Total carbon dioxide and total alkalinity from R/V Thomas G. Thompson TT043, TT045, TT049, TT053, TT054 cruises in the Arabian Sea in 1995 (U.S. JGOFS Arabian Sea project)

Website: https://www.bco-dmo.org/dataset/2536
Version: May 8, 2001
Version Date: 2001-05-08

Project
» U.S. JGOFS Arabian Sea (Arabian Sea)

Program
» U.S. Joint Global Ocean Flux Study (U.S. JGOFS)

Contributors	Affiliation	Role
Goyet, Catherine	Woods Hole Oceanographic Institution (WHOI)	Principal Investigator
Millero, Frank	University of Miami Rosenstiel School of Marine and Atmospheric Science (UM-RSMAS)	Principal Investigator
O'Sullivan, Daniel	University of Miami	Co-Principal Investigator
Chandler, Cynthia L.	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

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Dataset Description

Total carbon dioxide and total alkalinity

Methods & Sampling

See Platform deployments for cruise specific documentation

Data Processing Description

NOTE: The depth, temp and salinity contained in this data set (as submitted by the PI) were extracted from the preliminary version of the bottle data and are reported here to show what was used in calculating to gravametric units. The final version of bottle data are reported by L. Codispoti. (JGOFS Data Management Office)

This file briefly discribes the methods that were used to make the carbon dioxide system measurements in the Arabian Sea on the JGOFS Process #2 cruise by the University of Miami, CO2 group. More detailed sampling and analytical methods descriptions can be found in the references given below.

Discrete Total Carbon Dioxide measurements:

The total inorganic carbon dioxide (TCO2) in a volume of seawater was determined coulometrically after acidification with 8.5 % H3PO4. The system has been used in earlier studies by Goyet and Hacker (1992) and it is similar to the SOMMA (Single-Operator Multiparameter Metabolic Analyzer), contructed by Johnson et al. (1987). The system is composed of five units: a DICE (Dissolved Inorganic Carbon Extractor) which controlls the movement and delivery of acid and sample to the stripper, a coulometer (UIC Inc., model 5011), a CO2 free N2 generator (Balston, model 74-5021), a personal computer and a printer. Nitrogen gas from the Balston generator is split into two streams, one for pneumatic controll of sample and acid movements, and the other for the carrier gas for the CO2 stripped from the seawater sample. The sample is acidified (with 1 to 1.5 mls of 8.5 % phosphoric acid) and the carbon dioxide is extracted with N2 and introduced into the coulometric cell where the CO2 reacts quantitatively with ethanolamine producing hydroxyethylcarbamic acid. Hydroxyethylcarbamic acid is titrated by electrochemically generated hydroxide ion. The number of electrons utilized in generating the titrant is proportional to the amount of inorganic carbon in the original sample.

The life time of the coulometer cell is about twelve hours, after which the cell solutions need to be changed. In addition to the cell solutions, the water trap was changed (Gelman, 0.2 (m PTFE ACRODISC). Changing the cell solution requires about 30 minutes. After which about three hours are need for the system to stabalize, determine new blank values, and confirm the calibration with analyses of CRM's. If the CRM value was not reproduced with in 2 (mol/kg TCO2, the system was recalibrated with Na2CO3 standards. A single measurement takes about 25 minutes, and a 24 bottle station cast can be completed in eight hours.

Calibration of the system:

The electrical calibration of the coulometer is not perfectly accurate and the current efficiency of the electrode processes occurring in the coulometer cell has been shown to vary from 100 %. Consequently, the system was calibrated using aqueous solutions of sodium carbonate which were treated as if they were samples. The consistency of the calibration was checked for each cell solution using the Certified Reference Material (Dr. Andrew Dickson, Marine Physical Laboratory, La Jolla, California).

