JIMAR
Joint Institute for Marine and Atmospheric Research

A Cooperative Institute for the Pacific Islands Region

A Proposal
to the National Oceanic and Atmospheric Administration
NOAA-NMFS-PIFSC-2011-2002847
TABLE OF CONTENTS

1. TITLE PAGE ............................................................................................................................................. 3
2. ABSTRACT .............................................................................................................................................. 4
3. RESULTS FROM PRIOR RESEARCH .................................................................................................... 6
4. PROJECT DESCRIPTION........................................................................................................................ 8
   4.1 Mission, Vision, and Goals ..................................................................................................... 8
   4.2 Capabilities, Facilities, and Resources ..................................................................................... 8
   4.2.1 Contributions to NOAA Research Milestones in 5-Year Research Plan .................. 9
   4.2.2 Integration with NOAA Mission Goals and Next Generation Strategic Plan....... 11
   4.3 Research Themes .................................................................................................................. 12
   4.3.1 Ecosystem Forecasting ............................................................................................ 12
   4.3.2 Ecosystem Monitoring .............................................................................................. 15
   4.3.3 Ecosystem-Based Management .............................................................................. 17
   4.3.4 Protection and Restoration of Resources ................................................................ 19
   4.3.5 Equatorial Oceanography ........................................................................................ 20
   4.3.6 Climate Research and Impacts ................................................................................ 20
   4.3.7 Tropical Meteorology ............................................................................................... 23
   4.3.8 Tsunamis and Other Long-Period Ocean Waves .................................................... 25
   4.4 Education ................................................................................................................................ 26
   4.4.1 Integration of Students and Post-Docs into Research ............................................. 26
   4.4.2 Outreach and Education Activities in Support of Research Themes ....................... 27
   4.4.3 NOAA-related Education Programs Offered ............................................................ 27
   4.5 Business Plan ......................................................................................................................... 28
   4.5.1 Organization Structure ............................................................................................. 28
   4.5.2 Director ..................................................................................................................... 28
   4.5.3 Senior Fellows .......................................................................................................... 28
   4.5.4 Advisory Boards: Executive Board and Council of Fellows ..................................... 28
   4.5.5 Fiscal and Human Resource Management ................................................................... 29
   4.5.6 Strategic Planning and Accountability ..................................................................... 29
   4.5.7 Selection of Projects, Progress Review, and Supporting Enhanced Communication and Collaboration with NOAA ........................................................ 30
   4.6 Performance Measures ......................................................................................................... 30
5. BUDGET AND BUDGET JUSTIFICATION ............................................................................................ 31
   5.1 Total and Annual Budgets by Tasks .................................................................................. 31
   5.2 Task I Budget ..................................................................................................................... 32
   5.3 Budget Justification ............................................................................................................. 33
   5.4 Cost Share and Match ......................................................................................................... 34
6. VITAE ...................................................................................................................................................... 35
7. CURRENT AND PENDING SUPPORT .................................................................................................. 37
1. TITLE PAGE

COOPERATIVE AGREEMENT PROPOSAL

INSTITUTION: University of Hawaii
Joint Institute for Marine and Atmospheric Research (JIMAR)
1000 Pope Road, MSB 312
Honolulu, Hawaii 96822

TITLE: Joint Institute for Marine and Atmospheric Research (JIMAR)

PRINCIPAL INVESTIGATOR: Mark A. Merrifield, PhD

SPONSOR: National Oceanic and Atmospheric Administration (NOAA),
National Marine Fisheries Service (NMFS) and Office of Oceanic and Atmospheric Research (OAR)

FEDERAL FUNDING OPPORTUNITY NO.: NOAA-NMFS-PIFSC-2011-2002847


DURATION: 5 Years

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YEAR 2 REQUEST: $19,000,000.00
YEAR 3 REQUEST: $19,000,000.00
YEAR 4 REQUEST: $19,000,000.00
YEAR 5 REQUEST: $19,000,000.00

TOTAL REQUEST: $95,000,000.00

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3
2. ABSTRACT – JIMAR: Joint Institute for Marine and Atmospheric Research

Principal Investigator: Mark A. Merrifield, PhD
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Total Amount Requested: $95,000,000.00

Project/Budget Period: October 1, 2011 – September 30, 2016

In response to Federal Funding Opportunity NOAA-NMFS-PIFSC-2011-2002847, we propose to host a Cooperative Institute (CI) for the Pacific Islands Region at the University of Hawaii at Manoa. The new CI would build on the Joint Institute for Marine and Atmospheric Research (JIMAR), which represents over 35 years of experience in a broad range of basic and applied research areas relevant to Pacific island regions. Given JIMAR’s high profile throughout the region, we propose to maintain the JIMAR name for the new CI. The mission, vision, and goals of JIMAR are highly complementary with those of NOAA, especially the focus on resilient ecosystems, communities, and economies, which for island settings includes many unique challenges and research opportunities.

In addition to the geographic advantage of being located in the central Pacific with access to an unparalleled natural laboratory, JIMAR is particularly well-positioned to pursue the research themes defined for the Pacific Islands Region CI. JIMAR brings together NOAA scientists with the considerable expertise and resources available at the School of Ocean and Earth Science and Technology (SOEST), as well as other schools and research groups at the University of Hawaii at Manoa. Under JIMAR, NOAA and University of Hawaii researchers have established an impressive record of excellence over the years in pursuing studies of tsunamis and coastal inundation, sustainable fisheries, sea-level rise, the El Nino Southern Oscillation and interannual to decadal climate variations, the health of coral reefs, tropical storm dynamics, and the observation and modeling of a wide range of oceanographic and atmospheric processes. Most of these research themes carry over to the new CI, and the previous JIMAR emphasis on fisheries and coastal research will easily transition into the new ecosystem-based themes.

Our list of proposed research topics highlights some of the directions that we hope to explore in the next five years in collaboration with NOAA scientists. The new CI will ensure that long-standing research partnerships between UH and NOAA will continue to flourish, including numerous programs associated with the National Marine Fisheries Service, the University of Hawaii Sea Level Center, and the Pacific ENSO Application Center to name a few. In addition, the new CI represents an opportunity to invigorate the UH/NOAA partnership with the participation of new faculty members and research initiatives. Expertise within SOEST has grown in recent years to include state-of-the-art regional ocean modeling, new approaches to ecosystem monitoring and modeling, and expanded nearshore and coastal observing capabilities. This is not an exhaustive list of research topics by any means; JIMAR has the built-in flexibility and scientific capability to respond to new initiatives and challenges as they arise.

Education is central to the mission of SOEST, and JIMAR will strive to maximize educational and training opportunities for UH graduate and undergraduate students in NOAA programs and projects. Likewise, the opportunity to work with promising young researchers will be one of the main benefits that the CI will provide for NOAA scientists. The connection with SOEST also ensures that outreach opportunities will be a priority for the CI. The dissemination of our research findings will be aided by the outreach infrastructure available through the SOEST Dean’s office, UH Sea Grant, and the Pacific Island Ocean Observing System (PacIOOS), which is centered at SOEST.

The structure of the new CI is designed to ensure a high level of communication and feedback between NOAA and JIMAR through active advisory boards, which will be relied upon to ensure that JIMAR is fulfilling its commitments to NOAA, and that collaborative research programs are taking full advantage of
the talents available at NOAA and UH. One of the unheralded strengths of JIMAR throughout the years has been an outstanding administrative staff. Support of this unit will ensure that the CI operates in an efficient and cost-effective manner.
3. RESULTS FROM PRIOR RESEARCH

The current CI Director is Dr. Thomas A. Schroeder. Dr. Schroeder will step down as director and retire in Fall, 2011. Dr. Mark Merrifield has agreed to develop the proposal for a new Pacific Islands Cooperative Institute, with the intention of retaining the JIMAR name. In light of this situation, “Results from Prior Research” for Dr. Merrifield is provided in the following text and links to annual reports of the existing CI will serve to describe results from Dr. Schroeder’s tenure as director.

**Joint Institute for Marine and Atmospheric Research (JIMAR), NOAA, NA17RJ1230 and NA09OAR4320075, Thomas Schroeder, 7/1/2001-9/30/2011, $127,638,724.**


**University of Hawaii Sea Level Center, NOAA/OCO, NA09OAR4320075, Mark A. Merrifield, 7/1/2009-6/30/2010, $1,471,000.**

A paper has been accepted by the Journal of Climate (Merrifield, 2011) on the spatial pattern of Pacific sea-level rise during 1993-2009 from satellite altimetry compared to previous time periods as sampled by the tide gauge network. The region of highest rise rates in the western Pacific is associated with a steady increase in trade wind strength over that time period. The trade wind increase and sea level response appear to be unrelated to the dominant climate time scale indices in the region such as ENSO, the Pacific Decadal Oscillation, and the North Pacific Gyre Oscillation. This multi-decadal sea level change has similar time variability as a global warming pattern represented by the dominant EOF mode of outgoing long-wave radiation. The sea level pattern is believed to represent an oceanic response to recent warming trends via the intensification of trades winds driven by increased latent heat release.

An analysis of extreme sea level events is nearing completion based on the global tide gauge network. Extreme sea level climatologies are characterized in terms of tidal forcing, storm variability, and larger-scale wind-driven ocean variability. Trends in these forcing components have been assessed and the impact of global sea-level rise on extremes is described. A manuscript on extreme sea levels is in preparation.

The impacts of land motion on relative sea level trends and global sea level reconstructions are being assessed in two ways. Land motion trends from GPS measurements are being incorporated into an algorithm for estimating global sea level from tide gauges (Merrifield et al., 2009). In addition, a collaboration with Dr. Clint Conrad and Julia Fiedler is underway that will assess the impacts on global sea level reconstructions of their estimates of coastal land motion based on water retention by dams.


**Merrifield, M. A., A shift in Pacific sea level trends during the 1990s, in press, J. Climate, 2011.**

**Pacific Island Land-Ocean-Typhoon (PILOT) Experiment: Coastal run-up and fringing reefs, UCSD, pass through from US Army Corps of Engineers, PO 10306151, Mark A. Merrifield, 9/1/2009 – 8/31/2011, $191,000.**

Field observations have been collected of wave, current, and water level changes over fringing reefs in Guam, Saipan, and Hawaii in support of the Pacific Islands Land-Ocean Typhoon (PILOT) experiment. Our primary objective has been to measure wave transformation properties directly over these terrains to estimate runup (Vetter et al., 2010) and particularly the conditions leading to coastal flooding at island shorelines. These observations have led to empirical relationships to predict runup as a function of incident wave height and period, water level over reefs, and to some degree bottom roughness. The observations indicate that setup behaves similarly as on sand beach environments without a strong...
indication of frictional effects, infragravity swash depends on incident wave height in the manner of incident bound waves with additional forcing by local breaking swell, and wind wave swash is strongly depth-limited and affected by reef roughness (Pequignet et al., 2011).

Routine predictions of extreme runup and coastal inundation at island shorelines are being incorporated into ocean observing systems such as HIOOS. Given the highly three-dimensional and complex nature of reef nearshore topography, observations from different topographic settings are being used to test semi-empirical runup parameterizations developed to date.


Hanauma Bay Circulation Study, NOAA (UH Sea Grant), NA09OAR4170060, Mark A. Merrifield, 2/1/2010-1/31/2011, $11,072.

