STARLITE 2007 McArthur II CTD PROCESSING

STARLITE 2007 CTD data files were collected using a Sea-Bird 911*plus* profiling instrument aboard the NOAA Ship McArthur II (MACII). The 911*plus* consists of the 9*plus* underwater CTD and 11*plus* V2 Deck Unit, which has high resolution sampling (24Hz) and pump-controlled conductivity and temperature flow-through sensors. Data were collected using Sea-Bird's SeaSave Win32 Version 7.14c and have been processed using Sea-Bird's SBE Data Processing v. 7.26.7. More information regarding the SBE software and recommended data processing procedures can be found online at www.seabird.com.

Each CTD directory on the data server contains two folders named Raw and Data. CTD set-up information, pressure test results, and data collected at sea are stored in the Raw folder. All information and files used in processing are saved in the Data folder, including documentation, configuration files, calibration sheets, intermediate processing steps and final data.

Sensor use on the MACII CTD during the STARLITE 2007 cruise went through several changes at the beginning of Leg 1 when spiking was noted in the dissolved oxygen (DO) data. The table below describes the period for which each sensor was used. Voltage sensors, such as dissolved oxygen, can be assigned to one of eight analog/digital channels; if problems with the sensor are observed, the sensor may be assigned to a new channel. Consequently, the channel for the oxygen sensor is included in the table below. The temperature and conductivity sensors, both primary and secondary, did not change during the cruise. The owners of the sensors are responsible for their maintenance.

2007	Casts	Temp 1, 2	Cond 1, 2	DO, channel	Pressure-CTD Fish
Leg 1	001	*T4677*, T4803	*C3201*, C3353	O1294, 2	*P3001-39443*
Leg 1	002-020	*T4677*, T4803	*C3201*, C3353	O1294, 0	*P3001-39443*
Leg 1	021-030	*T4677*, T4803	*C3201*, C3353	-	*P3001-39443*
Leg 2	031	*T4677*, T4803	*C3201*, C3353	O1295, 0	*P3001-39443*
Leg 2	032-063	*T4677*, T4803	*C3201*, C3353	O1295, 4	*P3001-39443*
Leg 3	064-075	*T4677*, T4803	*C3201*, C3353	O1295, 4	*P0405-61183*
Leg 3,4	076-131	*T4677*, T4803	*C3201*, C3353	O1295, 4	P0311-53561
Leg 4	132	*T4677*, T4803	*C3201*, C3353	O1294, 4	P0311-53561

MACII-owned, PRD-owned

STARLITE 2007 MACII CTD SENSOR CALIBRATION

SWFSC MMTD uses Sea-Bird Electronics conductivity, temperature and pressure sensors. Sea-Bird Electronics conductivity sensors drift with usage and time, while temperature and pressure sensors drift primarily over time. Annual calibrations of the conductivity and temperature sensors are necessary to estimate and correct for this drift during data processing. Pre and post-

cruise calibration certificates for the DSJ sensors used during STARLITE 2007 are in the \CON_Files\Calibrations folder.

Conductivity, temperature, and pressure are computed as polynomial functions of the sensor frequencies stored in the raw data file. We follow Sea-Bird recommended procedures for adjusting calibration coefficients for drift between calibrations (Sea-Bird App. Note # 31). Details can be found in the internal document "CTD Calibration Adjustments MMTD.pdf".

The Excel spreadsheet, CTDcalibrations STARLITE 2007_MACII.xlsx, in the \Documentation folder, contains the pre and post-cruise calibration information for the conductivity, temperature, pressure, and dissolved oxygen sensors. It then derives slope or offset values used to correct the calibration coefficients used in the Data Conversion and Derive modules of Sea-Bird's SBE Data Processing software. The adjusted configuration files used to process the STARLITE 2007 MacII data (Appendix 1) are in the \CON_Files folder.

Conductivity Sensor Correction:

The SBE 4C series conductivity sensor has a measurement range of 0.0 to 7.0 Siemens/meter (S/m), which spans the conductivity range of SWFSC MMTD's study areas. The SBE 4C sensor is rated to have an initial accuracy of 0.0003 S/m; with a resolution (at 24Hz) of 0.00004 S/m.

