



## DEPARTMENT OF COMMERCE RESEARCH PERFORMANCE PROGRESS REPORT (RPPR)

*For instructions, please visit*

[http://www.osec.doc.gov/oam/grants\\_management/policy/documents/RPPR%20Instructions%20and%20Privacy%20Statement.pdf](http://www.osec.doc.gov/oam/grants_management/policy/documents/RPPR%20Instructions%20and%20Privacy%20Statement.pdf)

AWARD INFORMATION	
1. Federal Agency: Department of Commerce / NOAA	2. Federal Award Number: NA20OAR4320278
3. Project Title: Cooperative Institute for Marine, Earth and Atmospheric Systems (CIMEAS)	
4. Award Period of Performance Start Date: 07/01/2020	5. Award Period of Performance End Date: 06/30/2025
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR	
6. Last Name and Suffix: ,	7. First and Middle Name: ,
8. Title:	
9. Email:	10. Phone Number:
AUTHORIZING OFFICIAL	
11. Last Name and Suffix: Park , III	12. First and Middle Name: William , Thomas
13. Title: Principal Contract and Grant Officer	
14. Email: wparkiii@ucsd.edu	15. Phone Number: 858-822-1350
REPORTING INFORMATION	
Signature of Submitting Official: William Thomas Park	
16. Submission Date and Time Stamp: 04/12/2022	17. Reporting Period End Date: 03/31/2022
18. Reporting Frequency:  <input checked="" type="radio"/> Annual <input type="radio"/> Semi-Annual <input type="radio"/> Quarterly	19. Report Type:  <input checked="" type="radio"/> Not Final <input type="radio"/> Final
RECIPIENT ORGANIZATION	
20. Recipient Name: UNIVERSITY OF CALIFORNIA SAN DIEGO	
21. Recipient Address: 8622 DISCOVERY WAY RM 116, LA JOLLA, CA 92093-1500 USA	
22. Recipient UEI: QJ8HMDK7MRM3	23. Recipient EIN: 956006144

## ACCOMPLISHMENTS

### 24. What were the major goals and objectives of this project?

The goal of the Cooperative Institute for Marine, Earth, and Atmospheric Systems (CIMEAS) is to facilitate and enhance research cooperation between NOAA entities and partner institutions including the University of California (UC), California State Universities (CSU), and the Farallon Institute (FI). CIMEAS strives to improve resilience by providing decision makers usable information through integrating cutting edge physical, ecological, and social science. Projects provide graduate student training in NOAA-related fields, including marine resource assessment and quantitative population dynamics.

Only a subset of accomplishments can be reported due to space considerations, so some contributions will not be covered here but can be found in the individual reports.

The California Cooperative Oceanic Fisheries Investigations (CalCOFI) is the world's longest multi-disciplinary ocean observation program. Its 70-year time series monitors interannual and decadal-scale variability of the southern California Current System (CCS) and its fisheries.

The Fisheries Collaborative Program (FCP) fosters research collaborations between NOAA scientists, UC Santa Cruz (UCSC) faculty, Institute of Marine Sciences researchers, and students. The research includes field and laboratory experiments and modeling. It covers marine and freshwater species and habitats and studies the ecology and life history of Pacific salmonids and other fishes. The FCP supports resource managers, fisheries, and resource science in general.

The Seal Monitoring program is validating the monitoring of Alaska seal body condition by small UAS.

A new program at FI analyzes the spatial distributions and suitability of current and future potential habitats for Pacific cod.

CIMEAS plays key roles within U.S. and international Argo including instrumentation development, float production and deployment, communications and data management, and scientific analyses to demonstrate the value of Argo data. With CIMEAS funding, SIO produces and deploys one-fourth of the U.S. Core Argo floats, builds and deploys Deep Argo and BGC floats, carries out float technology development, participates in delayed-mode quality control, coordinates the U.S. Argo partnership, and provides leadership for international Argo.

The SIO High-Resolution Expendable Bathythermograph Network (HR-XBT) (<http://www-hrx.ucsd.edu>) provides boundary-to-boundary quarterly repeating ocean transects of temperature, mass, and heat transports.

The U.S. High Frequency Radar Network (HFRNet) maintains and improves their data management system to support both operational and research communities by providing high quality, spatially dense, ocean surface current data in near real-time.

### 25. What was accomplished under these goals?

CIMEAS and UCSC administration continued.

The programs built research collaborations with NOAA scientists, published peer-reviewed and other papers, mentored undergraduate and graduate students, postdoctoral scholars, and junior scientists, attended and presented at conferences and professional meetings. They also disseminated results to scientific colleagues, resource managers, and the public through education and outreach efforts.

The CalCOFI program completed 3 quarterly cruises with pandemic protocols; the results were put online: <https://www.calcofi.org/cruises.html> The program hosted a large conference and stakeholder and community working groups.

