Data from moored instruments (pH, dissolved oxygen, temperature, salinity, PAR, pressure) at 9 depths outside and inside the kelp canopy at Hopkins Marine Station, recorded between June and October 2018.

Website: https://www.bco-dmo.org/dataset/822549
Data Type: Other Field Results
Version: 1
Version Date: 2020-09-02

Project
» Collaborative Research: RUI: Building a mechanistic understanding of water column chemistry alteration by kelp forests: emerging contributions of foundation species (Kelp forest biogeochemistry)

Contributors	Affiliation	Role
Nickols, Kerry J.	California State University Northridge (CSU-Northridge)	Principal Investigator, Project Coordinator
Dunbar, Robert B.	Stanford University	Co-Principal Investigator
Hirsh, Heidi	Stanford University	Scientist, Contact
Monismith, Stephen G.	Stanford University	Scientist
Mucciarone, David	Stanford University	Scientist
Takeshita, Yuichiro	Monterey Bay Aquarium Research Institute (MBARI)	Scientist
Traiger, Sarah	United States Geological Survey (USGS)	Scientist
Soenen, Karen	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
Data from moored instruments (pH, dissolved oxygen, temperature, salinity, PAR, pressure) at 9 depths outside (36° 37.342′ N, 121° 54.049′ W) and inside the kelp canopy (36° 37.297′ N, 121° 54.102′ W.) at Hopkins Marine Station, recorded between June and October 2018. The tidal depth of the kelp canopy mooring ranges from 8 to 11 meter. The outside mooring is located 115m north and offshore from the kelp forest, the tidal range is 16 to 9 meters.

Table of Contents

Coverage

Spatial Extent: **N**:36.6224 **E**:-121.9008 **S**:36.6216 **W**:-121.9017
Temporal Extent: 2018-06-07 - 2018-10-04

Dataset Description

These data are published in Hirsh *et al.,* see related publications section.

Acquisition Description

The moorings were deployed from June to October 2018. The moorings consisted of a subsurface mooring buoy anchored to a weight so that it was approximately 1 m below the surface at spring low tide. A 5 m line connected the subsurface buoy to a small float at the surface.

Inside Kelp Forest Mooring Instruments:

- 3 MiniDO2T dissolved oxygen loggers (Precision Measurement Engineering (PME), 5 minute sampling frequency)
- 3 SBE 56 thermistors (Sea-Bird Electronics, 1 minute sampling frequency)
- 2 HOBO Pro v2 temperature loggers (Onset Data Loggers, 1 minute sampling frequency)
- 1 HOBO U20L pressure sensor (Onset Data Loggers, 1 minute sampling frequency)
- 1 miniPAR sensor (PME, 1 minute sampling frequency). PME miniPAR sensors were paired with PME miniWIPERs set to wipe the PAR sensors every six hours to prevent biofouling.
- 7 pH loggers were deployed on the kelp mooring between July and October. The kelp mooring configuration included two SeapHOx instrument packages (Bresnahan et al., 2014) deployed 1 meter above the bottom (mab) and just below the subsurface mooring buoy. Each SeapHOx consisted of a Honeywell Durafet pH electrode (Martz et al., 2010), an Aanderaa 4835 oxygen optode, and an SBE-37 MicroCAT CTD equipped with a pressure sensor. The other 5 pH loggers (mFETs) were custom built at the Monterey Bay Aquarium Research Institute utilizing Honeywell Durafet electrodes (Martz et al., 2010). SeapHOxes measured pH, O2, temperature, salinity and pressure every 10 minutes, whereas mFETs measured pH and temperature every 5 minutes.
- An SBE 37-SM MicroCAT CTD recorder was deployed at mid depth on the mooring beginning in mid-August with sampling frequencies of 5 minutes.
- A miniDO2T sensor was installed on a surface buoy located ~50 m from the kelp mooring between July 18 and August 1. This two-week miniDO2T deployment provided the only in situ surface O2 data inside the kelp forest.

