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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: NA20OAR4320271
3. Project Title: Cooperative Institute for Climate, Ocean, and Ecosystem Studies (CICOES)	
4. Award Period of Performance Start Date: 07/01/2020	5. Award Period of Performance End Date: 07/31/2025
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR	
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13. Title: Compliance Analyst	
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REPORTING INFORMATION	
Signature of Submitting Official: Lester W Villaflor	
16. Submission Date and Time Stamp: 04/03/2023	17. Reporting Period End Date: 03/31/2023
18. Reporting Frequency: (●) Annual ( ) Semi-Annual ( ) Quarterly	19. Report Type: (●) Not Final ( ) Final
RECIPIENT ORGANIZATION	
20. Recipient Name: THE UNIVERSITY OF WASHINGTON VICE PR	
21. Recipient Address: 4333 BROOKLYN AVE NE, SEATTLE, WA 98195-0001 USA	
22. Recipient UEI: HD1WMN6945W6	23. Recipient EIN: 916001537

ACCOMPLISHMENTS

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

See appendix 2

25. What was accomplished under these goals?

See appendix 1

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?

Here is a list of highlights of training and professional development at CICOES during the reporting period:

- CICOES has a dedicated professional development fund for research staff and postdocs for conference attendance and enrichment courses. An employee committee reviews applications and decides which applicants to fund

- Individual groups, PIs, and research science staff also participated in many international and national remote conferences including American Geophysical Union, American Fisheries Society, Alaska Marine Science Symposium, and American Society for Limnology and Oceanography Ocean Sciences meeting.

- Approximately once per year, the CICOES Diversity, Equity and Inclusion (DEI) committee organizes a DEI-related training for CICOES staff—led by outside experts in the field.

- Undergraduate students who participate in our summer Internship Program are invited to apply for CICOES funds to attend a research conference (often with their mentors) during the academic year following their internship.

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

CICOES scientists and affiliated faculty publish primary and popular literature and conduct public education events. The following list are representative highlights held during the reporting period:

- Results were disseminated through public talks, including the NOAA seminar series and scientist and student presentations at the ASLO Ocean Sciences meeting.

- Each year, the Innovative Technology for Arctic Exploration (ITAE) group works with its partners such as EcoFOCI to disseminate scientific information and continues to enhance and adapt how that information is shared. The group's approach targets the scientific community, local communities, and fishery management institutions: Science Community: Alaska Marine Science Symposium, the ASLO Ocean Sciences meeting, the North Pacific Research Board's Arctic Integrated Ecosystem Research Program (NPRB-AIERP); Local Communities: NPRB-IERP, Arctic Waterways Safety Committee, Alaska Eskimo Whaling Commission; Fishery management Institutions: Bering Sea and Arctic Ecosystem Status Reports

- In the Genetics and Genomics group, CICOES scientists work with intermediaries to inform local tribal partners and are actively establishing relationships with these communities

ACCOMPLISHMENTS *(cont'd)*

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

See appendix 2

PRODUCTS

29. Publications, conference papers, and presentations

See appendix 6

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

PRODUCTS *(cont'd)*

30. Technologies or techniques

Technological developments that enable new measurements in support of NOAA's mission are an integral component of CICOES' annual activities. Examples of technological development during the reporting period include:

- Large Eddy Simulation cloud-resolving model System for Atmospheric Modeling (SAM) version 6.10
- Environmental (e)DNA metabarcoding, whole-genome sequencing, nanopore long-read sequencing, Illumina NovaSeq and Illumina MiSeq sequencing, automated eDNA samplers
- Algorithm development in geospatial computation, machine learning, ordinary least squares regressions (with fixed effects), and logistic regression (with fixed effects)
- Mathematical, oceanographic and economic modelling
- Line-transect aerial survey methodology, aircraft belly mounted camera system.
- Passive acoustic monitoring and analysis techniques, including noise metrics and autodetection and classification
- Drones (hexacopters), aerial survey methodology, HD video cameras
- Machine Learning/AI project development currently in development for photo-id.
- Implantable satellite transmitter
- Environmental monitoring sensor packages for long term deployment at high latitudes (e.g. Prawler mooring for water profile sampling)
- Oculus autonomous underwater glider
- Pop-up floats for long term bottom deployments

31. Inventions, patent applications, and/or licenses

Nothing to Report

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

PRODUCTS *(cont'd)*

32. Other products

Nothing to Report

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

33. What individuals have worked on this project?

John Horne, PI
Uma Bhatt, Co-PI (lead UAF)
Muyin Wang, Deputy Director
Joseph Resing Deputy Director
Ivonne Ortiz, Associate Director

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?

