



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

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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	
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8. Title:	
9. Email:	10. Phone Number:
AUTHORIZING OFFICIAL	
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REPORTING INFORMATION	
Signature of Submitting Official: William Thomas Park	
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RECIPIENT ORGANIZATION	
20. Recipient Name: UNIVERSITY OF CALIFORNIA SAN DIEGO	
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## 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 (Cal State), and the Farallon Institute. CIMEAS strives to improve resilience by providing decision makers usable information through integrating cutting edge physical, ecological, and social science. 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 continues to elucidate the effects of interannual and decadal-scale variability on the southern California Current System (CCS) and its fisheries.

The Fisheries Collaborative Program (FCP) fosters research collaborations between NOAA scientists, UC Santa Cruz faculty, Institute of Marine Sciences researchers, and students. The research includes field and laboratory experiments, modeling, and computational studies, and involves marine and freshwater species and habitats where comprehensive studies are being conducted on the ecology and life history of Pacific salmonids and other fishes. The FCP serves to support resource managers, fisheries, and resource science in general.

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, carries out float technology development, participates in delayed-mode quality control, coordinates the U.S. Argo partnership, and provides leadership for international Argo. SIO is producing and deploying ~10 Deep Argo floats per year in regional pilot arrays.

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

The goal of the U.S. High Frequency Radar Network (HFRNet) is to maintain and improve the data management system of the network in order to support both operational and research communities by providing high quality, spatially dense, ocean surface current data in near real-time.

The California Underwater Glider Network (CUGN) is maintaining sustained glider observations in the California Current System (CCS).

The Global Drifter Program (GDP) provides a real-time data stream of drifter locations, SST, and other critical variables.

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

See attachment

## ACCOMPLISHMENTS (cont'd)

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

Most 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.

The UCSC Freshwater Ecology Collaboration has contributed to the training of 6 graduate students (two defended their PhD dissertations during the project period), 3 postdoctoral researchers, and 10 undergraduate interns.

CalCOFI regularly hosts student volunteers, graduate students and postdocs on research cruises. These opportunities provide unique opportunities to gain ship-based research experience.

The Argo dataset provides a major resource for basic research and education of graduate and undergraduate students, post-docs, and young scientists. Over 375 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 datasets for the SIO O2 program have supported projects for postdocs Eric Morgan and Benjamin Birner, and graduate student Yuming Jin. It also supported the professional development of three junior staff (Clark, Seibel, Hatley)

Several early career scientists (3 post-docs, 9 project scientists) and two UCSC graduate students were supported by and contributed to Climate ecosystem interactions/CA Current integrated ecosystem assessment/Species habitat modeling.

The HSU freshwater ecology project has trained a total of 5 Masters students (3 current, 2 complete) and provided hands-on research experience for >20 undergraduates. Fifteen total students have trained as part of the NOAA/HSU collaborative research effort. The project PI teaches undergraduate classes in fish ecology, river ecology, and limnology to >50 undergraduates per year.

The Semmens Lab, including graduate students and postdocs, hosted REU students and ran discussion groups and short courses designed to build capacity in quantitative marine and fisheries ecology among UCSD students and foster interactions between UCSD graduate students, faculty, and NMFS scientists.

Students are involved with the Women and Minorities in Science (WMIS) group which encourages the participation of anyone who supports minorities and women in science and wishes to work towards a more equitable, equal, and inclusive community.

~~Two students (one funded by the NOAA award, one on NSF award) worked at CCHDO with experienced physical oceanographers~~

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

In addition to the datasets, software applications, and wiki guides for end users that have been put online, publications listed elsewhere, scientific talks, public and stakeholder meetings, interviews, workshops, and symposia, here are a few summaries of selected dissemination achievements:

CalCOFI scientists regularly interact with media outlets and the general public to share findings of interest.

Over 4600 papers spanning a wide variety of topics have been published using Argo data. See <https://www.argo.ucsd.edu/outreach/publications/bibliography/>. In addition, 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 only 1/4 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.

The CUGN website ([spraydata.ucsd.edu](http://spraydata.ucsd.edu)) enables public access of quality controlled delayed mode data. CUGN data continues to be provided to the GTS in real time, and to be used in several models of the CCS.

The SVP program is posting the drifter observations of 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.

UCSC Investigations in Fisheries Ecology participated in international working groups and organized two management strategy evaluation workshops and webinars for fishery managers and stakeholders.

*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 planned 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 projects and some are scheduled to complete their research and graduate during the project period.

Some details include:

Argo will continue fabrication and deployment of Core Argo and Deep Argo floats worldwide. Technology improvement will continue in the SOLO-II and Deep SOLO floats, and finish development and deploy the first Biogeochemical SOLO float. Improvements will target better float performance and lifetime, and use of a new Iridium/GPS antenna to reduce damage due to ice contact. We will continue to assist with coordination and leadership of the International Argo Program, to enable and support education and outreach applications of Argo, and to play a part in demonstrating the high scientific value of Argo.

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

CCHDO is a mature and operational program, and the primary work plan is to continue its core mission of assembling and serving repeat hydrography data. Critical system improvements are planned to meet evolving security and interoperability expectations.

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 Acoustic project will deliver the long-line HARP systems to PIFSC. Data collection is in progress and should deliver relevant recordings. They will finalize two manuscripts over the next months. They will finalize the classifier to automatically extract beaked whale signals in long-term acoustic data. They will conclude the statistical analysis to document sonar impact on beaked whales. They will complete the analysis on seismic signals and source localization.

UCSC Ecosystem based fisheries management will continue to engage in collaborative research with NOAA scientists, train undergraduate and graduate students, mentor postdocs and junior scientists, support resource managers, participate in education and outreach activities, disseminate research through publications and other methods.

