

VITA

Richard R. Fay
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Born Holden, MA, 5/5/44 Citizenship: USA

Education:

B.A. Bowdoin College, 1966 - Psychology
M.A. Connecticut College, 1968 - Experimental Psychology
Ph.D. Princeton University, 1970 - Experimental Psychology and Sensory Physiology

Completed: "Neural Systems and Behavior" course, Marine Biological Lab, Woods Hole, MA, Jul.-Aug., 1989.

Research and Professional Experience:

Presently: Professor of Psychology, Loyola University Chicago.

Director, Parmly Hearing Institute

Director, Interdisciplinary Neuroscience Minor, Loyola University Chicago

Loyola University Faculty Scholar

Member of the Graduate Faculty

Adjunct Professor in Otolaryngology

1993-Present: Summer Scientist, Marine Biological Laboratory, Woods Hole. Lecturer, Boston University Marine Program (Jan. 1, 1994-June 1, 1996).

1982-1983 & 1987-1988: Acting Director, Parmly Hearing Institute, Loyola University Chicago.

1980-Present: Professor of Psychology, Graduate Faculty, Loyola University Chicago.

1975-1980: Associate Professor of Psychology, Graduate Faculty, Loyola University Chicago.

1974-1975: Assistant Professor of Otolaryngology, Bowman Gray School of Medicine, Wake Forest University.

1972-1974: Assistant Researcher, G. von Békésy, supervisor, Laboratory of Sensory Sciences.

Adjunct Assistant Professor of Psychology, Member of the Graduate Faculty, Department of Zoology, University of Hawaii. Visiting Scientist, Eniwetok Marine Biological Laboratory, Marshall Islands.

1970-1971: Visiting Research Fellow, E.G. Wever, supervisor, Auditory Research Lab, Princeton University.

1968-1970: Pre-doctoral Trainee (UPHS), E.G. Wever, supervisor, Dept. Psychology, Princeton University.

1967-1968: Research Assistant, J.D. Harris, supervisor, U.S.N. Sub Base Med. Res. Lab., Groton, Conn.

Major Research Interests:

Neural mechanisms of perception, sensory neuroscience, evolution of hearing.

Extramural Research Grants:

- 2002: "Sound Source Segregation and Determination," R. Fay, P.I. A five-year individual research grant from National Institutes of Health (NIDCD).
- 2001: "Fish Bioacoustics: Sensory Biology, Behavior, and Practical Applications," R. Fay, P.I. A conference grant from the U.S. Minerals Management Service (MMS).
- 2001: "Fish Bioacoustics: Sensory Biology, Behavior, and Practical Applications," R. Fay, P.I. A conference grant from the Office of Naval Research (ONR).
- 2001: "Fish Bioacoustics, Sensory Biology, Behavior, and Practical Applications," R. Fay, P.I., A conference grant from the National Science Foundation (NSF).
- 2001: "Fish Bioacoustics, Sensory Biology, Behavior, and Practical Applications," R. Fay, P.I., A conference grant from the Electric Power Research Institute (EPRI).
- 1998: "Information Processing by the Auditory System," R. Fay, Investigator, W. Yost, P.I. A five-year Center Grant from National Institutes of Health (NIDCD).
- 1998: Neural Mechanisms of Hearing," R. Fay, P.I. A five-year research grant grant from the NIH, NIDCD.
- 1994: "Neural Mechanisms of Hearing and Balance in Fish. R. Fay, Investigator, S. Highstein, P.I. A four-year Program Project Grant from the National Institutes of Health (NIDCD).
- 1994: "Sound Source Localization by Fish: Mechanisms and Models." R. Fay, Investigator, A. Popper, P.I. A three-year grant from the Office of Naval Research.
- 1993: "Information Processing by the Auditory System," R. Fay, Investigator, W. Yost, P.I. A five-year Center Grant from National Institutes of Health (NIDCD).
- 1990: "International Conference on Evolutionary Biology of Hearing," R. Fay, P.I., National Institutes of Health (NIDCD) 1990.
- 1988: "Information Processing by the Auditory System," R. Fay, Investigator. A five-year Center Grant from National Institutes of Health (NIDCD).
- 1985: "Information Processing by the Auditory System," R. Fay, Investigator. A Program Project Grant from National Institutes of Health (NINCDs).
- 1985: "The Sensory Biology of Aquatic Animals: An International Conference." A. Popper, P.I., R. Fay, J. Atema, W. Tavalga, Co-Convenors. NSF, 1985-1986.
- 1983: "Biomedical Research Support Grant," R. Fay P.I., Lakeshore Campus of Loyola University, National Institutes of Health. 1983-1988.
- 1982: "Mechanisms of Auditory Analysis by Nervous Systems," National Institutes of Health (NINCDs), 1982-1985. R. Fay, P.I.
- 1981: "Neural Mechanisms of Directional Hearing," National Science Foundation, 1981-1983. R. Fay, P.I.
- 1980: Research Career Development Award. National Institutes of Health, (NINCDs), 1980-1985.
- 1980: ISEP Program Instructional Equipment Grant, National Science Foundation, 1980-1982.
- 1979: "Mechanisms of Auditory Analysis by Nervous Systems." National Institutes of Health (NINCDs). 1979-1982.

1979: Conference on Hearing and Sound Communication in Fishes. Co-P.I. with A. Popper and W. Tavalga. National Science Foundation. 1979-1980.

1976: Instructional Equipment Grant. National Science Foundation, 1976-1977.

1975: "Mechanisms of Auditory Analysis by Nervous Systems." National Science Foundation. 1975-1978.

Honors:

Loyola University Faculty Scholar, 2000-2003

NIH, NINCDS Research Career Development Award, 1980-1985.

Hearing Research Study Section, NIH, NINCDS, member, 1984-1989.

Phi Beta Kappa, Connecticut College.

Fellow, Acoustical Society of America.

Chicago Emmy Award Nominee, 1987, for producer/writer of the film "Red Hot Chicago."

Memberships:

Acoustical Society of America (Fellow)

Technical Committee on Psychological and Physiological Acoustics, 1982-1987: 1998-present.

