



HOLLINGS MARINE LABORATORY 2013 ANNUAL REPORT

CONFRONTING COASTAL CHALLENGES

HOLLINGS MARINE LABORATORY



HML Annual Report - 2013

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message from the director

We are pleased to present the 2013 Annual Report for the Hollings Marine Laboratory (HML). HML is a multi-institutional, multi-disciplinary laboratory with five primary research partners: 1) National Oceanic and Atmospheric Administration's (NOAA) National Ocean Service (NOS), 2) National Institute of Standards and Technology (NIST), 3) South Carolina Department of Natural Resources (SCDNR), 4) Medical University of South Carolina (MUSC), and 5) College of Charleston (CofC). HML is also a center within NOS's National Centers for Coastal Ocean Science (NCCOS).

HML has had a successful year continuing our mission of providing science and technology that sustains, protects and restores coastal ecosystems. Our research efforts have emphasized an understanding of the linkages between the condition of the coastal environment and human health. With over 100,000 square feet of space designed to promote collaborative research, we are well positioned to continue our mission with scientific investigations that range from experiments conducted at a molecular level to studies of full-scale ecosystems.

We appreciate that you are taking the time to learn more about HML's accomplishments in 2013, and we hope you will find the information provided in this annual report useful in your own work. Should you be interested in learning more about HML, please visit us at our website <http://coastalscience.noaa.gov/about/centers/hml> or contact us at 843-762-8811.

Sincerely,

Jeffrey K. King, Ph.D.
Acting Director, Hollings Marine Laboratory



about HML

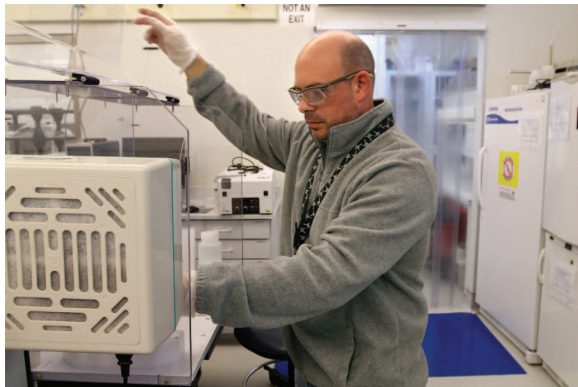
The Hollings Marine Laboratory (HML), a 103,000 square-foot facility in Charleston, South Carolina, was established in 2001. HML assesses environmental impacts on marine ecosystems and potential linkages to human health and well-being through collaborative research efforts by our multi-institutional, multidisciplinary science partners. NOAA and the National Institute of Standards and Technology (NIST) are federal agencies located at the facility.



The South Carolina Department of Natural Resources (SCDNR) is a state agency, and the two academic partners are College of Charleston (CofC) and the Medical University of South Carolina (MUSC).

Benefits of the Partnerships

Studies of marine environments, aquatic organisms and their integral connections to human health have become increasingly complex, and this requires a multidisciplinary approach in order to achieve success. The scale, diversity and connectivity of issues suggest that no single organization possesses the breadth of scientific expertise needed to address these problems completely. The partnership structure at HML allows scientists to address these multi-faceted, science issues by combining expertise to conduct research they could not otherwise accomplish. The resulting synergy produces exciting and innovative approaches that address issues of immediate concern to coastal, marine, health and civic professionals.



Research

Research at HML includes diverse topics such as wildlife epidemiology and health assessments for sentinel species, development of molecular diagnostic tools, toxin discovery, aquaculture, fisheries science, pollution chemistry, and the valuation of human dimensions of coastal ecosystems and communities. Collectively, these and other disciplines at HML have contributed greatly to coastal preparedness and resiliency in South Carolina, the Southeast, and United States. Moreover, HML's principal investigators are also integrating science and services to provide public and private decision makers with more actionable information. HML researchers focus on studies of sentinel species and sentinel habitats with a goal of identifying early warning signals and developing tools for detecting environmental threats, which then can be incorporated into coastal management decisions. By informing these decisions with new data and innovative tools, HML researchers will continue to serve as essential partners for improving coastal communities and preserving aquatic resources.



CONFRONTING COASTAL CHALLENGES: *Lessons Learned from the Deepwater Horizon Oil Spill*

The air hangs hot and humid in the mesocosm as Dr. Michael Fulton tours stacked, rectangular bins of *Spartina* cordgrass, a patchwork of mini-marsh ecosystems in this greenhouse laboratory. Scientists here at the Center for Coastal Environmental Health & Biomolecular Research drop in oil pollutants. They wait, watch and measure to learn how the simulated coastal ecosystem will respond.

Nearby at the Marine Environmental Specimen Bank operated by the National Institute of Standards and Technology (NIST), the temperature drops sharply. Research biologist Rebecca Pugh, decked out in Tyvek coveralls, sinks her gloved hands into a cold abyss of mists spiraling atop barrel-shaped nitrogen freezers where temperatures at the base sink down to minus 150 degrees Celsius. She pulls out a long tray housing barcoded marine samples.

The scene takes a medical twist at the Marine Biomedicine & Environmental Sciences Center where Medical University of South Carolina (MUSC) researchers Dr. Louis J. Guillette, a reproductive endocrinologist and developmental geneticist known for his fieldwork in alligator studies, and Dr. Demetri Spyropoulos, a developmental biologist and an expert in the manipulation of embryonic stem cells, pair their talents to investigate marine environmental contaminants and their possible effects on human health.

The same is true of two other researchers nearby who want to know more about this environmental connection to human health.



This dolphin, coated in oil, was observed in Bay Jimmy, Barataria Bay, Louisiana, August 5, 2010.

Dr. Susan Lovelace, an environmental social scientist and Human Dimensions Program manager at Hollings Marine Laboratory (HML), is working out a scientific method to monitor how an area's environmental health affects the well-being of its coastal residents. Dr. Lori Schwacke, chief of the Oceans & Human Health Branch of NOAA/National Centers for Coastal Ocean Science (NCCOS) HML, is investigating the impact of environmental contaminants on dolphins in the Gulf.

What pulls these disparate fields and institutions together in a creative, scientific stew is HML, where they are all housed. The other unifying factor is the *Deepwater Horizon (DWH)* oil spill, aka BP oil spill, an event called one of the worst oil disasters in history. All of the groups, using their distinctive skill sets, are investigating the environmental effects of the spill that began

April 20, 2010, in the Gulf of Mexico and was capped 87 days later. It impacted about 500 miles of the Gulf's shoreline and caused approximately five million gallons of oil to gush into the Gulf.

Dr. Jeffrey King, HML's Acting Director, said it's amazing to have one event being looked at from so many different angles. "Who would have ever thought that there would have been so many unique individuals from all of our different partners working on the same project?" he said. "It speaks to what we have in the way of talented individuals with diverse skill sets and expertise. They were asked to be a part of something that was important to our nation at a time when things were getting out of hand and out of control."

King said NOAA looked to NCCOS to come up with solutions for a very difficult problem that was happening in the Gulf, knowing that it wasn't going to be a quick fix. HML is one of five centers within NCCOS, and the laboratory hosts five primary research partners that include: NOAA, NIST, the South Carolina Department of Natural Resources, MUSC, and the College of Charleston. "They understood this event was something we'd have to deal with for many years. We have to know what those long-term impacts are now. In fact, there are effects we probably won't see for another 10 to 15 years."

In what might seem to be a bureaucratic nightmare of partnering organizations, researchers find that's not the case at all. HML provides a laboratory of collaboration and cooperation. It's an environment Guillette, who has conducted research worldwide, has found

Dark clouds of smoke and fire emerge as oil burns during a controlled fire in the Gulf of Mexico May 6, 2010, as part of the Deepwater Horizon oil spill response in the Gulf of Mexico. The U.S. Coast Guard working in partnership with BP P.L.C., local residents, and other federal agencies conducted the "in situ burn" to aid in preventing the spread of oil following the April 20, 2010 explosion on the mobile offshore drilling unit.

Jeff King, Ph.D.

“...It speaks to what we have in the way of talented individuals with diverse skill sets and expertise who were asked to be a part of something that was important to our nation at a time when things were getting out of hand and out of control.”





Employees of Elastec/American Marine Inc. inspect a fire boom for collected oil prior to conducting a controlled burn in the Gulf of Mexico May 5, 2010.

The Deepwater Horizon Story

cover story

nowhere else. Although the agencies may have different missions, the scientists working together can have the same mission - trying to understand how the environment influences the health of the organisms that live in that environment, he said. "I've spent years doing environmental health. I've never been at a place where more than one or two people were interested in what I was doing, intellectually. Here, there are 20 or 30 people interested, so the difference is astronomical."

King agrees. He recalls bringing all the principle investigators together in spring 2013. The first agenda item had everyone introducing themselves and their work. "I swear we couldn't make it around the table because people were already starting to ask questions and form partnerships. What was supposed to be an hour-long conversation became a 2.5-hour conversation filled with brainstorming on possible projects."

