

Hydrographic Data: temperature, salinity, nutrients from Niskin bottle samples from R/V Thomas G. Thompson cruises in the Arabian Sea in 1995 (U.S. JGOFS Arabian Sea project)

Website: <https://www.bco-dmo.org/dataset/2528>

Data Type: Cruise Results

Version: October 28, 1996

Version Date: 1996-10-28

Project

» [U.S. JGOFS Arabian Sea](#) (Arabian Sea)

Program

» [U.S. Joint Global Ocean Flux Study](#) (U.S. JGOFS)

| Contributors | Affiliation | Role |
|--------------------------------------|--|---------------------------|
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Table of Contents

- [Dataset Description](#)
 - [Methods & Sampling](#)
 - [Data Processing Description](#)
- [Parameters](#)
- [Instruments](#)
- [Deployments](#)
- [Project Information](#)
- [Program Information](#)
- [Funding](#)

Dataset Description

Hydrographic Data: temp, salinity, nutrients from Niskin bottles

Methods & Sampling

See Platform deployments for cruise specific documentation

Final Corrections to Arabian Sea Niskin Bottle Data performed at US JGOFS DMO October 28, 1996

From: Lou Codispoti
Subject: Final Corrections

Dear JGOFS investigator, This is to inform you that some minor corrections were made to the JGOFS Arabian Sea nutrient data after the 1996 meeting in New Hampshire. It is doubtful that any of these corrections will alter any of your hypotheses, but they may have some significance in documenting changes over long periods

cause significant errors. Our calculations suggest that the maximum differences arising from our decision to not correct to an "in vacuo" basis would range from 0.02% (oxygen standards) to 0.06% (ammonium standards).

3) The protocols give one a choice of adjusting nutrient methods so that calibration curves are strictly linear, or opting for more response and taking into account non-linearities. We choose the latter method.

4) No corrections were made for "carryover" between nutrient samples run on the Technicon Autoanalyzer. Data from this cruise, suggest that carryover effects in our nutrient analyses are generally less than ~2% of the concentration difference between adjacent samples. Examination of cases where more than one sample was taken from a depth at which there was a significant increase in nutrient concentrations will help the user determine the carryover effect for many individual casts.

5) Calibration and re-calibration of volumetric ware were not exactly as described in the JGOFS protocols, but this was largely compensated for by comparing independent standards diluted with independent volumetric ware, and by re-calibration of some of the volumetric ware after cruises TN045 and TN050. WE HAVE NOT YET RECALIBRATED THE VOLUMETRIC WARE USED DURING TN053. WE WILL UPDATE THE DATA IF RECALIBRATION SUGGESTS A NEED TO DO THIS, BUT WE DO NOT EXPECT SIGNIFICANT CHANGES

6) Duplicate oxygen samples were not drawn from every Niskin or Go-Flo bottle, but there were several comparisons of bottles tripped at the same depth.

7) Azide was added to the Winkler oxygen pickling reagents to destroy nitrite that can be present in relatively high concentrations in the Arabian Sea. ON LEGS PRIOR TO TN053, OXYGEN STANDARDIZATIONS WERE RUN USING REAGENTS THAT DID NOT CONTAIN AZIDE, BUT DISCUSSIONS AND TESTS SUGGESTED THAT IT WOULD BE BETTER TO STANDARDIZE WITH AZIDE, DESPITE SOME CONFUSION IN THE LITERATURE ON THIS MATTER. CONSEQUENTLY, WE SWITCHED PROCEDURES BEGINNING WITH LEG TN053 AND USED REAGENTS CONTAINING AZIDE TO STANDARDIZE. OUR TESTS SUGGEST THAT THE MAXIMUM CHANGE IN OXYGEN CONCENTRATIONS ARISING FROM THIS CHANGE WOULD OCCUR AT THE HIGHEST OXYGEN CONCENTRATIONS AND BE $< \sim 0.01$ ML/L.

Temperature:

The temperature data associated with each bottle depth were taken by the CTD system during the bottle tripping process. Consult the companion CTD data report for this cruise to learn more about the CTD system.

Sampling:

The samples in this report were taken from 10 liter Niskin bottles.

Because there is little or no lag time between triggering a bottle and bottle closure with the new SeaBird rosette systems, bottles were generally held at the sampling depth for at least 30 seconds before tripping or until the deck read-outs stabilized if this took more than 30 seconds.

NOTE THAT THE MID-POINT OF THE SAMPLING BOTTLES WAS ONE METER ABOVE THE CTD SENSORS. THE DATA HAVE NOT BEEN CORRECTED FOR THIS ONE METER OR 1.01 DECIBAR DIFFERENCE BETWEEN CTD SENSOR AND SAMPLING BOTTLE POSITIONS.

Salinity:

Salinities were determined with Guildline Autosol salinometers. New vials of standard sea-water were used to standardize before and at the end of every run. Agreement between bottle salinities and the recently calibrated sensors on the Sea Bird CTD systems was usually better than 0.02 (except in regions of strong gradients) before post-cruise data processing which employs the bottle salinities to correct the CTD salinities. More information on the quality of the salinity data are

given in the companion CTD report. Both the CTD salinity data at the time of bottle tripping and the salinities run on the Niskin bottle samples with an Autosal salinometer are reported here.

Dissolved oxygen:

The Winkler dissolved oxygen set-up was built and supplied by the SIO/ODF group. This system is computer controlled and detects the end-point photometrically. Temperature of the thiosulfate and standard solutions is automatically monitored by this system. Checks on cruises TN039 and TN043 between independent standards prepared with independent volumetric ware gave agreement of ± 0.02 per cent. A similar check made during TN054 suggested agreement of better than ± 0.15 per cent. The linearity of the "Dosimat" automatic buret was also checked during cruises TN043 and TN054 with good results.

Nutrients:

Note that the terminology used to describe nutrients has become somewhat loose over the years and that silicate=silicic acid, and phosphate=reactive phosphorus.

Nutrient analyses were performed on a 5-channel Technicon II AA system that was modified and provided by the SIO/ODF group.

In assessing the nutrient standard comparisons outlined below, note that the full-scale ranges for nutrients were as follows:

Ammonium =0 to 5 micromolar

Nitrate =0 to 45 "

Nitrite =0 to 5 "

Phosphate =0 to 3.6"

Silicate =0 to 180 "

These ranges were arrived at after an Internet poll of PI's and were selected to cover the full depth concentration range for the Arabian Sea. Since, we found nitrite concentrations that exceeded 5 micromolar on several occasions, the nitrite concentration range was expanded to 0-7 micromolar on leg TN050.

On the set-up and calibration cruise (TN039), the SIO/ODF nitrate and nitrite standards and standards from the National Institute of Oceanography in India (provided by S.W.A. Naqvi) were compared with the following results:

NIO Nitrate Std.= 22.6 micromolar; SIO/ODF=22.5 micromolar

NIO Nitrite Std.= 2.42 micromolar; SIO/ODF = 2.50 micromolar

As can be inferred from the above, the nitrate plus nitrite values were almost identical in the mixed standards;

25.02 (NIO) vs 25.00 (SIO)micromolar.

On TN039, Lou Codispoti prepared independent primary nitrate, nitrite, silicate and phosphate standards for comparison with SIO/ODF primary standards and made dilutions using glassware entirely independent of the SIO/ODF glassware.

The results were as follows:

| | Codispoti | SIO/ODF |
|-----------|------------------|------------------|
| Nitrate | 26.96 micromolar | 26.85 micromolar |
| Nitrite | 2.90 " | 2.86 " |
| Silicate | 86.4 " | 85.8 " |
| Phosphate | 2.36 " | 2.36 " |

On TN043, the volumetric equipment used for making routine nitrate and phosphate standards was checked against volumetric ware calibrated by LAC. The average difference between these comparisons of mid-range standards was + or - 0.2% for phosphate and + or -0.4% for nitrate.

Because nitrite values in the suboxic waters of the Arabian Sea can

attain values of approximately 6.5 micromolar and because our routine standards contained 22.5 micromoles of nitrate and 2.5 micromoles of nitrite, we kept track of the efficiency of the Cd column that reduces nitrate to nitrite in the nitrate analysis. The efficiencies were all greater than 97.7%, except for station 10 (TN053010xx). Nitrate data are not reported for casts TN05301001 to TN05301008 because of problems with the cadmium reduction column. For the remaining casts at this station, the Cd column efficiency was ~96.4%. No corrections have been made for any errors in nitrate arising from deviations in cadmium column efficiency. NOTE THAT THE FULL-SCALE NITRITE RANGE FOR THIS CRUISE WAS 7 MICROMOLAR.

The ammonium results are the least precise of all the nutrient results. On TN039, three primary standards were compared with agreement of about plus or minus three per cent of the full-scale (5.0 micromolar) value. These standards may have agreed within the precision of the method, but we found a significant salinity effect on the ammonium results that might explain some of these differences since the salinities of the comparison standards varied a bit. Experiments on the first JGOFS Arabian Sea process study cruise (TN043) suggested that the ammonium signal decreases by approximately 3.5% for a salinity increase of 1.00. Comparisons of an independent standard compared by LAC with the SIO standard on this cruise (TN043) when corrected for salinity differences between the standards agreed to ~ + -0.1% of the full-scale value. The largest absolute difference was 0.025 micromolar and the average difference was 0.013 micromolar for six comparisons between 1-3 micromolar. Thus, the average difference between these two independent standards was + -0.006 micromolar. Comparisons of independent high concentration ammonium standards (~2.5 and 5.0 micromolar) prepared by LAC with SIO standards during TN054 agreed to better than + - 1% for four out of the five standards when corrected for a salinity effect of 4.5%/1.00S on that cruise. One standard agreed to only + - 2.5%, but we assume that this was due to a dilution error. We believe that the suite of ammonium comparisons suggests no systematic differences arising from standards and dilutions, as all of the differences are within the precision of the ammonium analysis. Our results tend to confirm the need to take salinity differences between samples and standards into account when calculating the final ammonium concentrations. THE AMMONIUM VALUES IN THIS REPORT HAVE BEEN CORRECTED FOR THIS EFFECT. ON THE TN053 CRUISE THE SALINITY EFFECT CORRECTION IS A 3% DECREASE IN SIGNAL FOR A SALINITY INCREASE OF 1.00. The average salinity of the working standards used to calibrate the ammonium method was ~34.35 for stations TN053001-TN053012 (inclusive) and ~34.96 for the remainder of the stations. The ammonium method has additional problems, such as contamination of "baseline" water etc. These problems can introduce inaccuracies on the order 0.1 micromolar, so differences in ammonium concentrations of less than ~ 0.1 micromolar should not be over-interpreted.

[[table of contents](#) | [back to top](#)]

Parameters

| Parameter | Description | Units |
|------------|--|---------------------|
| event | a unique number assigned to each sampling operation consisting of month MM, day DD and time TT.T | |
| sta | station number | |
| cast | CTD cast number | |
| date | date (YYYYMMDD) decoded as follows YYYY = year, MM = month, DD = day Date converted to UTC(GMT). | |
| time | time of day in UTC(GMT) | decimal hours |
| lat | latitude (negative = South) | decimal degrees |
| lon | longitude (negative = West) | decimal degrees |
| bot | CTD rosette bottle number | |
| press | sample depth reported as pressure | decibars |
| temp | temperature, taken from CTD, IPTS-68 | degrees C |
| sal_bot | bottle salinity (Autosal; PSU) | dimensionless |
| O2_ml_L | oxygen (Winkler) | milliliters/liter |
| O2_umol_kg | oxygen (Winkler) | micromoles/kilogram |
| O2_umol_L | oxygen (Winkler) | micromoles/liter |
| O2_4 | oxygen (colorimetric) | milliliters/liter |
| NO3 | nitrate | micromoles/liter |
| PO4 | phosphate (reactive phosphorus) | micromoles/liter |
| SiO4 | silicate (silicic acid/reactive silica) | micromoles/liter |
| NO2 | nitrite | micromoles/liter |
| NH4 | ammonium | micromoles/liter |
| sta_std | Arabian Sea standard station identifier | |
| time_begin | start time of cast in UTC(GMT) | decimal hours |
| time_end | end time of cast in UTC(GMT) | decimal hours |
| lat_begin | start latitude of cast (negative = South) | decimal degrees |
| lon_begin | start longitude of cast (negative = West) | decimal degrees |
| lat_end | end latitude of cast | decimal degrees |
| lon_end | end longitude of cast | decimal degrees |
| depth | depth calculated from pressure | meters |
| sal_ctd | CTD salinity (PSS-78) when bottle tripped | dimensionless |

[[table of contents](#) | [back to top](#)]

Instruments

| | |
|---|---|
| Dataset-specific Instrument Name | Niskin Bottle |
| Generic Instrument Name | Niskin bottle |
| Dataset-specific Description | 10-liter Niskin type bottle |
| 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. |

[[table of contents](#) | [back to top](#)]

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 |
| | <p>Purpose: Process Cruise #1 (Late NE Monsoon)</p> <p>Methods & Sampling</p> <p>PI: Lou Codispoti of: Old Dominion University dataset: Temp, salinity, nutrients from Niskin bottles 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/TTN043 - Process Cruise 1 (Late NE Monsoon) ship: Thomas Thompson Final Corrections performed at US JGOFS DMO October 28, 1996 From: Lou Codispoti Subject: Final Corrections Dear JGOFS investigator, This is to inform you that some minor corrections were made to the JGOFS Arabian Sea nutrient data after the 1996 meeting in New Hampshire. It is doubtful that any of these corrections will alter any of your hypotheses, but they may have some significance in documenting changes over long periods of time, and in WOCE-style investigations. The need for these corrections arose, as a consequence of post-cruise re-calibration of pipets, and because we did not properly account for the nutrient content of our low nutrient sea-water. The corrections have already been applied to the US JGOFS Arabian Sea nutrient data collected with the hydrographic rosette, by personnel at WHOI who maintain the US JGOFS data. I list them here for your information. 1) All ammonium and nitrite data from Thompson leg TN053 were multiplied by 0.997. 2) All ammonium and nitrite data from ALL US JGOFS Arabian Sea cruises (TN039, 043, 045, 049, 050, 053 and 054) were multiplied by 0.995. 3) ALL phosphate data from ALL US JGOFS Arabian Sea cruises (TN039, 043, 045, 049, 050, 053 and 054) were multiplied by 0.992. Corrections 2) and 3) should probably be applied to the ONR data as well, but I will leave this up to Burt Jones, as I am not exactly sure how he did his standardizations. Basically, corrections 2) and 3) arise from a failure to take into account dilution of the Low Nutrient Sea Water signal by standards in cases where the LNSW contains appreciable quantities of nutrients. The above corrections are pretty minor within the scheme of nutrient analyses, but we should always attempt to eliminate such systematic errors. George and Chris have made these corrections on the US JGOFS Arabian Sea nutrient data collected from the hydrographic rosette. Trace metal rosette data and experimental data have not yet been corrected. Cheers, Lou Codispoti -- +-----+-----+-----+ Louis Codispoti Center for Coastal Physical Oceanography Research Professor Old Dominion</p> |