The primary conductivity sensor, C3201, was calibrated on 1 February 2007 and 8 January 2008. The difference between the iSlope values at the start and end of the cruise was less than 0.0003, but the iSlope at the end of the cruise was >0.00015 from 1; consequently, the average iSlope (1.0005508) was used as the slope adjustment. Pre-cruise calibration coefficients were used to process the data.

The secondary conductivity sensor, C3353, was calibrated on 6 July 2007 and 12 February 2008. The difference between the iSlope values at the start and end of the cruise was greater than 0.00030; consequently, iSlope values were calculated for each leg. Pre-cruise calibration coefficients were used to process the data with slope adjustments by leg (slopes = 1.0004619, 1.0006389, 1.0008236, 1.0010084).

Temperature Sensor Correction:

The SBE 3*plus* series temperature sensor has a measurement range of -5.0 to 35 °C, which spans the range of temperatures in SWFSC MMTD's study areas. The SBE 3*plus* sensor is rated to have an initial accuracy of ± 0.001 °C and a resolution (at 24 samples per second) of 0.0003 °C.

The primary temperature sensor, T4667, was calibrated on 6 February 2007 and 8 January 2008. The iOffset at the end of the cruise was less than 2mdeg C; consequently, no offset calibration adjustment was needed.

The secondary temperature sensor, T4803, was calibrated on 22 June 2007 and 12 February 2008. The iOffset at the end of the cruise was also less than 2mdeg C; consequently, no offset calibration adjustment was needed.

Pressure Sensor Correction:

The SBE Paroscientific Digiquartz pressure sensor is rated to have an initial accuracy of 1.02m (i.e., 0.015% of the full scale range, which is 0 – 6800m). We do not exceed a maximum vertical depth of 1100m. Initial resolution (at 24Hz) is 0.068m (i.e., 0.001% of the full scale range).

CTD pressure deck tests are stored in the \Raw\MACII\Pressure Tests folder.

Three deck tests were conducted on the CTD pressure sensor P30013, which was used during Legs 1 – 2 on fish 39443, resulting in offsets of 11.149, 11.138 and 10.767 db; these results were consistent with Sea-Bird calibrations from 12 February 2007 and 11 February 2008 (average iOffset=10.685). Therefore, the average deck test offset of 11.018 was used in the *.con file.

Two deck tests were conducted on the CTD pressure sensor P0405, which was used during a portion of Leg 3, resulting in offsets of -0.652 and -0.574 db; this result was consistent with Sea-Bird calibrations from 8 March 2003 and 29 January 2008 (average iOffset=-0.613). Therefore, the average deck test offset of -0.613 was used in the *.con file.

Four deck tests were conducted on the CTD pressure sensor P0311, which was used during Legs 3 – 4 on fish 53561, resulting in offsets of -5.3117, -5.3002, -5.2040 and -5.1899 db; this result trend was consistent with Sea-Bird calibrations from 12 April 2007 and 13 April 2010 (average iOffset=-4.712). Therefore, the average deck test offset of -4.712 was used in the *.con file.

Oxygen Sensor Correction:

The SBE 43 oxygen sensor has a measurement range of 0 to 120% of surface saturation (approximately 200 µmol/Kg). The SBE 43 sensor is rated to have an initial accuracy of 2% of surface saturation (approximately 4 µmol/Kg).

The sensor outputs a voltage that is linearly related to dissolved oxygen concentration by a slope (Soc) and offset (Voffset). The sensor is expected to drift over time due to a decrease in sensitivity. Drift is expected to occur only at sea because the sensor membrane is sealed against exposure to air between cruises. Sea-Bird recommends a simple interpolation based on usage time between the pre- and post-cruise calibration values of Soc. On the advice of Dave Griffiths (SWFSC Fisheries Resources Division), both Soc and Voffset were interpolated.

The dissolved oxygen sensor O1294 was calibrated on 31 July 2007 and 20 February 2008 and was used during Leg 1, as well as the final cast of leg 4. The interpolated slope (iSoc) was 0.4444 for Leg 1 usage and 0.4492 for Leg 4 usage. The interpolated Voffset (iVoffset) was -0.4769 for Leg 1 usage and -0.4815 for Leg 4 usage.

The dissolved oxygen sensor O1295 was calibrated on 22 February 2007 and 5 January 2009 and was used Leg 2 – 4. The interpolated slope (iSoc) was 0.3945 and the interpolated Voffset (iVoffset) was -0.5003.