SIO Argo fabricated, shipped, and deployed 83 Core Argo floats, 14 deep Argo, and 4 BGC Argo floats. Deployment was by R/Vs Kaharoa, Revella, Paragon, Thompson, and Tangaroa. Float technology was upgraded to increase float lifetime, improve the bottom encountering behavior on deep floats, integrate the RBR CTD on Core Argo, and develop a new BGC Argo float.

The HR-XBT deployed ~1500 XBTs with delayed-mode quality control of all profiles and dissemination.

HFRNet collected data as planned and disseminated them as noted below. Throughout the reporting period, data management efforts focused on refining network and management tools, determining critical utilities for multi-server configuration and code management.

The fundamental contribution of the CUGN to the global ocean observing system is the sustained monitoring of the California Current System. A major advance this past year is the addition of calibrated dissolved oxygen to the real-time data stream.

The GDP purchased, fabricated, and deployed drifters, including in front of hurricanes.

The Scripps O2 Program maintained time series at the ten flask sampling stations, improved measurement accuracy, error analysis, quality control, and did international intercalibration.

CCHDO merged 148 new data files into CCHDO standard data products posted 77 new files online as received and are in the queue to merge. CCHDO now serves data from a cumulative 2513 cruises.

Passive acoustic studies added to its catalog of toothed whale signals from the Western North Atlantic, trained an improved classifier for beaked whales, allowing investigation of habitat preference and reactions to active SONAR. Preliminary results suggested that

*Attach a separate document if more space is needed for #6-10, or #24-50.*

## ACCOMPLISHMENTS (cont'd)

### 26. What opportunities for training and professional development has the project provided?

Projects support undergraduate, graduate student, and postdoc training in NOAA-related fields through informal education, mentoring, participation in labs and fieldwork, and formal course offerings. CIMEAS observations and results have been used in many student dissertations (see lists of products supplementing this report). Opportunities for professional development include leading workshops, giving oral and poster presentations at professional meetings, participating in professional organizations such as the AFS student subunit, and participating in local outreach opportunities.

HSU FEC fully supported one graduate student's research stipend. To date, the Cal Poly Humboldt freshwater ecology project CIMEAS project has trained a total of 8 Masters students (6 current, 2 complete) and provided hands-on research experience for >20 undergraduates. Since its initiation, eighteen total students have trained as part of the NOAA/Humboldt collaborative research effort. The project PI teaches undergraduate classes in fish ecology, river ecology, and limnology to >50 undergraduates per year.

Passive Acoustic Studies supported a graduate student who will be finalizing her PhD thesis in August 2022 and provided training to NOAA scientists in the use of their analysis tools.

A CUGN-supported student successfully defended her PhD thesis in June 2022. 2 Undergraduate students interned at CUGN, one will return to do a MS.

The HR-XBT Program is a source of data for many students. PIs serve as mentors for two SIO PhD graduate students who use XBT data in their thesis research.

The HR-XBT Program also employs two women marine technicians (Ms. Justine Parks and Ms. Jennifer Rogers) who manage the maintenance of the instrumentation and are responsible for the logistics of the HRX operation. Ms. Lisa Lehman is the HR-XBT program Data Manager.

UCSC Freshwater Ecology trained 6 PhD students, 2 postdoctoral researchers, and several undergraduate research interns.

CCHDO supported an undergraduate learning ocean data curation and data systems and did outreach.

The Argo dataset provides a major resource for basic research and education of graduate and undergraduate students, post-docs, and young scientists. Over 400 PhD theses worldwide have utilized Argo data. SIO-Argo P.I.s serve as advisors and mentors for students, post-docs, and young scientists.

The CalCOFI program supports training and professional development in data collection/ocean observations sampling, research, data analysis & visualization, as well as at the science to policy interface. For example, CalCOFI regularly hosts student volunteers.

### 27. How were the results disseminated to communities of interest?

CIMEAS programs maintain datasets, software applications, and wiki guides for end users online. Results were disseminated via peer-reviewed and other publications, presentations at scientific meetings, meetings with the public, stakeholders, and resource managers, conferences, seminars, press releases, social media, websites, response to media inquiries, and participation in published news articles.

Here are a few summaries of selected dissemination achievements:

CalCOFI held an annual conference with over 500 attendees, 46% of whom are early-career.

Over 5300 papers spanning a wide variety of topics have been published using Argo data. See <https://www.argo.ucsd.edu/outreach/publications/bibliography/>. Operational models for ocean reanalysis and forecasting are dependent on Argo data, and the results of these data assimilating models are widely disseminated to interested communities. The community-service aspect of Argo is underlined by the fact that less than 20% of publications using Argo data have an Argo P.I. in their author list.

All HR-XBT data were made available without restriction in near real-time through the GTSP and delayed mode versions through NCEI and at the SIO web site ([www-hrx.ucsd.edu](http://www-hrx.ucsd.edu)).

HFRNet results are disseminated through listservs and online portals that are publicly available. Collaboration and communication are enhanced by community forums and workshops.

CUGN data were distributed in real-time on the national Glider Data Assembly Center, and in delayed mode on [spraydata.ucsd.edu](http://spraydata.ucsd.edu). CUGN data is provided to the GTS in real time and is used in several models of the CCS.

