Remote Monitoring of Dolphins and Whales in the High Naval Activity Areas in Hawaiian Waters.

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LONG-TERM GOALS

The axiom that knowledge is power applies directly to the problems experienced by the U.S. Navy in encountering dolphins and whales. These encounters can be avoided if more knowledge and understanding of the behavior, distribution, and movements of these animals. Simply stated, if the Navy had more knowledge of the **what**, **where**, **when** and **why** of marine mammals in a given body of water, encounters between Naval vessels and marine mammals could be reduced or avoided all together. The ocean is large and the chances of avoiding any interaction with any sizable group of marine mammals are probably much greater than the probability of encountering marine mammals. However, the cost of negative encounters is disproportionately high in terms of negative publicity and law suits so it would be prudent to take steps to increase the odds against any encounters. Therefore, basic information on the biology, natural history, and behavior of cetaceans that frequent waters of high Navy activity are needed to understand ways to avoid encounters. A robust database of this information currently does not exist. There is a higher probability of Naval encounters with marine mammals in Hawaiian waters than in most other regions of the world because of the large number of cetacean species that inhabit or frequent these waters. Approximately 16-20 species of cetaceans can be found in Hawaiian waters. This is a large number of species for such a small geographic area. Knowing **what** animals are present in a given body of water is important because different species utilize their habitat in different ways. Therefore, it is important to understand the distribution, abundance and movement of dolphins and whales over the day-night cycles and seasonal periods.

OBJECTIVES

The objective of this study is to map the distribution and abundance of whales and dolphins in selected regions of Hawaiian waters. The waters surrounding the islands of Kauai and Oahu, where most Naval activities occur, will be the focus of this study. The Pacific Missile Range is in the waters of Kauai and the Pearl Harbor Naval Base is the home of the U.S. Pacific Fleet.

APPROACH

Five relatively low-cost autonomous, remote acoustic recorders denoted as the **EAR** (Ecological Acoustic Recorder) have been deployed around the island of Kauai and five more EARs are moored around Oahu, to simultaneously monitor for the presence of dolphins and whales. The EARs are retrieved, refurbished and redeployed after a battery change and swapping of hard drive on a periodic basis. The data disks are taken back to the laboratory for analysis. Various species of cetaceans are of interest, but for the first two years, the effort has been concentrated on deep diving beaked whales around Kauai and at one location off Oahu. The original locations of the EARs are shown in Figure 1.

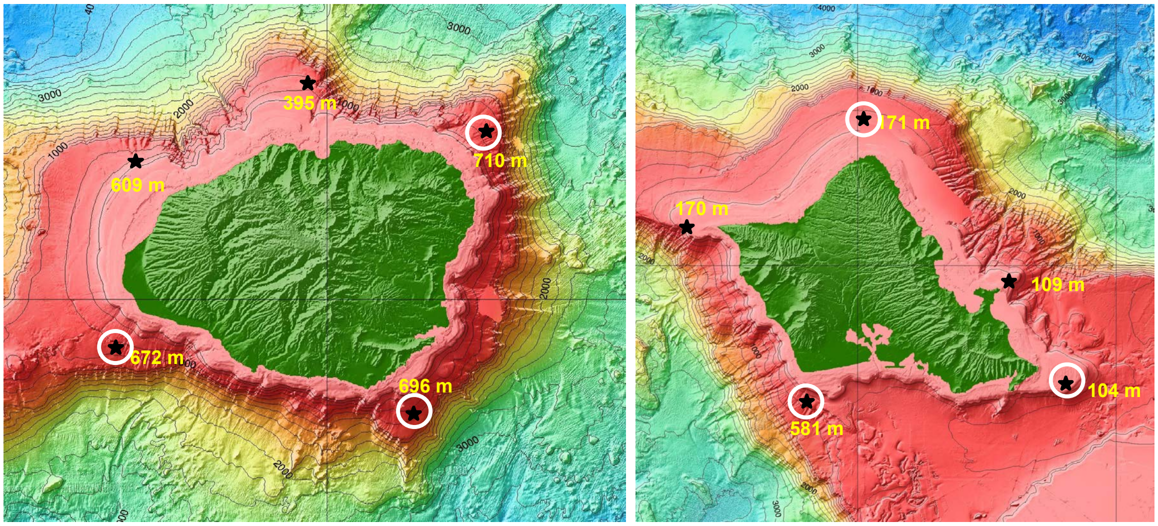

Figure 1. Original locations of EARs around Kauai and Oahu. Results from the EARs that are circled will be discussed in this report.

