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: NA19OAR4320074
3. Project Title: CINAR: A Cooperative Institute for the North Atlantic Region	
4. Award Period of Performance Start Date: 07/01/2019	5. Award Period of Performance End Date: 06/30/2024
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16. Submission Date and Time Stamp: 05/25/2022	17. Reporting Period End Date: 03/31/2022
18. Reporting Frequency: ◉ Annual ○ Semi-Annual ○ Quarterly	19. Report Type: ◉ Not Final ○ Final
RECIPIENT ORGANIZATION	
20. Recipient Name: WOODS HOLE OCEANOGRAPHIC INSTITUTION	
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22. Recipient UEI: GFKFBWG2TV98	23. Recipient EIN: 042105850

ACCOMPLISHMENTS

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

The Cooperative Institute for the North Atlantic Region (CINAR) is a regional CI that focuses on the Northeast U.S. Shelf Large Marine Ecosystem (NEUS LME), a critical region within the North Atlantic that spans from Cape Hatteras to Nova Scotia, encompassing the continental shelf from the continental slope to the northern wall of the Gulf Stream. The CINAR consortium is led by the Woods Hole Oceanographic Institution (WHOI), and includes the Gulf of Maine Research Institute (GMRI), Rutgers University (Rutgers), University of Maryland Center for Environmental Science (UMCES), University of Maryland Eastern Shore (UMES), University of Massachusetts Dartmouth - School for Marine Science and Technology (SMAST), University of Maine (UMaine), and University of Rhode Island (URI). Through our NOAA and academic partnerships, the CINAR consortium provides a mechanism for NOAA scientists to easily and rapidly obtain research assistance and facilities or infrastructure support for projects, and respond to technical needs through the development of instruments, models, and approaches that contribute to management decisions. This CI was established in 2019, and is completing the first year of a five-year award.

CINAR projects are carried out under five research themes: (1) Sustained Ocean Observations and Climate Research; (2) Ecosystem Research, Observation, and Modeling; (3) Stock Assessment Research; (4) Protected Species Research and Recovery; and (5) Ecosystem-Based Fisheries Management. Research carried out by CINAR investigators over the past year encompassed a variety of activities and programs under these five themes to address NOAA research and management needs in the Northeast region and beyond.

In addition to these activities, an important goal of CINAR is to promote education and outreach among member institutions and within the broader scientific community. To achieve this goal, we have provided traineeships and fellowships at a variety of academic levels, including undergraduate internship programs, CINAR Minority Traineeships, and faculty fellowships to help train future generations of NOAA marine scientists. Student participation in CINAR research is further facilitated through the NOAA Living Marine Resources Cooperative Sciences Center at the University of Maryland Eastern Shore. Our outreach programs span a diversity of topics, and include activities to foster better management of harmful algal blooms in the U.S., as well as a series of science and management workshops for commercial and recreational fishermen to foster improved cooperation and trust among fishermen, scientists, and managers.

25. What was accomplished under these goals?

Select research accomplishments from a subset of CINAR programs are highlighted below, organized under each of our CI's five major research themes. Detailed progress reports from each CINAR investigator are distributed directly to project sponsors. Figures cited in text can be found in Appendix 6. Education, outreach, and training activities are described in comment field 26.

Theme I – Sustained Ocean Observations and Climate Research. CINAR activities generated datasets and analyses that are critical to quantifying and modeling climate forcing and consequent ecological impacts, including efforts to: 1) support and redeploy the Stratus, NTAS and WHOTS Ocean Reference Stations (ORS), which provide sustained, climate-quality observing of the trade wind region (PIs: R. Weller/A. Plueddemann, WHOI; Figs. 1 & 2); 2) use spray gliders for autonomous collection of upper ocean heat measurements for hurricane forecasting by NOAA (PI: R. Todd, WHOI; Fig. 3); and 3) expand the global fleet of Argo floats, including designation fifty floats for collection of high frequency sampling to support hurricane forecasting (PI: S. Wijffels, WHOI; Fig. 4).

