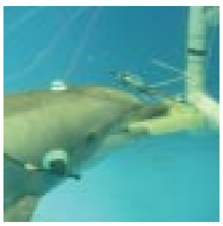
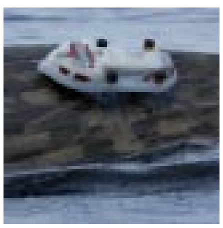
N45's Marine Mammal Expert Provides Insights into the Navy's Knowledge & Future Investments





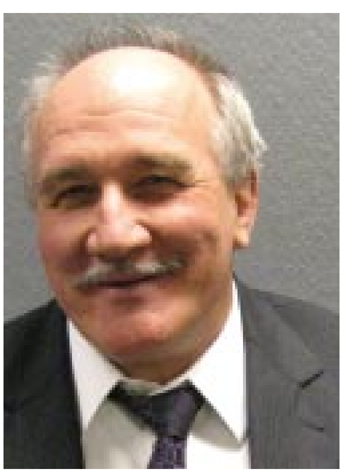
ON 20 OCTOBER 2010, Ken Hess from the public affairs staff at the Chief of Naval Operations Energy and Environmental Readiness Division (N45) and Bruce McCaffrey, managing editor of Currents magazine, interviewed Bob Gisiner, who joined N45 in May 2010 as head of the marine science branch. Dr. Gisiner spoke about N45's past and future investments in understanding the behavior of various species of marine mammals and the potential impact of man-made sounds on those mammals.

CURRENTS: Tell us a little about your background.

BOB GISINER: I am a biologist by training, but a biologist with an unusual background. I had a professor, Ron Schusterman, who was a psychologist by training. I learned a great deal from him about how to ask experimental questions about animal behavior. This approach differed from that of my primary background in the field of natural behavior of wild animals and how ecology shapes behavior and social structures. My Ph.D. was on Steller sea lions and their social behavior. I did some work for the Navy training dolphins and pigeons, and then did my post-doctoral work with Schusterman on animal language learning, complex cognition and linguistics. Eventually, I went back to work with the Navy doing similar work on animal cognition and bioacoustics before coming to the Office of Naval Research (ONR) in 1994 to manage ONR's marine mammal science program.

I have an interest in seeing how science is applied to the practicalities of conservation and resource management.

Dr. Gisiner reviews a draft Navy Integrated Comprehensive Monitoring Plan.

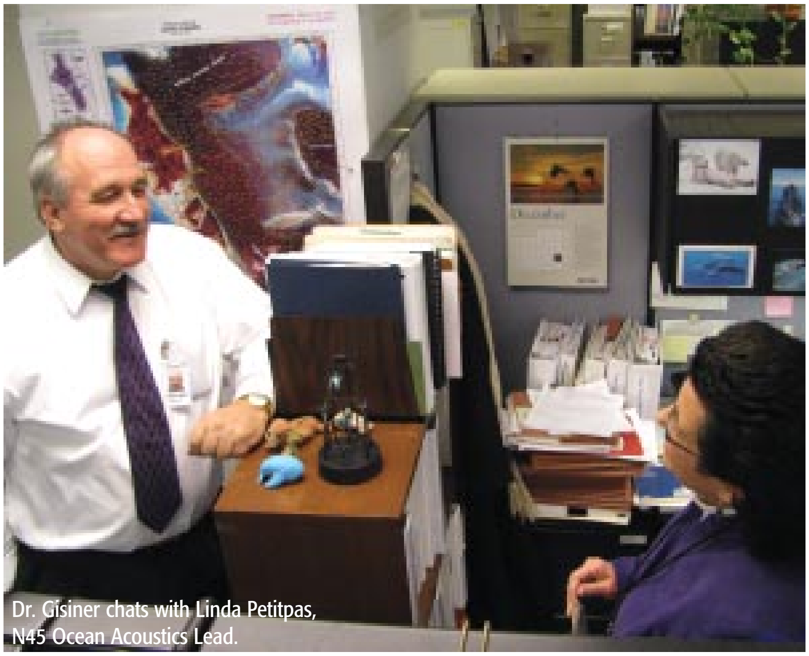


I have an interest in seeing how science is applied to the practicalities of conservation and resource management. It's very difficult at times to understand how some scientific findings would actually be implemented in the day-to-day world of rules and regulations. The Marine Mammal Commission plays a very important role in that process. I left ONR in June 2007 to serve as the Commission's Scientific Program Director through May 2009. At the Commission, I was interested in a number of issues from fisheries interactions to establishing goals for recovering species that have been depleted from commercial exploitation.