Membership Committee, 1987-2001.

Association for Research in Otolaryngology

Society for Neuroscience

J.B. Johnston Club

American Association for the Advancement of Science

Sigma Xi, President-Elect of the Loyola Chapter, 1989.

Member, Reviewer in Reserve Program, NIH, NIDCD, 1988-present.

Conferences Organized:

1. "Comparative Studies of Hearing in Vertebrates," an international conference convened in Honolulu, HI, 1978, during joint meetings of the Acoustical Societies of America and Japan. R. Fay and A. Popper, co-convenors.
2. "Hearing and Sound Communication in Fishes," an international conference convened at Mote Marine Laboratory, Sarasota, FL, 1980. R. Fay, A. Popper, and W. Tavalga, co-convenors.
3. "Hearing and Other Senses: Presentations on Honor of E. G. Wever," an international conference convened at Princeton University, 1982, R. Fay and G. Gourevitch, co-convenors.
4. "Sensory Biology of Aquatic Animals," an international conference convened at Mote Marine Laboratory, Sarasota, FL, 1985, R. Fay, A. Popper, J. Atema, and W. Tavalga, co-convenors.
5. "The Evolutionary Biology of Hearing," an international conference convened at Mote Marine Laboratory, Sarasota, FL, 1990, R. Fay, D. Webster, and A. Popper, co-convenors.
6. "The Evolution of Sensory Systems," J.B. Johnston Club, Washington, D.C., November, 1996. A. Popper and R. Fay, co-convenors.

7. "Fish Bioacoustics: Sensory Biology, Behavior, and Practical Applications," an international conference convened at Loyola University Chicago, May 30-June 2, 2001: R Fay, J. Webb, and A. Popper, co-convenors.

Publications:

1. Fay, R.R. (1969) Auditory sensitivity of the goldfish within the near acoustic field. U.S. Naval Submarine Medical Center, Submarine Base, Groton, Connecticut, Report No. 605, 1-11.
2. Fay, R.R. and MacKinnon, J.R. (1969) A simplified technique for conditioning respiratory mouth movements in fish. *Behav. Res. Meth. & Instru.* 1, 123-124.
3. Fay, R.R. (1969) Behavioral audiogram for the goldfish. *J. Aud. Res.* 9, 112-121.
4. Fay, R.R. (1970) Auditory frequency generalization in the goldfish (*Carassius auratus*). *J. Exp. Anal. Behav.* 14, 353-360.
5. Fay, R.R. (1970) Auditory frequency discrimination in the goldfish (*Carassius auratus*). *J. Comp. Physiol. Psychol.* 73, 175-180.
6. Fay, R.R. (1972) Perception of amplitude-modulated auditory signals by the goldfish. *J. Acoust. Soc. Am.* 52, 660-666.
7. Fay, R.R. (1973) Multisensory interaction in control of eye-stalk rotation response in the crayfish (*Procambarus clarkii*). *J. Comp. Physiol. Psychol.* 84, 527-533.
8. Fay, R.R. and Popper, A.N. (1973) Vibration isolation for small aquaria. *Behav. Res. Meth. Instr.* 5, 502-503.
9. Popper, A.N. and Fay, R.R. (1973) Sound detection and processing by teleost fishes: A critical review. *J. Acoust. Soc. Am.* 53, 1515-1529.
10. Fay, R.R., Kendall, J.I., Popper, A.N., and Tester, A.L. (1974) Vibration detection by the macula neglecta of sharks. *Comp. Biochem. Physiol.* 47, 1235-1240.
11. Fay, R.R. (1974) Sound reception and processing in the carp: saccular potentials. *J. Comp. Biochem. Physiol.* 49, 29-42.
12. Fay, R.R. (1974) Masking of tones by noise for the goldfish (*Carassius auratus*). *J. Comp. Physiol. Psychol.* 87, 708-716.
13. Fay, R. (1974) Auditory frequency discrimination in vertebrates. *J. Acoust. Soc. Am.* 56, 206-209.
14. Fay, R.R. Popper, A.N. (1974) Acoustic stimulation of the ear of the goldfish (*Carassius auratus*). *J. Exp. Biol.* 61, 243-260.
15. Fay, R.R. and Popper, A.N. (1975) Modes of stimulation of the teleost ear. *J. Exp. Biol.* 62, 379-387.
16. Fay, R.R. (1975) Dynamic properties of the compensatory eye-stalk rotation response of the crayfish (*Procambarus clarkii*). *Comp. Biochem. Physiol.* 51, 101-103.
17. Popper, A.N. and Fay, R.R. (1977) Structure and function of the elasmobranch auditory system. *Amer. Zool.* 17, 443-452.
18. Fay, R.R. (1978) Coding of information in single auditory-nerve fibers of the goldfish. *J. Acoust. Soc. Amer.* 63, 136-146.
19. Fay, R.R. Ahroon, W.A. and Orawski, A.A. (1978) Auditory masking patterns in the goldfish (*Carassius auratus*): Psychophysical tuning curves. *J. Exp. Biol.* 74, 83-100.
20. Fay, R.R. (1978) Sound detection and sensory coding by the auditory systems of fishes. In D.