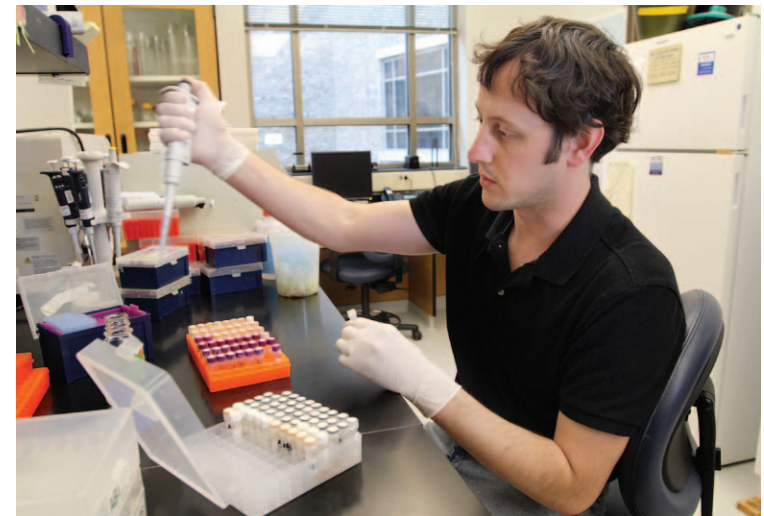
The difference goes beyond the collection of intellectual capital, though.

King said HML has an unusual pool of partners. Take NIST for example, which sets the gold standard in measurement, bringing to the table vast analytical capabilities. With a focus on the development of tools and very precise measurement that can be offered to other academic institutions, the federal government and other stakeholders, NIST sets important benchmarks with its rigorous standards. "Because of NIST's capabilities, you know that the technology, new methods, or resulting data have been tested and verified on many different levels. It gives the HML partners that one extra step of validation as our products and results go forward towards application," he said.

Add to that base the extra dimension of having a medical university in the research mix, and it creates a synergy hard to find anywhere else. "There's no other entity such as HML that's partnered with a medical university," King said. "That's the whole idea behind it. Back in the late

nineties, the partner institutions were present at the Fort Johnson Campus, but they existed in their own individual buildings until former U.S. Senator Fritz Hollings, local stakeholders, the partners and the community recognized how valuable it would be to bring all these entities together under one roof," he said.

"You can have a fisheries biologist working side by side with M.D.'s or Ph.D.'s who are investigating issues concerning human health. With these scientists working together, we can answer complex questions originating in estuaries and ocean-based environments, and link them to issues concerning human health and communities."



Matt Walker, a Wildlife Biologist with SCDNR, is genotyping Red Drum.

The Deepwater Horizon Story

mesocosm

THE MESOCOSM

Since NOAA's Environmental Sensitivity Index maps list salt marshes as the most vulnerable habitat in the Gulf of Mexico, researchers undertook a mesocosm study to assess potential impacts of crude oil and dispersants in a simulated salt marsh community.

Dr. Fulton, a researcher who specializes in aquatic toxicology and physiology of marine organisms at the Center for Coastal Environmental Health & Biomolecular Research, said the mesocosm offers a unique way to do testing, particularly given the *Deepwater Horizon (DWH)* oil spill in the Gulf of Mexico involved about 2.1 million gallons of dispersant being applied. About 1.4 million gallons were applied on surface slicks and 771 thousand gallons were pumped into the water column at the wellhead.

"We submitted a proposal to evaluate the impacts of oil with and without chemical dispersants on a salt marsh ecosystem. Our work was not really designed to mimic what happened with *DWH*, but to have information that would be useful in future spills for understanding what kind of damage you might get in a salt marsh if you had incoming oil and dispersants together and whether there's a difference between the oil alone, the dispersants alone or both together."

The use of chemical dispersants to mitigate oil spills has been a controversial issue for many years since dispersants do not reduce the amount of oil in the environment, but rather alter the chemical and physical properties of oil, which affects transport and possible bioeffects, he said.

A major objective of the study was to improve NOAA's capacity to respond to major spills by increasing the information on crude oil impacts with and without dispersants. Researchers used the salt marsh mesocosm to track the movement of oil and the dispersant over time, taking various measurements. Results indicated that various animals, plants and microbiota were sensitive to the oil and dispersant alone as well as to the combination of both.

As opposed to looking at individual species in a laboratory, the mesocosm approach simulates a coastal ecosystem. The systems, consisting of two tanks stacked on top of each other, allow researchers to control water levels creating incoming and outgoing tides just as a coastal tidal creek system would have. Researchers introduced the oil and dispersant - alone and in various types of combinations as might be seen in regions with these types of spills - and tested the effects on the coastal environment, including plants, animals and water quality.

"We saw impacts associated with the oil on the growth of marsh grass. We also saw effects on the water quality, specifically a sag in dissolved oxygen associated with the oil and the oil plus dispersant," Fulton said. "We saw that the oil plus dispersant caused more of an effect and was quicker to affect the water quality than the oil alone. Reduced dissolved oxygen can lead to a negative impact on the health of a variety of species in the ecosystem."

Fulton said they want to expand to look at other types of dispersants and oils. Different oils have

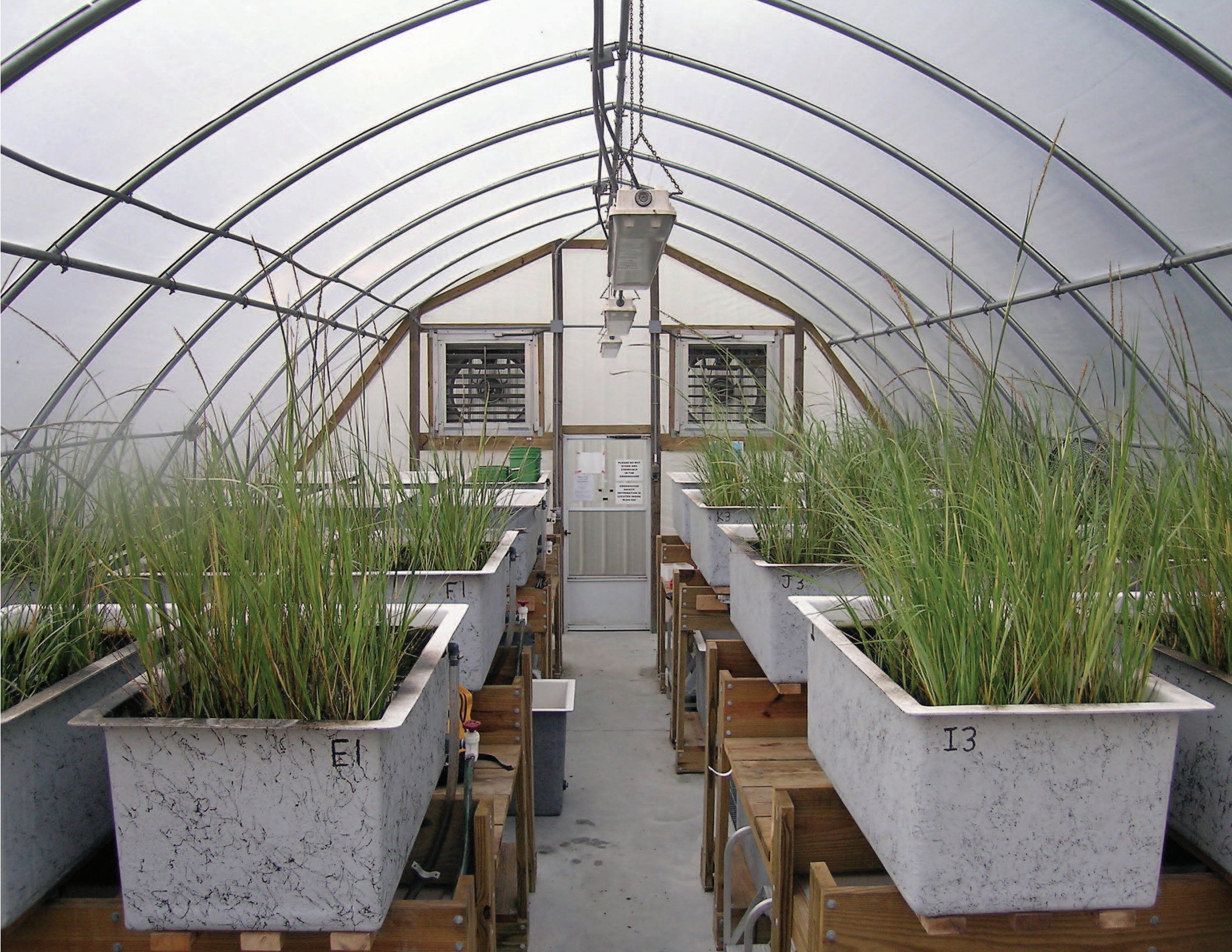
different chemical characteristics that would make them more or less toxic - a relationship they want to understand better.

Though working in the greenhouse setting can be a little too realistic with the humidity and "bug" factor, Fulton said the beauty of the mesocosm from an experimental standpoint is that the system allows researchers to see interactions in the ecosystem. "It allows us to look at community level effects of oil, rather than just trying to figure out what happens as a result of individual species testing. It also points out that there is an interaction between the oil and the dispersants, and there are effects associated with them, both individually and in combination."



Michael Fulton, Ph.D.

This mesocosm facility was used to test the effects of crude oil and chemical dispersants on a simulated saltmarsh ecosystem.



The Deepwater Horizon Story

well-being

MEASURING WELL-BEING

When it comes to taking a community-level view, no one knows that better than Dr. Lovelace, an environmental social scientist for NOAA, who works at the interface of socio-economic and biophysical data. When most people think about the implications of the *Deepwater Horizon (DWH)* oil spill, environmental damage comes to mind, but it's not the only impact. Lovelace, along with Maria Dillard at NCCOS' HML and Theresa Goedeke from NCCOS's Center for Coastal Monitoring and Assessment, created a set of indicators that identify human well-being.

