of best hearing sensitivity. Future studies can potentially examine the relevance of frequency composition and other vocalization parameters using psychophysical methods that include complex acoustic stimuli and an analysis of subject response latencies. Such methods have proven useful for studying the manner in which birds perceptually categorize vocalizations [Dooling *et al.*, J. Comp. Psychol. **101**, 367–381 (1987)] and they may provide novel tools for investigating the link between vocalization structure and auditory perception in otariids. [Work supported by ONR.]

8:25

3aABa2. Why do Weddell seals shout? Jack Terhune (Dept. of Biology, Univ. of New Brunswick, 100 Tucker Park Rd., Saint John, NB, E2L 4L5, Canada, terhune@unb.ca)

Source levels (SLs) of Weddell seal (*Leptonychotes weddellii*) underwater calls near Mawson, Antarctica, were determined using a two hydrophone array. SLs were 161 ± 10 dB *re* 1 μPa m (range 135–179, $n = 280$). SLs from 0.1–6 kHz varied little with frequency ($r^2 = 0.02$, $t = -2.46$, $P = 0.01$, $n = 251$). One-sixth octave ambient noise levels (ANLs) from 0.1–6 kHz were measured on low ($n = 1$), medium ($n = 7$), and high ($n = 7$) noise level days. The ANLs were flat (0.1–6 kHz) and the mean 1/6 octave ANLs were 77 ± 2.8, 96 ± 6.5, and 110 ± 6.1 dB *re* 1 μPa. SLs were randomly paired against ANLs in a Monte Carlo ($n = 100\,000$) model to calculate the seal communication ranges (*m*), assuming spherical spreading and received levels 20 dB above threshold. The mean communication ranges for low, medium, and high ANLs were 2806 ± 2718, 428 ± 662, and 83 ± 124 m, respectively (median distances were 2006, 205, and 43*m*). The distributions were highly skewed toward the shorter distances. The high amplitude calls of Weddell seals may have evolved to facilitate local communication under noisy conditions rather than for very long range purposes.

8:45

3aABa3. Vocalization source levels of adult male northern elephant seals (Mirounga angustirostris). Brandon L. Southall (SEA, Inc., 9099 Soquel Dr., Ste. 8, Aptos, CA 95003), Stephen Insley (Univ. of California, Santa Cruz, OCA.), Marla Holt (Northwest Fisheries Sci. Ctr.), and Colleen Reichmuth (Univ. of California, Santa Cruz, CA)

Aerial vocalization source levels were obtained for adult male northern elephant seals from 1999–2010. Vocalizations from known individuals (marked within years) were selected from three breeding seasons (1999–2000, 2004–2005, and 2009–2010) evenly spaced during this interval so that it is unlikely animals were resampled across seasons. Sound pressure levels of calls were measured on-axis (0-deg orientation) at 1-m range using Brel and KJær 2203 and 2250 precision sound level meters. Calls almost always occurred in series, as previously described; the maximum received level for any pulse in each series is used as the source level. Source levels are reported for individuals with at least four complete bouts. All sex/age classes were measured; the adult male data will be discussed and compared with other mammals in terms of rms levels (two temporal weighting functions) and peak sound pressure levels. Results indicate that calls almost always exceed 100 dB rms (re: 20 μPa) with peak levels regularly exceeding 120 dB. These loud sounds might suggest long-range communication, but considering hearing data Ron Schusterman and Dave Kastak first collected on this species and environmental noise levels in their rookeries, intense signals are likely required even for the small ranges over which they apparently function. [Funding provided by ONR.]

9:05

3aABa4. Vocal recognition of individuals versus relative dominance rank among breeding male northern elephant seals (*Mirounga angustirostris*). Stephen J. Insley (Dept. of Biology, Univ. of Victoria, P.O. Box 3020, Station CSC, Victoria, BC V8W 3N5, Canada, sinsley@uvic.ca), Marla M. Holt (Northwest Fisheries Sci. Ctr., Seattle, WA 98112), and Brandon L. Southall (Southall Environ. Assoc., Santa Cruz, CA 95060)