CURRENTS: What are your responsibilities at N45?

GISINER: I have two primary roles at N45. One is to know the subject matter. I've been involved with the science for a long time, and getting the science into the Navy's plan for marine stewardship is a very important issue to the Navy. So, they hired me to be their scientist.

There are challenging science issues, such as when behavioral effects from underwater sound become biologically meaningful. Cumulative effects assessment, space-based management in the oceans, biodiversity—these are all very interesting questions to me.



Dr. Gisiner chats with Linda Petitpas, N45 Ocean Acoustics Lead.

The other responsibility involves turning the science into environmental stewardship practices. How do we take our scientific knowledge and turn it into effective management and responsible behavior to minimize our impact on the natural world? That's another interesting and challenging question.

CURRENTS: What is the Navy doing with the science that ONR and N45 have been sponsoring to promote environmental stewardship?

GISINER: A major priority for the Navy is to develop science to inform our environmental planning as we work with the National Marine Fisheries Service to obtain permits for our at-sea training and testing. As part of the scientific process, we also encourage peer reviewed publication in public forums, presentations in meetings and peer review journals. The science is not just for us to use, it's for everybody to mull over and discuss how to use it. These are matters of interpretation. This science doesn't specifically say, "This is the right thing to do."

One of the first things we chose to focus on, which has become an integral part of risk assessment of underwater noise, is understanding Temporary Threshold Shift (TTS)—a common, recoverable partial hearing loss caused by overexerted cells. Understanding TTS for an animal tells you something about the likelihood of Permanent Threshold Shift (PTS), or permanent hearing loss, at least for the narrow bandwidth of frequencies to which the animal is being exposed.

Now, what to do with that information has been an ongoing debate, and will continue to be. TTS is not really an injury, but it's not simply a behavioral effect. It has a relationship to an injury. A partial loss of hearing capacity can result if you exceed the PTS. Is that loss sufficiently injurious to severely hamper the animal? It's difficult to say.

A major priority for the Navy is to develop science to inform our environmental planning.

These issues are regulated in some way under the Marine Mammal Protection Act (MMPA). Both behavioral and injurious effects are regulated. They are treated a little differently, but you can see that TTS and PTS are in a gray area. Where some people see TTS and PTS as definitely injurious or deleterious to the animal, others see them as minor. They may or may not have biological significance in the course of that animal's life, or in a population of individuals.

CURRENTS: Can you tell us how you see science playing a larger role in what the Navy does to protect the environment?

GISINER: We're approaching this from two different directions. One is to understand how animals respond to sound in general, and in particular, man-made sources of sound. There wasn't much man-made sound in the water until the industrial age. We're talking about an experience, in terms of the evolution of these animals, of 150 to 200 years. The question is, how do animals respond to these increasing ways in which we use sound, the increasing amount of sound as human populations grow, and the increasing use of the oceans? What are the deleterious effects versus the innocuous or even beneficial effects? How do we minimize the deleterious effects while balancing all the other factors that society balances when it makes decisions?

Digital data tag (D-TAG) attached to the back of a male Blainville's beaked whale.
Ari Friedlaender

Secondly, we don't really know much about the animals themselves. In many cases, we don't know how many there are, where they are, or what they need from the environment. When you talk about lions and tigers and elephants, people can tell you where they are and what they eat. For most marine mammals, we can't say that. If we went out to the Chesapeake Bay right now, I couldn't tell you what we might see. But if we hiked the Shenandoah Trail, I could tell you which mammals we'd expect to see with some degree of certainty.