The GDP program posts the observations from the NOAA-funded drifters that use the Iridium satellite system to the Global Telecommunication System (GTS).

The O2/N2 and CO2 data are made available without embargo on the [ScrippsO2.ucsd.edu](http://ScrippsO2.ucsd.edu) website. This data is also mirrored on the archival California Digital Library site, <https://library.ucsd.edu/dc/collection/bb3381541w>

The CLIVAR and Carbon Hydrographic Data Office (CCHDO) serves reference-quality repeat hydrography data and supporting documentation primarily by the website, [cchdo.ucsd.edu](http://cchdo.ucsd.edu).

All data collected aboard ships operated by Scripps Institution of Oceanography are provided to the NSF Rolling Deck To Repository program.

*Attach a separate document if more space is needed for #6-10, or #24-50.*

**ACCOMPLISHMENTS (cont'd)**

**28. What do you plan to do during the next reporting period to accomplish the goals and objectives?**

All continuing projects plan to maintain and, where possible, improve their operations. This includes observing systems; data quality; timely, web-accessible data access; algorithm and ML systems development and dissemination; collaborations with NOAA scientists and national and international marine science, conservation, and management communities; to facilitate the use of their data locally, nationally, and internationally to advance science and inform decisions in marine resource management and policy. They will continue to teach, mentor, and train the next generation of scientists, and communicate results to the scientific community with publications and to the public through outreach and interviews. Graduate students will continue their research and some will graduate during the project period.

Some details include:

Argo will continue fabrication and deployment of Core Argo and Deep Argo floats worldwide. To maintain the interest of the manufacturers for Argo technology development, the number of Deep Argo float deployments will increase compared to last year. Technology improvement will continue in the SOLO-II (Core), Deep SOLO floats, and the newly developed BGC SOLO float. Improvements will target better float and sensor performance and lifetime. They will continue to assist with coordination and leadership of the International Argo Program, to enable and support education and outreach applications of Argo.

HFRNet programmers plan to review configuration management strategies, reconfigure front-end web interface, and evaluate radial data access.

CCHDO will continue its core mission of assembling and serving reference-quality data and progress towards evolving standards for a F.A.I.R. and trustworthy data repository.

SIO HR-XBT plans to continue with the occupation of XBT transects, the free and quick dissemination of data to the research community, the training of students and personnel and the publication of manuscripts that involve the use of XBT transect data.

The Passive Acoustics project in the Pacific will finalize a classifier to automatically extract beaked whale signals in long-term acoustic data and the statistical analysis to document sonar impact on beaked whales. They will complete the analysis on seismic signals and source localization and plan new data analysis elucidating foraging ecology of false killer whales from a multi-month recording near Lanai, Hawaii. They will continue to support NOAA PIFSC to collect passive acoustic data at remote locations.

For the Atlantic, a manuscript on the beaked whale classifier will be finalized. Sonar impact on beaked whale acoustic behavior will be analyzed and a publication submitted. Results on the geographic and temporal occurrence and levels of seismic survey pulses in the WAT region will be prepared for publication.

**PRODUCTS**

**29. Publications, conference papers, and presentations**

See Attachment

**PRODUCTS (cont'd)**

**30. Technologies or techniques**

Daniel Rudnick  
California Underwater Glider Network  
The efficacy of a sustained underwater glider network has been established

Brice Semmens  
California Cooperative Oceanic Fisheries Investigations: Ocean Observations to Inform Ecosystem-Based Management  
The CalCOFI Capstone projects developed online applications: <https://reznikovl.github.io/calcofi1-book/intro.html>  
<https://shiny.calcofi.io/capstone/> CalCOFI website was revamped: <https://calcofi.org/> CalCOFI packages and data serving tools:  
<https://calcofi.io/>

Trond Kristiansen  
Climate change and essential fish habitats of Gulf of Alaska and East Bering Sea  
Improved Python programming libraries (xarray, pandas)

Kaitlin Frasier  
3 awards: 2016793-SP CIMEAS Parallel NA21NMF4050278 FRASIER,KAITLIN NRDA; MPL Gulf of Mexico Passive Acoustic Monitoring RESTORE CIMEAS;MPL Gulf of Mexico,Â Rice,Â Whale Passive Acoustic CIMEAS Amd 42  
High-frequency Acoustic Recording Packages (HARPs), deep learning for large scale passive acoustics.

Eric Terrill  
HF Radar National Network Data Management Development  
High Frequency radar surface current mapping

**31. Inventions, patent applications, and/or licenses**

None

**PRODUCTS (cont'd)**

**32. Other products**

Data Set: Ziegenhorn, M. (2022). Echolocation clicks and anthropogenic detections with neural network labels in Hawaiian Island HARP data from Kona, Kauai, and Pearl and Hermes Reef. Dryad, Dataset, <https://doi.org/10.5061/dryad.8pk0p2npb>"

A climatology of the CUGN data is updated monthly.

