Coastal Hazards:
Looking to the Past, Planning for the Future
Ka Pili Kai

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As the only state entirely surrounded by the ocean, Hawai‘i faces numerous unique challenges. As history has shown, coastal hazards such as tsunamis, coastal storms, hurricanes, and chronic coastal erosion have the potential to devastate our coastal communities and cause widespread loss and destruction. In this issue we are pleased to share just a few of the significant accomplishments we have made in this area in recent months, including our work on Hawai‘i’s tsunami inundation maps; the implementation of the NOAA Coastal Storms Program in the Pacific Islands region; efforts to map areas prone to coastal erosion; outreach and training efforts in the Republic of the Marshall Islands to assess local vulnerability to sea-level rise; and much more.

Cindy Knapman
Communications Leader
Hawai‘i experienced five statewide destructive tsunamis with 234 deaths during the last century. This unfortunate experience led Hawai‘i to become the first state in the United States to develop and implement tsunami evacuation maps for emergency management. During a tsunami warning, evacuation in potentially affected areas is mandatory and enforced by police. The four county civil defense agencies, in collaboration with Hawai‘i State Civil Defense, published the first generation of tsunami evacuation maps in 1991. The evacuation maps reflected the inundation inferred from run-up records of the five destructive tsunamis during the last century as well as the coastal land use and enforcement resources at the time. The national effort to develop tsunami evacuation maps subsequently began in the late 1990s.

The rapid coastal development in many parts of Hawai‘i and advances in numerical modeling and data collection techniques make it necessary to update the tsunami evacuation maps regularly. The University of Hawai‘i, through a memorandum of agreement with Hawai‘i Department of Defense, is developing the tsunami inundation maps for the state. This multi-agency effort with federal and state funding involves the National Tsunami Hazard Mitigation Program, Hawai‘i
State Civil Defense, and the county civil defense and emergency response personnel. The project continues to use the five destructive tsunamis as the basis in map development, but utilizes the latest topography and bathymetry, Geographical Information System and Google Earth technologies, and two-dimensional numerical models that can describe tsunami propagation from the sources at the Pacific Rim to the Hawaiian Islands.

An important part of the project is the development of an accurate digital elevation model (DEM) for the six major Hawaiian Islands. Extremely useful are the high-resolution LiDAR (Light Detection and Ranging) datasets from 40 m water depth to 15 m elevation and the School of Ocean and Earth Science and Technology multi-beam data along the island chain. The project term verified the datasets through geo-referencing with topographic maps, nautical charts, and aerial photos; removed or corrected data due to instrumentation and post-processing errors; and filled the gaps with data from private organizations, hydrographic and land surveys, and digitization of maps and charts. The rectified datasets were then merged with the National Elevation Dataset and global topography through a common datum. It is rather trivial to adjust the water level in the DEM to account for tidal

Spreckelsville Beach, Maui, March 9, 1957. A tsunami was generated by a magnitude 8.3 earthquake in the Aleutian Islands. Waves of up to 12 feet were reported in the Hawaiian Islands.
fluctuations and long-term sea-level increase for any application.

Hawai'i has 1475 km of coastlines for the six major islands. The mapping project covers approximately 1000 km of coastlines with nearshore population and infrastructure. The project team has completed the tsunami inundation maps for O'ahu and Hawai'i Island and is currently working on Maui. Hawai'i is the only state that conducts peer reviews of the tsunami inundation maps by an independent panel of scientists prior to their distribution to the counties for implementation. The Honolulu Department of Emergency Management coordinated the effort to update the evacuation maps and conducted a series of public meetings before their official release on August 27, 2010. The Hawai'i County Civil Defense Agency is currently updating its evacuation maps for publication in early 2011.