A field experiment was conducted in Hanauma Bay, Hawaii during Spring 2009 to determine the role that tides, waves, and winds play in establishing the circulation in one of the State of Hawaii’s premier Marine Protected Areas. Trade wind waves tend to drive onshore flows along the sides of the bay, with compensating outflow through the center of the bay. Waves also drive a strong rip current through the channels in the reef. The strength of the rip current depends on the size of breaking waves on the reef, but also on the tidal height over the reef – for a given breaking wave height the rip is stronger at low tide than at high tide. The tidally modulated wave-driven circulation explains why the heat flux into and out of the back-reef lagoon varies on an approximately fortnightly cycle. When low neap tides occur at the warmest time of day, there tends to be a greater wave-driven outflow of heat from the lagoon to the outer bay than during the same time of day at high spring tides. During the late spring/early summer, the stratification in the bay increases, which favors leads to enhanced internal tide activity. The internal tides often appear as pulses of cold water, usually occurring twice per day. The cold flux associated with these pulses largely enters the bay on the southwest side of the bay mouth, and it is a source of nutrient-rich waters. Since the live coral population in the bay is highest on the southwest side, these nutrient-rich flows may be a factor influencing coral distribution in the bay. Results from this study will assist in ecosystem modeling, assessments of dangerous rip events, and in basic research on internal tide dynamics in the nearshore zone.
4. Project Description
The new Pacific Islands regional CI will build on the 35 year legacy and achievements of the previous CI, the Joint Institute for Marine and Atmospheric Research (JIMAR). Given JIMAR’s established reputation and high profile in the Pacific region, we propose to maintain the JIMAR name for the new CI.

4.1 Mission, Vision, and Goals
JIMAR’s mission is to conduct research that is necessary for understanding and predicting changes in the Indo-Pacific region, for conserving and managing coastal and marine resources in island environments, notably the Hawaiian Islands and the U.S.-affiliated Pacific Islands, and for meeting the Nation’s economic, social, and environmental needs in these regions.

JIMAR’s vision is to support NOAA’s concept of Resilient Ecosystems Communities and Economies while recognizing the special challenges and opportunities that the Pacific Islands face in achieving a sustainable and prosperous future in changing global and regional environments.

JIMAR’s goals are to:
- provide a sound infrastructure that facilitates innovative collaborative research between scientists at NOAA and the University of Hawaii in the JIMAR research theme areas;
- support high quality educational opportunities for basic and applied research in the Earth Sciences at the undergraduate, graduate, and post-doctoral levels;
- encourage the exchange of new ideas and differing views through sponsorship of visiting scientists and scholars at the University of Hawaii;
- promote the effective dissemination of research outcomes for societal benefit in the Pacific Basin region.

4.2 Capabilities, Facilities, and Resources
The University of Hawaii (UH) Manoa campus has been the home for JIMAR since its establishment in 1977 as the successor to the Joint Tsunami Research Effort (JTRE), which was created by UH and NOAA’s predecessor agency in 1967 after the Great Alaska Earthquake and Tsunami of 1964. UH is a research intensive Land Grant, Sea Grant and Space Grant University. UH is a member of the University Corporation for Atmospheric Research (based on doctoral programs in atmospheric and oceanic sciences), Ocean Leadership, and the University-National Oceanography Laboratory System (UNOLS). JIMAR resides within the School of Ocean and Earth Science and Technology (SOEST), a premier research institution that offers a broad range of state-of-the-art laboratory and engineering facilities.

SOEST features four academic units:
- Oceanography
- Meteorology
- Ocean and Resource Engineering
- Geology and Geophysics

three organized research units:
- Hawaii Institute of Marine Biology (HIMB)
- Hawaii Institute of Geophysics and Planetology (HIGP)
- Hawaii Natural Energy Institute (HNEI)

two NOAA collaborative centers in addition to JIMAR:
- Hawaii Sea Grant College Program
- Hawaii Undersea Research Laboratory (HURL)

and two additional science centers:
- The International Pacific Research Center (IPRC), a US-Japan collaboration in climate research, and
The Center for Microbial Oceanography Research and Education (C-MORE), a NSF Science and Technology Center.

Nearly all of the SOEST units include scientists that are, or have been, involved in collaborative research with NOAA programs and scientists through JIMAR.

SOEST also operates the University Marine Center at Snug Harbor, Oahu, which supports research cruises by UH vessels and hosts visiting UNOLS vessels. The Marine Center also hosted NOAA vessels prior to their move to Pearl Harbor. The Marine Center provides access to UH research vessels as well as those of other UNOLS members and foreign institutions.

Additional relevant research expertise resides within the UH Manoa Colleges of Arts and Sciences (Natural Sciences and Social Sciences), Tropical Agriculture and Human Resources, Engineering, as well as the Pacific Biosciences Research Center and the John A. Burns School of Medicine.

UH Manoa facilities and capabilities specified in the RFP include:
- Analytical chemistry laboratories (including radioisotope, water and carbon chemistry labs) reside within SOEST (Oceanography, Geology and Geophysics, and HIGP),
- Biological and microbiological labs are available within SOEST (Oceanography) and the College of Natural Science,
- Genetics (including mtDNA and microsatellite analysis) labs exist within SOEST, the College of Natural Sciences, the Pacific Biosciences Research Center, and the John A. Burns School of Medicine,
- Office space for 45 Federal employees exists within the Hawaii Institute of Geophysics Building (National Weather Service Honolulu Forecast Office) under lease since 1995,
- Acoustics-based observations and research are conducted at ORE, HIGP, and HIMB,
- A marine and electronics engineering facility exists within SOEST as a support unit,
- Instrument repair facilities exist within SOEST,
- The Class 1 research vessel, RV Kilo Moana,
- HURL operates two submersibles (Pisces 5 and Pisces 6), a support vessel (Ka Imikai-O-Kanaloa), and an ROV,
- High-performance computing and very large storage devices for advanced numerical modeling and data assimilation are accessible at the Maui High Performance Computing Center as well as within SOEST (especially within the International Pacific Research Center).
- Integrated observing and data management systems reside within the UH Marine Center and the Pacific Islands Ocean Observing System (PacIOOS), another joint NOAA/UH/SOEST venture.
- SOEST possesses a wide range of state-of-the-art ocean observing systems.
- SOEST has satellite data reception capabilities as well as sensor-design capabilities. Designs have included sensors for planetary missions (HIGP).
- The Pelagic Fisheries Research Program (PFRP) and the HIMB provide electronic fisheries monitoring equipment. They also have procured equipment shared with NMFS scientists.
- UH Manoa does not have veterinary medicine therefore we have historically worked with NMFS in contracting necropsy facilities.
- Captive care animal facilities exist at HIMB as well on a contract basis elsewhere on Oahu and neighbor islands.
- UH operates several small boats for coastal and nearshore field work. Recently PFRP acquired and equipped a boat suitable for deploying small sensor packages and is capable of radio direction searches for package recoveries.
- Cold and dry storage facilities exist at Snug Harbor and on the UH Manoa campus.

4.2.1 Contributions to Research Milestones in NOAA’s 5-Year Research Plan

The existing CI (JIMAR) has contributed directly and indirectly to research milestones in NOAA’s five-year research plan. Many of these efforts span more than a decade of interactions with NOAA scientists. Here we highlight some of JIMAR’s main achievements in a wide range of endeavors. A detailed
description of research outcomes for prior themes can be found in the JIMAR Annual Report (http://www.soest.hawaii.edu/jimar/JIMAR_2010_annual_report.pdf). Prior year reports are available on request.

JIMAR has contributed to the goal of increasing adequate fishery and protected species stock assessments. JIMAR staff have collaborated with NMFS to improve knowledge of fish stock status both through participation in research groups within the NMFS PIFSC Fisheries Research and Monitoring Division (Fisheries Biology and Stock Assessment and Fisheries Monitoring programs) and via the efforts of the PFRP, which supports competitive research in support of the Western Pacific Fisheries Management Council.

JIMAR has supported research to improve understanding of factors affecting threatened, endangered, and protected species and the potential success of alternative remediation/management strategies. Highlights include staffing field camps that study the behavior of Monk Seal populations, testing techniques to limit longliner/sea turtle interactions and (through PFRP) assessing interactions between longline fishing vessels and Albatross.

JIMAR has provided access to human dimensions capabilities resident within UH Manoa’s Colleges of Social Sciences and Tropical Agriculture and Human Resources. We have supported faculty and graduate students in these fields and aid them in developing skills relevant to NOAA. Likewise, PFRP will continue its long-standing support of human dimensions research. This effort has extended beyond ecosystems issues to human dimensions of climate and weather variability as well, primarily through the Pacific El Nino/Southern Oscillation Applications Center (PEAC) as well as collaborations such as the Pacific RISA.

The UH Sea Level Center (UHSLC) is a prime component in the establishment and maintenance of tide gauges within the Global Sea Level Observing System. UHSLC contributes to climate and oceanographic research related to sea-level rise, regional sea level variability and extreme sea level events.

JIMAR has been active in supporting a sister NOAA program: the Pacific Islands Ocean Observing System (PacIOOS). SOEST maintains local observing networks (e.g., coastal radars, water quality sensors, wave buoys) in the coastal zone as part of HIOOS. JIMAR has contributed through infrastructure investments (wave buoys, moored current profilers) and graduate student support.

A collaboration among JIMAR oceanographers and meteorologists, Sea Grant specialists, UH social scientists, engineers and local water boards have developed interdisciplinary proposals to assess the future pressures on Hawaii water resources and policy responses.

JIMAR supports state-of-the-art ocean and atmospheric predictive modeling over a broad range of scales from weekly to seasonal to inter-annual. UH participants include SOEST faculty from Meteorology and Oceanography. External partners have been established through units such as the IPRC, which studies Asia-Pacific climate and impacts. IPRC efforts have been supported by U.S. agencies (NASA and NOAA Climate Program Office and NESDIS) as well as international partners (Japan and South Korea). The Climate Program Office has supported research on decadal climate prediction at JIMAR as well.

JIMAR’s Pacific ENSO Applications Center has developed sea level prediction schemes for the US Affiliated Pacific Islands on seasonal to inter-annual time scales. Recently we collaborated with scientists from the International Research Institute for Climate and Society in downscaling GCM projections to regional scales. These efforts will be expanded to other Pacific islands.

JIMAR coastal scientists are currently exploring ecological impacts of sea-level rise and climate change in Micronesia and Hawaii. New initiatives are included in the research themes section of this proposal.

JIMAR Fellows at UH and the Pacific Marine Environmental Laboratory (PMEL) currently collaborate on a study of carbon cycles using moorings in Kaneohe Bay, Oahu. UH also maintains the Hawaii Ocean
Time-series (HOT) site at Station Aloha north of Oahu. Ocean chemistry at this site has been documented since 1988. Recent discussions have proposed extending carbon cycle sampling to the Northwest Hawaiian Islands.

JIMAR’s origin lies in tsunami research. The original research on ocean bottom pressure sensors for tsunami measurement (precursor to the DART buoys) was conducted by Martin Vitousek in the mid-1970’s. UHSLC tide gauges are integral parts of the Pacific and Indian Ocean tsunami warning networks. We have supported (in concert with Hawaii Sea Grant) run-up modeling research at UH.

JIMAR scientists were deployed with NMFS scientists to the Gulf of Mexico during the Deepwater Horizon disaster. Our protected species staff were especially active in this event. We anticipate continuation of research and development of field tools for operations in the aftermath of that event.

JIMAR also has contributed to the NOAA research milestone of improved hurricane intensity forecasts through our interactions with the Hurricane Research Division of the Atlantic Oceanographic and Meteorology Laboratory (AOML).

JIMAR has seeded the development dispersion modeling of Volcanic Smoke and Haze (VOG), a Hawaii regional problem. VOG consists of sulfate aerosols developing from sulfur dioxide emitted by Kilauea Volcano. This effort contributes to NOAA’s Air Quality goal.

4.2.2 Integration with NOAA Mission Goals and Next Generation Strategic Plan

NOAA’s Vision of the Future is “Resilient Ecosystems Communities and Economies”. As a Land Grant public university with a Pacific focus, UH is well positioned to assist in the fulfillment of this vision through JIMAR and regional partners. We share NOAA’s mission of understanding and predicting changes in the areas of climate, weather, oceans, and coasts, sharing that knowledge and information with others and conserving and managing coastal and marine ecosystems and resources.

