Larvae and suspended benthic fauna collected with a plankton pump near deep-sea hydrothermal vents at the East Pacific Rise from 1998 to 2025

Website: https://www.bco-dmo.org/dataset/986309
Data Type: Cruise Results
Version: 1
Version Date: 2025-10-08

Project
» Effects of Disturbance and Larval Supply on Communities at Hydrothermal Vents (Larval supply at EPR vents)
» Trajectories in functional diversity after disturbance at vents on the East Pacific Rise (EPR Functional Diversity)
» RUI: Collaborative: The Predictive Nature of Microbial Biofilms for Cuing Larval Settlement at Deep-Sea Hydrothermal Vents (Vent Settlement Cues)

Contributors	Affiliation	Role
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Abstract
This dataset provides the counts for larvae and some later life stage benthic fauna, identified to varying levels of taxonomic granularity, collected with a large-volume plankton pump near deep-sea hydrothermal vents on the East Pacific Rise on 13 cruises from 1998 to 2025. Sampling for this 27-year time series of larval abundance was conducted using a plankton pump (McLane WTS-LV50) filtering up to ~40 cubic meters over 63-micron mesh. Specimens were preserved in ethanol and identified morphologically under a dissecting microscope. Samples were sorted completely, thus concentrations per taxon may be derived from the counts and volume filtered. The primary data file is a single compiled table with the leftmost columns as a Darwin Core Occurrence extension table and rightmost columns from a Darwin Core Event core table; these are provided separately as two additional files formatted for the Ocean Biodiversity Information System.

Table of Contents

Coverage

Location: East Pacific Rise hydrothermal vents
Spatial Extent: **N**:9.90507 **E**:-104.24008 **S**:9.48755 **W**:-104.29633
Temporal Extent: 1998-11-28 - 2025-02-08

Dataset Description

Sampling for this 27-year time series of larval abundance was funded by multiple awards and projects.

OCE-1947735 for project "RUI: Collaborative: The Predictive Nature of Microbial Biofilms for Cuing Larval Settlement at Deep-Sea Hydrothermal Vents" (https://www.bco-dmo.org/project/851182). Funded pump collections for 2021-2025, sample processing, species identification and enumeration, and composite/harmonized data product.

OCE-1829773 for project "Trajectories in functional diversity after disturbance at vents on the East Pacific Rise" (https://www.bco-dmo.org/project/783674). Funded pump collections in 2019, sample processing, species identification, and enumeration.

OCE-1356738 for project "Effects of Disturbance and Larval Supply on Communities at Hydrothermal Vents" (https://www.bco-dmo.org/project/472885). Funded sample processing, species identification, and enumeration.

OCE-0424953 for project "EPR 9 North Plume Particles" (https://osprey.bco-dmo.org/project/654288). Funded pump collections 2006-2007, sample processing, species identification, and enumeration.

OCE-9619605 for project "RIDGE: Dispersal Potential of Hydrothermal Vent Animals: Larval Energetics, Depth Regulation and Field Distribution" (https://osprey.bco-dmo.org/project/986332). Funded pump collections from 1998 - 2000, sample processing, species identification, and enumeration.

Methods & Sampling

Sample Collection:
Larvae and early life stage benthic invertebrates were collected with a large-volume plankton pump (McLane WTS-LV50, Falmouth, MA, USA) deployed on moorings, landers, and elevators (and one wire deployment). Note that this version of the dataset is only for pumps deployed near-bottom (height above bottom less than 6 m). Each pump sampled for up to 24 hrs at 30 L per minute (prior to 2022-12-25) or 25 L per minute (since 2022-12-25) over a 63-micron mesh, yielding a filtered volume of up to ~40,000 L (~40 cubic meters).

