Experimental results on larvae primed by turbulence and the effect on settlement size from Bodega Marine Lab in 2014 (Turbulence-spurred settlement project)

Website: https://www.bco-dmo.org/dataset/640538
Data Type: experimental
Version: 2016-03-15

Project
» Turbulence-spurred settlement: Deciphering a newly recognized class of larval response (Turbulence-spurred settlement)

Contributors	Affiliation	Role
Gaylord, Brian	University of California - Davis: Bodega Marine Laboratory (UC Davis-BML)	Principal Investigator
Ferner, Matthew	San Francisco State University (SFSU)	Co-Principal Investigator, Contact
Lowe, Christopher	Stanford University - Hopkins (Stanford-HMS)	Co-Principal Investigator
Copley, Nancy	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

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Dataset Description

Figure 8. Precompetent larvae primed by turbulence exposure settle at a smaller size. (a) Mean test area in 12-day-old juveniles (n=49) deriving from turbulence exposure (approx. 2 W kg−1 for 3 min) while precompetent, compared to 15-day-old competent juveniles (n =29) never exposed to turbulence. Shown are standard Tukey box plots with the dots as outliers. Representative 12-day-old turbulence-exposed juvenile (b) and 15-day-old control juvenile (c) from this experiment, photographed at the same magnification. White dotted lines indicate the major and minor axes of the ellipses used to estimate cross-sectional test area. Note also the relatively shorter spines in (b), another indication of the precocious state of these turbulence-induced juveniles. Scale bars, 100µm. The effect size here (mean size on day 15−mean size on day 12) is 19 437 µm2.

See Hodin et al (2015) for full details.

Related Reference:
Hodin J, Ferner MC, Ng G, Lowe CJ, Gaylord B. 2015. Rethinking competence in marine life cycles: ontogenetic changes in the settlement response of sand dollar larvae exposed to turbulence. Royal Society Open Science. 2: 150114. doi: 10.1098/rsos.150114.

Related Datasets:
Turbulence settlement: fig.3
Turbulence settlement: fig.4-6_Batches A & B
Turbulence settlement: fig.4-6_Batch C
Turbulence settlement: fig.6b
Turbulence settlement: fig.7

Turbulence settlement: fig.8 bootstrap

Data Processing Description

BCO-DMO Processing:

- added conventional header with dataset name, PI name, version date, reference information
- renamed parameters to BCO-DMO standard
- replaced blank cells and hyphen with NA (not applicable) or nd (no data)

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Data Files

File
fig8a.csv (Comma Separated Values (.csv), 6.56 KB) MD5:dbb9b5cf2e1666845c43de67e5a6e943 Primary data file for dataset ID 640538

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Parameters

Parameter	Description	Units
set	description of image: ruler; micrometer; 11-day juvenile with turbulence; 14-day juvenile with no turbulence	unitless
num_juv_tmt	identification number of juvenile in treatment	unitless
len1_um	length 1 of juvenile test	micrometers
len2_um	length 2 of juvenile test	micrometers
pixels1	number of pixels for length 1	pixels
pixels2	number of pixels for length 2	pixels
len1_mm_long	length 1 * 1000 (long format)	millimeters
len2_mm_long	length 2 * 1000 (long format)	millimeters
len1_mm_rnd	rounded length 1	millimeters
len2_mm_rnd	rounded length 2	millimeters
area	area of juvenile test	microns^2
um_per_pixel	area of juvenile test in pixels: (len1 /2)*(len2 /2)*PI	pixels
comment	comment	unitless

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Instruments

Dataset-specific Instrument Name	
Generic Instrument Name	Camera
Dataset-specific Description	Leica (Solms, Germany) MC170 HD camera mounted on a Leica M125 dissecting microscope and a Leica DM1000 compound microscope
Generic Instrument Description	All types of photographic equipment including stills, video, film and digital systems.

