



DEPARTMENT OF COMMERCE RESEARCH PERFORMANCE PROGRESS REPORT (RPPR)

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RECIPIENT ORGANIZATION	
20. Recipient Name: UNIVERSITY OF HAWAII	
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22. Recipient UEI: NSCKLFSSABF2	23. Recipient EIN: 996000354

ACCOMPLISHMENTS

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

The Cooperative Institute for Marine and Atmospheric Research (CIMAR) is one of 16 distinct 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 Hawai'i;
- 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 Hawai'i at Manoa (UHM), a research-intensive land-grant, Sea Grant, space-grant, and Sun 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 UHM 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 NOAA 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 15 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 collaborates 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 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 Sea Level Center, 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, training, outreach, plans, technologies,~~

25. What was accomplished under these goals?

At the beginning of the reporting period, remote field camps were already established at most major seal and turtle reproductive sites in the Northwestern Hawaiian Islands (NWHI) within the Papahānaumokuākea Marine National Monument (PMNM). CIMAR seasonal staff had been hired in preparation for the four month deployment in the PMNM for the monk seal and marine turtle field survey campaign. Staff are trained in the following areas: 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, and food and medications. 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 researchers surveyed several PMNM reefs for coral health and observed low levels of coral bleaching as well as a high prevalence of dead coral on shallow coral reefs. CIMAR staff helped conduct surveys to investigate the abundance and distribution of invasive algae on coral reefs, including at forereef and inner atoll/lagoon sites. The team found abundant *Chondria tumulosa* at some reefs, with a great deal of spatial variability from reef to reef. This invasive alga was observed over growing corals as well as in more cryptic locations, e.g., the underside of rocks and interwoven into floating mats of other algal species. The project also observed *Hypnea cervicornis* forming large aggregations that can be observed as dark areas in satellite imagery, adding to the capability of remotely monitoring the distribution, abundance, and impacts over time of invasive algae species.

CIMAR staff continued to support 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 and 2014 in the North Atlantic (EX1304, EX1404), dives in the Discoverer seamount range in the PMNM (NA134), and are halfway through dives on the Liliuokalani ridge in PMNM (NA138). In total we submitted data for 58 dives representing 71,252 individual video annotations.

The Electronic Monitoring (EM) project conducts research in the Hawai'i longline fishery with the objective to advance EM capabilities in the Pacific Island Region (PIR). This is done through continued efforts in Artificial intelligence (AI) and machine learning (ML) research to automate catch detections in the fishery with more accurate detection models. During FY2023 the EM program continued to advance our AI research, upgrading several aspects of our Google cloud platform (GCP) environment to allow for faster training compute times and increasing the number of images allowed per training. With these advancements and adding annotations to our image library, project staff trained a Machine Learning object detection model. This model was successful in detecting fish on deck and sea turtles in the water and on deck using 86,000 EM program annotations. Another objective was to conduct research on the feasibility of assessing post interaction mortality of protected species using collected EM data. During this year, program staff reviewed protected species interactions for marine mammals and sea turtles gathered from EM data to determine what data could be

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 staff help manage intern participant activities, including the NOAA Hollings Preparation Program at UH, which prepares undergraduates to be competitive applicants for the full NOAA Hollings Scholarship in their sophomore year of college. CIMAR and federal staff coordinated events for the students, including a meet-and-greet and cultural introduction, public speaking and presentation skills workshop, Hawai'i graduate program information session, NOAA career opportunity discussion, a service learning opportunity, and the annual Inouye Research Center Intern Symposium, which includes interns participating in a variety of national internship programs in all the local NOAA offices.

CIMAR supports and facilitates the PIFSC Young Scientist Opportunity (PYSO) program that annually employs several undergraduate students. For the past few years, the program focused on developing local science undergraduates either from Hawai'i or attending college in Hawai'i. PYSO is currently active with four young researchers, hired into CIMAR to work in PIFSC alongside CIMAR and federal mentors on summer science projects.

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.

CIMAR programs support continuing education through the hiring of talented Postdoctoral Researchers. Research topics include: unraveling the links between ENSO and Hawai'i 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 Hawai'i 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. Five CIMAR staff members were recruited during this reporting period for federal employment with NOAA.

As employees of the Research Corporation of the University of Hawai'i, 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 initiated an alternative approach to professional improvement, with training and workshops now frequently held virtually and available from around the country.

