REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503
PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED
8-20-2002	Final Report	4/1/1998 - 3/30/2002

4. TITLE AND SUBTITLE

Bioacoustics of Monterey Bay Pinnipeds:
Extraction of Information from Acoustic Signals

5a. CONTRACT NUMBER

5b. GRANT NUMBER

N00014-98-1-0603

5c. PROGRAM ELEMENT NUMBER

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

6. AUTHOR(S)

Ronald J. Schusterman

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

University of California Santa Cruz
Institute of Marine Sciences
1156 High Street
Santa Cruz, CA 95060

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Office of Naval Research
800 N. Quincy Street
Arlington, VA 22217-5000

10. SPONSOR/MONITOR'S ACRONYM(S)

ONR

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AILABILITY STATEMENT

Distribution Unlimited

DISTRIBUTION STATEMENT A:
Approved for Public Release -
Distribution Unlimited

20020829 053

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Two doctoral students at UCSC were supported by this ASSERT award. The students participated in an ongoing ONR funded research program on the bioacoustics of pinnipeds while developing and carrying out complementary independent investigations. During the award period, both students received specialized training in animal psychophysics, experimental design, and acoustic instrumentation and measurement. Both students completed and published significant original research related to sensory biology, communication, and cognition in seals and sea lions. Their concurrent participation in the primary ONR funded research program improved productivity and efficiency. The technical and research skills developed by the students while supported by this grant will be useful to independent and government supported research agencies.

15. SUBJECT TERMS

pinniped, bioacoustics, California sea lion, harbor seal, northern elephant seal

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Ronald J. Schusterman
unclass.	unclass.	unclass.	UL	4	19b. TELEPHONE NUMBER (Include area code) 831-459-3345

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std Z39.18

FINAL REPORT

GRANT #: N00014-98-1-0603

PRINCIPAL INVESTIGATOR: Dr. Ronald Schusterman

INSTITUTION: University of California, Santa Cruz

GRANT TITLE: Bioacoustics of Monterey Bay Pinnipeds: Extraction of Information from Acoustic Signals

AWARD PERIOD: 1 April 1998 - 30 March 2002

OBJECTIVE: Provide training and support for two doctoral students investigating aspects of pinniped sensory systems and cognition related to ongoing ONR supported research.

APPROACH: Doctoral students are supported while being trained in a range of technical disciplines and experimental methods related to ONR funded research. Students participate in the ongoing research program while developing and carrying out complementary independent investigations.

ACCOMPLISHMENTS: Both students received specialized training in animal psychophysics, experimental design, and acoustic instrumentation and measurement. One of the students, Brandon Southall, investigated the effects of noise exposure on hearing by obtaining underwater and aerial masked hearing thresholds for three pinniped species (*Phoca vitulina, Mirounga angustirostris, and Zalophus californianus*). He also investigated other aspects of auditory processing in these species, including laboratory measurements of critical bandwidths and field measurements of biological signals and ambient noise levels. The other student, Colleen Reichmuth Kastak, investigated aspects of problem solving and memory with one pinniped species (*Zalophus californianus*). She demonstrated the capability of this species to form categories of functionally equivalent stimuli, use fast-mapping to expand these meaningful categories, and remember conceptual strategies for up to ten years. In addition to carrying out their independent research projects, both students consistently contributed to the collection of acoustic data in the laboratory that was critical to the success of the ONR funded research program.

CONCLUSIONS: Both students were highly successful, completing significant research and presenting their findings at professional meetings and in a range of peer-reviewed publications. Both students graduated with their doctorates in Ocean Sciences at the top of their class. The concurrent participation of the students in ongoing ONR funded research improved productivity and efficiency, allowing more research to be completed in a shorter period of time.

SIGNIFICANCE: The grant-supported students completed important research in the fields of animal sensory biology and animal cognition. For example, their findings improve our understanding of the effects of

DISTRIBUTION STATEMENT A:
Approved for Public Release -
Distribution Unlimited

noise on pinniped hearing and communication, and reveal some of the key cognitive mechanisms used by pinnipeds to categorize and remember significant sensory events. The technical and research skills developed by the students while supported by this grant will be useful to independent and government supported research agencies.