All HR-XBT transect data are available on a cruise-by-cruise basis at <http://www-hrx.ucsd.edu/>

The SIO HR-XBT data continues to be assimilated into multiple ocean state estimates, including several using the Estimating the Circulation and Climate of the Ocean (ECCO) framework, based on the MIT GCM and its adjoint model. The assimilation of XBT data into the global ECCO models (<http://www.ecco.ucsd.edu/index.html>), including the California Current System State Estimate (CASE), the Tropical Pacific Ocean State Estimate (TPOSE), the Northwest Pacific State Estimate (NWPac) and the Southern Ocean State Estimate (SOSE), enable a better understanding of ocean circulation and its variability. In addition, all SIO HR-XBT data is included in the regularly updated NCEI Ocean Heat Content estimate that provides scientific researchers with a high-quality Climate Data Record

Freshwater Ecology

Documentary Film: Southern Range: Salmon in the Santa Cruz Mountains (produced by the Fisheries Collaborative Program and the Seymour Marine Discovery Center)

Investigations in Fisheries Ecology

ISC 2021. Report of the North Pacific albacore tuna management strategy evaluation. Annex 11 - 21st Meeting of the International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean. <https://meetings.wcpfc.int/node/12593>

California Current Trophic Database (CCTD), a SQL relational food habits database that includes diet composition and prey size information for 143 predator taxa sampled throughout the California Current during 1967-2019. Several manuscripts based on the application of this database are in preparation.

The Argo Program , A Global Observations for Understanding and Prediction of Climate Variability

Scripps Argo trajectory-based velocity product: <https://library.ucsd.edu/dc/collection/bb6630688j>

Roemmich and Gilson Argo climatology

[https://sio-argo.ucsd.edu/RG\\_Climatology.html](https://sio-argo.ucsd.edu/RG_Climatology.html)

International Argo website:

<http://www-argo.ucsd.edu>

**PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS**

**33. What individuals have worked on this project?**

See Attachment

**PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS (cont'd)**

34. Has there been a change in the active other support of the PD/PI(s) or senior/key personnel since the last reporting period?

Brice Semmens

California Cooperative Oceanic Fisheries Investigations: Ocean Observations to Inform Ecosystem-Based Management

This past year, we hired Dr. Marina Frants as the new 50% CalCOFI data manager (responsible for database integration and management). We also hired a CalCOFI molecular ecologist, Dr. Zack Gold, to lead applied research efforts to design and implement environmental DNA biomonitoring efforts for CalCOFI and coastal California ecosystems, especially as related to understanding climate change and ocean acidification/hypoxia impacts on coastal pelagic fish and zooplankton communities. Lastly, we brought on Dr. Rasmus Swalethorp who is a biological/fisheries oceanographer and trophic ecologist as the new supervisor to the CalCOFI-SIO technical group. Aside from supervising at sea and technical operations Dr. Swalethorp will carry out CalCOFI associated research and lead the charge on the implementation and use of novel compound specific stable isotope based trophic indicators in ecosystem assessments and impacts on fishery.

Colleen Reichmuth

Monitoring body condition of seals in Alaska using small UAS: UCSC validation study

We have submitted a related CIMAES proposal to NOAA for 2022-2025

Eric Terrill

HF Radar National Network Data Management Development

Thomas Cook, Scripps Institution of Oceanography, UC San Diego has accepted a new position outside of the University and no longer work on this project.

35. What other organizations have been involved as partners?

See Attachment

**PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS (cont'd)**

36. Have other collaborators or contacts been involved?

NAVO, UCLA, UCSC, UC Davis  
Captain Robert Kamphaus, Marine Superintendent, University of Washington  
UC Santa Cruz: Chris Edwards, Jerome Fiechter, Raphael Kudela, Andrew Moore. NOAA Collaborators: Michael Alexander, Eric Anderson, Eric Bjorkstedt, Steven Bograd, David Boughton, Antonietta Capotondi, Eric Danner, David Demer, Heidi Dewar, Edward Dick, Hui Ding, Liz Drenkard, Lisa Eisner, John Field, Kevin Friedland, Jeanette Gann, John Carlos Garza, Elizabeth Gilbert, Jeff Harding, Chris Harvey, Elliott Hazen, Xi He, Andrew Hein, Kirsten Holsman, Michael Jacox, Rachel Johnson, Isaac Kaplan, Joseph Kiernan, Rosemary Kosaka, Thomas Laidig, Steve Lindley, Steve Lonhart, Aaron Mamula, Nate Mantua, Benjamin Martin, Melissa Monk, Stephan Munch, Michael O'Farrell, Devon Pearse, Tonya Rogers, Dave Rundio, Ryan Rykaczewski, Keith Sakuma, Jameal Samhouri, Jarrod Santora, William Satterthwaite, Kalei Shotwell, Margaret Siple, Cameron Speir, Brian Spence, Kevin Steirhoff, Charles Stock, Erick Sturm, Andrew Thompson, Jordan Watson, Diana Watters, George Watters, Brian Wells, Thomas Williams, and Phoebe Woodworth-Jefcoats.  
Dr. Philip Sutton, National Institute of Water and Atmospheric Research, New Zealand

**IMPACT**

37. What was the impact on the development of the principal discipline(s) of the project?

In addition to basic research, projects have contributed observations, measurement techniques, peer-reviewed publications, courses, training programs, best practices, ecosystem management plans and assessments, and outreach activities for marine sciences including climate. The publications are listed in the database and their breadth and diversity speak to the value of CIMEAS programs.