Dissolved oxygen data were not processed because of the data collection problems. Preliminary processing with the adjustments described above produced unreasonable values for most casts.

Comparison of the Primary and Secondary Sensors

Differences between primary and secondary sensors by cast are summarized in Figure 1. Fortran program COMPSENS.EXE (programmer: Paul Fiedler) calculates the mean difference between the primary and secondary sensors for each profile. The output file, compsens08m.dat, is in the \Documentation folder. Figure 1 shows that the temperature and conductivity values measured by and salinity values derived from the primary and secondary sensors did not differ by more than the desired accuracy of the sensors, except for conductivity and salinity during Leg 1. Bottle salinity analyses (Appendix 2) indicate that the secondary conductivity sensor was more accurate than the primary sensor and should be used to process the CTD data from all legs.

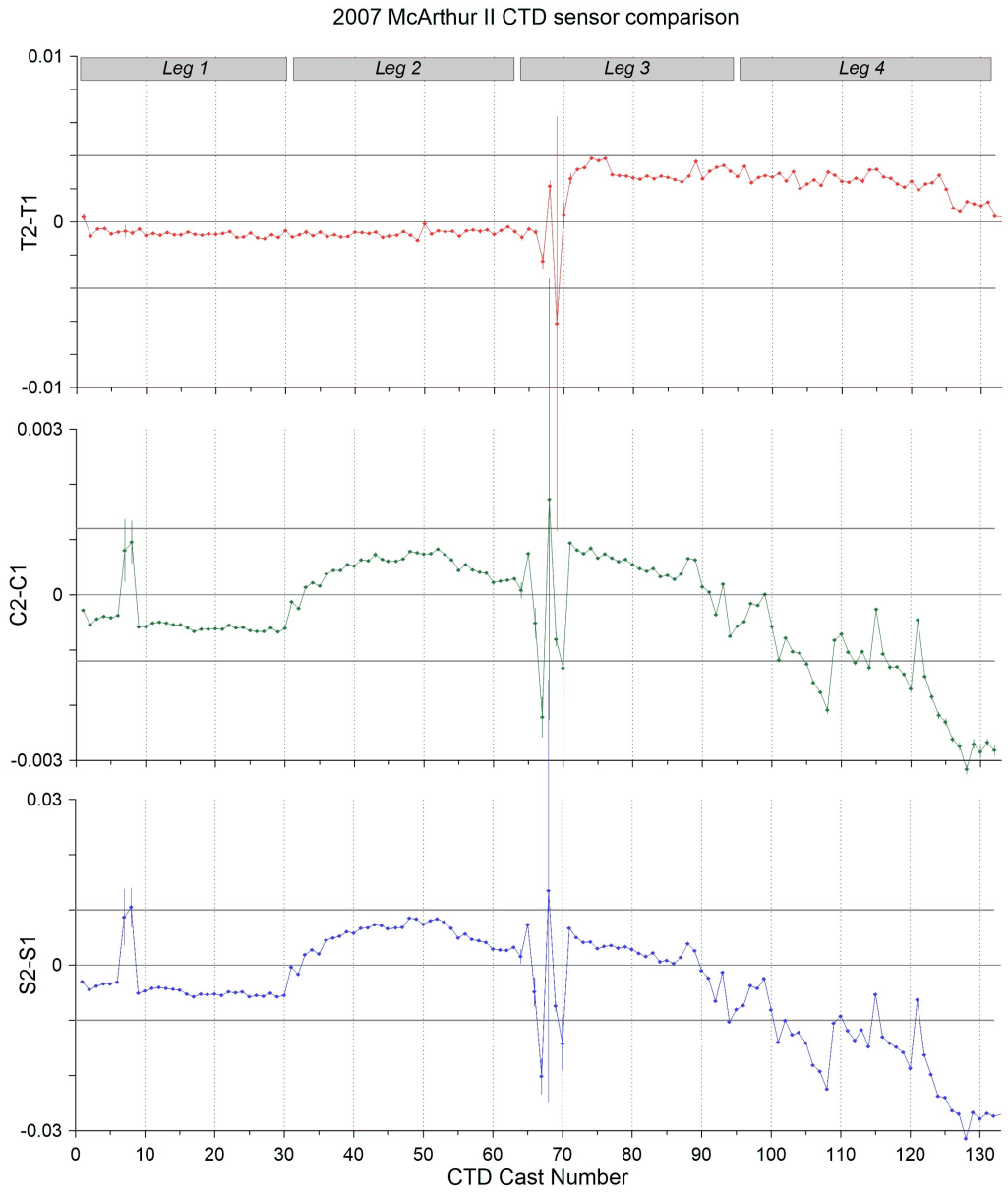


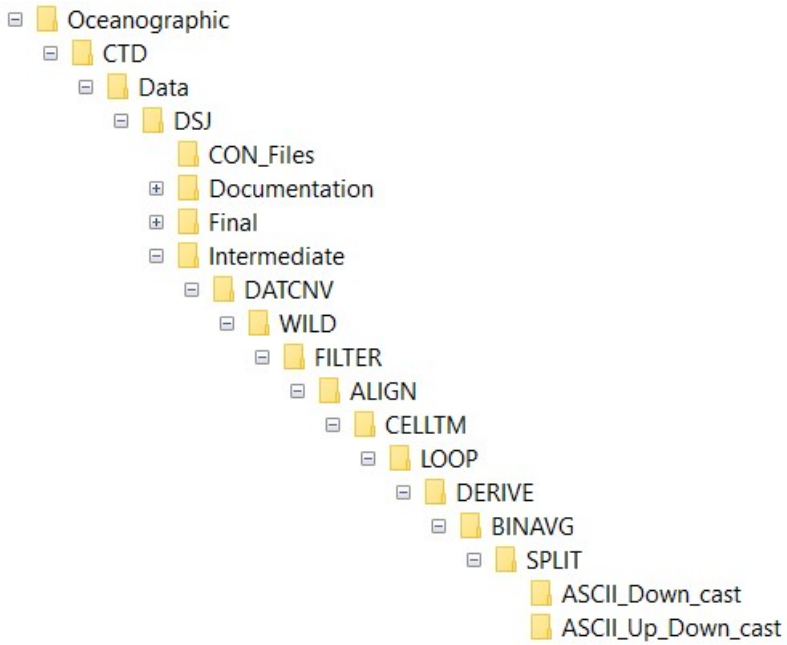
Figure 1. Time series of differences between primary and secondary temperature and conductivity sensors for STARLITE 2007 McArthur II CTD casts. Each temperature (T2-T1), conductivity (C2-C1), and salinity (S2-S1) difference is a mean of 1m bin-averaged downcast values (excluding the upper 10m and bins with density changes >0.003 σ_t). Gray lines represent desired accuracy (±0.004 ºC, ±0.0012 S/m, ±0.010 psu, which are 4x the specified initial accuracies of the Sea-Bird temperature and conductivity sensors).

