

Shore-based Data Analysis Plan

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Collaborative research: Integrated studies of biological community structure at deep-sea hydrothermal vents

Specific analyses on datasets

In 2003, we (R. Lutz, G. Luther, C. Vetriani, and T. Shank) proposed an integrated research program to identify first order biological-geochemical interactions in the context of previously observed patterns of faunal succession at deep-sea hydrothermal vents through time-series studies at the East Pacific Rise near 9° 50'N that combined molecular genetic characterization of microbial communities and metazoan colonists with in-situ measurements of H₂, H₂S, O₂, H₂O₂, pH and temperature. In 2004 and 2005, we systematically conducted co-located chemical, microbial, and faunal surveys at the EPR in diffuse flow vent habitats occupied by different foundation species (i.e., *Riftia* and *Tevnia* tubeworms), examined habitat variability using autonomous in-situ chemical sensors in association with faunal and microbial sampling, and documented these studies with digital time-lapse camera systems. We also designed and conducted mussel clearing and exclusion cage experiments to investigate the variability of vent fluid flux and chemistry in controlling tubeworm succession. Increases in fluid flux, temperature, and sulfide composition were predicted to reverse the sequential colonization order in tubeworms (from mussels to *Riftia* or *Tevnia*). Initial results have been published [Lutz et al., 2008; Nees et al., 2008; Nees et al., in press; Moore et al., in press]. These studies confirmed our predictions as being consistent with strong controls of fluid flux/chemistry, whereby *Tevnia* colonization was observed on colonization blocks bathed in the increased flux. These data sets have been provided to the Ridge 2000 Data Management Office (DMO) and are indicated as available now in the Table below (similarly, the complete companion set of in-situ chemical data has been submitted by G. Luther; and our PI group has submitted our Level 1 and Level 2 metadata to the DMO).

Attempts to continue these experiments were interrupted (and paved over) by seafloor eruption(s) in April 2006 (with one year remaining on our funded program) [Tolstoy et al., 2006, Soule et al. 2007; Cowen et al., 2007]. After mounting a rapid response effort to assess the eruptive impact, we adaptively conducted co-located integrated measurements and obtained data aimed at our original goals- not only utilizing our best knowledge of post-eruptive processes but also making best use of the opportunity to maximize data collection and comparisons (in that final year of the grant) between pre- and post-eruptive biological-geochemical interactions in the context of community succession. As a result, the final integrative analyses of these collected data are the subject of a currently pending proposal (submitted to R2K in April 2009) and are indicated by an * in the Table below.

Data Set	Metadata	Specific Analyses	Storage	Status/ Delivery Date	References
*Navigated down-looking digital imagery	From Alvin dives during 4 cruises: 2004 (AT11-10), 2005 (AT11-26), 2006 (AT15-06), 2007 (AT15-15)	Mosaic rendering; biological & hydrothermal mapping	Archived and backed up on external hard drives (2 copies)	Partial Mosaic set available on the R2K Data Portal; Original images will be submitted to DMO by 5/2009) *with access by request until 10/2011 *10/2011 for	

				final mosaic map data	
*Time-lapse camera digital imagery	4 deployments: 2005 (A4001), 2005 (A4110), 2007 (A4301), 2007 (A4313)	Time-series analysis (image target subtraction; spectral analysis; presence/absence; size, etc.)	Archived and backed up on external hard drives (2 copies)	Images will be submitted to DMO by 5/2009 *with access by request until 10/2011	
*Temperature records in diffuse-flow vent habitats records; with <i>in situ</i> chemical sensor (ISEA) and colonization substrates (TAMS)	With ISEA: 2004 (A4001), 2004 (A4007), 2005 (A4106), 2007 (A4206), 2007 (A4302) With TAMS: 2006 (A4203-07), 2006 (A4282), 2007 (A4305)	Raw data and spectral analysis for tidal and temporal signals; correlation with colonization data	Archived and backed up on external hard drives (2 copies)	All pre-2006 data from Scheirer et al available on the R2K Data Portal; 2006-7 TAM temperature records will be submitted to DMO by 5/2009	Scheirer et al. 2006
*Time-series faunal samples, collocated with chemical and microbial samples	From Alvin dives during 4 cruises: 2004 (AT11-10), 2005 (AT11-26), 2006 (AT15-06), 2007 (AT15-15)	Taxonomic and molecular identification, population genetic analysis, gene expression	Frozen, preserved in 95% ethanol	Full lists of sampled species available now on the R2K Data Portal; *10/2011 for final integrated data	Fusaro et al. 2008
Mussel removal/caged colonization substrates-macrofaunal colonists	3 deployments: 2004 (A3998, A4001, A4010)	Direct counts and molecular identification of colonists	Frozen, preserved in 95% ethanol	Final species lists available now on the R2K Data Portal	Lutz et al. 2008
*TAMS colonization substrates-macrofaunal colonists	3 deployments: 2006 (A4203-07), 2006 (A4282), 2007 (A4305)	Direct counts and molecular identification of colonists	Frozen, preserved in 95% ethanol	Species lists (without vestimentiferans identified) to be submitted to DMO by 5/2009. *Final Species list to DMO by 10/2010	

References Relevant to the PI's work above

- Cowen, J.P., D.J. Fornari, T.M. Shank, B. Love, B. Glazer, A.H. Treuch, R.C. Holmes, S.A. Soule, E.T. Baker, M. Tolstoy, and K.R. Pomraning (2007) Volcanic Eruptions at East Pacific Rise Near 9°50'N. *EOS, Transactions of the American Geophysical Union* 88: 81-83.
- Fusaro, A.J, A.R. Baco, G. Gerlach, and T.M. Shank (2008) Development and characterization of 12 microsatellite markers from the deep-sea hydrothermal vent siboglinid *Riftia pachyptila*. *Molecular Ecology Notes* 7(5) doi: 10.1111/j.1471-8286.2007.01897.

