2012, *Oceanography* 25(1):256–268, http://dx.doi.org/10.5670/oceanog.2012.24

Larval Dispersal: Vent Life in the Water Column

Authors | Abstract | Full Article | Citation | References

Authors

Diane K. Adams | Biology Department, Woods Hole Oceanographic Institution (WHOI), Woods Hole, MA, USA

Shawn M. Arellano | Biology Department, WHOI, Woods Hole, MA, USA

Breea Govenar | Rhode Island College, Providence, RI, USA

Top

Abstract

Visually striking faunal communities of high abundance and biomass cluster around hydrothermal vents, but these animals don't spend all of their lives on the seafloor. Instead, they spend a portion of their lives as tiny larvae in the overlying water column. Dispersal of larvae among vent sites is critical for population maintenance, colonization of new vents, and recolonization of disturbed vents. Historically, studying larvae has been challenging, especially in the deep sea. Advances in the last decade in larval culturing technologies and more integrated, interdisciplinary time-series observations are providing new insights into how hydrothermal vent animals use the water column to maintain their populations across ephemeral and disjunct habitats. Larval physiology and development are often constrained by evolutionary history, resulting in larvae using a diverse set of dispersal strategies to interact with the surrounding currents at different depths. These complex biological and oceanographic interactions translate the reproductive output of adults in vent communities into a dynamic supply of settling larvae from sources near and far.

Top

Full Article

983 KB pdf

Top

Citation

Adams, D.K., S.M. Arellano, and B. Govenar. 2012. Larval dispersal: Vent life in the water column. *Oceanography* 25(1):256–268, http://dx.doi.org/10.5670/oceanog.2012.24.

Top

References

Adams, D.K., D.J. McGillicuddy, L. Zamudio, A.M. Thurnherr, X.F. Liang, O. Rouxel, C.R. German, and L.S. Mullineaux. 2011. Surface-generated mesoscale eddies transport deep-sea products from hydrothermal vents. *Science* 332:580–583, http://dx.doi.org/10.1126/science.1201066.

Adams, D.K., S.W. Mills, T.M. Shank, and L.S. Mullineaux. 2010. Expanding dispersal studies at hydrothermal vents through species identification of cryptic larval forms. *Marine Biology* 157:1,049–1,062, http://dx.doi.org/10.1007/s00227-009-1386-8.

Adams, D.K., and L.S. Mullineaux. 2008. Supply of gastropod larvae to hydrothermal vents reflects transport from local larval sources. *Limnology and Oceanography* 53:1,945–1,955, http://dx.doi.org/10.4319/lo.2008.53.5.1945.

Arellano, S.M., and C.M. Young. 2009. Spawning, development, and the duration of larval life in a deep-sea cold-seep mussel. *Biological Bulletin* 216:149–162.

Bailly-Bechet, M., M. Kerszberg, F. Gaill, and F. Pradillon. 2008. A modeling approach of the influence of local hydrodynamic conditions on larval dispersal at hydrothermal vents. *Journal of Theoretical Biology* 255:320–331, http://dx.doi.org/10.1016/j.jtbi.2008.08.016.

Bouchet, P., and A. Warén. 1994. Ontogenetic migration and dispersal of deep-sea gastropod larvae. Pp. 98–119 in *Reproduction, Larval Biology, and Recruitment of the Deep-Sea Benthos*. C.M. Young and K.J. Eckelbarger, eds, Columbia University Press, NY.

Bright, M., and F.H. Lallier. 2010. The biology of vestimentiferan tubeworms. Pp. 213–265 in *Oceanography and Marine Biology: An Annual Review*. R.N. Gibson, R.J.A. Atkinson, and J.D.M. Gordon, eds, Volume 48, CRC Press.

Brooke, S.D., and C.M. Young. 2009. Where do the embryos of *Riftia pachyptila* develop? Pressure tolerances, temperature tolerances, and buoyancy during prolonged embryonic dispersal. *Deep-Sea Research Part II* 56:1,599–1,606, **http://dx.doi.org/10.1016/j.dsr2.2009.05.003**.

