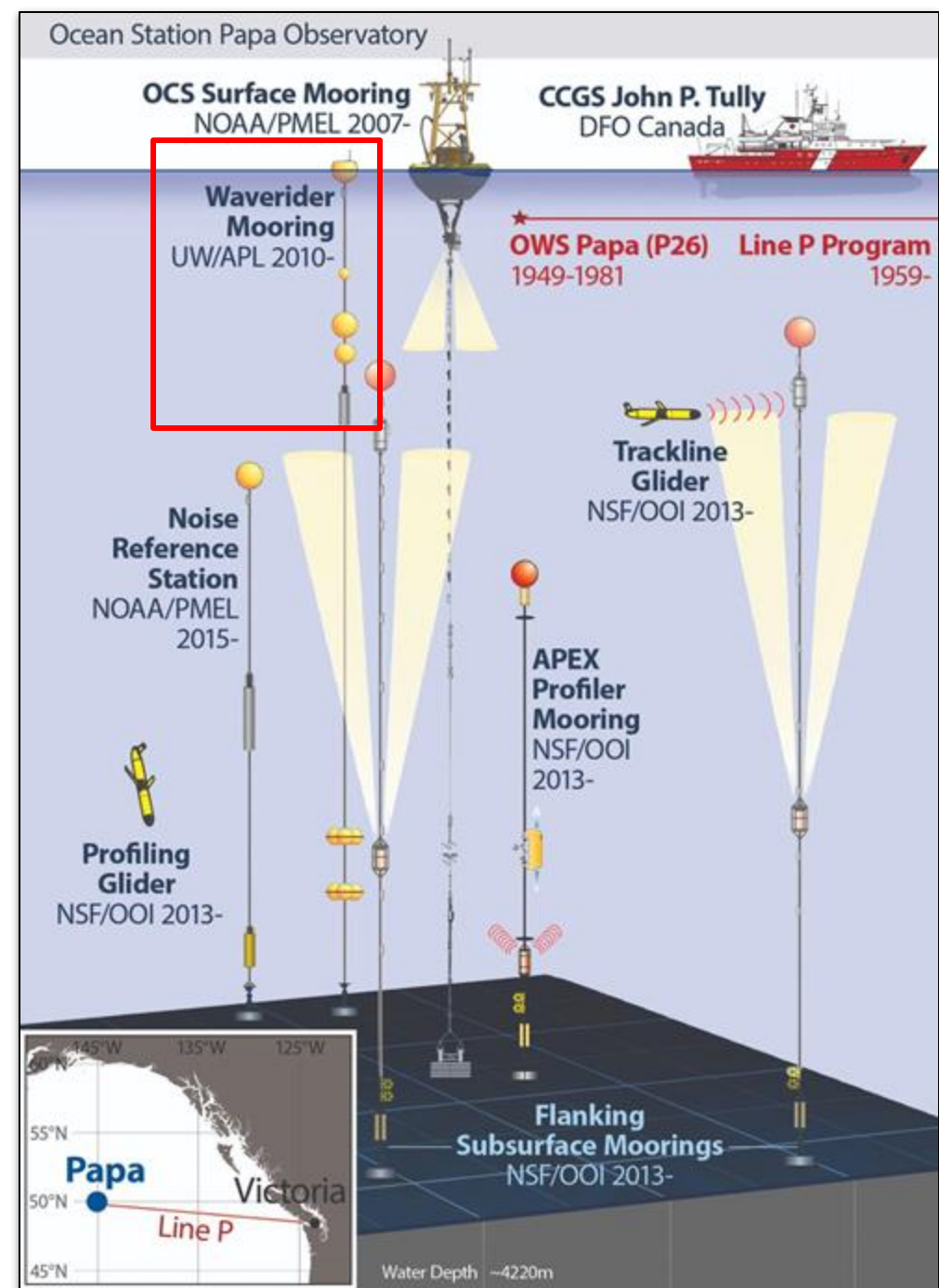
JGR Oceans Published in 2013

Regular Article | Free Access

Waves and the equilibrium range at Ocean Weather Station P

J. Thomson, E. A. D'Asaro, M. F. Cronin, W. E. Rogers, R. R. Harcourt, A. Shcherbina

First published: 08 October 2013 | <https://doi.org/10.1002/2013JC008837> | Citations: 55



