

Adam Gray Marsh

Present Position: Associate Professor
Present Address: School of Marine Science, University of Delaware
Lewes, Delaware 19958
amarsh@udel.edu, 302.645.4367

Academic Degrees:

1989 Ph.D., Marine Science

Advisor: Dr. Kenneth R. Tenore, Chesapeake Biological Laboratory, University of Maryland.

Dissertation: Energetics, population dynamics, nutrition and growth of benthic macroinfauna.

1983 M.S., Invertebrate Zoology,

Advisor: Dr. John M. Lawrence, College of Natural Sciences, University of South Florida, Tampa.

Thesis: Physiological ecology and isosmotic cell-volume regulation in a sea star.

1981 B.A., Biology, College of Natural Sciences, University of South Florida, Tampa.

1981 B.A., English Literature, College of Arts and Letters, University of South Florida, Tampa.

Professional Appointments:

2012 – present co-Founder and Chief Science Officer, Genome Profiling, LLC.

2010 – present co-Founder and Chief Science Officer, Evozym Biologics, Inc.

2008 – present Associate Professor, Bioinformatics and Computational Biology, University of Delaware

2006 – present Associate Professor, School of Marine Science, University of Delaware

2000 – 2006 Assistant Professor, College of Marine Studies, University of Delaware

Postdoctoral Research Experience:

1995-1999: Molecular Physiology.

Postdoctoral Research Associate under Dr. Donal Manahan, Univ. Southern California. Primary project focused on the molecular physiology and biochemistry of invertebrate larvae in extreme environments.

1993-1995: Invertebrate Immunology

Postdoctoral Research Associate under Dr. Gerardo R. Vasta, Center of Marine Biotechnology, Univ. of Maryland. Primary project focused on the host/parasite interactions between oysters and their pathogens.

1991-1993: Invertebrate Molecular Biology and Growth Regulation

NSF Postdoctoral Fellowship in Biotechnology with Dr. Thomas T. Chen, Center of Marine Biotechnology, Univ. of Maryland. Primary project focused on the role of a cell-cycle control gene in regulating organismal growth rates in oysters and opportunistic polychaetes.

1989-1991: Invertebrate Reproduction and Cell Biology

Postdoctoral Research Associate under Dr. Charles Walker, Univ. of New Hampshire. Primary project focused on physiological and molecular controls of spermatogenesis in a starfish.

Career Distinctions:

2013 NSF I-Corp Innovation Grant Award to support business development activities associated with the epigenetic quantification and profiling software platform I have developed.

2011 International Patent Application submitted (PCT/US11/21562), “Systems and Methods for identifying structurally or functionally significant nucleotide sequences and cross reference to related application.”

2009 US Patent Application submitted (PTO #61/208,513), “Systems and Methods for identifying structurally or functionally significant amino acid sequences.”

2004 US Patent No. 6,326,485, “Assay for *Perkinsus* in shellfish”: This patent was awarded for a genetic diagnostic assay that was developed for detecting the oyster protozoan pathogen, *Perkinsus marinus*. The patent covers the work performed at the Center of Marine Biotechnology between 1994 and 1995.

2003 NSF CAREER Award, Office of Polar Programs, Geosciences Directorate: This grant is ongoing and focuses on describing the role of gene expression network structures in contributing to the molecular adaptation of marine invertebrate embryos to extreme environments.

2001 First author publications in the journals *Science* and *Nature*, both in 2001. These works culminate several years of postdoctoral research with D. Manahan (Univ. Southern California) into the molecular physiology and energetics of larvae in an Antarctic sea urchin and a hydrothermal vent polychaete, respectively.

- 1993 NSF Antarctic Marine Biology Course Participant: One of ten postdoctoral researchers and graduate students selected as a student in this NSF-funded, international course, on molecular adaptations in polar marine organisms. The course was held over a 4 week period at McMurdo Station, Antarctica, and involved an intensive series of lectures, laboratory experiments and field collections.
- 1991 Awarded NSF Postdoctoral Fellowship in Marine Biotechnology (OCE): The grant focused on the cloning and characterization of the *c-myc* oncogene in oyster larvae.

Research Area:

My general interests are in molecular ecology and genetic mechanisms of environmental imprinting. At present, my NSF funded research is focusing on how low temperatures in polar environments shift epigenetic patterns of DNA methylation to favor increased metabolic efficiency in polar marine invertebrates. My success in this field has largely resulted from my computational skills at programming (c++, perl, python) and my statistical knowledge (SAS, R) from my early years conducting field ecology research. I have successfully developed several novel bioinformatic algorithms that have not only opened new avenues of research to me, but these new tools have also supported commercial applications.