Many of the pump moorings were re-positioned by a submersible, such as *HOV Alvin* or *ROV Jason*, at the seafloor so that they were located within meters of a named vent site. For eight of the 15 named vent sites in this dataset, we used the most recent benchmarked, georeferenced positions from Table 1 in Wu et al. (2022). For three vent sites, we used positions from the Ridge2000 program as downloaded from the Marine Geoscience Data System (MGDS). For three vent sites, we used positions from the most recent cruises that visited these sites. For the remaining vent site, we triangulated the position using QGIS software. For those deployments noted for distance off-axis or distance off-site (on axis), we used the reported distance in meters and direction to calculate position from the named vent site. We expect our coordinate uncertainty to be greater for the pumps that were off-axis/off-site and not re-positioned by a submersible at the seafloor. Bottom depth for positions near 9 50’ N was determined in QGIS using bathymetry acquired in 2018, 2019, and 2021 (Parnell-Turner et al. 2021); for off-site positions near 9 30’ N, we used the AT15-14 cruise report.

We thank members of our lab group over the years, including Ayinde Best, Heather Hunt, and Anna Metaxas, for preparing the pumps. We thank the Captains, crews, and deep submergence teams of the many cruises for assistance with deployment and recovery.

Shipboard sample processing:
Upon recovery, the pump filter was rinsed with chilled, filtered (0.5- or 1-micron) seawater into a container in a cold room (4 deg C). The samples were examined live and on ice under a stereomicroscope to select some individuals for experiments (e.g., Zúñiga Mouret et al. 2025). Within an hour, the container was poured over a 63-micron sieve and washed using 95% non-denatured ethanol into a 250 mL jar.

Laboratory sorting and morphological identification:
Samples were poured over nested 300- and 63-micron sieves and washed into dishes for sorting in tap water (prior to 2006) or ethanol (since 2006) under a dissecting scope at magnifications up to 50X. Individuals were identified as morphotypes to the lowest taxonomic level with emphasis on larval gastropods (Mills et al. 2009). All larval morphotypes of benthic fauna, and some later life stage benthic fauna (e.g., amphipods), were enumerated and placed into taxon-specific containers. Holoplanktonic taxa (e.g., planktonic copepods) were

excluded from counts and returned to the jar as “residue”. All containers are stored in the Mullineaux laboratory at WHOI.

We used the morphotype plus genetic evidence when available to match our lowest-level identification to the World Register of Marine Species (WoRMS) taxonomic database. Genetic evidence is presented in Adams et al. (2010), referenced in a related dataset (Beaulieu et al. 2021), and includes barcoding data from AT50-33 at YBW Shimmering Forest, which was assessed against GenBank and BOLDv5 (J. Weston, unpub. data). Some morphotypes contain morphologically indistinguishable larvae from multiple species; DNA barcoding can provide a useful alternative line of evidence for determining identification.

We thank members of our lab group over the years, including Diane Adams, Anne Beaudreau, and Andrew Sweetman, for sample sorting and facilitating identification. All morphological identifications were verified by Susan Mills.

Harmonization of data sheets for the long time series:
This dataset compiles “raw” data sheets recorded for 13 cruises. Several morphotypes were excluded from the composite sheet (e.g., “chaetognaths,” “cyphonautes,” “‘?eggs,” “fish,” “kinorhynch,” “mashed gastropods,” “other possible bivalve inc D-stage,” “possibly planktonic gastropods”). The composite sheet has 64 morphotypes. Harmonization of these sheets required accommodating changes in morphotype names and taxonomic assignments that occurred over the 27-year time series. Some of the morphotype names are more specific today than in our photographic larval identification guide (Mills et al. 2009); for example, “pointy apex” ultimately was identified to *Sutilizona theca*. For taxonomic standardization to WoRMS, some morphotype names (verbatimIdentification) were assigned to a higher rank for certainty in the taxonomic assignment (e.g., “*Planorbidella planispira* (Unknown W)” to superfamily Neomphaloidea). For one cruise (AT11-20 in 2004) we retained a more conservative morphotype name for the many individuals tentatively identified to genus *Ophryotrocha* (“polychaete larvae & juvs - misc”, instead of categorizing to *Ophryotrocha akessoni*).