Description

dissolved oxygen and nutrients were not adjusted to an "in vacuo" basis as suggested in the protocols. It is unlikely that this departure from procedure would cause significant errors. Our calculations suggest that the maximum differences arising from our decision to not correct to an "in vacuo" basis would range from 0.02% (oxygen standards) to 0.06% (ammonium standards). 3) The protocols give one a choice of adjusting nutrient methods so that calibration curves are strictly linear, or opting for more response and taking into account non-linearities. We choose the latter method. 4) No corrections were made for "carryover" between nutrient samples run on the Technicon Autoanalyzer. Data from this cruise suggest that carryover effects in our nutrient analyses are generally less than 2% of the concentration difference between adjacent samples. When cases of a larger carryover effect could be determined, they are noted in the cast specific comments. Examination of cases where more than one sample was taken from a depth at which there was a significant increase in nutrient concentrations will help the user determine the carryover effect for many individual casts. 5) Calibration and re-calibration of volumetric ware were not exactly as described in the JGOFS protocols, but this was largely compensated for by comparing independent standards diluted with independent volumetric ware, and by re-calibration of some of the volumetric ware after cruise TN045. 6) Duplicate oxygen samples were not drawn from every Niskin or Go-Flo bottle, but there were several comparisons of bottles tripped at the same depth. 7) Azide was added to the Winkler oxygen pickling reagents to destroy nitrite that can be present in relatively high concentrations in the Arabian Sea. Temperature: The temperature data associated with each bottle depth were taken by the CTD system during the bottle tripping process. Consult the companion CTD data report for this cruise to learn more about the CTD system. Sampling: The samples in this report were taken from 10 liter Niskin bottles. Because there is little or no lag time between triggering a bottle and bottle closure with the new SeaBird rosette systems, bottles were generally held at the sampling depth for at least 20 seconds before tripping. This value was based on data obtained during TN039 when the rosette was equipped with fewer electronic packages. During this cruise (TN043), a decision was made to increase soak times to 30 seconds or until the deck read-outs stabilized because differences between bottle salinities and the values obtained by the CTD when the bottles were tripped were, in some cases, larger than anticipated. The bottles were probably flushing relatively rapidly but it was noted that the companion CTD data sometimes continued to change for periods longer than 20 seconds. This was probably because of the additional equipment mounted near the CTD sensors during TN043. This equipment can act as a heat source/sink and interfere with flushing and equilibration of the CTD sensors on the up cast. This adjustment was made approximately mid-way through TN043. Whether 20 second soak times were the cause of some of the differences has not been determined. The cast specific comments notes those instances where agreement between bottle and CTD salinities was greater than expected. NOTE THAT THE MID-POINT OF THE SAMPLING BOTTLES WAS ONE METER ABOVE THE CTD SENSORS. THE DATA HAVE NOT BEEN CORRECTED FOR THIS ONE METER OR 1.1 DECIBAR DIFFERENCE BETWEEN CTD SENSOR AND SAMPLING BOTTLE POSITIONS. Salinity: Salinities were run on almost every bottle sample with new vials of standard sea-water used before and at the end of every run (12-36 samples). Agreement between bottle salinities and the recently calibrated sensors on the Sea Bird CTD systems was usually better than 0.01 except in regions of strong gradients and in the cases that have been noted above and mentioned in the headers for individual casts. More information on the quality of the salinity data are given in the companion CTD report. Dissolved oxygen: The Winkler dissolved oxygen set-up was built and supplied by the SIO/ODF group. This system is computer controlled and detects the end-point photometrically. Temperature of the thiosulfate and standard solutions is automatically monitored by this system. An independent "Sagami" standard was compared with a SIO/ODF primary standard. The agreement between these standards was ± 0.02 per cent. These standards were made up at sea with independent volumetric ware. The linearity of the "Dosimat" automatic buret was also checked during this cruise. NOTE THAT THE TWO LAST DECIMAL PLACES ARE MEANINGLESS IN THE COLUMNS THAT EXPRESS DISSOLVED OXYGEN IN mM and in mM/kg. Nutrients: Note that the terminology used to describe nutrients has become somewhat loose over the years and that silicate=silicic acid, and phosphate=reactive phosphorus. Nutrient analyses were performed on a 5-channel Technicon II AA system that was modified and provided by the SIO/ODF group. In assessing the nutrient standard comparisons outlined below, note that the full-scale ranges for nutrients were as follows: Ammonium =0 to 5 micromolar Nitrate =0 to 45 " Nitrite =0 to 5 " Phosphate =0 to 3.6" Silicate =0 to 180 " These ranges were arrived at after an Internet pole of PIs and cover the full depth concentration range for the Arabian Sea. On the set-up and calibration cruise (TN039), the SIO/ODF nitrate and nitrite standards and standards from the National Institute of Oceanography in India (provided by S.W.A. Naqvi) were compared with the following results:

NIO Nitrate Std.= 22.6 micromolar; SIO/ODF= 22.5 micromolar NIO Nitrite Std.= 2.42 micromolar; SIO/ODF = 2.50 micromolar As can be inferred from the above, the nitrate plus nitrite values were almost identical in the mixed standards; 25.02 (NIO) vs 25.00 (SIO) micromolar. On TN039 Lou Codispoti prepared independent primary nitrate, nitrite, silicate and phosphate standards with SIO/ODF primary standards, and made dilutions using glassware entirely independent of the SIO/ODF glassware. The results were as follows: Codispoti SIO/ODF Nitrate 26.96 micromolar 26.85 micromolar Nitrite 2.90 " 2.86 " Silicate 86.4 " 85.8 " Phosphate 2.36 " 2.36 " All of the above results are within plus or minus 0.5% of the full scale values, and with the exception of nitrite, the rest are within plus or minus 0.2% of the full scale values. On TN043 the volumetric equipment used for making routine nitrate and phosphate standards was checked against volumetric ware calibrated by LAC. The average of the results agreed to within +0.1% of the full scale value for phosphate and +0.2% of the full scale value for nitrate. The three Eppendorf maxipettors used to make the routine standard dilutions were calibrated at Old Dominion University after cruise TN045. For the three maxipettors and three tips that were returned for re-calibration, the largest departure from the nominal values was 0.5% at 2.50 ml. For the 5.00ml range, used to make the working standards, the "worst" of these maxipettors (with its companion tip) was "off" by 0.2%, and the agreement between dialed and calibrated values for all three instruments/tips was better than 0.1% at the 7.50 and 10.00 ml settings. The 2.50, 7.50 and 10.00 ml settings were used for weekly determinations of the linearity of each nutrient analysis. Because nitrite values in the suboxic waters of the Arabian Sea can attain values of approximately 5 micromolar, we kept track of the efficiency of the Cd column that reduces nitrate to nitrite in the nitrate analysis towards the end of the cruise. The efficiencies were all greater than 96.7% and frequently close to 100%. Corrections have been made that should reduce any errors in nitrate arising from deviations in cadmium column efficiency to less than 0.1 micromolar in nitrite even for cases where nitrite concentrations concentrations were maximal and Cd column efficiencies were minimal. The ammonium results are the least precise of all the nutrient results. On TN039 three primary standards were compared with agreement of about plus or minus three per cent of the full-scale value. These standards may have agreed within the precision of the method, but we found a significant salinity effect on the ammonium results that might explain some of these differences since the salinities of the comparison standards varied a bit. Experiments on this first JGOFS Arabian Sea process study cruise (TN043) suggest that the ammonium signal decreases by approximately 3.5% for a salinity increase of 1.00. Comparisons of an independent standard compared by LAC with the SIO standard on this cruise (TN043) when corrected for salinity differences between the standards agreed to ~ + -0.1% of the full-scale value. The largest absolute difference was 0.025 micromolar and the average difference was 0.013 micromolar for six comparisons between 1-3 micromolar. Thus, the average difference between these two independent standards was + -0.006 micromolar. These results tend to confirm the need to take salinity differences between samples and standards into account when calculating the final ammonium concentrations. THE AMMONIUM VALUES IN THIS REPORT HAVE BEEN CORRECTED FOR THIS EFFECT.

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 | <p>PI: Lou Codispoti (Old Dominion University) dataset: Temp, salinity, nutrients from Niskin bottles dates: March 14, 1995 to April 08, 1995 location: N: 22.4858 S: 9.9993 W: 57.3007 E: 68.7532 project/cruise: Arabian Sea/TTN045 - Process Cruise 2 (Spring Intermonsoon) ship: Thomas Thompson Cast specific comments, quality assessment, analytical methods as prepared by L. Codispoti FOR THE HYDROGRAPHIC BOTTLE DATA L.A. Codispoti (lou@ccpo.odu.edu) Old Dominion University, November 1995 General Comments: This "readme" file pertains to the salinity, dissolved oxygen, and nutrient data taken from sampling bottles with the hydrographic rosette that was typically equipped with 24 10-liter Niskin type bottles during RV T.G. Thompson cruise TN045. This cruise was the second JGOFS Arabian Sea Process Leg and took place during March-April 1995. Dr. John Marra of the Lamont Doherty</p> |

Earth Observatory (marra@ldeo.columbia.edu) was the chief scientist. DATA TAKEN WITH THE CLEAN ROSETTE USED FOR OBTAINING PRIMARY PRODUCTION AND OTHER TYPES OF BIOLOGICAL SAMPLES ARE NOT INCLUDED IN THIS REPORT. Some questionable data are not included in this report. These data are still retained in files at Old Dominion University, and are available upon request. No units are given for salinity in this report because the most recent definitions of salinity define it as a dimensionless number. To accommodate every preference, Winkler oxygen values are reported in ml/l, micromolar and micromoles per kg. The latter values can only be calculated with a knowledge of the oxygen sample temperatures when the samples were drawn. These "draw temperatures" are not reported here, but can be obtained by contacting lou@ccpo.odu.edu. Nutrient values are reported in micromolar. They can be converted to micromoles per kg, by combining lab. temperature on the Thompson (approx. 23.5 deg C) and the salinity of the sample to compute density and then dividing the value in micromolal by this number. Final Corrections performed at US JGOFS DMO October 28, 1996 From: Lou Codispoti Subject: Final Corrections Dear JGOFS investigator, This is to inform you that some minor corrections were made to the JGOFS Arabian Sea nutrient data after the 1996 meeting in New Hampshire. It is doubtful that any of these corrections will alter any of your hypotheses, but they may have some significance in documenting changes over long periods of time, and in WOCE-style investigations. The need for these corrections arose, as a consequence of post-cruise re-calibration of pipets, and because we did not properly account for the nutrient content of our low nutrient sea-water. The corrections have already been applied to the US JGOFS Arabian Sea nutrient data collected with the hydrographic rosette, by personnel at WHOI who maintain the US JGOFS data. I list them here for your information. 1) All ammonium and nitrite data from Thompson leg TN053 were multiplied by 0.997. 2) All ammonium and nitrite data from ALL US JGOFS Arabian Sea cruises (TN039, 043, 045, 049, 050, 053 and 054) were multiplied by 0.995. 3) ALL phosphate data from ALL US JGOFS Arabian Sea cruises (TN039, 043, 045, 049, 050, 053 and 054) were multiplied by 0.992. Corrections 2) and 3) should probably be applied to the ONR data as well, but I will leave this up to Burt Jones, as I am not exactly sure how he did his standardizations. Basically, corrections 2) and 3) arise from a failure to take into account dilution of the Low Nutrient Sea Water signal by standards in cases where the LNSW contains appreciable quantities of nutrients. The above corrections are pretty minor within the scheme of nutrient analyses, but we should always attempt to eliminate such systematic errors. George and Chris have made these corrections on the US JGOFS Arabian Sea nutrient data collected from the hydrographic rosette. Trace metal rosette data and experimental data have not yet been corrected. Cheers,

Lou Codispoti -- +-----+-----+-----+ | Louis
 Codispoti | Center for Coastal Physical Oceanography | | Research Professor | Old Dominion
 University | | lou@ccpo.odu.edu | Norfolk Virginia, 23529 USA | | <http://www.ccpo.odu.edu/> |
 PH: 804-683-5770 FAX: 804-683-5550 | +-----+-----+-----+

-----+ The depth values in the bottle file have been calculated from pressure using the algorithm below. The US JGOFS Data Management Office is the source of the calculations. The latitude used in computation was the lat_begin of the bottle file. The CHECKVALUE was used to verify the accuracy of the computation. The stated accuracy of this algorithm is 0.1 meters Thanks to Edward Peltzer (MBARI) for supplying the algorithm and for discussions regarding the computation. function DEPTH=depth(P,LAT); DEPTH Computes depth given the pressure at some latitude D=DEPTH(P,LAT) gives the depth D (m) for a pressure P (dbars) at some latitude LAT (degrees). Fofonoff and Millard (1982). UNESCO Tech Paper #44. Notes: (ETP3, MBARI) This algorithm was originally compiled by RP @ WHOI. It was copied from the UNESCO technical report. The algorithm was endorsed by SCOR Working Group 51. The equations were originally developed by Saunders and Fofonoff (1976). DSR 23: 109-111. The parameters were re-fit for the 1980 equation of state for seawater (EOS80). CHECKVALUE: D=9712.653 M FOR P=10000 DECIBARS, LAT=30 DEG CALCULATION ASSUMES STD OCEAN: T = 0 DEG C; S = 35 (IPSS-78) X = sin(LAT/57.29578); X' = X*X; GR = GRAVITY VARIATION WITH LAT: ANON (1970) BULLETIN GEODESIQUE GR = 9.780318*(1.0+(5.2788E-3+2.36E-5*X')*X') + 1.092E-6*P D = DEPTH BEFORE GRAVITY CORRECTION D = (((-1.82E-15*P+2.279E-10)*P-2.2512E-5)*P+9.72659)*P DEPTH = D/GR

Processing Description

Methods: In general, the methods employed for the bottle salinity, Winkler dissolved oxygen, and nutrient analyses did not differ significantly from those described in the JGOFS protocols that were distributed in June, 1994. Minor differences included the following: 1) Sea Bird CTD systems and bottle carousels were employed (SBE- 9+ underwater units, SBE-11 deck units, SBE-32 carousels). These units represent a newer generation of equipment than the units described in the JGOFS protocols. 2) The weights of the salts used for primary standards for

