HLY-02-03 Service Group Bottle Data Documentation

15 July to 26 August 2002
Nome, Alaska to Nome, Alaska

Dr. Lou Codispoti, (on board PI),
Horn Point Laboratory
P.O. Box 775
2020 Horns Point Road
Cambridge MD 21613-0775
410-221-8479 phone
codispot@hpl.umces.edu

Dr. Jim Swift (PI)
Scripps Institution of Oceanography
University of California, San Diego, 0214
9500 Gilman Dr.
La Jolla, CA 92093-0214
858-534-3387 phone
jswift@ucsd.edu

On board team: Kristin Sanborn, Carny Cheng, Emily Cooper, Doug Masten, Rob Palomares
Other team members: John Gunn (ADCP), Dean Stockwell (Chlorophyll)

Funded by National Science Foundation OPP0125399

Data Set Overview

159 CTD casts on 45 stations were attempted. Four of these were completely aborted: no CTD data and no water samples, three additional casts were aborted, the CTD data was reported, but there were no water samples.

Instrumentation

CTD casts were performed with a rosette system consisting of a 12-place rosette frame with 30 liter Niskin-type bottles equipped with internal plastic coated springs and a 24-place SBE-32 Carousel pylon. Underwater electronic components consisted of:

- Sea-Bird Electronics, Inc. (SBE) 911plus CTD,
- WETLabs C-Star transmissometer with a 25cm path length and 660nm wavelength,
- Biospherical Instruments, Inc. Photosynthetically Active Radiation (PAR) sensor,
- Chelsea MkIII Aquatracka fluorometer, and
- Simrad, 5 volt - 500 meters altimeter.

Additionally, a Dr. Haardt fluorometer designed to detect colored organic matter (CDOM), and a Secchi disk were mounted on the CTD package. The CTD, transmissometer and fluorometers were mounted horizontally along the bottom of the rosette frame. The PAR sensor was located at the top of the rosette. The surface PAR sensor was located on the aft, port side of the flight deck. All sensors except the Secchi disk were interfaced with the CTD system. This instrument package provided pressure, dual temperature and dual conductivity channels as well as light transmissivity and fluorometric signals at a sample rate of 24 scans per second.

The rosette system was suspended from a standard UNOLS 3 conductor 0.322” electromechanical cable.

The CTD used was serial number 09P12613-0474 and the sensor’s model and serial numbers are listed in Table 1.

TABLE 1 Instrument/Sensor Serial Numbers

Primary Temperature	Primary Conductivity	Secondary Temperature	Secondary Conductivity	Pressure	Transmissometer
SBE 3plus	SBE 4C	SBE 3plus	SBE 4C	401K-105	C-Star
03-2324	04-2112	03-2166	04-23193	69008	CST-479DR

Oxygen	Fluorometer	PAR	Surface PAR	Altimeter
SBE 43	Aqua 3	QSP-2300	QSR-240	807
0060	88191	4644	6368	9701090

The bottles on the rosette were General Oceanic 30 liter bottles. The bottles were equipped with nylon coated springs and silicone o-rings. Bottle numbering is 1 to 12 with 12 tripped first usually at the deepest sampling level and 1 tripped last at the shallowest sampling level.

The distance of the mid-points of the 30 L Niskin bottles from the bottom-mounted sensors was ~1m. The PAR sensor was ~ 0.6 m above the mid-point of the Niskin bottles, and the Secchi disk which is mounted on a rod was ~ 0.9 m above the mid-point of the 30 L Niskin bottles. The distance between the PAR sensor and the bottom mounted sensors was ~1.7 m. The 30 Liter Niskin bottles are ~1.0 m long.

Most of the 30 liter Niskin-type bottles were manufactured by General Oceanics, but some were Ocean Test Equipment bottles that had their external springs replaced with the same internal springs used in the General Oceanics bottles. Bottle 7 was replaced after station 010 cast 01 and again after station 24 cast 4. Bottle 4 was replaced after station 14 cast 2. To minimize toxicity the bottles were equipped with silicone O-rings. At times the plastic coating on the springs broke down and some rust was apparent. To minimize the occurrence of rust, the springs were inspected before the cruise and, as feasible during the cruise. During the mid-cruise servicing of the CTD/rosette system that occurred following station 024 cast 04, all springs were inspected and some were re-coated with plastic

CTD Data

CTD Laboratory Calibration Procedures

Pre-cruise laboratory calibrations of CTD pressure, temperature and conductivity sensors were used to generate coefficients for the calculation of these parameters from their respective sensor frequencies. The conductivity calibrations were performed at Sea-Bird Electronics, Inc. in Bellevue, Washington. Calibrations of the pressure and temperature sensors were performed by

Scripps Institution of Oceanography, Shipboard Technical Support/Oceanographic Data Facility (SIO/STS/ODF) personnel. These laboratory temperature calibrations were referenced to the International Temperature Scale of 1990 (ITS-90).

CTD Data Acquisition

The CTD 911plus was operated generally as suggested in the Sea-Bird CTD Operating and Repair Manual, which contains a description of the system, its operation and functions (Sea-Bird Electronics, Inc., 2002). One difference from Sea-Bird's operation is that data acquisition was started on deck. This procedure allows a check of the pressure offset and an unblocked reading of the transmissometer. The Seasoft acquisition program as described in the CTD Data Acquisition Software Manual (Sea-Bird Electronics, Inc., 2001) provided a real-time graphical display of selected parameters adequate to monitor CTD performance and information for the selection of bottle-tripping depths. Raw data from the CTD were archived on the PC's hard disk at the full 24 Hz sampling rate.

A CTD Station Sheet form was filled in for each deployment, providing a record of times, positions, bottom depth, bottle sampling depths, and every attempt to trip a bottle, as well as any pertinent comments. When the equipment and personnel were ready, data acquisition was started. The CTD operator pressed a control key (flag), which appends a summary line into one of the two files created for "inventory" files. These files contain a summary of the time, ship's position, and current scan number each time the control key is pressed. They are used as a reference to mark important events during the cast, such as on deck pressure, when the lowering was initiated, when the package was at the bottom, when bottles were tripped and the on-deck pressure with ending position. After the initial flag, the rosette/CTD system was lowered into the water and held at or near the surface for 3-5 minutes to permit activation of the CTD pumps and equilibration of the sensors. Then, the operator again created a flag and simultaneously directed the winch operator to begin lowering. The operator created a flag at the deepest point of the cast. Bottom depths were calculated by combining the distance above bottom, reported by the altimeter, and the maximum depth of the CTD package when bottom altimeter readings were available. If there was no altimeter reading, then the bottom depth is reported from the ship's Bathy 2000 or Knudsen model 320B/R depth recorder. These data, corrected for the draft of the transducer, were logged in uncorrected meters (assuming a sound velocity of 1500 m/sec). If the altimeter and depth recorder data were unavailable, the final resort was to use depth data from the SeaBeam system (corrected sound velocities).

The depth of each bottle trip was written on the station log and flagged in the data file. The performance of all sensors was monitored during the cast. After the rosette recovery, the operator created a final flag denoting the end of the cast. Any faulty equipment or exceptionally noisy data were noted on the log sheet.

CTD Data Processing

Sea-Bird Seasoft CTD processing software was employed. The processing programs are outlined below. A more complete description may be found in the Sea-Bird Software Manual which is available from the Sea-Bird website (www.seabird.com).

The sequence of programs that were run in processing CTD data from this cruise are as follows:

- ***DATCNV*** - Converts data from raw frequencies and voltages to corrected engineering units

- ***WILDEDIT*** - Eliminates large spikes
- ***CELLTM*** - Applies conductivity cell thermal mass correction
- ***FILTER*** – A low pass filter to smooth pressure for LOOPEDIT
- ***LOOPEDIT*** - Marks scans where velocity is less than selected value to avoid pressure reversals from ship roll, or during bottle flushing.
- ***DERIVE*** - Computes calculated parameters
- ***BINAVG*** - Average data into desired pressure bins

The quality control steps included:

- ***Sensor verification*** After the CTD was set up and sensor serial numbers and sensor location were entered into the computer, and another check was made to verify that there were no tabulation errors.
- ***Seasoft Configuration File*** was reviewed to verify that individual sensors were represented correctly, with the correct coefficients.
- ***Temperature*** was verified by comparing primary and secondary sensor data.
- ***Conductivity*** was checked by comparison of the two sensors with each other and with bottle salinity samples.
- ***Position Check*** A chart of the ship's track was produced and reviewed for any serious problems. The positions were acquired from the ship's Trimble P-code navigation system.
- ***Visual Check*** Plots of each usable cast were produced and reviewed for any noise and spikes that may have been missed by the processing programs.
- The density profile was checked for inversions that might have been produced by sensor noise or response mismatches. Additional Sea-Bird programs were run on all or some stations to maximize the data quality.
- ***WFILTER*** - Provides a median filter for data smoothing of .CNV files
- ***WFILTER*** was employed on selected stations where there were spikes in the data, specifically in the transmissometer data. This program was run after ***WILDEDIT***.**Pressure**

CTD values determined on deck before and after each cast were compared to determine a pressure offset correction. The comparison suggested that no pressure offset was necessary.

