In Situ Amphipod and Copepod Video Output Captured by the Hoodsport ORCA Profiling Mooring Mounted SPC-2 Zoocam in the Hood Canal, Puget Sound, Washington from August to September 2018 (Zooplankton Swimming project)

Website: https://www.bco-dmo.org/dataset/928222
Data Type: Other Field Results
Version: 1
Version Date: 2024-05-21

Project
» Causes and consequences of hypoxia and pH impacts on zooplankton: Linking movement behavior to vertical distribution. (Zooplankton Swimming)

Contributors	Affiliation	Role
Keister, Julie E.	University of Washington (UW)	Principal Investigator
Grunbaum, Daniel	University of Washington (UW)	Co-Principal Investigator
Roberts, Paul	University of California-San Diego (UCSD)	Scientist
Wyeth, Amy	University of Washington (UW)	Student, Contact
Newman, Sawyer	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
This dataset consists of videos of zooplankton swimming taken by an in-situ camera system (the SPC UW ZooCam) that was deployed on the Hoodsport ORCA profiling mooring in Hood Canal (Puget Sound), WA in summer 2018. Understanding zooplankton population dynamics is challenging, largely because traditional methods for quantifying zooplankton distributions are costly, limited in scope, and require extended analysis by trained analysts. We developed a novel methodology that combined remotely deployed camera systems, Machine Learning-based identification of zooplankton, and video-based tracking technology to quantify copepods' and amphipods' in situ swimming behaviors in a seasonally hypoxic and acidified fjord.

Table of Contents

Coverage

Location: Hoodsport, hood Canal, Puget Sound, WA, USA
Spatial Extent: **Lat**:47.421817 **Lon**:-123.112583
Temporal Extent: 2018-08-01 - 2018-09-30

Dataset Description

The primary file of this dataset is a tabular file of data containing an overview of each in situ video included in this analysis, the nearest CTD cast to the recording location of that vide, and selected environemntal data from the nearest CTD cast.

Methods & Sampling

Videos were recorded only under low-flow (< 1 cm/s) conditions, using infrared lighting to avoid modifying zooplankton behavior. The video camera recorded swimming in the X (left, right) and Z (up, down) directions, observing true vertical motion and projected horizontal motion. Videos were recorded at an average frame rate of 20 frames per second. The frame rate varied slightly during videos due to data throughput limitations of the onboard, single-board computer. However, each video frame was precisely timestamped, and the exact difference in time between frames was used when converting speeds from pixels per frames to mm per second. Each frame was 650 x 876 pixels, and each pixel was 0.088 mm2, corresponding to a 57.2 x 77.1 mm field of view.

Data Processing Description

Zooplankton and other particles appeared in videos as grayscale images against a dark background. Regions of Interest (ROIs) from each frame were identified using the Python package OpenCV (version 4.7.0) (Bradski 2000). OpenCV-fitted contours and rotated bounding boxes were used to calculate width, height, and area metrics for each ROI. The nominal “length” of each ROI was defined as the longer of its width and height measurements. Position, defined as the optical centroid of the zooplankter outline, and size metrics were saved for each ROI that were potentially zooplankton (areas larger than 30 pixels) within each frame.

Zooplankton positions were assembled into swimming trajectories using the Matlab software Tracker3D (Chan and Grünbaum 2010). Small particles in videos were used to reconstruct a background flow field with Particle Image Velocimetry (PIV), using the Python package OpenPIV (version 0.23.9) (Liberzon et al. 2021).

Each zooplankton ROI was assigned a taxonomic identification using a Machine Learning (ML) image classification algorithm. The algorithm was generated using a pre-trained convolutional neural network 50 layers deep (ResNet-50) with PyTorch, an open-source, Python-based machine learning framework.