All morphotypes can be considered fully assessed, such that concentrations can be derived by dividing counts by volume. For samples collected in 2019 and onwards, zeroes in the composite data sheet indicate absence of that morphotype.

Data Processing Description

This dataset was built from three inputs: the composite data sheet (counts by morphotype per sorted pump sample), an assignment per morphotype to a standardized taxon, and a lookup table for location and depth. To compile the dataset, we used a script in R version 4.4.2 with packages including dplyr 1.1.4, geosphere 1.5-20, and anytime 0.3.12 [https://github.com/sbeaulieu/EPR-traits/blob/master/EPR_pumps_BCODMO_OBIS.R].

Processing included joining the input sheets, calculating off-site positions, calculating minimum and maximum depth for the pump inlet, and adding Darwin Core terms required for the Ocean Biodiversity Information System (OBIS; e.g., occurrenceID, occurrenceStatus). The first operation in the script confirms that the input composite sheet (augmented with eventID) matches the composite sheet being used in data analysis (S. Mills, manuscript in prep; additional provided csv file). One eventID was replaced to match a sampling event previously published in BCO-DMO (Beaulieu et al. 2021) and OBIS (“AT1526_30Nov2007_Tica_3_0_0” was replaced with “AT1526-mooringL21”; note that occurrenceIDs previously submitted to OBIS for this eventID are subsets of the corresponding occurrenceIDs for the total counts per morphotype in this dataset).

This dataset is provided as a long-format, comma-separated variable (csv) file that joins left/right 2 additionally provided csv files. Leftmost columns match to the provided Darwin Core Occurrence extension table; rightmost columns match to the provided Darwin Core Event core table. The occurrence columns of the data table include taxonomic standardization for the counts, and the event columns include spatiotemporal metadata for the volume filtered.

[table of contents | back to top]

Related Publications

Adams, D. K., Mills, S. W., Shank, T. M., & Mullineaux, L. S. (2010). Expanding dispersal studies at hydrothermal

vents through species identification of cryptic larval forms. Marine Biology, 157(5), 1049–1062. https://doi.org/10.1007/s00227-009-1386-8
Results

Beaulieu, S. E., Mullineaux, L. S., Adams, D. K., & Mills, S. W. (2009). Comparison of a sediment trap and plankton pump for time-series sampling of larvae near deep-sea hydrothermal vents. Limnology and Oceanography: Methods, 7(3), 235–248. Portico. https://doi.org/10.4319/lom.2009.7.235
Results

Fleming, B., Beaulieu, S., Mills, S., Gaggiotti, O., & Mullineaux, L. (2024). Ecological connectivity in Pacific deep-sea hydrothermal vent metacommunities. Marine Ecology Progress Series, 731, 267–278. https://doi.org/10.3354/meps14182
Results

Mills, S. W., Beaulieu, S. E., & Mullineaux, L. S. (2009). Photographic identification guide to larvae at hydrothermal vents. https://doi.org/10.1575/1912/2996
Methods

Mills, S., Mullineaux, L., Beaulieu, S., & Adams, D. (2013). Persistent effects of disturbance on larval patterns in the plankton after an eruption on the East Pacific Rise. Marine Ecology Progress Series, 491, 67–76. https://doi.org/10.3354/meps10463
Results

Mullineaux, L., Mills, S., Sweetman, A., Beaudreau, A., Metaxas, A., & Hunt, H. (2005). Vertical, lateral and temporal structure in larval distributions at hydrothermal vents. Marine Ecology Progress Series, 293, 1–16. https://doi.org/10.3354/meps293001
Results

QGIS, Q. G. (2024). Development Team.(2014). Quantum GIS Geographic Information System. Open Source Geospatial Foundation Project.
Software

