



DEPARTMENT OF COMMERCE RESEARCH PERFORMANCE PROGRESS REPORT (RPPR)

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RECIPIENT ORGANIZATION	
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ACCOMPLISHMENTS

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

The Cooperative Institute for Marine and Atmospheric Research (CIMAR) is one of 22 NOAA Cooperative Institutes (CIs) across the U.S. CIMAR's mission is to conduct research that is necessary to: understand and predict environmental change in the Pacific Islands Region; conserve and manage coastal and marine resources in island environments, notably the Hawaiian Islands and the U.S.-affiliated Pacific Islands; and, support the region's economic, social, and environmental needs. To achieve these mission objectives, CIMAR has applied the following strategies:

- facilitate innovative collaborative research between scientists at NOAA and the University of Hawaii;
- provide educational opportunities for basic and applied research in the Life and Earth Sciences at the undergraduate, graduate, and postdoctoral levels;
- stimulate interactions through the support of visiting scientists and postdoctoral scholars; and
- promote the transition of research outcomes to operational products and services that benefit the Pacific Islands Region.

CIMAR is located at the University of Hawaii at Manoa (UHM), a research-intensive land grant, Sea Grant, and Space Grant public university, which maintains a service mission to the State as well as to the Pacific Islands Region. CIMAR is a unit within the School of Ocean and Earth Science and Technology (SOEST), which includes centers of excellence in marine, atmospheric, and earth sciences that align substantially with the mission interests of NOAA. The University also provides enhanced capacity for social science research via several academic units. Adjacent to the UH campus is the independent, publicly funded East-West Center, which provides policy analysis and applied science across the Pacific Rim. CIMAR serves as a bridge to facilitate engagements between NOAA in the Pacific Region and these academic research units. CIMAR activities are aligned with the NOAA strategic plan and the University's Indo-Pacific mission.

CIMAR collaborates very closely with the NMFS Pacific Island Fisheries Science Center (PIFSC) at the Inouye Regional Center (IRC) in Pearl Harbor, Oahu. CIMAR scientists and students within PIFSC are oceanographers, marine biologists, zoologists, geographers, coastal and environmental scientists, economists, fisheries scientists, sociologists, computer scientists, and engineers. The work with PIFSC is undertaken across 17 CIMAR projects, including coral reef monitoring and research; marine mammal and turtle research; human dimension investigations and economics of fisheries; fisheries bycatch mitigation research; oceanic and reef ecosystems modeling; insular and pelagic fisheries stock assessment research; fisheries database management; and more.

CIMAR also interacts with the NOAA National Ocean Service, NOAA National Weather Service, National Environmental Satellite, Data, and Information Service, and Oceanic and Atmospheric Research Line Offices, which support another half dozen projects in the four research themes of oceanographic monitoring and forecasting, climate science and impacts, air-sea interactions, and tsunamis and other long-period ocean waves. Well known CIMAR programs active in these areas include the UH ADCP Data Acquisition System, Asia-Pacific Data Research Center, and a component of the Argo program.

~~Because it is impossible to provide a full accounting of all the significant accomplishments, plans, technologies, products, and~~

25. What was accomplished under these goals?

Below are highlights demonstrating the scope of CIMAR research in the reporting period.

A lengthy observational cruise campaign was conducted on the reef systems of the Mariana Islands. CIMAR divers completed fish count surveys, recovered and deployed numerous calcification, bioerosion units, and temperature recorders, and conducted assessment and site surveys via several hundred dives.

CIMAR tracked and assessed the distribution of nuisance algae within the lagoons and reefs in the Papahānaumokuākea Marine National Monument (PMNM) using high resolution satellite imagery. The work assists efforts to understand algae distribution, abundance, and impacts over time.

CIMAR supports the NOAA deep sea corals research via dive video annotation for corals, sponges, fish, and fauna. The team generated records and images for archive from dives by the Okeanos Explorer ROV platforms from 2013.

CIMAR was instrumental in developing the PIFSC Marine and Applied Knowledge for Ecosystem Research Laboratory (MAKER Lab), which assists researchers in designing and developing innovative tools, gear, and instruments to enhance data sampling efforts. MAKER enabled the creation of systems to capture real time optical data to study 'opelu (mackerel scad). CIMAR also constructed subsurface automated samplers for eDNA in the field to eliminate post-collection water filtering and supports other projects such as artificial lighting to complement fish surveys.

