Contribution ID: **47** Type: **Invited Lecture**

How new technology has revolutionized the study of cetacean bioacoustics and suggestions for new directions and collaborations for the future

Monday, 21 October 2013 14:30 (50 minutes)

Our human sense of audition is adapted for hearing in air, so we need to rely upon electronic apparatus to hear well underwater, to localize sounds, and to broadcast them. After modest development in the first 40 years of the twentieth century, WWII brought rapid development of excellent gear for listening, locating, and broadcasting sound underwater. Unfortunately for civilians interested in this topic, most of this military equipment was very expensive, was so large as to require large ships, and often its use was restricted by military security. When Roger Payne and Doug Webb proposed in 1973 that baleen whale calls might be audible over ranges of hundreds of km, many biologists rejected this as implausible, not knowing that navies used networks of hydrophones to routinely track whales and other sound sources at these ranges. While the methods became more openly available by the end of the 1980s and the end of the Cold War, their expense limited their use for marine bioacoustics.

The increasing power and miniaturization of digital electronics through the 1990s finally opened the door to allow normal biological projects access to sophisticated signal processing for bioacoustics in the field. Finally a graduate student could build an array of hydrophones, program a personal computer to process the data for beamforming, and put it all on the small boats typically used by field biologists. By 2000, the miniaturization of digital electronics made it possible to put a recording system directly onto a whale. These developments turned marine bioacoustics from the realm of expensive cruises on large research vessels to a tool that could be used by field biologists. This has led to an explosion of research in this area, promoting the use of bioacoustics tools to answer questions from behavior to estimating population size.

These relatively cheap small-scale devices also have shown great value in combination with large expensive research programs. When a tag recording the vocalizations and orientation of a calling whale is combined with measurements from acoustic arrays, either towed from a ship or mounted on the seafloor, it becomes possible to measure the three dimensional beam pattern of the animal's sound production. Similar tags can monitor behavioral and physiological reactions to potential sources of disturbance such as naval sonar, yielding functions relating acoustic dosage to behavioral response. These dose-response functions are essential for managing the risk of disturbance.

As we recognize that sound may affect marine life globally, and that acoustic methods can help us to track the distribution and abundance of vocal species such as marine mammals and fish, this suggests future needs for developing bioacoustics methods that work over longer spatial and temporal scales than ever before. Current acoustic recording tags only last a day or so. This is not long enough to sample much behavior and physiology, nor to monitor the effects of seismic surveys or sonar exercises. These data needs argue for acoustic tags that last several weeks to months. The development of long-term global ocean observatories offers the promise for supporting these needs, but the acoustic components of current plans need to be greatly strengthened. I hope that if communities such as marine biologists and particle physicists who use sound in the ocean, can work together with one voice, we may be more successful in adding the critical acoustic capabilities to ocean observatories.

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Session Classification: Advanced marine research for conservation