Wu, J. N., Parnell-Turner, R., Fornari, D. J., Kurras, G., Berrios-Rivera, N., Barreyre, T., & McDermott, J. M. (2022). Extent and volume of lava flows erupted at 9 50′ N, East Pacific Rise in 2005–2006 from autonomous underwater vehicle surveys. Geochemistry, Geophysics, Geosystems, 23(3). DOI:10.1029/2021GC010213
Methods

Zúñiga Mouret, R., Hourdez, S., Curran, M., DiBenedetto, M. H., Mills, S. W., Vetriani, C., Arellano, S. M., Weston, J. N. J., Dykman, L. N., Best, A. C., Pires, A., & Mullineaux, L. S. (2025). Pressurized plankton observatory offers a new window into deep-sea larval behavior. Limnology and Oceanography: Methods. Portico. https://doi.org/10.1002/lom3.10708
Results

[table of contents | back to top]

Related Datasets

Related Research

Beaulieu, S., Mills, S., Mullineaux, L., Carrier, T., & Reitzel, A. (2021). Larvae collected near deep-sea hydrothermal vent fields for microbiome study. United States Geological Survey. Occurrence dataset https://obis.org/dataset/b920c161-c295-4a73-b9a4-96ab1ab0b357

Parnell-Turner, R., Fornari, D., McDermott, J., Barreyre, T., & Wu, J.-N. (2021). *Processed bathymetric data (netCDF grid) from 9°50'N, East Pacific Rise, acquired in 2018, 2019 and 2021 during AUV Sentry near-bottom dives* (Version 1) [Data set]. Interdisciplinary Earth Data Alliance (IEDA). https://doi.org/10.26022/IEDA/330373

[table of contents | back to top]

Parameters

Parameters for this dataset have not yet been identified

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	McLane Large Volume Pumping System WTS-LV
Generic Instrument Name	McLane Large Volume Pumping System WTS-LV
Dataset-specific Description	Larvae and early life stage benthic invertebrates were collected with a large-volume plankton pump (McLane WTS-LV50, Falmouth, MA, USA) deployed on moorings, landers, and elevators
Generic Instrument Description	The WTS-LV is a Water Transfer System (WTS) Large Volume (LV) pumping instrument designed and manufactured by McLane Research Labs (Falmouth, MA, USA). It is a large-volume, single-event sampler that collects suspended and dissolved particulate samples in situ. Ambient water is drawn through a modular filter holder onto a 142-millimeter (mm) membrane without passing through the pump. The standard two-tier filter holder provides prefiltering and size fractioning. Collection targets include chlorophyll maximum, particulate trace metals, and phytoplankton. It features different flow rates and filter porosity to support a range of specimen collection. Sampling can be programmed to start at a scheduled time or begin with a countdown delay. It also features a dynamic pump speed algorithm that adjusts flow to protect the sample as material accumulates on the filter. Several pump options range from 0.5 to 30 liters per minute, with a max volume of 2,500 to 36,000 liters depending on the pump and battery pack used. The standard model is depth rated to 5,500 meters, with a deeper 7,000-meter option available. The operating temperature is -4 to 35 degrees Celsius. The WTS-LV is available in four different configurations: Standard, Upright, Bore Hole, and Dual Filter Sampler. The high-capacity upright WTS-LV model provides three times the battery life of the standard model. The Bore-Hole WTS-LV is designed to fit through a narrow opening such as a 30-centimeter borehole. The dual filter WTS-LV features two vertical intake 142 mm filter holders to allow simultaneous filtering using two different porosities.

Dataset-specific Instrument Name	Optical stereomicroscope
Generic Instrument Name	Microscope - Optical
Dataset-specific Description	The samples were examined live and on ice under a stereomicroscope to select some individuals for experiments
Generic Instrument Description	Instruments that generate enlarged images of samples using the phenomena of reflection and absorption of visible light. Includes conventional and inverted instruments. Also called a "light microscope".