Highlights include:

Argo is widely credited for revolutionizing large-scale physical oceanography by providing ocean data that are more evenly distributed in space and time.

Peer-reviewed publications used CalCOFI data as foundational information for analysis and scientific innovation as well as management. This includes research questions that require an integrated approach, such as fisheries, biological and ecosystem oceanography, physical oceanography, and chemical oceanography; as well as questions that require long time series and broad spatial extent, e.g., climate variability and change, species distribution and range shifts, or population and ecosystem dynamics. From the start, CalCOFI data have been used to support the management of sustainable fisheries and marine resources. CalCOFI collects information on the entire marine ecosystem, so CalCOFI data are relevant to biodiversity and ecosystem assessments; emerging ocean uses such as renewable energy and aquaculture; water quality, pollution, and human health; spatial marine planning; climate variability, change, and associated stressors; and to understand the broader oceanographic context of nearshore and coastal processes.

HSU FEC graduate student James Whelan performed the first experimental evaluation of salmon survival through the upper reaches of the Klamath River, providing valuable information in advance of dam removal and efforts to reestablish salmon in the area.

The O2 project provides data that is fundamental to tracking global sources and sinks of carbon dioxide and long-term changes in ocean biogeochemistry.

UCSC Fisheries Ecology contributed fundamental insights into marine and freshwater species and habitats

CCHDO data support a diverse set of ocean science research. While full metrics on the impact of data accessed through CCHDO are difficult to develop, CCHDO is the data assembly and distribution center for GO-SHIP, who have identified a cumulative 605 GO-SHIP scientific publications, and over 65,000 publications citing GO-SHIP, GO-SHIP data, or GO-SHIP publications.

*Attach a separate document if more space is needed for #6-10, or #24-50.*



## IMPACT (*cont'd*)

### 38. What was the impact on other disciplines?

Argo data is used across the earth sciences. Recent uses outside physical oceanography include studies of storm tracks, atmospheric water transport, ocean deoxygenation, biology of reef systems, primary production, anthropogenic carbon sequestration, ice-ocean interactions, glacier melting dynamics, sea ice predictability, and weather forecasting. Advances in Core Argo float technology contribute to other autonomous platforms (e.g., BGC floats and gliders) and has been used to inform the design of a future space craft capable of sampling Europa's oceans.

CalCOFI observations of both the biological and physical ocean environment in the California Current Ecosystem were used in studies furthering the fields of fisheries science, remote sensing and physical ocean models, zooplankton ecology and ocean chemistry. CalCOFI observations were used to validate/calibrate satellite derived products related to carbon export and spatiotemporal nutrient patterns.

CalCOFI publications focused on ocean time series (from decades to millennia) aimed at characterizing ocean biological and chemical variability and contextualizing ongoing change. Several peer-reviewed studies made use of CalCOFI data to better understand the physical ocean processes (water mass advection, wind events) that influence recruitment dynamics in fisheries species along the California coast.

Information from the SIO HR-XBT network is used to assess models, and so produce better estimates of the coupled ocean/atmosphere variability. This is contributing to, for example, the redesign of the ENSO-Observing System as part of the Tropical Pacific Observing System TPOS-2020 effort.

HFRNet supports operations and provides information for local and national entities such as U.S. Coast Guard Search and Rescue Optimal Planning System, NOAA Office of Response and Restoration Environmental Response Management Application, National Weather Service Advanced Weather Interactive Processing System, and California Office of Spill Prevention and Response. The data feeds include many organizations and agencies.

The CUGN is at the forefront of operational ocean robotics. Data from the CUGN is used by NOAA SWFSC to help in their fisheries management responsibilities, including the California Current Integrated Ecosystem Assessment.

Passive acoustics' impact on other disciplines will emerge as these novel techniques are applied to answer ecological and applied management questions. E.g., although they analyzed the acoustic data with respect to impact on cetaceans, noise sources such as seismic events affect a broad range of marine species in ways that have yet to be further explored. It addresses data needs for implementation of adaptive management strategies in the Gulf of Mexico. The O2 program atmospheric time series are intrinsically interdisciplinary, spanning climate sciences, and ocean and land biogeochemistry and ecology. They provide time series of high

### 39. What was the impact on the development of human resources?

In addition to the educational, training, and professional development components of CIMEAS projects detailed in other entries, undergraduates, graduate students, postdocs, and junior scientists receive practical training in advanced laboratory and field research in NOAA-related fields and find employment with NOAA.

