Ocean Acoustic Observatory Federation

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LONG-TERM GOALS

To establish and maintain a sparse network of acoustic receivers and sources and to make the data collected available for research. The observatories serve a dual purpose: capitalize on the proven potential for acoustics and observatories as oceanographic tools and maintain the momentum towards unveiling the ultimate limits to underwater surveillance.

OBJECTIVES

There are several objectives in our research:

- Instrument and operate several retired SOSUS stations in the Pacific with the goal of archiving a large, continuous collection of data which can be used to study oceanographic phenomena including acoustics, climate, seismology and biology.
- Monitor the acoustic environment near the Acoustic Thermometry of Ocean Climate (ATOC) source in Kauai.
- Operate and maintain the Naval Postgraduate School (NPS) ocean acoustic observatory.
- Conduct ocean acoustic tomography experiments in the vicinity of coastal North America.
- Monitor, in real time, marine mammals, earthquakes and volcanoes in the NE Pacific.
- Use portable acoustic stations for monitoring marine mammal migration and behavior in the NE Pacific.
- Conduct research on the data collected to integrate acoustic and satellite data, understand the coupling of elastic energy to acoustic signals capable of propagating large distances, coastal tomography and thermometry, and earthquakes and volcanoes in the northern Pacific.

APPROACH

The members of the Ocean Acoustic Observatory Federation are:

Scripps Institution of Oceanography
John Orcutt, Bill Kuperman, Walter Munk, Peter Worcester, Bill Hodgkiss, and Frank Vernon
Naval Postgraduate School
Curt Collins and Ching-Sang Chiu
University of Washington Applied Physics Laboratory
Chris Fox, Eddie Bernard, and Bob Dziak

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NOAA/Pacific Marine Environmental Laboratory
Bob Spindel, Bob Odom, and Jim Mercer

The roles of the members of the consortium are:

Scripps Institution of Oceanography
Coordinate the activities of the Federation, outfit additional retired SOSUS stations in the Pacific, conduct research in Pacific basin earthquake and volcano seismicity, monitor whale activity near the Kauai source with portable stations, conduct coastal tomographic studies, archive Pacific SOSUS data and integrate SOSUS and satellite data.

Naval Postgraduate School
Operate the NPS ocean acoustic observatory and conduct ocean margin tomography.

University of Washington/Applied Physics Lab
Outfit retired SOSUS stations, conduct research in Pacific ocean basin phenomenology using SOSUS, and integrate SOSUS and satellite data.

NOAA/Pacific Marine Environmental Laboratory
Monitor in real time NE Pacific marine mammals, earthquakes and volcanoes, integrate SOSUS and satellite data and use portable stations in monitoring.

WORK COMPLETED

NPS and SIO, using the R/V Point Sur, placed an acoustic source on Hoke seamount during a cruise on 30 April - 7 May 1999, 600 km from the Pt. Sur SOSUS array. The location of the HLF-5 source is at 32° 6.32'N, 126° 54.57'W in 765m of water. The purpose of the mooring is to provide a signal for imaging the California Current using SOSUS arrays at Pt. Sur and San Nicholas Island, California. The source is transmitting both tomographic M-sequence and RAFOS signals at 250Hz with an output level of 192 dB re 1μPa. During the bulk of the year's deployment, the source will transmit every four days for the M-sequence and every day for RAFOS. During the transmission days, the signals will be sent every four hours in order to resolve tidal variability. While the experiment was designed to be regional, the signals are recorded at several west coast SOSUS stations as well as the Barbers Point array, 2000 km distant. While the SNR at Pt. Sur is 4 dB, the processed SNR is 43 dB.

SIO has monitored the ATOC source located at Kauai since June 1998. The following table shows the dates of field trips to Kauai to service the two instruments deployed:

Deploy 1:	6/27/98	Start of experiment
Deploy 2:	8/27/98	•
Deploy 3:	11/23/98	•
Deploy 4:	2/10/99	•
Deploy 5:	4/28/99	•
Deploy 6:	8/14/99	•
Recover 6:	10/06/99	End of experiment

The final recording was completed on 6 October 1999. The instruments used for monitoring were the IGPP Low-Cost Hardware for Earth Applications and Physical Oceanography (L-CHEAPO). The instruments record for several months autonomously at a sample rate of 4 kHz in order to capture the full bandwidth of the whale vocalizations.

SIO has hired a PostDoc, Paul Gendron, who will be working with Bill Hodgkiss and Bill Kuperman in applying modern techniques in signal processing, especially wavelet analysis, to the long time series collected by the Federation. These will include earthquakes and whale calls. When both Barbers Point and Pt. Sur are being recorded full time, he will address the inter-processing of cross-basin arrays. SIO will acquire a new 1.4 TB mass store early in 2000 to house the growing collection of acoustics data.

NOAA/PMEL continued data acquisition from ten operational SOSUS arrays in the North Pacific. The data are continuously recorded, analyzed and archived at over 10 GB of information each week. The archived data are currently being re-analyzed and migrated from 8mm cartridge tape storage media to digital linear tape (DLT). The data collected are all analyzed for basin wide seismicity, volcanic eruption monitoring, and marine mammal analysis. NOAA/PMEL also assists the Navy command, NOPF, at Whidbey Island, Washington, in the maintenance of shore facilities on the Washington and Oregon coasts.

