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The influence of acoustic signals on a juvenile gray whale

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and applying least-squares techniques. This information can be used to increase our knowledge of blue whale distribution in the northeast Pacific. The methods described here may also be extended to other species that employ low-frequency vocalizations or to other ocean areas.

2:45

2pAO4. Effects of boat noise on the acoustic behavior of humpback whales. Thomas F. Norris (Dept. of Vertebrate Zoology, Moss Landing Marine Labs., P.O. Box 450, Moss Landing, CA 95039)

The effects of boat noise on cetacean acoustic behavior are not well understood. To examine these, real sources of boat noise were experimentally introduced to singing humpback whales (*Megaptera novaeangliae).* Humpback whales were chosen as subjects because they sing long songs that are easy to record. Also, they are often distributed in nearshore environments with heavy boat traffic. Songs from nine animals were analyzed ($n=9$). Ten variables describing time and frequency characteristics of humpback song signals and the structure of song patterns were compared before and during exposure to boat noise. Means of two variables (unit duration and phrase duration) were significantly less during boat passes than during control periods. Means of eight other variables were not significantly different. The statistical power of detecting a difference between the means was >90% for all variables describing frequency characteristics of songs. Because the durations of some variables were shortened, these results indicate that boat noise might affect humpback whale singing behavior. However, power analyses indicate that frequency structure is probably not affected. The significance of these effects concerning the behavioral biology of humpback whales is uncertain at this time.

3:05

2pAO5. Temporal and spatial distribution of whale calls off Monterey, California. Khosrow Lashkari (Monterey Bay Aquarium Res. Inst., Pacific Grove, CA 93950)

Twenty-seven hours of acoustic data were recorded from a horizontal array in deep waters off the central coast of California. These data were analyzed to determine the characteristics of diverse underwater acoustic sources. Some of the identified sources were: moored RAFOS sources at ranges of 150–1000 km, low-frequency ship and machinery noise, and sounds of biological origin. Over 400 whale calls were identified and analyzed to determine the distribution of these calls in both time and azimuth. Spectral analysis of the vocalizations indicate that most of the calls were from humpback whales. [Work supported by the United States Navy, Naval Postgraduate School, and Monterey Bay Aquarium Research Institute.]

Contributed Papers

3:25

2pAO6. The influence of acoustic signals on a juvenile gray whale. Peter J. Rovero, Robert M. Keolian, and James H. Miller (Code PH/Kn, Naval Postgraduate School, Monterey, CA 93943)

In May 1994, a juvenile gray whale, *Eschrichtius glaucus,* entered the Petaluma River, which empties into the north end of San Francisco Bay, CA. The Marine Mammal Center of Sausalito, CA, coordinated a rescue and asked us to lure the whale to deeper water with sound. The Petaluma River is muddy and brackish, 20 km long, and generally 75 m wide and 3 to 4 m deep. Recorded gray whale calls and synthetic signals in the range of 100–900 Hz were broadcast with a J-9 acoustic transducer providing a source level of 153 dB *re*: 1 μPa at 1 m. Over several hours, the whale, who surfaced for air every 140 s, seemed to be attracted to these sounds as we traveled at a few knots down river, our sound boat typically 50 m ahead of the whale. The whale appeared to lose interest in the sound boat much beyond 100 m. A split step parabolic equation model of acoustic propagation in the river suggests that the sound level was 123 dB near the river bottom at a range of 50 m and 120 dB at 200 m. On one occasion the whale approached to within 3 m of the active source. The sound level at this distance would be about 144 dB.

3:40–3:55 Break

3:55

2pAO7. A procedure for the calculation of the noise impacts from a spatially stochastic source. Rodolfo T. Arrieta (Spectrum Sciences and Software, Ft. Walton Beach, FL 32547)

There is growing concern over the impact of human intrusion into the habitat of certain wild animal species. A major part of this intrusion is in the form of noise from moving vehicles. The level on the ground or underwater caused by moving noise sources has been dealt with as single-event intrusions that may cause startle and associated physiological responses, and as cumulative noise exposures. The later approach allows correlation between the cumulative noise exposure of the whole animal population, and the change in population numbers and overall health. Currently, the most difficult part of this analysis lies in determining the sound exposure of the population since both the animals and the noise sources are spatially and temporally varying. There is a certain amount of knowledge about the movement of both the noise sources and the population; this knowledge can be used to create a kinematic simulation of the motions of both entities. Such a simulation has been used to yield long-term spatial probability distributions of noise sources that can then be superimposed over similarly obtained distributions of the population. This superimposition yields the required estimates of the total noise exposure of the population.

4:10

2pAO8. Low-frequency hearing in California sea lions and harbor seals. David Kastak (Long Marine Lab., 100 Shaffer Rd., Santa Cruz, CA 95060) and Ronald J. Schusterman (California State Univ., Hayward, CA 94542)

Studies on pure-tone detection thresholds were conducted on two female California sea lions and on a harbor seal. The older sea lion and the harbor seal were trained to wear custom-fitted headphones in order to determine minimum audible pressures in a binaural listening task. All three animals were trained to respond to underwater signals at frequencies ranging from 100–1600 Hz at a depth of about 1.5 m. Results were very reliable, owing to a combination of psychophysical threshold determining measures. Sensitivity to low-frequency sounds by both species were 25–30 dB better underwater than in air. The low-frequency hearing of the harbor seal was 2–25 dB better than the older seal lion. At 100 Hz, the sensitivity of the harbor seal was 17 dB superior to that of the younger seal ion, and 23 dB superior to the older seal lion. Results at low frequencies support the notion that the harbor seal (phocid) ear is more water adapted than the sea lion (otariid) ear.