In addition to our UH and NOAA colleagues, JIMAR has collaborated with regional and local partners including the East-West Center, the University of Guam, the State of Hawaii, and Pacific Island governments. We have provided climate services (PEAC), a variety of programs in support of ecosystems management (PFRP and Task II collaborations with PIFSC) and training of professional meteorologists (National Weather Service Pacific Region Fellows and the International Pacific Training Desk).

JIMAR contributes to the four long-term goals of the NOAA Next Generation Strategic Plan and stands ready to expand its role:

1. Healthy Oceans. Marine fisheries, habitats and biodiversity are sustained within healthy and productive ecosystems. The University recognized the importance of fisheries to Hawaii and the Pacific by entering into an agreement (1940’s) with the then National Marine Fisheries Service in the Department of Interior by ceding land on behalf of the then Territory of Hawaii to establish the then Honolulu Laboratory adjoining the UH Manoa campus. The collaboration strengthened in 1991 with JIMAR assuming management of the PFRP and adding a fisheries oceanography research theme. This effort has grown to be two-thirds of our funding base and a major asset to the now PIFSC. We propose further integration of UH efforts in support of the newly established Papahanaumokuakea Marine National Monument and inclusion of greater participation of the Hawaii Institute of Marine Biology in our program.

2. Climate Adaptation and Mitigation. An informed society has the capability to anticipate and respond to climate changes and associated impacts. PEAC has taken on an expanded role in the Pacific basin in response to the needs of its customers. For example, PEAC researchers have devoted much effort recently to the issue of sea-level rise and its impacts. The primary mission of PEAC had been to develop seasonal-to-interannual (ENSO) climate forecasts. JIMAR also supports the Pacific RISA and other NOAA climate efforts such as PRIDE, the IDEA Center and PACSIS. JIMAR supports fundamental climate research through the Climate Program Office competitive grants programs.
3. Weather-ready Nation. Society is prepared for and responds to weather-related events. Through our tropical meteorology efforts, JIMAR performs basic research on the full range of tropical weather, especially hurricanes and regional weather phenomena. We train meteorologists for both Pacific-basin nations and the US National Weather Service. Embedded within the National Weather Service is the tsunami research program. We continue to support modeling and observations of tsunamis. This was the root function of the JIMAR predecessor, the Joint Tsunami Research Effort.

4. Resilient Coastal Communities and Economies. Coastal and Great Lakes communities are environmentally and economically sustainable. JIMAR recognized the importance of coastal processes and community resilience in 1999 when we proposed adding a new research theme in coastal research. We have supported interdisciplinary research on coastal issues and support several new initiatives at UH devoted to island resilience. UH has embraced this concept and stands ready to contribute in an expanded role.

4.3 Research Themes
The proposed science themes for the Pacific Islands Region CI complement the research strengths of the existing CI: ecosystem forecasting, ecosystem modeling, ecosystem-based management, protection and restoration of resources, equatorial oceanography, climate research and impacts, tropical meteorology, and tsunamis and other long-period waves. The existing CI includes fisheries oceanography and coastal research themes; these will be maintained within the proposed ecosystem and protected species themes. In the following subsections, we present a partial listing of potential research projects in the redefined theme areas that UH Manoa scientists would be interested in pursuing with NOAA colleagues.

4.3.1 Ecosystem Forecasting

Hawaii Regional Forecasting System Project (Brian Powell, Oceanography)
Despite their relatively small size, the Hawaiian Islands have a significant impact upon the atmospheric and oceanic circulations of the northern, sub-tropical Pacific. High volcanic mountains extending from the seafloor block the NE trade winds and Northern Equatorial Current, forcing them to squeeze between the islands and creating a wake that extends thousands of miles across the Pacific. Because the oceanic circulation is tightly coupled to the winds, climatic effects have the potential to alter the flows around the islands. Locally, these flows exert a significant influence upon the biology in the region, from nutrient production and availability to larvae of the managed fish stocks in the Hawaiian Islands. Ecosystem management in the region begins with the strong physical flows.

As part of the NOAA Integrated Ocean Observing System, the University of Hawaii is responsible for the Pacific Islands (PaciOOS). Ocean modeling forms a critical component of the system by integrating observations with the model to create full field estimates of the ocean system: circulation, temperature, salinity, etc. We operate a real-time, coupled, multiple-nested atmospheric/ocean (WRF/ROMS) state-estimation and prediction modeling system. For the ocean, we operate a daily assimilation, ensemble prediction, and observational impact (OSSE) system, over nested grids ranging from 4km around the island chain to 50m horizontal resolution on the South Shore of Oahu. We utilize all available observational data from sources including real-time HF radar radial currents, in situ autonomous gliders, Argo floats, satellite temperature and height data, as well as a variety of research vessels. These data are combined with a model to generate daily nowcasts and forecasts as well as quantify the impact from each observation.

This project produces: (i) daily 3-day hindcast (with all available observations assimilated) and 7-day forecasts for the main Hawaiian Islands; (ii) estimates of temporal and spatial forecast errors from the ensemble of predictions; (iii) daily quantification of how each observation contributed to the hindcast analysis for optimal observational studies and quality control, which is important when faced with limited observational budgets; (iv) estimates of the predictive skill of the system; (v) scientific model data disseminated to any user (via open web access); (vi) data products for general users to understand the
current and future ocean conditions around the islands; and, (vii) data in support of focused, federally funded studies in the region, as detailed below.

We are currently working with NOAA to examine the transport mechanisms for discarded military munitions along the west coast of Oahu in an effort to prevent items from coming ashore or entering the biological food-web. We utilize the modeling system to examine the spread of harmful land and freshwater bacteria into the ocean from strong rain events on Oahu. Circulation estimates around Hawaii provide a crucial component of the ecosystem that can be utilized by local NOAA offices including the Marine Protected Areas, Humpback Whale National Marine Sanctuary, Marine Debris Program, Fisheries, as well as regional biologists. Although we currently do not extend to the Northwest Hawaiian Islands National Monument, we have had discussions with NOAA employees who have voiced a need for such data. As the climate changes, the impact upon the islands remains unknown. Hawaiian coral ecosystems may face a daunting future as temperatures and oceanic pH increase. With such regional modeling capabilities, we will be able to assist NOAA biologists with estimates of the oceanic conditions that they will need to prepare for.

**Coral Reef Modeling (Robert Toonen, Hawaii Institute of Marine Biology)**

A key challenge in the effective management of marine ecosystems is translating from small-scale studies of distribution and dynamics to the regional scale of management action. In many marine ecosystems, including the Hawaiian Archipelago, there are extensive survey data of nearshore communities from multiple investigators, representing a huge investment of resources. Often, these data are underutilized and remain of limited use to managers. In the Hawaiian Archipelago, at least seven separate entities are engaged in surveys of coral reef communities, with varying degrees of coordination. The synthesis of these data to allow forecasting of ecosystem responses to anthropogenic exploitation and impacts requires integrated modeling approaches at multiple scales.

This study would build on an existing database and extend two existing models: the Coral Recovery Model (CRM) of stochastic coral recovery after disturbance and the Coral Mortality and Bleaching Output (COMBO) model of the synergistic impacts of increasing acidification and temperature on coral reefs. Two innovative modeling approaches (scale transition theory and fundamental niche modeling) will be used to extend this prior work to predict coral community composition and dynamics at the regional scale. Fundamental niche modeling uses multiple data fitting approaches (regression, machine learning, etc.) to describe the relationship between species and their environments, using a split dataset for training and validation. A niche modeling approach can generate a predictive and validated spatially continuous model of species distribution from discrete data points. The scale transition modeling will use the completed database of species distributions as the landscape on which species interactions occur. These interactions are described by a local model, here, based on recruitment, growth, and mortality from the Coral Recovery Model. In scale transition theory, the local model plus landscape information on the distribution and co-distribution of organisms and their environments predicts how a species assemblage responds (locally and regionally) to changes in biotic and abiotic factors on the landscape. Together, this novel approach to ecosystem forecasting will provide an unprecedented basis to manage coral reef ecosystems across the Pacific.

NOAA has responsibility for managing several of the new Pacific Monuments and is the primary entity responsible for ecosystem monitoring across the US-affiliated remote Pacific. On-going partnerships with the UH Mānoa will generate products directly relevant to management and forecasting responses of these ecosystems to anthropogenic stressors. In particular, the following products are currently under development for better ecosystem forecasting capabilities, and will have significant impacts beyond the immediate Hawaiian research community: (i) A Hawaiian Archipelago-wide GIS database of coral distribution, benthic community data, fish surveys, and other data gathered by such sources as the Hawai‘i Coral Reef Assessment and Monitoring Program (CRAMP), the National Park Service (NPS), various divisions in NOAA, the Hawai‘i Division of Aquatic Resources (DAR) into a single GIS database. (ii) A validated, predictive, and spatially continuous map of coral species distribution throughout the Hawaiian Archipelago. (iii) A validated Coral Recovery Model for coral reef mitigation in the Main Hawaiian Islands; this is an essential component to habitat equivalency analysis and any legal settlements for groundings, unpermitted run-off, and such that can be more broadly applied to the US-
affiliated Pacific Islands and beyond. (iv) Prediction of coral community response to climate change throughout the Hawaiian Archipelago, based on known and predicted coral distributions and the COMBO model.

**Connectivity and Metapopulation Structure of Marine Species (Kevin Weng, Oceanography; Kim Holland, Hawaii Institute of Marine Biology; Kelvin Richards, Oceanography)**

Most marine fishes, particularly commercially valuable species, have nektonic adults (that are able to swim from place to place) and planktonic larvae (that are carried by ocean currents). In order to maintain a sustainable fishery, we require a healthy spawning stock of adults, in a location where the larvae produced will successfully enter the population (and not be carried into unsuitable habitats).

PFRP-supported research is tackling problems at both ends of this spectrum. In order to understand where adult fish populations live, their migratory patterns and home range scale, PFRP researchers are undertaking tracking studies using sophisticated electronic tags, as well as conventional dart tags. Such studies will provide key input variables into models of population dynamics, spatial structure and mixing that are the basis of fishery management in the Pacific and around the globe. By providing home range and movement information, such studies feed directly into marine spatial planning initiatives, elucidating the relevant scales for managed areas such as MPAs to protect spawning stocks. PFRP-supported researchers are conducting these movement studies in pelagic, seamount and groundfish species in the Hawaii region, thereby covering all major commercial resources of the archipelago; and are collaborating with a major research initiative in the Western Tropical Pacific to understand species targeted by the purse seine industry, the largest tuna fishery on the planet.

At the other end of the size spectrum, PFRP-supported researchers are investigating the movement patterns of larvae to determine source-sink patterns and metapopulation structure. Such studies will reveal which adult spawning populations are successfully contributing to the population, and should be maintained as key spawning stocks, and which are sending larvae into unsuitable regions. Research to date has revealed that the movements of fish larvae are far more complex than would be predicted from ocean current patterns alone, likely because fish larvae are able to use vertical movements to select different currents, and also undertake surprising horizontal movements. Therefore, these studies are combining two disparate areas of science — state-of-the-art ocean circulation models, and larval behavior studies — to produce a better understanding of larval movement patterns.

**Predicting the Impacts of Fishing (Kevin Weng, Pelagic Fisheries Research Program)**

Mathematical models of fish population dynamics are used to manage fisheries, to predict how many of a particular species are in the ocean. The PFRP has supported projects to develop such models, including new tools for building models (Auto Differentiation Model Builder http://admb-project.org/); tailored models to estimate how many fish can be caught each year (Multifan-CL); large scale studies of the impacts of fishing on marine ecosystems; and software (TUMAS) to allow non-specialists to use highly technical models (allowing fishery managers faster access to information).

