Hydrographic, nutrient, and carbonate system data from R/V Janan cruises in the Arabian Gulf in December 2018 and May 2019

Website: https://www.bco-dmo.org/dataset/833517
Data Type: Cruise Results
Version: 1
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Project
» Carbonate System Chemistry in the Arabian Gulf (Arabian Gulf CO2)

Contributors	Affiliation	Role
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Abstract
The data show that the average value of pCO2 in surface seawater in the Exclusive Economic Zone of Qatar is supersaturated with respect to the atmosphere. The excess pCO2 reflects a balance between a source due to the impact of increasing T and S on the carbonate system equilibrium constants and a sink due to CO2 loss due to gas exchange from surface seawater after it enters the Gulf through the Strait of Hormuz. Nevertheless, CaCO3 formation was still more important, relative to net biological production, than in the open ocean. The tracer Alk* has values determined by CaCO3 formation and had values suggesting substantial CaCO3 formation.

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Coverage

Spatial Extent: **N**:26.225167 **E**:52.404167 **S**:25.485833 **W**:51.749167
Temporal Extent: 2018-12-05 - 2019-05-18

Dataset Description

Hydrographic, nutrient and carbonate system data was collected aboard the R/V Janan on two single day cruises in the Arabian Gulf.

Methods & Sampling

Sampling
Water column sampling using rosette mounted 10-L PVC Niskin bottles was conducted on December 5, 2018 and May 18, 2019 in the Arabian Gulf on the R/V Janan (Figure 1). Surface water samples and hydrographic data were collected at seven stations (stations 1C, 2C, 3C, 4C, 5C, 6B, 6C) along a transect from the central east coast of Qatar across the Qatari Exclusive Economic Zone (EEZ). Stations were chosen to be nearly perpendicular to the major axis of the Gulf to capture main regional hydrographic features across the EEZ. The transect provides a reasonable representation of hydrographic distributions across the wider part of the Gulf. Samples were collected in triplicate at each station. Vertical profiles with one surface sample, one bottom sample, and 1 to 3 mid-depth samples were collected at stations 2C, 4C, 6B, and 6C.

Samples for DIC and total alkalinity were collected in 300 mL Wheaton BOD glass bottles with ground glass stoppers. Samples were sealed immediately after collection to prevent loss of CO_2. Samples were poisoned with 50 µL $HgCl_2$ (0.05% by volume) to prevent biological activity, then covered with aluminum foil to eliminate light and biological growth.

Analysis
The best approach for understanding ocean acidification is to measure the primary capacity factors of the carbonate system chemistry which are dissolved inorganic carbon (DIC) and total alkalinity (TAlk). DIC and alkalinity are the best set of parameters use for calculating pH, pCO_2 and carbonate ion, because they are conservative properties during water mass mixing.

After collection, samples were shipped to the University of Washington for DIC and TAlk analyses in Dr. Alex Gagnon's laboratory. Carbonate system measurements follow the methods of Dickson et al. (2007). Briefly, TAlk (µmol kg^{-1}) was determined through open-cell automated titration (876 Dosimat plus, Metrohm AG) with a solution of 0.1M hydrochloric acid (HCl)+0.6M sodium chloride (NaCl). Total DIC (µmol/kg) was obtained through coulometric determination (VINDTA 3D, Marianda with UIC coulometer). Certified reference materials for TAlk and DIC obtained from Andrew Dickson (Scripps Institution of Oceanography) were run in conjunction with seawater samples as a calibration standard and to monitor precision. Long-term precision for DIC and TAlk in this lab, based on repeated measurements of CRM materials, was ± 3.7 µmol kg^{-1} (2σ std. dev.) and ± 4.3 µmol kg^{-1} (2σ std. dev.), respectively (Bolden et al., 2019).

pCO_2 and pH were calculated from DIC and Alk using CO2Calc using the total pH scale with carbonate equilibrium constants refit from Mehrbach et al. (1973) by Dickson and Millero (1987); borate alkalinity was calculated using the boron/chlorinity (salinity) relationship provided by Lee et al. (2010) and equilibrium constants from Dickson (1990). Where necessary, NTAlk, and NDIC values used in subsequent calculations were salinity-normalized to a mean salinity value of 40.0. Data analysis was executed using Microsoft Excel. Certain data properties were calculated using CO_2Calc. This includes parameters such as pH, CO_3^{2-}, and pCO_2.

During both cruises, samples were also collected and analyzed for: Hydrographic properties using a SeaBird Electronics, SBE 911 on a CTD SeaBird rosette (T, S, O_2, pH, % Transmission and fluorescence). The pH sensor used in our project is the SBE 27 pH/O.R.P (Redox) Sensor.