CIMAR seasonal staff were hired in preparation for a 4-month deployment in the PMNM for the monk seal and marine turtle field survey campaign. Staff are trained on data collection and animal handling techniques, zoonotic disease, necropsy and specimen collection techniques, communication, biosecurity, wilderness first aid, and small boat operations. Staff prepared science and camping gear, food and medications, and deployment began in April with research stations established at major reproductive sites. CIMAR conducts seal research and recovery including collection of life history data, tagging and marking, and performing necropsies. Staff may intervene to reunite mother-pup pairs, provide medications and vaccinations, disentangle animals from derelict fishing gear, translocations, etc. For marine turtles, CIMAR conducts nesting and basking surveys, deploys satellite tags and data loggers, and mitigates entrapments.

CIMAR completed small-boat surveys for spinner dolphins around Oahu. These surveys use the line transect methodology to assess movements of individuals using photo-identification to estimate abundance.

The CIMAR Electronic Monitoring (EM) project conducted feasibility studies and fishing vessel deployment cameras to assess protected species interactions. Protected species interactions were examined from the videos to determine if post release fates can

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?

CIMAR supports and facilitates the PIFSC Young Scientist Opportunity (PYSO) program that annually employs several undergraduate students from across the nation to work in PIFSC alongside CIMAR and federal mentors on summer science projects. This project was successfully established for the Summer of 2022. Four local university undergraduate student interns, recruited in a competitive national process, are being hosted virtually this summer on research projects with PIFSC and CIMAR mentors.

Although many student activities were deferred during the pandemic, CIMAR projects regularly hire UH undergraduate students to work on various projects. A number of UH students also participate in projects as volunteers (see RPPR Appendix 3).

CIMAR projects supported several graduate assistant students, primarily at UH, who are pursuing Masters and PhD degrees in oceanography, marine sciences, and social sciences. Their research topics include: kinematics and dynamics of short- and long-period gravity waves that periodically produce coastal flooding along West Maui; coral reef demographics; ocean pelagic ecosystem modeling; economics; stony coral health; human dimensions of coastal marine management; modeling social-ecological systems to support coral reef management; spatial-temporal changes of shark territorial use; etc.

CIMAR programs support continuing education through the hiring of talented Postdoctoral Researchers. Research topics include: unraveling the links between ENSO and Hawaii rainfall (e.g., transition diversity and precursors, hydroclimate impacts of different ENSO types); and evolution of the internal tide, including its nonlinear byproducts, in environmental settings appropriate to Hawaii and specific mid-latitude locations.

Former CIMAR staff members are frequently recruited into federal service, including leadership positions for PIFSC. Over 30 former CIMAR staff are currently serving as federal employees in PIFSC. One CIMAR staff member was recruited during this reporting period for federal employment with NOAA.

As employees of the Research Corporation of the University of Hawaii, CIMAR staff are afforded tuition reimbursement for a limited number of credits of educational training directly applicable to the individual's job. Several CIMAR employees take advantage of this program each year.

CIMAR staff regularly take advantage of training and professional development opportunities, and the pandemic provided an alternative approach to professional improvement, with training and workshops held virtually and available around the nation.

Also see RPPR Appendix 3 for CI Employee Support Table.

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

Communication of research findings to the larger scientific community is fundamental to the progress of science. CIMAR staff regularly participate in national and international symposia, professional conferences, and subject focused workshops. During the pandemic, travel to attend such events was limited, however, staff were able to take advantage of opportunities to contribute to the scientific dialog through online presentations, if they choose to not travel.

Project scientific outputs, including research results, datasets and software tools, are disseminated in several ways: provided directly to co-located NOAA Sponsors as part of normal workflow at PIFSC; submitted to professional science print and online journals as contributions to the research literature; presented at professional scientific meetings and conferences; contributed as white papers to regional and international management organizations; or provided on open access websites and data repositories. Several CIMAR projects started late during the reporting period, but three CIMAR first author, refereed journal articles were published in the scientific literature.

CIMAR outreach activities are numerous and wide-ranging. CIMAR researchers contribute to science communication at UH by presenting talks at regular seminar series. Seminars presented by CIMAR and federal researchers at PIFSC are also web-streamed to interested researchers and students at UH.

Under appropriate COVID-19 safety guidelines, researchers participate in elementary, middle, and high school career and science day events, UH and community events (e.g., SOEST Open House), Waikiki Aquarium Family Night, Honolulu Seafood Festival, Hanauma Bay Education Lectures, teacher workshops, podcasts, fishing derbies, tables at community events, fisher forums, various expositions and conferences, and events at local hotels to educate tourists on ocean concerns. CIMAR staff also regularly teach courses or individual classes as expert researchers at various campuses in the UH system.

CIMAR leads or collaborates on numerous contributions to NOAA/NMFS/PIFSC blog postings, podcasts, story maps, and other web content.

Elementary and high school classroom outreach activities were maintained virtually through the end of the school year.

CIMAR facilitates the annual PIFSC Young Scientist Opportunity program, which brings undergraduates from across the nation to PIFSC to work with CIMAR and federal mentors (see Section 26 for a description of this activity).

CIMAR staff meet with local and U.S. territorial government officials to communicate scientific endeavors within their jurisdictions.

CIMAR researchers regularly meet with fishermen and fisheries observers in the Pacific Islands Region to discuss reporting requirements and instruct them on bycatch mitigation efforts for protected species.

CIMAR staff create and distribute a quarterly newsletter for the Hawaii Community Tagging Program

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

ACCOMPLISHMENTS (cont'd)

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

CIMAR will conduct field surveys to monitor fisheries data collection and sampling in the U.S.-Affiliated Pacific Islands and work toward generation of life history traits of harvested species scheduled for assessment in the Territories. Focus will be on sampling specific species for reproduction characteristics analysis and strategically sampling to address data gaps. Work will continue on investigating the use of aquatic biochronology to assess biological responses to climate change. CIMAR will also lead the stock assessment of American Samoa bottomfish.

CIMAR will work to reduce fishing mortality of sharks, rays and other protected non-target species with outreach and education via the Hawaii Community Tagging Program, continue monitoring tag deployments across fishing sectors, and analyze data to understand habitat use and movement around Hawaii and Pacific Islands. CIMAR will conduct ongoing research and monitoring of association dynamics of oceanic whitetip and silky sharks around FADs in Hawaii.

CIMAR will implement EM into regular fishery operations by integrating datasets with direct observations. The fishery bycatch team will create a conceptual model for EM data; assess protected species interactions from various cameras for determination of the use of EM for post release mortality assessment; continue to grow the annotation library of target, non-target, and protected species; and train algorithms to automatically identify species using AI algorithms.

CIMAR will participate in the multi-vessel Hawaiian Islands Cetacean Ecosystem and Abundance Survey (HICEAS) campaign in 2023, conducting line-transect abundance surveys for cetaceans over five months.

CIMAR will continue progress on an AI project for automating aspects of dolphin dorsal fin photo-identification, including testing of a modified algorithm using a novel data set of spinner dolphins from the Mariana Islands.

CIMAR will manage deployments of High-frequency Recording Packages (HARPs) and support development of acoustic analysis tools to enable efficient use of this dataset. Two Seagliders will be deployed within the main Hawaiian Islands to collect passive acoustic and environmental data which CIMAR will analyze.

CIMAR will again staff, plan, and deploy the annual monk seal and marine turtle field campaign in the Northwestern Hawaiian Islands, with about 20 researchers deployed for 4–5 months to conduct critical protected species assessments and research. Advanced technologies (cameras, UAS) may also be utilized to monitor seals and turtles.

CIMAR will continue to complete video analyses for fish abundance and lengths for insular bottomfish surveys, with resulting data delivered for stock assessment. Technicians will collaborate to improve undersea camera systems for fisheries surveys, in support of stock assessments of Hawaii Deep 7 bottomfish.

PRODUCTS

29. Publications, conference papers, and presentations

Refer to RPPR Appendix 2 for a summary of scholarly publications.

Refer to RPPR Appendix 2a for a complete list of conference proceedings, presentations, and reports.

A complete list of scholarly publications will be submitted to the NOAA Institutional Repository by the end of August 2022.

Below is the list of CIMAR first-author, refereed publications.

Fukunaga, A., et al., 2022: Underwater photogrammetry captures the initial recovery of a coral reef at Lalo Atoll, *Diversity*, 14(1), 39.

Gruden, P., Y. Barkley, and J.L. McCullough, 2022: Insights into acoustic behavior of false killer whales, *J. Acoust. Soc. Am.*, 151, A74, <https://doi.org/10.1121/10.0010703>.

Johnson, G.C., and J.M. Lyman, 2022: A global ocean surface mixed layer monthly climatology: Means, percentiles, skewness, and kurtosis, *J. Geophys. Res.*, 127, e2021JC018219, doi: 10.1029/2021JC018219.

