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.

Website: https://www.bco-dmo.org/dataset/823008
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
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Abstract
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Coverage

Spatial Extent: **Lat**:36.6216 **Lon**:-121.9017
Temporal Extent: 2018-06-07 - 2018-10-04

Dataset Description

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

Methods & Sampling

In order to estimate other carbonate parameters from sensor pH data, we require an additional carbonate parameter. To accomplish this, we created a local empirical relationship to estimate total alkalinity (TA) based on discrete samples, and combined this with sensor data to calculate DIC, pCO2, and aragonite saturation state (ΩAr).

TA was estimated using a multiple linear regression (MLR) approach, with temperature (T) and salinity (S) as inputs (Alin et al., 2012; Carter et al., 2018). This approach has been demonstrated to be effective in the open ocean (Carter et al., 2018) and along the California Coast below 50 m depth (Alin et al., 2012). Takeshita et al. (2015) demonstrated that this MLR approach can be extended to nearshore environments and showed TA could be estimated to ± 6 µmol kg-1 (RMSE) inside a kelp forest in Southern California by applying an offset to the equations from Alin et al. (2012).

Here, we fit an equation of the form used in Alin et al. (2012) to the discrete samples (n = 271) collected in the kelp forest, and obtained the following equation:

TA est = alpha0 + alpha1 (T - Tr) + alpha2 (S - Sr) + alpha3 (T-Tr) x (S - Sr)

with a RMSE of ± 7.3 µmol kg-1. Tr and Sr are the mean temperature and salinity for the deployment. The estimated total alkalinity (TAest) was combined with sensor pH to estimate DIC, pCO2, and ΩAr using equilibrium constants from Lueker et al. (2000) and CO2SYS (van Heuven et al., 2011). For a range of pH from 7.56 to 8.30 the standard uncertainty for estimated carbonate system parameters was 8.98 to 13.43 µmol kg-1 DIC, 54.22 to 9.42 µatm pCO2, and 0.0501 to 0.223 ΩAr. These uncertainties were calculated using the 'errors' function in seacarb (Gattuso et al., 2020, version 3.2.13 - Accessed 6 Mar 2020) with inputs of TAest and measured pH, temperature and salinity over depth inside the kelp forest.

Data Processing Description

CO2SYS (Matlab) was used to estimate DIC, pCO2, and ΩAr from estimated TA and pH. The 'errors' function in seacarb (R) was used to estimate uncertainties.

BCO-DMO processing notes:

- Adjusted column headers to comply with database requirements
- Converted Timestamp to ISO format

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Data Files

File
carbonate.csv (Comma Separated Values (.csv), 22.84 MB) MD5:d80e450a7eff5be93ad4c4e350b6c7c3 Primary data file for dataset ID 823008

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Related Publications

Alin, S. R., Feely, R. A., Dickson, A. G., Hernández-Ayón, J. M., Juranek, L. W., Ohman, M. D., & Goericke, R. (2012). Robust empirical relationships for estimating the carbonate system in the southern California Current

System and application to CalCOFI hydrographic cruise data (2005-2011). Journal of Geophysical Research: Oceans, 117(C5), n/a–n/a. doi:10.1029/2011jc007511 https://doi.org/10.1029/2011JC007511
Methods

Carter, B. R., Feely, R. A., Williams, N. L., Dickson, A. G., Fong, M. B., & Takeshita, Y. (2017). Updated methods for global locally interpolated estimation of alkalinity, pH, and nitrate. Limnology and Oceanography: Methods, 16(2), 119–131. doi:10.1002/lom3.10232
Methods

Hirsh, H. K., Nickols, K. J., Takeshita, Y., Traiger, S. B., Mucciarone, D. A., Monismith, S., & Dunbar, R. B. (2020). Drivers of Biogeochemical Variability in a Central California Kelp Forest: Implications for Local Amelioration of Ocean Acidification. Journal of Geophysical Research: Oceans, 125(11). Portico. https://doi.org/10.1029/2020jc016320 https://doi.org/10.1029/2020JC016320
Results

Lavigne H, Gattuso JP (2014) Seacarb: seawater carbonate chemistry with R, R package version 3.0. Available from http://CRAN.R-project.org/package=seacarb
Methods

Lueker, T. J., Dickson, A. G., & Keeling, C. D. (2000). Ocean pCO2 calculated from dissolved inorganic carbon, alkalinity, and equations for K1 and K2: validation based on laboratory measurements of CO2 in gas and seawater at equilibrium. Marine Chemistry, 70(1-3), 105–119. doi:10.1016/s0304-4203(00)00022-0 https://doi.org/10.1016/S0304-4203(00)00022-0
Methods

Takeshita, Y., Frieder, C. A., Martz, T. R., Ballard, J. R., Feely, R. A., Kram, S., … Smith, J. E. (2015). Including high-frequency variability in coastal ocean acidification projections. Biogeosciences, 12(19), 5853–5870. doi:10.5194/bg-12-5853-2015
Methods

Van Heuven, S., Pierrot, D., Rae, J. W. B., Lewis, E., & Wallace, D. W. R. (2011). MATLAB Program Developed for CO2 System Calculations. ORNL/CDIAC-105b. Carbon Dioxide Information Analysis Center (CDIAC). https://doi.org/10.3334/CDIAC/OTG.CO2SYS_MATLAB_V1.1 https://doi.org/10.3334/CDIAC/otg.CO2SYS_MATLAB_v1.1
Software

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Related Datasets

IsDerivedFrom

Hirsh, H., Nickols, K. J., Takeshita, Y., Traiger, S., Monismith, S. G., Mucciarone, D., Dunbar, R. B. (2020) **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.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2020-09-02 doi:10.26008/1912/bco-dmo.822549.1 [view at BCO-DMO]
Relationship Description: The derived carbonate system data comes from the kelp mooring data (pH, temperature, salinity)

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Parameters

Parameter	Description	Units
Depth_ID	ID to distinguish depth	unitless
Mooring_ID	Mooring name	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)
DIC	Disolved Inorganic Carbon	micromoles per kilogram (umol/kg)
TA	Total Alkalinity	micromoles per kilogram (umol/kg)
Omega	Aragonite saturation state	aragonite (ΩAr)
pCO2	Partial pressureof CO2	microatmosphere (uatm)
ISO_DateTime_UTC	Timestap (date and time) in ISO format, UTC (yyyy-mm-ddThh:mmZ)	unitless

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Instruments

Dataset-specific Instrument Name	mFET and SeapHOx
Generic Instrument Name	pH Sensor
Dataset-specific Description	pH was directly measured (via mFET and SeapHOx) on the mooring at 6 depths (and estimated for 2 weeks at the surface based on the near-surface pH-O2 relationship). Please see metadata for kelp mooring data for additional pH details (https://www.bco-dmo.org/dataset/822549).
Generic Instrument Description	An instrument that measures the hydrogen ion activity in solutions. The overall concentration of hydrogen ions is inversely related to its pH. The pH scale ranges from 0 to 14 and indicates whether acidic (more H+) or basic (less H+).

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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 Award 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 (CO2) 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 CO2. 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 CO2 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.

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Funding

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

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