Theme II – Ecosystem Research, Observation, and Modeling. CINAR projects used data from CINAR's ocean observing programs to understand and describe ecological parameters and processes in the NEUS LME, and developed tools and techniques to improve regional ecosystem forecasting, management, and policy decisions. Highlights included: 1) deployment of acoustic tags on Atlantic cod in Southern New England to track the spawning population and assess with other cod populations (PI: S. Cadrin, UMass Dartmouth; Fig. 5), and 2) development of data products critical for analysis of decadal-scale trends in pH and impacts of ocean acidification in the Northeast Shelf (PI: G. Saba, Rutgers Fig. 6).

Theme III – Stock Assessment Research. CINAR research is working to improve stock assessments of species found in the NEUS LME through the development and refinement of technologies and techniques for data collection, and the development of new modeling and forecasting approaches. These activities support better management of fisheries and decision making in the region. Highlights included: 1) evaluation of management procedures to resolve the identified mismatch in biological populations and management units of Atlantic cod (PI: L. Kerr, GMRI; Fig. 7); comparison of acoustic data and eDNA signals for assessing biomass and distribution of herring (PI: G. Sherwood, GMRI; Fig. 8); and 3) HabCamV4 vehicle staging and deployment in the 2021 NMFS Scallop Survey (PI: S. Lerner; WHOI; Fig. 9).

Theme IV – Protected Species Research and Recovery. CINAR researchers developed new technologies, research tools, and approaches for the assessment and recovery of protected species in the NEUS LME, including the critically endangered North Atlantic right whale. These efforts contribute to improvements in defining, protecting, and restoring essential habitat for these species. Research highlights included: 1) use of aerial photogrammetry to provide quantitative body condition indices that reflect the health of NARW in Cape Cod Bay (PI: M. Moore; WHOI; Fig. 10); and 2) use of Slocum gliders to monitor and study the occurrence and distribution of whales and commercially important fish, and, contribute near real-time detections of the NARW for NOAA's Slow Zones program (PI: M. Baumgartner; Fig. 11).

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?

Over the past year, CINAR investigators provided research, training and professional development opportunities through direct participation of students and postdocs in research, as well as specific programs to connect with communities. Below we highlight selected achievements and programs:

1. Undergraduate minority traineeship program: For many years, CINAR has supported an undergraduate minority traineeship program, which provides funding to each CI partner institution in support of summer fellowships for students from underrepresented communities. Over the past year, CINAR partnered with the newly developed NOAA undergraduate diversity internship program IN FISH (An Inclusive NOAA Fisheries Internship Program), which provides internship opportunities for undergraduate students largely under-represented in the marine science and resource management ¿elds, as well as mentorship/training opportunities to the host investigators and institutions so that they learn together with the students. The goal of IN FISH is to build diverse talent to be the future workforce of NOAA, representative of our constituency. Under this partnership, CINAR will support five undergraduate students in 2022, who have the opportunity to participate in coursework and cohort building activities along with a larger cohort of IN FISH students, and will then participate in an additional 8 week intensive mentor-led research or resource management project.   We look forward to reporting on these students' activities and this newly initiated partnership in our next progress report.

2. Graduate/undergraduate student, and postdoc participation in research: CINAR research programs offer many opportunities to engage graduate students, postdocs, and early career scientists, and provide career training to the next generation of NOAA scientists. Students are introduced to an active and collaborative research environment, interact with scientific leaders in ecosystem research, start building a network of contacts for advanced studies and a career in science or resource management, and gain experience with ecosystem-scale research, proposal writing and presentation skills. Over the past year, CINAR investigators included 15 graduate students, 26 undergraduate student, and 13 postdocs in their research programs, and expanding student and postdoc participation in research is an important priority going forward.

