EPISODE SIXTY-FOUR OF "ARMED WITH SCIENCE: RESEARCH APPLICATIONS FOR THE MODERN MILITARY," A DEPARTMENT OF DEFENSE WEBCAST

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DATE: WEDNESDAY, APRIL 21, 2010

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DR. OHAB: Good afternoon. You're listening to episode number 64 of the Armed With Science podcast. Today is Wednesday, April 21st, 2010.

I am Dr. John Ohab at the Office of the Assistant Secretary of Defense for Public Affairs. I hope you're having your best day ever.

Today, we're joined by Dave Moretti of the Naval Undersea Warfare Center located in Newport, Rhode Island. He is the principal investigator for the marine mammal monitoring on the Navy Ranges program, which is sponsored by the Chief of Naval Operations Environmental Readiness Division.

We will be discussing ongoing Navy-funded studies into the effects of sonar on marine mammals. Researchers are analyzing data from tools designed to monitor animals before, during and after active sonar operations, then they combine it with visual and tag data to better understand animals' reaction to sonar.

Dave, we're really looking forward to learning about some of this exciting research. Thanks for being here today.

MR. MORETTI: Yeah. Thanks, John. And I'm happy to have the time to talk to you.

DR. OHAB: As I mentioned, we'll be exploring Navy-funded studies into how underwater sound impacts marine mammals. Much of this research is taking place at the Atlantic Undersea Test and Evaluation Center or AUTEC in the Bahamas.

Dave, can you get us started by providing an overview of the research and explain some of the major goals.

MR. MORETTI: The goal of our program, actually, is to try to study animals in their natural environment through the application of passive acoustics, which basically means we listen for the vocalizations that are made by animals and then try to use detections of vocalization as a proxy for the behavior.

So we're combining acoustics with signal processing as it relates to passive acoustics to try to study these animals, both as you said, before, during and after sonar.

DR. OHAB: Now, the research is taking place at the Atlantic Undersea Test and Evaluation Center or AUTEC, which is located in the Bahamas. Can you describe the facility for us?

MR. MORETTI: Yeah. AUTEC is a Navy undersea acoustic range and we're actually two sites, soon to be three. Our primary site is AUTEC or the Atlantic Undersea Test and Evaluation Center. We also work off the coast of California in what's called the SCORE Range and we'll be putting a system also out in Hawaii off of Hawaii at the Pacific missile range facility. And all of these facilities are Navy undersea acoustic ranges, which basically means it's an area in the ocean that's been outfitted with listening devices, hydrophones, which are basically underwater microphones, and normally they're used to track undersea vehicles, be it a submarine or a torpedo or a target or whatever platform happens to be under the water. And we're trying to take the infrastructure of these facilities and apply it to passive acoustics for the study of marine mammals.

DR. OHAB: Now, what are some of the marine mammal species in this area?

MR. MORETTI: Well, at AUTEC, there are several different species that range from very large species like sperm whales to the smaller species like beaked whales that we're studying and then everything in between. There are several different dolphin species that will come and go.

It's interesting actually to compare the three areas that we're working in, the AUTEC range down in the Bahamas, the SCORE range off of California and the range in Hawaii because it turns out that there are really different environments with different numbers of species of different densities and it really relates to the productivity of the waters that you're in.

AUTEC is fairly unproductive waters. That's why you can go snorkeling or scuba diving in the Bahamas and see for a long way. There's not a lot of productivity in the water, which means the densities are lower. SCORE, on the other hand off the Southern California coast is an area of very high density with many more species and also many, many more animals.

So it's interesting because it gives us the ability to actually study animals in different environments and also different species as well.

DR. OHAB: So I understand there's what's known as a stranding event that took place in 2000 about 40 miles north of the AUTEC ranges. Can you tell us what it is, what this event was? What is a stranding event?

MR. MORETTI: Yeah. It's really one of the things that makes AUTEC so interesting for this study. In 2000 what happened is there were a number of Navy ships that went through a channel called the Northwest Providence Channel. It's really a deep ocean canyon that sort of splits the upper Bahamas. AUTEC, by the way, is on a branch of that called the Tongue of the Ocean, so it's a separate canyon and together they make the up the Great Bahama canyon. And in that event, ships went through using active sonar and swept from the east to the west through the Northwest Providence Channel and in the process, animals ended up stranding on the islands as they went through it.