- Mostofsky (Ed.) *The Behavior of Fish and Other Aquatic Animals*. Academic Press, New York, 197-236.
21. Fay, R.R. and Olsho, L.W. (1979) Discharge patterns of lagenar and saccular neurones of the goldfish eighth nerve: Displacement sensitivity and directional characteristics. *Comp. Biochem. Physiol.* 62, 377-386.
 22. Fay, R.R. (1978) Phase-locking in goldfish saccular nerve fibres accounts for frequency discrimination capacities. *Nature*, 275, 320-322.
 23. Labs, S.M. Gescheider, G.A. Fay, R.R. and Lyons, C.H. (1978) Psychophysical tuning curves in vibrotaction. *Sensory Processes*, 2, 231-247.
 24. Fay, R.R. (1980) Psychophysics and neurophysiology of temporal factors in hearing by the goldfish: Amplitude modulation detection. *J. Neurophysiol.* 44, 312-332.
 25. Fay, R.R. and Popper, A.N. (1980) Structure and function in teleost auditory systems. In A.N. Popper and R.R. Fay (Eds.), *Comparative Studies of Hearing in Vertebrates*. Springer-Verlag, New York, pp. 3-42.
 26. Fay, R.R. (1981) Coding of acoustic information in the eighth nerve. In W.N. Tavolga, A.N. Popper, and R.R. Fay (Eds.), *Hearing and Sound Communication in Fishes*. Springer-Verlag, New York, pp. 189-219.
 27. Hall, L. Patricoski, M. and Fay, R. (1981) Neurophysiological mechanisms of intensity discrimination in the goldfish. In W.N. Tavolga, A.N. Popper, and R.R. Fay (Eds.), *Hearing and Sound Communication in Fishes*. Springer-Verlag, New York, pp. 179-186.
 28. Fay, R.R. and Patricoski, M. (1980) Sensory mechanisms for low frequency vibration detection in fishes. In R. Buskirk (Ed.), *Abnormal Animal Behavior Prior to Earthquakes, II*. U.S. Geological Survey Open File Report 80-453, 63-91.
 29. Lombard, R.E., Fay, R.R. and Werner, Y.L. (1981) Underwater hearing in the frog, *Rana catesbeiana*. *J. Exp. Biol.* 91, 57-71.
 30. Fay, R.R., Hillery, C.M. and Bolan, K. (1982) Representation of sound pressure and particle motion information in the midbrain of the goldfish. *Comp. Biochem. Physiol.* 71, 181-191.
 31. Fay, R.R. (1982) Neural mechanisms of an auditory temporal discrimination by the goldfish. *J. Comp. Physiol.* 147, 201-216.
 32. Hillery, C.M. and Fay, R.R. (1982) Forward masking and suppression in the midbrain of the southern grey treefrog (*Hyla chrysoscelis*) *J. Comp. Physiol.* 146, 435-447.
 33. Fay, R.R. and Passow, B. (1982) Temporal discrimination in the goldfish. *J. Acoust. Soc. Amer.* 72, 753-760.
 34. Fay, R.R. and Coombs, S. (1983) Neural mechanisms in sound detection and temporal summation. *Hearing Research*, 10, 69-92.
 35. Fay, R.R. Yost, W.A., and Coombs, S. (1983) Psychophysics and neurophysiology of repetition noise processing in a vertebrate auditory system. *Hearing Research*, 12, 31-55.
 36. Fay, R.R. and Popper, A.N. (1983) Hearing in fishes: Comparative anatomy of the ear and the neural coding of auditory information. In R. Fay and G. Gourevitch (Eds.), *Hearing and other Senses: Presentations in Honor of E.G. Wever*. Amphora Press, Groton, Conn., pp. 123-148.
 37. Fay, R.R. (1983) Effects of noise on acoustic detection and communication by fishes. 11th International Congress on Acoustics, vol. 8, 245-248.
 38. Popper, A.N. and Fay, R.R. (1984) Sound detection and processing by teleost fish: A

- selective review. In L. Bolis, R.D. Keynes, and S.H.P. Maddrell (Eds.), *Comparative Physiology of Sensory Systems*, Cambridge University Press, Cambridge, UK, 67-101.
39. Fay, R.R. (1984) The goldfish ear codes the axis of acoustic particle motion in three dimensions. *Science*, 225, 951-954.
 40. Fay, R.R. (1985) Temporal processing by the auditory system of fishes. In A. Michelsen (Ed.) *Time Resolution in Auditory Systems*, Springer-Verlag, Berlin, 28-57.
 41. Fay, R.R. (1985) Sound intensity processing by the goldfish. *J. Acoust. Soc. Amer.* 78, 1296-1309.
 42. Coombs, S. and Fay, R.R. (1985) Adaptation effects on amplitude modulation detection: Behavioral and neurophysiological assessment in the goldfish auditory system. *Hearing Research*, 19, 57-71.
 43. Fay, R. and Popper, A. (1985) Functional morphology of the octavolateralis system. In M. Hildebrand, D.M. Bramble, K.F. Liem and D.B. Wake (Eds.) *Functional Vertebrate Morphology*, The Belknap Press, Cambridge, MA, pp. 291-316.
 44. Fay, R.R. and Ream, T.J. (1986) Acoustic response and tuning in saccular nerve fibers of the goldfish (*Carassius auratus*). *J. Acoust. Soc. Amer.* 79, 1883-1895.
 45. Fay, R.R. (1986) Frequency selectivity, adaptation, and suppression in goldfish auditory nerve fibers. In B.C.J. Moore and R. Patterson (Eds.) *Auditory Frequency Selectivity*. Plenum Publishing Corporation, New York, pp. 137-145.
 46. Coombs, S.L. and Fay, R.R. (1987) Response dynamics of goldfish saccular fibers: Effects of stimulus frequency and intensity on fibers with different tuning, sensitivity, and spontaneous activity. *J. Acoust. Soc. Amer.* 81, 1025-1035.
 47. Fay, R.R. and Feng, A.S. (1987) Directional hearing among nonmammalian vertebrates. In W.A. Yost and G. Gourevitch (Eds.), *Directional Hearing*, Springer-Verlag, New York, pp. 179-213.
 48. Bowen, R. and Fay, R. (1987) "The Big Feed," *Chicago Magazine*, Feb.
 49. Fay, R.R. (1987) Peripheral adaptations for spatial hearing in fish. In J. Atema, R.R. Fay, A.N. Popper, and W.N. Tavolga (Eds.), *Sensory Biology of Aquatic Animals*, Springer-Verlag, New York, pp. 711-731.
 50. Fay, R.R. and Coombs, S.L. (1988) Psychophysics and neurophysiology of frequency selectivity and masking in the goldfish. In H. Duifhuis, W. Horst, and H. Wit (Eds) *Basic Issues in Hearing*, Groningen University Press, Groningen, The Netherlands, pp. 169-176.
 51. Fay, R.R. (1988) Comparative psychoacoustics. *Hearing Research*, 34, 295-305.
 52. Platt, C, Popper, A.N. and Fay, R.R. (1989) The ear as part of the octavolateralis system. In S.L. Coombs, P. Gärner, and H. Münz (Eds.) *The Mechanosensory Lateral Line: Neurobiology and Evolution*. Springer-Verlag, New York, pp. 633-651.
 53. Fay, R.R. (1989) Intensity discrimination of pulsed tones by the goldfish (*Carassius auratus*). *J. Acoust. Soc. Amer.* 85, 500-502.
 54. Fay, R.R. (1989) Frequency discrimination in the goldfish (*Carassius auratus*): Effects of roving intensity, sensation level, and the direction of frequency change. *J. Acoust. Soc. Amer.* 85, 503-505.
 55. Coombs, S.L., Fay, R.R., and Janssen, J. (1989) Hot-film anemometry for measuring lateral line stimuli. *J. Acoust. Soc. Amer.* 85, 2185-2193.
 56. Coombs, S.L., and Fay, R. (1989) The temporal evolution of masking and frequency