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. As a result of the pandemic, more events are being held in a virtual or hybrid environment, which enlarges the opportunities for scientific dialog through online presentations when travel to such events isn't possible.

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. Although several CIMAR projects started late during the reporting period, 16 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; 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 local undergraduates 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 Hawai'i 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?

Plans for the Ecosystem Structure and Function project include: conclusion of stomach collections for the mahimahi project; collection of ichthyoplankton tows for managed species in Hawai'i waters via the HICEAS cruise; and light trapping efforts to attempt to catch the settling stages of uku larvae around O'ahu. This large expansion of field work will permit a better characterization of the early life stages of managed species and the environmental associations of their habitat.

The EM program will continue to advance AI development by adding annotations to the image library focusing on data gaps, protected species and common false positives. This will enable the continued development of more accurate and robust ML object detection models, which can automate detection of catch on longline fishing vessels. Post-release mortality assessment will continue for protected species interactions collected by EM data.

Under CIMAR's contribution to the National Ocean Acidification Observing Network, we continue comparing reef data across sites in the Pacific and Atlantic and calculating Net Ecosystem Calcification and Net Ecosystem Production variations among Coral Reef Instrumented Platforms and moorings in Kaneohe Bay, Oahu. The findings of the reef carbon system comparison will be published in a special issue of the journal *Frontiers in Marine Science* under the research topic Time-Series Observations of Ocean Acidification: A Key Tool for Documenting Impacts on a Changing Planet.

Within the Economics and Human Dimensions of Marine Ecosystems project, CIMAR economists will complete and disseminate cost-earnings surveys and analyses of Hawai'i longline fleet data, and small boat cost-earnings and species diversification data from Guam, CNMI, and Hawai'i, including the bottomfish fishery. A CIMAR social scientist will work with NMFS social scientists to review NOAA forms and surveys across all regions in order to improve the comprehensiveness of longitudinal data surrounding fish catch, focusing on the role of fisheries in local and regional food systems, cultural practices, fishing community well-being, and non-market benefits. A CIMAR social scientist will develop a culturally grounded process for discerning which marine taxa that fishing communities would like prioritized within marine research and management. A CIMAR social scientist will test this process as part of the West Hawai'i Integrated Ecosystem Assessment to better ensure cohesion between NOAA science and management with community concerns and priorities.

During the next year, the Cetacean Research in the Pacific Islands Region (CRPIR) project will be dominated by the Hawaiian Islands Cetacean Ecosystem and Abundance Survey (HICEAS), which is part of a greater collaborative effort. The Pacific Marine Assessment Program for Protected Species is a partnership among Federal Agencies (Bureau of Ocean Energy Management, NOAA Fisheries (Alaska, Northwest, Pacific Islands, and Southwest Fisheries Science Centers), U.S. Navy, and U.S. Fish and Wildlife Service) to conduct surveys to assess the abundance of multiple species and their ecosystem. HICEAS is a collaborative project with the Southwest Fisheries Science Center consisting of two ships conducting line-transect abundance surveys for cetaceans within the Hawai'i exclusive economic zone over a period of five months (five legs), using visual and passive acoustic

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 2023.

Below is the list of the 16 CIMAR first-author, refereed publications for this reporting period.

Asbury M., et al., 2023: Geological age and environments shape reef habitat structure, *Global Ecology and Biogeography*, 32:1230-1240. <https://doi.org/10.1111/geb.13691>

Ayers, A., K. Leong, 2022: Focusing on the human dimensions to reduce protected species bycatch, *Fisheries Research*, 254, 106432. <https://doi.org/10.1016/j.fishres.2022.106432>

Barkley, Y.M., et al., 2022: Examining distribution patterns of foraging and non-foraging sperm whales in Hawaiian waters using visual and passive acoustic data, *Frontiers in Remote Sensing*, 3, 940186. <https://doi.org/10.3389/frsen.2022.940186>

Gruden, P., Y.M. Barkley, J.L.K. McCullough, 2023: Vocal behavior of false killer whale (*Pseudorca crassidens*) acoustic subgroups, *Frontiers in Marine Science*, 10, 1147670. <https://doi.org/10.3389/fmars.2023.1147670>

Halperin, A.A., et al., 2023: Coral cover remains suppressed three years after derelict net removal in a remote shallow water coral reef ecosystem, *Marine Pollution Bulletin*, 188, 114703. <https://doi.org/10.1016/j.marpolbul.2023.114703>

