MEMORANDUM

To: KIRC Commissioners

From: Dean Tokishi, Ocean Resources Specialist III

Subject: Water quality survey from nearshore (0.5NM) to offshore (2.7NM)

circumnavigating Kaho'olawe using autonomous surface vehicles.

RECOMMENDED MOTION:

That the KIRC, authorize the Executive Director to allow Christopher Sabine PhD, Dept. of Oceanography University of Hawai'i Mānoa, to sample water quality from nearshore waters around Kaho'olawe using autonomous surface vehicles.

BACKGROUND:

The water quality characteristics that will be measured includes: temperature, salinity, dissolved oxygen, chlorophyll, as well as pH and partial pressure of carbon dioxide in seawater and air. Having both pH and partial pressure of carbon dioxide measurements will help describe the way carbon is changing in the seawater. This is of major importance because it influences the ability of corals to grow, as well as any other species which use calcium carbonate (i.e., lobsters, opihi, crabs).

ANALYSIS:

The sampling of the waters around Kahoʻolawe will be done by three unmanned Saildrones from nearshore (0.5 NM) to offshore (2.7 NM) circumnavigating around the island. Sensors onboard the vehicles will measure all water quality characteristics mentioned above as it moves through the water. None of the water sampled will be removed from the Reserve.

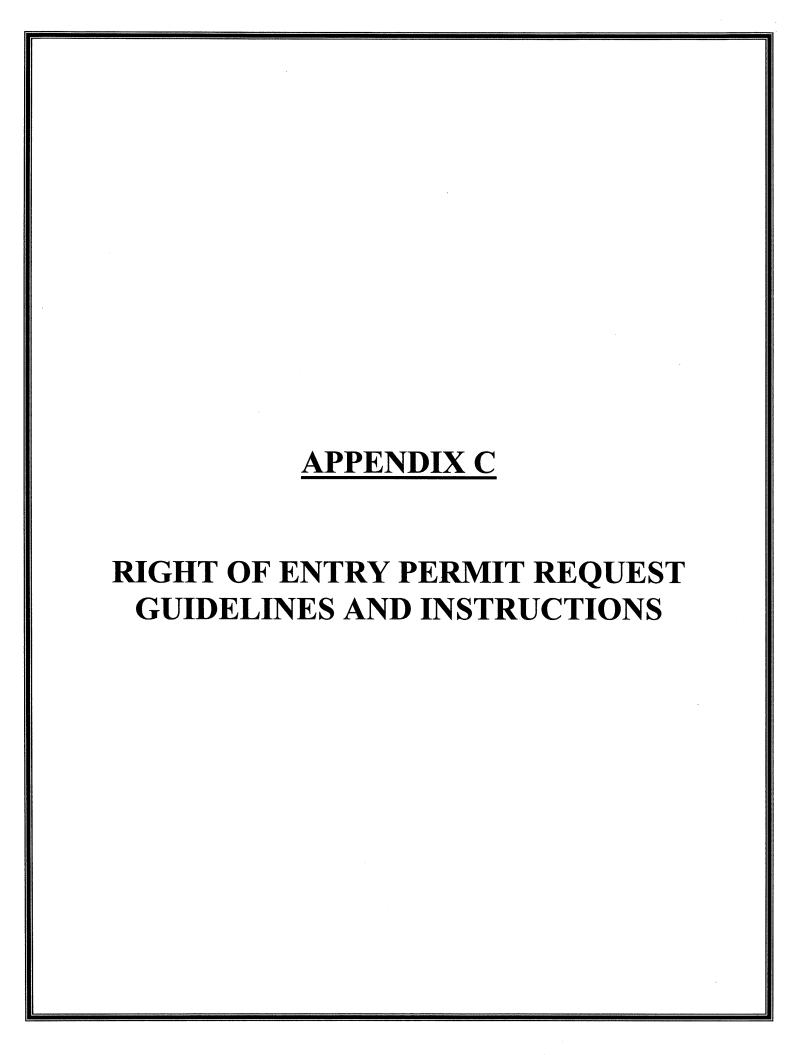
DISCUSSION:

The proposed project would allow the KIRC to gain a time stamp and comparison on the water quality characteristics around Kahoʻolawe in contrast to other neighboring waters. This spatial representation would be a foundation of baseline data to compare all other future water samples.

RECOMMENDATION

Entrance of the three Saildrones and sampling would occur on a non-permitted trolling and non PKO access weekend. A minimum of a 24-hour notice will be provided to the KIRC prior to the entrance of the Saildrones into the Reserve.

Given the relative absence of data the KIRC currently possesses regarding the proposed metrics of water sampling within the Reserve, there is a definite value to supporting Dr. Sabine's efforts. It is recommended that the Commission authorize the Executive Director to allow the Dr. Christopher Sabine to survey the water quality from nearshore (0.5 NM) to offshore (2.7 NM) circumnavigating the island using Saildrones.





811 Kolu St., Suite 201, Wailuku, HI 96793 • ph. 808-243-5020 • fx. 808-243-5885

Guidelines For Right Of Entry Permit Requests

The Kaho'olawe Island Reserve (Reserve) includes the island of Kaho'olawe and those waters and submerged lands seaward of the shoreline of Kaho'olawe to a distance of two nautical miles. The Kaho'olawe Island Reserve Commission (KIRC) is responsible for the internal management of the Reserve and establishes the criteria, policies, and controls for permissible uses within the Reserve. The United States and its allies used the island and surrounding waters as a military target from 1941 to 1990 and a substantial amount of unexploded ordnance remains present on the island and within the surrounding waters posing an imminent threat to public health and safety. Pursuant to State law, commercial uses within the Reserve are strictly prohibited; the Reserve shall be used solely and exclusively for the following purposes:

- Preservation and practice of all rights customarily and traditionally exercised by native Hawaiians for cultural, spiritual, and subsistence purposes;
- Preservation and protection of its archaeological, historical, and environmental resources;
- Rehabilitation, revegetation, habitat restoration, and preservation; and
- Education.

Hawai'i Administrative Rules §13-261-11 provides the procedure for entrance into and activity within the Reserve. It is unlawful for any person to enter the Reserve without approval from the KIRC. All persons or organizations seeking to enter into or to conduct activity in the Reserve shall submit a written Right of Entry Permit Request (Request) to the KIRC. Request forms are available at www.kahoolawe.hawaii.gov. Requests will be decided within 90 days of receipt of a completed and accepted Request Form and will be evaluated through the following process:

Request is reviewed for completeness. Incomplete Requests will not be processed.

- Within 30 days of receipt of a completed *and* accepted Request, the KIRC determines if approval by the KIRC Executive Director or the Commission is appropriate.
 - o KIRC-approved program Requests may be approved administratively.
 - Requests that are not part of a KIRC-approved program, or are proposed by non-KIRC employees, or are determined to necessitate Commission review, will be submitted by KIRC staff to the Commission for placement on the next Commission agenda. There will be opportunity for public comment during the meeting.
- If the Request is approved, a Right of Entry Permit (Permit) will be processed within 14 working days. Conditions to the Permit may be attached.
- If the Request is denied, the requestor will be notified of the reason(s) for denial.

The submission of a Request shall not obligate the KIRC to approve the Request nor constitute a right on the part of the requestor to enter into or conduct activities the Reserve. In approving a Request, the KIRC relies upon the information provided by the requestor. If any of the submitted information is false, incomplete or inaccurate, or if the requestor has acted in violation of the terms of the Permit, or for any good cause shown, the KIRC may immediately amend, suspend, or revoke the Permit, in whole or in part, temporarily or indefinitely. KIRC personnel will monitor activities to ensure compliance. The discovery of any irregularities in conformance to this Permit will be promptly reported and appropriate action shall be taken.

RIGHT OF ENTRY PERMIT REQUEST INSTRUCTIONS:

Request Forms must be completed and submitted at least 90 days prior to the requested access date. Incomplete applications will not be processed. Send all forms to the:

Kaho'olawe Island Reserve Commission 811 Kolu Street, Suite 201 Wailuku, Hawai'i 96793 Fax: (808) 243-5885

PAGE 1 (ROE 1):

Group Requests:

- List the name, contact information, and title of the Group Leader. This is the person who will be held legally responsible for the actions and impacts from activities in the Reserve.
- Subsequent substitutions or change in the number of participants is prohibited unless approved in advance with the KIRC prior to the start of the access.
- Minors 12 years of age or younger must be supervised by a responsible adult at a ratio of 1 adult for each minor.
- Minors between 13 and 17 must be supervised by a responsible adult at a ratio of 1 adult to 5 minors.

Requested Access Date(s):

• Submit the date(s) of your requested access. Dates should not exceed a one year period. If a range of dates is requested, please specify (i.e. June through July '09).

Location:

• Indicate the location of the requested access, and attach any applicable maps.

Description of Activities:

- Benefit, relevance or importance of the proposed project to the Reserve;
- How the project will benefit management of the Reserve;
- Whether the proposed project could be conducted outside the Reserve;
- Cultural, scientific or educational merits of the project; and
- Whether the project will cause harm to or adversely impact the Reserve.

ADDITIONAL ATTACHMENTS: (as applicable)

- List name, address, contact number(s), and email address for all individuals in the group requesting access. List the age of all individuals under the age of 18.
- Signed Release of Liability Forms must be submitted for *all* persons requesting entry.
- Safety and Logistics Plan addressing transportation to and from the island and safety protocols while in the Reserve. All requestors shall demonstrate their capability of providing KIRC with the opportunity to track their overall location while within the reserve (e.g. GPS, VMS, and communications tools including email or satellite phone).

PAGE 2a (ROE 2a):

Select Access Type:

- Native Hawaiian Traditional and Customary Cultural Access
- Archaeological, Historical, and Environmental Resources
- Educational Access
- Professional Photography or Videography Access

Native Hawaiian Traditional and Customary Cultural Access

- Traditional and customary rights and practices are those that are consistent with the Hawaii State Constitution, Hawaii Revised Statutes, and case law.
- Traditional and customary cultural access requests may be provided to native Hawaiians for practices consistent with the long-term preservation of the Reserve's resources.
- *Native Hawaiian* means descendants of native Hawaiians who inhabited the Hawaiian Islands prior to 1778.
- Native Hawaiian Subsistence means the use of resources by native Hawaiians to perpetuate traditional knowledge, while taking responsibility for and understanding how to aloha 'āina (care for the earth and strengthening cultural and spiritual connections to the Reserve). Resources extracted for native Hawaiian subsistence will be used only for direct personal consumption in the Reserve and cannot be exported from the Reserve or sold. Allowable methods for subsistence fishing are: handline, pole-and-line or hand-held spear. Fishing by use of weapon, trap, throw net, poison or spear guns is prohibited.
- The KIRC may consult with native Hawaiian Cultural Practitioners regarding your Request. Please list the name(s) and contact number(s) of the native Hawaiian Cultural Practitioner(s) participating or consulting in the requested activity.

Archaeological, Historical, and Environmental Resources Access

- Attach all appropriate approvals and permits with Request.
- Research/activities involving native wildlife (vertebrates) requires a Scientific Collecting permit (Scott Fretz; scott.fretz @hawaii.gov)
- Research/activities involving native plants requires a Scientific Collecting permit (Vickie Caraway; vickie.l.caraway@hawaii.gov)
- Research/activities involving native invertebrate wildlife (terrestrial) requires a Scientific Collecting permit (Betsy Gagné; betsy.h.gagne@hawaii.gov)
- Research/activities involving collection or possession of Threatened & Endangered Species or migratory birds requires a U.S. Fish and Wildlife Service permit.
- Permits to collect or export injurious wildlife (Patrick Chee; patrick.c.chee@hawaii.gov)
- Research/activities involving fresh water or marine species (Division of Aquatic Resources (808) 587-0110)
- Research/activities involving historical sites (Historic Preservation Division (808) 692-8015)

Educational Access

• Attach a description of the curriculum to be used in the Reserve or an outline of the curriculum intended to be drafted as a result of this entry.

Professional Photography or Videography Access

- List any large or special equipment necessary for your access.
- A State Film Permit is required prior to your access.

PAGE 2b (ROE 2b):

Research Access

- List the Institution, Department, Agency, or Company the Principal Investigator/Coordinator is working for with respect to this Request.
- If the Request is for undergraduate or graduate research, list the educational institution, study program and name of the major Professor.
- Attach CVs and Resumes for all research participants.
- List all Hawaii references/cooperators/collaborators (with contact information).
- Attach all appropriate approvals and permits with Request. Requests lacking such documents will not be processed.

Statement of Proposed Research Activities:

- Describe all procedures that will be used in the proposed project.
- Include documentation of safety protocols, data collection techniques, data sheets, and sample collection techniques.
- Describe all training, experience, and capabilities of those who will be conducting the sample collection and analysis.

Activities Involving Extraction or Collection:

- List specimens of organisms or objects that will be collected. Give the common name, scientific name, number and size of specimens and collection locations(s).
- Describe handling techniques and equipment use for capturing, handling and collecting.
- Describe what will be done with collected specimens after project completion. Specify whether collected organisms will be kept alive after collection. Describe how and where samples will be stored in the Reserve and once they are removed from the Reserve.
- Describe anticipated impacts of the project on target populations, impacts on other species, effects of installations, effects of invasive procedures, methods for evaluating impact of the proposed project, methods for reducing or compensating for impacts.

Requests Involving Vessels:

- Please provide detailed vessel information.
- All vessels must be Coast Guard compliant and certified.
- All vessels must be equipped with a GPS system and Depth Finder.
- Applicants are required to sign the KIRC Independent Vessel Release of Liability form.
- Any vessel causing damage to marine resources within the Reserve may be subject to citation by the DLNR and administrative fines from the KIRC.
- All non-government requestors' vessels must be covered by Wreck Removal and Pollution Insurance. Attach copies of the corresponding policies.

Fixed Installations and Instruments:

- Describe fixed installations and instruments you wish to install in the Reserve.
- Attach pictures and/or diagrams of the proposed installation.
- Where, how, and how long will it be installed?
- Who will maintain the equipment and how often?
- How and when will it be removed?



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Right of Entry Permit Request

REQUESTOR'S NAME				TITLE
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PURPOSE OF ENTRY				
DESCRIPTION OF ACTIVITIES (attach	additional	l pages if neces	sary)	
PLEASE ATTACH THE FOLLOWING I	OCUME	NTS:		
			and ac	ges of people requesting entrance.
Signed Release of Liability Form				
☐ Safety and Logistics Plan addre	ssing tran	isportation to	trom a	nd protocols within the Reserve.



