current

THE JOURNAL OF MARINE EDUCATION

Volume 28 • Number 1 • 2012

special issue featuring

A Closer Look at Ocean Careers through the NOAA Ship *Okeanos Explorer*:

A Case Study

NATIONAL MARINE EDUCATORS ASSOCIATION

"... to make known the world of water, both fresh and salt."

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CURRENT LOG *Just over two years ago after the commissioning of the National Oceanic and Atmospheric Administration (NOAA) Ship* Okeanos Explorer, *an* Okeanos Explorer *Education Forum was held during which participants made recommendations for developing an education program based on the ship's unique capabilities and assets. Participants discussed at length the importance of making the* Okeanos Explorer *"come alive" by capturing the enthusiasm of the ship's officers, crew, and explorers as they live and work onboard the Nation's first dedicated ship for ocean exploration. We present, in this issue of* Current, *a personal look into the lives of some of these people.*

They are, of course, not the only officers, crew, and explorers in the world and the instrumentation is not unique to the Okeanos Explorer, *however, the* combination *of personnel and instrumentation on a* single vessel dedicated *to ocean exploration in this way is unique and is presented here as a "case study" for educators and students wanting to know more about the career paths traveled and daily work routines of those who dedicate their lives to understanding more about our little-known ocean world. Who knows? Perhaps one educator will tell a little different "career" story to one student as a result of reading an article in this issue, and together, they can make a difference…just like the differences that are being made by those represented in the stories told here.*

Paula Keener
Director of Education Programs, Office of Ocean Exploration and Research
National Oceanic and Atmospheric Administration

The beauty, mystique, bounty, and vastness of the ocean have always inspired the hearts and minds of mankind. When the first explorers ventured forth on the ocean, I'm sure they could not help but wonder "What lies below?" That wonder makes explorers of us all.

Our Nation is bounded by two great oceans and by the Gulf of Mexico. These bodies of water have offered resources, protection, avenues of trade, recreation, and other important benefits. Indeed, the welfare of humankind depends on the health of Earth's ocean system, and it increasingly depends on our stewardship.

And yet, we know so little about the ocean—much exploration remains. We need explorers, engineers, scientists, and technicians as we dive deeper and to new places to discover myriad wonders that await us. We also need those who will support and embrace the role of stewards of our ocean ecosystem and natural resources.

The ocean will continue to inspire us. And teachers and educators will surely inspire the next generation of scientists, technicians, engineers, and mathematicians. Thank you for your dedication to teaching and nurturing the sense of wonder that will inspire the next generation of ocean explorers, just as my teachers did for me.

Tim Arcano, Ph.D., P.E.
Director, Office of Ocean Exploration and Research
National Oceanic and Atmospheric Administration

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This issue of Current *has been supported in part by the National Marine Sanctuary Foundation and the National Oceanic and Atmospheric Administration's Office of Ocean Exploration and Research.*

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Ocean Exploration: Interdisciplinary Expeditions to Reveal an Unknown Ocean

By Dr. Stephen H. Hammond

Although it is surprising to many, the disquieting fact is that the *Earth's ocean remains virtually unexplored. Even though one can easily find bathymetric maps of all the world's seafloors, in fact, nearly all of them present relatively low-resolution representations of seafloor topography. It is also a fact that we have much higher resolution maps of the surfaces of planets and moons in our solar system than we do of Earth.*

The extent to which we know very little about Earth's ocean also includes lack of precise knowledge of the physical and chemical nature of the ocean itself and how it changes through time. This especially holds true for the deep ocean. At least equally startling is the lack of knowledge about the organisms that live there. This is the case for both large organisms, i.e., those visible to the naked eye and even more so for the vast ecosystems of microscopic organisms (which we now know occupy the upper oceanic crust in areas heated by submarine volcanoes).

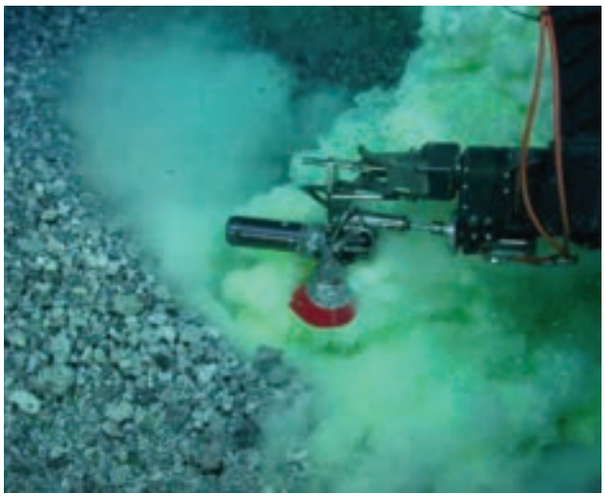
Our ocean is critical to life on Earth and the scope of what we don't know about it, coupled with the fact that the Earth's ocean/atmosphere system is in the process of rapid and accelerating large-scale change, were the impetus for a recommendation made by a blue-ribbon Presidential Panel in 2000 for a national program of ocean exploration that would begin to reveal the ocean's secrets.

This map, while extremely informative, could mislead one to assume that the global seafloor is fully mapped. In fact, the bathymetry shown is at very low-resolution, especially in southern latitudes.

The National Oceanic and Atmospheric Administration (NOAA) initiated a program of Ocean Exploration for just this reason in 2001. This Ocean Exploration Program, now in its 11th year, sponsors both global systematic explorations using its new dedicated ship, the *Okeanos Explorer,* as well as targeted exploration expeditions funded by means of a national call for proposals. Ocean exploration involves scientists from all disciplines of oceanography, geological, physical, chemical, and biological. It even includes exploration of maritime human history, marine archaeology.

INTERDISCIPLINARY OCEAN EXPLORATION OF A FUNDAMENTAL PLANETARY PROCESS

Simply based on a cursory glance at a map of the global seafloor, one immediately notices that the bottom of the ocean is host to hundreds of thousands of volcanic features, including the globe-encircling network system of seafloor spreading centers. In fact, well over 80% of the volcanic eruptions which occur on Earth do so hidden in the deep ocean. Seafloor spreading centers are where the crustal plates of the Earth are formed as magma wells up from the Earth's mantle. The 60,000 km-long seafloor spreading center system is, in fact, the single largest volcanic feature on Earth. Elsewhere, where crustal plates collide with one another, there are other extensive volcanic terrains that in this case are characterized by violently erupting volcanoes. Although eruptions along spreading centers and plate collision zones (which are also known as subduction zones) have distinct eruption styles, both are responsible for local to regional scales of physical, chemical, and biological ocean environmental impacts.



Sampling gas bubbles at a volcanically active vent on NW Rota-1 submarine volcano, Mariana Arc, in March 2010. The yellow and white material is particulate elemental sulfur produced by degassing of sulfur dioxide from erupting lava. The gases produced by volcanically or hydrothermally active submarine volcanoes often results in local to regional regions of high acidity.

NOAA, as the Nation's civilian ocean agency with responsibility for ocean stewardship, has a goal of understanding the effects of planetary-scale submarine volcanism on the ocean. To accomplish this, the effort must be interdisciplinary. The expertise of a geological oceanographer is required to understand the volcanological processes. Physical and chemical oceanographers provide expertise into understanding how an eruption impacts the surrounding water. Biological oceanographers understand how an eruption's physical and chemical manifestations impact existing ecosystems in the area and, interestingly, also initiate new ecosystems especially adapted to eruption-produced hydrothermal venting. It was this kind of interdisciplinary synergy that led to the discovery of chemosynthetic animal communities associated with venting at several locations along the Galápagos Rift in 1977, forever changing our understanding of life on Earth.

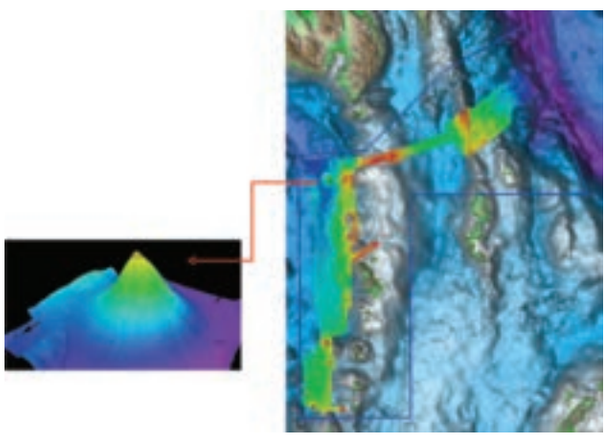
Coincidentally, very recent exploration of submarine volcanoes in the Mariana Arc revealed, for the first time, spectacular examples of volcanoes spewing immense quantities of carbon dioxide and sulfur dioxide. Both styles of venting are resulting in intense acidification of the volcanoes' regional environments. Although from a human perspective the environments around these volcanoes are highly toxic, each volcano is host to a unique ecosystem of highly adapted organisms. Recognizing that the global ocean is becoming acidified as a consequence of absorbing increasing quantities of atmospheric carbon dioxide, these discoveries raise the possibility of utilizing these volcanoes as natural ocean acidification laboratories. Again, gaining an understanding of these and other submarine volcanism sites and their environmental impacts requires an interdisciplinary oceanographic approach.

DISCOVERIES IN INDONESIA'S DEEP SEAS

In the summer of 2010, the NOAA Ship *Okeanos Explorer* embarked on its maiden voyage of exploration (http://oceanexplorer.noaa.gov/okeanos/explorations/10index/welcome.html). The expedition was the culmination of a long and complicated planning effort that involved high-level diplomatic, science, and technical leadership in the U.S. and Indonesia. Indonesia has long been recognized for the spectacular diversity of its land-based fauna. Indonesia's shallow seas likewise are rich with a diversity of marine life. What particularly intrigued the interests of both U.S. and Indonesian ocean scientists was to find out if Indonesia's deep seas, which are nearly unexplored, are just as biologically diverse.

The geological setting of the Indonesian region is incredibly complicated. Indonesia itself consists of 17,000 inhabited islands all of which lie in an area of multiple spreading centers and collision, or subduction zones. There are vast areas of relatively shallow seas punctuated by trenches and deeps that reach depths of more than 9 km. The area is subject to incessant earthquakes and is the most volcanically active region on the planet. Knowing this—and combined with the knowledge that areas of volcanically and hydrothermally active submarine volcanoes elsewhere in the world are places where spectacular biological discoveries are common—an interdisciplinary team of U.S. and Indonesian oceanographers devised a cruise plan that they believed offered a high probability of finding never-before-seen ecosystems.

The expedition planning began with highly skilled mapping technicians working closely with the scientists to create a high-resolution map of the area of interest. Utilizing this map, the



The NOAA Ship *Okeanos Explorer* mapped an area larger than the state of Delaware during its maiden international voyage to explore Indonesia's deep seas. The new bathymetry is shown by the bright colors. Such high-resolution bathymetry is required in order to effectively explore seafloor features in more detail with remotely operated vehicles (right). The volcano shown in more detail, Kawio Barat (left), was found to be hydrothermally active.

interdisciplinary science team could then pick targets where active submarine volcanoes were most likely to be encountered. Once the *Okeanos Explorer* reached the exploration area, her state-of-the-art multibeam sonar mapping system was used to create more refined bathymetric maps of the target exploration areas, with the first leg of the expedition primarily devoted to creating a map of the entire exploration area (see article on page 15).

Once the map was completed, features that were clearly volcanic in origin were identified by the science team. The second phase of exploration consisted of steaming slowly over the areas of interest while repeatedly lowering and raising a conductivity-temperature-depth (CTD) sensor package to depth. Operated by a Senior Survey Technician onboard the ship (see article on page 13), the CTD provided real-time data that revealed whether or not there were heat and chemical plumes in the water column. The CTD survey was augmented by the ability to take water samples by triggering Niskin bottles when plumes were encountered. With input from chemical oceanographers ashore who specialize in hydrothermal vent chemistry, the onboard science team was able to guide the CDT's path through the water column and home in on areas from which plumes were originating.

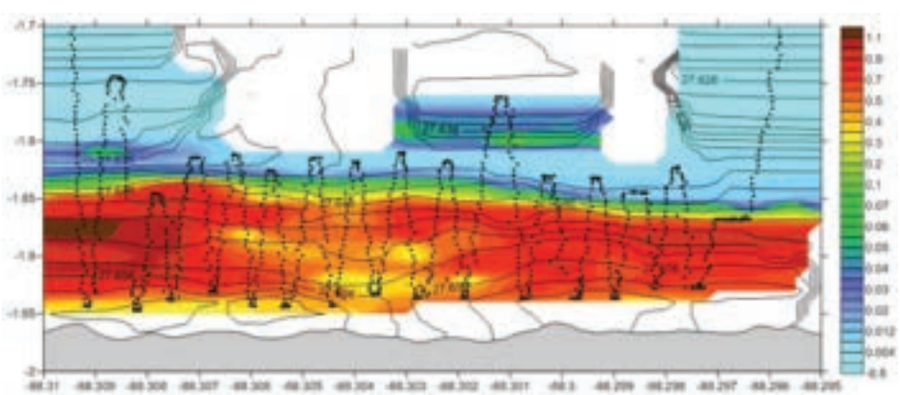
The third and ultimate phase of the exploration was then to deploy a remotely operated vehicle (ROV) equipped with thrusters (for precise maneuvering), lights, and high-definition cameras. The ROV and its companion overhead vehicle were tethered to the ship by a fiber-optic tow cable. Both the ROV, and the overhead vehicle (whose chief utility was to eliminate any ship motion being transferred to the ROV) then embarked on a near-bottom, high-resolution visual search for active venting. The ROV, *Little Hercules,* which was made state-of-the-art for this expedition, produced stunning HD video imagery of both the geology and biology of the dive sites (see article on page 20).

When the Galápagos Rift discoveries were made, the principal near-bottom visual search tool was a human occupied submarine (or vehicle), an HOV. The deepest diving HOVs can carry a maximum of three persons and are limited to a few hours when at their maximum depths. By contrast, video and other sensor information from an ROV is transmitted by fiber optic cable to the overhead vessel thereby enabling the entire science team on the ship to participate in real-time in the dive. Moreover, an ROV can hypothetically stay submerged indefinitely.

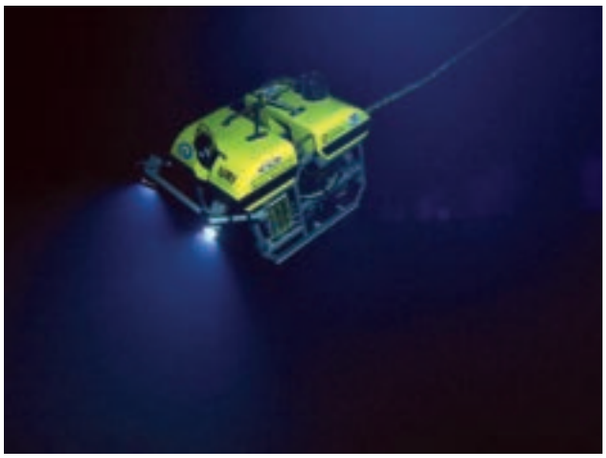
The *Okeanos Explorer,* however, has another capability that makes even the methodology just described pale by comparison in terms of real-time accessibility to the seafloor. The *Okeanos Explorer* is one of only two civilian ocean exploration vessels in the world equipped with "telepresence." Telepresence is made possible by a broadband satellite-based communication system that enables three high-definition video streams to not only be accessible onboard the ship but also to be transmitted from the ship to shore-based "Exploration Command Centers" with Internet2 connectivity. In addition, the video and one-way audio can be provided in near real-time on the Ocean Exploration Program's website (http://oceanexplorer.noaa.gov). Combined, these means of communication enable a virtually unlimited number of interested scientists, educators, students, and the public to participate in real-time exploration and discovery (see article on page 23).

The telepresence-enabled U.S./Indonesian expedition was a spectacular success. The deep Indonesian seas are indeed biologically diverse and pristine. To illustrate a participating biologist noted that previously no one had ever seen the numbers and species diversity of deep corals encountered in the areas explored with the ROV. Further, a spectacular active vent site was discovered on the top of a large volcano (Kawio Barat; page 3, bottom left image). The site is characterized by numerous active white smokers, massive sulfide chimneys densely colonized by what appear to be new species of animals, including dense populations of barnacles. All told, it was estimated that there were over 100 new species of vertebrates

A CTD sensor package.



CTDs are slowly tow-yo'ed through the water column (the path of the CTD is shown by the sawtooth line in the data plot) in order to detect, and then home in on, heat and particulate plumes coming from active eruptions or hydrothermal vents.



Little Hercules during one of its dives off Indonesia.

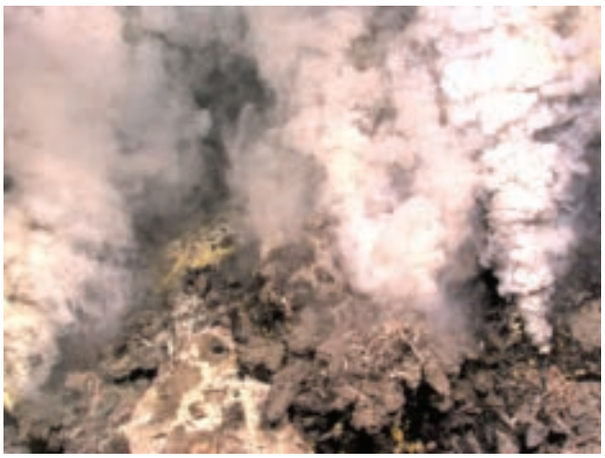


Image of a very active hydrothermal site on Kawio Barat submarine volcano collected by *Little Hercules*.

and invertebrates observed, including many new species of deep-sea corals. A high-resolution bathymetric map of an area approximately the size of Maryland was produced for an area of the seafloor never before explored.

Findings of the expedition are now being assessed and interpreted by the interdisciplinary science team. Results are being presented at professional meetings and will be published in scientific journals. Data from the U.S./ Indonesian expedition, as well as any other expedition of the *Okeanos Explorer,* are open and available to those requesting them virtually as soon as they are accessible, which is yet another important pioneering way of expediting ocean exploration (see article on page 26). Ocean science educators are connecting classroom teachers and informal educators through lessons plans, professional development, and other offerings to the science of ocean exploration and the people who make it happen (see article on page 32). The oceans are still almost entirely unexplored. NOAA's Ocean Exploration Program with its many partners is endeavoring to change that.

DR. STEPHEN R. HAMMOND is the Acting Chief Scientist of the National Oceanic and Atmospheric Administration's (NOAA) Office of Ocean Exploration and Research as well as Director of the NOAA's Pacific Marine Environmental Laboratory's Ocean Environment Research Division and Vents program. He is an adjunct professor in the College of Ocean and Atmospheric Studies at Oregon State University.

Dr. Hammond has a Ph.D. in marine geophysics and has been involved in marine geophysics and submarine volcanic and hydrothermal research for more than 40 years. He has led

Telepresence: real-time, broadband video and audio communications made possible by the *Okeanos Explorer's* powerful satellite antenna (red arrow).

Arrays of monitors in the ship's control room and onshore in Exploration Command Centers display high-resolution streaming video of the remotely operated vehicle as it operates on the seafloor.

A sea anemone and hermit crab share a shell, providing a beautiful example of biological commensalism. The anemone's stinging cells help protect the crab from predators; the anemone benefits from having a free ride around the seafloor habitat, as well as from receiving scraps from the crab's feeding activities. This is one of hundreds of images of the spectacularly diverse biology discovered during *Okeanos Explorer's* Indonesian expedition.

the NOAA Vents ocean exploration program, an internationally recognized leader in submarine volcanic research, for more than 25 years. During that time, the Vents program's interdisciplinary teams of oceanographers have made many discoveries which have brought to light dramatic global ocean ecosystem impacts of submarine volcanic activity.