The mapping project has improved public safety as well as enhanced our knowledge base for multi-hazard assessment. The statewide DEM provides a valuable resource for coastal planning and flood hazard assessment in Hawai'i. The Federal Emergency Management Agency and Hawai'i State Civil Defense utilized the DEM to develop the inundation scenario for the Hawai'i Catastrophic Hurricane Response Plan, while the US Army Corps of Engineers is using the data to develop the capability to provide real-time forecasts of storm inundation at Hawai'i's coastlines. With additional support from the University of Hawai'i Sea Grant College Program and the National Science Foundation, graduate students in ocean and resources engineering have developed a new generation of coastal processes and inundation models for fringing reef environments. These models and the DEM will provide tsunami and storm inundation scenarios in Hawai'i for projected sea levels under the NOAA Coastal Storms Program. The model developed with Sea Grant support has been implemented for tsunami inundation mapping in Hawai'i, the US Gulf Coast states, Puerto Rico, Chile, and American Samoa.
The NOAA Coastal Storms Program (CSP) is entering the Pacific Islands region this year as part of a federal initiative to improve coastal community hazard resilience. The CSP is part of a nationwide NOAA effort to assist coastal communities decrease the negative impacts of coastal storms on families, communities, the environment, natural resources, and property. To accomplish this goal, local, state, and federal organizations form a team that focuses on a targeted coastal region for a specific time period (three to four years), then the program transitions into a different region.

To date regional CSP pilot programs have focused on Florida, the Pacific Northwest, Southern California, and the Gulf Coast. The Pacific Islands region pilot program is located on the University of Hawai‘i at Mānoa campus and hosted by the University of Hawai‘i Sea Grant College Program (UH Sea Grant), which resides within the School of Ocean and Earth Science and Technology. This new program’s reach is the State of Hawai‘i, the territories of Guam and American Samoa, the Commonwealth of the Northern Mariana Islands, the Federated States of Micronesia, and the Republic of the Marshall Islands. The CSP program is engaged with local partners and managers to assist in developing coastal hazard resilience efforts and capacity building.

Goals
The goals of the program are to provide better communication, awareness, and understanding of coastal hazard risks and community resilience. A few of the key items that will be explored include: community hazard resilience and awareness assessment; the ecological impacts of coastal storms and climate change on aquatic ecosystems; natural hazard mitigation and strategy (evacuation,
recovery, and adaptation); and best building practices for new developments in mitigating the effects of coastal storms and other natural hazards.

A common interest identified among all regional CSPs was the development of outreach and education programs. A successful outreach and education program should ensure that: 1) products are developed based on locally identified needs; 2) the availability of the products is communicated to the appropriate user group; 3) training is provided on the use and application of the tools; and 4) feedback is collected from CSP partners and user groups on product effectiveness and recommendations for improvements and suggestions for new products.

**Sea-Level Rise Research**

Sea-level rise (SLR) has been identified as a common and underlying natural hazard threat to the Pacific Islands region that will exacerbate the exposure to and risk of many coastal hazards. As such, SLR is a high priority for research, education, and outreach in the region. A pilot demonstration project is underway in Honolulu to map SLR, model and map storm surge inundation, and conduct a risk and vulnerability assessment of the study area including a socio-economic impacts assessment. The purpose of the pilot project is to develop an inundation model that measures and assesses the risk and vulnerability of selected low elevation coastal lands in Hawai`i.

The urban corridor of Honolulu on the southeast shore of O`ahu was selected due to the high density development and concentration of critical infrastructure exposed to coastal hazards. Recent global projections suggest that sea level elevations by the end of the century will be significantly higher, possibly one meter or higher than current mean sea level, and therefore coastal areas within low-elevation regions are vulnerable to impacts resulting from SLR. Identifying and mapping infrastructure and assessing socio-economic sectors that are likely to be impacted are critical components of coastal storm and hazard mitigation and adaptation to climate change. Another important part of this mapping effort will be to assess potential flooding and coastal inundation occurring at the confluence of high tides (and/or high waves) and rainfall.