Temperature

The primary temperature sensor was calibrated just before the expedition. The dual temperature sensors were monitored during the expedition and exhibited good agreement. It appears that no additional corrections need to be applied.

Conductivity

Corrected CTD pressure and temperature values were used with bottle salinities to back-calculate bottle conductivities. Comparison of these bottle values with the CTD primary conductivity values indicated no additional offset needed to be applied to the data.

Transmissometer
A WETLabs calibrated transmissometer was utilized throughout the cruise. An on deck calibration check was performed and even though there was little degradation from the last calibration the new coefficients were applied to the data set.

Oxygen, Fluorometer, and PAR
The CTD oxygen data are only intended for qualitative use. Similarly, the fluorometric and PAR data are not calibrated.

The winch grounding system was periodically cleaned to reduce modulo errors, which were not a significant problem during this leg (HLY0203). During the previous leg (HLY0201) there were several modulo word errors at the beginning of the expedition. A check of all connections and cables was performed and it was found that a shielding around the winch motor eliminated the spiking and most of the noise in the CTD signal.

The CTD down trace is reported unless there was a problem then the up trace is reported. A notation was made in the comments file if this was necessary.

CTD Data Footnoting
WHP water bottle quality flags were assigned as defined in the WOCE Operations Manual (Joyce and Corry, 1994). These flags and interpretation are tabulated in the CTD and Bottle Data Distribution, Quality Flags section of this document.

Data Comments

Fine structure including minor density inversions that may appear in the upper ~ 10 m of the profiles is most likely caused by ship discharges/turbulence. A comparison cast made from a small boat at station 14 is included in the data on the EOL web site. These data revealed generally similar profiles, but minor density inversions occurred in the shipboard profile and were absent in the profile taken from the small boat. To minimize the ship effect, engine cooling water discharges were restricted to the port side of the Healy starting with station 002 during the previous leg (HLY0201) and continuing on this leg. At about this time (station 002, HLY0201), a "yo yo" procedure was adopted to induce bottle flushing whenever waves and ship motion were weak. This procedure was employed for all bottle trips under quiescent conditions except for productivity casts, and for some thin low salinity surface lenses. In the latter cases, the CTD was raised slowly so as not to disturb the thin low-salinity surface layers with the CTD wake, and the soak time was relied on to flush the bottle. Even though this procedure may not have adequately flushed the surface bottle, it was sufficient to reveal some large salinity differences in the ~ 1m depth interval separating the CTD sensor from the bottle mid-point. These situations occurred in melting ice under low winds and waves, and it is suspected that the water may have been stratified even within the surface Niskin bottle. Regardless of the procedure employed, the CTD operators were instructed to wait for at least 1 minute (typically > 1.5 minutes) before tripping the bottle.

All salinity, nutrient and dissolved oxygen data collected by the service team have gone through several stages of editing and are not likely to change significantly.

Bottle Data

There were five generic types of casts performed with differing sampling protocols. Generally speaking, the sampling during these casts were as follows, but there is some cast-to-cast variation.

- **Hydrographic**
    - ***Oxygen,***
    - ***Total CO2,***
    - ***Total Alkalinity,***
    - ***Nutrients***
    - ***Chlorophyll***
    - ***Salinity***
    - ***O18/O16***
    - ***Dissolved Organic Carbon***
    - ***Dissolved Inorganic Carbon***
    - ***Particulate Organic Matter***
    - ***Benthic***
    - ***Stable Isotopes***
    - ***Radioisotopes***
- **Productivity**
    - ***Oxygen and/or Oxygen Respiration***
    - ***Productivity***
    - ***Nutrients***
    - ***Chlorophyll***
    - ***HPLC***
    - ***Bacteria***
    - ***Micro Zooplankton***
    - ***Bio-Optics***
- **Bio-Markers**
    - ***Dissolved Organic Matter***
    - ***Lignin***
- **Radium**
    - ***Nutrients***
    - ***Radium***
- **Zooplankton**
    - ***Nutrients***

There were two other special types of casts for Cesium 137 and bacterial DNA.

The correspondence between individual sample containers and the rosette bottle from which the sample was drawn was recorded on the sample log for the cast. This log also included any comments or anomalous conditions noted about the rosette and bottles.

Normal sampling practice included opening the drain valve before the air vent on the bottle, to check for air leaks. This observation together with other diagnostic comments (e.g., "lanyard caught in lid", "valve left open") that might later prove useful in determining sample integrity were routinely noted on the sample log. Drawing oxygen samples also involved taking the sample draw temperature from the bottle.

Pressure and Temperatures

All pressures and temperatures for the bottle data tabulations were obtained by averaging CTD data for a brief interval at the time the bottle was closed and then applying the appropriate calibration data.

The temperatures are reported using the International Temperature Scale of 1990.

Salinity

596 salinity samples were analyzed.

Equipment and Techniques

Salinity samples were drawn into 200 ml high alumina borosilicate bottles, which were rinsed three times with sample prior to filling. The bottles were sealed with custom-made plastic insert thimbles and Nalgene screw caps. This container provides very low container dissolution and sample evaporation.

A Guildline Autosal 8400A #57-526, standardized with IAPSO Standard Seawater (SSW) batch P-140, was used to measure the salinities. Prior to the analyses, the samples were stored to permit equilibration to laboratory temperature, usually 8-20 hours. The salinometer was modified by ODF and contained an interface for computer-aided measurement. The salinometer was standardized with a fresh vial of standard seawater at the beginning and end of the run. The SSW vial at the end of the run was used as an unknown to check for drift. The salinometer cell was flushed until two successive readings met software criteria for consistency; these were then averaged for a final result. The estimated accuracy of bottle salinities run at sea is usually better than 0.002 PSU relative to the particular standard seawater batch used.

Laboratory Temperature

The temperature stability in the salinometer laboratory was fair, sometimes varying as much as 3.5ºC during a run of samples. The laboratory temperature was generally 1-2ºC lower than the Autosal bath temperature.

Oxygen

729 samples were analyzed for oxygen.

Equipment and Techniques

Dissolved oxygen analyses were performed with an ODF-designed automated oxygen titrator using photometric end-point detection based on the absorption of 365nm wavelength ultra-violet light. The titration of the samples and the data logging were controlled by PC software. Thiosulfate was dispensed by a Dosimat 665 buret driver fitted with a 1.0 ml buret. The ODF method used a whole-bottle modified-Winkler titration following the technique of Carpenter (1965) with modifications by Culberson (1991), but with higher concentrations of potassium iodate standard (approximately 0.012N) and thiosulfate solution (55 g/l). Standard KIO_3 solutions prepared ashore were run at the beginning of each run. Reagent and distilled water blanks were determined, to account for presence of oxidizing or reducing materials.

Sampling and Data Processing
Samples were collected for dissolved oxygen analyses soon after the rosette was brought on board. Using a Tygon drawing tube, nominal 125ml volume-calibrated iodine flasks were rinsed, then filled and allowed to overflow for at least 3 flask volumes. The sample draw temperature was measured with a small platinum resistance thermometer embedded in the drawing tube. Reagents were added to fix the oxygen before stoppering. The flasks were shaken twice to assure thorough dispersion of the precipitate, once immediately after drawing, and then again after about 20 minutes. The samples were usually analyzed within a few hours of collection. Thiosulfate normalities were calculated from each standardization and corrected to 20ºC. The 20ºC normalities and the blanks were plotted versus time and were reviewed for possible problems. New thiosulfate normalities were recalculated as a linear function of time, if warranted. The oxygen data were recalculated using the smoothed normality and an averaged reagent blank. Oxygens were converted from milliliters per liter to micromoles per kilogram using the sampling temperature.

Volumetric Calibration
Oxygen flask volumes were determined gravimetrically with degassed deionized water to determine flask volumes at ODF's chemistry laboratory. This is done once before using flasks for the first time and periodically thereafter when a suspect bottle volume is detected. The volumetric flasks used in preparing standards were volume-calibrated by the same method, as was the 10 ml Dosimat buret used to dispense standard iodate solution.

Standards
Potassium iodate was obtained from Johnson Matthey Chemical Co. and was reported by the supplier to be >99.4% pure.

Nutrients

1603 samples were analyzed for nutrients.