Scheirer, D.S., T.M. Shank, and D.J. Fornari (2006) Temperature Variations at diffuse and focused flow hydrothermal vent sites along the northern East Pacific Rise. *Geochemistry, Geophysics, and Geosystems* 7(3): Q03002, doi:10.1029/2005GC001094.

Soule, A., D.J. Fornari, M.R. Perfit, K.H. Rubin (2007) New insights into mid-ocean ridge volcanic processes from the 2005-2006 eruption of the East Pacific Rise, 9°46'N-9°56'N. *Geology* 35:1079-1081. (not authored by the PI)

Tolstoy, M., J.P. Cowen, E.T. Baker, D.J. Fornari, K.H. Rubin, T.M. Shank, F. Waldhauser, D.R. Bohnenstiehl, D.W. Forsyth, R.C. Holmes, B. Love, M.R. Perfit, R.T. Weekly, S.A. Soule, Science Party R/V Horizon, Science Party R/V Knorr (2006) A seafloor spreading event captured by seismometers: forecasting and characterizing an eruption. *Science* 314: 1920-1922.

Lutz, R.A., T.M. Shank, G.W. Luther III, C. Vetriani, M. Tolstoy, D.B. Nuzzio, T.S. Moore, F. Waldhauser, M. Crespo-Medina, A. Chatziefthimou, E.R. Annis, and A.J. Reed (2008) Interrelationships between fluid chemistry, temperature, and seismic activity and biological community structure at a deep-sea hydrothermal vent along the East Pacific Rise. *Journal of Shellfish Research, Special Volume 27*(1): 177-190.

Sample requests

Samples can be obtained by contacting Tim Shank (508-289-3392, tshank@whoi.edu).

Anticipated products

- Shank, T.M., Govenar, B., Vetriani, C., Luther, G.W. and R.A. Lutz. Interactions of fluid chemistry and microbial and faunal colonization at hydrothermal vents on the East Pacific Rise (in preparation for *Journal of Experimental Marine Biology and Ecology*).
- Shank, T.M., Govenar, B., Buckman, K.L., Fornari, D.J., Soule, S.A., Luther, G.W., Lutz, R.A., Tolstoy, M., Rubin, K.H., Perfit, M.R., Cowen, J.P., and K.L. Von Damm. Initial Biological, Chemical, and Hydrothermal Results of the “2006” Volcanic Eruption at 9°50'N on the East Pacific Rise (in preparation for *Deep-Sea Research I*).
- Shank, T.M., Govenar, B., Von Damm, K.L., Fornari, D.J., Lilley, M., Luther, G.W., Lutz, R.A., Tolstoy, M. and C. Vetriani. Temporal and spatial dynamics of faunal community structure in relation to fluid geochemistry, microbial community structure and disturbance on the East Pacific Rise (in preparation for *Geochemistry Geophysics Geosystems*, special theme: “Recent Volcanic Eruptions, Properties, and Behavior of the Fast-Spreading East Pacific Rise at 8°-11°N”).

Additional Results Associated with this Program

Shank, T.M. and K.M. Halanych (2007) Toward a mechanistic understanding of larval dispersal: insights from genomic fingerprinting of deep-sea hydrothermal vent populations. *Marine Ecology* 28: 25-35.

Luther, G.W., B. Glazer, M. Shufen, R.E. Trouwborst, T.S. Moore, C. Kraiyya, T. Waite, G. Druschel, B. Sundby, M. Tallefert, D.B. Nuzzio, and T.M. Shank (2008) Use of voltammetric solid-state (micro)electrodes for studying biogeochemical processes: laboratory measurements to real-time measurements with an *in situ* electrochemical analyzer (ISEA). *Marine Chemistry* 108: 221-235

Moore, T. T.M. Shank, D.B. Nuzzio, G.W. Luther III. Time-series chemical and temperature habitat characterization of diffuse flow hydrothermal sites at 9°50'N East Pacific Rise. *Deep-Sea Research* (in press).

Nees, H.A., R.A. Lutz, T.M. Shank, G.W. Luther, III. Pre- & post-eruption diffuse flow variability among tubeworm habitats at 9°50'N on the East Pacific Rise. *Deep-Sea Research* (in press).

Ferrini, V.L., D.J. Fornari, T.M. Shank, J.C. Kinsey, M.A. Tivey, S.A. Soule, S.M. Carbotte, L.L. Whitcomb, D. Yoerger, and J. Howland (2007) Submeter bathymetric mapping of volcanic and hydrothermal features on the East Pacific Rise crest at 9°50'N. *Geochemistry, Geophysics, and Geosystems* 8, Q01006, doi:10.1029/2006GC001333.

Tolstoy, M., J.P. Cowen, E.T. Baker, D.J. Fornari, K.H. Rubin, T.M. Shank, F. Waldhauser, D.R. Bohnenstiehl, D.W. Forsyth, R.C. Holmes, B. Love, M.R. Perfit, R.T. Weekly, S.A. Soule, Science Party R/V Horizon, Science Party R/V Knorr (2006) A seafloor spreading event captured by seismometers: forecasting and characterizing an eruption. *Science* 314: 1920-1922.