A selection of the products that will be developed for the Pacific Islands region in the coming years will include a suite of new and improved tools to help with decision-making, hazard data, community resilience guidance and information, forecast models, education and outreach materials, and training for coastal communities. Hawai`i and the Pacific region will gain direct benefit from this program through research, education, extension, and improved capacity to prepare for coastal hazards.
In September of this year, a hands-on hazard and vulnerability training for members of the Marshallese government and the non-governmental organization community was held in the Marshall Islands. In recent years, the vulnerability of atoll islands to sea-level rise has garnered widespread awareness and attention. However, this attention generally focuses on the highly developed and densely populated urban atolls such as Majuro, but what has been largely overlooked is the unique nature of the outer-island communities and the local-scale variability of vulnerability within atoll nations.

The focus of this training, funded by the Asia Pacific Network for Global Change Research, was to help build in-nation capacity to assess the local variations in vulnerability, particularly with respect to coastal inundation and erosion. The team, which will also provide training in Tuvalu, was led by scientists from the University of Auckland in New Zealand with University of Hawai‘i Sea Grant College Program (UH Sea Grant) providing assistance for the Marshall Islands portion of the training. The training involved teaching local government workers, conservation specialists, and community members how to gauge island vulnerability using simple survey techniques and community consultations.

The practical reality is that outer-island communities are never going to have access to the types of high-end equipment found in areas with denser populations, such as Hawai‘i. Outer-islands need....
robust, easy-to-use tools that provide sound information for communities to use in making informed decisions.

The team worked with the local community on Jeh Island within Ailinglaplap Atoll, as well as Jabat Island, one of only a handful of reef platform islands (those which lack a lagoon) in the Marshall Islands. Local teams worked alongside UH Sea Grant faculty to establish the elevation of assets such as houses, agricultural land, and wells within the village relative to sea level. This will allow residents to see which areas could potentially be flooded under different sea-level rise scenarios.

The variability in island morphology and elevation between the islands emerged as one of the greatest concerns. Jeh Island and Jabat Island are not more than 10 miles apart, yet they are remarkably different in terms of elevation and vulnerability. There is no practical way to begin addressing hazard mitigation and adaptation options within these communities before they have a good handle on simple questions such as “how high is the island?” and “how far are our assets from the coast?” Vulnerability varies on a local scale and this type of training increases local capacity so that future adaptation projects are developed to target those areas most in need.

How will both the physical and socio-economic systems on low-lying islands respond to sea-level rise? How will the shorelines adjust with a higher sea level? How will various adaptation strategies such as better planning and building practices be included in local decision making processes? These questions and many more need to be addressed before the fate of these islands is determined, and UH Sea Grant is thankful for the opportunity to work closely with all the partners in the Marshall Islands on this critical issue.

Update from Majuro

Dr. Murray Ford, UH Sea Grant Coastal Processes Extension Specialist, is assisting a large team led by Dr. Mark Merrifield, professor of oceanography in the UH School of Ocean and Earth Science and Technology, looking to further the understanding of reef flat wave processes. In December 2008, Majuro was hit by a large wave event generated by a distant storm in the North Pacific. On a clear day, with no warning, waves swept across parts of Majuro, causing upwards of $500,000 in damages and displacing over 600 people from some of the most disadvantaged neighborhoods on the island. This event was the catalyst for further scientific investigation into nearshore wave processes around atolls.

Together with Dr. Maria Haws, UH Sea Grant Extension faculty based in Hilo, Hawai‘i, Ford is assisting with many aspects of the study as well as outreach activities focused around the investigation. Currently, the team has deployed a number of inshore pressure sensors and current meters on the reef adjacent to the College of the Marshall Islands, along with an offshore wave buoy. The study should strengthen the ability to predict the events most likely to result in coastal inundation. Understanding these events will strengthen hazard mitigation, disaster planning and adaptation strategies that can be tailored to local conditions. Ultimately, if we can provide a better understanding of events such as the December 2008 inundation, then we can reduce potential harm to people and property in the coastal zone.
The University of Hawai‘i Sea Grant College Program connects research and outreach, delivering the most up-to-date information to our island communities. Our scientists study pressing local issues and produce real results, then our extension faculty translates that research into useful information for a myriad of audiences. This column regularly highlights the important work done by our extension faculty on your behalf.