Equipment and Techniques

Nutrient analyses (phosphate, silicate, nitrate+nitrite, urea, ammonium, and nitrite) were performed on an ODF-modified 6-channel Technicon AutoAnalyzer II, generally within a few hours after sample collection. Occasionally samples were refrigerated for longer periods and the data are annotated if it was felt that the storage time had a significant effect. The analog outputs from each of the six channels were digitized and logged automatically by computer (PC) at 2-second intervals. A suite of frozen nutrient samples from the Bering Sea (~300) left for us to analyze by participants in HLY0202 (the cruise that separated the two Process cruises, HLY0201 and HLY0203) was also analyzed. Many of the frozen samples had extremely high silicate concentrations and only those values of about 50 micromolar or less should be considered reliable. This is because of the problem of silicate polymerization during freezing and because the silicate method employed was optimized for waters with silicate concentrations between 0 and 90 micromolar. The samples were thawed in a warm tap water bath and analyzed as soon as possible in order to obtain the best possible data on the nutrients other than silicate. For a discussion of the effects of freezing on silicate concentrations see Macdonald *et al.* (1986).

Silicate was analyzed using the technique of Armstrong *et al*., (Armstrong, 1967). The sample was passed through a 15mm flowcell and the absorbance measured at 660nm.

A modification of the Armstrong *et al*. (Armstrong 1967) procedure was used for the analysis of nitrate and nitrite. For the nitrate plus nitrite analysis, the seawater sample was passed through a cadmium reduction column where nitrate was quantitatively reduced to nitrite. The stream was then passed through a 15mm flowcell and the absorbance measured at 540nm. The same technique was employed for nitrite analysis, except the cadmium column was bypassed, and a 50mm flowcell was used for measurement. Periodic checks of the column efficiency were made by running alternate equal concentrations of NO2 and NO3 through the NO3 channel to ensure that column efficiencies were high (> 95%). Nitrite concentrations were subtracted from the nitrate+nitrite values to obtain nitrate concentrations.

Phosphate was analyzed using a modification of the Bernhardt and Wilhelms [Bernhardt 1967.] technique. The reaction product was heated to ~55ºC to enhance color development, then passed through a 50mm flowcell and the absorbance measured at 820m.

Ammonium was determined by the Berthelot reaction (Patton and Crouch 1977) in which sodium hypochlorite and phenol react with ammonium ion to produce indophenol blue, a blue compound, with an absorption maximum at 637nm. The solution was heated to 55°C and passed through a 50mm flowcell at 640nm.

Urea was analyzed via a modification of the method of Rahmatullah and Boyde (1980), which is based on the classic diacetyl monoxime method. A solution of diacetyl monoxime, thiosemicarbizide and acetone is followed by the addition of ferric chloride, which acts as a catalyst. The resultant solution is heated to 90°C and passed through a 50mm flowcell. The absorbance is measured at 520nm.

Sampling and Data Processing

Nutrient samples were drawn into 45 ml polypropylene, screw-capped "oak-ridge type" centrifuge tubes. The tubes were cleaned with 10% HCl and rinsed with sample three times before filling. Standardizations were performed at the beginning and end of each group of analyses (typically 6-24 samples) with an intermediate concentration mixed nutrient standard prepared prior to each run from a secondary standard in a low-nutrient seawater matrix. The secondary standards were prepared aboard ship by dilution from primary standard solutions. Dry standards were pre-weighed at the laboratory at ODF, and transported to the vessel for dilution to the primary standard. Sets of 6-7 different standard concentrations covering the range of sample concentrations were analyzed periodically to determine the deviation from linearity, if any, as a function of concentration for each nutrient analysis. A correction for non-linearity was applied to the final nutrient concentrations when necessary. After each group of samples was analyzed, the raw data file was processed to produce another file of response factors, baseline values, and absorbances. Computer-produced absorbance readings were checked for accuracy against values taken from a strip chart recording. A stable deep seawater check sample was run frequently as a substandard check.

Nutrients, when reported in micromoles per kilogram, were converted from micromoles per liter by dividing by sample density calculated at 1 atm pressure (0 db), *in situ* salinity, and an assumed laboratory temperature of 25ºC.

Also reported is N**, a parameter calculated from nitrate, nitrite, ammonium and phosphate concentrations. This parameter is defined as $N^{**} = ((N-16P + 2.98)\mu M)\ 0.87$, where P = the phosphate concentration in μM, and N = (nitrate+nitrite+ammonium in μM). This parameter is quite similar to the original N* parameter defined by Gruber and Sarmiento (1997) except that we include ammonium concentrations because of the high ammonium concentrations that can occur in the SBI region. The underlying premise of both N* and N** is that the N/P atomic regeneration ratio in seawater is normally close to the 16/1 N/P Redfield ratio. The assumption is that deviations from this ratio in N/P ratios in a water mass arise primarily from nitrogen fixation which produces organic matter with N/P ratios in excess of 16/1, or denitrification which consumes nitrate and other forms of fixed nitrogen and converts these forms into elemental dinitrogen gas. Values less than 2.98 suggest that a water mass has experienced net denitrification and higher values suggest net nitrogen fixation. The factors 2.98 and 0.87 are explained by Gruber and Sarmiento (1997), and there is some debate about whether they should be included, but we do so in order to facilitate comparison with the distributions presented by Gruber and Sarmiento (1997).

Nutrient Standards

Na_2SiF_6, the silicate primary standard, was obtained from Johnson Matthey Company and Fisher Scientific and was reported by the suppliers to be >98% pure. Primary standards for nitrate (KNO3), nitrite ($NaNO_2$), and phosphate (KH_2PO_4) were obtained from Johnson Matthey Chemical Company., and the supplier reported purities of 99.999%, 97%, and 99.999%, respectively. Ammonia, (NH4(SO4)2), and Urea primary standards were obtained from Fisher Scientific and reported to be >99% pure. In addition, during the HLY0201 leg, L. A. Codispoti supplied independent comparison~~s~~ standards for all nutrients. All standard intercomparisons, produced agreement well within the precision of the employed methods.

Post Cruise QA of Nutrient and Dissolved Oxygen Data

Post cruise quality assurance of the nutrient data included an analysis of the deep-water "check samples" and of abyssal nutrient and dissolved oxygen concentrations. This report appears as an **Addendum** to this document.

Bottle Data Processing

After the samples were drawn and analyzed, the next stage of processing involved merging the different data streams into a common file. The rosette cast and bottle numbers were the primary identification for all ODF-analyzed samples taken from the bottle, and were used to merge the analytical results with the CTD data associated with the bottle.

Diagnostic comments from the sample log, and notes from analysts and/or bottle data processors were entered into a computer file associated with each station (the "quality" file) as part of the quality control procedure. These comments are included in Appendix A. Sample data from bottles suspected of leaking were checked to see if the properties were consistent with the profile for the cast, with adjacent stations, and, where applicable, with the CTD data. Direct inspection of the tabular data, property-property plots and vertical sections were all employed to check the data. Revisions were made whenever there was an objective reason to delete, annotate or re-calculate a datum. WHP water sample flags were selected to indicate the reliability of the individual parameters affected by the comments. WHP bottle flags were assigned where evidence showed the entire bottle was affected, as in the case of a leak, or a bottle trip at other than the intended depth.

Bottle Data Footnoting

WHP water bottle quality flags were assigned as defined in the WOCE Operations Manual [Joyce]. These flags and interpretation as tabulated in the Data Distribution, Bottle Data, Quality Flags section of this document.

Data Distribution

The CTD and bottle data can be obtained via the NCAR/Earth Observing Laboratory (formerly JOSS [Joint Office for Science Support/UCAR]) web-site, www.eol.ucar.edu/projects/sbi. The data are reported using the WHP-Exchange (WOCE Hydrographic Program) format and the quality coding follows those outlined by the WOCE program (Joyce, 1994). In addition, the format can be obtained through the WOCE Hydrographic Program web-site, http://WHPO.ucsd.edu . The descriptions in this document have been edited from the reference to annotate the format specific to this data distribution. ASCII files for each station were created with comments recorded on the CTD Station Logs during data acquisition. These ASCII files include data processing comments noting any problems, the resolution, and the footnoting that may have occurred. A separate ASCII file was also created with the comments from the Sample Log Sheets that include problems with the Niskin bottles that could compromise the samples. Comments arising from inspection and checking of the data are also included in the ASCII file. These comment files are also in the EOL database. Raw (unprocessed) CTD data are located in the EOL database as well. The file hly0203_ctd_raw.zip contains ssscc.cfg, ssscc.con, ssscc.dat and ssscc.hdr (where sss = station number and cc = cast number) files as acquired by the SeaBird SeaSave acquisition program, sbscan.sum file and calibration information for all sensors. The *.cfg file is datcnv.cfg with the beginning scan number and *.con files may include a correction based on the bottle salinity samples. The sbscan.sum file is a list of stations and beginning scan number. Configuration files for the various SeaBird CTD processing programs are also included where applicable.

General rules for WHP-exchange:

1. Each line must end with a carriage return or end-of-line.
2. With the exception of the file type line, lines starting with a "#" character, or including and following a line which reads "END_DATA", each line in the file must have exactly the same number of commas as do all other lines in that file.
3. The name of a quality flag always begins with the name of the parameter with which it is associated, followed by an underscore character, followed by "FLAG", followed by an underscore, and then followed by an alphanumeric character, W.
4. The "missing value" for a data value is always defined as -999, but written in the decimal place format of the parameter in question. For example, a missing salinity would be written -999.0000 or a missing phosphate -999.00.
5. The first four characters of the EXPOCODE are the U.S. National Oceanographic Data Center (NODC) country-ship code, then followed by up to an 8 characters expedition name of cruise number, ie. 32H1HLY0203.