WORK COMPLETED & RESULTS

The project received one of the M3R nodes (same node used in the Navy underwater test ranges at AUTEC, SCOR and PMRF) in late August, 2010, courtesy of David Moretti, of the Naval Undersea Warfare Center Division in Newport, R.I. and Dr. Frank Stone, of N45. The node is currently being used to process the data from EARs deployed off Kauai and off Barbers Point, Oahu, which is at a depth of 581 m. The M3R system is designed to detect both Blainville's and Cuvier's beaked whales, as well as pilot whales, Risso's dolphins, sperm whales and small dolphins. Eventually all the EAR data will be analyzed with the M3R node. The energy ratio mapping algorithm (ERMA) developed by Holger Klinck and David Mellinger at Oregon State University to detect beaked (Cuvier's and Blainville's) whale biosonar signals is also being used to analyze the data. The beaked whale detections from the M3R system are compared with the beaked whale detection from ERMA and if the detections agree we accept the fact that beaked whale signals are present in a given file. If both detectors do not agree, we examine each of the files visually. Beaked whale and sperm whale signals are relatively simple to detect and classify visually.

We are in the process of reanalyzing the data obtained in the 2nd, 3rd and 4th deployment, using the M3R system along with the ERMA algorithm. However, we are approaching the analysis using data from the latest retrieval and working backwards. Examples of the number of files in which different species of deep diving echolocating odontocetes were detected, for the 5th deployment to the SW Kauai location are shown in Figure 2. The data period was from October 20, 2010 until January 26, 2011. The vertical axis depicts the number of files in which biosonar signals from a given species were detected and the scales for the five species are the same. Therefore, the relative number of files that contained biosonar signals from the different species can be compared. The histogram data indicate that at this SW Kauai location, deep diving echolocators were present almost every day during this period. Not all species were there every day, but at least one species was present almost every day. The histograms indicate that pilot whales were present at the SW location more often than other deep diving odontocete. They also indicate that beaked whales had the lowest detection rate.

