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Briefing Memo

Date: June 16, 2003

To: Commissioners and Interested Persons

From: Peter Douglas, Executive Director
Elizabeth A. Fuchs, Manager, Statewide Planning and Federal Consistency Division
Mark Delaplaine, Federal Consistency Supervisor

Subject: Naval Postgraduate School Active Acoustics and Potential Effects on Sea Otters

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Background

In response to public comments at the May 2003 Coastal Commission meeting (Attachment 5), the Commission requested its staff to determine what, if any, active offshore underwater acoustic activities were being conducted by the Naval Postgraduate School (NPGS) in Monterey. Allegations were made at the meeting that such acoustics could be affecting sea otters. The Commission also requested the staff to look into whether the activities should be reviewed under the federal agency provisions of the Coastal Zone Management Act (as have Scripps ATOC[1] sound experiments and Navy LFA sonar[2]).

Navy Sound Sources

The Navy conducts two types of activities at the NPGS involving active underwater acoustics: underwater autonomous vehicles (UAVs) and RAFOS[3] floats. Both of these types of equipment are used to study underwater currents and other subsea phenomena, and both are types of equipment used by other oceanographic institutions around the U.S. that are generally not, to date, subject to regulatory controls.

1 Acoustic Thermometry of Ocean Climate (ATOC) (CC-110-94 & CDP 3-95-40).

2 Surveillance Towed Array Sensor System Low-Frequency Active (SURTASS LFA) Sonar Program (CD-113-00).

3 RAFOS is the inverse of SOFAR, which is the acronym for Sound Fixing and Ranging.

The NPGS' UAVs are similar to those used by the Monterey Bay Aquarium Research Institute (MBARI) for oceanographic research (Attachment 3). The UAVs are tracked (usually with remotely operated vehicles (ROVs)) using sounds at an intensity of about 180 dB, which, due to the high frequency (22-28 kHz), dissipates very quickly in water. These types of sounds are similar to side-scan sonar, and fish finders, and a variety of marine sounds relying on high frequency sound. These types of sound are quite common in the marine environment and used by many oceanographic research institutions. They have not, to date, been implicated in concerns over noise pollution in the marine environment. A previous Commission staff memo[4] described the lack of concern over high frequency sound as follows:

> *The primary concerns that have been raised in the past decade about the effects of noise on the marine environment have been related to low-frequency (i.e., less than 1 kHz) and mid-frequency (i.e., 1-10 kHz) sound. High frequency sounds (i.e., greater than 10 kHz) with anthropogenic sources in the marine environment include: (1) fish finding sonars, which operate in the 18-200 kHz region (of which there are thousands deployed world-wide and many off the California coast); (2) depth sounding sonars, with operating frequencies often at 12 kHz (most ships transiting California use these sonars); (3) bottom profilers, which range from 400 Hz to 30 kHz; (4) side scan sonars (50-500 Hz); (5) navigation transponders (7-60 kHz); and (6) various military search and surveillance (2-57 kHz) and mine avoidance (25-500 kHz) sonars. (To date, the Coastal Commission has not attempted to regulate these high frequency sonars, which are fairly commonly used in coastal waters and whose sounds attenuate rapidly in the marine environment.)*

The NPGS' RAFOS floats do involve low frequency sound, although they could hardly be considered unique or unusual sound sources. The NPGS has deployed its sources since 1994, and RAFOS floats are used by many marine oceanographic institutions worldwide (there are currently hundreds of them in use) to study ocean current dynamics. The particular type of RAFOS sound sources used by the NPGS (deep water, low frequency) is designed to benefit from the sound transmission capabilities present in the SOFAR channel (SOFAR is an acronym for Sound Fixing and Ranging, and RAFOS is the inverse of SOFAR).

> [Note: The SOFAR channel is a layer of water deep in the ocean formed by the interplay between changes in ocean temperature and pressure with increasing depth (deeper (600-1200 m) at lower latitudes, and, shallower (200 m) towards the poles), where sound waves are trapped and travel great distances. For example, the Heard Island Feasibility Test (HIFT) conducted in 1992 (dubbed "the shot heard half way round the world"), used a sound level of 221 dB and a frequency of 57 Hz, transmitted through the SOFAR channel to receivers over distances of up to 17,000 km., demonstrating the tremendous potential for transmitting sound at transoceanic distances.]

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[4] *Background Discussion for Commission Briefing by Dr. Peter Tyack, High-frequency sonar tests to detect gray whales offshore of the San Luis Obispo County coast,* CCC Staff, November 20, 2002.

The locations of the NPGS' RAFOS sound sources are shown in Attachment 2. Fixed at a 500-650 meter depth (at the mid-depth of the SOFAR channel), these sources send acoustic signals to various receiver floats at a frequency of 261 Hz, enabling the tracking of ocean currents. The sound sources are located far offshore, at distances and depths (as well as very short duty cycles) that make it highly unlikely they could affect or even be detected by sea otters, which remain close to shore and near or at the water's surface. The closest source to Monterey Bay (SS3) is over 350 miles from shore. The sources transmit sound twice per day, for approximately 80 seconds per transmission. The NPGS sources broadcast at 183 dB[5] at 261 Hz.

RAFOS floats have been in use extensively for decades, throughout the world's oceans. In the early 1970s, they evolved to include the low frequency version (as used by NPGS) and to transmit via the SOFAR channel. The manufacturer of the particular sound sources used by the NPGS lists a number of other users of similar equipment, including Woods Hole Oceanographic Institution, University of Washington, University of Rhode Island, NOAA/Pacific Marine Environmental Laboratory, and German and French ocean institutes (Attachment 1).

Sea Otter Hearing

Little definitive information about sea otter (*Enhydra lutris)* hearing thresholds and ranges is available, especially for underwater hearing. Sea otters communicate in air in the 3-5 kHz frequency range. Their ear structures are similar to those of North American river otters (*Lutra canadensis)*, for which tests have indicated a functional hearing range in air of approximately 450 Hz to 35 kHz (with peak sensitivity at 16 kHz); however no audiograms or similar tests are available for sea otters. Sea otters have a well-defined external ear flap that folds downward on dives; however scientists do not know whether this affects their hearing underwater. (Ketten, 1996)

A few studies in California waters have attempted to correlate manmade noise and sea otter behavior. Industrial (oil- and gas-related) sounds, including simulated drilling and seismic surveying off the sea otter range in 1983 and 1984 (conducted as part of the 1983-1984 tests on gray whale migration *(Malme et al., 1983; 1984)*, did not induce strong behavioral reactions. The simulated drilling noises were on the order of 185 dB at the source (SL), and probably approximately 135 dB as received by the otters (RL). The seismic noises were louder, possibly 210 dB at the source, and possibly 160 dB RL (rough estimate only). Sea otter reactions were fairly minimal and short lived. The study's conclusions included:

> *The behavior, density and distribution of sea otters from Bixby Creek to Point Lobos was unaffected by the playback of industrial noises and the air gun-generated seismic sounds. ...*
>
> *During all acoustic experiments, the foraging and diving behaviors of otters were normal and undisturbed. ...*

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[5] re 1 μPa (1 micro Pascal) at 1 m (applies as well to subsequent references to dB levels in this paper).

During the single air gun experiments, the raft of otters in Lobos Cove was slightly alarmed at times by the close approach of the single air gun vessel or the relatively loud airborne sounds generated by the boat engines and compressor, rather than by the waterborne seismic sounds. ...

No movements of otters out of the sound projection vicinity or away from the sound sources took place during any of the acoustic experiments. ...

Information is lacking concerning the hearing sensitivity of the sea otter, as well as the importance of underwater acoustic signaling and sound reception to diving and socially interacting otters.

A second otter study (Davis et al., 1988) looked at whether visual, acoustic, or olfactory stimuli could be used effectively to intentionally deter sea otters from entering oil slicks. The sounds including a warble tone (530 Hz-1.38 kHz, 118-142 dB), air horn, killer whale sounds (500 Hz-3.5 kHz), underwater acoustic harassment devices (10-20 kHz, 190 dB), and sea otter pup calls (200-300 Hz, with harmonics). This study too showed minimal effects from the noise on sea otter behavior. Otters habituated to the sounds after 2 hours. Killer whale sounds elicited greater reactions in Alaska than in central California (where killer whales are scarce). The study concluded that "...certain sounds will alarm and disperse sea otters. Unfortunately [for this use - intentional dispersal away from an oil slick], the effect has a limited range (100-200 m) and habituation occurs quickly (within hours or, at most, 3-4 days)."

