Nearshore pH, temperature, (salinity, depth) at mooring sites in McMurdo Sound, Antarctica, spring 2011 (OA Antarctic Sea Urchins project, OA pH, Temp, Calc Inverts project)

Website: https://www.bco-dmo.org/dataset/514809
Version: 2014-05-13

Project
» Effect of Ocean Acidification on Early Life History Stages of the Antarctic Sea Urchins Sterechinus neumayeri (OA Antarctic Sea Urchins)
» Linking natural variability and anthropogenic changes in pH and temperature to performance in calcifying Antarctic marine invertebrates (OA pH, Temp, Calc Inverts)

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Dataset Description

Cape Evans-1, Hut Point, New Harbor: Temperature and salinity measurements from 3 nearshore mooring sites in McMurdo Sound, Antarctica, October and November 2011. pH measurements were from 2 stations (Hut Point and Cape Evans) and depth data were from two stations (Cape Evans and New Harbor).

Jetty: Temperature and pH measurements from nearshore mooring site in McMurdo Sound, Antarctica, December 2011 - May 2012.

Cape Evans-2: Temperature and pH measurements from nearshore mooring site in McMurdo Sound, Antarctica, November 2012 - June 2013.

Related References:

Bresnahan, P. J. J., Martz, T. R., Takeshita, Y., Johnson, K. S. & LaShomb, M. Best practices for autonomous measurement of seawater pH with the Honeywell Durafet. *Methods Oceangr.* **9**, 44–60 (2014).

Dickson, A. G., Sabine, C. L. & Christian, J. R. Guide to best practices for ocean CO_2 measurements. *PICES Special Publication* **3**, 191 pp. (2007).

Liu, X., Patsavas, M. C. & Byrne, R. H. Purification and characterization of meta-cresol purple for spectrophotometric seawater pH measurements. *Environ. Sci. Technol.* **45**, 4862-4868 (2011).

Kapsenberg, L., Kelley, A.L., Shaw, E.C., Martz, T.R. & Hofmann, G.E. Near-shore Antarctic pH variability has implications for the design of ocean acidification experiments. Sci. Rep. 5, 9638; DOI:10.1038/srep09638 (2015).

Martz, T. R., Connery, J. G. & Johnson, K. S. Testing the Honeywell Durafet® for seawater pH applications.

Limnol. Oceanogr. Methods **8**, 172-184 (2010).

Methods & Sampling

Hut Point and Cape Evans-1: The Cape Evans site was equiped with a benthic mooring suspended above the seafloor (~ 30 m depth) by a subsurface buoy. At Hut Point, the mooring was suspended from the surface by a steel cable from a wooden hut through a hole in the sea ice. Bottom depth was > 200 m.

All sensors were deployed at 20 m depth. The moorings were instrumented with a suite of sensors to record time series of temperature, salinity, pH, and tide. Temperature and salinity were measured using a non-pumped conductivity-temperature (CT) MicroCAT sensor (SBE-37 SM; Sea-Bird Electronics) that sampled at 5-min intervals. pH was measured using an autonomous data logger based on a Honeywell Durafet® pH sensor (Martz et al., 2010) and sampled at 1-hr intervals.

Calibration of pH sensors required a discrete water sample collected in situ. This single point calibration approach is justified when the sensor obeys the Nernst equation and the temperature component of the standard potential has been previously characterized; both of which have been repeatedly demonstrated for these sensors (Martz et al. 2010). The water sample was collected adjacent to the sensor by SCUBA divers (Cape Evans) or by lowering a 5 L Niskin sampling bottle from the surface (Hut Point) prior to retrieval. From this sample, a 500 mL water sample was returned to the laboratory for CO2 analysis modified from Standard Operating Procedures (SOP) for spectrophotometric pH (SOP 6b) and Total Alkalinity (TA, SOP 3b) (Dickson et al., 2007) as reported in Fangue et al. (2010). In situ pH was then calculated using CO2calc (Robbins et al., 2010) using the constants of Mehrbach et al. (1973) as refit by Dickson and Millero (1987). Due to the calibration approach used, sensor accuracy depends mostly upon collection of a representative discrete sample. Based on experience, there is an expectation that the data presented here accurately represent pH variability with a finite yet unquantified error in accuracy dominated by sampling errors. Past experience suggests that sampling errors lead to vicarious calibration errors of ~0.01 pH or less. Second order errors due to extending the fit of temperature dependent equilibrium constants in CO2calc and temperature dependent sensor calibration coefficients for the SeaFET sensor, both fit to data above zero, introduces additional unquantified error; yet this error is most likely smaller than the aforementioned discrete sampling error (Martz et al., 2010).