PRODUCTS (cont'd)

30. Technologies or techniques

CIMAR staff work with U.S. and International Argo Project partners on two broad aspects of the Argo Program. The first is to improve Core, Deep, and Biogeochemical Argo floats through testing, deployment, and data/engineering evaluation. The second includes delayed-mode quality control of Core and Deep Argo float data.

CIMAR coordinates the PIFSC EM project, which deploys video monitoring systems on longline vessels to compare catch and bycatch with logbook and observer data. CIMAR staff perform system development and installation, software improvement, and conduct analyses to determine best practices for the use of the systems and resulting video. The CIMAR EM team made progress using AI technology to train species detection algorithms. CIMAR was able to begin to train AI algorithms to detect fish on deck, and will research how to best train algorithms to detect fish and protected species.

CIMAR works with electronic reporting (ER) technologies to enable longline fishers to securely submit real-time logbook data. The team deploys tablets and software on local fishing vessels, representing the majority of the Honolulu-based longline fleet.

CIMAR deploys satellite linked pop-off archival tags (PATs) on incidental sharks and other species to study post-release mortality.

Unmanned aerial systems are used to scan reefs and atolls for derelict fishing gear and other plastics that are hazards to marine wildlife, including endangered species. These systems are also used to survey remote beaches for Hawaiian monk seals and marine turtles to complete population surveys and monitor animal behavior.

CIMAR uses novel photogrammetric techniques to detect subtle changes in coral reef communities and has applied the methods to the assessment of initial recovery at Rapture Reef (Lalo/French Frigate Shoals), which was severely damaged by Hurricane Walaka in 2018.

To support reef and bottomfish surveys, CIMAR supports the Modular Optical Underwater Survey System (MOUSS), a stereo-video survey tool that provides non-extractive size-structured relative abundance estimates of fish species in their natural habitat. CIMAR staff also support projects using 360o camera systems and the development of the next generation stereo camera system for future bottomfish surveys.

With eDNA sampling a NOAA scientific priority, CIMAR participates in the collection of eDNA to characterize nearshore ecosystems and develop metabarcoding in coordination with the Smithsonian, Bishop Museum, Scripps Institution of Oceanography, NOAA, and others.

CIMAR tags sea turtles in the Hawaiian Islands and U.S. Territories with metal alloy flipper tags, sub-dermal passive integrated transponder (PIT) tags, or satellite biotelemetry tags.

31. Inventions, patent applications, and/or licenses

Nothing to Report

PRODUCTS (cont'd)

32. Other products

The University of Hawaii Currents Group (UHCG) in CIMAR is engaged in a long-term project to foster global ocean current measurements for research into ocean circulation, its variability on a broad range of temporal and spatial scales, and its relation to ocean biogeochemistry and climate. A principal source of these measurements is the NOAA research fleet, equipped with shipboard acoustic Doppler current profilers (ADCPs) and high-precision navigation and orientation sensors. UHCG develops, deploys, and uses software systems and procedures (the UH Data Acquisition System; UHDAS) for routinely acquiring, monitoring, processing, and serving ADCP data on 11 NOAA ships. UHCG's objective in this project is to improve and apply their techniques to the NOAA fleet, thereby maximizing the scientific value of the measurements during work at sea and long into the future. This involves working with NOAA to get high-quality data at the start and make it as discoverable and easy to use as possible, long after it is acquired. CIMAR provides on-site upgrades and training, when possible, and remote consulting on UHDAS use and interpretation of acquired data. A major upgrade of UHDAS on the NOAA ship Ronald H. Brown was completed, and preparations were made for an upcoming installation on the NOAA ship Thomas Jefferson. CIMAR staff are working with NOAA to establish the NOAA-to-NOAA (N2N) real-time data pipeline from the ships to the National Centers for Environmental Information to make observations available for researchers quickly and accurately.

CIMAR staff maintain, improve, and disseminate the Automatic Differentiation Model Builder (ADMB), a free, open-source software package currently used by all NOAA Fishery Science Centers, as well as other U.S. and international institutions, to create fishery stock assessment tools. The project will release ADMB-13.0 by the end of summer 2022 that fixes defects, adds new features and provides improved documentation and support. Since 2011, ADMB has been cited 1934 times according to Google Scholar with 129 citations in 2021 and 44 citations as of June 2022.