Our personnel participated in many professional development courses in the areas of Psychological Safety, Preventing Harassment in the Field, Leadership, and Diversity, Equity & Inclusion. They also had the opportunity to peer review manuscripts and serve as guest editors.

CalCOFI's formal and informal student training has supported the development of many of the academic, state, and federal scientists that are currently active in the field today. The Semmens lab is training new scientists on quantitative methods and techniques to support up-and-coming quantitative ecologists who can achieve the mission and goals of NMFS.

Argo PIs have supported multiple postdocs, PhD, masters, and undergraduate students carrying out research using Argo data, who have successfully transitioned through the academic pipeline. In addition, the Argo lab trained undergraduate engineers who have transitioned to industry jobs.

The Global Drifter Program, the HR-XBT program, HRFNet, CUGN, and others are training skilled technical personnel in ocean engineering and marine technology.

Freshwater Ecology:

Megan Sabal received her PhD in 2021 and took a postdoc with Oregon State University and the NWFSC.

Ben Wasserman received his PhD in 2021 and took a postdoc at the University of Connecticut.

Tara Dolan (postdoc) took a permanent full time position with the Massachusetts Division of Marine Fisheries.

Litzia Galvan received her BS in 2022 and received a NOAA internship

HSU Freshwater Fish Ecology provided training in research, including data collection and analysis, for current graduate students. All past graduate students who have trained as part of the research collaboration have used the skills gained in their Masters' work to obtain career-path positions in fisheries science.

*Attach a separate document if more space is needed for #6-10, or #24-50.*

**IMPACT (cont'd)**

**40. What was the impact on teaching and educational experiences?**

Most projects gave experience to undergraduates, REU students, graduates, and postdoctoral researchers, both formally and informally, including participation on cruises. Many aspects of CIMEAS science are used in lectures by the PIs in classes, seminars, and public venues. Some selected specific examples are detailed in the following.

The Freshwater Fish Ecology Research Collaboration supports graduate research projects of students in Fisheries Biology at Cal Poly Humboldt. Student research projects are directed towards information needs of NOAA-Fisheries conservation and management efforts for listed salmon in Northern California and the Pacific Northwest.

Prof. Rudnick uses data from the CUGN in graduate and undergraduate courses.

HR-XBT PI Sprintall and PI Zilberman co-advises a PhD student Mitchell Chandler, BS/MA students Ms. Scarlett Hensen and Mr. Junnan Yan and PI Sprintall also co-advises SIO PhD student Manuel Guitierrez Villanueva. All students use the HR-XBT data as part of their research.

FEC PI Palkovacs taught several classes during the reporting period, maintaining an inclusive and active learning environment in all courses.

Freshwater Ecology provides students with the fundamental concepts for understanding the ecology of lakes and rivers, and the California water crisis.

Freshwater Ecology Lab is built on the course-based undergraduate research experience (CURE) concept. Many students go on to obtain internships and pursue graduate school.

Topics in Fisheries Ecology was co-taught with Tara Dolan (Postdoc), Steve Munch (NOAA), and John Field (NOAA) for 43 students (23 graduate students, 18 upper div undergrads, 2 postdoc/researchers). In addition, 35 other university participants, 7 UCSD/SIO participants, and 1 NOAA employee attended. Fisheries Ecology covers both ecological and policy dimensions of fisheries management, with a major case study on California's Chinook salmon fishery.

Scientific Skills covers the basics of scientific communication and ethical conduct in research. Students write NSF GRFP proposals, and each year a handful of these proposals are awarded.

He also provided research opportunities for many undergraduate students, including students from underrepresented backgrounds.

CCHDO staff led a presentation at the NSF Navas Teacher Conference on Teaching with Climate Data, and guest lectured in a

**41. What was the impact on physical, institutional, and information resources that form infrastructure?**

The Argo partnership has created a global array of over 3900 profiling floats spread every 3-degrees of latitude and longitude over the global deep ocean, providing a snapshot of the physical state of the ocean every 10 days.

The O2 program sustains physical resources (instrumentation, facilities, computer hardware and software) pertinent to long-term O2/N2 and CO2 measurements. These resources are relevant also for additional programs making these and similar gas measurements.

CCHDO represents an enhancement of research information infrastructure. While the CCHDO does not generate new data, it makes the data better and more usable, thus more far reaching and ultimately more scientifically and socially relevant. Via the CCHDO's actions, CTD, routine hydrography, ocean carbon, and tracer ocean profile data are more accessible and usable to a much wider audience in the research, educational, and broader communities who do not employ data specialists.

Passive acoustics have provided new recording systems to PIFSC for continued monitoring of interactions of long-line fishing gear with false killer whales.

The XBT network leverages extensive ship resources through partnerships with the ships, companies and international academic community and in doing so, also providing a degree of public outreach.

CalCOFI supports in-situ, ship based observational science (and the ships that carry out such observations) along the west coast of the US.

HFRNet Central repository nodes have been deployed and are maintained at the Scripps Institution of Oceanography and at the National Data Buoy Center to demonstrate an end to end distributed data system which links multiple regions to a central data repository.