BCO-DMO Processing Description

- Changed column name of video column to "vid_id" to match the "vid_id" columns of the supplemental files
- Changed date time format in nearest_ctd_cast from %m/%d/%y %H:%M to %Y-%m-%d %H:%M
- A human readable datetime column was created from the unix_datetimestamp value present in the filename, this column is named "datetime_utc"
- All video data has been compressed and uploaded to this data package in a zip folder called "fps_20.zip" the contents of this zip are represented in the primary tabular data file associated with this dataset

Problem Description

Many images are blurry or the organism was imaged at a non-oblique angle, making taxonomic classifications somewhat subjective, even for trained taxonomists. The classifications represent the best possible visual identification using a machine learning algorithm, and should not be considered definitive.

If there were too many passive particles (marine snow) in a video, the particle tracking technology was not always able to stitch together reliable zooplankton swimming trajectories. In those cases videos were dropped from the analysis and not provided in this dataset.

[table of contents | back to top]

Data Files

File
928222_v1_zooplankton_in_situ_video_inventory.csv (Comma Separated Values (.csv), 21.54 KB) MD5:f4ccf5a46912c9cbfeb019eff1bfbad6 Primary data file for dataset ID 928222, version 1

[table of contents | back to top]

Supplemental Files

File
Amphipod density data filename: 928222_v1_amphipod_density.csv (Comma Separated Values (.csv), 57.73 KB) MD5:1c7d44901c8aefcbca1dd52045884b73 Data file containing amphipod densities for each amphipod size bin (1-2mm, 2-3mm, 3-4mm, and > 4mm) from in situ videos recorded under a range of environmental conditions (e.g. hypoxic and normoxic). Amphipod densities were determined by calculating the average number of amphipod localization per frame.
Amphipod Hidden Markov Model outputs filename: 928222_v1_amphipod_hmm.csv (Comma Separated Values (.csv), 2.02 KB) MD5:37e7203d57d7a9f0938b2fd0f072b99e Data file containing outputs from Hidden Markov Models, which used amphipod swimming trajectories to predict average swimming speeds and transition probabilities between swimming behaviors under different environmental conditions (hypoxic and normoxic) and amphipod size bins (1-2mm, 2-3mm, 3-4mm, and >4mm).
Amphipod swimming speeds data filename: 928222_v1_amphipod_speeds.csv (Comma Separated Values (.csv), 155.78 KB) MD5:4b9d7f4d8e2ab2ff742555a847b07a37 Data file containing amphipod swimming metrics, such as the average swimming speed of different behaviors ("darting" and "hovering") and the probability of transitioning between behaviors. Swimming behaviors were extracted from in situ videos recorded under a range of environmental conditions (e.g. hypoxic and normoxic).
Copepod density data filename: 928222_v1_copepod_density.csv (Comma Separated Values (.csv), 57.87 KB) MD5:8a02e3e75f6d79ea9cf83f9e1f5b25c5 Data file containing copepod densities for each copepod size bin (1-2mm, 2-3mm, 3-4mm, and > 4mm) from in situ videos recorded under a range of environmental conditions (e.g. hypoxic and normoxic). Copepod densities were determined by calculating the average number of copepod localization per frame.
Copepod Hidden Markov Model outputs filename: 928222_v1_copepod_hmm.csv (Comma Separated Values (.csv), 3.17 KB) MD5:edf5f5ce054592400dad6b4bfe48b47b Data file containing an overview of each in situ video included in this analysis, the environmental conditions the video was recorded under, and the number of copepod swimming trajectories in each video.
Copepod Hidden Markov Model outputs filename: 928222_v1_copecod_hmm.csv (Comma Separated Values (.csv), 3.17 KB) MD5:edf5f5ce054592400dad6b4bfe48b47b Data file containing outputs from Hidden Markov Models, which used copepod swimming trajectories to predict average swimming speeds and transition probabilities between swimming behaviors under different environmental conditions (hypoxic and normoxic) and copepod size bins (1-2mm, 2-3mm, 3-4mm, and >4mm).
Copepod swimming speed data filename: 928222_v1_copepod_speeds.csv (Comma Separated Values (.csv), 267.15 KB) MD5:4030fb35357ef1111eb4d1faa422a60a Data file containing copepod swimming metrics, such as the average swimming speed of different behaviors ("drifting," "cruising," and "jumping") and the probability of transitioning between behaviors. Swimming behaviors were extracted from in situ videos recorded under a range of environmental conditions (e.g. hypoxic and normoxic).
Read me file for fps_20.zip filename: fps_20 READ ME.txt (Plain Text, 4.78 KB) MD5:6e42309febe90e6056198988875a3b8f Text file containing a description of the content and naming structure within the fps_20.zip file. fps_20.zip contains the full frame images, ROI (regions of interest) images, and swimming trajectories used in this analysis.