I think if I remember correctly it was on the order of 17 animals that came ashore, of predominately a species called beaked whales. And when you say beaked

whales, it really means not really a species, but a guild of animals and in particular a guild by the way is made up of about 20ish animals. Two of the species in particular that have been involved in some of these stranding events that were associated with Navy sonar are Cuvier's beaked whale and Blainville beaked whale. And both of those species were present in the Northwest Providence channel. And interestingly, we find both of those species on the AUTEC range.

DR. OHAB: And are those animals stranding in the AUTEC range as well?

MR. MORETTI: No. And that's one of the interesting things. There has been no reported mass strandings to my knowledge of beaked whales at AUTEC and a mass stranding, by the way in this community is two or more adult animals and the notion there is if it's a mother calf pair, they're bonded so if the mother happens to strand or the calf happens to strand that it may pull the other animal with it.

So mass stranding means two adult animals. And at AUTEC, to our knowledge, there haven't been any mass strandings of beaked whales and that's one of the interesting things because without question, there was a stranding associated with sonar in the Northwest Providence channel, but we don't see the same events at AUTEC, even though at AUTEC they use active sonar repetitively throughout the year.

So one of the interesting things in our study that we found is, A, there are beaked whales in an area where active sonar is being used, and the same by the way is true on the SCORE range. We're seeing Cuvier's beaked whales there. And secondly, you don't have mass strandings even when these sonar operations take place and it's one of the things that we're trying to tease out of the data to try to understand why that is and what the differences are between the Northwest Providence Channel and the routine sonar usage at AUTEC.

DR. OHAB: How do they even know when there a naval ships in the area?

MR. MORETTI: Well, because it's a Navy range, the ships are scheduled to be on range at a particular time and they're precisely tracked. And that's true of both surface vehicles and undersea vehicles. The range, remember, the sensors that I described are really set up to track anything under the water. But anything on the surface is also precisely tracked. And that's one of the advantages to us because we can take the data related to marine mammals, but we can put it together from vehicles that are on range that have been very precisely tracked. So now we can get a record of both animal behavior and also a precise record of ship tracks and in open ocean waters and in the cases like the Northwest Providence Channel, putting those data sets together often is either impossible or very, very difficult.

DR. OHAB: Now, I imagine you're using some pretty sophisticated equipment in this study. Can you describe the different instruments being employed?"

MR. MORETTI: Yeah. If you look at the general design of an undersea range, it really consists of an array of sensors. The sensors on the ocean bottom, first of all, they're bottom mounted, so they're sitting on the ocean bottom and they're approximately two nautical miles apart. But they cover a very large area, so at AUTEC they're on the order of 90 sensors spaced two miles apart, which cover an area of about 500 square nautical miles.

The signals from those sensors then are brought to shore via cables and they end up in a command and control building. It's at that point that we have access to those signals and those signals are digitized, in other words, the data from the sensors, from the microphone is turned into a numerical data stream and then we have signal processors, which actually received those data and then act on the data. And what we've developed are techniques that allow us to detect transient signals including marine mammal vocalizations. So, in other words, if an animal makes a call, we have the ability to detect that call on the sensors and that allows us to gain information as to where the animals are distributed and also behaviorally we

can make inferences as to how they're moving and what they're doing.

DR. OHAB: Now, I understand you're also using satellites to track the whales. How is that accomplished?

MR. MORETTI: One of the things that happens is we only know what we hear and the animals have to be vocalizing and they have to be over the sensors. So if the animals move off of the sensors, which is what we're seeing now, by the way, with beaked whales and something we'll talk about, at that point they're off the sensors, we can no longer detect or track them.

So what we're trying to do is integrate on some of the animals' satellite tags and the way that works is we put trained observers on the waters. We work at AUTEC very closely with Diane Claridge in the Bahamas Marine Mammal Research Organization and also on NOAA, John Durbin, who is from Southwest Fisheries in trying to identify individual animals, put satellite tags in animals and then also take some other measurements off the animals.