As Acting Chief Scientist for NOAA's Office of Ocean Exploration and Research, Dr. Hammond provides scientific guidance for a unique national program devoted to acquiring physical, chemical, and biological knowledge about the Earth's still vastly unknown ocean. The Office also funds research focused on marine archaeology and a national ocean literacy program for teachers and students.

Dr. Hammond received his Bachelor of Science degree from the University of Missouri at Kansas City and his Master of Science degree and Ph.D. from the University of Hawaii.

PHOTO CREDITS

Page 2: Courtesy of Heezen and Tharp, World Ocean Floor Panorama, 1977

Page 3 (top): Courtesy of James F. Holden, UMass Amherst

Page 3 (bottom), 5, and 6: Courtesy of NOAA *Okeanos Explorer* Program, INDEX-SATAL 2010

Page 4: Courtesy of NOAA *Okeanos Explorer* Program

Call for Papers

SHARE YOUR IDEAS, LESSONS, or RESEARCH in Marine Education!

The editors of *Current: The Journal of Marine Education* are seeking articles for upcoming general issues. We hope to review and publish articles on topics related to marine education. We seek original manuscripts that describe research, lessons, resources, or strategies for teaching marine and aquatic lessons to a variety of audiences. Please submit articles and/or activities to Lisa Tooker at ltooker@sbcglobal.net for consideration. For information on author guidelines, please visit the NMEA website at www.marine-ed.org and click "Get *Current* Guidelines."

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NOAA Corps Officer, NOAA Ship *Okeanos Explorer*

By Nicola VerPlanck

I was born in California but left the United States at the age of *four, the daughter of a British man and French woman who both left their homeland as precocious youths with the desire to see the world. They met in the hottest, driest, most un-ocean place in the United States—Death Valley. They dated, married, settled ever so briefly, and eventually bought a sailboat that they are still sailing around the world in to this day. I grew up on that sailboat, a 43-foot sloop. Most of my early childhood was spent in the South Pacific. I was homeschooled from the very beginning. I did not attend a real school until I was 11 years old. School off the boat began in the place I often refer to as home—New Caledonia, a small French-speaking island country. It's nothing like France. Like Jamaica to the U.S., they speak the same language with a strong accent and have their own totally different culture fed from their own unique history. During this time it became clear that I, too, had inherited the same travel bug as my parents.*

At the age of 15, I finished primary school and left New Caledonia on my own. I went to France where I attended a boarding school. After high school, I completed two years of college in the south of France. Eventually, I got the itch to travel again. I had not been back to the United States since leaving as a young child and had recently heard great things about a school in Florida so I transferred to the Florida Institute of Technology to finish my Bachelor of Science in Ocean Engineering. I was having so much fun there that I decided to continue my education and completed a Master of Science in Ocean Engineering. I chose the field of Ocean Engineering not because I had a career path or profession in mind but mostly because I was good in mathematics and physics, not so hot in arts and literature, and never considered not working near or on the water.

My parents, dreamers themselves, always encouraged me to pursue my dreams. My dreams were always of the ocean and so Ocean Engineering felt like a good fit. During my final year of undergraduate school and two years of graduate studies, I worked as a teacher's assistant on the Florida Tech research vessel and as research assistant on many different projects. Some of these projects included oceanographic and meteorological data collection analysis, underwater reef transect surveys, beach erosion-accretion calculations and factors, and monitoring experimental coastal structures such as the Rapid Installed Breakwater (RIB) for the U.S. Army Corps of Engineers. All these projects were fascinating, but they also made me acutely aware of the myriad of ocean and coastal career possibilities.

I enjoyed school not just for the education, but I also felt I was basking in a momentary respite before entering what most of us call *the real world* and starting *a real job.* The *real job* meant, so I thought, that it was going to be hard to travel the world. Eventually that notion proved to be false, but scared that I was about to begin a sedentary lifestyle and needing a break after seven years of being a student, I packed up all my belongings (one trunk and five boxes), stowed them at a friend's house, and took a nice little nine-month-long backpacking trip through Scandinavia and Eastern and Western Europe. I had worked hard through college and had saved up enough money to accomplish this dream.

I first learned about the National Oceanic and Atmospheric Administration (NOAA) from the nautical charts my parents occasionally used in our travels. After some later research, NOAA's diversity, their Corps Uniformed Service, and the many opportunities in a wide variety of fields, impressed me. The NOAA Corps seemed to be the perfect fit. I was especially excited with the opportunity every three years to rotate into a new position in different geographic locations all over the world. Still, I wasn't exactly sure what I was getting myself into when I applied. The decision to join was eased a bit after returning from my European trip with only a few dollars to my name. I figured I would give it a try and see where I would end up. It was the best decision I ever made.

A bachelor's degree in science or engineering is required in order to join NOAA's Commissioned Corps. Once accepted, you complete several months of training to learn how to handle and navigate ships. And these ships are nothing like the little sailboat I grew up on! After training, all successful trainees are assigned to one of NOAA's research vessels as Junior Officers. There are four types of vessels: Oceanographic, Fisheries, Hydrographic, and Exploration. I was appointed to the NOAA Ship *Rainier;* a hydrographic survey vessel home-ported out of Seattle, Washington. Its working grounds stretched from South East Alaska westward to the end of the Alaskan Peninsula, over 1,500 miles off a very northern, very chilly coastline. I have to admit that I cried for two days when I found out that they were sending me to Alaska. The only ocean I really knew was

between 23 degrees North and South. I had never lived in a place that cold; it was a very scary thought. I had requested for a ship in between the tropics. Instead I was going as far from the warm weather as possible! I survived the cold, but even more so, I found Alaska incredible.

The ship's mission was to conduct hydrographic surveys and update nautical charts. My job was as fascinating as it was busy. I not only navigated the vessel from working ground to working ground, but I also had collateral duties such as hydrographic survey data collection, Diving Officer, Tides Officer, Navigation Officer, Medical Officer, and Moral Officer. These new skills required further learning and training that I received on the job or in additional formal courses. There was also exciting and unusual training such as basic and advanced fire fighting training and Medical Person In Charge training. I also had to qualify at a military shooting range with the ship's firearms. We have firearms not to protect ourselves from pirates or thieves, but because the shoreside, coastal work we are involved in is often on the same shared coastline with some of Alaska's larger, furrier, toothier residents. Once the ship leaves the dock, we are our own little community. There are no hospitals, fire departments, or Department of Natural Resources personnel to come to the rescue, if needed. We had to be self-sufficient.

Two years in Alaska went quickly. I received a new assignment in Narragansett, Rhode Island, as Expedition Operations Coordinator with NOAA's Office of Ocean Exploration and Research (OER). The title sounded quite intimidating, if not a little vague. I wasn't sure what I was going to be doing. It was once again the start of a new adventure. Eventually I settled in and again learned an entirely new set of skills. I participated in joint expeditions with OER and Dr. Robert Ballard's Institute for Exploration in the Black Sea and Mediterranean Sea where I served as a remotely operated vehicle (ROV) navigator and helped with mapping the seafloor. I had extensive hydrographic survey experience from my previous assignment and was able to bring this expertise to the team. I also brought experience in ship handling and bridge communications. The ROV navigator position was an easy transition considering the position required being a liaison among the ROV pilot, co-pilot, and the bridge of the ship. Because I understood what the ship was capable of doing, I knew what maneuvers were reasonable. I also understood the formal way we communicated on the bridge and between vessels, and was able to make those maneuver requests clear and concise. Without realizing it during my time working for OER, I developed essential skills that would help prepare me for my next assignment—coordinating expeditions with teams at sea and interdisciplinary science teams participating both at sea and from shore-based stations.

The three years working in Narragansett came and went and once again I was rotated into a sea assignment. I was assigned to the NOAA Ship *Okeanos Explorer,* America's only Federal vessel dedicated to exploring the unknown ocean. It was the perfect next step for me. The work was again very different, but I knew how to handle a ship and had a firm grasp on the mission of the ship. Much of my time in my previous position at the OER was spent helping define this ship's mission. My new position aboard the *Okeanos Explorer* was as the vessel's Operation's Officer. Again I was a liaison (and occasionally a mediator) between the ship, the interdisciplinary science teams aboard the ship, and the shoreside support. Once again, my previous experiences and training helped me become accomplished in my new position. It was very challenging, but also intensely rewarding. I sometimes felt like a conductor leading an orchestra. I had to not only have a thorough understanding of the complete picture, but also the individual dynamics that shaped the bigger picture, such as managing expectations and personnel dynamics. Like the conductor, I had to guide each department and group when to enter, what the emphasis was, and what the pace should be.

As mentioned earlier, the *Okeanos Explorer* is comparable to a small community; each person has a well-defined role. There are 27 permanent crewmembers and 19 additional bunks for rotating mission personnel such as scientists, video and electrical engineers, ROV pilots, hydrographic technicians, and

The author dresses as a date line in a costume contest at sea after crossing the International Date Line on the way to Guam.

The author at an event hosted in Indonesia.

interns. The permanent crew is structured in six departments aboard the ship. The Engineering Department is responsible for keeping the ship's engines and everything mechanical running; the Deck Department is responsible for operating the deck equipment and ship's maintenance; and the Stewarts Department is responsible for feeding the crew (and keeping everybody happy). The Electronic Technicians are responsible for nearly everything high tech; the Survey Department is responsible for collection, processing, and archiving data; and the Command is responsible for handling the ship and ship management and administration.

As Operation's Officer, I do not need to know how to do everything to run the mission; instead I need to understand everybody's role and know who to talk to when required. Communication and organization are extremely important in this respect. For each mission to be a success, we all need to work as a team and the Operations Officer serves in a capacity similar to a team captain. Besides fulfilling mission duties, I also became a Senior Watch Officer (SWO) during my time on the *Okeanos Explorer.* The SWO qualification requires tremendous responsibility, as they have gained all the required skills and experience to navigate the ship without any senior assistance. This means that if something were to happen to the Captain and/or First Mate, an SWO is capable of all operations necessary to manage and navigate the ship.

The *Okeanos Explorer* has explored the waters off the West Coast of the United Stated, the Hawaiian Islands, Guam, and Indonesia. It's funny for me to remember the anxiety I felt after college. I was so worried my anchor might be permanently set. Well, I feel very fortunate now. My *real job* in the *real world* has taken me to places I never would have imagined traveling to on my own.

Who would have thought that with a degree in Ocean Engineering I would be researching and exploring the world's oceans with interdisciplinary and diversified experience in such unique areas as fire fighting, ship handling, and ROV navigation. I have lots of college friends with the same degree. They have cool jobs. They are Naval Architects, Port Engineers, Numerical Modelers, and Coastal Project Managers. These are great positions, great titles, some with great salaries. But their anchors are down and dug in. A wind might blow strong enough that they drag their hooks, but not very far. I get to sail wherever the wind takes me, and for that I am extremely grateful.

NICOLA "NICKY" VERPLANCK earned a Bachelor of Science in Ocean Engineering in 2001 and a Master of Science in Ocean Engineering in 2003, both from the Florida Institute of Technology. She joined the NOAA Corps in 2004. Her first sea tour was aboard the NOAA Ship *Rainier* conducting hydrographic surveys to update NOAA's nautical charts in Alaska. Her first shore assignment was with NOAA's Office of Ocean Exploration and Research (OER) in Rhode Island as an operations coordinator for telepresence-enabled expeditions conducted by OER and Dr. Robert Ballard's Institute for Exploration. This position prepared her well for her second sea assignment aboard the NOAA Ship *Okeanos Explorer* as Operation's Officer. Nicky recently rejoined OER in a billet as the OER Program's Deputy Program Manager in Seattle, Washington. She is working to plan and execute OER's program of systematic, telepresence-enabled exploration aboard the NOAA Ship *Okeanos Explorer.*

PHOTO CREDIT

All Photos Courtesy of NOAA

Exterior shot of the NOAA Ship *Okeanos Explorer* while in transit.

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NOAA Ship *Okeanos Explorer* Chief Bosun: Worth His Salt in His Own World and the Sea

By Carl VerPlanck

When my alarm rings at 0400, I already have a pretty good idea

of launch conditions. All night I've kept a tally on the weather. I know the seas: if they're steep, if they're high, if they're long, if they're steady or if they're mixed, if they're quartering or following or abeam, if it's wind-driven chop, or if it's long ocean swells rolling in from a distant storm. I know if it's raining and if the rain is a constant or only shower or if it's storming. I know if it's calm or windy or gusty. And I am not alone. Any deckhand, and especially any bosun, worth his salt, has dreams in two worlds, his own and the sea's.

So now, when I arrive on deck 15 minutes later, I'm not surprised everyone is already in rain gear. They were tuned to the same frequency; I have a top-notch department with years of experience. They've already made deck preparations. The hydraulics are humming; the crane is set; the deck lights are on; and the remotely operated vehicle (ROV) awaits in the hanger like a performer waiting to come on stage. We are ready to launch.

I am the Chief Bosun aboard the National Oceanic and Atmospheric Administration's (NOAA's) Ship *Okeanos Explorer*. The title is eccentric and ambiguous. Bosun (or Bos'n) is the phonetic spelling for "boatswain." Etymologically it's a concatenation of the Old English word *bat* (boat) and *svain* from Old Norse, which roughly means young man. Chief is a much later addition probably supplied by the U.S. Navy, but not used together with bosun. It was likely paired relatively recently, perhaps even here within NOAA. The grandiose title, "Chief Bosun" might be best described as a politically polite euphemism for the less decorous, but more descriptive and just as apt, "Chief Boat-Dude." We like bosun because like many things maritime, it has a history and story. It is the oldest rank of the Royal Navy. The position existed when ships were wood and canvas and tar, before anything was computerized, electrical, or even mechanical, including engines. It joins ranks from the early Royal Navy period with similar titles such as Master, Carpenter, and Cook. There are many distinguished bosuns who served heroically, often in the theatre of war, but most of those names are only recognizable to history buffs. The most famous bosuns are literary from the boatswain in Shakespeare's *The Tempest* to Smee, Captain Hook's right-hand man in *Peter Pan*.

Carl VerPlanck checks out NOAA Ship *Okeanos Explorer* rescue boat during test run.

Today, a bosun on a modern research (or exploration) ship is as likely to tar a sail, as one is at home to churn butter. Although traditions such as tarring and the like continue on beautiful tall ships throughout the planet, most of us have completely different abilities that more closely represent the requirements of working aboard thoroughly modern, engine-driven vessels. The responsibilities are similar but the materials and methodology are completely different.

The bosun's purview stretches from the vessel's decks to the operations involved upon them and all that is in between. The bosun, however, is not alone in contending with these responsibilities. The deck department is a highly skilled and motivated team who work with the bosun to attend to these affairs. The bosun supervises this department, but the job would be impossible without the assistance and support of the entire department, especially the Bosun Group Leader (BGL). She is an indispensible link between the deck department and me. She interprets my theoretical work lists and makes them tangible by ascribing duties throughout the department. I may assist with complicated maintenance, but the BGL is generally quite capable of coordinating maintenance-type work and many operations without assistance. This arrangement has its roots in

Carl VerPlanck communicates with other ship personnel while looking over port side of the NOAA Ship *Okeanos Explorer.*

The author on stern of the NOAA Ship *Okeanos Explorer* overseeing deployment of the camera sled for a ROV dive.

the Navy and other military chains-of-command, allows a "work under-study" to learn about his or her next position, allows for redundancy in supervision, and creates a clear pathway for conflict resolution.

Maintenance and administration are big parts of any bosun's job on any vessel anywhere but that is definitely not what draws NOAA bosuns to any one of the 18 NOAA vessels operating throughout the world. I consider the operations here aboard the *Okeanos Explorer* to be the most interesting in the fleet. Besides operations familiar to just about all ships, such as anchoring or mooring, we also conduct a variety of scientific, research, and exploratory operations. We have two, 22-foot jet boats that we launch, recover, and operate. We have a J-frame paired with either of two winches—one of which sits upon a rotating table and may be used for A-frame operation, but more frequently it is used for conductivity-temperature-depth (CTD) casts, and the other for small instrument deployment as well as man-overboard recovery. We have two, aft-deck cranes. One is for general deck lifts and the other for assisting in launch and recovery of the ROV. And of course, we have a large A-frame paired to 8,000 m of .68 fiber-optic cable spooled onto a large traction winch below deck. This is the heart of the ROV's Launch and Recovery System (LARS).

As a supervisor, I try to do as little of any of this as possible. I'm sure I'll get a lot of ribbing from the department and maybe something different from my superiors for making this statement. And superficially, it does sound antithetical to what one would expect from someone in my position but it is not nearly as easy as it sounds. I am qualified, trained, and experienced enough to operate any and all of the ship's deck equipment. I can run either of the telescopic knuckle cranes. I know what loads they can handle and what radii to use for a given load. I know how to rig them and if the boom head sheave is showing advanced wear around the groove, I probably know why. If I could slow down time like in that movie, *The Matrix* I could operate the A-frame, winch, tuggers, ROV crane, and maneuver the ship all at the same time and do ROV launches and recoveries mostly alone. I can recover or launch a jet boat and if it was possible, I could then hop aboard and operate it. I'm qualified to dive from that same jet boat too. If the ship's prop was fouled, I might be in the water to unfoul it. I operate dozens of power tools, many of them for specialized work. I can tie a dozen knots (and engineers take note, they're all different!). I know as many splices for as many types of line. I know way too much about line in fact. I know why to use a certain compression fitting and how to swage it to what wire rope and for which purpose. I know about preventative maintenance, about maritime protective coating systems, about water tight doors and hatches, and about lubing and greasing; I could tell you which Code of Federal Regulations regarding the size and color stenciling we use on the life rafts; I could tell you how to launch the life rafts and what is contained therein; and though I doubt anyone in the deck department believes me, I know how to swab a deck and clean a head.

I try not to do any of these tasks though. Not because I'm lazy but because there are many in the deck department who can do the same. They, like me, have learned and honed these skills through years of experience. The real test for any supervisor is how well you can teach others the technical skills learned over your career and then "sit back," watch, and make only the most necessary corrections. "Sitting back" is anything but easy after a career of hands-on involvement. The hallmark of a good bosun is to be able to supervise rather than interfere. It takes intent listening, watching, and communicating, in addition to a thorough knowledge of whatever the task might be.

It's difficult for me to imagine now, but about 13 years ago, I definitely was not working on an internationally bound research vessel as a supervisor for a department of skilled hands launching and recovering high-tech, multi-million dollar pieces of deep-sea equipment. I was sharing a basement apartment in Southern Indiana with three other people, washing dishes three times a week at a bar, and discovering different ways to shape Bisquick into food types. Popcorn was the chameleon of international cuisine. If seasoned right, popcorn could be Mexican, Thai, or Italian. I was 18-years-old and had no interest in going to school, although I probably could have. My parents were middle class and both well educated. My father was a Rhodes Scholar; my mother had a full ride to the University of Michigan, but I had done exceptionally uneven work in high

school. I would conjure an A in chemistry and an F in history during one semester and reverse those in the next. It was the hardest labor of my life to learn about subjects in which I did not have an interest at the time. I "ended-up" at an alternative high school with a career center. After buoying my grades, I returned to regular high school, turned 18, and "dropped-out." I was eligible for early graduation in just three more weeks. Ultimately, I knew the subjects I was interested in were not going to be found in rooms of books and blackboards and professors. A couple weeks later with my GED in hand, I left my hometown of Fort Wayne, Indiana.

For a while I felt like a boulder on the edge of a steep precipice. I'd heard that a friend of a friend was going to work in Alaska on fishing boats. I'd never been farther west than Chicago. I found an application online and submitted it via fax. I carefully crafted my resume—in hindsight anyone breathing would have sufficed! I remember a plane ride and real mountains, clouds and glaciers, a landscape painted in light blues and an infinite amount of grays. I remember being picked-up in an old, short school bus with broken windows and seeing tundra for the first time. We'd flown into King Salmon, Alaska, and I was making the short ride to Naknek to process sockeye for the seasonal Bristol Bay run. My shift was 10:00 p.m. to 2:00 p.m., 16 hours a day, five days a week. Weekends were eight hour days. Pay was minimum wage. The cooks put salmon in everything.