Nothing to Report

35. What other organizations have been involved as partners?

CICOES is a Cooperative Institute consortium with the University of Alaska Fairbanks (UAF) and Oregon State University (OSU)

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

36. Have other collaborators or contacts been involved?

Mike Alexander, Simone Alin, Aleksandr Araykin, Diego Arcase, Kerim Aydin, Dan Ayers, M.O. Baringer, Sonia Batten, Tamara Baumberger, S. Becker, Catherine Berchok, Bryan Black, Nicholas Bond, Peter Boveng, Charlotte Boyd, William Brazelton, J.L. Bullister, Randie Bundy, Eugene Burger, Michael Cameron, Antonietta Capotondi, C.A. Carlson, William Chadwick, Carolina Chambers, Guiwan Chen, Wei Cheng, Dezhang Chu, Kathryn Chumbley, Sarah Converse, Lee Cooper, Kelly Corbett, Jessica Crance, Jessica Cross, Shawn Dahle, Michael Dalton, Alison Deary, S.C. Doney, Stan Dosso, John Dunne, Marie Eble, Steven Emerson, Reagan Errera, Andrea Fassbender, Richard Feely, Megan Ferguson, Bridget Feris, R.A. Fine, E. Firing, Robert Foy, Nancy Friday, Thomas Gelatt, Christopher German, Georgina Gibson, Dan Goethel, Maxime Grand, Jackie Grebmeier, N. Gruber, Jen Hagen, Melissa Haltuch, Owen Hamel, D.A. Hansell, Ed Harrison, Alan Haynie, Tom Helser, Albert Hermann, Gaelle, Hervieux, Kevin Hiers, Anne Hollowed, Kirstin Holsman, Makio Honda, Julie Huber, Jim Ianelli, Katrin Iken, M.O. Ishii, Catherine Jeandel, G.C. Johnson, Ken Johnson, Isaac Kaplan, Stephen Kasperski, K. Katsumata, Yoshimi Kawai, Kelly Kearney, Julie Keister, R.M. Key, Peter Kiffney, Laura Kong, M.O. Kramp, Jason Kriesel, Arun Kumar, Edward Laman, Susan Lang, C. Langdon, Sim Larkin, Wes Larson, Marvin Lilley, Xiaopei Lin, Maeve Lohan, Josh London, Rick Lumpkin, Chris Lunsford, John Lupton, A.M. MacDonald, Nathan Marshall, J.T. Mathis, Beth Matta, Liz McCullough, E.L. McDonagh, S. Mecking, Chris Meinig, Susan Merle, Richard Methot, F.J. Millero, Dong-Ha Min, Christopher Moore, Erin Moreland, Danielle Naiman, T. Nakano, Julie Nielsen, Jan Newton, Jeff Nystuen, Eitarou Oka, James Orr, Christopher Paight, Surya Prakash, Sulagna Ray, Heather Renner, Marie Robert, Nora Rojek, Kenneth Rubin, Greg Ruggerone, Steve Rutledge, C.L. Sabine, Peter
Salameh, Beth Sanderson, Jorge Sarmiento, Ajda Savarin, Joe Schumacker, Roland Schweitzer, Sarah Seabrook, Peter Sedwick, Kim Shelden, Samantha Siedlecki, Bob Simons, B.M. Sloyan, W.M. Smethie, Matthew Snyder, Laura Spencer, Paul Spencer, Ingrid Spies, Phyllis Stabeno, Valentina Staneva, Timothy Stanton, Jeremy Sterling, William Stockhausen, Robert Stone, Adrienne Sutton, Rob Suryan, J.H. Swift, Cody Szuwalski, Alessandro Tagliabue, Lynne Talley, Dajun Tang, T. Tanhua, James Thorson, Eric Thorsos, Andrew Thurber, A.M. Thurnherr, Vasily Titov, Jason Toft, Verena Tunnicliffe, Henry Vanderploog, Morgan Varner, Paul Wade, Sharon Walker, Hu Wang, R.A. Wanninkhof, Eric Ward, Amanda Warlick, Mark Warner, Janet Watt, Wilbert Weijer, Tom Wilderbuer, Sarah Wise, Lixin Wu, Yan Xue, Jie Yang, Stephani Zador, Jeannette Zamon, Tonya Zeppelin, and J.-Z. Zhang.