PATENT INFORMATION: N/A

AWARD INFORMATION:
Colleen Reichmuth Kastak, Outstanding Student Achievement Award, Ocean Sciences Department, University of California Santa Cruz, 1998-1999.

Colleen Reichmuth Kastak, Invited participant in the Pauley Workshop on Cetacean Hearing, Hawaii Institute of Marine Biology, Summer 2001.

Colleen Reichmuth Kastak, Invited talk to the American Psychological Association, sponsored by division 25, San Francisco, CA, August 26th, 2001.

Brandon L. Southall, Invited talk to the 14th Biennial Conference on the Biology of Marine Mammals, Vancouver, Canada, December 2nd, 2001.

Brandon L. Southall, Invited talk to the 142nd meeting of the Acoustical Society of America, Ft. Lauderdale, Florida, December 5th, 2001.

PUBLICATIONS AND ABSTRACTS (for total period of grant):

1. Schusterman, R.J., Kastak, D., Levenson, D.H., **Southall, B.L.**, and **Reichmuth, C.** (1999) Why pinnipeds don't echolocate: the role of selection in pinniped biosonar. J. Acoust. Soc. Amer., 107:2256-2264.

2. Kastak, D., Schusterman, R.J., **Southall, B.L.** and **Reichmuth, C.** (1999) Underwater temporary threshold shift induced by octave-band noise in three species of pinniped. J. Acoust. Soc. Amer., 106(2):1142-1148.

3. **Reichmuth, C.**, and Schusterman, R.J. (1999) Cognition in California sea lions: the role of different fish reinforcers. Abstract presented November 28-December 3, Proc. 13th Biennial Conference on the Biology of Marine Mammals, p 155.

4. Hayes, S. A., Kumar, A., Costa, D.P., **Southall, B.L.**, Harvey, J.T., Le Boeuf, B.J., and Mellinger, D.K. (1999) I am harbor seal, hear me roar; a playback experiment. Abstract presented November 28-December 3, Proc. 13th Biennial Conference on the Biology of Marine Mammals.

5. Holt, M. M., Schusterman, R.J., Kastak, D. and **Southall, B.L.** (1999) Pinniped acoustical psychophysics: individual strategies. Abstract presented November 28-December 3, Proc. 13th Biennial Conference on the Biology of Marine Mammals.

6. Emery, J.H., **Reichmuth, C.**, Schusterman, R.J., and Wilson, E.G. (1999) Versatile signaling by female harbor seals (Phoca vitulina) during the pup attendance period. Abstract presented November 28-

December 3, Proc. 13th Biennial Conference on the Biology of Marine Mammals, p 53.

7. Schusterman, R.J., Kastak, D., Levenson, D.H., **Reichmuth, C.** and **Southall, B.L.** (1999) Why pinnipeds don't echolocate. Abstract presented November 28-December 3, Proc. 13th Biennial Conference on the Biology of Marine Mammals, p 168.

8. **Southall, B.L.,** Kastak, D., Schusterman, R.J., **Reichmuth, C.,** Grayson, J.W. (1999) Underwater temporary threshold shift (TTS) in pinnipeds: the effects of moderate noise levels. Abstract presented November 28-December 3, Proc. 13th Biennial Conference on the Biology of Marine Mammals, p 176.

9. Schusterman, R.J., **Reichmuth, C.** and Kastak, D. (2000) How animals classify friends and foes. Current Directions in Psychol. Sci., 9(1):1-6.

10. Schusterman, R.J., **Reichmuth Kastak, C.,** and Kastak, D. (2000) Equivalence classification as an approach to social knowledge: from sea lions to simians. Abstract presented August 23-26, Animal Social Complexity and Intelligence Conference, Chicago, Illinios.

11. **Southall, B. L.,** Schusterman, R.J., and Kastak, D. (2000) Masking in three pinnipeds: underwater low frequency critical ratios, J. Acoust. Soc. Amer., 108:1322-1326.

12. **Reichmuth Kastak, C.,** Schusterman, R.J, and Kastak, D. (2001) Equivalence classification in California sea lions using class-specific reinforcers. J. Exp. Anal. Beh. 76:131-158.