The stock assessment model Multifan-CL is now the workhorse of the international fishery management body for the Western and Central Pacific Ocean. At present, this model, and other stock assessment models (e.g., Stock Synthesis) used around the world do not directly incorporate the detailed movement data derived from electronic tags. PFRP-funded researchers are developing new methods to integrate electronic and conventional tagging data into modern stock assessment models. These new methods are anticipated to yield improved results as early as the 2012 stock assessments used for managing tuna fisheries in the western and central Pacific. Collaborators include John Sibert and Pierre Kleiber.

**Predicting the Impacts of Climate Change on Fish Stocks (Kevin Weng, Pelagic Fisheries Research Program)**

Ecosystem-based management is a major goal of NOAA. To successfully manage living resources, we must understand both direct and indirect effects, and how a change in one species or fishery might reverberate through the whole ecosystem. The PFRP has funded development of computer models such as SEAPODYM that describe the entire ecosystem, from climate to algae, to the animals that eat them—and the larger animals that humans like to eat. Such models will bridge the gap between single species
management and ecosystem-based management. Whereas traditional stock assessment tools use population dynamics models that are independent of climate, tools such as SEAPODYM are driven by physical forcing.

A key component of ecosystem models is the transfer of energy from physical forcing to primary production to high trophic levels (such as commercially valuable fish stocks). In order to successfully model these transfers, we must understand ocean food webs. Mid trophic levels are the link between algae and tunas, and yet are poorly understood at present. The PFRP has funded a series of projects on the food-web connecting tunas, billfishes, sharks, and their prey – information that is essential to building ecosystem models. These studies are using a combination of traditional stomach sampling and novel biochemical techniques to understand the pathways leading to commercial fishes.

The impacts of ocean acidification on coral reefs and pelagic primary producers have received much attention due to the importance of these resources. The impacts of changing pH on fishes has received comparatively little attention. PFRP-funded researchers are conducting controlled experiments to determine the combined impacts of decreasing pH and increasing temperature on the survivorship of tuna larvae. This information is critical to predicting pH-mediated changes in commercial fish stocks. John Sibert is a collaborator on this project.

**Humans as Part of the Ecosystem (Kevin Weng, Pelagic Fisheries Research Program)**

Humans have become the dominant apex predator and ecosystem engineer of planet earth, and therefore we must include ourselves in ecosystem models. In order to understand the human responses to changes in the ecosystem or in the governance of living resources, we must know the economic value of these resources and the social-cultural setting in which they are utilized. PFRP-funded researchers have conducted studies to determine how commercial fishers respond to various changes in governance (e.g., fishing regulations), and to quantify the direct and indirect economic value produced by fisheries. Collaborators include Ping Sun Leung, Sam Pooley, and Stuart Allen.

**4.3.2 Ecosystem Monitoring**

**Coastal Substrate Mapping (Geno Pawlak, Ocean and Resource Engineering)**

We propose to carry out high-resolution autonomous underwater vehicle (AUV) based sidescan sonar surveys (SSS) of coral reefs around the island of Oahu. The primary research objective for the proposed work is to resolve small-scale (sub-meter) roughness distributions over a contiguous stretch of tropical reef coastline. This data will allow characterization of roughness distributions for reef environments over a large area and will enable examination of spectral roughness signatures for various substrate classes. Based on our observations to date at Kilo Nalu, we hypothesize that the roughness in the reef environment can be characterized by a spectral distribution with a constant slope for coral covered regions, while sandy regions can be identified by high anisotropy associated with ripples.

While roughness mapping is the principle research goal, we also aim to provide high-resolution acoustic imagery that can contribute to a wide range of applications, with implications for Sustainable Coastal Development, Hazard Resilience, and Healthy Coastal Ecosystems. The surveys will generate a high quality dataset over a critical region of Oahu that can serve as a baseline for comparisons with later surveys to gauge effects of sedimentation, invasive species, natural (storms, tsunamis) and anthropogenic (spills, vessel groundings) events and climate change. We aim to apply existing methodologies for benthic classification using SSS, modified for locally relevant substrate classes and to compare results with existing (lower resolution) databases. We will further develop methodologies for before/after SSS assessments targeting natural or anthropogenic events. An important objective for the proposed work will be to carry out outreach activities with prospective partners to extend the value of AUV mapping capabilities and to examine new sampling methodologies that can address partner interests.

**Marine Animal Telemetry (Kim Holland, Hawaii Institute of Marine Biology)**

The ascendance of the ocean observing system (HIOOS and PacIOOS) and marine spatial planning concepts have served to highlight the role of marine animal telemetry in modern ocean sciences. In the first instance, animal-borne tags can augment oceanographic data acquired by more traditional (often
static) methods and, in the latter case, can provide "before and after" data concerning habitat use in locations being considered for purposes such as energy generation, aquaculture or the implementation of marine protected areas.

SOEST, through HIMB and JIMAR's PFRP, has a well-established record as a pioneer in the development and deployment of the sophisticated electronic tags on species such as tuna, sharks and reef fishes. This places SOEST/JIMAR/PFRP in an ideal position to play a lead role in future marine spatial planning and ocean observing projects. Easy access to both captive and wild animals will allow us to continue to develop, test and deploy new generations of tags designed to address the emerging questions of wise ocean stewardship.

_Coral Reef Monitoring Datasets (Robert Toonen, Hawaii Institute of Marine Biology)_

Human impacts on coral reef ecosystems are far-reaching, from coastal cities to remote atolls, but long-term data sets on reefs are scarce, especially in the remote Pacific regions where coastal development and direct anthropogenic exploitation are not confounded with global impacts of climate change. Where there are large coastal populations, combined stresses have generally led to dramatic shifts in coral reef community structure and often resulted in a transition from coral to algae dominance. These shifts in reef communities can be dramatic and, of greater concern, may be self-reinforcing alternative stable states, in which recovery to the coral-dominated state is hampered by positive feedbacks.

To address how coral reef ecosystem resistance and resilience vary along an environmental gradient, we need many ecosystems fully characterized for the range of environmental heterogeneity they experience. In particular, parameters such as water temperature, flow, irradiance, pH, sedimentation, nutrient levels, exploitation, pollution, coastal development, and so forth are needed, as well as the genetic and taxonomic diversity of corals, coral symbionts and the associated flora and fauna on the reefs.

This proposal will provide a powerful combination of observational and experimental approaches, advancing our understanding of the dependence of ecosystem function on the taxonomic, genetic, and functional diversity of reef ecosystems. We have long-term collaborative efforts with a number of NOAA partners that would benefit directly from continued ecosystem monitoring. These data would allow us to characterize: (i) the response of ecosystems to changing environments (e.g., How does coral growth rate vary within and between clones on a reef, and can growth differences be explained by fine-scale environmental variation?); (ii) ecosystem function (e.g., are reefs with greater genetic or species diversity more resistant or resilient to anthropogenic insults?); and (iii) ecosystem forecasting (e.g., can reef-to-reef patterns of change be predicted by dynamic forecasting models as outlined above?).

_The Near Shore Sensor System (Margaret McManus, Oceanography)_

The overarching goal of the 'Near Shore Sensor System' is to provide real-time monitoring of coastal waters. Observations have included temperature, salinity, pressure, chlorophyll a and light transmission. This system provides both (1) an early warning system that can indicate when our coastal environment is not safe for recreational and commercial use, and (2) long-term ecosystem monitoring data that can be used for ecosystem forecasting and ecosystem based management (when coupled with numerical models of the coastal environment), as well as provide critical information to climate scientists, and those concerned with the impacts of tsunamis and other long period waves on our coastal environment. Near shore sensors have been deployed in Hawaii as part of HIOOS, and in the Republic of the Marshall Islands (RMI), Federated States of Micronesia (FSM), Guam, Palau and American Samoa as part of PacificIOOS. A sixth sensor is planned for the Commonwealth of the Northern Mariana Islands (CNMI in conjunction with a NOAA Integrated Coral Observing Network (ICON) station. We are interested in expanding the network to other near shore sites, extending platform capabilities with the addition of new sensors, and collaborating on research projects that utilize the data for ecosystem monitoring.

_Using Deepwater Corals and Sponges as Biological Current Meters (Christopher Kelley, Hawaii Undersea Research Laboratory)_

Measurement of deepwater currents and determining how they interact with seafloor topography is both difficult and expensive to achieve due to the costs and technology required to adequately instrument deepwater sites. Current direction and intensity is believed to be one of the most important factors
determining where deepwater corals and sponges are located. These filter feeding organisms dominate hard substrate communities below 1000m and have evolved many different types of colony forms for capturing prey from the water column. Certain species of fan-shaped corals and asymmetrical hexactinellid sponges are of considerable interest because their colonies are rigid and appear to grow perpendicular to the prevailing current direction in order to optimize interception of potential prey organisms. This is particularly obvious in high density beds where virtually all of the corals and sponges are oriented in the same direction.

Colony orientations of these species are therefore providing records of long term current direction and in so doing, can be used as biological current meters. Submersible and ROV surveys can document hundreds of colony orientations per dive around and along topographic features of interest such as seamounts and volcanic rift zone ridges. These data can then be imported into a GIS project to visualize how water is flowing around these obstacles, and ultimately be used to groundtruth and improve deepwater flow models. It’s proposed here that the submersibles and ROV of the Hawaii Undersea Research Laboratory (HURL) be used to conduct coral and sponge orientation surveys on several of the Geologist Seamounts located approximately 100 miles south of Honolulu. Complex large scale gyres are known to form near the surface in this area, however, the nature of deeper currents below 500-1000m and how their flows are altered by the seamounts is unknown. In this project, the potential deep water flow around the seamounts will first be modeled, the output of which will then be used to select the most appropriate study sites for testing the model’s validity. If possible, ADCPs will be deployed at selected sites to further confirm the relationship between the flow and colony orientation.

Marine Debris Program (Nikolai Maximenko, International Pacific Research Center)
IPRC researchers are interested in pursuing a full-range of projects dealing with the distribution, monitoring, and prediction of marine debris. Specific research areas might include:

- **Shorelines as a sink of marine debris.** "Rocky" beaches in the Hawaiian Islands are known to accumulate marine plastic under layers of rocks. This project would dig into the rocks in an attempt to find "old" plastic in the deeper layers and to describe how the composition of plastic debris changes with depth and, therefore, with time.

- **Impact of debris from the March 11, 2011 tsunami on Midway.** The plume of debris from the March 2011 tsunami is currently drifting eastward. The first landfall impacts of the plume outside of Asia will be on Midway Atoll. Midway is located closer to the subtropical front than the main Hawaiian Islands and is subject to debris originating from Asia and other source regions. Observations of debris floating around Midway and washed onto its beaches provide a unique opportunity to assess the make-up and quantity of debris drifting towards the US mainland. This project could expand to include other island sites as well as a coordinated effort along the US West Coast.

- **Coastal dynamics of debris near Kamilo Beach.** The amount of debris on Kamilo Beach is highly correlated with the tide. High tides seem to reduce wave energy dissipation on reefs, thus allowing waves to transport debris from outside the reef all the way to the shoreline. However, what mechanisms cause the debris to retreat back to the ocean at low tide is not clear. There are also indications (both in debris observations and in models) of very strong along-shore jets induced by the tide. Near-shore release of recoverable drifters would help to understand these coastal processes.

- **Establishment of Marine Debris Center at UH.** Existing modeling capabilities at the IPRC can be transitioned into a real-time mode, which would improve our ability to serve multiple regional and global projects, users, and operations, including tracking marine debris, search and rescue, optimization of routes and voyages, coordination of ocean cleaning, etc.