To do that, we actually sit on shore using our equipment to find animals based on their vocalizations and then we send the observers, Diane and John and company in a rib out to the animals and they try to find the animals and then at that point, we'll attach a satellite tag if possible to an animal. The tag is gone actually with the small dart into the dorsal fin, so they'll stay on for quite a while. They can stay on up to four months. And what happens is the satellite tags relay position, animal position. So it's not a precise track that we'll get positions on the order of four to six times a day, but over longer periods of time, we get better information on the movement of these animals as they move potentially off the range. And we've done that now on several animals, including beaked whales and also pilot whales and its been very, very interesting, some of the data that's come out of that.

DR. OHAB: Now, you've mentioned a wide variety of scientific disciplines, things like acoustics, marine biology, animal behavior. I was hoping you could take a second just to talk about your background and how you got to be the principal investigator for the marine mammal monitoring on Navy ranges program.

MR. MORETTI: Yeah, it's interesting because and I find this throughout the discipline, people come at it from different angles and the path by which they get to this point is somewhat interesting. I actually have undergraduate degrees in biology, one is actually in genetics; another one in resource management and forestry, but then I taught for a while and then went back to graduate school in electrical engineering.

So my technical training is actually as an electrical engineer and the reason we managed to evolve into what we have today is our expertise or my expertise working for the Navy was designing the signal processors for the undersea acoustic ranges. So I led a group of engineers that were tasked with trying to build hardware to detect underwater signals. And back in 1999, it's just when this interest in marine mammals and sonar started to ramp up, we had put in a proposal to the Office of Naval Research, at the time, Bob Gisiner was actually the program director and suggested that you could use the Navy sensors to potentially detect and study marine mammals in their natural environment. And we were lucky enough to get funding for that and the rest is, as they say, is history. Then, of course in the year 2000 was the major stranding event in the Northwest Providence Channel and that's sort of driven the research since then.

So we have and it's true of my colleagues to sort of an odd collection of backgrounds, but our primary expertise has been in the adaptation of signal processing, acoustic signal processing to the study of marine mammals.

DR. OHAB: Now, in addition to drawing from a variety of scientific disciplines, it also sounds like you draw from a number of non-Navy organizations who are involved in the study. You mentioned a few. Can you talk about some of the

other organizations you work for, work with?

MR. MORETTI: Yeah. As I mentioned, at AUTEC for instance, we work with Diane Claridge and the Bahamas folks, Marine Mammal Research Organization folks. But in order to really understand what's happening, to really drill down into what's going on with animals and their behavior related to sonar. It takes multiple disciplines. So we work very closely with the folks at Woods Hole, Peter Tyack and Mark Johnson. Peter is actually a marine biologist and he brings that to the table, plus a wealth of experience. And Mark actually has designed not a satellite tracking tag, but a data recovery tag that we've also used at AUTEC to try to get very fine grained information from animals in the Tongue of the Ocean.

In addition, we work very closely with the folks over at St. Andrews University, Ian Boyd, Len Thomas and John Harwood in several different disciplines. Ian, again, is a marine biologist and Len and John are actually statisticians that have concentrated on environmental issues.

So it brings a set of expertise together to help make sense of these data sets that are being collected and the data that we've collected has proliferated out into several other studies.

On the West Coast, we actually work quite closely with the folks up at Cascadia Research. They're similar to the folks at Bahamas Marine Mammal Research Organization in that they are expert observers. So on the West Coast, we; again, send trained observers from Cascadia, Karen Falcone, Greg Shore, John Kalvakitas (sp). We started working with Robin Baird (sp) in Hawaii and they give us the ability to understand what we're hearing. Like I said, our expertise is in signal processing; it's not in animal identification.

So when we hear a sound, it takes a degree of verification, people actually identifying the animal, identifying the species and then relaying that information and we start to put the pieces of the puzzle together, so that when we hear a sound, for instance, we can identify what it is.