**PRODUCTS**

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

See Attachment

**PRODUCTS (cont'd)**

30. Technologies or techniques

N/A

31. Inventions, patent applications, and/or licenses

N/A

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

**PRODUCTS (cont'd)**

32. Other products

N/A

**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?

No

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?

See Attachment

**IMPACT**

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

See attachment



**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.

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.

Data from the CUGN is used by NOAA SWFSC to help in their fisheries management responsibilities, including the California Current Integrated Ecosystem Assessment.

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 integrity that relate to very large-scale phenomena and thus are among the first places to look for indicators of global change.

The general approach of using a broad ecosystem-based perspective (physics-to-fish) to understand larval ecology and recruitment dynamics of fish stocks is still relatively new to the discipline. Our research is influencing that development, in particular, trying to find the linkages that relate ecosystem variability to the particular prey types that are preferred/selected by tuna larvae, and therefore most influence their feeding, growth, and survival.

UC Santa Cruz Freshwater Ecology Research has yielded important information for food security, economics, sustainable fisheries,

**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.

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.

UCSC Freshwater Ecology supports 4 outstanding graduate students who have won many awards and fellowships. They study Chinook salmon restoration in California's Central Valley, the effects of sexual selection on eco-evolutionary dynamics in mosquitofish, the eco-evolutionary dynamics of a keystone supergene in steelhead trout, and the effects of predators on migrating prey.

Two recent PhD graduates studied the eco-evolutionary dynamics of California estuarine threespine stickleback and the effects of human activity on salmonid life history variation.

Three Postdoctoral Researchers are studying Salmon Management Strategy Evaluation, Food web dynamics of the California Current, and Genomics of maturation age in Chinook salmon.

HSU Freshwater Fish Ecology provided training in research, including data collection and analysis, for current graduate students. All 12 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.

In addition to the training detailed above, the O2 project also contributed to sustaining core capabilities at Scripps involving CO2, O2/N2 and Ar/N2 measurements.

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**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. 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.

Each year 6-12 graduate and/or undergraduate students participate in ship-based science as part of the CalCOFI program. CalCOFI scientists (both at SIO and SWFSC) work closely with undergraduate and graduate students on scientific projects that leverage CalCOFI data.

Eric Palkovacs taught undergraduate courses in Ecology and Freshwater Ecology and graduate courses in Scientific Skills and Fisheries Ecology.

The Argo dataset provides a major resource for basic research and education of graduate and undergraduate students, post-docs, and young scientists. Over 375 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 HSU freshwater ecology project has trained 15 Masters students and provided hands-on research experience for >50 undergraduates. The project PI teaches undergraduate classes in fish ecology, river ecology, and limnology to >50 undergraduates per year.

The O2 project data are featured in the PI's course on climate change and have fueled multiple projects by graduate students and postdocs, both at Scripps and elsewhere.

Peter Dudley helped facilitate the educational opportunities of a NOAA NERTO intern during the field season. The molecular ecology team delivered guest lectures in biology at several local universities and a high school.

A training session on CCHDO and other ocean data resources was provided to new graduate students entering Scripps Institution of Oceanography.

HR-XBT PI Sprintall and PI Zilberman co-advise a PhD student Mitchell Chandler and PI Sprintall also coadvise SIO PhD student Manuel Guitierrez Villanueva. Both students use the HR-XBT data as part of their research.

HFRNet near-real-time surface currents and related products are available in public repositories and online visualizations providing opportunities for education for all ages from elementary schools to postdoctoral institutions.

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

The Argo partnership has created a global array of over 3800 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 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 network may reasonably be thought of as observational 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.

The California Cooperative Oceanic Fisheries Investigations (CalCOFI) program maintains the world's oldest and most comprehensive ocean ecosystem monitoring and data serving program. CalCOFI's information resources have been used in 100s-

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

**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

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.

There are three primary surface current mapping systems from manufacturers: CODAR Ocean Sensors, WaveE RAdar (WERA), and Least Expensive RAdar (LERA) that are installed for measuring surface currents.

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.

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.

New and improved instrumentation is now available for PIFSC acoustic research.

NEFSC personnel were trained in analysis techniques.

**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. These observations will help us to 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.

The research and subsequent dynamic ocean management products provide a framework for maintaining sustainable and healthy marine ecosystems. Through the reduction of bycatch species in fisheries, CIMEAS is helping protect important non-target species while maintaining the intrinsic beauty of our marine environments. Quantifying catch will help to understand each fishery's impact on target populations, enabling better management.

CIMEAS science supports NOAA's conservation and hatchery programs for threatened and endangered species, such as salmonids and white abalone, and contributes to the recovery of economically and socially important species. These species and resources have great social and cultural value throughout the US, including to indigenous and Native American communities, and support economically valuable tourism.

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 pathway 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.

The data and results from the O2 project may eventually help ground policy discussions in the arena of climate and global change, particularly in relation to the carbon cycle.

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

Approximately 1% (Argo)

**CHANGES/PROBLEMS**

45. Changes in approach and reasons for change

The number of SIO Argo floats deployed was lower than normal because there were less deployment opportunities during the COVID pandemic. In addition, some vendors providing float parts have been slower than normal to deliver owing to COVID. Finally, no travel was possible this year due to COVID travel restrictions

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

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

See Attachment

47. Changes that had a significant impact on expenditures

Argo: COVID-19 has slowed international sea shipping by several months and generated large uncertainty regarding port delays. For that reason, shipments of the NOPP Argo floats were made via air freight.

CUGN: The pandemic has led to some additional expenses, and to some savings. At this point, it appears that the net effect is close to neutral.

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

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

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

None

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

Work shifted from SIO/UCSD space to home offices due to COVID-19.

**PROJECT OUTCOMES**

50. What were the outcomes of the award?

See Attachment

**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.*