Description

dissolved oxygen and nutrients were not adjusted to an "in vacuo" basis as suggested in the protocols. It is unlikely that this departure from procedure would cause significant errors. Our calculations suggest that the maximum differences arising from our decision to not correct to an "in vacuo" basis would range from 0.02% (oxygen standards) to 0.06% (ammonium standards). 3) The protocols give one a choice of adjusting nutrient methods so that calibration curves are strictly linear, or opting for more response and taking into account non-linearities. We choose the latter method. 4) No corrections were made for "carryover" between nutrient samples run on the Technicon Autoanalyzer. Data from this cruise, suggest that carryover effects in our nutrient analyses are generally less than ~2% of the concentration difference between adjacent samples. Examination of cases where more than one sample was taken from a depth at which there was a significant increase in nutrient concentrations will help the user determine the carryover effect for many individual casts. 5) Calibration and re-calibration of volumetric ware were not exactly as described in the JGOFS protocols, but this was largely compensated for by comparing independent standards diluted with independent volumetric ware, and by re-calibration of some of the volumetric ware after cruises TN045 and TN050. DATA FOR THIS CRUISE (TN045) HAVE BEEN CORRECTED FOR ERRORS IN THE PIPETS BY MULTIPLYING THE NITRATE AND PHOSPHATE VALUES BY 0.998, THE SILICATE VALUES BY 0.999, THE NITRITE VALUES BY 1.004 AND THE AMMONIUM VALUES BY 1.003. 6) Duplicate oxygen samples were not drawn from every Niskin or Go-Flo bottle, but there were several comparisons of bottles tripped at the same depth. 7) Azide was added to the Winkler oxygen pickling reagents to destroy nitrite that can be present in relatively high concentrations in the Arabian Sea. Pressure: There was a change in pressure sensors during this cruise: Station 04500101 --- Station 04501003 used SeaBird Pressure Sensor 34901 Station 04501101 --- Station 04503002 used SeaBird Pressure Sensor 43434 It turns out that Sensor 43434 had a pressure hysteresis problem. This problem appears to be linear. In order to correct the upcast pressures, the following method was used: 1. A nominal "surface" pressure was computed for the CTD using the mean surface pressure for the previous cruise which was 2.2 db +/- 1.0 db. (If we do this for the first 10 stations on TN045, the comparable value was 2.3 +/- 1.0 db). We assume that this is the nominal surface pressure reading from the pressure sensor when the CTD package is just below the surface of the water. 2. Also, the pressure offset for the deepest station (04501311) was 7.4 meters and the station depth was 4300 meters. When we look at the pressure offsets for all of the stations, they linearly increase as a function of maximum station depth, with a slope of .0017 (for example for station 04501311 the offset was -7.2 meters). 3. This correction was applied in the following manner: Corrected Pres = (Max Pres for Station - Original Bottle Pres) * .017 + Original Bottle Pres 4. Using this method, the accuracy of the corrected pressure is on the order of +/- 1 db. John M. Morrison Dept of Marine, Earth and Atmospheric Sciences North Carolina State University 1125 Jordan Hall --- Box 8208 Raleigh, NC 27695 - 8208 Phone: (919) 515-7449 Fax: (919) 515-7802 Email: John.Morrison@NCSSU.EDU Temperature: The temperature data associated with each bottle depth were taken by the CTD system during the bottle tripping process. Consult the companion CTD data report for this cruise to learn more about the CTD system. Sampling: The samples in this report were taken from 10 liter Niskin bottles. Because there is little or no lag time between triggering a bottle and bottle closure with the new SeaBird rosette systems, bottles were generally held at the sampling depth for at least 30 seconds before tripping or until the deck read-outs stabilized if this took more than 30 seconds. NOTE THAT THE MID-POINT OF THE SAMPLING BOTTLES WAS ONE METER ABOVE THE CTD SENSORS. THE DATA HAVE NOT BEEN CORRECTED FOR THIS ONE METER OR 1.1 DECIBAR DIFFERENCE BETWEEN CTD SENSOR AND SAMPLING BOTTLE POSITIONS. Salinity: Salinities were run on almost every bottle sample with new vials of standard sea-water used before and at the end of every run (12-36 samples). Agreement between bottle salinities and the recently calibrated sensors on the Sea Bird CTD systems was usually better than 0.01 except in regions of strong gradients. More information on the quality of the salinity data are given in the companion CTD report. Both the CTD salinity data at the time of bottle tripping and the salinities run on the Niskin bottle samples with an Autosol salinometer are reported here. Dissolved oxygen: The Winkler dissolved oxygen set-up was built and supplied by the SIO/ODF group. This system is computer controlled and detects the end-point photometrically. Temperature of the thiosulfate and standard solutions is automatically monitored by this system. Checks on cruises TN039 and TN043 between independent standards prepared with independent volumetric ware gave agreement of +/-0.02 per cent. The linearity of the "Dosimat" automatic buret was also checked during cruise TN043. Nutrients: Note that the terminology used to describe nutrients has become somewhat loose over the years and that silicate=silicic acid, and phosphate=reactive phosphorus. Nutrient analyses were performed on a 5-channel Technicon II AA system that was modified and provided by the SIO/ODF group. In assessing the nutrient standard

comparisons outlined below, note that the full-scale ranges for nutrients were as follows: Ammonium =0 to 5 micromolar Nitrate =0 to 45 " Nitrite =0 to 5 " Phosphate =0 to 3.6" Silicate =0 to 180 " These ranges were arrived at after an Internet pole of PI's and cover the full depth concentration range for the Arabian Sea. On the set-up and calibration cruise (TN039), the SIO/ODF nitrate and nitrite standards and standards from the National Institute of Oceanography in India (provided by S.W.A. Naqvi) were compared with the following results: NIO Nitrate Std.= 22.6 micromolar; SIO/ODF=22.5 micromolar NIO Nitrite Std.= 2.42 micromolar; SIO/ODF = 2.50 micromolar As can be inferred from the above, the nitrate plus nitrite values were almost identical in the mixed standards; 25.02 (NIO) vs 25.00 (SIO)micromolar. On TN039 Lou Codispoti prepared independent primary nitrate, nitrite, silicate and phosphate standards for comparison with SIO/ODF primary standards, and made dilutions using glassware entirely independent of the SIO/ODF glassware. The results were as follows: Codispoti SIO/ODF Nitrate 26.96 micromolar 26.85 micromolar Nitrite 2.90 " 2.86 " Silicate 86.4 " 85.8 " Phosphate 2.36 " 2.36 " All of the above results are within plus or minus 0.5% of the full scale values, and with the exception of nitrite, the rest are within plus or minus 0.2% of the full scale values. On TN043, the volumetric equipment used for making routine nitrate and phosphate standards was checked against volumetric ware calibrated by LAC. The average of the results agreed to within +/-0.1% of the full scale value for phosphate and +/-0.2% of the full scale value for nitrate. Because nitrite values in the suboxic waters of the Arabian Sea can attain values of approximately 5 micromolar, we kept track of the efficiency of the Cd column that reduces nitrate to nitrite in the nitrate analysis. The efficiencies were all greater than 98.8% and frequently close to 100%. Therefore, no corrections have been made for any errors in nitrate arising from deviations in cadmium column efficiency. NOTE THAT THE FULL-SCALE NITRITE RANGE FOR THIS CRUISE WAS 5 MICROMOLAR AND THAT SOME CONCENTRATIONS EXCEEDED THIS VALUE. IN THESE CASES, THE SAMPLES EITHER HAD TO BE DILUTED OR THE VOLTAGE RANGE CHANGED ON THE RECORDER. THESE MANIPULATIONS TEND TO DEGRADE THE ACCURACY OF NITRITE VALUES IN EXCESS OF 4.5 TO 5 MICROMOLAR. The ammonium results are the least precise of all the nutrient results. On TN039, three primary standards were compared with agreement of about plus or minus three per cent of the full-scale value. These standards may have agreed within the precision of the method, but we found a significant salinity effect on the ammonium results that might explain some of these differences since the salinities of the comparison standards varied a bit. Experiments on this first JGOFS Arabian Sea process study cruise (TN043) suggest that the ammonium signal decreases by approximately 3.5% for a salinity increase of 1.00. Comparisons of an independent standard compared by LAC with the SIO standard on this cruise (TN043) when corrected for salinity differences between the standards agreed to ~ +/-0.1% of the full-scale value. The largest absolute difference was 0.025 micromolar and the average difference was 0.013 micromolar for six comparisons between 1-3 micromolar. Thus, the average difference between these two independent standards was +/-0.006 micromolar. These results tend to confirm the need to take salinity differences between samples and standards into account when calculating the final ammonium concentrations. THE AMMONIUM VALUES IN THIS REPORT HAVE BEEN CORRECTED FOR THIS EFFECT. ON THIS CRUISE THE SALINITY EFFECT CORRECTION IS A 3.2% DECREASE IN SIGNAL FOR A SALINITY INCREASE OF 1.00. On this cruise, the salinity of the working standards used to calibrate the ammonium method was 34.39.

TT049

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| Website | https://www.bco-dmo.org/deployment/57710 |
| Platform | R/V Thomas G. Thompson |
| Start Date | 1995-07-17 |
| End Date | 1995-08-15 |
| | <p>Methods & Sampling PI: Lou Codispoti (Old Dominion University) dataset: Temp, salinity, nutrients from Niskin bottles 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/TTN049 - Process Cruise 4 (Middle SW Monsoon) ship: Thomas Thompson Cast specific comments, quality assessment, analytical methods as prepared by L. Codispoti JGOFS Arabian Sea Cruise TN049 FOR THE HYDROGRAPHIC BOTTLE DATA L.A. Codispoti (lou@ccpo.odu.edu) Old Dominion University, April 1996 General</p> |

Comments: This "readme" file pertains to the salinity, dissolved oxygen, and nutrient data taken from sampling bottles with the hydrographic rosette that was typically equipped with 24 10-liter Niskin type bottles during RV T.G. Thompson cruise TN049. This cruise was the third JGOFS Arabian Sea Process Leg and took place during July-August 1995. Prof. Richard T. Barber of the Duke University Marine Laboratory (rbarber@acpub.duke.edu) was the chief scientist. DATA TAKEN WITH THE CLEAN ROSETTE USED FOR OBTAINING PRIMARY PRODUCTION AND OTHER TYPES OF BIOLOGICAL SAMPLES ARE NOT INCLUDED IN THIS REPORT. NOTE THAT STATION 049027 WAS A "DRIFT STATION" THAT INCLUDES 21 INDIVIDUAL CTD CASTS THAT DIFFER IN POSITION BY MORE THAN 35 KM IN SOME CASES. Some questionable data are not included in this report. These data are still retained in files at Old Dominion University, and are available upon request. We note, in particular, that SIGNIFICANT PROBLEMS WERE ENCOUNTERED WITH THE PHOSPHATE ANALYSIS EQUIPMENT DURING THIS LEG, AND PHOSPHATE DATA FOR SEVERAL CASTS HAVE NOT BEEN INCLUDED WITH THIS SUBMISSION. These deleted phosphate values are probably good to about 5% or better and can be made available upon request. No units are given for salinity in this report because the most recent definitions of salinity define it as a dimensionless number. To accommodate every preference, Winkler oxygen values are reported in ml/l, micromolar and micromoles per kg. The latter values can only be calculated with a knowledge of the oxygen sample temperatures when the samples were drawn. These "draw temperatures" are not reported here, but can be obtained by contacting lou@ccpo.odu.edu. Nutrient values are reported in micromolar. They can be converted to micromoles per kg, by combining lab. temperature on the Thompson (approx. 24 deg C during this leg) and the salinity of the sample to compute density and then dividing the value in micromolar by this number. Final Corrections performed at US JGOFS DMO October 28, 1996 From: Lou Codispoti Subject: Final Corrections Dear JGOFS investigator, This is to inform you that some minor corrections were made to the JGOFS Arabian Sea nutrient data after the 1996 meeting in New Hampshire. It is doubtful that any of these corrections will alter any of your hypotheses, but they may have some significance in documenting changes over long periods of time, and in WOCE-style investigations. The need for these corrections arose, as a consequence of post-cruise re-calibration of pipets, and because we did not properly account for the nutrient content of our low nutrient sea-water. The corrections have already been applied to the US JGOFS Arabian Sea nutrient data collected with the hydrographic rosette, by personnel at WHOI who maintain the US JGOFS data. I list them here for your information. 1) All ammonium and nitrite data from Thompson leg TN053 were multiplied by 0.997. 2) All ammonium and nitrite data from ALL US JGOFS Arabian Sea cruises (TN039, 043, 045, 049, 050, 053 and 054) were multiplied by 0.995. 3) ALL phosphate data from ALL US JGOFS Arabian Sea cruises (TN039, 043, 045, 049, 050, 053 and 054) were multiplied by 0.992. Corrections 2) and 3) should probably be applied to the ONR data as well, but I will leave this up to Burt Jones, as I am not exactly sure how he did his standardizations. Basically, corrections 2) and 3) arise from a failure to take into account dilution of the Low Nutrient Sea Water signal by standards in cases where the LNSW contains appreciable quantities of nutrients. The above corrections are pretty minor within the scheme of nutrient analyses, but we should always attempt to eliminate such systematic errors. George and Chris have made these corrections on the US JGOFS Arabian Sea nutrient data collected from the hydrographic rosette. Trace metal rosette data and experimental data have not yet been corrected. Cheers, Lou Codispoti -- +-----+-----

+-----+ | Louis Codispoti | Center for Coastal Physical Oceanography | |
Research Professor | Old Dominion University | | lou@ccpo.odu.edu | Norfolk Virginia, 23529
USA | | <http://www.ccpo.odu.edu/> | PH: 804-683-5770 FAX: 804-683-5550 | +-----+-----