Are marine mammals migrating? Are they feeding? Are they looking for food? It's very difficult for us to put the background in place. A lot of the work we do with tagging animals, surveys, and acoustic monitoring is simply to find out what's out there. If you know what's out there, then you can manage your activities accordingly.

CURRENTS: How has tagging and monitoring evolved?

GISINER: When I first started as a graduate student around 1973, I had the opportunity to put some tags on elephant seals. We put the devices on the animals and stood on a nearby hill with headphones on. We intended to listen to the seals as they meandered around the island and were eating fish just offshore. We were surprised and dismayed to lose the animals after about ten seconds. We never saw them again! Fast forward to 2010, and we now know that elephant seals go halfway out into the Pacific Ocean. Most of the time they are out there, they are 400 meters or more under the water.

The acoustic data logger tags on beaked whales have been astonishing.

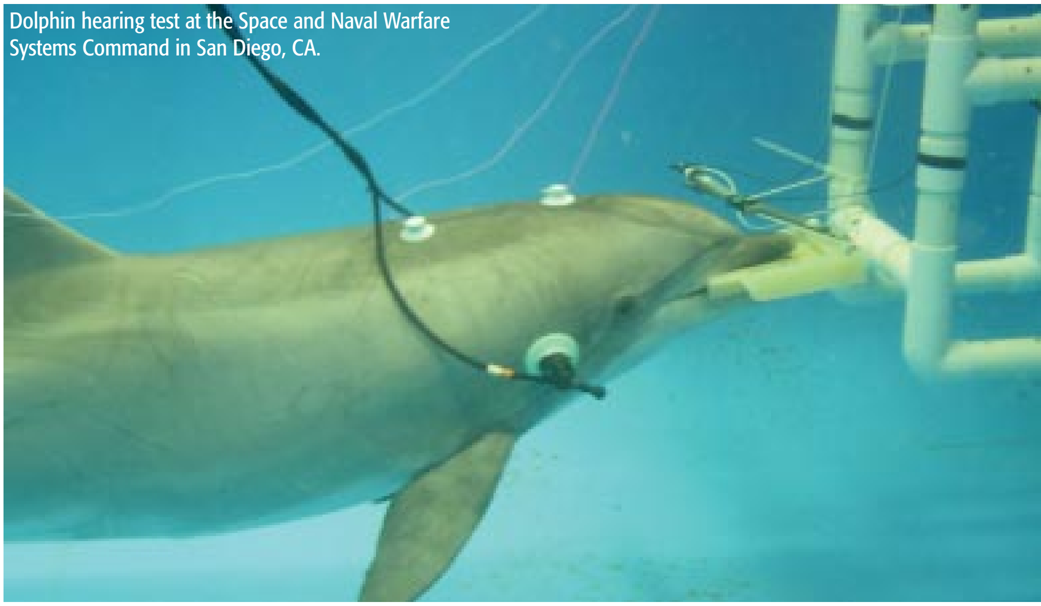
Today's acoustic data logging tags have to withstand more than 200 atmospheres of pressure to be used on deep-diving animals like sperm whales and elephant seals. Cell phone technology has allowed us to miniaturize these things. While the original package was about the size of a cigar box, the current package is about the size of a cell phone. These devices capture roll, pitch, yaw (side-to-side movement), acceleration, temperature, pressure, as well as stereo broadband acoustics.

What we're really doing is reconstructing the animal's dive. If you have the pressure, temperature, acceleration, and direction, you can basically reconstruct a three-dimensional track from the place it started at the surface to where it finished. Now you know why the animal is making the sound it's making, and what it's doing at that time.

The acoustic data logger tags on beaked whales have been astonishing. We've taken an animal that we knew almost nothing about, known only from museum specimens, and now we know how they behave 1,000 feet below the surface of the water. We really wanted to focus on these animals, and the new technologies have enabled us to do that.

