Bottle-calibrated dissolved oxygen (DO) profiles from US Overturning in the Subpolar North Atlantic Program (OSNAP) cruises in 2020 and 2022 (AR45 and AR69-03)

Website: https://www.bco-dmo.org/dataset/933743
Data Type: Cruise Results
Version: 1
Version Date: 2024-08-30

Project
» Collaborative Research: Gases in the Overturning and Horizontal circulation of the Subpolar North Atlantic Program (GOHSNAP) (GOHSNAP)

Contributors	Affiliation	Role
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Abstract
This dataset contains bottle-calibrated dissolved oxygen (DO) profiles collected from Conductivity Temperature Depth (CTD) casts during cruises in 2020 (AR45) and 2022 (AR69-03) to recover and redeploy Overturning in the Subpolar North Atlantic Program (OSNAP) moorings in the Labrador Sea and western Irminger Sea. DO profiles were used in conjunction with oxygen bottle measurements (Winklers) to produce a post-cruise oxygen-calibrated CTD product for scientific use as part of Gases in the Overturning and Horizontal circulation of the Subpolar North Atlantic Program (GOHSNAP), which has added moored oxygen sensors to the OSNAP mooring array, beginning in 2020. This documentation contains overviews of CTD data collection and processing and of the oxygen sensor calibration method. For each cruise, we provide a summary of relevant cruise events, oxygen sensor calibration results, and issues/problems associated with oxygen data collected.

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Coverage

Location: Labrador Sea (57.35°N, 50.10°W), Irminger Sea (60.46°N, 38.44°W)
Spatial Extent: **N**:62.6272 **E**:-27.6994 **S**:41.9062 **W**:-68.522
Temporal Extent: 2020-06-30 - 2022-09-23

Methods & Sampling

These data were during cruises onboard the R/V Neil Armstrong to recover and redeploy mooring infrastructure of the international Overturning in the Subpolar North Atlantic Program (OSNAP) in 2020 (AR45) and 2022 (AR69-03). The mooring infrastructure maintained on these cruises is located in the eastern Labrador Sea (referred to as the LS line) and western Irminger Sea (referred to as the CF line). Beginning in 2020, the Gases in the Overturning and Horizontal circulation of the Subpolar North Atlantic Program (GOHSNAP) has added moored oxygen sensors to these sections of the OSNAP mooring array. During these cruises, Conductivity Temperature Depth (CTD) casts are conducted to provide data necessary to calibrate the moored sensors (Miller et al., in review), as well as hydrographic data that provide a valuable dataset in and of themselves.

This dataset uses CTD data collected by the OSNAP and GOHSNAP programs during AR45 (OSNAP 22) and AR69-03 (OSNAP 32) cruises, alongside discrete samples collected for this project during the cruises (Related Dataset: Palevsky et al. 2024) to produce calibrated, quality-controlled oxygen depth profiles. For further information on CTD-DO calibration and its role in the calibration of moored oxygen sensors, see Miller et al. (in review).

Data collection

CTD casts were performed using a ship-provided SeaBird 911plus CTD and deck unit (http://www.seabird.com//sbe911plus-ctd) configured to measure pressure, temperature, conductivity, oxygen current, and other variables. Rosettes were equipped with primary and secondary pumped CTD sensor packages to measure pressure, temperature, and conductivity in duplicate. A SBE43 dissolved oxygen sensor was integrated into the pumped flow path of the primary CTD sensor package. Sensor data were acquired by an SBE Deck Unit providing demodulated data to a personal computer running SEASAVE (http://www.seabird.com/software/seasavev7) acquisition software. Calibrations for CTD sensors were performed by the manufacturer before the cruise.

SeaBird processing

CTD data are processed using SeaBird data processing software. The raw 24 Hz CTD data are converted from HEX to ASCII, lag corrected, edited for large spikes, smoothed according to sensor, and pressure averaged into 2 db bins for final data quality control and analysis. Table 1 summarizes the order in which SeaBird Modules were processed and the inputs applied during each module.