Many CIMAR projects contribute directly to PIFSC databases, specimen collections, software, models, and outreach and educational endeavors. Furthermore, because CIMAR staff inhabit all of the research and operational programs in PIFSC, CIMAR contributed to nearly every product developed by the PIFSC programs.

The activities of CIMAR staff at the Asia-Pacific Data-Research Center (APDRC) support climate research within the UH International Pacific Research Center (IPRC) for a broad spectrum of users throughout the region. The APDRC meets critical regional needs by providing ocean, climate and ecosystem information, and also by generating relevant data products. The vision of the APDRC is to link data management and preparation activities to research activities within a single center, and provide one-stop shopping of climate data and products to local researchers and collaborators, the national climate research community, and the public. APDRC is organized around three goals: provide integrated data server and management systems for climate data and products; develop and serve new climate-related products for research and applications users; and conduct climate research in support of the IPRC and NOAA research goals. The APDRC hosts over 125 different data sets from in situ platforms, satellites, and numerical models, comprising ~645 TB of redundantly stored data. For ease of access, APDRC maintains a suite of data transport and discovery servers.

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

33. What individuals have worked on this project?

Cooperative Institute for Marine and Atmospheric Research (CIMAR) Senior Personnel
Douglas S. Luther, PhD - Principal Investigator & CIMAR Director
Jeffrey Hare, PhD - CIMAR Deputy Director for PIFSC Projects
Kevin Higaki - CIMAR Assistant Director for Administration

Refer to RPPR Appendix 3 for CI Employee Support Table.

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?

Nothing to Report

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?

Oceanography/Pelagic Ecosystem Science. CIMAR conducts and disseminates research to inform the science community, management and conservation agencies, and the public. Work in oceanography includes elucidating pelagic ecosystem structure under the influence of climate change through examination of micronekton and modeling.

Marine Biology/Coral Reef Ecosystem Science. CIMAR monitors and characterizes the health and vitality of coral reef ecosystems in the Pacific by observing through time the reef systems in the Hawaiian Islands, U.S. Pacific Territories, and Remote Pacific Islands. Missions include SCUBA diving to monitor and collect data on coral benthic ecologies, fish assemblages, and oceanography, using traditional and novel technologies (e.g., photogrammetry). Results appear in NOAA reports and refereed literature with the potential impact of preserving and enhancing coral reef health. A related activity is the removal of derelict fishing gear and plastics from reefs to reduce hazards to both sessile and mobile marine life.

Fisheries Ecology and Biology. CIMAR collaborates with PIFSC to ensure timely delivery of high-quality fisheries data in Hawaii and the U.S. Pacific Territories to inform state, regional, and international fisheries management. This work requires maintenance of best practices in managing and administering fisheries data. CIMAR also develops life histories and stock assessment models for Pacific fish species. Impacts are the sustained health and vitality of fisheries populations among the Pacific Islands.

Social Sciences and Economics. Human interactions with the environment influence the ability of ecosystems to provide societal goods and services. CIMAR researchers account for the social, economic, and cultural interactions of people and ecosystems, with emphasis on impacts of changes to the fisheries by natural, human-induced, and management influences. CIMAR works with fishers to elucidate impacts that bycatch has on catch, quantify interaction rates, and conduct tagging experiments. CIMAR also created a network for information flow between fishers, scientists, and managers.

Endangered/Threatened Species Sciences. CIMAR researchers conduct population assessments and study behaviors and interactions of Pacific marine life, including the Hawaiian monk seal, marine turtles, cetaceans, and sharks. The work produces knowledge that informs strategies for the preservation of endangered and threatened marine species, as well as informing the public.

Tropical Oceanography/Climate. CIMAR supports technological and data processing activities with broad impacts in oceanic and meteorological disciplines. For example, the UH DAS for shipboard ADCP observation of near surface currents is valued in physical, chemical and biological oceanography, and is currently deployed on 11 NOAA vessels (see Section 32).

Tsunamis and Other Long-Period Waves. CIMAR scientists have completed a hazard assessment study for Barbados. CIMAR has

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?

Nothing to Report

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

CIMAR partners with PIFSC to bring undergraduate students from around the nation to Honolulu to conduct paid summer research with federal and CIMAR scientists. The PIFSC Young Scientist Opportunity provides young scientific talent an in-depth perspective on how fisheries, marine protected species, and ecosystems research are conducted and how they serve the scientific and local communities. The program provides professional experience and teaches skills to future scientists to assist with their career goals, and presents a networking opportunity for the scientists in CIMAR and federal service, and for students. This program typically receives over forty applications for placement in three or four projects established in the research divisions of PIFSC. Each project has federal and CIMAR mentors working directly with the students on a daily basis.