New Harbor: Benthic moorings was suspended above the seafloor (~ 30 m depth) by a subsurface buoy. All sensors were deployed at 20 m depth, with the exception of pressure sensors, which were attached to the mooring anchor. Mooring was instrumented with a suite of sensors to record time series of temperature, salinity, pH, and tide. Temperature and salinity were measured using a non-pumped conductivity-temperature (CT) MicroCAT sensor (SBE-37 SM; Sea-Bird Electronics) that sampled at 5-min intervals. Tidal height was measured using water level loggers (Hobo U20-001-03-Ti; Onset) that recorded water pressure at 10-min intervals.

Jetty and Cape Evans-2: All methods are described in Kapsenberg et al. (2015). Data were collected using an autonomous SeaFET pH sensor containing Honeywell DuraFET electrodes (Martz et al., 2010). Sensor depth was 18 m with ~27 m bottom depth. Sensors sampled on a 2-hour frequency.

Conversion from voltage to pH (on a total scale) was performed using a single discrete calibration sample collected via SCUBA using a 5 L GO-FLO sampling bottle. Sample collection was conducted within the first two weeks of sensor deployment, after sensor conditioning to seawater, in-situ. Samples were preserved with saturated mercuric chloride Standard Operating Procedure (SOP) 1 (Dickson et al., 2007) and analyzed for spectrophotometric pH (total scale, at 25 degrees Celsius) and total alkalinity following SOP 6b and 3b (Dickson et al. 2007). Sample salinity was measured using a calibrated YSI 3100 Conductivity Instrument. In-situ pH was calculated using the program CO2Calc [Version 1.0.1, 2010, U.S. Geological Survey] using SeaFET temperature recorded at the time of sample collection.

The combined standard uncertainty associated with the pH measurement of the calibration sample is ± 0.026 pH units (Kapsenberg et al., 2015). The sources of error are use of unpurified m-cresol dye (0.02, Liu et al., 2011), spatio-temporal mismatch of the calibration sample (± 0.015, Bresnahan et al., 2014), user differences (± 0.006), and calibration of the SeaFET thermistor (± 0.005).

SeaFET thermistors were not individually calibrated resulting in a maximum estimated temperature offset of ~0.3 degrees Celsius.

Data Processing Description

2011: Data for temperature and salinity were processed using a 1 hr low-pass filter. At Cape Evans and New Harbor, the pressure was measured by a benthic-mounted HOBO U20 water level logger, using a 1hr low-pass filter, in units of meters of water above the sensor.

BCO-DMO Processing:

Original data files:
2014-05-13 submission:
  B134_2011_oce_dataset_CapeEvans.txt (2011-2012)
  B134_2011_oce_dataset_HutPoint.txt
  B134_2011_oce_dataset_NewHarbor.txt
2015-03-13 submission:
  data_Jetty.csv (2011-2012)
  data_CapeEvans.csv (2012-2013)

version 1 [2014-05-13] includes 2011 data from Cape Evans-1, Hut Point, and New Harbor sites
version 2 [2015-03-13] includes 2012-13 data from Cape Evans-2 and Jetty sites.

Reformatting:
added conventional header with dataset name, PI name, version date
renamed parameters to BCO-DMO standard
added lab, lat, lon, ISO date and julian year-day columns
replaced blank cells with nd and spaces with underscores
reduced number of significant digits

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Data Files

File
pHctd_v2.csv(Comma Separated Values (.csv), 850.02 KB) MD5:baedd014ff9627660710a9d04d0c5e6a Primary data file for dataset ID 514809

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Parameters

Parameter	Description	Units
station	mooring station id	unitless
lat	latitude; north is positive	decimal degrees
lon	longitude; north is positive	decimal degrees
date	UTC date	YYYYMMDD
year	year	YYYY
month	month	1-12
day	day of month	1-31
time	time of day	HH:MM
yrday_gmt	GMT day and decimal time; as 326.5 for the 326th day of the year; or November 22 at 1200 hours (noon)	unitless
ISO_DateTime_UTC	Date/Time (UTC) ISO formatted	YYYY-MM-DDTHH:MM:SS[.xx]Z
pH	The measure of the acidity or basicity of an aqueous solution	total hydrogen ion scale
temp	temperature	degrees Celsius
sal	salinity	practical salinity units
depth	depth	meters
date_start	utc sampling start date	YYYYMMDD
date_end	utc sampling end date	YYYYMMDD

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Instruments

Dataset-specific Instrument Name	CTD MicroCAT 37
Generic Instrument Name	CTD Sea-Bird MicroCAT 37
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	pH Sensor
Generic Instrument Name	pH Sensor
Dataset-specific Description	SeaFET pH sensor containing Honeywell Durafet® pH sensor (Martz et al., 2010)
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+).