Sea Otter Declines

In regular surveys of the California sea otter population between 1995 and 2002, the number of sea otter counted has declined about 10%. While this year's counts are up ("Officials counted 2,505 otters between May 10 and May 15, a 17 percent increase over the 2,139 otters tallied in the same period last year," Associated Press, June 6, 2003), the number of otter deaths for otters in a healthy age range indicates cause for continued concern. Furthermore, researchers generally look at 3 years of data for establishing a trend. The causes for the declines in recent years are complex and not well understood. Factors include disease, entrapment in fisheries gear, habitat degradation through pollution and other human impacts, and food limitations. Recent studies indicate a growing concern over parasites (in particular, parasites related to cat feces (*Toxoplasma gondii)* and opossums (*Sarcocystis neurona)*).

A recent news article (June 2, 2003, San Francisco Chronicle) reported:

A recent UC Davis study found that two protozoans -- Toxoplasma gondii and Sarcocystis neurona -- were responsible for an increasing number of California sea otter deaths. Another parasite that lives in sand crabs, which otters sometimes eat, also was implicated in some deaths.

While Toxoplasma and Sarcocystis infect a wide variety of animals, only two species transmit infective "cysts" in their feces -- house cats for Toxoplasma, and the Virginia opossum for Sarcocystis.

No firm parasite transmission routes from terrestrial animals to otters have been established, but researchers think contaminated cat and opossum feces could be accumulating in backyards, parks and vacant lots throughout the year, to be ultimately flushed into coastal waters during winter storms.

Cat owners also may be unwittingly distributing Toxoplasma by flushing biodegradable cat litter into municipal sewer systems.

The infective cysts then could be present in tidal waters and ingested by filter-feeding clams and mussels, or they might attach to algae and be consumed by abalone. The otters probably are infected by the parasites when they eat the shellfish, which are among their preferred foods. The study found high incidences of sea otter infection near freshwater outfalls.

To date, researchers have not been focusing on noise as either a direct or indirect factor in the recent declines in sea otter populations. For example, there is no evidence to suggest that anthropogenic noises might be causing otters to modify their behavior (e.g., by causing them to relocate to areas where they could be exposed to greater levels of toxins or parasites).

Conclusion

The Commission staff does not believe the Naval Postgraduate School is conducting acoustic activities that have the potential to affect coastal zone resources (such as sea otters or other coastal marine mammals) to the degree that would warrant Commission federal consistency review.

Attachments

1. RAFOS Floats Manufacturer, Web Site
2. Location of NPGS RAFOS sources
3. Artist's rendering, MBARI AUV
4. Noise excerpt, Ecosystem Observations, Monterey Bay National Marine Sanctuary
5. Letter to Commissioners, May 9, 2003, Jay Murray

Sources

1. Riedman, M.L. 1983. *Studies of the effects of experimental noise associated with oil and gas exploration and development on sea otters in California.* Report by Center for Coastal Marine Studies, UC Santa Cruz, for U.S. U. S. Dept. of the Interior, Minerals Management Service, Anchorage Alaska. NTIS B86-218575.

2. Riedman, M.L. 1984. *Effects of sounds associated with petroleum industry activities on the behavior of sea otters in California*, Appendix D, *Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior. Phase II: January 1984 migration,* Malme CI, PR Miles, CW Clark, P Tyack and JE Bird (1984), Bolt Beranek and Newman Report No. 5586 submitted to Minerals Management Service, U. S. Dept. of the Interior. NTIS PB86-218377.

3. Malme CI, PR Miles, CW Clark, P Tyack and JE Bird (1984), Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior. Phase II: January 1984 migration; and Malme CI, PR Miles, CW Clark, P Tyack and JE Bird (1983), Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior. Bolt Beranek and Newman Report No. 5586 and 5366, respectively, submitted to Minerals Management Service, U. S. Dept. of the Interior.

4. Davis, R., W., T.M. Williams, and F. Awbrey, 1988, Sea otter oil spill avoidance study, Sea World Research Institute, Hubbs Marine Research Center, San Diego, CA. Prepared for U.S. Department of the Interior, MMS Contract No. 14-12-0001-30256. OCS Study MMS 88-0051

5. *Marine Mammal Auditory Systems: A Summary Of Audiometric And Anatomical Data And Its Implications For Underwater Acoustic Impacts,* Darlene R. Ketten, Ph. D., Woods Hole Oceanographic Institution (August 1996).

6. *Background Discussion for Commission Briefing by Dr. Peter Tyack, High-frequency sonar tests to detect gray whales offshore of the San Luis Obispo County coast,* CCC Staff, November 20, 2002.

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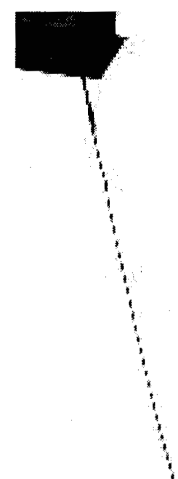
RAFOS MOORED SOUND SOURCE

Moored sound source, user programmable. Multi-year life, depending on application. Suitable for RAFOS and other applications.

Nominal Specifications:



Frequency range:	**Standard RAFOS sweep, 261Hz**
SPL:	**181 dB re 1 micropascal at 1 m**
Projector:	**"Organ-Pipe" free flooded, 36 cm diameter**
Controller:	**SeaScan/Tillier design. Programmable via external connector. Temperature compensated time base. (Delta f)/f = 5 x 10^{-8}**
Batteries:	**Alkaline "D" cell assembly**
Endurance:	**4000 transmissions**
Maximum operating depth:	**2000 m**
Material:	**Aluminum 6061-T6 End-caps hard anodized**
Weight:	**360 kg (140 kg submerged)**
Mooring Tension Maximum:	**4400 kg (10,000 kg with optional external tension member)**

Current Users:
Woods Hole Oceanographic Institution
University of Washington
University of Rhode Island
NOAA/Pacific Marine Environmental Laboratory
Institut für Meereskunde, University of Kiel (Germany)
Institut Francais de Recherche pour L'Exloitation de la Mer (France)

Related Links:
University of Rhode Island RAFOS Float Group
Naval Postgraduate School Subsurface Lagrangian Studies

Attachment 1

RAFOS Float Home Page - Taygeta Scientific
Rafos Float Trajectories from the Labrador Sea Water Level in the Iceland Basin - IFM, Kiel

Webb Research manufactures neutrally buoyant drifters, drifting profilers, RAFOS sound sources, and Tomography transceivers of a variety of standard and custom designs.