Whether an animal truly recognizes an individual or a simple rule-based category (e.g., neighbor or offspring) has important behavioral and evolutionary implications such as the accuracy of social reciprocity. Many tests of individual recognition have focused on neighboring territorial males (“dear enemy” or “neighbor-stranger” recognition). Unfortunately the static territorial context of these tests, mostly with male songbirds, opens them to the criticism of being merely associative habituation. More dynamic mating assemblages, such as leks where vocally advertising animals encounter numerous others, are a potentially rich and largely untested alternative. The female defense polygyny practiced by male northern elephant seals during terrestrial breeding is such a dynamic system. To examine whether elephant seals were recognizing individuals or dominance categories we conducted a total of 53 playback experiments to 18 males at Año Nuevo State Reserve. Each playback was a series of threat calls assigned to four dominance conditions relative to the subject. Dominance was based on the outcomes of interactions among contesting male dyads. Responses were measured using three assays *in situ* and from video records of each experiment. Results thus far are consistent with the males not recognizing individuals but instead recognizing and responding appropriately to relative rank.

9:25

3aABa5. Directionality of male northern elephant seal (*Mirounga angustirostris*) threat calls and how it influences receiver behavior. Marla M. Holt (Marine Mammal Ecology Team, NOAA Fisheries Northwest Fisheries Sci. Ctr., 2725 Montlake Blvd. East, Seattle, WA 98112, marla.holt@noaa.gov), Brandon L. Southall (Southall Environ. Assoc. Inc., Santa Cruz, CA 95060), Stephen J. Insley, and Ronald J. Schusterman (Univ. of California, Santa Cruz, CA 95064)

Many animal sounds are directional in which the sound energy is focused in a direction that depends on the signaler’s orientation. In the 1970s, Ron Schusterman quantitatively showed this in barking California sea lions and dogs. Several investigators have suggested ways that such features might be particularly useful among individuals in acoustic communication networks. However, only a few have tested such hypotheses experimentally and even fewer have investigated how directional signals affect receiver behavior. In this study, we measured directivity patterns of male northern elephant seal threat calls and used an acoustic playback approach to determine how call directionality influenced the responses of male seals in reproductive competition. We collected data on adult and older subadult seals on a breeding rookery (Ano Nuevo State Park) over three field seasons. Threat calls had substantial directionality, particularly at

frequencies above 1 kHz and responses to playbacks depended on call directivity patterns. Males moved farther away from the playback source when it simulated a caller oriented toward them compared to when playbacks simulated a caller oriented away from them. These results suggest that threat call directionality provides meaningful information about the auditory scene and spatial orientation of male elephant seals in reproductive competition.

Contributed Papers

9:45

3aABa6. Source characteristics of the underwater knocking displays of a male Pacific walrus (*Odobenus rosmarus divergens*). William R. Hughes (Dept. of Ecology and Evolutionary Biology, Univ. of California, Santa Cruz, CA 95064), Colleen Reichmuth (Univ. of California, Santa Cruz, CA 95060), Jason L. Mulsow (U.S. Navy Marine Mammal Program, SSC Pacific, San Diego, CA 92152), and Ole Næsbye Larsen (Univ. of Southern Denmark, Odense DK-5230, Denmark)

Walruses breed in winter at high latitudes in conditions that make close-range observations difficult. Males are known to produce complex underwater songs that can extend over multiple days and propagate over several kilometers. These acoustic displays are comprised of highly rhythmic sharp "knocks" punctuated by occasional metallic "bells." The source characteristics of the knocking sounds that were regularly emitted by a male walrus raised in captivity were examined. Knocks were produced as single 20 ms pulses, or as doublets and triplets, and were typically repeated at rates of 0.8/s to 1.2/s. These were loud sounds with greater bandwidth than previously reported: mean source levels were 186 dB pk-pk *re* 1 μPa at 1 m (range 161–196) with maximum frequency >24 kHz. Production of each knock was associated with visible impulsive movement of the forehead. During rut, this walrus had difficulty inhibiting sound production and would often continue to emit knocks in air during haul-out and even while eating, suggesting an endogenous component to this behavior. A strong correlation between his seasonal testosterone levels and the persistence of knocking displays was confirmed. Captive research provides unique access to acoustic and reproductive behavior that is presently impossible to study in wild walruses.