Papa research provides scientific grounding for SOFAR Ocean Technology, Inc. founded in 2016 by Tim Janssen



Tim Janssen, PhD
(SOFAR)

The screenshot shows the SOFAR website homepage. At the top left is the SOFAR logo. To the right are navigation links: Sofar Approach, Wayfinder, Spotter Platform, Updates, Support, and a blue 'Get in Touch' button. Below the navigation is a horizontal menu with tabs: Key Features, Surface, Subsurface, Customizable, Dashboard, API, and Data Access. The main content area features four columns, each with an image and a benefit description:

- Connected:** Image of a yellow and black Spotter buoy on the water. Description: Use the Spotter Dashboard and API to access real-time data sent via satellite and cellular and stored in the cloud. Two-way communication reduces downtime and enables over-the-air firmware updates.
- Scaleable:** Image of a woman in a hat operating a Spotter buoy on a boat. Description: Significantly lower total cost of ownership compared to traditional platforms. Deploy Spotters at scale to maximize the spatial density of observational networks.
- Rapidly Deployable:** Image of a person holding a yellow Spotter buoy on a dock. Description: Easy to deploy by hand without prior experience. Rugged design has enabled thousands of successful deployments from all vessel types.
- Extremely Durable:** Image of a Spotter buoy underwater with a diver nearby. Description: Designed by ocean engineers and scientists and proven to withstand any marine environment, from ice to high latitudes to extreme heat. Operates continuously using a solar rechargeable battery.