Home	Products	General Information	Related Links

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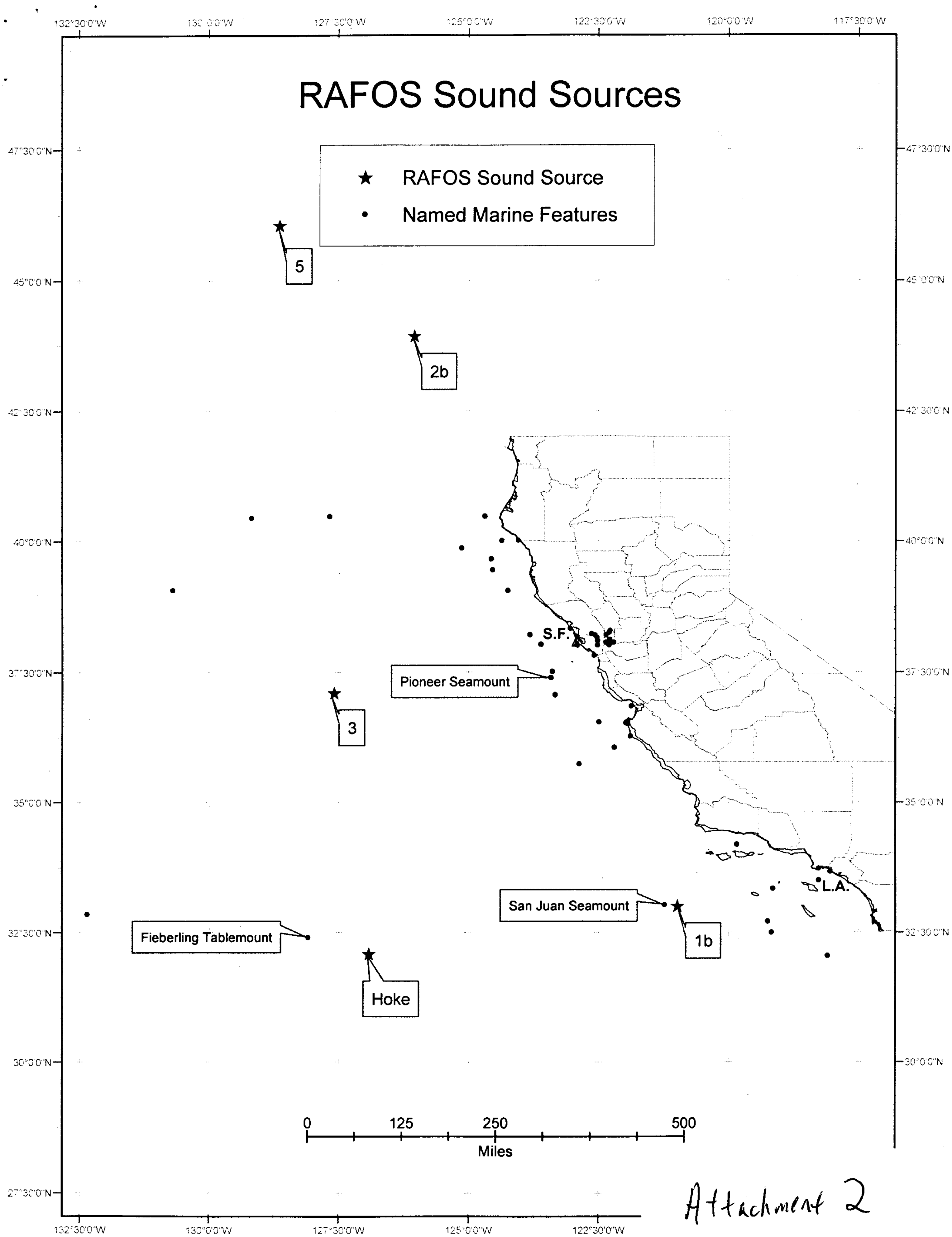
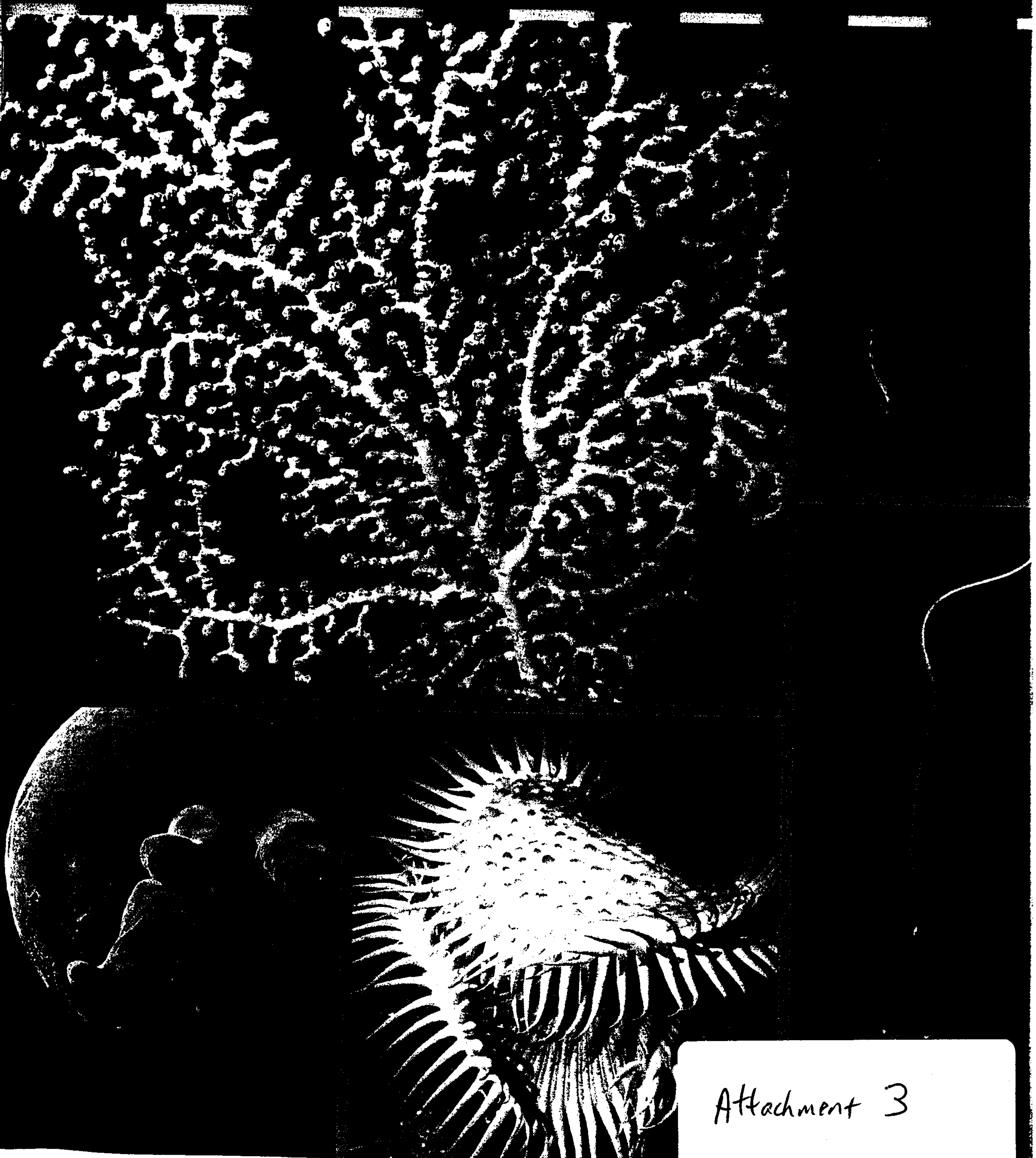


Attachment 2

ECOSYSTEM OBSERVATIONS

for the Monterey Bay National Marine Sanctuary
2002



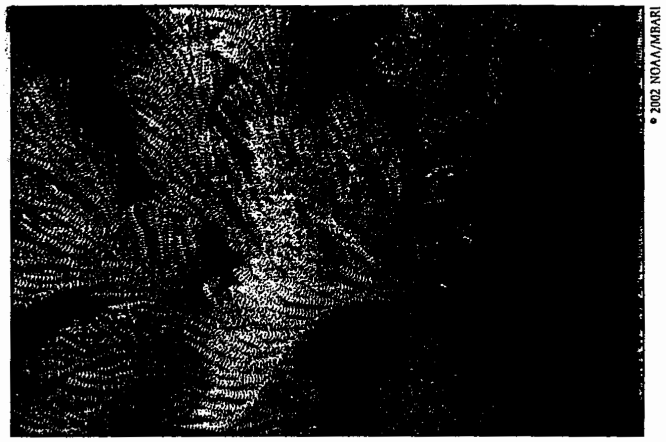
Attachment 3

Above the seamount, we made observations of birds and mammals during the daylight hours. We encountered a total of nine different species of mammal, including killer whales, as well as fifteen species of bird, of which the Black-Footed Albatross was the most common. We followed a pod of sperm whales with a small boat launched from the ship but were not able to obtain skin samples requested by NOAA Fisheries for genetic analysis.