IMPACT

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

See appendix 2

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?

Impacts from studies conducted by CICOES scientists are not constrained within single research themes. Impacts from CICOES research projects on other disciplines included:
• Continued development and deployment of Biogeochemical Argo floats shifts focus from physical oceanography to enable climate and atmospheric science investigations and modeling efforts.
• Development of an ageing technique for otoliths has impacted development of deep learning neural networks that incorporate disparate data types.
• Advances in quantitative metabarcoding approaches are broadly applicable across public health, and ecology by increasing the understanding of how microbial, algal, fungal, zooplankton, fish, and marine mammal assemblages are responding to environmental patterns.
• Multi-omics approaches can be used to characterize stress in marine species, which enables characterization of physiological pathways from genes to transcription to proteins, lipids, and hormones in relation to changing environmental conditions.
• Ocean acidification model output is being used by biologists to characterize species sensitivity to reduced pH and ecological projections on changes in commercial fish and crab abundance and catch.
• Coordinated ecosystem modeling efforts provide pathways to address economic questions relevant to blue economy development.
• Autonomous ocean measurements are used by national prediction centers to improve weather and climate prediction, and allow researchers to study exchanges of heat, moisture, momentum, and carbon dioxide between the sea and air.

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

In addition to the previously discussed DEI workshops, we continue efforts to encourage the hiring of underrepresented groups in all personnel hires. While the number of female PhD students and postdoc researchers in the sciences has increased in recent years, retention of female scientists beyond Postdoctoral Scholar appointments remains a challenge to CICOES as well as US Universities and Government agencies. CICOES has a dedicated HR Manager who works with the CICOES DEI committee to ensure fair and unbiased hiring.
Our outreach efforts include programs that reach out to students of all ages and levels, including talks on Career Day at elementary schools, and contributing support to three high school summer interns in collaboration with the Pacific Science Center, where the students trained in stomach sample analysis and data exploration – providing exposure to STEM careers.
Undergraduate students, graduate students, postdocs, and early career scientists are all active participants in our education, outreach, and mentoring programs. All students have access to the CICOESS community for help with their research and are encouraged by established scientists.
Two CICOES scientists recently had an INBRE Curriculum Development grant funded to introduce UAF undergraduate and graduate students to phylogenetics and transcriptomics bioinformatic techniques. Additional activities associated with the NSF RCN collaboration 'Seascape Genomics of North Pacific Forage Fishes' provided training to three graduate students across two universities and produced publicly available outreach/educational materials.

IMPACT *(cont'd)*

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

Training and mentoring took numerous forms in association with CICOES research over the reporting period:
Postdoctoral Scholars and Early Career Scientists: 58
Graduate students: 52 (including students receiving partial support)
Undergraduate interns: 13 (2 received NOAA support, others funded from other sources)

We supported undergraduate student class activities and graduate students in their research, thesis/dissertation preparation, and provided field experiences through Oceanographic Expeditions and/or Resource Management Surveys.