- selectivity in the goldfish (*Carassius auratus*). *J. Acoust. Soc. Amer.* 86, 925-933.
57. Fay, R.R. (1990) Suppression and excitation in auditory nerve fibers of the goldfish, *Carassius auratus*. *Hearing Research*, 48, 93-110.
 58. Fay, R.R. and Ream, T.J. (1992) The effects of temperature change and transient hypoxia on auditory nerve response in the goldfish (*Carassius auratus*). *Hearing Research*, 58, 9-18.
 59. Fay, R.R. (1991) Masking and suppression in auditory nerve fibers of the goldfish, (*Carassius auratus*). *Hearing Research*, 55, 177-187.
 60. Fay, R.R. and Coombs, S.L. (1992) Psychometric functions for level discrimination and the effects of signal duration in the goldfish (*Carassius auratus*): Psychophysics and neurophysiology. *J. Acoust. Soc. Amer.*, 92, 189-201.
 61. Fay, R.R. (1992) Analytic listening by the goldfish. *Hearing Research*, 59, 101-107.
 62. Fay, R.R. (1992) Structure and function in sound discrimination among vertebrates. In D. Webster, R.R. Fay, and A.N. Popper (Eds.), *The Evolutionary Biology of Hearing*, Springer-Verlag, New York, pp. 229-263.
 63. Fay, R.R. (1992) Ernest Glen Wever: A brief biography and bibliography. In D. Webster, R.R. Fay, and A.N. Popper (Eds.), *The Evolutionary Biology of Hearing*, Springer-Verlag, New York, pp. xliii-li.
 64. Popper, A.N., and Fay, R.R. (1993) Sound detection and processing by fish: Critical review and major research questions. *Brain Behav. Evol.*, 41, 14-38.
 65. Coombs, S., and Fay, R.R. (1993) Source level discrimination by the lateral line system of the mottled sculpin, *Cottius bairdi*. *J. Acoust. Soc. Amer.*, 93, 2116-2123.
 66. Lu, Z., and Fay, R.R. (1993) Acoustic response properties of single units in the torus semicircularis of the goldfish, *Carassius auratus*. *J. Comp. Physiol.*, 173, 33-48.
 67. Fay, R.R., Edds-Walton, P.L., and Highstein, S.M. (1994) Directional sensitivity of saccular afferents of the toadfish to linear acceleration at audio frequencies. *Biol. Bull.* 187, 258-259.
 68. Fay, R.R. (1994) Comparative auditory research. In R.R. Fay, and A.N. Popper (Eds.) *Springer Handbook of Auditory Research. Vol. 4. Comparative Mammalian Hearing*. Springer-Verlag, New York, 1994, pp. 1-17.
 69. Echteler, S.M., Fay, R.R., and Popper, A.N. (1994) Structure of the mammalian cochlea. In R.R. Fay, and A.N. Popper (Eds.) *Springer Handbook of Auditory Research. Vol. 4. Comparative Mammalian Hearing*. Springer-Verlag, New York, 1994, pp 134-171.
 70. Fay, R.R. (1994) Perception of temporal acoustic patterns by the goldfish (*Carassius auratus*). *Hearing Research*, 76, 158-172.
 71. Fay, R.R. (1994) The sense of hearing in fishes: psychophysics and neurophysiology. *Sensory Systems*, 8, 222-232.
 72. Fay, R.R. (1995) Psychoacoustical studies of the sense of hearing in the goldfish using conditioned respiratory suppression. In G. Klump, R. Dooling, R.R., Fay and W.C. Stebbins (Eds.) *Methodology in Animal Psychophysics*. Birkhauser Verlag, Berlin.
 73. Fay, R.R. (1995) Physiology of primary saccular afferents of goldfish: Implications for Mauthner cell response. *Brain, Behavior, and Evolution*, 46, 141-150.
 74. Fay, R.R. (1995) Comparative studies of sound source perception. In G.A. Manley, G.M. Klump, C. Köppl, H. Fastl, and H. Oeckinghaus (Eds.) *Advances in Hearing Research*, World Scientific Publishers, Singapore, pp. 183-197.
 75. Lu, Z., and Fay, R.R. (1995) Acoustic response properties of single units in the central