3. Quantitative Fisheries and Ecosystem Science faculty support: The goal of this program is to engage early career scientists in research to improve and enhance the assessment and management of fisheries resources in the region. With support provided by NOAA's Quantitative Ecology and Socioeconomics Training (QUEST) program, these two-year fellowships provide support to early career faculty at CINAR partner institutions that conduct research and educational activities related to stock assessment and quantitative fisheries science in the NEUS LME. Complete information about this fellowship program, current fellows and their research activities can be found on the CINAR website: https://website.whoi.edu/cinar/people/fellows/.   Over the past year, CINAR supported five fellowships to early career faculty, and during the upcoming year, CINAR will held a competition to fund a second round of fellowships, which will extend from 2023-2024.

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

In addition to the educational and outreach programs described in comment box #26, results were disseminated through the numerous peer-reviewed publications, websites, and public presentations. These are too numerous to list here, but are described and detailed in Appendices 4 and 5, and comment field 32.

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?

Work on all ongoing and new research and educational programs will continue under CINAR's new award. Over the upcoming year, CINAR will seek opportunities to expand our partnership with the NOAA IN FISH program, and to support a greater number of summer student fellowships. We will continue to explore opportunities to augment programmatic funding for our education programs, and for expanded engagement of UMES undergraduate and graduate students in research at CINAR consortia via the LMRCSC. Finally, in fall 2022, CINAR will hold a second competition for CINAR will held a competition to fund a second round of QUEST early career fellowships, which will extend from 2023-2024.

PRODUCTS

29. Publications, conference papers, and presentations

A comprehensive listing of all publications, conference papers, and presentations by CINAR investigators associated with the current reporting period are provided as Appendix 4 and Appendix 5. Please note that DOI numbers are provided for each peer-reviewed publication.

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

PRODUCTS *(cont'd)*

30. Technologies or techniques

Technologies and techniques associated with CINAR research are listed below:
• Anderson (WHOI) Imaging FlowCytobot for unprecedented resolution of the composition and abundance of primary producers in ecosystems.
• Baumgartner (WHOI): The publicly accessible website http://robots4whales.whoi.edu/ continues to be used for displaying near real-time detections of whales from autonomous gliders and buoys.
• Cadrin (SMAST, Cod research): Acoustic receiver data continues to be shared with other researchers through the Atlantic Cooperative Telemetry Network (ACT), www.theactnetwork.com)
• Fay (SMAST): Development of Demonstration Simulation Model tutorial for use in stakeholder workshops and to inform about the project and methodology. Published on github at: https://github.com/thefaylab/SimSurvey/blob/master/tutorial/sseep-wk2-demo.Rmd
• Foote (WHOI): Three-dimensional morphometric data derived from CT or MRI scanning of specimens of adult butterfish (Peprilus triancanthus) and Atlantic mackerel (Scomber scombrus).
• Grebmeier (UMCES): As part of our national and international activities, the DBO-NCIS is tracking identified Essential Ocean Variable (EOV) in relation to benthic populations in the Pacific Arctic, such as seawater temperature and salinity, inorganic and organic carbon, nutrients, phytoplankton biomass, zooplankton, microbial activities, and macrofaunal abundance and distribution (an emerging EOV) -- https://arctic.noaa.gov/Arctic-News/ArtMID/5556/ArticleID/385/Distributed-Biological-Observatory and https://dbo.cbl.umces.edu
• Jayne (WHOI) Argo floats for physical and biogeochemical sensing.
• Jakuba (WHOI): This project developed hardware and software that enabled a Wave Glider to autonomously tend the NWFSC SeaBED class AUV. Wave Glider operations were fully integrated with AUV topside. There is a seamless transition between the communications and navigation systems used by the AUV team during regular operations and the equivalent systems on the Wave Glider.
• Lerner (WHOI): HabCam vehicle updates included reducing specific multiple computer systems that had their own displays to a single topside computer running multiple displays. Now the engineering GUI, image viewer, pilot display, and winch display are all driven with a single computer. This eliminates problems with time synchronization and latency, reduces equipment size and installation time, and provides an easy method to spare the system. Additionally, software was developed on the HabCamV4 topside computer to easily switch between these hardware configurations.
• Lohrenz (SMAST): Derived a series of frontal indicators which isolate prominent frontal features (from daily satellite data) for both SST and CHL – these products are being refined and will be available soon; beta versions have been shared with other researchers. Shiny app for viewing/assessing oceanographic indicators is in development. Created Github repositories that served as project management tools and will host final code for GAM models and frontal metrics.
• Sherwood (GMRI): eDNA primers have been developed to amplify short and long-fragment Atlantic herring eDNA.
• Todd (WHOI): New post-processed data from Gulf Stream glider missions are routinely added to this publicly available data set: doi: 10.21238/S8SPRAY2675. Plots of real-time and post-processed glider data can be found here: http://gliders.whoi.edu.
• Weller (WHOI): The Ocean Climate Observations and Analyses effort supports three Ocean Reference Stations (ORS), which are