We complement those advances with advances in passive acoustics, listening to animals that are almost continuously vocally active when they are underwater. Most of the behaviors important to the animals—feeding, breeding, migrating, social interaction, avoiding predators, finding food—all of that takes place underwater. It's just not visually accessible. The combination of these two methods is relatively new and has opened up access to the underwater world.

CURRENTS: What progress are we making applying the data tags?


Dolphin hearing test at the Space and Naval Warfare Systems Command in San Diego, CA.

GISINER: We've tagged dozens and dozens of species. At this point, we have trouble tagging small dolphins (because of the size of tag we think they can safely carry). And attaching the tags is also a challenge. If you attach a tag with a suction cup, the tag is only going to stay on for a few hours, and that only tells you so much. If you attach tags that penetrate the skin, the tags will stay on for months. In some cases, they've stayed on for over a year. But we only feel comfortable doing that right now with larger whales. There are some new types of attachments—dart-type tags—that stay on for a few days. ONR has issued a Request for Proposals to look at new methods to attach tags.

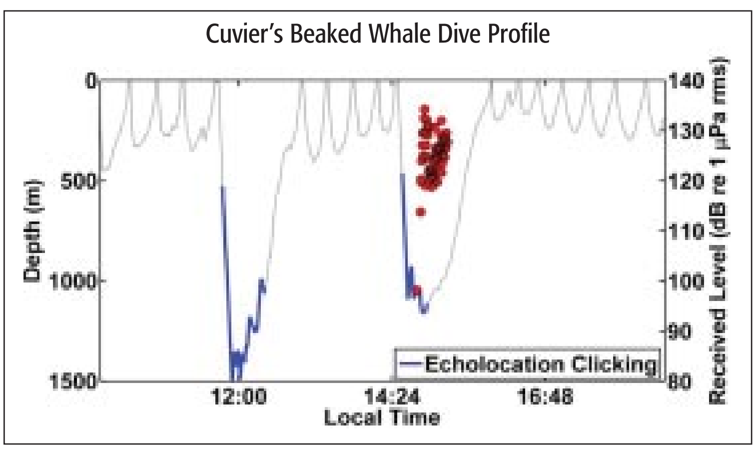
CURRENTS: What other efforts have we implemented to learn more about marine mammals?

GISINER: We've explored some things that have yet to work for us. We've looked at infrared as a possible technology, because the Germans have had some success using it in the Antarctic. It seems to work well with large whales blowing hot breath into cold, 20-below zero air.

A Duke University researcher attaches a D-TAG to an adult male pilot whale.
Brandon Southall

We've had less success using infrared to detect whales off the coast of Florida. We've tried using ship navigational radar to detect blows or the body of the whale. But there are false alarms—it's hard to distinguish whales from waves and other things. We've also tried using satellite imagery without much success.