I met someone there who knew "someone" who knew "someone" else that worked on a boat. I folded the slip of paper with the name and tucked it in a back pocket. I returned home to the Midwest but I'd seen Alaska and tasted opportunity. I'd leave again after saving enough to get to Seattle. I established myself in Seattle with a friend who had an apartment and took another minimum wage job. I found that old contact. I called and called and made visits to the office and called again and eventually when they got sick of my voice mails and the visits,

Carl VerPlanck on stern of the NOAA Ship *Okeanos Explorer* with camera sled on stern.

I received a call. I went down to a big white ship and shook hands with a guy they called the bosun. And then didn't hear anything for two months. One day after coming home from work I listened to the answering machine and heard a woman tell me that they had booked me a flight to Homer, Alaska, on Sunday, to join the ship. That was the sum of all the details. It was a Thursday when I received that call. I walked into work the next day and casually explained to my boss that that day was my last day. I have never used him as a reference.

I began sailing with NOAA on an Alaskan survey ship called the *Rainier* in 2000 as a General Vessel Assistant and then an Ordinary Seaman. Within six years I worked my way up to an Able Body Seaman position, then Deck Utilityman, then Seaman Surveyor, then Bosun Group Leader, and finally to where I am now as a Chief Bosun. Along the way I received my Unlimited 3rd Mates License and am now licensed to be a deck officer on a vessel of any size, of any type, anywhere in the world.

I've participated in and supervised incredible operations in just as many incredible places. I've had experiences of a lifetime; standing a lookout on the flying bridge underneath the arching Aurora Borealis; watching brown bears snatch airborne salmon out of cascading falls as I took tide gauge measurements; diving on and investigating submerged wrecks in uncharted waters; surveying the face of a 300-foot tall, three-mile long glacier while pieces of ice larger than ships calved away beside me. I've worked the decks and nets of fishing trawlers as we "rode out" hurricanes, conducted CTD casts as lightning-lit waterspouts danced so close you could hear the vacuum, and launched and recovered a deep sea ROV to explore the ocean floor of the Celebs Sea off the coast off Indonesia, where creatures never seen before were discovered. This all happened and much more because of that first phone call I made to a contact on a piece of paper that I'd put away in a pocket.

I was fortunate that I got that first contact number, but more importantly, I saw value in that number. Recognizing opportunity, mobility, adaptability, determination, and elbow grease got me farther than many friends with advanced degrees. When my friends and I get together now, we occasionally chat about work. I find myself trying to make my stories a bit more mundane than I really remember them. I would get looks or I'd be accused of exaggerating, or worse! I realized a while ago that the truth sounded just too fantastic!

CARL VERPLANCK is the Chief Boatswain for the NOAA Ship *Okeanos Explorer.* He is responsible for all operations of the ship's Deck Department. Carl has extensive experience in working with boats and has worked on the NOAA Ship *Rainier* conducting surveys off Alaska and was in the augmentation pool for two years where he worked on the NOAA Ship *Nancy Foster* and *Albatross IV.*

PHOTO CREDIT

All Photos Courtesy of NOAA

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TOOLS OF THE TRADE, SENIOR SURVEY TECHNICIAN, NOAA SHIP *OKEANOS EXPLORER*

BY COLLEEN PETERS

IN HIGH SCHOOL AND COLLEGE, WHEN ASKED ABOUT MY CAREER PLANS, *all I could think of was that I did not want to work in a conventional office. I did not like to commute in morning traffic. I did not want to work in a cubicle, and I certainly did not like fluorescent lighting. I have always wanted to be a little bit different from the 'norm.' Most of my friends wanted to work in New York City, or go to college locally or where their parents graduated. I wanted desperately to do my own thing. I first started working on boats when I was in high school, and from then on I was hooked. I liked working with tools, and seeing a finished product emerge right before my eyes. Whether it was painting the hull or splicing a line, I have always liked getting dirty and working with my hands.*

The author views CTD data in the Control Room onboard the NOAA Ship *Okeanos Explorer.*

Colleen Peters (right) assists with CTD on stern of NOAA Ship *Okeanos Explorer.*

Nowadays, I do work in an office of sorts. However, this office is far from conventional. Although I have to deal with the fluorescent lighting, my office floats. My office takes me places that few have ever seen before. My office takes me to faraway lands as well as the bottom of the ocean.

Currently, much of my time while on duty onboard the NOAA Ship *Okeanos Explorer* is spent in front of a computer. These computers are used to collect and process a variety of data collected about the water column and the seafloor. By mapping the seafloor with multibeam sonar, we are later able to visualize features in 3D. I also stand watch with the remotely operated vehicle (ROV) team, awaiting the opportunity to see the ocean floor and everything that is living near or on it through high-definition (HD) video. There are no windows to the outside from the lab spaces onboard the NOAA Ship *Okeanos Explorer.* Although we can see outside with cameras, it does not compare to having the sun shine on your face. As captivating as our work may be, there are times when even I need to take a break from staring at computers and get outside to do some work with my hands.

This is one of the reasons that I like working with the conductivity-temperature-depth (CTD) sensors. It gets me out of the 'office' and out on the weather decks where I can see the horizon for myself and breathe the fresh sea air firsthand. Any time a sensor needs to be swapped or installed, or the configuration changed, I am the first to go simply because I get to use some tools and get outside.

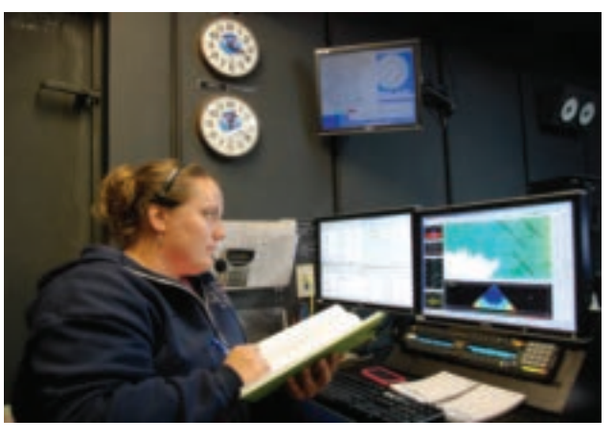
The CTD is one of the most basic, and generally, reliable pieces of oceanographic equipment onboard any type of research (or

The author checks water bottles on CTD on NOAA Ship *Okeanos Explorer*.

Colleen Peters collects water samples from CTD on deck of NOAA Ship *Okeanos Explorer*.

in this case, exploration) vessel. It allows us to measure the physical and chemical properties of the water. Without sensing the particulates and chemical composition, we could not find hydrothermal vents as easily. We can also take water samples, which can be processed for any number of compounds, each one providing us with more useful information about the surrounding environment.

As a technician, what I enjoy most, besides taking things apart and putting them together, is having an understanding for how each system works, which gives me a better appreciation for how data are collected and later utilized. On this ship, I have been involved in many system installations, calibrations, and inaugural testing. As a Senior Survey Technician, I am able to see the data all the way through the process, from building and installing the systems, calibration, conducting data acquisition, through processing and to some extent, its incorporation into final products.



Senior Survey Technician Colleen Peters makes an entry in the mapping watch log book.

As the *Okeanos Explorer* is still a relatively new vessel, and exploration is a constantly evolving process, there have been times when operations have not gone according to plan. A system component will break without notice, so you have to be prepared for anything to happen while at sea because you cannot simply go to the store to pick up a spare. No one learns as much about a system until it stops working; when you get to take a break from staring at the computer and get on your hands and knees to dig around the boxes and wires spewing out from the rack room to trace the problem. Having to go back to the basics to troubleshoot electronic systems and being able to pinpoint the problem and devise a solution—that's when I remember why I like being a technician.

COLLEEN PETERS graduated from Maine Maritime Academy with a Bachelor of Science degree in Marine Science and an Associate Degree in Small Vessel Operations with a 200-ton USCG Master's License. She has worked on 11 ships—from sail training to passenger to research and currently ocean exploration. As a Senior Survey Technician for the National Oceanic and Atmospheric Administration (NOAA), Colleen conducts oceanographic operations and mapping surveys, as well as manages, processes, and distributes all of the data acquired on the NOAA Ship *Okeanos Explorer.* She has sailed in Alaska, Hawaii, Indonesia, and the East Coast from Nova Scotia to the Gulf of Mexico and Caribbean.

PHOTO CREDIT

All Photos Courtesy of NOAA

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INTRODUCING EDUCATORS TO OCEAN MAPPING TOOLS

BY MASHKOOR A. MALIK, COLLEEN PETERS, LT MEGAN NADEAU, AND ELIZABETH LOBECKER

MODERN MAPPING TOOLS PROVIDE A WEALTH OF INFORMATION ABOUT *the marine environment. Incorporating data from these sophisticated technologies into K-12 education settings is an exciting, and sometimes challenging, process for educators. This article introduces data that are gathered by modern mapping sensors and presents some of the basics of modern mapping that educators may find useful for introducing students to mapping ocean features. The NOAA Ship* Okeanos Explorer *has been working with academic institutions around the U.S. to provide at-sea experiences and basic training in operating mapping sensors to college students through an internship program. In addition to these opportunities, post-college educational opportunities are also described, which may be useful for students who want to consider ocean mapping as a career.*

INTRODUCTION

Over the last three decades, technological advances in sensor instrumentation have significantly changed the way we conduct exploration and research on and in the ocean. Ocean exploration and research vessels host a variety of oceanographic sensory instruments, including optical and acoustic sensors. Due to very limited sampling ranges of optical sensors, acoustic tools are the only viable and efficient means for wide-area ocean reconnaissance, as they are capable of collecting data from the full ocean water depth, vast expanses of the seafloor, and below the seafloor (sub-bottom). Acoustic mapping tools consist of a large array of sensors and provide versatile data sets that can be used to observe ocean currents, depth, sediment distribution, sub-bottom sedimentary structure, distribution of biomass in the water column, and the presence of gas in sediment and in the water column. These observations have been shown to be relevant to a wide range of applications (Hughes Clarke et al. 1996).

This article focuses specifically on Multibeam Echo Sounders (MBES) that have increasingly become the tools of choice of those involved in fisheries research; marine geology; marine ecology; coastal zone management; exploration for oil and gas; nautical charting; and oceanographic research, to name a few. We also address education requirements needed to understand and use the MBES aboard the NOAA Ship *Okeanos Explorer.*

INTERACTION WITH BATHYMETRIC DATA

Echo sounding is the basic principle used to find the depth of the seafloor. It is analogous to the method used to collect the first-ever measurement of the speed of sound in water recorded by Daniel Colladon and Charles-Francois Sturm in Lake Geneva in the early 1800s by using a bell suspended under water from a boat and striking the bell with a hammer. Another boat at a known distance away from the boat where the bell was suspended was equipped with an underwater listening device. The time it took for the sound waves to travel between the two boats was measured using a pocket clock; the speed of the sound was determined to be within 0.2 percent of the currently accepted value of sound speed at 1,440 m/s at 8°C (see Allaby 2009 for more details). Since 1826, when this experiment was conducted, the measuring techniques have advanced considerably. Today, modern sonars use a very accurate estimate of time between the transmission of the sound waves from the transmitter and reception of the sound waves by the receiver after scattering back from the seafloor. The time it takes for the sound waves to travel to the seafloor and then back to the receiver is the two-way travel time. If the sound speed is precisely known, a very robust estimate of the range

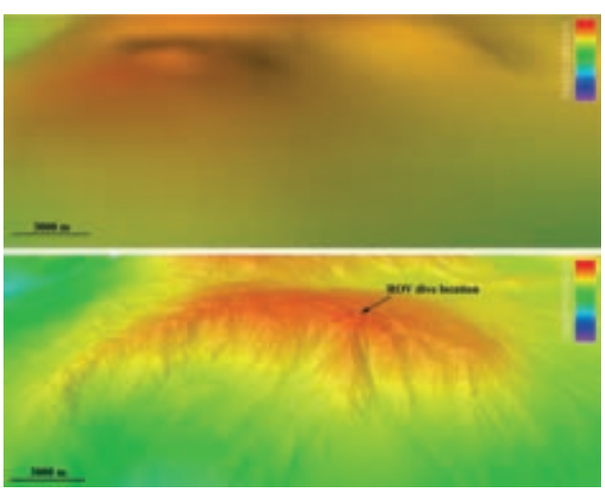

Figure 1. Image of the seafloor before and after MBES bathymetry data were collected during the 2010 Indonesia-USA Deep-Sea Exploration of the Sangihe-Talaud Region. Top panel shows the best available data prior to collection of MBES data.

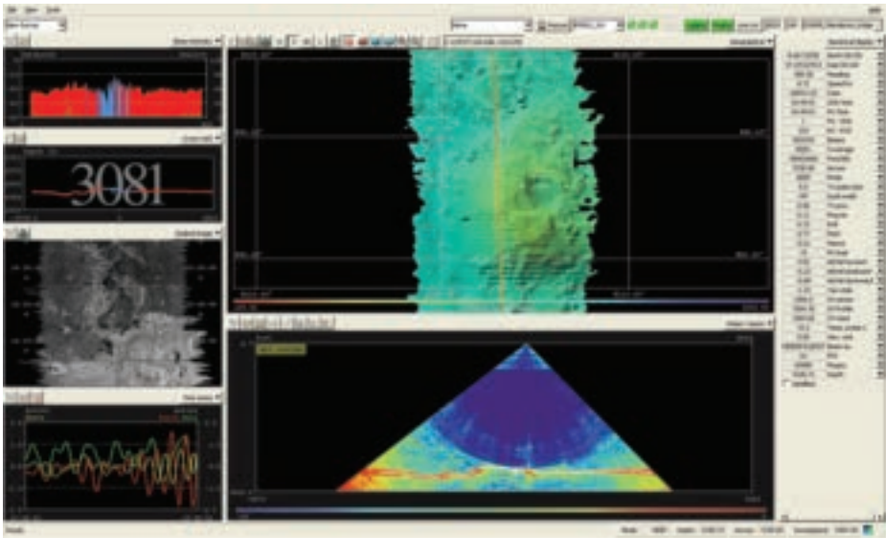

Figure 2. Data acquisition screen of the multibeam sonar used on the NOAA Ship *Okeanos Explorer*. The screen allows the watch standers to monitor the sonar performance through various windows. Some of the windows available include (from top left clockwise) Beam Intensity; Geographical Display of the Soundings; Numerical Display to show Ancillary Information; Water Column Display showing targets in the water column; time series window to show time series of the Ship's Attitude; seabed image to show Bottom Backscatter; and cross track window to show Bottom Depth. Data collected using Kongsberg EM 302 (30kHz).

to the seafloor can be made. The advent of MBES has allowed several hundred of these measurements to be taken at a single instance (hence the term "multibeam" sonars), increasing the area the sonar can cover on the seafloor in one pass.

Unlike optical video data, computer visualizations are required to interpret the data. Computer visualizations usually constructed in a 2D Geographic Information System (GIS) fail to display detailed topographic features when compared to those collected by the MBES. Over the last two decades, the more complex 3D computer visualizations have advanced enough to depict a realistic picture of the water column and the seafloor (Mayer et al. 2002). In exploration missions, seafloor bathymetry is usually the first data layer collected to provide insights into seafloor features so as to identify potential locations for more in-depth observations. Figure 1 shows a small portion (~ 20 x 14 km) of seafloor before and after the MBES mapping in the Sangihe-Talaud region off Indonesia during the NOAA Ship *Okeanos Explorer's* expedition in 2010 (INDEX 2010). INDEX 2010 was primarily focused on biodiversity in one of the world's most diverse deep-sea regions of the world (Herrera et al. 2010). The MBES survey revealed detailed structures of the seafloor which enabled scientists to identify areas where deep-sea corals might exist based on understandings of the direction of bottom currents and topographic structures of the seafloor. Subsequently, locations for remotely operated vehicle dives were selected. Similar determinations about the seafloor features would not have been possible without the sophisticated imagery provided by the MBES survey.

Water column backscatter and seafloor backscatter are two other types of data collected by the MBES. Because the water column and the seafloor are not "uniform" throughout or "featureless," some of the sonar energy is "scattered back" as it encounters certain features, such as schools of fishes or hard sediments. Variations in the seafloor backscatter data enable scientists to discriminate between different types of seafloor features, which provide valuable information for benthic geologists and ecologists. For example, in Figure 3 on page 17, MBES data on the left shows the bathymetry of Mount Dent (yellow feature) near the Cayman Islands. The image on the right is the seafloor backscatter of the same site. Areas of hard bottom are indicated by the lighter shades of gray, which helped scientists understand the geologic setting of this exploration site. Using the two images together, scientists were not only able to better understand the topography of the seafloor, but also were able to infer characteristics of the sediments and organisms that may be living on or within them.

Water column backscatter data are used by fisheries scientists to study the distribution of biomass, including zooplankton and fish distribution. In a recent expedition to the Gulf of Mexico sponsored by the NOAA Office of Ocean Exploration and Research (OER) in 2011, the MBES sonar acoustically detected gas seeps (Figure 4 on page 18). Integration of the MBES-derived bathymetry and backscatter with other data sets can also be integrated with data sets in the Geographical Information System (GIS), layering baseline bathymetric data with habitat/species distribution maps. In this way, scientists are able to better interpret biogeospatial connections in the deep ocean.

INTEGRATING *OKEANOS EXPLORER* OCEAN MAPPING INTO CLASSROOMS

The MBES are highly sophisticated instruments and their use requires a deep understanding of acoustic wave propagation, electronics, digital signal processing, and interaction of sound with the marine environment. Some knowledge of benthic geology, oceanography, marine ecology, and geology is also required to fully interpret data and images generated by the MBES. Since MBES offers rich opportunities for teaching science through multiple disciplines, educators working with OER have developed lesson plans for students in Grades 5-12 that introduce them to basic bathymetry and the techniques used

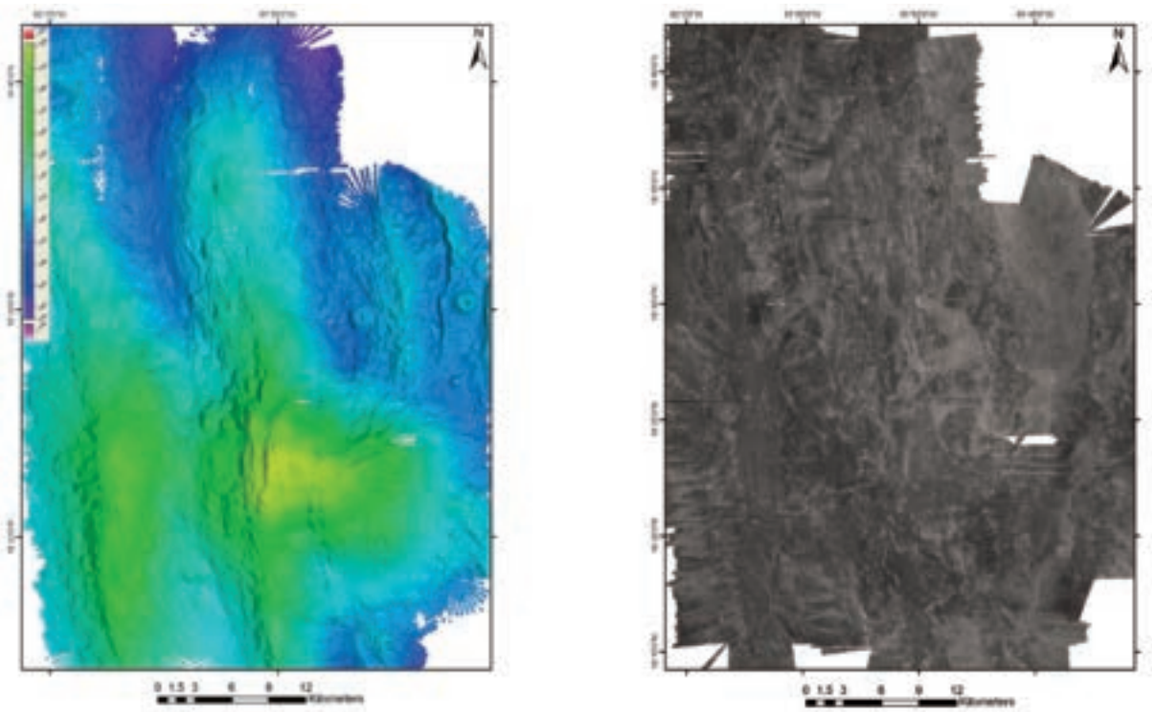

Figure 3. Multibeam bathymetry (above left) and seafloor backscatter (above right) 50 meter grids of the same area around Mount Dent, near the Cayman Islands, collected by the multibeam.

in basic interpretations of MBES data. Several lessons display output of the bathymetric data in the form of grids with hands-on exercises for students in Grades 9-12 using data collected by the *Okeanos Explorer.* These lessons are described below.