High wind event Oct. 18, 2022

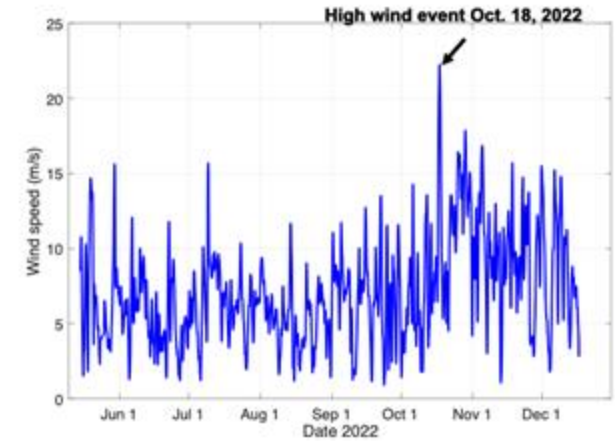
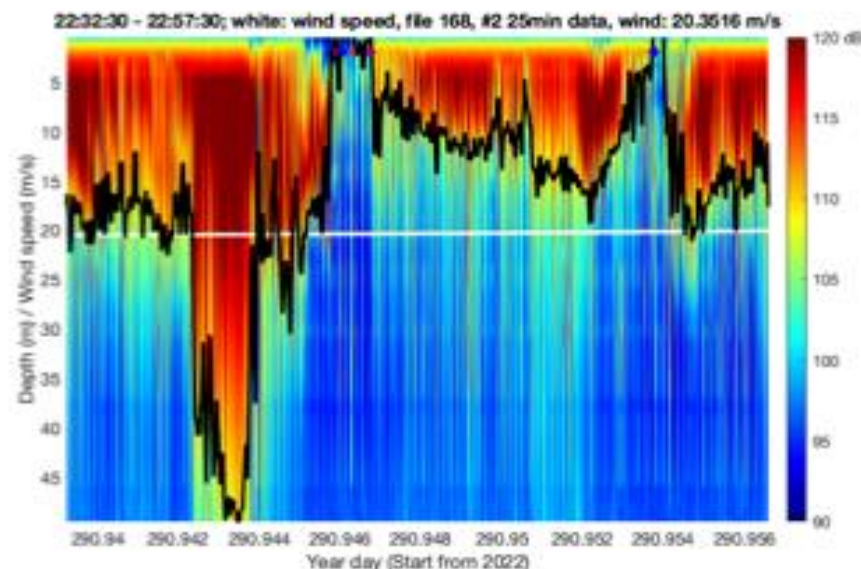
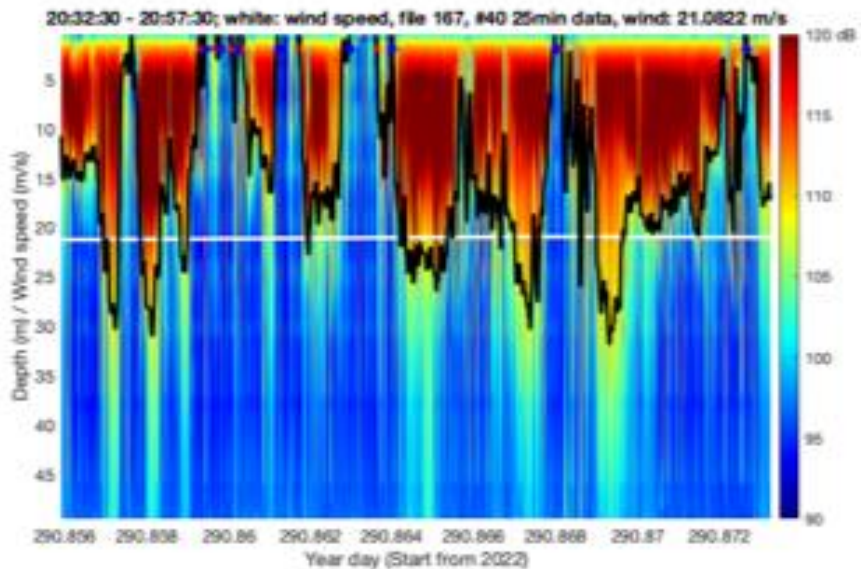
