The Influence of Oceanographic and Biological Processes on the Distribution of Cetaceans on the West Florida Shelf: A Synoptic Study Based on Underwater and Space-Based Remote Sensing

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LONG-TERM GOALS

Studies employing visual surveys for cetaceans typically suffer from high levels of spatial and temporal aliasing due to limitations in the number of vessels and the amount of survey time. We will use autonomous acoustic data recorders to monitor cetaceans over a large spatial and temporal scale, overcoming some of the limitations of studies based on visual surveys alone. These data will be complemented by visual survey data within the acoustic survey area during recorder deployment and retrieval. With *in-situ* and satellite remote sensing oceanographic data, relationships between the distribution of cetaceans and such factors as sea surface temperature, chlorophyll levels and background noise levels will be investigated on appropriate temporal and spatial scales. Results from existing numerical circulation models of the Gulf of Mexico will help understand underlying oceanographic processes.

OBJECTIVES

1. Determine the spatial and temporal distribution of cetaceans and noise on the central West Florida Shelf (WFS) through autonomous passive acoustic monitoring

2. Determine source levels of common cetacean species on West Florida Shelf and model sound propagation

3. Detect and quantify biological and physical oceanographic features present on the central WFS with satellite imagery, *in-situ* measurements, and modeling

4. Develop a library of sounds produced by common cetaceans from the Gulf of Mexico

5. Characterize the relationships between cetacean distribution, oceanographic variables and ambient noise levels

APPROACH AND WORK PLAN

Scientific Approach

In order to determine the spatial and temporal distribution of cetaceans on the central WFS, a sparse array of 80 acoustic recorders will be deployed over a 48,750 km^2 area (Figure 1). These recorders will record at high sampling rate, which is necessary for recording the high frequency vocalizations of many cetacean species. These recorders are designed to overcome the memory limitations associated with high sample rate recordings, and will have the memory and battery capacity for deployments up to seven months. Recorded cetacean vocalizations throughout the array will be used to determine the spatial and temporal distribution for a one year period, and these data will be complemented with ship-board visual surveys. Satellite data, including sea surface temperature from AVHRR sensors and sea surface color from SeaWiFS, will be collected for the same spatial and temporal scale as the cetacean distribution data. Algorithms have been developed for the detection of oceanographic fronts from such data; this and other techniques will be used to investigate relationships between cetacean distribution and oceanographic events. *In-situ* measurements, such as ADCP current vector data, and circulation models will be used to complement this work. A variety of pre-existing cetacean recordings will be collected to construct a library of cetacean sounds for the Gulf of Mexico. These recordings will be analyzed for species / genus-specific spectral features, which will allow us to develop species / genus identification algorithms. These algorithms will be applied to the WFS array recordings, allowing species or genus-specific distribution to be determined. During deployment & recovery cruises, a towed hydrophone array will be deployed. Cetacean recordings from these cruises will be added to the cetacean recording catalog, and will also be used to determine source levels for cetacean species encountered.

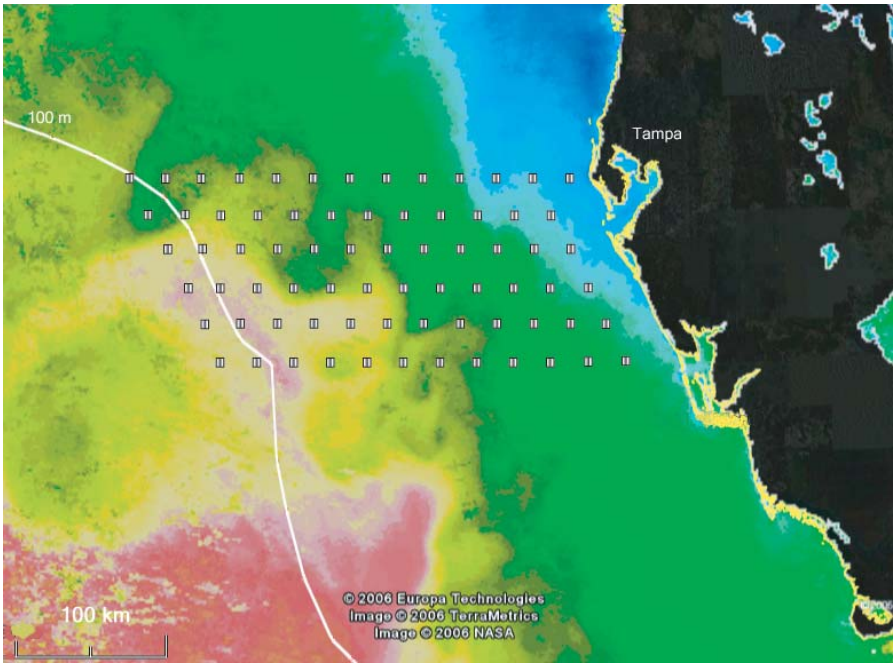

Figure 1. Planned DSG recorder array deployment on the West Florida Shelf with overlaid. The background picture is sea-surface temperature to illustrate the scale of variability over the array.