GRADES 5-6

Wet Maps
- Focus: Bathymetric Mapping
- Students describe three types of bathymetric maps, and discuss how each type may be used by ocean explorers. They compare and contrast bathymetric mapping technologies; explain why multibeam mapping is used aboard the *Okeanos Explorer;* and simulate a multibeam sonar system to create a 3D map of a model seafloor.
- **http://oceanexplorer.noaa.gov/okeanos/edu/lessonplans/media/hdwe_56_wetmaps.pdf**

GRADES 7-8

Mapping the Deep Ocean Floor
- Focus: Bathymetric Mapping
- Students explain the advantages of multibeam sonar and its role in the exploration strategy used aboard the *Okeanos Explorer;* and use data from the *Okeanos Explorer* to create a bathymetric map.
- **http://oceanexplorer.noaa.gov/okeanos/edu/lessonplans/media/hdwe_78_oceanfloor.pdf**

Sonar Simulation
- Focus: Side-Scan Sonar
- Students describe side-scan sonar, compare and contrast side-scan sonar with other methods used to search for underwater objects, and make inferences about the topography of an unknown and invisible landscape based on systematic discontinuous measurements of surface relief.
- **http://oceanexplorer.noaa.gov/explorations/08bonaire/background/edu/media/sonarsim.pdf**

GRADES 9-12

Watching in 3-D
- Focus: Multibeam Sonar
- Students describe multibeam sonar and explain why the velocity of sound in water must be measured before maps can be created with the *Okeanos Explorer's* multibeam sonar system; students interpret 3D multibeam data of underwater features mapped by the *Okeanos Explorer.*
- **http://oceanexplorer.noaa.gov/okeanos/edu/lessonplans/media/hdwe_912_3d.pdf**

Hot Maps
- Focus: Multibeam Sonar Exploration of a Hydrothermal Vent System
- Students describe multibeam sonar; discuss the advantages of multibeam sonar bathymetry compared to 2D topographic

bathymetry; and interpret 3D multibeam bathymetric data from the vicinity of the Galápagos Spreading Center.
- **http://oceanexplorer.noaa.gov/okeanos/explorations/ex1103/background/edu/media/ex1103_hotmaps.pdf**

Sound Pictures
- Focus: Sonar
- Students explain the concept of sonar, describe the major components of a sonar system, explain how multibeam and side-scan sonar systems are useful to ocean explorers, and simulate sonar operation using a motion detector and a graphing calculator.
- **http://oceanexplorer.noaa.gov/explorations/09lophelia/background/edu/media/09sound.pdf**

***Tools of Exploration:* Multibeam**
- Focus: Multibeam Sonar
- Students describe multibeam sonar, discuss the advantages of multibeam sonar bathymetry compared to 2D topographic bathymetry, and interpret 3D multibeam bathymetric data.
- **http://oceanexplorer.noaa.gov/okeanos/explorations/10index/background/edu/media/multibeam.pdf**

The NOAA *Okeanos Explorer* Program has offered hands-on, at-sea training in MBES data collection and processing through internships for college students. This has provided an opportunity for students to participate onboard during an expedition, work closely with the ship staff, and observe scientists at work firsthand; and, in most cases, provided a first-time opportunity for students to be at sea for an extended period of time. These at-sea experiences offer exceptional value to students beyond them needing to have a solid understanding of wave mechanics, oceanography, computer visualizations, MBES data acquisition, data processing, product display, and modern mapping tools obtained in a classroom setting. While at sea, students are given a brief introduction to acoustics, multibeam operations, data acquisition and processing systems; and students are then teamed up with experienced mapping watch standers to stand watch during expeditions. While at sea, students have worked on projects of their own to discover how mapping data generated by the ship are applicable to their respective areas of interest. Examples of past student projects include understanding the engineering calibration of MBES, geological interpretation of multibeam sonar, characterization of schools of fishes in the MBES water column data, application of MBES data targeted to school children to study historical wrecks, and use of MBES data to produce maps of the seafloor.

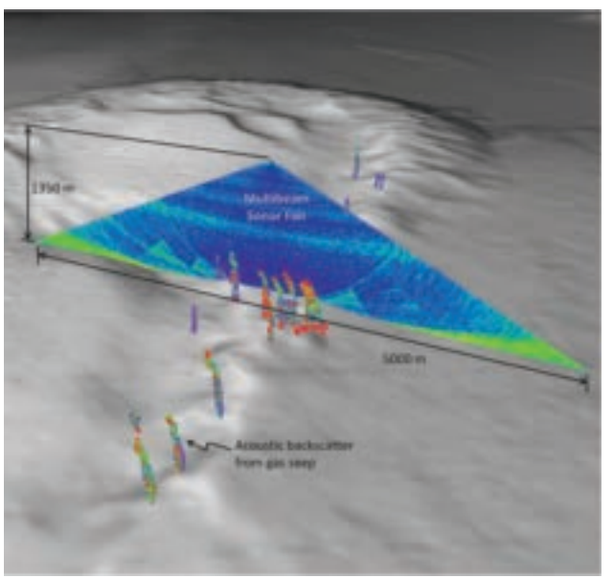

Figure 4. A view of the multibeam sonar water column backscatter data used to detect gas seeps. Gas seeps detected by the sonar are shown in the foreground.

The NOAA *Okeanos Explorer* Program has supported more than 40 interns since the commissioning of the ship in August 2008. Participating students have come from throughout the U.S. and have varied backgrounds, including biology, geology, social sciences, and engineering. The *Okeanos Explorer* mapping team has been fortunate to work with students who have brought their individual interests in the ocean to the ship. Through these experiences, it is the hope that these interns will return and consider marine sciences as a career.

CAREERS IN OCEAN MAPPING

The ocean mapping community, as compared to other marine fields, although small, is very integrated. The primary professional organization that many ocean mappers are members of is The Hydrographic Society of America (THSOA). Additionally, researchers working on other marine-related topics often use ocean mapping data, thus expanding the community of ocean scientists and researchers who use MBES.

One academic pathway for ocean mappers may include a four-year degree program in engineering, earth sciences, or biology with emphasis in mathematics. The specialized training programs for the study of the ocean mapping tools are offered through several universities, including, University of New Hampshire and University of Southern Mississippi. Increasingly more universities are incorporating courses that focus on the use of acoustics for remote sensing in their curriculum. Several companies, government organizations, and NGOs operate vessels which carry MBES sonars. An opportunity to sail on one of these vessels offers invaluable practical learning skills and at-sea experience for students interested in modern mapping tools. Online resources for ocean mapping education include:

Center for Coastal & Ocean Mapping Joint Hydrographic Center:
http://ccom.unh.edu

National Geographic:
http://education.nationalgeographic.com/education/activity/ocean-maps/?ar_a=1&ar_r=1

Ocean Mapping Group:
http://www.omg.unb.ca/

International Hydrographic Organization:
http://www.iho.int/srv1/index.php?option=com_content&view=article&id=318&Itemid=676

NOAA Ocean Service:
http://oceanservice.noaa.gov/education/seafloor-mapping/welcome.html

Google Earth:
http://earth.google.com/ocean/

NOAA Ocean Explorer:
http://oceanexplorer.noaa.gov/edu/materials.html

NOAA Ship *Okeanos Explorer:*
http://oceanexplorer.noaa.gov/okeanos/edu/welcome.html

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MASHKOOR MALIK works with the Earth Resources Technology, Inc. and NOAA *Okeanos Explorer* mapping program and supports planning, executing, and processing of mapping data generated by the ship *Okeanos Explorer.* Malik holds a Master of Science degree in Ocean Engineering and Ocean Mapping from the University of New Hampshire and a Bachelor of Science degree in Marine Sciences from Karachi University, Karachi, Pakistan. Malik has participated in numerous mapping expeditions. His research interests include the seafloor backscatter derived from MBES.

COLLEEN PETERS graduated from Maine Maritime Academy with a Bachelor of Science degree in Marine Science and an Associate Degree in Small Vessel Operations with a 200-ton USCG Master's License. She has worked on 11 ships—from sail training to passenger to research and currently ocean exploration. As a Senior Survey Technician for the National Oceanic and Atmospheric Administration (NOAA), Colleen conducts oceanographic operations and mapping surveys, as well as manages, processes, and distributes all of the data acquired on the NOAA Ship *Okeanos Explorer.* She has sailed in Alaska, Hawaii, Indonesia, and the East Coast from Nova Scotia to the Gulf of Mexico and Caribbean.

ELIZABETH (MEME) LOBECKER is a Physical Scientist with the NOAA Office of Ocean Exploration and Research (OER). Prior to working for NOAA, Meme began her career in hydrography in 2002 at Science Applications International Corporation, Inc., (SAIC) in her hometown of Newport, Rhode Island, where she spent five years mapping the U.S. East Coast, Gulf of Mexico, and Alaska, primarily for NOAA and USGS contracts. She was also a main in-house software tester for SAIC's multibeam acquisition and processing software suite. Meme completed her Master of Science degree in Marine Affairs at the University of Rhode Island in 2008, where her work focused on the recent string of Californian and U.S. Supreme Court cases attempting to manage the potential effects of U.S. Navy mid-frequency sonar testing in the Southern California Range Complex on marine mammals. She holds a Bachelor of Science degree from The George Washington University in Environmental Studies, with minors in geography and biology.

LT MEGAN NADEAU graduated from the University of Maine, Orono in 2004 with a Bachelor of Science degree in Marine Sciences. Her first sea tour was onboard the NOAA Ship *Thomas Jefferson,* conducting hydrographic surveys to update NOAA's nautical charts along the Eastern seaboard. On her shore assignment with the NOAA Office of Ocean Exploration and Research, Megan worked with the NOAA Ship *Okeanos Explorer* from shore and sailed as a mapping watch stander on many cruises. Gaining experience with ocean exploration, both onshore and at sea, helped her prepare for her current position as Operations Officer onboard the ship.

PHOTO CREDITS

Pages 15, 16, and 17: Courtesy of NOAA *Okeanos Explorer* Program, Mid-Cayman Rise Expedition 2011

Page 18: Produced by the University of New Hampshire Center for Coastal and Ocean Mapping/Joint Hydrographic Center using IVS Fledermaus software. Data Courtesy of NOAA *Okeanos Explorer* Program, Gulf of Mexico exploration, 2011

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The Anatomy of a Career in Submersible Vehicle Design

By Dave Lovalvo

There was a point in my life where I knew I was hooked. The images *coming across my television were, in my mind, "stunning." I could "taste them." I could "feel" them. They removed me from my chair and transported me. When reality hit and the hour was up, I was one step closer to a place that I knew would never release me. Was the narration so exquisitely delivered that it reminded me of a romantic language? You bet. However, the seduction of what I was seeing and hearing was beyond the dialogue. Was it the creatures, large and small? Most certainly. However, it was even more. For me, it was the "magic." The "magic" of how people, immersed in a world of fluid, could produce such vivid pictures of places that seemed so foreign and out of reach. But, what captured my complete attention was watching a team of very talented people using exotic and complex equipment to tell an amazing story. It was during those early teenage years when I made a silent promise to myself. The promise that I would one day design, build, and operate similar types of equipment so that I, too, could tell a story like the one told to me.*

The author working on the tether mounting plate of Dr. Robert Ballard's ROV *Hercules* during the 2004 *Titanic* expedition.

The promise I made to myself is now a reality. On any typical day, my job responsibilities may include preparing budgets, engaging people, writing proposals, planning trips, and addressing equipment issues. As a consultant to the National Oceanic and Atmospheric Administration's (NOAA's) Office of Ocean Exploration and Research (OER), I am called a "Lead." My responsibilities at a glance are simple: all underwater vehicles owned by the program are designed, maintained, modified, upgraded, and operated under my guidance. Our ship, the NOAA Ship *Okeanos Explorer,* our shore-based infrastructure, and our underwater vehicles are all part of the only Federal program dedicated to systematic telepresence-enabled exploration of the planet's largely unknown ocean.

When I share what I do with others, I'm usually asked, "how did you get a job like this" and "what is your background?" As you might guess, the answers to these questions are not very straightforward and certainly not as traditional as one might think. I started my journey with the Aqualung. SCUBA, although not a new sport at the time, was still a rather unique activity amongst my friends and family. Certification by a recognized organization was a requirement and it opened the door to many of the activities that paved the road to my later career path.

I began by exploring shipwrecks, which allowed me to hone my skills for more rigorous dives. As I gained experience, I attracted the attention of a small commercial diving company and began conducting deep penetrations into the underground cooling water intake tunnels of several New York power plants. Inspecting these tunnels was done solely by touch, as there was little or no visibility in the waters that cooled the generators. I also trekked back and forth between the U.S. and Europe inspecting the condition of propellers on container ships (almost 300 meters in length). This endeavor was also conducted mostly by touch, but with the added challenge of actually riding the approximately eight-meter diameter blades, while they turned continuously on their jacking gear. At almost 18, I earned my instructors license so I could also begin teaching the sport of diving. However, I wanted to pursue a more serious career path toward technology. As a result, I enrolled in a school for Deep Saturation Diving, and spent the next part of my career training under retired U.S. Navy master divers. This proved to be a perfect strategy for me, as the highly disciplined life of the Navy didn't quite match my personality. This level of training exposed me to the types of equipment I so eagerly desired to work with. From the relatively simple, self-contained diving systems, to the more complex, surface-supplied mixed gas helmets, I was in

my glory. Even the old copper helmet MKV diving systems were absolutely fascinating to me. Learning to use such traditional equipment (or tools) made me appreciate the challenges of exploring the little-known environment of the ocean. But still I wanted more.

I needed a plan as well as a paying job and was deeply intrigued with submarines, but I also knew I wasn't interested in the military, so I pursued submersibles and research and exploration. There were not many organizations using human-occupied submersibles at the time, and one of the major operators was a private company located close to where I grew up. In my initial research of this company, I grew intrigued with what I was able to learn about them. They operated three human-occupied submersibles and were one of the largest diving companies in the world, maintaining offices in several locations throughout the U.S. and abroad. They had major interests and capabilities in deep saturation diving systems, which affirmed my suspicion that technology was clearly a major part of their focus. The icing on the cake was the sole owner and CEO. He was an aeronautical engineer, a legend in the early days of diving development and had worked side-by-side with the French diver and explorer, Jacques Cousteau. Once again, I was hooked, but I needed to get in the door.

I packed up my resume, drove to their offices, and announced to the CEO's secretary that I was there for a job. She asked if I had an appointment, so I confessed that I didn't. She politely but firmly assured me that there would be no meeting without an appointment. I told her I would simply wait in her office until the CEO was able to see me. "No" was not an option I was willing to entertain. I was there to work, and I had an idea on how I was going to achieve this. When she realized I was serious, she exited the room. I was now face-to-face with the CEO who politely informed me that he was not hiring. However, my reaction was not quite what he expected. I responded with, "I'll work for free." After handing him my resume and explaining what I proposed,

Dave Lovalvo overseeing work on the Camera Sled *Seirios* that his team built for NOAA's Office of Ocean Exploration and Research. The team of young engineers in the picture are mechanical and software engineers making some adjustments after a dive.

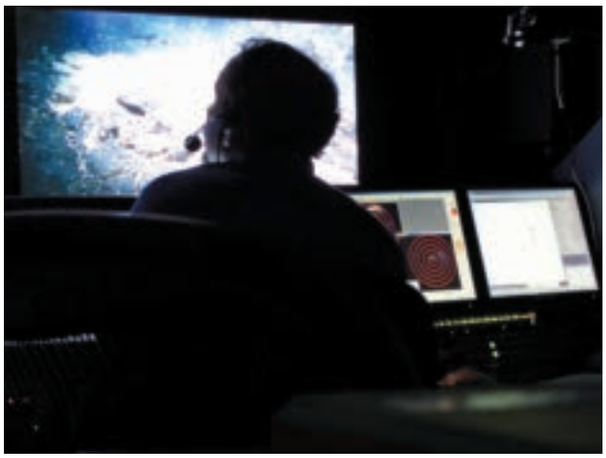
I was told to report for work the following day. The caveat I inserted was simple and to the point, I said, "If you don't like what I do for you over the next two weeks, I'll leave and you'll owe me nothing. However, if you agree that I have value to you and your company, I will expect to be hired and compensated so I can resume the obligations of paying my bills." We agreed and the next day I was introduced to *Mermaid II.*

I was on my way. I had a four-hour round trip commute everyday but I was working with the equipment I had only earlier dreamed about. One week later I began receiving a salary. Two weeks later I was told to pack my bags. I was sent to the Southwest Research Center in San Antonio, Texas to supervise the building of a 1000-foot saturation diving system. Upon the completion of the new saturation diving system, I went back to work on *Mermaid II.* When the system was ready for diving, the news came. I was to move to Europe, where I would be expected to work with the system in the support of offshore oil drilling in the North Sea. For me this was not good news, as I wanted to use this technology in support of science and exploration, not offshore oil. With no other option, I chose not to follow through with the offshore oil project and continued to pursue my dreams.

I went off to Maine to visit a retired U.S. Navy submarine captain. He was building a small one-person submarine. The submarines were certainly not as large and sophisticated as *Mermaid II,* but they were also not as expensive. With the financial support of a family member, I purchased my first submarine.

ABC News got wind of my story and wanted to know why a 20 year old was buying his own submarine. They filmed the factory testing and acceptance dives for a news spot and off I went. My first potential client called me shortly thereafter. It was the Smithsonian Institution and they asked, "Would you be interested in taking your submarine to the island of Bimini to look for the Lost City of Atlantis?" I packed my bags and loaded the submersible on the trailer and off I went to the Smithsonian Institution. You might imagine their surprise when I parked the submersible in front of their building. The project eventually fell through but not before leading to my next endeavor.

A jet engine designer for Pratt Whitney left his vocation to start a marine engineering and design company. He designed large aluminum and fiberglass boats, and took me under his wing at a very important time in my career. When we first met, he had finished designing a small aluminum vessel for launching a two-person wet submersible to be used in one of the James Bond movies. If submersibles were my passion, his current project was soon to be my obsession. Sitting in the fabrication yard of what was then one of the most prominent manned submersible design companies in the world was an ungainly piece of fabrication attached to a very large concrete base. It was called *"Hydrolab"* and it was the next generation of human-occupied underwater habitats. In its previous stint, it was a primitive yet effective edifice installed on the ocean bottom off the Bahamas. It was now under a total retrofit with planned



The author piloting the ROV *Hercules* during the 2004 Mountains in the Sea Expedition.

modifications. As an engineer and a fabricator, he was working closely with the prime contractor who was responsible for the overall system. I was there just in time. The direction this new turn would take proved to be one of the major highlights of my life. I learned aluminum and fiberglass fabrication, obtained my master electrician's license and, through further encouragement, learned to fly airplanes.