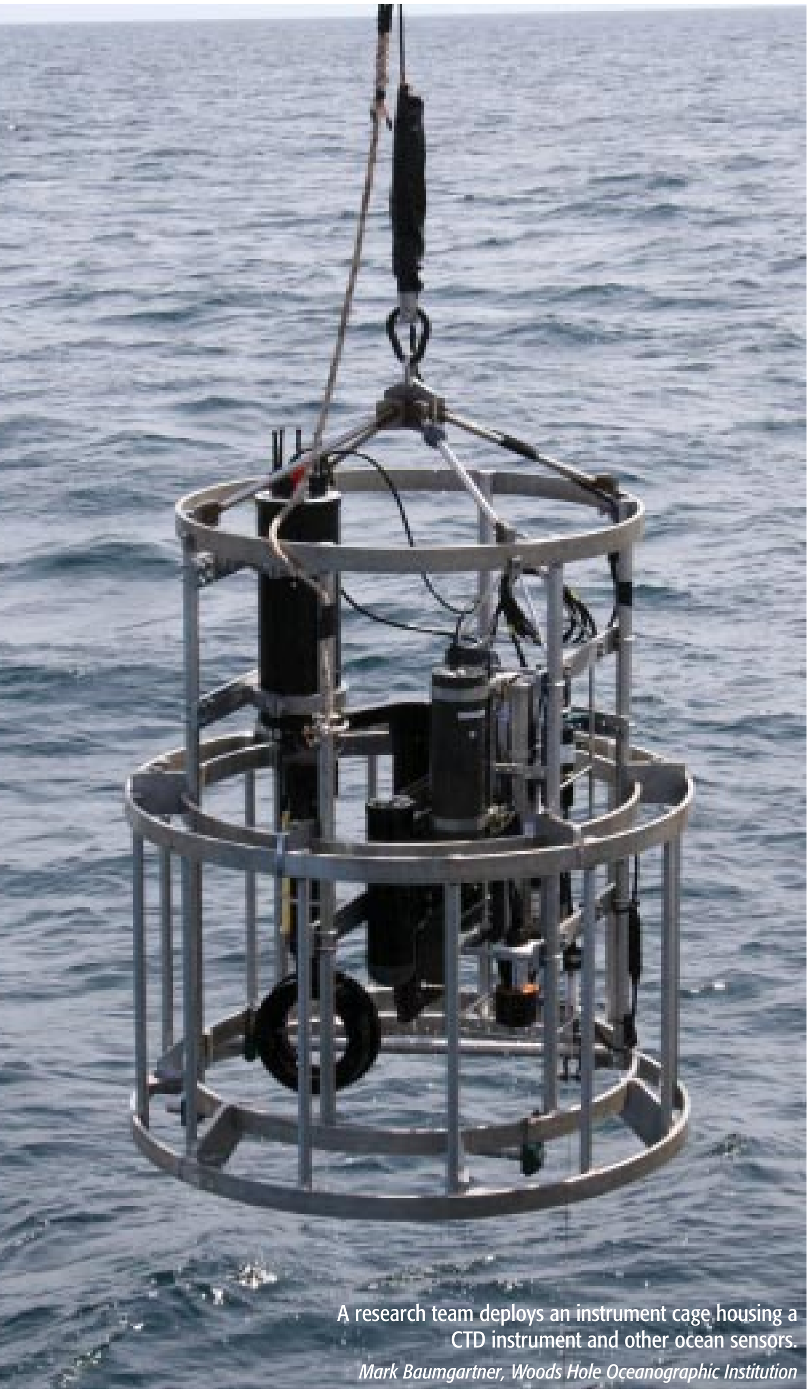
But there are things that are working really well. Advances in tag technology have been tremendous—and not just data loggers or video tags—but tags that do simple things like measure pressure, temperature and salinity at the same quality that an oceanographic Conductivity, Temperature, and Depth (CTD) device does. (Note: CTDs assess the essential physical properties of sea water.) These tags essentially turn the animals into oceanographers. We've actually supplied more and better oceanographic data from marine mammals in the last several years than we've accumulated from all the hydrographic surveys accumulated over the last 150 years.



Depth and duration of Cuvier's beaked whale dives (gray line) and echolocation clicks (blue line) over a seven-hour period during a controlled exposure experiment on the Southern California Range Complex. Lowest red dot shows when sonar-like sound source was turned on, and additional red dots represent receive levels of the sound based on the location of the beaked whale in the water column.

In addition to being highly effective from an oceanographic data gathering standpoint, tagging marine mammals for that purpose is also economical. A ship costs tens of thousands of dollars a day to operate, and you only have so many ships. But we can put 50 CTD tags on elephant seals and map the entire southern ocean boundary current.

A Global Positioning System (GPS) location gets the precision of localization down to a few meters, instead of a kilometer or more with the ARGOS system. (Note: Argos is a worldwide location and data collection system dedicated to the study and protection


A research team deploys an instrument cage housing a CTD instrument and other ocean sensors.
Mark Baumgartner, Woods Hole Oceanographic Institution

of the environment. For more information, visit www.argos-system.org.) The University of St. Andrews in Scotland figured out a way to do fast-lock GPS. It basically receives the signal from a GPS and then interpolates a location from the one-way communications path. It's not as accurate as a perfect two-way GPS fix, but it's pretty close.