The CUGN proves that underwater gliders are an essential part of ocean observing infrastructure. The CUGN is made possible by the Spray underwater glider fleet infrastructure at the Instrument Development Group at Scripps Institution of Oceanography. Data management activities are proving influential, particularly in our use of the DOI to identify data sets from the CUGN.

A capable and reliable fleet of academic research vessels is vital to the health of the U.S. oceanographic research community.

**IMPACT (cont'd)**

**42. What was the impact on technology transfer?**

SIO-Argo works with MRV Systems to provide commercial versions of the Argo floats developed at Scripps

In the past year, CalCOFI's observations continued to support model validation for applications in remote sensing products, fisheries and ecosystem modeling, and physical ocean models. Each of these model products represents technologies that improve our understanding of current and future ocean state CalCOFI's methods are used by other international oceanographic institutions and sampling cruises. Finally, CalCOFI promotes open science so supports development and sharing of data, code, models, and methods associated with long term observations.

The use of innovative systems including SEAS formats for data transfer, iridium data streams and sftp protocols, as well as continuing development of best practices have improved the success rate of the XBT probe deployment.

Passive acoustics software developed at Scripps Institution of Oceanography was made available to NOAA scientists who were trained on the use of acoustic data analysis software developed for this and other projects.

Interactive graphical user interfaces for interactive machine learning software tools for classifying species identity of cetacean echolocation signals in passive acoustic recordings were developed for non-expert government users. New and improved instrumentation is now available for PIFSC acoustic research.

The analytical products developed by members of the Semmens lab are made freely available over software sharing portals such as Github. As detailed above, these software tools have found a broad audience, including many scientists in the NMFS.

**43. What was the impact on society beyond science and technology?**

The multi-decadal, multi-variate ocean data sets taken, maintained, and served by CIMEAS are used for basic research in the ocean/climate system to understand the dynamics of the coupled ocean, atmosphere, land, and ecosystem and assess the state of the global and regional oceans. This basic research is applied in global and regional models for understanding and prediction of the economic and human impacts of variability in the state of the oceans, such as heat and carbon content, sea level, hurricanes, or ecosystem-based management of fisheries, water regulations, ecosystem health, allocation of water resources, and other public policy concerns. These observations will help us understand the earth system under climate change, including habitat changes for important fisheries and threatened or endangered species. National and international climate assessments (e.g., IPCC) depend on CIMEAS data and results to quantify and clarify policy discussion.

Outreach presentations and media engagement enhance public understanding of marine ecosystems and climate. Education, outreach, and teaching efforts at CIMEAS have reached thousands of students over the last few years alone, spanning students from the K-12 to the graduate level, and including interested members of the general public.

CIMEAS personnel have led workshops on Equity, Diversity, and Inclusion (EDI) topics and hosted various panels on EDI topics and participated in groups that work towards a more equitable, equal, and inclusive community, within science and in the broader world.

Some selected specific highlights follow.

Argo data improves short and long-term weather forecasting, hurricane path predictions, and projections of regional to global rates of sea level rise. Argo has also vastly improved estimates of year-to-year variability in ocean heat content, accounting for over 90% of the global anthropogenic energy imbalance.

GUGN information on the ongoing ocean heat increase off the US West Coast is of general societal interest.

The FCP communicated important information about ecosystem management to the public through news interviews and digital media.

FCP researchers engaged in three public "Labside Chats" and one "Science Sunday" in collaboration with the Seymour Marine Discovery Center in Santa Cruz. Each of these talks had attendance of nearly 100 people with the recordings available on both websites for additional reach. FCP and the Santa Cruz Monterey Bay Area Student Subunit of the American Fisheries Society (SCMBAS) co-hosted five Diverse Voices in Fisheries Science Seminars to present research conducted by leading scientists from under-represented groups.

*Attach a separate document if more space is needed for #6-10, or #24-50.*

**IMPACT (cont'd)**

44. What percentage of the award's budget was spent in foreign country(ies)?

0 , Janet Sprintall

SIO High Resolution XBT Transects

Approximately 5% primarily on accommodation for ship riders when their XBT cruise ends in a foreign port.

Karen Stocks

NOAA Support for the CCHDO Hydrographic Data Office at UCSD/SIO

4%

Dean Roemmich

The Argo Program , A Global Observations for Understanding and Prediction of Climate Variability

1%

Luca Centurioni

The Global Drifter Program

2%

**CHANGES/PROBLEMS**

45. Changes in approach and reasons for change

Bruce Appelgate

Operation of R/V Roger Revelle: Escanaba Trough hydrothermal sulfide system- exploring the seafloor and oceanic footprints

This mission was executed by R/V Thomas G. Thompson instead of Roger Revelle. This resulted from COVID-19 pandemic delays that caused a 120-day stand-down of the Academic Research Fleet in 2020, which in turn required a complete re-scheduling of the fleet. As a result, the only vessel available for this project was Thomas G. Thompson.