"When the oil spill happened, many people were looking at the environment, but not as many were studying how it affected the communities. Quality of life is an important area of research. We wanted to start trying to measure the connections between environmental quality and well-being. The ecosystem services we get from nature support well-being," Lovelace said.

Most of the research on the *DWH* disaster focused on either the environmental damage caused by the disaster or the human health impacts. However, little research has been focused on the connections between the environment, human health and the communities of the Gulf Coast. "Throughout the event, these connections became increasingly clear. The oil harmed fish and shellfish, clean water, recreational activities and beautiful views - many of the important ecosystem services that people regularly enjoy."

In an effort to understand how changes in the environment are connected to community well-being, researchers working for NCCOS's Hollings Marine Laboratory and the Center for Coastal Monitoring and Assessment developed a method to monitor the relationship between the health and welfare of coastal residents and the health of the adjacent coastal environment over time. Multiple indicator measurements from human well-being to the environment were used



HML's Human Dimensions DWH research focuses on the connections between the environment, human health and the communities of the Gulf Coast.

to develop a "Community Well-Being Index." The indicators, which include basic needs, governance, economic security, safety, access to social services, social connectedness, education and health, were initially identified through a workshop that brought together individuals from federal, state and academic institutions.

Dr. David Abramson, Deputy Director of the National Center for Disaster Preparedness, praised this tool as an enduring contribution to the field of sociometrics in providing a way to measure the human ecosystem.

Lovelace, who has been doing this type of work for more than 20 years, said it's a small group of researchers who are in the field. "It's critical work, though, because it's in creating this method of measuring human and environmental

welfare that researchers will be able to define benchmarks to better assess the social impacts of environmental disasters like the *DWH* event."

Lovelace said assessment of well-being occurred at the county level and their research covered coastal counties directly affected by the oil spill, as well as a selection of unaffected counties for comparison. Data from three time points were collected to provide a longitudinal perspective for the years 2000-2009.

"What we learn from this research can inform public health and resource managers in their decision-making. When we make decisions about the environment it is often thought that we are just using economic value, however, we make a lot of decisions based on things other than dollars. The research is trying to measure some of the things we care about and how those things are connected to the well-being of people. It's about the well-being of communities, not an individual. Being able to measure changes in communities will allow us to use data to support community decisions," Lovelace said.

“When the oil spill happened, many people were looking at the environment, but not as many were studying how it affected the communities. Quality of life is an important area of research...the ecosystem services we get from nature support well-being.”

Dr. Susan Lovelace

Lovelace and her team, who have done assessments based on data before the spill, will continue the research to see which indicators the spill affected once more funding is available. The group works with large data models, not determining causal changes but rather establishing relationship patterns. For example, they can see that counties that have had comprehensive plans in place for longer periods have better environmental conditions. “That says something good about planning. If we plan, we may be able to maintain a coastal environment that supports our needs. “

More of these data are needed to set baseline levels in a community to make comparisons. “You’d think we have this kind of information, but we don’t,” she said, and it affects the ability of political leaders and the public to be able to decide what kind of communities they want to create. “We need to understand coastal communities so when we do development plans and want to change things - whether it’s putting in a new shipping channel or gas or oil rig or whether we dredge new inlets or whether we put in a lot of new driveways in a coastal area - those are all things that could turn around and affect the community as a whole.”

She will continue to tweak the model so it’s responsive to a comprehensive scale of indicators.

“What we’re trying to do is model the socioeconomic data with the biophysical data.

Instead of just making a model of how the environment is, we’re actually trying to include communities in that too, so when you push on one part of the model, you can not only see how it affects contaminants in the sediment and how shrimp are doing, but you also can see how communities are doing.”

Through using this model and measuring the changes in the health and well-being of

residents in counties impacted by the *DWH* industrial-environmental disaster, researchers can set a baseline measurement of well-being to which indicators collected after the disaster can be compared. “Modeling changes of indicators over time will allow researchers to predict changes in well-being in relation to changes in the environment so that appropriate interventions to protect community well-being can be designed.”



Using the Gulf of Mexico as a regional case study, the research team developed a set of composite indicators to monitor well-being at the county-level.

The Deepwater Horizon Story

well-being

Lovelace believes that although we can use technology to compensate for some aspects of a polluted environment, there is more to life than technology, which can distance people from the environment.

“I’m a big user of technology, but I think if we’re not concerned with environmental quality, then we’re really giving up something important in our lives, and if we don’t find a way to measure what is important, it won’t be taken into account when decisions are made.”

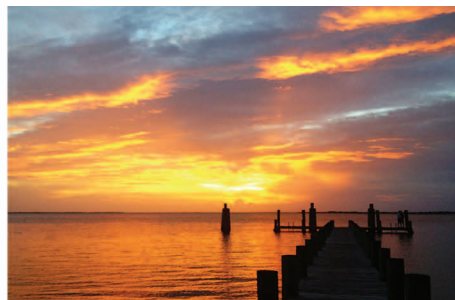
She likes working in the collaborative environment of HML because her work touches so many different environmental areas, and she knows where to go to be on top of the issues. “It’s nice to be able to go down the hall to talk to somebody instead of trying to figure out where to go.”



Maria Dillard, Ph.D. candidate and Susan Lovelace, Ph.D.

How can it impact interventions? She lists the following highlights:

- Better assessment of the social impacts of environmental disasters and changing conditions, from oil spills and hurricanes to decreasing water quality and changing shorelines.
- A roadmap for targeted action by public health and county officials, as well as government agencies and social service organizations, that uses well-being dimensions to identify communities in need.
- Improved monitoring of the well-being of the counties affected by *DWH*, and improved understanding of the impacts of such hazards on the basic needs, health, economies and social structure of coastal communities,
- A new tool for local managers and government officials to use to update emergency plans and take a critical look at government structure, housing, labor source, public health practices and other factors to determine how to lessen the impacts of environmental disasters.
- Information to assist state and federal agencies with understanding the links between environmental conditions and well-being in order to assess the trade-offs of decisions that impact societal benefits and the condition of the environment.



The Deepwater Horizon Story

from the deep

A VIEW FROM THE DEEP

One of the laboratories where Dr. Lovelace might go is to that of Dr. Lori Schwacke, Chief of Oceans & Human Health Branch of the NOAA/NCCOS Hollings Marine Laboratory, who is researching the health of bottlenose dolphins in the Gulf of Mexico following the *DWH* oil spill. Schwacke said the dolphin health assessments in the aftermath of the *DWH* were only possible because of the long-term research her team had been conducting to understand the health of marine mammals in coastal waters, and the factors that influence their health.



Lori Schwacke, Ph.D.

Though her group also does research with other marine animals, dolphins hold a particular allure for her.

“These dolphins are top level predators in coastal ecosystems in the Gulf, and the loss of a top level predator can have cascading effects within that ecosystem. Also, the health of the dolphins reflects the condition of the broader ecosystem. Our dolphin health research is critical so that we are not only prepared to assess the impacts of events, such as the *DWH* spill, but also so that we can understand effects of more gradual, but long-term environmental changes.”

“These dolphins are top level predators in coastal ecosystems in the Gulf, and the loss of a top level predator can have cascading effects within that ecosystem...”

Dr. Lori Schwacke



Dr. Jean Hermann takes a dental x-ray of a dolphin onboard the RV Megamouth during dolphin health assessments in Barataria Bay, Louisiana.

The Deepwater Horizon Story

from the deep

HML researchers continued efforts in 2013 to assess injuries to dolphins in the Gulf of Mexico as a result of the *DWH* oil spill, expanding health assessment studies to include dolphins in Mississippi and Alabama waters in addition to the previously sampled dolphin population in Barataria Bay, Louisiana.

A dolphin health assessment study in 2011 led by HML researchers found that dolphins in Barataria Bay, an area that received significant and prolonged oiling from the *DWH* spill, suffered from a number of disease conditions. Barataria Bay dolphins showed symptoms of hypoadrenocorticism, consistent with adrenal toxicity previously described in experimental studies of mink exposed to oil. “Cortisol, produced by the adrenal gland, is essential for responding to stressful conditions. Barataria Bay dolphins had abnormally low cortisol concentrations and this could ultimately lead to a number of complications and in some situations even death.”

The Barataria Bay dolphins also were five times more likely to have moderate to severe lung disease, sometimes characterized by lung masses.

The findings surprised them because of the severity of the disease in the animals.

The health assessment study was repeated in June 2013 to examine whether the health of Barataria Bay dolphins had improved. Researchers

from the HML Genomics Core joined the collaboration and sampling was conducted to examine how gene expression profiles may differ among dolphins with different disease conditions. New field-based techniques for dental examination, including radiographs, also were added.