Cannon, G.A., and D.J. Pashinski. 1997. Variations in mean currents affecting hydrothermal plumes on the Juan de Fuca Ridge. *Journal of Geophysical Research* 102:24,965–24,976, **http://dx.doi.org/10.1029/97JC01910**.

Di Iorio, D., J.W. Lavelle, P.A. Rona, K. Bemis, G. Xu, L.N. Germanovich, R.P. Lowell, and G. Genc. 2012. Measurements and models of heat flux and plumes from hydrothermal discharges near the deep seafloor. *Oceanography* 25(1):168–179, **http://dx.doi.org/10.5670/oceanog.2012.14**.

Dittel, A.I., G. Perovich, and C.E. Epifanio. 2008. Biology of the vent crab *Bythograea thermydron*: A brief review. *Journal of Shellfish Research* 27:63–77, **http://dx.doi.org/10.2983/0730-8000(2008)27[63:BOTVCB]2.0.CO;2**.

Dixon, D.R., D.M. Lowe, P.I. Miller, G.R. Villemin, A. Colaco, R. Serrao-Santos, and L.R.J. Dixon. 2006. Evidence of seasonal reproduction in the Atlantic vent mussel *Bathymodiolus azoricus*, and an apparent link with the timing of photosynthetic primary production. *Journal of the Marine Biological Association of the United Kingdom* 86:1,363–1,371, **http://dx.doi.org/10.1017/S0025315406014391**.

Eckelbarger, K.J., and L. Watling. 1995. Role of phylogenetic constraints in determining reproductive patterns in deep-sea invertebrates. *Invertebrate Biology* 114:256–269.

Gage, J.D., and P.A. Tyler. 1991. *Deep-sea Biology: A Natural History of Organisms at the Deep-sea Floor*. Cambridge University Press, Cambridge.

Govenar, B. 2010. Shaping vent and seep communities: Habitat provision and modification by foundation species. Pp. 403–432 in *The Vent and Seep Biota: Aspects from Microbes to Ecosystems*. S. Kiel, ed., Topics in Geobiology, Volume 33, Springer Science+Business Media, **http://dx.doi.org/10.1007/978-90-481-9572-5_13**.

Govenar, B. 2012. Energy transfer through food webs at hydrothermal vents: Linking the lithosphere to the biosphere. *Oceanography* 25(1):246–255, **http://dx.doi.org/10.5670/oceanog.2012.23**.

Hebert, P.D.N., S. Ratnasingham, and J.R. deWaard. 2003. Barcoding animal life: Cytochrome c oxidase subunit 1 divergences among closely related species. *Proceedings of the Royal Society of London Series* B 270:S96–S99, **http://dx.doi.org/10.1098/rsbl.2003.0025**.

Hilário, A., M. Capa, T.G. Dahlgren, K.M. Halanych, C.T.S. Little, D.J. Thornhill, C. Verna, and A.G. Glover. 2011. New perspectives on the ecology and evolution of siboglinid tubeworms. *PLoS ONE* 6, e16309, **http://dx.doi.org/10.1371/journal.pone.0016309**.

Kelly, N., and A. Metaxas. 2010. Understanding population dynamics of a numerically dominant species at hydrothermal vents: A matrix modeling approach. *Marine Ecology Progress Series* 403:113–128, **http://dx.doi.org/10.3354/meps08442**.

Kim, S.L., L.S. Mullineaux, and K.R. Helfrich. 1994. Larval dispersal via entrainment into hydrothermal vent plumes. *Journal of Geophysical Research* 99:12,655–12,665, **http://dx.doi.org/10.1029/94JC00644**.

Lavelle, J.W., A.M. Thurnherr, J.R. Ledwell, D.J. McGillicuddy, and L.S. Mullineaux. 2010. Deep ocean circulation and transport where the East Pacific Rise at 9°–10°N meets the Lamont seamount chain. *Journal of Geophysical Research* 115, C12073, **http://dx.doi.org/10.1029/2010JC006426**.

Lavelle, J.W., A.M. Thurnherr, L.S. Mullineaux, D.J. McGillicuddy Jr., and J.R. Ledwell. 2012. The prediction, verification, and significance of flank jets at mid-ocean ridges. *Oceanography* 25(1):277–283, **http://dx.doi.org/10.5670/oceanog.2012.26**.