Current Work:

At present, my lab is working with an opportunistic marine polychaete, *Capitella teleta*, from mid-Atlantic estuaries, USA, and a congeneric species, *Capitella perarmata*, from McMurdo Station, Antarctica. This work is supported by the US National Science Foundation, Office of Polar Programs. The goal of the project is to compare genes that undergo rapid DNA methylation shifts when exposed to temperature stress in both species.

Publications:

- 63) 2016 Marsh, A.G., K.Hoadley and M.E. Warner. Distribution of CpG Motifs in Upstream Gene Domains in a Reef Coral and Sea Anemone: Implications for Epigenetics in Cnidarians. PLoS ONE 11(3): e0150840. doi:10.1371/journal.pone.0150840.
- 62) 2014 Marsh, A.G. and A. Pasqualone. DNA methylation and temperature stress in an Antarctic polychaete, *Spiophanes tcherniai*. Frontiers in Physiology, 5:173, doi: 10.3389/fphys.2014.00173
- 61) 2014 Grzymalski, J. and A.G. Marsh. Protein Languages Differ Depending on Microorganism Lifestyle. PLoS One, 9(5): e96910, doi:10.1371/journal.pone.0096910
- 60) 2013 Marsh, A.G., M. Powell, S. Watts, 2013, Biochemical and Energy Requirements of Gonad Development, In: Sea Urchins: Biology and Ecology, 3rd Edition, J. Lawrence, ed., Elsevier, London, pp. 45-55.
- 59) 2011 Kunjeti, S.G., Evans, T.A., **Marsh, A.G.**, Gregory, N.F., Kunjeti, S., Meyers, B., Kalavacharla, V.S., Donofrio, N.M. RNA-Seq reveals infection-related global gene changes in *Phytophthora phaseoli*, the causal agent of lima bean downy mildew. *Mol Plant Path*, DOI: 10.1111/J.1364-3703.2011.00761.
- 58) 2011 Cowart, D.A., S.M. Guida, S.I. Shah, **A.G. Marsh**. Effects of Ag nanoparticles on survival and oxygen consumption of zebra fish embryos, *Danio rerio*. *J Environ Health Sci, A*, 46, 1122-1128.
- 57) 2009 Ulrich, P.N. and **A.G. Marsh**. Thermal Sensitivity of Mitochondrial Respiration Efficiency and Protein Phosphorylation in the Clam *Mercenaria mercenaria*. *Marine Biotechnology*, 11, 608-618.
- 56) 2009 Dominique A. Cowart, Paul N. Ulrich, Douglas C. Miller, **A. G. Marsh**. Salinity Sensitivity of Early Embryos of the Antarctic Sea Urchin, *Sterechinus neumayeri*. *Polar Biology*, 32, 435-441.
- 55) 2009 **Marsh, A.G.** Environmental and Molecular Mechanisms of Cold Adaptation in Polar Marine Invertebrates. In: Krupnik, Igor, Lang, Michael A. and Miller, Scott E., eds. Smithsonian at the Poles: Contributions to International Polar Year Science pp. 253-264.
- 54) 2008 Ulrich, P.N. and **A.G. Marsh**. Proteome assay of temperature stress and protein stability in extreme environments: Groundwork with the heat stress response of the bivalve *Mercenaria mercenaria*. *Journal of Shellfish Research* 27, 243-246.
- 53) 2008 Hoover, C.A., M. Slattery N.M. Targett and **A.G. Marsh**. Secondary metabolite production and gene expression patterns in response to artificial predation in a benthic soft coral, *Sinularia polydactyla*. *Biological*