SeaBird (Version 7.26.7) data processing module inputs

* DATCNV: Convert the raw data (.hex) to pressure, temperature, conductivity, and dissolved oxygen (V) to a file with a .cnv extension. Use default hysteresis correction
* BOTTLESUM: Writes out a summary of the bottle data to a file with a .btl extension
* ALIGNCTD: Advance Oxygen raw [V] by time determined by processing relative to pressure
* WILDEDIT: Checks for and marks ‘wild’ data points: first pass 2.0 standard deviations; second pass 20 standard deviations
* CELLTM: Conductivity cell thermal mass correction; alpha = 0.03 and 1/beta = 7.0
* FILTER: Low pass filter pressure and depth (DO [V]) with a time constant of 0.15 seconds to increase pressure resolution for LOOPEDIT
* LOOPEDIT: Mark scans where the CTD is moving less than the minimum velocity (0.25 m/s) or traveling backward due to ship roll
* BINAVG: Average data into 2 db pressure bins to match bottle-calibrated salinity files
* SPLIT (u or d): Split .cnv file into upcast and downcast files. Files are appended automatically with leading u or d

Data Processing Description

Post-processing SBE oxygen calibrations

To produce the highest-quality oxygen measurements, post-processing procedures were modeled after methods described in Uchida et al. 2010. The following Seabird-recommended calibration equation was used to calibrate the SBE-43 oxygen sensor data:

O2= SOC(V+ Voff)* Oxysol(T,S)*(1 + A*T + B*T2 + C*T3) * eE*p/(273.15 +T) (Equation 1)

where *O2* is the CTD oxygen [µmol/kg], *V* is the output voltage signal processed with the SBE default hysteresis correction [volts], *Oxysol* is the oxygen saturation [µmol/kg], *T* is temperature [deg C], *S* is salinity

[psu], and *P* is pressure [dbar] (SBE Application Note 64-2). Coefficients for the oxygen calibration slope (*SOCa*; voltage offset at 0 (*Voff*); temperature-related calibration coefficients of *A, B and C*; and pressure-related *E* term were determined initially from an 18-point factory calibration and provided by the manufacturer (Appendix A). *Voff, A, B,* and *C* are constant over the sensor life while values for *SOC* and *E* can be optimized using discrete water samples measured analytically for dissolved oxygen, and commonly referred to as Winklers.

Calibration coefficients for *SOC* and *E* were optimized by applying a non-linear least-squares fit to Winkler samples while calibration coefficients for *A, B, C*, and *Voff* were held constant. Oxygen sensor hysteresis due to pressure effects on the sensor membrane was improved by enabling the Seabird default hysteresis correction (Edwards et al. 2010; SBE Application Note 64-3). The optional response time correction, or *tau* correction, was determined to add excessive signal noise in relatively stable, deep portions of the water column; and, therefore, was not applied in the calibration equation.

While using this approach, a non-linear functional fit of Equation 1 was first attempted using one set of coefficients for the entire data set (whole cruise). Model fits were iterative with outliers discarded. Outliers were determined as values more than three scaled median absolute deviations from the median.

With outliers removed, residuals between CTD values and water sample values were then examined as a function of pressure, temperature, oxygen concentration, and cast number (≈ cruise time). An examination of the residuals as a function of cast number was used to 1) identify episodic events resulting in abrupt changes in *SOC* values, and 2) determine potential drift in *SOC* over the course of the cruise. After examining the residuals, cast numbers were grouped if necessary to minimize the residuals with an attempt to limit the number of groups used per cruise. New calibration coefficients were then determined for each group.

If a linear drift as a function of cast number (*cn*) or cruise time (*dt*) was determined for a group, a linear correction of the *SOC* drift was applied to the group while keeping other coefficients constant. The linear drift as a function of cast number/cruise time was then incorporated into the calibration equation, replacing *SOC* in Equation 1 as a function of cruise number/cruise time as:

SOCcn/dt = SOC1 + F*cn/dt (Equation 2)

where *cn* or *dt* is the cast number [-] or time since first cast [d], respectively. *SOC*1 is the initial *SOC* value, and *F* is the rate of *SOC* change per cast number or day since first cast.