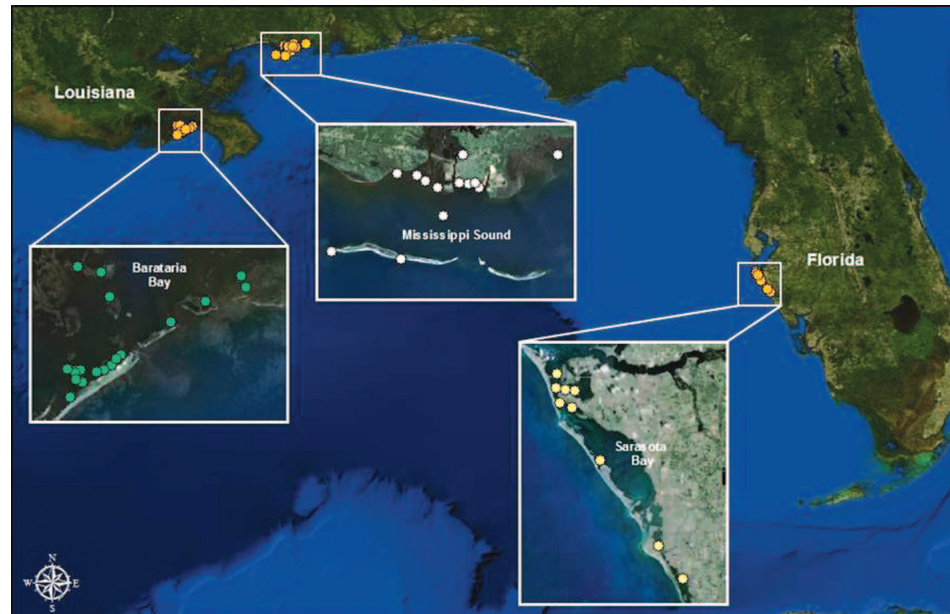
Sampling also was expanded to include Mississippi and Alabama coastal waters, and improved satellite-linked tags were used to monitor dolphin movements for several months following their evaluation.

Laboratory analyses of samples and follow-up photographic monitoring in the study sites will

continue in 2014, she said. The potential population-level impacts of the *DWH* spill are still being assessed, but the high prevalence and severity of disease conditions and an ongoing rise in dolphin deaths in the northern Gulf of Mexico raise significant concern and suggest the need for continued monitoring, she said.

“This is the first peer-reviewed publication to come out on what we’re finding in the Gulf with regard to mammals following the *DWH* oil spill. We are seeing significant health issues in the dolphins,” she said. “The issues are consistent with the effects you might expect to see after exposure to oil. Particularly with marine mammals, which are long-lived species, if there are health effects, it may take years to fully quantify the ultimate impacts on survival and reproduction.”

That ties into work being done in other labs, such as that of MUSC researcher Louis Guillette. Schwacke said the HML collaborative environment is a scientific catalyst. “Having someone down the hall who you can bounce ideas off of is fantastic.”



This map shows locations of dolphins captured and sampled for health assessments and then released during 2013 in the Barataria Bay, Mississippi Sound and Sarasota Bay areas.



NOAA Permit 932-1905-MA-009526

A dolphin has been hoisted onboard a specially designed processing boat and is being given a comprehensive health examination by an interdisciplinary research team consisting of experts in veterinary medicine, toxicology, marine mammal biology, and wildlife epidemiology. Dr. Cynthia Smith conducts an ultrasound while the team monitors the dolphin and prepares for the next procedures.

The Deepwater Horizon Story

biological view

A BIOLOGICAL VIEW

Work in the laboratories of MUSC researchers Louis J. Guillette, Demetri Spyropoulos, Satomi Kohno and John Baatz gets down to the stem cell level. The major focus is to determine if exposure to crude oil – specifically the mixture represented by the *Deepwater Horizon (DWH)* oil spill – affects long-term human health. The other critical question, just as in the mesocosm, is does the dispersant used on the spill to break down the oil also have detrimental health effects. In other words, is our ‘cure’ causing more harm?

Spyropoulos said diluted mixtures of substances might be just as potent as more concentrated single components of those mixtures, suggesting that single-component testing may be misleading as far as determining safe levels of exposures.

“Dispersant was deemed non-toxic at low, “working” dilutions. It’s been sold as something that allows for easier breakdown of crude oil by microorganisms, but it also makes oil components more bioavailable to people and aquatic organisms, including seafood. So crude oil components or the detergent- and solvent-type components of dispersant, may not be toxic individually, but combined, impact long-term health. We’re trying to find out how that works, and we’re now trying to break apart the dispersant into its components and test new combinations of components.”

If you want to really see Spyropoulos light up, bring up how the researchers are doing just that. “We take adult cells and make stem cells out of them. The stem cells are seen as surrogates for fetal growth. We have whale, dolphin, alligator and human cells. We’ve focused on human health, but we need to know how these other top, trophic predators are faring as well, partly because we share common food sources with shared exposure histories.”

Guillette said the problem with long-term studies or even large-scale studies based on epidemiological approaches in such a large area as was affected in the Gulf is the complexity of sorting out one factor – the oil spill – versus so many other factors affecting human health, such as smoking, diet and stress.

“We decided to use the power of in vitro systems and either stem cells or ‘engineered cells’ to approach the question of potential detrimental health effects.”

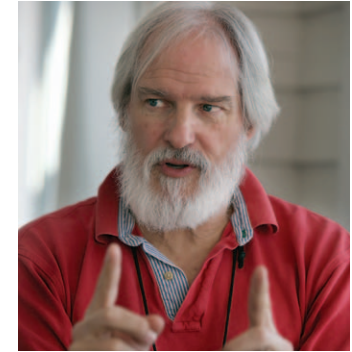
The lab groups of Guillette, Spyropoulos, Kohno and Baatz have extensive experience working with engineered cells and using them to examine environmental factors. In this case, they are culturing engineered cells from humans and other organisms to determine if exposure to oil changes the fate of the cell. “That is, can we change a cell’s fate by exposure to crude oil or dispersant or a mixture of components of the two?” Guillette said.

“In our case, we are finding exposure to crude oil alters development so that stem cells are more likely to become fat cells versus bone or connective tissue. This has serious implications as the fate of these cells is critical for future embryonic health, and more fat cells lead to obesity.”

Guillette joined forces with Spyropoulos in pathology and lab medicine, Kohno in obstetrics and gynecology, and Baatz in pediatrics. Together they outlined a way they could test oil and oil components on



Demetri Spyropoulos, Ph.D.



Louis J. Guillette, Ph.D.

surrogates for developing embryos without manipulating the embryos. The researchers are using an ‘engineered cell’ system that’s exciting in two ways, he said. It spares research animals’ lives, for one, given how the technology works, and it provides a high-end biotechnology model that can be used to test hundreds of substances to determine potency of suspected environmental contaminants, he said.

“We suspected that, like in a lot of environmental health studies, the developing embryo is a major target because it’s at a sensitive stage of development. We can’t expose human embryos –before we even get to exposing other kinds of embryos, we thought, there’s a mechanism that we can actually start to use, kind of this high-end biotechnology that we have to try and assess what’s going on. More importantly, because we also have NIST here and their principal chemists involved with analytical chemistry, we could marry this kind of world-class analytical chemistry with our biology.”

It’s been a formula for success in how the research is developing.



Dr. Louis Guillette (right) works with Ph.D. student James Nifong with National Geographic's Crittercams to capture video footage from alligators to get a view into their private lives. The study results were published in the January 2014 issue (Volume 9) of PLOS One.

biological view

The Deepwater Horizon Story

Guillette said they know if a developing embryo is exposed to certain compounds that will alter its development and in many – if not most – cases, will establish a predisposition for disease. “We are now collecting data. It took us a year to establish and validate our assays and approaches for use with crude oil and its fractions and the surfactants used during the oil spill. Early data suggests that there are components of crude oil – dispersant mixtures that are obesogenic – driving the fate of stem cells toward fat cells. Work over the next year or two will further these initial observations.”

Though the *DWH* spill provided the impetus for the current research, which is funded by the BP/The Gulf of Mexico Research Initiative, the results will go far beyond the spill.

“It accelerates the work in this area and fosters the science,” he said of the *DWH* spill research. “Here’s a component we use every day, and it’s forcing us to look in very different ways, at an oil spill, and because of its scale, because it was so massive, it demanded a massive response. There are tankers that hit shoals every day and spill 100,000 gallons of oil, and everybody goes ‘well that’s just modern society.’ But the fact is that oil has an impact on those systems and quite bluntly, we don’t understand them. We still don’t understand all the ramifications of Exxon Valdez, which was ‘just’ an oil spill off the Alaskan coast.”

Another beneficial effect is how the *DWH* research was put together so that scientists from different areas were encouraged to collaborate. Guillette said in his past 30 years

experience as a scientist, he has found the greatest discoveries take place at the interfaces of science fields. When this kind of complex problem presents itself, that’s where the solutions will appear. The *DWH* spill is requiring people with different skill sets to work together to try and understand the impacts.

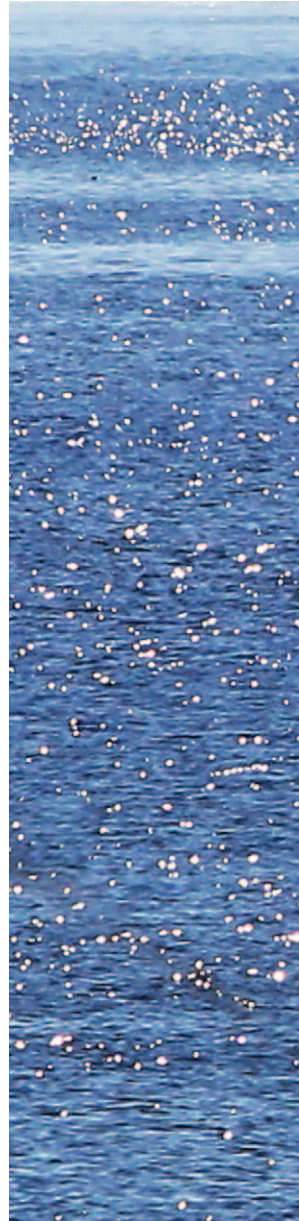
“Chemists can fractionate oil, but they can’t do what we do with those fractions in our engineered cells. By working together, we’re actually going to make much bigger discoveries, and that’s the model of the HML. All of the faculty members who are a part of the central mission of HML are, in fact, interested in that interface between environment and health. Whether it’s chemists, biologists, molecular biologists or managers who are trying to understand how you manage food or the other resources that the state is going to use, that’s how it all links together. That’s the bigger picture.”