CIMAR projects regularly hire University of Hawaii undergraduate students. The pandemic has limited this employment activity, due to lack of regular access to federal facilities. A dozen graduate assistants were supported during the year, primarily from UHM in the SOEST Departments of Oceanography and Atmospheric Sciences, or from the Hawaii Institute for Marine Biology or College of Tropical Agriculture and Human Resources, in the pursuit of Masters and PhD degrees in oceanography, marine sciences, economics, and social sciences. Postdoctoral researchers are supported each year for their own continuing education and for the skills they bring to CIMAR projects. (See RPPR Appendix 3.)

CIMAR staff are integral to PIFSC programs' outreach and education efforts, with engagements at Hawaii and Territorial elementary, middle, and high schools. Subject areas include: cetacean research; protection of monk seals; marine turtle biology and ecology; coral reef ecosystem health; fish and fisheries research; shark and bycatch mortality; and marine debris impacts on our environment. CIMAR staff regularly participate in community educational events including: Hawaii Conservation Conference; IRC Summer Intern Symposium; NOAA Discovery Day at Kapolei Library; Marine Educator's Night; Career Fair at UH Manoa; Hawaii Fish & Dive Expo; various high school career fairs; school visits to the NOAA IRC; Earth Day events; Waikiki Aquarium events; and World Ocean Day.

Refer to RPPR Appendix 3 for CI Employee Support Table.

IMPACT (cont'd)

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

The CIMAR-supported Dissertations Symposium in Chemical Oceanography (DISCO) provides recent graduates, or soon to graduate, PhD-level chemical oceanographers with an opportunity to present their dissertation research in front of their professional peers and forge professional relationships that will facilitate their future research and academic careers. DISCO participants (currently 25 per meeting) are selected from universities all over the world, with a majority of attendees from U.S. universities. The number of participants to date (DISCO I–XXVI) exceeds 640 and they were selected from an applicant pool that exceeded 80 eligible doctorates in recent years. At each meeting, a single senior scientist is invited to provide a keynote address and serve as a mentor during the meeting. The most recent DISCO (#27) took place on 17–21 October, 2021 in Lihue, Hawaii.

Many datasets acquired by CIMAR researchers are posted on NOAA-supported websites (e.g., PMEL; PaclOOS; National Centers for Environmental Information (NCEI)) in forms appropriate for easy use in classroom settings. For example, the UHM Department of Oceanography uses CO₂ and other environmental data from CIMAR autonomous buoys near Oahu's coasts to discuss the biogeochemistry of the ocean carbon cycle and ocean acidification (i.e., OCN 623—Chemical Oceanography). These buoys are part of NOAA's National Ocean Acidification Network and have operated continuously in Hawaii for over ten years, permitting the illustration of seasonal and interannual variability in the carbon cycle.

Argo floats prepared by CIMAR staff at NOAA/PMEL are deployed by undergraduate college students from the SSV Robert C. Seamans of the Sea Education Association and occasionally by cadets from the TS Golden Bear of the California Maritime Academy. These deployments involve students in a global ocean observing system, which both institutions value. In addition, the CIMAR Argo group frequently participates when student groups (both K–12 and undergraduate) tour or visit PMEL.

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

CIMAR supports the fisheries and ecosystem data management infrastructure for PIFSC, providing database development, data management, and data application development support and services to scientists and resource managers to facilitate quality scientific research and resource management. CIMAR support and guidance includes reviews and feedback to facilitate projects, performing setup and troubleshooting, developing software solutions, and compiling documentation.

CIMAR staff lead biweekly Software Development Team (SDT) meetings with representatives from each PIFSC division to discuss common data needs and collaboration opportunities as well as review and recommend software standards, best practices, tools, and procedures to improve the quality of scientific data management.

Other examples of CIMAR database infrastructure support include multiple software modules and procedures for the Ecosystem Sciences Division and extensive software development for deployment during field missions, and collaboration with the PIFSC Fisheries Research and Monitoring Division to develop a generalized approach to make non-confidential fishery data summaries available securely from the enterprise database.