### 4.3.3 Ecosystem-Based Management

**Investigating Open Ocean Food Webs (Jeffrey Drazen, Oceanography)**
Global fisheries are overexploited. In the USA, managers are now mandated to employ an ecosystem based approach which considers the interconnectedness of the entire exploited community. In the North Pacific, recent investigations have found reductions in the biomass of tunas and swordfish and increases in the abundance of lower trophic level predators. Theories as to the mechanisms behind such
community shifts require information on the feeding relationships between species. We are investigating the diet of these species to describe the food web of the open ocean pelagic environment. We seek to develop collaborations with NOAA to further develop food web models of large marine ecosystems and to use these models to assist in fisheries management strategies.

By using a variety of biochemical food web markers we have found that in the central North Pacific Gyre the food web, at depth, may differ from that in shallow water. Using bulk and compound specific stable isotope approaches, we have found that deeper water micronekton, small fishes, squids, and shrimps, are at higher trophic levels. In addition, our recent results have discovered that these deeper micronekton have higher mercury burdens so that much of the variability in mercury levels in commercially harvested top predators such as tunas and swordfish, can be explained by their foraging depth. By examining biochemical food web markers in particulate matter through top predators and across depths, we propose to investigate the mechanisms by which shallow water and deep water food webs are interconnected.

**Coral Reef Management (Robert Toonen, Hawaii Institute of Marine Biology)**

Marine reserves and protected areas (MPAs) are now accepted tools for managing and protecting marine resources and are beginning to be used for fisheries management. In the United States, marine reserves have been limited to a scattered set of research and recreational sites, primarily in California, Washington, Florida, and the Virgin Islands. The establishment of the Papahānaumokuākea Marine National Monument in Hawai‘i in 2006 and the new national marine monuments in the Pacific Remote Islands & Atolls, Rose Atoll, and the Marianas Trench in 2008 have made the tropical Pacific the focus of the largest and most pristine marine protected areas in U.S. waters, and some of the largest in the World. The formal recognition of the Papahānaumokuākea Marine National Monument as a world heritage site brings additional national and international focus to the science of large marine protected areas in the Pacific. Marine reserves and protected areas allow scientists to research how and why different species respond to protection and to provide data for species management. MPAs are sites where the effects of climate change and ocean acidification can be observed without the confounding influence of local anthropogenic stressors. The national focus on the science of marine reserves is largely confined to temperate waters despite the efforts in Florida and the Virgin Islands. With the formation of the new U.S. marine national monuments in the Pacific, there is an opportunity and need to enlarge our efforts in the science of tropical marine protected areas.

NOAA, the FWS, and state authorities have the responsibility for managing many of the Pacific MPAs. These authorities have engaged their scientists to provide benthic mapping, oceanographic studies, endangered species management, and other services for the Pacific MPAs; however, ecosystem sciences have been limited by personnel and resources. There is a great need for partnerships with management authorities to develop comprehensive ecosystem sciences for management of the Pacific MPAs. We have essentially created a research center for the scientific basis for ecosystem-based management of tropical marine protected areas through our combined research efforts over the past 5 years. We envision the University of Hawai‘i at Mānoa’s Hawai‘i Institute of Marine Biology, in partnership with the National Marine Sanctuary Program and the Coral Reef Conservation Program in NOAA could expand on our success to date and continue to develop ecosystem-based models for the predictive management of tropical MPAs in the Pacific and provide science-based information for the sustainable management of tropical marine resources.

HIMB has been providing scientific support for the ecosystem-based management of the marine areas within the Papahānaumokuākea Marine National Monument since 2005. The institute brings to this effort more than 40 scientists whose investigations with NOAA, FWS, and DLNR of the State of Hawai‘i have produced findings that have had a major impact on the management of the monument. To date more than 100 peer-reviewed manuscripts have been published, 50 post-doctoral and post-graduate students have been trained, and over 1000 news articles in the media have resulted from this partnership. We have just recently had a special issue of the *Journal of Marine Biology* focus on the results from these efforts and the Ecosystem-based Management of Pacific Islands (http://www.hindawi.com/journals/jmb/2011/si.empi/) was so successful that the journal has decided to make this an annual special focus issue. The United Nations University has just put forth a call for
changing the approach to coral reef conservation around the globe, and the partnership between the Hawai‘i Institute of Marine Biology and the Papahānaumokuākea Marine National Monument leads the globe in having successfully implemented many of the recommendations before they were even issued. UH Mānoa offers state-of-the-art facilities, research expertise, and experience unique to the Pacific demonstrating the potential for university-agency partnerships across the US-affiliated Pacific Islands to provide sound scientific data to inform ecosystem-based management.

4.3.4 Protection and Restoration of Resources

Protected species research has been an important and highly gratifying Task II activity in the current CI (JIMAR). Our scientists work closely with their NMFS (PIFSC Protected Species Division) sponsors in research to aid in the preservation of Hawaiian Monk Seals, Cetaceans and Sea Turtles. Especially notable have been JIMAR staff contributions in efforts to mitigate sea turtle interactions with the long line fishery of the central North Pacific. JIMAR Protected Species Division staff participated in the NOAA response to the Deepwater Horizon disaster. The leadership of this effort resides with the NMFS sponsors and we hope to continue to support these efforts.

**Vibrio vulnificus Detection and Prediction (Margaret McManus, Oceanography)**

According to the Centers for Disease Control, nearly 300 individuals in the United States have died from *Vibrio vulnificus* infections over the past decade. Excluding toxigenic *V. cholerae, V. vulnificus* is the most deadly species of vibrio with the majority of these infections and deaths in warm water states around the Gulf of Mexico and Hawaii. However, Hawaii leads the nation in per capita vibrio infections with an average of 1.65 per 100,000 each year, compared to the next highest, Louisiana at 0.72 per 100,000. Unfortunately, the rate of death from *V. vulnificus* infections has averaged more than 35% over the past decade. Toxigenic *V. vulnificus* resides in warm, coastal and brackish waters and has been shown to be sensitive to temperature and salinity. Human infections are typically through contact of marine or brackish water with open wounds or ingestion (swimming in contaminated waters, eating raw shellfish, etc.). Despite the pathways of infection being known, the current understanding of the ecology of *V. vulnificus* and its strains is lacking. Without even a first-order ecological assessment, risk assessment and prediction of potential harm to human activities is not possible. There are two primary strain types of *V. vulnificus* (ribotype A and B) with further genomic differences within those strains. Ribotype A has been found to be less toxic to humans than type B; however, the ecologies of the two are distinct.

We propose a coordinated, state-of-the-art laboratory, field, and ecosystem modeling experiment to quantify, observe, and predict the ecology of *V. vulnificus* strains. Because both strains are present year-round in the tropical waters around Hawaii, we are ideally situated for this study. The results of this study present a valuable opportunity to provide meaningful predictive skill to state and local policy makers to minimize human contact with waters at times and locations of high concentrations of virulent *V. vulnificus*.

This project will develop a more comprehensive ecology of the deadly strain of bacteria, *Vibrio vulnificus*, to develop an improved approach to predicting the abundance. Although the work is focused on the tropical waters in Hawaii, the results and methods are applicable around the world. The work bridges two areas of current emphasis in ocean sciences: 1) Oceans and Human Health and 2) Ocean Observing Systems. This transformative research coordinating laboratory, observing, and modeling provides a means to estimate *V. vulnificus* abundance using existing observing system techniques and methods without additional equipment. Only such an integrated effort can provide communities with reasonable estimates of the potential water hazards.

Because of the frequency and lethality of *V. vulnificus* infections in Hawaii, this project will contribute to the mitigation of a significant health issue. In addition, the observing and modeling components are leveraged against the Pacific Integrated Ocean Observing System, which maintains relationships with the city of Honolulu, State of Hawaii, US Army Corps of Engineers, National Weather Service, and US Coast Guard. Through these connections, we are able to keep all relevant agencies up-to-date on potential *V. vulnificus* threats.
Monitoring of Exploited Resources (Kevin Weng, Pelagic Fisheries Research Program)

Monitoring of exploited living resources is traditionally accomplished via the fisheries themselves. While this provides a much higher level of sampling than is possible through traditional scientific programs, it comes with major complications, since commercial fisheries are neither controlled nor designed. In order to utilize such datasets for ecosystem monitoring, the nuances of fisheries must be understood and the data corrected and normalized for biases. PFRP-funded researchers have conducted exhaustive review and analysis of raw fishery logbook data in order to produce corrected catch and effort time series that can be used by NOAA for stock assessment and management. These efforts have been undertaken for high value species such as blue marlin, important incidental catch species such as dolphin fish, wahoo, moonfish and pomphret, and key bycatch species that are of conservation concern, such as sharks. Collaborators include Mike Seki and Bill Walsh.

4.3.5 Equatorial Oceanography

The Joint Archive for Shipboard ADCP (Eric Firing, Oceanography)

The Joint Archive for Shipboard ADCP (JASADCP) at UH is a collaboration among the National Oceanographic Data Center (NODC), the National Coastal Data Development Center (NCDDC), and JIMAR (Eric Firing and Julia Hummon). It serves as the official NODC archive for processed shipboard ADCP data sets from domestic and foreign research ships, and presently includes data from over 1100 cruises. To our knowledge, it is the most complete single source of such datasets, and it is increasingly being used for regional studies of ocean currents. We plan to continue to support the JASADCP by supplying data, by encouraging other ship users to process and submit their data, and by providing software and advice to the JASADCP and to SADCP users. In particular we would like to help the JASADCP modernize and streamline its web presence and data access system, providing easy access to the full-resolution processed data in the standard NetCDF format.

TAO Mooring SADCP (Eric Firing and Jules Hummon, Oceanography)

An important side-effect of the TAO/TRITON equatorial Pacific monitoring program is the generation of a long time series of upper ocean current profile sections from the shipboard ADCP on the ships that maintain the moorings. We have collaborated with NOAA in monitoring and maintaining the instrument systems and software on the NOAA Ships Ka‘imimoana and Ron Brown, and in processing and archiving the data from the TAO cruises. These cruises are the primary source of information about sub-surface currents in the equatorial region—a complex circulation system that plays an important role in the ventilation of the eastern tropical Pacific Oxygen Minimum Zone, but the dynamics of which are only beginning to be revealed. Greg Johnson at PMEL is our primary NOAA scientific partner in obtaining and analyzing these data sets.

We would like to not only continue but improve the data return and analysis from the TAO cruises. Opportunities include:

- Installation of a 300-kHz ADCP to provide shallower coverage and higher resolution.
- Instituting routine high-frequency lowered ADCP measurements and/or microstructure measurements to study fine-structure and mixing in and above the equatorial thermocline.
- Augmentation of the moorings with deeper current measurements.

Firing and Hummon have a longstanding collaboration with the Honolulu NMFS lab in supporting the shipboard ADCP on the NOAA Ship Hi‘ialakai. As with the Ka‘imimoana and the Ron Brown, we propose to provide and maintain the data acquisition software and monitor the instrument systems. We look forward to a closer collaboration with NMFS in applying our observations and understanding of physical processes to their ecosystem and fisheries studies.

4.3.6 Climate Research and Impacts

Sea level Research and the UHSLC (Mark Merrifield, Oceanography)

UHSLC researchers have identified a new mode of sea level change in the Pacific associated with a prolonged period (since the early 1990s) of intensifying trade wind speeds. This pattern accounts for the “hot spot” of sea-level rise in the western equatorial warm pool region. Other aspects of the Pacific
tropical circulation are changing in response to the wind shift, including intensifications of the tropical surface gyre, the Equatorial Undercurrent, the Indonesian Throughflow, and Subtropical Overturning Cells. We intend to continue studies of the dynamics and implications of this variability using analyses of other datasets and model simulations. In addition, we hope to relate the recent tropical Pacific sea level changes with a similar increase in globally averaged sea level over the same time span.