File
Supplemental Data File Parameters filename: 928222_supplemental_data_file_parameters.csv (Comma Separated Values (.csv), 14.64 KB) MD5:c6c6749b57f57a5487a1fca1343f197e This file contains the parameter descriptions and units for Supplemental Data Files: 928222_v1_copepod_metdata.csv, 928222_v1_amphipod_metadata.csv, 928222_v1_copepod_density.csv, 928222_v1_amphipod_density.csv, 928222_v1_copepod_speeds.csv, 928222_v1_amphipod_speeds.csv, 928222_v1_copepod_hhm.csv, and 928222_v1_amphipod_hmm.csv
Video overview with amphipod paths filename: 928222_v1_amphipod_metadata.csv (Comma Separated Values (.csv), 13.01 KB) MD5:36c9437fa3bac0d947ea4064088d8a0a Data file containing an overview of each in situ video included in this analysis, the environmental conditions the video was recorded under, and the number of amphipod swimming trajectories in each video.
Video overview with copecod paths filename: 928222_v1_copecod_metadata.csv (Comma Separated Values (.csv), 13.11 KB) MD5:84c49b0ef0cf0dcd54498a24106d3570 Data file containing an overview of each in situ video included in this analysis, the environmental conditions the video was recorded under, and the number of copepod swimming trajectories in each video.
Video overview with copepod paths filename: 928222_v1_copepod_metadata.csv (Comma Separated Values (.csv), 13.11 KB) MD5:84c49b0ef0cf0dcd54498a24106d3570 Data file containing an overview of each in situ video included in this analysis, the environmental conditions the video was recorded under, and the number of copepod swimming trajectories in each video.

[table of contents | back to top]

Related Datasets

IsRelatedTo

Keister, J. E., Grunbaum, D. (2024) **Classified Zooplankton ZooCam Images Captured by the Hoodsport ORCA Profiling Mooring Mounted SPC-2 Zoocam in the Hood Canal, Puget Sound, Washington from July to September 2018 (Zooplankton Swimming project).** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-05-14 http://lod.bco-dmo.org/id/dataset/927518 [view at BCO-DMO]
Relationship Description: The classification algorithm applied against the videos in the zip archive associated with this dataset was trained against the images in this related dataset.

Keister, J. E., Grunbaum, D. (2024) **Results from Calanus pacificus Acidification Laboratory Experiments from 2019-2020 (Zooplankton Swimming project).** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-04-30 doi:10.26008/1912/bco-dmo.926368.1 [view at BCO-DMO]
Relationship Description: The laboratory experiments producing these related data were conducted ahead of field operations to provide behavioral context to in-situ zooplankton responses to environmental stressors.

Keister, J. E., Grunbaum, D. (2024) **Results from Calanus pacificus Hypoxia Laboratory Experiments from 2019-2020 (Zooplankton Swimming project).** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-04-30 doi:10.26008/1912/bco-dmo.926332.1 [view at BCO-DMO]
Relationship Description: The laboratory experiments producing these related data were conducted ahead of field operations to provide behavioral context to in-situ zooplankton responses to environmental stressors.