In addition, we've worked quite heavily with people in the classification world. So Marie Roach is out at San Diego State University, Dave Mellinger at Oregon State University as well, plus folks out at Hawaii. Because when you start talking about an inclusive study that looks at all of these different aspects, it really takes that level of expertise in these different disciplines. Plus the other thing that happens when you are engaged in more of a collaborative environment, it helps to keep people, A, honest, and also ask questions that might not occur to you because of your particular point of view or your particular experience.

So its been quite interesting, actually.

DR. OHAB: Can you talk about which animals have been tagged so far and what kind of information you actually get from them?

MR. MORETTI: Yeah. There are several different species that have been tagged and we probably should break the tags into the two types, one is the satellite tag efforts and that gives you information as to animal movements. So in the tongue in the ocean, we've tagged both beak whales, the species in particular that is most prevalent on the AUTEC ranges, it's called Blainevilles and also pilot whales. On the West Coast, we've also employed tags, but you tend to see a broader range of species and also you tend to see large veiling species, which we don't see in any great numbers in the Tongue of the Ocean.

So, on the West Coast, there have been quite a few tags placed on fin whales, also, Cuvier's beaked whales and what happens now is those data are starting to answer some of the questions relating to animal movement and gives us some idea as to the range and what to expect on a baseline because if you're going to study these things with and without sonar, you'll really need to understand what they do when they aren't any sound sources present. And for especially beaked whales, that

level of understanding is not very good. They're deep diving species. They don't spend a lot of time on the surface. They're very hard to observe.

So the amount of information as to their movements is up until the last few years has been just about non-existent. Also, they've been putting tags, the Cascadia folks, Robin Baird in particular has been putting tags on beaked whales in Hawaii that have provided information as to their movements as well. And you never know quite what you're going to find, so, for instance, at SCORE two years ago we put a tag on a Cuvier's beaked whale and the animal basically stayed within 30 miles of the area it was tagged, plus or minus 30 miles of the area it was tagged.

So our pre-conception was that the animals do basically that that they're resident to a particular area that they stay there for most of the year. That tag, by the way, stayed on for about 120 plus days. I think that's the longest tag actually on record on a beaked whale.

A year later, again, this is Greg Shore and Aaron Falcone (sp) put a tag on another Cuvier's beaked whale, this was an adult male and the animal, lo and behold, actually moved about 200 miles south and most of its course was a pretty straight line. We had no idea that they would do that.

So we're still in our infancy trying to understand what these animals do and how they move. And it seems every time we go out, we learn something new.

Now, the other type of tag that's put on it would be recording tags. So we work, as I said, very closely with the Woods Hole Oceanographic Institution and Mark Johnson has developed what's called the D tag or digital tag, which would record pitch, roll, depth -- (inaudible) -- and also records stereo hydrophones. Now, those tags stay on about 19 to 20 hours; they're held on with suction cups. But they give very, very precise movement, very pristine data on the movement of animals within that time span.

And those data have been extremely important for what we're doing because it's giving us an understanding of how vocalizations for beaked whales are associated with their behavior. And we know from Mark and Peter Tyack's work that these animals produce echolocation clicks, but they only do that on deep foraging dives and their deep foraging dives happen about every couple of hours and they're very metronomic. They just do that over and over again day and night. And because of that when we hear animals; we start to understand what the animals are doing in their environment.

The other thing that now that you can start to combine the tag data with the acoustic data, so we've done a lot of work trying to understand the level of sound that these animals put out, how loud it is and also understand it's bean pattern and you find out that beaked whales, in particular, put out sound at a very loud level, over 200 dB and also they put out sound like a flashlight beam, so they're down echolocating looking for food and it's effectively like they're shining a flashlight through the water in a very tight beam.

So when we hear them, we basically hope that they shine the flashlight towards one of our sensors and that allows us to pick them up. But now from the tag, we also know that they're foraging.

So you start to get sort of a much more rich picture of how these animals are using their environments and how they're distributed through the range, how they're foraging. So it gives you a better ability to put that together now with data that we get from the range regarding sonar to understand what they're actually doing in response to the sonar.

DR. OHAB: And from all this data, have you been able to make any conclusions regarding which animals are residents of the area?