A nonlinear functional fit including the cast or time-dependent SOCcn/dt was then fit to the group determining coefficients for *E*, *SOC1*, and *F* while holding *A, B, C,* and *Voff* constant. After iterative fitting and outliers removed, residuals were examined again as a function of pressure, temperature, oxygen concentration and cast number to ensure no linear dependence of residuals as a function of time. Outliers were determined as values more than three scaled median absolute deviations from the median.

For each cruise, CTD-derived measurements of salinity and oxygen solubility were calculated using the TEOS-10 Gibbs-SeaWater Oceanographic Toolbox (McDougall and Barker, 2011). Measurements from primary CTD sensors recorded in line with the SBE43 oxygen sensors were used to calculate oxygen concentrations unless collected data was poor. In these instances, measurements from the secondary CTD sensors were used. Bottle-calibrated CTD salinity measurements were used to produce oxygen concentrations. The measurements of temperature, salinity, pressure and oxygen voltage (processed with SBE default hysteresis correction; Application Note 64-3) used to produce oxygen concentration profiles are included in files for downcasts (indicated with ‘d’ appended) or upcasts (indicated with ‘u’ appended).

Throughout this documentation, oxygen profiles calibrated using a constant *SOC* value are indicated by *SOCk* while oxygen profiles calibrated using an *SOC* term that varies with time or cast (station) number are indicated by *SOCdt* and *SOCcn*, respectively. Lastly, oxygen sensor gain is determined as the Winkler-determined *SOC* value over the factory-determined *SOC* to assess changes in oxygen calibration slope since factory calibration. Note, the manufacturer recommends factory service inspection and calibration for a SBE43 DO sensor with a gain correction greater than 1.2 from the original factory value (Application Note 64-2).

Deployment Cruise AR45

Summary of Relevant Cruise Information

The AR45 Cruise Report (see cruise report in Pickart & McRaven (2022)) was generated by participants of OSNAP22. The COVID-19 pandemic presented a number of challenges for sea-going operations in 2020.

Traditionally, Winkler measurements are made at sea by trained technicians; however, to minimize shipboard personnel in 2020, discrete samples for oxygen were collected and stored according to methods described by Zhang et al. (2002) until subsequent analysis back on land. Results of discrete sample analyses for AR45 are available on BCO-DMO (related dataset: Palevsky et al. 2024).

A total of 163 CTD casts were performed on-board the R/V Armstrong. CTD-derived salinity data were calibrated by Leah McRaven at Woods Hole Oceanographic Institution using discrete bottle samples (Pickart and McRaven 2022). Conductivity and temperature data on this cruise were affected by biofouling issues and CTD pump issues. Issues with the CTD pump resulted in unphysical density inversions and uncharacteristic oxygen profiles in near surface waters for Casts 1-70. These pump-related density and oxygen issues were resolved by replacing the CTD package pump before Cast 71. The biofouling and pump issues are summarized in the AR45 CTD Calibration Report (see CTD calibration report in Pickart & McRaven (2022)) The temperature, bottle-calibrated salinity and depth data from the primary CTD package were used in the oxygen sensor calibration equation to calibrate SBE43 (SN 1960) oxygen sensor data. The hysteresis between upcast and downcast oxygen data due to sensor response time was removed by advancing the oxygen sensor data 5 seconds relative to the pressure sensor data.

Oxygen calibration Results

Calibration coefficients for *SOC* and *E* in Equation 1 were determined using a non-linear least squares fit between CTD oxygen values and 68 Winkler samples while calibration coefficients for *A, B, C,* and *Voff* were held constant at their factory-determined values (Appendix A). Residuals (Winkler - *SOCk* model) determined using a constant *SOC* revealed no relationship between residuals and pressure, temperature, or oxygen concentration (Figure 1, supplemental file: AR45_OxygenCalibration_Results.pdf). The *SOCk* model (RMSE = 0.78 µmol/kg, $R2 = 0.995$) flagged 9 Winkler samples (13.2%) as outliers. It was decided that only a constant *SOC* correction was appropriate for this cruise since 1) Winklers were not measured onboard, 2) Winklers were measured on just 4.3% of casts, and 3) negative relationship observed between *SOC* and time is not representative of typical electrochemical sensor drift (Application Note 64-2). The Winkler-optimized calibration coefficients and model results are summarized in Table 1. Oxygen data before and after calibration is shown in Figure 2 (supplemental file: AR45_AR6903_OxygenCalibrationResults_FiguresTables.pdf).