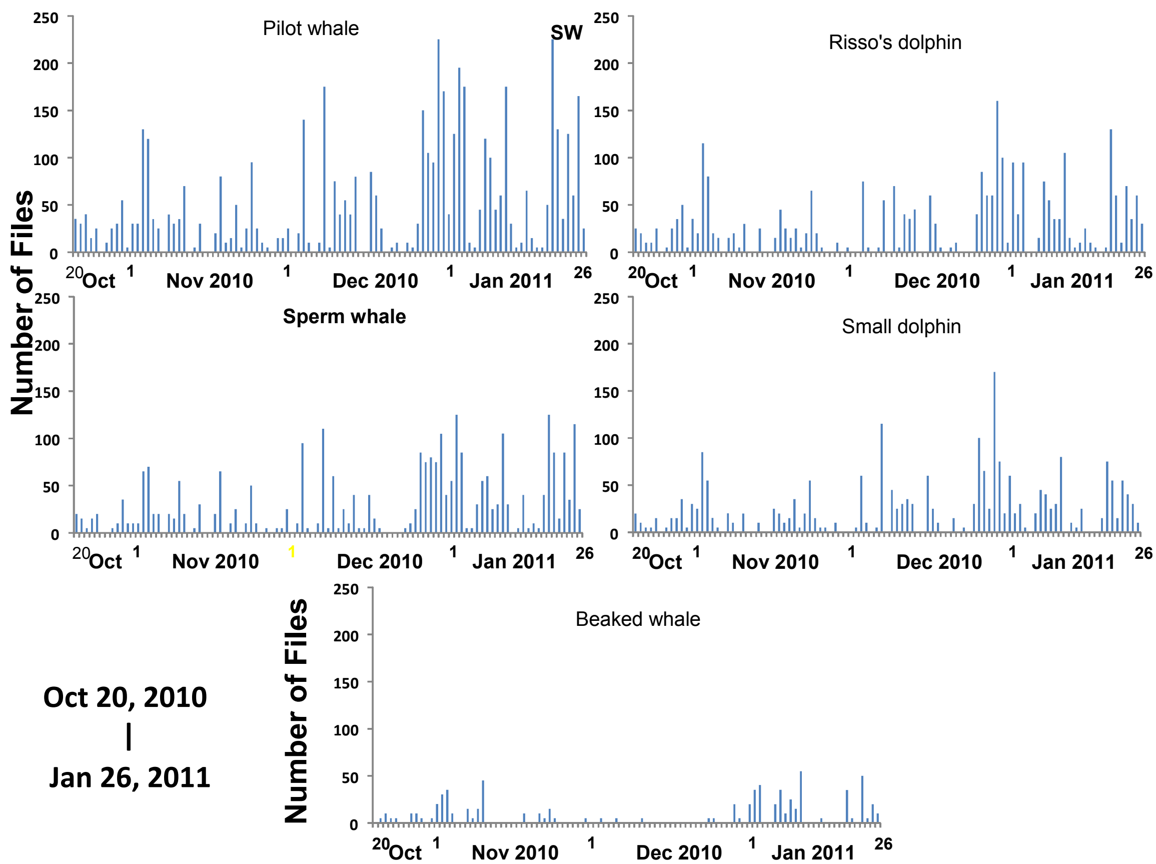

Figure 2. Histograms showing the number of files in which the different species of deep diving odontocetes were detected during the October 20, 2010 – January 26, 2011 time period. Signals from several species of animals are often found in a single file.

The number of files containing biosonar clicks from the five different species in the three different locations are shown in Figure 3. The data indicate most of the biosonar clicks were from pilot whales at the three locations. The data also indicate that clicks from beaked whales were the least abundant in all three locations. The figure also suggests that there is not a clear "hot spot" for a given species at these three locations. This conclusion was also stated in the 2010 progress report submitted to ONR. The low number of files containing beaked whale clicks suggests that beaked whales are not very abundant in the waters around Kauai. Only 1% of the files from the NE location contained beaked whale clicks. At the SE and SW locations, the percentage was 4 and 5%, respectively.

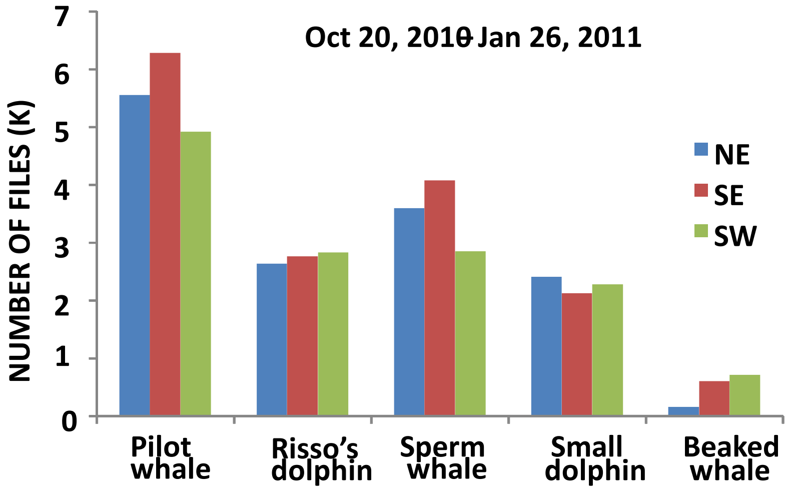

Figure 3. The number of files that contained biosonar signals from the five different species of deep diving odontocetes at three different locations around Kauai during the time period between October 20 – January 26, 2011.

The EARs locations was changed in April of 2011 from deploying them around Kauai to having a string of them along a south coast line. The four EARs are a about the same depth of 750 m and spaced approximately 4 miles apart. We hope to obtain an deeper understand of how animal utilize a shore line.