Spyropoulos agrees, noting the wealth of individuals with warehouses of data, samples and technology at HML. “There’s a huge amount of measurements on toxic exposures in different regions and sentinel organisms. I can go and talk to a host of HML partners involved in water, sediment and marine organism tissue acquisition, contaminant analysis and fractionation, and they can tell me what I need to know. For example, if organisms in those areas carry such contamination. I can go to HML partners that have been conducting health assessments on coastal dolphins and get cells from individual dolphins that have been tracked since 2005.”

“We have partners who can measure heavy metals, including the obesogen Trybutyltin used in antifouling paint – people who can measure these compounds with world expertise. If I want to make sense of huge amounts of data on mixtures of components of crude oil and dispersant, I can access HML partners’ ‘Machine Learning Tools.’”

Guillette said all these researchers are tied together by the marine environment, where sentinel organisms, such as alligators and dolphins, reveal important clues about human health and the growing field of epigenetics. It’s why a place such as HML, with such diverse groups, has such cohesion. They all are tied together by a similar mantra.

“The mantra that we always have is, ‘if it’s not healthy for this organism living out there, it’s probably not healthy for us. If it’s not healthy for their kids, it’s probably not healthy for our kids.’ Now, is it always a one-to-one relationship? Of course not, but a red flag is a red flag. So if we’re seeing something going on in the environment, we have to ask is there something going on in ourselves?”



Though there’s a wide breadth of researchers at HML, the group holds a central mission of improving the quality of the marine environment and discovering the interconnections with human health.

*'...if it's not healthy for this organism living out there, it's probably not healthy for us.
If it's not healthy for their kids, it's probably not healthy for our kids.'*

Dr. Louis Guillette



The Deepwater Horizon Story

bank on it

YOU CAN BANK ON IT

When it's all said and done, a study is only as good as the accuracy of its data. Tasked by NOAA to be the central chain-of-custody cryogenic repository for marine mammal samples collected as a result of the *Deepwater Horizon (DWH)* oil spill disaster, biologists at the NIST Marine Environmental Specimen Bank follow the three P's – precision, procedures and protocols. It's what they are known for and do so well.

Rebecca Pugh, NIST Marine Environmental Specimen Bank Program Coordinator and research biologist, said NOAA relied on NIST's knowledge of sample collection, measurement and archival during the onslaught of samples that needed to be stored and processed following the disaster. The bank receives and maintains marine samples under secure conditions following strict chain-of-custody procedures and distributes them to investigators involved in damage assessment studies.

Their sample set includes frozen tissues that are being collected from several sources, including NOAA's Northern Gulf of Mexico Unusual Mortality Event, bottlenose dolphin dart biopsy collections (skin and blubber samples) and some samples collected from bottlenose dolphin health assessments. In 2013, NOAA conducted health assessments in Sarasota, Florida, Barataria Bay, Louisiana, and Mississippi Sound, Mississippi. Samples from these sources are securely stored in -80 °C electric freezers or in liquid nitrogen vapor-phase (-150 °C) freezers and are monitored 24/7.

To ensure samples remain uncontaminated, Pugh and colleagues don Tyvek clean room apparel and work in ISO Class 5 to ISO Class 7 clean air freezer and sample preparation rooms.

"We have very strict protocols that assure no additional contamination, which is important especially if exposure occurs in the lab setting while we are processing the sample for eventual analysis."

As of summer 2013, NIST researchers implemented a bar code labeling system for all samples collected during the health assessments, not just the samples NIST maintains, but also for the thousands of samples collected for other researchers during the health assessments as part of the *DWH* event.

"All samples are bar coded using our specimen tracking database system and strict attention is paid to the unique identifier for each sample. This ensures that every sample is not only unique but can be scanned to determine its location within the bank or if shipped, can track what scientist received the sample and for what research purpose. In addition, a chain of custody document accompanies every sample that is shipped. There were several hundred samples per animal, so thousands of samples per capture were bar-coded and either sent out for analysis or stored here," Pugh said.

Also as part of the *DWH* effort, NIST developed contaminant-sampling protocols and provided support and supplies for sample collection kits and personnel to assist with sample collections. To date, the bank is storing approximately

12,400 frozen marine mammal samples collected from more than 1,200 animals as a part of the *DWH* oil spill and, at the request of NOAA, has shipped more than 3,000 samples to multiple researchers for analysis.

NIST also develops standard reference materials to help researchers verify if the data they produce are accurate.

"We have developed very precise and standardized protocols which are used to collect, process, and store our samples. Having that level of detail can make a difference when trying to understand where that animal may have been exposed to environmental contaminants, from our oceans and waterways, or from how we may have handled the sample during collection, processing and storage."

They aid with "hind casting," enabling investigators to extend their research into the past through retrospective studies of banked samples. "It's exciting to know that we may be archiving a set of tissues that could help identify what may be an emerging contaminant or a disease that wasn't detected 20 years ago in the marine environment – but with NIST's banked samples, scientists can look into the past to hopefully find some answers to today's concerns."

Pugh scans the rows of barrel-shaped liquid nitrogen freezers and smiles. "We have no idea what secrets lie in these freezers. Though not conducting the research myself, I feel like we touch hundreds of studies because the samples and data that are associated with that sample are so important to the research study and the final results.



“It’s exciting to know that we may be archiving a set of tissues that could help identify what may be an emerging contaminant or a disease that wasn’t detected 20 years ago in the marine environment.”

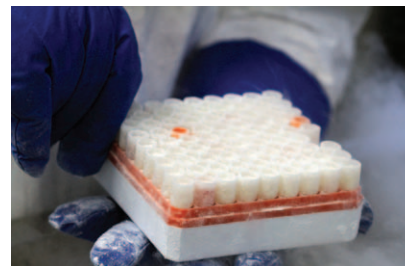
Rebecca Pugh, M.S.

QUICK FACTS:

- The *DWH/NRDA* samples take up four of the bank’s -80 °C upright freezers and one LN₂ vapor-phase (-150 °C) freezer.
- The specimen bank houses 12,400 frozen marine mammal samples collected from more than 1,200 animals as part of *DWH* incident.
- At the request of NOAA, the Marine Environmental Specimen Bank has shipped more than 3,000 samples to researchers for analysis.
- In total, the bank stores over 85,000 frozen samples representing 49 species of marine mammals, 10 species of sea birds, 5 species of sea turtles, and several species of mussels, oysters and fish.



Amanda Moors and Rebecca Pugh prepare samples for the NIST Marine Environmental Specimen Bank.



education

EDUCATION HIGHLIGHTS

Our partner institutions and HML provide several programs and initiatives that allow students the opportunity to conduct research at the laboratory. During 2013, 76 students participated in educational programs including opportunities for summer undergraduate research as well as masters and doctoral level research.

Undergraduate Programs

Minorities in Marine and Environmental Sciences Internship Program (MIMES):

The Marine Resources Division of the South Carolina Department of Natural Resources (SCDNR) offers internship positions for undergraduate, minority students. The program receives funding from the National Science Foundation and other cooperating partners, such as NOAA, and other state agencies. It also provides interested students with an opportunity to work at HML. During the 12-week program, students develop a research project while learning scientific problem solving, writing and presentation skills. Mentors experienced in various fields of marine, environmental and coastal ocean science (including chemistry, marine biology, marine policy, toxicology, microbiology, fisheries science, marine, estuarine and wetland ecology) provide instruction and guidance for the interns. At the conclusion of the program, students complete written reports and make oral presentations that describe their summer



HML's visiting undergraduate scholars gather in HML's reception area during the summer of 2013.

research. For more information please visit <http://www.dnr.sc.gov/marine/minority/>.

Summer Undergraduate Research Program (SURP):

The Medical University of South Carolina (MUSC) offers outstanding undergraduate students the opportunity to work closely with faculty members on cutting-edge biomedical research projects. Participants in this 10-week program are to perform at a graduate student level. Students are placed with faculty members whose research is closely related to academic interests and professional goals of the students. Students work with faculty on an individual basis or as part of a research team in the area of Marine Biomedicine and Environmental Sciences. For more information please visit <http://www.musc.edu/mbes/GraduateEdu/summerstudents.htm>.

Research Experiences for Undergraduates (REU) Program:

This program is funded by a grant through the National Science Foundation and hosted locally by the College of Charleston (CofC). Each summer, CofC provides research training for as many as 10 students for 10 weeks. The program focuses on the multidisciplinary theme of "Marine Organism Health: Resilience and Response to Environmental Change." Students participating in this program investigate the impacts of climate change, natural disasters, pollution, and coastal development. There are a wide variety of research projects available to students ranging from marine organisms at the individual level to the community and population levels. For more information, please visit <http://reu.cofc.edu>.

NOAA's Hollings Scholars:

The Hollings Scholarship Program is sponsored by NOAA and provides successful undergraduate applicants with awards that include academic assistance for full-time study during the 9-month academic year; a 10-week, full-time internship position during the summer at a NOAA facility; and, if reappointed, academic assistance for full-time study during a second 9-month academic year. For more information, please visit <http://www.oesd.noaa.gov/scholarships/hollings.html>.