Key Personnel

Dr. David Mann (University of South Florida) is the project leader and an expert in marine bioacoustics. He will oversee the acoustic data collection and analysis of the cetacean recordings, and will be assisted by a PhD student. Dr. Bernd Würsig (Texas A&M at Galveston) is a leading expert in cetacean ecology and will oversee the cetacean acoustic catalog and cetacean distribution components of the project. Dr. Bob Weisberg (USF) is a physical oceanographer who currently operates an extensive *in-situ* monitoring array on the WFS. He will oversee the application of the numerical models, and will be assisted by three post-doctoral researchers and several technicians. Dr. Frank Muller-Karger (University of Massachusetts Dartmouth) and Dr. Chuanmin Hu (USF) are leading experts in satellite oceanography, and will manage the satellite data collection and analysis with the assistance of several post-doctoral researchers and graduate students. Dr. Beth Forys (Eckerd College) is a GIS specialist who will assist in the spatial analysis of cetacean distribution data. Dr. Adam Frankel (Marine Acoustics, Inc.) is also an expert in marine bioacoustics, and will develop the acoustic propagation models and source levels.

Work plans for upcoming year

Prototype acoustic recorders will be deployed in the next two months in shallow, nearshore waters. The acoustic recorder design will be finalized and a full deployment will follow in spring 2008. During this deployment, the first visual surveys for cetaceans will be conducted, and acoustic recordings for source level estimation will be collected. After the deployment, quality controlled satellite data will be collected. We will also begin modeling the active space using physical oceanographic data. For the acoustic catalog, additional cetacean recordings will be collected from a variety of sources, and the quantifiable components of the recordings will be analyzed. Salient features of species-specific vocalizations will be identified using principle components analysis.

WORK COMPLETED

This project began in August 2007 and is thus in the early stages. To date we have initiated a design for a Secure Digital card based acoustic recorder (DSG) with integrated acoustic release. This system is capable of sampling continuously at 100 kHz. In the next year we will implement real-time FFT algorithms for cetacean whistle contour extraction. We have obtained recordings of cetacean sounds from Dr. Würsig and are initiating analysis of them to develop our species-specific detection algorithms. Initial test deployments of the DSG will take place in December, and then an initial array of 20 DSG recorders will be deployed near the coast in the Gulf of Mexico in the spring of 2008. At the same time we will initiate array recordings with Marine Acoustics Inc (MAI) on the West Florida shelf to obtain cetacean source level estimates. We will also work with MAI to perform some initial modeling on hydrophone active space using physical data from Dr. Weisberg along with the cetacean source level measurements. Dr. Muller-Karger's team is currently performing an initial analysis on typical locations of front development on the West Florida Shelf. This analysis will be used to fine-tune the locations of the deployment of the DSG recorders in 2008/2009 when eighty recorders will be deployed. We have also begun integration of acoustic recorders with the Bottom-Stationed Ocean Profiler (BSOP). The BSOP is used to profile the water column and communicates physical oceanographic data back to shore via satellite. The incorporation of the passive acoustic sensors in the BSOP will allow us real-time access to summary acoustic data (the raw data would require too high a bandwidth to transmit).

RESULTS

The main technical result of this period was the development of the prototype DSG recorder, which is a low-power high-bandwidth acoustic recording system. We have also tested the whistle extraction algorithms with MATLAB software. These will now be implemented on the DSG recorders.

IMPACT AND APPLICATIONS

National Security

The passive acoustic devices developed as part of this project will be used to explore both natural and man-made sounds in the ocean environment. It is also potentially useful for detection of vessels in controlled areas, such as ports, and the incorporation of the passive acoustic recorders into the BSOP will allow a real-time vessel detection system with satellite communications to be developed.

Economic Development

The DSG recorder being developed by this project is a strong candidate for the basis of a start-up company focused on ocean acoustics.

Quality of Life

The results from this project will allow us to determine patterns of cetacean distributions in relationship to physical and biological oceanographic features. It will establish baseline data for understanding future potential impacts, such as the effect of seismic air-gun exposures on the behavior and distribution of whales and dolphins. This is important information for the oil and gas industry.

Science Education and Communication

This project's focus is on the sounds produced by whales and dolphins and is thus a topic that students and the public are naturally curious about. It provides a hook for education about the physics of sound and the ocean and food webs in the ocean.

RELATED PROJECTS

The MATLAB based program DPASS has been developed to automatically detect dolphin whistles and echolocation clicks from recorded sound files. The program uses a series of FFT's to develop a peak frequency plot, which is used to extract whistle contours. Echolocation clicks are identified using an energy detector. Initial algorithms have been developed, and have been applied with success to identify vocalizations of bottlenose dolphins recorded in New Pass, Sarasota Bay, Florida. Further development of the identification algorithms are currently underway. The final algorithms will be used to extract cetacean vocalizations from the recordings made during the NOPP funded project, and will provide the basis for species identification algorithms. This project was initially funded by Florida Sea Grant.