I later worked side-by-side with a man responsible for the *Hydrolab* rebuild and was asked to join him in St. Croix to help install it under water. Because this was essentially a shallow water saturation diving system, I was qualified to do this type of work. We installed *Hydrolab* on the edge of a submarine canyon, prepared the system for saturation diving, and began training the personnel to operate it. Before we were through, we would saturate a Senator and support him for a few days in this wonderful undersea laboratory.

Hydrolab was owned by the same branch of the Federal government for which I now work. At the time, it was not called NOAA's Office of Ocean Exploration and Research (OER). It was NOAA's Manned Undersea Science and Technology Office (MUST). In the process of handing off the responsibilities of *Hydrolab,* I would meet two more key people. One was a very talented mechanical engineer on leave from the Woods Hole Oceanographic Institution (WHOI) and the other a highly respected fisheries biologist for NOAA's National Marine Fisheries Service. One would eventually hire me to work with the deep submergence vehicle, *Alvin,* and one would award me the first contract to study herring egg beds in the Bay of Fundy with my first ROV system.

What can one say about *Alvin*? Without question, it is the most successful human-occupied submersible ever developed and used for scientific research. Managed and operated by some of the most gifted engineers and technicians, the system and the people are the hallmark of WHOI. I was hired to work on the sub's electrical system and eventually went to pilot training and obtained certification by the Navy and WHOI. My interests were now moving toward what I considered the next generation of technology.

In the early 1980s, remotely operated vehicles (ROVs) became my focus. Until this point, I had worked with two human-occupied submersibles and owned two more. But, it became clear to me that ROVs would become the systems of choice for doing the type of work I was most interested in. I bought them, I built them, and I operated them all over the world. I would film John Kennedy's PT109 and *Titanic* with them. I would find new biological life at the bottom of Yellowstone Lake, I would film hydrothermal features and stunning corals in the world's ocean, and I would film ancient shipwrecks and downed aircraft with these tools. I was now more than ever, finally, telling a story.

This year I am once again tasked with an even greater project, which is to retrofit, modify, and partially redesign OER's larger and deeper diving ROV. In all instances, I assemble a team of engineers and technicians and guide the process on behalf of OER. Those I have assembled will now be the mentors and, over time, these complex systems will be taken to sea by the next generation of engineers and technicians dedicated to exploring the world's ocean.

DAVE LOVALVO is the founder and owner of Eastern Oceanics. For 30 years, he has filmed and supported underwater research projects in just about every major ocean and many of the world's major inland lakes. Dave has spent 26 years exploring, filming, and mapping Yellowstone Lake and continues to support projects in Yellowstone and many other locations around the world. He has been an engineering consultant to Woods Hole Oceanographic Institution, working with the manned submersible *Alvin* and has been a pilot and/or member of the design team for the ROV *Jason, Jason 2, Hercules,* and *Little Hercules.* He has explored and documented some of the most exciting underwater thermal features in the world, including areas of the Mid-Atlantic Ridge, Nine Degrees North, the Juan De Fuca Ridge, Lost City, the Galápagos, and Mid-Cayman Rise. He was part of a team who built and installed one of the first underwater habitats for science and had his first manned submersible built at age 20. While Dave has maintained two major science ROVs under his own company, he is currently consulting with 2020 LLC to coordinate the new ROV systems for NOAA's Office of Ocean Exploration and Research (OER).

PHOTO CREDITS

Pages 20 and 22: Courtesy of NOAA OE/IFE

Page 21: Courtesy of NOAA *Okeanos Explorer* Program

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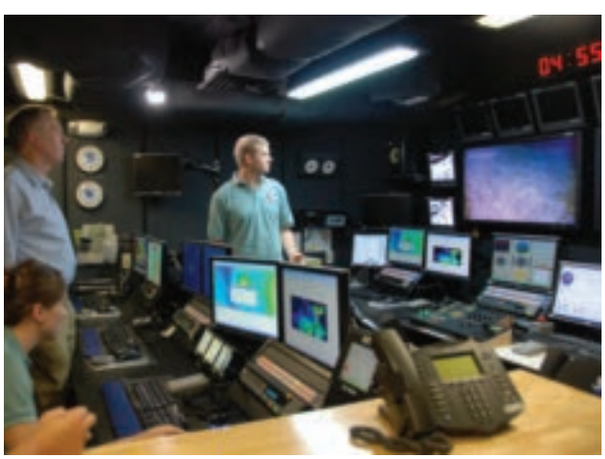
"Knowing Enough to be Dangerous" with Telepresence

By Webb Pinner

My formal education ended with a Bachelor of Science degree in *Computer Engineering from Virginia Polytechnic Institute in the fall of 2001. It was the worst time to graduate. The economy was in a tailspin from the dotcom bubble burst and the country was in the wake of the 9/11 terrorist attacks. Jobs in the computer sector were few and far between. Even the position I spent my last two years in college developing disappeared. I spent the next two years traveling the country, taking odd jobs where I could. These included bartending and fixing computers in Steamboat Springs, Colorado; working as a freelance web developer in Kenosha, Wisconsin; and as the IT helpdesk for a small real estate agency in Atlanta, Georgia. It was a humbling experience and an interesting way to see the country but it was not fulfilling and it was not a career.*

After watching the successes of my colleagues who majored in Ocean Engineering and were at the time working for the U.S. Navy and large oil companies, I decided to follow suit. After two semesters of taking classes in Middle Georgia College and Virginia Tech, I was accepted into the Ocean Engineering Master's Program at the University of Rhode Island (URI). Coming into Ocean Engineering (OE) with a background in computer engineering, I lacked many of the fundamental classes required of OE graduate students. My lack of a proper background was perceived as a real disadvantage by the OE Department faculty. Because of this I did not receive any type of assistantship through the department and was even told by the faculty that I probably should not have been accepted into the program. I was lucky enough to find an assistantship on the URI main campus. The assistantship was running the College of Engineering's Computer Lab. This assistantship covered my tuition and meager living expenses but removed me from the OE Department and the associated culture. To stay better connected with the OE Department and my ocean engineering peers on the URI Narragansett Bay Campus, I took a second job running the OE Computer Lab. Working as both a student and employee of the OE Department was a great opportunity. I not only met the professors, but also the instrument development and support staff.

By sheer luck, while working in the OE computer lab, I met two broadcast engineers returning from Dr. Robert Ballard's 2003 Black Sea Expedition. The engineers were unpacking the mobile remotely operated vehicle (ROV) control vans. These two 20-foot shipping containers were outfitted to operate Dr. Ballard's ROVs, *Argus* and *Hercules*. The vans were also used to broadcast the underwater video and operator's voices via satellite to viewers onshore, allowing them to participate in the discoveries (a concept I soon learned was called "telepresence").



Webb Pinner explaining the capabilities of the telepresence system of the NOAA Ship *Okeanos Explorer.*

The author aboard the NOAA Ship *Okeanos Explorer* operating the high-definition cameras mounted on the *Little Hercules* ROV during ROV sea trials in Hawaii.

I knew from the OE staff that the ROVs were stored in a nearby lab. I inquired with the broadcast engineers if there was anyone I could speak with about seeing the ROVs. By complete chance, Dr. Ballard's Chief Engineer, Mr. Jim Newman, was walking across the OE Department parking lot. I immediately introduced myself. Mr. Newman was gracious enough to give me a tour of the vehicles. After the tour and the short conversation that followed, I provided Mr. Newman with my resume and strong interest in getting involved in any way possible. Several months passed before I heard anything but in the spring of 2004, Mr. Newman contacted me. I had hopes of working with the ROVs, but at the time Dr. Ballard's Institute for Exploration (IFE) had all the ROV technicians required. However, the team was lacking in the areas of IT support and data management, the very jobs I currently conducted for the URI and OE. The position started out as a third job. I worked for Mr. Newman whenever my other jobs and coursework would allow. I fixed computers, organized the network, and helped IFE prepare for the upcoming field season comprised of a deep-sea coral cruise, and Dr. Ballard's 2004 return to the RMS *Titanic*.

A month before the field season began I received the invitation. Mr. Newman wanted me to join the IFE team as a private contractor for the 2004 field season. During the corals cruise I worked with IFE to learn their at-sea data responsibilities, and for the *Titanic* cruise, I piloted the ROV *Argus*. It was an amazing sequence of events. In 18 months, I went from not knowing what I was going to do with my life to piloting an ROV deployed to the RMS *Titanic* with the man who had discovered the shipwreck 20 years earlier.

The 2004 expeditions have served as the cornerstone for my career in ocean exploration. It was my first introduction into the world of ocean vehicles, broadcast engineering, and the concept of telepresence; using satellite communications to remotely engage with scientists, educators, students, and the general public from around the world in the real-time excitement of ocean exploration. It also introduced me to several of my now closest friends and colleagues, including the lead scientist from this year's GALREX-2011, Dr. Timothy Shank; self-taught electrical guru and ROV technical lead aboard the *Okeanos Explorer,* Dave Wright; and the ROV operations coordinator for the *Okeanos Explorer,* David Lovalvo.

In mid-2005, I was approached by OER to support the design, build, and integration of the telepresence infrastructure aboard the *Okeanos Explorer.* This was a career changing opportunity but presented a hard choice. The hours required managing a project of this scale and complexity necessitated I leave my master's program at URI prematurely. It was a difficult decision, but one that I think has ultimately served me well. I cannot imagine any opportunities a master's degree would have provided that working on the *Okeanos Explorer* hasn't exceeded.

The next few years passed quickly. OER was attempting to do something that had never been attempted. No one had ever outfitted a ship with a dedicated ROV and telepresence system with the sole mission to conduct remote exploration. I was propelled into a world as foreign to me as the bottom of the ocean. This was the first project I ever managed. After many trials and tribulations and ultimately a successful design, build, integration, and testing period, the *Okeanos Explorer* became one of the world's premier ocean exploration platforms. The ship's telepresence system streamed real-time voice, video, and data from the Indonesian seafloor during the ship's maiden voyage to international waters to Exploration Command Centers (ECCs) located around the world. For possibly the first time a global community of ocean explorers came together and made new discoveries almost every time the ROVs were put in the water. I count myself as extraordinarily fortunate for the role I was given to play and the experiences I received.

MY CURRENT ROLE AS TELEPRESENCE TEAM LEAD

My role has changed many times since joining the OER team. Currently, I am the Telepresence Team Lead for 2020 LLC supporting the *Okeanos Explorer.* I plan and implement ongoing upgrades, maintenance, and operation of the vessel's telepresence system, the system that I supported from design through acceptance testing. My job requires that I go to sea for all ROV cruises, as well as cruises focused on system development and expanding the remote exploration paradigm. This translates into between 60 and 100 days a year at sea.

While at sea, I coordinate day-to-day operations of the telepresence infrastructure. I am the technical point of contact for running live events between the ship and shore. I am the technical point of contact for video, imagery, and data management as well as data transfers to shore. I lead and support resolving any technical issues with the telepresence system. I also serve as a technical resource for the ship's network/IT infrastructure and the ship's satellite communication system.

The *Okeanos Explorer* is a global exploration vessel and in its first two years in full operation has worked with foreign countries from Indonesia to Ecuador to the United Kingdom. With each new foreign partner comes a new list of requirements and special considerations for data management and transfer. As shipboard lead for data management, I also help ensure the data collected is properly maintained onboard, transferred to shore, and available to scientists and others during and following a cruise.

During ROV operations, I coordinate a four-person team. The team is comprised of two professional broadcast engineers, a professional cameraman, and a data specialist. Each member of the team was selected for their skill sets and proven professionalism in the broadcast and ocean technology industries and ability to train or be trained in new technologies. We work closely with the ROV Operation Team to operate the ROVs' high-definition cameras and ancillary video systems. The team and I also work closely with the vessel's Survey Department to meet the vessel's data management objectives.

Performing data management duties on his first oceanographic research cruise.

Webb Pinner overseeing the construction of the ROV Control Room aboard the NOAA Ship *Okeanos Explorer*.

When I am not at sea, I work out of the OER office in Rhode Island. My onshore responsibilities include finalizing data and product development from previous cruises, preparing for upcoming cruises, and developing new capabilities. When not working, you can find me restoring my 130-year-old house, riding motorcycles, or playing in the ocean as an avid surfer and kiteboarder.

WHAT SKILLS ARE NEEDED?

The most important skill I need to do my job is the ability to assess complex and sometimes extremely technical situations quickly, and make decisions that will allow the office the greatest chance of success. Nothing about my job is certain—equipment breaks, and funding, ship schedules, and personnel availability all change. I attribute most of my success as Telepresence Team Lead to being able to properly assess the impact of the change and adjust plans as needed.

The second most important skill is personnel management. The OER *Okeanos Explorer* Program is an extremely dynamic working environment. The constant change is stressful on all involved. Knowing how to recognize when a member of the team is starting to struggle with something or burn out is the most important part of my job. Making sure everyone is treated fairly and has the resources to do their job is what keeps the machine running and the quality of our product at the highest possible standard.

The technical skills required in my position are almost too long to list. I deal with everything from the ROVs that travel to the seafloor to the satellite antenna that broadcasts video into outer space. As new technologies are injected into the system, I strive to learn as much as I can. I do not consider myself an expert on any of the equipment I work with, but rather the poster child for the individual that "knows just enough to be dangerous."

WEBB PINNER is the Remote Exploration Technical Operations Lead with 2020 LLC supporting the NOAA Office of Ocean Exploration. He is a graduate of the Virginia Polytechnic Institute, holds a Bachelor of Science degree in Computer Engineering and is the primary system architect of the telepresence subsystem that is installed on NOAA's state-of-the-art exploration vessel *Okeanos Explorer*. He is also a data management systems architect and works with NOAA and the NOAA Central Library to develop and implement a semi-automated system for collecting, organizing, cataloging, and accessing oceanographic data, high-resolution imagery, and video originating from the ship. He is a veteran of many offshore expeditions and is an accomplished ROV navigator, pilot, and co-pilot, having participated in several cruises to the Mid-Atlantic Ridge, the Black Sea, and to the RMS *Titanic* with Dr. Robert Ballard.

PHOTO CREDITS

Page 23 (left): Courtesy of NOAA *Okeanos Explorer* Program, INDEX-SATAL 2010

Page 23 (right): Courtesy of NOAA *Okeanos Explorer* Program, 2010

Page 25 (left): Courtesy of IFE, NOAA OER, Mountains in the Sea II, 2004

Page 25 (right): Courtesy of *Okeanos Explorer* Program, 2008

CAREERS MANAGING SCIENTIFIC INFORMATION COLLECTED ABOARD THE NOAA SHIP *OKEANOS EXPLORER*

BY BRENDAN RESER, SHARON MESICK, AND SUSAN GOTTFRIED

THE ENHANCED TECHNOLOGICAL CAPABILITIES ABOARD THE NOAA SHIP Okeanos Explorer *enable a broad range of oceanographic data collections, on-scene data processing, and information sharing in near real-time. This rapid turnaround model for information sharing complements ongoing requirements for documentation, access, and long-term data preservation. Operation of this complex "End-to-End" information management model is made possible through detailed planning and implementation by the diverse Data Management Team, composed of scientists, librarians, information technology specialists, and computer scientists.*

In implementing the vision for a national exploration program of the world's ocean, described in the 2000 Report of the President's Panel on Ocean Exploration[1], the National Oceanic and Atmospheric Administration's (NOAA's) Office of Ocean Exploration and Research (OER) has sponsored 10 years of path-finding ocean exploration expeditions. In step with these activities, an extramural Data Management Team has developed a robust strategy for managing the large, multidisciplinary exploration data collections[2], from "End-to-End" (E2E)—that is from planning a strategy to manage information at each step from collection to archival—while ensuring timely public access as well as long-term preservation of these important scientific data and information products[3] (Figure 1).

NOAA's exploration flagship, the *Okeanos Explorer*, is uniquely equipped to incorporate information management objectives into data collection and processing activities. In particular, the ship's satellite communication links, devised to enable direct, timely communication between scientists onboard the ship and scientists and educators onshore, are also leveraged to enable "Remote Data Management." Technology such as the Very Small Aperture Terminal (VSAT) satellite link and information technology like the automated software systems blur the distinctions between tasks that must be done onboard ship and those that are performed onshore. This has advantages, particularly in guiding students toward career choices, in that many tasks formerly limited to sea-going duties can now be performed from shoreside computer consoles, making these careers more accessible to all students. Three primary groups of skills are valuable in managing large, multidisciplinary scientific data collections. One needs to have a sound understanding of the science behind the expedition, the information technology techniques to be employed, and the documentation standards to be used, as these skills all intersect and overlap in a successfully implemented data management plan.

There are two primary streams of information from the *Okeanos Explorer* (detailed in Inset 1 on page 31). These data pathways support both near real-time data sharing with shoreside partners, as well as long-term data management requirements for data dissemination, access, and independent usability over the long term. The Data Management Team uses and supports both the real-time and long-term information streams from both shipboard and shoreside locations. A shared data lifecycle model (Figure 2) helps describe the tasks, skills, and functions of each data management phase.

COORDINATING DATA MANAGEMENT

The E2E approach begins with planning. Before each cruise, the data management team collaborates with the Expedition

Figure 1. A diverse set of skills are needed by data managers.

Figure 2. Phases of the data management lifecycle.

Coordinator, principal investigators, and other mission critical personnel to develop a Data Management Plan (Plan). The Plan outlines the intended data collection activities, identifies which instruments and sensors will be used, and when and where these activities will occur during the mission. Data disposition is agreed upon—that is, which data and analytical products will be transmitted to which data centers for preservation and long-term access. Known requirements, such as standard documentation formats for different data types, are applied. Any data sensitivities that might prohibit immediate data release (such as data collected over Historic Preservation sites) are identified for special handling.

The Data Management Coordinator is the center of this activity, and is responsible for ensuring that the Plan is followed or adapted as needed during real-world execution. This role requires organizational skills and the ability to work well with others. An understanding of the data management lifecycle, the science behind the expedition, the information technology techniques, and documentation standards are all important. But, key are the abilities to follow through with expedition participants so that the Plan is successfully implemented.

DURING THE CRUISE AND POST-CRUISE

Data collected aboard the *Okeanos Explorer* can be grouped into three primary categories: video data, seafloor mapping data, and oceanographic data. During at-sea data collection activities, endurance and the ability to work long hours in a fast-paced environment are valuable personal attributes. An understanding of each instrument, sensor, processing software, and end user requirements are often introduced in the classroom but learned on the job in internships or similar positions.

MANAGEMENT OF REAL-TIME VIDEO AND STILL IMAGERY

The *Okeanos Explorer* and remotely operated vehicles (ROVs) are equipped with a total of eight high-definition (HD) and 21 standard-definition (SD) cameras. Video is recorded opportunistically in full-resolution, and is selected for processing based on video and audio content as well as on feedback from the mission science team (Figure 3). Compressed versions of the videos are created for easy transmittal and web viewing. Still imagery is created post-process from recorded video clips. This process allows greater control over the image selection and improves image quality and reusability. Video data are transmitted to the Shoreside Repository Server (SRS) where they are shared with mission participants and the public via a range of web-based access points.

SEAFLOOR MAPPING DATA MANAGEMENT

The *Okeanos Explorer* is equipped with an EM302 multibeam array and an EK60 echo sounder. Data gathered using these instruments are used to characterize the seafloor and water column. The Mapping Team aboard the *Okeanos Explorer* is fully staffed 24 hours a day during mapping cruises, and 12 hours a day during mapping/ROV combination cruises, to ensure the collection of high-quality data and to generate quality-controlled daily multibeam products. The standard set of daily mapping products includes 50-meter gridded multibeam bathymetry data in the following formats: Google Earth KMZ, georeferenced TIFF images, IVS 3D Fledermaus SD objects, and ASCII longitude/latitude/depth text files. Additionally, gridded bottom backscatter data are overlaid on the bathymetric data to provide information about the character of the seabed. To facilitate the ease of daily product use, efforts are made to achieve appropriate data resolution while maintaining acceptable file sizes. Mapping products are transmitted to the SRS and are displayed on the *Okeanos* Atlas, an interactive web mapping tool which updates daily with information from the ship. The constant, reliable stream of information provided to cruise participants is integral to the real-time interaction that allows shoreside scientists and the shipboard mapping and science teams to jointly and dynamically control exploration.