- posterior nucleus of the thalamus of the goldfish (*Carassius auratus*). *J. Comp. Physiol.*, 176, 747-760.
76. Fay, R.R. (1995) Perception of spectrally and temporally complex sounds by the goldfish (*Carassius auratus*). *Hearing Research*, 89, 146-154.
 77. Edds-Walton, P., and Fay, R.R. (1995) Regional differences in directional response properties of afferents along the saccule of the toadfish (*Opsanus tau*). *Biol. Bull.*, 189, 211-212.
 78. Lu, Z., Popper, A., and Fay, R.R. (1996) Behavioral detection of acoustic particle motion by a teleost fish (*Astronotus ocellatus*): Sensitivity and directionality. *J. Comp. Physiol.*, 179, 227-234.
 79. Lu, Z. and Fay, R.R. (1996) Two-tone interaction in auditory nerve fibers and midbrain neurons of the goldfish, *Carassius auratus*. *Auditory Neuroscience*, 2, 257-273.
 80. Fay, R.R., Chronopoulos, M. and Patterson, R.D. (1996) The sound of a sinusoid: Perception and neural representations in the goldfish (*Carassius auratus*). *Auditory Neuroscience*, 2, 377-392.
 81. Fay, R.R., Edds-Walton, P.L., and Highstein, S.M. (1996) Tuning in saccular afferents of the toadfish revealed by the reverse correlation method. *Biol. Bull.*, 191, 255-257.
 82. Fay, R.R. (1997) Hearing and sound perception among vertebrate animals. In M. Crocker (Ed.) *Handbook of Acoustics*. John Wiley & Sons, New York, pp. 1789-1797.
 83. Fay, R.R. (1997) Frequency selectivity of saccular afferents of the goldfish revealed by revcor analysis. In E.R. Lewis, G.R. Long, R.F. Lyon, P.M. Narins, C.R. Steele, and E. Hecht-Poinar (Ed.) *Diversity in Auditory Mechanics*, World Scientific Publishers, Singapore, pp. 69-75.
 84. Popper, A.N., and Fay, R.R. (1997) Evolution of the Ear and Hearing: Issues and Questions. *Brain, Behavior, and Evolution*, 50: 213-221.
 85. Fay, R.R. and Popper, A.N. (1997) Preface to special issue of *Brain, Behavior, and Evolution* on Evolution of Sensory Systems, 50, 1-2.
 86. Fay, R.R. and Edds-Walton, P.L. (1997) Directional response properties of saccular afferents of the toadfish, *Opsanus tau*. *Hearing Research*, 111: 1-21.
 87. Fay, R.R., Edds-Walton, P.L. (1997) Diversity in frequency response properties of saccular afferents of the toadfish (*Opsanus tau*). *Hearing Research*, 113: 235-246.
 88. Fay, R.R., and Popper, A.N. (1999) The auditory periphery in fishes. In R.R. Fay and A.N. Popper (Eds.) *Springer Handbook of Auditory Research. Vol. 10. Hearing in Fishes and Amphibians*. Springer-Verlag, New York, 43-100.
 89. Fay, R.R., and Popper, A.N. (1999) Hearing in Fishes and Amphibians: An Introduction. In R. Fay and A. Popper (Eds.) *Springer Handbook of Auditory Research. Vol. 10. Hearing in Fishes and Amphibians*. Springer-Verlag, New York, 1-14.
 90. Fay, R.R., and Megela Simmons, A. (1999) The sense of hearing in fishes and amphibians. In R. Fay and A. Popper (Eds.) *Springer Handbook of Auditory Research. Vol. 10. Hearing in Fishes and Amphibians*. Springer-Verlag, New York, 269-318.
 91. Fay, R.R. (1998) Perception of two-tone complexes by goldfish (*Carassius auratus*). *Hear. Res.* 120, 17-24.
 92. Fay, R.R. (1998) Auditory stream segregation in goldfish (*Carassius auratus*). *Hearing Research*, 120, 69-76.
 93. Edds-Walton, P.L., and Fay, R.R. (1998) Directional auditory responses in the descending

- octaval nucleus of the toadfish (*Opsanus tau*). *Biol. Bull.*, 195, 191-192
94. Edds-Walton, P.L., Fay, R.R., and Highstein, S.M. (1999) Dendritic arbors and central projections of auditory fibers from the saccule of the toadfish (*Opsanus tau*). *J. Comp. Neurol.*, 411: 212-238.
 95. Fay, R.R., and Edds-Walton, P.L. (1999). Sharpening of directional auditory responses in the descending octaval nucleus of the toadfish (*Opsanus tau*). *Biol. Bull.*, 197: 240-241.
 96. Fay, R.R. and Edds-Walton, P.L. (2000). Directional encoding by fish auditory systems. *Philosophical Transactions of the Royal Society London. B*, 355: 1281-1284.
 97. Fay, R.R. (2000) Frequency contrasts underlying auditory stream segregation in goldfish. *Journ. Assoc. Res. Otolaryngol.*, 01: 120-128.
 98. Fay, R.R. and Popper, A.N. (2000) Evolution of hearing in vertebrates: the inner ears and processing. *Hear. Res.*, 149:1-10.
 99. Fay, R.R. and Edds-Walton, P.L. (2000) Frequency response of auditory brainstem units in toadfish (*Opsanus tau*). *Biol. Bull.*, 199:173-174.
 100. Fay, R.R. (2000) Hearing in Vertebrate Animals. In: *McGraw-Hill Encyclopedia of Science and Technolog.*
 101. Fay, R.R. (2001). Stream segregation in goldfish: Auditory scene analysis. In Breebaart, D.J., Houtsma, A.J.M., Kohlrausch, A., Prijs, V.F., and Schoonhoven, R. (Eds.) *Physiological and Psychophysical Bases of Auditory Function: Proceedings of the XIIIth Symposium on Hearing*, Maastricht, The Netherlands: Shaker Publishing, pp. 485-491.
 102. Fay, R.R., and Edds-Walton, P.L. (2001) Bimodal units in the torus semicircularis of the toadfish (*Opsanus tau*). *Biol. Bull.*, 201, 280-281.
 103. Fay, R.R. (2002) The sense of hearing in fishes. *Bioacoustics*, 12: 167-169.
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39. Fay, R. Three lectures; 1) "Sound conduction to the ear and the neural coding of acoustic information". 2) "Acoustic behavior and its neural correlates". 3) "Frequency and time domain processing by a vertebrate auditory system", delivered by invitation as part of the course *Behavior*, Marine Biological Laboratory, Woods Hole, Mass., Jan. 7, 1983.
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56. Coombs, S., and Fay, R. PST histogram profiles from goldfish saccular nerve fibers as a function of stimulus intensity and frequency. Paper presented at the midwinter meeting of the Assoc. Res. Otolaryngology, Clearwater, FL, Jan, 1986 .
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75. Fay, R. (with D. Webster and A Popper) Convenor: International Conference on Evolutionary Biology of Hearing, Mote Marine Laboratory, May 19-23, 1990 .
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81. Fay, R. Session Chair, Animal Bioacoustics II. Meeting of the Acoustical Society of America, San Diego, CA, Nov. 1990 .
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85. New, J. and Fay, R. (1991) Computer simulation in neurophysiology instruction. *Soc. Neurosci. Abstracts*, 17, 203.18, 521 .
86. Fay, R.R. (1992) Vertebrate sound discrimination. Invited paper, Symposium on Evolutionary Biology of Hearing, Association for Research in Otolaryngology, St. Petersburg FL, Feb .
87. Fay, R.R. (1992) Co-convenor and co-moderator, Symposium on Evolutionary Biology of Hearing, Assoc. Res. Otolaryngol., Mid-winter meeting, St. Petersburg, FL, Feb .
88. Fay, R.R. (1992) Physiology of the saccular nerve in fishes. Invited paper, Symposium on the Mauthner cell and hearing, International Congress of Neuroethology. (abstract) .
89. Fay, R.R. (1992) Analytic listening in the goldfish: simultaneous frequency analysis. *J. Acoust. Soc. Amer.*, 91, 2435-2436.
90. Lu, J., and Fay, R.R. (1992) Acoustic response properties of single units and unit clusters in