We use pre-cruise calibration coefficients for each sensor when available. Before running the processing modules, it is essential to ensure that the correct sensor configuration coefficients and corrections are loaded into the *.con files used by the SBE Data Processing program. Offset and slope adjustments are obtained from CTDcalibrations STARLITE 2007_MACII.xlsx in the \Documentation folder. Configuration files for the sensors used on the McArthur II during ORCAWALE 2008 are listed in Appendix 1. The configuration file changes that do not show sensor changes are for oxygen sensor serial number or voltage channel changes. Casts 200-211, 300-314, 400-413 and 500-511 are for series of yoyo casts conducted on one night during each of Legs 1-4, respectively.

STARLITE 2007 CTD SBE MODULE PROCESSING

The SBE Data processing modules that were applied to the raw STARLITE 2007 MacII data are listed below. Each SBE module creates a program setup file, named *.psa. The *.psa files are located in the folder preceding their output, i.e. the 'Derive.psa' file is found in the 'LOOP' folder. Output .cnv files are kept in binary format to speed processing and reduce file sizes. The final module – ASCII Out – converts the binary data to ASCII format; if examination of the data is needed during earlier processing steps, the Translate module can be used to convert to the binary data to ASCII.

Modules are run in the following order: Data Conversion, Wild Edit, Filter, Align CTD (as needed), Cell Thermal Mass, Loop Edit, Derive, Bin Average, Split, ASCII Out. The processed data in various stages are in the \Intermediate folder:



1.**Data Conversion Module:**

Data Conversion converts raw SBE 911plus data, which are typically stored as frequencies and voltages in the *.dat file, to engineering units and stores the converted data in a *.cnv file.