Outside Kelp Forest Mooring Instruments:

- 3 MiniDO2T dissolved oxygen loggers (Precision Measurement Engineering (PME), 5 minute sampling frequency)
- 3 SBE 56 thermistors (Sea-Bird Electronics, 1 minute sampling frequency)
- 2 HOBO Pro v2 temperature loggers (Onset Data Loggers, 1 minute sampling frequency)
- 1 HOBO U20L pressure sensor (Onset Data Loggers, 1 minute sampling frequency)
- 1 miniPAR sensor (PME, 1 minute sampling frequency). PME miniPAR sensors were paired with PME miniWIPERs set to wipe the PAR sensors every six hours to prevent biofouling.
- 1 pH logger (mFET) was deployed between July and October and measured pH and temperature every 5 minutes. The mFET was custom built at the Monterey Bay Aquarium Research Institute utilizing Honeywell Durafet electrodes (Martz et al., 2010).
- An SBE 37-SM MicroCAT CTD recorder was deployed at 13.5 man beginning in mid-August with sampling frequencies of 5 minutes.

Calibration by taking discrete samples alongside sensors in situ can lead to relatively large uncertainties, especially in highly dynamic coastal environments (Bresnahan et al. 2014); therefore, we decided to calibrate sensors in a flow through tank where the pH is more stable, and multiple discrete samples for

DIC and TA analysis could be collected. Prior to deployment, the mFET sensors logged in a tank for 6 days (3 discrete samples) and the SeapHOxes logged in an adjacent tank for 1 day (2 discrete samples). We estimate the accuracy of the pH sensor data to be ± 0.015.

Oxygen sensors were calibrated by making measurements in a black bucket filled with freshwater while bubbling air for 8 hours. We assumed 100% saturation and applied a gain correction to the raw sensor output (Bittig & Körtzinger, 2015; Bushinsky & Emerson, 2013; Johnson et al., 2015). Because the air-stone was placed at the bottom of the bucket, elsewhere we would expect slight over-saturation. However, since the depth of the bucket was < 40 cm, we estimate the accuracy of this calibration to be better than 1-2%. Post-deployment calibration indicated no drift in the oxygen sensors.

Processing Description

Sensor data were quality controlled with several steps. First, obviously erroneous data such as spikes were removed. When bubbles were present on the sensors they led to clearly erroneous data; for instance, pH values typically changed in a large, stepwise manner (usually >0.3 or more) with no correlation to temperature or O2.

Second, the sensors were deployed facing downwards on the mooring line, and bubbles from divers were sometimes trapped on the sensing surface for several hours, leading to incorrect sensor readings. The data bias by bubbles was clearly evident. Sensor data that showed short, stepwise shifts when divers were near the mooring were manually removed.

Finally, the first day of sensor data is not included in this data set to ensure that the instruments were fully equilibrated with environmental conditions.

BCO-DMO Processing notes:

- Adjusted column headers to comply with database requirements
- Converted Timestamp to ISO format, and timezone from Pacific Standard Time (PST) to UTC

[table of contents | back to top]

Related Publications

Bittig, H. C., & Körtzinger, A. (2015). Tackling Oxygen Optode Drift: Near-Surface and In-Air Oxygen Optode Measurements on a Float Provide an Accurate in Situ Reference. Journal of Atmospheric and Oceanic Technology, 32(8), 1536–1543. doi:10.1175/jtech-d-14-00162.1 https://doi.org/10.1175/JTECH-D-14-00162.1
Methods

Bresnahan, P. J., Martz, T. R., Takeshita, Y., Johnson, K. S., & LaShomb, M. (2014). Best practices for autonomous measurement of seawater pH with the Honeywell Durafet. Methods in Oceanography, 9, 44–60. doi:10.1016/j.mio.2014.08.003
Methods

Bushinsky, S. M., & Emerson, S. (2013). A method for in-situ calibration of Aanderaa oxygen sensors on surface moorings. Marine Chemistry, 155, 22–28. doi:10.1016/j.marchem.2013.05.001
Methods