13. Schusterman, R.J., **Southall, B.L.,** Kastak, D. and **Reichmuth Kastak, C.** (2001) Pinniped vocal communication: Form and function. Proceedings of the 17th International Congress on Acoustics, Volume IV, September 2-7, Rome, Italy.

14. **Southall, B.L.,** Schusterman, R.J. Kastak, D., and Reichmuth Kastak, C. (2001) Pinniped hearing and anthropogenic noise. Abstract presented December 3-7, 142nd Meeting of the Acoustical Society of America, p. 2722.

15. **Reichmuth Kastak, C.,** Schusterman, R.J., and Kastak, D. (2001) Concept learning and memory in California sea lions. Abstract presented November 28-December 5, 14th Biennial Conference on the Biology of Marine Mammals.

16. Schusterman, R.J., **Reichmuth Kastak, C., Southall, B.L.,** Kastak, D., and Spillman, S. (2001) Proximate mechanisms involved in pinniped vocal communication. Abstract presented November 28-December 5, 14th Biennial Conference on the Biology of Marine Mammals.

17. Holt, M.M., **Southall, B.L.,** Kastak, D., **Reichmuth Kastak, C.,** and Schusterman, R.J. (2001) Aerial hearing thresholds in pinnipeds: a comparison of free-field and headphone thresholds. Abstract presented November 28-December 5, 14th Biennial Conference on the Biology of Marine Mammals.

18. **Southall, B.L.,** Schusterman, R.J., and Kastak, D. (2001) Noise constraints on pinniped vocal communication: Integrating source level, ambient noise, and audiometric data. Abstract presented November 28-December 5, 14th Biennial Conference on the Biology of Marine Mammals.

19. Schusterman, R.J., **Southall, B.L.**, Kastak, D. and **Reichmuth Kastak, C.** (2001) Pinniped vocal communication: Form and function Abstract presented September 2-7, 17th International Congress on Acoustics, Rome, Italy.

20. Schusterman, R.J., **Southall, B.L.,** Kastak, D. and **Reichmuth Kastak, C.** (2001) Acoustic communication in pinnipeds. Abstract presented August 22-29, Tubigen, Germany, In: Advances in Ethology: Contributions to the XXVII International Congress on Acoustics, p 261.

21. **Reichmuth Kastak, C.,** Schusterman, R.J., and Kastak, D. (2001) Acquisition and retention of equivalence classes in California sea lions. Abstract presented August 34-26, 109th Annual Convention of the American Psychological Association, San Francisco, California.

22. **Reichmuth Kastak, C.** (2002) Concept learning and memory in California sea lions. Ph.D. Thesis, University of California at Santa Cruz.

23. **Southall, B.L.** (2002) Northern elephant seal field bioacoustics and aerial masked hearing thresholds in three pinniped species. Ph.D. Thesis, University of California at Santa Cruz.

24. **Reichmuth Kastak, C.** and Schusterman, R.J. (2002) Exclusion and classification in California sea lions. Abstract presented March 13-16, 2002 International Conference on Comparative Cognition, Melbourne, Florida.

25. Schusterman, R.J., **Reichmuth Kastak, C.,** and Kastak, D. (2002) The cognitive sea lion: meaning and memory in the lab and in nature. In: The Cognitive Animal, M. Bekoff, C. Allen, and G. Burghardt (Eds). MIT Press, pp 217-228.

26. **Reichmuth Kastak, C.** and Schusterman, R.J. (in press) Sea lions and equivalence: extending classes by exclusion. J. Exp. Anal. Beh.

27. Schusterman, R.J., **Reichmuth Kastak, C.,** and Kastak, D. (in press) Equivalence classification as an approach to social knowledge: from sea lions to simians. In: Animal Social Complexity: Intelligence, Culture, and Individualized Societies, F. B. M DeWaal and P.L. Tyack (Eds), Harvard University Press.

28. Schusterman, R.J., Kastak, D., Levenson, D.H., **Reichmuth, C.** and **Southall, B.L.** (in press) Pinniped sensory systems and the echolocation issue in the year 2000. In: Echolocation in Bats and Dolphins, J.A. Thomas, C. Moss, M. Vater (Eds). University of Chicago Press.

29. **Reichmuth Kastak, C.** and Schusterman, R.J. (in press) Long-term memory for concepts in a California sea lion. Anim. Cognition.