Llodra, E.R., P.A. Tyler, and J.T.P. Copley. 2000. Reproductive biology of three caridean shrimp, *Rimicaris exoculata, Chorocaris chacei* and *Mirocaris fortunata* (Carudea: Decapoda), from hydrothermal vents. *Journal of the Marine Biological Association of the United Kingdom* 80:473–484.

Lutz, R.A., D. Jablonski, and R.D. Turner. 1984. Larval development and dispersal at deep-sea hydrothermal vents. *Science* 226:1,451–1,454, **http://dx.doi.org/10.1126/science.226.4681.1451**.

Marsh, A.G., L.S. Mullineaux, C.M. Young, and D.T. Manahan. 2001. Larval dispersal potential of the tubeworm *Riftia pachyptila* at deep-sea hydrothermal vents. Nature 411:77–80, **http://dx.doi.org/10.1038/35075063**.

Matabos, M., and E. Thiebaut. 2010. Reproductive biology of three hydrothermal vent peltospirid gastropods (*Nodopelta heminoda, N. subnoda* and *Peltospira operculata*) associated with Pompeii worms on the East Pacific Rise. *Journal of Molluscan Studies* 76:257–266, **http://dx.doi.org/10.1093/mollus/eyq008**.

McGillicuddy, D.J., L.W. Lavelle, A.M. Thurnherr, V.K. Kosnyrev, and L.S. Mullineaux. 2010. Larval dispersion along an axially symmetric mid-ocean ridge. *Deep-Sea Research Part I* 57:880–892, **http://dx.doi.org/10.1016/j.dsr.2010.04.003**.

Metaxas, A. 2004. Spatial and temporal patterns in larval supply at hydrothermal vents in the Northeast Pacific Ocean. *Limnology and Oceanography* 49:1,949–1,956, **http://dx.doi.org/10.4319/lo.2004.49.6.1949**.

Metaxas, A., and N.E. Kelly. 2010. Do larval supply and recruitment vary among chemosynthetic environments of the deep sea? *PLoS ONE* 5, e11646, http://dx.doi.org/10.1371/journal.pone.0011646.

Mills, S.W., S.E. Beaulieu, and L.S. Mullineaux. 2009. *Photographic Identification Guide to Larvae at Hydrothermal Vents.* Woods Hole Oceanographic Institution Technical Report WHOI-2009-05, http://www.whoi.edu/science/B/vent-larval-id.

Miyake, H., M. Kitada, T. Itoh, S. Nemoto, Y. Okuyama, H. Watanabe, S. Tsuchida, K. Inoue, R. Kado, S. Ikeda, and others. 2010. Larvae of deep-sea chemosynthetic ecosystem animals in captivity. *Cahiers de Biologie Marine* 51:441–450.

Mullineaux, L.S., D.K. Adams, S.W. Mills, and S.E. Beaulieu. 2010. Larvae from afar colonize deep-sea hydrothermal vents after a catastrophic eruption. *Proceedings of the National Academy of Sciences of the United States of America* 107:7,829–7,834, http://www.pnas.org/cgi/doi/10.1073/pnas.0913187107.

Mullineaux, L.S., S.L. Kim, A. Pooley, and R.A. Lutz. 1996. Identification of archaeogastropod larvae from a hydrothermal vent community. *Marine Biology* 124:551–560, http://dx.doi.org/10.1007/BF00351036.

Mullineaux, L.S., S.W. Mills, A.K. Sweetman, A.H. Beaudreau, A. Metaxas, and H.L. Hunt. 2005. Vertical, lateral and temporal structure in larval distributions at hydrothermal vents. *Marine Ecology Progress Series* 293:1–16, http://dx.doi.org/10.3354/meps293001.

Mullineaux, L.S., C.H. Peterson, F. Micheli, and S.W. Mills. 2003. Successional mechanism varies along a gradient in hydrothermal fluid flux at deep-sea vents. *Ecological Monographs* 73:523–542, http://dx.doi.org/10.1890/02-0674.