+-----+-----+ The depth values in the bottle file have been calculated from pressure using the algorithm below. The US JGOFS Data Management Office is the source of the calculations. The latitude used in computation was the lat_begin of the bottle file. The CHECKVALUE was used to verify the accuracy of the computation. The stated accuracy of this algorithm is 0.1 meters Thanks to Edward Peltzer (MBARI) for supplying the algorithm and for discussions regarding the computation. function DEPTH=depth(P,LAT); DEPTH Computes depth given the pressure at some latitude D=DEPTH(P,LAT) gives the depth D (m) for a pressure P (dbars) at some latitude LAT (degrees). Fofonoff and Millard (1982). UNESCO Tech Paper #44. Notes: (ETP3, MBARI) This algorithm was originally compiled by RP @ WHOI. It was copied from the UNESCO technical report. The algorithm was endorsed by SCOR Working Group 51. The equations were originally developed by Saunders and Fofonoff (1976). DSR 23: 109-111. The parameters were re-fit for the 1980 equation of state for seawater (EOS80). CHECKVALUE: D=9712.653 M FOR P=10000 DECIBARS, LAT=30 DEG CALCULATON ASSUMES STD OCEAN: T = 0 DEG C; S = 35 (IPSS-78) X = sin(LAT/57.29578); X' = X*X; GR = GRAVITY VARIATION WITH LAT: ANON (1970) BULLETIN GEODESIQUE GR =

$9.780318 \times (1.0 + (5.2788 \times 10^{-3} + 2.36 \times 10^{-5} \times X') \times X') + 1.092 \times 10^{-6} \times P$ D = DEPTH BEFORE GRAVITY CORRECTION
 $D = (((-1.82 \times 10^{-15} \times P + 2.279 \times 10^{-10}) \times P - 2.2512 \times 10^{-5}) \times P + 9.72659) \times P$ DEPTH = D/GR

Processing Description

Description

Methods: In general, the methods employed for the bottle salinity, Winkler dissolved oxygen, and nutrient analyses did not differ significantly from those described in the JGOFS protocols that were distributed in June, 1994. Minor differences included the following: 1) Sea Bird CTD systems and bottle carousels were employed (SBE- 9+ underwater units, SBE-11 deck units, SBE-32 carousels). These units represent a newer generation of equipment than the units described in the JGOFS protocols. 2) The weights of the salts used for primary standards for dissolved oxygen and nutrients were not adjusted to an "in vacuo" basis as suggested in the protocols. It is unlikely that this departure from procedure would cause significant errors. Our calculations suggest that the maximum differences arising from our decision to not correct to an "in vacuo" basis would range from 0.02% (oxygen standards) to 0.06% (ammonium standards). 3) The protocols give one a choice of adjusting nutrient methods so that calibration curves are strictly linear, or opting for more response and taking into account non-linearities. We choose the latter method. 4) No corrections were made for "carryover" between nutrient samples run on the Technicon Autoanalyzer. Data from this cruise, suggest that carryover effects in our nutrient analyses are generally less than ~2% of the concentration difference between adjacent samples. Examination of cases where more than one sample was taken from a depth at which there was a significant increase in nutrient concentrations will help the user determine the carryover effect for many individual casts. 5) Calibration and re-calibration of volumetric ware were not exactly as described in the JGOFS protocols, but this was largely compensated for by comparing independent standards diluted with independent volumetric ware, and by re-calibration of some of the volumetric ware after cruises TN045 and TN050. DATA FOR THIS CRUISE (TN049) HAVE BEEN CORRECTED FOR ERRORS IN THE PIPETS BY MULTIPLYING THE SILICATE VALUES BY 0.999. 6) Duplicate oxygen samples were not drawn from every Niskin or Go-Flo bottle, but there were several comparisons of bottles tripped at the same depth. 7) Azide was added to the Winkler oxygen pickling reagents to destroy nitrite that can be present in relatively high concentrations in the Arabian Sea.

Temperature: The temperature data associated with each bottle depth were taken by the CTD system during the bottle tripping process. Consult the companion CTD data report for this cruise to learn more about the CTD system. Sampling: The samples in this report were taken from 10 liter Niskin bottles. Because there is little or no lag time between triggering a bottle and bottle closure with the new SeaBird rosette systems, bottles were generally held at the sampling depth for at least 30 seconds before tripping or until the deck read-outs stabilized if this took more than 30 seconds. NOTE THAT THE MID-POINT OF THE SAMPLING BOTTLES WAS ONE METER ABOVE THE CTD SENSORS. THE DATA HAVE NOT BEEN CORRECTED FOR THIS ONE METER OR 1.1 DECIBAR DIFFERENCE BETWEEN CTD SENSOR AND SAMPLING BOTTLE POSITIONS.

Salinity: Salinities were determined with Guildline Autosol salinometers. New vials of standard sea-water were used to standardize before and at the end of every run (12-36 samples). Agreement between bottle salinities and the recently calibrated sensors on the Sea Bird CTD systems was usually better than 0.01 (except in regions of strong gradients) before post-cruise data processing which employs the bottle salinities to correct the CTD salinities. More information on the quality of the salinity data are given in the companion CTD report. Both the CTD salinity data at the time of bottle tripping and the salinities run on the Niskin bottle samples with an Autosol salinometer are reported here.

Dissolved oxygen: The Winkler dissolved oxygen set-up was built and supplied by the SIO/ODF group. This system is computer controlled and detects the end-point photometrically. Temperature of the thiosulfate and standard solutions is automatically monitored by this system. Checks on cruises TN039 and TN043 between independent standards prepared with independent volumetric ware gave agreement of +/-0.02 per cent. A similar check made during TN054 suggested agreement of +/-0.15 per cent. The linearity of the "Dosimat" automatic buret was also checked during cruises TN043 and TN054 with good results. Nutrients: Note that the terminology used to describe nutrients has become somewhat loose over the years and that silicate=silicic acid, and phosphate=reactive phosphorus. Nutrient analyses were performed on a 5-channel Technicon II AA system that was modified and provided by the SIO/ODF group. In assessing the nutrient standard comparisons outlined below, note that the full-scale ranges for nutrients were as follows: Ammonium =0 to 5 micromolar Nitrate =0 to 45 " Nitrite =0 to 5 " Phosphate =0 to 3.6" Silicate =0 to 180 " These ranges were arrived at after an Internet pole of PI's and cover the full depth concentration range for the Arabian Sea. On the set-up and calibration cruise (TN039), the SIO/ODF nitrate and nitrite standards and standards from the National Institute of Oceanography in India (provided by S.W.A. Naqvi) were compared with the

following results: NIO Nitrate Std.= 22.6 micromolar; SIO/ODF=22.5 micromolar NIO Nitrite Std.= 2.42 micromolar; SIO/ODF = 2.50 micromolar As can be inferred from the above, the nitrate plus nitrite values were almost identical in the mixed standards; 25.02 (NIO) vs 25.00 (SIO)micromolar. On TN039 Lou Codispoti prepared independent primary nitrate, nitrite, silicate and phosphate standards for comparison with SIO/ODF primary standards, and made dilutions using glassware entirely independent of the SIO/ODF glassware. The results were as follows: Codispoti SIO/ODF Nitrate 26.96 micromolar 26.85 micromolar Nitrite 2.90 " 2.86 " Silicate 86.4 " 85.8 " Phosphate 2.36 " 2.36 " All of the above results are within plus or minus 0.5% of the full scale values, and with the exception of nitrite, the rest are within plus or minus 0.2% of the full scale values. On TN043, the volumetric equipment used for making routine nitrate and phosphate standards was checked against volumetric ware calibrated by LAC. The average of the results agreed to within +/-0.1% of the full scale value for phosphate and +/-0.2% of the full scale value for nitrate. Because nitrite values in the suboxic waters of the Arabian Sea can attain values of approximately 5 micromolar, we kept track of the efficiency of the Cd column that reduces nitrate to nitrite in the nitrate analysis. The efficiencies were all greater than 99% during this cruise, so no corrections have been made for any errors in nitrate arising from deviations in cadmium column efficiency. NOTE THAT THE FULL-SCALE NITRITE RANGE FOR THIS CRUISE WAS 5 MICROMOLAR AND THAT SOME CONCENTRATIONS EXCEEDED THIS VALUE. IN THESE CASES, THE SAMPLES EITHER HAD TO BE DILUTED OR THE VOLTAGE RANGE CHANGED ON THE RECORDER. THESE MANIPULATIONS TEND TO DEGRADE THE ACCURACY OF NITRITE VALUES IN EXCESS OF 4.5 TO 5 MICROMOLAR. The ammonium results are the least precise of all the nutrient results. On TN039, three primary standards were compared with agreement of about plus or minus three per cent of the full-scale value. These standards may have agreed within the precision of the method, but we found a significant salinity effect on the ammonium results that might explain some of these differences since the salinities of the comparison standards varied a bit. Experiments on this first JGOFS Arabian Sea process study cruise (TN043) suggest that the ammonium signal decreases by approximately 3.5% for a salinity increase of 1.00. Comparisons of an independent standard compared by LAC with the SIO standard on this cruise (TN043) when corrected for salinity differences between the standards agreed to ~ +/-0.1% of the full-scale value. The largest absolute difference was 0.025 micromolar and the average difference was 0.013 micromolar for six comparisons between 1-3 micromolar. Thus, the average difference between these two independent standards was +/-0.006 micromolar. These results tend to confirm the need to take salinity differences between samples and standards into account when calculating the final ammonium concentrations. THE AMMONIUM VALUES IN THIS REPORT HAVE BEEN CORRECTED FOR THIS EFFECT. ON THIS CRUISE THE SALINITY EFFECT CORRECTION IS A 2.7% DECREASE IN SIGNAL FOR A SALINITY INCREASE OF 1.00. On this cruise, the salinity of the working standards used to calibrate the ammonium method was ~35.14.

TT050

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| Website | https://www.bco-dmo.org/deployment/57711 |
| Platform | R/V Thomas G. Thompson |
| Start Date | 1995-08-18 |
| End Date | 1995-09-15 |
| | <p>Methods & Sampling</p> <p>PI: Louis Codispoti (Old Dominion University) dataset: Temp, salinity, nutrients from Niskin bottles dates: August 18, 1995 to September 13, 1995 location: N: 22.4878 S: 9.919 W: 57.3004 E: 68.7494 project/cruise: Arabian Sea/TTN050 - Process Cruise 5 (Late SW Monsoon) ship: Thomas Thompson US JGOFS Arabian Sea Cruise TN050 HYDROGRAPHIC BOTTLE DATA L.A. Codispoti (lou@ccpo.odu.edu) Old Dominion University, June 1996 General Comments: This "readme" file pertains to the salinity, dissolved oxygen, and nutrient data taken from sampling bottles with the hydrographic rosette that was equipped with 24 10-liter Niskin type bottles during RV T.G. Thompson cruise TN050. This cruise was the fourth JGOFS Arabian Sea Process Leg and took place during Aug.-Sept. 1995. Prof. Sharon L. Smith of the University of Miami (ssmith@rsmas.miami.edu) was the chief scientist. NOTE THAT MULTIPLE CASTS WERE TAKEN AT MOST STATIONS AND THAT, IN SOME CASES, (WHEN FOLLOWING THE PRIMARY PRODUCTIVITY DROGUE, FOR EXAMPLE) THE GEOGRAPHIC POSITIONS OF CASTS AT THE SAME STATION CAN VARY BY MORE THAN 5 MILES. FOR EXAMPLE, CAST 9 AT STATION 7</p> |

(TN05000709) WAS MORE THAN 10 MILES AWAY FROM THE "STANDARD" POSITION. TN05002109 WAS MORE THAN 5 MI "OFF" AND TN002609 AND TN002610 WERE ABOUT 10 MI "OFF". Some questionable data are not included in this report. These data are still retained in files at Old Dominion University and are available upon request. No units are given for salinity in this report because the most recent definitions of salinity define it as a dimensionless number. To accommodate every preference, Winkler oxygen values are reported in ml/l, micromolar and micromoles per kg. The latter values can only be calculated with a knowledge of the oxygen sample temperatures when the samples were drawn. These "draw temperatures" are not reported here, but can be obtained by contacting lou@ccpo.odu.edu. Nutrient values are reported in micromolar. They can be converted to micromoles per kg, by combining laboratory temperature on the Thompson (approx. 24.5 deg C during this leg) and the salinity of the sample to compute density and then dividing the value in micromolar by this number. The depth values in the bottle file have been calculated from pressure using the algorithm below. The US JGOFS Data Management Office is the source of the calculations. The latitude used in computation was the lat_begin of the bottle file. The CHECKVALUE was used to verify the accuracy of the computation. The stated accuracy of this algorithm is 0.1 meters Thanks to Edward Peltzer (MBARI) for supplying the algorithm and for discussions regarding the computation. function DEPTH=depth(P,LAT); DEPTH Computes depth given the pressure at some latitude D=DEPTH(P,LAT) gives the depth D (m) for a pressure P (dbars) at some latitude LAT (degrees). Fofonoff and Millard (1982). UNESCO Tech Paper #44. Notes: (ETP3, MBARI) This algorithm was originally compiled by RP @ WHOI. It was copied from the UNESCO technical report. The algorithm was endorsed by SCOR Working Group 51. The equations were originally developed by Saunders and Fofonoff (1976). DSR 23: 109-111. The parameters were re-fit for the 1980 equation of state for seawater (EOS80). CHECKVALUE: D=9712.653 M FOR P=10000 DECIBARS, LAT=30 DEG CALCULATON ASSUMES STD OCEAN: T = 0 DEG C; S = 35 (IPSS-78) X = sin(LAT/57.29578); X' = X*X; GR = GRAVITY VARIATION WITH LAT: ANON (1970) BULLETIN GEODESIQUE GR = 9.780318*(1.0+(5.2788E-3+2.36E-5*X')*X') + 1.092E-6*P D = DEPTH BEFORE GRAVITY CORRECTION D = (((-1.82E-15*P+2.279E-10)*P-2.2512E-5)*P+9.72659)*P DEPTH = D/GR Final Corrections performed at US JGOFS DMO October 28, 1996 From: Lou Codispoti Subject: Final Corrections Dear JGOFS investigator, This is to inform you that some minor corrections were made to the JGOFS Arabian Sea nutrient data after the 1996 meeting in New Hampshire. It is doubtful that any of these corrections will alter any of your hypotheses, but they may have some significance in documenting changes over long periods of time, and in WOCE-style investigations. The need for these corrections arose, as a consequence of post-cruise re-calibration of pipets, and because we did not properly account for the nutrient content of our low nutrient sea-water. The corrections have already been applied to the US JGOFS Arabian Sea nutrient data collected with the hydrographic rosette, by personnel at WHOI who maintain the US JGOFS data. I list them here for your information. 1) All ammonium and nitrite data from Thompson leg TN053 were multiplied by 0.997. 2) All ammonium and nitrite data from ALL US JGOFS Arabian Sea cruises (TN039, 043, 045, 049, 050, 053 and 054) were multiplied by 0.995. 3) ALL phosphate data from ALL US JGOFS Arabian Sea cruises (TN039, 043, 045, 049, 050, 053 and 054) were multiplied by 0.992. Corrections 2) and 3) should probably be applied to the ONR data as well, but I will leave this up to Burt Jones, as I am not exactly sure how he did his standardizations. Basically, corrections 2) and 3) arise from a failure to take into account dilution of the Low Nutrient Sea Water signal by standards in cases where the LNSW contains appreciable quantities of nutrients. The above corrections are pretty minor within the scheme of nutrient analyses, but we should always attempt to eliminate such systematic errors. George and Chris have made these corrections on the US JGOFS Arabian Sea nutrient data collected from the hydrographic rosette. Trace metal rosette data and experimental data have not yet been corrected. Cheers, Lou Codispoti -- +-----+-----+ | Louis Codispoti | Center for Coastal Physical Oceanography | | Research Professor | Old Dominion University | | lou@ccpo.odu.edu | Norfolk Virginia, 23529 USA | | <http://www.ccpo.odu.edu/> | PH: 804-683-5770 FAX: 804-683-5550 | +-----+-----+