- the midbrain of the goldfish. *J. Acoust. Soc. Amer.*, 91, p. 2398.
91. Fay, R.R. (1992) Chair, Session on Psychological and Physiological Acoustics, *J. Acoust. Soc. Amer.*, 91, 2435-2438.
 92. Fay, R.R., and Lu, Z. (1992) Auditory midbrain cells in goldfish: transformations of peripheral input. *Soc. Neurosci. Abstr.*, 166.1, 382 .
 93. Fay, RR (1993) Temporal pattern perception in the goldfish: methods and models. *J. Acoust. Soc. Amer.*, 93, p. 2409.
 94. Fay, RR (1993) Session Chair. Symposium on Collaborations in Psychological and Physiological Acoustics. *J. Acoust. Soc. Amer.*, 93, p. 2408 .
 95. Fay, RR (1993) Comparative hearing research on the mechanisms of perception by the octavolateralis system. Parmlly Hearing Institute Progress Report, 1992-1993 .
 96. Fay, RR (1993) Comparative hearing research on the mechanisms of perception by the octavolateralis system. Invited lecture: Symposium for the 50th Anniversary of the Parmlly Hearing Institute, June 12, 1993. .
 97. Fay, R.R. Hearing in fishes: Neurobiology and behavior. Invited lecture, Department of Neurobiology and Behavior, Cornell University, October, 1993 .
 98. Fay, R.R. Neural mechanisms of sound perception in fishes. Invited lecture, Boston University, Department of Biomedical Engineering, November, 1993 .
 99. Lu, Z., and Fay, R. (1993) Response properties of primary afferents and auditory midbrain cells of the goldfish to two-tone stimuli. *Soc. Neurosci. Abstr.*, 19(2), 693.1 .
 100. New, J., Fay, C., and Fay, R. (1993) Distribution of Gamma aminobutyric acid immunoreactivity in the brain of the channel catfish with special reference to octavolateralis systems. *Soc. Neurosci. Abstr.*, 19(1), 68.7 .
 101. Fay, R.R. (1993) The sense of hearing in fishes: Psychophysics and neurophysiology. Invited lecture, Joint US-Russia Meeting on Sensory Physiology, University of Maryland, College Park, August .
 102. Lu, Z, and Fay, R. (1994) Acoustic response properties of single units of the central posterior nucleus of the thalamus in goldfish (*Carassius auratus*). *Abstracts of the Assoc. for Res. in Otolaryngol.*, Feb., 1994 .
 102. Fay, R.R. (1994) Comparative studies of sound source perception. Invited Plenary Lecture, 10th International Symposium on Hearing, Irsee, Germany, June 26-July 1, 1994 .
 103. Fay, R.R. (1994) Pitch and timbre perception in fishes. Invited presentation, Department of Psychology, Harvard University, April, 1994 .
 104. Fay, R.R. (1994) Behavioral methods for investigating complex sound perception in fishes. Invited presentation, Dept. Psychology, Boston University, March, 1994 .
 105. Fay, R.R., and Patterson, R. (1994) Perception of sinusoid "ramps" and "damps" by the goldfish. *J. Acoust. Soc. Amer.* 95, p. 2941.
 106. Fay, R.R., Edds-Walton, P., and Highstein, S. (1994) Sensitivity, frequency response, and directionality of primary saccular afferents in toadfish (*Opsanus tau*) to linear motion. Presentation at the Woods Hole Marine Biological Laboratory Summer Scientist Symposium, Aug, 1994.
 107. Fay, R.R., Edds-Walton, P.L., and Highstein, S.H. (1995) Sensitivity and directionality of primary saccular afferents in toadfish (*Opsanus tau*) to linear motion. *Abstracts of the Assoc. for Res. in Otolaryngol.* #49, pg. 13 .
 108. Fay, R.R., Chronopoulos, M., and Patterson, R. (1995) Representation of sinusoid "ramps"

- and "damps" in auditory-nerve fibers of the goldfish. *J. Acoust. Soc. Amer.* 97, p. 3414.
109. Edds-Walton, P., and Fay, R.R. (1995) Regional differences in directional response properties of afferents along the saccule of the toadfish (*Opsanus tau*). Presentation at the Woods Hole Marine Biological Laboratory Summer Scientist Symposium, Aug, 1995.
 110. Fay, R.R. (1995) Psychophysical studies of complex sound perception in goldfish using classical conditioning. Invited presentation at the eleventh annual meeting of the International Society for Psychophysics, Cassis, France, October, 1995.
 111. Fay, R.R. (1995) Psychophysical studies of complex sound perception in goldfish using classical conditioning. In C.-A. Possamai (Ed.) Fechner Day: Proceedings of the Eleventh Annual Meeting of the International Society for Psychophysics, Cassis, France. pp. 79-84.
 112. Fay, R.R. (1995) Directional hearing by fishes. Invited lecture in Neural Systems and Behavior course, Marine Biological Laboratory, August, 1995.
 113. Fay, R.R. (1995) What fish hear. Invited presentation: Using Sound to Modify Fish Behavior at Power-production and Water-control Facilities: A Workshop. Portland State University, Portland, Oregon, Dec. 12-14, 1995.
 114. Fay, R.R. and Edds-Walton, P.L. (1996) Hearing in toadfish: the saccule codes the axis of acoustic particle motion in three dimensions. *Abstracts of the Assoc. for Res. in Otolaryngol.* #402, Pg. 101.
 115. Lu, Z., Popper, A.N. and Fay, R.R. (1996) Behavioral detection threshold of a teleost fish (*Astronotus ocellatus*) to linear acceleration at various axes. *Abstracts of the Assoc. for Res. in Otolaryngol.* #777, p. 195.
 116. Fay, R.R. (1996) Chair, lecture session on peripheral auditory neurophysiology, Association for Research in Otolaryngology, St. Petersburg, FL, Feb.
 117. Chronopoulos, M. Fay, R., Dye, R., Sheft, S., and Shofner, W. (1996) Envelope perception in the goldfish. *J. Acoust. Soc. Amer.*
 118. Fay, R.R., Edds-Walton, P., Highstein, S. (1996). Tuning in saccular afferents of the toadfish revealed by the reverse correlation method. General Scientific Meeting of the Marine Biological Laboratory, Woods Hole, MA, August.
 119. Edds-Walton, P.L., Highstein, S.M., and Fay, R.R. (1996) Characteristics of directional auditory afferents in the toadfish (*Opsanus tau*). *Soc. Neuroscience Abstracts*, 178.4, p. 447.
 120. Fay, R.R., Edds-Walton, P.L., and Highstein, S.H. (1996) Tuning in primary saccular afferents of the toadfish: REVCOR analysis. *J. Acoust. Soc. Amer.* 100, p. 2786.
 121. Ma, D. W.-L., and Fay, R.R. (1996) Directional response properties of cells of the goldfish midbrain. *J. Acoust. Soc. Amer.*, 100, p. 2786.
 122. Fay, R.R. (1996) Perception of two-tone mixtures by the goldfish. *J. Acoust. Soc. Amer.*, 100, p.2594.
 123. Chronopoulos, M, and Fay, R. [Fay as co-author was inadvertently deleted from the published abstract] (1996) Eighth nerve responses to side-band attenuated and center frequency phase-shifted three-tone complexes. *J. Acoust. Soc. Amer.* 100, p. 2786.
 124. Popper, A.N., and Fay, R.R. (1996) Evolution of octavo-lateralis systems. Invited paper, J.B. Johnston Club, November, 1996.
 125. Coombs, S.L., and Fay, R.R. (1997) Encoding of dipole near fields by the goldfish auditory system. *Soc. Neurosci. Abstracts*.

126. Fay, R.R. (1998) Auditory stream segregation in goldfish. *Abstracts of the Assoc. for Res. in Otolaryngol.*
127. Edds-Walton, P.L., Highstein, S., and Fay, R.R. (August, 1998) Neurobiotin-filled saccular afferents in the toadfish (*Opsanus tau*): Directionality, dendritic arbors, and central projections. Paper presented at the annual meeting of the International Society for Neuroethology, San Diego, CA.
128. Edds-Walton, P.L., and Fay, R.R. (August, 1998) Directional auditory responses in the descending octaval nucleus of the toadfish (*Opsanus tau*). General Scientific Meeting of the Marine Biological Laboratory, Woods Hole, MA .
129. Edds-Walton, P.L., Highstein, S., and Fay, R.R. (November, 1998) dendritic arbors and central projections of auditory fibers from the saccule of the toadfish, *Opsanus tau*. Presentation at the J.B. Johnston Club, Los Angeles.
130. Fay, R.R. (October, 1998) How do fishes localize sound sources? Invited presentation to the Kresge Hearing Research Institute, University of Michigan School of Medicine, Ann Arbor, MI.
131. Fay, R.R. (October, 1998) Sound source localization in fishes. Invited presentation, Department of Biology, Loyola University Chicago.
132. Ma, D., and Fay, R.R. (February, 1999) Distribution of GAD in the auditory tract of the goldfish, *Carassius auratus*. Abstracts of the Association for Research in Otolaryngology, Mid-winter meeting, St. Petersburg Beach, FL.
133. Fay, R.R., and Edds-Walton, P. L. Directional encoding by fish auditory systems. Presentation at the 1st International Conference on Sensory Processing of the Aquatic Environment, Heron Island, The Great Barrier Reef, Australia, March 22-28, 1999.
134. Fay, R.R. (1999) The sense of hearing in fishes: methodologies and results. Invited paper at the NIH symposium "Toward a Behavioral Ecology of Zebrafish." Marine Biological Laboratory, Woods Hole, MA, August, 1999.
135. Fay, R.R., and Edds-Walton, P.L. (1999) Sharpening of directional auditory responses in the descending octaval nucleus of the toadfish (*Opsanus tau*). Presentation at the Marine Biological Laboratory Summer Research Symposium, Woods Hole, MA, August, 1999.
136. Fay, R.R., and Edds-Walton, P.L. (1999) Directional Encoding by Fish Auditory Systems, *J. Acoust. Soc. Amer.*, 106: 2205 (abstract).
137. Fay, R.R. (1999) Technical Session Chair, Columbus Ohio meeting of the Acoust. Soc. Amer., 4 November, 1999.
138. Fay, R.R. (1999) Invited presentation, Brown University Dept. Neuroscience "Sound Source Localization by Fishes". December 2, 1999.
139. Fay, R.R. (2000) Evolution of the Sense of Hearing in Vertebrates. Invited symposium presentation at the midwinter meeting of the Assoc. Res. Otolaryngol., Feb., 2000.
140. Fay, R.R. (2000) Complex sound source determination: behavioral studies on goldfish. Invited presentation at a special session of the Acoustical Society of America, Atlanta, June, 2000.
141. Fay, R.R. (2000) Mechanisms and strategies for sound source localization by fishes. Invited presentation to the Neuroscience Program, Univ. Maryland, College Park, March 17, 2000.
142. Fay, R.R. (2000) The sense of hearing in fishes. Invited presentation, Institute for Zoology, University of Vienna, Austria, May 8, 2000.

143. Fay, R.R. (2000) Sound source localization in fishes. Invited presentation, Neurobiology group, University of Vienna, Austria, May 9, 2000.
144. Fay, R.R. (2000) Auditory scene analysis in fishes. Invited presentation, Bioacoustics group, Dept. Zoology, University of Vienna, Austria, May 10, 2000.
145. Fay, R.R. (2000) The sense of hearing in fishes and auditory scene analysis. Invited presentation at the International meeting: "Sensors and Sensing in the Natural and Artificial Worlds." Il Ciocco, Italy, June 22, 2000.
146. Fay, R.R. (2000) Stream segregation in goldfish: Auditory scene analysis. Presentation at the XIIth Symposium on Hearing, Mierlo, The Netherlands, August 11, 2000.
147. Fay, R.R., and Edds-Walton, P.L. (2000) Frequency response of auditory brainstem units of toadfish (*Opsanus tau*). Presentation at the General Scientific Meeting, Marine Biological Laboratory, Woods Hole, MA, August 16, 2000.
148. Ma, D., and Fay, R.R. (2000) Directional response properties and models of midbrain auditory units of goldfish. Abstracts of the Society for Neuroscience, Nov. 2000.
149. Fay, R.R. (2001) The sense of hearing in fishes. Presentation at the international symposium "Fish Bioacoustics: Sensory Biology, Behavior, and Practical Applications." May 30 – June 2, Evanston, IL.
150. Fay, R.R., Coombs, S., and Elepfandt, A. (2001) Response of goldfish otolithic afferents to a moving dipole sound source. Presentation at the international symposium "Fish Bioacoustics: Sensory Biology, Behavior, and Practical Applications." May 30 – June 2, Evanston, IL.
151. Edds-Walton, P.L., and Fay, R.R. (2001) Directional auditory processing by the oyster toadfish, *Opsanus tau*. Presentation at the international symposium "Fish Bioacoustics: Sensory Biology, Behavior, and Practical Applications." May 30 – June 2, Evanston, IL.
152. Ma, D. W.-L., and Fay, R.R. (2001) Neural representations of acoustic particle motion direction in the midbrain of the goldfish, *Carassius auratus*. Presentation at the international symposium "Fish Bioacoustics: Sensory Biology, Behavior, and Practical Applications." May 30 – June 2, Evanston, IL.
153. Fay, R.R. and Edds-Walton, P.L. (2001). Bimodal cells in the torus semicircularis of the toadfish (*Opsanus tau*). Paper presented at the General Scientific Meeting of the Marine Biological Laboratory, Woods Hole, MA, August, 2001.
154. Fay, R.R. Perception of sound by goldfish. Invited presentation and abstract, Acoustical Society of America, Ft. Lauderdale, FL, Dec., 2001.
155. Fay, R.R., and Edds-Walton, P.L. (2001) Directional response and morphological characteristics of auditory cells in the descending octaval nucleus of the oyster toadfish (*Opsanus tau*). Abstracts of the Society for Neuroscience, in press.
156. Fay, R.R. (2001) The sense of hearing in goldfish. Invited presentation, Boston University Department of Biomedical Engineering, September 21, 2001.
157. Fay, R.R. (2002) How do fishes locate sound sources. Invited presentation at the Marine Biological Laboratory, July, 2002.
158. Fay, R.R., and Edds-Walton, P. (2002) Preliminary Evidence for Interpulse Interval Selectivity of Cells in the Torus Semicircularis of the Oyster Toadfish (*Opsanus tau*). Presentation at the General Scientific Meeting of the Marine Biological Laboratory, August, 2002.
159. Fay, R.R. (2002) New developments in auditory physiology of fishes. Invited seminar, Dept.

Biology, University Maryland, College Park, MD.

- 160: Fay, R.R. (2002) Frequency and directional selectivity in primary auditory afferents in fishes. Invited presentation in Animal Bioacoustics at the meeting of the Acoustical Society of America, Cancun, Mexico, December, 2002.
- 161: Fay, R.R. (2003) Hearing in fishes: overview and persistent problems. Invited presentation, 1st International Conference on Sound Communication by Animals, University of Maryland, July 27-30.
- 162: Fay, R.R. (2003) Do goldfish miss the fundamental? Paper to be presented at the meeting of the Acoustical Society of America, Austin, TX, Nov. 3.
- 163: Fay, R.R. (2004) The Evolution of Hearing in Vertebrates. Invited presentation to the Loyola University Neuroscience Club, Feb. 4, 2004.
- 164: Fay, R.R., and Walton, P.L. (2004) Sharpening of directional responses by auditory cells in the brainstem of the toadfish, *Opsanus tau*. Paper to be presented at the midwinter meeting of the Association for Research in Otolaryngology, Daytona Beach, FL, Feb. 22-26, 2004.
- 165: Meyer, M., Popper, A.N., and Fay, R.R. (2004) Frequency tuning and directional preferences in lagenar nerve fibers of the goldfish, *Carassius auratus*. Paper to be presented at the midwinter meeting of the Association for Research in Otolaryngology, Daytona Beach, FL, Feb. 22-26, 2004.
- 166: Zeddies, D., and Fay, R.R. (2004) Development of the acoustic startle response in zebrafish to pure tones. Paper to be presented at the midwinter meeting of the Association for Research in Otolaryngology, Daytona Beach, FL, Feb. 22-26, 2004.
- 167: Fay, R.R. (2004) The sense of hearing of fishes: behavioral analyses. Invited paper to be presented at the International Congress on Acoustics (ICA2004), Kyoto, Japan, April 4-9, 2004.
- 168: Meyer, M., Fay, R.R., and Popper, A.N. (2005) What Can an Ancient Fish Tell Us About the Evolution of Directional Hearing and Frequency Selectivity? Paper presented at the Midwinter Meeting of the Association for Research in Otolaryngology, New Orleans, LA.
- 169: Fay, RR (2005) Common hearing functions among mammals and birds. Invited presentation, Acoustical Society of America, Vancouver, Canada, May, 2005.