Cumulative and Synergistic Effects of Physical, Biological and Acoustic Signals on Marine Mammal Habitat Use

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LONG-TERM GOAL

The long-term goal of this collaborative research effort is to enhance understanding of how variability in physical, biological and acoustic signals impact cetacean habitat use. In particular, what are the effects of manmade underwater sound on marine mammal health and physiology, and what are the consequences of these effects at the marine mammal population level?

OBJECTIVES

The objectives of this collaborative research effort are to make synoptic measurements of cetacean habitat use, prey concentrations, physical oceanographic processes, and noise levels in the Bering Sea. Integrated data such as these will be vital in understanding the relationship between cetaceans and their environment both in the presence and absence of specific noise sources. Long-term measurements will play an important role in determining the point at which cumulative effects of the environment and human activities impact animal populations, and in identifying the kinds of exposure that pose the greatest risk. The Bering Sea is an ecosystem that is presently experiencing rapid climate change, has relatively healthy populations of cetaceans and supports the largest fishery in the US EEZ.

APPROACH

This project is a three-year field study involving long-term monitoring of the physical and biological environment at two established NOAA mooring sites (known as M2 and M5) in the Bering Sea (Figure 1) (Stabeno and Hunt, 2002). An acoustic monitoring system using both active and passive acoustic sensors will be developed and deployed. The passive component will be used to assess the physical environment and to detect and identify cetaceans present near the moorings. The active component will be used to investigate zooplankton distribution and abundance. Ancillary measurements of water column characteristics (temperature, salinity, nutrients, ice cover, etc.) will be available from the standard NOAA instrumentation on the moorings.

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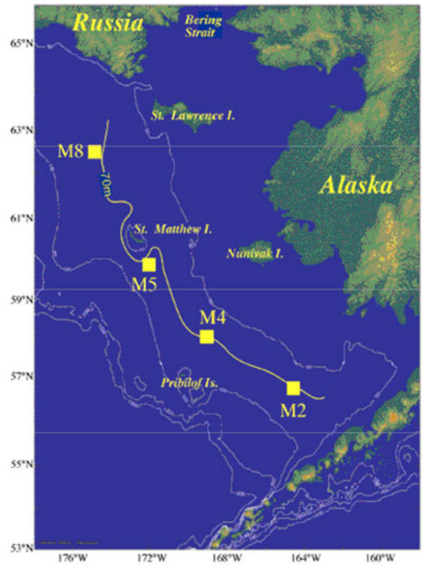

Figure 1. Map showing the location of the moorings (M2 and M5) that will be used in this project.

The component of the project that is associated with the passive acoustic monitoring of the environment is the specialty of Nystuen (APL/UW). The instrumentation used are Passive Aquatic Listeners (PALs), designed and developed at APL/UW. This report describes the use and interpretation of these instruments to support the objectives of this research project. This is the APL/UW component of this research effort.

PALs have been used for nearly a decade to quantitatively monitor the physical marine environment (Ma and Nystuen, 2005). Recently, they have been used to detect and identify specific cetacean species, in particular, killer whales (Nystuen et al. 2007).

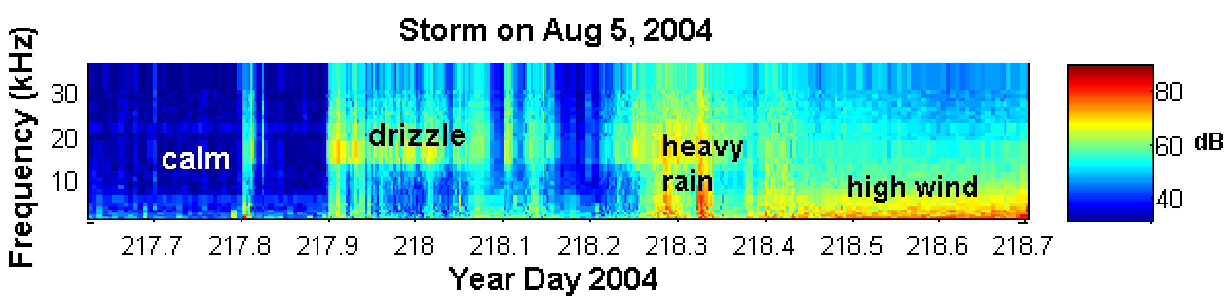

Figure 2. The underwater acoustic record of a storm passing on August 5, 2004 (Year Day 218) at the M2 mooring in the Bering Sea. [The colorized units for sound intensity are in decibels (dB) relative to 1 µPa^{2}Hz^{-1}.]

Figure 2 shows an example of the underwater acoustic record of a storm passing the M2 mooring on Aug 5, 2004. The record is interpreted as a period of calm, followed by drizzle, heavy rain and finally high winds as a strong atmospheric front passes over the mooring location. This interpretation is possible because different physical sea surface processes such as wind wave breaking and raindrop splashes have characteristic underwater sound spectra that allow the processes to be detected and quantified (Ma and Nystuen, 2005). Other sounds are also present, including shipping, sonar or other human noises, and biological sounds such as cetacean calls and clicking. Again, these other sounds have temporal and spectral characteristics that allow them to be identified. In turn, these sounds can be used to detect, identify and census marine animal populations (e.g. Moore et al., 2006).

A new feature of the PAL operating software allows short time series to be recorded. This feature allows the verification of the sound source. Figure 3 shows an example of a killer whale call that triggered this feature of the operating software. The playback was quickly identified as belonging to a "transient type" killer whale. (Nystuen et al., 2007).