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

 Other products developed by CINAR PIs are listed below:

• Anderson (WHOI): Cyst cruise data supports NOAA harmful algal bloom forecasting and modeling: https://products.coastalscience.noaa.gov/hab/gomforecast.aspx.
• Anderson and Richlen (WHOI): U.S. National Office for Harmful Algal Blooms website (https://hab.whoi.edu/), which serves as a "clearinghouse" for information related to national and international activities on HAB issues.
• Cadrin (SMAST, Groundfish research): Hankowsky K, M Grezlik, L McGinnis, G Fay, S Cadrin, & A Hansell. 2021. Catch Rate Standardization of American Plaice Trawl Fishery. American Plaice Research track Stock Assessment Working Paper (https://docs.google.com/document/d/1_vRs5vqup5OIZlMnQ1E247cr3rWrseRW/edit)
• Fay (SMAST) Workshops: Workshop 1 & 2 Reports. SSEEP Project Website: https://thefaylab.github.io/sseep/; Fishery Dependent Data Openscapes Champions Cohort: https://openscapes.github.io/2021-fdd/
• Grebmeier (UMCES): The project's Arctic webpage at CBL (http://arctic.cbl.umces.edu), along with a updated DBO website (https://dbo.cbl.umces.edu/) provides a platform for highlighting our core research activities in the Pacific Arctic, including the DBO-NCIS activities.
• Jayne (WHOI): Argo float data and metadata: http://doi.org/10.17882/42182
• Mills (GMRI): Published a blog story for public audiences on our salmon research, called Searching for Clues in Salmon Scales -- https://www.gmri.org/stories/searching-clues-salmon-scales/
• Moore (WHOI): Online popular presentation on right whale health -- https://www.whoi.edu/multimedia/all-whalers/
• O'Brien (GMRI): website -- mrep.gmri.org
• Pickart (WHOI): Compiled a database of shipboard acoustic Doppler current profiler (ADCP) data for the Chukchi / western Beaufort Seas, including 56 cruises over the time period 2002-2021 (June-November).
• Pinsky (Rutgers): Public website OceanAdapt (https://oceanadapt.rutgers.edu) -- bottom trawl survey database for North America (both the US and Canada) as well as species range shift indicators at species, regional, and national scales.
• Saba (Rutgers): Data products produced during this reporting period were published in the NOAA NEFSC 2022 State of the Ecosystem reports for the Mid-Atlantic (https://doi.org/10.25923/5s5y-0h81)and New England (https://doi.org/10.25923/ypv2-mw79)
• Schwartz (URI): Nutrient data have been merged with other physical and chemical data collected by NOAA and are publicly available at NCEI's OCADS portal.
• Sherwood (GMRI): This website gives background on our project and eDNA in general: https://www.gmri.org/projects/environmental-dna-validation/
• Todd (WHOI): Gliders in the Gulf Stream [Data set]. Scripps. Doi: 10.21238/S8SPRAY2675. New post-processed data from Gulf Stream glider missions are routinely added to this publicly available data set. Plots of real-time and post-processed glider data -- http://gliders.whoi.edu
• Waller (UMaine): No fieldwork occurring in 2021 due to COVID.
• Weller (WHOI): Multi-year time series of surface meteorology and air-sea fluxes, have been merged into the longest possible