Regional sea-level rise rates in recent decades along the US west and east coasts are significantly lower than globally averaged rates. Shifts in local and remote wind forcing are believed to account for the regional rate minima; however, the nature of the wind forcing and the remote and local wind-forced response have yet to be described in full. We propose to examine recent low sea level rates along these coastal boundaries in relation to long-term sea level records, and wind-forced model simulations on decadal and interdecadal time scales.

Extreme, short-term water level events generally are associated with storms, but also with less energetic sea level anomalies (ENSO, mesoscale eddies, wind-driven downwelling) that coincide with higher than normal tides. We have examined these forcing mechanisms using a global network of tide gauges and defined the relative importance of these high water level contributors on a regional basis. We next hope to include wave-driven setup as an additional source of high coastal water levels. Collaborations with NOAA wave modelers and wave buoy specialists are sought.

Risk and Vulnerability to Sea-Level Rise (Charles Fletcher, Geology and Geophysics)

In Hawaii, sea-level rise resulting from global warming is a particular concern. Riding on the rising water are high waves, hurricanes, and tsunami that will be able to penetrate further inland with every fraction of rising tide. In addition, the coastal groundwater table is likely to crop out above ground level and lead to widespread flooding. The physical effects of sea-level rise include:

- Marine inundation of low-lying areas including developed portions of the coast,
- Erosion of beaches, sandy shoals, atoll islets, and bluffs,
- Salt intrusion into aquatic ecosystems and coastal plain aquifer systems,
- Higher water tables leading to reduced drainage and other effects, and
- Increased flooding and storm damage due to heavy rainfall.

Assessing the impact of these in Hawaii and among other Pacific islands requires identifying a likely regional and local sea-level scenario as well as mapping the spatial and temporal threat of sea-level rise. There are a number of studies needed to assess the risk and vulnerability of human communities and natural ecosystems to these impacts.

Inundation and erosion of sandy shoals in the Papahanaumokuakea Marine National Monument. This region is highly vulnerable to sea-level rise that brings with it erosion of sandy features, marine inundation by high waves, tsunami, storm surge, and extreme tides. Sea-level rise has accelerated to the northwest of the main Hawaiian Islands and these effects threaten critical nesting and ecosystem habitat. Studies should include highly resolved mapping using LiDAR and application of geomorphic models of sand transport, historical aerial photography analysis, and monitoring using repeat surveys to document ongoing changes and impacts. Projected configurations of critical habitat may provide managers with improved ability to adapt to impacts associated with sea-level rise.

Food and water security among low-lying Pacific communities. In the tropical western Pacific the rate of sea-level rise has accelerated to over 1 m per century. High water levels associated with extreme tides and meteorological processes have already produced events of marine inundation that damaged the agro-forestry on low-lying atoll islets, caused salt intrusion to traditional taro and other wetland crops, and damaged groundwater resources that are critical to local communities. In 2009 the President of the Federated States of Micronesia declared a national emergency due to marine inundation and loss of food and water resources among dozens of island communities. These problems are going to grow worse with time and require the development of models projecting the temporal and spatial pattern of inundation in high resolution. Coastal erosion is a component of this problem that exposes freshwater aquifers to marine intrusion, leads to beach loss, and threatens community resources. To develop community-based
adaptation plans, it is important to have projections of inundation, erosion, and other types of vulnerabilities to sea-level rise. These would include detailed topographic and bathymetric surveys, assessments of aquifer characteristics, highly resolved datasets depicting historical rates of shoreline change, and model projections of future change. Intensive studies of a few locations would provide important datasets to managing the larger region.

Threats to urban development. As sea level rises among the main Hawaiian Islands, American Samoa, Majuro, Pohnpei, Chuuk, and other urban corridors, several types of processes threaten daily commerce, the quality of islander's lives, critical ecosystems that exist on the fringes of developed lands, and human infrastructure. Rising sea levels generally threaten coastal lands with direct inundation associated with seasonal large wave events, storms and tsunami, and extreme tides. Rising waters cause infrequent wave-related inundation to increase in frequency and impact; waves that previously caused only minor harm, with time, will lead to growing damage. Studies show that with only 0.6 m of sea-level rise, wave inundation that was historically timed at 15 to 25 year frequency begins to occur annually. Understanding how these processes will impact the urban coastal zone requires detailed mapping and modeling feeding into a community discussion of what features are threatened, what assets are valued, and identifying strategies to adapt to impacts. Geomorphic models of coastal processes can be applied to improving understanding of erosion, wave overtopping, and marine inundation that threaten properties, buildings, roads, and other types of community infrastructure. A key element of sea-level rise that is often overlooked in planning is the rise of the coastal water table leading to decreased drainage on low-lying lands. This problem will produce regions of standing water, essentially new wetlands located in urban settings that threaten daily activities on developed lands. Standing pools of water will develop on critical intersections and road segments bringing to a halt the traffic volume, evacuation efforts, and daily travel related to commerce. Thus, improving our understanding of groundwater processes on the coastal plain and the connectivity to the ocean and the processes of water table evolution in response to tidal, seasonal and event-based forcings, is a key element in adapting to the impacts of sea-level rise in coming decades.

In summary, managing the impacts of sea-level rise will require continued development of topographic, shoreline, groundwater, and water level datasets, improved modeling skill, and innovative combinations of these to resolve the problems faced by low-lying Pacific communities.

The Asia-Pacific Data-Research Center (APDRC) of the International Pacific Research Center (Kevin Hamilton, Meteorology)
The number and variety of observations and model-based products that are available to study Asia-Pacific climate have increased dramatically in the last decade, owing to recent international observational programs and to advances in satellite technology and modeling capability. Despite their availability, however, observational data and model products are often underutilized by researchers and the broader community interested in environmental data. The IPRC's APDRC works to increase the ease and efficiency by which users can find and access data. Toward this end, the APDRC has built and maintains a public server for web-based browsing and viewing of both gridded and non-gridded (in situ) data sets and products. This provides easy access for downloading data in their original formats and in user-friendly and assimilation-friendly formats. In addition the APDRC and IPRC research staff work towards producing their own model and observational data sets.

In the next few years APDRC will concentrate on (i) expanding its current data archives to include more climate-relevant satellite data and results form large field campaigns, (ii) generation of additional specialized data products in collaboration with IPRC researchers, and (iii) providing appropriate training in the use of climate data for undergraduate and graduate students as well as for a broader community of potential users of APDRC’s resources.

Climate Controls of the Tropical Cyclone (TC) Genesis, Rapid Intensification, and Tracks (Bin Wang, Meteorology).
Prediction of the most deadly TC storms on time scales beyond weather becomes a deep societal concern. The TC activity shows prominent intraseasonal, interannual, and interdecadal variations
associated with other modes of climate variability such as the MJO, ENSO, and IPO (interdecadal Pacific Oscillation). This research targets at understanding both the climate variability of TC activity and potential future projected changes under anthropogenic forcing with a geographic focus on the Pacific basin.

**Predictability and Future Change of the Global Monsoon (Bin Wang, Meteorology)**

There is no climate variability that will impose greater impacts on society than changes in monsoon precipitation which exists as the life blood of about two-thirds of the world’s population. We shall explore the fundamental dynamics that determine variability and future changes in global monsoon precipitation by using an integrated study of variations and changes across a broad time scale, from past to future.

**4.3.7 Tropical Meteorology**

**Ocean-Atmosphere Carbon Cycle (Eric DeCarlo and Roger Lukas, Oceanography)**

JIMAR currently supports a small program in carbon cycle research in partnership with Richard Feely of the Ocean Climate Division of PMEL. Special buoys have been maintained in Kaneohe Bay, Oahu. There have been discussions of expanding this program to include further instrumentation of the Northwest Hawaiian Islands as well as interactions with the Hawaii Ocean Timeseries (HOT) program, a multi-decade monitoring program at Station Aloha north of Oahu. Participants in the discussion have included UH chemical oceanographers, Principal Investigators of HOT and members of the Coral Reef Initiative. In response to specification of this as a science topic (under Tropical Meteorology) in the RFP, we are committed to expanding this program should NOAA support it further.

**Intraseasonal Predictability and Multi-model Ensemble Prediction of Madden-Julian Oscillation (MJO) (Bin Wang, Meteorology)**

The MJO is the most prominent form of intraseasonal variability in the tropics and a primary source of predictability for sub-seasonal variations, including those in the subtropics and extra-tropics. Prediction of MJO comprises many aspects of low-frequency weather modulation, including high impact events such as hurricanes, as well as tropical-extratropical interactions that can lead to extreme precipitation events, for example along the US west coast. Dynamical models have improved greatly in the past decade and a few models have produced rather credible simulations of the MJO, with evidence of useful prediction skill of the principal characteristics of the MJO out to a lead-time comparable to empirical-statistical schemes. Despite significant societal and environmental demands for accurate prediction of MJO and notable improvements in our ability to simulate the MJO, operational prediction of MJO and intraseasonal variability (ISV) is still in its infancy and its achievement seen as a great challenge faced by operational weather forecast centers.

**Hurricane Research (Gary Barnes, Meteorology)**

Over the next 2-3 years there are two collaborative experiments that JIMAR fellow Gary Barnes would like to conduct with colleagues at the Hurricane Research Division (HRD). Each experiment is designed to use about one hour of flight time and therefore fits easily into the requisite IFEX flight strategy currently being exercised.

The first experiment is designed to measure the sensible and latent fluxes through the top of the inflow boundary layer. The low-level inflow is the conduit for the warm equivalent potential temperature that is responsible for the low pressures of a hurricane. Flux divergence in this layer, or the losses or gains through the top of the inflow is an important part of the energy budget that needs to be determined to better understand how a hurricane intensifies. This flight plan includes the deployment of GPS sondes and several legs at different altitudes above and below the inflow layer top which is about 2 km thick. Key collaborator is Jun Zhang at HRD.

The second experiment is a circumnavigation of the eyewall. Changes in the eyewall radius, height of the convective clouds, updraft strength, rain rate and angular momentum gain and loss have been correlated with variations in the maximum sustained winds in the eyewall (intensity change). A circumnavigation of the eyewall with deployments of GPS sondes captures the low-level inflow traits and the radar and Doppler radar obtain the reflectivity and three-dimensional wind fields of the eyewall. The aircraft will fly
about 10 km radially outward of the eyewall at an altitude of 3 km. The key collaborator for this experiment is John Gamache of HRD.

**Vog Forecasting (Steven Businger, Meterology)**

The overarching object of this research is to develop accurate and timely volcanic gas forecasting capability with a program of verification based on best choice gas dispersion and wind models. In the process, we will develop measurement methods in near real-time to estimate the volcanic gas emission rate and will develop high-resolution 4-D wind fields as input for the dispersion model.

Emissions from the Kilauea volcano pose significant environmental and health risks to the Hawaiian community. The goals of the VMAP project are (i) to create accurate and timely volcanic gas modeling and forecast capability to predict the concentration and dispersion of SO2 and PM2.5 from the Kilauea volcano based on state-of-the-art gas dispersion and numerical weather prediction (wind) models, (ii) cooperatively develop operational near real-time volcanic gas emission rate measurement methods (e.g., UV FLYSPEC spectrometer arrays) for use as input to the dispersion model, (iii) cooperatively develop and deploy an array of stationary SO2 sensors to record the spatial characteristics of Kilauea’s gas plume in high temporal and spatial resolution to be used for verification and improvement of the gas dispersion forecasting, (iv) to develop an online data archive that comprises all existing volcanic gas concentration data and facilitate estimation of historical concentration frequency-of-exposure, (v) to characterize gas emissions from coastal lava flows entering the ocean for the purpose of establishing long-term monitoring, (vi) to disseminate forecasts via the web, providing guidance for safety officials to protect the public, and to raise public awareness of potential hazards of volcanic emissions to respiratory health, agriculture, and general aviation, and (vii) to provide technical support for researchers and health professionals. The stakeholders in this effort will collaborate in the development of the products disseminated by the project. These stakeholders include the Hawaii State Civil Defense, Hawaii Department of Health, Clean Air Branch, the Hawaiian Volcano Observatory, NOAA, and the National Park Service.