Deployment Cruise AR69-03

Summary of Relevant Cruise Information

The AR69-03 Cruise Report (see cruise report in Straneo (2023)) was generated by participants of OSNAP32. Results of discrete sample analyses for AR69-03 are available on BCO-DMO (Related Dataset: Palevsky et al. 2024). A total of 214 CTD casts were performed on-board the R/V Armstrong. CTD-derived salinity data were calibrated by Aaron Mau at Scripps Institution of Oceanography using discrete bottle samples, and results are summarized in the AR69-03 CTD Calibration Report (see CTD calibration report in Straneo (2023)). Temperature, bottle-calibrated salinity and depth data from the primary CTD package were used in the oxygen sensor calibration equation to calibrate SBE43 (SN 1960) oxygen sensor data. The hysteresis between upcast and downcast oxygen data due to sensor response time was removed by advancing the oxygen sensor data 5 seconds relative to the pressure sensor data.

Oxygen calibration Results

Calibration coefficients for *SOC* and *E* in Equation 1 were attempted first using a non-linear least square fit between CTD oxygen values and the 585 Winkler samples collected on 82 unique casts. Resulting residuals were linearly correlated with temperature and oxygen concentration. Examination of Winkler residuals revealed issues with relatively high concentration Winklers collected in colder, surface waters. This may either indicate issues in the CTD dissolved oxygen sensor’s sensitivity and fit at these concentrations, or it may indicate a systematic measurement error in the Winkler dissolved oxygen analysis (for instance, due to possible oxygen degassing prior to sample collection and preservation). As such, Winklers greater than 316 µmol/kg were removed from this analysis, leaving 462 Winklers to determine oxygen sensor calibration coefficients.

The calibration coefficient for the *E* term in Equation 1 was determined using a non-linear least square fit between CTD oxygen values and 311 Winkler samples collected on 38 deep casts (deeper than 1000 m). The *SOCk* model (RMSE = 0.840 µmol/kg, $R2 = 0.993$, $n = 283$) for deep casts flagged 28 Winkler samples (9.0%) as outliers. The calculated *E* term of 0.0372 was then held constant for the sensor over the duration of AR69-03 and the *SOC* calibration coefficient was optimized by breaking stations into groups.

Group 1: The calibration coefficient for *SOC* in Equation 1 was determined for Group 1 using a non-linear least square fit between CTD oxygen values and the 21 Winkler samples collected at Stations 1-2. Residuals (Winkler - *SOCk* model) determined using a constant *SOC* revealed no relationship between residuals and pressure, temperature, station or oxygen concentration. The *SOCk* model (RMSE = 0.191 µmol/kg, R2 = 1.00, n = 18) flagged 3 Winkler samples (14.3%) as outliers.

Group 2: Group 2 consisted of Stations 3-24, and application of the non-linear regression model using a time-dependent *SOC* term (Equation 2) was found to minimize the residuals between 109 collected Winklers and CTD oxygen. No relationship between residuals (Winkler- *SOCdt* model) and pressure, temperature, station or oxygen concentration remained with the *SOCdt* model fit. The *SOCdt* model for Group 2 (RMSE = 0.517 µmol/kg, R2 = 0.998, n = 98) flagged 11 Winklers (10.1%) as outliers.

Group 3: The calibration coefficient for *SOC* in Equation 1 was determined for Group 3 using a non-linear least square fit between CTD oxygen values and the 59 Winkler samples collected at Stations 25-63. Residuals (Winkler - *SOCk* model) determined using a constant *SOC* revealed no relationship between residuals and pressure, temperature, station or oxygen concentration. The *SOCk* model (RMSE = 1.23 µmol/kg, R2 = 0.986, n = 51) flagged 8 Winkler samples (13.6%) as outliers.