Hirsh, H., Nickols, K., Takeshita, Y., Traiger, S., Monismith, S. G., Mucciarone, D. A., & Dunbar, R. B. Drivers of biogeochemical variability in a central California kelp forest and implications for local amelioration of ocean acidification. Journal of Geophysical Research: Oceans.
Results

Johnson, K. S., Plant, J. N., Riser, S. C., & Gilbert, D. (2015). Air Oxygen Calibration of Oxygen Optodes on a Profiling Float Array. Journal of Atmospheric and Oceanic Technology, 32(11), 2160–2172.

doi:10.1175/jtech-d-15-0101.1 https://doi.org/10.1175/JTECH-D-15-0101.1
Methods

Martz, T. R., Connery, J. G., & Johnson, K. S. (2010). Testing the Honeywell Durafet® for seawater pH applications. Limnology and Oceanography: Methods, 8(5), 172–184. doi:10.4319/lom.2010.8.172
Methods

[table of contents | back to top]

Related Datasets

IsSourceOf

Hirsh, H., Nickols, K. J., Takeshita, Y., Traiger, S., Monismith, S. G., Mucciarone, D., Dunbar, R. B. (2020) **Kelp forest mooring DIC, TA, pCO2, and aragonite saturation state estimations inside the kelp canopy (36° 37.297′ N, 121° 54.102′ W.) at Hopkins Marine Station, recorded between June and October 2018.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2020-09-02 http://lod.bco-dmo.org/id/dataset/823008 [view at BCO-DMO]

[table of contents | back to top]

Parameters

Parameter	Description	Units
Depth_ID	ID to distinguish depth	unitless
Mooring_ID	Mooring name: KELP = inside kelp forest mooring; OUTSIDE = mooring outside kelp forest	unitless
Latitude	Latitude of mooring location, south is negative	decimal degrees
Longitude	Longitude of mooring location, west is negative	decimal degrees
MAB	Meters above bottom	meters (m)
pH	pH of water	unitless
DO	Dissolved oxygen	micromoles per kilogram (umol/kg)
DOSAT	oxygen saturation	percentage (%)
Temperature	Water temperature	degrees Celsius (°C)
Salinity	Salinity	unitless
Pressure	Pressure. Pressure at bottom (0 mab, depth_i=9) provides mab for surface (depth_id=1)	meter (m)
PAR	Photosynthetic Active Radiation	micromoles photons per square meter per seconds (umol/m2/s)
ISO_DateTime_UTC	Timestap (date and time) in ISO format, UTC (yyyy-mm-ddThh:mmZ)	yyyy-MM-dd'T'HH:mm:ss'Z'

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	miniPAR sensor
Generic Instrument Name	Photosynthetically Available Radiation Sensor
Dataset-specific Description	1 miniPAR sensor (PME, 1 minute sampling frequency). PME miniPAR sensors were paired with PME miniWIPERs set to wipe the PAR sensors every six hours to prevent biofouling.
Generic Instrument Description	A PAR sensor measures photosynthetically available (or active) radiation. The sensor measures photon flux density (photons per second per square meter) within the visible wavelength range (typically 400 to 700 nanometers). PAR gives an indication of the total energy available to plants for photosynthesis. This instrument name is used when specific type, make and model are not known.

Dataset-specific Instrument Name	SBE 37-SM MicroCAT CTD
Generic Instrument Name	CTD Sea-Bird MicroCAT 37
Dataset-specific Description	An SBE 37-SM MicroCAT CTD recorder was deployed at mid depth on the mooring beginning in mid-August with sampling frequencies of 5 minutes.
Generic Instrument Description	The Sea-Bird MicroCAT CTD unit is a high-accuracy conductivity and temperature recorder based on the Sea-Bird SBE 37 MicroCAT series of products. It can be configured with optional pressure sensor, internal batteries, memory, built-in Inductive Modem, integral Pump, and/or SBE-43 Integrated Dissolved Oxygen sensor. Constructed of titanium and other non-corroding materials for long life with minimal maintenance, the MicroCAT is designed for long duration on moorings. In a typical mooring, a modem module housed in the buoy communicates with underwater instruments and is interfaced to a computer or data logger via serial port. The computer or data logger is programmed to poll each instrument on the mooring for its data, and send the data to a telemetry transmitter (satellite link, cell phone, RF modem, etc.). The MicroCAT saves data in memory for upload after recovery, providing a data backup if real-time telemetry is interrupted.