CTD Data

CTD data is located in file 32H1hly0203_ct1.zip. This file contains ssscc_ct1.csv files for each station and cast where sss=3 digit station identifier and cc=2 digit cast identifier.

Description of ssscc_ct1.csv file layout.

1st line	File type, here CTD, followed by a comma and a DATE_TIME stamp YYYYMMDDdivINSwho YYYY 4 digit year MM 2 digit month DD 2 digit day div division of Institution INS Institution name who initials of responsible person
# lines	A file may include 0-N optional lines at the start of a data file, each beginning with a "#" character and each ending with carriage return or end-of-line. Information relevant to file change/update history may be included here, for example.
2nd line	NUMBER_HEADERS = n (n = 10 in this table and the example_ct1.csv file.)
3rd line	EXPOCODE = [expocode] The expedition code, assigned by the user.
4th line	SECT_ID = [section] The SBI station specification. *Optional*.
5th line	STNNBR = [station] The originator's station number
6th line	CASTNO = [cast] The originator's cast number
7th line	DATE = [date] Cast date in YYYYMMDD integer format.
8th line	TIME = [time] Cast time that CTD was at the deepest sampling point.
9th line	LATITUDE = [latitude] Latitude as SDD.dddd where "S" is sign (blank or missing is positive), DD are degrees, and dddd are decimal degrees. Sign is positive in northern hemisphere, negative in southern hemisphere
10th line	LONGITUDE = [longitude] Longitude as SDDD.dddd where "S" is sign (blank or missing is positive), DDD are degrees, and dddd are decimal degrees. Sign is positive for "east" longitude, negative for "west" longitude
11th line	DEPTH = [bottom] Reported depth to bottom. Preferred units are "meters" and should be specified in Line 2. In general, corrected depths are preferred to uncorrected depths. Documentation accompanying data includes notes on methodology of correction. *Optional.*
next line	Parameter headings.
next line	Units.
data lines	A single _ct1.csv CTD data file will normally contain data lines for one CTD cast.
END_DATA	The line after the last data line must read END_DATA, and be followed by a carriage return or end of line.
other lines	Users may include any information they wish in 0-N optional lines at the end of a data file, after the END_DATA line.

Parameter names, units, format, and comments

Parameter	Units	Format	Comments

CTDPRS	DB	F7.1	CTD pressure, decibars
CTDPRS_FLAG_W		I1	CTDPRS quality flag
CTDTMP	ITS-90	F8.3	CTD temperature, degrees C (ITS-90)
CTDTMP_FLAG_W		I1	CTDTMP quality flag
CTDSAL		F8.3	CTD salinity
CTDSAL_FLAG_W		I1	CTDSAL quality flag
CTDOXY	UMOL/KG	F7.1	CTD oxygen, micromoles/kilogram
CTDOXY_FLAG_W		I1	CTDOXY quality flag
XMISS	%TRANS	F7.1	Transmissivity, percent transmittance
XMISS_FLAG_W		I1	XMISS quality flag
FLUOR	VOLTS	F8.3	Fluorometer, voltage
FLUOR_FLAG_W		I1	Fluorometer quality flag
PAR	VOLTS	F8.3	PAR, voltage
PAR_FLAG_W		I1	PAR quality flag
FLCDOM	VOLTS	F8.3	CDOM Fluorometer, voltage
FLCDOM_FLAG_W		I1	CDOM Fluorometer quality flag

Quality Flags

CTD data quality flags were assigned to the CTDTMP (CTD temperature), CTDSAL (CTD salinity) and XMISS (Transmissivity) parameters as follows:

2 Acceptable measurement.

3 Questionable measurement. *The data did not fit the station profile or adjacent station comparisons (or possibly bottle data comparisons). The data could be acceptable, but are open to interpretation.*

4 Bad measurement. *The CTD data were determined to be unusable.*

5 Not reported. *The CTD data could not be reported, typically when CTD salinity is flagged 3 or 4.*

9 Not sampled. *No operational sensor was present on this cast*

WHP CTD data quality flags were assigned to the CTDOXY (CTD O_2), FLUORO (Fluorometer), PAR (PAR), SPAR (Surface PAR), and HAARDT (Haardt Fluorometer CDOM) parameter as follows:

1 Not calibrated. *Data are uncalibrated.*

9 Not sampled. *No operational sensor was present on this cast. Either the sensor cover was left on or the depth rating necessitated removal.*

Bottle Data

Description of 32H1HLY0203_hy1.csv file layout.

1st line	File type, here BOTTLE, followed by a comma and a DATE_TIME stamp YYYYMMDDdivINSwho YYYY 4 digit year MM 2 digit month DD 2 digit day div division of Institution INS Institution name who initials of responsible person
#lines	A file may include 0-N optional lines, typically at the start of a data file, but after the file type line, each beginning with a "#" character and each ending with carriage return or end-of-line. Information relevant to file change/update history of the file itself may be included here, for example.
2nd line	Column headings.
3rd line	Units.
data lines	As many data lines may be included in a single file as is convenient for the user, with the proviso that the number and order of parameters, parameter order, headings, units, and commas remain absolutely consistent throughout a single file.
END_DATA	The line after the last data line must read END_DATA.
other lines	Users may include any information they wish in 0-N optional lines at the end of a data file, after the END_DATA line.

Header columns

Parameter	Format	Description notes
EXPOCODE	A12	The expedition code, assigned by the user.
SECT_ID	A7	The SBI station specification. *Optional*.
STNNBR	A6	The originator's station number.
CASTNO	I3	The originator's cast number.
BTLNBR	A7	The bottle identification number.
BTLNBR_FLAG_W	I1	BTLNBR quality flag.
DATE	I8	Cast date in YYYYMMDD integer format.
TIME	I4	Cast time (UT) as HHMM
LATITUDE	F8.4	Latitude as SDD.dddd where "S" is sign (blank or missing is positive), DD are degrees, and dddd are decimal degrees. Sign is positive in northern hemisphere, negative in southern hemisphere
LONGITUDE	F9.4	Longitude as SDDD.dddd where "S" is sign (blank or missing is positive), DDD are degrees, and dddd are decimal degrees. Sign is positive for "east" longitude, negative for "west" longitude
DEPTH	I5	Reported depth to bottom. Preferred units are "meters" and should be specified in Line 2. In general, corrected depths are preferred to uncorrected depths. Documentation accompanying data includes notes on methodology of correction. *Optional.*

Parameter names, units, and comments:

Parameter	Units	Format	Comments
CTDPRS	DB	F9.1	CTD pressure, decibars
CTDPRS_FLAG_W		I1	CTDPRS quality flag
SAMPNO		A7	Cast number *100+BTLNBR. *Optional*
CTDTMP	ITS-90	F9.4	CTD temperature, degrees C, (ITS-90)
CTDTMP_FLAG_W		I1	CTDTMP quality flag
CTDCOND	MS/CM	F9.4	CTD Conductivity, milliSiemens/centimeter
CTDCOND_FLAG_W		I1	CTDCOND quality flag
CTDSAL		F9.4	CTD salinity
CTDSAL_FLAG_W		I1	CTDSAL quality flag
SALNTY		F9.4	bottle salinity
SALNTY_FLAG_W		I1	SALNTY quality flag
SIGMA	THETA	F9.4	Sigma Theta
SIGMA_FLAG_W		I1	Sigma Theta quality flag
CTDOXY	UMOL/KG	F9.1	CTD oxygen, micromoles/kilogram
CTDOXY_FLAG_W		I1	CTDOXY quality flag
CTDOXY	ML/L	F9.3	CTD oxygen, milliliters/liter
CTDOXY_FLAG_W		I1	CTDOXY quality flag
OXYGEN	UMOL/KG	F9.1	bottle oxygen
OXYGEN_FLAG_W		I1	OXYGEN quality flag
OXYGEN	ML/L	F9.3	bottle oxygen, milliliters/liter
OXYGEN_FLAG_W		I1	OXYGEN quality flag
O2TEMP	DEGC	F6.1	Temperature of water from spigot during oxygen draw, degrees C
O2TEMP_FLAG_W		I1	O2TEMP quality flag
SILCAT	UMOL/KG	F9.2	SILICATE, micromoles/kilogram
SILCAT_FLAG_W		I1	SILCAT quality flag
SILCAT	UMOL/L	F9.2	SILCATE, micromoles/liter
SILCAT_FLAG_W		I1	SILCAT quality flag
NITRAT	UMOL/KG	F9.2	NITRATE, micromoles/kilogram
NITRAT_FLAG_W		I1	NITRAT quality flag
NITRAT	UMOL/L	F9.2	NITRATE, micromoles/liter
NITRAT_FLAG_W		I1	NITRAT quality flag
NITRIT	UMOL/KG	F9.2	NITRITE, micromoles/kilogram

