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Issue No. 5, 2009

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Darlene Ketten, Ph.D.
Marine Mammal Research Pioneer

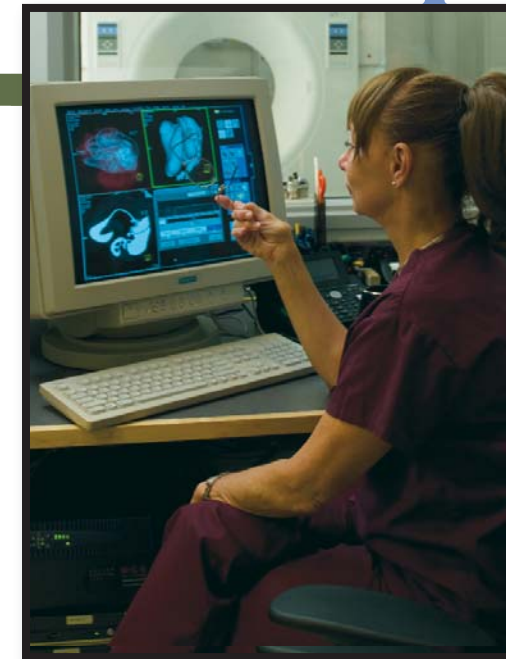
Shattering Sonar and Similar Misconceptions

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Marine Mammal Research Pioneer

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As the world's foremost expert on marine mammal ears, Darlene R. Ketten, Ph.D. and Senior Scientist at Woods Hole Oceanographic Institution (www.whoi.edu), travels extensively to perform beached whale necropsies (autopsies on non-human animals) in countries from Africa to Australia. Her expertise is continuously requested on numerous boards, panels, committees and briefings such as at NATO's Intergovernmental Conference, for the Brazilian government's Seminar on Seismic Impacts and with Advisory Panels for both the U.S. House of Representatives and the U.S. Senate. Ketten's visiting faculty appointments and invited specialty lectures have taken her from the University of Hawaii's Institute of Marine Biology to the National Institutes of Health



(NIH) to Denmark's Odense University. Even National Geographic has enlisted Ketten's expert opinion for one of its televised specials on whales. According to her WHOI biography, Ketten "is a marine biologist and neuro-anatomist . . . whose work is a blend of modern biomedical imaging, forensics and biophysical models of hearing in both humans and marine mammals. Her research focuses on two areas: how structural differences in marine vs. terrestrial mammal ears relate to physical differences, habitats and feeding behaviors and how electrode placement and inner ear pathologies impact hearing and the effectiveness of hearing aids and inner ear prosthesis." This research pioneer is breaking barriers and crossing scientific specialties for the betterment of marine mammals and mankind.



This feature is excerpted from a series of interviews that began in August 2008 at Woods Hole Oceanographic Institution (WHOI) with Darlene Ketten, Ph.D., and Rear Admiral (Ret.) Dick Pittenger. The discussions ended in February 2009 with diverse U.S. Naval perspectives thanks to Rear Admiral Larry Rice, Vice Admiral Sam Locklear and Vice Admiral Mike Loose. All were exceedingly charming and enlightening while collectively offering a 360° view of the sonar controversy. The article is tightly excerpted from those interviews because of space limitations. Original transcriptions will be available in their entirety within Center for a Better Life's Distinguished Speaker Series on Sonar at www.centerforabetterlife.com, as well as within an electronic version, within a few months.

With all this under her belt, it's not surprising that Ketten is "the" person to consult regarding sonar effects on marine mammal hearing. Although the U.S. Navy has a clear perspective and understanding of the use and need for sonar in accomplishing its mission (see "U.S. Navy and Sonar" below), Ketten offers a science-based, objective and highly expert opinion regarding its effect upon marine mammal ears. This is especially important in light of the misinformation and inaccuracies advanced by media and environmental organizations since the sonar controversy began.