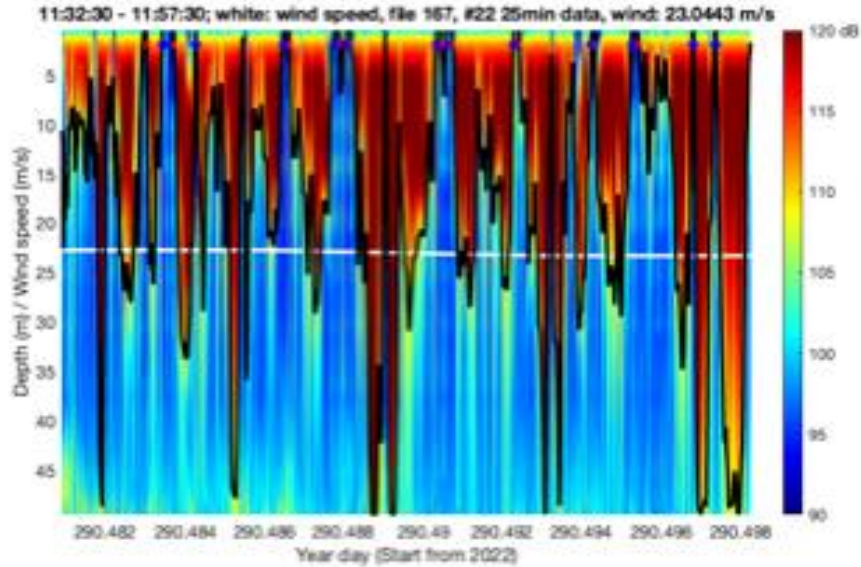
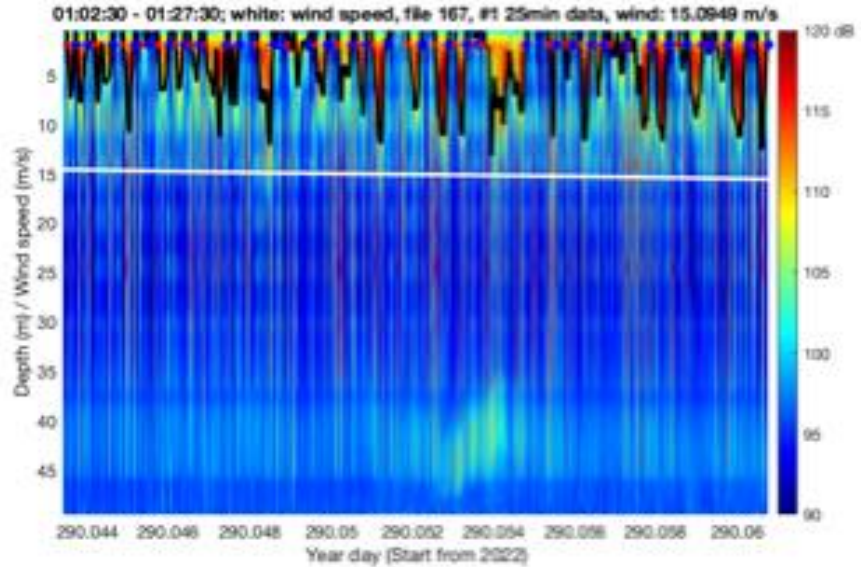
Identifying bubble plume structure using a fixed backscatter strength level