The Charleston Computational Genomics Group (C2G2):

This program is sponsored by a NSF-funded GEAR: CI grant to advance next-generation genomics-enabled research and collaboration in the greater Charleston scientific community. The grant supports four undergraduate student research internships dedicated to training through hands-on collaborative technology support and data analysis. C2G2 conducts biweekly discussions and data analysis workshops at HML.

Graduate Programs

Our academic partners (CofC and MUSC) offer programs that provide graduate students the opportunity to conduct research at HML while they complete their coursework and other requirements pursuant to master's or doctor of philosophy degrees. While working at the laboratory, graduate students are able to participate in activities at their home institution, and they also have access to seminars and other resources at HML. Moreover, these students are provided the unique opportunity to collaborate with other students, post-doctoral fellows, staff scientists and principal investigators affiliated with other HML-based partners. The close proximity of scientists with diverse skill sets and expertise, coupled with state-of-the-art laboratory space and equipment, provide students a distinctive environment where an investment in graduate education can be amplified.

In 2013, HML was the research home to 30 students pursuing a master's degree. Twenty-eight of these students were part of the CofC's Graduate Program in Marine Biology or the Master of Science in Environmental Studies Program. For more information please visit <http://marinebiology.cofc.edu> and <http://mes.cofc.edu/>. The other two students were visiting from other academic institutions in order to conduct research at HML.

During the 2013 calendar year, HML also provided opportunities to 12 students pursuing a doctor of philosophy degree. Nine were with the Marine Biomedical and Environmental Sciences Center at the Medical University of South Carolina. For more information please visit <http://academicdepartments.musc.edu/mbes/>. Three others were visiting from other academic institutions in order to conduct research at HML.

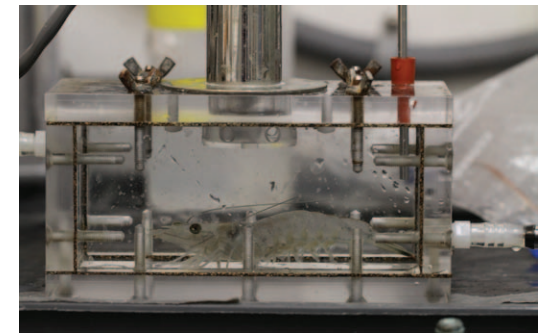
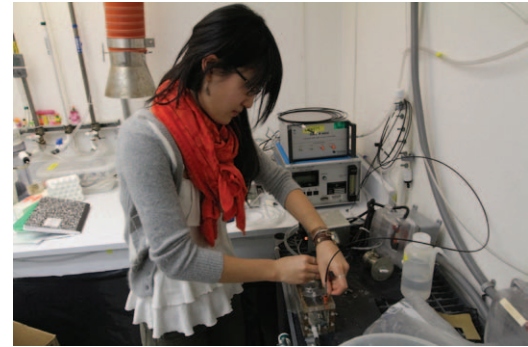


Bi-weekly C2G2 meetings at HML advance collaboration by targeted computational problem solving of individual student-driven research projects.

Institutions of the Visiting Graduate and Undergraduate Students

Allegheny College
American University
Citadel
Clemson University
Coastal Carolina University
College of Charleston
College of Saint Benedict
Delaware state University
Emory University
Franciscan University
Grinnell College
Hawaii Pacific University
Inter-American University of Puerto Rico
Lake Superior State University
Lyon College

Morris College
National Institute for Basic Biology, Japan
New York University
Savannah State University
South Dakota State University, Brookings
Texas A&M University
University of Connecticut
University of Florida
University of Hawaii
University of Indianapolis
University of Louisville
University of Scranton
University of South Carolina
University of South Florida
University of Southern Maine



Post-Doctoral Research Opportunities

Because of our state-of-the-art facilities and synergistic research environment, the HML attracts the very best in post-doctoral research fellows. In fact, opportunities abound for those post-doctoral researchers interested in developing advanced tools and/or assessing the impacts of environmental stressors on marine ecosystems and human health. In 2013, there were 15 post-doctoral fellows conducting research at HML. All of these individuals have contributed to HML's highly productive and collaborative research environment. Questions concerning opportunities for post-doctoral research at HML should be directed toward the principal investigators conducting work in a specific field of interest.



View of batik displayed overhead in HML's front lobby. The artwork was created by Mary Edna Fraser, and the three silk fans combine to depict a portion of South Carolina's coast located near HML.

facilities and infrastructure

FACILITIES AT THE HOLLINGS MARINE LABORATORY

The HML is a laboratory designed to promote interdisciplinary research through the sharing of expertise, specialized equipment, space, and other resources. Among the many tools available to scientists, the HML is equipped with state-of-the-art analytical instrumentation necessary to identify and quantify pollutants, toxicants, and pathogens; Level 2+ biosafety laboratories for dealing with viruses and other disease-causing organisms; seawater systems and aquaculture facilities to produce quantities of selected marine species for research; a nuclear magnetic resonance (NMR) facility for identification of marine toxins and potential pharmaceutical agents and for environmental metabolomics research; an ecological field collection launching and sample preparation area; a cryogenic specimen bank for preservation of a variety of marine-related biological samples, including protected species, and one of the nation's leading genomic laboratories devoted to marine species.

The HML has more than 41,000 square feet of dedicated laboratory space including:

Analytical and Environmental Chemistry

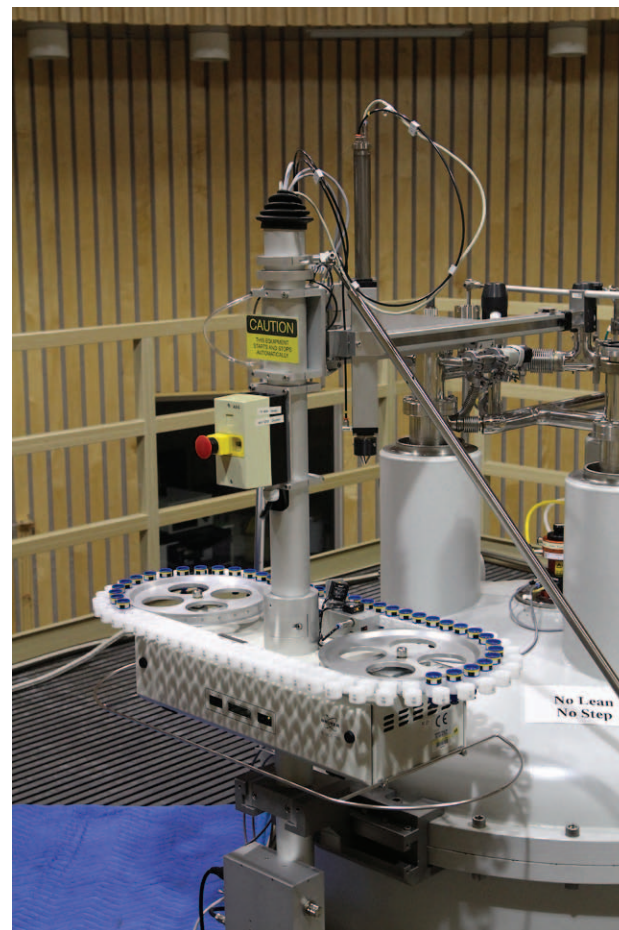
- Chemical measurement laboratories for environmental analyses which include elemental or molecular mass, molecular structure, and quantity of substances
- Nuclear magnetic spectrometry
- Mass spectrometry, including liquid chromatography, tandem, gas chromatography, and inductively coupled plasma mass spectrometry

Aquatic Production

- Ten independent seawater culture systems each with a self-contained filtration package totaling more than 100 cubic meters of culture volume together with a support lab and food preparation area
- Access to Waddell Mariculture Center

Ecological Field Processing

- Facilities for launching field collection activities, sample processing and equipment storage for ecological assessments and a platform for testing new tools and techniques
- R/V TideCreek (18' with 82" beam)



One of two high-field Nuclear Magnetic Resonance spectrometers (800 and 700 MHz) outfitted with a sample changer for automated, high-throughput analysis of metabolites, small molecules and proteins.

