Retinal responses during exposure to decreasing oxygen partial pressure (pO2)

Project
» Vision-mediated influence of low oxygen on the physiology and ecology of marine larvae (Vision under hypoxia)

Contributors	Affiliation	Role
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Abstract
Retinal responses during exposure to decreasing oxygen partial pressure (pO2) in marine invertebrate larvae determined with electroretinograms.

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Dataset Description

Retinal responses during exposure to decreasing oxygen partial pressure (pO2) in marine invertebrate larvae determined with electroretinograms.

Please see additional datasets for this paper, including the "OxygenMetrics_Vision" and the "Experiment_Metrics" datasets.

Methods & Sampling

Detailed methods can be found in McCormick *et al.*, 2019

Briefly, the time series test recorded electroretinogram (ERG) responses to a 1 s square step of light at a constant irradiance of 3.56 µmol photons m−2 s−1 repeated every 20 s, providing a nearly continuous measure of ERG response in a tethered, live larva during the experimental manipulation of partial pressure of oxygen (pO2). There was a constant flow of pH-buffered sterile seawater in the chamber where the larva was held, and after a brief period in "normoxia" (surface-ocean oxygen levels), the pO2 was decreased, and then held at a low pO2 before re-oxygenating the solution.

This dataset shows the retinal responses measured every 20 s for all individuals used in Figure 1 (top panel) of McCormick et al., 2019. The retinal responses show a decline in retinal function during a decrease in oxygen availability.

Oxygen was measured using a Microx4 (PreSens) oxygen meter and a Pst-7 oxygen optode probe.

Data Processing Description

All electrophysiology data was recorded and analyzed using Igor Pro 7 Software (Wavemetrics) using custom code. Oxygen data was analyzed using PreSens Measurement Studio 2. Post-processing analysis was completed in R Studio (version 3.3.3).

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Data Files

File
retinal_response.csv (Comma Separated Values (.csv), 185.63 KB) MD5:2190f8807d89dc2c900d031f7a6b4967
Primary data file for dataset ID 779540

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Related Publications

McCormick, L. R., Levin, L. A., & Oesch, N. W. (2019). Vision is highly sensitive to oxygen availability in marine invertebrate larvae. The Journal of Experimental Biology, 222(10), jeb200899. doi:10.1242/jeb.200899
Methods

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Parameters

Parameter	Description	Units
Species	Species name. Format is "Species_genus".	unitless
Experiment_Name	Original experiment name that can be linked back to raw datafile collected in Igor.	unitless
Round	The number of seconds since starting each individual experiment.	unitless
O2_umol_l	Oxygen concentration in umol O2/L for each retinal measurement.	micromole per liter (umol/L)
O2_ml_l	Oxygen concentration in mL O2/L for each retinal measurement.	milliliter per liter (ml/l)
O2_umol_kg	Oxygen concentration in umol O2/kg for each retinal measurement.	micromole per kg (umol/kg)
O2_pO2	The partial pressure of oxygen of the given metric "n.ctrl.area": The ERG response normalized to the average retinal response measured during exposure to normoxia.	kiloPascal (kPa)
n_ctrl_area	The integration of the ERG wave at any given time divided by the average integrated ERG during control oxygen conditions. Normalization was done to compare between individuals and species.	unitless
RunningAvg	The running average of retinal responses in the last minute, used to show smoothed responses over time.	unitless
RunAvgLine	The line number for the running average, used to order measurements within an individual experiment.	unitless
Condition	Oxygen exposure during the experiment, either "normoxia", "decrease", or "Low". First, animals were exposed to "normoxia" (~100-105% oxygen saturation), then a "Deacrease" in oxygen (slow decline of oxygen), until the "Low" oxygen was reached.	unitless

Instruments

Dataset-specific Instrument Name	
Generic Instrument Name	Oxygen Microelectrode Sensor
Dataset-specific Description	Oxygen was measured using a Microx4 (PreSens) oxygen meter and a Pst-7 oxygen optode probe.
Generic Instrument Description	Any microelectrode sensor that measures oxygen.

Project Information

Vision-mediated influence of low oxygen on the physiology and ecology of marine larvae (Vision under hypoxia)

Coverage: Southern California Bight, Northeast Pacific Ocean

NSF abstract:
Oxygen is being lost in the ocean worldwide as a result of ocean warming and the input of nutrients from land. Vision requires a large amount of oxygen, and may be less effective or require more light when oxygen is in short supply. This is especially true for active marine animals with complex eyes and visual capabilities, including active arthropods (crabs), cephalopods (squid), and fish. The California coastal waters exhibit a sharp drop in oxygen and light with increasing water depth. This project examines how visual physiology and ecology in young (larval) highly visual marine animals respond to oxygen loss, with a focus on key fisheries and aquaculture species. Experiments and observations will test the hypothesis that oxygen stress will change the light required for these organisms to see effectively, influencing the water depths where they can live and survive. The project will provide interdisciplinary experiences to students and an early career scientist and inform both the public (through outreach at the Birch Aquarium at Scripps Institution of Oceanography) and policy makers about the effects of oxygen decline in the ocean.

Negative effects of oxygen loss on vision have been described for humans and other terrestrial organisms, but never in the marine environment, despite the large changes in oxygen that can occur with depth and over time in the ocean, and the high metabolic demand of visual systems. This project will test the effects of low oxygen on vision in 3 combinations of eye design and photo-transduction mechanisms: compound eye with rhabdomeric photoreceptors (arthropods), simple eye with rhabdomeric photoreceptors (cephalopods), and simple eye with ciliary photoreceptors (fish). A series of oxygen- and light-controlled laboratory experiments will be conducted on representative taxa of each group including the tuna crab, Pleuroncodes planipes; the market squid, Doryteuthis opalescens, and the white sea bass, Atractoscion nobilis. In vivo electrophysiology and behavioral phototaxis experiments will identify new oxygen metrics for visual physiology and function, and will be compared to metabolic thresholds determined in respiration experiments. Hydrographic data collected over 3 decades by the CalCOFI program in the Southern California Bight will be evaluated with respect to visual and metabolic limits to determine the consequences of oxygen variation on the critical luminoxyscape (range of oxygen and light conditions required for visual physiology and function in target species) boundary in each species. Findings for the three vision-based functional groups may test whether oxygen-limited visual responses offer an additional explanation for the shoaling of species distributions among highly visual pelagic taxa in low oxygen, and will help to focus future research efforts and better understand the stressors contributing to habitat compression with expanding oxygen loss in the ocean.

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.

Funding

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NSF Division of Ocean Sciences (NSF OCE)	OCE-1829623