The Hybrid Single-Particle Lagrangian Integrated Trajectory (HY-SPLIT) model will be used to produce comprehensive statewide forecasts of the concentration and dispersion of volcanic emissions. Wind fields and thermodynamic data from the state-of-the-art Weather Research and Forecast (WRF) model, with a statewide resolution of 3 km and a resolution of 1 km covering the Big Island of Hawaii, will provide input for the HY-SPLIT model. A combination of remote sensing and in situ observations will be used to provide initial conditions regarding volcanic emissions for the dispersion model and to validate the model simulations. Three research improvements to be explored are i) a plume model to more accurately distribute the emissions in the vertical over the volcano vent, ii) implement wet processes in the model to improve the conversion rate from SO2 to SO4, iii) implement an ensemble model run to allow probability that a certain concentration will be exceeded at a point to be forecast.

**Tropical Pacific Testbed (TPT) for GOES-R Application Development (Steven Businger, Meteorology)**

The Pacific Region of the NWS covers an area more than four times the size of the continental United States, yet ironically it suffers from the greatest paucity of observational data of all six of the NWS regions. Therefore, the potential represented by the suite of GOES-R sensors to produce improved understanding and forecast services is greatest in this region of the NWS. JIMAR will collaborate closely with the PRH ESSD Chief to ensure that the products and services developed through this proposal will be made available to the entire Pacific Region and to the Joint Typhoon Warning Center (JTWC). The Tropical Pacific Testbed (TPT) will focus on three forecast challenges that are critical to the tropical Pacific by targeting applications and products that will help improve i) flash-flood forecasting, ii) tropical cyclone intensity and iii) support for aviation including detection and modeling of deep convection and volcanic plumes (ash, SO2 gas and sulfate aerosols). The focus of the UH effort will be on blended GEO-LEO products enabled by the xband and in using polar satellite data to validate and enhance GOES-R products. The TPT will coordinate and accommodate a visiting scientist program and actively facilitate transition of algorithms/products from the Algorithm Working Group (AWG) to operations in the Pacific Region. NWS HFO staff agrees to be focal points and to look at the products in real time, during their
forecast preparation. High impact weather events over the wider Pacific region will be targeted for TPT demonstration where appropriate.

Next Generation Hurricane Balloon: LAMP (Low Altitude Measurement Platform) LAMP is a low cost, long term, simple to use balloon system that would be used in large numbers to provide information from “data poor” regions in the Atlantic. Data from LAMP would be used to help understand and characterize the evolution of the energy content of the low marine boundary-layer inflow to hurricanes, its relationship with hurricane intensity changes, the influence of ocean temperature, and estimates of surface fluxes. Measurements that LAMP would make just above the ocean surface include:

- Balloon position (Latitude, Longitude and Altitude)
- Wind speed
- Wind direction
- Barometric pressure
- Air temperature
- Relative humidity
- Sea surface temperature
- Solar radiation
- Other sea surface measurements

The LAMP feasibility research and testing is intended to help develop a measurement platform that would make long term, low cost measurements in the low surface layer of the atmosphere (30 to 70 meters above the ocean). To do this requires a lift platform capable of closely controlling altitude near the ocean surface under varying winds and weather conditions. This needs to be done taking into account the need for safety. The LAMP balloons would be equipped with an independently operated fail-safe device that would deflate the balloon if the altitude exceeds its intended operating altitude, if it approaches land, if it receives a terminate command, or if it loses communications with the payload electronics.

A simple way to precisely control the altitude of a lift platform near the water surface is to attach a ballast buoy or buoyant rope with a weight that is greater than the net lift of the platform/payload. The net lift of the platform must be enough that loss of lift over time due to helium permeability of the balloon wall, changes in atmospheric conditions, and loading from rain and condensation leave the balloon/payload with positive net lift.

4.3.8 Tsunamis and Other Long-Period Ocean Waves

*Infragravity Waves and Harbor Seiches (Douglas Luther, Oceanography)*

Sea surface infragravity waves at periods from minutes to hours can amplify the destructive effects of tsunamis and short-period swell events at the coast and in harbors. Of special concern are infragravity modes, or seiches, that are trapped to the coast or exist within harbors, and that can resonate, producing amplitudes far higher than expected given the amplitudes of the initial forcing events. Harbor and coastal seiches have been found to be excited at many locations in the Hawaiian Islands by either tsunamis or swell events. Indeed, the study of the modes excited by tsunamis has been helpful in our development of hypotheses for the behavior of infragravity waves in harbors under forcing by swell events.

However, using data archived since 1997 under the JIMAR-supported Archive of Rapidly-Sampled Hawaiian Sea Level, we have found for at least one Hawaiian harbor, Haleiwa on the north shore of Oahu Is., that the excitation of the harbor’s seiches by tsunamis and small amplitude swell events does not provide an understanding of the harbor’s infragravity wave response under forcing by large amplitude swell events. Such a finding has a profound impact on our ability to predict dangerous harbor conditions, and it begs further investigation of the physical mechanisms responsible for the observed non-modal, high amplitude infragravity wave excitation. The applicability of these findings to other harbors, in Hawaii and elsewhere, will also be investigated.
**Tsunami Modeling (Kwok-Fai Cheung, Ocean Resource Engineering)**

Most researchers consider tsunamis as non-breaking long waves despite clear evidence of dispersion, breaking, and bore formation during the 2004 Indian Ocean and 2011 Tohoku-oki Tsunamis. It is not well understood how these processes influence tsunami impacts on coastal communities. In addition, the time history of seafloor deformation needs to be considered in modeling tsunami generation and near-field wave conditions. The Non-hydrostatic Evolution of Ocean Waves (NEOWAVE) model builds on the nonlinear shallow-water equations with a vertical velocity term to account for dispersion in tsunami generation and propagation and a momentum conservation scheme to describe flow discontinuities associated with breaking waves and bores. The vertical velocity term also facilitates modeling of tsunami generation from seafloor deformation for accurate description of the earthquake rupture process. NEOWAVE utilizes a staggered finite difference scheme with two-way nested grids to describe processes of different time and spatial scales.

At the 2009 Benchmark Challenge of the Inundation Science and Engineering Cooperative Workshop sponsored by the National Science Foundation, NEOWAVE correctly reproduced the energetic breaking waves and hydraulic processes over a complex reef system in the Tsunami Wave Basin at Oregon State University and won the competition from more than 10 numerical models developed in the US and Europe. The National Tsunami Hazard Mitigation Program (NTHMP) has recently held a benchmarking workshop for tsunami inundation models. NEOWAVE once again demonstrated its capabilities and robustness, and has been approved by the NTHMP committee as an official model for inundation mapping in the US and its territories. NEOWAVE has been used in the Tsunami Mapping Project of Hawaii, and recently been released to the tsunami research communities in Chile through the Chilean Navy Hydrographic and Oceanographic Service (SHOA). In addition, NEOWAVE has been the primary model for tsunami mapping along the U.S. Gulf coast and will be used in the Puerto Rico and American Samoa mapping projects as well.

The development of NEOWAVE provides alternative research directions in tsunami studies. It is one of the first models to include generation, dispersion, breaking, and bore formation in the evolution processes of both distant and local tsunamis. The shock-capturing, dispersive wave model allows investigation of tsunami resonance over shallow shelves and embayments with proper dispersion properties, and examination of bore propagation over shallow reefs in tropical island environments. Recent collaboration with seismologists has led to further understanding of earthquake rupture mechanisms. Improvement of dispersion properties in NEOWAVE will further extend its capability to examine undular bore propagation as observed in the 2004 Indian Ocean and 2011 Tohoku-oki Tsunamis.

### 4.4 Education

#### 4.4.1 Integration of Students and Post-Docs into Research

JIMAR has and will continue to support student and post-doctoral education via both its Task I activities and individual projects within Tasks II and III. These activities are essential to the function of UH Manoa as a whole. JIMAR has supported these activities from its creation.

Post-doctoral fellows have been a successful component of JIMAR from the start, with some transitioning to either UH or NOAA positions. In recent years limited budgets have reduced our capability to support post-doctoral researchers from Task I. Nevertheless, we intend to pursue post-docs as a particularly effective way of fostering collaborations between UH and NOAA PIs.

Graduate and undergraduate students have been supported in a variety of projects and capacities and again some have migrated to NOAA careers. A good example is the National Weather Service Fellowship supported through NWS funds. This program was established by NWS and UH/SOEST in the 1990's as part of the move of the Honolulu Forecast Office to the Manoa campus. Most of the Fellows have been MS students in Meteorology who have moved to careers within the Weather Service.

For many years JIMAR and the Hawaii Sea Grant College Program jointly have supported graduate students in tsunami modeling. One of these students is now a post-doctoral researcher at PMEL.
Several students have benefitted from our collaboration with the Hurricane Research Division (HRD) of AOML. The HRD Director, Dr. Frank Marks, is a JIMAR Fellow. Our students, primarily working with JIMAR Fellow Gary Barnes of UH, have been able to participate in research flights and use HRD data in thesis/dissertation research. Six MS theses and one PhD dissertation have resulted from this collaboration. One HRD employee completed her MS with UH Meteorology.

In the past five years JIMAR has supported an average of 26 undergraduate and 19 graduate students annually.

NOAA scientists (primarily at PIFSC) serve as affiliate faculty in UH graduate programs and make substantial contributions to graduate education at UH. We expect these collaborations to flourish in the future. These scientists include JIMAR Fellows.

The Research Corporation of the University of Hawaii (RCUH) provides educational support for its employees as well. RCUH employees are eligible for tuition assistance and employees of JIMAR have made frequent use of this opportunity. A number of employees are graduate students at UH.

4.4.2 Outreach and Education Activities in Support of Research Themes

JIMAR supports initiatives reaching out to minorities. Unfortunately, current definitions used by the NOAA Office of Education preclude UH/JIMAR access to most NOAA program funds. Nevertheless, JIMAR has supported interdisciplinary efforts in Earth science education of native Hawaiian students through an initiative in Hawaiian Language Newspaper translation. While targeted at filling gaps in the historical record of 19th century weather, climate, and geophysical events, this initiative has spawned curriculum development in teacher training and invigorated Hawaiian language study as well.

The CI will work closely with outreach offices within SOEST and the Hawaii Sea Grant College Program. JIMAR supports the Hanauma Bay Lecture Series, the SOEST Open House and the Ocean Sciences Bowl among other ventures. We also will continue to work closely with outreach efforts by HIOOS and PacIOOS.

4.4.3 NOAA-related Education Programs Offered

The University of Hawaii at Manoa is a research-intensive, comprehensive university offering education in a broad range of NOAA-related disciplines. These range from physical and biological sciences through the social sciences. Degrees offered span baccalaureate through PhD.

The interests of NOAA are broad and any listing of all relevant degrees at UH may be inadequate. We list the most obvious degrees below. Most of these programs have trained JIMAR/RCUH employees or have had students and faculty supported by NOAA funds.