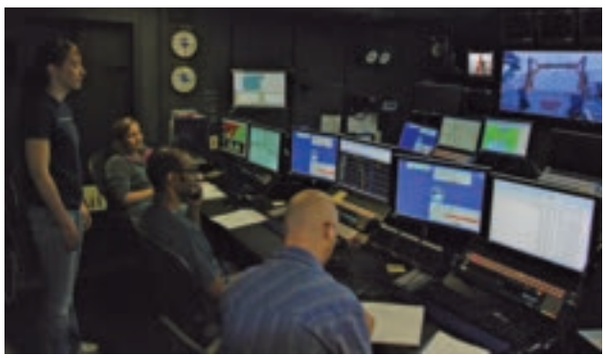


Figure 3. Team members manage complex arrays of data in the *Okeanos Explorer* Control Room.

OCEANOGRAPHIC DATA MANAGEMENT

The ship, camera platform, and ROV are each equipped with CTD instruments (an instrument used to measure conductivity, temperature, and depth). The physical properties of the water column described by these instruments may be used to calibrate the EM302, characterize a specific site, or to identify potential dive locations. Data are included in SRS updates, and locations are displayed in the *Okeanos* Atlas, where temperature profiles may be compared to historical averages in the World Ocean Atlas.

Data streams from integrated navigational, meteorological, oceanographic, and flow-through sensors on the ship are monitored and recorded in the Scientific Computing System (SCS). The SCS mission data collection are transmitted daily to the SRS, and are compiled and converted post-cruise to an Open Geospatial Consortium (OGC) compliant NetCDF3 format for archive and immediate public access.

POST-PROCESSING

After collection, the acquired datasets undergo additional processing and analysis by mission scientists and support staff. Once the data have been processed, they are then exported into a variety of formats suitable for scientific and public consumption. This is an area where science is the primary field of benefit. Mission scientists can have backgrounds in physical oceanography, marine geology, marine biology, and other similar fields. These individuals typically have post-graduate degrees and are field subject matter experts. They have extensive experience with software packages used to process data in their scientific discipline. They have a familiarity with data standards, and a working knowledge of hardware and software systems. ASCII file manipulation (using spreadsheets and scripting languages), MATLAB or other analysis programs, and GIS systems are commonly used for visualization.

THE ROLE OF LIBRARIANS AND ARCHIVISTS

The final repositories for data from the *Okeanos Explorer* expeditions include the NOAA Central Library and two of the NOAA National Data Centers. Surface data and water column information is archived at the National Oceanographic Data Center (NODC); bathymetric and multibeam water column information is archived at the National Geophysical Data Center (NGDC); and images, video, cruise reports, and publications are archived at the NOAA Central Library. It is at these institutions that exploration data are archived for preservation and long-term discovery and access.

For data to be catalogued and discoverable in a data center, the data must have accompanying metadata. Metadata are essentially data about data. This documentation allows data managers to "tag" the data with information such as who collected it, when it was collected, where it was collected, how it was collected, how it was processed, what instruments were used to collect it, what vessel it was collected on, and so on.

Figure 4. NOAA Librarians catalog, archive, and distribute digital video highlights and clips, still images, and cruise documentation.

Metadata records are documented in standard formats that must be recognizable and readable. The metadata generated for all of these datasets allows researchers, administrators, policy creators, and others to locate and access the data via search interfaces such as geospatial portals, and for ensuring data are independently understandable by users.

Metadata experts, Librarians, and Data Archivists are other examples of career pathways that are called upon as part of the data management process for the *Okeanos Explorer* (Figure 4).

THE ROLE OF INFORMATION TECHNOLOGY

The quantity of digital data gathered during a field season by a single ship, particularly one equipped such as the *Okeanos Explorer*, can be tens of thousands of gigabytes. The fundamental units of all digital data are bits and bytes. Full data collections are transmitted via external computer drives, while subsets of digital data are transmitted via satellite from ship to shore and between shoreside systems. Data are compressed and uncompressed, annotated, synched, thinned, averaged, and analyzed.

An understanding of computer hardware and software are integral to streamlining, automating, and standardizing these and similar tasks. To handle the enormous amount of data gathered, data management computer scientists and engineers have developed a battery of customized scripts and software. Such automation is typically an integral component to system implementations that leverage such complex and emerging technologies. Each Data Management Team must have someone with a broad understanding of digital data manipulation techniques. This person typically will have advanced education in computer science, computer engineering, or electrical engineering, combined with hands-on experience.

In addition to high-end data manipulation, a routine understanding or familiarity with desktop computer systems is essential. In order to operate effectively and efficiently, data exchange systems rely on common information technology

management techniques, including structured file organization and standard file naming conventions. This serves to reduce ambiguity and to support the standardized documentation that is one of the key outcomes. Data managers must operate comfortably within this realm.

All the data collected are geospatial data collected at a certain geographic location. These data thus lend themselves to geospatial analysis and map display, which depends on database and digital mapping skills. Information from the *Okeanos Explorer* is displayed in the *Okeanos* Atlas. Another map, the OER Digital Atlas, provides a central point of access to long-term data holdings in archive centers and the Library. A degree in Geography, Computer Science, or Management Information Systems, or a certificate in GIS skills will provide the basic background for this type of work.

CASE STUDY

There is no specific path into the field, however, data managers typically tend to be individuals with degrees in physical or computer sciences. Although previous experience with marine field sampling procedures is certainly beneficial, a great deal can be learned "on the job." An example is student Ryan Keith, who began working with the OER Data Management Team as a summer intern in 2009. At the time, Ryan was a sophomore in Mississippi State University's (MSU's) Biology Department and had a long-term interest in marine science. In his first summer with OER, Ryan shipped out on the Research Vessel (R/V) *Seward Johnson*, which was also his first time to sea. While aboard, in addition to learning about and applying metadata standards to at-sea collections, sorting biological specimens, and assisting with the preparation and deployment of the "Eye-in-the-Sea" camera system (developed to capture digital video of benthic organisms), Ryan joined the elite ranks of submariners through his participation in submersible dives aboard the *Johnson-Sea-Link* as an observer and dive logger (Figure 5).

Excited at getting his feet wet, Ryan returned the next two years as an intern, once again shipping out on the *Seward Johnson*. Now a seasoned veteran to the job, Ryan has graduated from MSU and has gained full-time employment in data management at NOAA's National Marine Fisheries Service. He plans to continue on to graduate school in marine science.

CONCLUSION

NOAA data management encompasses a multitude of roles, and all benefit greatly from knowledge of field sampling procedures and the scientific analysis in which they are used. This is greatly aided by understanding the scientific principles and operational methodology behind sampling efforts. To that end, data managers frequently ship out as science team members during the field season. As with any other member of the crew, while at sea, data managers are called on to participate in a variety of roles. These can include serving as a watch stander, collecting or processing data, learning and documenting a new system or

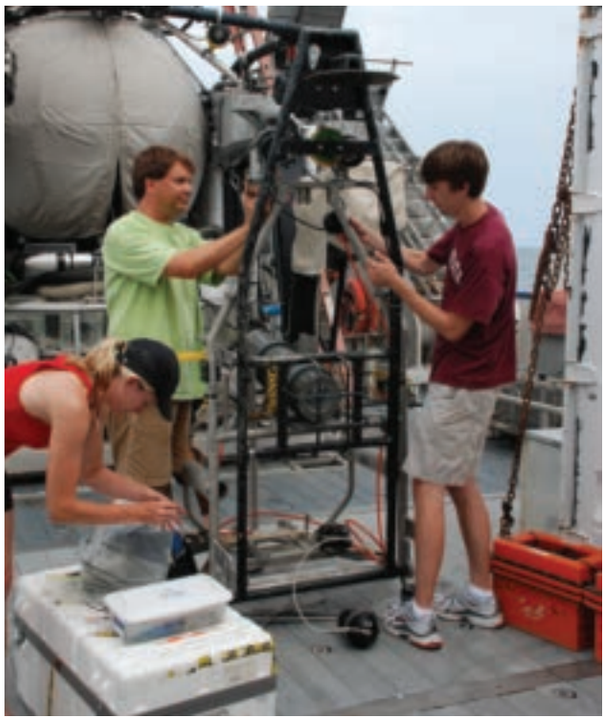


Figure 5. (From left) Dr. Erika Raymond, Dr. Sönke Johnsen, and data manager Ryan Keith prepare the Eye-in-the-Sea camera system for a dive.

piece of equipment, collecting field samples, conducting public service announcements as to the ship's current status, taking photographs, species identification, recording observations during ROV dives, and so on.

More specialized roles require additional education and experience in marine science and technology, scripting languages, software development, networking and telecommunications protocols and technologies, non-linear video editing, and scientific software packages such as Mathworks MATLAB and IVS 3D Fledermaus. As our understanding of Earth's ocean continues to expand, so must our means of recording and maintaining that knowledge for future generations.

RESOURCE LINK

NOAA Ship *Okeanos Explorer* Education Materials Collection:

The Education Vision for the NOAA Ship *Okeanos Explorer* is that this is the ship upon which learners of all ages embark together on scientific voyages of exploration to poorly known or unexplored areas of the global ocean. Learners will participate in innovative ways as ocean explorers in breakthrough discoveries leading to increased scientific understanding and enhanced literacy about our ocean world. Data and information products collected aboard the *Okeanos Explorer* and managed using

these methods are integrated throughout the materials as illustrations, and into many of the lesson plans (visit http://oceanexplorer.noaa.gov/okeanos/edu/welcome.html and see pages 43-44 in this issue).

ENDNOTES

[1] Presidents Panel Report
http://explore.noaa.gov/media/http/pubs/pres_panel_rpt.pdf

[2] Data Management Strategy for the Ocean Exploration Program
http://www.lib.noaa.gov/uhtbin/cgisirsi/x/x/0/5/?searchdata1=ocn707095023

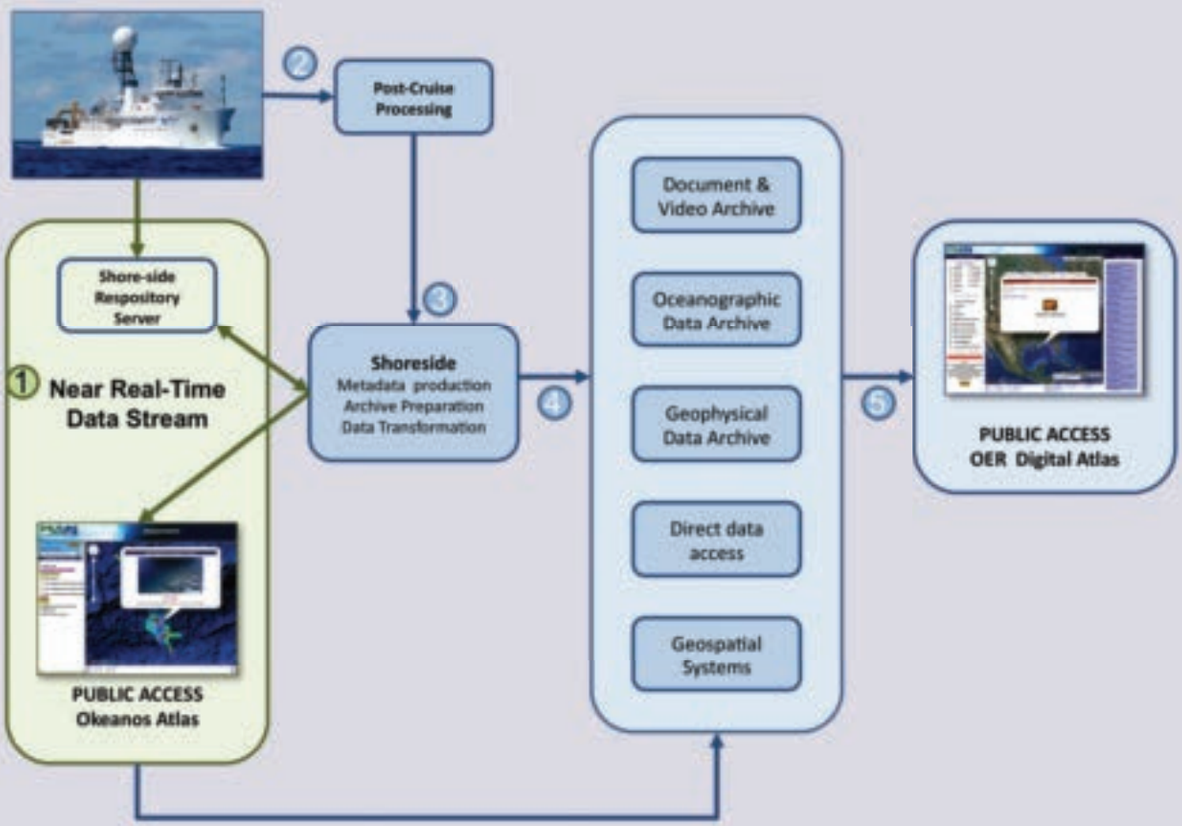
[3] Ocean Exploration Program Metadata Strategy
http://www.lib.noaa.gov/uhtbin/cgisirsi/x/x/0/5/?searchdata1=ocn707093763

BRENDAN RESER is an Oceanographer working with the data management contract team. A recent addition to the team, Brendan was involved in field sampling and data management efforts following the Deep Water Horizon incident. Since joining the team, he has participated in NOAA Ship *Okeanos Explorer* cruises, both on ship and shoreside. Brendan has a Master of Science degree in Oceanography from Oregon State University and a Bachelor of Science degree in Biology from the University of New Mexico. He is currently employed by General Dynamics Information Technology, and is contracted to support OER through NOAA's National Coastal Data Development Center (NCDDC). His operational base is the NOAA field office located at NCDDC, Stennis Space Center, Mississippi.

SHARON MESICK is a Regional Scientist at NOAA's National Coastal Data Development Center, a field office of the National Oceanographic Data Center. She is the Federal Program Manager for the extramural project team that has developed a unique, end-to-end management system to organize, archive, and disseminate ocean exploration information. Prior to joining NOAA in 2003, Sharon worked as a software engineer in private industry, where she developed geospatial visualization and decision support systems for coastal and marine environmental data. She began her career as a data technical analyst with the U.S. Naval Oceanographic Office.

SUSAN GOTTFRIED has been the Project Team Lead for the data management contract team since 2004 and OER's Data Management Coordinator since 2006. In these roles, Susan works with all project principals and data management team members to plan and coordinate the disposition of data collected for OER sponsored expeditions. Currently, she is employed by General Dynamics Information Technology (GDIT) at NOAA's National Coastal Data Development Center at Stennis Space Center, Mississippi.

INSET 1. NOAA SHIP *OKEANOS EXPLORER* DATA PIPELINES



The NOAA Ship *Okeanos Explorer* is equipped with unique communications capabilities that are used to facilitate data access in near real-time and are leveraged to improve data management throughput.

1. The ship transmits data and shipboard generated data products hourly from the Ship-Board Repository Server (SBRS) to the Shoreside Repository Server (SRS). Two immediate tasks are performed: a) create metadata and returns to the SRS for redistribution; and b) integrate data products into the *Okeanos* Atlas (online geospatial display), providing the public with near real-time access to ship location, activities, and products.
2. Post-cruise, large raw data are transferred via hard drive to the processing center, where multibeam data are post-processed. Quality assurance is performed on the raw data and additional data products are created.
3. Corresponding metadata are generated for all data and products.
   a) Data are prepared for archival and public access.
   b) Cruise documents, video, imagery, and outreach materials are submitted to the NOAA Library with metadata for Library cataloging.
   c) Oceanographic, meteorological, and shipboard navigation data are documented and submitted to the National Oceanographic Data Center for archival and direct public access.
   d) Geophysical data are documented and submitted to the National Geophysical Data Center for archival and direct public access.
   e) Geospatial data and products (including those displayed in the *Okeanos* Atlas) are integrated into a geospatial database for GIS analysis.
4. The OER Digital Atlas provides a central point of access to OER data collections. While each of the data centers also provide direct data access methods, the Digital Atlas presents a holistic picture of all data collection and documentation activities for the OER Program.

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IT TAKES A VILLAGE: BRINGING THE NOAA SHIP *OKEANOS EXPLORER* TO LIFE FOR EDUCATORS AND STUDENTS

BY SUSAN E. HAYNES AND MELISSA RYAN

NOAA'S EDUCATION MISSION: TO ADVANCE ENVIRONMENTAL LITERACY

and promote a diverse workforce in ocean, coastal, Great Lakes, weather, and climate sciences, encouraging stewardship and increasing informed decision making for the Nation.

With the commissioning of the new NOAA Ship *Okeanos Explorer,* we knew we had an exceptional platform from which to communicate the importance of exploring and understanding our ocean to teachers, students, and the public and an incredibly intriguing tool to share the tremendous variety of career paths associated with ocean exploration. This state-of-the-art vessel and its telepresence capabilities open new doors in ocean science education. Working directly with ocean explorers, the ship's crew, technicians and national education partners, we've begun to build out education materials and online and onsite educator professional development opportunities associated with this new paradigm of ocean exploration and the discoveries being made. Through creative partnering, we are building an ocean exploration learning community.

Cover of NOAA Ship *Okeanos Explorer* Education Materials Collection developed to encourage educators and students to become personally involved with the voyages and discoveries of America's first Federal ship dedicated to ocean exploration.

Working closely with ocean explorers, scientists, and technicians is a unique and critical aspect of bringing ocean exploration into the classroom. Many of these individuals are extremely passionate about their work, and are happy to share with educators the thrill of participating in an ocean expedition. The scientist/explorer-educator connection is crucial to quality science education. Scientists need to know how best to communicate their research to educators and to share upcoming workforce needs in their fields. Educators need to be able to understand how and why ocean exploration and research is taking place, and how they can play a role in ensuring that their students become ocean-literate citizens. A significant aspect of an ocean science educator's job is to help make these connections possible.

Using the *Okeanos Explorer* as an education platform helps us excite the inquisitive nature of educators and students with questions such as: "What does the bottom of the ocean look like?"; "What kinds of creatures live there and how do they exist at such great depths?"; "What happens when Earth's tectonic plates move?" and; most importantly, "How does the ocean influence my life and how do I influence the ocean?" Through the capabilities of the ship, we are finding answers to some of these questions and constantly formulating new questions yet to be answered.

> *OE reminds teachers that it all starts with those questions, and the desire to know, which is innate in all children. The discoveries of a ship like the* Okeanos Explorer *turn students on to science as it is happening. This exploration is BEFORE the hypothesis. It is from the ship's findings that hypotheses emerge.*
>
> –Elizabeth Day-Miller,
> NOAA OER Education Facilitator
> BridgeWater Education Consultants, LLC

Educator professional development associated with the *Okeanos Explorer* brings participants in direct contact with ocean science experts and provides background material and lessons associated with modern reasons for ocean exploration, including climate change, energy, ocean health, and human health. Through online professional development courses conducted in cooperation with The College of Exploration and ocean explorers, onsite professional development executed in partnership with aquariums and universities nationwide, an award-winning website, and an ocean explorer listserv, we have developed a large community of educators and ocean explorers. Members of this community are passionate about our ocean, interested in sharing what they know with each other and with students and the general public, and deeply curious and excited about what new ocean discoveries will be made in the near future.

