DEPARTMENT OF COMMERCE
RESEARCH PERFORMANCE PROGRESS REPORT (RPPR)

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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. Education, outreach, and training activities are described in comment field #26:

Theme I – Sustained Ocean Observations and Climate Research. CINAR activities developed and improved data sets quantifying Atlantic basin climate forcing, and used these data sets to examine the projection of climate modes onto the NEUS LME, including efforts to: 1) expand the Atlantic array of the global fleet of Argo floats, which collect systematic observations of subsurface ocean temperature, salinity, and circulation (Fig. 1); 2) renewal of the Continuous Plankton Recorder Surveys between the Gulf of Maine and Nova Scotia, a sampling project that ran from 1961-2013; 3) support and redeploy Ocean Reference Stations (ORS) to provide sustained, climate-quality observing of the trade wind region (Figs. 2 & 3); and 4) use autonomous underwater gliders to monitor upper ocean heat as a forecasting method for hurricanes in the Gulf Stream (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) expanded deployment of acoustic tags on Atlantic cod in Southern New England to track the spawning population and assess their thermal habitats and connectivity with other cod populations (Fig. 5), 2) development of a novel 3D model to simulate the behavioral movement of thousands of individual fish (Fig. 6); and 3) expanded development and deployment of HabCam, a stereo optical and acoustic imaging system used by NOAA to survey demersal fish and scallops along the northeast continental shelf.

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. Research highlights included: 1) comparison of acoustic estimates of longfin and shortfin squid to environmental DNA (eDNA) concentration as a method to assess populations in the open ocean (Figs. 7 & 8); 2) compilation and analysis of haddock data from scientific, state and industry sources to determine accurate biomass assessments of the Gulf of Maine population from 1996-2019; and 3) development of a new Wave Glider to serve as support to AUV investigation of fisheries stock, which reduces ship time and disturbance in study region (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 (NARW), Atlantic salmon, and other species. These efforts contribute to improvements in defining, protecting, and restoring essential habitat for these species. Research highlights included: 1) use of drone photogrammetry to assess the health of NARWs in Cape Cod Bay (Fig. 10); and 2) aggregation and analysis of telemetry and electrofishing data for the Atlantic salmon

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 local communities. Below we highlight selected achievements and programs:

1. The Marine Resource Education Program (MREP) fishery science and management workshop series: These workshops engage commercial and recreational fishermen, managers, and scientists in discussions about approaches to fisheries management, and help to foster collaboration among these groups. Designed by fishermen for fishermen, MREP workshops include introductory sessions on fisheries science and management, and advanced modules on stock assessments, ecosystem-based management and climate change. Over the past year, project PIs developed a five-part virtual meeting series to deepen fishery science and management literacy among MREP alumni. A total of 7 virtual events were successfully delivered. In addition, 4 sessions of the MREP Greater Atlantic five-part virtual meeting series were delivered, along with an MREP Greater Atlantic Steering Committee (SC) meeting, and an MREP National SC Formational Meeting. The MREP Southeast program facilitated two virtual MREP Southeast SC meetings, 2 virtual MREP SC meetings, and developed and executed 3 virtual opportunities for fishermen. Finally, GMRI created an MREP website to host resources and information about the program, with significant feedback and buy-in from MREP industry leadership.

2. Undergraduate summer student fellowships: CINAR sponsors an undergraduate minority traineeship program, which provides funding to each CI partner institution in support of summer fellowships for students from underrepresented communities. These students work on a project selected in collaboration with their sponsor that provides results during a 10 to 12 week period. This highly successful program was established under our prior award, and will continue throughout the duration of our new award. While the ability to host students was significantly impacted by COVID-19, two undergraduates were able to work in CINAR labs in 2020.

3. 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. During the second year of our award, CINAR investigators included 16 graduate students and 7 postdoc in their research programs, and expanding student and postdoc participation in research is an important priority going forward.

4. 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. Over the past year, CINAR awarded five fellowships to early career faculty. 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/.

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 (e.g., see Figure 6, Appendix 6). 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 also 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.