Dean Roemmich

The Argo Program ,Äi Global Observations for Understanding and Prediction of Climate VariabilityPI Roemmich formally retired from UCSD in October 2019. Roemmich remains the lead PI of Argo through UCSD,Äôs Recall to Active Duty appointment, with increasing roles played by PIs Purkey, Zilberman and Gilson.

Brice Semmens

California Cooperative Oceanic Fisheries Investigations: Ocean Observations to Inform Ecosystem-Based Management

"This past year some of our sampling was delayed due to the global COVID-19 pandemic."

Colleen Reichmuth

Monitoring body condition of seals in Alaska using small UAS: UCSC validation study

Research schedule was delayed by 9 months due to Covid-related restrictions on travel for Federal employees.

**CHANGES/PROBLEMS (cont'd)**

**46. Actual or anticipated problems or delays and actions or plans to resolve them**

Simone Baumann-Pickering

Passive Acoustic Studies in the Central Pacific

Propagation modeling was delayed due to COVID-related delay in data collection. Data has now been received and analysis will proceed.

Janet Sprintall

SIO High Resolution XBT Transects

COVID-19 has significantly impacted the HR-XBT program over the past 2 years. However, we expect to be able to re-establish high-density quarterly sampling of all transects in the near future if shipping and international travel becomes more viable.

Bruce Appelgate

Operation of R/V Roger Revelle: Escanaba Trough hydrothermal sulfide system- exploring the seafloor and oceanic footprints This project was originally hoped to sail in CY2020, but due to delays related to the COVID-19 pandemic could not occur until CY2022.

Brice Semmens

California Cooperative Oceanic Fisheries Investigations: Ocean Observations to Inform Ecosystem-Based Management

The COVID pandemic caused massive difficulties in terms of greatly increased staffing turnover and hampered ship operations with both academic and NOAA technicians, given disparities in pandemic protocols, and cruise delays or cancellations due to COVID positive cases amongst ship crews. In addition, both NOAA and UC San Diego are still not fully back to normal lab/personnel operation. We continuously work towards aligning COVID protocols across institutions.

Colleen Reichmuth

Monitoring body condition of seals in Alaska using small UAS: UCSC validation study

Research schedule and data collection targets have been modified to account for Covid-related travel restrictions in Year 1 of this project.

Luca Centurioni

The Global Drifter Program

reduced budget is affecting the global drifter array

Mark Henderson

Species distribution models for Deep-sea Corals and Sponges in the Southern California Bight

We requested a no cost extension because of delays due to the Covid-19 pandemic. The pandemic hindered our ability to collaborate

**47. Changes that had a significant impact on expenditures**

Investigations in Fisheries Ecology

State, county, and campus closures to address COVID reduced/eliminated expected travel and delayed participation in conferences and meetings

Brice Semmens

California Cooperative Oceanic Fisheries Investigations: Ocean Observations to Inform Ecosystem-Based Management

This year, the costs associated with UNOLS ship operations have increased by 50%, resulting from a complex combination of increased operational costs associated with the pandemic, and a reduction in cost-sharing across the various programs/grants that typically make use of RV Sally Ride. We continue to explore alternative options for future ship operations that are more economical, and will allow us to continue to survey the core CalCOFI grid. Note, however, that because ~16 ship days on RV Sally Ride (the equivalent of 1 of 2 full CalCOFI SIO led cruises) are covered by NSF/ONR, we are committed to at least one Sally Ride cruise per year. Regardless of the year-to-year Sally Ride cost fluctuations, the fundamental challenge our program faces is that the core NOAA operational funds have not had a cost-of-living adjustment in any recent year. In addition, salary increases to our technicians have served to further shrink our operational budget.

Luca Centurioni

The Global Drifter Program

We now must pay for satellite telemetry, which add about \$300K/year burden to the program

**CHANGES/PROBLEMS (cont'd)**

48. Significant changes in use or care of human subjects, vertebrate animals, biohazards, and/or select agents

Colleen Reichmuth

Monitoring body condition of seals in Alaska using small UAS: UCSC validation study

Federal marine mammal research permit 18902 issued to C. Reichmuth has been updated to marine mammal research permit 23554.

49. Change of primary performance site location from that originally proposed

None

**PROJECT OUTCOMES**

50. What were the outcomes of the award?

See Attached

**DEMOGRAPHIC INFORMATION FOR SIGNIFICANT CONTRIBUTORS (VOLUNTARY)**

Gender:

- Male
- Female
- Do not wish to provide

Ethnicity:

- Hispanic or Latina/o Not
- Hispanic or Latina/o Do not
- wish to provide

Race:

- American Indian or Alaska Native Asian
- Black or African American
- Native Hawaiian or other Pacific Islander
- White
- Do not wish to provide

Disability Status:

- Yes
  - Deaf or serious difficulty hearing
  - Blind or serious difficulty seeing even when wearing glasses
  - Serious difficulty walking or climbing stairs
  - Other serious disability related to a physical, mental, or emotional condition
- No
- Do not wish to provide

*Attach a separate document if more space is needed for #6-10, or #24-50.*