> *There is so much still not known about our ocean. The education efforts of the NOAA OER program get science out of the textbook. Teachers and students understand that science is exciting, new, and innovative.*
>
> –Tami Lunsford
> University of Delaware, Adjunct Professor
> MATE Internship Coordinator

Most people do not have direct access to ocean scientists, technology experts, or exploration vessel crewmembers, so NOAA OER brings the excitement of ocean exploration alive through its education resources. The Ocean Explorer website hosts near real-time updates of ocean exploration missions so that educators, students, and the public can follow along with the discoveries, challenges, seafloor mapping, and data collection during missions. On the website, students can investigate the lives and adventures of many of the talented people who explore our ocean planet.

OCEANAGE (OCEAN CAREERS TO INSPIRE ANOTHER GENERATION OF EXPLORERS)

From underwater pilots to ecologists to engineers, these marine explorers provide students with firsthand knowledge of exciting careers through live interviews, profiles, and mission logs. Recently, several of the individuals working aboard the *Okeanos Explorer* have been added to the site, many of whom are highlighted in this issue.

Educators can use the enthusiasm generated by the *Okeanos Explorer's* methods of exploration to stimulate students' interest in many ocean-related career opportunities. The field of ocean exploration and research involves multiple disciplines and in fact, cannot advance without the integration of disciplines such as technology, engineering, science, videography, education, data management, and communications. In today's world, students interested in the ocean have many choices for career paths, whether they choose an engineering path such as building a remotely operated vehicle, an information technology path where they manage oceanographic data, or the path of a journalist who documents ocean expeditions. It is certainly not necessary to pursue an ocean science degree to work in ocean science.

> *This program exposes students to aspects of ocean exploration such as satellite technology and videography, inspiring those that may not have a direct interest in science as it is taught in the classroom.*
>
> –Tami Lunsford
> University of Delaware, Adjunct Professor
> MATE Internship Coordinator

Providing innovative educator professional development and exposure to authentic ocean explorers helps us to meet the NOAA Education Mission: *To advance environmental literacy and promote a diverse workforce.* Educators come away with quality ocean science content to share with their students, giving them more confidence in teaching that content as well as insight into unprecedented ocean discoveries and the career paths necessary to make such discoveries possible.

In teaching about ocean exploration, it is very helpful to have a science background to effectively communicate ocean science content, and to be able to talk about at-sea operations aboard ships such as the *Okeanos Explorer*. It is also valuable if an ocean science educator is familiar with the "language" of ocean exploration—from the nautical terminology that helps to describe a research vessel and its functions to the biological, chemical, and geological terms that describe a new underwater discovery. Both of us, and most of the ocean explorer facilitators who help us to instruct OER educator professional development programs around the country, began our college education and early careers with a focus on science and scientific research. Through very different career paths, we each found we enjoyed working with students and educators and found our niche in science education, specifically marine science education. With a passion for the ocean environment, a clear understanding of the importance of translating science for educators and the public, and a desire to continue to build the well-informed village necessary to protect, preserve, and understand our ocean, our work teaches "us" something new every day!

This purple octopus with large glassy eyes was observed during a deep sea expedition with the ROV *Little Hercules* in Indonesia.

RESOURCE LINKS

NOAA Ship *Okeanos Explorer* Education Materials Collection *Volume 1 – Why Do We Explore?:*
http://oceanexplorer.noaa.gov/okeanos/edu/collection/wdwe.html

NOAA Ship *Okeanos Explorer* Education Materials Collection *Volume 2 – How Do We Explore?:*
http://oceanexplorer.noaa.gov/okeanos/edu/collection/hdwe.html

NOAA Office of Ocean Exploration Onsite Professional Development:
http://oceanexplorer.noaa.gov/edu/development/onsite_development.html

NOAA Ship *Okeanos Explorer* Education Materials *How Do We Explore?* Online Professional Development:
www.coexploration.org/oe-hdwe

NOAA Ocean Explorer Exploration Education Modules:
www.oceanexplorer.noaa.gov/edu/modules/welcome.html

NOAA Ocean Exploration INDEX/SATAL 2010 Maiden Voyage to Indonesia:
http://oceanexplorer.noaa.gov/okeanos/explorations/10index/background/edu/edu.html

NOAA Office of Ocean Exploration and Research Galápagos Rift 2011 Expedition Education Module:
http://oceanexplorer.noaa.gov/okeanos/explorations/ex1103/background/edu/edu.html

NOAA Office of Ocean Exploration and Research Mid-Cayman Rise 2011 Expedition Education Module:
http://oceanexplorer.noaa.gov/okeanos/explorations/ex1104/background/edu/edu.html

Crew members, technicians, scientists, and program managers are pictured here from both the NOAA Ship *Okeanos Explorer* and an Indonesian research vessel.

Scientists conduct an XBT cast which measures temperature through the water column.

SUSAN HAYNES is the 2020 LLC NOAA OER Education Program Manager. She is responsible for Ocean Exploration teacher professional development in cooperation with 14 national Alliance Partners and the College of Exploration. She is currently working as part of a development team designing and implementing the education offerings associated with the *Okeanos Explorer*. Prior to arriving at NOAA in May 2008, Susan spent four years as the Director for the National Ocean Sciences Bowl (NOSB) at the Consortium for Ocean Leadership (CORE division) in Washington, D.C. Formerly an Education Specialist for Virginia Sea Grant at the Virginia Institute of Marine Science, her past work has included working with scientific faculty to design graduate courses for teachers and developing classroom activities using authentic research data. She has also been an Education Specialist at Oregon Coast Aquarium and National Aquarium in Baltimore. With 21 years of experience in marine education, Susan has spent a significant portion of her career working to better engage marine scientists in student and teacher education. Susan is currently on the NMEA Board of Directors and a member of the NMEA Executive Committee.

MELISSA RYAN is the ERT LLC Lead Program Instructor for NOAA's Office of Ocean Exploration and Research. She facilitates Ocean Exploration teacher professional development online and onsite workshops. She is currently working as part of a development team to design the education offerings associated with the NOAA Ship *Okeanos Explorer*. Melissa is also the Project Manager for the Ocean Technology Foundation, where she manages marine archaeological surveys. She also spent 10 years working in environmental policy for the Connecticut Council on Environmental Quality. Melissa has 20 years of combined experience in marine education, marine science, and policy.

PHOTO CREDIT

All Photos Courtesy of NOAA *Okeanos Explorer* Program

OceanAGE (Another Generation of Explorers): Career Feature on NOAA's Ocean Explorer Website

By Laura Paris

NOAA's Ocean Explorer OceanAGE website gives students the opportunity to learn about marine explorers and their careers through live links, profiles, and mission logs.

The NOAA Ocean Explorer OceanAGE web presence (http://oceanexplorer.noaa.gov/edu/oceanage/welcome.html) is a unique online educational resource that enables users to learn more about a variety of ocean careers available to those interested in work on or in the ocean. The site is populated with a wide variety of talented people who explore our ocean planet, and range from explorers, graduate students, remotely operated vehicle (ROV) pilots, and vessel crew to NOAA Corps Officers. The target audience for this interesting mini-database of scientific and technical careers is students of any age, and any other user groups interested in learning more about the diversity of career options for scientific and technical work that supports ocean exploration and research careers at sea.

Components of the OceanAGE site consist of video profile interviews presenting a multitude of scientific careers. These are supplemented with imagery, biographies, and other related content and resources. The OceanAGE online video profiles offer a storyline of each featured career, including an introduction about the person being featured, his/her background, education, type of research or job currently involved/employed in, and personal rewards/obstacles encountered along the way. A career timeline is also presented, from youth to adult professional accomplishments. Other career opportunities they might be qualified for, as well hobbies, are also featured. Through the video web interfaces, visitors to the site can hear from explorers and scientists such as *Titanic* discoverer Dr. Robert Ballard, who details his background and his job as an oceanographer (http://oceanexplorer.noaa.gov/edu/oceanage/05ballard/welcome.html), and Dr. Shirley A. Pomponi, who has dedicated her life to researching the ocean for marine natural products (http://oceanexplorer.noaa.gov/edu/oceanage/03pomponi/pomponi.html).

OceanAGE videos are filmed at sea during an expedition, and in the workplace or laboratory where the featured presenters continue their exploration work. Appealing imagery highlights the most interesting achievements for each specific career. Depending on the individual background, additional resources are provided, including research papers, articles, and other relevant content.

Many of those featured on OceanAGE travel worldwide through their work. Students interested in careers that would enable them to travel while working on or in the ocean hear firsthand about these experiences. OceanAGE can also open many doors for learning about ocean technologies and personal life experiences. OceanAGE online video profiles have also been used in higher education as material for introducing careers such as that of a ROV pilot, an archaeologist, a fish ecologist, and a mammal biologist.

OceanAGE continues to be populated with those involved in exploration efforts in partnership with NOAA's Office of Ocean Exploration and Research (OER), so that users will be able to more effectively learn from personal stories about the fascinating people who explore our little-known ocean world. OER encourages educators to use the OceanAGE site with their students in an effort to potentially inspire their career choices and build a more robust, competitive science and engineering workforce to help meet the needs of the future ocean sciences community.

Laura Paris is part of the team involved in the development and maintenance of the Ocean Explorer educational website. She is an experienced web management professional, with 25 years of professional background in the Information Technology (IT)/Marketing/Design fields. Her background also includes a variety of affiliated IT fields such as Print/Media/Publication Management, System Administration, Networking, Business Analysis, and Project Management. Paris is pursuing her Master degree in Information Technologies with a special emphasis on IT Project Management.

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AN OCEANAGE (ANOTHER GENERATION OF EXPLORERS) INTERVIEW WITH RICHARD CONWAY, CHIEF ELECTRONICS TECHNICIAN (CET), NOAA SHIP *OKEANOS EXPLORER*

NOAA Ship *Okeanos Explorer* Chief Electronics Technician, Richard Conway.

Where do you work?

My base of operations is the ship's Electronics Technician (ET) shop but I work throughout the ship. I even have equipment in engineering areas that I need to work on.

What sparked your initial interest in ocean sciences?

I am one of those people who started down one path toward an occupation, then veered off toward another path, then ended up not on my original path but on a different path in the same community. I have a Bachelor of Science degree from Oregon State University (OSU) in Zoology, yet my job is in electronics working on an oceanographic research vessel. When I was little, I always liked water animals. I caught tadpoles and fish and kept them in jars. I watched a tadpole turn into a frog. When I was in high school, a modular program on the ocean came to our school. Being from the Midwest, I was fascinated by what it showed me. The module covered biology, geology, and chemistry. Upon graduating, I packed up my bags and went to OSU with the intention of getting a degree in zoology.

While working on my undergraduate degree, I had the opportunity to go on some oceanographic cruises. I also talked to some of the scientists, who were in the field, and one asked me if I liked doing the work or did I like observing and writing about what I saw. I told him I liked doing the work. I liked getting my hands dirty, so to speak. He said that he noticed my energy level changed. It was really high when I was gathering the samples and running them, and then it dropped when I was the recorder. I never forgot that comment. So after graduating, I managed to get a job with the School of Oceanography working with zooplankton for Dr. Charlie Miller.

During the early1980s, environmental science research took a big hit in the funding department. I was laid off and took a job with the Forest Service and became an insect dietician. This meant I made artificial food for groups doing research with insects. After three years and a lab procedure, anyone could run the lab. In fact, to test the procedures I had written, I had one of the secretaries walk me through making a batch of diet. I knew then it was time for me to leave. My decision was to get re-educated in another love, electronics. That led to another decision. Did I want to pay my way through school or did I want someone to pay for me to go to school? The answer was for someone else to pay me, of course. I joined the Navy and served six years as a sonar technician onboard a submarine. After getting out, I tried to get a job with NOAA but there were no openings at that time. I went to work for Motorola at a Research and Development facility as an electronics technician for 11 years. Motorola closed the facility, and I worked a few other places before trying NOAA again and getting hired. I served three years on the NOAA hydrographic vessel, the *Fairweather* before getting assigned to the NOAA Ship *Okeanos Explorer*, where my job contributes to the understanding of the ocean.

Who influenced you or encouraged you the most?

My mother encouraged me the most. I am told I am a happy person, and she is the reason I am that way. She always told me that I was the one person she knew that if I set my mind to do something, I could. She also believed in education. We were a low-income family. She bought an entire set of encyclopedias, and there were two volumes written for kids that contained science projects. I know financially it was a big burden on our family, but my mother thought it was important. I read every book from cover to cover. We used to sit down at the table and read parts of the books, especially the science section. My mother liked to say to me, "Do your best. If you do your best and fail, then there is nothing to be unhappy about." The other was "No matter what bad thing happens to you, there is always someone that has it worse." I believe I am her legacy. Any of my accomplishments are her accomplishments too.

Do you travel often? To where?

Yes, to wherever the ship goes.

What are the educational requirements for your job?

Technical school and/or military school/training.

What is the salary range for someone with your type of job?

The starting salary is around $40,000 a year and it goes up from there depending on responsibility, equipment type, area (consumers' electronics, medical electronics, etc.), and experience.

How many hours do you work per week?

Normally I work 40 hours per week in home port, 48 or more hours when in other ports, and 56 or more hours when at sea. The extra hours are because when the ship is normally in port, things can be shut down for maintenance, especially on weekends, but at sea the equipment doesn't keep set hours.

Tell us more about the types of things you do.

It is the ET's responsibility to make sure all the electronics equipment that is non-propulsion or engineering department-related is in working order. The electronics equipment onboard that ETs are responsible for can be broken down into five groups:

1. Navigation: includes the radar, GPS, electronic charts, and such.
2. Communications: includes the radios, internal phone systems, external satellite phones.
3. Network: includes the servers, computer, routers, switches, and the miles of connections. This also includes the VSAT because it's essentially a wireless network connection to shore.
4. Scientific systems: includes the many types of sonar, CTD, environmental sensors, and some specialized computers.
5. Entertainment systems: includes the movie players and TVs in staterooms and common areas.

What is the most fascinating thing you have ever seen or done?

There are a bunch, but the most unique and the one that a minute percentage of the human population has ever experienced is being hit by the shock wave of an earthquake while in a submarine. We are talking about a 19-ton moving object, 600-feet long, being brought to a dead stop. Dishes crashed, things fell over, and some people were falling out of chairs. The person next to me came out of his seat, but he was okay. The crew started automatically moving to general quarters, making the sub internally water tight, before the alarm was given. We thought we had collided with another submarine. The sonar supervisor was yelling at us to find the contact we collided with. The Executive Officer came into the sonar shack wanting to know "who we hit." It took a few seconds for the submarine to start moving again. We could not find or detect anything. There was nothing around or near us. It was a week later that we found out what hit us. There was a big earthquake about 45 minutes before we got hit. When we re-analyzed the recording tape from the sensors we saw the band appear and disappear at the time we got hit. That was the signature of the earthquake shock wave.

What are the personal rewards of your work?

Knowing that what I do helps the ship accomplish its mission, which is the exploration of the world's ocean.

How does your work benefit the public?

In this particular case, the devices I work with and maintain are the vehicles which gather, analyze, and provide the information used to increase knowledge of the ocean.

What else could someone with your background do?

Wow, there is so much you can do! You can work with space exploration, medicine, public services, consumer electronics (I used to work with cell phone research and development), and military, to name a few. The problem would be which field to choose.

What obstacles did you encounter along the way?

Educationally I was behind my fellow students. A lot of the educational background I was supposed to have had in high school I did not get. I was from a low-income family, and during the 1960s and early 1970s there was no equality of schools. The school I went to had limited educational classes. In some cases, we had to make a choice such as biology or physics. You couldn't take both because they were given at the same time due to limited space and the availability of qualified teachers. Another example was math. The highest level of math offered by the school was Algebra I. A teacher voluntarily came in during the morning before school just to teach Algebra II to those of us planning on attending college.

What are your hobbies?

I'm a big Seahawks football fan and season ticket holder. It has been hard to attend games since coming to NOAA because of the ship's schedule. Another of my hobbies is graphic design. One example is the EEB logo on our department computer monitor. I also fly RC electric helicopters. Right now I have five.

Looking back, was there anything you would have done differently in your education or career journey?

I would like to say get an electronic engineering degree but when I think about it, if I did, I would not be out here. Some of the experiences that I cherish would not have happened, and I would never have met a lot of the people who have become my lifelong friends. So I would not change anything.

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An OceanAGE (Another Generation of Explorers) Interview with Margret Collins, Engine Utilityman, NOAA Ship *Okeanos Explorer*

The author aboard the NOAA Ship *Okeanos Explorer*.

Where do you work?

I live and work aboard the *Okeanos Explorer.* As a shipboard engineer my work takes me "stem to stern." On an average day underway, I will begin in our propulsion motor room, move through the main engine room, into our air conditioning "flat," up to the emergency generator room, back down to the winch room, pass through the stern thruster room, make a turnaround in the steering gear room, and then head up to the bridge, all before breakfast! I also work "outboard" (on the weather decks) doing things like maintaining our Fast Rescue Boat and workboat, greasing the "bull gears" of our fantail deck cranes, and repairing/replacing light fixtures, to name a few tasks.

What sparked your initial interest in ocean sciences?

To be honest, my work is, while in close proximity to the scientific and technical work conducted on the vessel, virtually unrelated to the conduct/content of the missions. The ship's merchant mariner crew exists in symbiosis with our visiting scientists and technicians. Without them, there is no reason to operate the ship and without us, there is no ship with which to explore.

Who influenced you or encouraged you the most?

My parents.

Do you travel often? To where?

I live and work aboard the *Okeanos Explorer* so where she goes, I go! In the past three years, I've lived in/been to Bellingham, Washington; Seattle, Washington; Astoria, Oregon; San Francisco, California; Honolulu, Hawaii; Kona, Hawaii; Sulawesi, Indonesia; Hagatna, Guam; Alameda, California; San Diego, California; Puntarenas, Costa Rica; Panama City, Panama; and I am writing this from 18D 22M North, 81D 47M West, which is about 60 miles Southwest of Grand Cayman Island (UK) in the Caribbean. I do not maintain a residence ashore, keeping my worldly possessions (those that I can't cram into the state room that I share) in a storage unit I've had since I signed on with NOAA.

What are the educational requirements for your job?

There are more technical proficiency, legal, and health requirements for this job than educational ones. For example, a high school diploma will do just fine, if you also have a U.S. Coast Guard issued Merchant Mariners' Credential (MMC) endorsed with Qualified Member of the Engine Department; Oiler Rating (or better), a Certificate of Completion for a USCG-approved Basic Shipboard Fire Fighting course, Certificates of Completion for USCG-approved Standards of Training, Certification and Watchkeeping (STCW) Basic Safety courses, a Transportation Workers Identification Credential (TWIC) card, and a valid driver's license. You must be able to pass a USCG physical (can't be color blind, must be able to see 20/20 with corrective lenses, can't be dependent on some forms of medication, must meet a height/weight standard, must be able to pass a standard hearing "beep" test, etc.); and, finally, you cannot have any felony convictions, any alcohol related misdemeanors and must be a U.S. citizen. An aptitude for engineering will make your job a lot more enjoyable.

What is the salary range for someone with your type of job?

With NOAA, my pay rate is federally established and publicly accessible. Since my pay "locality" is San Diego (NOAA port closest to my "home of record") my straight time (S/T) wage is $41,315.00 per year, $34.27 in hourly over time (O/T) and $12.02 per hour in penalty pay (P/P). I average—but am never guaranteed—about $20,000.00 in O/T and P/P per year in addition to my S/T wage.

How many hours do you work per week?

Underway, I average about 70 hours per week. While we're in port it's usually closer to 40.

Tell us more about the types of things you do.