Group 4: The calibration coefficient for *SOC* in Equation 1 was determined for Group 4 using a non-linear least square fit between CTD oxygen values and the 47 Winkler samples collected at Stations 64-82. Residuals (Winkler - *SOCk* model) determined using a constant *SOC* revealed no relationship between residuals and pressure, temperature, station or oxygen concentration. The *SOCk* model (RMSE = 0.614 µmol/kg, R2 = 0.998, n = 47) flagged no Winkler samples as outliers.

Group 5: Application of the non-linear regression model using a time-dependent *SOC* term (Equation 2) was found to minimize the residuals between the 65 Winklers collected and CTD oxygen at Stations 83-99. No relationship between residuals (Winkler- *SOCdt* model) and pressure, temperature, station or oxygen concentration remained with the *SOCdt* model fit. The *SOCdt* model for Group 5 (RMSE = 0.699 µmol/kg, R2 = 0.993, n = 56) flagged 9 Winklers (13.9%) as outliers.

Group 6: The calibration coefficient for *SOC* in Equation 1 was determined for Stations 100-172 using a non-linear least square fit between CTD oxygen values and 134 Winkler samples. Residuals (Winkler - *SOCk* model) determined using a constant *SOC* revealed no relationship between residuals and pressure, temperature, station or oxygen concentration. The *SOCk* model (RMSE = 0.885 µmol/kg, R2 = 0.988, n = 116) flagged 18 Winkler samples (13.4%) as outliers.

Group 7: Application of the non-linear regression model using a time-dependent *SOC* term (Equation 2) was found to minimize the residuals between the 27 Winklers collected and CTD oxygen at Stations 173-214. No relationship between residuals (Winkler- *SOCdt* model) and pressure, temperature, station or oxygen concentration remained with the *SOCdt* model fit. The *SOCdt* model for Group 7 (RMSE = 1.13 µmol/kg, R2 = 0.988, n = 25) flagged 2 Winklers (7.4%) as outliers.

Residuals as a function of pressure, station number, temperature, and concentration are shown for all 7 groups in Figure 3. The Winkler-optimized calibration coefficients and model results for the 7 groups are summarized in Table 2. Oxygen data before and after calibration is shown in Figure 4 (supplemental file: AR45_AR6903_OxygenCalibrationResults_FiguresTables.pdf).

BCO-DMO Processing Description

* Merged data from cruise AR45 and AR69-03 into 1 dataset
* Added ISO date notation to dataset
* Converted missing value flag 9 and missing identifier -999 to blank

Problem Description

Quality flags

WOCE quality flags for CTD temperature and salinity were carried over from their respective calibrated datasets. WOCE quality flags:

1 = Not calibrated with water samples
2 = Acceptable measurement
3 = Questionable measurement
4 = Bad measurement
9 = Not sampled

Quality flags for oxygen for each pressure-averaged bin were applied to this dataset following the recommendations of Jiang et al. 2022.

1 = not evaluated/quality unknown
2 = acceptable
3 = questionable
4 = known bad
6 = median of replicates
9 = Missing value

AR45
* Issues with the pump on the CTD package resulted in suspect oxygen profiles in the surface waters during the downcast for Casts 1- 70. Affected data points have been flagged as questionable and the scientific use of the upcasts for Casts 1-70 is recommended.
* Near-surface oxygen data collected during the upcast for Casts 10 and 87 and downcast for Cast 117 were also flagged as questionable.

AR69-03
* Surface values on downcasts for Stations 37, 46, 116 - 120 are consistent with a pump issue and have been marked as questionable.
* Blockage of the plumbing line on Cast 86 resulted in questionable oxygen data for the entire upcast and downcast data.
* No calibrated temperature and salinity data for Cast 146 was provided; therefore, no calibrated oxygen data was produced.
* Values at the deepest parts of the downcasts for Stations 169 and 176 have been marked as questionable.