A New Breed of Scientist

The average person may think that listening to a Ph.D. in neuroethology and experimental radiology from The Johns Hopkins University could be boring, but Ketten's use of everyday vocabulary, in combination with her infectious personality and sense of humor, provides an educational experience that's both entertaining and enlightening. In addition, she's refreshingly blunt, doesn't play politics, is honest beyond reproach and is multi-talented.

Ketten took a serendipitous turn toward

her present career while at St. Louis' Washington University. A biology class attended for a science requirement opened up a fascinating, new world that led to a dual degree in Biology and French. The new undergraduate was interested in aquatic ecology and had a deep curiosity about oceans. However, Ketten had never seen one so she moved to Florida and took courses at Florida State University. She elaborates: "From there I moved to Boston and worked at MIT on plankton, which led to a master's degree in Oceanography. That work re-

sulted, to my surprise, in a paper published in *Nature*. For my Ph.D. I went to The Johns Hopkins University to work on dolphin hearing. I was technically enrolled at the medical institutions because of a curious twist that had my advisor, a behavioral ecologist and marine mammalogist, working there in collaboration with parasitologists on animal vectors of disease. It actually turned into an advantage because it afforded me great opportunities to learn about and to use medical techniques, including experimental radiology. It was a

scientist's dream – access to great minds and great technology."

Ketten finished her doctorate in 1984. Marine mammal science positions were scarce so she opted into human hearing and auditory science, which led back to MIT and then to Harvard Medical School. A post-doctoral fellowship in hearing physiology evolved into working for the next 10 years almost exclusively on cochlear implant research and with implant patients. Ketten's findings led to improved imaging of their prosthesis along with a better understanding of how each patient's success was related to his/her hearing loss history and implant positions. Ketten remarks: "I had migrated over to the medical world and human hearing. After 2 years as a post-doc, I was made an instructor at Harvard Med in Otology and Laryngology, where I still have an appointment. Now my work really is a blend of the two worlds, marine mammal and human hearing."

In 1992 Ketten migrated back to marine mammals when her first proposal was funded by ONR (Office of Naval Research) prior to any sonar issues. For the most part her work has been funded by NIH to study

cochlear implant patients and pathology and by ONR within their extensive Marine Mammal Program. Seemingly unrelated projects fed off each other to create an interplay that advanced both ends. Ketten explained: "The more work I did on trying to use radiology to peer into dolphin ears, the more I learned how to improve micro-imaging of human ears, their pathologies and implants. I gradually learned a good deal about the radiologic appearance of head and neck trauma and diseases as well as hearing physiology." The scientist's continued pursuit of knowledge in related fields led to pathology training at the AFIP (Armed Forces Institute of Pathology) and to forensics, neuroradiology and veterinary pathology training at Harvard Medical School.

Much of Ketten's work involves necropsies, about which she said: "Not too surprisingly, about one-fourth of all stranded marine mammals that I've necropsied have some kind of ear problem. But that's not necessarily why they strand. Even more important, we need to remember that not every animal that ends up on the beach has a hearing problem because of human activi-

ties. They're subject to the same causes of hearing loss as we are. It may be related to sound, but losses also come from disease, trauma, aging and congenital conditions. It's part of being a wild animal, being alive and having ears. That's part of the fascination with marine mammal ears: They're important for their survival; they work well underwater and, in some species, in the air. Yet, they can be damaged and age just like ours."

Whale Strandings and Sonar

Sonar has been around for approximately 50 years with limited impact upon marine mammals during that time period. The first clear indication of a causal relationship between mid-frequency sonar and whales' behavioral changes occurred in the Bahamas during a 2000 U.S. Naval sonar exercise. Beaked whales, the only marine mammals now known to be impacted by sonar-related activities, suddenly showed up on the beach, thus prompting the Bahamian government to contact the National Oceanic and Atmospheric Association (NOAA). NOAA, in turn, contacted Ketten not only for her necropsy expertise but also because she was one of the few people in the world who had