Dissolved oxygen was measured using the SBE 43 Dissolved Oxygen sensor. Additional discrete samples were analyzed for dissolved oxygen within a few hours of collection using the titrimetric method (Winkler, 1888). Nutrients (NO_3, NO_2, NH_4, PO_4, and Si) and chlorophyll were analyzed on filtered samples using classical techniques (Parsons et al., 1984).

Suspended particulate matter for particulate Ca analyses was sampled using 47 mm filter holders and 0.45 µM mesh size Nuclepore filters. Filtration volumes of 2 L, provided sufficient samples for analyses. Particulate samples were acid digested in a clean lab on hot plates using trace metal grade concentrated HF (16.5M), HCl (6M) and, HNO_3 (16M) acids (Yigiterhan and Murray, 2008; Yigiterhan et al., 2011, Yigiterhan et al., 2018). H_2O_2 was added for complete removal of the organic material. The elemental analyses were performed using ICP-OES.

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Data Files

File
arabian_gulf_chemistry.csv (Comma Separated Values (.csv), 5.33 KB) MD5:523db5ea12ad4974d558159d0ecdad97 Primary data file for dataset ID 833517

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Supplemental Files

File
Figure1_ArabianGulf_stations filename: Murray_Figure1_ArabianGulf_stations.pdf (Portable Document Format (.pdf), 121.18 KB) MD5:85593a68892315f020f2db22a09012b1 Station locations off Qatar in the Arabian Gulf

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Related Publications

Bolden, I. W., Sachs, J. P., & Gagnon, A. C. (2019). Temporally-variable productivity quotients on a coral atoll: Implications for estimates of reef metabolism. Marine Chemistry, 217, 103707. doi:10.1016/j.marchem.2019.103707
Methods

Dickson, A. G. (1990). Thermodynamics of the dissociation of boric acid in synthetic seawater from 273.15 to 318.15 K. Deep Sea Research Part A. Oceanographic Research Papers, 37(5), 755–766. doi:10.1016/0198-0149(90)90004-f https://doi.org/https://doi.org/10.1016/0198-0149(90)90004-F
Methods

Dickson, A. G., & Millero, F. J. (1987). A comparison of the equilibrium constants for the dissociation of carbonic acid in seawater media. Deep Sea Research Part A. Oceanographic Research Papers, 34(10), 1733–1743. doi:10.1016/0198-0149(87)90021-5
Methods

Dickson, A.G., Sabine, C.L. and Christian, J.R. (Eds.) 2007. Guide to Best Practices for Ocean CO2 Measurements. PICES Special Publication 3, 191 pp https://isbnsearch.org/isbn/1-897176-07-4
Methods

Lee, K., Kim, T.-W., Byrne, R. H., Millero, F. J., Feely, R. A., & Liu, Y.-M. (2010). The universal ratio of boron to chlorinity for the North Pacific and North Atlantic oceans. Geochimica et Cosmochimica Acta, 74(6), 1801–1811. doi:10.1016/j.gca.2009.12.027
Methods

Mehrbach, C., Culberson, C. H., Hawley, J. E., & Pytkowicx, R. M. (1973). Measurement of the apparent dissociation constants of carbonic acid in seawater at atmospheric pressure. Limnology and Oceanography, 18(6), 897–907. doi:10.4319/lo.1973.18.6.0897
Methods

Parsons, T. R., Y. Maita, and C. M. Lalli. "A Manual of Chemical and Biological Methods of Seawater Analysis", Pergamon Press (1984). ISBN: 9780080302874
Methods

Winkler, L. W. (1888). Die Bestimmung des im Wasser gelösten Sauerstoffes. Berichte Der Deutschen Chemischen Gesellschaft, 21(2), 2843–2854. doi:10.1002/cber.188802102122
Methods

Yigiterhan, O., Alfoldy, B. Z., Giamberini, M., Turner, J. C., Al-Ansari, E. S., Abdel-Moati, M. A., Al-Maslamani, I. A., Kotb, M. M., Elobaid, E. A., Hassan, H. M., Obbard, J. P., & Murray, J. W. (2018). Geochemical composition of Aeolian dust and surface deposits from the Qatar Peninsula. In Chemical Geology (Vol. 476, pp. 24–45). Elsevier BV. https://doi.org/10.1016/j.chemgeo.2017.10.030
Methods

Yiğiterhan, O., & Murray, J. W. (2008). Trace metal composition of particulate matter of the Danube River and

Turkish rivers draining into the Black Sea. Marine Chemistry, 111(1-2), 63–76. doi:10.1016/j.marchem.2007.06.019
Methods