One of the other successes we've had is with passive acoustics, or what the Navy would call passive sonar. It turns out the oceans are quite noisy. People generate noise as do fish, mammals, shrimp, and all kinds of other creatures. These noises are meaningful sounds to marine mammals. So passive acoustics can tell us something about the animals' environment and help to identify them.

Passive acoustics can tell us something about the animals' environment and help to identify them.

We've had a fair amount of success acoustically distinguishing one species of whale from another. We are able to tell the difference between a ziphius beaked whale and a mesoplodon beaked whale. We can distinguish a blue whale from a fin whale, a fin whale from a sei whale, a humpback whale from almost anything else.

Through sophisticated applications of multiple units of these technologies, we can start to answer questions about how many animals are in a given area and how they are using the area seasonally. One of the successful developments, which was kicked off by ONR but since driven by many other users, is the Marine Autonomous Recording Unit (MARU). This is the next generation of a device called a "pop-up" that was originally developed by Cornell University. Approximately 150 of these units are deployed around the world, from Madagascar to the Antarctic to the Pacific Ocean. The MARU is a broadband device that can listen across a wide range of frequencies. They are small and can be thrown over the side of a boat (attached to a buoy) with a weight attached, and will sit there for months. They have a lot of memory and can sample at any desired frequency. The devices are eventually pulled back to the surface where their data are downloaded. They are generating terabytes and terabytes of data, so the analysis, storage, and archiving of the data is becoming a major concern.

CURRENTS: Who is helping us solve the problem of collecting and archiving all this data?

GISINER: We have a whole parallel databasing effort going on, and that too is in the process of maturation. ONR partnered with the Sloan Foundation, a private foundation, on something called the Census of Marine Life. We came up with a project called Sea Map, centered at Duke University to build a database of marine mammal sightings, surveys, tagging and acoustic data. (For more information about Sea Map, visit http://seamap.env.duke.edu.)

Researchers aboard North Atlantic Treaty Organization Research Vessel Alliance use passive acoustic arrays to monitor marine mammals.

We've got another group at the University of St. Andrews that does methodology for visual surveys that developed something called distant sampling. They are working on a project now to calibrate the acoustic data collection with a simultaneous standardized visual distance sampling survey. So you've got the gold standard of visual survey, do your passive acoustic survey at the same time, then calibrate one against the other.

CURRENTS: You've also invested quite a bit of time and resources in acoustic signal processing.

GISINER: Yes. You get the (acoustic signal) data back, and it's just wind noise, bubbles, ship sounds, electronic noise from the gear itself, snapping shrimp, fish, etc. It comes in a stream as a raw electronic signal, and you've got to pick out the dolphin or whale sounds of interest. A lot of investment goes into automating that process so that it is reliable. We need a low false alarm rate, and a high probability of detection.

CURRENTS: This is quite a multi-faceted science, from collecting the data to compiling the results.

GISINER: You can see that a number of different efforts have come together—building devices to record the sounds in the first place, getting them out there and getting the data back, managing the data and archiving it, developing algorithms to process the data, and then doing these paired calibration studies to interpret the meaning of the analyzed data. These are all taking place in parallel by multiple organizations, including research organizations, the U. S. Navy, other government agencies, and the oil industry.

We are working to understand injuries associated with stranded beaked whales.

CURRENTS: Is there a goal for what we are trying to do with this science?

GISINER: A lot of the science we're working on right now has to do with the behavioral effects of sound. But we remain most concerned about are the things that could kill or injure animals. So we look at the levels of sound that are likely to produce harm. We are working to understand injuries associated with stranded beaked whales. We're not sure if the injuries to these animals are a product of the stranding, or the fleeing from sound. There have been hypotheses that the sound could produce bubbles in the bloodstream, but bubbles are pretty common in mammalian circulation in general. In these deep-diving mammals, we don't really know how they manage these bubbles. Is it a normal healthy part of being a marine mammal, or is it pathological? These are all very open questions, and difficult to address with an experiment or a study.