MR. MORETTI: Well, it appears and I stress the word, appears, that the

beaked whales that we're seeing are a resident population. The other thing that's being collected at the same time during these tests that are being run is when the observers are on the animals, they'll also take pictures of the animals, so they can create a photo ID catalog of animals that allows them every time they go out to take new pictures and then check to see if they've seen the same animals again.

In addition, they'll take biopsy samples. So they'll shoot a small dart into the animal that pulls out a small, very small amount of tissue and you can start to use that tissue to look at DNA and also to look at some of the fatty acids to see, get some idea as to what the animal was eating. And you can start to compare that to other areas.

So, interestingly, the site we work at in the Bahamas, remember, I said there's a canyon called the Tongue Of The Ocean that goes off the Northwest Providence Channel. The folks at BMMRO actually work pretty heavily with the population up off of Abaco and it appears that's a separate population, and again, it's pretty early, but that looks to be what's happening, two separate populations.

DR. OHAB: So as you're looking forward, what are some of the next steps?

MR. MORETTI: Well, what we're trying to do, the first thing we're trying to do is to look at data that we collect with and without sonar. And when we look at those data, what it seems to be showing is that during times of sonar operations on the AUTEC range, beaked whales, which we know to be sonar-sensitive move off the range. And we believe that the same animals actually after the operation is over come back onto the range, which seems almost intuitive, but remember the popular perception of how animals react to sonar is quite a bit more harsh than that.

So we're trying to now expand that because, as I said, once these animals are off our sensors, we lose touch with them. So if an animal returns after an operation, there's no way that I can prove definitively that it's the same animal and that's where the -- (inaudible) -- come in. Now, if we can combine saftags (sp) with this broad data set, we start to get some direct measurements of animal movement on and off and verify what we believe we're seeing from the acoustic data, that is that animals move off during sonar and back on after.

Now, the next big thing is to try to understand how animals will move in relation to sonar, so there's actually an active program, actually the PI as Len Thomas at St. Andrews that is designed to come up with a model that looks at animal movement relative to sonar based on these data sets that we're collecting, both the satellite data, the opportunistic passive acoustic data and also the D tag data, which gives you that fine grain movement.

And hopefully when you combine those, we can get an understanding of how animals move and that can be used as somewhat of a predictor and as a tool to study reaction of these animals to sound because the real question is why do these animals strand under certain circumstances? There's no question in the Northwest Providence Channel that animals stranded, yet they don't at AUTEC. What's the difference? What defines why animals would strand in one location, but just south not, even though -- (inaudible) -- it looks very similar in terms of the ocean conditions, in terms of the terrain. They're both deep ocean canyons and quite close to one another.

So trying to understand those differences and trying to predict how animals react under given situations is really of primary concern to the Navy because the Navy, you know, has the responsibility to operate in an environmentally, in a way that maintains an environmental compliance. So, hopefully, these studies will provide some basic understanding that can be applied to that.

DR. OHAB: Now, is there any other related work going on?

MR. MORETTI: Yeah, there is. There are several different studies that are happening. There's a separate study actually that's related to sort of an outgrowth

of past studies that were done called the behavioral response studies and in those particular studies, animals were isolated, a tag was attached, a recording tag now, a D tag was attached to the animal and then a playback was executed. Then the tag was recovered and then analyzed. So, actually in 2007 and 2008, actually, there were two studies that happened at AUTEC and then last year there was actually a study that happened in the Med.

There's a follow on to that that's taking place off the coast of California, and again, that's a similar design in that the hope is to attach tags to individual animals, execute a playback, in other words, deterministically play a sound at a known range from the animal and then recover the tag to try to understand the reaction of the animal directly to the sound.

Also, as I said, there are other tagging studies that are going on. There are studies that are being done in Europe and Norway, for instance, Patrick Miller and company have been attaching tags to pilot whales and doing playbacks on those animals in an effort to, again, understand their reaction to sound. And then they're tagging studies that are going on in Hawaii as well to try to understand movements. In addition -- (inaudible) -- runs a program with the Navy dolphins that's designed to understand how animals use sound, how animals produce sound, how animals react to sound, what levels of a sound animals can tolerate without serious injury, just to name a few.