Hirsh, H.K., et al., 2023: Predicting coral reef carbonate chemistry through statistical modeling: Constraining nearshore residence time around Guam, *Aquatic Geochemistry*, 29, 73-94. <https://doi.org/10.1007/s10498-023-09411-6>

Huntington, B., et al., 2022: Oceanic productivity and high-frequency temperature variability—not human habitation—supports calcifier abundance on central Pacific coral reefs, *Frontiers in Marine Science*, 9, 1075972. <https://doi.org/10.3389/fmars.2022.1075972>

Hutchinson, M., et al., 2023: Habitat use and movement patterns of adult male and juvenile scalloped hammerhead sharks, *Sphyrna lewini*, throughout the Hawaiian archipelago, *Endangered Species Research*, in press.

Lyman, J.M., G.C. Johnson, 2023: Global high-resolution random forest regression maps of ocean heat content anomalies using in

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

PRODUCTS (cont'd)

30. Technologies or techniques

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. This year, CIMAR staff in the Lab supported a variety of PIFSC projects by developing battery banks with solar charging capability to support the Hawaiian Monk Seal Research Program (HMSRP) field camp operations. CIMAR staff designed and fabricated new biopsy bolts to collect tissue samples for the Cetacean Research Program (CRP). They also designed and fabricated railing fishing pole adapters to support the Life History Program's (LHP) bottomfish sampling efforts. The Lab additionally worked with Pelagic Research Program (PRP) researchers to design and fabricate a high speed mini surface trawl to be used to support several projects, including the collection of biological and anthropogenic samples in the surface neustonic layer, such as early life history stages of commercially-important fish species (e.g., bigeye tuna (*Thunnus obesus*)) and floating microplastic debris.

CIMAR staff worked 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 very good progress using AI technology to train species detection algorithms. CIMAR was able to train AI algorithms to detect fish and protected species (e.g., turtles) on deck and in the water.

CIMAR and federal staff work 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. This effort provides the best available fisheries monitoring data for research and sustainable management of fisheries in the Pacific Islands Region.

CIMAR uses novel photogrammetric techniques to detect subtle changes in coral reef communities and applied the methods to assess the 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 bottomfish surveys.

~~CIMAR participates in the collection of eDNA to characterize nearshore ecosystems and develop metabarcoding in coordination with~~

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. An important source of these measurements is the NOAA research fleet, which is 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) to routinely acquire, monitor, process, and serve 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. UHDAS servers were repaired or replaced on two vessels this year. CIMAR staff worked 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. A formal rolling, daily submission and accession of ADCP data to NCEI started in March 2023. In total, UHCG submitted over 88 cruise bundles thus far from NOAA ships Nancy Foster and Bell Shimada, and continues to work through a large backlog of cruises on those ships.

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 released ADMB-13.1 in December, 2022, a minor revision that included improvements and fixes to the documentation, installation, testing, and source code. ADMB-13.0 is the latest major version that was released on August 8, 2022. Since the initiation of the first public download version in 2008, ADMB has been downloaded 841 times.

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 generates 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 ~650 TB of redundantly stored data. For ease of access, APDRC maintains a suite of data transport and discovery servers.

One of the main data productions of the CIMAR Deep Corals and Sponge Initiative Project are records of coral and sponge observations incorporated into the NOAA Deep Sea Coral Research and Technology Program (DSCRTP) national database. This

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?

Dr. Jeffrey Hare, CIMAR Deputy Director for PIFSC Projects resigned in February, 2023. A recruitment to fill this position with an expanded purview to cover all co-located CIMAR projects is currently underway.

35. What other organizations have been involved as partners?

Nothing to Report

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 Hawai'i 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 currently deployed on 11 NOAA vessels (see Section 32).

Tsunamis and Other Long-Period Waves. CIMAR scientists are completing a tsunami hazard assessment for four populated islands in the Republic of the Marshall Islands that support PEM development. The assessment includes the study of the impact of tsunamis on the islands' infrastructure and the impact of tsunamis on the islands' environment.

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 develop local science undergraduates either from Hawai'i or who are attending college in Hawai'i. These students conduct paid summer research with federal and CIMAR scientists. This PIFSC Young Scientist Opportunity (PYSO) 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 Hawai'i undergraduate students. The pandemic 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, Hawai'i Institute for Marine Biology, and 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 the skills they bring to CIMAR projects. (See RPPR Appendix 3.)