NITRIT_FLAG_W		I1	NITRIT quality flag
NITRIT	UMOL/L	F9.2	NITRITE, micromoles/liter
NITRIT_FLAG_W		I1	NITRIT quality flag
PHSPHT	UMOL/KG	F9.2	PHOSPHATE, micromoles/kilogram
PHSPHT_FLAG_W		I1	PHSPHT quality flag
PHSPHT	UMOL/L	F9.2	PHOSPHATE, micromoles/liter
PHSPHT_FLAG_W		I1	PHSPHT quality flag
NH4	UMOL/KG	F9.2	AMMONIUM, micromoles/kilogram
NH4_FLAG_W		I1	NH4 quality flag
NH4	UMOL/L	F9.2	AMMONIUM, micromoles/liter
NH4_FLAG_W		I1	NH4 quality flag
UREA	UMOL/KG	F9.2	UREA, micromoles/kilogram
UREA_FLAG_W		I1	UREA quality flag
UREA	UMOL/L	F9.2	UREA, micromoles/liter
UREA_FLAG_W		I1	UREA quality flag
FLUORO	VOLTS	F8.3	Fluorometer, voltage
FLUORO_FLAG_W		I1	Fluorometer quality flag
PAR	VOLTS	F8.3	PAR, voltage
PAR_FLAG_W		I1	PAR quality flag
SPAR	VOLTS	F8.3	Surface PAR, voltage
SPAR_FLAG_W		I1	Surface PAR quality flag
HAARDT	VOLTS	F8.3	CDOM Fluorometer, voltage
HAARDT_FLAG_W		I1	CDOM Fluorometer quality flag
N**	UMOL/L	F9.2	N**, micromoles/liter
N**_FLAG_W		I1	N** quality flag
CHLORO	UG/L	F8.2	Chlorophyll, micrograms/liter
CHLORO_FLAG_W		I1	Chlorophyll quality flag
PHAEO	UG/L	F8.2	Phaeophytin, micrograms/liter
PHAEO_FLAG_W		I1	Phaeophytin quality flag
BTL_DEP	METERS	F5.0	bottle depth, meters
BTL_LAT		F8.4	Latitude at time of bottle trip, decimal degrees
BTL_LONG		F9.4	Longitude at time of bottle trip, decimal degrees
JULIAN		F8.4	Julian day and time as fraction of day of the bottle trip.

Quality Flags

CTD data quality flags were assigned to CTDPRS (CTD pressure), CTDTMP (CTD temperature), CTDCOND (CTD Conductivity), and CTDSAL (CTD salinity) as defined in Data Distribution, CTD Data, Quality Flags section of this document. CTDOXY (CTD O_2), FLUORO (Fluorometer), PAR (PAR), and SPAR (Surface PAR) parameters are flagged with either a 2, acceptable or 9, not drawn.

Bottle quality flags were assigned to the BTLNBR (bottle number) as defined in the WOCE Operations Manual [Joyce] with the following additional interpretations:

2	No problems noted.
3	Leaking. *An air leak large enough to produce an observable effect on a sample is identified by a flag of 3 on the bottle and a flag of 4 on the oxygen. (Small air leaks may have no observable effect, or may only affect gas samples.)*
4	Did not trip correctly. *Bottles tripped at other than the intended depth were assigned a flag of 4. There may be no problems with the associated water sample data.*
9	The samples were not drawn from this bottle.

WHP water sample quality flags were assigned to the water samples using the following criteria:

1	The sample for this measurement was drawn from the water bottle, but the results of the analysis were not (*yet*) received.
2	Acceptable measurement.
3	Questionable measurement. *The data did not fit the station profile or adjacent station comparisons (or possibly CTD data comparisons). No notes from the analyst indicated a problem. The data could be acceptable, but are open to interpretation.*
4	Bad measurement. *The data did not fit the station profile, adjacent stations or CTD data. There were analytical notes indicating a problem, but data values were reported. Sampling and analytical errors were also flagged as 4.*
5	Not reported. *The sample was lost, contaminated or rendered unusable.*
9	The sample for this measurement was not drawn.

Not all of the quality flags are necessarily used on this data set.

References

Armstrong, F. A. J., Stearns, C. R., and Strickland, D. H., "The measurement of upwelling and subsequent biological processes by means of the Technicon AutoAnalyzer and associated equipment," *Deep-Sea Research*, 14, pp. 381-389, (1967).

Bernhardt, Wilhelms A., "The continuous determination of low level iron, soluble phosphate and total phosphate with the AutoAnalyzer", *Technicon Symposia*, **I**, pp. 385-389 (1967).

Carpenter, J. H., "The Chesapeake Bay Institute technique for the Winkler dissolved oxygen method," *Limnology and Oceanography*, 10, pp. 141-143 (1965).

Culberson, C. H., Knapp, G., Stalcup, M., Williams, R.T., and Zemlyak, F., "A comparison of methods for the determination of dissolved oxygen in seawater," Report WHPO 91-2, WOCE Hydrographic Programme Office (Aug 1991).

Gordon, L.I., Jennings, J.C., Ross, A.A. and J.M. Krest, "A Suggested Protocol for Continuous Flow Automated Analysis of Seawater Nutrients in the WOCE Hydrographic Program and the Joint Global Ocean Fluxes Study". 1993. WOCE Hydrographic Programs Office, Methods Manual WHPO 91-1.

Gruber, N. and J.L. Sarmiento, "Global patterns of marine nitrogen fixation and denitrification." *Global Biogeochem. Cycles,* 11(2), pp. 235-266, (1997).

Intergovernmental Oceanographic Commission, Scientific Committee on Oceanic Research Manual and Guides 29 Protocols for the Joint Global Ocean Flux Study (JGOFS) Core Measurements. UNESCO, 170pp., (1994).

Joyce, T. ed., and Corry, C. ed., "Requirements for WOCE Hydrographic Programme Data Reporting," Report WHPO 90-1, WOCE Report No. 67/91 3.1, pp. 52-55, WOCE Hydrographic Programme Office, Woods Hole, MA, USA (May 1994, Rev. 2), UNPUBLISHED MANUSCRIPT

Macdonald, R.W., F. A. McLaughlin and C.S. Wong, "The storage of reactive silicate samples by freezing," *Limnology and Oceanography,* 31, pp. 1139-1142 (1986).

Patton, C.J. and Crouch, S.R., "Spectrophotometric and kinetics investigation of the Berthelot reaction for the determination of ammonia," *Analytical Chemistry*, 49(3), pp.464-469 (1977).

Rahmatullah, Mohammed, and Boyde, T.R.C, "Improvements in the determination of urea using diacetyl monoxime; methods with and without deproteinisation," *Clinica Chimica Acta, 107, pp.3-9 1980.*

Sea-Bird Electronics, Inc, CTD Data Acquisition Software Manual, March 2001

Sea-Bird Electronics, Inc., CTD Operating and Repair Manual, February 2002

APPENDIX A: Bottle Quality Comments

Remarks for deleted samples, missing samples, PI data comments, and WOCE codes other than 2 from USCGC Healy, HLY-02-03. Comments from the Sample Logs and the results of ODF's investigations are included in this report. Investigation of data may include comparison of bottle salinity and oxygen data with CTD data, review of data plots of the station profile and adjoining stations, and rereading of charts (i.e. nutrients). Units stated in these comments are degrees Celsius for temperature, Practical Salinity Units for salinity, and unless otherwise noted, milliliters per liter for oxygen and micromoles per liter for Silicate, Nitrate, Nitrite, Phosphate and Urea and Ammounium, if appropriate. The first number before the comment is the cast number (CASTNO) times 100 plus the bottle number (BTLNBR).

Station 001.001
102 Oxygen: "No endpoint, sample lost."
112 Salinity was not drawn.
Cast 1 Sample Log: "Had to rush cast because of shallow water and drift, but suspect bottles were adequately flushed. Ship roll ˜1 meter and waited 1 minute at each depth and yoyo'd."
Station 002.001
102 Oxygenand salinity not drawn per sampling schedule.
103 SampleLog: "Slight leak in bottle." Data are acceptable.
104 Oxygenand salinity not drawn per sampling schedule.
106 Oxygenand salinity not drawn per sampling schedule.
107 SampleLog: "Slight leak from spigot." Data are acceptable.
108 Oxygen and salinity not drawn per sampling schedule.
110 Oxygenand salinity not drawn per sampling schedule.
112 Oxygenand salinity not drawn per sampling schedule.
Station 003.001
102-103 Oxygen, Salinity, and Nutrients were not drawn.
103 Sample Log: "Top vent not closed prior to cast." Data are acceptable, no samples taken, extra bottle trip."
104 SampleLog: "Slight leak from spigot." Data are acceptable.
106 Oxygen, Salinity, and Nutrients were not drawn.
107 SampleLog: "Slight leak from spigot." Data are acceptable.
108 Oxygen, Salinity, and Nutrients were not drawn.
110 Oxygen, Salinity, and Nutrients were not drawn.
112 Oxygen, Salinity, and Nutrients were not drawn.
Station 004.001
102 Oxygen, Salinity, and Nutrients were not drawn.
104 Oxygen, Salinity, and Nutrients were not drawn.
106 Oxygen, Salinity, and Nutrients were not drawn.
108 Oxygen, Salinity, and Nutrients were not drawn.
110 Oxygen, Salinity, and Nutrients were not drawn.
111 Sample Log: "Medium leak from bottom endcap. The cap was adjusted, leakage was stopped." Data are acceptable.
112 Oxygen, Salinity and Nutrients were not drawn.