CIMAR continues to develop a centralized cruise database (CCD) to manage all PIFSC cruise information and allow all research divisions to integrate their scientific data with the cruise database. The centralized conductivity, temperature, depth (CTD) database enables the management of data collected by PIFSC. The project also developed a data integration standard operating procedure (SOP), which can be used by any PIFSC division to easily define the relationship between their scientific data and the CCD using a code template. CIMAR drafts multiple SOPs throughout the year for deploying end-user applications, requesting Oracle resources, automating backend testing, integrating data, and guiding software development by contractors. CIMAR develops and updates multiple data tools throughout the year, including shared database utility packages and a flexible automated backend testing process. The CIMAR project developed a data model, flexible automated data import module, data quality control (QC) criteria, web application for visualizing and downloading CTD data, and extensive documentation on the different aspects of the PIFSC data system.

The shipboard ADCP (UHDAS) program, and APDRC both provide data acquisition, data quality control, database construction and management, and product construction on a variety of environmental datasets. While the utilization of these materials is deeply rooted within NOAA, their value has made many of them fundamental staples within the international science and engineering communities concerned with both understanding oceanic and atmospheric phenomena and promoting sustainable resource utilization.

The Tsunami Hazard Assessment for Barbados was presented to the Caribbean Tsunami Warning Center director and staff, Barbados Emergency Management Division, and Kingston city planning officials. This multimedia presentation included modeling

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?

In order for the transfer of CIMAR's developed technologies to reach wider audiences, CIMAR researchers implemented training on the usage of ADMB, UHDAS, and APDRC software.

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

Many of CIMAR's projects result in conservation of natural resources as regional and national economic and recreational assets. These resources include a wide variety of fisheries and fish species (e.g., longline and purse seine fisheries targeting highly migratory species, tuna and billfish, reef and bottomfish in Hawaiian and U.S. Territorial waters), protected and threatened species (e.g., whales, dolphins, marine turtles, Hawaiian monk seals, albatross, sharks), and coral reef ecosystems in the Hawaiian Islands, the Commonwealth of Northern Mariana Islands, Guam, American Samoa, and the Pacific Remote Islands. Much of the data and reporting for these projects are delivered to local governmental resource management agencies, Regional Fisheries Management Organizations (RFMOs), and international commissions. In addition, CIMAR projects work to understand human behavior and economic impacts due to fisheries and ecosystem management decisions, and potentially provide community education on these management determinations.

Short and long term forecasts of swell wave-driven run-up and flooding along West Maui, based on the CIMAR-supported nonlinear, hydrodynamical model of these hazards, was implemented and are available through the PacIOOS website. These forecasts are used by residents, business owners and coastal planners to mitigate immediate threats to life and property, and formulate strategies for coastal protection and development as sea level rises.

IMPACT (cont'd)

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

0 , No portion of the award's budget was spent in foreign countries.

CHANGES/PROBLEMS

45. Changes in approach and reasons for change

All CIMAR projects were seriously impacted by the pandemic, with many cancellations of field and travel activity, reductions and restriction of communication between staff and co-workers, delays and cancellations of the NOAA vessel embarkations, restrictions on small boat and diving activities, reductions of conference attendance, and more. CIMAR projects adjusted underwater survey plans in response to cruise delays and ship allocation, responded to ship delays with additional spending on hotels and per diem, and established alternate sampling strategies to achieve project goals. In addition, schedule changes to ship activity often required staff to re-design surveys and field staffing. Several projects that conduct interviews with fishers or fisheries managers did so via video conferencing or by phone, which represents a communication variation from past surveys.

CHANGES/PROBLEMS (cont'd)

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

The COVID-19 pandemic will continue to negatively impact every planned CIMAR field deployment as well as all activities requiring sustained access to the laboratories and facilities at the IRC. Health and safety protocols for staging field activities are important components for executing CIMAR project work. A coral reef monitoring and research diving cruise in the Mariana Islands experienced a series of delays due to the health and safety protocols and required testing. CIMAR recently participated in a research cruise that had to return to port after several days at sea due to a COVID test result. This required CIMAR administrative time to process travel multiple times, in addition to extending travel costs for CIMAR invitational travelers also participating in the cruise. Other delays include: sampling in the bottomfish fisheries and ecosystems research around the main Hawaiian Islands and Pacific Islands Region; bycatch mitigation and shark tagging research in the main Hawaiian Islands; and several technology development deployments. Operational activities delayed or otherwise impacted include: field logistics planning and execution; laboratory work such as classification and analyses of water, algae, and fish samples; operation and maintenance of the IRC Sea Water System; and more. CIMAR continues to coordinate closely with federal management to adjust the design of activities and schedules in order to optimize staff skills and maintain a safe environment where success is viable for each project.