NOAA/PMEL has developed an advanced autonomous hydrophone and recorder which is capable of recording 32 GB of data and maintaining timing at an accuracy of 200 ms/year. Fifteen of these units have been built and an array of six were deployed in the Gulf of Alaska in October 1999 to record at 1 kHz for a year. The primary objective is to study the blue whale migration along the West Coast and the Aleutian Chain, although new information will also be gathered on other whale species (fin-backed whales, humpback whales, and sei whales), and analysis of seismicity in the Aleutian trench is possible.

RESULTS

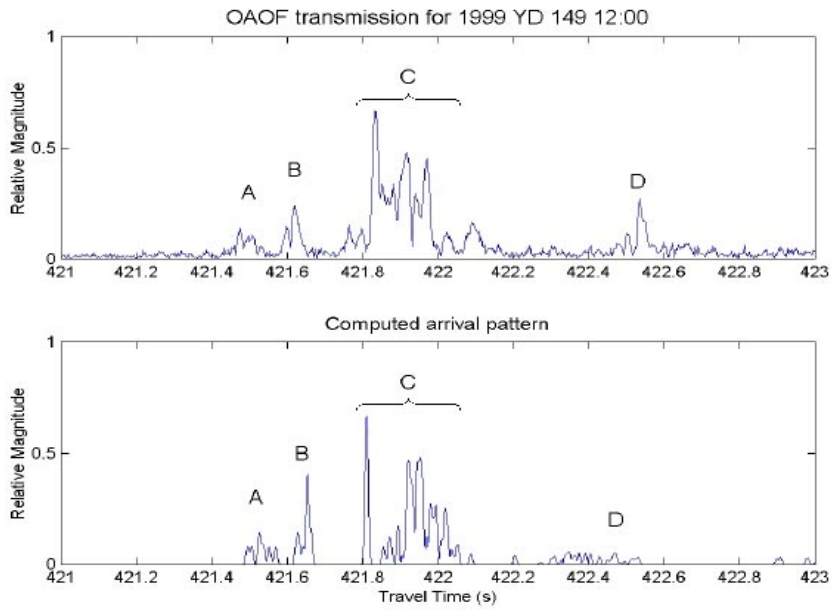

Figure 1: Modeled acoustic arrival structure (lower panel) of the transmitted signal from Hoke Seamount and a comparison to the observed arrival structure (upper panel). Our modeling used a range-dependent ray-theory model with input sound speed field and bathymetry derived from hydrographic and echo sounding measurements obtained from the source deployment cruise. Four

groups of arrivals (A, B, C, and D) are consistently observed in all of the transmissions. The fine structure within each group, however, is observed to vary from time to time. Model results show that each of the four groups are composed of overlapping individual ray arrivals and that the variation of the fine structure within each group is due to phase interference. The temporal variability of the ray group travel times can be related to range-averaged temperature changes. In an effort to increase spatial resolution, an inversion scheme that can account for the phase interference of the multipaths are being formulated.

Figure 1 illustrates a comparison between predicted and observed ray/mode arrivals at Pt. Sur from the source at Hoke Seamount. The coherence and quality of the recordings provide an excellent data set for collecting long-term time series of the behavior of the California Current.

We have demonstrated that the two classes of T-phases (abyssal and slope) can be synthesized under the assumption that T-phases are excited by Rayleigh scattering from a round seafloor. Seafloor scattering at shallow depths preferentially excites low order acoustic modes that propagate efficiently within the ocean sound channel. At greater depths, scattering excites higher order modes which interact weakly with the seafloor along much of the propagation path. Details can be found in de Groot-Hedlin and Orcutt (1999 a,b) below.

IMPACT/APPLICATIONS

We are not anywhere near the limits of what can be done with underwater acoustics, and the key to exploiting these capabilities is to work with and not against the ocean environment. At this time when the operational surveillance systems are being disbanded, we have established and maintained a sparse network of acoustic receivers and sources with data available for research. The observatory has a dual purpose: one is to capitalize on the sources and receivers proven potential as an oceanographic and geophysical observatory; the other is to maintain the momentum towards unveiling the ultimate limits to underwater surveillance. The two goals are very closely related. The detection of things in the sea, be they submarines, volcanoes, earthquakes, slumping, whales and other mammals, near-surface processes, global warming,…, is tantamount to studying the sea itself.

TRANSITIONS

Dr. Chris Fox has served on the Scientific Committee of the International Whaling Commission to encourage the use of acoustic techniques for marine mammal assessment. In addition, he serves on a Working Group for the Office of the Chief of Naval Operations for the environment (N45) to formulate plans for Navy environmental compliance for living marine resources. He has also briefed the Commander Undersea Surveillance (CUS) in Dam Neck, VA on Federation efforts in ocean acoustics and visited the Naval Ocean Processing Facility, St. Mawgan, UK to explain Federation efforts and seek approval for installation of Federation systems at NOPF.

RELATED PROJECTS

John Orcutt, with Specialist in Geophysics Catherine de Groot-Hedlin, conducts research related to the excitation and propagation of acoustic energy for DoD. The purpose of this research is to understand

the excitation of T-phases by explosions and earthquakes and the use of acoustic systems in monitoring the Comprehensive Test Ban Treaty. The grants are:

Detection of oceanic events at T-phase and seismic stations: observations and modeling. DSWA-01-09-1-004, 9/30/98 - 9/29/01.

The use of hydroacoustic phases for the detection of oceanic events: observations and numerical modeling. DSWA-01-97-C-0162, 9/22/97 - 10/22/00.

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