Dataset-specific Instrument Name	water level logger
Generic Instrument Name	sea level recorder
Dataset-specific Description	Hobo U20-001-03-Ti; Onset: http://www.onsetcomp.com/products/data-loggers/u20-001-03-ti
Generic Instrument Description	Instrument that makes smoothed measuremeants of the elevation of the sea surface relative to a fixed vertical datum. Also called a tide gauge, various types.

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Deployments

Hut_Point_2011

Website	https://www.bco-dmo.org/deployment/514796
Platform	Hut Point Mooring
Start Date	2011-10-22
End Date	2011-11-30
Description	The mooring was suspended from the surface by a steel cable from a wooden hut through a hole in the sea ice. Bottom depth was > 200 m. All sensors were deployed at 20 m depth. The mooring was instrumented with a suite of sensors to record time series of temperature, salinity, pH, and tide. Temperature and salinity were measured using a non-pumped conductivity-temperature (CT) MicroCAT sensor (SBE-37 SM; Sea-Bird Electronics) that sampled at 5-min intervals. pH was measured using an autonomous data logger based on a Honeywell Durafet® pH sensor (Martz et al., 2010) and sampled at 1-hr intervals.

Cape_Evans_2011

Website	https://www.bco-dmo.org/deployment/514797
Platform	Cape Evans Mooring
Start Date	2011-10-29
End Date	2011-11-30
Description	Benthic mooring was suspended above the seafloor (~ 30 m depth) by a subsurface buoy. All sensors were deployed at 20 m depth. The moorings was instrumented with a suite of sensors to record time series of temperature, salinity, pH, and tide. Temperature and salinity were measured using a non-pumped conductivity-temperature (CT) MicroCAT sensor (SBE-37 SM; Sea-Bird Electronics) that sampled at 5-min intervals. pH was measured using an autonomous data logger based on a Honeywell Durafet® pH sensor (Martz et al., 2010) and sampled at 1-hr intervals. Tidal height was measured using water level loggers (Hobo U20-001-03-Ti; Onset) that recorded water pressure at 10-min intervals.

New_Harbor_2011

Website	https://www.bco-dmo.org/deployment/514802
Platform	New Harbor Mooring
Start Date	2011-11-11
End Date	2011-11-29
Description	Benthic mooring was suspended above the seafloor (~ 30 m depth) by a subsurface buoy. All sensors were deployed at 20 m depth, with the exception of pressure sensors, which were attached to the mooring anchor. Mooring was instrumented with a suite of sensors to record time series of temperature, salinity, pH, and tide. Temperature and salinity were measured using a non-pumped conductivity-temperature (CT) MicroCAT sensor (SBE-37 SM; Sea-Bird Electronics) that sampled at 5-min intervals. Tidal height was measured using water level loggers (Hobo U20-001-03-Ti; Onset) that recorded water pressure at 10-min intervals.

Jetty_2011

Website	https://www.bco-dmo.org/deployment/553632
Platform	McMurdo_Jetty_Mooring
Start Date	2011-12-04
End Date	2012-05-27

Cape_Evans_2012

Website	https://www.bco-dmo.org/deployment/553631
Platform	Cape Evans Mooring
Start Date	2012-11-15
End Date	2013-06-24
Description	Mooring fitted with an autonomous SeaFET pH sensor containing Honeywell DuraFET electrodes (Martz et al., 2010). Sensor depth was 18 m with ~27 m bottom depth. Sensors sampled on a 2-hour frequency. SeaFET thermistors were not individually calibrated resulting in a maximum estimated temperature offset of ~0.3 degrees Celsius.

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Project Information

Effect of Ocean Acidification on Early Life History Stages of the Antarctic Sea Urchins Sterechinus neumayeri (OA Antarctic Sea Urchins)