Processing Description

Methods: In general, the methods employed for the bottle salinity, Winkler dissolved oxygen, and nutrient analyses did not differ significantly from those described in the JGOFS protocols that were distributed in June, 1994. Minor differences included the following: 1) Sea Bird CTD systems and bottle carousels were employed (SBE-9+ underwater units, SBE-11 deck units, SBE-32 carousels). These units represent a newer generation of equipment than the units described in the JGOFS protocols. 2) The weights of the salts used for primary standards for

Description

dissolved oxygen and nutrients were not adjusted to an "in vacuo" basis as suggested in the protocols. It is unlikely that this departure from procedure would cause significant errors. Our calculations suggest that the maximum differences arising from our decision to not correct to an "in vacuo" basis would range from 0.02% (oxygen standards) to 0.06% (ammonium standards). 3) The protocols give one a choice of adjusting nutrient methods so that calibration curves are strictly linear, or opting for more response and taking into account non-linearities. We choose the latter method. 4) No corrections were made for "carryover" between nutrient samples run on the Technicon Autoanalyzer. Data from this cruise, suggest that carryover effects in our nutrient analyses are generally less than ~2% of the concentration difference between adjacent samples. Examination of cases where more than one sample was taken from a depth at which there was a significant increase in nutrient concentrations will help the user determine the carryover effect for many individual casts. 5) Calibration and re-calibration of volumetric ware were not exactly as described in the JGOFS protocols, but this was largely compensated for by comparing independent standards diluted with independent volumetric ware, and by re-calibration of some of the volumetric ware after cruises TN045 and TN050. DATA FOR THIS CRUISE (TN050) HAVE BEEN CORRECTED FOR ERRORS IN THE PIPETS BY MULTIPLYING THE SILICATE VALUES BY 0.999 AND THE PHOSPHATE AND NITRATE VALUES BY 0.998. 6) Duplicate oxygen samples were not drawn from every Niskin or Go-Flo bottle, but there were several comparisons of bottles tripped at the same depth. 7) Azide was added to the Winkler oxygen pickling reagents to destroy nitrite that can be present in relatively high concentrations in the Arabian Sea. ON LEGS PRIOR TO THIS ONE, OXYGEN STANDARDIZATIONS WERE RUN USING REAGENTS THAT DID NOT CONTAIN AZIDE, BUT DISCUSSIONS AND TESTS SUGGESTED THAT IT WOULD BE BETTER TO STANDARDIZE WITH AZIDE, DESPITE SOME CONFUSION IN THE LITERATURE ON THIS MATTER. CONSEQUENTLY, WE SWITCHED PROCEDURES BEGINNING WITH THIS LEG (TN050) AND USED REAGENTS CONTAINING AZIDE TO STANDARDIZE. OUR TESTS SUGGEST THAT THE MAXIMUM CHANGE IN OXYGEN CONCENTRATIONS ARISING FROM THIS CHANGE WOULD OCCUR AT THE HIGHEST OXYGEN CONCENTRATIONS AND BE $< \sim 0.01$ ML/L. Temperature: The temperature data associated with each bottle depth were taken by the CTD system during the bottle tripping process. Consult the companion CTD data report for this cruise to learn more about the CTD system. Sampling: The samples in this report were taken from 10 liter Niskin bottles. Because there is little or no lag time between triggering a bottle and bottle closure with the new SeaBird rosette systems, bottles were generally held at the sampling depth for at least 30 seconds before tripping or until the deck read-outs stabilized if this took more than 30 seconds. NOTE THAT THE MID-POINT OF THE SAMPLING BOTTLES WAS ONE METER ABOVE THE CTD SENSORS. THE DATA HAVE NOT BEEN CORRECTED FOR THIS ONE METER OR 1.1 DECIBAR DIFFERENCE BETWEEN CTD SENSOR AND SAMPLING BOTTLE POSITIONS. Salinity: Salinities were determined with Guildline Autosol salinometers. New vials of standard sea-water were used to standardize before and at the end of every run. Agreement between bottle salinities and the recently calibrated sensors on the Sea Bird CTD systems was usually better than 0.01 (except in regions of strong gradients) before post-cruise data processing which employs the bottle salinities to correct the CTD salinities. More information on the quality of the salinity data are given in the companion CTD report. Both the CTD salinity data at the time of bottle tripping and the salinities run on the Niskin bottle samples with an Autosol salinometer are reported here. Dissolved oxygen: The Winkler dissolved oxygen set-up was built and supplied by the SIO/ODF group. This system is computer controlled and detects the end-point photometrically. Temperature of the thiosulfate and standard solutions is automatically monitored by this system. Checks on cruises TN039 and TN043 between independent standards prepared with independent volumetric ware gave agreement of ± 0.02 per cent. A similar check made during TN054 suggested agreement of better than ± 0.15 per cent. The linearity of the "Dosimat" automatic buret was also checked during cruises TN043 and TN054 with good results. Nutrients: Note that the terminology used to describe nutrients has become somewhat loose over the years and that silicate=silicic acid, and phosphate=reactive phosphorus. Nutrient analyses were performed on a 5-channel Technicon II AA system that was modified and provided by the SIO/ODF group. In assessing the nutrient standard comparisons outlined below, note that the full-scale ranges for nutrients were as follows: Ammonium =0 to 5 micromolar Nitrate =0 to 45 " Nitrite =0 to 5 " Phosphate =0 to 3.6" Silicate =0 to 180 " These ranges were arrived at after an Internet poll of PI's and cover the full depth concentration range for the Arabian Sea. On the set-up and calibration cruise (TN039), the SIO/ODF nitrate and nitrite standards and standards from the National Institute of Oceanography in India (provided by S.W.A. Naqvi) were compared with the following results: NIO Nitrate Std.= 22.6 micromolar; SIO/ODF=22.5 micromolar NIO Nitrite Std.= 2.42 micromolar; SIO/ODF = 2.50 micromolar As can be inferred from the above, the nitrate plus

nitrite values were almost identical in the mixed standards; 25.02 (NIO) vs 25.00 (SIO)micromolar. On TN039, Lou Codispoti prepared independent primary nitrate, nitrite, silicate and phosphate standards for comparison with SIO/ODF primary standards and made dilutions using glassware entirely independent of the SIO/ODF glassware. The results were as follows: Codispoti SIO/ODF Nitrate 26.96 micromolar 26.85 micromolar Nitrite 2.90 " 2.86 " Silicate 86.4 " 85.8 " Phosphate 2.36 " 2.36 " On TN043, the volumetric equipment used for making routine nitrate and phosphate standards was checked against volumetric ware calibrated by LAC. The average difference between these comparisons of mid-range standards was + or - 0.2% for phosphate and + or -0.4% for nitrate. Because nitrite values in the suboxic waters of the Arabian Sea can attain values of approximately 5 micromolar, we kept track of the efficiency of the Cd column that reduces nitrate to nitrite in the nitrate analysis. The efficiencies were all greater than 99% during this cruise, so no corrections have been made for any errors in nitrate arising from deviations in cadmium column efficiency. NOTE THAT THE FULL-SCALE NITRITE RANGE FOR THIS CRUISE WAS 5 MICROMOLAR UP TO STATION TN05001708 WHEN THE SYSTEM WAS "RE-PLUMBED" TO COVER THE FULL NITRITE RANGE (~0.0-7.0 MICROMOLAR). BEFORE TN05001708 CONCENTRATIONS THAT EXCEEDED 5 MICROMOLAR EITHER HAD TO BE DILUTED OR THE VOLTAGE RANGE CHANGED ON THE RECORDER. THESE MANIPULATIONS TEND TO DEGRADE THE ACCURACY OF NITRITE VALUES IN EXCESS OF 4.5 TO 5 MICROMOLAR. The ammonium results are the least precise of all the nutrient results. On TN039, three primary standards were compared with agreement of about plus or minus three per cent of the full-scale value. These standards may have agreed within the precision of the method, but we found a significant salinity effect on the ammonium results that might explain some of these differences since the salinities of the comparison standards varied a bit. Experiments on this first JGOFS Arabian Sea process study cruise (TN043) suggested that the ammonium signal decreases by approximately 3.5% for a salinity increase of 1.00. Comparisons of an independent standard compared by LAC with the SIO standard on this cruise (TN043) when corrected for salinity differences between the standards agreed to ~ + -0.1% of the full-scale value. The largest absolute difference was 0.025 micromolar and the average difference was 0.013 micromolar for six comparisons between 1-3 micromolar. Thus, the average difference between these two independent standards was + -0.006 micromolar. These results tend to confirm the need to take salinity differences between samples and standards into account when calculating the final ammonium concentrations. THE AMMONIUM VALUES IN THIS REPORT HAVE BEEN CORRECTED FOR THIS EFFECT. ON THIS CRUISE THE SALINITY EFFECT CORRECTION IS A 2.9% DECREASE IN SIGNAL FOR A SALINITY INCREASE OF 1.00. On this cruise, the salinity of the working standards used to calibrate the ammonium method was ~35.06 for stations TN001-TN013 and ~34.89 for the remainder of the stations.

TT053

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|-------------------|--|
| Website | https://www.bco-dmo.org/deployment/57714 |
| Platform | R/V Thomas G. Thompson |
| Start Date | 1995-10-29 |
| End Date | 1995-11-26 |
| | <p>Methods & Sampling</p> <p>PI: Louis Codispoti of: Old Dominion University dataset: Temp, salinity, nutrients from Niskin bottles dates: October 29, 1995 to November 25, 1995 location: N: 24.3329 S: 10.0823 W: 56.4858 E: 67.1784 project/cruise: Arabian Sea/TTN053 - Process Cruise 6 (bio-optics) ship: Thomas Thompson US JGOFS Arabian Sea Cruise: TN053 HYDROGRAPHIC BOTTLE DATA L.A. Codispoti (lou@ccpo.odu.edu) Old Dominion University, June 1996 General Comments: This "readme" file pertains to the salinity, dissolved oxygen, and nutrient data taken from sampling bottles with the hydrographic rosette that was equipped with 24 10-liter Niskin type bottles during RV T.G. Thompson cruise TN053. This cruise was the sixth JGOFS Arabian Sea Process Leg and took place during Oct.-Nov. 1995. Dr. William M. Balch of the Bigelow Laboratory for Ocean Sciences (bbalch@bigelow.org) was the chief scientist. NOTE THAT MULTIPLE CASTS WERE TAKEN AT MOST STATIONS AND THAT, IN SOME CASES, THE GEOGRAPHIC POSITIONS OF CASTS AT THE SAME STATION MAY VARY SIGNIFICANTLY. Some questionable data are not included in this report. These data are still retained in files at Old Dominion University and are available upon request. No units are given for salinity in this report because the most recent definitions of salinity define it as a dimensionless number. To accommodate every preference,</p> |

Winkler oxygen values are reported in ml/l, micromolar and micromoles per kg. The latter values can only be calculated with a knowledge of the oxygen sample temperatures when the samples were drawn. These "draw temperatures" are not reported here, but can be obtained by contacting lou@ccpo.odu.edu. Nutrient values are reported in micromolar. They can be converted to micromoles per kg, by combining laboratory temperature on the Thompson (approx. 25 deg C during this leg) and the salinity of the sample to compute density and then dividing the value in micromolar by this number. NOTE THAT AIR CONDITIONING PROBLEMS DURING THIS LEG CAUSED LABORATORY TEMPERATURES TO RANGE FROM ~23-27 DEGREES. Final Corrections performed at US JGOFS DMO October 28, 1996 From: Lou Codispoti Subject: Final Corrections Dear JGOFS investigator, This is to inform you that some minor corrections were made to the JGOFS Arabian Sea nutrient data after the 1996 meeting in New Hampshire. It is doubtful that any of these corrections will alter any of your hypotheses, but they may have some significance in documenting changes over long periods of time, and in WOCE-style investigations. The need for these corrections arose, as a consequence of post-cruise re-calibration of pipets, and because we did not properly account for the nutrient content of our low nutrient sea-water. The corrections have already been applied to the US JGOFS Arabian Sea nutrient data collected with the hydrographic rosette, by personnel at WHOI who maintain the US JGOFS data. I list them here for your information. 1) All ammonium and nitrite data from Thompson leg TN053 were multiplied by 0.997. 2) All ammonium and nitrite data from ALL US JGOFS Arabian Sea cruises (TN039, 043, 045, 049, 050, 053 and 054) were multiplied by 0.995. 3) ALL phosphate data from ALL US JGOFS Arabian Sea cruises (TN039, 043, 045, 049, 050, 053 and 054) were multiplied by 0.992. Corrections 2) and 3) should probably be applied to the ONR data as well, but I will leave this up to Burt Jones, as I am not exactly sure how he did his standardizations. Basically, corrections 2) and 3) arise from a failure to take into account dilution of the Low Nutrient Sea Water signal by standards in cases where the LNSW contains appreciable quantities of nutrients. The above corrections are pretty minor within the scheme of nutrient analyses, but we should always attempt to eliminate such systematic errors. George and Chris have made these corrections on the US JGOFS Arabian Sea nutrient data collected from the hydrographic rosette. Trace metal rosette data and experimental data have not yet been corrected. Cheers, Lou Codispoti -- +-----

+-----+ | Louis Codispoti | Center for Coastal Physical Oceanography | | Research Professor | Old Dominion University | | lou@ccpo.odu.edu | Norfolk Virginia, 23529 USA | | <http://www.ccpo.odu.edu/> | PH: 804-683-5770 FAX: 804-683-5550 | +--