- 52) 2007 Ulrich, P.N. Ewart, J.W. and **A.G. Marsh**. Incidence of *Perkinsus marinus*, *Haplosporidium nelsoni* (MSX), and QPX in bivalves of Delaware's Inland Bays and quantitative, high throughput diagnosis of Dermo infections by QPCR. *Journal Eukaryotic Microbiology*. 54, 520–526
- 51) 2007 Hoover, C.A., M. Slattery and **A.G. Marsh**. Comparing gene expression profiles of benthic soft coral species, *Simularia polydactyla*, *S. maxima*, and their putative hybrid at different life history stages. *Comparative Biochemistry and Physiology* (Part D, Genomics & Proteomics) 2, 135-143.
- 50) 2006 Hoover, C.A., M. Slattery and **A.G. Marsh**. Profiling transcriptome complexity and secondary metabolite synthesis in a benthic soft coral, *Simularia polydactyla*. *Marine Biotechnology*, 9, 166-178.
- 49) 2006 Ulrich, P.N. and **A.G. Marsh**. Interindividual variation in malate dehydrogenase activity in the oyster *Crassostrea virginica*. *Marine and Freshwater Behavior and Physiology* 39, 293-306.
- 48) 2006 Zeng Y, Garcia-Frias J, **Marsh AG**. Organization of genes and genome domains in humans. In: Meyers R (ed) Genomics and Genetics, Vol 2. Wiley-VCH, pp 108-136.
- 47) 2006 **Marsh AG**, SA Watts. Biochemical and Energy Requirements of Gonad Development. In: Edible Sea Urchins: Biology and Ecology, J.M. Lawrence (Ed.), 2nd Edition, Balkema, Amsterdam, pp 35-54.
- 46) 2006 Pace DA, **AG Marsh**, PKK Leong, AJ Green, D Hedgecock, DT Manahan. Physiological bases of genetically determined variation in growth of marine invertebrate larvae: A study of heterosis in the bivalve *Crassostrea gigas*. *Journal of Experimental Marine Biology and Ecology*, 335, 188-209.
- 45) 2006 Evans, C.W., L. Pace, P. Cziko, **A.G. Marsh**, C.-H. C. Cheng and A.L. DeVries. Metabolic energy utilization during development of the Antarctic naked dragonfish (*Gymnodraco acuticeps*). *Polar Biology* 29, 519-525
- 44) 2006 R.R. Strathmann, L.R. Kendall, **A.G. Marsh**. Embryonic and larval development of a cold adapted Antarctic ascidian. *Polar Biology* 29, 495-501.
- 43) 2006 **Marsh, A.G.**, Y. Zheng and J. Garcia-Frias. The expansion of information entropy in ecological systems: Emergence as a quantifiable state. *Ecological Informatics*, 1, 107-116.
- 42) 2005 Fielman, K.T. and **A.G. Marsh**. Genome complexity and repetitive DNA in metazoans from extreme marine environments. *Gene*, 362, 98-108.
- 41) 2005 **Marsh, A.G.** and K. T. Fielman. Transcriptome profiling of individual larvae of two different developmental modes in the poecilogonous polychaete *Streblospio benedicti* (Spionidae). *Journal Experimental Zoology - Molecular Development and Evolution*, 304B, 238-249.
- 40) 2005 Szela, T.L. and **A.G. Marsh**. Microtiter plate, optrode respirometry reveals large interindividual variance in metabolic rates among individual nauplii of *Artemia* sp. *Marine Ecology Progress Series*, 296, 281-289.
- 39) 2004 Zeng, Y., J. Garcia-Frias, **A.G. Marsh**, Gene distributions in the human genome, in Meyers, R. (ed), *Encyclopedia of Molecular Cell Biology and Medicine*, Vol. 5, 2nd edition, Wiley-VCH. pp. 394-428.
- 38) 2004 Glazer, B., **A.G. Marsh**, K. Stierhoff, G. Luther III, The dynamic response of optical oxygen sensors and voltammetric electrodes to temporal changes in oxygen concentrations. *Acta Chemica Analytica* 518, 93-100.
- 37) 2003 Michaud, D., **A.G. Marsh**, P. Dhurjati. *XPatGen*: A Web-Based Generator of Dynamic Gene Expression Patterns for Evaluation of Analysis Methods. *Bioinformatics* 19, 1140-1146.
- 36) 2001 **Marsh, A.G.**, S. Cohen and C.E. Epifanio. Larval energy metabolism and physiological variability in the Asian shore crab, *Hemigrapsus sanguineus*. *Marine Ecology Progress Series*, 218, 303-309.
- 35) 2001 **Marsh, A.G.** and S.A. Watts. Energy metabolism and gonad development. In: Edible Sea Urchins: Biology and Ecology, J.M. Lawrence (Ed.), Balkema, Amsterdam, pp. 27-42.
- 34) 2001 **Marsh, A.G.**, R. Maxson, D.M. Manahan. 2001. High macromolecular synthesis with low metabolic cost in Antarctic sea urchin embryos. *Science*, 291, 1950-1952.
- 33) 2001 **Marsh, A.G.**, L. Mullineaux, C. Young and D. Manahan. Larval dispersal potential of the tubeworm *Riftia pachyptila* at deep-sea hydrothermal vents. *Nature* 411, 77-80.
- 32) 2000 **Marsh, A.G.**, P.K. Leong and D.T. Manahan. Gene expression and enzyme activities of the sodium pump during sea urchin development. *Biological Bulletin*, 199, 100-107.
- 31) 2000 **Marsh, A.G.** and D. T. Manahan. Metabolic differences between 'demersal' and 'pelagic' development of the Antarctic sea urchin *Sterechinus neumayeri*. *Marine Biology*, 137, 215-222.