Coverage: McMurdo Sound, Antarctica

The research examine the effects of ocean acidification on embryos and larvae of a contemporary calcifier in the coastal waters of Antarctica, the sea urchin Sterechinus neumayeri. The effect of future ocean acidification is projected to be particularly threatening to calcifying marine organisms in coldwater, high latitude seas, making tolerance data on these organisms a critical research need in Antarctic marine ecosystems. Due to a high magnesium (Mg) content of their calcitic hard parts, echinoderms are especially vulnerable to dissolution stress from ocean acidification because they currently inhabit seawater that is barely at the saturation level to support biogenic calcification. Thus, cold-water, high latitude species with a high Mg-content in their hard parts are considered to be the 'first responders' to chemical changes in the surface oceans. Studies in this proposal will use several metrics to examine the physiological plasticity of contemporary urchin embryos and larvae to CO2-acidified seawater, to mimic the scenarios defined by IPCC models and by analyses of future acidification predicted for the Southern Ocean. The research also will investigats the biological consequences of synergistic interactions of two converging climate change-related stressors - CO2- driven ocean acidification and ocean warming. Specifically the research will (1) assess the effect of CO2-acidified seawater on the development of early embryos and larvae, (2) using morphometrics, examine changes in the larval endoskeleton in response to development under the high-CO2 conditions of ocean acidification, (3) using a DNA microarray, profile changes in gene expression for genes involved in biomineralization and other important physiological processes, and (4) measure costs and physiological consequences of development under conditions of ocean acidification. The proposal will support the training of undergraduates, graduate students and a postdoctoral fellow. The PI also will collaborate with the UC Santa Barbara Gevirtz Graduate School of Education to link the biological effects of ocean acidification to the chemical changes expected for the Southern Ocean using the 'Science on a Sphere' technology. This display will be housed in an education and public outreach center, the Outreach Center for Teaching Ocean Science (OCTOS), a new state-of-the-art facility under construction at UC Santa Barbara.

Relevant Publications:

Evans, T.G and G.E. Hofmann. "Defining the limits of physiological plasticity in marine organisms: how gene-expression profiling can aid in predicting the consequences of ocean change," *Phil. Trans. of Royal Society B*, v.367, 2012, p. 1733.

Fangue, N.A., M.J. O'Donnell, M.A. Sewell, P.G. Matson, A.C. MacPherson and G.E. Hofmann. "A laboratory-based experimental system for the study of ocean acidification effects on marine invertebrate larvae," *Limnol. Oceanogr.: Methods*, v.8, 2010, p. 441.

Hofmann, G.E., T.R. Martz + 10 co-authors. "High-Frequency Dynamics of Ocean pH: A Multi-Ecosystem Comparison," *PLoS ONE*, v.6, 2011.

Kapsenberg, L., & Hofmann, G. E. Signals of resilience to ocean change: high thermal tolerance of early stage Antarctic sea urchins (Sterechinus neumayeri) reared under present-day and future pCO2 and temperature. Polar biology, 37(7), 967-980 (2014)

Kapsenberg, L., Kelley, A.L., Shaw, E.C., Martz, T.R. & Hofmann, G.E. Near-shore Antarctic pH variability has implications for the design of ocean acidification experiments. Sci. Rep. 5, 9638; DOI:10.1038/srep09638 (2015).

Matson, P.G., T.R. Martz and G.E. Hofmann. "High frequency observations of pH under Antarctic sea ice in the southern Ross Sea.," *Antarctic Science*, v.23, 2011, p. 607.

Sewell, M.A., G.E. Hofmann. "Antarctic echinoids and climate change: a major impact on brooding forms.," *Global Change Biology*, v.17, 2011, p. 734.

Yu, P.C., P.G. Matson, T.R. Martz and G.E. Hofmann. "The ocean acidification seascape and its relationship to the performance of calcifying marine invertebrates: laboratory experiments on the development of urchin larvae framed by environmentally-relevant pCO2/pH," *J. Exp. Mar. Biol. Ecol.*, v.400, 2011, p. 288.

Linking natural variability and anthropogenic changes in pH and temperature to performance in calcifying Antarctic marine invertebrates (OA pH, Temp, Calc Inverts)

Coverage: McMurdo Sound, Antarctica

Abstract: The research supported in this project will examine the effects of environmental change on a key Antarctic marine invertebrate, a pelagic mollusk, the pteropod, Limacina helicina antarctica. There are two main activities in this project: (1) to deploy oceanographic equipment, in this case, autonomously recording pH sensors called SeaFETs and other devices that record temperature and salinity, and (2) to use these environmental data in the laboratory at McMurdo Station to study the response of the marine invertebrates to future changes in water quality that is expected in the next few decades. Notably, changes in oceanic pH (aka ocean acidification) and ocean warming are projected to be particularly threatening to calcifying marine organisms in cold-water, high latitude seas, making tolerance data on these organisms a critical research need in Antarctic marine ecosystems.

These Antarctic shelled-animals are especially vulnerable to dissolution stress from ocean acidification because they currently inhabit seawater that is barely at the saturation level to support biogenic calcification. Indeed, these polar animals are considered to be the 'first responders' to chemical changes in the surface oceans. Thus, this project will lead to information about the adaptive capacity of L. helcina antarctica. From an ecological perspective this is important because this animal is a critical part of the Antarctic food chain in coastal waters and changes in its abundance will impact other species. Finally, the research conducted in this project will serve as a training and educational opportunity for undergraduate and graduate students as well as postdoctoral scholars.

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Funding

Funding Source	Award
NSF Antarctic Sciences (NSF ANT)	PLR-0944201
NSF Antarctic Sciences (NSF ANT)	PLR-1246202

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