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Data Files

File
933743_v1_bottleprofiles.csv (Comma Separated Values (.csv), 27.87 MB) MD5:0a54578d9aa54453631b913cd63f0a5f Primary data file for dataset ID 933743, version 1

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Supplemental Files

File
AR45.zip (ZIP Archive (ZIP), 898.69 KB) MD5:fa8f0e51e53562aebbacbbb0a5f79e3c Original submitted files for cruise AR45, in different format than served (merged) dataset.
AR45_AR6903_OxygenCalibrationResults_FiguresTables.pdf (Portable Document Format (.pdf), 627.85 KB) MD5:8c0dfcbe16c8b78d5a55d9920ae98065 Tables and figures related to oxygen calibration results of cruise AR45 and AR69-03, part of dataset 933743.
AR69-03.zip (ZIP Archive (ZIP), 1.64 MB) MD5:906266e20091e36a80fd382580c2c0f8 Original submitted files for cruise AR69-03, in different format than served (merged) dataset.

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Related Publications

Bittig, H. C., & Körtzinger, A. (2017). Technical note: Update on response times, in-air measurements, and in situ drift for oxygen optodes on profiling platforms. Ocean Science, 13(1), 1–11. https://doi.org/10.5194/os-13-1-2017
Methods

Bittig, H. C., Körtzinger, A., Neill, C., van Ooijen, E., Plant, J. N., Hahn, J., Johnson, K. S., Yang, B., & Emerson, S. R. (2018). Oxygen Optode Sensors: Principle, Characterization, Calibration, and Application in the Ocean. Frontiers in Marine Science, 4. https://doi.org/10.3389/fmars.2017.00429
Methods

Edwards, B., Murphy, D., Janzen, C., & Larson, N. (2010). Calibration, Response, and Hysteresis in Deep-Sea Dissolved Oxygen Measurements. Journal of Atmospheric and Oceanic Technology, 27(5), 920–931. https://doi.org/10.1175/2009jtecho693.1 https://doi.org/10.1175/2009JTECHO693.1
Methods

Jiang, L.-Q., Pierrot, D., Wanninkhof, R., Feely, R. A., Tilbrook, B., Alin, S., Barbero, L., Byrne, R. H., Carter, B. R., Dickson, A. G., Gattuso, J.-P., Greeley, D., Hoppema, M., Humphreys, M. P., Karstensen, J., Lange, N., Lauvset, S. K., Lewis, E. R., Olsen, A., … Xue, L. (2022). Best Practice Data Standards for Discrete Chemical Oceanographic Observations. Frontiers in Marine Science, 8. https://doi.org/10.3389/fmars.2021.705638
Methods

McDougall, T.J. and P.M. Barker, (2011). Getting started with TEOS-10 and the Gibbs Seawater (GSW) Oceanographic Toolbox, 28pp., SCOR/IAPSO WG127, ISBN 978-0-646-55621-5
Methods

Miller, U. K., Fogaren, K., Atamanchuk, D., Johnson, C., Koelling, J., Le Bras, I., Lindeman, M., Nagao, H., Nicholson, D. P., Palevsky, H. I., Park, E., Yoder, M., and Palter, J. B. (in review) Oxygen optodes on oceanographic moorings: recommendations for deployment and in-situ calibration, in review at Frontiers in Marine Sciences.
Methods

Sea-Bird Electronics, Inc. (2012). Application Note No. 64-2: SBE 43 Dissolved Oxygen Sensor Calibration and Data Corrections, 5 pp http://www.argodatamgt.org/content/download/26540/181268/file/SBE43_ApplicationNote64-2_RevJun2012.pdf
Methods

Sea-Bird Electronics, Inc. (2014). Application Note No. 64-3: SBE 43 Dissolved Oxygen (DO) sensor – Hysteresis corrections, 8 pp. https://www.seabird.com/asset-get.download.jsa?code=251035
Methods

Uchida, H. Johnson, G.,C. and McTaggart, G,. C. (2010) CTD Oxygen Sensor Calibration Procedures. In, The GO-SHIP Repeat Hydrography Manual: A Collection of Expert Reports and Guidelines. Version 1, (eds Hood, E.M., C.L. Sabine, and B.M. Sloyan), 17pp. (IOCCP Report Number 14; ICPO Publication Series Number 134). DOI: https://doi.org/10.25607/OBP-1344
Methods