The CIMAR-supported Dissertations Symposium in Chemical Oceanography (DISCO) and Physical Oceanography Dissertations Symposium (PODS) provide recent PhD graduate, or soon-to-be graduate, chemical and physical oceanographers, respectively, with the 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 and PODS participants (currently 25 in each cohort) are selected from universities all over the world, with a majority of attendees from U.S. universities. Participants are selected from applicant pools that typically exceed 60 eligible doctorates. 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 (#28) and PODS (#12) took place together on 16–20 October, 2022, in Kailua-Kona, Hawai'i.

IMPACT (cont'd)

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

CIMAR staff are integral to PIFSC programs' outreach and education efforts, with engagements at Hawai'i and Territorial elementary, middle, and high schools. The staff deliver scientific outreach and education products, programs, and services involving community events, scheduled educational interactions, career fairs, student participation in research, and printed and online products. 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. Staff also participated in escorting visits to the PIFSC lab at the Inouye Research Center on Ford Island, Oahu, by high school and middle school programs, participated as judges at the Hawai'i State Science Fair, and developed curricula for middle and high school science classes.

The CIMAR-supported Argo float group at NOAA/PMEL established an Adopt-a-Float program (<https://www.pmel.noaa.gov/gobop/aaf>) aimed at local high school students to introduce them to a global ocean observing system. The Argo group usually participates when student groups (both K-12 and undergraduate) tour or visit PMEL.

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 Hawai'i for over ten years, permitting the illustration of seasonal and interannual variability in the carbon cycle.

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

CIMAR operations support or provide the following: analyses and evaluation of fishery data and collection methods for insular fish stocks in the Pacific Islands Region (PIR); operational services to support PIFSC missions and projects; development of advanced and innovative survey and sampling technology and techniques; operational support for research infrastructure and aquaculture systems management; support to enhance fisheries research data management; and creation of products and tools that provide a mechanism for efficient access to fisheries data and information. This work is organized under four project elements, each of which produced significant impacts in the current reporting period. A few impacts are discussed here.

(1) Analysis and Evaluation of Fishery Independent Data, Habitat, and Collection Methods for PIFSC Missions.

The CIMAR Marine Optical Imagery (MOI) team supports PIFSC researchers and partners to maintain and improve fisheries image-based data streams. The MOI team completed the Modular Optical Underwater Survey System (MOUSS) video analysis for the 2022 Bottomfish Fishery Independent Survey in Hawai'i (BFISH), resulting in a size-structured species abundance data product. The MOI team evaluated photo annotations generated by the citizen scientist project OceanEYES, which encourages the public to participate in the scientific process by reviewing images from its annual MOUSS BFISH surveys. OceanEYES had a total of 17,348 volunteers in more than 67 countries and from all age groups who helped process images since the project began in September, 2020. This year, OceanEYES processed 86,347 images, identifying a total of 1,298,351 fish.

(2) Operations and Logistics Services to Support PIFSC Missions

CIMAR staff supported multiple PIFSC projects by providing operational and small boat support to all PIFSC Divisions. CIMAR was heavily engaged in operations planning, mobilization, execution, and demobilization of SE-22-07 BFISH surveys aboard NOAA Ship Oscar Elton Sette and Pacific Islands Fisheries Group (PIFG) contract vessels.

(3) Advanced Technology, Marine Instrumentation, Design & Fabrication, Acquisition, and Infrastructure Support for PIFSC Research

The MAKER Lab team works with PIFSC Researchers to design and develop innovative tools, equipment, instruments, and other physical products to enhance ecological data sampling efforts that support the conservation and management of coastal and marine ecosystems in the PIR. (See Section 30 for a partial list of this year's accomplishments.)

(4) Enhanced Fisheries Research Data Management to Support PIFSC Missions

CIMAR staff provided troubleshooting, consultation, and collaboration support to PIFSC for data processing and stewardship, database and application development, software development, and server administration to improve the functionality and quality of the data projects. Accomplishments were broad in scope, including the development of ten software development best practices; three procedures that streamline the software development process, including automated database testing and implementing template projects for new or existing data systems; six new or upgraded enterprise solutions that address software development and data stewardship needs; and two new data systems implemented as containerized web applications that provide on-demand

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 software to access the ADMB, UHDAS, and APDRC data discussed previously in this report.