What we are finding in the sound exposure studies—the playback studies in the Bahamas, Mediterranean, and now in Southern California—is that beaked whales are unusual in how aversive they find sound in general, particularly sonar. They will flee from sounds more so than other species of marine mammals in the area. We look at big whales, pilot whales, dolphins and other things we've tagged, and they do not react as strongly as beaked whales. We don't know why that is; it's an interesting result.

Navy and Sonoma State University researchers test a live elephant seal's hearing.

In the Bahamas and Southern California, we can now see this taking place regularly with Navy exercises. The ships move through doing anti-submarine exercises with their sonar on, and the beaked whales clear out. If we have tags on the animals, we actually see them move away from the source. Within 24 to 48 hours, they are back again, and we don't know what they do during this time away.

So we're still working on this. If there's a behavioral response, what does it mean? What does it take for that behavioral response to cross some tipping point where the animals actually go up on the beach?

CURRENTS: Have you studied other comparably-sized mammals as well?

GISINER: We have a lot of data for elephant seals, and we think that when they dive they go into a state that is similar to hibernation. Their heart rate slows to something like one beat per minute. They have selective blood shunts that route the blood away from organs they are not going to use when diving. They go completely catatonic, drift down 1,000 feet, saving oxygen, and then do the same thing coming back up. Now, if the sound interrupts that routine, and that routine is physiologically necessary, disrupting the routine can cause physiological problems.

It has to do with animals pushing themselves to their physiological limits to exploit a very specialized but successful niche—they are the only warm blooded animal at 1,000 feet below the surface. The cold-blooded animals down there are in the oxygen minimum zone, and the water temperature is two to three degrees above freezing. Then, here come these big-brained, fast predators, and they just clean up down there.

We will continue to work on ways to detect marine mammals. One of the things we're working on is platforms. We've got good sensors, so how do you get them out there where the animals are and survey the information? We're very interested in unmanned platforms, both aerial and underwater. They are a good spin off from tactical, military applications. Unmanned vehicles have been very successful in the Middle East, and a lot of funding is coming into companies to build them. As the technology gets better and easier to use, the price goes down. An additional advantage is that we don't subject our researchers to the risks associated with field studies in the open ocean.

CURRENTS: What is the potential to use and share all of this information?

> When the Natural Resources Defense Council and others raise issues, we can discover commonalities and shared points of view.

GISINER: We intend to make all of this information accessible to the general public. It gets published in peer reviewed journals, and there's some extra effort to digest the information and put it in presentable form. All of the data we are generating right now, as a condition of the permits, is reported annually to the National Oceanic and Atmospheric Administration. Everything we saw, everything we did is reported and accessible.

One of the ways to make this information most accessible is the Ocean Biogeographic Information System (OBIS). (For more information about OBIS, visit www.iobis.org.) It makes sense to me that, when we're talking about ecosystem-based management for the oceans, you have to have an inventory of what's out there to make wise management decisions.

CURRENTS: Are there other initiatives out there that might make this information more digestible?

GISINER: I think there are others out there, and plenty of partnership opportunities. This is an opportunity for groups to say what it is they need, and what form they need it in, and then for us to work on it. There will always be aspects of military activities that will be classified for national security reasons, but most of what we're doing here is publicly accessible and available to be shared.

CURRENTS: Why is the Navy funding research on marine mammals?

Autonomous underwater glider funded by Woods Hole Oceanographic Institution and ONR.

GISINER: Our primary responsibility is national security—the defense of our nation. But consistent with that, we will also be good stewards of our marine environment. That is part of the mission of every Sailor on every ship. We have the same stewardship responsibilities for our land holdings—Camp Pendleton or China Lake and all of our other installations. Nobody questions the idea that we have to keep those pieces of property in good shape, because it belongs to the American people. The same is true of the marine environment.

CURRENTS: Are there any areas that come to mind that are open to potential improvement?

GISINER: The dialogue is important. So when the Natural Resources Defense Council and others raise issues, we can discover commonalities and shared points of view. That's one of the most important things we've got to work on. ⚓