Each frame: 25-min Signature 500 echo data; white curve: wind speed (m/s)



Jie Yang (UW APL)

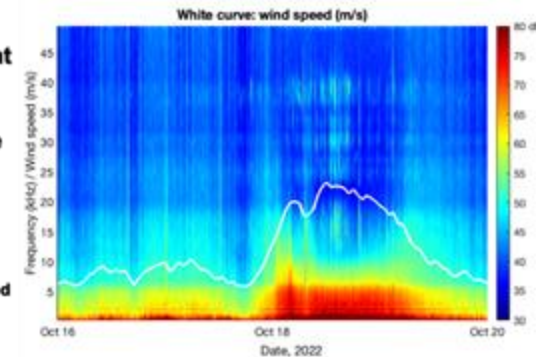
ADCP with echo
sounder
Nortek Signature 500



High wind event
Oct. 18, 2022

Ambient noise
vs
wind speed

Background color:
ambient noise
spectrogram recorded
by PAL



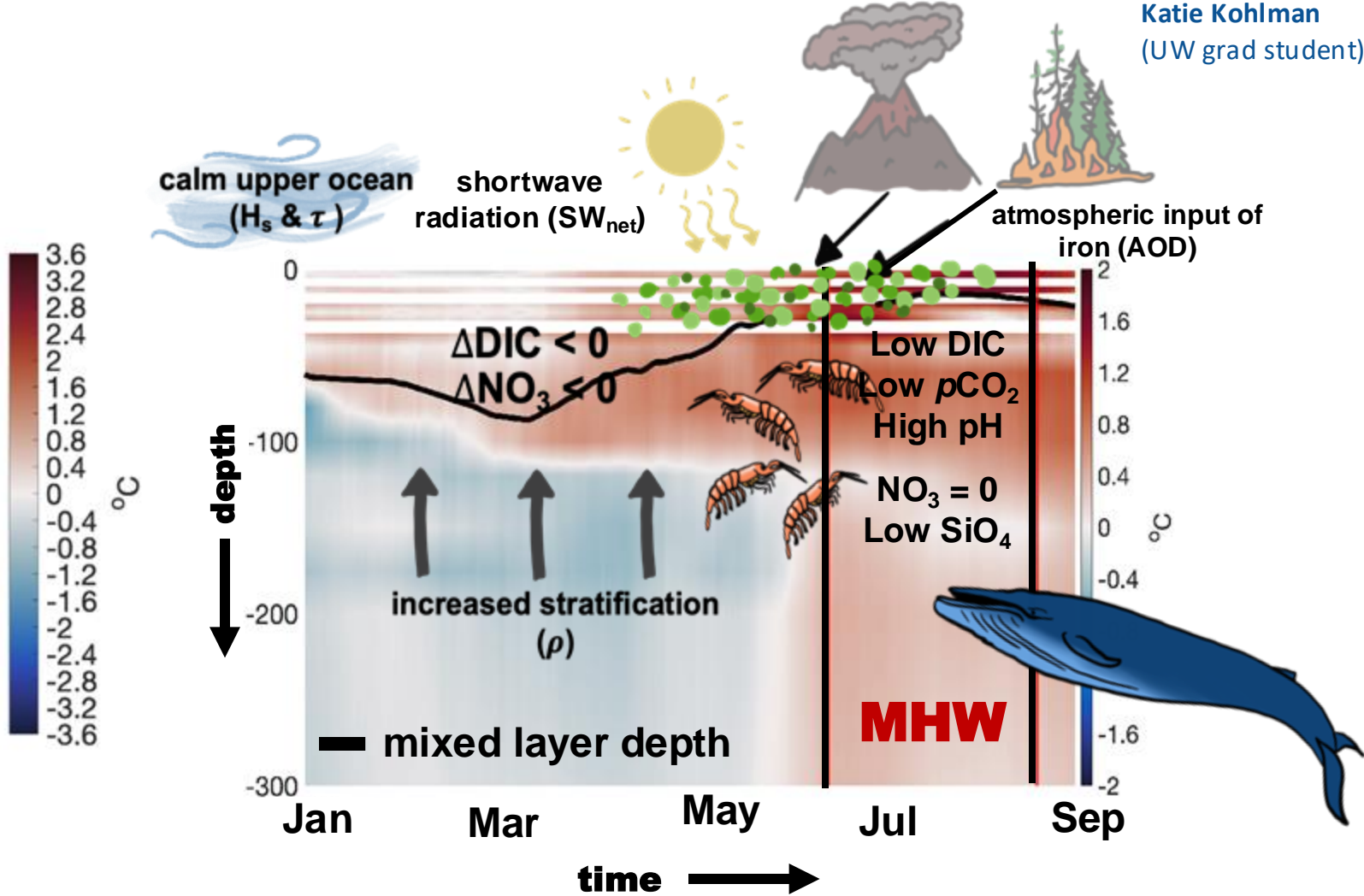
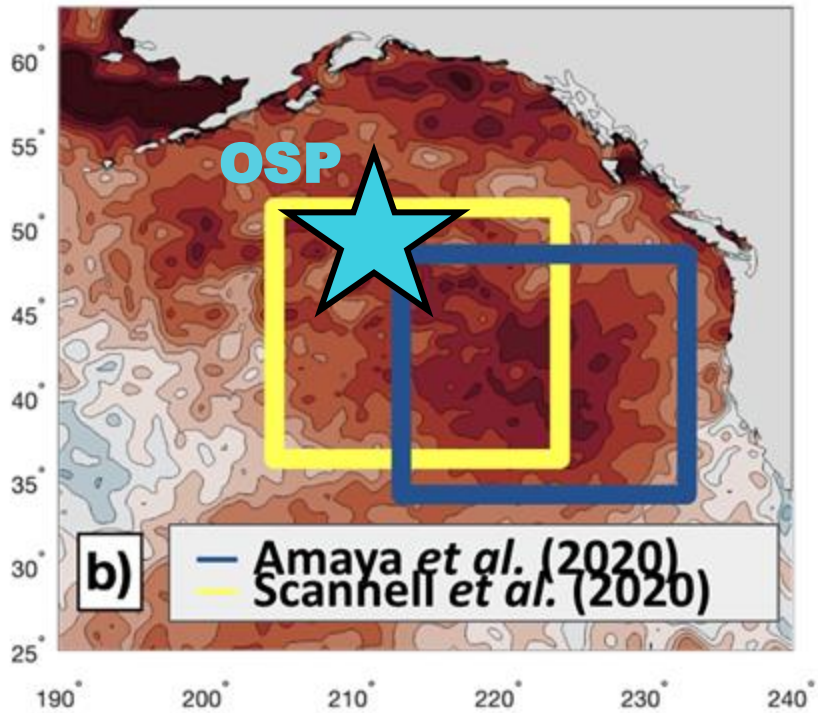
Kohlman et al. (2024): The 2019 marine heatwave at Ocean Station Papa: A multi-disciplinary assessment of ocean conditions and impacts on marine ecosystems