The options selected for processing in Data Conversion were as follows:

name 0 = prDM: Pressure, Digiquartz [db]
name 1 = c0S/m: Conductivity [S/m]
name 2 = t090C: Temperature [ITS-90, deg C]
name 3 = c1S/m: Conductivity, 2 [S/m]
name 4 = t190C: Temperature, 2 [ITS-90, deg C]
name 5 = flag: 0.000e+00

Fortran program ScrData (programmer: Paul Fiedler) was used to flag values outside of these broad ranges: pressure -5 to 1200 db, temperature -1 to 33 deg C, and conductivity 2.5 to 7.0. The program first checks the range of values (primary and secondary, if present) in the header file. If any span exceeds the above limits, the program writes a new file in which each bad value, and the values in the two scans preceding and the two scans succeeding the bad value, are flagged. The original file is renamed with an "x" prefix. For each edited file, the total number of scans, the number of values that were outside limits, and the number of values flagged is summarized in the file *ScrData.dat* in the \Intermediate\DATCNV\ folder. Of 192 CTD files, 138 had no outliers, 51 had primary conductivity outliers, 50 had secondary conductivity outliers, 36 had primary temperature outliers, 31 had secondary temperature outliers, and 16 had pressure outliers. Most of the outliers were caused by starting the CTD on deck during the start of Leg 1 and by a replacement CTD fish at the start of Leg 3 (casts 064-075). Flagged values are ignored in subsequent processing.

2. Wild Edit Module:

Wild Edit flags outliers in temperature, conductivity, and oxygen data so that they are not used in further processing. Wild Edit's algorithm requires two passes through the data in blocks of *npoint* scans. The first pass computes the mean and standard deviation and temporarily flags values that differ from the mean by more than *pass1_nstd* standard deviations. The second pass recalculates the mean and standard deviation, excluding values flagged in the first pass. Scans that differ from the mean by more than *pass2_nstd* standard deviations are replaced with a bad data flag. The criteria established by *pass2_nstd* can be overridden using *pass2_mindelta*; specifically, if data are within *pass2_mindelta* of the mean, they are not flagged.

The options selected for processing in Wild Edit were as follows for all casts:

wildedit_pass1_nstd = 2.0
wildedit_pass2_nstd = 15.0
wildedit_pass2_mindelta = 0.000e+000
wildedit_npoint = 100
wildedit_vars = c0S/m t090C c1S/m t190C

These options are Sea-Bird defaults, except that *pass2_nstd* was changed from 20.0 to 15.0 to identify more outliers.

3. Filter Module:

The Filter module is run to reduce high-frequency noise in the pressure data, which is caused by counting jitter or other unknown sources. It is important to remove this noise before running the Loop Edit module. Loop Edit flags data that exhibit a change in the CTD velocity. Velocity is calculated using only three successive scans; consequently, noisy pressure data can result in erroneously flagged scans. Filter runs a low-pass filter on the data, which smoothes high frequency (rapidly changing) data. To produce zero phase (i.e., no time shift), the filter is first run forward through the data and then run backward through the data. Pressure data is typically filtered with a time constant equal to four times the CTD scan rate. We run a low-pass filter on the pressure data with time constant = 0.15 seconds, as recommended by Sea-Bird Electronics Inc.

The options selected for processing in Filter were as follows for all CTD casts:

filter_low_pass_tc_A = 0.030
filter_low_pass_tc_B = 0.150
filter_low_pass_A_vars =
filter_low_pass_B_vars = prDM

4. Align CTD Module:

It is essential that all derivations, such as salinity, density, and sound speed, use measurements of temperature and conductivity from same parcel of water. Logistically, it is practically impossible to instantaneously measure the same parcel of water with all sensors due to the physical location of the sensors on the unit and the different time delays of the sensors. The typical time delay of conductivity relative to temperature, 0.073 seconds, is automatically corrected by the SBE 11plus Deck Unit during data collection. If spikes are observed in the processed salinity profiles, further alignment of conductivity may be necessary. The Align CTD module can be used to align the conductivity data relative to pressure.