Dataset-specific Instrument Name	
Generic Instrument Name	Taylor-Couette system
Dataset-specific Description	To generate turbulence intensities (quantified in terms of the energy dissipation rate, in units of Wkg−1) ranging from those found in open ocean waters to those arising on wave-battered coasts, we employed a Taylor–Couette cell [29], an apparatus composed of two vertically oriented, coaxial cylinders separated by a 3.5mm gap that contains seawater (described in greater detail in [1]). We held the stationary inner cylinder, and thus the water in the gap, at 19–21◦C by means of a circulating water stream from a temperature-controlled water bath passing through the cylinder's interior. During operation, the outer cylinder rotated at a prescribed speed causing relative motion between the cylinders and thereby shearing the seawater between them. At rotation speeds employed for testing sand dollar larvae, the sheared flow was turbulent [1]. [1]Gaylord B, Hodin J, Ferner MC. 2013 Turbulent shear spurs settlement in larval sea urchins. Proc. Natl Acad. Sci. USA 110, 6901–6906. (doi:10.1073/pnas. 1220680110)
Generic Instrument Description	An apparatus composed of two vertically oriented, coaxial cylinders separated by a gap that contains seawater. During operation, the outer cylinder rotates at a prescribed speed causing relative motion between the cylinders and thereby shearing the seawater between them.

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Deployments

Gaylord_Turb-Settlement

Website	https://www.bco-dmo.org/deployment/640417
Platform	lab Bodega Marine Laboratory
Start Date	2014-06-01
End Date	2014-08-31
Description	sand dollar settlement studies

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Project Information

Turbulence-spurred settlement: Deciphering a newly recognized class of larval response (Turbulence-spurred settlement)

Coverage: Northeast Pacific

Description from NSF award abstract:
With this award the investigators will explore a habitat-scale oceanographic process that has the potential to integrate studies of larval delivery with an understanding of how larvae respond to substrate-associated cues. This work will build on published and preliminary data indicating that turbulent shear characteristic of high-energy near shore environments primes larvae to initiate settlement and to transform into the juvenile stage. These prior findings suggest that: 1) Because turbulence intensity varies predictably as a function of the strength of wave breaking and other factors, turbulence could operate as an indicator for larvae of their approach to suitable habitat, providing a link between larger-scale dispersal phenomena, and near-bottom search and selection behaviors; and 2) The larval response to turbulence acts in an unprecedented fashion. In contrast to typical cues, turbulence does not induce settlement directly, but rather spurs otherwise "pre-

competent" larvae that are refractory to chemical cues to become "competent", thereby causing them to acquire responsiveness to such cues and undergo settlement. The interdisciplinary team has combined expertise in larval biology, sensory ecology, and organism-flow interactions necessary to address this topic. They will employ a phylogenetically robust approach to explore the scope and adaptive significance of the turbulence response in a widespread and ecologically important class of organisms (echinoids; sea urchins and their relatives), and will determine whether the response is aligned with environmental conditions characteristic of these organisms' adult habitat. They will also test for ecologically important functional consequences of precocious, turbulence-induced settlement. This work will provide a detailed look at an entirely new class of settlement inducer, one with strong potential for changing current conceptualizations of dispersing larval stages, their ability to detect signatures of habitat across multiple scales, and the ways in which organism-level traits might influence population connectivity.

How organisms with dispersing life stages find their way back to adult habitat is a fundamental question in marine ecology. Considerable research has explored links between transport, delivery, settlement, and recruitment, with important advances in knowledge. However, a complete understanding of the larval recruitment process remains elusive. Standard tools for estimating dispersal (e.g., numerical circulation models) have limited spatial resolution, which prevents them from predicting at scales below a few hundred meters how larvae will interact with the shore. Studies investigating larval attachment have focused on chemical, tactile, or near-bottom hydrodynamic cues active across microns to centimeters. The novelty of the present project is that it will focus on processes at habitat scales -- between transport and settlement -- where there is a gap in the understanding of processes.

This project will provide a framework for integrating key concepts of propagule dispersal and settlement, two fundamental but largely disjunct themes in marine science. The understanding that will come from this study will provide key information for ecosystem based management of coastal marine resources. The investigators will develop a "Surfing to Settlement" virtual lab activity based on their research that will be incorporated into the VirtualUrchin web platform, a widely exploited educational resource at Stanford that gets thousands of unique users per month. Through connections to the San Francisco Bay National Estuarine Research Reserve, they will integrate the "Surfing to Settlement" activity into one of NERRs professional development workshops for central California educators, thus disseminating this resource to and gaining valuable feedback from dozens of teachers and thousands of students.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1356966
NSF Division of Ocean Sciences (NSF OCE)	OCE-1357033
NSF Division of Ocean Sciences (NSF OCE)	OCE-1357077

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