The Territory Electronic Reporting (ER) Project focuses on fisheries in the three US territories in the Pacific region: American Samoa, Commonwealth of the Northern Mariana Islands (CNMI) and Guam. Territory fisheries are regionally and culturally important commercial, recreational, and subsistence fisheries. Reliable data on total removals and effort is needed to assist in the management of fishery species and maintaining healthy oceans, which provides for resilient and economically sound communities. With its inherent reach and scalability, ER will provide fisheries managers and stakeholders with access to higher quality and more timely data that cannot be met currently with existing in-person data collection programs.

The primary in-progress component of this project was to create a suite of applications that can run on mobile devices, smartphones, and tablets, as well as desktop and laptop computers, to allow for commercial catch and effort data from fishers and fish sales data from vendors to be electronically reported with data going to the PIFSC and the Western Pacific Fisheries Information Network (WPacFIN). WPacFIN assists the territories with database and application systems development as well as providing technical support to fishery partner agencies.

The effort will also modernize fisheries information systems in the territories and move them from Visual FoxPro (VFP) applications to progressive web applications (PWA) for both agency office fishery applications and electronic reporting (ER) for fishers and vendors. The overarching plan is to develop a "Log It Suite" consisting of three modules: 1) "Catch It Log It", to log and transmit catch and effort data; 2) "Sell It Log It", to log and transmit sales data; and 3) Admin Portal for administrative and reporting activities.

Two smaller components of this project are as follows: 1) assist with planning and preparations for American Samoa's ER project for the longline fleet; and 2) provide ongoing technical support to Hawai'i and the territories for all system applications developed by WPacFIN.

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.

The CIMAR Economics and Human Dimensions of Marine Ecosystems project supports effective management of fisheries and marine ecosystems in the U.S. Pacific Islands region by conducting economic and human dimensions research through partnerships and collaborations with NOAA Fisheries, the University of Hawai'i, and other relevant stakeholders. The project seeks to understand the role of human behavior in fisheries to improve outreach and communications and contribute to the well-being of Pacific communities.

This project is multifaceted and includes three project focus areas: 1. characterize fisheries, fishing communities, and social-ecological systems; 2. analyze and model dynamic relationships between fishing communities, governance processes, ecosystems, and climate; and 3. enhance access and participation in science and management. The most significant accomplishments this year include the following.

Social Vulnerability Indicators for Coastal Communities: CIMAR staff managed and maintained a statistical program that processes U.S. Census Bureau data to create a social vulnerability index dataset for Hawai'i, which is reported to NOAA headquarters to be compiled in a national dataset. The NOAA Fisheries Community Social Vulnerability Indicators pulls together multiple statistically robust social, economic, and climate change indicators that can characterize and evaluate community vulnerability/resilience to disturbances.

Tier 1 Economic Indicators for Economic Performance of Fisheries: CIMAR staff created, maintained, and managed a statistical program that summarized economic fishing activity and characteristics (active vessels, trips, days at sea, total revenue, revenue per trip, etc.) at the annual level as well as the commercial marine license level for the State of Hawai'i. This data set is reported to NOAA headquarters and is included with other commercial fishery data collected across the United States.

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. 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)?

1 , About 1% of the award's budget was spent in foreign countries. This includes foreign travels, a vessel charter under Sustaining Healthy Coastal Ecosystems Project, and tide observer activities under the UH Sea Level Center project.

CHANGES/PROBLEMS

45. Changes in approach and reasons for change

All CIMAR projects continued to be impacted by the COVID-19 pandemic, especially during the earlier portions of the reporting period. Since emerging from the pandemic, field and travel activity and NOAA vessel embarkations have resumed to a more normal operational level.

CHANGES/PROBLEMS (cont'd)

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

The COVID-19 pandemic continued to negatively impact planned CIMAR field deployment as well as all activities requiring sustained access to the laboratories and facilities at the IRC during the earlier portions of the reporting period. Health and safety protocols for staging field activities were important components for executing CIMAR project work.