Cellular-Molecular Biology

- Biosafety Level 2+ facilities
- Marine Genomics Core Facility equipped with: a TissueLyser Homogenization System for RNA extractions; Nanodrop Spectrophotometer and Qubit Fluorometer for RNA quantification; Agilent Bioanalyzer for RNA quality measurement; Agilent Microarray Hybridization oven; Agilent Microarray scanner; Agilent Feature Extraction Software; Rosetta Resolver data warehousing and gene expression analysis system; and Genespring and DNA Star gene expression analysis software
- Illumina MiSeq sequencer
- CEQ 8000 Genetics Analysis System sequencers (2)
- ABI 7500 and ABI 7000 Real-time PCR Instruments
- Illumina Eco qPCR instrument
- Genetix Q-bot colony picking robot
- Dako MoFlo sorting flow cytometer

Microscopy

- Scanning Electron Microscope
- Confocal Microscope with multi-line argon, green helium neon, and red helium neon lasers
- Light Microscopes

Marine Environmental Specimen Bank and Reference Materials Production Facility

- Cryogenic facilities for long term-archival of well documented and preserved specimens for both retrospective and comparative environmental health analysis
- Clean rooms
- Specialized equipment for production of reference and control materials used in analytical and environmental chemistry

Challenge Laboratories

- Suite of laboratories adaptable to environmental conditions that include light, temperature, salinity and oxygen for animal health and toxicology research

Level 2+ Biosafety Laboratories

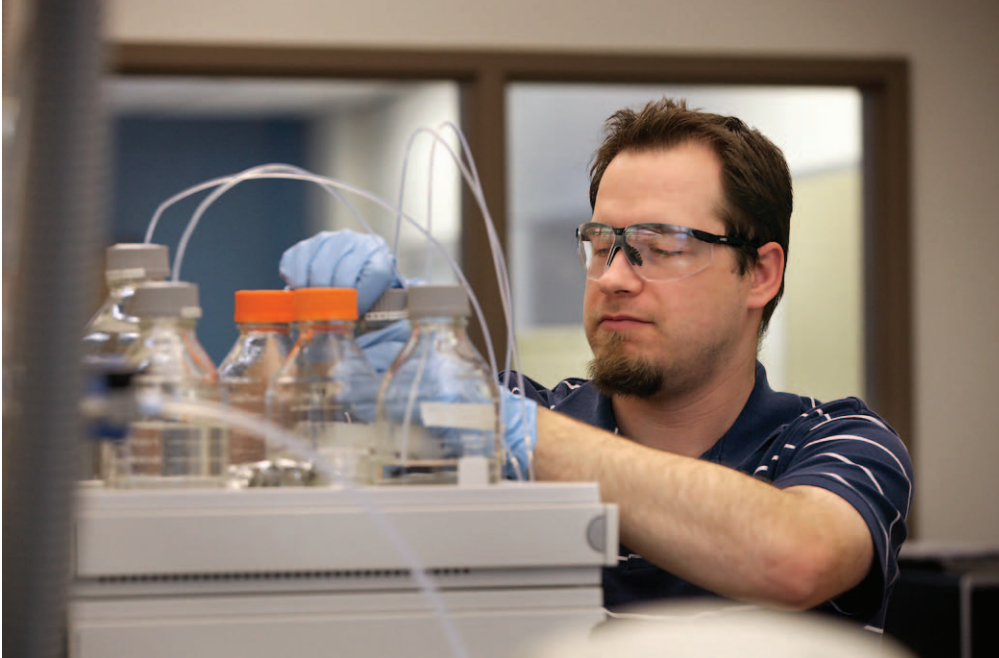
- Four Level 2+ laboratories to bring in unknowns and separate projects that require a heightened level of safety and isolation

Nuclear Magnetic Resonance

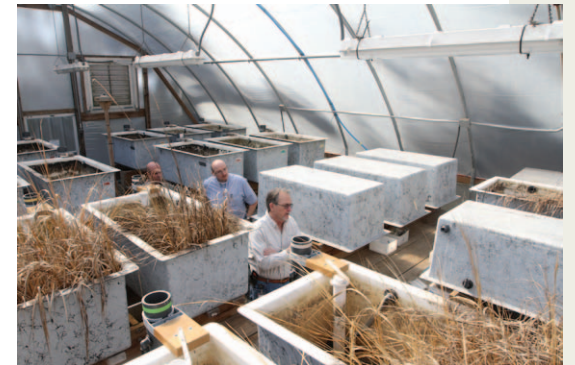
- High field facilities and laboratories to support structural biology, metabolomics and natural product research
- 800 MHz instrument
- 700 MHz instrument
- Auxiliary equipment such as magic angle and flow probe



Kevin Huncik, a research chemist with NIST (National Institute of Standards and Technology), looks for contaminants in all types of marine mammals.



John Bowden, a research chemist with NIST (National Institute of Standards and Technology), works on a liquid chromatography mass spectrometry machine.



Colden Battey, Aquaculture Specialist, stands in front of one of several culture systems at the Hollings Marine Laboratory Aquaculture Section. The versatile system has been used to culture many different animals including oysters, shrimp, red drum, cobia and even alligators.

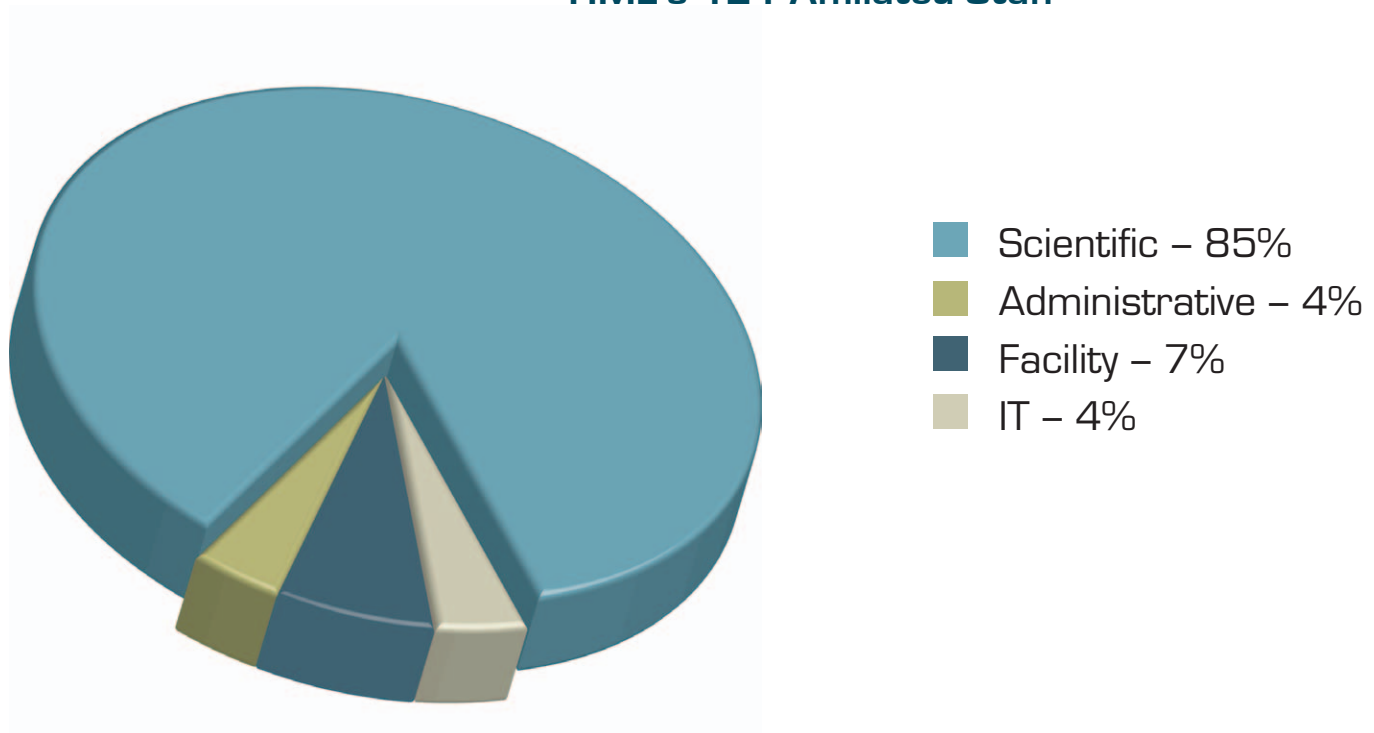


demographics

HML is a multi-institutional, multi-disciplinary laboratory.

In 2013 HML provided a safe work environment for 210 personnel. Excluding the 76 students and 13 visiting scientists, the HML supported 121 affiliated staff. This includes personnel serving in an administrative, facility, IT, or scientific capacity. HML is able to maintain operations with very few support staff: 85% of the total staff at HML served in a scientific capacity in 2013.

HML's 121 Affiliated Staff

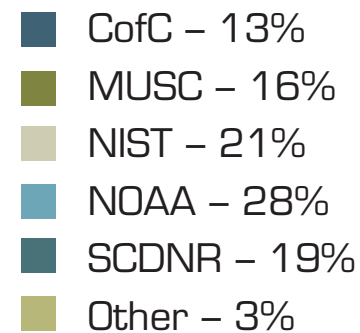
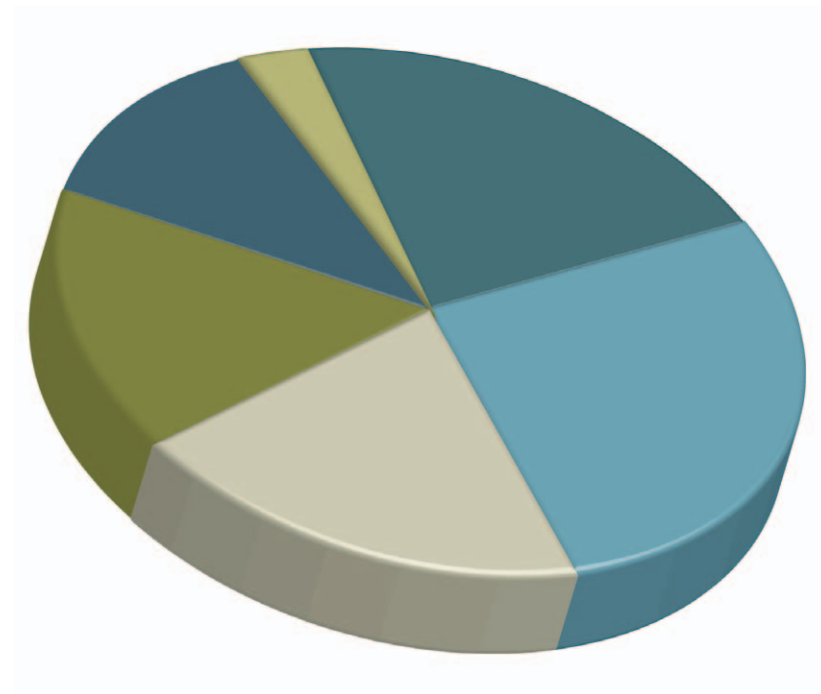