Mullineaux, L.S., P.H. Wiebe, and E.T. Baker. 1991. Hydrothermal vent plumes: Larval highways in the deep sea. *Oceanus* 34:64–68.

Nussbaumer, A.D., C.R. Fisher, and M. Bright. 2006. Horizontal endosymbiont transmission in hydrothermal vent tubeworms. *Nature* 441:345–348, http://dx.doi.org/10.1038/nature04793.

Pond, D.W., A. Gebruk, E.C. Southward, A.J. Southward, A.E. Fallick, M.V. Bell, and J.R. Sargent. 2000. Unusual fatty acid composition of storage lipids in the bresilioid shrimp *Rimicaris exoculata* couples the photic zone with MAR hydrothermal vent sites. *Marine Ecology Progress Series* 198:171–179, http://dx.doi.org/10.3354/meps198171.

Pradillon, F., and F. Gaill. 2007. Adaptation to deep-sea hydrothermal vents: Some molecular and developmental aspects. *Journal of Marine Science Technology* SI:37–53.

Pradillon, F., A. Schmidt, J. Peplies, and N. Dubilier. 2007. Species identification of marine invertebrate early stages by whole-larvae in situ hybridisation of ^{18}S ribosomal RNA. *Marine Ecology Progress Series* 333:103–116, http://dx.doi.org/10.3354/meps333103.

Pradillon, F., B. Shillito, C.M. Young, and F. Gaill. 2001. Deep-sea ecology: Developmental arrest in vent worm embryos. *Nature* 413:698–699, http://dx.doi.org/10.1038/35099674.

Ramirez-Llodra, E., P.A. Tyler, M.C. Baker, O.A. Bergstad, M.R. Clark, E. Escobar, L. Levin, L. Menot, A.A. Rowden, C.R. Smith, and C.L. Van Dover. 2011. Man and the last great wilderness: Human impact on the deep sea. *PLoS ONE* 6 (8), e22588, http://dx.doi.org/10.1371/journal.pone.0022588.

Rittschof, D., R.B. Forward, G. Cannon, J.M. Welch, M. McClary, E.R. Holm, A.S. Clare, S. Conova, L.M. McKelvey, P. Bryan, and C.L. Van Dover. 1998. Cues and context: Larval responses to physical and chemical cues. *Biofouling* 12:31–44.

Salerno, J.L., S.A. Macko, S.J. Hallam, M. Bright, Y.J. Won, Z. McKinness, and C.L. Van Dover. 2005. Characterization of symbiont populations in life-history stages of mussels from chemosynthetic environments. *Biological Bulletin* 208:145–155.

Sievert, S.M., and C. Vetriani. 2012. Chemoautotrophy at deep-sea vents: Past, present, and future. *Oceanography* 25 (1):218–233, http://dx.doi.org/10.5670/oceanog.2012.21.

Sponaugle, S., R.K. Cowen, A. Shanks, S.G. Morgan, J.M. Leis, J.S. Pineda, G.W. Boehlert, M.J. Kingsford, K.C. Lindeman, C. Grimes, and J.L. Munro. 2002. Predicting self-recruitment in marine populations: Biophysical correlates and mechanisms. *Bulletin of Marine Science* 70:341–375.

Thomson, R.E., S.F. Mihaly, A.B. Rabinovich, R.E. McDuff, S.R. Veirs, and F.R. Stahr. 2003. Constrained circulation at Endeavour ridge facilitates colonization by vent larvae. *Nature* 424:545–549, http://dx.doi.org/10.1038/nature01824.

Thomson, R.E., S.E. Roth, and J. Dymond. 1990. Near-inertial motions over a midocean ridge: Effects of topography and hydrothermal plumes. *Journal of Geophysical Research* 95:7,261–7,278, http://dx.doi.org/10.1029/JC095iC05p07261.

Thomson, R.E., M.M. Subbotina, and M.V. Anisimov. 2009. Numerical simulation of mean currents and water property anomalies at Endeavour Ridge: Hydrothermal versus topographic forcing. *Journal of Geophysical Research* 114, C09020, http://dx.doi.org/10.1029/2008JC005249.