An example of an undergraduate research project is a rip current hazard forecasting project. Rip currents, fast offshore-directed flows, are the leading cause of rescues and death on surf beaches worldwide. Rip currents include bathymetric currents that form when waves break on sandbars interspersed with channels and transient currents that form when waves break from multiple directions. NOAA seeks to minimize the threat of rip currents by providing rip current hazard likelihood forecasts based on environmental conditions from the Nearshore Wave Prediction System (NWPS). Because the NOAA model was developed and tested in an area where bathymetric rip currents may be the most prevalent type of current, the model's performance in regions where other types of currents may be more ubiquitous (e.g., transient rip currents) remains unknown. The central question for this project was, "Is the NWPS input conducive for transient rip current activity?" CICOES intern Audrey Casper used Python to evaluate the performance of the NOAA model. She compared predicted rip current probabilities with lifeguard observations of bathymetric and transient rip currents from Salt Creek Beach, California. She also compared the NOAA model estimates with physical-based parameterizations of bathymetric and transient rip current speeds. The results suggested that though the NOAA predictions generally performed well, hazardous rip currents were under-forecasted when large waves were directionally spread when lifeguards observed transient rip currents.

Additional educational examples during the reporting period included:
- 'Omics scientists hosted undergraduate interns each summer to improve marine biology and molecular ecology research skills.
- Undergraduate and Graduate students are trained in chemical analysis methods and preparation of specialized sampling instruments during research cruises.
- Postdoctoral Scholars use observational data to further constrain model uncertainty for climate hindcasts.
- Graduate students participated in research projects using Deep learning.
- Undergraduate students were trained in video analysis for cetacean research, to assess polar-orbiting satellite products using the software and computing systems that generate the data products.

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

Nothing to Report

IMPACT *(cont'd)*

42. What was the impact on technology transfer?

Drone and sensor operations development includes both underwater and air-sea interaction observing platforms: saildrones, sea gliders, coastal gliders, moored floats, pop-up floats, profiling floats, and deep ocean methane laser spectrometers. The Kuroshio Extension Observatory 2022 mooring included new dissolved oxygen sensors, a nitrate sensor, a testbed for biodegradable "plastic-alternative" materials from the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), the University of Washington-Applied Physics Lab's bubble and acoustic observations, and a moored CO2 system.
Atmospheric sciences will benefit from advances in unmanned aircraft development. Satellite data and traditional sensors data processing and analysis procedures will benefit from improved software and algorithms that provide new data products and faster public data availability, which increases the efficiency and usability of the observation systems.
Fisheries and aquaculture stakeholders will benefit from: improved salmon bycatch management through improvement genetic stock composition that distinguishes chum from Chinook salmon, best practices to increase reliability of oyster seed production, improved drones use during surveys and computer vision for analyses, underwater microscopes for zooplankton; autonomous eDNA samplers, and physiological genomics to understand how ocean acidification may affect growth, embryonic development, shell strength, metabolic rates, immune system, behavior, and mortality of shellfish.

See appendix 4 for additional info

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

Impacts on society beyond science and technology during the reporting period increased coastal community resilience, national and international food security, and better civil planning and engineering for future climate changes. Associated education and outreach efforts increased public awareness of environmental issues and trained the next generation of physical and biological scientists. Specific examples include:
• Subseasonal to seasonal forecasting of river ice breakup and flooding increases preparation time for potential flooding impacts in Alaskan communities.
• Northwest water year impacts and resilience planning resulted in changes to policy that requires Washington State water systems of a certain size to incorporate climate resilience into water system plans and used to develop guidance for water system planners when updating plans to consider climate impacts and resilience options.
• Understanding the role of the ocean in carbon sequestration through primary productivity and its export to the deep ocean provides guidance when applying anthropomorphic techniques to remove carbon dioxide from the atmosphere.
• Development and deployment of the current generation of biogeochemical Argo floats enabled better climate forecasts.
• Production of tsunami inundation maps Caribbean and Pacific islands will increase societal awareness and emergency planning for potential tsunami hazards.
• The Ocean Climate Stations (OCS) webpage displays ocean and atmosphere observations in real time to scientists and the general public and better informs society of our changing environment.

IMPACT *(cont'd)*

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

1 , Best estimate

CHANGES/PROBLEMS

45. Changes in approach and reasons for change

Nothing to Report

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

CHANGES/PROBLEMS *(cont'd)*

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

Nothing to Report

47. Changes that had a significant impact on expenditures

Nothing to Report

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

CHANGES/PROBLEMS *(cont'd)*

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

Nothing to Report

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

Nothing to Report

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

PROJECT OUTCOMES

50. What were the outcomes of the award?

See appendix 5

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.