[table of contents | back to top]

Deployments

RR2102

Website	https://www.bco-dmo.org/deployment/879915
Platform	R/V Roger Revelle
Start Date	2021-03-24
End Date	2021-04-25

AT11-20

Website	https://www.bco-dmo.org/deployment/654275
Platform	R/V Atlantis
Start Date	2004-11-05
End Date	2004-11-26
Description	More information is available from the Rolling Deck to Repository (R2R).

AT15-14

Website	https://www.bco-dmo.org/deployment/734059
Platform	R/V Atlantis
Report	http://datadocs.bco-dmo.org/docs/Larval_Supply_EPR_Vents/data_docs/AT15-14_LADDER-2_Cruise_Report_39303.pdf
Start Date	2006-12-05
End Date	2007-01-05
Description	Part of Ridge Interdisciplinary Global Experiments (Ridge2000).

AT15-12

Website	https://www.bco-dmo.org/deployment/734057
Platform	R/V Atlantis
Report	http://datadocs.bco-dmo.org/docs/Larval_Supply_EPR_Vents/data_docs/AT15-12_LADDER-1_Cruise_Report_36250.pdf
Start Date	2006-10-24
End Date	2006-11-18
Description	Part of Ridge Interdisciplinary Global Experiments (Ridge2000).

AT15-26

Website	https://www.bco-dmo.org/deployment/734071
Platform	R/V Atlantis
Report	http://datadocs.bco-dmo.org/docs/Larval_Supply_EPR_Vents/data_docs/AT15-26_LADDER-3_Cruise_Report_Feb4_36252.pdf
Start Date	2007-11-13
End Date	2007-12-03
Description	Part of Ridge Interdisciplinary Global Experiments (Ridge2000).

AT42-21

Website	https://www.bco-dmo.org/deployment/879912
Platform	R/V Atlantis
Start Date	2019-12-17
End Date	2020-01-07

AT50-06

Website	https://www.bco-dmo.org/deployment/933990
Platform	R/V Atlantis
Start Date	2022-12-03
End Date	2023-01-01
Description	Project: RUI: Collaborative: The Predictive Nature of Microbial Biofilms for Cuing Larval Settlement at Deep-Sea Hydrothermal Vents START/END PORT: Puntarenas, Costa Rica

AT3-29

Website	https://www.bco-dmo.org/deployment/986356
Platform	R/V Atlantis
Start Date	1998-11-23
End Date	1998-12-12
Description	The R/V Atlantis left from Manzanillo, Mexico on Nov 23, 1998 and returned to Manzanillo on Dec 12, 1998. https://www.dla.whoi.edu/cruise-details/AT3-29

AT3-44

Website	https://www.bco-dmo.org/deployment/986362
Platform	R/V Atlantis
Start Date	1999-12-07
End Date	1999-12-28
Description	The R/V Atlantis left from Manzanillo, Mexico on Dec 07, 1999 and returned to San Diego, California on Dec 28, 1999.https://www.dla.whoi.edu/cruise-details/AT3-44

AT3-51

Website	https://www.bco-dmo.org/deployment/986368
Platform	R/V Atlantis
Start Date	2000-05-02
End Date	2000-05-27

AT50-33

Website	https://www.bco-dmo.org/deployment/986371
Platform	R/V Atlantis
Start Date	2025-01-23
End Date	2025-02-17

AT50-20

Website	https://www.bco-dmo.org/deployment/983951
Platform	R/V Atlantis
Start Date	2024-01-11
End Date	2024-02-11
Description	RUI: Collaborative: The Predictive Nature of Microbial Biofilms for Cuing Larval Settlement at Deep-Sea Hydrothermal Vents

AT3-33

Website	https://www.bco-dmo.org/deployment/986360
Platform	R/V Atlantis
Start Date	1999-04-17
End Date	1999-05-04
Description	The R/V Atlantis left from Manzanillo, Mexico on Apr 17, 1999 and returned to Manzanillo on May 04, 1999.https://www.dla.whoi.edu/cruise-details/AT3-33

[table of contents | back to top]