Thorson, G.L. 1950. Reproductive and larval ecology of marine bottom invertebrates. *Biological Reviews* 1:1–45, http://dx.doi.org/10.1111/j.1469-185X.1950.tb00585.x.

Thurnherr, A.M., J.R. Ledwell, J.W. Lavelle, and L.S. Mullineaux. 2011. Hydrography and circulation near the crest of the East Pacific Rise between 9° and 10°N. *Deep-Sea Research Part I* 58:365–376, **http://dx.doi.org/10.1016/j.dsr.2011.01.009**.

Thurnherr, A.M., G. Reverdin, P. Bouruet-Aubertot, L.C. St. Laurent, A. Vangriesheim, and V. Ballu. 2008. Hydrography and flow in the Lucky Strike segment of the Mid-Atlantic Ridge. *Journal of Marine Research* 66:347–372, **http://dx.doi.org/10.1357/002224008786176034**.

Thurnherr, A.M., and L.C. St. Laurent. 2012. Turbulence observations in a buoyant hydrothermal plume on the East Pacific Rise. *Oceanography* 25(1):180–181, **http://dx.doi.org/10.5670/oceanog.2012.15**.

Tyler, P.A., S. Pendlebury, S.W. Mills, L. Mullineaux, K.J. Eckelbarger, M. Baker, and C.M. Young. 2008. Reproduction of gastropods from vents on the East Pacific Rise and the Mid-Atlantic Ridge. *Journal of Shellfish Research* 27:107–118, **http://dx.doi.org/10.2983/0730-8000(2008)27[107:ROGFVO]2.0.CO;2**.

Tyler, P.A., and C.M. Young. 1999. Reproduction and dispersal at vents and cold seeps. *Journal of the Marine Biological Association of the United Kingdom* 79:193–208.

Underwood, A.J., and M.J. Keough. 2001. Supply-side ecology: The nature and consequences of variation in recruitment of intertidal organisms. Pp. 183–200 in *Marine Community Ecology*. M.D. Bertness, S.D. Gaines, and M.E. Hay, eds, Sinauer Associates, Sunderland, MA.

Van Dover, C.L. 2000. *The Ecology of Deep-Sea Hydrothermal Vents*. Princeton University Press, Princeton, 424 pp.

Van Dover, C.L. 2011. Mining seafloor massive sulphides and biodiversity: What is at risk? *ICES Journal of Marine Science* 68(2):341–348, **http://dx.doi.org/10.1093/icesjms/fsq086**.

Vrijenhoek, R.C. 2009. Cryptic species, phenotypic plasticity, and complex life histories: Assessing deep-sea faunal diversity with molecular markers. *Deep-Sea Research Part II* 56:1,713–1,723, **http://dx.doi.org/10.1016/j.dsr2.2009.05.016**.

Vrijenhoek, R.C. 2010. Genetic diversity and connectivity of deep-sea hydrothermal vent metapopulations. *Molecular Ecology* 19:4,391–4,411, **http://dx.doi.org/10.1111/j.1365-294X.2010.04789.x**.

Werner, F.E., R.K. Cowen, and C.B. Paris. 2007. Coupled biological and physical models: Present capabilities and necessary developments for future studies of population connectivity. *Oceanography* 20(3):54–69, **http://dx.doi.org/10.5670/oceanog.2007.29**.

Wray, G.A., and R.A. Raff. 1991. The evolution of developmental strategy in marine invertebrates. *Trends in Ecology and Evolution* 6:45–50, **http://dx.doi.org/10.1016/0169-5347(91)90121-D**.

Young, C.M. 2003. Reproduction, development and life-history traits. Pp. 381–426 in *Ecosystems of the World, Volume 28: Ecosystems of the Deep Oceans*. P.A. Tyler, ed., Elsevier, Amsterdam.

Top

Oceanography Magazine, The Oceanography Society, P.O. Box 1931, Rockville, MD 20849-1931, USA
Tel: (1) 301-251-7708, Fax: (1) 301-251-7709, E-mail: **magazine@tos.org**
Send comments about this site to **webmaster@tos.org**