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The U.S. Navy and Sonar

Rear Admiral (Ret.) Richard Pittenger

Special Asst. for Strategic Planning
Woods Hole Oceanographic Institution Directorate

"Regarding the Bahamas mass stranding event, without a doubt, it was cause and effect – Navy and whales. However, I think it's absolutely bogus that the Navy was physiologically injuring these animals because they're just not close enough. Sonars are powerful, but a human diver can swim up and put his hand on a sonar dome; and it's not rupturing his eyes or ears. I've had big whales and porpoises ride on the bow wave of the sonar dome even while active. They love that. So this notion that some environmental groups are trying to prove that sonar is shattering whales' ear drums or their membranes in their brains or that whales are panicking, come to the surface and then get air embolus – the bends, basically – is totally inaccurate and not scientifically supported. These groups are

being extreme and trying to convey a message that is not true. The Navy has admitted its involvement in the Bahamas incident, but that does not make it culpable for other atypical strandings. Right now every time a marine mammal strands, somebody says it's sonar-related. In addition, there's never been a mass stranding in California even though many Navy sonar exercises are done there. In fact, the whole East Coast, Gulf of Mexico and West Coast have not had atypical mass strandings associated with sonar.

"The world is very complex. People believe celebrities with no credibility on the subject before they believe scientists like Darlene Ketten. Public opinion is so strongly against the Navy on the sonar issue that anyone seen as supporting them is viewed as being against the whales. There was a time in this country when you could stand up and speak the truth without fear of retribution but not now. This is such a hot potato. And over time the seriousness of the fisheries' by-catch issue (the

Marine Mammal Protection Act was enacted as a result of fisheries' by-catch) has been subsumed by talks of sonar 'takes.' My analogy for sonar 'takes' is if you're driving across a meadow with two deer eating along the forest's edge and they look up at your car as you're driving by, that's a 'take.' Actually, that's 2 'takes' because there are 2 deer. The same holds true for whales; every time they hear your sonar, that's a 'take.' Some groups make it sound like sonar is deafening exorbitant numbers of marine animals and they've stopped breeding as a result of these 'takes.' If that were true, there wouldn't be any whales, particularly because sonar has been around for 50 years."

Rear Admiral Larry Rice

Director, Environmental Readiness Division
Office of the Chief of Naval Operations, United States Navy

"The U.S. Navy is the largest investor in marine mammal and sound research with \$100 million invested within the past 5 years. This research is credible and objective because worldwide

respected marine mammal organizations such as Woods Hole Oceanographic Institution, Scripps Institute, University of California schools and the University of Hawaii are doing it. Unfortunately, emotions, not necessarily the facts, are what get people excited about the sonar issue.

"We've been doing lots of research in lots of different areas, and we've been getting interesting data back. For example, the multi-million dollar behavioral response study yielded information about beaked whales and their responses to loud sounds. The reason I say 'loud sounds' instead of just 'sonar' is that in 2007 we put a sonar-like sound in the water, and the beaked whales reacted to it. They slowed their ascent and swam away from it. Then we put an orca, or killer whale, sound in the water; and the beaked whales did the same thing. In 2008 we put a pseudo-random noise in the water, an old dial-up modem sound, and the beaked whales responded almost exactly the same as they did to the orca and sonar sounds. This shows they're responding to the sound in the water – not necessarily to the sonar sound.



Beaked whale inner ear

© Photograph: D. Ketten/WHOI

done any scientific research on beaked whale hearing.

Ketten's role now is to find out why sonar affects only beaked whales. Ketten explains: "Obviously, something related to the sonar sounds and the exercises disturbed the whales to the point that they went onto the beach. However, it's not the sound directly that created the traumas we found in animals that died after they stranded. We do see in going back through the stranding records that there is an increase in beaked

whale strandings from 1963 onward. Clearly, there seems to be a correlation between some sonar exercises and some strandings. Exercises like those in the Bahamas and more recently in the Canary Islands by the Spanish Navy took place near waters and coastlines where beaked whales are more common than in other parts of the ocean. It could be the sound or even that the ships

are unknowingly 'herding' the whales.