+-----+ The depth values in the bottle file have been calculated from pressure using the algorithm below. The US JGOFS Data Management Office is the source of the calculations. The latitude used in computation was the lat_begin of the bottle file. The CHECKVALUE was used to verify the accuracy of the computation. The stated accuracy of this algorithm is 0.1 meters Thanks to Edward Peltzer (MBARI) for supplying the algorithm and for discussions regarding the computation. function DEPTH=depth(P,LAT); DEPTH Computes depth given the pressure at some latitude D=DEPTH(P,LAT) gives the depth D (m) for a pressure P (dbars) at some latitude LAT (degrees). Fofonoff and Millard (1982). UNESCO Tech Paper #44. Notes: (ETP3, MBARI) This algorithm was originally compiled by RP @ WHOI. It was copied from the UNESCO technical report. The algorithm was endorsed by SCOR Working Group 51. The equations were originally developed by Saunders and Fofonoff (1976). DSR 23: 109-111. The parameters were re-fit for the 1980 equation of state for seawater (EOS80). CHECKVALUE: D=9712.653 M FOR P=10000 DECIBARS, LAT=30 DEG CALCULATION ASSUMES STD OCEAN: T = 0 DEG C; S = 35 (IPSS-78) X = sin(LAT/57.29578); X' = X*X; GR = GRAVITY VARIATION WITH LAT: ANON (1970) BULLETIN GEODESIQUE GR = 9.780318*(1.0+(5.2788E-3+2.36E-5*X')*X') + 1.092E-6*P D = DEPTH BEFORE GRAVITY CORRECTION D = (((-1.82E-15*P+2.279E-10)*P-2.2512E-5)*P+9.72659)*P DEPTH = D/GR

Processing Description

Methods: In general, the methods employed for the bottle salinity, Winkler dissolved oxygen, and nutrient analyses did not differ significantly from those described in the JGOFS protocols that were distributed in June, 1994. Minor differences included the following: 1) Sea Bird CTD systems and bottle carousels were employed (SBE-9+ underwater units, SBE-11 deck units, SBE-32 carousels). These units represent a newer generation of equipment than the units described in the JGOFS protocols. 2) The weights of the salts used for primary standards for dissolved oxygen and nutrients were not adjusted to an "in vacuo" basis as suggested in the protocols. It is unlikely that this departure from procedure would cause significant errors. Our calculations suggest that the maximum differences arising from our decision to not correct to an "in vacuo" basis would range from 0.02% (oxygen standards) to 0.06%(ammonium

Description

standards). 3) The protocols give one a choice of adjusting nutrient methods so that calibration curves are strictly linear, or opting for more response and taking into account non-linearities. We choose the latter method. 4) No corrections were made for "carryover" between nutrient samples run on the Technicon Autoanalyzer. Data from this cruise, suggest that carryover effects in our nutrient analyses are generally less than ~2% of the concentration difference between adjacent samples. Examination of cases where more than one sample was taken from a depth at which there was a significant increase in nutrient concentrations will help the user determine the carryover effect for many individual casts. 5) Calibration and re-calibration of volumetric ware were not exactly as described in the JGOFS protocols, but this was largely compensated for by comparing independent standards diluted with independent volumetric ware, and by re-calibration of some of the volumetric ware after cruises TN045 and TN050. WE HAVE NOT YET RECALIBRATED THE VOLUMETRIC WARE USED DURING TN053. WE WILL UPDATE THE DATA IF RECALIBRATION SUGGESTS A NEED TO DO THIS, BUT WE DO NOT EXPECT SIGNIFICANT CHANGES 6) Duplicate oxygen samples were not drawn from every Niskin or Go-Flo bottle, but there were several comparisons of bottles tripped at the same depth. 7) Azide was added to the Winkler oxygen pickling reagents to destroy nitrite that can be present in relatively high concentrations in the Arabian Sea. ON LEGS PRIOR TO THIS ONE, OXYGEN STANDARDIZATIONS WERE RUN USING REAGENTS THAT DID NOT CONTAIN AZIDE, BUT DISCUSSIONS AND TESTS SUGGESTED THAT IT WOULD BE BETTER TO STANDARDIZE WITH AZIDE, DESPITE SOME CONFUSION IN THE LITERATURE ON THIS MATTER. CONSEQUENTLY, WE SWITCHED PROCEDURES BEGINNING WITH THIS LEG (TN053) AND USED REAGENTS CONTAINING AZIDE TO STANDARDIZE. OUR TESTS SUGGEST THAT THE MAXIMUM CHANGE IN OXYGEN CONCENTRATIONS ARISING FROM THIS CHANGE WOULD OCCUR AT THE HIGHEST OXYGEN CONCENTRATIONS AND BE $< \sim 0.01$ ML/L. Temperature: The temperature data associated with each bottle depth were taken by the CTD system during the bottle tripping process. Consult the companion CTD data report for this cruise to learn more about the CTD system. Sampling: The samples in this report were taken from 10 liter Niskin bottles. Because there is little or no lag time between triggering a bottle and bottle closure with the new SeaBird rosette systems, bottles were generally held at the sampling depth for at least 30 seconds before tripping or until the deck read-outs stabilized if this took more than 30 seconds. NOTE THAT THE MID-POINT OF THE SAMPLING BOTTLES WAS ONE METER ABOVE THE CTD SENSORS. THE DATA HAVE NOT BEEN CORRECTED FOR THIS ONE METER OR 1.01 DECIBAR DIFFERENCE BETWEEN CTD SENSOR AND SAMPLING BOTTLE POSITIONS. Salinity: Salinities were determined with Guildline Autosol salinometers. New vials of standard sea-water were used to standardize before and at the end of every run. Agreement between bottle salinities and the recently calibrated sensors on the Sea Bird CTD systems was usually better than 0.02 (except in regions of strong gradients) before post-cruise data processing which employs the bottle salinities to correct the CTD salinities. More information on the quality of the salinity data are given in the companion CTD report. Both the CTD salinity data at the time of bottle tripping and the salinities run on the Niskin bottle samples with an Autosol salinometer are reported here. Dissolved oxygen: The Winkler dissolved oxygen set-up was built and supplied by the SIO/ODF group. This system is computer controlled and detects the end-point photometrically. Temperature of the thiosulfate and standard solutions is automatically monitored by this system. Checks on cruises TN039 and TN043 between independent standards prepared with independent volumetric ware gave agreement of ± 0.02 per cent. A similar check made during TN054 suggested agreement of better than ± 0.15 per cent. The linearity of the "Dosimat" automatic buret was also checked during cruises TN043 and TN054 with good results. Nutrients: Note that the terminology used to describe nutrients has become somewhat loose over the years and that silicate=silicic acid, and phosphate=reactive phosphorus. Nutrient analyses were performed on a 5-channel Technicon II AA system that was modified and provided by the SIO/ODF group. In assessing the nutrient standard comparisons outlined below, note that the full-scale ranges for nutrients were as follows: Ammonium =0 to 5 micromolar Nitrate =0 to 45 " Nitrite =0 to 5 " Phosphate =0 to 3.6" Silicate =0 to 180 " These ranges were arrived at after an Internet poll of PI's and were selected to cover the full depth concentration range for the Arabian Sea. Since, we found nitrite concentrations that exceeded 5 micromolar on several occasions, the nitrite concentration range was expanded to 0-7 micromolar on leg TN050. On the set-up and calibration cruise (TN039), the SIO/ODF nitrate and nitrite standards and standards from the National Institute of Oceanography in India (provided by S.W.A. Naqvi) were compared with the following results: NIO Nitrate Std.= 22.6 micromolar; SIO/ODF=22.5 micromolar NIO Nitrite Std.= 2.42 micromolar; SIO/ODF = 2.50 micromolar As can be inferred from the above, the nitrate plus nitrite values were almost identical in the mixed standards; 25.02 (NIO) vs 25.00 (SIO)micromolar. On TN039, Lou Codispoti prepared independent primary nitrate, nitrite,

silicate and phosphate standards for comparison with SIO/ODF primary standards and made dilutions using glassware entirely independent of the SIO/ODF glassware. The results were as follows: Codispoti SIO/ODF Nitrate 26.96 micromolar 26.85 micromolar Nitrite 2.90 " 2.86 " Silicate 86.4 " 85.8 " Phosphate 2.36 " 2.36 " On TN043, the volumetric equipment used for making routine nitrate and phosphate standards was checked against volumetric ware calibrated by LAC. The average difference between these comparisons of mid-range standards was + or - 0.2% for phosphate and + or -0.4% for nitrate. Because nitrite values in the suboxic waters of the Arabian Sea can attain values of approximately 6.5 micromolar and because our routine standards contained 22.5 micromoles of nitrate and 2.5 micromoles of nitrite, we kept track of the efficiency of the Cd column that reduces nitrate to nitrite in the nitrate analysis. The efficiencies were all greater than 97.7%, except for station 10 (TN053010xx). Nitrate data are not reported for casts TN05301001 to TN05301008 because of problems with the cadmium reduction column. For the remaining casts at this station, the Cd column efficiency was ~96.4%. No corrections have been made for any errors in nitrate arising from deviations in cadmium column efficiency. NOTE THAT THE FULL-SCALE NITRITE RANGE FOR THIS CRUISE WAS 7 MICROMOLAR. The ammonium results are the least precise of all the nutrient results. On TN039, three primary standards were compared with agreement of about plus or minus three per cent of the full-scale (5.0 micromolar) value. These standards may have agreed within the precision of the method, but we found a significant salinity effect on the ammonium results that might explain some of these differences since the salinities of the comparison standards varied a bit. Experiments on the first JGOFS Arabian Sea process study cruise (TN043) suggested that the ammonium signal decreases by approximately 3.5% for a salinity increase of 1.00. Comparisons of an independent standard compared by LAC with the SIO standard on this cruise (TN043) when corrected for salinity differences between the standards agreed to ~ + -0.1% of the full-scale value. The largest absolute difference was 0.025 micromolar and the average difference was 0.013 micromolar for six comparisons between 1-3 micromolar. Thus, the average difference between these two independent standards was + -0.006 micromolar. Comparisons of independent high concentration ammonium standards (~2.5 and 5.0 micromolar) prepared by LAC with SIO standards during TN054 agreed to better than + - 1% for four out of the five standards when corrected for a salinity effect of 4.5%/1.00S on that cruise. One standard agreed to only + - 2.5%, but we assume that this was due to a dilution error. We believe that the suite of ammonium comparisons suggests no systematic differences arising from standards and dilutions, as all of the differences are within the precision of the ammonium analysis. Our results tend to confirm the need to take salinity differences between samples and standards into account when calculating the final ammonium concentrations. THE AMMONIUM VALUES IN THIS REPORT HAVE BEEN CORRECTED FOR THIS EFFECT. ON THIS CRUISE (TN053) THE SALINITY EFFECT CORRECTION IS A 3% DECREASE IN SIGNAL FOR A SALINITY INCREASE OF 1.00. The average salinity of the working standards used to calibrate the ammonium method was ~34.35 for stations TN053001-TN053012 (inclusive) and ~34.96 for the remainder of the stations. The ammonium method has additional problems, such as contamination of "baseline" water etc. These problems can introduce inaccuracies on the order 0.1 micromolar, so differences in ammonium concentrations of less than ~ 0.1 micromolar should not be over-interpreted.

TT054

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| Website | https://www.bco-dmo.org/deployment/57715 |
| Platform | R/V Thomas G. Thompson |
| Start Date | 1995-11-30 |
| End Date | 1995-12-28 |
| | <p>Methods & Sampling PI: Louis Codispoti of: Old Dominion University dataset: Temp, salinity, nutrients from Niskin bottles dates: November 30, 1995 to December 26, 1995 location: N: 22.5171 S: 9.9673 W: 57.2992 E: 68.7849 project/cruise: Arabian Sea/TTN054 - Process Cruise 7 (Early NE Monsoon) ship: Thomas Thompson US JGOFS Arabian Sea Cruise: TN054 HYDROGRAPHIC BOTTLE DATA L.A. Codispoti (lou@ccpo.odu.edu) Old Dominion University, July 1996 General Comments: This "readme" file pertains to the salinity, dissolved oxygen, and nutrient data taken from sampling bottles with the hydrographic rosette that was equipped with 24 10-liter Niskin type bottles during RV T.G. Thompson cruise TN054. This cruise was the seventh JGOFS Arabian Sea</p> |

Process Leg and took place during Nov.- Dec. 1995. Dr. Wilford Gardner of the Department of Oceanography at Texas A&M University was the chief scientist (wgardner@astra.tamu.edu). NOTE THAT MULTIPLE CASTS WERE TAKEN AT MOST STATIONS AND THAT, IN SOME CASES, THE GEOGRAPHIC POSITIONS OF CASTS AT THE SAME STATION MAY VARY SIGNIFICANTLY. Some questionable data are not included in this report. These data are still retained in files at Old Dominion University and are available upon request. No units are given for salinity in this report because the most recent definitions of salinity define it as a dimensionless number. To accommodate every preference, Winkler oxygen values are reported in ml/l, micromolar and micromoles per kg. The latter values can only be calculated with a knowledge of the oxygen sample temperatures when the samples were drawn. These "draw temperatures" are not reported here, but can be obtained by contacting lou@ccpo.odu.edu. Nutrient values are reported in micromolar. They can be converted to micromoles per kg, by combining laboratory temperature on the Thompson (approx. 24.5 deg C during this leg) and the salinity of the sample to compute density and then dividing the value in micromolar by this number. Final Corrections performed at US JGOFS DMO October 28, 1996 From: Lou Codispoti Subject: Final Corrections Dear JGOFS investigator, This is to inform you that some minor corrections were made to the JGOFS Arabian Sea nutrient data after the 1996 meeting in New Hampshire. It is doubtful that any of these corrections will alter any of your hypotheses, but they may have some significance in documenting changes over long periods of time, and in WOCE-style investigations. The need for these corrections arose, as a consequence of post-cruise re-calibration of pipets, and because we did not properly account for the nutrient content of our low nutrient sea-water. The corrections have already been applied to the US JGOFS Arabian Sea nutrient data collected with the hydrographic rosette, by personnel at WHOI who maintain the US JGOFS data. I list them here for your information. 1) All ammonium and nitrite data from Thompson leg TN053 were multiplied by 0.997. 2) All ammonium and nitrite data from ALL US JGOFS Arabian Sea cruises (TN039, 043, 045, 049, 050, 053 and 054) were multiplied by 0.995. 3) ALL phosphate data from ALL US JGOFS Arabian Sea cruises (TN039, 043, 045, 049, 050, 053 and 054) were multiplied by 0.992. Corrections 2) and 3) should probably be applied to the ONR data as well, but I will leave this up to Burt Jones, as I am not exactly sure how he did his standardizations. Basically, corrections 2) and 3) arise from a failure to take into account dilution of the Low Nutrient Sea Water signal by standards in cases where the LNSW contains appreciable quantities of nutrients. The above corrections are pretty minor within the scheme of nutrient analyses, but we should always attempt to eliminate such systematic errors. George and Chris have made these corrections on the US JGOFS Arabian Sea nutrient data collected from the hydrographic rosette. Trace metal rosette data and experimental data have not yet been corrected. Cheers, Lou Codispoti -- +-----+-----