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Right of Entry Permit Request

Request Type (non-Research)

SELEC	T AC	CESS	TYPE:

	ARCI	HAEOLOGICAL, HISTORIC	CAL, AND ENVIRON	MENTAL RESOURCE	E ACCESS
	Please attach the following documents				
	State Historic Preservation Division approval if activities involve historic sites.				
		Appropriate State and Federal p	permits if activities invo	lve native wildlife or pla	ants.
		Appropriate State and Federal p	permits if activities invo	lve threatened or endang	gered species.
		Appropriate State and Federal p	permits if activities invo	lve migratory birds.	
	FDII	CATIONAL ACCESS			
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		N ACTIVITIES BE CONDUCTED	ELSEWHERE: (explain)		
	Please	attach the following documents	S		
		Copies of curriculum to be used	d in Reserve.	•	
		Outline of curriculum intended	to be drafted as a result	of entry.	
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	I have	e reviewed and understood the K	IRC Guidelines for Rig	ght of Entry Permit Requ	ests.
	I have	e reviewed, understood, signed,	and attached the approp	riate KIRC Release of L	iability Forms.
L,	PRI	NT NAME	SIGNATURE		DATE





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Right of Entry Permit Request

Request Type (Research only)

]]	RESI	EARCH ACCESS			
	ST	UDY PROGRAM AND INSTITUTE	ON	NAME/AFFILIATION OF MAJ	OR PROFESSOR
	Please	e attach the following documents CV/Resume with related educa Signed KIRC Independent Vess Copies of Wreck Removal and State Historic Preservation Div All appropriate State and Feder List of Hawaii references/coope Attach a \$50 check for process	tional backgrousel Release of I Pollution Insursision approval it al permits.	nd and work experience for restability Form. ance. f activities involve historic site ators (with contact information	s.).
	1. 2.	EMENT OF PROPOSED RESEARCH How will research results beneficially the proposed research ben	CH ACTIVITIES fit management efit the Reserve	(attach research plans and necessarion of the species?	
	 Is the proposed research important? Explain your research objectives and methods. How is the research to be accomplished? (List research/survey techniques). Can the proposed research be conducted elsewhere? 				
	7. Will specimens be collected/removed? List kind, quantities, storage methods, and disposition? 8. What will be done with the specimens after project completion?				
	9. Will the proposed research damage or threaten to damage the resources in the Reserve?10. List steps that will be taken to minimize effects on the species and the surrounding habitat.				
	11. Has any research been conducted that is similar to the one proposed? If yes, please cite.				
	12. Who will actively participate (i.e., collect, possess, propagate) on the permit for this research? 13. Will your research require camping or night work?				
	13. Will your research require camping or night work? 14. Will your research involve the use of aircraft in any way?				
	15.	Will your research involve the			
	16. Will the research require structures/equipment to be left in the field? When will they be removed?				
	17. Are permits from other agencies required for your research? If yes, list agencies.				
	18. What is the expected report date for your findings?				
	19. Are there plans for publication of data or findings gathered from the proposed research? 20. How will research results be disseminated?				
	20. How will research results be disseminated? 21. List funding sources. If this research is supported by grant(s), list grant(s).				
	 I have reviewed and understood the KIRC Guidelines for Right of Entry Permit Requests. I have reviewed, understood, signed, and attached the appropriate KIRC Release of Liability Forms. 				
	PRI	NT REQUESTOR'S NAME	REQUI	ESTOR'S SIGNATURE	DATE
	PRI	INT ADVISOR'S NAME	ADVIS	OR'S SIGNATURE	DATE

1. How will research results benefit management/conservation of the species?

The proposed research will survey the water quality from nearshore (0.5NM) to offshore (2.7NM) in a zig-zag pattern, circumnavigating the islands using autonomous surface vehicles, called Saildrones, to look at variability in water quality characteristics around each of the main Hawaiian Islands, including Kahoʻoalwe. This will give us a better understanding of the habitat which species live in and help identify areas of interest for management. The water quality characteristics we are measuring includes: temperature, salinity, dissolved oxygen, chlorophyll, as well as pH and partial pressure of carbon dioxide in seawater and the air (pCO₂). In particular, having both pH and pCO₂ measurements will help us describe the way that carbon is changing in the water – which influences the ability of corals to grow, as well other species which use calcium carbonate. We have seen in other areas of the world that there can be localized changes in carbon, or coastal acidification, which can be identified by this survey.

2. Will the proposed research benefit the Reserve?

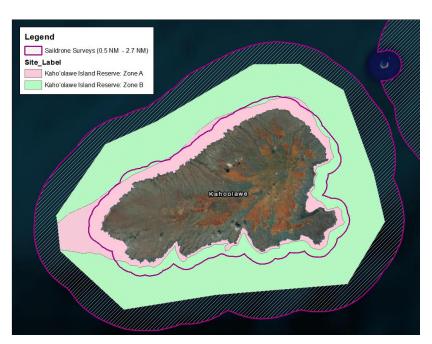
Kahoʻolawe's protection as a reserve and its history of military use means that there are both potential remnants of impacts to water quality from the military use, but also protection from further impacts via the reserve status. This research would give a spatial map of water quality that would provide a status update of water quality around this island.

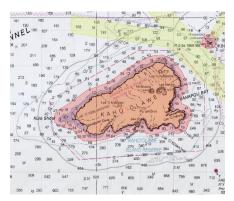
3. Is the proposed research important?

It will be the first time all of these water quality characteristics will be surveyed as extensively around the coastline for the Main Hawaiian Islands. It would be important to included Kahoʻolawe in this survey because often when surveys of the islands are done, they typically only include the larger islands in the chain and the smaller islands (Kahoʻolawe, Molokai, Lanaʻi, Niʻihau) are left out. This will help us identify potential hot spots of coastal and ocean acidification around our islands.

4. Explain your research objectives and methods.

Objectives are to look at the nearshore to offshore gradients in water quality parameters around each of the islands. Three (3) Saildrones will zig-zag from nearshore (0.5 NM) to offshore (2.7 NM) and circumnavigate around the islands (See the Figure). The sensors onboard the vehicles will measure water quality characteristics including temperature, salinity, dissolved oxygen, chlorophyll, as well as pH and partial pressure of carbon dioxide





in seawater and the air (pCO₂). For further descriptions of the sensors, please see the answer to the question below. We have the temperature, salinity chlorophyll and dissolved oxygen set to measure every 5 minutes. The pH and the pCO₂, will be measured every 30 minutes.

Survey area nearby Kuia shoal (dotted outer and red inner boundary) supplied by Saildrone.

5. How is the research accomplished? (List research/survey techniques).

We are utilizing the following sensors on the Saildrones:

Seabird CTD (<u>SBE 16plux V2 SeaCAT</u>) to measure temperature and salinity, Seabird Flurometer (<u>ECO-FLNTUS</u>) to measure chlorophyll and dissolved oxygen, Sunburst iSAMI (<u>iSAMI</u>) to measure pH, and the <u>ASVCO₂ system</u> co-developed by NOAA Pacific Marine Environmental Laboratory (PMEL) and Saildrone for the partial pressure of carbon dioxide (pCO₂) measurements.

6. Can the proposed research be conducted elsewhere?

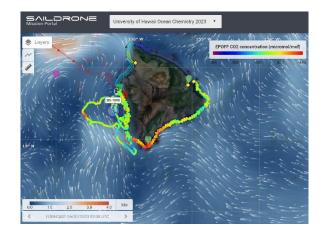
It is being conducted on the other Main Hawaiian Islands, but the data will not be the same around each of the islands, and will leave a gap around Kahoʻolawe that would have to be estimated by a model utilizing Maui, Molokaʻi, and Lanaʻi.

7. Will specimens be collected/removed? List kind, quantities, storage methods, and disposition?

No specimens will be collected/removed. The sensors on the Saildrones automatically test the water quality as they move through the water. We have the temperature salinity set to measure every 5 minutes. The chlorophyll and dissolved oxygen will also be measured at this frequency of 5 minutes. The pH and the pCO2, will be measured every 30 minutes.

8. What will be done with the specimens after project completion?

No specimens to be taken, but spatial maps of the results of water quality can be made and provided to KIRC for use in management from the Saildrone online Portal.



The data will also be available on the PacIOOS voyager viewer (https://www.pacioos.hawaii.edu/voyager/).

To see the data on the viewer: Click on Observations > Remotely Operated Vehicles > SD:1090: carbon dioxide > Click Auto-Zoom and xCO2 Water > Click the orange plus sign magnifying glass symbol > Click the Play Button in the middle of the screen



9. Will the proposed research damage or threaten to damage the resources in the Reserve?

There will be no damage, or threaten to damage the resources in the Reserve.

10. List steps that will be taken to minimize effects on the species and the surrounding habitat.

There are pilots from Saildrone that will be watching the drones sail pattern, as well as video feed to navigate around any hazards or resources. The limit of 0.5 NM inshore distance also will help reduce any potential overlap with resources (like the reef below) and is a standard safety precaution Saildrone uses.

11. Has any research been conducted that is similar to the one proposed? If yes, please cite.

Not quite the same survey methods or research, but previous use of the Saildrones off O'ahu, for more information about the capabilities of the drones can be found here:

https://www.pmel.noaa.gov/ocs/ocs-saildrone-mission-blog-tpos-2018-mission https://www.pmel.noaa.gov/ocs/ocs-saildrone-mission-blog-tpos-2019-mission

12. Who will actively participate (i.e. collect, possess, propagate) on the permit for this research?

We will not be collecting, but we will be monitoring the progress of the Saildrone around the reserve via an online portal. We can provide access to view the portal for KIRC staff if there is

interest. Also as listed above for minimizing damage, there are pilots from Saildrone that actively help to direct the vehicles and design their sail pattern.

13. Will your research require camping or night work?

No camping requirements. The saildrones do sail at night.

14. Will your research involve the use of aircraft in any way?

No aircraft.

15. Will your research involve the use of a vessel in any way?

Yes, the research involves vessels. We have also had the Saildrone company fill out a vessel form via their legal team. Please reference that attachment for more information.

16. Will the research require structures/equipment to be left in the field? When will they be removed?

No structures or equipment to be left in the field. No removal required.

17. Are permits from other agencies required for your research? If yes, list agencies.

We have already notified the US Coast Guard of the research and they have given notice to Mariners. We checked with NOAA Marine Mammal to check if a take permit was required, it was not because we are not actively using sonar or doing any benthic mapping utilizing passive or active sonar.

18. What is the expected report date for your findings?

We will have an annual fiscal year report, as well as future publications (still to be determined). As mentioned above, we can give viewing privileges to KIRC staff if requested and data will also be viewable on the PacIOOS voyager viewer.

19. Are there plans for publication of data or findings gathered from the proposed research?

Yes, future plans to publish, but no determination on when or what journal. Initial findings and maps will and can be provided to KIRC.

20. How will research results be disseminated?

Again as mentioned above, we can give viewing privileges to KIRC staff if requested and data will also be viewable on the PacIOOS voyager viewer.

21. List funding sources. If this research is supported by grant (s), list grant (s).

This effort is a part of the \$50 million gift from Dr. Priscilla Chan and Mark Zuckerberg to the Hawai'i Institute of Marine Biology in 2022 to improve Hawai'i's ocean health: https://www.hawaii.edu/news/2022/01/19/50m-gift-ocean-health/

Ph.D. Student, Oceanography Department University of Hawai'i at Mānoa, Honolulu, HI 96822 (808) 683 — 5898 | <u>amarkel@hawaii.edu</u>

Education

Ph.D., Oceanography: Geology and Geochemistry, 2022 - Current

University of Hawai'i at Mānoa (UHM), Honolulu, O'ahu

Advisor: Dr. Christopher Sabine

Tentative Dissertation Topics: Analyzing new time-series and spatial data of ocean acidification parameters in the Main Hawaiian Islands from the deployment of three new autonomous MAPCO₂ buoys on Maui, Hawai'i, and Kaua'i, and Saildrone mission around the Main Hawaiian Islands.

M.Sc., Natural Resources and Environmental Management, 2016

University of Hawai'i at Mānoa, Honolulu (UHM), O'ahu

Advisor: Dr. Mehana Vaughan

Thesis: A mixed-method approach for identifying land-based sources of pollution and considerations for community monitoring efforts, a case study on the north shore Kaua'i reefs. Utilized stable isotope analysis of water and macroalgae samples to determine potential sources of elevated nitrogen levels from outflow from cesspools and listed the logistical considerations for monitoring by interested community groups.

B.Sc., Double Major: Marine Science; Biology (Ecology, Evolution and Conservation Track), 2014

University of Hawai'i at Hilo (UHH), Hilo, Hawai'i

Advisor: Dr. Marta deMaintenon

Thesis: Variation in internal morphology of soft coral, <u>Sarcothelia edmonsoni</u>, with variations in water quality

Ernest F. Hollings Scholar, National Oceanic and Atmospheric Administration (NOAA) 2012 - 2013

Northwest Fisheries Science Center, Marine Mammal Ecology Team, Seattle, WA, summer of 2012

Semester at Sea, Institute for Shipboard Education, University of Virginia, 4 months at sea, Spring Voyage 2013

Coursework: International Law, Conservation Biology, Marine Biology, and Anthropology of Religion

Countries visited: Japan, China, Vietnam, Singapore, Myanmar, India, Mauritius, South Africa, Ghana, Morocco, Spain

Certificates of Competence, University of Hawai'i Maui College (UHMC), Kahului, Maui Geographic Information Systems (GIS) in Ecosystem Management (2016), and Certified Nursing Assistant (2015)

Professional and Technical Positions

Research Assistant, Dr. Christopher Sabine

University of Hawai'i at Mānoa, Honolulu, O'ahu

Working with Dr. Christopher Sabine, Interim Vice Provost of Research and Scholarship, and Professor in the Department of Oceanography at the University of Hawai'i at Mānoa, I am assisting with:

- Coordination and logistical planning of deployments of ocean acidification buoys (MAPCO₂ buoys) to three new locations in the Main Hawaiian Islands.
- Coordination with Dr. Sabine and Saildrone about sail plans to collect spatial coverage data of ocean acidification parameters around the Main Hawaiian Islands.

Research Technician

9/2021 - 12/2021

1/2022 - Present

Hawai'i Coral Reef Initiative, Telework

3 months, 40 hrs/wk

- Assisted with permit applications for two collaborative watershed restoration projects on O'ahu led by the Division of Aquatic Resources: He'eia & Kako'o 'Ōiwi, and West Loch, Honouliuli & Hui o Ho'ohonua (HOH808)
- Assisted as needed with report tracking and preparation for strategic planning for Division of Aquatic Resources

Ph.D. Student, Oceanography Department University of Hawai'i at Mānoa, Honolulu, HI 96822 (808) 683 — 5898 | amarkel@hawaii.edu

E. Gordon Grau Coastal and Marine Resource Management Fellowship Program University of Hawai'i Sea Grant College Program

9/2019 – 9/2021

Host Office: **Division of Aquatic Resources,** Honolulu, Oʻahu

2 years, 40 hrs/wk

- **State of Hawai'i Ocean Acidification Action Plan**, Lead Planner:
 - Lead for the Division of Aquatic Resources on ocean acidification (OA) action planning process
 - Point person for organizing climate change planning for the Division of Aquatic Resources in coordination with the State Climate Commission and other divisions within the Department of Land and Natural Resources.
 - Important visioning for future partnerships, grant opportunities, and future state driven adaptation and mitigation planning concerning the nexus of ocean and climate planning.

Holomua: Marine 30x30 Initiative, Planning Assistant:

- Lead a multi-district effort to coordinating planning for the initial scoping of statewide rules package for herbivore management
- Developing a framework for community-based monitoring, in collaboration with non-profit community engaged partners, and state coworkers, for incorporation into data and indicators used for state management
- Lead a spatial habitat mapping project to complete 60 benthic habitat maps, one for each marine management area in the state, an SOP for the future areas to be included, and narratives to be included alongside map images inside of the management plans. Benthic habitat maps were comprised of underlying benthic structure and were developing using NOAA's Benthic Habitat Mapping of the Main Hawaiian Islands.

WRRC Marine Technician – Kaua'i Lead, Pl: Dr. Celia Smith University of Hawai'i at Manoa, Honolulu, O'ahu, and Kaua'i Island wide

1/2019 – 7/2019 4 months, 40 hrs/wk

- As a part of Act 132, the Hawai'i State Department of Health has contracted the Water Research Resource
 Center (WRRC) to conduct the research to ground truth modelled nutrient effluent related to density of onsite
 disposal systems (OSDS, e.g. cesspool and septic), by collecting macroalgae and water samples in suspected high
 N-loading sites, for stable isotope analysis.
- Organizes and coordinates field research trips for the island of Kaua'i, maintained field check lists and
 instruments, prepares field equipment, instruments, and supplies, and coordinated with partners at the Kaua'i
 Community College and community partners.
- Coordinated field data collection and sample processing for water quality and macroalgal samples.
- Trained, coordinated, and supervised undergraduate students assisting in the field and laboratory.

Graduate Research Assistant, *Dr. Mehana Vaughan* **University of Hawai'i at Mānoa,** Honolulu, O'ahu and Northshore Kaua'i

1/2017 - 1/2018, 6 - 8/2018 1 year, 3 months, 30 hrs/wk

- Organized research of land-based sources pollution and effect on coastal ecosystems, including macro-algae collection, nutrient analysis, interviews, and literature review.
- Lead and instructed an undergraduate intern, from Hawai'i Pacific University, on water quality and macroalgal sampling and processing for stable isotope analysis.
- Assisted with logistical and other administrative tasks (flight booking, scheduling, transcription).
- Developed written outlines of chapters, lecture presentations, exams, homework assignments for the capstone course for Natural Resource Environmental Management Bachelor's degree students: NREM 494 Environmental Problem Solving.

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Graduate Teaching Assistant, Dr. Peter Garrod

8/2016 - 12/2016

NREM 203 Applied Calculus, University of Hawai'i at Manoa, Honolulu, O'ahu

5 months, 20 hrs/wk

• Assisted the professor with two lab sections of the course including monitoring and review of homework completion on online program WebAssign, and distribution and grading of quizzes.