"With the Bahamas we actually had a very nice control case that showed us the concern really is for beaked whales yet, fortunately, not for all whales. Beaked whales were spread on the beach in an arc that followed exercise patterns of ships. We also had one spotted dolphin that stranded on the opposite side of the island near the same time. That dolphin was very ill and had not eaten for quite a while. She appeared to be a coincidental stranding,

That's what I mean by a 'control case.' The beaked whales by contrast, except for injuries received getting onto the beach, were all otherwise healthy. The real cause of death in these animals was hyperthermia – severe overheating – because they were stuck on the sand. These are big animals. They got hot; they collapsed; and they died. Another thing that raised a red flag is that beaked whales don't often mass strand."

Mid-frequency sonars correlated with strandings are not specific to the U.S. Navy. Navies and other shipping and marine vessels worldwide use sonar. That's one reason Ketten isn't convinced that the sonar sound itself is the culprit, but something much more complex is. The Northern Hemisphere shipping lanes are ripe with continuous sound as a result of shipping, recreation, construction and the military. However, ironically, given the media attention on U.S. Navy sonar, the military activity is less than 5 percent of the oceans' sound budget, according to a National Academy of Sciences report. In addition, mass strandings are known historical phenomena. Ketten remarked: "Most years more than 4,000 marine mammals strand on U.S. coasts.

Strandings can be a natural phenomenon caused by a number of conditions such as toxins like red tide, diseases and storms. The reason we know some mass strandings are not necessarily related to human actions is that there are centuries-old records. In New England they go back to the Puritan era; except then it wasn't called 'a terrible and unfortunate circumstance.' It was called a 'feast.' That shows our cultural shift in attitude. Whales have been dying without man's hand for a very long time. Now when a whale strands, the first thing we hear is 'Was it sonar?' Sometimes the whale is just old and sick."

Knowing the Facts

According to Ketten, sonar sounds are not killing whales. Unfortunately, some groups continue to provide press statements to the contrary even though these ideas have already been proven inaccurate per the stranding investigation facts. Many people, especially those within the scientific community, believe inaccuracies and misstatements continue to be supported

because the public wants to be fed drama. Ketten underscores this sentiment: "The press is doing that more and more. It's very difficult to get the true but dull story out. If you say 'The Navy is killing whales,' that's going to get more public attention than saying '7 out of 14 animals died in a Bahamas stranding event. The Navy was in the vicinity. Initially it was thought that the sound of sonars may have had a direct impact, but it's now been proven that isn't true. We don't yet know the answer.' And that's the truth. Part of the reason this sonar issue



3D false killer whale

© Photograph: D. Ketten/WHOI

has dragged on for close to 9 years is that a lot of research is not getting done. Funds are going, instead, to deal with lawsuits and public media and to address firestorms of public outrage from misstatements in the press."

Contrary to some published press reports, sonar effects and related strandings are immaterial to whale species' survival and, in particular, beaked whale survival. In fact, within the past 50 years, fewer than 300 animals have been stranded in association with naval exercises – U.S. or otherwise. Although only small numbers are impacted, Ketten still believes it's important to know why sonar-related strandings occur. She also believes it's important to put these numbers into perspective: "Navy sonar exercises impact about 6 animals per year on average. Compare that, over a 10-year period, with hundreds of thousands of animals caught in fisheries and hit by boats just within U.S. coastal waters alone. The estimated worldwide deaths of dolphins and whales as by-catch – caught accidentally in fisheries – are between 100,000-400,000 per year. Human impacts are serious and they are, essentially, a global problem. We

"I think there's a perception that the Navy, when it comes to the oceans, can do whatever it wants, wherever it wants and play a national security trump card to avoid compliance with the law and to avoid being good environmental stewards. Nothing could be further from the truth. N45's (Navy Environmental) job is to make sure that wherever the fleets operate, they're environmentally prepared to do so – morally, ethically and legally. Our Sailors reflect society; they're great Americans who are very environmentally conscious. In addition, there's a big environmental ethic in the Navy. On every ship there's an understanding that we need to take care of our second home. The one thing that I looked forward to as the CO (Commanding Officer) of an aircraft carrier every single day was getting up at sunrise, going up on the bridge and seeing what was out there. We would routinely see dolphins and whales and big hammerhead sharks. It's just fabulous out there! When you're steaming around a pod of 200 dolphins jumping out of the water and riding the bow wave, it's incredible!