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.
• Apprill (WHOI): Becker CC, Brandt M, Miller CA, Apprill A. 2021. Stony Coral Tissue Loss Disease biomarker bacteria identified in corals and overlying waters using a rapid field-based sequencing approach. BioRxiv. https://doi.org/10.1101/2021.02.17.431614
• Baumgartner (WHOI): Tag detection and passive acoustic monitoring of spawning cod near Stellwagen Bank using WHOI gliders.
• Cadrin (SMAST): Spatiotemporal distribution map of spawning cod in the Southern New England region through data collected from acoustic transmitters deployed on cod in the vicinity of Cox Ledge during two spawning seasons
• Foote (WHOI): Three-dimensional morphometric data derived from CT or MRI scanning of specimens of adult butterfish (Peprilus triancanthus) and Atlantic mackerel (Scomber scombrus).
• Gallager (WHOI): HabCam for surveying benthic habitats and living resources.
• Jayne (WHOI) Argo floats for physical and biogeochemical sensing.
• Jakuba (WHOI): Final selections have been made for the ultra-short baseline (USBL) equipment, which is primarily a hardware and software integration project. Conceptual integration plans have been generated for integration onto the SeaBED AUV and onto the Wave Glider ASV. Detailed mechanical design is underway for the Wave Glider integration.
• Sherwood (GMRI): eDNA primers have been developed to amplify short and long-fragment Atlantic herring eDNA. Primers are being developed for squid, a likely candidate for schooling species in the acoustic results.
• Rose (UMCES): 3-D Regional Ocean Modeling System (ROMS) model grid of Gulf of Mexico conditions and particle-tracking bookkeeping to permit simulation of 2-D (horizontal) and 3-D (vertical included) behavioral movement of individual fish and simulate the dragging of optical samplers through the grid.
• Stanley (WHOI): Research sites with active deployed hydrophones and acoustic telemetry receivers.
• Todd (WHOI): Spray gliders deployed to survey the Gulf Stream between Miami, FL and New England during the 2019 Atlantic hurricane season. 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 well-equipped surface moorings, deployed to provide sustained observations of the trade wind region.

31. Inventions, patent applications, and/or licenses

None 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): Updated and expanded the U.S. National Office for Harmful Algal Blooms website (https://hab.whoi.edu/).
• Baumgartner (WHOI): Website http://robots4whales.whoi.edu/ is used for displaying near real-time detections of whales from autonomous gliders and buoys.
• Cadrin (SMAST): Acoustic receiver data shared with other researchers through Atlantic Cooperative Telemetry Network (ACT), www.theactnetwork.com)
• Jayne (WHOI): Argo float data and metadata: http://doi.org/10.17882/42182
• Lohrenz (SMAST): Github repository for multispecies Hydra model and project. Docker image containing ADMB and repository for building the Hydra model.
• O'Brien (GMRI): Designed and developed a website -- mrep.gmri.org. Specific goals of the MREP website include recruitment, alumni engagement. Developed a video to be used in outreach -- https://www.youtube.com/watch?v=CzBZykfhJl0.
• Nesslage (UMCES): Models to identify the effects of environmental drivers on golden tilefish landings and catch-per-unit effort for both the northern and southern stock units. All modeling code has been archived at UMCES, in addition to R code and example data files that can be used to produce a suite of ageing metrics to data users.
• Nicholson (WHOI): Floats, equipped with sensors to measure temperature, salinity, oxygen, nitrate, pH and bio-optics, are being deployed in the North Atlantic Ocean and contribute to an eventual global biogeochemical Argo system.
• Pickart (WHOI): Updateddatabase of shipboard acoustic Doppler current profiler (ADCP) data for the Chukchi / western Beaufort Seas, including 47 cruises spanning the time period 2002-2018 (June-November). Obtained data from the Chinese research vessel Xue Long, and domestic ships in the region in 2020.
• Pinsky (Rutgers): Updated the public website OceanAdapt (https://oceanadapt.rutgers.edu) with 2020 data on the location of marine species ranges around North America. Worked with the Canadian DFO to gain access to data from new regions, including Canadian Pacific and Gulf of St. Lawrence.
• Stanley (WHOI): Websites include:
(1) Black sea bass and impacts of noise disturbances from pile driving:
https://www.nefsc.noaa.gov/psb/acoustics/psbAcousticsWindEnergyEffects.html; and (2) SanctSound: Soundscape monitoring program:
https://www.nefsc.noaa.gov/psb/acoustics/psbAcousticsSoundscapeNMS.html
https://sanctuaries.noaa.gov/science/monitoring/sound/.
• Todd (WHOI): Products include:
(1) Gulf Stream mean and eddy kinetic energy from Spray underwater glider measurements data set