Assistant Aquarist, Curatorial Team

04/2016 - 8/2016

Maui Ocean Center Ma'alea, Maui

5 months, 20 hrs/wk

- Assists with exhibit maintenance (vacuuming and algae, CCA removal), life support maintenance (waterflow, air supply), animal feeding, for the small and large exhibits within Maui Ocean Center.
- Occasional behind the scenes tours and dive presentations.

Hui Kāpehe Internship Recruiter

12/2015 - 07/2016

University of Hawai'i Maui College (UHMC), Kahului, Maui

8 months, 40 hrs/wk

- Recruited and tracked student progress for the Hui Kāpehe internship program, an internship for students of native Hawaiian ancestry to be a part of workshops, career and technical education (CTE) trainings, and access trips to the island of Kaho'olawe through internship developed by the Kaho'olawe Island Reserve Commission.
- Managed an excel database of student interests, retention, status in the program, and follow-up after program
 completion to provide to grant funder Alu Like for a federal grant for Native Hawaiian Career and Technical
 Education Programs.

The Learning Center (TLC) Tutor

10/2015 - 04/2016

University of Hawai'i Maui College, Kahului, Maui

6 months, 10 hrs/wk

- Tutor for Math and Science provided education and materials to students and assist in their learning.
- Manned staff information desks in visitor center or contact stations, assistance to public and students.

Maui Natural Area Reserve System (NARS) Americorps KUPU Intern

03/2015 - 09/2015

Department of Forestry and Wildlife (DOFAW), 'Āhihi-Kīna'u Natural Area Reserve

6 months, 40 hrs/wk

- Assisted with the natural resource management outlined in the Coastal Wetlands Conservation Program Grant from US Fish and Wildlife, including: Ungulate fence construction (cattle panel in 'ā'ā lava), removal of invasive species by mechanical and chemical means, trail/sign construction, native plant seed collection and outplanting, endangered species outplanting ('āwikiwiki) and marine debris removal.
- Talked with an average of 25 visitors per day when working with the volunteer coordinator.

Ocean Educator and Snorkel Tour Guide

05/2014 - 12/2014

Reef Guides Hawai'i, Mālama Ke Kai, Hanalei, Kaua'i

8 months, 40 hrs/wk

- Educated visitors about the reef fish and the coral reef (common names, Hawaiian names, ecology) and proper use of snorkel equipment and reef etiquette.
- Lifeguarded and guided tours of approximately six people snorkeling around the reef while photographing underwater images of visitors, turtles, and reef fish.

Lifeguard, Student Life Center (SLC)

06/2013 -05/2014

University of Hawai'i at Hilo, Hilo, Hawai'i

11 months, 10-20 hrs/wk

• Instructing swim lessons during the summer, also responsible for the safety of patrons to the Student Life Center including: Basic Life Support, Enforcement of Facility Rules and Regulation, Organization and Maintenance of Pool Deck and Pool Filtration System

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Field Office Assistant, Work Study Scholarship

01/2013 - 04/2013

Semester at Sea Field Office Spring Voyage 2013, Institute for Shipboard Education

3 months, 20 hrs/wk

- Aided students selecting purchase trips for countries visited during the voyage, as well as processed paperwork to prepare students and the financial office for their trips.
- Maintained a database of evaluation forms for each of the trips from participants as well as student course required trips

Student Office Assistant National Student Exchange (NSE) Office

10/2012 -05/2014

University of Hawai'i at Hilo, Hilo, Hawai'i

1 year 7 months, 10 hr/wk

- Developed brochures, handouts, table events to promote the program to the student body at UH Hilo, as well as other campuses via social media.
- Drafted a variety of written materials including news releases, articles, correspondence, and event flyers.
- Provided students with assistance selecting campuses to exchange to, as well as processing paperwork to prepare students for their exchanges.

Ernst F. Hollings Scholarship Intern, National Oceanic and Atmospheric Administration Northwest Fisheries Science Center, Marine Mammal Ecology Team, Seattle, WA

06/2012 - 8/2012

3 months, 40hr/wk

- Identified the seasonal occurrence and distribution of common endangered cetacean species, of the Washington state coast, from recordings using underwater acoustic recorders (Ecological Acoustic Recorders, Lammers et al. 2008) deployed during 2011
- Familiarity with the Endangered Species Act, Marine Mammal Protection Act

Teaching and Tutoring

Fall 2016	Graduate Teaching Assistant, UH Manoa, NREM 203: Applied Calculus (~100 students)
Spring 2016, Fall 2015	Math and Science Tutor, UH Maui College The Learning Center

Leadership Positions

2016 – 2018	Lab Manager for Vaughan Lab Meetings (Piko), Dr. Mehana Vaughan
2016 – 2018	Community Garden Coordinator, East West Center Participant Association Board
2014	Ka Lama Ku Student Leadership Conference, UH Hilo
2012	Marine Mammal Club Vice President, University of Hawai'i at Hilo's RISO
2011 – 2012	Marine Mammal Club Treasurer, University of Hawai'i at Hilo's RISO

Qualifications

SCUBA Diving:

DAN+ CPR, First Aid and O₂ provider (2022), AAUS 60ft UH Dive Safety Program (2014), PADI Divemaster (2014), NAUI Rescue Diver, Nitrox, Master Diver (2014), QUEST UH Hilo (2012)

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Memberships

Association for the Sciences of Limnology and Oceanography The Oceanography Society Hawai'i Chapter of Society for Conservation Biology

Honors and Awards

2022 – current (Ph.D.)	Student Affiliate, East-West Center (EWC)
2019 – 2021	E. Gordon Grau Fellowship, University of Hawai'i Sea Grant College Program
2018	International Travel Conference Scholarship, EWC
2016 - 2019 (M.Sc.)	Student Affiliate, EWC
2016 – 2018	Mānoa Opportunity Grant, University of Hawai'i at Mānoa
2015, 2017, 2018	Hau'oli Mau Loa Student Rate Scholarship, Hawai'i Conservation Alliance (HCA)
2016	IUCN World Conservation Congress Student Participation Opportunity, HCA
2014	Undergraduate Travel Grant, 99 th Annual Ecology Society of America Conference, SEEDS
2011 – 2014	College of Arts and Sciences Dean's Scholarship, University of Hawai'i at Hilo (UHH)
2013	Work Study Stipend as well as a Merit Scholarship, Institute for Shipboard Education
2013	Semester at Sea Scholarship, UHH
2012 – 2013	Ernest F. Hollings Scholar, National Oceanic and Atmospheric Administration (NOAA)
2009 – 2012	Diversity Scholarship, Oregon State University (OSU)
2009 – 2011	Singer Foundation Scholarship Award

Conferences Attended

2022	5 th International Symposium on the Ocean in a High CO ₂ World <i>(Poster)</i> , Lima, Peru
2021, 2020	Capitol Hill Ocean Week, National Marine Sanctuaries, Virtual
2020	International Marine Conservation Congress, Society for Conservation Biology, Virtual
2020	Pacific Risk Management 'Ohana (PRiMO) Conference, Hawai'i Convention Center, Honolulu, HI
2020	Aquaculture America Conference, Hawai'i Convention Center, Honolulu, HI
2020	First Annual Workshop on Green Turtle Diets in Hawai'i, Hawai'i Pacific University, Honolulu, HI
2018	Society for Conservation Biology – Oceania Congress (<i>Poster</i>), Te Papa, Wellington, Aoterora (NZ)
2015 – 2018	Hawai'i Conservation Congress (Poster 2018) Hawai'i Convention Center, Honolulu, HI
2014	Ecology Society for America <i>(Poster)</i> Sacramento, CA
2011	American Fisheries Society Oregon Chapter Annual Meeting, Bend, OR

Professional Training

2021	Introduction to Algae and Biotechnology, Algae Technology and Educational Consortium UC San Diego
2020	Reimagining Our Communities, Reimaging Equity, Bang The Table, Virtual Engagement Strategies
2020	Water Infrastructure Funding Forum, EPA, FEMA, and NOAA
2019	Communication Workshop - Ocean Science and Teaching Pedagogy, UH Sea Grant College Program
2019	Reproducible Research w/R and RStudio workshop, American Statistical Association
2019	State to State Workshop on Ocean Acidification, International Alliance to Combat Ocean Acidification
2019	Land-based Pollutants and Reef Fishes Workshop, UH Sea Grant College Program, WWRC, and HIMB
2016 – 2018	E Alu Pū, cultural practioner annual gathering (as notetaker and transcriber), Kuaʻāina Ulu ʻAuamo
2014 & 2017	Career Conservation Symposium Participant, US Fish and Wildlife Service
2016	Marine Habitat Mapping from Monitoring Data Workshop, US Fish and Wildlife Service

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Skills and Expertise

Virtual Teamwork: Extensive experience with Microsoft Office (Word, Excel, PowerPoint, Sharepoint, Teams). Extensive experience with Google Suite (Docs, Sheets, Slides, Drive, Forms, Calendar). Scheduling, setup and facilitation up of virtual meetings, especially Zoom, but also Google Meet, and Teams meetings (including waiting room management, breakout rooms, polls). Experience running and pulling results from online polling software such as Menti and Slido

Mapping, Statistics, and Photo Analysis: ArcGIS experience, UHMC certificate course, R – basic coding for hydrology for watershed modeling from UHM course, MiniTab Statistical Software (UH Hilo), Zotero reference manager

Archival Research, Interviewing: Experience working through databases from State of Hawai'i, Bishop Museum, Kipuka, AvaKohohiki. Experience using both digital, paper, and audio archives to develop research findings. Experience in transcribing interviews, coding from notes, assisted in this for Mehana Vaughan's book Kaiāulu: Gathering Tides (2018)

Design: Web Design (Weebly, Wix, Wordpress, and some Dreamweaver/HTML). Flyer, 1 and 2 pager development utilizing web-based template platforms Piktochart and Canva, and some Adobe InDesign.

Laboratory Work: Stable Isotope Analysis: prep and weight of solid samples. Training for the bacterial growth needed for stable isotope analysis of water, Biogeochemical Stable Isotope Facility, UH Manoa, Biosafety Training UH Manoa. Development of wet slides and permeant slides of algae, and cleaning of algae for drying or herbarium. UH Hilo EPSCoR Genetic Core Facility course in molecular and biotechnological techniques: DNA isolation, PCR basics, gel electrophoresis, Microsatellites, t-RFLP Basics, real time PCR, molecular cloning, DNA sequence.

Marine and Freshwater Field Experience: Collection and prepping of Algae for Herbarium. Water Sampling: Nutrients, FIB. Water Quality Equipment: YSI meter, pH meter, turbidimeter, light intensity meter. Tracking: Radio telemetry, floy-tagging, radio and satellite tagging of fishes and turtles, whale fin ID, underwater acoustic recorders and acoustic ID of whales (humpback, sperm, grey). Monitoring: Transect, quadrat, and timed abundance surveys

Terrestrial Field Experience: Fence building (cattle panel in 'a'a flow). Collection: Soil, Leaf, Seed ('ōhi'a lehua, naio, 'awikiwiki, a'ali'i) and Seedling Samples. Invasive Species Removal: kiawe, strawberry guava, java plum, invasive grasses removal. Monitoring: transect/quadrat, tree measurements. Outplanting of native trees and plants: mountain apple, 'ōhi'a lehua, koa, mamake, 'awikiwiki, 'ilima, maia pilo, a'ali', kalo, 'a'ali'i

Community Involvement and Volunteering

O'ahu

- Waimanalo Limu Hui, 2019, 2020 (2 days) Saturday workdays to plant limu and help repair the loko 'ia
- Kalaeloa (USFWS), 2019 (3 days) nighttime 'opae 'ula surveys (1 night), removal of weeds in the refuge (2 days)
- Waikalua Loko 'la, 2016, 2017, 2019 (3 days) limu workshop, removal of invasive mangrove species
- Ho'oulu 'Āina, 2018, 2019, 2020 (4 days) Saturday workdays removal of invasive species, planting of native species
- Hawaii Institute of Marine Biology, Gates Lab Intern, 2016 (1 month in summer) Under the direction of post-doc Katie Barrot, working on transplant of coral fragment studies to look at the ability to adapt to a new area
- Punalu'u Lo'i Volunteer, 04/13/2015 (1 day) Removed weeds from the lo'i and reformed the mud around the kalo
- Malāekahana Beach Volunteer, 04/15/2015 (1 day) Removed marine debris nets, ropes, plastic, glass, fishing line from a'a shoreline and removed invasive mangrove from the nearby stream

Amy Markel

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Community Involvement and Volunteering (continued)

Kaua'i

- Waipā Community Poi Day Volunteer, 08/2014, 10/2014, 11/2014 03/2015, 05/2017 7/2017 (4 hrs/wk)
 Cleaned the kalo for table and for poi for the island of Kaua'i, Waipā produces 1200 lbs of poi/kalo for Kaua'i weekly
- Waipā Stream Restoration Workday Volunteer, 10/2014 12/2014 (4hrs/mo) Distributed wood chip mulch and planted native plants including mamake, mountain apple, native hibiscus, ferns, at the upper stream site
- Hā'ena, Community Based Subsistence Fishing Area (CBSFA), Public Hearing Attendee, 10/2014 Talked to community members that were preparing to give their testimony for the CBFSA designation for Hā'ena
- Limahuli Gardens Volunteer, 07/2014, 11/2014 (4 hrs/mo) Removed invasive grasses from the manicured areas of the garden, as well as clean the sugar cane area of dead leaves to display the sugar cane for visitors

Maui

- The Nature Conservancy Marine Program 'Opihi Annual Monitoring at Mu'olea and Kipahulu 05/2015 06/2015 (8hrs/mo) Counted and sized 'opihi within shoreline designated "rest areas" via transect and photo,
- Paeloko Lo'i 3/2016 (2 days) Removed grass and weeds from a fallowed lo'i, and removed weeds from 'auwai
- Baldwin Beach Cleanup, hosted by Surfrider 2/2016 (4 hrs, 1 day) Picked up plastic and debris from Baldwin beach
- West Maui Mountains Watershed Partnership 09/2015 (10hrs/2days) Removed invasive species strawberry guava and checked snares for signs of ungulate activity

Hawai'i

- The Nature Conservancy Kiholo Bay Beach Clean-Up and Kiawe Removal, 05/2014 (6hr/mo) Helped removed Kiawe from the Kiholo Bay area with the Marine Option Program at UH Hilo
- NOAA Hawaiian Island Humpback Whale National Marine Sanctuary Volunteer, 01/2012, 03/2014 (8 hr/mo)
 Seasonal Ocean Counts Volunteer counted the number of humpbacks that swam by during that day as part of a national count for humpbacks
- **Hilo Marine Mammal Response Network Volunteer, 2011 2014 (1hr/wk)** Was trained to respond to stranded marine mammals and establish a perimeter to avoid public contact until the NOAA official arrived
- NOAA Semi-Annual Monk Seal Count Volunteer, 2011 (4hr/mo) Was assigned to an area of beaches to count monk seal presence on a day that is part of a national count for monk seals
- NOAA National Marine Fisheries Service Sea Turtle Team Volunteer, 06/2011 (6hr/mo) Data recorder and Turtle Handler for Turtle Tagging at Punalu'u Beach

NOAA/PMEL, 7600 Sand Point Way NE, Seattle, WA 98115 work: 206.526.6879 fax: 206.526.6744 email: adrienne.sutton@noaa.gov websites: bio, program, ORCID

RESEARCH INTERESTS: Adrienne Sutton's research centers around the patterns of air-sea CO₂ exchange and ocean acidification, aiming to advance understanding of the ocean carbon cycle and how it is changing over time. Her recent publications focus on characterizing natural variability and long-term anthropogenic trends using time series observations and models, uncertainty in observation-based CO₂ flux estimates, and modern-day exposure of marine organisms to corrosive carbonate chemistry conditions. Adrienne also collaborates with her team and engineers on observing technology development and maintains nearly 40 moored autonomous time series around the globe that track air-sea CO₂ and surface ocean biogeochemistry.

