500-Hz range and produce significant acoustic energy in an overlapping frequency band in the case of close encounter roars. Other utterances within the vocal repertoire of tigers also contain, and are often dominated by, low frequency acoustic energy that can extend into the infrasonic range. Efforts to determine temporal bone correlates of *P. tigris* bioacoustical features were recently initiated using computerized tomography to assess key aspects of middle and inner ear morphology from a small set of adult Siberian tigers (*P. tigris altaica*) and one neonate. Obvious peripheral auditory specializations were not observed and structures comprising the auditory periphery were consistent with the anatomical character of felids generally. Although cochlear dimensions appeared to be adultlike, or nearly so, in the case of the neonate, other temporal bone features were grossly immature. The relationship between acoustic sensitivity, the spectral character of a subset of close encounter calls and cochlear dimensions will be considered.

2:15

2pAB6. Sound detection and production in the American lobster, *Homarus americanus*: Sensitivity range and behavioral implications. Heidi J. Pye and Winsor H. Watson III (Univ. of New Hampshire, 46 College Rd., Durham, NH 03824)

Many crustaceans including spiny lobsters, some crabs, and a few shrimp are known to produce sounds for a variety of purposes. One brief report and several preliminary studies indicate that American lobsters also produce sounds, and may be capable of detecting acoustic signals. The focus of this study was to (1) quantify the frequency range over which lobsters are capable of detecting sounds and (2) characterize the sounds that lobsters produce. Twelve sexually immature and 11 mature lobsters were tested for their ability to detect frequencies in the range of 20–10 000 Hz. Immature lobsters of both sexes detected sounds in the range of 20–1000 Hz ($>50\%$), while sexually mature lobsters exhibited two distinct peaks in their acoustic sensitivity (20–300 Hz and 1000–5000 Hz). Lobsters of both sexes produced a buzzing vibration when grasped but larger lobsters (120–149 mm in carapace length) vibrated most consistently ($>35\%$ of surveyed lobsters). The greater tendency for sound production in large lobsters may indicate a role in mating behavior. Currently, we are characterizing the acoustical properties of produced sounds and investigating the possibility that the American lobster may produce sounds for more than one purpose. [Work supported by University of New Hampshire Center for Marine Biology.]

2:30

2pAB7. Probability density functions for hyperbolic and isodiachronic locations. John L. Spiesberger (Dept. of Earth and Environ. Sci., Univ. Pennsylvania, 240 S. 33rd St., Philadelphia, PA 19104, johnsr@sas.upenn.edu) and Magnus Wahlberg (Aarhus Univ., DK-8000 Aarhus C, Denmark)

Animal locations are sometimes estimated with hyperbolic techniques by estimating the difference in distances of their sounds between pairs of receivers. Each pair specifies the animal's location to a hyperboloid because the speed of sound is assumed to be spatially homogeneous. Sufficient numbers of intersecting hyperboloids specify the location. A non-linear method is developed for computing probability density functions for location. The method incorporates *a priori* probability density functions for the receiver locations, the speed of sound, winds, and the errors in the differences in travel time. The traditional linear approximation method overestimates bounds for probability density functions by one or two orders of magnitude compared with the more accurate non-linear method. The non-linear method incorporates a generalization of hyperbolic methods because the average speed of sound is allowed to vary between different receivers and the source. The resulting "isodiachronic" surface is the locus of points on which the difference in travel time is constant. Isodiachronic locations yield correct location errors in situations where hyperbolic methods yield incorrect results, particularly when the speed of propagation varies significantly between a source and different receivers.

2:45–3:00 Break

3:00

2pAB8. Information entropy analysis of leopard seal vocalization bouts. John R. Buck (ECE Dept. and SMAST, UMass Dartmouth, 285 Old Westport Rd., North Dartmouth, MA 02747), Tracey L. Rogers (Zoological Parks Board of NSW, Mosman, NSW 2088, Australia), and Douglas H. Cato (Defence Sci. and Technol. Organisation, Pyrmont, NSW 2009, Australia)

Leopard seals (*Hydrurga leptonyx*) are solitary pinnipeds who are vocally active during their brief breeding season. The seals produce vocal bouts consisting of a sequence of distinct sounds, with an average length of roughly ten sounds. The sequential structure of the bouts is thought to be individually distinctive. Bouts recorded from five leopard seals during 1992–1994 were analyzed using information theory. The first-order Markov model entropy estimates were substantially smaller than the independent, identically distributed model entropy estimates for all five seals, indicative of constraints on the sequential structure of each seal's bouts. Each bout in the data set was classified using maximum-likelihood estimates from the first-order Markov model for each seal. This technique correctly classified 85% of the bouts, comparable to results in Rogers and Cato [Behaviour (2002)]. The relative entropies between the Markov models were found to be infinite in 18/20 possible cross-comparisons, indicating there is no probability of misclassifying the bouts in these 18 comparisons in the limit of long data sequences. One seal has sufficient data to compare a nonparametric entropy estimate with the Markov entropy estimate, finding only a small difference. This suggests that the first-order Markov model captures almost all the sequential structure in this seal's bouts.

3:15

2pAB9. Localization of airborne pure tones by pinnipeds. Marla M. Holt, Ronald J. Schusterman, Brandon L. Southall, and David Kastak (Univ. of California, Santa Cruz Long Marine Lab., 100 Shaffer Rd., Santa Cruz, CA 95060, iris@ucsc.edu)

Although all pinnipeds communicate acoustically in air, most previous research on sound localization has been done under water. We have recently shown that several pinniped species localize aerial broadband signals as well as some terrestrial carnivores [Holt *et al.*, J. Acoust. Soc. Am. **113** (2003)]. However, it is unclear which frequencies are particularly important for localization in these animals. In this study, we tested a harbor seal (*Phoca vitulina*) and a California sea lion (*Zalophus californianus*) in a hemianechoic chamber at frequencies ranging between 0.8 and 20 kHz. A left/right procedure was used to measure minimum audible angles (MAAs) corresponding to 75%-correct discrimination. MAAs ranged from approximately 4 to 13 deg in both subjects, with the largest MAAs or poorest acuity measured at the intermediate frequencies tested. These results are consistent with the duplex theory of sound localization in that low-frequency sounds appear to be localized on the basis of interaural time differences, while high-frequency sounds appear to be localized on the basis of interaural intensity differences. Testing with a northern elephant seal (*Mirounga angustirostris*) will provide further insight on the use of binaural cues and head-size effects with respect to localization in pinnipeds.

3:30

2pAB10. Determination of West Indian manatee vocalization levels and rate. Richard Phillips, Christopher Niezrecki, and Diedrich Beusse (Univ. of Florida, Gainesville, FL 32611-6250, niezreck@ufl.edu)

The West Indian manatee (*Trichechus manatus latirostris*) has become endangered partly because of a growing number of collisions with boats. A system to warn boaters of the presence of manatees, based upon the vocalizations of manatees, could potentially reduce these boat collisions. The feasibility of this warning system would depend mainly upon two factors: