

CURRICULUM VITAE

Richard B. Forward, Jr.

Personal

Born, January 13, 1943, Washington, D.C.
Married, 1969, to Margaret Heumann, 2 children

Education

B.A., Stanford University, 1965
Ph.D., University of California, Santa Barbara, 1969

Professional Positions

Research Assistant, University of California, Santa Barbara, 1966-68
Teaching Assistant, University of California, Santa Barbara, 1968-69
Research Associate, Yale University, New Haven, Connecticut, 1969-71
Assistant Professor, Department of Zoology, Duke University, 1971-77
Associate Professor, Department of Zoology, Duke University, 1977-88
Professor, Department of Zoology, Duke University, 1988-
Professor, School of the Environment Sciences, Duke University, 1992-
Lee Hill Snowdon Professor of Marine Biology, 1999 - 2003

Honorary Position

Fellow, American Association for the Advancement of Science, 1988

Professional Societies

American Society of Limnology and Oceanography
Society for Integrative and Comparative Biology
The Crustacean Society
Sigma Xi

Symposia Attended, Papers Presented

Symposium on the Physiological Ecology of Marine Animals at Belle Baruch Coastal
Research Institute, 1973
Estuarine Research Federation, Symposium on Bioassays for Environmental Perturbations,
1975
Joint U.S.-U.S.S.R. Symposium on the Ecology of Fouling Communities, 1975
12th European Symposium on Marine Biology, Scotland, 1977
ICES workshop on Problems of Monitoring Biological Effects of Pollution in the Sea, 1979
Estuarine Research Federation Symposium on Larval Transport, 1981

Symposia Attended, Papers Presented (cont.)

Symposium on Migration: Mechanisms and Adaptive Significance at U. of Texas, 1983
Symposium on Arthropod Photoreceptors honoring T.H. Waterman, Yale University, 1985
Symposium on Signposts in the Sea, Florida State University, 1986
Second International Symposium on Indo-Pacific Marine Biology, Guam, 1986
21st European Symposium on Marine Biology, Poland, 1986
Zooplankton Behavior Symposium, U. of Georgia, 1987
Symposium on Daily Vertical Migration, The Netherlands, 1991
Symposium on Larval Ecology, SUNY, Stony Brook, 1993
Symposium on Sensory Ecology and Physiology of Zooplankton, Hawaii, 1995
3rd International larval Biology Meeting, Australia, 1998
SICB – Ontogenetic Strategies of Invertebrates in Aquatic Environments 2001

Marine Laboratory Activities

Director of Graduate Studies, 1976, 1979, 1995-1996
Director of Undergraduate Studies, 1976-2006
Assistant Director of the Marine Laboratory, 1990-1999
Chairman – Coastal Systems Science and Policy division, 2000 - 2004

Graduate Students Directed

Lesley A. Barling, M.A. 1975 - A preliminary study of orientation and growth of the bay scallop *Argopecten irradians concentricus* (Say) in water currents of various speeds.
Thomas W. Cronin, Ph.D. 1979 - Factors contributing to the retention of larvae of the crab *Rhithropanopeus harrisi* in the Newport River estuary, North Carolina.
Pamela L. Harges, M.A. 1980 - Salinity perception in larvae of *Rhithropanopeus harrisi* (Gould).
Donald E. Stearns, Ph.D. 1983 - Control of nocturnal vertical migration in the calanoid copepod *Acartia tonsa* Dana in the Newport River estuary, North Carolina.
Andrew J. Sweatt, Ph.D. 1983 - Photobiology of the chaetognath *Sagitta hispida* Conant.
Roger Robbins, Ph.D. 1986 - Morphological and behavioral constraints on feeding in two species of ophiuroids (Echinodermata) from Beaufort, N.C.
John K. Douglass, Ph.D. 1986 - The ontogeny of light and dark adaptation in the compound eyes of grass shrimp, *Palaemonetes pugio*.
Mona C. De Vries, Ph.D. 1990 - Control of egg hatching in crabs: A comparative study of species from different tidal heights.
Sydney M. Goddard, Ph.D. 1991 - The role of sun and underwater polarized light in the celestial orientation behavior of the grass shrimp, *Palaemonetes vulgaris*.
Bret S. Danilowicz, Ph.D. 1994 - The development of recruitment variation in the damselfish *Dascyllus albisella*.
Maureen P. Small, Ph.D. 1994 - Intraspecific and interspecific variations in the 16S ribosomal gene of the *Ostreidae*.
Leslie McKelvey, Ph.D. 1997 – Planktivore chemical cues mediate zooplankton diel vertical migration
John E. Layne, Ph.D. 1997 – Mechanisms and ecological implications of eye stalk stability in the sand fiddler crab *Uca pugnator* (Bosc).

James Welch, Ph.D. 1998 – Swimming and settlement site selection behavior of blue crab megalopae.
Robert Mayer, Ph.D. 2004, Studies of brine shrimp physiological ecology
Jonathan Cohen, Ph.D. 2004, Diel vertical migration of copepods: effects of predator cues.
Tracy Ziegler, Ph.D. 2007. Larval release rhythms and larval behavior of Palinurid lobster: A comparative study.
Mathew Ogburn, Ph.D. 2008 Estuarine ingress of the blue crab *Callinectes sapidus*

Post Doctoral Research Associates

1. Richard A. Tankersley, 1992-1993
2. Mona C. De Vries, 1992-1995.
3. Nathalie Reyns, 2005

Courses Taught at Duke University Marine Laboratory

Physiology of Marine Animals - BIO 150L/ENV 228L
Marine Animal Navigation - BIO 295S/ENV 295S.08
Sensory Physiology and Behavior of Marine Animals – Bio 156L

National Service

Council for International Exchange of Scholars (Fulbright), 1981-1984. Life Science - A Committee, Chairman, 1984
National Science Foundation - Panel on Equipment and Facilities for Research at Biological Field Station and Marine Laboratories, 1989-1990

Journal and Grant Activities

Senior Advisor for Marine Ecology - Progress Series 1988-1998
Regular reviewer for Journal of Experimental Marine Biology and Ecology, Marine Biology, Marine Behaviour and Physiology, and Biological Bulletin
Reviewer for grants from NSF, EPA, and Sea Grant

Visiting Research Positions

Fullbright Scholar, University of Bergen, Norway, 1978
Visiting Researcher, EPA Environmental Research Laboratory, Rhode Island, 1977
Visiting Scholar, Scripps Institution of Oceanography, 1978, 1985
Visiting Researcher, Friday Harbor Laboratories, University of Washington, 1985
Visiting Scientist, Harbor Branch Oceanographic Institution, 1999
Visiting Scientist, University of Alaska, Juneau, 1999
Visiting Scientist, University of South Carolina, 2007

Curriculum Vitae: Richard B. Forward, Jr.

Past Grant Support

- National Science Foundation. "Neurohumor regulation of a unicellular photoreceptor." \$14,000, September 1973-October 1976.
- Environmental Protection Agency (with C.G. Bookhout and J.D. Costlow). "Effects of insect growth regulators and juvenile hormone mimics in crustacean development." \$18,000, September 1973-December 1974.
- Environmental Protection Agency (with J.D. Costlow and C.G. Bookhout). "Effects of insect growth regulators and juvenile hormone mimics in crustacean development." \$121,699, April 1975-April 1977.
- National Science Foundation. "Crustacean larvae: An interrelated study of behavioral physiology and population distribution in an estuary." \$36,000, January 1978-December 1979.
- Environmental Protection Agency (with C.G. Bookhout and J.D. Costlow). "Effects of soluble fractions of drilling fluids on crustacean larval development and behavior." \$58,000, July 1980-November 1981.
- National Science Foundation. "Vertical migration of estuarine zooplankton." \$81,218, May 1981-October 1983.
- National Science Foundation. "Zooplankton phototaxis: An ecological meaningful behavior or laboratory artifact." \$79,755, January 1984-June 1986.
- Environmental Protection Agency (with R.T. Barber, J.D. Costlow and W. Kirby-Smith). "Fates and effects of herbicides and pesticides in estuaries." \$508,815, July 1986-June 1989.
- National Science Foundation. "Responses of crustacean larvae to environmental factors." \$126,393, July 1986-January 1990.
- National Science Foundation (with D. Rittschof). "Regulation of crustacean larvae release." \$110,000, August 1987-January 1990.
- CIFO/SABRE. "Mechanism of depth regulation of Atlantic menhaden and spot larvae during onshore transport." \$66,000, November 1991-October 1993.
- CIFO. "Flood tide transport of estuarine crab larvae." \$14,970, November 1991-October 1992.

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National Science Foundation (with T.C. Wolcott and D.L. Wolcott). "Evaluation of larval transport models using a programmable vertically migrating zooplankton mimic." \$40,530, November 1989-April 1993.

National Science Foundation. "Behavioral basis of flood tide transport by crustacean larvae." \$110,528, January 1992-August 1995.

CIFO. "Habitat selection by blue crab postlarvae." \$24,994. September 1995-August 1996.

National Science Foundation (with D. Rittschof). "Zooplankton photoresponses during diel vertical migration: Modification by chemical cues from predators." \$122,235, June 1993-June 1997.

CIFO/SABRE. "Behavioral basis of estuarine transport of Atlantic menhaden and spot larvae." \$136,500, September 1993-August 1998

National Science Foundation (with D. Rittschof and R. Tankersley). " Settlement site location and development of an estuarine crustacean: Response to chemical and current cues". \$114,414 (Duke portion). 3/99-2/28/02.

NOAA "Brevetoxin exposure experiments" \$23,284. (9/1/2001- 6/1/2002).

National Science Foundation (with R. Leuttich and R. Tankersley). " Collaborative research: A multidisciplinary study of selective tidal-stream transport: Bio-physical coupling and behavioral mechanisms." \$98,261 (Duke portion). 3/1/2001 – 8/28/2004.

NOAA Coastal Ocean Program. (with P. Tester). "Effects of the toxic dinoflagellate "*Karenia brevis*" on copepod survival, feeding, swimming behavior and photobehavior involved in diel vertical migration. \$154,312 (Duke portion) 9/1/02-8/31/06.

National Science Foundation (with D. B. Eggleston and T. S. Hopkins) "Collaborative Research: Estuarine crabs transport: Linking post-settlement dispersal, bio-physical mechanisms and hydrodynamic corridors." \$64,460 (Duke portion). 8/01/02-1/31/06.

North Carolina Sea Grant. Seasonal patterns of Blue crab postlarval immigration into an estuary. \$68,010. 5/2004-3/2006.

North Carolina Sea Grant. Blue crab post-larval immigration into an estuary. \$36,415. 5/1/06 – 10/30/07

North Carolina Sea Grant. Distribution and Transport of Blue Crab megalopae. \$30,410. 5/01/07-4/30/08.

Current Grant Support

National Science Foundation (with D. Rittschof) – "REU Site: Undergraduate Research in Estuarine and Coastal Marine Systems", \$334,724. 5/1/2009 – 4/30/2010

Publications

- 1967 W.G. Hand, R.B. Forward, Jr. and D. Davenport. Short-term photic regulation of a receptor mechanism in a dinoflagellate. Biological Bulletin 133:150-165.
- 1968 R.B. Forward, Jr. and D. Davenport. Red and far-red light effects on a short-term behavioral response of a dinoflagellate. Science 111:1028-1029.
- 1970 D. Davenport, J. Greaves, J. Culler, R.B. Forward, Jr. and W. Hand. The investigation of the behavior of microorganisms by computerized television. IEEE Transactions on Biomedical Engineering 17:230-237.
- R.B. Forward, Jr. Changes in the photoresponse action spectrum of the dinoflagellate *Gyrodinium dorsum* Kofoid by red and far-red light. Planta (Berlin) 92:248-258.
- R.B. Forward, Jr. and D. Davenport. The circadian rhythm of a behavioral photoresponse in the dinoflagellate *Gyrodinium dorsum*. Planta (Berlin) 92:259-266.
- T.H. Waterman and R.B. Forward, Jr. Field evidence for polarized light sensitivity in the fish *Zenarchopterus*. Nature 228:85-87.
- 1972 R.B. Forward, Jr., K.W. Horch and T.H. Waterman. Visual orientation at the water surface by the teleost *Zenarchopterus*. Biological Bulletin 143:112-126.
- R.B. Forward, Jr. and D. Davenport. Red and far-red light effects on a short-term behavioral response of a dinoflagellate. Reprinted in The Biology of Plankton, MSS Information Corporation, New York. Pp. 68-70.
- T.H. Waterman and R.B. Forward, Jr. Field demonstration of polarotaxis in the fish *Zenarchopterus*. Journal of Experimental Zoology 180:33-54.
- 1973 R.B. Forward, Jr. Phototaxis in a dinoflagellate: action spectra as evidence for a two-pigment system. Planta (Berlin) 111:167-178.
- R.B. Forward, Jr. and T.H. Waterman. Evidence for e-vector and light intensity pattern discrimination by the teleost *Dermogenys*. Journal of Comparative Physiology 87:189-202.
- 1974 R.B. Forward, Jr. Phototaxis by the dinoflagellate *Gymnodinium splendens*. Journal of Protozoology 21:312-315.
- R.B. Forward, Jr. Crustacean larval negative phototaxis: possible functional significance. Journal of Experimental Marine Biology and Ecology 16:11-18.
- R.B. Forward, Jr. and J.D. Costlow, Jr. The ontogeny of phototaxis by larvae of the crab *Rhithropanopeus harrisi* (Gould). Marine Biology 26:27-33.

- 1975 R.B. Forward, Jr. Dinoflagellate phototaxis: pigment system and circadian rhythm as related to diurnal migration. In: *Symposium on the Physiological Ecology of Estuarine Organisms* (ed. F. John Vernberg). Univ. of South Carolina Press. Pp. 367-381.
- S. Via and R.B. Forward, Jr. The ontogeny and spectral sensitivity of polarotaxis on larvae of the crab *Rhithropanopeus harrisi* (Gould). *Biological Bulletin* 149:251-266.
- 1976 R.B. Forward, Jr. Light and diurnal vertical migration: photobehavior and photophysiology of plankton. In: *Photochemical and Photobiological Reviews*, Vol. 1 (ed. K. Smith). Plenum Press, New York. Pp. 157-209.
- R.B. Forward, Jr. A shadow response in a larval crustacean. *Biological Bulletin* 151:126-140.
- R.B. Forward, Jr. and J.D. Costlow. Crustacean larval behavior as an indicator of sublethal effects of an insect juvenile hormone mimic. In: *Estuarine Processes*, Vol. I. Academic Press, Inc., New York. Pp. 279-289.
- F.S. Ott and R.B. Forward, Jr. The effect of temperature upon phototaxis and geotaxis by larvae of the crab *Rhithropanopeus harrisi*. *Journal of Experimental Marine Biology and Ecology* 23:97-107.
- 1977 R.B. Forward, Jr. Occurrence of a shadow response among Brachyuran larvae. *Marine Biology* 39:331-341.
- R.B. Forward, Jr. The effects of neurochemicals upon a dinoflagellate photoresponse. *Journal of Protozoology* 3:401-405.
- M.I. Latz and R.B. Forward, Jr. The effect of salinity upon phototaxis and geotaxis in a larval crustacean. *Biological Bulletin* 155:163-179.
- 1978 R.B. Forward, Jr. and T.H. Cronin. Crustacean larval phototaxis: possible functional significance. In: *12th European Symposium on Marine Biology* (eds. D.S. McClusky and A.J. Berry). Pp. 253-261.
- R.B. Forward, Jr. and J.D. Costlow, Jr. Sublethal effects of insect growth regulators upon crab larval behavior. *Water Air and Soil Pollution* 9:227-238.
- E.A. Roberts, R.V. Dimock and R.B. Forward, Jr. Positive and host-induced negative phototaxis to a symbiotic water mite *Unionicola formosa*. *Biological Bulletin* 155:599-607.
- 1979 T.W. Cronin and R.B. Forward, Jr. Tidal vertical migration: an endogenous rhythm in estuarine crab larvae. *Science* 205:1020-1022.

Curriculum Vitae: Richard B. Forward, Jr.

R.B. Forward, Jr. and T.W. Cronin. Spectral sensitivity of larvae from intertidal crustaceans. *Journal of Comparative Physiology* 133:311-315.

- W.H. Lang, R.B. Forward, Jr. and D.C. Miller. Behavioral responses of *Balanus improvisus* nauplii to light. I. Spectral and intensity sensitivity. Biological Bulletin 157:166-181.
- 1980 T.W. Cronin and R.B. Forward, Jr. The effects of starvation on phototaxis and swimming of larvae of the crab *Rhithropanopeus harrisi*. Biological Bulletin 158:283-294.
- R.B. Forward, Jr. Phototaxis of a sand-beach amphipod: Physiology and tidal rhythms. Journal of Comparative Physiology 135:243-250.
- R.B. Forward, Jr. and T.W. Cronin. Tidal rhythms in activity and phototaxis by an estuarine crab larva. Biological Bulletin 158:295-303.
- W.H. Lang, R.B. Forward, Jr., D.C. Miller and M. Marcy. Acute toxicity and sublethal behavioral effects of copper on barnacle nauplii (*Balanus improvisus*). Marine Biology 58:139-145.
- M.C. Swift and R.B. Forward, Jr. Photoresponses of *Chaoborus* larvae. Journal of Insect Physiology 26:365-371.
- 1981 M.C. Swift and R.B. Forward, Jr. *Chaoborus* prey capture efficiency in light and dark. Limnology and Oceanography 26:461-466.
- 1982 T.W. Cronin and R.B. Forward, Jr. Tidally timed behavior: their effects on larval distributions in estuaries. In: Estuarine Comparisons (ed. V.S. Kennedy). Academic Press, New York. Pp. 505-520.
- R.B. Forward, Jr. and T.W. Cronin. Crab. In: McGraw Hill Yearbook of Science and Technology (1982-1983). Pp. 178-180.
- R.B. Forward, Jr., K. Lohmann and T.W. Cronin. Rhythms in larval release by an estuarine crab (*Rhithropanopeus harrisi*). Biological Bulletin 163:287-300.
- P.L. Harges and R.B. Forward, Jr. Salinity perception by larvae of the crab *Rhithropanopeus harrisi* (Gould). Marine Behaviour and Physiology 8:311-331.
- M.C. Swift and R.B. Forward, Jr. Photoresponses of second instar *Chaoborus* larvae. Journal of Insect Physiology 28:183-187.
- 1983 T.W. Cronin and R.B. Forward, Jr. Vertical migration rhythms of newly-hatched larvae of the estuarine crab, *Rhithropanopeus harrisi*. Biological Bulletin 165:139-153.

Curriculum Vitae: Richard B. Forward, Jr.

R. B. Forward, Jr. and H.J. Fyhn. Osmotic regulation of the Krill *Meganyctiphanes norvegica*. Comparative Biochemistry and Physiology 74A:301-305.

R.B. Forward, Jr. and K.J. Lohmann. Control of egg hatching in the crab

- Rhithropanopeus harrisii* (Gould). Biological Bulletin 165:154-166.
- M.C. Swift and R.B. Forward, Jr. Photoresponses of the copepod *Mesocyclops edax*. Journal of Plankton Research 5:407-415.
- 1984 D.J. Bradley and R.B. Forward, Jr. Phototaxis of adult brine shrimp *Artemia salina*. Canadian Journal of Zoology 62:2357-2359.
- C.G. Bookhout, R. Monroe, R.B. Forward, Jr. and J.D. Costlow, Jr. Effects of soluble fractions of drilling fluids on development of crabs, *Rhithropanopeus harrisii* and *Callinectes sapidus*. Water Air and Soil Pollution 21:183-197.
- C.G. Bookhout, R. Monroe, R.B. Forward, Jr. and J.D. Costlow, Jr. Effects of hexavalent chromium on development of crabs *Rhithropanopeus harrisii* and *Callinectes sapidus*. Water Air and Soil Pollution 21:199-216.
- R.B. Forward, Jr., T.W. Cronin and D.E. Stearns. Control of diel vertical migration: photoresponses of a larval crustacean. Limnology and Oceanography 29:146-154.
- R.B. Forward, Jr. Periodicity in organisms. In: McGraw Hill Yearbook of Science and Technology for 1985. Pp. 326-328.
- D. E. Stearns and R.B. Forward, Jr. Photosensitivity of the calanoid copepod *Acartia tonsa*. Marine Biology 82:85-89.
- D.E. Stearns and R.B. Forward, Jr. Copepod photobehavior in a simulated natural light environment and its relation to nocturnal vertical migration. Marine Biology 82:91-100.
- 1985 R.B. Forward, Jr. Behavioral responses of larvae of the crab *Rhithropanopeus harrisii* (Brachyura; Xanthidae) during diel vertical migration. Marine Biology 90:9-18.
- D. Rittschof, R.B. Forward, Jr. and D. Mott. Larval release in the crab *Rhithropanopeus harrisii*: Chemical cues from hatching eggs. Chemical Senses 10(4):567-577.
- A.J. Sweatt and R.B. Forward, Jr. Diel vertical migration and photoresponses of the chaetognath *Sagitta hispida* Conant. Biological Bulletin 168:18-31.
- A.J. Sweatt and R.B. Forward, Jr. Spectral sensitivity of the chaetognath *Sagitta hispida* Conant. Biological Bulletin 168:32-38.

Curriculum Vitae: Richard B. Forward, Jr.

- J.E. Wilson, R.B. Forward, Jr., and J.D. Costlow. Effects of embryonic exposure to sublethal concentrations of Dimilin[®] on the photobehavior of grass shrimp larvae. pp. 377-396. In: Marine Pollution and Physiology: Recent Advances (eds. F.J. Vernberg, F.P. Thurberg, A. Calabrese, and W. Vernberg). University of South Carolina Press.
- 1986 T.W. Cronin and R.B. Forward, Jr. Vertical migration cycles of crab larvae and their role

- in larval dispersal. Bulletin of Marine Sciences 39:192-201.
- R.B. Forward, Jr. Behavioral responses of a sand-beach amphipod to light and pressure. Journal of Experimental Marine Biology and Ecology 102:55-74.
- R.B. Forward, Jr. A reconsideration of the shadow response of a larval crustacean. Marine Behaviour and Physiology 12:93-113.
- R.B. Forward, Jr., J. Douglass and B.E. Kenney. Entrainment of the larval release rhythm of the crab *Rhithropanopeus harrisi* (Brachyura; Xanthidae) by cycles in salinity change. Marine Biology 90:537-544.
- R.B. Forward, Jr., B. Rojas de Mendiola and R.T. Barber. Effects of temperature on swimming speed of the dinoflagellate *Gymnodinium splendens*. Fisheries Bulletin 84:460-463.
- A.J. Sweatt and R.B. Forward, Jr. Light responses and vertical migration of planktonic chaetognaths. In: McGraw Hill Yearbook of Science and Technology for 1987. Pp. 125-127.
- 1987 R.B. Forward, Jr. A comparative study of crustacean larval photoresponses. Marine Biology 94:589-595.
- R.B. Forward, Jr. Crustacean larval vertical migration: a perspective. In: Signposts in the Sea, (eds. W.F. Hermkind and A.B. Thisle). Florida State University. Pp. 29-44.
- R.B. Forward, Jr. Larval release rhythms of decapod crustaceans: An overview. Bulletin of Marine Science 41:165-176.
- R.B. Forward, Jr., D. Rittschof, and M.C. De Vries. Peptide pheromones synchronize crustacean egg hatching and larval release. Chemical Senses 12:491-498.
- J.E.H. Wilson, R.B. Forward, Jr. and J.D. Costlow. Delayed effects of diflubenzuron on the swimming and vertical distribution of *Palaemonetes pugio* larvae. In: Physiology and Pollution of Marine Organisms (eds. W. Vernberg, A. Calabrese, F.P. Thurberg, and F.J. Vernberg). Univ. of South Carolina Baruch Institute. Pp. 351-371.

- 1988 E. Blasco and R.B. Forward, Jr. Osmoregulation of the xanthid crab *Panopeus herbstii*. Comparative Biochemistry and Physiology 90A:135-139.
- T.W. Cronin and R.B. Forward, Jr. The visual pigments of crabs. I. Spectral characteristics. Journal of Comparative Physiology 162:463-478.
- R.B. Forward, Jr. Diel vertical migration: Zooplankton photobiology and behavior. In: Oceanography and Marine Biology: An Annual Review (ed. M. Barnes), Vol. 26. Pp. 361-393.
- R.B. Forward, Jr., T.W. Cronin and J.K. Douglass. The visual pigments of crabs. II. Environmental adaptations. Journal of Comparative Physiology 162:479-490.
- M.C. Swift and R.B. Forward, Jr. Relative light intensity vs. rate of change: The role of light in the vertical migration of *Chaoborus punctipennis* larvae. In: Zooplankton Behavior Symposium (eds. G.A. Paffenhofer and H. Price). Bulletin of Marine Sciences 43:604-619.
- R.L. Takacs, R.B. Forward, Jr. and W. Kirby-Smith. Effects of the herbicide alachlor on larval development of the mud-crab *Rhithropanopeus harrisi* (Gould). Estuaries 11:79-82.
- 1989 M.C. De Vries and R.B. Forward, Jr. Rhythms in larval release of the subtidal crab, *Neopanope sayi*, and the supralittoral crab *Sesarma cinereum* (Decapoda: Brachyura). Marine Biology 100:241-248.
- M.C. De Vries, D. Rittschof and R.B. Forward, Jr. Response of rhizocephalan-parasitized crabs to analogues of crab larval-release pheromones. Journal of Crustacean Biology 9:517-524.
- D.W. Diamond, L.K. Scott, R.B. Forward, Jr. and W. Kirby-Smith. Respiration and osmoregulation of the estuarine crab *Rhithropanopeus harrisi* (Gould): Effects of the herbicide alachlor. Comparative Biochemistry and Physiology 93A:313-318.
- J.K. Douglass and R.B. Forward, Jr. The ontogeny of superposition optics in a shrimp eye: Hatching through metamorphosis. Cell and Tissue Research 258:289-300.
- R.B. Forward, Jr. Behavioral responses of crustacean larvae to rates of salinity change. Biological Bulletin 176:229-238.
- R.B. Forward, Jr. Depth regulation of larval marine decapod crustaceans: Test of an hypothesis. Marine Biology 102:195-201.
- R.B. Forward, Jr. and C.U. Buswell. A comparative study of behavioral responses of larval crustaceans to light and pressure. Marine Behaviour and Physiology 16:43-56.

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- R.B. Forward, Jr. and J. Douglass. Crustacean larval visual sensitivity during diel vertical migration. In: Proceedings of the 21st European Marine Biology Symposium. Polish Academy of Sciences - Institute of Oceanology. Pp. 59-66.
- R.B. Forward, Jr. and C.A. Wellins. Behavioral responses of a larval crustacean to hydrostatic pressure: *Rhithropanopeus harrisi* (Brachyura: Xanthidae). Marine Biology 101:159-172
- R.B. Forward, Jr., C.A. Wellins and C.U. Buswell. Behavioral responses of larvae of the crab *Neopanope sayi* to hydrostatic pressure. Marine Ecology Progress Series 57:267-277.
- S.M. Goddard and R.B. Forward, Jr. The use of celestial cues in the offshore escape response of the shrimp *Palaemonetes vulgaris*. Marine Behavior and Physiology 16:11-18.
- W.W. Kirby-Smith, S.P. Thompson and R.B. Forward, Jr. Use of grass shrimp (*Palaemonetes pugio*) larvae in field bioassays of the effects of agricultural runoff into estuaries. In: Pesticides in Terrestrial and Aquatic Environments - Proceedings of a National Research Conference, May 11-12, 1989 (ed. D.L. Weigmann). Virginia Water Resources Research Inst., Blacksburg, Virginia. Pp. 29-36.
- D. Rittschof, R.B. Forward, Jr., D.A. Simons, P.A. Reddy, and B.W. Erickson. Peptide analogues of the mud crab pumping pheromones: Structure-function studies. Chemical Senses 14:137-148.
- 1990 R.B. Forward, Jr. Behavioral responses of crustacean larvae to rates of temperature change. Biological Bulletin 178:195-204.
- R.B. Forward, Jr. Responses of crustacean larvae to hydrostatic pressure: behavioral basis of high barokinesis. Marine Behaviour and Physiology 180:1-11.
- S.M. Goddard and R.B. Forward, Jr. The decay and learning of an Y-axis orientation behavior: The offshore escape response of the shrimp, *Palaemonetes vulgaris* (Say). Journal of Experimental Marine Biology and Ecology 142:137-150.
- D. Rittschof, R.B. Forward, Jr. and B.W. Erickson. Larval release in brachyuran crustaceans: functional similarity of the peptide pheromone receptor and the catalytic site of trypsin. Journal of Chemical Ecology 16:1359-1370.
- 1991 M.C. De Vries and R.B. Forward, Jr. Control of egg-hatching time in crabs from different tidal heights. Journal of Crustacean Biology 11:29-39.
- M.C. De Vries and R.B. Forward, Jr. Mechanisms of crustacean egg hatching: Evidence for enzyme release by crab embryos. Marine Biology 110:281-291.

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- M.C. De Vries, D. Rittschof and R.B. Forward, Jr. Chemical mediation of larval release behavior in the crab *Neopanope sayi*. Biological Bulletin 180:1-11
- S.M. Goddard and R.B. Forward, Jr. The role of the underwater polarized light pattern in sun compass navigation of the grass shrimp *Palaemonetes vulgaris*. Journal of Comparative Physiology 169: 479-491.
- C.E. Reisser and R.B. Forward, Jr. Effect of salinity on osmoregulation and survival of a rhizocephalan parasite *Loxothylacus panopaei* and its crab host *Rhithropanopeus harrisi*. Estuaries 14:102-106.
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