Station 005.001
102 Salinity and Nutrients were not drawn.
104 Salinity and Nutrients were not drawn.
106 Salinity and Nutrients were not drawn.
107 Salinity appears high in gradient area. Footnote salinity questionable. Sample Log: "Slight leak from out of spigot." Data are acceptable.
108 Salinity and Nutrients were not drawn.
110 Salinity and Nutrients were not drawn.
111 SampleLog: "Medium leak from bottom end cap after o2 draw." Data are acceptable.
112 Salinity and Nutrients were not drawn. Oxygen is about 0.03 high. Footnote questionable.
Station 006.001
102-111 Nutrients were not drawn.
Cast 1 Radium cast. Oxygen and Salinity were not drawn.
Station 006.002
201 Oxygen, Salinity: "Samples were not drawn."
204 SampleLog: "Slight leak." Data are acceptable.
208 SampleLog: "Very slight leak." Data are acceptable.
210 Sample Log: "Very slight leak." Data are acceptable. CTD salinity appears high, temperature and oxygen low. Bottle tripped in gradient. Okay.
Station 007.001
102 Oxygen, Salinity, and Nutrients were not drawn.
103 Oxygen, Salinity, and Nutrients were not drawn.
106 Sample Log: "Slight leak when spigot was pushed in and vent closed." Data are acceptable.
107 Oxygen, Salinity and Nutrients were not drawn.
110 Oxygen, Salinity and Nutrients were not drawn. Sample for POM. CTD trip information had have the "shed-wake" data, higher salinity lower temperatures eliminated.
The water from lower in the water column "caught-up" with the CTD and mixed with the water from this level.
112 Attempted to reaverage trip level, spiking caused incorrect CTD salinity. Reaveraging was unsuccessful. Footnote CTD salinity bad.
Station 007.002
201 Oxygen, Salinity and Nutrients were not drawn.
202 Oxygen, Salinity and Nutrients were not drawn.
203 Salinity was not drawn.
204 Oxygen, Salinity and Nutrients were not drawn.
205 Oxygen, Salinity and Nutrients were not drawn.
206 Salinity was not drawn. Oxygen:"Noisy ending. Sample was overtitrated and backtitrated. Okay." Data are acceptable.
207 Oxygen, Salinity and Nutrients were not drawn.
208 Salinity was not drawn.
209 Oxygen, Salinity and Nutrients were not drawn.
210 Salinity was not drawn.
211 Oxygen, Salinity and Nutrients were not drawn.
212 Salinity was not drawn.
Station 007.003

301 Oxygenand Salinity were not drawn.
307-302 Oxygen, Salinity and Nutrients were not drawn.
308 Oxygenand Salinity were not drawn.
312-309 Oxygen, Salinity and Nutrients were not drawn.
Station 008.001
107 SampleLog: "Top vent was not tight." Data are acceptable.
108 Oxygen: "Noisy ending. Sample was overtitrated and backtitrated. Okay." Data are acceptable.
Station 008.002
Cast 2 Oxygen, Salinity and Nutrients were not drawn.
Station 010.001
101 Oxygen:"Noisy ending. Sample overtitrated and backtitrated. Okay." Data are acceptable.
104 SampleLog: "Bottom end cap leak." Oxygen:"Noisy ending. Sample overtitrated and backtitrated. Okay." Data are acceptable.
105 SampleLog: "Slight excess of Mn while pickling." Data are acceptable.
107 SampleLog: "Large leak, no oxygen was drawn." Data are acceptable.
112 Sample Log: "Tripped surface bottle quickly had to lower for ice then raise again, O2 temp appears high." Strong gradient, low temp, salinity and high oxygen. Data are acceptable.
Station 010.002
207 SampleLog: "Bottle changed out before cast."
211 Sample Log: "Bottom end cap not seated properly, leaking, reseated then okay." Data are acceptable.
Station 011.001
101 Oxygen:"Noisy ending. Sample overtitrated and backtritrated. Okay." Data are acceptable.
104 Oxygenand Nutrients were not drawn.
107 SampleLog: "Slight drip from spigot after venting." Data are acceptable.
110 Bottle and CTD oxygen have a large difference. Strong gradient. Suspect bottle and CTD oxygen okay.
111 Oxygen: "Water was dirty. No endpoint was reached during titration. Sample was lost."
112 Oxygen and Nutrients were not drawn.
112-110 CTD operator error. Bottle 10-12 rushed due to ice encroachments-30 second flush time. Possibility of poor bottle flushing. Samples appear to be okay."
Cast 1 CTD sheet: "Modulo word errors at 30m/min, slowed to 15m/min for cast-errors stopped. Bottle 5 to 6 moved between bottles Salinity was not drawn.
Station 012.001
101 Oxygen:"No endpoint. Sample overtitrated and backtitrated. Okay." Data are acceptable.
102 Oxygen:"No endpoint. Sample overtitrated and backtitrated twice. Sample lost."
103 Sample Log:"Slight spigot leak." Oxygen:"Bubbles were present. No endpoint. Sample overtitrated and backtriated twice." Oxygen sample appears high. Footnote oxygen bad.
104 Sample Log:"Bottle leaking from bottom end cap with vent open." Oxygen:"Bubbles were present. Sample overtitrated and backtitrateed. Okay." Data are acceptable.
105 SampleLog:"Smaller than pin-head bubble in o2 bottle." Data are acceptable.

107 SampleLog:"Slight spigot leak." Data are acceptable.
112 SampleLog:"Surface bottle was not yo-yo'd." Data are acceptable.

Station 012.002

204 SampleLog: "Replaced top and bottom o-rings."
204-203 Sample Log: No nutrients were drawn.
207 SampleLog: "Checked bottle, found no problem as reported on previous station."
209 SampleLog: No nutrients were drawn.
211-202 Sample Log: No nutrients were drawn.
Cast 2 Sample Log: No salinity was drawn.

Station 013.001

101-112 Nutrients stored over 12 hours, appear to be okay, but not normal quality. Footnote nutrients questionable.
104 Sample Log: "Leaking after O2 drawn, was seated properly." Oxygen: "Bubbles in endpoint. Overtitrated and backtitrated. Okay." Data are acceptable.
112 Oxygen: "Computer failed. Bottle oxygen value questionable." CTD oxygen low. Sensor may have been blocked by surface particulates. Footnote CTD oxygen bad.

Station 013.002

201 Oxygen: "No endpoint. Overtitrated and backtitrated. Okay." Data are acceptable.
202 Samplefor organics, DOM and Lignin only.
204 Samplefor organics only.
206 Samplefor O2 incubations, bacteria and O18 only.
208 SampleLog: "Vent not closed." Data are acceptable.
211 Samplefor o2 incubations, bacteria and bio-optics only.

Station 014.001

101 Oxygen: "Sample was dirty. Sample was lost."
103 SampleLog: "Jelly fish remains around spigot." Data are acceptable.
105 Oxygen: "Sample was dirty. Overtitrated and backtitrated. Okay." Data are acceptable.
108 SampleLog: "Vent was open." Data are acceptable.
110 Sample Log: "Jelly fish remains around spigot." Oxygen: "Computer program failure. Sample was lost."
112 Sample Log: "Oxygen sample was redrawn." Sample Log: "No water left before all samples were drawn." Data are acceptable.
Cast 1 Sample Log: "Jelly fish remains on PAR sensor." Data are acceptable.

Station 014.002

203 SampleLog: "Bottom cap leaked when valve open." Data are acceptable.
207 Sample Log: "Spigot leak." Sample Log: "Two extra drops NaOH in oxygen flask 707." Data are acceptable.
208 Oxygen: "Bubbles in sample. Overtitrated and backtitrated. Okay." Data are acceptable.

Station 014.003

104 SampleLog: "Replaced bottle before cast."

Station 014.004

402 Nutrients appear to have been mixed up, perhaps with bottle 11. Footnote nutrients lost.
411 Nutrients appear to have been mixed up, perhaps with bottle 2. Footnote nutrients lost.

