Copepod swimming particle image velocimetry raw videos collected from the North Atlantic and Gulf of Mexico from 2011-2014 (Protist Behavior and Imposed Flow project)

Website: https://www.bco-dmo.org/dataset/636357
Data Type: experimental
Version: 2016-01-25

Project
» Linking Propulsive Morphology, Swimming Behavior and Sensory Perception by Marine Planktonic Protists to their Trophic Roles within Marine Food Webs (Protist Behavior and Imposed Flow)

Contributors	Affiliation	Role
Buskey, Edward J.	University of Texas - Marine Science Institute (UTMSI)	Principal Investigator
Gemmell, Brad J.	University of South Florida (USF)	Contact
Copley, Nancy	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

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Dataset Description

Related Reference:

Gemmell et al. 2014. A new approach to micro-scale particle image velocimetry (µPIV) for quantifying flows around free-swimming zooplankton. Journal of Plankton Research. 36 (5): 1396-1401. doi: 10.1093/plankt/fbu067

Methods & Sampling

To achieve high resolution fluid velocity vectors in µPIV, high cell densities are required to maintain enough particles in such small fields of view. We used approximately 30,000-50,000 cells ml-1 at 40X and 2000-5000 cells ml-1 at 10X. While these cell densities are high, naturally occurring blooms of algae have been documented exceeding 500,000 cells ml-1 (Buskey *et al.*, 2001).

The specific lenses used in this study were: A Nikon E Plan 10/0.25 160/0 LWD 10X Objective and a Nikon BD Plan 40/0.5 210/0 ELWD 40X microscope objective. The working distance of these objectives are 10.5 mm and 9.8 mm for 10X and 40X respectively. For the results presented in this paper, the 10X configuration positioned the lens at the front plane of the filming vessel. Therefore, when accounting for the glass thickness (1 mm), all copepods that were within the focal plane (appropriate data) were filmed at least 9.5 mm (approx. 10 body lengths) from any wall. For the 40X case (9.8 mm working distance), the total vessel thickness was 10 mm but when accounting for front and rear glass panel thickness, the water portion total 8 mm thick. By focusing at the front plane of the glass and moving the vessel back 5 mm with a micron-resolution translating stage, we were able to focus in the middle of the volume, making nauplii (~100 µm), 4 mm (40 body lengths) away from any wall.

The resolutions of the recorded images were 0.75 microns per pixel for the 40X application and 2.3 microns per pixel for the 10X applications. Based on the best available PIV of copepods using standard planar PIV methods (Kiørboe *et al.*, 2010) resolution was roughly 10 microns per pixel. Thus, our 10X observations had ~5 times the resolution and our 40X observations had ~13 times the resolution. Calibration was achieved using a 2-point calibration from a recorded image of an in-focus stage micrometer scale (Olympus). This is similar to how traditional planar PIV can be calibrated and no additional considerations are necessary for brightfield PIV imaging. To achieve accurate near-body flows, the animal was manually masked prior to running cross-correlation algorithms.

Supplemental Discussion:

Experimental results obtained in this manuscript used broad spectrum 'white' light from a fiber optic illuminator. Copepods are known to be positively phototactic to these bright point sources of light in the laboratory. While many previous experiments with copepods have used 'white' light in the past and there has been no evidence to suggest that escape and feeding kinematics are altered, this type of illumination should be avoided for certain types of experiments where directed swimming and/or copepod aggregation would be problematic. For these types of experiments, using near-IR light sources would be preferred. We have found through initial testing using an 850 nm wavelength, that brightfield µPIV results appear indistinguishable from 'white' light sources as long as the camera sensor does not filter this wavelength.