As an engineering technician, most of my work is either in the Engine Department below-decks work spaces or up on

the "small boats." We've got a sign taped to the door of our engineering shop that says, "If it ain't broke, fix it till it is!" We don't really do that, though. There are three distinct parts of my job: maintenance, repair, and operations. Maintenance is scheduled: changing filters, hydrometer testing batteries, running the small boats every week, etc. Repair work is what I must do when something fails: remove and replace a clothes washer pump when it stops working, build a small wiring harness for an anti-fouling anode when the cannon plug is broken, water-proof a smoke detector, etc. The smallest part of my job is operational. For me that means serving as the small boat engineer during "man overboard" drills (we throw a lead weighted survival suit overboard, not people), "pax (passenger) transfers," or sundry other reasons and standing "steering gear" watch as my duty during our "sea and anchor" evolutions. When I'm the small boat engineer, I assist in releasing the boat from the hook once it is lowered and reaches the water, and sometimes "letting go" lines that hold us to the ship. Then I'm just there in case the boat fails for some reason, which it very rarely does. Having a "steering gear" watch is a precautionary measure: should the bridge lose ability to steer the ship from that location, there is a back-up steering station in the steering gear room. Should that situation occur, the bridge would call down to me on our sound-powered phone and give me helm commands like, "Five degrees right rudder" which I would repeat back once I had used the electrical controller to bring the rudder to that position.

In addition to the above, like every other crew member, I have a job to do during our weekly (while underway) fire drills. As a member of the Damage Control Team, I assist the lead Damage Controller by doing things like replenishing air bottles our fire fighters have used up, carrying rolls of fire hose to fire teams to add to what they've got, and bring high-powered fans to spaces that have been "smoked out" by our safety officer with a smoke machine to simulate a real fire during a drill. We also have weekly "Abandon Ship" drills, but all I do is carry my life jacket and survival suit up to the 01 Deck, don the life jacket, test the whistle and strobe light, and take it off again. However, this week was the first of the month and we took new passengers aboard so we all had to put on our survival suits—also known as "Gumby Suits"—which can be a little comical. They're like a giant, neoprene "onesy" for grown-ups.

What is the most fascinating thing you have ever seen or done?

What first comes to mind is a time when I was sailing commercially in the South China Sea during an electrical storm. I was awakened from a dead sleep by what sounded like a bomb going off nearby and a flash of light so bright it was like a paparazzi camera right in my face! What had happened was that the large container ship I was on had been struck by lightning. The flash was the light of the lightning through my porthole curtain. Although the ship was struck, since ships are grounded through the water, nothing was damaged.

What are the personal rewards of your work?

In my job, I feel rewarded twofold: I help maintain the ship for safe and efficient operations, and I get to indirectly help America explore Earths' ocean for our benefit and that of others. Last year, through the work of the *Okeanos Explorer*, it is believed that over 50 new species were discovered on volcanic seamounts near Indonesia. The results of this season's work are yet to be revealed, but I'm confident it'll be exciting and worthwhile, too.

How does your work benefit the public?

The *Okeanos Explorer* is "America's ship for Exploration." We serve the interests of all Americans by exploring the largely unknown and mysterious great depths (up to 6,000 m/19,685 ft) of our planet. What we find may help us better understand what goes on in our ocean, especially the things we've never seen before. I've heard scientists aboard speak about medical, environmental, geological, and other potential applications of our work.

What else could someone with your background do?

Given my professional background, someone like me is probably best suited for the specific maritime career I'm embarked on. I could possibly also get work in a shoreside power plant or work with generators in some other application. However, I am considering going ashore to study maritime management, since I do have a bachelor's degree. Going to sea is wonderful—I came back to it because I missed it so much. It is very difficult to maintain a life ashore, though, when you're out to sea 280 days a year, which is our average.

What obstacles did you encounter along the way?

When I first started out in this industry, a person had to have a maritime job to be able to apply for what was known then as a "Z-card," now known as a Merchant Mariners' Credential. Yep, that's a catch 22. How can you get the work if you don't have the document to get it which you can't get until you have the work? Luckily, merchant mariners aren't regulated in that way anymore. At the time, though, I overcame that obstacle by attending a merchant mariner training program through Job Corps. Now, to be able to afford all of the training necessary to obtain the required certifications/documents to sail, you often need an employer to pay for those or be independently wealthy. Again, Job Corps got me started on that path. It was also through them that I got my first job as an Able Seaman out in Kwajalein, Republic of the Marshall Islands in 1997. I've mostly had employer-paid training since then.

What are your hobbies?

I really enjoy exploring the ports we visit! Because of the various ports we've visited, I've had opportunities to go skydiving, kayaking, rock climbing, stand-up paddle boarding, hiking through jungles, zip-lining, snorkeling, four-wheeling, eating at amazing restaurants, seeing a variety of live bands from everywhere, visiting historical sites, and on and on. When aboard the ship, I like to read and watch DVD's of television shows and movies.

CAREER TIMELINE

Interests in Elementary School

I thought that the Foss tugboats that brought our supply barges to Ketchikan, Alaska when I was a kid were fantastic! I desperately wanted to go to sea with them.

Beginning of Interest in Marine Sciences

I never seriously considered following that path until I found myself at a professional crossroads in my mid-20s and decided to obtain professional training/certification to that end.

First Marine Science Class

I first arrived at Tongue Point Job Corps Center in Astoria, Oregon in October of 1995. I embarked on an 18-month program in Seamanship and Marine Engineering that resulted in my first "Z-card" endorsed as an Able Seaman-Limited and Qualified Member of the Engine Department - Oiler, Junior Engineer.

Degrees

I graduated from The Evergreen State College with a Bachelor of Arts degree in Liberal Arts in 1994.

First Career-related Job

My first career-related job was a Godsend! I was offered an opportunity to apply to Raytheon-Range Systems Engineering to be an Able Seaman aboard a T-AGOS class ship called the *Worthy* at Kwajalein Island, The Republic of the Marshall Islands just before I graduated from Tongue Point in 1997.

Employment Journey/Career Transitions

I held down insignificant, part-time jobs in college like cold-calling university alumni requesting school donations. After I graduated from college, I had a pleasant but barely livable job working for a coffee shop in Olympia, Washington. That's when I decided to obtain the necessary training to become a Merchant Mariner. Merchant Mariner training technically paid a pittance, but the value of the program wasn't in the wages. The free training, food, clothing, and lodging for 18 months, resulting in professional certification that was otherwise difficult to obtain, was worth it!

I arrived in Kwajalein, Marshall Islands in September of 1997 ready to work as an Able Seaman aboard the M/V *Worthy.* I did that for two years. Then I was eligible to test for a Coast Guard regulated professional advancement to 200 Gross Ton Mate (upon Near Coastal Waters) License. I returned to Kwajalein and then sailed as the Mate aboard the tugboat *Mystic.* We sailed within the Kwajalein Atoll (the largest lagoon in the world) on regular barge delivery runs. I wasn't aboard a Foss tugboat in South East Alaska—where I'd grown up—this was even better! After three years on a three-mile-long island, 4,500 miles from North America, it was finally time to go.

I went back to Washington State for more formal training, this time to refresh my marine engineering skills I'd lost while sailing only as an Able Seaman. During this time, the U.S. was attacked by terrorists flying airplanes into the World Trade Center towers. After that I felt I had to do something to defend my country so I joined the Marine Corps. I served five years active duty as a helicopter engine mechanic (MOS 6123) stationed in or deployed to Okinawa, Japan; USS *Essex* (LHD-2); San Diego, California; and Al Asad, Iraq.

After leaving the service, I took some science and math courses at a local community college, biding my time for professional inspiration. I then went to work manufacturing equipment installed in aircraft specifically configured to carry medical patients. That's when I felt the need to go to sea again. I applied to NOAA for a General Vessel Assistant (GVA) entry level position. I was eventually hired and met the *Okeanos Explorer* in Bellingham, Washington in March of 2008. About each year since then I've advanced a rung up the Engineering Department ladder going from GVA to Oiler and now to Engine Utility.

Other Accomplishments

I was chosen by the Seafarers' International Union (SIU) to go to the Paul Hall Center in Piney Point, Maryland for a week to help negotiate the present union Agreement between the SIU and NOAA. The new Agreement went into effect May of this year.

I'm proud of my service as a United States Marine which began in March of 2002 and ended March of 2007.

Looking back, was there anything you would have done differently in your education or career journey?

I don't spend a lot of time thinking "what if...." Although I've had lots of amazing adventures around the world, I am not a well-established person. If I had it all to do over again I might start with one career path and just stick with it so that, after all of these years, I might be farther along with it. I think I might have a more conventional life ashore now had I done that. By the same token, knowing myself, if I had I'd probably find myself often staring out windows wondering what it would be like to be out traveling the world. Bottom line: no regrets.

The author works from "stem to stern" on the ship.

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AN OCEANAGE (ANOTHER GENERATION OF EXPLORERS) INTERVIEW WITH BRIAN KENNEDY, NOAA CORPS OFFICER, NOAA SHIP *OKEANOS EXPLORER*

The author onboard the NOAA Ship *Okeanos Explorer*.

Where do you work?

I work all over the world. Wherever the ship goes is my home and office. In the last 18 months we have worked in Indonesia, Costa Rica, the Galapágos, Panama, the Cayman Islands, the Gulf of Mexico, and up and down both coasts of the United States, including Hawaii.

What sparked your initial interest in ocean sciences?

When I was about five or six, I was on a vacation with my parents in the Florida Keys and we encountered an adult manatee in a harbor on the north side of Marathon Key. As my parents tell the story, it was like the light bulb turned on over my head and I have wanted to be involved in marine science ever since.

Who influenced you or encouraged you the most?

My parents had a huge impact on my career choices. They were always encouraging me to pursue my dreams and helping make opportunities become realities whenever possible. Several teachers also stand out. In high school, my Ocean Sciences Bowl Coach Vicki Souter helped me make many contacts that were very influential later in my life. In college, Dr. Leslie Sautter and Dr. Gorka Sancho, both at the College of Charleston, had a lot of influence on my decision to join NOAA.

Do you travel often? To where?

I get the opportunity to travel often. Not only is the ship continually moving from one exploration area to another, but I often get the opportunity to attend training all over the country. In the last two years, the ship has worked in Indonesia, Costa Rica, the Galápagos, Panama, the Cayman Islands, the Gulf of Mexico, and along both coasts of the United States, including Hawaii.

What are the educational requirements for your job?

In order to join NOAA Corps, you must have at least a bachelor's degree in science or engineering with course work in physics and calculus. After you are accepted, you must complete a multi-month training program to learn how to handle and navigate ships.

What is the salary range for someone with your type of job?

NOAA Corps officers are paid on the same scale that U.S. Naval officers are. The starting salary for an Ensign is about $35,000 per year, including housing.

How many hours do you work per week?

While the ship is in port, we work a normal 40-hour week, plus being on call a couple nights a week if something comes up on the ship. While the ship is underway it is not uncommon to work 9 to 11 hours a day, seven days a week.

Tell us more about your work and the types of things you do.

The *Okeanos Explorer* is America's ship for ocean exploration. The ship systematically explores areas of the world's ocean that have been understudied or have never been studied before. We employ a wide breadth of sensors and equipment that allow us to quickly characterize areas of the seafloor. We have a high-resolution multibeam mapping sonar, a remotely operated vehicle (ROV), and a full suite of chemical sensors on our CTD (an instrument that measures conductivity, temperature, and depth). The goal of the ship is to explore an area and get a basic understanding of what is there, then move on to the next area of interest, allowing another team's specialists to return and conduct a more detailed analysis of the area.

What is the most fascinating thing you have ever seen or done?

One of the best things about my job is that I get to do some new and fascinating things and there is no way for me to pick just one.

The author shows educators the remotely operated vehicle, *Little Hercules,* on board the NOAA Ship *Okeanos Explorer.*

Some of the images the ROV has returned have been simply jaw-dropping: creatures never before seen by human eyes that bioluminesce in the water so strongly that dolphins swimming next to the ship leave glowing contrails 10 meters long. And, diving on the ship's hull while the ship is in over 3,000 meters of water to remove fishing gear that was entangled in the ship's propellers. Routinely, I get to see or do something new which is one of the wonderful things about my job.

What are the personal rewards of your work?

Being part of uncovering the mystery of the deep ocean and helping to facilitate discoveries that literally rewrite the textbooks is a huge personal reward for me.

How does your work benefit the public?

I believe that knowledge is intrinsically valuable to the public. We do not know what we are going to find until we go out and look. It has been said that we know more about the surface of the moon than we do about the surface of the deep ocean.

What else could someone with your background do?

I have a bachelor's degree in marine biology and a minor in geology, so I could work as a research assistant in a lab or in the field. If someone was interested in following a career in marine science, an advanced degree is really necessary.

What obstacles did you encounter along the way?

There are always obstacles that everyone encounters, but the biggest thing I can say about obstacles is that you must be persistent to get by them. Do not give up easily. If you need to make a dozen phone calls, then make them. If someone tells you to call back, then call back. I was trying to get an internship researching right whales and they did not really think I was qualified for it. So they tactfully told me to call back in a month. So I did and when I did they told me to call back in two weeks. This went on for almost six months until they finally gave up and let me have the internship. It turned out to be one of the coolest experiences I have ever had. It was well worth the couple dozen phone calls I had to make.

What are your hobbies?

I am an avid SCUBA diver and kayaker, I enjoy photography, and I have my private pilot's license.

Looking back, was there anything you would have done differently in your education or career journey?

Not really, I am very happy where I am right now.

PHOTO CREDIT

All Photos Courtesy of NOAA

Brian Kennedy busy at work aboard the ship.

ACTIVITY: CALLING ALL EXPLORERS

THIS GUIDE HELPS STUDENTS LEARN ABOUT WHAT IT MEANS TO BE AN EXPLORER, *and the importance of curiosity, exploration, and the ability to document what one studies. Students are asked to visit the Ocean Explorer website and by researching and answering the questions below, they find out more about "real life" ocean explorers. Students then complete a Reflection Sheet (page 44), which gives them the time to reflect on what they've learned from both modern and historic explorers.*

OCEAN EXPLORERS WEB QUEST GUIDE

Welcome, Ocean Explorers! Please proceed to the following website: http://oceanexplorer.noaa.gov/explorations/explorations.html

1. List three places in the deep sea visited by ocean explorers within the past three years.
2. Now proceed to this website: http://oceanexplorer.noaa.gov/edu/oceanage/welcome.html. There are many individuals studying the deep sea. List at least five, and describe their fields of research.
3. Describe what your day might be like if you were a marine mammal biologist.
4. In some ways, deep-sea explorers of modern times are similar to historic explorers. They are brave, curious men and women who are at the cutting edge of their field of interest. They are very unique individuals. One of the senior scientists interviewed on the OceanAGE web page explains the difference between a submarine and a submersible. Find her name and record what she says about this difference.
5. What is the name of the fish ecologist who wanted to be an astronaut until he realized that the ocean was virtually unexplored and the other-worldly creatures that he wanted to see and study were living right here at home?
6. How do you think that exploring the deep sea is similar to exploring outer space?
7. Which NOAA Corps Officer studies the geology of hydrothermal vents and submarine volcanoes, and says her parents and college advisor were great mentors and role models?
8. There is a big world waiting for you to explore it, and the technology to do so gets better every day. Yesterday's discoveries are today's necessities. Which explorer looks for marine plants and animals that produce chemicals that may be developed into drugs to treat human diseases?
9. As we learn more about Earth's ocean, we realize that even though the ocean is vast, its resources are limited and need protection. Which marine ecologist looks for "sweet spots" in the ocean, places where life is rich and abundant, and then works with governments and nonprofit organizations to secure protection of those resources for future generations?
10. Explore further (optional):

    Go to the log essay from July 7, 2010 (http://oceanexplorer.noaa.gov/okeanos/explorations/10index/logs/july07/july07.html) to see brief biographies of 13 members of the *Okeanos Explorer* ROV team.

    Meet some of ocean exploration's next generation among members of the INSPIRE: Chile Margin 2010 Expedition; an expedition that was spearheaded by a team of graduate students! See http://oceanexplorer.noaa.gov/explorations/10chile/background/explorers/explorers.html.

    The log essay from July 29, 2010 (http://oceanexplorer.noaa.gov/okeanos/explorations/10index/logs/july29/july29.html) gives a glimpse of the range of activities involved in a typical day aboard the *Okeanos Explorer.*

    Read more about the ship's NOAA Corps Officers in the log essay from August 12, 2010 (http://oceanexplorer.noaa.gov/okeanos/explorations/10index/logs/aug02/aug02.html), and find out more about the ship's crew here: http://www.moc.noaa.gov/oe/.

Congratulations, Explorers! You have successfully navigated the Ocean Explorers Web Quest! To view the answers to these questions, go to the link http://oceanexplorer.noaa.gov/okeanos/edu/collection/media/vol1_wdwe.pdf and scroll down to page 76 of the PDF document "The NOAA Ship *Okeanos Explorer* Education Materials Collection for Grades 5-12" from *Volume 1: Why Do We Explore?*

OCEAN EXPLORERS REFLECTION SHEET

Now you are ready for some quiet reflection on what you learned with your colleagues after completing the Web Quest Guide on page 43.

1. Reflect and write about differences and similarities between explorers of the past and modern day explorers. What types of hardships do both have in common?

2. Name some places that have been explored in modern times.

3. Name places that were explored during the early history of humans.

4. Name a place that you have explored. What was unique about it that you think another visitor to that site would not have noticed?

5. Name a place that you would like to explore. What do you think you would find there? Why?

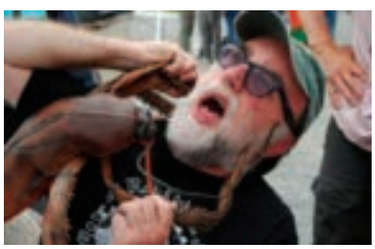
6. Why is it important to document your explorations? What is your favorite way to remember your own adventures?

7. List a few of your science and exploration role models (alive or historic) and why they inspire you. On a sheet of notebook paper or on the computer, compose a letter to one of your science and exploration role models. Write something you would want them to know about you and why you consider them an inspiration.

NMEA 2012 Annual Conference
North to Alaska's Seas: A Confluence of Science and Culture

Join us in Anchorage, Alaska June 24-28, 2012 on the shores of

Tikatnu, the "big ocean river" of the Dena'ina Athabascan Indians, on Cook Inlet. Conference strands will focus on science and art, science and culture, science and technology, and Large Marine Ecosystem science and education. The conference will be co-sponsored by the Northwest Aquatic and Marine Educators (NAME; www.pacname.org) and the Alaska Center for Ocean Science Education Excellence (COSEE; coseealaska.net).



The conference will kick off the evening of June 24 with keynote speaker Fran Ulmer, former Lieutenant Governor of Alaska and current Chair of the Arctic Research Commission, along with a presentation by Mr. and Mrs. Fish. Some of the special events include a reception at the Alaska Native Heritage Center, day field trips to Seward and other locations around Anchorage, post-conference field trips beginning the afternoon of June 28 and, of course, NMEA's traditional auction.

Ray Troll who designed this year's conference logo (third image down on left) will be delivering the 2012 Stegner Lecture. Ray is an award-winning artist who can't resist a pun, loves to draw and paint fish, sharks, and other marine creatures with scientific accuracy and humor; and is a musician in addition to a visual artist. He recently received a national Guggenheim Fellowship Award, which he is using to travel to write and illustrate a book about the entire coastline of Alaska.

The conference will be held on the University of Alaska Anchorage campus. Lodging will be available in university dorms and in nearby hotels. Dorm housing will be limited, so make your reservations as soon as possible to keep your lodging costs low.

For additional information, please visit the NMEA website at www.marine-ed.org or go directly to the conference website at http://www.nmeaweb.org/.

KEY DATES:

January 16-April 14: Pre-registration
April 1: Deadline for Traditional Knowledge stipend applications
April 15: Deadline for Expanding Audiences scholarship applications
June 23-24: Pre-conference meetings and short courses
June 24: Opening evening reception
June 25-26: Plenary and concurrent sessions, exhibits
June 27: Day field trips to Seward and other destinations in the Anchorage area
June 28: Plenary and concurrent sessions (ending at 2:00 p.m.)
June 28-30: Post-conference field trips and short courses

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