Among the five partners, there were 103 affiliated scientists conducting research at HML during the 2013 calendar year. Approximately 51% of our scientists have obtained a PhD or MD degree. Another 29% have a master's degree. Backgrounds for these individuals are incredibly diverse, with scientific expertise in fields such as zoology, earth sciences, environmental science/engineering, oceanography, coastal resources management, microbiology, marine biology, marine science/chemistry, organic chemistry, pharmacology, sociology, public health, and medicine. From aquatic organisms and ecosystems to human health and well-being, the depth and breadth of available expertise allow HML's scientists and principal investigators to evaluate and subsequently derive solutions to the most complex, multi-scale questions. This wealth of knowledge and experience in numerous disciplines provides opportunities for collaborations that result in comprehensive and incredibly insightful solutions. Our personnel and unique collaborative environment have positioned HML on a local, regional and national level to lead scientific investigations that focus on the dynamic and interdependent relationship between aquatic/marine ecosystems and human health.

Publications

During the 2013 calendar year, scientists at HML collectively published 50 peer-reviewed articles.

HML's 103 Affiliated Scientists



financial information

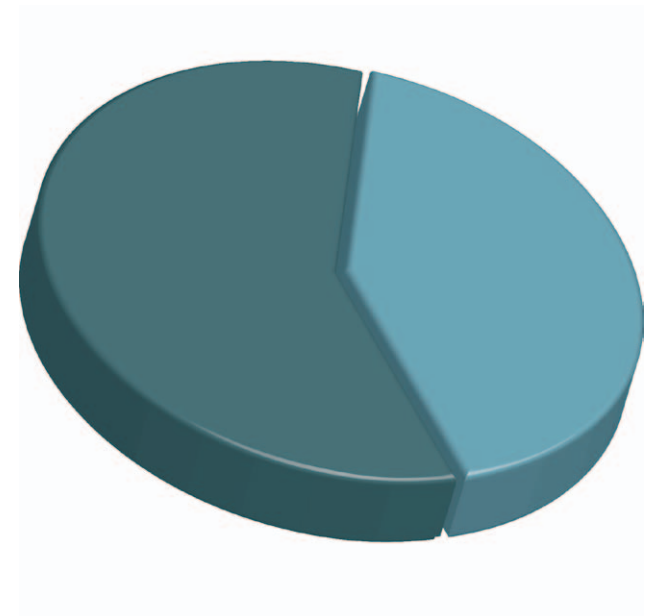
Five partner institutes are represented within HML. The NOAA/ National Ocean Service's National Centers for Coastal Ocean Science (NCCOS) serves as lead for facility operations/maintenance and supports the salary and research efforts of approximately 30 NOAA scientists.

In 2013, total funding for HML operations, NOAA-based staff and NCCOS-derived science/research was approximately \$5.3 million. Fifty-eight percent of those funds were contributed as base funds through congressional appropriations to NOAA. The remaining 42% were associated with leveraged (or reimbursable) funds.

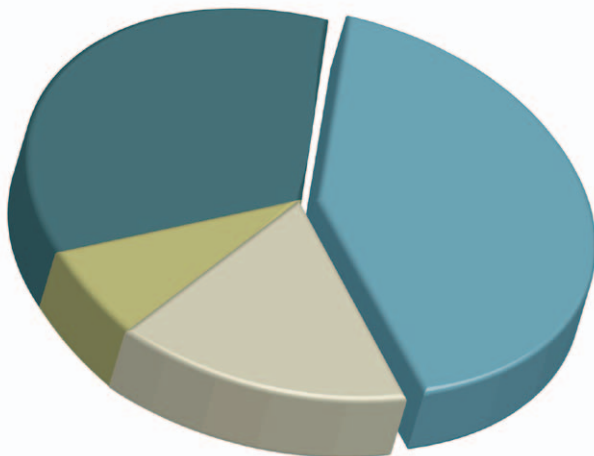
A breakout of leveraged funds contributed to HML during 2013 is provided in the second figure. The National Institute of Standards and Technology (NIST) contributed approximately \$1 million (42%) of the leveraged funds received in 2013

2013 Primary Funding Breakout

- NOAA Base Funds
- Leveraged Funds



2013 Leveraged Funds Breakout

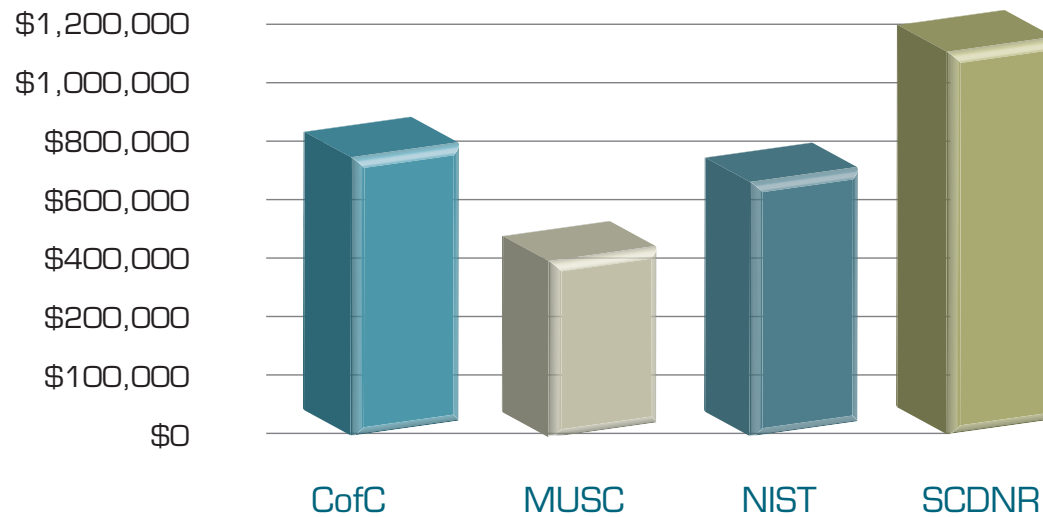


- National Institutes of Standards and Technology
- Coral Reef Conservation Program
- National Marine Fisheries Service
- Dept. of Defense - Strategic Environ. Research & Dev. Program



In 2013, HML's partner institutions were also successful in securing external funding for use in fulfilling collaborative research objectives for the laboratory. When NOAA scientists assigned to HML are excluded from calculations, our other researchers with primary appointments to the laboratory collectively received approximately \$3.8 million in combined grants and awards. A breakout of grants and awards by partner is provided below.

HML's Grants/Awards 2013



HML leadership

HOLLINGS MARINE LABORATORY LEADERSHIP

Jeffrey King, Ph.D., Acting Director *Hollings Marine Laboratory, National Centers for Coastal Ocean Science, National Ocean Service, NOAA*
Lori Schwacke, Ph.D., Branch Chief *Oceans and Human Health, Hollings Marine Laboratory, National Centers for Coastal Ocean Science, National Ocean Service, NOAA*

HML Executive Board

Holly Bamford, Ph.D., Chair *Assistant Administrator, National Ocean Service, National Oceanic and Atmospheric Administration*
Laurie Locascio, Ph.D. *Director, Material Measurement Laboratory, National Institute of Standards and Technology*
Robert Boyles *Deputy Director for Marine Resources, South Carolina Department of Natural Resources*
Stephen Lanier, Ph.D. *Vice President, Academic Affairs and Provost, Medical University of South Carolina*
Michael Auerbach, Ph.D. *Dean, School of Sciences and Mathematics, College of Charleston*

HML Science Board

Jeffrey King, Ph.D., Chair *HML, National Centers for Coastal Ocean Science, National Ocean Service, NOAA*
Paul Becker, Ph.D., Co-Chair *NIST HML Site Director, National Institute of Standards and Technology*
Geoff Scott, Ph.D. *Director, Center for Coastal Environmental Health and Biomolecular Research, National Centers for Coastal Ocean Science, National Ocean Service, NOAA*
Michael Denson, Ph.D. *Director, Marine Resources Research Institute, South Carolina Department of Natural Resources*
Louis Guillette, Ph.D. *Director, Marine Biomedicine and Environmental Sciences Center, Center of Economic Excellence Endowed Chair of Marine Genomics, Medical University of South Carolina*
Robert Podolsky, Ph.D. *Director, Grice Marine Laboratory, College of Charleston*



LJG'13

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OIL ON WATER Cover pages, NOAA

LIVE OILED DOLPHIN p. 6, Louisiana Department of Wildlife and Fisheries

OIL SPILL RESPONSE p. 7, U.S. Navy, Mass Communication Specialist, Justin Stumberg

OIL CONTAINMENT p. 8-9, U.S. Navy, Mass Communication Specialist, Justin Stumberg

MESOCOSM FACILITY p. 11, NOAA

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HOLLINGS MARINE
LABORATORY

 MUSC
MEDICAL UNIVERSITY
of SOUTH CAROLINA

 BOHR

 COLLEGE of
CHARLESTON

 NIST