Station 015.001

102 SampleLog: "DOM-2 sample not drawn."
104 SampleLog: "Organics sample not drawn."
107 SampleLog: "Close to turn of hull due to close ice." Data are acceptable.

Station 015.002

Cast 2 Sample Log: "Cast was aborted. No samples were drawn."

Station 016.002

206 Oxygen: "Bubbles in sample. Overtitrated and backtirated. Okay." Data are acceptable.
207 Oxygen: "Bubbles in sample. Sample was not overtitrated and backtitrated. Questionable." Data are acceptable.

Station 016.004

401 SampleLog: "Oxygen sample was redrawn." Data are acceptable.

Station 016.005

501 SampleLog: "Bottom lid was askew. Water was lost on deck." Data are acceptable.
502 SampleLog: "Oxygen sample was redrawn." Data are acceptable.

Station 016.008

8all Pushing ice the entire cast. Data are acceptable. Sample Log: "All tops vents were open. Samples were drawn." Data are acceptable.

Station 017.001

101 Ammonium and Urea are too high, contamination during sampling. Footnote sample bad.
108 Sample Log: "Slight dripping, bottom spigot pushed in, but bottle was nominally full." Data are acceptable.

Station 017.002

202 Sample Log: "Air leak, water come out of spigot with top vent closed." Data are acceptable.

Station 017.007

702 SampleLog: "Leak from spigot." Data are acceptable.
704 SampleLog: "Replaced lower endcap o-ring prior to cast."

Station 018.001

102 Oxygen: "Titration was very dirty. Sample was overtitrated and backtitrated. Sample is bad."
104 Sample Log: "Leaking from bottom-did not sample for salinity, oxygen or nutrients." Oxygen, Salinity, and Nutrients were not drawn.
105 Oxygen: "Titration was very dirty. Sample was overtitrated and backtitrated. Sample is questionable."
107 SampleLog: "Has a spigot leak." Data are acceptable.
109 Oxygen: "Water was dirty. Sample was overtitrated and backtitrated. Okay."
Cast 1 Sample Log: "Lost secchi disk."

Station 018.002

201 Oxygen: "Titration was noisy. Sample was overtitrated and backtitrated. Results were lost."
202 Sample Log: "Spigot leak." Data are acceptable. Oxygen: "Bubbles during titration. Sample was overtitrated and backtitrated. Okay."
204 Sample Log: "Big leak from bottom cap with vent open." Data are acceptable. Oxygen: "Bubbles during titration. Sample was overtitrated and backtitrated. Okay."
207 SampleLog: "Small spigot leak." Data are acceptable.

Station 018.006
605 SampleLog: "Flask 1662 was broken. Sample was redrawn."
608 SampleLog: "Vent was not closed." Data are acceptable.
610 Oxygen: "Computer failure during backtitration. Sample lost."
611 Oxygen: "Noisy titration. Sample was overtitrated and backtitrated. Okay"
Station 019.001
102 SampleLog: "Flask 1452 has possible small bubbles." Data are acceptable.
103 Sample Log: "Flask 1615 has possible small bubbles." Sample Log: "Small spigot leak." Data are acceptable.
107 SampleLog: "Pretty bad spigot leak." Data are acceptable.
109 SampleLog: "Flask 1546 has possible small bubbles." Data are acceptable.
Station 019.002
107 SampleLog: "Has a small spigot leak." Data are acceptable.
Station 019.006
605 Oxygenappears low, it is in large gradient. Footnote oxygen questionable.
611 Oxygen: "Floating particles in sample. Titration found no endpoint. Sample lost." Sample Log: "Flask 1638. Oxygen sample was redrawn."
Station 020.001
101 Sample Log: "Possibly 2ml Mn in oxygen sample. Flask 1658." Data are acceptable.
102 Sample Log: "Possibly 2ml Mn in oxygen sample. Flask 1654." Data are acceptable.
107 SampleLog: "Minor spitting from spigot when pushed in." Data are acceptable.
108 SampleLog: "Slight spigot leak."^M Data are acceptable.^M
Station 020.002
207 SampleLog: "Minor spitting from spigot when pushed in." Data are acceptable.
208 SampleLog: "Moderate spigot leak." Data are acceptable.
210 Oxygen: "Noisy endpoint. Sample was overtitrated and backtitrated." Data are acceptable.
211 Oxygen: "Computer failure during backtitration. Sample lost."
212 Oxygen: "Computer failure during backtitration. Sample lost."
Station 021.002
203 Oxygen: "No endpoint. Sample was lost."
204 Oxygen: "No endpoint. Overtitrated and backtitrated. Sample Lost."
208 SampleLog: "No water for nutrient sample. No sample was drawn."
212-207 Oxygen and Salinity were not drawn.
Station 021.003
301 SampleLog: "Changed spigot before cast." Data are acceptable.
307 SampleLog: "Spigot was dribbling water." Data are acceptable.
Station 022.001
102 Oxygen, Salinity, and Nutrients were not drawn.
107 SampleLog: "Minor spitting from spigot when pushed in." Data are acceptable.
108 SampleLog: "Vent was not closed before cast." Data are acceptable.
110 Oxygen: "Sample result is slightly lower than ctd. Sample was taken in high gradient area. Value is reasonable."
Station 022.003
303 Sample Log: "CTD oxygen appears high, but downtrace suggests large O2 gradients in this depth range." Data are acceptable.

307 SampleLog: "Spigot was dribbling water." Data are acceptable.
312-301 Sample Log: "Stringy substance scattered over rosette."
Station 022.004
404 SampleLog: "Very slight leakage from bottom and spigot." Data are acceptable.
Station 023.001
102 Oxygen, Salinity, and Nutrients were not drawn.
104 SampleLog: "Bottle was tripped just after "yoyo" by mistake." Data are acceptable.
107 SampleLog: "Spigot still has significant leaking." Data are acceptable.
109 Oxygen, Salinity, and Nutrients were not drawn.
Station 024.003
302-307 Oxygen, Salinity, and Nutrients were not drawn.
308 Sample Log: "Slight spigot leak." Oxygen: "Results appear high. Profile shows large gradient." Data are acceptable.
312-310 Sample Log: "Bottles not tripped. Had to end cast early due to ice."
Station 024.004
402 Oxygen, Salinity, and Nutrients were not drawn.
404 Oxygen, Salinity, and Nutrients were not drawn.
406 Oxygen, Salinity, and Nutrients were not drawn.
407 SampleLog: "Spigot leak." Data are acceptable.
408 Oxygen, Salinity, and Nutrients were not drawn.
410 Oxygen, Salinity, and Nutrients were not drawn.
412 Oxygen, Salinity, and Nutrients were not drawn.
Station 025.001
101 SampleLog: "Duplicate salinity samples were drawn."
102 Oxygenand Salinity were not drawn.
105 SampleLog: "Lanyard hung up on bracket for external spring."
108-103 Oxygen, Salinity, and Nutrients were not drawn.
109 Oxygen: "Precipitate was stirred before acidified. Questionable." Data seem acceptable.
112-109 Sample Log: "Duplicate salinity samples were drawn."
Station 026.001
105 SampleLog: "Lanyard hung up on bracket for external spring."
Station 026.003
105 SampleLog: "Lanyard hung up on bracket for external spring."
Station 026.004
401 Salinity: "Sample appears to be low." Footnote salinity questionable.
402 Salinity was not drawn.
403 SampleLog: "Oxygen sample had slight bubbles. Flask 1638." Data are acceptable.
404 Salinity was not drawn.
406 Salinity was not drawn.
Station 026.005
105 SampleLog: "Lanyard hung up on bracket for external spring."
Station 027.001
106 SampleLog: "Ice delay, rosette sat at depth for 9 minutes." Data are acceptable.
106-105 Sample Log: "Jelly fish strings on bottles." Data are acceptable.
Cast 1 Sample Log: "Pushing ice while rosette was at 150m." Data are acceptable.
Station 027.002