So the Navy runs a very, very broad program and we're just one part of that, certainly, the folks from N 4, 5, Dr. Stone at ONR and Dr. Wease (sp) and Dr. Eckman (sp) could talk much more eloquently on the breadth of studies that are going on throughout the Navy than I can.

DR. OHAB: And give us a sense of the time frame for some of these research projects you mentioned.

MR. MORETTI: Well, most of the ones that I mentioned are actually ongoing studies that have evolved over time. You use the M3R program that -- (inaudible) -- it actually started in 1999 and we spent quite a few years just trying to develop the tools that would let us actually study behaviorally what animals were doing and its actually evolved over time, so initially we came up with different algorithms and hardware that would allow us to monitor these animals in their environment using sensors on the ranges. And the tools are to the point where they're certainly not perfect and their flawed in many, many ways, but they for the most part work and they're being used and applied to study of actual behavior of animals on the ranges.

So over time, over time, things have gotten much, much better and our level of understanding has improved significantly, but its taken a lot of time. I think what people forget is we're trying to study animals in their natural environment, but these animals live in the deep ocean. They don't come to the surface often. It's extremely difficult to study their behavior because it's an environment we're just not equipped to deal with well.

DR. OHAB: Now, just a couple of questions before we wrap up today's program. If you could sum things up, what is really the ultimate goal of all this research?

MR. MORETTI: Well, ultimately, I think there are really two goals, one is to understand their behavior as it relates to anthropogenic or manmade sound, including sonar. And the second, especially in terms of the research we're doing is to understand the health of populations. Much of the initial focus with animals has been on the individual animal, which is different when you think about terrestrial animals. In terrestrial animals, we tend to look at the health of populations. So, for instance, this is my standard analogy. If you're driving to work in the morning and you hit a deer and you kill the deer, in fact, if you kill yourself hitting the deer, we accept that. It's not that we want that to happen, but we accept it and I think part of the reason we accept that is we know on a population level that those populations, both the deer and humans are healthy.

But in the water, especially with marine mammals, a lot of the focus has been on individual animals and we'd like to really shift that so we start thinking in terms of populations.

So on the ranges especially where we have this infrastructure, we'd like to be able to understand health of population because when we study these animals, we know that they're there. We can start to estimate their numbers based on some of the techniques that have been developed, but, in fact, one of the things that is in debate are these animals, for instance, on the ranges, is that a healthy population or does activity on the ranges affect the population? And right now, I really can't say one way to the other. We think that given the numbers that it's a robust population, but whether it's healthy or not, that's a different story.

So we'd like these tools to evolve to the point where we can say something about population health and there's an effort underway actually to start some programs to adapt algorithms for the study of these animals on a population level. Its actually been dubbed the PCAD modeling or population consequences of acoustic disturbance and that's in its infancy, actually. We're starting now to apply some of these data to those ends.

DR. OHAB: Now, you certainly covered a lot on today's program. Is there anything else you'd like to share with the audience before we conclude today's program?

MR. MORETTI: Well, I guess the biggest thing from, at least my point of view, I have a unique, I guess, a unique position in that I work for the Navy, yet we're working directly on understanding the behavior of these marine mammals. So you get a certain attachment to these animals, I have to say. But from a Navy standpoint, I also interact with some of the admirals and they're trying very hard to work in this environment, in an environmentally responsible way, but at the same time they have, you know, responsibility for ships that are crewed by, you know, basically a bunch of 19 and 20-year-olds. So it's a balancing act. They're trying to balance both the needs of the Navy against their environmental responsibilities and it's to that end that we're funded and that the Navy ends up spending the money that they do on these particular series of research projects.

So hopefully with time, we'll be able to answer questions that are out there and also give some understanding and some guidelines for future environmental compliance.

DR. OHAB: Dave Moretti is the principal investigator for the marine mammal monitoring on Navy ranges program, which is sponsored by the Chief of Naval Operations Environmental Readiness Division.

Dave, this is a really interesting discussion and a really important topic. Thanks again for taking the time to join us today.

MR. MORETTI: Thanks, John.

DR. OHAB: As always, I'd like to thank our listeners for tuning in to today's program. I hope you have a happy Earth Day. I am Dr. John Ohab and you've been scienced.

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