+-----+ | Louis Codispoti | Center for Coastal Physical Oceanography | |
 Research Professor | Old Dominion University | | lou@ccpo.odu.edu | Norfolk Virginia, 23529
 USA | | <http://www.ccpo.odu.edu/> | PH: 804-683-5770 FAX: 804-683-5550 | +-----+-----

+-----+ June 25, 1997 Lou Codispoti and Steve Gaurin realized there was a slight error in the way the JGOFS data was originally processed. There are only 2 stations involved for cruise ttn-054. For these stations, only 2 bottles are affected. These should not contain oxygen data because, according to Lou's notes, there were bubbles in the samples when these were analyzed. Please remove all 3 O2 values for these records: sta cast bot 28 1 24 28 1 22 29 1 24 29 1 21 The depth values in the bottle file have been calculated from pressure using the algorithm below. The US JGOFS Data Management Office is the source of the calculations. The latitude used in computation was the lat_begin of the bottle file. The CHECKVALUE was used to verify the accuracy of the computation. The stated accuracy of this algorithm is 0.1 meters Thanks to Edward Peltzer (MBARI) for supplying the algorithm and for discussions regarding the computation. function DEPTH=depth(P,LAT); DEPTH Computes depth given the pressure at some latitude D=DEPTH(P,LAT) gives the depth D (m) for a pressure P (dbars) at some latitude LAT (degrees). Fofonoff and Millard (1982). UNESCO Tech Paper #44. Notes: (ETP3, MBARI) This algorithm was originally compiled by RP @ WHOI. It was copied from the UNESCO technical report. The algorithm was endorsed by SCOR Working Group 51. The equations were originally developed by Saunders and Fofonoff (1976). DSR 23: 109-111. The parameters were re-fit for the 1980 equation of state for seawater (EOS80). CHECKVALUE: D=9712.653 M FOR P=10000 DECIBARS, LAT=30 DEG CALCULATON ASSUMES STD OCEAN: T = 0 DEG C; S = 35 (IPSS-78) X = sin(LAT/57.29578); X' = X*X; GR = GRAVITY VARIATION WITH LAT: ANON (1970) BULLETIN GEODESIQUE GR = 9.780318*(1.0+(5.2788E-3+2.36E-5*X')*X') + 1.092E-6*P D = DEPTH BEFORE GRAVITY CORRECTION D = (((-1.82E-15*P+2.279E-10)*P-2.2512E-5)*P+9.72659)*P DEPTH = D/GR

Processing Description

Description

Methods: In general, the methods employed for the bottle salinity, Winkler dissolved oxygen, and nutrient analyses did not differ significantly from those described in the JGOFS protocols that were distributed in June, 1994. Minor differences included the following: 1) Sea Bird CTD systems and bottle carousels were employed (SBE-9+ underwater units, SBE-11 deck units, SBE-32 carousels). These units represent a newer generation of equipment than the units described in the JGOFS protocols. 2) The weights of the salts used for primary standards for dissolved oxygen and nutrients were not adjusted to an "in vacuo" basis as suggested in the protocols. It is unlikely that this departure from procedure would cause significant errors. Our calculations suggest that the maximum differences arising from our decision to not correct to an "in vacuo" basis would range from 0.02% (oxygen standards) to 0.06% (ammonium standards). 3) The protocols give one a choice of adjusting nutrient methods so that calibration curves are strictly linear, or opting for more response and taking into account non-linearities. We choose the latter method. 4) No corrections were made for "carryover" between nutrient samples run on the Technicon Autoanalyzer. Carryover effects in our nutrient analyses are generally less than ~2% of the concentration difference between adjacent samples. Examination of cases where more than one sample was taken from a depth at which there was a significant increase in nutrient concentrations will help the user determine the carryover effect for many individual casts. 5) Calibration and re-calibration of volumetric ware were not exactly as described in the JGOFS protocols, but this was largely compensated for by comparing independent standards diluted with independent volumetric ware, and by re-calibration of some of the volumetric ware after cruises TN045 and TN050. WE HAVE NOT YET RECALIBRATED THE VOLUMETRIC WARE USED DURING TN054. WE WILL UPDATE THE DATA IF RECALIBRATION SUGGESTS A NEED TO DO THIS, BUT WE DO NOT EXPECT SIGNIFICANT CHANGES 6) Duplicate oxygen samples were not drawn from every Niskin or Go-Flo bottle, but there were several comparisons of bottles tripped at the same depth. 7) Azide was added to the Winkler oxygen pickling reagents to destroy nitrite that can be present in relatively high concentrations in the Arabian Sea. ON LEGS PRIOR TO THIS ONE, OXYGEN STANDARDIZATIONS WERE RUN USING REAGENTS THAT DID NOT CONTAIN AZIDE, BUT DISCUSSIONS AND TESTS SUGGESTED THAT IT WOULD BE BETTER TO STANDARDIZE WITH AZIDE, DESPITE SOME CONFUSION IN THE LITERATURE ON THIS MATTER. CONSEQUENTLY, WE SWITCHED PROCEDURES BEGINNING WITH LEG TN053 AND USED REAGENTS CONTAINING AZIDE TO STANDARDIZE. OUR TESTS SUGGEST THAT THE MAXIMUM CHANGE IN OXYGEN CONCENTRATIONS ARISING FROM THIS CHANGE WOULD OCCUR AT THE HIGHEST OXYGEN CONCENTRATIONS AND BE $< \sim 0.01$ ML/L. Temperature: The temperature data associated with each bottle depth were taken by the CTD system during the bottle tripping process. Consult the companion CTD data report for this cruise to learn more about the CTD system. Sampling: The samples in this report were taken from 10 liter Niskin bottles. Because there is little or no lag time between triggering a bottle and bottle closure with the new SeaBird rosette systems, bottles were generally held at the sampling depth for at least 30 seconds before tripping or until the deck read-outs stabilized if this took more than 30 seconds. NOTE THAT THE MID-POINT OF THE SAMPLING BOTTLES WAS ONE METER ABOVE THE CTD SENSORS. THE DATA HAVE NOT BEEN CORRECTED FOR THIS ONE METER OR 1.01 DECIBAR DIFFERENCE BETWEEN CTD SENSOR AND SAMPLING BOTTLE POSITIONS. Salinity: Salinities were determined with Guildline Autosol salinometers. New vials of standard sea-water were used to standardize before and at the end of every run. Agreement between bottle salinities and the recently calibrated sensors on the Sea Bird CTD systems was usually better than 0.02 (except in regions of strong gradients) before post-cruise data processing which employs the bottle salinities to correct the CTD salinities. More information on the quality of the salinity data are given in the companion CTD report. Both the CTD salinity data at the time of bottle tripping and the salinities run on the Niskin bottle samples with an Autosol salinometer are reported here. Dissolved oxygen: The Winkler dissolved oxygen set-up was built and supplied by the SIO/ODF group. This system is computer controlled and detects the end-point photometrically. Temperature of the thiosulfate and standard solutions is automatically monitored by this system. Checks on cruises TN039 and TN043 between independent standards prepared with independent volumetric ware gave agreement of ± 0.02 per cent. A similar check made during TN054 suggested agreement of better than ± 0.15 per cent. The linearity of the "Dosimat" automatic buret was also checked during cruises TN043 and TN054 with good results. Nutrients: Note that the terminology used to describe nutrients has become somewhat loose over the years and that silicate=silicic acid, and phosphate=reactive phosphorus. Nutrient analyses were performed on a 5-channel Technicon II AA system that was modified and provided by the SIO/ODF group. In assessing the nutrient standard comparisons outlined below, note that the full-scale ranges for nutrients were as follows: Ammonium =0 to 5 micromolar Nitrate =0 to 45 " Nitrite =0 to 5 " Phosphate =0 to 3.6"

Silicate =0 to 180 " These ranges were arrived at after an Internet poll of PI's and were intended to cover the full depth concentration range for the Arabian Sea. Starting with TN050 the nitrite range was expanded to 0-7micromolar because we found maximum nitrite concentrations to be ~6.5 micromolar. On the set-up and calibration cruise (TN039), the SIO/ODF nitrate and nitrite standards and standards from the National Institute of Oceanography in India (provided by S.W.A. Naqvi) were compared with the following results: NIO Nitrate Std.= 22.6 micromolar; SIO/ODF=22.5 micromolar NIO Nitrite Std.= 2.42 micromolar; SIO/ODF = 2.50 micromolar As can be inferred from the above, the nitrate plus nitrite values were almost identical in the mixed standards; 25.02 (NIO) vs 25.00 (SIO)micromolar. On TN039, Lou Codispoti prepared independent primary nitrate, nitrite, silicate and phosphate standards for comparison with SIO/ODF primary standards and made dilutions using glassware entirely independent of the SIO/ODF glassware. The results were as follows: Codispoti SIO/ODF Nitrate 26.96 micromolar 26.85 micromolar Nitrite 2.90 " 2.86 " Silicate 86.4 " 85.8 " Phosphate 2.36 " 2.36 " On TN043, the volumetric equipment used for making routine nitrate and phosphate standards was checked against volumetric ware calibrated by LAC. The average difference between these comparisons of mid-range standards was + or - 0.2% for phosphate and + or -0.4% for nitrate. Because nitrite values in the suboxic waters of the Arabian Sea can attain values of approximately 5 micromolar and because our routine standards contained 22.5 micromoles of nitrate and 2.5 micromoles of nitrite, we kept track of the efficiency of the Cd column that reduces nitrate to nitrite in the nitrate analysis. The lowest column efficiency determined on this cruise was 97.5%. No corrections have been made for any errors in nitrate arising from deviations in cadmium column efficiency. NOTE THAT THE FULL-SCALE NITRITE RANGE FOR THIS CRUISE WAS 7 MICROMOLAR. The ammonium results are the least precise of all the nutrient results. On TN039, three primary standards were compared with agreement of about plus or minus three per cent of the full-scale (5.0 micromolar) value. These standards may have agreed within the precision of the method, but we found a significant salinity effect on the ammonium results that might explain some of these differences since the salinities of the comparison standards varied a bit. Experiments on the first JGOFS Arabian Sea process study cruise (TN043) suggested that the ammonium signal decreases by approximately 3.5% for a salinity increase of 1.00. Comparisons of an independent standard prepared by LAC with an SIO standard on this cruise (TN043), when corrected for salinity differences between the standards agreed to ~ + -0.1% of the full-scale value. The largest absolute difference was 0.025 micromolar and the average difference was 0.013 micromolar for six comparisons between 1-3 micromolar. Thus, the average difference between these two independent standards was + -0.006 micromolar. Comparisons of independent high concentration ammonium standards (~2.5 and 5.0 micromolar) prepared by LAC with SIO standards during TN054 agreed to better than + - 1% for four out of the five standards when corrected for a salinity effect of 4.5%/1.00S on that cruise. One standard agreed to only + - 2.5%, but we assume that this was due to a dilution error. We believe that the suite of ammonium comparisons suggests no systematic differences arising from standards and dilutions, as all of the differences are within the precision of the ammonium analysis. Our results tend to confirm the need to take salinity differences between samples and standards into account when calculating the final ammonium concentrations. THE AMMONIUM VALUES IN THIS REPORT HAVE BEEN CORRECTED FOR THIS EFFECT. ON THIS CRUISE (TN054) THE SALINITY EFFECT CORRECTION IS A 4.5% DECREASE IN SIGNAL FOR A SALINITY INCREASE OF 1.00. The average salinity of the working standards used to calibrate the ammonium method was ~34.96 for casts TN05400101-TN05401302 (inclusive), ~35.27 for casts TN05401303-TN05401902 (inclusive), 35.14 for casts TN05401903-TN05402601 (inclusive), and 34.59 for the remainder of the casts. The ammonium method has additional problems, such as contamination of "baseline" water etc. These problems can introduce inaccuracies on the order 0.1 micromolar, so differences in ammonium concentrations of less than ~0.1 micromolar should not be over-interpreted.