Yiğiterhan, O., Murray, J. W., & Tuğrul, S. (2011). Trace metal composition of suspended particulate matter in the water column of the Black Sea. Marine Chemistry, 126(1-4), 207–228. doi:10.1016/j.marchem.2011.05.006
Methods

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Parameters

Parameter	Description	Units
ISO_DateTime_UTC	Date and time in ISO8601 standard format (YYYY-MM-DDThh:mm:ssZ)	unitless
Cruise_ID	Cruise ID	unitless
Station	Station	unitless
Latitude	Latitude of sample collection	decimal degrees
Longitude	Longitude of sample collection	decimal degrees
Total_Depth	Water depth at sampling location	meters (m)
Sampling_Depth	Depth of sample collection	meters (m)
Bottle_Number	Bottle number	unitless
Temperature	Temperature	degrees Celsius
Salinity	Salinity	unitless
Dissolved_Oxygen	Dissolved oxygen (DO)	micromole per liter (umol/L)
Nitrate	Nitrate (NO3)	micromole per liter (umol/L)
Phosphate	Phosphate	micromole per liter (umol/L)
Silicate	Silicate (SiO4)	micromole per liter (umol/L)
DIC	Dissolved organic carbon (DIC)	micromole per liter (umol/L)
Alkalinity	Alkalinity (ALK)	microequivalent per kilogram (uEquiv/kg)
pCO2	Partial pressure of carbon dioxide	microatmospheres (uatm)
pH_calc	Calculated pH	unitless

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Instruments

Dataset-specific Instrument Name	Metrohm AG 876 Dosimat plus
Generic Instrument Name	Automatic titrator
Dataset-specific Description	Total Alkalinity (µmol kg-1) was determined through open-cell automated titration (876 Dosimat plus, Metrohm AG)
Generic Instrument Description	Instruments that incrementally add quantified aliquots of a reagent to a sample until the end-point of a chemical reaction is reached.

Dataset-specific Instrument Name	SBE 911 on a CTD SeaBird rosette
Generic Instrument Name	CTD Sea-Bird 911
Dataset-specific Description	Hydrographic properties were measured using a SeaBird Electronics, SBE 911 on a CTD SeaBird rosette (T, S, O2, pH, % Transmission and fluorescence).
Generic Instrument Description	The Sea-Bird SBE 911 is a type of CTD instrument package. The SBE 911 includes the SBE 9 Underwater Unit and the SBE 11 Deck Unit (for real-time readout using conductive wire) for deployment from a vessel. The combination of the SBE 9 and SBE 11 is called a SBE 911. The SBE 9 uses Sea-Bird's standard modular temperature and conductivity sensors (SBE 3 and SBE 4). The SBE 9 CTD can be configured with auxiliary sensors to measure other parameters including dissolved oxygen, pH, turbidity, fluorescence, light (PAR), light transmission, etc.). More information from Sea-Bird Electronics.

Dataset-specific Instrument Name	ICP-OES
Generic Instrument Name	Inductively Coupled Plasma Optical Emission Spectrometer
Dataset-specific Description	The elemental analyses were done using ICP-OES
Generic Instrument Description	Also referred to as an Inductively coupled plasma atomic emission spectroscope (ICP-AES). These instruments pass nebulised samples into an inductively-coupled gas plasma (8-10000 K) where they are atomised and excited. The de-excitation optical emissions at characteristic wavelengths are spectroscopically analysed. It is often used in the detection of trace metals.

Dataset-specific Instrument Name	VINDTA 3D, Marianda with UIC coulometer
Generic Instrument Name	MARIANDA VINDTA 3C total inorganic carbon and titration alkalinity analyser
Dataset-specific Description	Total DIC (µmol/kg) was obtained through coulometric determination (VINDTA 3D, Marianda with UIC coulometer)
Generic Instrument Description	The Versatile INstrument for the Determination of Total inorganic carbon and titration Alkalinity (VINDTA) 3C is a laboratory alkalinity titration system combined with an extraction unit for coulometric titration, which simultaneously determines the alkalinity and dissolved inorganic carbon content of a sample. The sample transport is performed with peristaltic pumps and acid is added to the sample using a membrane pump. No pressurizing system is required and only one gas supply (nitrogen or dry and CO2-free air) is necessary. The system uses a Metrohm Titrino 719S, an ORION-Ross pH electrode and a Metrohm reference electrode. The burette, the pipette and the analysis cell have a water jacket around them. Precision is typically +/- 1 umol/kg for TA and/or DIC in open ocean water.