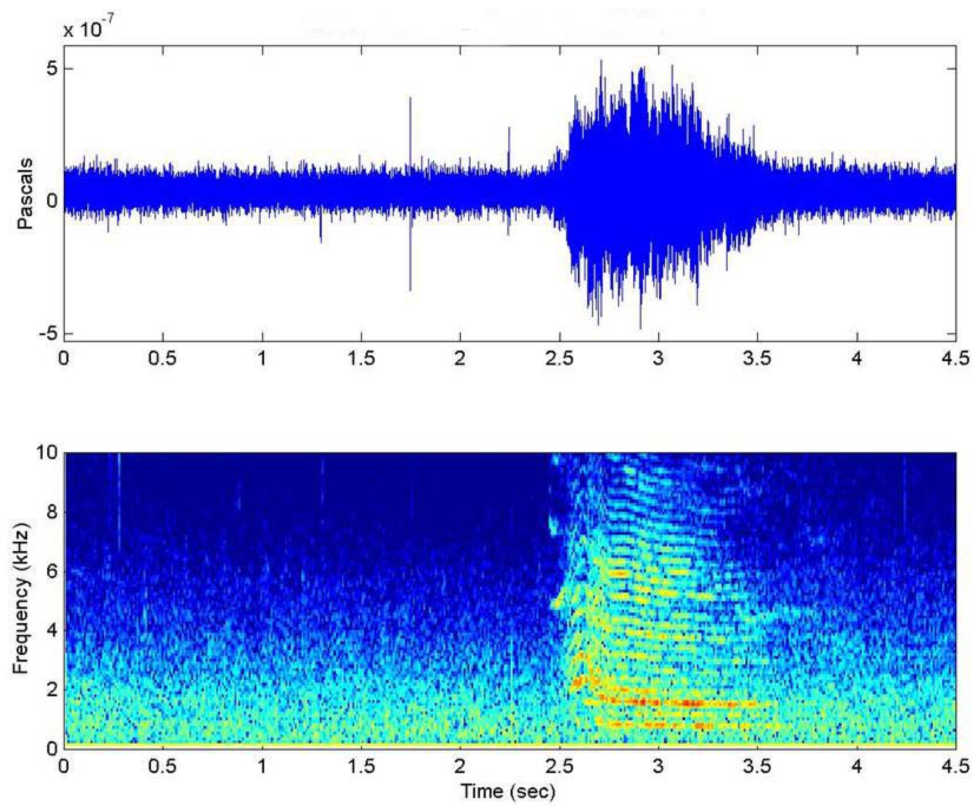

Figure 3. Time series and sonogram of a transient killer whale call off of Cape Flattery, WA on Apr 26, 2005. The PAL sampling rate is 100,000 Hz, allowing echo-locations with frequencies up to 50 kHz to be recorded. Most killer whale calls have frequency contents at less then 10 kHz.

WORK COMPLETED

Three active/passive acoustic instrumentation packages have been acquired by ARL/PSU (Miksis-Olds). Two existing PALs from APL/UW (Nystuen) have been refurbished and are being used for the initial field deployment in September 2008 by Miksis-Olds. Three new PALs are under production at APL/UW (Nystuen) and will be available during the second and third years of the project.

A PAL located at M5 will be recovered in September 2008. Data from this PAL will be used to modify the data collection algorithm to be used in the second and third years of the project.

RESULTS

This is the first year of this project. No results have been produced.

IMPACT/APPLICATIONS

The acoustic measurement system used in this project has the advantage of being deployed for long periods of time on subsurface moorings, affording the opportunity to collect valuable data during the harshest conditions of the winter season when traditional sampling techniques are not possible. The combination of year-round acoustic data collected with the active-passive acoustic system, hydrographic data collected by NOAA mooring sensors, and biological samples collected during each research cruise afford the opportunity to apply the acoustics to a large spectrum of scientific questions. Identifying relationships between physical forcing mechanisms, biological activity, and cetacean habitat use will not only be critical in understanding and ultimately predicting how cetaceans respond noise but also to how ecosystems respond to variability on multiple time scales.

The system used in this study is appropriate for use in almost all marine environments. It provides an advantage over continuous recording instruments in that the initial real-time processing of environmental sound by the PALs detect and identify sources of interest without an overwhelming amount of data needing post-processing. The PALs and active acoustic sensors can be programmed to sample at the same time scale to ensure synoptic data collection.

TRANSITIONS

Underwater ambient sound contains quantifiable information about the marine environment, especially sea surface conditions including wind speed, rainfall rate and type, and sea state conditions (bubbles). Furthermore, the presence or absence of sea ice is likely to have distinctive acoustic signature. Mostly this information is unused by oceanographers and the Navy. This project represents a transition from the study of these sounds into the application of the physical and biological interpretation of the sound to provide quantitative assessment of the acoustic marine environment to address a higher level question: What is the effect of changes in the physical marine environment on cetacean use of the habitat? This is a fundamental advance for practical use of passive acoustic monitoring of the underwater marine environment.

RELATED PROJECTS

The ONR-supported project "Monitoring sea surface processes using high frequency ambient sound", N00014-04-1-099, has as its principal goal to make passive acoustic monitoring of the marine environment an accepted quantitative tool for measuring sea surface conditions (wind speed, rainfall and sea state), monitoring for the presence and identity of marine wildlife (especially whales), and monitoring anthropogenic activities including shipping, sonar and other industrial activities. The new effort described here builds on the research of this ongoing project.

Several NOAA-supported projects, including Passive Acoustic monitoring of killer and beluga whales at the Barren Islands, Alaska, the Bering Sea Acoustic Report, Marine Mammal Monitoring for NW Fisheries, and Monitoring killer whale predation at Stellar Sea Lion rookeries in the Aleutian Islands, use PALs as the principal monitoring instrument for the description of the environment and for the detection an identification of marine cetaceans and other marine animals. This project benefits directly from the data collection strategies and interpretation developed for these projects.

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