Alkalinity Titration system:

The alkalinity titration system is similar to the one used in our earlier studies (Millero et al., 1993). The titration systems used to determined TA consisted of a titrator (Metrohm, model 665 Dosimat) and a pH meter (Orion, model 720A) that is controlled by a personal computer. The temperature of both the acid titrant in a water jacketed burette and the seawater sample in a water jacketed cell were controlled to a constant temperature of 25 0.1C with a constant temperature bath (Neslab, model RTE 221). The plexiglass water jacketed cells used during the cruise were similar to that used by Bradshaw et al. (1988) except a larger volume (about 200 cm3) was used to increase the precision. Each cell had a fill and drain valve which increased the reproducibility of the volume of sample contained in the cell. A LabWindows-C program was used to run the titration, record the volume of the added acid and the emf of the electrodes using RS-232 communication interfaces. Seawater samples were titrated by adding HCl to exceed the carbonic acid end point. During a typical titration the emf readings are recorded after the readings become stable (0.05 mV),and then a volume of acid is added to change the voltage to a pre-assigned increment (13 mV). In contrast to the delivery of a fixed volume increment of acid, this method gives an even distribution of data points in the range of rapid increase in the emf near the endpoint. A full

titration (25 points) takes about 20 minutes. Using two systems a 24 bottle station cast can be completed in 4 hours.

Selected References:

DOE (1994) Handbook of methods for the analysis of the various parameters of the carbon dioxide system in sea water, version 2, A. G. Dickson & C. Goyet, eds.

Goyet, C. and Hacker, S.D. (1992) Procedure for calibration of a coulometric system used for total inorganic carbon measurements. Marine Chemistry 38, 37-51

Millero, F. J., Zhang, J., Lee, K., and Campbell, D. M. (1993) Titration alkalinity of seawater. Mar. Chem., 44:153-165.

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Parameters

Parameter	Description	Units
event	event number, from event log	
sta	station number, from event log	
sta_std	Arabian Sea standard station identifier	
cast	CTD cast number, from event log	
bot	CTD rosette bottle number	
press	sample depth	decibars
TCO2	total carbon dioxide	micromoles/kilogram
TALK	total alkalinity	micromoles/kilogram
depth_n	depth of sample (nominal)	meters
sal	salinity (preliminary) PSS-78	dimensionless
temp	temperature (preliminary)	degrees C
pH_sw	pH in sea water, pH scale described in DOE CO2 handbook (see Methodology for complete citation)	sea water scale

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Instruments

Dataset-specific Instrument Name	Niskin Bottle
Generic Instrument Name	Niskin bottle
Dataset-specific Description	CTD/Niskin Rosette bottles.
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.

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Deployments

TT043

Website	https://www.bco-dmo.org/deployment/57704
Platform	R/V Thomas G. Thompson
Report	http://osprey.bcodmo.org/datasetDeployment.cfm?ddid=2580&did=353&flag=view
Start Date	1995-01-08
End Date	1995-02-05
Description	Purpose: Process Cruise #1 (Late NE Monsoon) **Methods & Sampling** PI: Catherine Goyet of: Woods Hole Oceanographic Institution dataset: Total carbon dioxide and total alkalinity dates: January 08, 1995 to February 01, 1995 location: N: 22.483 S: 9.9826 W: 57.2999 E: 68.75 project/cruise: Arabian Sea/TTN-043 - Process Cruise 1 (Late NE Monsoon) ship: R/V Thomas Thompson Methods are described in: DOE (1994) Handbook of Methods for the Analysis of the Various Parameters of the Carbon Dioxide System in Sea Water; Version 2, A.G. Dickson and C. Goyet, eds. ORNL/CDIAC-74.