Hawai‘i is a land of ecological diversity and geological grandeur. With its rainforests, active volcanoes, and dramatic sea cliffs, the Big Island, or Island of Hawai‘i, has its fair share of this spectacle. The alluring beauty of the island’s coastline is known to many, but coastal hazards are less well understood. Unfortunately, these dangers have become more worrying in recent years as residential construction has edged closer to the shoreline, and this growing unease has led to recognition of the need to prepare for these coastal hazards in a more coordinated fashion.

In response, the University of Hawai‘i Sea Grant College Program (UH Sea Grant) hired Andy Bohlander to help address this need. As a new coastal processes and hazards specialist, Bohlander is an expert in his field, though he wears his scholarship lightly. Based in Hilo on the Island of Hawai‘i, he advises local county government on issues relating to coastal hazards and the environment, among other topics. He also works closely with the County of Hawai‘i Planning Department on land use, community development, and education and outreach activities.

Prior to joining UH Sea Grant, Bohlander obtained a bachelor of science in environmental geoscience from Clarion University and a master’s degree in marine affairs from the University of Washington. He has experience in geographic information systems, or GIS, as well as emergency management, with an emphasis on hazard and vulnerability analysis, and hazard mitigation planning.

Bohlander’s responsibilities cover several broad areas. In his role as an advisor to the County Planning Department, he frequently conducts site visits to evaluate applications for development in the Special Management Area. He advises on a variety of issues including sea-level rise, climate adaptation, tsunamis, coastal storms, shoreline hardening, anchialine ponds, shoreline certifications and setbacks, and cesspool issues. He strives to promote sustainable coastal development practices and to enhance community resilience to coastal hazards.

Since arriving, Bohlander has engaged a variety of stakeholders and local experts to identify the most pressing needs of the community. His position was a new one, so Bohlander was able to tailor the position to meet those needs accordingly. In the coming year, he plans to assist the County in developing new policies and management strategies to address complex coastal hazards, particularly coastal bluff erosion and sea-level rise. Bohlander will also provide technical assistance in the development of the Hamakua Community Development Plan, and will continue his efforts to ensure appropriate siting for new coastal development.
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The University of Hawai‘i Sea Grant College Program (UH Sea Grant) is part of a national network of 32 university-based programs that promote interactions, contributions, and shared expertise from each of its members. A good example of such collaboration is the production of two separate reports, the Hawai‘i Coastal Hazard Mitigation Guidebook and the Homeowner’s Handbook to Prepare for Natural Hazards. These books have a similar theme and provide reasonable, easy to understand direction or guidance to the target audience on how to reduce hazard risk. The target audience for the Homeowner’s Handbook is the homeowner while the Coastal Hazard Mitigation Guidebook is geared toward anyone involved in coastal development or living along the coast. Because the concepts in these books would make other coastal communities safer, UH Sea Grant faculty offered to share their time and expertise with others in the Sea Grant network. As a result, several recent publications in the Gulf Coast have been developed with the assistance of UH Sea Grant faculty.

In 2005, UH Sea Grant, along with the NOAA Pacific Services Center, NOAA Coastal Services Center, State of Hawai‘i Department of Land and Natural Resources, and Hawai‘i Coastal Zone Management Program published the Hawai‘i Coastal Hazard Mitigation Guidebook. Written by Dennis Hwang, UH Sea Grant extension faculty member, this book is used in the land use process in Hawai‘i, and has also been incorporated into the shoreline setback rules for Kaua‘i and in new rules that the State of Hawai‘i Department of Land and Natural Resources recently completed public hearings for in August of 2010.