Dataset-specific Instrument Name	HOBO Pro v2 temperature logger
Generic Instrument Name	Onset Pro v2 temperature logger
Dataset-specific Description	2 HOBO Pro v2 temperature loggers (Onset Data Loggers, 1 minute sampling frequency)
Generic Instrument Description	The HOBO Water Temp Pro v2 temperature logger, manufactured by Onset Computer Corporation, has 12-bit resolution and a precision sensor for ±0.2°C accuracy over a wide temperature range. It is designed for extended deployment in fresh or salt water. Operation range: -40° to 70°C (-40° to 158°F) in air; maximum sustained temperature of 50°C (122°F) in water Accuracy: 0.2°C over 0° to 50°C (0.36°F over 32° to 122°F) Resolution: 0.02°C at 25°C (0.04°F at 77°F) Response time: (90%) 5 minutes in water; 12 minutes in air moving 2 m/sec (typical) Stability (drift): 0.1°C (0.18°F) per year Real-time clock: ± 1 minute per month 0° to 50°C (32° to 122°F) Additional information (http://www.onsetcomp.com/) Onset Computer Corporation 470 MacArthur Blvd Bourne, MA 02532

Dataset-specific Instrument Name	HOBO U20L pressure sensor
Generic Instrument Name	Pressure Sensor
Dataset-specific Description	1 HOBO U20L pressure sensor (Onset Data Loggers, 1 minute sampling frequency)
Generic Instrument Description	A pressure sensor is a device used to measure absolute, differential, or gauge pressures. It is used only when detailed instrument documentation is not available.

Dataset-specific Instrument Name	MiniDO2T dissolved oxygen logger
Generic Instrument Name	Dissolved Oxygen Sensor
Dataset-specific Description	3 MiniDO2T dissolved oxygen loggers (Precision Measurement Engineering (PME), 5 minute sampling frequency)
Generic Instrument Description	An electronic device that measures the proportion of oxygen (O2) in the gas or liquid being analyzed

Dataset-specific Instrument Name	SBE 56 thermistor
Generic Instrument Name	Thermistor
Dataset-specific Description	3 SBE 56 thermistors (Sea-Bird Electronics, 1 minute sampling frequency)
Generic Instrument Description	A thermistor is a type of resistor whose resistance varies significantly with temperature, more so than in standard resistors. The word is a portmanteau of thermal and resistor. Thermistors are widely used as inrush current limiters, temperature sensors, self-resetting overcurrent protectors, and self-regulating heating elements. Thermistors differ from resistance temperature detectors (RTD) in that the material used in a thermistor is generally a ceramic or polymer, while RTDs use pure metals. The temperature response is also different; RTDs are useful over larger temperature ranges, while thermistors typically achieve a higher precision within a limited temperature range, typically 90C to 130C.

Dataset-specific Instrument Name	SeapHOx instrument package
Generic Instrument Name	SeapHOx/SeaFET
Dataset-specific Description	The outside kelp mooring included one mFET pH sensor and the kelp mooring included 2 seapHOx sensors and 5 mFET pH sensors.
Generic Instrument Description	The SeapHOx and SeaFET are autonomous sensors originally designed and developed by the Todd Martz Lab at Scripps Institution of Oceanography. The SeaFET was designed to measure pH and temperature. The SeapHOx, designed later, combined the SeaFET with additional integrated sensors for dissolved oxygen and conductivity. Refer to Martz et al. 2010 (doi:10.4319/lom.2010.8.172). The SeapHOx package is now produced by Sea-Bird Scientific and allows for integrated data collection of pH, temperature, salinity, and oxygen. Refer to Sea-Bird for specific model information.