TT045

Website	https://www.bco-dmo.org/deployment/57706
Platform	R/V Thomas G. Thompson
Start Date	1995-03-14
End Date	1995-04-10
	Methods & Sampling PI: Frank Millero and Daniel O'Sullivan of: University of Miami dataset: Total carbon dioxide, total alkalinity and pH dates: March 14, 1995 to April 08, 1995 location: N: 22.4853 S: 9.9993 W: 57.3007 E: 68.3455 project/cruise: Arabian Sea/TTN-045 - Process cruise 2 (Spring Intermonsoon) ship: R/V Thomas Thompson Caution: The depth, temp and salinity contained in this data set (as submitted by the PI) were extracted from the preliminary version of the bottle data and are reported here to show what was used in calculating to gravametric units. The final version of bottle data are reported by Lou Codispoti. **Processing Description** NOTE: The depth, temp and salinity contained in this data set (as submitted by the PI) were extracted from the preliminary version of the bottle data and are reported here to show what was used in calculating to gravametric units. The final version of bottle data are reported by L. Codispoti. (JGOFS Data Management Office) ---------- This file briefly discribes the methods that were used to make the carbon dioxide system measurements in the Arabian Sea on the JGOFS Process #2 cruise by the University of Miami, CO2 group. More detailed sampling and analytical methods descriptions can be found in the references given below. Discrete Total Carbon Dioxide measurements: The total inorganic carbon dioxide (TCO2) in a volume of seawater was determined coulometrically after acidification with 8.5 % H3PO4. The system has been used in earlier studies by Goyet and Hacker (1992) and it is similar to the SOMMA (Single-Operator Multiparameter Metabolic Analyzer), contructed by Johnson et al. (1987). The system is composed of five units: a DICE (Dissolved Inorganic Carbon Extractor) which controlls the movement and delivery of acid and sample to the stripper, a coulometer (UIC Inc., model 5011), a CO2 free N2 generator (Balston, model 74-5021), a personal computer and a printer. Nitrogen gas from the Balston generator is split into two streams, one for pneumatic controll of sample and acid movements, and the other for the carrier gas for the CO2 stripped from the seawater sample. The sample is acidified (with 1 to 1.5 mls of 8.5 % phosphoric acid) and

Description	the carbon dioxide is extracted with N2 and introduced into the coulometric cell where the CO2 reacts quantitatively with ethanolamine producing hydroxyethylcarbamic acid. Hydroxyethylcarbamic acid is titrated by electrochemically generated hydroxide ion. The number of electrons utilized in generating the titrant is proportional to the amount of inorganic carbon in the original sample. The life time of the coulometer cell is about twelve hours, after which the cell solutions need to be changed. In addition to the cell solutions, the water trap was changed (Gelman, 0.2 (m PTFE ACRODISC). Changing the cell solution requires about 30 minutes. After which about three hours are need for the system to stabalize, determine new blank values, and confirm the calibration with analyses of CRM's. If the CRM value was not reproduced with in 2 (mol/kg TCO2, the system was recalibrated with Na2CO3 standards. A single measurement takes about 25 minutes, and a 24 bottle station cast can be completed in eight hours. Calibration of the system: The electrical calibration of the coulometer is not perfectly accurate and the current efficiency of the electrode processes occurring in the coulometer cell has been shown to vary from 100 %. Consequently, the system was calibrated using aqueous solutions of sodium carbonate which were treated as if they were samples. The consistency of the calibration was checked for each cell solution using the Certified Reference Material (Dr. Andrew Dickson, Marine Physical Laboratory, La Jolla, California). Alkalinity Titration system: The alkalinity titration system is similar to the one used in our earlier studies (Millero et al., 1993). The titration systems used to determined TA consisted of a titrator (Metrohm, model 665 Dosimat) and a pH meter (Orion, model 720A) that is controlled by a personal computer. The temperature of both the acid titrant in a water jacketed burette and the seawater sample in a water jacketed cell were controlled to a constant temperature of 25 0.1C with a constant temperature bath (Neslab, model RTE 221). The plexiglass water jacketed cells used during the cruise were similar to that used by Bradshaw et al. (1988) except a larger volume (about 200 cm3) was used to increase the precision. Each cell had a fill and drain valve which increased the reproducibility of the volume of sample contained in the cell. A LabWindows-C program was used to run the titration, record the volume of the added acid and the emf of the electrodes using RS-232 communication interfaces. Seawater samples were titrated by adding HCl to exceed the carbonic acid end point. During a typical titration the emf readings are recorded after the readings become stable (0.05 mV),and then a volume of acid is added to change the voltage to a pre-assigned increment (13 mV). In contrast to the delivery of a fixed volume increment of acid, this method gives an even distribution of data points in the range of rapid increase in the emf near the endpoint. A full titration (25 points) takes about 20 minutes. Using two systems a 24 bottle station cast can be completed in 4 hours. Selected References: DOE (1994) Handbook of methods for the analysis of the various parameters of the carbon dioxide system in sea water, version 2, A. G. Dickson & C. Goyet, eds. Goyet, C. and Hacker, S.D. (1992) Procedure for calibration of a coulometric system used for total inorganic carbon measurements. Marine Chemistry 38, 37-51 Millero, F. J., Zhang, J., Lee, K., and Campbell, D. M. (1993) Titration alkalinity of seawater. Mar. Chem., 44:153-165.