EDUCATION

Ph.D., University of Maryland Center for Environmental Science (UMCES),	2000-2006
Horn Point Laboratory, Cambridge, MD	
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GPA 3.7, Area of Study: Oceanography, Advisor: Dr. Thomas Fisher

B.S., University of North Carolina at Wilmington (UNCW), Wilmington, NC	1996-2000
GPA 3.6, B.S. in Biology and Marine Biology with Chemistry minor, cum laude	
Honors Directed Individual Study with Dr. Stephen Skrabal	2000
Research Experience for Undergraduates (REU), Scripps Institution of Oceanography	1999
with Dr. Peter J.S. Franks	

PROFESSIONAL AND RESEARCH EXPERIENCE

Oceanographer, National Oceanic and Atmospheric Administration (NOAA)	2017-present
Pacific Marine Environmental Laboratory (PMEL), Seattle, WA	
Affiliate Assistant Professor, University of Washington (UW) School of	2020-present
Oceanography, Seattle, WA	

Principal investigator in PMEL Carbon Program; oversee scientific and technical details of NOAA's air-sea CO₂ flux and ocean acidification (OA) mooring network; ocean carbon sensor development Affiliate Assistant Professor, School of Oceanography, University of Washington

Research Scientist 4, NOAA - UW Joint Institute for the Study of the Atmosphere 2012-2017 and Ocean (JISAO), PMEL, Seattle, WA

Principal investigator in PMEL Carbon Program; oversee scientific and technical details of NOAA's air-sea CO₂ flux and ocean acidification (OA) mooring network

Cruise experience: R/V Fairweather, West Coast OA Cruise, Co-Chief Scientist and lead DIC analyst, 3 – 14 August 2013; R/V Kilo Moana, Validation Team of Wendy Schmidt Ocean Health XPRIZE competition, 14 – 20 May 2015

National Research Council (NRC) Research Associate, NOAA, PMEL, Seattle, WA 2010-2012

Postdoctorate researcher with Drs. Richard Feely and Chris Sabine

Cruise experience: R/V Wecoma, West Coast OA Cruise, DIC analyst, 9 August – 3 September 2011; R/V Shimada, West Coast OA Cruise, DIC analyst, 4 – 18 September 2012

Lab work: DIC measurements; use of autonomous sensors (CO₂, pH, SSTC, dissolved oxygen, fluorescence, and turbidity); OA mooring data quality control

Assistant Director of Strategic Planning, Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO), Oregon State University, Corvallis, OR

2008-2009

Postdoctorate researcher with Drs. Jane Lubchenco and Bruce Menge Developed PISCO's 5-Year Science Plan

Congressional Affairs Specialist, NOAA Office of Legislative Affairs, Washington, DC 2007-2008

Congressional Affairs Specialist for NOAA's role in the U.S. Climate Change Science Program and the Intergovernmental Panel on Climate Change

Office of Legislative Affairs representative for NOAA's Science Advisory Board

Issue areas: NOAA's Office of Oceanic and Atmospheric Research, including climate science, ocean exploration and undersea research, weather and air quality research, hurricane research, invasive species, NOAA's Laboratories and Cooperative Institutions, National Sea Grant College Program

Knauss Sea Grant Fellow, NOAA Office of Legislative Affairs

2006-2007

Issue areas: harmful algal blooms, hypoxia, oceans and human health, fishery regulations, marine protected areas, coral reefs, northeast and Chesapeake Bay fisheries, sea turtles

Research Assistant, laboratory of Dr. Thomas Fisher, UMCES

2000-2006

Lab work: nutrient analyses (NH₄, NO₃₊₂, NO₂, TN, PO₄, TP, PP, TSS, Si, DOC); gas and liquid chromatography; membrane inlet mass spectrometry; stream water flow measurements; groundwater hydrologic characterizations; soil property characterizations; use of ISCO 3700 portable samplers; use of Solinst automatic temperature and pressure loggers; use of GPS

Undergraduate Honors Student, laboratory of Dr. Stephen Skrabal, UNCW

2000

Lab work: trace metal analyses including cathodic stripping voltammetry

REU Fellow, laboratory of Dr. Peter J.S. Franks, Scripps Institution of Oceanography (SIO)

1999

Lab work: methods used to culture phytoplankton; fluorometer for analysis of photosynthesis in phytoplankton; water column measurements (e.g., phytoplankton, zooplankton, chlorophyll, CTD)

PEER-REVIEWED PUBLICATIONS

- *Indicates advisee-led publication. <u>See ORCID</u> for links to publications.
- Nicholson, S.-A., D.B. Whitt, I. Fer, M.D. Du Plessis, A.D. Lebéhot, S. Swart, A.J. Sutton, and P.M.S. Monteiro (2022): Storms drive outgassing of CO2 in the subpolar Southern Ocean. Sci. Adv., 13, 158, doi: 10.1038/s41467-021-27780-w.
- Meléndez, M., J. Salisbury, D. Gledhill, C. Langdon, J.M. Morell, D. Manzello, and A.J. Sutton (2022): Net ecosystem dissolution and respiration dominate metabolic rates at two western Atlantic reef sites. Limnol. Oceanogr., doi: 10.1002/lno.12009.
- Newton, J., P. MacCready, S. Siedlecki, D. Manalang, J. Mickett, S. Alin, E. Schumacker, J. Hagen, S. Moore, A. Sutton, and R. Carini (2021): Multi-stressor observations and modeling to build understanding of and resilience to the coastal impacts of climate change. Oceanography, 34(4), 86-87, doi: 10.5670/oceanog.2021.supplement.02-31.
- Shadwick, E.H., A.S. Rigual-Hernández, R.S. Eriksen, P. Jansen, D.M. Davies, C.A. Wynn-Edwards, A. Sutton, C. Schallenberg, E. Shulz, and T.W. Trull (2021): Changes in Southern Ocean biogeochemistry and the potential impact on pH-sensitive planktonic organisms. Oceanography, 34(4), 14-15, doi: 10.5670/oceanog.2021.supplement.02-06.
- Tamsitt, V., S. Bushinsky, Z. Li, M. du Plessis, A. Foppert, S. Gille, S. Rintoul, E. Shadwick, A. Silvano, A.

- Sutton, S. Swart, B. Tilbrook, and N.L. Williams (2021): Southern Ocean. In State of the Climate in 2020, Antarctica and the Southern Ocean. Bull. Am. Meteorol. Soc., 102(8), S341–S345, doi: 10.1175/BAMS-D-21-0081.1.
- Lovenduski, N.S., N.C. Swart, A.J. Sutton, J.C. Fyfe, G.A. McKinley, C.L. Sabine, and N.L. Williams (2021): The ocean carbon response to COVID-related emissions reductions. Geophys. Res. Lett., 48(6), e2020GL092263, doi: 10.1029/2020GL092263.
- Chen, S., A.J. Sutton, C. Hu, and F. Chai (2021): Quantifying the atmospheric forcing effect on surface ocean pCO2 in the North Pacific subtropical gyre in the past two decades. Front. Mar. Sci., 8, 636881, doi: 10.3389/fmars.2021.636881
- Sutton, A.J., N.L. Williams, and B. Tilbrook (2021): Constraining Southern Ocean CO2 flux uncertainty using uncrewed surface vehicle observations. Geophys. Res. Lett. [Accepted]
- Torres, O., L. Kwiatkowski, A.J. Sutton, N. Dorey, and J.C. Orr (2021): Characterising mean and extreme diurnal variability of ocean CO2 system variables across marine environments. Geophys. Res. Lett., 48(5), e2020GL090228, doi: 10.1029/2020GL090228.
- Friedlingstein, P., M. O'Sullivan, M.W. Jones, R.M. Andrew, J. Hauck, A. Olsen, G.P. Peters, W. Peters, J. Pongratz, S. Sitch, C. Le Quéré, J.G. Canadell, P. Ciais, R. Jackson, S. Alin, L.E.O.C. Aragão, V. Arora, A. Arneth, N.R. Bates, M. Becker, A. Benoit-Cattin, H.C. Bittig, L. Bopp, S. Bultan, N. Chandra, F. Chevallier, L.P. Chini, W. Evans, L. Florentie, P. Forster, T. Gasser, M. Gehlen, D. Gilfillan, T. Gkritzalis, L. Gregor, N. Gruber, I. Harris, K. Hartung, V. Haverd, R.A. Houghton, T. Ilyina, A.K. Jain, E. Joetzjer, K. Kadono, E. Kato, V. Kitidis, J.I. Korsbakken, P. Landschützer, N. Lefèvre, A. Lenton, S. Lienert, Z. Liu, D. Lombardozzi, G. Marland, N. Metzl, D.R. Munro, J.E.M.S. Nabel, S.-I. Nakaoka, Y. Niwa, K. O'Brien, T. Ono, P.I. Palmer, D. Pierrot, B. Poulter, L. Resplandy, E. Robertson, C. Rödenbeck, J. Schwinger, R. Séférian, I. Skjelvan, A.J.P. Smith, A.J. Sutton, T. Tanhua, P.P. Tans, H. Tian, B. Tilbrook, G.R. van der Werf, N. Vuichard, A.P. Walker, R. Wanninkhof, A.J. Watson, D. Willis, A.J. Wiltshire, W. Yuan, X. Yue, and S. Zaehle (2020): Global Carbon Budget 2020. Earth Sys. Sci. Data, 12, 3269–3340, doi: 10.5194/essd-12-3269-2020.
- Sutton, A.J., and J.A. Newton (2020): Reaching consensus on assessments of ocean acidification trends. EOS, 101, doi: 10.1029/2020EO150944
- Sabine, C., A.J. Sutton, K. McCabe, N. Lawrence-Slavas, S.R. Alin, R.A. Feely, R. Jenkins, S. Maenner, C. Meinig, J. Thomas, E. van Ooijen, A. Passmore, and B. Tilbrook (2020): Evaluation of a new carbon dioxide system for autonomous surface vehicles. J. Atmos. Oceanic Technol., doi: https://doi.org/10.1175/JTECH-D-20-0010.1.
- Cai, W.-J., Y.-Y. Xu, R.A. Feely, R. Wanninkhof, B. Jönsson, S.R. Alin, L. Barbero, J. Cross, K. Azetsu-Scott, A. Fassbender, B.R. Carter, L-Q. Jiang, P. Pepin, B. Chen, N. Hussain, J. Reimer, L. Xue, J.E. Salisbury, M. Hernandez-Ayon, C. Langdon, Q. Li, A.J. Sutton, C.-T.A. Chen, and D. Gledhill (2020): Controls on surface water carbonate chemistry along North American ocean margins. Nature Commun., 11, 2691, doi: 10.1038/s41467-020-16530-z
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- Steinhoff, K. Sullivan, H. Sun, A.J. Sutton, T. Suzuki, C. Sweeney, T. Takahashi, J. Tjiputra, N. Tsurushima, S.M.A.C. van Heuven, D. Vandemark, P. Vlahos, D.W.R. Wallace, R. Wanninkhof, and A.J. Watson. 2013. An update to the surface ocean CO₂ atlas (SOCAT version 2). Earth Syst. Sci. Data 6: 69–90, doi: 10.5194/essd-6-69-2014.
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- Sutton, A.J., T.R. Fisher, and A.B. Gustafson. 2009. Historical changes in water quality at German Branch watershed in the Choptank River basin. Water, Air, and Soil Pollution 199: 353-369.
- Fisher, T.R., J.A. Benitez, K.-Y. Lee, and A.J. Sutton. 2006. History of land cover change and biogeochemical impacts in the Choptank River basin in the mid-Atlantic region of the U.S. International Journal of Remote Sensing 27: 3683-3703.

BOOK CHAPTERS, WHITEPAPERS, AND REPORTS

- Kessler, W.S., S. Cravatte, P.G. Strutton, A.J. Sutton, A. Kumar, Y. Takaya, H. Hendon, K. O'Brien, N. Smith, S.E. Wijffels, J. Sprintall, A.T. Wittenberg, K. Ando, K. Hill, W. Large, D. Legler, K. Tedesco, and S. Lucas (2021): Final Report of TPOS 2020. GOOS-268, TPOS 2020, 86 pp.
- Lindquist, A., A. Sutton, A. Devol, A. Winans, A. Coyne, B. Bodenstein, B. Curry, B. Herrmann, B. Sackmann, B. Tyler, C. Maloy, C. Greengrove, C. Fanshier, C. Krembs, C. Sabine, C. Cook, C. Hard, C. Greene, D. Lowry, D. Harvell, E. McPhee-Shaw, E. Haphey, G. Hannach, H. Bohlmann, H. Burgess, I. Smith, I. Kemp, J. Newton, J. Borchert, J. Mickett, J. Apple, J. Bos, J. Parrish, J. Ruffner, J. Keister, J. Masura, K. Devitt, K. Bumbaco, K. Stark, L. Hermanson, L. Claassen, L. Swanson, M. Burger, M. Schmidt, M. McCartha, M. Peacock, M. Eisenlord, M. Keyzers, N. Christman, N. Hamel, N. Burnett, N. Bond, O. Graham, P. Biondo, P. Hodum, R. Wilborn, R.A. Feely, S. Pearson, S. Alin, S. Albertson, S. Moore, S. Jaeger, S. Pool, S. Musielwicz, T. King, T. Good, T. Jones, T. Ross, T. Sandell, T. Burks, V. Trainer, V. Bowes, W. Ruef, and W. Eash-Loucks (2020): Puget Sound Marine Waters: 2019 Overview. J. Apple, R. Wold, K. Stark, J. Bos, P. Williams, N. Hamel, S. Yang, J. Selleck, S. K. Moore, J. Rice, S. Kantor, C. Krembs, G. Hannach, and J. Newton (eds.), NOAA Northwest Fisheries Science Center for the Puget Sound Ecosystem Monitoring Program's (PSEMP) Marine Waters Workgroup.
- Lindquist, A., A. Sutton, A. Devol, A. Winans, A. Coyne, B. Bodenstein, B. Curry, B. Herrmann, B. Sackmann, B. Tyler, C. Maloy, C. Greengrove, C. Fanshier, C. Krembs, C. Sabine, C. Cook, C. Hard, C. Greene, D. Lowry, D. Harvell, E. McPhee-Shaw, E. Haphey, G. Hannach, H. Bohlmann, H. Burgess, I. Smith, I. Kemp, J. Newton, J. Borchert, J. Mickett, J. Apple, J. Bos, J. Parrish, J. Ruffner, J. Keister, J. Masura, K. Devitt, K. Bumbaco, K. Stark, L. Hermanson, L. Claassen, L. Swanson, M. Burger, M. Schmidt, M. McCartha, M. Peacock, M. Eisenlord, M. Keyzers, N. Christman, N. Hamel, N. Burnett, N. Bond, O. Graham, P. Biondo, P. Hodum, R. Wilborn, R.A. Feely, S. Pearson, S. Alin, S. Albertson, S. Moore, S. Jaeger, S. Pool, S. Musielwicz, T. King, T. Good, T. Jones, T. Ross, T. Sandell, T. Burks, V. Trainer, V. Bowes, W. Ruef, and W. Eash-Loucks (2020): Puget Sound Marine Waters: 2019 Overview. J. Apple, R. Wold, K. Stark, J. Bos, P. Williams, N. Hamel, S. Yang, J. Selleck, S. K. Moore, J. Rice, S. Kantor, C. Krembs, G. Hannach, and J. Newton (eds.), NOAA