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

33. What individuals have worked on this project?

The CINAR PIs include Donald M. Anderson, CINAR Director, Woods Hole Oceanographic Institution; Paulinus Chigbu, University of Maryland Eastern Shore; Paula Bontempi, University of Rhode Island; Steve Lohrenz, University of Massachusetts Dartmouth School for Marine Science and Technology; Graham Sherwood, Gulf of Maine Research Institute; Oscan Schofield, Rutgers University; Michael Roman, University of Maryland Center for Environmental Science; and David Townsend, University of Maine. Additional CINAR personnel include Mindy Richlen (CINAR Associate Director), Claire Anacreon (Administrative Associate). A listing of project investigators is provided in Appendix 1.

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

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?

Consortium members and subawardees include Woods Hole Oceanographic Institution, University of Maine, Rutgers University, Gulf of Maine Research Institute, University of Maryland Center for Environmental Science, University of Massachusetts Dartmouth School for Marine Science and Technology, University of Maryland Eastern Shore, University of Rhode Island, the Bermuda Institute for Ocean Sciences, and the World Meterological Organization.

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

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

36. Have other collaborators or contacts been involved?

Nothing to Report

IMPACT

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

Impacts of CINAR research on the principal project discipline(s) are summarized below, organized according to research theme. Examples are drawn from progress reports provided by each CINAR investigator, which are distributed directly to project sponsors. Figures can be found in Appendix 6.

Theme I – Sustained Ocean Observations and Climate Research. CINAR activities under this research theme included supporting ocean observing programs critical to climate assessments and hurricane forecasting. These included autonomous collection of ocean measurements through the Stratus, NTAS and WHOTS Ocean Reference Stations (ORS) (PIs: R. Weller/A. Plueddemann, WHOI; Figs. 1 & 2) and the global array of Argo floats (PI S. Wijffels, WHOI; Fig. 4), and through spray glider missions (PI: R. Todd, WHOI; Fig. 3). In addition to providing new approaches and datasets for hurricane forecasting, these efforts are contributing to our understanding of marine heatwaves and warming trends, and their impact on living marine resources and fisheries.

Theme II – Ecosystem Research, Observation, and Modeling. The NOAA scientific community is using data collected by CINAR's ocean observing assets and programs to understand and describe ecological and environmental parameters and processes in the NEUS LME. State-of-the art ecological models and data assimilation methods developed by CINAR investigators have been applied to practical problems facing key ecological and commercial species. One example is development of OA data synthesis products for the scientific community that describe decadal-scale trends in pH where potentially vulnerable commercially important species reside (PI: G. Saba, Rutgers; Fig 6).

Theme III – Stock Assessment Research. CINAR activities have contributed valuable technologies and datasets to advance our understanding of critical species in the NEUS LMS, and for effective management and resource stewardship in the region. Examples include multiple years of benthic survey data and maps produced by annual deployments of the HabCam vehicle, providing NOAA with critical information used in stock assessments in the Northeast (PI: S. Lerner; WHOI; Fig. 9), and the evaluation of molecular approaches for assessing of herring biomass and distribution (PI: G. Sherwood, GMRI; Fig. 8).

Theme IV – Protected Species Research and Recovery. CINAR activities under this theme are developing new technologies, research tools, and approaches for the assessment and recovery of protected species in the NEUS LME, including, among others, the critically endangered North Atlantic right whale (NARW). These research efforts span the spectrum from basic to applied research on protected species, and are contributing new datasets and approaches to better define, protect, and restore essential habitat. Examples include autonomous approaches utilizing aerial photogrammetry to quantify health of whales in the NEUS LME (M. Moore, WHOI; Fig. 10), and the employment Slocum gliders for autonomous monitoring the distribution of NARW whales and commercially important fish (M. Baumgartner, WHOI; Fig. 11).