Fortran program TRIALIGN (programmer: Paul Fiedler) was run to find the optimum alignment value for conductivity (i.e., the number of scans by which to shift conductivity relative to temperature). TRIALIGN finds the maximum temperature gradient within a 240-scan window using linear regression; TRIALIGN tests for the gradient using only the first 10,000 scans to ensure data are from the downcast and imposes the criteria that depth must change by at least 5m in the 240-scan window. Conductivity alignments are tested within the region of maximum temperature gradient because misalignment of temperature and conductivity often results in excessive salinity spikes when temperature is changing rapidly. Within the window, conductivity is shifted by -24 to +24 scans. For each shift, salinity is derived from the temperature and conductivity data in each scan and a linear regression is fit to the salinity values. The shift that results in the minimum standard deviation of the regression residuals is selected as the optimal value for that cast. Optimal values for all casts are averaged to obtain a single alignment value for the cruise (one scan is 0.042 seconds).

TRIALIGN gave a mean optimum advances of -0.030 sec (SE=0.0091) for primary sensor, C3201, and +0.057 sec (SE=0.0034) for secondary sensor, C3353, (see Trialign0.dat and Trialign1.dat in \FILTER, which has the following columns: CTD file name, pressure (db) at the maximum temperature gradient, maximum temperature gradient (deg C/db), optimal advance (scans), and relative standard deviation of residuals).

The options selected for processing in Align CTD were as follows:

alignctd_adv = c0S/m -0.030, c1S/m 0.057

5. Cell Thermal Mass Module:

Cell Thermal Mass uses a recursive filter to remove conductivity cell thermal mass effects from the measured conductivity. In areas with large temperature gradients, the thermal mass correction is on the order of 0.005 psu. In areas with small temperature gradients, the correction is negligible.

The following Sea-Bird Electronics Inc. recommendations for Cell Thermal Mass when processing SBE 9plus data, with TC duct, were used:

celltm_alpha = 0.0300, 0.0300
celltm_tau = 7.0000, 7.0000
celltm_temp_sensor_use_for_cond = primary, secondary

6. Loop Edit Module:

Loop Edit flags data that exhibit a change in the mean CTD ascent or descent rate (e.g., pressure reversals or slowdowns). Such changes in ascent or descent rates are usually created by ship heave as the CTD unit is lowered or raised, and indicate unreliable data. Data that have been flagged are documented in the *.cnv header. In this module, we remove any scans that were flagged as bad during data collection. Examination of pressure vs. scan count in Sea Plot showed that data collection for some casts was started before the CTD had been returned to near the surface after the 10m surface soak.

The options selected for processing in Loop Edit follow the recommendations of Sea-Bird Electronics Inc. for casts in which data collection begins after the surface soak:

loopedit_minVelocity = 0.250
loopedit_surfaceSoak: minDepth = 5.0, maxDepth = 20, useDeckPress = 0

7. Derive Module:

Derive uses pressure, temperature, and conductivity from the input *.cnv file to compute the following oceanographic variables, which are routinely used in the assessment of protected species (other variables are available upon request):

· Salinity

- Density (density, sigma-theta, sigma-t, sigma-1, sigma-2, sigma-4)
- Depth (salt water, fresh water)
- Sound velocity (which can be calculated using the Chen-Millero, DelGrosso or Wilson equation)
- Average sound velocity (the harmonic mean from the surface to the current CTD depth, which is calculated on the downcast only)

The following processing options were selected in this module for all CTD casts:

name 5 = depSM: Depth [salt water, m], lat = 14.4385
name 6 = potemp090C: Potential Temperature [ITS-90, deg C]
name 7 = sal00: Salinity, Practical [PSU]
name 8 = sigma-é00: Density [sigma-theta, kg/m^3]
name 9 = svCM: Sound Velocity [Chen-Millero, m/s]
name 10 = avgsvCM: Average Sound Velocity [Chen-Millero, m/s], minP = 2, minS = 20
name 11 = potemp190C: Potential Temperature, 2 [ITS-90, deg C]
name 12 = sal11: Salinity, Practical, 2 [PSU]
name 13 = sigma-é11: Density, 2 [sigma-theta, kg/m^3]
name 14 = svCM1: Sound Velocity, 2 [Chen-Millero, m/s]

Note that there is no option in Sea-Bird's SBE Data Processing SEASOFT-Win32 to calculate Average Sound Velocity from secondary sensor data.