- 30) 1999 Robledo, J.A, A.C. Wright, **A.G. Marsh** and G.R. Vasta. Nucleotide sequence variability in the nontranscribed spacer of the rRNA locus in the oyster parasite *Perkinsus marinus*. J. Parasitology, 85, 650-656.
- 29) 1999 **Marsh, A.G.**, P. Leong and D.T. Manahan. Energy metabolism during embryonic development and larval growth of an Antarctic sea urchin. J. Experimental Biology, 202, 2041-2050.
- 28) 1999 **Marsh, A.G.** and D.T. Manahan. A method for accurate measurements of the respiration rates of marine invertebrate embryos and larvae. Marine Ecology Progress Series, 184, 1-10.
- 27) 1998 **Marsh, A.G.** and D.T. Manahan. Feeding and energetic costs of larval development in the Antarctic sea urchin, *Sterechinus neumayeri*. Antarctic Journal of the U.S., 32, 94-96.
- 26) 1997 **Marsh, A.G.** and D.T. Manahan. Physiological energetics of 'pelagic' and 'demersal' development in the Antarctic sea urchin, *Sterechinus neumayeri*. Antarctic Journal of the U.S., 31, 117-118.
- 25) 1996 Vasta, G.R. and **A.G. Marsh**. Strategies for optimizing growth and disease resistance in invertebrate aquaculture. In: Altman, H. (ed.), *Biotechnology in Agriculture*, Marcel Dekker Inc., New York.
- 24) 1995 Vasta, G.R., J.D. Gauthier and **A.G. Marsh**. Molecular and biochemical adaptations of the protozoan pathogen *Perkinsus marinus* for its eastern oyster host, *Crassostrea virginica*. J. Marine Biotechnology, 3, 35-41.
- 23) 1995 **Marsh, A.G.**, J.D. Gauthier and G.R. Vasta. A semiquantitative PCR assay for the detection and enumeration of *Perkinsus marinus* infections in oyster tissues. J. Parasitology, 81, 577-583.
- 22) 1995 **Marsh, A.G.** and T.T. Chen. A divergent homolog of the *c-myc* proto-oncogene in the eastern oyster *Crassostrea virginica*. Molecular Marine Biology and Biotechnology, 4, 185-192.
- 21) 1994 Vasta, G.R., H. Ahmed, N.E. Fink, M.T. Elola, **A.G. Marsh**, A. Snowden and E. Odom. Animal lectins as self/non-self recognition molecules: Biochemical and molecular approaches to understanding their biological roles and evolution. Annals New York Acad. Sci., 712, 55-73.
- 20) 1994 Chen, T., **A.G. Marsh**, M. Shambloot, K. Chan, Y. Tang, C. Cheng and B. Yang. Functional model for the evolution of fish growth hormone and insulin-like growth factor genes. In: Sherwood, N.M. and C.L. Hew (eds.), *Fish Physiology, Volume XIII: Molecular Endocrinology of Fish*, Academic Press, New York, pp. 179-209.
- 19) 1994 Chen, T.T., M. Shambloot, C.M. Lin, Y.L. Tang, K.M. Chan, C.M. Cheng, B.Y. Yang and **A.G. Marsh**. Structure and evolution of fish growth hormone and insulin-like growth factor genes. In: K.G. Davey, R.E. Peters and S.S. Tobe (eds.), *Perspectives in Comparative Endocrinology*, National Research Council of Canada, Ottawa, pp. 352-364.
- 18) 1993 **Marsh, A.G.** and C.W. Walker. The effect of estradiol and progesterone on *c-myc* expression in the sea star testis and the seasonal regulation of spermatogenesis. Molecular Reproduction and Development, 40, 62-68.
- 17) 1992 Walker, C.W., J. Boom, and **A.G. Marsh**. First non-vertebrate member of the *myc* gene family is seasonally expressed in an invertebrate testis. Oncogene, 7, 2007-2012.
- 16) 1991 Sible, J., **Marsh, A.G.** and C.W. Walker. Stimulation of ornithine decarboxylase and thymidine uptake in the testis of *Asterias vulgaris* (Echinodermata: Asteroidea) by polyamines. Int. J. Invert. Reprod., 19, 257-264.
- 15) 1990 **Marsh, A.G.**, A. Gremare, R. Dawson, and K. Tenore. Translocation of algal pigments to oocytes of *Capitella* sp. I (Annelida: Polychaeta). Marine Ecology Progress Series, 67, 301-304.
- 14) 1990 **Marsh, A.G.** and K.R. Tenore. The role of nutrition in regulating the population dynamics of opportunists in a mesohaline community. Limnology and Oceanography, 35, 710-724
- 13) 1990 **Marsh, A.G.**, H.R. Harvey, A. Gremare, and K. Tenore. Dietary effects on oocyte yolk-composition in *Capitella* sp. I (Annelida: Polychaeta): Fatty acids and sterols. Marine Biology, 106, 369-374
- 12) 1989 **Marsh, A.G.**, A. Gremare, and K. Tenore. Food type and food ration effects on growth of juvenile *Capitella* sp. I (Annelida: Polychaeta): Macro- vs. Micro- Nutrients. Marine Biology, 102, 519-527