TT049

Website	https://www.bco-dmo.org/deployment/57710
Platform	R/V Thomas G. Thompson
Start Date	1995-07-17
End Date	1995-08-15
Description	**Methods & Sampling** PI: Catherine Goyet of: Woods Hole Oceanographic Institution dataset: Total carbon dioxide and total alkalinity dates: July 18, 1995 to August 13, 1995 location: N: 22.5268 S: 9.911 W: 57.2997 E: 68.7507 project/cruise: Arabian Sea/TTN-049 - Process Cruise 4 (Middle SW Monsoon) ship: Thomas Thompson Methods are described in: DOE (1994) Handbook of Methods for the Analysis of the Various Parameters of the Carbon Dioxide System in Sea Water; Version 2, A.G. Dickson and C. Goyet, eds. ORNL/CDIAC-74.

TT053

Website	https://www.bco-dmo.org/deployment/57714

Platform	R/V Thomas G. Thompson
Start Date	1995-10-29
End Date	1995-11-26
Description	**Methods & Sampling** PI: Frank Millero and Dan O'Sullivan of: University of Miami dataset: Total carbon dioxide, total alkalinity and pH dates: October 29, 1995 to November 23, 1995 location: N: 24.3329 S: 10.0866 W: 56.5005 E: 67.1668 project/cruise: Arabian Sea/TTN-053 - Process cruise 6 (bio-optics) ship: R/V Thomas Thompson Caution: The depth, temp and salinity contained in this data set (as submitted by the PI) were extracted from the preliminary version of the bottle data and are reported here to show what was used in calculating to gravametric units. The final version of bottle data are reported by Lou Codispoti. **Processing Description** NOTE: The depth, temp and salinity contained in this data set (as submitted by the PI) were extracted from the preliminary version of the bottle data and are reported here to show what was used in calculating to gravametric units. The final version of bottle data are reported by L. Codispoti. (JGOFS Data Management Office) ---------- This file briefly discribes the methods that were used to make the carbon dioxide system measurements in the Arabian Sea on the JGOFS Process #2 cruise by the University of Miami, CO2 group. More detailed sampling and analytical methods descriptions can be found in the references given below. Discrete Total Carbon Dioxide measurements: The total inorganic carbon dioxide (TCO2) in a volume of seawater was determined coulometrically after acidification with 8.5 % H3PO4. The system has been used in earlier studies by Goyet and Hacker (1992) and it is similar to the SOMMA (Single-Operator Multiparameter Metabolic Analyzer), contructed by Johnson et al. (1987). The system is composed of five units: a DICE (Dissolved Inorganic Carbon Extractor) which controlls the movement and delivery of acid and sample to the stripper, a coulometer (UIC Inc., model 5011), a CO2 free N2 generator (Balston, model 74-5021), a personal computer and a printer. Nitrogen gas from the Balston generator is split into two streams, one for pneumatic controll of sample and acid movements, and the other for the carrier gas for the CO2 stripped from the seawater sample. The sample is acidified (with 1 to 1.5 mls of 8.5 % phosphoric acid) and the carbon dioxide is extracted with N2 and introduced into the coulometric cell where the CO2 reacts quantitatively with ethanolamine producing hydroxyethylcarbamic acid. Hydroxyethylcarbamic acid is titrated by electrochemically generated hydroxide ion. The number of electrons utilized in generating the titrant is proportional to the amount of inorganic carbon in the original sample. The life time of the coulometer cell is about twelve hours, after which the cell solutions need to be changed. In addition to the cell solutions, the water trap was changed (Gelman, 0.2 (m PTFE ACRODISC). Changing the cell solution requires about 30 minutes. After which about three hours are need for the system to stabalize, determine new blank values, and confirm the calibration with analyses of CRM's. If the CRM value was not reproduced with in 2 (mol/kg TCO2, the system was recalibrated with Na2CO3 standards. A single measurement takes about 25 minutes, and a 24 bottle station cast can be completed in eight hours. Calibration of the system: The electrical calibration of the coulometer is not perfectly accurate and the current efficiency of the electrode processes occurring in the coulometer cell has been shown to vary from 100 %. Consequently, the system was calibrated using aqueous solutions of sodium carbonate which were treated as if they were samples. The consistency of the calibration was checked for each cell solution using the Certified Reference Material (Dr. Andrew Dickson, Marine Physical Laboratory, La Jolla, California). 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	change the voltage to a pre-assigned increment (13 mV). In contrast to the delivery of a fixed volume increment of acid, this method gives an even distribution of data points in the range of rapid increase in the emf near the endpoint. A full titration (25 points) takes about 20 minutes. Using two systems a 24 bottle station cast can be completed in 4 hours. Selected References: DOE (1994) Handbook of methods for the analysis of the various parameters of the carbon dioxide system in sea water, version 2, A. G. Dickson & C. Goyet, eds. Goyet, C. and Hacker, S.D. (1992) Procedure for calibration of a coulometric system used for total inorganic carbon measurements. Marine Chemistry 38, 37-51 Millero, F. J., Zhang, J., Lee, K., and Campbell, D. M. (1993) Titration alkalinity of seawater. Mar. Chem., 44:153-165.