[table of contents | back to top]

Deployments

KELP

Website	https://www.bco-dmo.org/deployment/826373
Platform	Mooring - Hopkins Marine Stations
Start Date	2018-06-08
End Date	2018-10-04
Description	This deployment represents the mooring itself and data that has been acquired at this site or in close proximity of it, and are considered samples "inside a kelp forest": ADCP data:

OUTSIDE

Website	https://www.bco-dmo.org/deployment/826371
Platform	Mooring - Hopkins Marine Stations
Start Date	2018-06-07
End Date	2018-10-04
Description	This deployment represents the mooring itself and related datasets that have been taken in close proximity of it and are reviewed as samples "outside a kelp forest": ADCP data:

[table of contents | back to top]

Project Information

Collaborative Research: RUI: Building a mechanistic understanding of water column chemistry alteration by kelp forests: emerging contributions of foundation species (Kelp forest biogeochemistry)

Coverage: Central California 36.6 N 122 W

NSF abstract: Kelp forest ecosystems are of ecological and economic importance globally and provide habitat for a diversity of fish, invertebrates, and other algal species. In addition, they may also modify the chemistry of surrounding waters. Uptake of carbon dioxide (CO_2) by giant kelp, Macrocystis pyrifera, may play a role in ameliorating the effects of increasing ocean acidity on nearshore marine communities driven by rising atmospheric CO_2. Predicting the capacity for kelp forests to alter seawater chemistry requires understanding of the oceanographic and biological mechanisms that drive variability in seawater chemistry. The project will identify specific conditions that could lead to decreases in seawater CO_2 by studying 4 sites within the southern Monterey Bay in Central California. An interdisciplinary team will examine variations in ocean chemistry in the context of the oceanographic and ecological characteristics of kelp forest habitats. This project will support an early career researcher, as well as train and support a postdoctoral researcher, PhD student, thesis master's student, and up to six undergraduate students. The PIs will actively recruit students from underrepresented groups to participate in this project through Stanford University's Summer Research in Geosciences and Engineering (SURGE) program and the Society for Advancement of Hispanics/Chicanos and Native Americans in Science (SACNAS). In addition, the PIs and students will actively engage with the management community (Monterey Bay National Marine Sanctuary and California Department of Fish and Wildlife) to advance products based on project data that will assist the development of management strategies for kelp forest habitats in a changing ocean. This project builds upon an extensive preliminary data set and will link kelp forest community attributes and hydrodynamic properties to kelp forest biogeochemistry (including the carbon system and dissolved oxygen) to understand mechanistically how giant kelp modifies surrounding waters and affects water chemistry using unique high-resolution measurement capabilities that have provided important insights in coral reef biogeochemistry. The project sites are characterized by different oceanographic settings and kelp forest characteristics that will allow examination of relationships between kelp forest inhabitants and water column chemistry. Continuous measurements of water column velocity, temperature, dissolved oxygen, pH, and photosynthetically active radiation will be augmented by twice-weekly measurements of dissolved inorganic carbon, total alkalinity, and nutrients as well as periods of high frequency sampling of all carbonate system parameters. Quantifying vertical gradients in carbonate system chemistry within kelp forests will lead to understanding of its dependence on seawater residence time and water column stratification. Additional biological sampling of kelp, benthic communities, and phytoplankton will be used to 1) determine contributions of understory algae and calcifying species to bottom water chemistry, 2) determine contributions of kelp canopy growth and phytoplankton to surface water chemistry and 3) quantify the spatial extent of surface chemistry alteration by kelp forests. The physical, biological, and chemical data collected across multiple forests will allow development of a statistical model for predictions of kelp forest carbonate system chemistry alteration in different locations and under future climate scenarios. Threshold values of oceanographic conditions and kelp forest characteristics that lead to alteration of water column chemistry will be identified for use by managers in mitigation strategies such as targeted protection or restoration.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1737096
NSF Division of Ocean Sciences (NSF OCE)	OCE-1737176

[table of contents | back to top]