- Northwest Fisheries Science Center for the Puget Sound Ecosystem Monitoring Program's (PSEMP) Marine Waters Workgroup.
- Feely, R.A., S. Alin, B. Carter, J.P. Dunne, D.K. Gledhill, L. Jiang, V. Lance, C. Stepien, A. Sutton, and R. Wanninkhof (2020): Open ocean region acidification research. Chapter 2 in NOAA Ocean, Coastal, and Great Lakes Acidification Research Plan: 2020-2029, Jewett, E.B., E.B. Osborne, K.M. Arzayus, K. Osgood, B.J. DeAngelo, and J.M. Mintz (eds.), https://oceanacidification.noaa.gov/ResearchPlan2020.
- Kessler, W.S., S.E. Wijffels, S. Cravatte, N. Smith, A. Kumar, Y. Takaya, Y. Fujii, H. Hendon, A. Sutton, P. Strutton, Y. Serra, B. Dewitte, C.A. Clayson, M.F. Cronin, J.T. Farrar, J. Sprintall, X. Song, K. O'Brien, K. Ando, K. Takahashi, L. Moreno, D. Roemmich, S. McGregor, A. Wittenberg, T. Lee, S.G. Penny, W. Large, S. de Szoeke, I. Ueki, L. O'Neill, E.R. Kursinski, F. Gasparin, W. Yu, D. Chen, Y. Xue, I. Montes, D. Legler, L. Upchurch, and S. Brunner (2019): Second Report of TPOS 2020. GOOS-234, TPOS 2020, View online at TPOS2020.org.
- Lindquist, A., A. Sutton, A. Devol, A. Winans, A. Coyne, B. Bodenstein, B. Curry, B. Herrmann, B. Sackmann, B. Tyler, C. Maloy, C. Greengrove, C. Fanshier, C. Krembs, C. Sabine, C. Cook, C. Hard, C. Greene, D. Lowry, D. Harvell, E. McPhee-Shaw, E. Haphey, G. Hannach, H. Bohlmann, H. Burgess, I. Smith, I. Kemp, J. Newton, J. Borchert, J. Mickett, J. Apple, J. Bos, J. Parrish, J. Ruffner, J. Keister, J. Masura, K. Devitt, K. Bumbaco, K. Stark, L. Hermanson, L. Claassen, L. Swanson, M. Burger, M. Schmidt, M. McCartha, M. Peacock, M. Eisenlord, M. Keyzers, N. Christman, N. Hamel, N. Burnett, N. Bond, O. Graham, P. Biondo, P. Hodum, R. Wilborn, R.A. Feely, S. Pearson, S. Alin, S. Albertson, S. Moore, S. Jaeger, S. Pool, S. Musielwicz, T. King, T. Good, T. Jones, T. Ross, T. Sandell, T. Burks, V. Trainer, V. Bowes, W. Ruef, and W. Eash-Loucks (2018): Puget Sound Marine Waters: 2017 Overview. S. Moore, R. Wold, K. Stark, J. Bos, P. Williams, N. Hamel, A. Edwards, C. Krembs, and J. Newton (eds.), NOAA Northwest Fisheries Science Center for the Puget Sound Ecosystem Monitoring Program's (PSEMP) Marine Waters Workgroup, Published online.
- Cooley, S.R., D.J.P. Moore, S.R. Alin, D. Butman, D.W. Clow, N.H.F. French, R.A. Feely, Z.I. Johnson, G. Keppel-Aleks, S.E. Lohrenz, I.B. Ocko, E.H. Shadwick, A.J. Sutton, C.S. Potter, Y. Takatsuka, A.P. Walker, and R.M.S. Yu (2018): Biogeochemical effects of rising atmospheric carbon dioxide. Chapter 17 in Second State of the Carbon Cycle Report (SOCCR2): A Sustained Assessment Report, Cavallaro, N., G. Shrestha, R. Birdsey, M.A. Mayes, R.G. Najjar, S.C. Reed, P. Romero-Lankao, and Z. Zhu (eds.), U.S. Global Change Research Program, Washington, DC, 690–727., https://carbon2018.globalchange.gov/, doi: 10.7930/SOCCR2.2018.Ch17.
- Lindquist, A., A. Sutton, A. Devol, A. Winans, A. Coyne, B. Bodenstein, B. Curry, B. Herrmann, B. Sackmann, B. Tyler, C. Maloy, C. Greengrove, C. Fanshier, C. Krembs, C. Sabine, C. Cook, C. Hard, C. Greene, D. Lowry, D. Harvell, E. McPhee-Shaw, E. Haphey, G. Hannach, H. Bohlmann, H. Burgess, I. Smith, I. Kemp, J. Newton, J. Borchert, J. Mickett, J. Apple, J. Bos, J. Parrish, J. Ruffner, J. Keister, J. Masura, K. Devitt, K. Bumbaco, K. Stark, L. Hermanson, L. Claassen, L. Swanson, M. Burger, M. Schmidt, M. McCartha, M. Peacock, M. Eisenlord, M. Keyzers, N. Christman, N. Hamel, N. Burnett, N. Bond, O. Graham, P. Biondo, P. Hodum, R. Wilborn, R.A. Feely, S. Pearson, S. Alin, S. Albertson, S. Moore, S. Jaeger, S. Pool, S. Musielwicz, T. King, T. Good, T. Jones, T. Ross, T. Sandell, T. Burks, V. Trainer, V. Bowes, W. Ruef, and W. Eash-Loucks (2017): Puget Sound Marine Waters: 2016 Overview. S. Moore, R. Wold, K. Stark, J. Bos, P. Williams, N. Hamel, A. Edwards, C. Krembs, and J. Newton (eds.), NOAA Northwest Fisheries Science Center for the Puget Sound Ecosystem Monitoring Program's (PSEMP) Marine Waters Workgroup,
- Cravatte, S., W.S. Kessler, N. Smith, S. Wijffels, K. Ando, M. Cronin, T. Farrar, E. Guilyardi, A. Kumar, T. Lee, D. Roemmich, J. Sprintall, Y. Serra, P. Strutton, A. Sutton, K. Takahashi, and A. Wittenberg. 2016. TPOS 2020 Project: First Report. In TPOS 2020, TPOS2020.org.
- Siedlecki, S., E. Bjorkstedt, R. Feely, A. Sutton, J. Cross, and J. Newton. 2016. Impact of the Blob on the northeast Pacific Ocean biogeochemistry and ecosystems. U.S. CLIVAR Variations, 14(2), 7–12, http://usclivar.org/newsletter/newsletters.

- Mathis, J.T., R.A. Feely, A.J. Sutton, C. Carlson, F. Chai, F. Chavez, M. Church, C. Cosca, M. Ishii, C. Mordy, A. Murata, J. Resing, P. Strutton, T. Takahashi, and R. Wanninkhof. 2014. TPOS Whitepaper #6. Tropical Pacific biogeochemistry: Status, implementation and gaps. In Proceedings of the Tropical Pacific Observing System 2020 Workshop, A Future Sustained Tropical Pacific Ocean Observing System for Research and Forecasting, La Jolla, CA, 27–30 January 2014.
- Sutton, A.J., among other contributors. 2014. Puget Sound Marine Waters: 2013 Overview. Moore, S.K., K. Stark, J. Bos, P. Williams, J. Newton, and K. Dzinbal (eds.), NOAA Northwest Fisheries Science Center for the Puget Sound Ecosystem Monitoring Program's (PSEMP) Marine Waters Workgroup, 60 pp.
- Wanninkhof, R., D. Bakker, N. Bates, A. Olsen, T. Steinhoff, and A.J. Sutton. 2013. Incorporation of Alternative Sensors in the SOCAT Database and Adjustments to Dataset Quality Control Flags. http://cdiac.ornl.gov/oceans/Recommendationnewsensors.pdf. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, US Department of Energy, Oak Ridge, Tennessee. doi: 10.3334/CDIAC/OTG.SOCAT ADOCF
- Sutton, A.J. 2013. Acidification of Ocean Water. In: Miller, I.M., C. Shishido, L. Antrim, and C.E. Bowlby. Climate Change and the Olympic Coast National Marine Sanctuary: Interpreting Potential Futures. Marine Sanctuaries Conservation Series ONMS-13-01. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 238pp.
- Wanninkhof, R., R. Feely, A.J. Sutton, C. Sabine, K. Tedesco, N. Gruber, and S. Doney. 2013. An integrated ocean carbon observing system (IOCOS). In Proceedings of the IOOS Summit, Interagency Ocean Observation Committee (IOOC), Herndon, Virginia, 13-16 November 2012.
- Gledhill, D.K., E.B. Jewett, K. Arzayus, J. Newton, J. Salisbury, and A.J. Sutton. 2013. An integrated coastal ocean acidification observing system (ICOAOS). In Proceedings of the IOOS Summit, Interagency Ocean Observation Committee (IOOC), Herndon, Virginia, 13-16 November 2012.
- Sutton, A.J., among other contributors. 2012. Puget Sound Marine Waters: 2011 Overview. S.K. Moore, R. Runcie, K. Stark, J. Newton, and K. Dzinbal (eds.), NOAA Northwest Fisheries Science Center for the Puget Sound Ecosystem Monitoring Program's (PSEMP) Marine Waters Workgroup, 54 pp.
- Sutton, A.J. 2012. Ocean Acidification Measurements. In <u>Encyclopedia of Sustainability: Measurements</u>, <u>Indicators, and Research Methods for Sustainability</u>, edited by I. Spellerberg, D. Fogel, and S. Fredericks: Berkshire Publishing. Great Barrington, MA.
- Feely, R.A., R. Wanninkhof, J. Stein, M.F. Sigler, E. Jewett, F. Arzayus, D.K. Gledhill, and A.J. Sutton. 2010. NOAA Ocean and Great Lakes Acidification Research Plan. NOAA Special Report, April 2010, 143 pp.
- Fisher, T.R., T.E. Jordan, K.W. Staver, A.B. Gustafson, A.I. Koskelo, R.J. Fox, A.J. Sutton, T. Kana, K.A. Beckert, J.P. Stone, G. McCarty, and M. Lang. 2010. The Choptank Basin in transition: intensifying agriculture, slow urbanization, and estuarine eutrophication. In <u>Coastal Lagoons: Systems of Natural and Anthropogenic Change</u>, edited by M. J. Kennish and H. W. Paerl: CRC Press. Boca Raton, FL.
- Sutton, A.J. 2006. Evaluation of agricultural nutrient reductions in restored riparian buffers. University of Maryland Dissertation.

OUTREACH PUBLICATIONS

- Sutton, A.J. 2016. Career profiles: Options and insights—Adrienne J. Sutton, Research Scientist, University of Washington Joint Institute for the Study of the Atmosphere and Ocean, NOAA Pacific Marine Environmental Laboratory. Oceanography, 29(2), 298–299. [available online]
- Sutton, A.J. 2012. Everyday Scientists: High School Poets, Home Brewers, and Scuba Divers. Sources: The Journal of Underwater Education 24(4): 56-57. [pdf]

- Sutton, A.J. 2011. Coral Reefs Face Increasing Stress from Local Human Activities, Warming Waters, and Ocean Acidification. Sources: The Journal of Underwater Education 23(3): 34-35. [pdf]
- Sutton, A.J. 2010. Ocean Acidification: A Fundamental Problem for the Future of Recreational Diving. Sources: The Journal of Underwater Education 22(2): 54-57. [pdf]
- Sutton, A.J. 2010. Deep-Sea Corals and the Changing Chemistry of the Sea. NOAA National Marine Sanctuary Deep-Sea Coral Expedition online cruise report. [website]

SELECTED PRESENTATIONS

- Sutton, A.J. 2021. New observing technologies investigating the Southern Ocean carbon sink, COP26 Cryosphere Pavilion event "Tale of Two Oceans", virtual, November 2021 (invited).
- Sutton, A.J. 2021. Advances and new opportunities in air-sea CO2 observing, University of Southern Mississippi's Marine Science Spring Semester Series, virtual, May 2021 (invited).
- Sutton, A.J. 2021. Tropical Pacific biogeochemistry: background, gaps, and open questions, US CLIVAR Phenomena, Observations, and Synthesis (POS) Panel webinar series, virtual, April 2021 (invited).
- Sutton, A.J. 2021. Recent advances in observing technology create new opportunities in air-sea CO2 exchange research, NOAA Geophysical Fluids Dynamics Laboratory Virtual Formal Seminar Series, virtual, March 2021 (invited).
- Sutton, A.J., S. Chu, A. Fassbender, K. McCabe, P. Monteiro, C. Sabine, and B. Tilbrook. 2020. Recent progress and future opportunities in autonomous ocean CO2 flux observing, 2020 AGU Fall Meeting, virtual, December 2020.
- Sutton and Newton. 2020. Developing best practices for determining multi-decadal change in ocean acidification time series, GAO-ON Ocean Acidification Week, virtual, September 2020 (invited).
- Sutton, A.J. Uncertainty in autonomous ocean carbonate chemistry observations. 2020. Evolving and Sustaining Ocean Best Practices System Workshop IV, virtual, September 2020 (invited).
- Sutton, A.J. NOA-ON Buoy Data Tools and Synthesis. 2020. NOAA Ocean Acidification Program Review, virtual, August 2020 (invited).
- Sutton and Chu. Considering Low-Cost Options for Measuring Ocean Carbon Chemistry, USGCRP Integrated Observations Interagency Working Group Meeting, virtual, August 2020 (invited).
- Sutton, A.J., N.L. Williams, and B. Tilbrook. 2020. Air-sea CO₂ flux measurements on the first autonomous circumnavigation of Antarctica, Ocean Sciences Meeting, San Diego, California, February 2020.
- Sutton, A.J. and 30+ collaborators. 2019. Autonomous Ocean Acidification Observations for Constraining Variability, Detecting Trends, and Predicting Biological Exposure, 4th Global Ocean Acidification Observing Network International Workshop, Hangzhou, China, April 2019.
- Sutton, A.J. and 30+ collaborators. 2019. Constraining change and variability in surface ocean CO₂: A global network of autonomous time series, OceanObs'19, Honolulu, Hawaii, September 2019.
- Sutton, A.J. and 30+ collaborators. 2018. Ocean Carbon Variability and Change Constrained by Seawater pCO₂ Time Series Observations, AGU Fall Meeting, Washington DC, December 2018.
- Sutton, A.J. and 30+ collaborators. 2018. Magnitude and timing of ocean carbon uptake variability constrained by seawater pCO2 time series observations, Synthesis and intercomparison of ocean carbon uptake in CMIP6 models, Ocean Carbon and Biogeochemistry Project, Washington DC, December 2018. (invited)
- Sutton, A.J. and 30+ collaborators. 2018. Ocean carbon variability and change constrained by seawater pCO₂ time series observations, UMCES Horn Point Laboratory Cambridge, MD, December 2018 (invited).
- Sutton, A. J., R.A. Feely, and C.L. Sabine. 2018. Surface ocean carbon from days to decades: unique signals emerging from moored autonomous time series, Ocean Sciences Meeting, Portland, Oregon, February 2018.

- Sutton, A.J., C.L. Sabine, and R.A. Feely. 2017. Moored autonomous observing of air-sea CO₂ flux and ocean acidification: A growing global network, 10th International Carbon Dioxide Conference, Interlaken, Switzerland, August 2017.
- Sutton, A.J., C.L. Sabine, and R.A. Feely. 2016. Natural variability and anthropogenic change revealed by moored time series observations of pCO₂ and pH. Oceans in a High CO₂ World, Hobart, Australia, 3 May 2016.
- Sutton, A.J., C.L. Sabine, and R.A. Feely. 2016. Using present day observations to detect when ocean acidification exceeds natural variability of surface seawater Ωaragonite. Ocean Sciences Meeting, New Orleans LA, 22-26 Feb 2016.
- Sutton, A. J., R.A. Feely, C.L. Sabine, M.J. McPhaden, and T. Takahashi. 2014. Natural and anthropogenic change since 1997: A synthesis of Equatorial Pacific surface ocean pCO₂ observations on the TAO Array. Ocean Sciences Meeting, Honolulu HI, 24-28 Feb 2014.
- Sutton, A.J., R.A. Feely, C.L. Sabine, C.E. Cosca, and S. Maenner-Jones. 2012. Rising Atmospheric CO₂ and Ocean Acidification: the Tropical Oceans and Beyond. Tropical Oceans: Challenges of the 21st Century Meeting, Universidade Federal of Pernambuco, Recife, Brazil (invited).
- Sutton, A.J., R.A. Feely, C.L. Sabine, S.R. Alin, and J. Mathis. 2012. Rising Atmospheric CO₂ and Ocean Acidification: From the Poles to Puget Sound. NOAA Senior Research Council Meeting, Seattle, WA (invited).
- Sutton, A.J., R.A. Feely, C.L. Sabine, and S.R. Alin. 2012. From the global ocean to the Puget Sound: how OA is playing out locally and afar. JISAO Annual Luncheon, Seattle, WA (invited).
- Sutton, A.J., M. Conathan, C.A. English, A. Mace, and J.J. Meyer. 2012. Pups in the Shark Tank: skills marine studies graduates develop while navigating Washington's political waters. Ocean Sciences Meeting, Salt Lake City, UT, 19-24 Feb 2012.
- Sutton, A.J. 2011. Biogeochemistry overview: global and coastal ocean acidification. National Council for Science and the Environment, Washington, DC (invited).
- Regular presentations on ocean and climate policy and legislation to NOAA's Science Advisory Board and other NOAA Leadership panels. 2006-2008.
- Sutton, A.J. 2008. Ocean issues in the 110th Congress and why Washington needs more scientists. UMCES Horn Point Laboratory Cambridge, MD (invited).