"Everybody has to know that national security is the Navy's

No. 1 priority. But we've demonstrated our ability to take care of the environment while completing the primary mission. Our Sailors are trained to do both at the same time. I've never come across a time when national security interests were mutually exclusive with protecting the environment. I would agree that in the past that wasn't necessarily the case. Americans in general didn't care as much about the environment, or they didn't know to care for the environment as much as we do now."

Vice Admiral Sam Locklear

Commander, 3rd Fleet, United States Navy

"For me it's really about how you balance our very serious concern for marine mammal safety, or any aspect of environmental encroachment that the Navy may make, as we pursue our training and mission. Not just special groups have a corner on being 'green.' I'd like to invite anybody in this country to come on our ships to meet these young Americans and their leadership who are very, very environmentally conscious – who are very, very

concerned about everything from water quality to air quality to marine mammal survival, etc. You'll see bright young Sailors who know more about whales – what they look like, their migratory paths, how to spot them, how to avoid them – than, I would challenge, anybody else in the country.

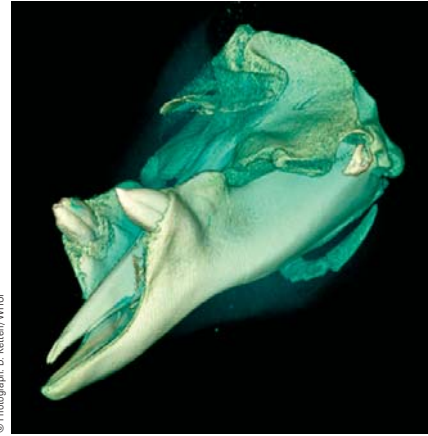
"Why is active sonar important today? It's really about technology and about how other countries are making investments in technology – in particular, diesel electric submarines. For a number of years we had the ability to track and to conduct operations against any submarine using passive sonars. But because of rapid advances in technology, these submarines cannot properly be addressed without the use of mid-frequency sonar. What's the big problem with other people having diesel submarines? Well, the only reason you have a diesel electric submarine in today's world is for access denial. As long as people are doing that for security of their own home, their own ports and their own entrances to their own harbors, this is probably not a problem. But when they decide to use diesel electric submarines to influence the rest of the world's maritime freedom of navigation,

freedom of global economic flow and use them to control critical sea lines of communication, then these anti-access weapons become something every American should be concerned about. Today there are about 380 or so submarines in the world. Three hundred of those are diesel electric submarines. Of the 41 countries that have them, those countries include North Korea, Iran and China, just to name a few.

"As it relates to my responsibility as a Fleet Commander, to the responsibility of my Strike Group Commanders and to the responsibilities of the people who command these ships, it's important that we seek the right balance that allows us to get our mission done and to make sure the environment is properly protected. Why is that important to us? One, we don't want to fail our mission. And, two, we want to assure, as we forward-deploy our forces, that I can look these 19- to 25-year-old Sailors' and Marines' families in the eye and say that we can get their spouses, parents, sons and daughters to their mission and back safely. And in today's environment a diesel electric submarine, if not properly managed, can be a considerable

have a responsibility to understand the sonar problem, and I hope we have some clear answers soon. However, if what you're saying, as some of these lawsuits claim, is that we're doing this in order to save hundreds of thousands of whales from dying, then we should be looking instead at how hundreds of thousands of whales really are dying."