47. Changes that had a significant impact on expenditures

The COVID-19 pandemic affected travel and other labor costs associated with fieldwork and conference participation for every CIMAR project. Field activities were undertaken with utmost safety considerations as determined by federal and UH site and facilities administrations.

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

Approximately 115 CIMAR staff and students (figure fluctuates with seasonal hires) work in the NOAA IRC on Ford Island in Honolulu. To accommodate work during the closure of federal facilities due to the COVID-19 pandemic (since mid-March 2020), CIMAR staff regularly prepare daily or weekly work plans sufficient to conduct scientific and operational support activities from their designated telework worksite, which is typically a home office. CIMAR staff are able to maintain productivity throughout the closure through daily exchanges with CIMAR colleagues, supervisors, and federal collaborators/sponsors using a variety of online video and audio meeting facilitation software. In some cases, CIMAR staff were able to safely enter the IRC on a regular or occasional basis, with required health and safety protocols in place.

CIMAR participation in the mission staging and meetings has resumed with appropriate levels of health and safety protocols developed by UH and NOAA management entities.

PROJECT OUTCOMES

50. What were the outcomes of the award?

Several CIMAR coral monitoring data products are available and hosted on the PacIOOS website at the UHM, and CIMAR's coral bleaching products can be viewed from the NCEI website. The bleaching database contains live coral cover percentage and average bleaching severity, as well as tax-specific metrics. Datasets from CIMAR dive missions are submitted to appropriate NOAA archives and include observations of reef fish and coral demographic surveys, data from subsurface temperature recorders, benthic images, and benthic cover.

CIMAR continues to install, maintain, and upgrade the UHDAS acquisition and processing software for the acoustic current profilers on NOAA research fleet vessels. Staff also provide training and consulting on the usage and interpretation of acquired acoustic data and resultant processed upper ocean current profiles.

CIMAR maintains and improves the ADMB, a free, open-source software tool used by all NOAA Fishery Science Centers, as well as international institutions, to create fishery stock assessments. The project will release ADMB-13.0 shortly, which fixes defects, adds new features and provides improved documentation and support. Since 2011, ADMB has been cited 1934 times with 129 citations in 2021 and 44 citations as of June 2022.

The activities of CIMAR staff at the APDRC support climate research within the IPRC at the UHM. The APDRC meets critical needs for ocean, climate and ecosystem information through local support of climate research, and by generating data products for a broad spectrum of users throughout the Asia-Pacific region. The APDRC hosts over 125 data sets from in situ platforms, satellites, and numerical models. The APDRC now archives ~645 TB of data, readily accessible via a suite of servers.

Short- and long-term forecasts of swell wave-driven run-up and flooding along West Maui, based on the CIMAR-supported nonlinear, hydrodynamical model of these hazards, were implemented and are available through the PacIOOS website.

DEMOGRAPHIC INFORMATION FOR SIGNIFICANT CONTRIBUTORS (VOLUNTARY)

<p>Gender:</p> <p><input type="radio"/> Male</p> <p><input type="radio"/> Female</p> <p><input type="radio"/> Do not wish to provide</p>	<p>Ethnicity:</p> <p><input type="radio"/> Hispanic or Latina/o Not</p> <p><input type="radio"/> Hispanic or Latina/o Do not wish to provide</p>
<p>Race:</p> <p><input type="radio"/> American Indian or Alaska Native Asian</p> <p><input type="radio"/> Black or African American</p> <p><input type="radio"/> Native Hawaiian or other Pacific Islander</p> <p><input type="radio"/> White</p> <p><input type="radio"/> Do not wish to provide</p>	<p>Disability Status:</p> <p><input type="radio"/> Yes</p> <p style="padding-left: 20px;"><input type="checkbox"/> Deaf or serious difficulty hearing</p> <p style="padding-left: 20px;"><input type="checkbox"/> Blind or serious difficulty seeing even when wearing glasses</p> <p style="padding-left: 20px;"><input type="checkbox"/> Serious difficulty walking or climbing stairs</p> <p style="padding-left: 20px;"><input type="checkbox"/> Other serious disability related to a physical, mental, or emotional condition</p> <p><input type="radio"/> No</p> <p><input type="radio"/> Do not wish to provide</p>

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