TT054

Website	https://www.bco-dmo.org/deployment/57715
Platform	R/V Thomas G. Thompson
Start Date	1995-11-30
End Date	1995-12-28
Description	**Methods & Sampling** PI: Frank Millero and Dan O'Sullivan of: University of Miami dataset: Total carbon dioxide, total alkalinity and pH dates: November 30, 1995 to December 25, 1995 location: N: 22.5011 S: 9.9789 W: 57.6326 E: 68.7757 project/cruise: Arabian Sea/TTN-054 - Process cruise 7 (Early NE Monsoon) ship: R/V Thomas Thompson Caution: The depth, temp and salinity contained in this data set (as submitted by the PI) were extracted from the preliminary version of the bottle data and are reported here to show what was used in calculating to gravametric units. The final version of bottle data are reported by Lou Codispoti. **Processing Description** NOTE: The depth, temp and salinity contained in this data set (as submitted by the PI) were extracted from the preliminary version of the bottle data and are reported here to show what was used in calculating to gravametric units. The final version of bottle data are reported by L. Codispoti. (JGOFS Data Management Office) ---------- This file briefly discribes the methods that were used to make the carbon dioxide system measurements in the Arabian Sea on the JGOFS Process #2 cruise by the University of Miami, CO2 group. More detailed sampling and analytical methods descriptions can be found in the references given below. Discrete Total Carbon Dioxide measurements: The total inorganic carbon dioxide (TCO2) in a volume of seawater was determined coulometrically after acidification with 8.5 % H3PO4. The system has been used in earlier studies by Goyet and Hacker (1992) and it is similar to the SOMMA (Single-Operator Multiparameter Metabolic Analyzer), contructed by Johnson et al. (1987). The system is composed of five units: a DICE (Dissolved Inorganic Carbon Extractor) which controlls the movement and delivery of acid and sample to the stripper, a coulometer (UIC Inc., model 5011), a CO2 free N2 generator (Balston, model 74-5021), a personal computer and a printer. Nitrogen gas from the Balston generator is split into two streams, one for pneumatic controll of sample and acid movements, and the other for the carrier gas for the CO2 stripped from the seawater sample. The sample is acidified (with 1 to 1.5 mls of 8.5 % phosphoric acid) and the carbon dioxide is extracted with N2 and introduced into the coulometric cell where the CO2 reacts quantitatively with ethanolamine producing hydroxyethylcarbamic acid. Hydroxyethylcarbamic acid is titrated by electrochemically generated hydroxide ion. The number of electrons utilized in generating the titrant is proportional to the amount of inorganic carbon in the original sample. The life time of the coulometer cell is about twelve hours, after which the cell solutions need to be changed. In addition to the cell solutions, the water trap was changed (Gelman, 0.2 (m PTFE ACRODISC). Changing the cell solution requires about 30 minutes. After which about three hours are need for the system to stabalize, determine new blank values, and confirm the calibration with analyses of CRM's. If the CRM value was not reproduced