Colleges of Arts and Sciences
- Biology (BA, BS in Biology, BS in Marine Biology)
- Botany (BA, BS in Botany, BS in Ethnobotany, MS in Botany, PhD in Botany)
- Economics (BA, MA, and PhD in Economics)
- Geography (BA, MA, and PhD in Geography)
- Information and Computer Sciences (BA in Information and Computer Sciences, BS, MS, and PhD in Computer Science)
- Zoology (BA, BS, MS, and PhD in Zoology)

College of Engineering
- Civil and Environmental Engineering (BS, MS, and PhD in Civil Engineering)

School of Ocean and Earth Science and Technology
- Geology and Geophysics (BA in Geology, BS, MS, and PhD in Geology and Geophysics).
- Global Environmental Science (BS in Global Environmental Science)
- Meteorology (BS, MS, and PhD in Meteorology)
• Ocean and Resource Engineering (MS, PhD in Ocean and Resource Engineering)
• Oceanography (MS and PhD in Oceanography)

College of Tropical Agriculture and Human Resources
• Natural Resources and Environmental Management (BS, MS, and PhD in Natural Resources and Environmental Management)
• Plant and Environmental Biotechnology (BS in Plant and Environmental Biotechnology).

4.5 Business Plan
4.5.1 Organizational Structure
Activities at JIMAR will be organized into three tasks.
• Task I activities will involve the management of JIMAR as well as general education and outreach activities. The task also will include support of the visiting scientist program.
• Task II activities will include research activities involving on-going direct collaboration with NOAA scientists which will often be fostered by the collocation of federal and JIMAR employees in NOAA facilities.
• Task III activities will involve minimal collaboration with NOAA scientists and includes the Pelagic Fisheries Research Program (PFRP). Task III will also include research funded by other NOAA competitive grant programs.

In accord with the NOAA Cooperative Institute Interim Handbook, the proposed organizational structure of JIMAR includes a director; senior fellows; two advisory boards representing senior management officials (Executive Board) and scientists (Council of Fellows) from JIMAR, the University of Hawaii, and NOAA; and an administrative services unit. The responsibilities of each are described below.

4.5.2 Director
The Director of JIMAR is responsible for the scientific leadership of JIMAR and is expected to contribute actively to the development of research programs, and to involve local and visiting scientists in JIMAR activities. The director will be a regular member of the University of Hawaii faculty and appointed through joint decision by UH and NOAA leadership. The director will report to an Executive Board composed of University and NOAA Officials and serve as ex-officio member of that Board. The director will manage day-to-day operations through the administrative staff, a deputy director for PIFSC-collaborative projects, program managers, and faculty PIs/directors.

4.5.3 Senior Fellows
JIMAR Senior Fellows are scientists of established national or international standing who hold faculty appointments in the University, or who are staff members of NOAA holding authorized NOAA billets. Their assignment as JIMAR Senior Fellows requires the concurrence of both parent organizations. In making these assignments, the University and NOAA will take into consideration the advice of the Council of Fellows and the recommendation of the JIMAR Director. Senior Fellows are normally appointed for three years and may be reappointed.

Visiting Senior Fellows are appointed by the University after approval by the Council of Fellows, and recommendation by the JIMAR Director. Their selection is based on JIMAR program needs and upon scholarly criteria. Visiting Senior Fellows are normally given appointments for one year, but may be renewed upon approval of the Council of Fellows.

4.5.4 Advisory Boards: Executive Board and Council of Fellows
The Executive Board will consist of senior management officials from JIMAR, the University of Hawaii, and NOAA. The Board will be responsible for providing advice and recommendations to the JIMAR Director concerning management and budgetary issues. The Board also will evaluate JIMAR programs and activities, recommend new program directions, and review general policies of JIMAR and initiate appropriate recommendations. The Board also will be responsible for recommendations for the JIMAR
Directorship and changes to the Memorandum of Understanding (MOU) between the University of Hawaii and NOAA.

The Council of Fellows will consist of mid- and senior-level scientists from JIMAR, the University of Hawaii, and NOAA. It will be comprised of three (3) members from the University of Hawaii, three (3) members from NOAA, and the JIMAR Director. Its role will be to ensure that high-quality scientific research is being conducted, promote cooperation between UH and NOAA, and to help identify other research opportunities that will maintain and enhance the current research program. The Council will also advise the director of major expenditures on visiting scientists, the selection of and renewal of Fellows, and adoption of appropriate rules for the operation of JIMAR.

4.5.5 Fiscal and Human Resource Management

JIMAR’s Administrative Services Unit, under the direction of the JIMAR Director, will be responsible for the administrative operations for the institute. The unit will be comprised of Administrative Services Managers who are responsible for the day-to-day administrative operations, a Personnel Services Specialist, and several Administrative Services Associates. The Administrative Services Unit will be responsible for pre- and post-award administration including, but not limited to, proposal review and submission; fund oversight and management; and maintaining compliance with institutional policies and procedures, as well as award terms, conditions, and federal assistance (grant) regulations.

Fiscal transactions including purchasing, travel, visiting scientist invitational travel, subcontracts, service agreements, reimbursements, and payments will be initiated, processed, reviewed, approved, and reconciled based on established policies, procedures, and guidelines established by the University of Hawaii and RCUH. The majority of fiscal transactions will be processed through the RCUH. The RCUH is akin to a service bureau and, because of its exemption from state statutes such as those relating to procurement and personnel, it has the flexibility to process transactions expeditiously. This makes it possible for research activities to operate more efficiently. The administrative unit will also provide principal investigators with budget status reports and projections on a regular basis in order to adequately track, plan, and forecast financial requirements of individual projects. The SOEST Fiscal Office will provide guidance and general oversight on fiscal related matters including sub-recipient monitoring, compliance, and audit.

JIMAR will have two options available for employing staff. Most employment for the institute will be handled through RCUH. The remaining employees will be employed through the State of Hawaii/University of Hawaii (UH). Both employment methods offer various employment classifications to meet the needs of the institute and comprehensive benefits plans for regular employees.

The RCUH personnel system is very flexible and responsive, allowing the institute to recruit, attract, retain, and reward valuable employees. Working with RCUH, JIMAR has been able to develop several “in-house” programs and policies including a deployment compensation and accumulated time off policy for field personnel, an outstanding performance award program, a hardship allowance policy, and a policy for alternative work schedules and telework.

Graduate Research Assistants will be employed through the State of Hawaii/UH through 50% FTE appointments that currently include a tuition waiver for the appointee.

Both RCUH and UH employees will have the opportunity to enroll in classes at the University of Hawaii with no charge or on a reimbursed basis. Institute employees also are recognized in a variety of ways including service awards, employee of the year nominations/awards, and nomination for NOAA’s team member of the month/year. Opportunities for training are available to employees. Training both locally and out-of-state allow employees to develop and grow professionally in their jobs as well as to network with other individuals with similar backgrounds.

4.5.6 Strategic Planning and Accountability

A CI serves two institutions, NOAA and their parent university, each of whom engage in multiple strategic planning efforts. The research agenda is driven by NOAA’s strategic plan. NOAA has engaged the CI’s in
their strategic planning exercises. CI Directors attend the Senior Research Council (OAR) Meetings, meet annually with the NOAA Research Council and, individually, attend strategic planning town hall discussions at scientific meetings. Within the CI, planning involves the director, the Executive Board, and the Council of Fellows. The director contributes to strategic planning within the academic unit hosting the CI. The strategic interests of NOAA and UH SOEST are similar.

The director serves at the pleasure of the Executive Board. On a day-to-day basis, the director reports to the Dean of the School (SOEST).

4.5.7 Selection of Projects, Progress Review, and Supporting Enhanced Communication and Collaboration with NOAA

Projects may be proposed by either NOAA or University partners. NOAA line offices may support projects at the CI under any of the approved research themes. Funds primarily come from NOAA line offices under Task II or via competitive awards through Task III. The director has limited discretionary funds that may support internally-supported projects. The sources of these funds are contributions to Task I from Task II, and indirect cost recovery from Task III awards. Some historical examples include:

- ESRL/ Mauna Loa Observatory approached JIMAR with an interest in collaborating to expand the scope of research at the observatory. JIMAR agreed to support the project and the relationship has flourished.
- JIMAR approached the Hurricane Research Division (AOML) about collaborative efforts in hurricane research. HRD was receptive and JIMAR supported exchanges between UH and HRD using discretionary funds. Further funding from NSF became available and the effort grew. Six (6) MS and one (1) PhD have resulted from this effort. One JIMAR Fellow (Gary Barnes) is qualified to fly as Chief Scientist on HRD hurricane research missions.

Progress review is part of the annual report process as well as individual reports for competitive awards. NOAA also will conduct an onsite review during the five-year term of the CI award to determine scientific and administrative performance for purposes of continuation or termination of the CI.

Time, distance, and complexity necessitate the use of telecommunication to enhance communication and collaboration. As the Advisory Boards are established, we propose regular meetings via Skype or other appropriate video technology. Many NOAA facilities have videoconferencing capabilities as does the National Weather Service Forecast Office on the UH Manoa campus. This could serve as a venue for regular meetings.

The CI Directors communicate through a list serve created at OAR and it was announced at the recent CI Directors Meeting that under the leadership of the new CI Program Manager, regular conference calls will be held. The CI Administrators will also have regular conference calls on administrative matters. NOAA has a Pacific Islands Regional Collaboration Team and JIMAR has participated in this group, and remains willing to do so in the future should the opportunity arise.

4.6 Performance Measures

JIMAR will deliver to NOAA a copy of its annual report. The annual report covers JIMAR research activities as well as its research progress and results. We shall report the number of students supported, the diversity of our students, and our professional work force. We also will track and report on the migration of our students and staff into the NOAA workforce. Additionally, we will report our contributions to performance metrics specified in NOAA’s five-year research plan.

Individual major projects funded under various tasks will provide NOAA with comprehensive reports and copies of any publications derived from research results as requested.

Visiting scientists will provide lectures and seminars on their areas of research in residence.
6. VITAE

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University of California, Berkeley  Physics   AB, 1982

Appointments
Oceanography, University of Hawaii  Professor   2004-present
Oceanography, University of Hawaii  Associate Professor  1999-2004
Oceanography, University of Hawaii  Assistant Professor  1997-1999
Ocean Engineering, University of Hawaii  Assistant Professor  1994-1997
Scripps Institution of Oceanography  Assistant Researcher  1993-1994
Scripps Institution of Oceanography  Project Scientist  1991-1993
Mathematics, Univ. of New South Wales  Research Associate  1989-1991
Scripps Institution of Oceanography  Research Assistant  1982-1989

Recent Publications


**Courses Taught**
Topics in Oceanography (Data Analysis) OCN 760, cross-listed as Probability and statistics for ocean engineers ORE 608.
Physical Oceanography OCN 620.

**Other Activities**
Director, University of Hawai'i Sea Level Center
Chair, Global Sea Level Observing System, Group of Experts
Lead, Waves & Water Level Component, Hawai'i Ocean Observing System (HiOOS)
Member, Jason Science Working Team
Member, NOAA Climate Observations Panel
7. CURRENT AND PENDING SUPPORT

Current Research Projects:

1. Effects of Sea Level on Wave-Driven Inundation for Reef-Fringed Shorelines, NSF, Award #OCE-0927407, PI, 3 investigator months over 3 years, $1,584,380, 9/15/2009-8/31/2012.

2. The University of Hawaii Sea Level Center, NOAA, Award #NA09OAR4320075, PI, 1 investigator month, $1,470,999, 7/1/2010-6/30/2011.

3. Pacific Region Integrated Climatology Information Products (PRICIP), East West Center, Award #HC12562, Amd. 1, PI, $120,000, 10/1/2009-3/31/2011.


5. PILOT Coastal Run-up and Fringing Reefs, UCSD, Award #PO 10306151, PI, 1 investigator month, $191,000, 9/1/2009-8/31/2011.

Pending Research Projects:


2. The University of Hawaii Sea Level Center, NOAA, PI, 1 investigator month, $1,371,000, 7/1/2011-6/30/2012.