203 Sample Log: "Top cap was loose." Sample Log: "Oxygen sample was redrawn. Flask 1659." Data are acceptable.
Cast 2 Footnote CTD temp and conductivity bad. Data from secondary sensors.
Station 028.001
108 Oxygen: "Problems with the UV reader. Sample was lost."
111 Sample Log: "Lanyard hooked around two pylon hooks. Bottle did not trip." Salinity and Nutrients were not drawn.
Station 028.004
405 SampleLog: "Bottle did not trip. Bottle was cocked onto wrong latch."
Station 028.006
608 Oxygen: "Computer failure. Sample was lost."
611 Oxygen: "Computer failure. Sample was lost."
Station 029.002
202 SampleLog: "Flask bottle 2 in position 4."
203 Sample Log: "Bubble was found in flask. Oxygen sample was redrawn." Data are acceptable.
204 SampleLog: "Flask bottle 4 in position 5."
205 SampleLog: "Flask bottle 5 in position 2."
Station 030.002
212 SampleLog: "Strings of seaweed on bottle." Data are acceptable.
Station 031.001
101 Bottle did not trip as scheduled. It appears that the bottle may have hung up and tripped at about 1250 meters. Footnote bottle did not trip as scheduled and samples bad, urea footnoted lost.
101-112 Nutrients: "Urea samples lost due to bubble problems."
Station 031.003
301-312 Nutrients: "Urea samples lost due to bubble problems."
310 Oxygen: "Computer failure. Sample was lost."
Station 032.002
208 SampleLog: "Vent not closed." Data are acceptable.
Station 032.005
110 SampleLog: "Collar came loose." Data are acceptable.
Station 033.001
101 Salinity ˜0.01 high, appears to have been incorrectly drawn from bottle 2. Footnote salinity bad.
102 SampleLog: "Vent was slightly loose." Data are acceptable.
108 SampleLog: "Vent was slightly loose." Data are acceptable.
Station 033.004
401 Nitrite: "Sample was lost."
412 Nitrite: "Sample was lost."
Station 033.005
Cast 5 Sample Log: "Screws were turning 150m on down and all the way back up. 45 deg. wire angle aft and 20 deg outboard. Difficult to maintain bottle stop depth."
Station 033.006
6all Sample Log: "Pumps turning. Nose was pointed towards floe. Strong wind gusts to 40 knots"

Station 034.001
108 Sample Log:"Big leak. Vent was loose and spigot was open." Sample Log:"No oxygen sample was drawn." Oxygen was not drawn.
Station 035.001
106 SampleLog: "Bottle was possibly mistripped." Data are acceptable.
110 SampleLog: "Slight leak from the bottom cap." Data are acceptable.
Cast 1 Sample Log: "Props turning due to high winds and waves Needed to have some control on the wire angle.
Station 035.002
Cast 2 Sample Log: "Props and Bow thruster turning due to strong winds and good sized swell that required maneuvering on the wire.
Station 038.001
102 Salinity: Bad bottle salt value. Footnote salinity bad.
106 Oxygen, Salinity, and Nutrients were not drawn.
Cast 1 Sample Log: "Lots of jellyfish tentacles on rosette/CTD. Possible explanation for low light transmission values.
Station 039.001
104 Oxygen: "Computer Failure. Sample lost."
108 SampleLog: "Vent not closed." Data are acceptable.
Station 039.003
302 Salinity was not drawn.
304 Salinity was not drawn.
Station 040.001
104-102 Oxygen, Salinity, and Nutrients were not drawn.
106 During salinity analyses, sample had to be run 3 times before two readings agreed. All three readings were slightly high. A salinity crystal may have gotten into the sample. Footnote salinity bad.
112 Oxygenwas not drawn.
Cast 1 Sample Log: "Bottles were no yo-yo'd. They were held at depth for ˜1 - 1.5 minutes. Some wave action. Ship drifting ˜1 knot.
Station 041.001
110 Sample Log: "Leaking at spigot, large amounts, then at bottome cap." Oxygen sample was drawn immediately. Data are acceptable.
Station 042.001
110 SampleLog: "Leaking from bottom endcap." Data are acceptable.
Station 042.002
201 Nutrient was drawn, but not run until more than 12 hours after collection. Results are questionable.
212 Nutrient was drawn, but not run. It was not discovered until two days later. Sample was lost.
Station 043.001
105-103 Sample Log: "Temps were approximated because the thermometer was on hold."
110 SampleLog: "Very tingy leak from spigot and bottom cap." Data are acceptable.
Station 043.002
205 SampleLog: "Bottle was not tripped. Lanyard angle was too shallow."
Station 043.003

305 SampleLog: "Bottle was not tripped. Lanyard angle was too shallow."
Station 044.001
101 Nutrient samples lost.
104 Oxygen, Salinity, and Nutrients were not drawn.
106 Oxygen, Salinity, and Nutrients were not drawn.
108 SampleLog: "Vent not closed completely." Data are acceptable.
110 Oxygen, Salinity, and Nutrients were not drawn.
Station 044.003
301 SampleLog: "Bottle did not trip. Lanyard angle was too shallow."
308 SampleLog: "Vent not closed completely." Data are acceptable.
Station 045.001
101 Sample Log: "Bottle did not trip. Lanyard angle was too shallow." Oxygen, Salinity, and Nutrients were not drawn.
104 Oxygen, Salinity, and Nutrients were not drawn.
107-106 Oxygen, Salinity, and Nutrients were not drawn.
108 SampleLog: "Vent not closed completely." Data are acceptable.
109 Oxygen, Salinity, and Nutrients were not drawn.
Station 045.002
Cast 2 Footnote CTD temp and conductivity bad. Data from secondary sensors.

Addendum

Additional Precision and Accuracy Notes for Nutrient and Dissolved Oxygen Data: 2002 SBI (Western Arctic Shelf Basin Interactions) Process Experiment Cruises (HLY 02-01 & HLY 02-03)

L.A. Codispoti[1, *]

[1]University of Maryland Center for Environmental Sciences, P.O. Box 775, Cambridge, MD 21613, USA, codispot@hpl.umces.edu

Introduction:

This document provides supplementary information about the precision and accuracy of the hydrographic nutrient and dissolved oxygen data collected during the SBI (Western Arctic Shelf-Basin Interactions) 2002 process cruises (HLY 02-01, HLY 02-03). The material herein supplements comments submitted with the Service Team Activity Reports for cruises HLY 02-01 and HLY 02-03, and the comments on methods in Codispoti et al. (2005). The Service Team Activity Report for each cruise discusses the procedures employed, the purity of standards, etc. in considerable detail.

Precision of the Dissolved Oxygen Analyses:

Examination of data from Niskin bottles tripped in mixed surface layers or in layers of uniform concentration suggest that the precision of our results (including sample collection and "pickling" errors) is ~ ± 0.01 ml/l (± 0.45 µM).

Precision of Nutrient Analyses:

Comparisons of nitrite samples drawn from Niskin bottles tripped at the same depth suggests that the within-run precision of the nitrite analyses is better than ± 0.01 µM. Station to station baseline variability could introduce an additional uncertainty of ~ 0.01 µM. During HLY 02-01, determinations of the silicate concentration of a deep water "check" sample during 38 separate autoanalyzer runs over a three week period gave an average of 10.8 µM and a standard deviation of 0.2 µM. During HLY 02-03 two deep water "check" samples were used. The first lasted almost one month, and the average of 72 runs was 10.2 µM. with a standard deviation of 0.2 µM. The second was used for ~ one week, and the average value over 17 runs was 10.0 µM with a standard deviation of 0.1 µM. To estimate run-to-run and cruise-to-cruise precision for nitrate and phosphate, nitrate and phosphate values from 18 samples collected between 2200 – 3300 db where vertical gradients were weak were examined. Seven of these samples were collected during HLY 02-01 and the remaining 11 were collected during HLY 02-03. Since there should be some natural variability and since this comparison includes sampling error, these samples should give a robust estimate of precision. The average nitrate value was 14.77 µM with a standard deviation of 0.13 µM. The average phosphate value was 1.05 µM with a standard deviation of 0.01 µM.

Within-run precision of the ammonium and urea analyses was generally better than ± 0.05 µM, but the accuracy and precision of these methods suffers from, the relative instability of these methods, the labile nature of ammonium and urea, variation in ammonium baselines, and refractive index effects, we suggest that differences of less than ~ 0.2 µM in ammonium and urea concentrations may not be significant. Because the refractive index of sea-water increases linearly with salinity and because there can be salt effects in some analyses, standards were prepared in a low nutrient sea-water matrices with salinities ranging from 30 to 34, depending on the source of the low nutrient sea water. During HLY 02-01, salinities ranged between 29-35, and maximum refractive index errors arising from deviations between matrix salinity and sample salinity would be approximately 0.03 for ammonium, 0.02 µM for nitrate, 0.01 µM for nitrite, 0.01 µM for phosphate, 0.2 µM for silicate, and 0.05 µM for urea. During HLY 02-03 customized refractive index corrections were applied to samples with salinities < 29, so the maximum refractive index errors should be similar for both cruises.

Acknowledgements

These data would not exist were it not for the dedication of the men and women who serve on the USCGC *Healy* and for the leadership of the chief scientists (J.M. Grebmeier and L.W. Cooper). The members of the hydrographic team that produced the data were: Carney Cheng, Emily Cooper, John Gunn, Erik Haberkern, Doug Masten, Robert Palomares, Kristin Sanborn, Dean Stockwell, and Bob Williams. The help provided by Steve Roberts and Greg Stossmeister of the Joint Office for Science Support (JOSS) is also deeply appreciated. Finally, we are grateful for the financial support provided by the Office of Polar Programs at the National Science Foundation *via* Arctic System Science Program grant OPP0125399 to J.H. Swift.

Reference:

Codispoti, L.A., Flagg, C., Kelly, V, Swift, J.H., 2005. Hydrographic conditions during the 2002 SBI process experiments. Deep-Sea Research II 52:3199-3226.