Uchida, H., Kawano, T., Kaneko, I., & Fukasawa, M. (2008). In Situ Calibration of Optode-Based Oxygen Sensors. Journal of Atmospheric and Oceanic Technology, 25(12), 2271–2281. https://doi.org/10.1175/2008jtecho549.1 https://doi.org/10.1175/2008JTECHO549.1
Methods

Zhang, J.-Z., Berberian, G., & Wanninkhof, R. (2002). Long-term storage of natural water samples for dissolved oxygen determination. Water Research, 36(16), 4165–4168. https://doi.org/10.1016/s0043-1354(02)00093-3 https://doi.org/10.1016/S0043-1354(02)00093-3
Methods

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Related Datasets

IsRelatedTo

Palevsky, H. I., Yoder, M., Nicholson, D. P., Fogaren, K. E. (2024) **Discrete sample measurements of dissolved oxygen, dissolved inorganic carbon, and total alkalinity from US Overturning in the Subpolar North Atlantic Program (OSNAP) cruises in 2020 and 2022 (AR45 and AR69-03).** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-08-30 doi:10.26008/1912/bco-dmo.934025.1 [view at BCO-DMO]
Relationship Description: Companion dataset containing discrete bottle samples (Winklers) used for CTD-DO calibration

Pickart, R., & McRaven, L. (2022). *Conductivity-Temperature-Depth (CTD) data as part of the OSNAP (Overturning in the Subpolar North Atlantic Program), from 2020 on the R/V Neil Armstrong* [Data set]. Georgia Institute of Technology. https://doi.org/10.35090/GATECH/66767 https://doi.org/10.35090/gatech/66767

Straneo, F. (2023). CTD data from 33VB20220819 [Dataset]. Retrieved from CCHDO https://cchdo.ucsd.edu/cruise/33VB20220819

IsDerivedFrom

Rolling Deck To Repository. (2021). *CTD (Conductivity, Temperature, Depth) data collected during research cruise AR45 using a Sea-Bird SBE-911+ instrument system onboard the platform RV Neil Armstrong* (Version 1) [Data set]. Rolling Deck to Repository (R2R) Program. https://doi.org/10.7284/141990

Rolling Deck To Repository. (2023). *CTD (Conductivity, Temperature, Depth) data collected during research cruise AR69-03 using a SeaBird SBE-911+ instrument system onboard the platform RV Neil Armstrong* (Version 1) [Data set]. Rolling Deck to Repository (R2R) Program. https://doi.org/10.7284/153092

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Parameters

Parameter	Description	Units
Cruise	Cruise identification (AR45 or AR69-03)	unitless
Station	Station Identification	unitless
Down_Up	Down or up CTD cast (d or u)	unitless
Date_UTC	Sampling date in ISO format (UTC time zone)	unitless
Lat	Latitude in deceimal degrees, south is negative	decimal degrees
Lon	Longitude in decimal degrees, west is negative	decimal degrees
CTDPRES	Hydrostatic pressure recorded from CTD at the depth where the sample was taken	dbar
CTDTEMP_ITS90	In situ temperature recorded from CTD on the ITS-90 scale	degrees Celsius
CTDTEMP_flag	WOCE quality control flag	unitless
CTDSAL_PSS78	Calibrated salinity (Practical Salinity Scale of 1978) calculated from conductivity recorded with CTD	unitless
CTDSAL_flag	WOCE quality control flag	unitless
CTDOXYCUR	Oxygen current from the SeaBird SBE43 oxygen sensor on the CTD package processed with the SBE default hysteresis correction	volts
CTDOXYCUR_flag	Quality control flag; see data documentation with this and Fogaren et al. dataset	unitless
CTDOXY	Calibrated dissolved oxygen content from oxygen sensor mounted on the CTD	umol/kg
CTDOXY_flag	Quality control flag; see data documentation with this and Fogaren et al. dataset	unitless
file_name	File name	unitless