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; Oscar Schofield, Director, Institute of Earth, Ocean, and Atmospheric Science, Rutgers University; Michael Roman, Director, Horn Point Laboratory, University of Maryland Center for Environmental Science; David Townsend, Associate Director of Research and Graduate Studies, University of Maine; and Andrew Pershing, Chief Scientific Officer, Gulf of Maine Research Institute. The CINAR PIs meet regularly in person or via conference call to discuss issues and to ensure that partner institutions are updated on CINAR activities. 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?

In July 2020, the former PI at the University of Rhode Island, Dr. Lucie Maranda, retired, and the role of PI was filled by the new supervisor, Dr. Malia Schwartz.

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, 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 discipline(s) of this cooperative institute during the first year of our award are summarized below, organized according to research theme.

Theme I – Sustained Ocean Observations and Climate Research. CINAR activities under this research theme included supporting the global array of Argo floats, which produce sustained and systematic global observations of subsurface ocean temperature, salinity, biogeochemistry, and circulation (See Appendix 6, Fig. 1). Similarly, data produced by CINAR-supported Ocean Reference Stations are essential to critical climate assessments worldwide (Figs. 2 & 3). Regionally, autonomous glider data collected from the Gulf Stream are providing new insights into worsening Atlantic hurricanes (Fig. 4). These efforts have contributed to our understanding of marine heatwaves and warming trends in the Northeast, 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. Examples include mapping the distribution of spawning Atlantic cod (Fig. 5), and modeling the movement of fish aggregations for accuracy in fisheries stock assessments and management (Fig. 6).

Theme III – Stock Assessment Research. CINAR activities have contributed valuable datasets to advance our understanding of critical species in the NEUS LMS, which are used for effective management and resource stewardship in the region. Examples include development of new environmental DNA techniques to accurately assess longfin and shortfin squid populations (Figs. 7 & 8), and designing an autonomous tender to improve the efficiency of AUV-based fisheries seafloor surveys (Fig. 9). These efforts advance knowledge and techniques in the areas of ecosystem research, monitoring, and modeling, and address EBFM implementation by supporting surveys and stock assessment of fisheries resources.

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. 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. One such project improved analysis of aerial photogrammetry to quantify health of whales in the NEUS LME (See Fig. 10), which can be applied by investigators elsewhere in the study of large marine mammals.

Theme V – Ecosystem-Based Fisheries Management. CINAR researchers are studying a broad range of topics directly relevant to EBFM in the NEUS LME. As climate change has become more apparent in the region, understanding the impact of climate change

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, engagement of fisheries stakeholders through CINAR's Marine Resource Education Program (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.

In addition, CINAR investigators are engaged in developing software and data portals such as the OceanAdapt (https://oceanadapt.rutgers.edu) website, which allows fisheries managers and the public to track changes in species distributions. For commercially and recreationally important species, including many species of coastal fish and invertebrates, shifts in species distributions have clear and immediate impacts on coastal communities, economies, and societies. Together, 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.

Data and analyses carried out by CINAR investigators also supported efforts to integrate human interactions and socioeconomic considerations, thereby promoting sustainable coastal development and community resiliency. For example, over the past year CINAR investigators were involved in convening a 2020 workshop on the socio-economic effects of marine and fresh water Harmful Algal Blooms (HABs) in the United States. The report from the workshop, released in March 2021, documents the proceedings and presents recommendations developed by forty workshop participants, mostly university and federal economists and social scientists from a range of institutions, agencies, and regions. These recommendations call for enhanced interagency coordination; improved research communications and coordination among research networks; integration of socioeconomic assessments into HAB forecasts and observing networks; using open-access databases to establish baselines and identify baseline departures; facilitating rapid response studies; improving public health outcome reporting and visibility of HAB-related illnesses; fostering the use of local and traditional ecological knowledge to improve HAB responses; engaging affected communities in citizen science; and engaging graduate students in HAB socio-economic research.