SELECTED AWARDS

Department of Commerce Bronze Award for successfully deploying the first MAPCO₂ buoy in a southern hemisphere coral reef to monitor ocean acidification (2021)

Department of Commerce Group Gold Medal in Scientific/Engineering Achievement for the first autonomous circumnavigation of Antarctica, allowing three-season observation of carbon dioxide flux in the Southern Ocean (2020)

UNCW Athletic Hall of Fame inductee (2014)

National Research Council Postdoctoral Research Associate Fellowship (2010)

Colonial Athletic Association's (CAA) Silver Anniversary Team for Women's Swimming and Diving (2009)

NOAA Administrator's Award for outstanding leadership in and dedication to developing U.S. Climate Change Science Program (CCSP) Synthesis & Assessment Products integrating climate research for decision support (July 2008)

NOAA Recognition Award for exceptional performance (July 2007 and Nov 2007)

John A. Knauss Marine Policy Fellowship (Feb. 2006-Jan. 2007)

Horn Point Laboratory Graduate Fellowship (2000-2002)

UNCW Departmental Honors in Biology (2000)

CAA Conference Scholar Athlete (1997-2000)

UNCW Golden Seahawk Academic Award (1997-2000)

Dean's List UNCW (1996-2000)

NSF Research Experience for Undergraduates Fellowship, SIO (1999)

CAA Conference Rookie of the Year (1997)

COMMITTEES

Scientific Steering Group, International Ocean Carbon Coordination Project, 2021 to present.

Executive Council, Global Ocean Acidification Observing Network, 2021 to present.

Science Steering Committee, OceanSITES, 2011 to present.

Scientific Steering Group, PIRATA, 2018 to present.

Member, United Nation's Sustainable Development Goal 14.3.1 Indicator Development Expert Group, 2017 to present.

Member, Filling the gaps in observation-based estimates of air—sea carbon fluxes, Ocean Carbon and Biogeochemistry Program Working Group, 2019 to present.

Co-chair, Biogeochemistry Task Team, Tropical Pacific Observing System 2020, 2015 to 2021.

Advisory Board, Advancing Climate Literacy through Investment in In-service and Pre-service Science Educators, Lawrence Hall of Science at the University of California Berkeley and Western Washington University, 2014 to 2018.

Advisor, Wendy Schmidt Ocean Health XPRIZE, 2012 to 2016.

Science Communication Advisory Group, UW College of the Environment, 2012 to 2017.

PROFESSIONAL SERVICE

Earth Science Women's Network, 2020-present.

Society for Women in Marine Science, Seattle Chapter, 2020-present.

American Geophysical Union. Member, 2009-present.

American Society of Limnology and Oceanography, Dissertations Initiative for the Advancement of Limnology and Oceanography, 2007-2011.

Scientific Session Convener at AGU Fall Meeting 2010, 2016; Ocean Sciences 2012, 2014, 2020, 2022; Goldschmidt 2017.

Reviewer for Nature, Geophysical Research Letters, PLOS ONE, Scientific Reports, Limnology and Oceanography, Journal of Geophysical Research – Oceans, Progress in Oceanography, Biogeosciences, Aquatic Geochemistry, Journal of Advances in Modeling Earth Systems, Frontiers in Marine Science, Global Biogeochemical Cycles, Ocean Science.

NOAA Science Advisory Board Congressional Liaison, 2007-2008.

POSTGRADUATE-SCHOLAR ADVISOR

Sophie Chu (UW JISAO, 2017-2019)

Andrea Fassbender (Postdocs Applying Climate Expertise Postdoctoral Fellowship Program, 2015-2016) Remy Okazaki (Wendy Schmidt Ocean Health XPRIZE Validation Lead, 2014-2016)

GRADUATE ADVISOR

Treasure Warren (UW School of Oceanography, 2021 to present)

SCIENCE EDUCATION AND COMMUNITY OUTREACH ACTIVITIES

Mentor, Global Ocean Acidification Observing Network Pier2Peer Program: Mary Chris Lagumen, University of the Philippines, 2016-present.

Undergraduate summer interns: Ilyana Collins (co-mentored), NOAA Educational Partnership Program with Minority Serving Institutions Undergraduate Scholarship Program, 2020 to 2021; Isabelle Chan (co-mentored), Research Experience for Undergrads, 2019; Treasure Warren, Research Experience for Undergrads, 2018; Virginia Parker, NOAA College-Supported Internship Program, 2018. High school student mentor: pilot project of the Educurious Expert Network, Bellevue Big Picture School, 2011.

Trainer, Ocean Teacher Global Academy, Ocean Acidification Course, virtual, 2021.

Trainer, Technical Meeting on the Management, Analysis and Quality Control of Ocean Acidification Observation Data, Ocean Acidification International Coordination Centre of the International Atomic Energy Agency, Monaco, 2018.

Workshop presenter, Expanding Your Horizons for Middle School Girls, Bellevue Community College, semi-annual 2011 to 2016.

Guest speaker/lecturer, UW Marine Pollution class, 2019, 2020; UW Chemical Oceanography seminar, 2019; American Petroleum Institute Upstream Water Issues Group, 2017; Seattle Art Institute, 2016; Graduate and Professional Student Senate Science and Policy Summit, 2015; Guest Scientist, toAster (the Oceanography All Student Educational Retreat), UW School of Oceanography, 2013; Western Washington Univ. Huxley College of the Environment on the Peninsulas, Puget Sound Research course, 2013; Central Washington Univ. Oceans and Atmosphere course, 2013; UW School of Marine and Environmental Affairs, Society and Oceans course, 2012; JISAO summer intern lecture series, 2012; UW School of Marine and Environmental Affairs Contemporary Issues in Marine Affairs Course, 2012; Institutes for Journalism and Natural Resources Puget Sound Learning Expedition, 2011; COSEE Pacific Partnerships - Community College Faculty Summer Teaching Institute, 2011; Seattle Girls School science class, 2010; Washington State Ocean Caucus, 2010.

SELECTED PRESS

New technology offers insights on Southern Ocean's carbon secrets, Yale Climate Connections, July 2021

Is the Southern Ocean absorbing or emitting carbon dioxide?, NOAA Research News Highlight, February 2021

Study sheds light on Antarctic Ocean climate riddle, Climatewire, January 2021

Little boats for whale songs sail into climate hot spots, E&E News, September 2020

An ocean of data: A day in the life of a NOAA oceanographer, NOAA Research Women's History Month Spotlight, March 2020

Seafaring robot crashes into iceberg, still finishes scientific trip around Antarctica, Mashable, August 2019
Saildrone's Journey Around Antarctica Uncovers New Climate Clues, Bloomberg Businessweek, August 2019
First saildrone circumnavigates Antarctica, seeking carbon dioxide, Climate.gov, August 2019
The Southern Ocean may be less of a carbon sink than we thought, ScienceNews, June 2019
New NOAA, partner buoy in American Samoa opens window into a changing ocean, NOAA Research, May 2019
Scientists seek larger ocean acidification monitoring buoy network, Environmental Monitor, October 2014

CURRICULUM VITAE - CHRISTOPHER LEE SABINE

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Research and Administrative Interests

My research addresses the role of the ocean in the global carbon cycle. In particular, my work centers on interpreting ocean inorganic carbon measurements and understanding ocean acidification. This includes understanding the air-sea exchange of CO₂ at the ocean surface, examining the basin-scale distributions of both natural and anthropogenic carbon in the ocean's interior, understanding multiple tracer relationships (e.g. anthropogenic CO₂ and dissolved oxygen), evaluating ocean carbon cycle GCMs with data-based global carbon distributions, and examining carbonate and organic matter re-mineralization within the open ocean and in coastal environments. My administrative interests are grounded in a desire to help advance science and technology more effectively at the national and international levels. I enjoy working with a broad scope of researchers and technology developers to take a "big picture" view of the current state of science and contribute to the development of research directions and innovative technologies that will help both the ocean and society to prosper.

Education

1992 Ph.D. in Oceanography, University of Hawai'i at Mānoa, Honolulu, HI 96822 (Fred T.

Mackenzie, Advisor).

B.S. in Marine Science, Texas A&M University at Galveston, Galveston, TX 77553.

Professional History

Professional History	
Interim Vice Provost for Research and Scholarship	
Full Professor (tenured 2020), Oceanography Department, University of Hawai'i at Mānoa	
Interim Director, Hawaii Institute of Marine Biology	
Associate Dean of Research, SOEST, University of Hawai'i at Mānoa	
Interim Associate Dean of Research, SOEST, University of Hawai'i at Mānoa	
Acting Associate Dean of Research (50%), SOEST, University of Hawai'i at Mānoa	
Affiliate Full Professor, Department of Oceanography, University of Washington	
Senior Fellow, University of Washington Joint Institute for the Study of the Atmosphere and	
Ocean	
Director, NOAA Pacific Marine Environmental Laboratory	
Supervisory Oceanographer, NOAA Pacific Marine Environmental Laboratory	
Oceanographer, NOAA Pacific Marine Environmental Laboratory	
Affiliate Associate Professor, Department of Oceanography, University of Washington	
Research Scientist, Joint Institute for the Study of the Atmosphere and the Ocean, University of	
Washington/NOAA Pacific Marine Environmental Laboratory.	
Research Staff, Program in Atmospheric and Ocean Sciences, Department of Geosciences, Princeton University.	
Research Associate, Program in Atmospheric and Ocean Sciences, Department of Geological and	
Geophysical Sciences, Princeton University.	
Graduate Research Assistant, Hawaii Institute of Geophysics, University of Hawai'i at Mānoa.	
Research Technician, University of Texas Medical Branch, Department of Microbiology	
Summer Intern, Harbor Branch Foundation Inc., Marine Geology Department, Ft. Pierce, FL (C.	
Hoskin, Advisor)	

Scholarships and Awards

2018	Department of Commerce Bronze Medal for strengthening NMFS-OAR collaborations through the pioneering use of a Saildrone for next-generation ecosystem surveys in the Bering Sea
	(Pacific Marine Environmental Laboratory 2016 Saildrone Team).
2017	Department of Commerce Bronze Medal for creating the Global Ocean Acidification Observing
2017	
2014	Network, a collaborative international approach to document the progress of ocean acidification.
2014	NOAA Administrator's Award for scientific expertise, leadership and outstanding contributions
• • • •	to the IPCC 5 th Assessment Report
2013	AGU Fellow
2012	Honorary Doctor of Science Degree from Gustavus Adolphus College
2011	NOAA Technology Transfer Award
2010	Seattle Federal Executive Board's 2010 Public Service Award for Space Needle CO ₂ sensor
	outreach project with the Pacific Science Center
2009	NOAA Research Employee of the Year (leadership)
2009	NASA Group Achievement Award for outstanding accomplishments and interagency
	collaboration in the Southern Ocean Gas Exchange Experiment 2008.
2009	American Geophysical Union Editor's Citation for Excellence in Refereeing from Geophysical
_009	Research Letters
2009	OAR Outstanding Scientific Paper Award "Feely, R.A., C.L. Sabine, J.M. Hernandez-Ayon, D.
200)	Ianson, and B. Hales (2008): Evidence for upwelling of corrosive "acidified" water onto the
	Continental Shelf. Science, 320(5882), doi: 10.1126/science.1155676, 1490–1492."
2008	PMEL Outstanding Scientific Paper Award "Sabine, C.L., and R.A. Feely (2007): The oceanic
2008	
	sink for carbon dioxide. In <i>Greenhouse Gas Sinks</i> , D. Reay, N. Hewitt, J. Grace, and K. Smith
2000	(eds.), CABI Publishing, Oxfordshire, UK, 31–49."
2008	NOAA/OAR Special Act Award
2007	Special recognition from IPCC for contributing to the 2007 Nobel Peace Prize.
2007	NOAA employee of the month for October 2007.
2006	Department of Commerce Gold Medal Award for pioneering research leading to the discovery of
2005	increased acidification in the world's oceans due to the absorption of carbon dioxide.
2005	PMEL Outstanding Scientific Paper Award "Sabine, C.L., R.A. Feely, N. Gruber, R.M. Key, K.
	Lee, J.L. Bullister, R. Wanninkhof, C.S. Wong, D.W.R. Wallace, B. Tilbrook, F.J. Millero, TH.
	Peng, A. Kozyr, T. Ono, and A.F. Rios (2004): The oceanic sink for anthropogenic CO ₂ . <i>Science</i> ,
	305(5682), 367-371."
2005	NOAA Outstanding Scientific Paper Award "Feely, R.A., C.L. Sabine, K. Lee, W. Berelson, J.
	Kleypas, V.J. Fabry, and F.J. Millero (2004): Impact of anthropogenic CO ₂ on the CaCO ₃ system
	in the oceans. <i>Science</i> , 305(5682), 362-366."
2005	NOAA/OAR Significant Achievement Award
2004	NOAA/OAR Significant Achievement Award
2004	NOAA/OAR Special Act Award
2003	NOAA/OAR Significant Achievement Award
2002	NOAA Outstanding Scientific Paper Award "Feely, R.A., C.L. Sabine, T. Takahashi, and R.
	Wanninkhof (2001): Uptake and storage of carbon dioxide in the oceans: The global CO ₂ survey.
	Oceanography, 14(4), 18–32."
1999	Technical Communications Merit Award, Society for Technical Communication, for technical
	report "Surface water and atmospheric underway carbon data obtained during the World Ocean
	Circulation Experiment Indian Ocean cruises (R/V Knorr, December 1994-January 1996),
	NDP64."
1989	ARCS Scholarship Award, Achievement Rewards for College Scientists Foundation Inc.
1986	C. D. Mickey Award for excellence in marine chemistry, Texas A&M University at Galveston.
1986	Full scholarship to attend summer course in Sediment-Organism Relationships, Bermuda
1700	Biological Station (F. T. Mackenzie, Professor).
	Diological Station (1. 1. Macketizic, 110105501).

1985, 1986 Troy Sweatnam Memorial Scholarship, Texas A&M University at Galveston.

Professional Societies

American Geophysical Union The Oceanography Society Geochemical Society

Synergistic Activities

Synergistic Activities				
2018-present	IOC Integrated Ocean Carbon Research (IOC-R) Working Group Co-chair			
2019-2020	Chair, search committee for SOEST Hawaii Institute of Geophysics and Planetology director			
2017-2019	trainer for Global Ocean Acidification – Observing Network (GOA-ON) capacity building			
	workshops (Mauritius – August 2017, Fiji – October 2017, Hawaii – August 2018, Colombia –			
	January 2019)			
2018-2019	UH Oceanography Marine Geology and Geochemistry Division Head			
2018-2019	UH Oceanography Space Committee			
2018-2019	UH Oceanography Departmental Personnel Committee			
2018-2019	UH Oceanography Faculty Search Committee for 3 hires			
2017-2019	OceanObs'19 Program Committee			
2015-2019	Shell Ocean Discovery XPRIZE Scientific Advisory Board			
2017-2018	member of U.SChina Joint Scientific Experts Group (JSEG)			
2017-2018	co-chair of NOAA's Western Regional Coordination Team (NOAA West)			
2016-2018	member of OAR Performance Management and Awards Committee (PMAC)			
2013-2018	member of Joint Institute for the Study of the Atmosphere and the Ocean (JISAO) Executive			
	Board			
2013-2018	member of Joint Institute for Marine and Atmospheric Research (JIMAR) Executive Board			
2011-2018	member of Cooperative Institute for Alaska Research (CIFAR) Executive Board			
2011-2018	member of Cooperative Institute for Marine Resources Studies (CIMRS) Executive Board			
2011-2018	member of NOAA Senior Research Council			
2010-2018	member of Interagency Working Group on Ocean Acidification chartered under JSOST			
2013-2015	Wendy Schmidt Ocean Health XPRIZE Scientific Advisory Board			
2013-2016	member of NOAA Libraries Advisory Committee			
2009-2014	co-chair of the Global Ocean Ship-based Hydrographic Investigations Panel (GO-SHIP)			
2010-2013	Coordinating Lead Author for IPCC Working Group 1 Chapter 6			
2010-2011	ex-officio SSC member for U.S. Ocean Carbon and Biogeochemistry Program			
2006-2011	member of Ocean Carbon and Biogeochemistry Time-Series Advisory Committee			
2005-2011	member of PICES section on Carbon and Climate			
2003-2011	Member of the US CLIVAR/CO ₂ Repeat Hydrography Oversight Committee			
2008-2011	co-chair of the Carbon Cycle Science Working Group (develop a new US CCS Plan)			
2004-2011	Chair of IOC/SCOR International Ocean Carbon Coordination Project (IOCCP)			
2007-2010	member of International Repeat Hydrography Advisory Group			
2008-2010	advisory group for the <i>Ronald H. Brown</i>			
2005-2009	Scientific Steering Committee member for U.S. Ocean Carbon and Climate Change Program			
2005-2009	Scientific Steering Committee member for U.S. Ocean Carbon and Biogeochemistry Program			
2004-2008	Scientific Steering Committee member for U.S. North American Carbon Program			
2004-2006	Contributing author to IPCC Fourth Assessment Report			
2001-2006	Scientific Steering Committee member for IGBP/IHDP/WCRP Global Carbon Project			
2003-2005	Lead author for IPCC Special Report on carbon dioxide capture and storage			
2002-2005	Member of PICES Working Group 17: Biogeochemical Data Integration and Synthesis			
2001-2005	Member of International CLIVAR/CLIC Southern Ocean panel			
2001-2004	Working Group for the Implementation of the North American Carbon Program (NACP)			
2002-2004	Working Group for the Implementation of Ocean Carbon and Climate Change (OCCC) Program			
2001-2004	Member of US CLIVAR Southern Ocean panel			
2000-2003	Member of IGBP Integrated Global Carbon Observing (IGCO) theme team			
1998-2003	Member of CARbon dioxide IN the Atlantic (CARINA)			
-				

