

# Experimental results on turbulence exposure in sand dollars from Bodega Marine Lab in 2014 (Turbulence-spurred settlement project)

**Website:** <https://www.bco-dmo.org/dataset/640389>

**Data Type:** experimental

**Version:** 2016-03-14

## Project

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

Contributors	Affiliation	Role
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## Dataset Description

**Figure 3.** Turbulence exposure in sand dollars shortened the time to competence by approximately 20%. On each day indicated, three replicates of 20–25 larvae each were subjected to 3 min of turbulence exposure at approximately 6 W kg<sup>-1</sup> (500 r.p.m.), and then immediately transferred them into 40 mM excess KCl in MFSW; we also transferred three replicates of 20–25 larvae directly into 40 mM excess KCl in Millipore-filtered natural seawater (i.e. with no turbulence exposure; unmanipulated controls). All larvae in this analysis were from the same batch (larval batch A, fertilized 27 May 2014).

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.4-6\\_Batches A & B](#)

[Turbulence settlement: fig.4-6\\_Batch C](#)

[Turbulence settlement: fig.6b](#)

[Turbulence settlement: fig.7](#)

[Turbulence settlement: fig.8](#)

[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
- reformatted date from m/d/yyyy to yyyy-mm-dd
- reduced number of digits right of decimal
- replaced blank cells with NA ('not applicable')

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## Data Files

File
<b>fig3.csv</b> (Comma Separated Values (.csv), 1.15 KB) MD5:c9df217f4679a2a8afdd5bd59b06f5f3 Primary data file for dataset ID 640389

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## Parameters

Parameter	Description	Units
date_expt	experiment date	yyyy-mm-dd
batch	larval batch identification	unitless
rpm	speed of rotation creating turbulent flow; unmanip means unmanipulated/no rpm	rotations per minute
day_develop	age of larvae post-fertilization	days
settled_control	proportion of settled larvae in control replicates	larvae
settled_500rpm	proportion of settled larvae in treatment replicates	larvae
mean_settled	mean proportion of settled larvae by age	larvae

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## Instruments

<b>Dataset-specific Instrument Name</b>	
<b>Generic Instrument Name</b>	Taylor-Couette system
<b>Dataset-specific Description</b>	To generate turbulence intensities (quantified in terms of the energy dissipation rate, in units of $W/kg-1$ ) 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)
<b>Generic Instrument Description</b>	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

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/640417">https://www.bco-dmo.org/deployment/640417</a>
<b>Platform</b>	lab Bodega Marine Laboratory
<b>Start Date</b>	2014-06-01
<b>End Date</b>	2014-08-31
<b>Description</b>	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
<a href="#">NSF Division of Ocean Sciences (NSF OCE)</a>	<a href="#">OCE-1356966</a>
<a href="#">NSF Division of Ocean Sciences (NSF OCE)</a>	<a href="#">OCE-1357033</a>
<a href="#">NSF Division of Ocean Sciences (NSF OCE)</a>	<a href="#">OCE-1357077</a>

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