A key component of our expedition team was the educators, who were team members along with the scientists and resource managers. Our expedition was shared with students and the public on a web page that consisted of daily updates and video clips along with an "ask the explorer" e-mail option to link us with the rest of the world. Whether it was the unique creatures, the geology, or the technology, we piqued the interest of the public – with up to 140,000 visitors per day to our web site and a story on the CBS Evening News.

Resource managers came to the conclusion that the Davidson Seamount is a unique habitat, based on the number of new and rare species, large and long-lived species, and the potential fragility of this habitat. Currently, there are no seamount habitats under protection in any of the thirteen national marine sanctuaries around the United States. As part of the current sanctuary management plan revision process, a diverse working group of interested parties is assessing the necessity of including the Davidson Seamount within the sanctuary boundary.

Our cruise was exciting in terms of scientific discovery as well as educating the public and influencing resource management processes. Bringing educators and resource managers on what could have been a more standard science cruise was a successful experiment for us. Today, ocean exploration is clearly a wide-open field with many opportunities for public involvement and resource


© 2002 NOAA/MBARI

Pink gorgonian coral growing on hard substrate at 1,573 meters (5,161 feet). Shrimp, brittle stars, and crabs were often found associated with this gorgonian.

management. We're looking forward to finalizing our analyses of the collected video images and listing all the new patterns and questions that arise from our quantitative descriptions. Perhaps most importantly, we are eager to contribute to conservation efforts, if the public and formal decision makers decide that the Davidson Seamount deserves special protection.

The Davison Seamount expedition was a multidisciplinary effort with members from the following institutions: the sanctuary, Moss Landing Marine Laboratories, the Monterey Bay Aquarium, MBARI, the National Marine Fisheries Service, the Alliance for Coastal Technologies, and the Office of Exploration.

–Andrew DeVogelaere
Monterey Bay National Marine Sanctuary

One Year on Pioneer Seamount

Fifty miles off the California coast, just over the edge of the continental shelf, an underwater mountain rises from the Pacific Ocean floor, cresting 900 meters below the ocean surface. This underwater aerie, twice as high as Mount Tamalpais, surveys the open ocean to the west, the Juan de Fuca Plate to the north, and, to the south, the teeming wildlife of the Monterey Bay National Marine Sanctuary. Pioneer Seamount is an ideal vantage point for observing everything happening in this part of the ocean.

Underwater observation is not done with light. In even the clearest of seawater, light is strongly absorbed: two-thirds of blue light is absorbed over a distance of fifty meters, and red light fares even worse. In the murkier water of the Pacific, a whale can barely see its own tail, much less its mate or a straying baby. In this situation, sound replaces light and ears become eyes.

In contrast to light, sound travels almost forever underwater. Frequencies of 50 hertz (Hz) and below, favored by some whales, travel long distances with little attenuation. In 1995 this led the scientists of the Acoustic Thermometry of Ocean Climate (ATOC) project to choose Pioneer Seamount as a site for transmission and reception of low-frequency signals.

At the end of the project, an initiative was undertaken to preserve the underwater cable to shore for use in non-invasive environmental monitoring, spearheaded by our group at San Francisco State University, with the support of David Evans, Director of NOAA's division of Oceanic and Atmospheric Research. Concerned environmental groups acceded to the logic of this proposal. A team of scientists led by Chris Fox of NOAA's Pacific Marine Environmental Lab (PMEL) and Jim Mercer of the University of Washington's Applied Physics Lab then installed a small vertical linear array (VLA) of four hydrophones, covering the frequency range of 10 to 450 Hz. On September 1, 2001, the Pioneer Seamount Observatory came on line.

During the following year, the observatory suffered a variety of minor equipment problems and one failure that required bringing the "wet electronics" to the surface for repairs. This entailed a wait of four months for ship availability and suitable weather conditions. Even so, the observatory's live time averaged nearly 60 percent during a period of more than a year, and a large body of data is now available for analysis.

The accompanying figure (*see p. 11*) is a composite spectrogram of acoustic signals commonly observed at Pioneer Seamount. The spectrograms show frequency versus time, and most of the interesting phenomena can be located by scanning the spectrograms. Four signals of interest are shown.

Ship Propeller Sounds

The most obvious and loudest feature is the pattern of nested parabolic lines covering most of the spectrogram. This is the signal of a ship passing over Pioneer Seamount. Sounds like this are the loudest noises observed at Pioneer Seamount. Because of the long distances these sounds travel, the sounds from distant ships also make a major contribution to the ambient noise level.

The complex pattern of this spectrogram is due to the interference among the four hydrophones of the VLA, whose signals are added coherently. Where the bright lines dip down to their lowest frequencies, the ship is at its point of closest approach, and the frequency at that point gives its distance. From the rate at which the interference lines diverge, the speed of the ship can be determined. The pattern shown corresponds to a ship passing

Attachment 3 (cont'd)

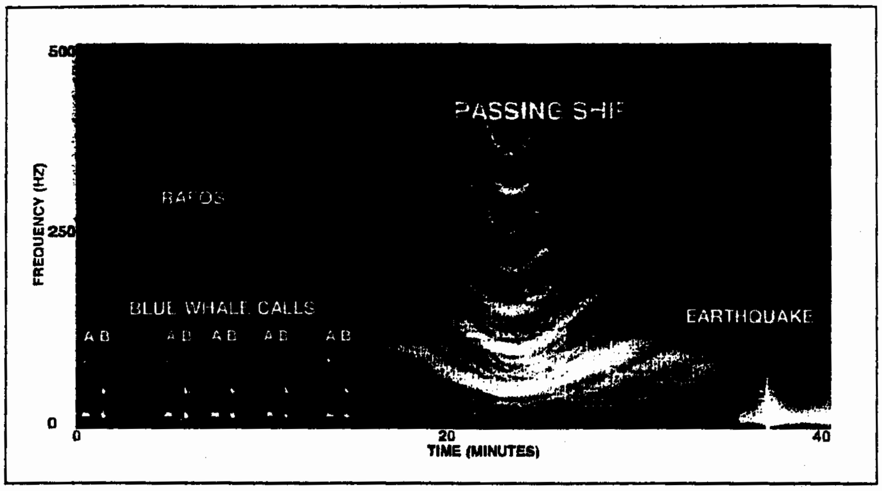


Figure 1. Composite spectrogram showing four commonly observed acoustic signals

about 350 meters from the array's location, and traveling roughly in a straight line, at a constant speed of twelve knots.

Blue Whale Calls

On the lower left-hand side of the figure appears a series of five blue whale (*Balaenoptera musculus*) "A-B" calls. Each pair starts with an "A" call about twenty seconds long, with substantial power at 16 Hz (below the limit of human hearing) and at 90 Hz, near the fifth harmonic of the low-frequency fundamental. The "B" call follows about fifty seconds later and has its frequencies concentrated at 16 and 48 Hz, the first and third harmonics of the same fundamental. These sounds are generally played back at between four and ten times their true speed, moving their frequencies into the center of the range of human hearing. The "A" call sounds like a series of "gurgles," and the "B" call that follows is a sad "moan," dropping steadily in frequency during its fifteen-second duration.

The "B" call, the less complex of the two, is fairly easy to recognize with automated pattern recognition. An effective method described in the literature uses a "matched filter" consisting of a perfect sine wave at about 16 Hz, dropping slightly in frequency during the "moan." This procedure identified about 5,000 "B" calls during the last year, most of them coming in the fall months of September through November. While data from a full year are not available, the difference between the busy fall and a silent spring is striking.

The large number of individual whale calls recorded may eventually provide a means of approaching the "holy grail" of marine mammal acoustics – the identification of individuals from their calls. The most striking feature of the blue whale calls is their lack of variability, as if the whale were repeating the same "word" over and over. However, there is some variation in harmonic structure, length of calls, and spacing of calls. In the future, these and other details of the calls may provide a way to tag individuals, age groups, or sex groups.

RAFOS Timing Sources

The fine, nearly horizontal line on the spectrogram labeled "RAFOS" is the signature of a swept-frequency signal (a "chirp") from one of the acoustic beacons that make up a sort of underwater GPS navigation array for the eastern Pacific Ocean. The signal shown is from a source moored 400 kilometers west of Portland, Oregon. The delay between the known broadcast time and the detection time can be translated into a distance from the source. The signals from multiple active sources permit the determination of the position of a drifting receiver. Plotting daily positions of each drifting instrument allows determination of the eastern Pacific subsurface ocean currents, something otherwise very difficult to measure. The Pioneer Seamount Observatory is used to monitor the timing accuracy of the sources.