The issue of wall effects becomes an important consideration for µPIV applications given that even long working distance objective lenses typically resolve only a short distance, usually ≤ 1 cm, into the filming vessel. Using Zaret's formula (Vogel, 1994) for determining when proximity to walls will be negligible for small, moving objects, we are able to demonstrate that our experimental setup is unlikely to have experienced significant wall effects. We applied the following formula:

$y/l > 20/Re$

where *y* is distance to nearest wall and *l* is the length of object. Adult copepods were approximately 1 mm in length and filmed at10 mm from a wall surface. At the cruising speeds filmed, Re of the copepods are approximately 8. Thus, 10 > 2.5 and meets the requirement for wall effects being negligible. Similarly, N1 *A. tonsa* copepod nauplii are roughly 0.1 mm in length and filmed 4 mm away from the nearest wall. Swimming speeds resulted in a Re of 4. Thus, 40 > 5 and meets the requirement for wall effects being negligible.

References:

Buskey, E. J., Liu, H., Collumb, C. and Bersano, J. G. F. (2001) The decline and recovery of a persistent Texas brown tide algal bloom in the Laguna Madre (Texas, USA). Estuaries, 24, 337-346.

Kiørboe, T., Jiang, H. and Colin, S. P. (2010) Danger of zooplankton feeding: the fluid signal generated by ambush-feeding copepods. Proceedings of the Royal Society B: Biological Sciences, 277, 3229-3237.

Vogel, S. (1994) Life in moving fluids: the physical biology of flow. Vol., Princeton University Press.

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Data Files

File
PIV_copepods.csv (Comma Separated Values (.csv), 689 bytes) MD5:21101b77fc4b45b75ef34380254fc83c Primary data file for dataset ID 636357

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Parameters

Parameter	Description	Units
fig	Figure number citing the video: Gemmell et al (2014) JPR	unitless
description	Description of PIV video subject	unitless
fps_playback	frames per second during playback	frames per second
file_size_MB	size of video file	megabytes
file_link	link to the video file	unitless

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Instruments

Dataset-specific Instrument Name	
Generic Instrument Name	Camera
Dataset-specific Description	Photron SA6 high-speed camera with a 150W fiber optic illuminator (Fisher Scientific)
Generic Instrument Description	All types of photographic equipment including stills, video, film and digital systems.

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Project Information

Linking Propulsive Morphology, Swimming Behavior and Sensory Perception by Marine Planktonic Protists to their Trophic Roles within Marine Food Webs (Protist Behavior and Imposed Flow)

Coverage: US coastal North Atlantic water, and US coastal Gulf of Mexico water

Description from NSF award abstract:
One of the central issues in biological oceanography is to understand the processes that regulate the biomass and distribution of phytoplankton in the ocean. The fate of most phytoplankton is to be consumed by grazers, and it is now generally accepted that marine planktonic protists are the most important grazers on phytoplankton, and that grazing by protists can fundamentally affect phytoplankton biomass and distribution in the ocean. Protists can become temporarily very abundant (up to tens of thousands per liter) and can grow nearly as rapidly as phytoplankton do, which gives them great potential to regulate phytoplankton populations. Adaptations by protists to feed selectively on the fastest growing species of phytoplankton and to reduce predation by metazoan zooplankton should enhance the coupling between phytoplankton growth and grazing, and therefore promote planktonic ecosystem stability. Compared to larger metazoan zooplankton such as copepods, relatively little is known about the morphological and behavioral adaptations in protists for selective feeding and predator avoidance.

The PIs will study details of selective feeding behavior and predator avoidance behavior of free-swimming planktonic protists in 3-dimension using high-speed video. Under the same conditions, they will measure flow fields imposed by individual free-swimming protists using a time-resolving stereo micro-particle image velocimetry (microPIV) system. To gain a mechanistic understanding, they will also conduct empirical data-driven, reality-reproducing computational fluid dynamics (CFD) simulations of the protist-imposed flow fields. The results will be used to test the hypothesis that diversity and flexibility in propulsive morphology facilitates protists to achieve sophisticated swimming behaviors and sensory perception capabilities that adapt them for selective feeding and predator avoidance. These capabilities may also serve as important driving forces for protistan biodiversity, represented by various sizes, shapes, propulsive morphologies and motility patterns.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1129668

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