After Hurricane Katrina in August of 2005, UH Sea Grant helped the Louisiana Sea Grant College Program create the Louisiana Coastal Hazard Mitigation Guidebook. The goal was to help Louisiana in the recovery process by helping to build more safely so that risk from future events could be reduced. Hwang had the opportunity to work closely with Jim Wilkins, Director of the Louisiana Sea Grant College Law and Policy Program, and the late Rod Emmer, Louisiana Sea Grant faculty and known for his work with the Association of State Floodplain Managers. Director Wilkins noted, “It was Rod’s dream that safer development through land use planning could even be discussed in Louisiana, and now many parishes have taken small but positive steps to build safer.” He went on to say, “The guidebook is a very good match
for Louisiana because the flexible implementation approach can be adjusted to fit the diverse political structure of each of the coastal parishes in the state.”

Following the efforts with the Hawai‘i and Louisiana Coastal Hazard Mitigation Guidebooks, Hwang, along with UH Sea Grant Extension Leader, Dr. Darren Okimoto, authored the Homeowner’s Handbook to Prepare for Natural Hazards. According to Okimoto, “I’m grateful for the opportunity to work with Dennis on the handbook project. The feedback that we have been getting from homeowners and our project partners has been very positive.” Since its publication in 2007, this guidebook has gone through four print runs with over 30,000 copies distributed in Hawai‘i. These books have been very popular, having been distributed at outreach events such as neighborhood board meetings, church groups, community emergency fairs, rotary club meetings, real estate companies, and insurance companies among others.

The Homeowner’s Handbook was also of interest in the Gulf Coast, and thus UH Sea Grant, including the Communications Office, assisted with their effort to create a similar book. As a result, the Mississippi Homeowner’s Handbook was officially released at the Gulf of Mexico Alliance (GOMA) in an all-hands meeting in Biloxi in August of 2010. The Coastal Storms Outreach Coordinator for the Mississippi-Alabama Sea Grant Consortium, Tracie Sempier, mentioned that the handbook has been well received by local residents in Mississippi, with requests for copies from real estate agents, clergy, floodplain managers, utility companies, local governments, non-profit groups, businesses, and state agencies. She noted, “Having a collection of the most important information, resources, and practical tips in one easy-to-use format has been a great asset to those who want to protect their family and property from natural hazards.” This consortium is now developing a third homeowner’s handbook for Alabama, while Louisiana State University is working on its version which will be the fourth book in the series.

According to Hwang, assisting the other state programs has been a rewarding experience. “They learned from us and we learned from them in the production of their books. We hope to apply some of those lessons in the updates to the Hawai‘i Coastal Hazard Mitigation Guidebook as well as the Hawai‘i Homeowner’s Handbook, which are both in the works. Hopefully, the network will continue to grow as we work and learn from each other on the most useful information to deliver to coastal communities on reducing hazard risk.” All of this would not have been possible without the strong support of the UH Sea Grant Communications Office, as well as Dr. E. Gordon Grau, director of UH Sea Grant.
With support from the University of Hawai‘i Sea Grant College Program and other government and non-profit organizations, the University of Hawai‘i (UH) Coastal Geology Group is investigating shoreline change around the Hawaiian Islands. Through these studies the group is learning more about shoreline variability and helping agencies responsible for protecting Hawai‘i’s beaches and communities by identifying areas prone to coastal erosion.

About 70 percent of the beaches on Kaua‘i, O‘ahu, and Maui have been lost or are chronically eroding; over the past century, 21 kilometers were completely lost to erosion. Chronic coastal erosion, or shoreline recession, is a problem along most of the U.S. coast, including Hawai‘i. It is particularly troublesome in Hawai‘i because beaches are a primary attraction for visitors, and are central to the culture and recreation of the local population. “Healthy” beaches provide a natural buffer for coastal development during temporary erosion from storms and large waves. Unfortunately, many of our beaches have disappeared or narrowed significantly over the past century resulting in loss of an invaluable public resource and hazards to coastal structures.