Project Information

Effects of Disturbance and Larval Supply on Communities at Hydrothermal Vents (Larval supply at EPR vents)

Coverage: Near 9 50'N on East Pacific Rise: 10 N 107 W

NSF award abstract:
The long-term aim of this project is to understand the effects of disturbance on species occurrence and regional diversity in vent systems. The investigator is working toward that goal by conducting field studies on larval dispersal and colonization processes, and by collaborating with theoretical ecologists. The present project investigates a unique set of field observations gathered from decade-long monitoring of vents before and after a recent catastrophic eruption on the East Pacific Rise (EPR). The specific objectives are to determine whether succession is deterministic (or are there alternative stable states?), and whether disturbance at one vent field can influence community structure on a larger spatial scale. Answering these questions requires characterization of larval exchange between vents and of the effect of pioneer colonists on successional trajectory. The approach is to characterize species composition of larvae and colonists at three vent sites on the EPR: one that was disturbed by the eruption (9 degrees 50 minutes N) and two that remained undisturbed (9 degrees 47 minutes N and 9 degrees 30 minutes N). The investigators are running out of time to process the samples, because they degrade over time and the specimens are at risk of losing morphological detail which is critical for species identification. This award has modest funding to focus specifically on species identification and enumeration, without attempting to interface with models or population genetic analyses. These will come later.

The question of how vent communities persist despite living in patchy, ephemeral habitat has intrigued scientists since the discovery of vents in the late 1970s. A necessary synthesis of the influence of larval connectivity on metacommunity dynamics at the regional scale continues to elude us. This project works toward that synthesis by characterizing critical aspects of larval exchange and community succession at vents on the well-studied EPR. This study has general application to vent systems globally because it challenges the assumption that vent succession is deterministic, and it will contribute to our understanding of spatial scales of larval connectivity. The data on larval exchange and community resilience that will result from this study are precisely the kind needed for metapopulations modeling, for prediction of vent community response to

anthropogenic events such as seafloor mining, and to inform management efforts at the Marianas Trench Marine National Monument.

Trajectories in functional diversity after disturbance at vents on the East Pacific Rise (EPR Functional Diversity)

Coverage: East Pacific Rise

NSF Award Abstract:
Hydrothermal vents support oases of life in the deep sea and are inhabited by unusual organisms that use chemical energy instead of photosynthesis as the basis of their food web. However, because the vents occur in geologically active areas of the seafloor, entire communities can be eradicated by catastrophic natural disturbances such as eruptions. The main objectives of this project are to quantify how quickly these communities recover from catastrophic disturbance and to determine what processes influence their resilience. The project focuses on both the structure (species diversity) and function (trait diversity) of the communities. The investigators will examine vents on an active segment of the East Pacific Rise where eruptive disturbance occurs on decadal time scales. These activities will create an unprecedented long-term (>14-year) quantitative time-series of colonist species composition and function. The application of trait-based analysis to the question of biological succession at vents has the potential to change the way we think about resilience in other patchy, transient and regionally-connected ecosystems. By considering how traits change over time, the researchers can untangle which species-level characteristics most influence abundance and distribution. The project objectives have broad significance with the growing potential for human-caused disturbances at deep-sea vents through deep-sea mining. Additional impacts include strengthening participation of under-represented minorities in marine science and contributing to international database development for functional traits of deep-sea vent species.