Earthquakes and LFA

The signal from a small earthquake is indicated on the spectrogram. Such quakes are detected about once per day. These arrivals will eventually be integrated with seismometer data to study earthquakes in the Pacific floor, although at present there are no ocean-floor seismometers in this general area of the Pacific. At present, study of plate-tectonic motion along the California coast is hampered by the fact that most observations are made east of the plate boundary. The addition of a seismometer would be very valuable for earthquake geologists.

The recent announcement by the U.S. Navy of its intention to test the SURTASS LFA (surveillance towed array sensor system, low-frequency active) sonar system for submarine detection in the Pacific lends additional interest to underwater acoustic monitoring. The proposed source level of the LFA array is 240 dB re 1 μPa ("water decibels," not "air decibels"; to convert from dB in water to dB in air, subtract 60 dB) at 1 meter. Operation 200 miles off the California coast would result in sound levels of 180 dB re 1 μPa (again "water decibels," not "air decibels") in the sanctuary, a sound level considered by some to be dangerous to marine mammals. Independent monitoring of these sounds at Pioneer Seamount during these tests would enable the sanctuary to quantify the noise levels produced and to look for the response of marine mammals to the noise.

The Future of the Pioneer Seamount Observatory

Pioneer Seamount is the first, and only, publicly accessible underwater observatory. Its first year of operation revealed the variety and quality of information to be obtained from a cabled offshore acoustic observatory. Its data support basic research in physical oceanography, geophysics, ocean engineering, and marine mammal research as well as the sanctuary missions of tracking populations of marine animals and monitoring their acoustic environment. With the use of air guns for geophysical investigations (potentially including oil exploration) and the prospect of SURTASS operation nearby, an acoustic monitoring station takes on added importance.

Pioneer Seamount went off the air on September 24, 2002 at 12:07 universal time. The center conductor of the coaxial cable is apparently shorted out to sea water. This is only the second cable failure over the seven years that the cable has been in place. The first failure (and possibly the current damage) was caused when a bottom trawler snagged the cable, an unavoidable hazard of the marine environment. Once repaired, this unique window into the ocean will continue to help scientists and regulators protect the sanctuary environment.

Interested readers can listen to the sounds of the Pioneer Seamount at www.physics.sfsu.edu/~seamount/gallery.html.

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MBARI - Annual Report

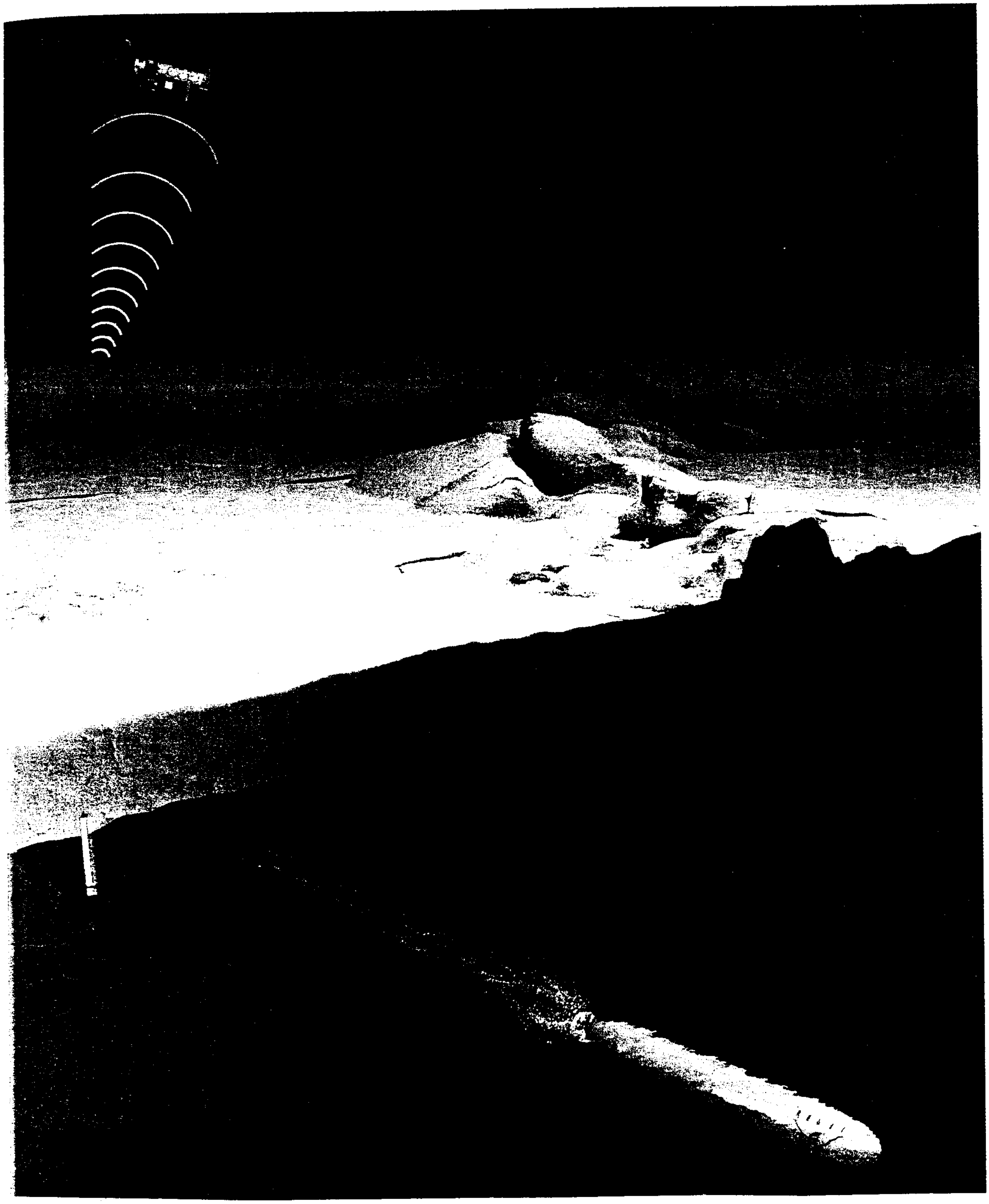

Figure 29. Artist's rendition of the Atlantic Layer Tracking Experiment (ALTEX) mission. The AUV was uniquely equipped for ALTEX with science sensors and an ice-buoy communication system that allowed it to gather data beneath the ice sheet and beam it back to researchers via satellite.

Attachment 4

gure 27. The AUV *Dorado* is lowered from the ship for a mission at the edge of ie arctic ice.

rom moorings and satellite show that winds would not have orced surface transport into the bay during the period when the ow chlorophyll plumes were observed, thus suggesting local upwelling from the canyon. The influence of Monterey Canyon on circulation and regional ecology is an important research topic, and what we learn about topographic effects locally will be applicable to better understanding of other coastal marine ecosystems where topography influences transport of waters, nutrients, organisms, and sediments.

AUV *Dorado*

Moored observatories provide very detailed knowledge of ocean processes in the vertical and temporal domains, but do a poor job of sampling in the horizontal domain. For this reason, MBARI is continuing development of the modular AUV, *Dorado*, capable of supporting a broad range of oceanographic investigations. One of the new payloads being integrated into *Dorado* is a state-of-the-art sonar to create high-resolution bathymetric maps of the deep ocean. Other sensor suites will measure the physical, chemical, and biological properties in Monterey Bay along oceanographic transects between moorings on a routine basis. Early development of *Dorado* has been partially funded by the National Ocean Partnership Program and the National Science Foundation.