- 11) 1989 Gremare, A., **A.G. Marsh**, and K.R. Tenore. Secondary production and reproduction of *Capitella capitata* (TypeI) (Annelida: Polychaeta) during a population cycle. *Marine Ecology Progress Series*, 51, 99-105.
- 10) 1989 **Marsh, A.G.** Seasonal dynamics of a mesohaline, soft-bottom, benthic community: Secondary production, sedimentation, predation, and nutrition. Ph.D. Dissertation, Univ. of Maryland, College Park, Md, 184pp.
- 9) 1988 Gremare, A., **A.G. Marsh**, and K.R. Tenore. Fecundity and energy partitioning in *Capitella capitata* (Type I) (Annelida: Polychaeta). *Marine Biology*, 100, 365-371.
- 8) 1988 Gremare, A., **A.G. Marsh**, and K.R. Tenore. Short-term reproductive responses of *Capitella capitata* (Type I) (Annelida: Polychaeta) fed on different diets. *J. Experimental Marine Biology and Ecology*, 123, 147-162.
- 7) 1986 Lawrence, J.M., T. Klinger, J. McClintock, S. Watts, C. Chen, **A. Marsh** and L. Smith. Allocation of nutrient resources to body components by regenerating *Luidia clathrata* (Echinodermata: Asteroidea). *J. Experimental Marine Biology and Ecology*, 102, 47-53.
- 6) 1986 **Marsh, A.G.**, S. Watts, C. Chen, and J. McClintock. The effect of high salinity on development, mortality, and ray number of *Echinaster spinulosus* (Echinodermata: Asteroidea) at different developmental stages. *Comparative Biochemistry and Physiology*, 83A, 229-231.
- 5) 1985 **Marsh, A.G.** and J.M. Lawrence. The effects of sodium, potassium, calcium, and magnesium on citrate synthase activity in *Luidia clathrata* (Echinodermata). *Comparative Biochemistry and Physiology*, 81B, 767-770.
- 4) 1984 Dawes, C.J., C. Chen, J. Smith, **A. Marsh** and S. Watts. Effect of phosphate and ammonium levels on photosynthetic and respiratory responses of the red algae *Gracilaria verrucosa*. *Marine Biology*, 78, 325-328.
- 3) 1983 **Marsh, A.G.** Purification and Characterization of Citrate Synthase from *Luidia clathrata* (Echinodermata: Asteroidea): The role of Krebs's Cycle Activity in the Isosmotic response. Master's of Science Thesis, University of South Florida, Tampa, Fl., 76pp.
- 2) 1983 Watts, S.A., R. Schiebling, **A. Marsh** and J. McClintock. Induction of aberrant ray numbers in *Echinaster* sp. (Echinodermata: Asteroidea) by high salinity. *Florida Scientist*, 46,125-128.
- 1) 1982 Watts, S.A., R. Schiebling, **A. Marsh** and J. McClintock. Effect of temperature and salinity on larval development of sibling species of *Echinaster* (Echinodermata: Asteroidea) and their hybrids. *Biological Bulletin*, 163, 348-354.