Dataset-specific Instrument Name	10-L PVC Niskin bottle
Generic Instrument Name	Niskin bottle
Dataset-specific Description	Water column sampling using rosette mounted 10-L PVC Niskin bottles was conducted
Generic Instrument Description	A Niskin bottle (a next generation water sampler based on the Nansen bottle) is a cylindrical, non-metallic water collection device with stoppers at both ends. The bottles can be attached individually on a hydrowire or deployed in 12, 24, or 36 bottle Rosette systems mounted on a frame and combined with a CTD. Niskin bottles are used to collect discrete water samples for a range of measurements including pigments, nutrients, plankton, etc.

Dataset-specific Instrument Name	SBE 27 pH/O.R.P (Redox) Sensor
Generic Instrument Name	Sea-Bird SBE 27 pH/O.R.P. sensor
Dataset-specific Description	The pH sensor used in our project is the SBE 27 pH/O.R.P (Redox) Sensor
Generic Instrument Description	The SBE 27 pH and O.R.P. (Redox) sensor combines a pressure-balanced, glass-electrode, Ag/AgCl reference probe and platinum O.R.P. electrode to provide in-situ measurements at depths to 1200 m. The replaceable pH probe is permanently sealed and is supplied with a soaker bottle attachment that prevents the reference electrode from drying out during storage. The SBE 27 is intended for use as an add-on auxiliary sensor for profiling CTDs (SBE 9plus; SBE 19, 19plus, and 19plus V2 SeaCAT; and SBE 25 and 25plus Sealogger).

Dataset-specific Instrument Name	SBE 43 Dissolved Oxygen sensor
Generic Instrument Name	Sea-Bird SBE 43 Dissolved Oxygen Sensor
Dataset-specific Description	Dissolved oxygen was measured using the SBE 43 Dissolved Oxygen sensor
Generic Instrument Description	The Sea-Bird SBE 43 dissolved oxygen sensor is a redesign of the Clark polarographic membrane type of dissolved oxygen sensors. more information from Sea-Bird Electronics

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Deployments

Janan_20181205

Website	https://www.bco-dmo.org/deployment/833513
Platform	R/V Janan
Start Date	2018-12-05
End Date	2018-12-05
Description	Exclusive Economic Zone (EEZ) of Qatar in the Central Arabian Gulf

Janan_20190518

Website	https://www.bco-dmo.org/deployment/833515
Platform	R/V Janan
Start Date	2019-05-18
End Date	2019-05-18
Description	Exclusive Economic Zone of Qatar in the Central Arabian Gulf

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Project Information

Carbonate System Chemistry in the Arabian Gulf (Arabian Gulf CO2)

Coverage: Exclusive Economic Zone of Qatar

Project Summary

There is concern that coral reefs in the Arabian (Persian) Gulf are being severely impacted by ocean acidification yet little is known about the carbonate system geochemistry in this region. The tropical coral reefs of the world reach their northernmost limits in the Gulf. Reefs there may be relatively small but they represent the regions biological store house. Historically, the countries bordering the Gulf used pearl oyster beds and coral reefs as a large part of their economy and cultural heritage. It comes as a surprise to many that the Gulf is a repository of biodiversity. The carbonate system chemistry in the Gulf was first sampled in 1977 but has not been studied since. Surface water enters the Gulf with relatively high concentrations of DIC and alkalinity from the Arabian Sea. As the water flows northward, alkalinity and DIC increase but salinity normalized alkalinity and DIC decrease. The decrease in concentrations of DIC and alkalinity can be used to determine the relative importance of CO2 removal by CaCO3 formation versus primary production. Another factor to consider is that as the water flows north some CO2 is lost due to gas exchange. At the time of the study in 1977 the Arabian Gulf was degassing CO2 to the atmosphere. Now 40 years have passed and the gradients and fluxes may have changed.

Because data regarding the progress of ocean acidification in the Arabian Gulf is sparse, an international collaboration between Qatar University (QU) and the University of Washington (UW) has been organized to fill this deficiency. This study started in 2018 with institutional funding from Qatar University. At present there is no definite end date. The initial study will consist of seasonal cruises on the *RV Janan* in the Exclusive Economic Zone of Qatar. Our core data set will include hydrographic parameters, nutrients, dissolved inorganic carbon (DIC) and alkalinity. pH and pCO2 will be calculated from DIC and alkalinity. After establishing regional concentrations we plan a detailed study of a healthy coral reef system to measure net calcification.

The goal of this study is to assess the status of the ocean carbonate system in the Exclusive Economic Zone of Qatar in the Arabian Gulf with respect to present and future impacts by ocean acidification and use the distributions of DIC and alkalinity to determine the relative importance of organic matter production and CaCO3 formation for sinks and sources of CO2.

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Funding

Funding Source	Award
International Research Co-Fund Collaboration Program of QU (IRCC)	IRCC-2019-002

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