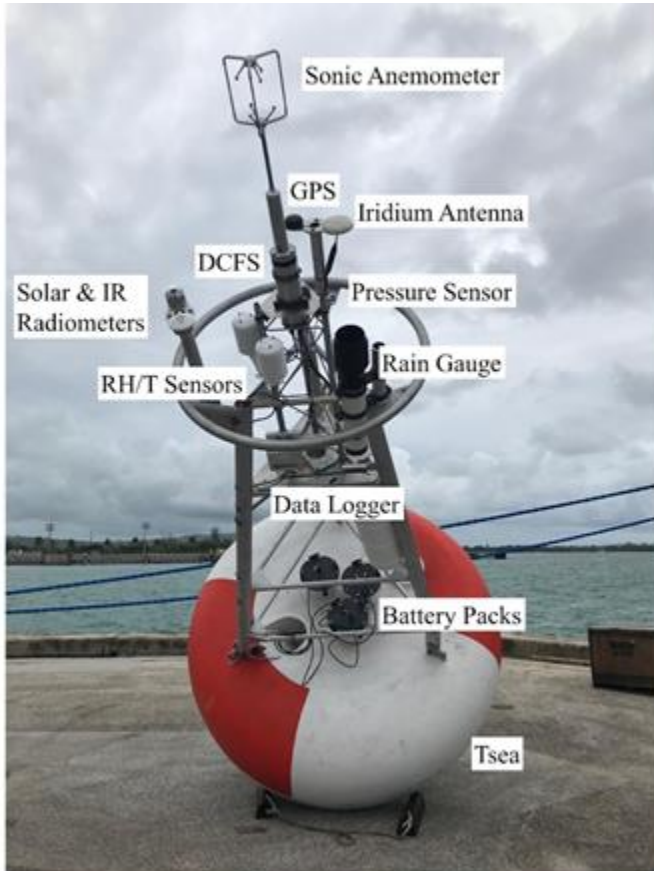
Katie Kohlman
(UW grad student)

2019 MHW or 'Blob2.0'

Jul 2019



WHOI Direct Covariance Flux System (DCFS) Enhancement for PMEL mooring would use similar configuration to what was done during the 2019 Pilot Study



Sensor locations for NDBC TAO buoy in 2019

Pilot Study Deployment

- Date: October 4, 2019
- Location: $0^\circ, 165^\circ\text{E}$

Instrumentation

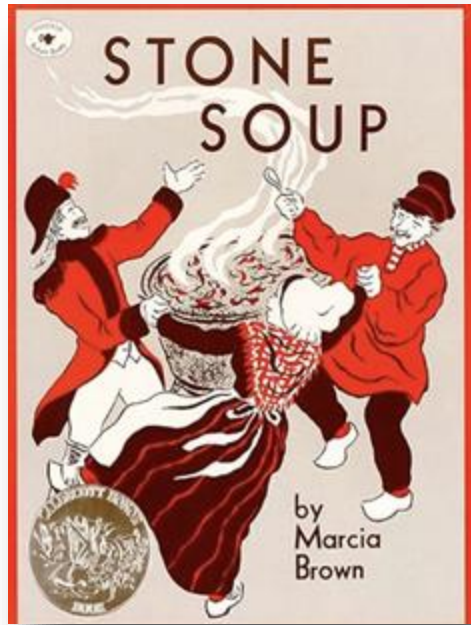
- 3-axis Sonic Anemometer
- 3-axis Motion Package
- Solar and IR Radiometers
- Redundant RH/T_{air} Sensors
- Barometer
- Rain Gauge
- T_{sea} and Salinity Sensor
- GPS (time) and Iridium

Real-time Delivery of

- Direct Covariance Surface Stress and Buoyancy Fluxes
- Radiative Fluxes
- Bulk Momentum, Sensible and Latent Heat Fluxes
- Net Heat Flux
- Waves



On the NOAA OCS Papa mooring, the WHOI DCFS would be placed on ring as a secondary wind system



Stone Soup & Christmas Trees – A story of Station Papa

- NOAA mooring turnarounds on the OOI cruise in 2025?
- OOI direct covariance flux system on the NOAA surface mooring?
- OOI data should be accessible through OceanSITES

About OASIS

Observing Air-Sea Interactions Strategy (OASIS) is harmonizing community recommendations from OceanObs'19 and UN Decade Laboratories into **three Grand Ideas + one Grandest Idea of All**