Data from Oahu EAR deployments were analyzed using the Matlab™ script Triton, developed by Sean Wiggins (Scripps Institute of Oceanography) and adapted for use with EAR data. Triton was used to create Long-Term Spectral Averages (LTSA) of the recordings for each deployment. LTSAs provide a visual representation of the acoustic energy across frequency and time over the deployment period. The LTSA is a composite spectrogram made up of Fourier Transforms averaged over a user-defined period. For this study, 10 seconds of recording time were used for each average. LTSAs were binned hourly and odontocete encounters were located by visually examining the LTSA for the presence of "hot spots" of acoustic energy in the frequency bands associated with their signals. Suspected odontocete calls were confirmed by examining a 1024-point, Hanning -windowed spectrogram of the original recording. Within each hour period, the three recordings with the greatest number of acoustic signals were given a call abundance score between 1 and 4 and these were averaged to give an hourly call abundance (HCA) score for the hour. This provided a normalized, quantitative metric for comparing calling rates over time and across locations. In addition, recordings were characterized on the basis of whether they contained echolocation click trains, mostly low frequency (< 10 kHz) whistles, mostly high frequency (> 10 kHz) whistles, or a combination of the three. Low frequency whistles were considered to be indicative of the presence of one or more of the following species: false killer whales (*Pseudorca crassidens*), short-finned pilot whales (*Globicephala macrorhynchus*), melon-headed whales (*Peponocephala electra*), Risso's dolphins (*Grampus griseus*) and rough-toothed dolphins (*Steno bredanensis*) (J. Oswald, pers. com.). High frequency whistles, on the other hand, were considered to be indicative of the presence of one or more of the following species: spinner dolphins (*Stenella longirostris*), spotted dolphins (*Stenella attenuate*), striped dolphins (*Stenella coeruleoalba*), and bottlenose dolphins (*Tursiops truncatus*) (J. Oswald, pers. com.).

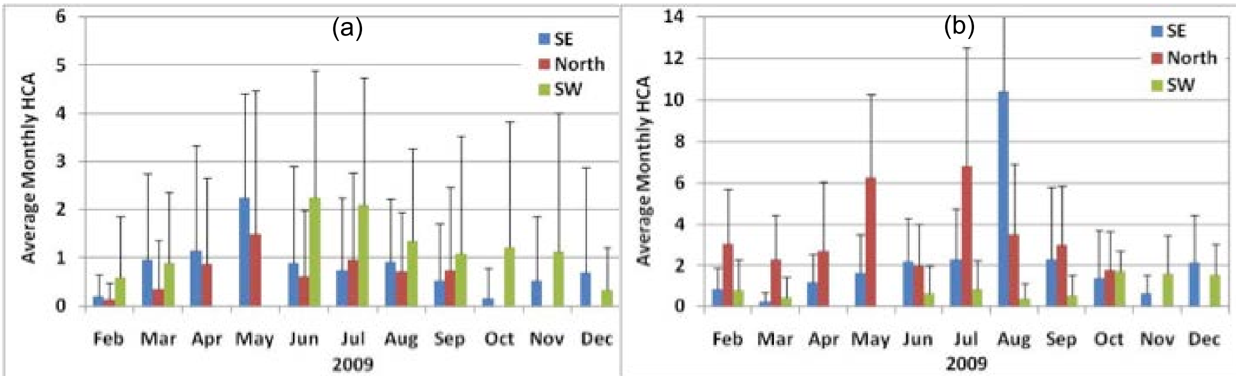

Figure 4. Averaged monthly occurrence of (a) low frequency whistles and (b) high frequency whistles at the three deployment locations. Note: missing data for the months of April, May, November and December represent gaps in the data sets, rather than a lack of signals.

Figure 4 shows the occurrence of low-frequency (LF) whistles at the three sites. Statistical comparison between sites revealed that there was no difference been N and SE Oahu, but that SW Oahu had significantly more LF whistling activity than either N or SE Oahu.

These results suggest that foraging activity, which is mediated by echolocation, may be greatest on the north side of Oahu and lowest on the southwestern side. In addition, it appears there are both spatial and seasonal variations in the occurrence of different species. Species producing high frequency whistles (e.g. *Stenella longirostris, S. attenuata*) were most commonly detected on the north side of Oahu and peaked in occurrence during summer months, whereas those producing lower frequency whistles (e.g. *Globicephala macrorhynchus, Pseudorca crassidens*) were recorded predominantly on the SW side of Oahu and were detected most frequently in spring. Very little visual survey have been done at some of these site, but these sites are clearly important habitats for a variety of species. The north side of Oahu in particular appears to be a more important area for high frequency whistling species than previously thought. Although still preliminary, the results obtained to date provide an unprecedented perspective on the occurrence of odontocetes around the island of Oahu and illustrate the value of applying a long-term acoustic monitoring approach to investigating odontocete occurrence and distribution.

IMPACT/APPLICATIONS

Potential future impact for Science and/or Systems Applications is gaining knowledge of how dolphins and whales utilize the waters surrounding Kauai and Oahu, two areas of high Naval activities and from that knowledge, operations can be planned that would maximize the probability of avoiding marine mammals. Successful results and methods used in this project could also be applied to other areas of high Naval activities.

RELATED PROJECTS

None.