According to Ketten, it's important to understand what a whale hears, particularly because not all species hear the same thing. In addition, it's important to avoid any disturbances, sound or otherwise, in areas where critical activities like breeding occur. In other places, human-induced noise may be inconsequential. The researcher elaborates: "We have a lot of potential impacts; but until we look at them or, rather, listen to them through a whale's ear, we know nothing about whether there will be an impact. And that's a concept that is perhaps the most important to get across to the public: You can't look at this solely with human hearing. What bothers us may be completely irrelevant to a whale or, in other words, auditorially nonexistent. They may not hear it. There is no single

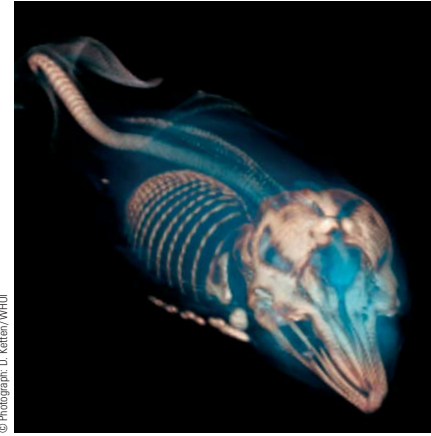


© Photograph: D. Ketten/WHOI

Beaked whale

sound byte that fits all ears or impacts. It's all different, and those differences tell you about that animal's world. The structures of whale and dolphin ears are different from ours in ways that make huge differences in what they can hear. On top of that, among whales and dolphins, every species has a different capacity. Whale species vary from one meter to 30 meters in length. What a tiny harbor porpoise, the smallest in the group, hears and what the blue whale, the largest in the group, hears are acoustically miles apart.

"We often think about perceptions of other animals in comparison to humans. However, sometimes other species' percep-



© Photograph: D. Ketten/WHOI

Dolphin fetus

tions or senses are better than ours. For example, bottlenosed dolphins hear extremely well at frequencies far beyond what our ears can detect, and they used sonar long before we did. So who knows what's out there? There's an entire world that is perceptible; but if we can't perceive it, then we don't even know it exists. That's what makes studying the senses of other animals such a privilege – we get to glimpse the world as they see, hear, smell, touch and even taste it. That's also why we can't really protect whales from our sounds unless and until we learn to 'see' what they hear." 🌿

threat to their safety. In the case of a Carrier Strike Group, that can be 7,000 people. In the case of an Amphibious Expeditionary Strike Group, that can be 4,000 people. So it's critical to the covenant that I basically have with the Sailors, when I ask them to do this job, that they have some sense that their safety is going to be guaranteed.

"We recently finished our EIS (Environmental Impact Statement) here in Southern California; it has taken several years to complete. And, literally, by the time we get through with them on 3 coasts, we'll have spent more than \$100 million in looking at the environment from all aspects of how we operate in these sensitive waters, how we manage our stewardship and how we make that balance."

Vice Admiral Mike Loose

Deputy Chief of Naval Operations
for Fleet Readiness & Logistics, United States Navy

"The Navy is very, very proud of its legacy when it comes to

defending America and to protecting the environment and marine mammals. We spend a significant amount of money, resources and time with the goal of doing everything we can to effectively conduct our training and to minimize and to mitigate any impacts or effects that we could have on marine mammals. As the sea-going Service, the sea is our home. And the last thing we'd ever want to do is harm where we live. We share our home with marine mammals.

"Science is something that we're aggressively chasing to fully assess our effects and to improve the marine mammals' environment. And we're looking to do that collaboratively – to share what we know with others and, hopefully, for others to share with us. Together, we can leverage and force-multiply science and this knowledge to enhance our environment and marine life. We just need to work together."

For more information on the U.S. Navy, the oceans and sonar, please go to www.navy.mil/oceans.

Sustaining America the Beautiful

A Team Effort by World-Renowned Photographer Robert Glenn Ketchum, the U.S. Department of Defense and Private Industry to Promote Sustainability

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