OASIS Mission is to develop a **practical, integrated approach for observing air-sea exchanges** associated with the Energy, Water, Carbon and **Life Cycles**

OASIS envisions a pathway to Get Involved in Ocean-Atmosphere Interaction Science for Sustainable Development.

www.airseaobs.org/get-involved

OASIS Co-Chairs:
Meghan Cronin (NOAA PMEL, USA), Christa Marandino (GEOMAR, Germany) & Sebastiaan Swart (University of Gothenburg, Sweden)
SCOR Working Group #162 & OASIS community

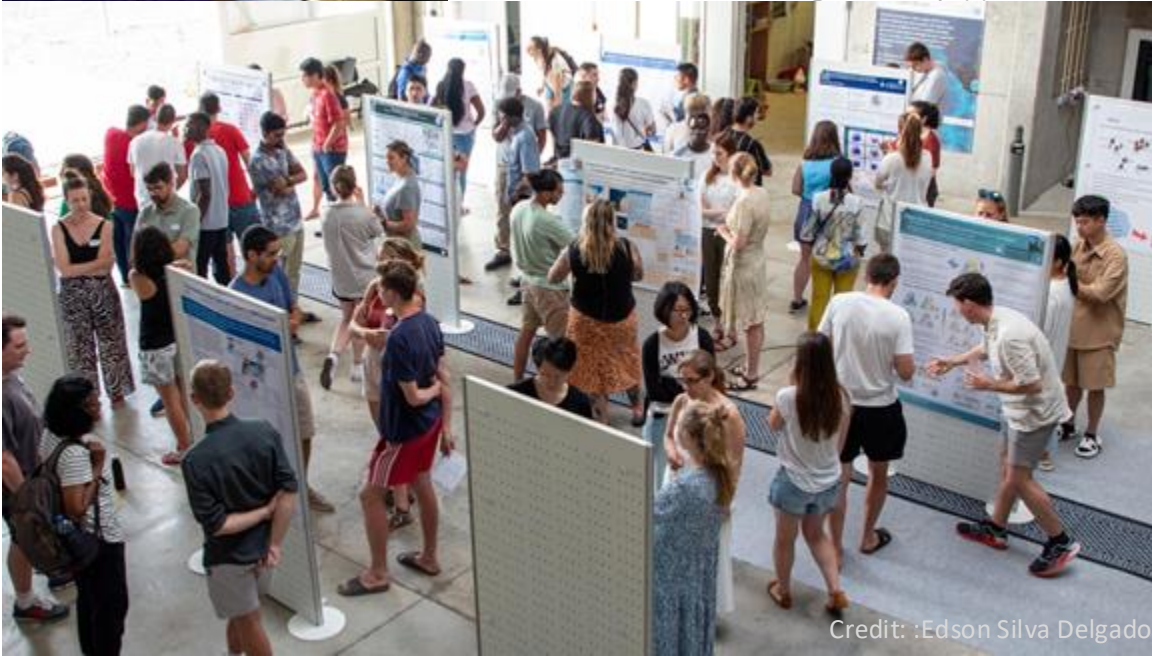
From Cronin et al. (2023)