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?

The impact and value of CINAR research extends beyond the scientific disciplines encompassed by this CI's research themes. Humans are an integral part of approaches to EBFM; therefore, human dimensions research is an important part of support EBFM and other ecosystem-based approaches to management. These activities provide a fuller understanding of interactions and interconnections within the NEUS LME, and support efforts to integrate economic, social, and cultural considerations in EBFM. For example, CINAR investigators are collaborating with fishermen to identify factors related to their catch rates and any gear modifications that they have made in the last decade which may have altered species and size selection of their gear (PI: S. Cadrin, UMass Dartmouth; Fig. 12). These efforts are contributing to the improvement of groundfish stock assessments in the Northeast US by providing fishery perceptions of relative abundance and potentially including fishery catch rates as indices of abundance in stock assessment models.

In addition, CINAR investigators are working with the NMFS and USDA to develop data collection methodology in support of a national assessment of seafood marketing practices in the United States. This work addresses will help NMFS understand the scope and scale of direct seafood marketing in the United States, better understand the revenue stream for and remove barriers to direct marketing for the commercial fishing sector. This effort will contribute to a better understanding of how fishing businesses are changing their marketing engagement and strategies in order to increase revenue (PI: J. Stoll, UMaine).

CINAR investigators are also involved in efforts to identify research priorities for the effective management of harmful algal blooms (HABs) and their impacts on human health and economies. Over the past year, CINAR investigators were involved in a significant collaborative effort to update "Harmful Algal Research and Response National Environmental Science Strategy" document, also known as HARRNESS. Activities included participating in the committee that is writing this document, and providing significant administrative and logistical support throughout this process. HARRNESS describes research and management recommendations for multiple HAB-related activities, and when complete, this national plan will be used by federal agencies to identify research and funding priorities (PIs: M. Richlen & D. Anderson, WHOI).

Finally, CINAR investigators continued to engage fisheries stakeholders through the highly successful Marine Resource Education Program (MREP). MREP is a stakeholder engagement and education program designed by fishermen, for fishermen, to cultivate industry leadership and enable effective collaborative management of fisheries. MREP engages stakeholders directly in the federal fishery science and management systems in multiple regions of the U.S. MREP offers fishermen the opportunity to learn about the complex fisheries science and management processes, and equips these fishermen with tools to effectively participate in these processes. MREP alumni continue to represent more than half of the new council member appointments nationwide, thus strengthening the capacity of industry leaders to engage in the highly complex issues of fisheries science and management (PI: L. O'Brien, GMRI).

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

Over the past year, CINAR programs supported 124 research scientists and staff, postdocs, and administrative staff, as well as 39 students. A complete personnel listing is provided in Appendix 3, and additional details regarding the impact of teaching and educational programs is described in comment field #40, below.

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?

CINAR research programs offer a variety of opportunities to involve undergraduate and graduate students, postdocs, and early career scientists in research programs related to our research themes, and provide career training to the next generation of marine scientists. Below we highlight selected achievements and programs:

1. Graduate student and postdoc participation in research: CINAR research programs offer many opportunities to engage graduate students, postdocs, and early career scientists, and provide career training to the next generation of NOAA scientists. Students are introduced to an active and collaborative research environment, interact with scientific leaders in ecosystem research, start building a network of contacts for advanced studies and a career in science or resource management, and gain experience with ecosystem-scale research, proposal writing and presentation skills. Although student participation was impeded by the COVID pandemic, CINAR investigators included 15 graduate students and 13 postdocs in their research programs, and expanding student and postdoc participation in research is an important priority going forward.
2. Undergraduate student participation: The ability of our consortium to host undergraduate students was significantly impacted by COVID-19; however, undergraduate participation in CINAR research expanded significantly over the past year from just 2 students during the 2020-2021 time period to 26 students in 2021-2022.
3. Undergraduate Minority Trainee program and NOAA IN FISH Partnership: For many years, CINAR has supported an undergraduate minority traineeship program, which provides funding to each CI partner institution in support of summer fellowships for undergraduate students from underrepresented communities. Over the past year, CINAR began partnering with the newly developed NOAA undergraduate diversity internship program IN FISH (An Inclusive NOAA Fisheries Internship Program), which provides internship opportunities for undergraduate students in the marine science and resource management ¿elds, as well as mentorship/training opportunities to the host investigators and institutions so that they learn together with the students. The goal of IN FISH is to build diverse talent to be the future workforce of NOAA, representative of our constituency. Under this partnership, CINAR is supporting five undergraduate students in 2022, who will participate in coursework and cohort building activities along with a larger cohort of IN FISH students, followed by an additional 8 week intensive mentor-led research or resource management project. We look forward to reporting on these students' activities and this newly initiated partnership in our next progress report.
4. Over the past year, CINAR supported five early career scientists at our partner institutions through funding from NOAA's Quantitative Ecology and Socioeconomics Training (QUEST) program. An important goal this program is to engage early career scientists in research to improve and enhance the assessment and management of fisheries resources in the region. Support provided by these two-year fellowships will enhance research, teaching, and advising activities and will help to establish laboratories and programs that can develop and implement new technologies to improve the assessment and management of fisheries resources in the NEUS LME. CINAR plans to hold a second competition for this fellowship program in Fall 2022. Complete information about this program, current fellows, and their research activities can be found on the CINAR website: https://website.whoi.edu/cinar/people/fellows/.

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

CINAR researchers continued to support the international Argo program, a global array of autonomous profiling floats, and provided leadership in technology improvement, sensor testing and validation, production and acquisition of floats, deployment logistics, float communications, data analysis and management, international coordination, and education. Contributions to physical, institutional, and information resources under this program included the preparation and deployment of 132 Argo floats in 2021 and 2022, and continued operation of a fleet of 423 active floats (Figs. 4 & 13).

Additional contributions to infrastructure included continued operation and maintenance of three Ocean Reference Stations (ORS), which are used to collect sustained, climate-quality observations in the trade wind regions and drive improvements in understanding and modeling at these sites. Over the past year, CINAR PIs R. Weller & A. Plueddemann (WHOI) redeployed the Stratus, NTAS and WHOTS Ocean Reference Stations (ORS), which provide sustained, climate-quality observing of the trade wind region (Figs. 1 & 2). Data produced by these CINAR-supported ORSs are essential to critical climate assessments worldwide.

CINAR infrastructure also included drones used for monitoring of cetacean health (Fig. 10), acoustic receivers for spray gliders to measure ocean heat content in the Gulf Stream (Fig. 3), and a variety of autonomous platforms for acoustic monitoring, including Slocum ocean gliders, wave gliders, and moored buoys (e.g., Fig. 11). In addition to these, CINAR investigators utilized a towed, stereo camera system (HabCam) for assessing and characterizing shellfish, demersal fish, and their habitats in the Northeast (Fig. 9).

Finally, CINAR investigators maintain multiple websites and informational resources, which are listed in comment field #32.

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?

CINAR investigators are pioneering multiple new tools, models, and approaches to collecting, analyzing, modeling, and disseminating biological and physical data in the NEUS LME. Additional information on some of these products is provided in comment fields #25 and #30. As mentioned above, CINAR investigators maintain multiple websites and informational resources, which are listed in comment field #32.

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

Data and analyses carried out by CINAR investigators are supporting efforts to integrate human interactions and socioeconomic considerations into marine species and ecosystem management, thereby promoting sustainable coastal development and community resiliency. Engagement of fisheries stakeholders by CINAR researchers through the MREP program promotes the involvement and participation of the general public and commercial sector in fisheries science and management in a productive way. In addition, CINAR research is contributing to better management of harmful algal blooms in the region, which contributes to human health disciplines and aquaculture management. These activities support efforts to integrate human interactions and socioeconomic considerations in EBFM, and contribute to a better understanding of interactions and interconnections within the NEUS LME.