Cruise Experience 30 research cruises (cumulative of ~2 years at sea), 6 as chief or co-chief scientist					
2/24/18-	R/V Kilo Moana; Hawaii Ocean Time-series Station				
2/28/18	ALOHA; sponsored by NSF				
5/14/15-	R/V Kilo Moana Wendy Schmidt Ocean Health X-Prize Sea Trials				
5/19/15	sponsored by X-Prize Foundation (co-chief scientist)				
2/20/09	Developed Construction Construction				
2/29/08- 4/12/08	Ronald H. Brown Southern Ocean Gasex sponsored by NOAA (chief scientist)				
1/12/00	sponsored by 1107171 (emer selendst)				
5/11/07-	R/V Wecoma NACP West Coast Cruise				
6/14/07	sponsored by NOAA (chief scientist)				
2/13/06-	R/V Thomas G. Thompson Carbon/CLIVAR P16N				
3/3/06	sponsored by NSF&NOAA (chief scientist)				
1/9/05-	R/V Revelle Carbon/CLIVAR P16S				
2/20/05	sponsored by NSF&NOAA COSP				
10/23/03-	R/V Knorr Carbon/CLIVAR A22				
11/14/03	sponsored by NSF&NOAA COSP				
2/2/01-	Ronald H. Brown GASEX – 2001				
3/8/01	sponsored by NOAA/OGP				
	- x				
7/16/97-	R/V Knorr, WOCE leg A20				
8/11/97	sponsored by WOCE/DOE				
11/1/95-	R/V Knorr; WOCE leg I10				
11/28/95	sponsored by WOCE/DOE				
1/24/05	DALK WOCE 1 ION				
1/24/95- 3/5/95	R/V Knorr; WOCE leg I9N sponsored by WOCE/DOE				
3/3/73	spensered by Weelh Bell				
10/5/93-	R/V Thomas G. Thompson; WOCE leg P10				
11/10/93	sponsored by WOCE/DOE				
10/6/92-	R/V Knorr; WOCE legs P16S/P17A				
11/26/92	sponsored by WOCE/DOE				
4/4/00					
4/1/90- 5/1/90	R/V Endeavor; to: Bermuda Atlantic Time-series				
3/1/90	Station; sponsored by University of South Florida				
1/89-	13 cruises to: Hawaii Ocean Time-series Station				
9/91	ALOHA; sponsored by JGOFS/WOCE				
12/6/88-	R/V Townsend Cromwell; to: Penguin Bank, Hawaii;				
12/12/88	sponsored by NMFS/University of Hawaii (co-chief scientist)				
5/26/88-	R/V Townsend Cromwell; to Northwestern Hawaiian				
6/26/88	Islands; sponsored by NMFS/University of Hawaii (co-chief scientist)				

11/12/87- R/V Townsend Cromwell; to: Penguin Bank, Hawaii;

sponsored by NMFS/University of Hawaii

Recent Collaborators

D. Bakker (UEA-UK); J. Bullister (PMEL); R.H. Byrne (USF); K. Cadeira (Lawrence Livermore Nat'l. Lab.); M. Cronin (PMEL); P. Ciais (LSCE-France); E. DeCarlo (UH); A. Dickson (Scripps); S. Diggs (Scripps); S. Doney (WHOI); S. Emerson (Univ. of Wash); A. Fassbender (UW); R.A. Feely (PMEL); B. Hales (OSU); M. Ishii (MRI-Japan); G. Johnson (PMEL); R. Key (Princeton); A. Kozyr (CDIAC); M. Kramp (IOC-UNESCO - France); C. Lee (KIOST-S. Korea); K. Lee (Pohang Univ.- S. Korea); F. Mackenzie (Univ. of Hawaii); M. McPhaden (PMEL); C. Meinig (PMEL); N. Metzl (IPSL-France); J. Newton (UW); J.H. Noh (KIOST-South Korea); A. Olsen (Bjerknes Center-Norway); B. Pfeil (Bjerknes Center-Norway); M. Rhein (U. Bremen-Germany); S. Rintoul (CSIRO-Australia); C. Rödenbeck (BGC-Jena-Germany); J. Reum (UW); J. Salisbury (UNH); J. Sarmiento (Princeton); U. Send (Scripps); B. Sloyan (CSIRO-Australia); A. Sutton (PMEL); J. Swift (Scripps); T. Takahashi (LDEO); B. Tilbrook (CSIRO-Australia); D. Vandemark (UNH); R. Wanninkhof (AOML)

Graduate Thesis Advisor (4 currently as primary) and Postgraduate-Scholar Sponsor (2 currently) Katherine Fagan (PhD 2011, Univ. of Washington); Andrea Fassbender (masters 2010, PhD. 2014, Univ. of Washington); Nancy Williams (masters 2014, Univ. of Washington); Gwenn Hennon (PhD 2015, Univ. of Washington, committee member); Laurie Juranek (NRC postdoc, 2011-2012); Adrienne Sutton (NRC postdoc, 2012); Chris Wall (PhD 2019, Univ. of Hawaii, committee member); Nathaniel Harmon (Masters 2020, Univ. of Hawaii); Evan Lechner (Masters 2022, Univ. of Hawaii); Caroline Jackson (masters student, Univ. of Hawaii); Lucie Knor (PhD student, Univ. of Hawaii); Noah Howins (masters student, Univ. of Hawaii); Amy Markel (PhD student, Univ. of Hawaii); Melissa Melendez (postdoc, 2020-present); Conall McNicholl (postdoc, 2021-present).

Classes Taught

OCN780 (seminar) – Spring18 (lead)

OCN 623 (Chemical Oceanography) 33% - Spring18, Spring19, Spring 20, Spring 21

OCN310 (Global Environmental Change) 50% - Fall18 (lead), Fall19 (lead), Fall20 (lead), Fall21 (lead)

OCN 201 (Science of the Sea [geology/chemistry]) 33% - Spring19

Guest lecture at WCC (discussed marine debris on OCN120 Global Environmental Challenges) Spring18

Guest lecture OCN490 (Communication of Research Results) Spring20, Spring21

Guest lecture OCN623 (Chemical Oceanography) Spring 22, Spring 23

Lecture at Coastal Ocean Environment Summer School in Ghana – Summer 2020

Ocean Teacher Global Academy (Ocean Acidification Lecturer) – Spring 2021

Recent Significant Abstracts, Presentations and Workshop Activities

- McKinley, GA, J. Cross, T. DeVries, J. Hauck, A. Fay, P. Landschützer, GG. Laruelle, N. Lovenduski, P. Monteiro, R. Najjar, L. Resplandy, C. Rodenbeck, C. Sabine, A. Sutton, R. Wanninkhof, and N. Williams (2021) Quantifying the ocean carbon sink for 1994-2007: Combined evidence from multiple methods, 2021 EGU meeting, talk given by G. McKinley
- McKinley,GA, J. Cross, T. DeVries, J. Hauck, A. Fay, P. Landschützer, GG. Laruelle, N. Lovenduski, P. Monteiro, R. Najjar, L. Resplandy, C. Rodenbeck, C. Sabine, A. Sutton, R. Wanninkhof, and N. Williams (2020) Applying multiple methods to quantify the mean ocean carbon sink, 2020 Fall AGU meeting, talk given byG. McKinley
- Lovenduski, N., A Sutton, N Swart, J Fyfe, G McKinley, C Sabine, and N Williams (2020) The influence of COVID-related emissions reductions on surface ocean pCO₂ and pH, 2020 Fall AGU meeting, talk given by N. Lovenduski
- Chu, SN, AJ Sutton, BR Hales, D Manzello, JB Mickett, JM Morell, JA Newton, S Noakes, MD Ohman, VC Parker, CL Sabine, J Salisbury, U Send, DC Vandemark and TA Warren (2020) Recommendations for Capturing Surface and Subsurface Carbonate System Variability in U.S. Coastal and Coral Ecosystems. 2020 Ocean Sciences Meeting, talk given by S. Chu.

- Briggs, E.M., Martz, T.R., De Carlo, E.H., **Sabine, C.L.** and Howins, N. (2020) Autonomous Total Alkalinity and pH Measurements on a Barrier Reef of Kāne'ohe Bay. *2020 Ocean Sciences Meeting*, poster.
- Knor, L, De Carlo, E H, Drupp, P S, Terlouw, G J, Howins, N, Mackenzie, F T, Musielewicz, S, Sutton, A J, Sabine, C L (2019) Hawaii's Coastal MAPCO₂ Network: A Decade of Observations on Tropical Coral Reefs. 2019 Fall AGU Meeting, talk given by L. Knor.
- De Carlo, E.H., L.A. Knor, N. Howins, G.J. Terlouw, F.T. Mackenzie, C.L. Sabine, S. Muscielewicz, A.J. Sutton, T.A. Cortney, H.N. Page, and A.J. Andersson (2019) A Decade of CO₂ System Observations at the Coastal Ocean Hawaii Acidification Network (COHAN): What Have We Learned? 4th Global Ocean Acidification Observing Network (GOA-ON) International Workshop, talk given by E. De Carlo.
- Valauri-Orton, A., A. Puritz, C. Sabine, S. Chu, A. Dickson, L. Hansson, K. Currie (2019) GOA-ON in a Box: A Suite of Cost-Effective Monitoring Equipment for Collecting Weather Quality Ocean Chemistry Data, 4th Global Ocean Acidification Observing Network (GOA-ON) International Workshop, poster.
- **Sabine**, C. (2019) Global Ocean Acidification Observing Network (GOA-ON) Applied Training Course on Ocean Acidification, Santa Marta, Columbia, lead trainer.
- Bronselaer, B., Winton, M., Russell, J. L., **Sabine, C. L.** and Khatiwala, S. (2018) OC24B-0449 Agreement of CMIP5 Simulated and Observed Ocean CO₂ Uptake, *2018 Ocean Sciences Meeting*, poster.
- Courtney, T., Lebrato, M., Bates, N. R., Collins, A., de Putron, S. J., Garley, R., Johnson, R.J., Molinero, J. C., Noyes, T. J., **Sabine, C. L.** and Andersson, A. J. (2018) OC34A-0460 New insights into the drivers of coral and reef-scale calcification from Bermuda, *2018 Ocean Sciences Meeting*, poster.
- De Carlo, E. H., Knor, L., Drupp, P. S., Terlouw, G. J., Howins, N., Mackenzie, F. T., Musielewicz, S., Sutton, A. J. and **Sabine, C. L.** (2018) OC12A-07: Hawaii's Coastal MAPCO₂ Network: A Decade of Observations on Tropical Coral Reefs, *2018 Ocean Sciences Meeting*, talk given by L. Knor.
- Fassbender, A. J., Rodgers, K. B., Palevsky, H. I. and **Sabine, C. L.** (2018) OC23A-04: Drivers of Seasonal pCO₂ Variability at Subtropical-Subpolar Boundaries and the Evolution of Sea-Air CO₂ Fluxes through 2100 Under the RCP8.5 Concentration Pathway, 2018 Ocean Sciences Meeting, talk given by A. Fassbender.
- Howden, S. D., Sutton, A. J., **Sabine, C. L.**, Cambazoglu, F. K. and Soto Ramos, I. M. (2018) OC34B-0481 Ocean Acidification Monitoring in the Western Mississippi Bight, *2018 Ocean Sciences Meeting*, poster.
- Sutton, A. J., Feely, R. A. and **Sabine, C. L.** (2018) OC23A-02: Surface ocean carbon from days to decades: unique signals emerging from moored autonomous time series, *2018 Ocean Sciences Meeting*, talk given by A. Sutton.
- Thomalla, S. J., Ansorge, I. J., du Plessis, M., Gregor, L., Levy, M., Little, H., Maenner, S., Mahadevan, A., Ogunkoya, G., Racault, M.-F. and **Sabine, C. L.** (2018) EP11A-04: What we have Learned from SOSCEx: A High-Resolution Glider Experiment in the Sub-Antarctic Southern Ocean, *2018 Ocean Sciences Meeting*, talk given by S. Thomalla.

Refereed Publications

- Sutton, AJ, R Battisti, B Carter, W Evans, JA Newton, SR Alin, NR Bates, W-J Cai, KI Currie, RA Feely, C Sabine, T Tanhua, B Tilbrook, R Wanninkhof (2022) Advancing best practices for assessing trends of ocean acidification time series. *Front. Mar. Sci.*, 10.3389/fmars.2022.1045667
- Lechner E, Rii YM, Ruttenberg K, Kotubetey K and **Sabine CL** (2022) Assessment of CO₂ and O₂ spatial variability in an indigenous aquaculture system for restoration impacts. *Front. Mar. Sci.* 9:1049744. doi: 10.3389/fmars.2022.1049744
- Aricò, S., J.M. Arrieta, D.C.E. Bakker, P.W. Boyd, L. Cotrim da Cunha, F. Chai, M. Dai, N. Gruber, K. Isensee, M. Ishii, N. Jiao, S.K. Lauvset, G.A. McKinley, P. Monteiro, C. Robinson, C. Sabine, R. Sanders, K.L. Schoo, U. Schuster, J.D. Shutler, H. Thomas, R. Wanninkhof, A.J. Watson, L. Bopp, E. Boss, A. Bracco, W. Cai, A. Fay, R.A. Feely, L. Gregor, J. Hauck, C. Heinze, S. Henson, J. Hwang, J. Post, P. Suntharalingam, M. Telszewski, B. Tilbrook, V. Valsala, and A. Rojas Aldana (2021): *Integrated ocean carbon research: A summary of ocean carbon research, and vision of coordinated ocean carbon research and observations for the next decade*. IOC Technical Series 158, R. Wanninkhof, C. Sabine, and S. Aricò (eds.), Intergovernmental Oceanographic Commission, UNESCO-IOC, Paris, France, 46 pp, doi: 10.25607/h0gj-pq41, View at UNESCO-IOC.