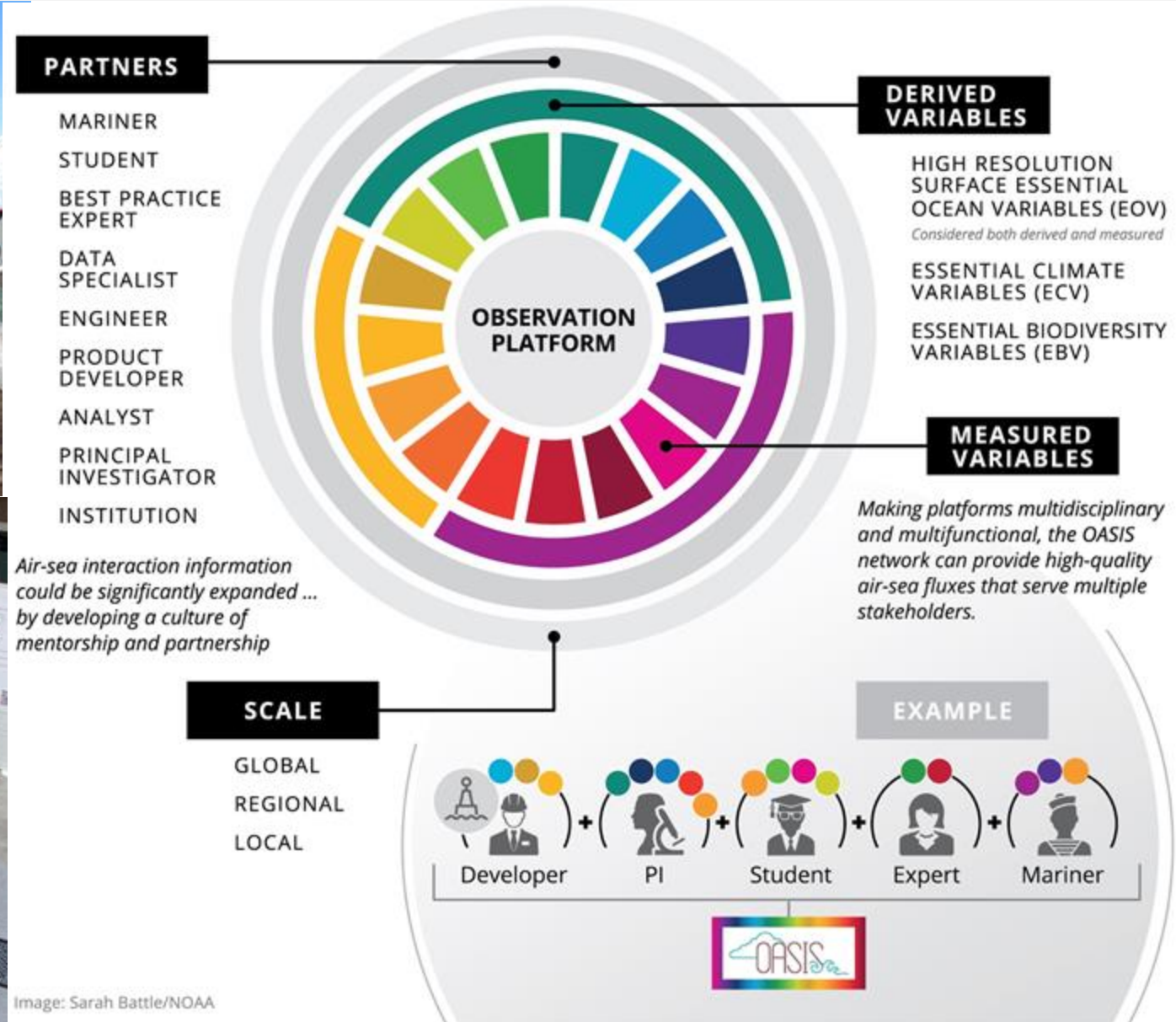
OASIS Theory of Change



Credit: Polar Glider, Gothenburg University, (c) Louise Biddle



Credit: :Edson Silva Delgado



To Join Task Teams: airseaobs.org/get-involved

➔ Grand Idea #1: Expanding the in situ observing system – Fill Gaps in GOOS!

- Areas where OOI could contribute
- Uncrewed Surface Vehicle Network for the Global Ocean Observing System Project
 - ECOP-led Community of Practice paper, Webinar Series!
 - Implementing the USV network for GOOS

➔ Grand Idea #2: Improve air-sea interaction observing from satellites

- Webinar Series! Satellite proposals, next Decadal Survey?

➔ Grand Idea #3: Improve hierarchy of Earth System Models for air-sea interactions

- Building international partnerships to expand process study field campaigns

➔ OASIS Theory of Change

- ECOP-organized Best Practices Workshops, ECOP-led Commentary, Community papers
- ➔ Interoperability Experiments
- Partnership & Capacity Strengthening (summer schools, SIDS AGU sessions)
- ➔ FAIR Data & OASIS Products

Webinar Series: airseaobs.org/resources/webinars [OASIS-youtube-channel](https://www.youtube.com/channel/UC...) (125 videos!)