In October 2001, following months of extensive tests in Monterey Bay, *Dorado* was deployed for its first major mission in the Arctic from the U.S. Coast Guard Ice Breaker *Healy* (Figure 27). The cruise focused on tracking the layer of Atlantic water entering the Arctic Ocean through the Fram Strait. The AUV instrument payload included temperature, conductivity, oxygen, nitrate, optical backscatter, and ice draft sonar sensors. The *In Situ* Ultraviolet Spectraphotometer (ISUS) sensor, developed at MBARI by Ken Johnson's group, provided nitrate measurements. Traditional hydrocasts and CTD (conductivity, temperature, depth) vertical profiles were conducted from the ship to provide ground truth for AUV observations and to obtain a significant data set characterizing the Atlantic Layer.

Operations of the vehicle were conducted in areas ranging from the Norwegian fjords, to the marginal ice zone, to deep in the ice pack. Diminishing light and temperatures created difficult operational conditions as the cruise progressed into the winter. Nevertheless, oceanographic sections were successfully obtained with the AUV to depths of 500 meters, through the bulk of the Atlantic intrusion (Figure 28). The AUV's ice-profiling sonar recorded ice draft in a wide variety of conditions. The data from the chemical sensors are being analyzed to determine whether nitrate and oxygen concentrations can be used as a tracer for the Atlantic water. Several important technical milestones were also achieved, including demonstrating the performance of the inertial navigation system at 82°N and the viability of using data buoys that melt through the ice to transmit installments of the AUV data back to the ship via satellite (Figure 29).

The cruise provided a clear demonstration of how important the AUV can be for providing hydrography in the ice and marginal ice zone. Earlier experience in Monterey Bay demonstrated the AUV could provide oceanographic data about twice as fast as a ship in open water. The advantage under ice is much greater.

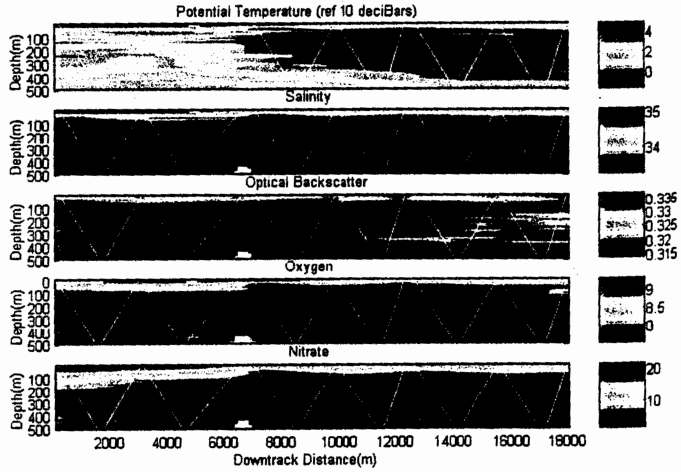

Figure 28. Data from sensors mounted on the AUV during an 18 kilometer long "yo-yo" profile. The AUV's path is represented by the sawtooth white lines.

Attachment 4 (cont'd)

Public Comment

5-9-03

Mr. Chairman, Commissioners and Staff: My name is Jay Murray and I'm a native Californian. I'm also a PADI Divemaster who worked for Aquarius Dive Shops here in Monterey in the mid to late 1990's. In 1996, I was asked to represent recreational SCUBA divers by the Department of the Interior, Minerals Management Service panel investigating noise impacts created by oil and gas exploration with high intensity air gun technology. While I declined to sit on the panel, I did review all the data they created. I have also been deeply involved investigating the impacts of high intensity military and research sonar on divers and marine life after being directly exposed to Low Frequency Active Sonar testing during the Magellan 2 Sea Trials conducted off the Farralon Islands in 1994.

As someone who has experienced both LFA sonar and the 3kHz mid frequency sonar proven to be the cause of the mass stranding and death of marine mammals in the Bahamas recently, I have to suggest the problems we are seeing with the California Sea Otter population, deepwater fisheries and the Grey Whales may be linked to acoustic transmissions. The annoyance and risk factors acoustic exposure creates are well documented.

In exhibit #1, Exposure Guidelines for Navy Divers Exposed to Low Frequency Active Sonar, page 2 lists under the heading "The Larger Problem / community noise," 1. Non-military divers and swimmers 2. Marine mammals and other marine fauna. Then on the same page under the heading "Possible Effects of Exposure to Low Frequency Acoustics", it says impacts range from "Auditory" to "Tissue shearing due to radiation pressure." Then on page 6 under the heading "Exposure Guidance and the Diver", it lists symptoms trained Navy divers reported from the test. They include vibrations, numbness, vertigo, imbalance, motion sickness and dizziness among others. That test also caused one Navy diver to experience a "symptomatic event" that required anti seizure and anti depressant drugs.

If the Otter population is being exposed to manmade sound transmissions and they experience any of these symptoms, they may be injured or altering their behavior to the point they no longer feed consistently in the same areas and on their usual prey. Sea Otters have been noticed in recent years foraging for Mud Clams well back in Elkhorn Slough. These are not their usual feeding grounds according to local marine biologists. Maybe that's where they're picking up the feline bacteria being suggested as the cause of their recent demise.

As you know, there have been many ocean basin scale acoustic tests

Attachment 5

conducted in our area in recent years. They include the "classified" 38Hz Magellan 2 Sea Trials that co-incided with the diver disturbance from Monterey to Fiji in 1994. The feebly designed and executed 75Hz ATOC MMRP that produced 3 dead Humpback Whales after unapproved "engineering tests" were performed. The related Alternate Source Test that transmitted 25Hz to 78Hz sound from a transmitter over Pioneer Seamount which co-incided with dozens if not hundreds of Sea Lions exiting the ocean and heading across Del Monte Avenue. And the NPS 260Hz RAFOS sources placed around the Pacific that transmit daily.

I'm not saying with certainty the current Sea Otter deaths are directly related to sonar transmissions. I am saying that from my personal experience, we cannot ignore the possibility. Certainly this form of pollution is the easiest to control, if you don't deliberately "hit the switch", there will be no active acoustic transmissions. Two recent court cases have ruled against active sound transmissions that may have impacted marine life as well.

I'm also providing 2 newspaper articles that quote former NPS Professor Jim Miller as saying the noises divers here complained about during 1994 were manmade and could be coming from a ship conducting some sort of acoustic experiment or research "beyond the horizon."

Thanks,

Jay R. Murray
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Carmel Valley, CA 93924
831-659-4729
Jaymurray2@aol.com

ARL
The University of Texas at Austin

Exposure Guidelines for Navy Divers Exposed to Low-Frequency Active Sonar

by

F. Michael Pestorius
Director, Applied Research Laboratories
The University of Texas at Austin

and

CAPT M. D. Curley
Naval Submarine Medical Research Laboratory
Groton, Connecticut

14 May 1996
Indianapolis, Indiana

P 20493

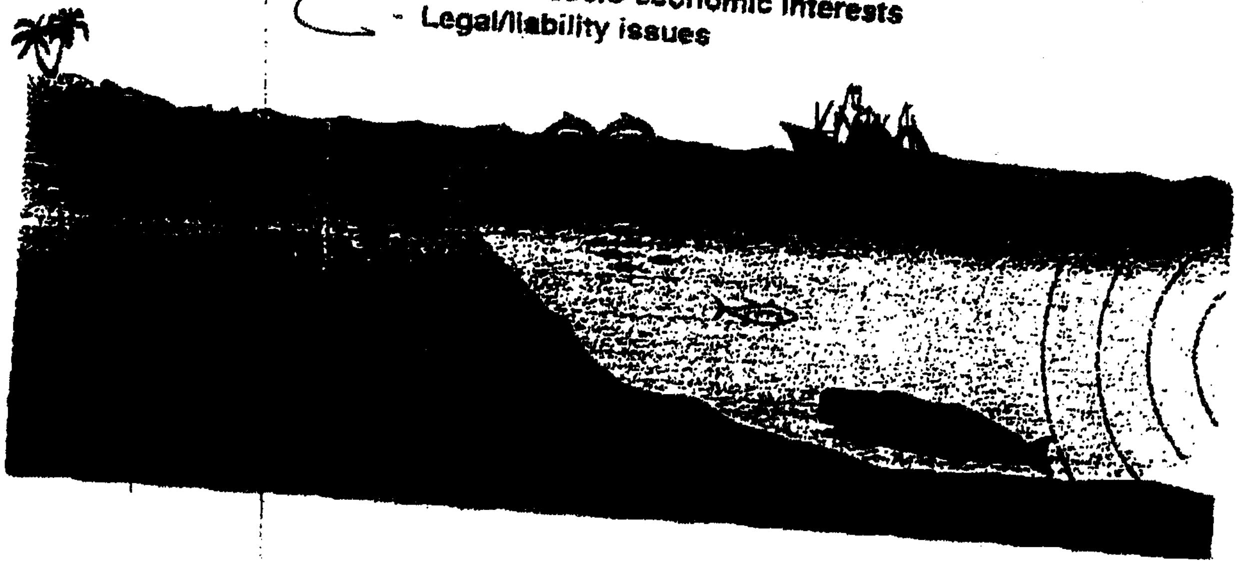
Final Study Goal

Develop exposure guidelines for:

- U.S. Navy divers
- Occupationally exposed to 160-320 Hz
- Depths to 130 FSW
- Representative sounds
- U.S. Navy diving equipment

The Larger Problem

Community Noise
- Non-military divers/swimmers
- Marine mammals and other marine fauna
- Political/socio-economic interests
- Legal/liability issues



Possible Effects of Exposure to Low Frequency Acoustics

- Auditory
- Vibro-tactile
- Contractile forces of muscles
- Irregular heartbeat
- Lung-gas interface
- Rectified diffusion
- Central nervous system/vestibular
- Cavitation (secondary)
- Hyperthermia (secondary)
- Tissue shearing by radiation pressure (secondary)

Study Participants

NAVY

NSMRL
NEDU
NRaD
NMRDC (Protocol Review)
USRD

UNIVERSITY

ARL:UT
APL/JHU
Vibrotactile Research
  Syracuse
Lung/Gas Bodies
  Georgia Tech
  Emory
  Boston
  APL/UW
Thermal, Cavitation Effects
  Vermont

Additional consultation from JPL, USRD Orlando, and Universities of Rochester, Minnesota, Florida, Illinois, Loyola, and SUNY Buffalo.

Assessment Measures

- Sensation
- Fine Motor Skills
- Perf. Assess. Battery
- Grip Strength
- Balance Platform
- Vibrometry
- SINBAD
- EEG
- ECG
- Blood/Urine/Stool
- Audiometry
- 2-point Discrimination
- Impedance Cardiography
- Video Oculography
- Neurological Exam
- Neuropsychological Exam
- Physical Exam
- Spirometry
- Blood Pressure
- Vestibular Function
- Dynamic Visual Acuity

RESULT: NO CLINICALLY SIGNIFICANT CHANGES IN GROUP PERFORMANCE DUE TO SOUND EXPOSURE (EXCEPTION: DIVER SELF-REPORTS).

In-water Human Exposures (~250 Hz)

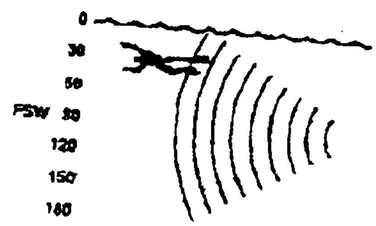
Study Location	dB re 1 μPa	Depth (FSW)	Rigs	#Man Dives
NSMRL 1994	130-140-150-160	1	None	22
NSMRL Puerto Rico 1993/4/5	111–161	30	Scuba	27
NEDU 1994	140-150-160	5-30-60	MK-20; 21	37
NEDU 1995	160	33-60-66-99-130	MK-16; 20; 21	156
NRL Bugg Spring 1995	160	30-60	MK-16; 20; 21	54
TOTAL				296

Symptomatic Event

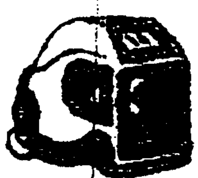
- 32 y/o male, experienced Navy diver.
- Pre-dive examination WNL.
- Exposed to 160 dB//1μPa for 15 minutes at 60 FSW wearing a MK 20 surface fed, soft helmet diver rig.
- At about 12 minutes experienced dizziness, somnolence, inability to concentrate, and residual tingling in arms for ~20 minutes.
- Received immediate medical attention and appeared to recover within about 30 minutes. Relapsed after 1 hour and was transported to Tindal AFB hospital for observation.
- Recovered overnight but relapsed again during the drive home.
- Subsequently received extensive medical, neurological, and psychological evaluations, all with no abnormalities.
- Was eventually returned to diving status. Retired voluntarily with no medical disability.
- As recently as early 1996, complained of irritability and minor memory dysfunction. Subequently suffered a "seizure." Now being treated with anti-depressant and anti-seizure drugs.

Exposure Guidance and the Diving Environment

- No restriction on depth during exposure
- Guidance applies to active sonar systems and potentially to other well-characterized sound sources in the same frequency band
- No safe stand-off distance provided

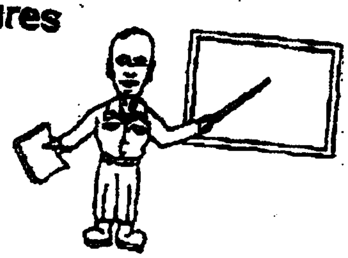


Exposure Guidance and Diving Equipment

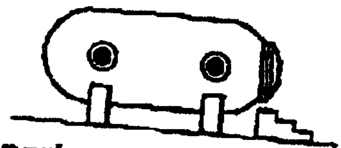


- No restrictions on diver dress or diving rig
- Divers wearing hard helmets are less likely to experience adverse effects including annoyance
- Interference with voice communications has been observed
- Bolt loosening in the MK-16 observed

Exposure Guidance and Diving Procedures



- Pre-dive briefs regarding possible effects
- Post-dive procedures should be strictly adhered to, especially when using the MK-16 diving rig
- Treat symptoms as if there were no sound exposure



- After-action reports requested from exposed divers

Exposure Guidance is Interim; Insufficient Data Re:

- Frequencies <160 Hz, >320 Hz
- SPL >160 dB
- Continuous sound exposures
- Damage thresholds for organ systems
- Impulsive/impact sources

knew everyone in the area."

To do that, the two experienced bike patrol officers say they will do whatever it takes. They'll mostly work out of bicycles or foot patrols and switch to cars when they have to. And they say they'll adjust their hours according to the hours that see the most crime.

"I'm just going to wait and see exactly what they're going to be committed to doing around here. I think that's what a lot of people out here are going to do."

Loyola Law School professor Laurie Levenson says "And if they come back positive (for Simpson' blood) jurors could know that before they even know i the test results are admissible at trial."

See **SIMPSON**/Back Page

Ocean sounds stump officials

By Christy Nemetz
The Californian

Mysterious sounds heard in the water off Point Lobos last week have scientists, divers and Monterey Bay National Marine Sanctuary officials puzzled.

Local divers reported hearing a series of staccato thumps followed by a pause last Wednesday and Thursday. Some described the sounds as mechanical because of their systematic on-and-off cycle.

Jay Murray, a divemaster with Aquarius Dive Shop in Monterey, said he has never heard anything like this in his 25 years of diving. He said he heard the low-frequency blasts again Tuesday.

"It vibrated enough to move your lungs. You can feel your chest cavity reverberating from it," Murray said. "It's not something I'll be able to shrug off and forget about."

Murray said he plans to take highly-sensitive recording equipment into the water this week in hopes of capturing the sound.