The unique, chemosynthesis-fueled fauna inhabiting deep-sea hydrothermal vents are subject to tectonic and eruptive disturbance that can eradicate entire communities. The main objectives of this project are to quantify how quickly these communities recover from catastrophic disturbance and to determine what processes influence their resilience. The focus is on vents on an active segment of the East Pacific Rise where eruptive disturbance occurs on decadal time scales. Field data on colonization and larval supply are used to characterize not only species succession but also the trajectory of functional diversity after a recent (2006) eruption. A new, promising approach to the colonization studies comes from incorporating trait-based analysis of functional diversity. Functional trait analysis is increasingly recognized in terrestrial and freshwater systems as a tool to holistically answer ecological questions, but trait analysis has not been often applied to marine systems. By considering how traits of incoming colonists change over time, the investigators can untangle which species-level factors most influence abundance and distribution. This project will create an unprecedented long-term (>14-year) quantitative time-series of colonist species composition and function. It includes multiple vent sites to encompass the full diversity of habitat conditions, and assesses both local processes and regional connectivity through larval supply. Field observations at individual sites contribute to broader questions when placed in the context of metacommunity theory. In this theoretical framework, field data such as this can be used to answer such questions as how the eradication of the vent community at a particular site affects the persistence of the metacommunity overall, and which vent sites contribute most to regional biodiversity.

RUI: Collaborative: The Predictive Nature of Microbial Biofilms for Cuing Larval Settlement at Deep-Sea Hydrothermal Vents (Vent Settlement Cues)

Coverage: East Pacific Rise, 9 North hydrothermal vents

NSF Award Abstract:
Over four decades of research have shown that tiny free-swimming offspring of the unique inhabitants of hydrothermal vents can disperse effectively between their specialized habitats. Yet, we know almost nothing about how these larval animals complete the journey by locating and settling down in suitable locations. This question remains one of the key unresolved puzzles in the ecology of the deep sea and is becoming

increasingly important to solve as hydrothermal vents are becoming threatened by human impacts. The investigators suggest that the films of bacteria that first form at vents are good signposts for settlement of larvae because they indicate that the hydrothermal vents are suitable for life. This project uses a combined program of field experiments, cutting-edge molecular biology techniques, and shipboard experiments with hydrothermal-vent larvae and cultured bacterial films. The project also connects undergraduate research interns at a primarily undergraduate institution (Western Washington University) with undergraduate research interns at two research institutions (Rutgers and Woods Hole Oceanographic Institution) while working on the project at sea together. Finally, the team is producing a science-in-action documentary filled with ocean science and exploration intended for television distribution and museum screenings. The investigators are using footage of the deep-sea vents, shipboard and diving operations, and laboratory work to create a documentary that highlights the foundation of scientific research—hypothesis-driven research, the application of the scientific method, and the importance of critical thinking—all in the framework of the study of an exciting, but threatened, ecosystem.

Hydrothermal vents are particularly tractable systems in which to study questions about the roles of biofilms in larval settlement because biofilms at vents are relatively low-complexity; vent animals are strictly dependent on vent microbes, often through symbiotic partnerships acquired after settlement; and environmental variations are present within the range of a common larval pool. Moreover, decades of research on settlement in model organisms give us good insight into biofilm cues; there is solid foundational understanding about colonization patterns at vents; we now have excellent tools to collect, identify, and culture vent larvae and microbes; and modern environmental "-omics" techniques are a good tool to characterize biological cues produced by biofilms. The project provides an unprecedented, quantitative look into the role of microbial biofilms in structuring larval settlement at hydrothermal vents, achieved only through the close collaboration of microbial and larval ecologists. The combined field program of short-term settlement experiments, microbial "-omics" work, and subsequent shipboard settlement experiments allows the investigative team to use field experiments to statistically model the factors that best predict larval settlement in the field, then test those predictions with shipboard experiments that decouple covarying conditions. This extensive characterization of putative larval settlement cues and their relationship to colonization success in heterogeneous vent habitat niches will contribute to a broader understanding of colonization success across diverse marine ecosystems. Understanding the role that the initial settlement of larvae plays in the recovery and resilience of hydrothermal-vent ecosystems is critical to developing informed management plans for deep-sea mining.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1356738
NSF Division of Ocean Sciences (NSF OCE)	OCE-0424953
NSF Division of Ocean Sciences (NSF OCE)	OCE-1829773
NSF Division of Ocean Sciences (NSF OCE)	OCE-1947735
NSF Division of Ocean Sciences (NSF OCE)	OCE-9619605

[table of contents | back to top]