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

Over the past year, CINAR programs supported 88 research scientists and staff, postdocs, and administrative staff, as well as 18 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 16 graduate students and 7 postdocs in their research programs, and the expansion student and postdoc participation in research is an important priority going forward.
2. Undergraduate summer student fellowships: CINAR sponsors an undergraduate minority traineeship program, which provides funding to each CI partner institution in support of summer fellowships for students from underrepresented communities. These students work on a project selected in collaboration with their sponsor that provides results during a 10 to 12 week period. This highly successful program was established under our prior award, and will continue throughout the duration of our new award. While the ability of our consortium to host students was significantly impacted by COVID-19, two undergraduates were able to work in CINAR labs in 2020.
3. Over the past year, CINAR initiated a fellowship program for supporting early career faculty 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. In 2020, CINAR held a competition and awarded five fellowships to early career faculty. 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/.

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 41 Argo floats in 2020 and 2021, and continued operation of a fleet of 356 active floats (Fig. 1).

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 recovered and redeployed the Stratus, NTAS, and WHOTS ORS (Figs. 2 & 3), including all pre and post calibration, cruise activities and logistics, and data processing and sharing. 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. 4), and a variety of autonomous platforms for acoustic monitoring, including Slocum ocean gliders, wave gliders, and moored buoys (e.g., Fig. 9). 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. 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.

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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

Several projects experienced significant and ongoing disruptions and delays due to the COVID-19 pandemic. These problems and delays are included in comment field #46

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

All projects that were extended beyond their originally scheduled project end date are listed below. Multiple projects experienced delays due to the COVID-19 pandemic.

• Appril Amy (WHOI): US Virgin Islands fied work delayed until Jan 2021. Project is still at sample processing and analysis stage. Conferences were postponed.
• Benway (WHOI): The 5th International Symposium on the Ocean in a High-CO2 World (http://www.highco2-lima.org/) is postponed until 2022, so travel support was not spent.
• Cadrin (SMAST, Cod research): Fieldwork was suspended -- resumed June 2020 and Feb. 2021 with revised field protocols. Fieldwork to maintain the receiver array continued as planned, but new protocols greatly impacted the number of tagged cod.
• Cadrin (SMAST, Groundfish research): Funding and data access were delayed. Kickoff meeting was online, delayed by 2 months. The delay should not impact the deliverables.
• Cadrin (SMAST, Multispecies research): In place of the June 2020 workshop, an online meeting is scheduled for June 2021. The delay also required re-budgeting from faculty to graduate student salary, this will not impact the proposed deliverable.
• Cullen (UMES): There was a delay for the CINAR investigator to access the HabCam image database remotely from UMES.
• Greig (UMaine): Fieldwork planned for Fall 2020 to guide power analyses of invertebrate sampling designs was not completed. Instead, previously collected Narraguagus river samples were used.
• Jakuba (WHOI): COVID delayed the cruise from June 2021 to August 2021.
• Leslie (UMaine): International travel and in-person activities were delayed, some done remotely.
• Lohrenz (SMAST, Postdoc program): Planned meetings were held remotely. Hiring a postdoctoral researcher was unsuccessful so funds were used to support a Postdoctoral Researcher and Technical Associate, both at SMAST.
• Lohrenz (SMAST, Quant. Fisheries): The original faculty member was transitioned to state support, and a research faculty member was hired, involving delays and a no-cost extension.
• Mills (GMRI, Salmon): Due to COVID, transition to this project planned for summer 2021.
• Mills (GMRI, Crossing boundaries): CINAR spending has been minimal, but we continuing work in summer 2021.
• Moore (WHOI): Substantive data analysis was done on 2020/2021 data.
• Nesslage (UMCES): Due to COVID, project was extended until June 2021 -- and is now complete.
• O'Brien (GMRI): In place of workshops, developed a virtual meeting series with the same guiding principles and core objectives.
• Rose (UMCES): Transferred the LTRANS particle-tracking model to stand-alone model. Work relied on slower remote access to the server for performing model simulations. No-cost extensions were approved for 1 year and 6 months.
• Schwartz (URI): Cruises to obtain the nutrient samples were postponed and rescheduled for 2021. A 1-year no-cost extension was approved.
• Sherwood (GMRI): Delays included acoustics setup, testing gear and conducting surveys. About 50% of the surveys were done. Given the change in focal species, extra time was needed to develop primers. Expect to complete all surveys and analyses over the

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).

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.