Some possible explanations for the noise, according to Jim Miller, associate professor of electrical and computer engineering at the Naval Postgraduate School in Monterey:

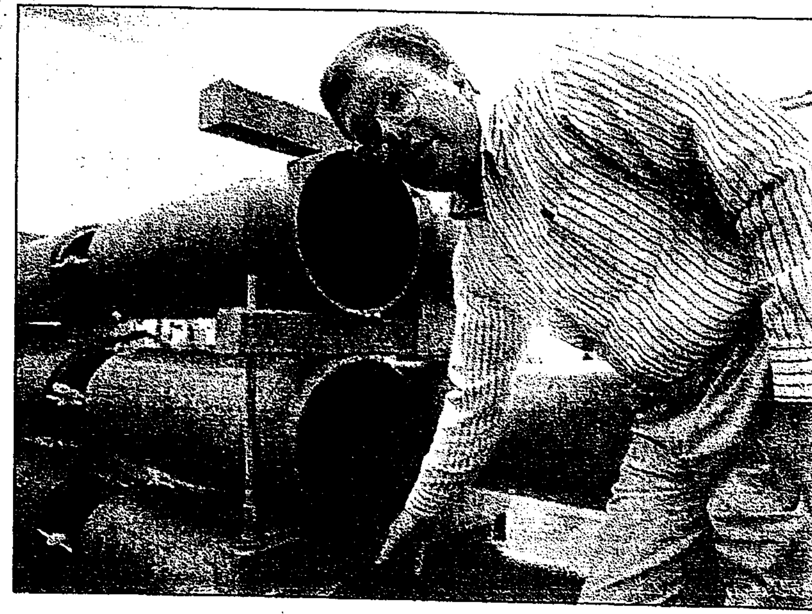
- It could be a U.S. Navy ship on a classified mission.
- A seismic ship could be mapping the ocean floor.
- A civil oceanographic ship may be performing experiments in the area.

Scott Kathey, the marine sanctuary's public affairs officer, said the sounds are no threat to divers or sea life in the area.

"It's really curious, but there's no evidence of any damage being done to the sanctuary," Kathey said. "Divers have gone down to check the bottom and there's no damage."

How to help

Anyone with information that could help the Monterey Bay National Marine Sanctuary's investigation should contact public affairs officer Scott Kathey at 647-4251.



Richard Green/The Californian

Jim Miller shows a sonic device that scientists use for experiments. But it's not responsible for the latest sounds.

MONTEREY HERALD
10-4-94

Strange Pacific Ocean noises causing a stir

Reuters News Service

CARMEL, Calif. — Mysterious thumping sounds in the Pacific Ocean have attracted the attention of the Navy and marine scientists and have touched off a media frenzy in the resort of Carmel.

Last week, divers reported hearing a deep, heartbeat-like thumping in the Pacific off Point Lobos, a rocky outcrop just south of Carmel. The thumping has no obvious origin.

"It's very eerie," said Justin Dubowitz, a Monterey diver who first taped the sound about 60 feet under water last weekend and turned his tapes over to the Navy.

The mystery is so intriguing that the experts, and the media, have poured in.

The Navy has sent in underwater sound experts; marine scientists have donned scuba gear, and professional divers have been leading network television crews into obscure coves.

NATIONAL NEWS

No one has been able to pinpoint the source of the noises, which have a steady pulse.

Divers from the National Oceanic and Atmospheric Administration and the Monterey Bay National Marine Sanctuary have joined recreational divers in the search for the source of the heartbeat.

The divers have discovered that it has a mechanically steady pulse but is intermittent, not continuous. But no one has been able to pinpoint the source.

Early theories have been discounted.

The experts have decided the heartbeat probably is not coming from whales or dolphins or a mystery animal that might be living in the coves along Point Lobos, a state nature preserve.

Experts have ruled out a link to submarine-contacting sonar equipment that the Navy used to operate nearby or to one of the dozen marine research institutions in the area.

"We're still scratching our heads," said Jim Miller, an underwater acoustics expert and a professor at the Naval Postgraduate School in Monterey.

Miller said the sound could be coming from a ship "far away, beyond the horizon."

F12a

Mark Delaplaine

From: JayMurray2@aol.com

Sent: Thursday, June 19, 2003 11:50 AM

To: mdelaplaine@coastal.ca.gov

Subject: Re: NPS AUV and RAFOS sources

Dear Mr. DeLaplaine: I have received and reviewed the Briefing Memo dated June 16, 2003, and am concerned Staff has based its conclusions on inaccurate information.

I am assuming the information provided concerning NPS activities has been provided by them.

Sentence #1 in paragraph #2 states "The NPGS' UAVs are similar to those used by the Monterey Bay Aquarium Research Institute" If what the CCC is concerned about is the use of sound in the marine environment, then the NPGS' are completely different from the MBARI AUV program, if what Marcia McNutt from MBARI has provided is true. I will fax the information she provided me which clearly states their AUV's are different from the NPS units because they have an inertial guidance system and don't use sound other than a low power bottom finder.

Sentence #2 says, "Using sounds at an intensity of about 180dB, which, due to the high frequency (22-28Khz), dissipates very quickly in water." These frequencies are not what the NPGS UAV operators told me. They specifically stated the system operated between 9kHz and 14kHz. I may be off on the upper number. They may have said 9kHz-16kHz. If you remember, I called you within 30 seconds of speaking with the NPGS UAV operators about 2 weeks ago. There is a major difference between the 2 frequency ranges. The 9 - 14kHz transmissions are directly in the middle of the human hearing frequency range in air. 22 - 28kHz is above the human hearing range, and I'm not certain about Sea Otter or Sea Lion hearing capabilities, but Professor Schustermnan at UCSC can provide that data.

Then they state "These types of sounds are similar to side-scan sonar, and fish finders..." The NPGS must provide the signal characteristics they use before any comparison can be made between other types of anthropogenic sound sources. Bottom finders, while using high frequency sound, emit a very quick "click" of sound. The total amount of energy transmitted is very small. If the same high frequency transmission was a continuous wave (CW) or frequency modulated (FM) transmission of many seconds or minutes, then the sound characteristics cannot be considered "similar."

They then say "These types of sound are quite common in the marine environment and used by many oceanographic research institutions. They have not, to date, been implicated in concerns over noise pollution in the marine environment." In my opinion this statement should make it clear there is a potential the use of these types of sound sources may increase in the future if there is no regulatory action taken. In the past, there was little concern that 3kHz Navy sonar had any negative impacts on marine life. The Bahamas incident and the recent Haro Straits deaths show that not to be the case. Just because there has been no direct evidence high frequency sonar can cause negative reactions doesn't mean it can't happen. If left unregulated, the clear choice for potential noise polluters will be to operate above any frequency limit placed on them. If they use high frequency then they need lots of power to get any range from the system. The problems are obvious.

On page 2 in the quote at the top of the page, number 6 states "various military search and surveillance (2-57kHz) and mine avoidance (25-500kHz sonars." It is clear the bottom end of the search and surveillance sonars fall within the "mid-frequency" sonars responsible for the Bahamas and Haro Straits incidents.

Then page 2 states "The NPGS RAFOS floats do involve low frequency sound, although they could hardly be considered unique or unusual sound sources." The only reason they can say they are not unique is "they are used by "many marine oceanographic institutions worldwide." They are certainly unusual sound sources in the marine environment. No creature, or natural phenomena transmits a 80 second 259-261Hz CW tone across the Pacific Ocean basin.

While the RAFOS sources are located well offshore, even the NPGS can only say it is "highly unlikely" that the Otters may be impacted by the sounds. At the last CCC meeting when I brought the potential problems about the RAFOS sources to light, I provided the CCC with a newspaper article with a photo of Prof. Jim Miller standing beside a "sonic device" that does not resemble the RAFOS float information Joe Johnson provided you a couple years ago. The device on the floor of the NPGS is an array of many tubes, not just a single 12 foot long transmitter. I'm concerned we are not getting the accurate information regarding the RAFOS/SOFAR transducers that are out there.

Conclusion. It is clear the NPGS has placed many RAFOS sources in the Pacific, deployed their AUV within 500 yards of all the Sea Lions we have hauled out and dying here in Monterey, and cannot guarantee they are not causing problems with Otters and Sea Lions. They have provided you with information that attempts to say "We aren't the only ones doing it!" so why shouldn't we be allowed to continue.

In the past there was little concern over the impacts sound can cause to marine mammals. Now Low Frequency and mid frequency sonars are known to be detrimental. Now is the time to investigate the complete spectrum of sound impacts. The CCC made what I considered a poor decision to allow the testing of high frequency sonar on the Gray Whale migration in the recent past. A judge agreed. Let's think this one through completely, and get all the correct info before we allow a potentially negative activity to occur within CA coastal waters.

Thanks, Jay Murray