[table of contents | back to top]

Parameters

Parameter	Description	Units
vid_id	Video identifier, also the timestamp of when the recording started in Unix epoch time	unitless
datetime_utc	Datetime value derived from the unix timestamp represented in the image filename.	unitless
total_frames	The total number of frames in the video, a way to measure the video length	frames
avg_frm_rate	The average frame rate of the video (frame rates varied slightly during videos)	frames per second
nearest_ctd_cast	Date and time of the nearest completed CTD cast to the recorded video	unitless
nearest_ctd_offset	Time difference between the nearest completed CTD cast and the video recording	unitless
depth	The depth the camera was parked when the video was recorded	meters (m)
oxygen	Oxygen concentration from the nearest CTD cast at the depth the video was recorded	milligrams per liter (mg/L)
temperature	Temperature from the nearest CTD cast at the depth the video was recorded	degrees Celcius

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	SPC-UW-Zoocam
Generic Instrument Name	Underwater Camera
Dataset-specific Description	The SPC-UW-Zoocam designed and built specifically for this project. The Zoocam was custom-built by Paul Roberts in the Jaffe Imaging Laboratory at the University of California San Diego. It is an underwater camera system with a 500-mL imaged area that captured still images while profiling using lighting in the visible wavelength range (images submitted as a separate dataset) and videos of zooplankton using IR lighting (while stationary and under low-flow conditions.
Generic Instrument Description	All types of photographic equipment that may be deployed underwater including stills, video, film and digital systems.

[table of contents | back to top]

Deployments

UW_SPC-2_Zoocam

Website	https://www.bco-dmo.org/deployment/775291
Platform	ORCA-UW-Hoodsport
Start Date	2018-06-26
End Date	2018-10-24
Description	A University of Washington SPC-2 Zoocam was deployed on UW/APL Hoodsport, Hood Canal ORCA buoy.

[table of contents | back to top]

Project Information

Causes and consequences of hypoxia and pH impacts on zooplankton: Linking movement behavior to vertical distribution. (Zooplankton Swimming)

Coverage: Puget Sound, WA

NSF Award Abstract:
Low oxygen (hypoxia) and low pH are known to have profound physiological effects on zooplankton, the microscopic animals of the sea. It is likely that many individual zooplankton change vertical mirgration behaviors to reduce or avoid these stresses. However, avoidance responses and their consequences for zooplankton distributions, and for interactions of zooplankton with their predators and prey, are poorly understood. This study will provide information on small-scale behavioral responses of zooplankton to oxygen and pH using video systems deployed in the field in a seasonally hypoxic estuary. The results will deepen our understanding of how zooplankton respond to low oxygen and pH conditions in ways that could profoundly affect marine ecosystems and fisheries through changes in their populations and distributions. This project will train graduate students and will engage K-12 students and teachers in under-served coastal communities by developing ocean technology-based citizen-scientist activities and curricular materials in plankton ecology, ocean change, construction and use of biological sensors, and quantitative analysis of environmental data.

Individual directional motility is a primary mechanism underlying spatio-temporal patterns in zooplankton population distributions. Motility is used by most zooplankton species to select among water column positions that differ in biotic and abiotic variables such as prey, predators, light, oxygen concentration, and pH. Species-specific movement responses to de-oxygenation and acidification are likely mechanisms through which short-term, localized impacts of these stressful conditions on individual zooplankton will be magnified or suppressed as they propagate up to population, community, and ecosystem-level dynamics. This study will quantify responses by key zooplankton species to oxygen and pH using in situ video systems to measure changes in individual behavior in hypoxic, low- pH versus well-oxygenated, high-pH regions of a seasonally hypoxic estuary. Distributions and movements of zooplankton will be quantified using three approaches: 1) an imaging system deployed in situ on a profiling mooring over two summers in a hypoxic region, 2) imagers deployed on Lagrangian drifters to sample simultaneously throughout the water column, and 3) vertically-stratified pumps and net tows to verify species identification and video-based abundance estimates. These field observations will be combined with laboratory analysis of zooplankton movements in oxygen and pH gradients, and with spatially-explicit models to predict how behavioral mechanisms lead to large-scale impacts of environmental stresses.

The following deployments were conducted in 2017 and 2018:
CB1077: https://www.bco-dmo.org/deployment/735746
CB1072: https://www.bco-dmo.org/deployment/735748
Zoocam_ORCA_Twanoh_2017: https://www.bco-dmo.org/deployment/735762

RC0008: https://www.bco-dmo.org/deployment/775288
Mooring ORCA_Hoodsport; NANOOS-APL4: https://www.bco-dmo.org/deployment/775291

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1657992

[table of contents | back to top]