The Mechanisms of Atmospheric Mercury Transport and Transformation in the Remote Pacific Marine Free Troposphere project collects and analyzes semi-continuous high altitude (11,144 feet) measurements of elemental mercury (Hg⁰), gaseous oxidized mercury (GOM), and particulate-bound mercury (PBM) at the Mauna Loa Observatory (MLO), Hawai'i. From July 1 to approximately November 28, 2022, all objectives of this monitoring program were on track to completion. However, the summit eruption of the Mauna Loa volcano at the end of November, 2022 disabled operations at the MLO. Lava flows blocked the access road from the Saddle Highway to the observatory and halted electrical power at the observatory. While some progress was made to install solar panels and battery backups to run low-power instruments, the mercury instrumentation was turned off and remains unpowered as of June 22, 2023. Now that additional solar power has been added to the MLO, plans are underway to resume measurements of elemental mercury only in the coming weeks, to continue indefinitely until sufficient power is restored to allow the measurement of all mercury species. As an alternative, plans are being considered to install the mercury instrumentation at a suitable site on Mauna Kea, although this possibility is uncertain at the moment.

A five-month extension from 11/30/2022–4/30/2023 was requested and approved for the Tsunami Research and Modeling project. This extension was necessary due to difficulties securing funding, which resulted in staff time being reduced to maintain the project. With funding subsequently secured and staff time fully restored, personnel were able to complete the project.

47. Changes that had a significant impact on expenditures

The COVID-19 pandemic continued to affect travel and other labor costs associated with fieldwork and conference participation for several CIMAR projects during the earlier parts of the reporting period. Field activities were undertaken with utmost safety considerations as determined by federal and UH site and facilities administrators.

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 100 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 during the earlier portions of the reporting period, CIMAR staff regularly prepared daily or weekly work plans sufficient to conduct scientific and operational support activities from their designated telework worksite, which was typically a home office. CIMAR staff were 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. Since emerging from the pandemic, CIMAR staff have been able to return to the IRC worksite with the option to telework for a part of the work week, as appropriate, and based on individual program/operational circumstances.

PROJECT OUTCOMES

50. What were the outcomes of the award?

CIMAR coral monitoring data products are available and hosted on the PacIOOS website; the coral bleaching products can also be viewed on the NCEI website. The bleaching database contains live coral cover percentage and average bleaching severity, as well as taxa-specific metrics. Datasets from CIMAR dive missions are submitted to NOAA archives and include observations of reef fish and coral demographic surveys, subsurface temperature data, benthic images, and benthic cover. These data help determine which factors enhance coral resilience to bleaching, identify where corals are most susceptible to bleaching, and inform intervention and restoration methods to help maintain the corals.

CIMAR continues to install, maintain, and upgrade the UHDAS acquisition and processing software for the acoustic current profilers on 11 NOAA research fleet vessels, thereby maximizing the scientific value of their 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. Every year, CIMAR provides on-site upgrades and training, when possible, and remote consulting on UHDAS use and interpretation of acquired data and resultant processed upper ocean current profiles.

The UH Sea Level Center (UHSCL) continues to provide collection, quality assessment, distribution and archiving of sea level data from nearly 500 stations maintained by 65 international agencies, focusing on stations in the IOC/UNESCO Global Sea Level Observing System (GLOSS) and the Global Climate Observing System. The UHSCL is a primary data center in GLOSS, curating and distributing two sea level datasets: the Fast Delivery dataset, which provides preliminary, quality-assured, hourly and daily data within 4–6 weeks; and the Research Quality dataset, an archive of hourly and daily sea level that have undergone a complete quality assessment within a year. Vertical land motion monitoring, as recommended for all GLOSS and GCOS stations, is measured by continuous GPS receivers at 11 UHSCL stations. Furthermore, UHSCL technicians collaborate directly with international partners to maintain 77 tide gauge stations that are essential for sea level and tsunami observing efforts. UHSCL involvement in acquiring and quality assessing land-based sea level observations ensures that research-quality and near-real-time monitoring datasets, which are essential to global research efforts in oceanography, geodesy, and climate change, are available from otherwise sparsely sampled areas of the global ocean, and that developing nations have access to training, technical support, and data processing services as needed.

The activities of CIMAR staff at the Asia-Pacific Data-Research Center (APDRC) support climate research within the IPRC at the UHM. The APDRC meets critical needs for ocean, climate, and ecosystem information for climate research by providing raw data and data products for a broad spectrum of users throughout the Asia-Pacific region. The APDRC hosts over 125 datasets from in situ platforms, satellites, and numerical models, archiving ~650 TB of data, readily accessible via a suite of servers. This year, ~250 TB of data was delivered, equaling about 30 GB of data every hour of every day.

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 continuously available to the public and government agencies through the PacIOOS website. This work attracted funding from the following sources to expand the locations of these forecasts: UNEP Global Climate Fund for

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</p> <p><input type="radio"/> 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.