10:00

3aABa7. Automatic localization of individual Hawaiian minke whales from boing vocalizations. Stephen W. Martin (Biosciences Div., SPAWAR Systems Ctr. Pacific, 53366 Front St., San Diego, CA 92152, steve.w.martin@navy.mil), Tom Norris (Bio-Waves Inc., 517 Cornish Dr., Encinitas, CA 92024), Eva-Marie Nosal (Univ. of Hawaii, 2540 Dole St., Honolulu, HI 96822), David K. Mellinger (Oregon St. Univ., 2030 SE Marine Sci. Dr., Newport, OR 97330), Ronald P. Morrissey, and Susan Jarvis (Naval Undersea Warfare Ctr., Bldg. 1351, Newport, RI 02841)

A method is described to automatically localize Hawaiian minke whales from their boing vocalizations. Recorded passive acoustic data from 15 deep water seafloor mounted hydrophones at the Pacific Missile Range Facility is utilized. A critical step is the automatic association of the same vocalization as received by the widely spaced hydrophones. The peak frequency of the vocalization in the detection bandwidth is shown to aid in the association process. Temporal integration of standard time difference of arrival localizations reduces erroneous automatic localizations, which occur for a variety of reasons. A case study of a 2009 minke visual sighting by a field team, which was facilitated by radioing near real-time location information from shore is described. The peak frequency feature (PFF) has unexpectedly been observed to be very stable for what is believed to be the sighted individual over a 6 hour time period (n = 57, $\overline{\mathrm{PFF}}$=1384.0Hz, σ = 1.78 Hz). When the minke ceased vocalizing at 13:44 HST, no vocalizations at this frequency were again observed until 18:30 HST. This suggests a possible acoustic feature unique to individual animals with potential anatomical relationship with the sound production mechanism.

WEDNESDAY MORNING, 25 MAY 2011 ISSAQUAH, 10:30 TO 11:45 A.M.

Session 3aABb

Animal Bioacoustics: General Topics in Bat Acoustics

James A. Simmons, Chair
Brown Univ., Neuroscience Dept., Providence, RI 02912

Contributed Papers

10:30

3aABb1. Echolocation of fluttering insects by using the frequency modulated sound. Ikuo Matsuo (Dept. of Information Sci., Tohoku Gakuin Univ., 2-1-1 Tenjinzawa, Sendai 981-3193, Japan, matsuo@cs.tohoku-gakuin.ac.jp) and Takuma Takanashi (Forestry and Forest Products Res. Inst., Tsukuba 305-8687, Japan)

Using the echolocation, bats can capture insects in real 3-D space. The echoes from the insect were changed with the wing beats and its orientation. In the case of emitting the constant-frequency (CF) sound, the wing beats could be estimated from the amplitude modulation and frequency modulation (FM) dependent on the Doppler-shift. In this study, the echoes were measured from several kinds of insects when both the CF and FM sounds were intermittently emitted from the ultrasonic loudspeaker. At the same time, the movements of the wing were measured by the high speed camera. The impulse responses and time-frequency pattern were computed by using the cross-correlation function and the convolution of the chirplet filters, respectively. It was examined that these patterns were related to its orientation and the wing beats, that is, the change of wing positions along the time axis. [Work supported by the Research and Development Program for New Bio-industry Initiatives.]

10:45

3aABb2. Developmental change in ultrasonic echolocation sounds of Japanese echolocating bats, *Pipistrellus abramus*. Shizuko Hiryu and Hiroshi Riquimaroux (Faculty of Life and Medical Sci., Doshisha Univ., 1-3 Miyakotani Tatara, Kyotanabe 610-0321, Japan)

The development of vocalization during the first post-natal month in *Pipistrellus abramus* was studied. Vocalizations were recorded from each pup (five pups from two mothers; captive-born and captive-raised in a laboratory) everyday when isolated from its mother. The sounds produced by pups on the day of birth were categorized into a long isolation call and seemingly an echolocation precursor call (EP call). The terminal frequencies of the fundamental (TF) was 19.3 ± 1.9 kHz (n = 98), indicating that TF ranges of the second harmonic produced by newborn bats almost corre-