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)?

5 , Our estimates indicate that <5% of our budget was spent in foreign countries.

CHANGES/PROBLEMS

45. Changes in approach and reasons for change

Multiple projects experienced delays due to the COVID-19 pandemic:

• Apprill WHOI): Due to COVID-19, participation in conferences was cancelled or postponed.
• Benway (WHOI): Due to COVID-19, "Ocean in a High-CO2 World" will now be a hybrid event in Sept. 2022.
• Bowen (WHOI): Progress in cable development was delayed due to Covid-19. This project has been successfully completed and able to support ongoing OET field programs and Ocean Exploration Cooperative Institute plans.
• Cadrin (SMAST, Cod research): Fieldwork was suspended in March 2020 and resumed June-Nov. 2020 and Feb. 2021. Fieldwork to maintain the receiver array continued; cod tagging was delayed.
• Cadrin (SMAST, Groundfish research): Funding and data access were delayed, and one new student deferred admission to Jan. 2021. Delays should not impact the deliverables.
• Fay (SMAST, Workshops): The initial workshop was delayed; workshops were held in January and February 2022. An NCE was requested.
• Fay (SMAST, fishery data): We requested an NCE to allow us to defer carpentries and instructor training until AY22-23.
• Foote (WHOI): Delays due to COVID-19. The need to secure fresh specimens from a seasonal fishery, as well as the need to scan these at a private institution with sufficient veterinarian capabilities prevented timely completion of tasks. An NCE was granted until 30 Jun 2022. A second NCE has been sought on the same basis.
• Grebmeier (UMCES): The original research cruise on the supply ship Discovery in August 2021 was cancelled after 6 days due to a COVID-19 outbreak. After departing the ship, the UMCES team stayed multiple days in both Dutch and Seattle, then returned home to plan the November 2021 RV Sikuliaq cruise.
• Greig (UMaine): The processing of invertebrate samples is taking longer than anticipated because of high densities of individuals and accumulations of fine organic material. Additional undergraduate research assistants have been recruited, but an NCE may be needed.
• Jakuba (WHOI): COVID-19 considerations pushed our cruise date from June 2021 to August 2021. We did secure an extension to 2022-09-30 to allow sufficient time for analysis and reporting activities.
• Kerr (GMRI): The process of hiring a new postdoctoral researcher for this project took longer than anticipated. COVID-19 caused delays host an in-person stakeholder meeting. Spending of the award has been slow due to these delays.
• Lerner (WHOI): No significant delays or changes to the project schedule, but COVID-19 did extend the time in implementing system improvements, integration, and testing. The NEFSC 2021 Scallop Survey was delayed 1 month.
• Mills (GMRI): Staff turnover, including the project postdoc and a research associate, has slowed progress on this project.
• Lohrenz (SMAST): In-person meetings held remotely.

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

Information will be forthcoming.

47. Changes that had a significant impact on expenditures

Impacts on expenditures are largely associated with the COVID-19 pandemic, and include cancelled travel reservations and expenditures associated with research cruises and other field work that was suspended (described in comment fields #45 and #46).

• Leslie (UMaine): Hosting a Marine Ecosytem-Based Management Evaluation Workshop at UMaine with participants from multiple countries around the world was not practical due to the pandemic. Instead, these activities will be conducted virtually and a request (AAR) was made for this project to be terminated.
• Weller (WHOI): Continued work with the Chilean Navy on the use of Cabo de Hornos mitigates the risk of ship availability but at the same time forces us to cover shipping costs, fees for working in Chilean ports, and agent's fees, all of which are increasing with time. The overlay of COVID protocols on ship availability and scheduling challenges has also increased costs. With tightly constrained budgets for years, we are now seeing increased risk of loss of data from the moorings as instruments, cables, and connectors age.

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?

Outcomes of this award are captured in the aforementioned "Accomplishments", "Products", and "Impact" sections, and in Appendices 1-6.

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.