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Instruments

Dataset-specific Instrument Name	SeaBird 911plus CTD
Generic Instrument Name	CTD Sea-Bird SBE 911plus
Generic Instrument Description	The Sea-Bird SBE 911 plus is a type of CTD instrument package for continuous measurement of conductivity, temperature and pressure. The SBE 911 plus includes the SBE 9plus Underwater Unit and the SBE 11plus Deck Unit (for real-time readout using conductive wire) for deployment from a vessel. The combination of the SBE 9 plus and SBE 11 plus is called a SBE 911 plus. The SBE 9 plus uses Sea-Bird's standard modular temperature and conductivity sensors (SBE 3 plus and SBE 4). The SBE 9 plus CTD can be configured with up to eight 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	SeaBird SBE43 oxygen sensor
Generic Instrument Name	Sea-Bird 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

AR45

Website	https://www.bco-dmo.org/deployment/933794
Platform	R/V Neil Armstrong
Report	https://doi.org/10.35090/gatech/66767
Start Date	2020-06-23
End Date	2020-08-01

AR69-03

Website	https://www.bco-dmo.org/deployment/933797
Platform	R/V Neil Armstrong
Report	https://cchdo.ucsd.edu/cruise/33VB20220819
Start Date	2022-08-19
End Date	2022-09-24

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Project Information

Collaborative Research: Gases in the Overturning and Horizontal circulation of the Subpolar

North Atlantic Program (GOHSNAP) (GOHSNAP)

Coverage: Subpolar North Atlantic

NSF Award Abstract:
Every winter, frigid winds blowing eastward from the North American continent cool the surface waters of the Labrador Sea, which is situated between Canada and Greenland. As the ocean cools, oxygen and carbon dioxide are mixed from the atmosphere into a thick layer of water that ultimately spreads southward to fill a large volume of the North Atlantic and beyond. The presence of this water mass prevents the North Atlantic anywhere from becoming completely devoid of oxygen. Vertical mixing in the Labrador Sea also redistributes carbon dioxide into the deep ocean, where it can remain for hundreds of years, preventing it from contributing to the greenhouse effect. Yet, the processes governing the uptake of gases by the ocean are not well understood or quantified. Given that, over the last century, the ocean has become steadily more depleted in oxygen while also absorbing a large fraction of anthropogenic carbon dioxide, observing gas exchange processes is essential for understanding and predicting the evolution of the ocean and climate system. The circulation of the Labrador Sea has been monitored since 2014 with an array of instrumented cables extending from the seafloor to nearly the ocean surface. This project adds gas sensors to this array to investigate the rates and processes governing gas exchange. Through this project, a student and postdoc will be trained in interdisciplinary oceanography with a rich network of international collaborators. Responding to the need to increase public ocean literacy, the project scientists will work with University of Rhode Island's Inner Space Center to broadcast live, interactive science sessions to educators at partner high schools and will follow-up with in-person science cafés at three participating schools.

Given the unique role of the Labrador Sea in providing a pathway for oxygen (O2) and carbon dioxide (CO2) to enter the intermediate depths of the ocean, a quantification and mechanistic understanding of the gas uptake and transport in the basin is a leading scientific priority. Oxygenation of Labrador Sea water prevents large-scale hypoxia from developing anywhere in the Atlantic Ocean and anthropogenic CO2 storage in the basin is the highest in the global ocean. The assumption that, in the Atlantic Ocean, O2 and CO2 uptake and their variability are tied to the dynamics of heat loss and the overturning circulation pervades the literature but has never been evaluated on the basis of direct observations. Thus, GOHSNAP (Gases in the Overturning and Horizontal circulation of the Subpolar North Atlantic Program) addresses this gap and the urgent need to better understand interactions between gas uptake, transport, and the overturning circulation. Specifically, this program will provide a continuous 2-year record of the trans-basin, full water column transport of O2 across the southern boundary of the Labrador Sea, leveraging the mooring infrastructure of the US-lead, international Overturning in the Subpolar North Atlantic Program (OSNAP). The addition of O2 sensors at various depths on this array, supplemented by observations collected by autonomous platforms will allow for the quantification of O2 export from the Labrador Sea. The data will further be used to empirically model carbon concentrations and estimate carbon export. Proposed instruments will also measure the mixed layer O2 and pCO2 for two winters, from which air-sea gas exchange will be calculated and compared against analogous observations in the convective interior of the Labrador Sea.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

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Funding

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