with in 2 (mol/kg TCO2, the system was recalibrated with Na2CO3 standards. A single measurement takes about 25 minutes, and a 24 bottle station cast can be completed in eight hours. Calibration of the system: The electrical calibration of the coulometer is not perfectly accurate and the current efficiency of the electrode processes occurring in the coulometer cell has been shown to vary from 100 %. Consequently, the system was calibrated using aqueous solutions of sodium carbonate which were treated as if they were samples. The consistency of the calibration was checked for each cell solution using the Certified Reference

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Project Information

U.S. JGOFS Arabian Sea (Arabian Sea)

Website: http://usjgofs.whoi.edu/research/arabian.html

Coverage: Arabian Sea

The U.S. Arabian Sea Expedition which began in September 1994 and ended in January 1996, had three major components: a U.S. JGOFS Process Study, supported by the National Science Foundation (NSF); Forced Upper Ocean Dynamics, an Office of Naval Research (ONR) initiative; and shipboard and aircraft measurements supported by the National Aeronautics and Space Administration (NASA). The Expedition consisted of 17 cruises aboard the R/V Thomas Thompson, year-long moored deployments of five instrumented surface buoys and five sediment-trap arrays, aircraft overflights and satellite observations. Of the seventeen ship cruises, six were allocated to repeat process survey cruises, four to SeaSoar mapping cruises, six to mooring and benthic work, and a single calibration cruise which was essentially conducted in transit to the Arabian Sea.

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Program Information

U.S. Joint Global Ocean Flux Study (U.S. JGOFS)

Website: http://usjgofs.whoi.edu/

Coverage: Global

The United States Joint Global Ocean Flux Study was a national component of international JGOFS and an

integral part of global climate change research.

The U.S. launched the Joint Global Ocean Flux Study (JGOFS) in the late 1980s to study the ocean carbon cycle. An ambitious goal was set to understand the controls on the concentrations and fluxes of carbon and associated nutrients in the ocean. A new field of ocean biogeochemistry emerged with an emphasis on quality measurements of carbon system parameters and interdisciplinary field studies of the biological, chemical and physical process which control the ocean carbon cycle. As we studied ocean biogeochemistry, we learned that our simple views of carbon uptake and transport were severely limited, and a new "wave" of ocean science was born. U.S. JGOFS has been supported primarily by the U.S. National Science Foundation in collaboration with the National Oceanic and Atmospheric Administration, the National Aeronautics and Space Administration, the Department of Energy and the Office of Naval Research. U.S. JGOFS, ended in 2005 with the conclusion of the Synthesis and Modeling Project (SMP).

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Funding

Funding Source	Award
National Science Foundation (NSF)	unknown Arabian Sea NSF

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