- Lovenduski, N.S., N.C. Swart, A.J. Sutton, J.C. Fyfe, G.A. McKinley, **C.L. Sabine**, and N.L. Williams (2021): The ocean carbon response to COVID-related emissions reductions. *Geophys. Res. Lett.*, 48(6), e2020GL092263, doi: 10.1029/2020GL092263.
- Winter, K. B., Y. M. Rii, F. A. W. L. Reppun, K. DeLaforgue Hintzen, R. A. Alegado, B. W. Bowen, L. L. Bremer, M. Coffman, J. L. Deenik, M. J. Donahue, K. A. Falinski, K. Frank, E. C. Franklin, N. Kurashima, N. Kekuewa Lincoln, E. M. P. Madin, M. A. McManus, C. E. Nelson, R. Okano, A. Olegario, P. Pascua, K. L. L. Oleson, M. R. Price, M. J. Rivera, K. S. Rodgers, T. Ticktin, C. L. Sabine, C. M. Smith, A. Hewett, R. Kaluhiwa, M. Cypher, B. Thomas, J.-A. Leong, K. Kekuewa, J. Tanimoto, K. Kukea-Shultz, A. Kawelo, K. Kotubetey, B. J. Neilson, T. S. Lee, and R. J. Toonen. 2020. Collaborative research to inform adaptive comanagement: a framework for the He'eia National Estuarine Research Reserve. Ecology and Society 25(4):15. https://doi.org/10.5751/ES-11895-250415
- **Sabine, C.,** A Sutton, K McCabe, N Lawrence-Slavas, S Alin, R Feely, R Jenkins, S Maenner, C Meinig, J Thomas, E van Ooijen, A Passmore, B Tilbrook (2020) Evaluation of a new carbon dioxide system for autonomous surface vehicles. *J. Atm. Ocn. Tech.*, DOI: 10.1175/JTECH-D-20-0010.1
- Briggs, E.M., De Carlo, E.H., **Sabine, C.L.**, Howins, N.M., and Martz T.R. (2020) Autonomous Ion-Sensitive Field Effect Transistor-Based Total Alkalinity and pH Measurements on a Barrier Reef of Kane'ohe Bay. *ACS Earth and Space Chem*, 4 (3), 355-362, DOI: 10.1021/acsearthspacechem.9b00274
- Carter, B.R., Feely, R.A., Wanninkhof, R., Kouketsu, S., Sonnerup, R.E., Pardo, P.C., **Sabine C.L.**, Johnson, G. C., Sloyan, B.M., Murata, A., Mecking, S., Tilbrook, B., Speer, K., Talley, L.D., Millero, F.J., Wijffels, S.E., Macdonald, A.M., Gruber, N., Bullister, J. L. (2019) Pacific anthropogenic carbon between 1991 and 2017. *Global Biogeochem. Cycles*, 10.1029/2018GB006154.
- Terlouw, G.J., De Carlo, E.H., Drupp, P.S., Knor, L., Mackenzie, F.T., Li, Y.-H., Sutton, A.J., Pleuddemann, A.J., and **Sabine, C.L.** (2019) Hawaii Coastal MApCO₂ Network: A statistical evaluation of eight years of observations on tropical coral reefs. *Frontiers in Marine Science*, doi: 10.3389/fmars.2019.00226.
- Gruber, N., D. Clement, B.R. Carter, R.A. Feely, S. van Heuven, M. Hoppema, M. Ishii, R.M. Key, A. Kozyr, S. Lauvset, C. Le Monaco, J.T. Mathis, A. Murata, A. Olsen, F.F. Perez, C.L. Sabine, T. Tanhua, and R. Wanninkhof (2019): The oceanic sink for anthropogenic CO₂ from 1994 to 2007. *Science*, 363(6432), 1193–1199, doi: 10.1126/science.aau5153
- Fassbender, A.J., Rodgers, K.B., Palevsky, H.I., and C.L. Sabine (2018) Seasonal asymmetry in the evolution of surface ocean pCO₂ and pH thermodynamic drivers and the influence on sea-air CO₂ flux. *Global Biogeochem. Cycles*, 10.1029/2017GB005855.
- **Sabine, C.L.** (2018): Good news and bad news of blue carbon. *Proc Natl Acad Sci USA*. 2018 Apr 10;115(15):3745-3746. doi: 10.1073/pnas.1803546115.
- **Sabine**, C.L. (2018): Hot and sour in the deep ocean. *Nature Clim. Change*, 7(12), 854–855, doi: 10.1038/s41558-017-0018-4.
- Bronselaer, B., M. Winton, J. Russell, **C.L. Sabine**, and S. Khatiwala (2017): Agreement of CMIP5 simulated and observed ocean anthropogenic CO₂ uptake. *Geophys. Res. Lett.*, 44, doi: 10.1002/2017GL074435.
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Kaho'olawe Island Reserve Commission



811 Kolu St., Suite 201, Wailuku, HI 96793 • ph. 808-243-5020 • fx. 808-243-5885

Independent Vessel Release of Liability PLEASE READ CAREFULLY

This document does not constitute authorization to visit or enter the Kaho'olawe Island Reserve ("Reserve"), meaning the area designated as the island of Kaho'olawe and the submerged lands and waters extending seaward two (2) nautical miles from its shoreline. Such authorization must be obtained from the Kaho'olawe Island Reserve Commission ("KIRC").

I have requested and the KIRC has authorized me, my passengers, and my vessel to enter the waters of the Reserve

I agree and acknowledge that MY SAFETY AND THE SAFETY OF MY PASSENGERS IS MY SOLE RESPONSIBILITY. I will follow all safety instructions both written and verbal. I will follow Federal, State, and County requirements, and comply with KIRC directives. I further agree to notify my passengers of these instructions and requirements.

I understand, and by my signature acknowledge that I understand that: (1) The island of Kahoʻolawe and its waters was used from 1941 to 1990 as a live ordnance impact training area; (2) The RESERVE IS DANGEROUS AND UNSAFE due to the presence of surface and subsurface UNEXPLODED ORDNANCE; (3) There may be hazardous conditions and unexploded ordnance on and under the surface of the island and in the waters surrounding the island; and (4) Unexploded ordnance may explode causing me, my passengers, my vessel, or my property serious bodily harm, injury, damage, and/or death.

I further understand and am aware that other natural and predatory dangers may exist. I understand the risks presented by the currents, surf, shoreline, and other marine conditions may

cause me, my passengers, my vessel, or my property serious bodily harm, injury, damage, and/or death.

Knowing that the island and its surroundings waters pose a RISK OF SERIOUS BODILY HARM OR DEATH, I voluntarily ASSUME THE RISK OF INJURY OR LOSS created by the presence of unexploded ordnances, other hazardous conditions, and natural and predatory dangers which exist in the Reserve for myself, my passengers, my vessel, and my property. I voluntarily ASSUME THE RISK OF INJURY OR LOSS associated with ocean going craft transportation. With full knowledge of the hazards, I will, to the extent permitted by law, agree to INDEMNIFY, DEFEND AND HOLD HARMLESS KIRC, its officers, agents, and employees, from and against all claims, actions, penalties, damages, liabilities and expenses, including but not limited to reasonable attorneys' fees, for loss or damage, including property damage, personal injury and wrongful death, based upon or arising out of or in connection with the entry, activities and/or presence of myself and my passengers in the Reserve, and will reimburse KIRC for all its costs and expenses, including reasonable attorneys' fees, incurred in connection with KIRC's defense of any such claims.

In consideration of allowing me the access which I have requested, I, for myself, my heirs, beneficiaries, executors and administrators, REMISE, RELEASE, AND FOREVER DISCHARGE the State of Hawai'i, and any and all of their officers, agents and employees, acting in their official capacity with due diligence, from any and all claim(s), demand(s), or cause(s) of action on account of my death or any injury to me, my vessel, or my property which may occur during or as a result of my access to the Reserve..

This release of liability is effective from

January 1, 2023

to

December 31, 2023

NOTA BENE: SAILDRONE operates Uncrewed Surface Vehicles (USVs), which do not qualify as "vessels," as defined under Title 1 of the U.S. Code, Section 3. Notwithstanding the prior provisions, SAILDRONE acknowledges this Release of Liability herein.

I have read and fully understand the KIRC Independent Vessel Release of Liability

Robbie Dean, VP - Vehicle Operations	DocuSigned by:	04/06/2023
PRINT VESSEL OWNER'S NAME	VÉSSEL OWNER'S SIGNATURE	DATE

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Saildrones to navigate Hawai'i waters for critical UH research

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Three



(Photo credit: Saildrone)

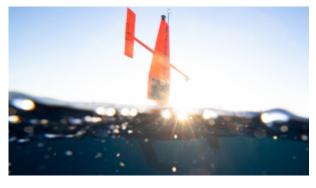
Saildrone Explorers, uncrewed surface vehicles used to measure ocean data, embarked on a six-month journey around Hawai'i Island, Maui, O'ahu and Kaua'i to evaluate ocean health across the state. The University of Hawai'i at Mānoa and the National Oceanic and Atmospheric Administration's Pacific Marine Environmental Lab (PMEL), and the Cooperative Institute for Climate, Ocean, and Ecosystem Studies (CICOES), are working with Saildrone Inc. to pilot this effort.

The 23-foot ocean drones will send back critical data and images in real-time to scientists in Hawai'i and Washington State so they can assess how climate change and ocean acidification are impacting our coastal waters.

The saildrones left from Pacific Shipyards International in Honolulu Harbor on O'ahu in March and the official mission started on April 1.

Each saildrone will collect critical ocean chemistry observations around Hawai'i to better assess the state's vulnerability to ocean chemistry changes. This effort is a part of the \$50 million gift from Dr. Priscilla Chan and Mark Zuckerberg to the Hawai'i Institute of Marine Biology in 2022 to improve Hawai'i's ocean health.

The saildrones will provide information about Hawaiian Island nearshore water quality and chemistry in a way that has not been possible using previous shipboard approaches. Advanced safety protocols including automated dynamic positioning and piloting based on real-time



(Photo credit: Saildrone)

measurements of GPS location, winds, and currents; 24/7 on-watch mission managers to oversee all operations; Automatic Identification System for identifying and avoiding other vessels; and highly visible lights and markings keep the vehicle safe even close to shore.

"These ocean drones will be out sampling continuously for the next six months, providing a thousand times more ocean chemistry measurements in coastal waters than has ever been available," said **Christopher Sabine**, PhD, UH Mānoa interim Vice Provost for Research and Scholarship and oceanography professor in the School of Ocean and Earth Science and Technology (SOEST).

Beginning off of Hawai'i Island, two saildrones will zigzag between the island's coastline and five kilometers offshore, and the third saildrone will sail a direct continuous route around the island. The instruments will only monitor atmospheric and ocean properties and will not collect any data that can be used to identify people, marine mammals or fish locations.

"The saildrones will be measuring different water quality measurements and this will help tell us a little bit about how our water chemistry is changing with climate change, and with



(Photo credit: Saildrone)

changing ocean conditions in our nearshore environment," said **Amy Markel**, an oceanography PhD student who is working with Sabine on this project.

'Hot spots' of ocean acidification

The saildrone's integration of pH and carbon dioxide measurements gives researchers the ability to better understand whether nearshore waters are accumulating fossil fuel emissions. They will be able to develop maps from field measurements to help them look for "hot spots" of ocean acidification.

With these maps, researchers can determine where it will be safe for organisms that use calcium carbonate to accrete (build) their skeletons or shells (corals, oysters, crabs, etc.), or where the carbon water chemistry will likely erode or reduce these organisms' ability to build their bodies.

It's important to recognize where there may be areas that are more vulnerable to changing carbon chemistry, or spots where organisms may have a lower ability to accrete.

A collaborative effort

This effort is a collaboration between UH Mānoa (who is covering the cost for two saildrones), CICOES (who is covering the cost of one saildrone with funding from the Integrated Ocean Observing System Ocean Technology Transition program), and Saildrone Inc. who will be operating the vehicles.

"Saildrone is thrilled to partner with UH Mānoa and CICOES on this important mission to better understand ocean chemistry around the Hawaiian Islands," said Matt Womble, Saildrone Director of Ocean Data Programs. "In 2013, Saildrone performed the first 'no-handed' Pacific Crossing from San Francisco to O'ahu; 10 years on, we're proud to continue our work in Hawai'i, further demonstrating the capabilities of our Explorer-class vehicles to better understand how oceans are changing."

The research is also connected to a NOAA-funded project to assess the vulnerability of the Hawaiian Islands to climate change and ocean acidification.

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Saildrones, buoys work together to monitor Hawai'i waters

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Three



(Photo credit: Saildrone)

Saildrone Explorers, uncrewed surface vessels used to measure ocean data, were deployed around Hawai'i Island, Maui, O'ahu and Kaua'i to evaluate ocean health across the state. To accompany the saildrones, buoys are being set up around each island to collect critical ocean chemistry observations to better assess Hawai'i's vulnerability to changes.

The University of Hawai'i at Mānoa, the National Oceanic and Atmospheric Administration's Pacific Marine Environmental Lab, and the Cooperative Institute for Climate, Ocean, and Ecosystem Studies (CICOES), are collaborating with Saildrone Inc. on the project. This effort is funded by a portion of a \$50 million gift from Dr. Priscilla Chan and Mark Zuckerberg to the Hawai'i Institute of Marine Biology in 2022 to improve Hawai'i's ocean health.

Researchers deployed a new buoy off Maui in May and will set up two more: one off Kaua'i and one off Hawai'i Island later this summer. They have also had two buoys off the coast of Windward O'ahu for more than 10 years collecting data and providing researchers with a time series of water quality information. The saildrones left from Pacific Shipyards International in Honolulu Harbor on O'ahu in March and started the official mission in April.

"The saildrones, these autonomous sailing boats, that are surveying all the way around O'ahu and the other islands, allow us to connect the time information we get from the buoys with the spatial information collected from these moving platforms," said Christopher Sabine, UH Mānoa interim vice provost for research and scholarship.

The 23-foot ocean drones and buoys will work together to send back critical data and images in real time to scientists in Hawai'i and Washington State so they can assess how climate change and ocean acidification are impacting our coastal waters.



'Hot spots' of ocean acidification

The saildrone's integration of pH and carbon dioxide measurements gives researchers the ability to better understand whether nearshore waters are accumulating fossil fuel emissions. They will be able to develop maps from field measurements to help them look for "hot spots" of ocean acidification.

"Collecting this data is important for Hawai'i because it'll tell us more about different hot spots around each of the islands, where we might want to pay attention to how the water chemistry and water quality is changing in those areas." said Amy Markel. UH Mār



water quality is changing in those areas," said Amy Markel, UH Mānoa Oceanography PhD student.

Saildrones safe close to shore

The saildrones will provide information about the nearshore water quality and chemistry in a way that has not been possible using previous shipboard approaches. The drones have advanced safety protocols including automated dynamic positioning and piloting based on real-time measurements of GPS location, winds and currents; 24/7 onwatch mission managers to oversee all operations; Automatic Identification System for identifying and avoiding other vessels; and highly visible lights and markings.

The saildrones will zigzag between the island's coastline and 5 kilometers offshore. The instruments will only monitor atmospheric and ocean properties and will not collect any data that can be used to identify people, marine mammals or fish locations. Mariners are encouraged to stay 500 meters away from the instruments.

"The saildrones look like sailboats, and they're working very close to shore, so if you see them please don't touch them or interfere with their operations," said Sabine. "They are being remotely piloted and they're operating in safe waters."

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Ocean users advised to avoid research drones, buoys

By Esme M. Infante einfante@staradvertiser.com

Ocean users are cautioned to keep far from three uncrewed Saildrone Explorer research vessels that have been deployed around the Hawaiian Islands to help look for signs of climate change.

The 23-foot, bright orange surface vessels are measuring ocean data around Oahu, Hawaii island, Maui and Kauai, cruising between the coastline and 3.1 miles offshore. People and other vessels are urged to stay at least 1,600 feet away.

The drones "look like

sailboats, and they're working very close to shore, so if you see them please don't touch them or interfere with their operations," Christopher Sabine, University of Hawaii at Manoa interim vice provost for research and scholarship, said in a UH news release. "They are being remotely piloted and they're operating in safe waters."

The UH statement said the Saildrones have "advanced safety protocols," including automated dynamic positioning and piloting based on real-time measurements of GPS location, winds and currents;

24/7 on-watch mission managers to oversee all operations; Automatic Identification System for identifying and avoiding other vessels; and highly visible lights and markings.

Meanwhile, several buoys are collecting water-quality data, working in conjunction with the drones: One buoy was deployed off Maui in May, and one each off Kauai and Hawaii island will be set up this summer, joining two existing buoys off Windward Oahu that have been collecting data for more than 10 years

The drones and buoys "will work together to send back

critical data and images in real time to scientists in Hawaii and Washington state so they can assess how climate change and ocean acidification are impacting our coastal waters," the news release said.

The instruments will only monitor atmospheric and ocean properties, and will not collect any data that can be used to identify people, marine mammals or fish locations, UH said.

Amy Markel, a UH Manoa doctoral student in oceanography, said the data collection is "important for Hawaii because it'll tell us more about different hot spots around each of the islands, where we might want to pay attention to how the water chemistry and water quality is changing in those areas."

The project is a collaboration of UH Manoa; the National Oceanic and Atmospheric Administration's Pacific Marine Environmental Lab; the Cooperative Institute for Climate, Ocean and Ecosystem Studies; and Saildrone Inc. The effort is funded by a portion of a \$50 million gift from Dr. Priscilla Chan and Mark Zuckerberg to the Hawai'i Institute of Marine Biology in 2022 to improve Hawaii's ocean health.



SAILDRONE

Uncrewed Saildrone Explorer research vessels are being used to collect ocean data and detect signs of climate change around the Hawaiian Islands.