The primary goal of mapping shoreline change is to measure long-term trends over the past few decades to a century, with the assumption that past trends may be used to make general predictions about future shoreline behavior. Historical trends using shoreline positions mapped from aerial photographs and coastal survey charts were measured. Also, movements in shoreline position through time are measured at regularly-spaced intervals (20 meters) along the beach, and annual rates of change are calculated from time series of shoreline positions.

Shoreline change in Hawai‘i is highly variable along the coast. Cells of erosion and accretion are often separated by only a few hundred meters on a continuous beach or by points that divide the coast into many separate “pocket beaches.” The Coastal Geology Group works to identify shorelines most vulnerable to future erosion and allows site-specific management based on local rates of shoreline change.

Hawai‘i state law requires a 40-foot building setback for coastal structures. This one-size-fits-all approach has proven inadequate on chronically eroding beaches, often resulting in construction of seawalls and loss of the beach. In response, Maui and Kaua‘i counties now calculate coastal building setbacks using local rates of historical shoreline change – hopefully, slowing the trend of beach loss on eroding coasts in Hawai‘i.

These results are the culmination of over 10 years of work by the UH Coastal Geology Group. Shoreline change maps, digital scans of aerial photographs, and other publications are available at the UH Coastal Geology website: http://www.soest.hawaii.edu/coasts/.

Thank you to Dr. Charles (Chip) Fletcher, Matthew Barbee, Dr. Neil Frazer, Tiffany Anderson, and Matthew Dyer for their contributions to this article.
Dr. Kelly Benoit-Bird, a former University of Hawai‘i Sea Grant College Program-funded graduate student, was recently awarded the prestigious 2010 MacArthur Fellowship. The award, commonly called the “genius grant,” is presented annually by the John D. and Catherine T. MacArthur Foundation and includes a $500,000 stipend.

Benoit-Bird, an associate professor in the College of Oceanic and Atmospheric Sciences at Oregon State University, was among 23 recipients recognized for their extraordinary originality, dedication, and capacity for self-direction. Specifically, Benoit-Bird was recognized for her work “using sophisticated acoustic engineering technology to explore the previously invisible behavior of ocean creatures and address long-unanswered questions about the structure and behavior of food chains.”

During her time with UH Sea Grant from 1999 to 2003, Benoit-Bird was pursuing her PhD under Dr. Whitlow Au of the Hawai‘i Institute of Marine Biology’s Marine Mammal Research Program. Her dissertation, titled “Dynamics of the Hawaiian Mesopelagic Boundary Community and their effects on Predator Foraging,” looked at the migration patterns of micronekton (small fish, crustaceans, and cephalopods), and the importance of this food source to both nearshore and oceanic species. An important part of this research, which was funded by the National Science Foundation and the Office of Naval Research, measured the abundance of spinner dolphins and their prey using sophisticated acoustics and sonar technologies to help understand their movement patterns and behavior. She also worked on several interrelated Sea Grant projects looking at marine animals living at different depths around the Hawaiian Islands, their migration patterns, and how they interact with each other at different times of the day and night.

With respect to the half-million-dollar grant Benoit-Bird received, she described it as “a gift of time,” and plans to take on challenging research that she would not have otherwise had time to tackle. The stipend is a no-strings attached award paid in quarterly installments over a five year period, and the awardees are free to decide how the funding should be spent. Dr. Benoit-Bird laughed as she reflected on the phone call she received from the foundation…“I did not even know I had been nominated,” she noted. “It is such an honor to have been selected.”

Benoit-Bird was awarded a bachelor of science in Aquatic Biology from Brown University in 1998; a PhD in zoology from the University of Hawai‘i at Mānoa in 2003; and she completed a post-doctoral fellowship at the Hawai‘i Institute of Marine Biology in 2004.
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