TT039

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|-------------------|---|
| Website | https://www.bco-dmo.org/deployment/57700 |
| Platform | R/V Thomas G. Thompson |
| Report | http://usjgofs.whoi.edu/arabian-docs/smith-update.html |
| Start Date | 1994-09-18 |

| | |
|-----------------|--|
| End Date | 1994-10-07 |
| | <p>Intercalibration and Training Cruise</p> <p>Methods & Sampling</p> <p>PI: Lou Codispoti dataset: Temp, salinity, nutrients from Niskin bottles project/cruise: Arabian Sea/TTN039 - Intercalibration Cruise ship: Thomas Thompson Codispoti TN039 comments and methodology Cast specific comments, quality assessment, analytical methods as prepared by L. Codispoti All stations See Codispoti documentation regarding data quality see section on DATA QUALITY below. Station 1 cast 1 This station was taken on the way to the Arabian Sea from Singapore near Sri Lanka to the South of the Bay of Bengal. Station 5 cast 1 This station was designed to check the flushing characteristics of the 10 liter Niskins on the hydrographic rosette. The rosette was pulled through a strong gradient into a fairly uniform layer and bottles were fired immediately, after 21 sec, etc. until 149 seconds. Based on these data, it was decided that a 20 second soak time was ample for flushing the 10 liter Niskin bottles. On later cruises, longer flushing times than would be suggested by the data were used. This is because the CTD sensors are surrounded by additional sensors added for other JGOFS investigators. Station 6 cast 1 This cast was made with the large bottle rosette for special chemical samples. The rosette was equipped with a mixture of bottles. Only salinities and Winkler O₂'s on selected bottles, no nutrients. The three replicate Oxygens near the surface agreed well, but one of the two oxygens at 28-29 decibars is suspect. Station 6 cast 3 This was a large bottle rosette cast for special chemistry samples. The data from bottle 23 (Seq.23) were deleted because this bottle appeared to be a mis-trip. Station 6 cast 4 Another large bottle rosette cast for special chemistry samples. As usual, the large bottles were paired with 10 L Niskins from which the samples for the chemical data were taken. CTD "spiking" problems occurred which could compromise the data, particularly the depths of bottles 13 and 15. Station 7 cast 1 All oxygen samples were drawn by trainees from Oman and Pakistan. Bubbles were noted in flasks from bottles 18-24. These questionable data have been deleted. Station 8 cast 1 We had "spiking" problems with the CTD/rosette that could have caused mis-trips at this station, but the depths seem o.k. The higher colorimetric oxygens seem to be systematically lower than the Winklers which probably means that they were outside the high range for accuracy with the colorimetric method. These values have been deleted. The elevated NH₄ value at 1514.7 db occurred on several casts. Competing hypotheses for this peak are contamination from the Niskin bottle or a concentration of zooplankton activity in this layer. Station 8 cast 4 Casts 02 and 03 at Station 008 were too badly compromised by electrical "spikes" to make it worthwhile to collect water. This shallow cast was taken because it was originally thought that the shallow values from cast 01 were compromised by spiking. We believe that the depths for samples for casts 01 and 04 are o.k. but there is a possibility that they are in error because of the spiking problem. Station 9 cast 1 No significant problems on this cast, but some questionable oxygens are not reported. Station 10 cast 1 The Silicate (Silicic Acid) from bottle 3 is probably incorrect and was deleted. Station 11 cast 1 The surface oxygen saturation at this station was 125% which is possible given the relatively high nutrients at the sea surface. The salinity at 252.3 db is questionable and was deleted. Station 12 cast 1 Another station with appreciable nutrients and O₂ supersaturation at the surface. Station 18 cast 1 Special Chemistry cast with large bottle rosette and mixture of bottles. All Winklers questionable and have been deleted because flasks were only shaken once before running. All data from bottle 13 are questionable because of leaking Niskin bottles. Station 18 cast 3 Special Chemistry cast with large bottle rosette and mixture of bottles. Station 18 cast 5 Another special chemistry cast. Station 18 cast 6 Another special chemistry cast with large bottle rosette. Station 18 cast 9 The bottles were not tripped in order of their sequence on the rosette. Station 19 cast 1 Electronic spiking in CTD/rosette system make depths between 26.8 and 454.4 db somewhat uncertain. The depths listed are our present "best guess". Station 21 cast 1 Spiking problems could have caused mis-trips, but depths look o.k. Because of the problems two bottles were tripped at 1014.5 db. Station 21 cast 2 Another special chemistry cast. Air leak at top of bottle 9 and relatively high result makes Winkler values questionable. Spiking problems occurred which makes bottle mis-trips a slight possibility. Station 21 cast 4 Slight possibility of mis-trips due to electrical spiking in CTD/rosette system, but data look good. Station 22 cast 1 Once again, electrical spiking in the CTD/rosette system introduces a possibility of mis-trips, particularly between 26-300db. Bottle 1 was definitely a mis-trip and the data have been eliminated. The bottle 5 "hung up". Station 23 cast 1 Another special chem. cast with large bottle rosette. Station 23 cast 2 The bottle 1 mis-tripped again. Station 23 cast 3 Another special chemistry cast with the large bottle rosette. Station 23 cast 4 Another special chemistry cast with the large bottle rosette. The bottle 9 leaked but the data look o.k. Station 23 cast 6 This is another special chemistry cast with the</p> |

Description

large bottle CTD/rosette. DATA QUALITY JGOFS Arabian Sea Cruise TN039 (Set-up and Calibration Cruise) Sept-Oct. 1994: QA/QC Report for the Niskin and Go Flow Bottle Data (Bottle Salinities, Oxygens and Nutrients) L.A. Codispoti (lou@ccpo.odu.edu) Old Dominion University, May 1995 General Comments: This "readme" file pertains to the salinity, dissolved oxygen, and nutrient data taken from sampling bottles during RV T.G. Thompson cruise TN039. This cruise took advantage of the sampling and training opportunities provided by the Thompson's transit leg from Singapore to Oman. The purposes of this cruise included: 1) testing equipment and methods that would be used on the subsequent JGOFS Arabian Sea process cruises, 2) finalizing the hydrographic and data-processing protocols that would be used on subsequent JGOFS Arabian Sea process cruises, 3) training participants from Pakistan and Oman, 4) collecting as much data as possible to extend the temporal and spatial coverage of the time-series observations included in the JGOFS Arabian Sea process study. Because the JGOFS data base system does not have a system for "flagging" questionable data, no questionable data are included in the files sent to the JGOFS Data Management Office. These data are available by sending an Internet message to "lou@ccpo.odu.edu". No units are given for salinity in this report because the most recent definitions of salinity define it as a dimensionless number. To accommodate every preference, Winkler oxygen values are reported in ml/l, micromolar and micromoles per kg. The latter values can only be calculated with a knowledge of the oxygen sample temperatures when the samples were drawn. These "draw temperatures" are not reported here, but can be obtained by contacting lou@ccpo.odu.edu. Nutrient values are reported in micromolar. They can be converted to micromoles per kg, by combining lab. temperature on the Thompson (approx. 23.5 deg C) and the salinity of the sample to compute density and then dividing the value in micromolar by this number. Methods: In general, the methods employed for the bottle Salinity, Winkler dissolved oxygen, and nutrient analyses did not differ significantly from those described in the JGOFS protocols that were distributed in June, 1994. Minor differences included the following: 1) Sea Bird CTD systems and bottle carousels were employed (SBE- 9+ underwater units, SBE-11 deck units, SBE-32 carousels). These units represent a newer generation of equipment than the units described in the JGOFS protocols. 2) The weights of the salts used for primary standards for dissolved oxygen and nutrients were not adjusted to an "in vacuo" basis as suggested in the protocols. It is unlikely that this departure from procedure would cause significant errors. Our calculations suggest that any differences arising from our decision to not correct to an "in vacuo" basis would range from 0.02% (oxygen standards) to 0.06%(ammonium standards). 3) The protocols give one a choice of adjusting nutrient methods so that calibration curves are strictly linear, or opting for more response and taking into account non-linearities. We choose the latter method. 4) No corrections were made for "carryover" between nutrient samples run on the Technicon Autoanalyzer. Data from this cruise and a subsequent cruise suggest that carryover effects in our nutrient analyses are generally less than 1-2% of the concentration difference between adjacent samples. 5) Calibration and re-calibration of volumetric ware was not as rigorous as described in the JFOFS protocols, but this was largely compensated for by comparing independent standards diluted with independent volumetric ware. 6) Duplicate oxygen samples were not drawn from every Niskin or Go-Flo bottle, but there were several comparisons of bottles tripped at the same depth and numerous comparisons of the Winkler and colorimetric oxygen values. 7) Azide was added to the Winkler oxygen pickling reagents to destroy nitrite that can be present in relatively high concentrations in the Arabian Sea. Cruise TN039 contains some oxygen determinations made using the colorimetric method of Broenkow in Cline (1969) which is optimized for low dissolved oxygen concentrations. This method is not described in the JGOFS protocols. Similarly, a method for the automated determination of ammonium is not included in the JGOFS protocols. The method described by Whitedge et al. (1981) as modified by K. Krogsland of the University of Washington (kkgrog@u.washington.edu) was employed for this analysis. Temperature Data: The temperature data associated with each bottle data depth were taken by the CTD system during the bottle tripping process. Consult the CTD data report for this cruise to learn more about the CTD system. Sampling Bottles: Most of the samples in this report were taken from 10 liter Niskin bottles. A few samples were taken from 20 and 30 liter Go- Flo or Niskin bottles. Information about what type of bottle a sample came from can be obtained by sending an Internet message to lou@ccpo.odu.edu. Because there is little or no lag time between triggering a bottle and bottle closure with the new SeaBird rosette systems a bottle flushing experiment was performed. The rosette was raised through a strong gradient into a mixed layer and then a sequence of bottles was tripped over about a two minute period. This experiment suggested that the bottles flushed fairly well and that a 20 second "soak time" should be sufficient before tripping a bottle at a given depth. On a subsequent cruise (TN043), it was found that bottle soak times had to be increased largely because of relatively slow

response times for the CTD sensors. The bottles were probably flushing relatively rapidly but the companion CTD data for salinity showed some variation that disappeared with longer soak times. This was probably because of the additional equipment mounted near the CTD sensors during the subsequent cruises. This equipment can act as a heat source/sink and interfere with flushing and equilibration of the CTD sensors on the up cast. NOTE THAT THE MID-POINT OF THE SAMPLING BOTTLES WAS ONE METER ABOVE THE CTD SENSORS. THE DATA HAVE NOT BEEN CORRECTED FOR THIS ONE METER DIFFERENCE BETWEEN CTD SENSOR AND SAMPLING BOTTLE POSITIONS. Salinity: Salinities were run on almost every bottle sample with new vials of standard sea-water used before and at the end of every run (12-36 samples). These runs, suggested that drift during runs was usually less than 0.0005. Agreement between bottle salinities and the recently calibrated sensors on the Sea Bird CTD systems was usually better than 0.01 after final data processing. For depths greater than 500 db, the standard deviation between bottle salinities and the CTD results after final calibration was 0.002 for two of the three CTD systems. The third system that was used only to collect a few "special chemistry" samples had a standard deviation of 0.005 for this depth range. Consult the companion TN039 CTD data report for a fuller discription of these data. Dissolved oxygen: The Winkler dissolved oxygen set-up was built and supplied by the SIO/ODF group. This system is computer controlled and detects the end-point photometrically. Temperature of the thiosulfate and standard solutions is automatically monitored by this system. A primary standard provided by Lou Codispoti was compared with the SIO/ODF primary standard. The agreement between these standards was plus or minus 0.02 per cent. These standards were made up at different institutions and diluted at sea with totally independent volumetric ware. We tested the effects of using silicone vs tygon Tubing to draw dissolved oxygen samples for the benefit of Ed. Peltzer who was concerned about DOC contamination from Tygon tubing. There appeared to be no difference between the results. Because we will not have the person power to perform colorimetric dissolved oxygen concentrations routinely during the process legs and because of the existence of suboxic water in the Arabian Sea, we did a comprehensive comparison of colorimetric vs automated Winkler oxygen analyses. Generally, the results agreed within better than plus or minus 0.005 ml/l with perhaps a tendency for the automated Winkler to overestimate by about 0.005ml/l in the less than 0.01 ml/l (about 0.5micromolar) range compared to the colorimetric method. NOTE THAT THE OBSERVATIONS WERE MADE WITH HIGHLY EXPERIENCED ANALYSTS DRAWING THE SAMPLES AND BY ALLOWING AT LEAST THREE BOTTLE VOLUMES TO OVERFLOW THE WINKLER OXYGEN FLASK (CONSUMING ABOUT AT LEAST 0.7L OF WATER)WHEN DRAWING WINKLER SAMPLES. We performed some iodine blanks on sea-water. The results were intriguing and suggest small positive and negative blanks (about 0.5 micromolar)in the suboxic waters. Stay tuned for further developments. Nutrients: Terminology describing nutrients has become somewhat loose over the years, so it may be useful to point out that for our purposes silicate=silicic acid, and phosphate=reactive phosphorus. Nutrient analyses were performed on a 5-channal Technicon II AA system that was modified and provided by the SIO/ODF group. In assessing the nutrient standard comparisons outlined below, note that the full-scale ranges for nutrients were as follows: Nitrate =0 to 45 micromolar Nitrite =0 to 5 " Phosphate =0 to 3.6" Silicate =0 to 180 " These ranges were arrived at after an Internet pole of PI's and cover the full depth concentration range for the Arabian Sea. The SIO/ODF nitrate and nitrite standards and standards from the National Institute of Oceanography (NIO) in India (provided by S.W.A. Naqvi) were compared with the following results: NIO Nitrate Std.= 22.6 micromolar; SIO/ODF=22.5 micromolar NIO Nitrite Std.= 2.42 micromolar; SIO/ODF = 2.50 micromolar As can be inferred from the above, the nitrate plus nitrite values were almost identical in the mixed standards; 25.02 (NIO) vs 25.00 (SIO) micromolar. Lou Codispoti prepared independent primary nitrate, nitrite, silicate and phosphate standards for comparsion with SIO/ODF primary standards, and made dilutions using glassware entirely independent of the SIO/ODF glassware. The results were as follows: Codispoti SIO/ODF Nitrate 26.96 micromolar 26.85 micromolar Nitrite 2.90 " 2.86 " Silicate 86.4 " 85.8 " Phosphate 2.36 " 2.36 " All of the above results are within plus or minus 0.5% of the full scale values, and with the exception of nitrite, the rest are within plus or minus 0.2% of the full scale values. Because nitrite values in the suboxic waters of the Arabian Sea can attain values of approximately 5 micromolar, we tested the efficiency of the Cd column that reduces nitrate to nitrite in the nitrate analysis towards the end of the cruise. The efficiency was 98.3 per cent. The column may have been more efficient at the beginning of the cruise. We assumed that the column was 100% efficient. A 2% error in assumed column efficiency would in the worst case introduce an error of 0.1 micromolar in nitrite (nitrite=5 micromolar), but most of the errors would be much smaller. The ammonium results were the least precise as expected given the state of the methods available. Three primary standards were compared with agreement of about plus or minus three per cent of the full-scale value. Based on our

experience, we feel that the standards probably agreed within the precision of the method, but we found a significant salinity effect on the ammonium results that might explain some of these differences since the salinities of the comparison standards varied a bit. Experiments on the first JGOFS Arabian Sea process study cruise (TN043) suggest that the ammonium signal decreases by approximately 3.5% for a salinity increase of 1.00. Thus, salinity differences between samples and standards have to be taken into account when calculating the final ammonium concentrations. The ammonium values in this report have been corrected for this effect. Acknowledgements: I thank everyone who helped me with the above work, particularly K. Krogsland, J. Kinder, R. Kohrman, D. Masten, W. Martin, S.W.A. Naqvi, R. Patrick, W. Peterson, J. Aftab, G. White, and M. Realander. References: Broenkow, W.W. and J.D. Cline (1969) Colorimetric determination of dissolved oxygen at low concentrations. *Limnology and Oceanography*, 14, 450-454. Whitledge, T.E., S.C. Malloy, C.J. Patton, and C.O. Wirick (1981) Automated Nutrient Analysis in seawater. Brookhaven National Laboratory Report 51398, 216pp.

[[table of contents](#) | [back to top](#)]

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.

[[table of contents](#) | [back to top](#)]

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).

[[table of contents](#) | [back to top](#)]

Funding

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

[[table of contents](#) | [back to top](#)]