To calculate average sound velocity, the following values were used:

# minimum pressure = 2 db	[average depth of the acoustic array]
# minimum salinity = 20 psu	[recommended by Sea-Bird Electronics Inc.]
# Latitude = 10	[this value is used only if NMEA latitude is not available in the header]

The profiles output by the Derive module were inspected by the Senior Oceanographer for bad data caused by sensor failure, temperature inversions, low surface salinity measurements (likely the result of rain), and spikes in salinity. Comments about each cast are in \Documentation\ STARLITE 2007 MACII CTD Cast info.xlsx. Comment codes are:

A – acceptable
N – acceptable for MMTD derived variables but not for NODC archiving
IV – temperature inversion
R – reject cast

8. Bin Average Module:

The Bin Average module averages temperature, conductivity, pressure, and oceanographic variables in user-selected intervals; the intervals may be defined using pressure, depth, scan

number, or time range. SWFSC MMTD uses 1m bins, with no surface bin. In this module, we exclude scans that were flagged as bad during the Loop Edit module.

The following processing options were selected in this module for all casts:

binavg_bintype = meters
binavg_binsize = 1
binavg_excl_bad_scans = yes
binavg_skipover = 0
binavg_surface_bin = no, min = 0.000, max = 5.000, value = 0.000

9. Split Module:

Split separates the data from an input *.cnv file into upcast (pressure decreasing) and downcast (pressure increasing) *.cnv files. Downcast only files are output because they do not contain the data collected when the bottles are fired (e.g., repetitive sampling at the same pressure). Consequently, they are used to derive variables such as thermocline depth and strength.

The following options were selected in this module for all casts:
split_excl_bad_scans = no
output the downcast only (into the \Split folder). This command adds a ‘d’ at the beginning of the filenames.

10. ASCII Out Module:

ASCII Out outputs the header and/or the data from a binary data file (*.cnv). Data are written to an ASCII file (*.asc), while the header information, which lists each processing module and the variables applied, is written to a separate ASCII file (*.hdr).

This module was run twice. First, to convert the complete cast; second, to convert the downcast-only files created with the SPLIT module.

The following options were selected in this module for all casts:
Output Header and Data files
Label Column at top of the file
Column separator = space

FINAL PRODUCT

ASCII Out outputs the header and/or the data from a binary data file (*.cnv). Data are written to an ASCII file (*.asc), while the header information, which lists each processing module and the variables applied, is written to a separate ASCII file (*.hdr).

ASCII down-cast output files, containing only data recorded by the secondary sensors and no error flags, can be found in the \Final\ASCII_Down_cast folder.

The file headers have been saved separately from the final ASCII data files in both directories. The header files contain time in two separate fields: “System UpLoad Time” and “NMEA UTC (Time)”. The time in the “System UpLoad Time” field is taken from the PC used to the collect the data and may not be accurate (e.g., this field may be recorded in local time, rather than Coordinated Universal Time, and may not have been adjusted for local time zone changes). The Coordinated Universal Time in the “NMEA UTC (Time)” field is taken from the GPS unit and is accurate as long as the GPS functioned properly.

The downcast profile is used to derive variables commonly used in protected species assessments, such as thermocline depth and strength. Plots of complete casts show hysteresis, or depth offsets, of 5-8 m. The error in the depth, as indicated by the offsets, are expected to occur primarily in the upcasts due to “package wake” (i.e., the “shadowing” of the sensors by the rosette and frame as the CTD is pulled up through the water column). Additionally, the upcasts include repetitive sampling of the same depth when bottles are fired to collect water samples.

In total, 190 CTD casts were conducted during STARLITE 2007 on the McArthur II. The data set is comprised of 132 normal station casts, 54 yo-yo casts to 200m at four night stations, and 4 test casts in which all bottles are tripped at 500m. The test cast typically precedes the first regular cast of each leg of the cruise. The output format for the combined up and down casts is shown below.

```
   PrDM     C0S/m    T090C     C1S/m T190C Sbeox0Mm/Kg   DepSM T2-T190C C2-C1S/m    Sal00
…..Sal11  SecS-priS Sigma-é00 Sigma-é11     SvCM  AvgsvCM    SvCM1       Flag
  2.016  4.119548  16.0437  4.118264  16.0450  260.875   2.000  0.0013 -0.001284  32.5584
…..32.5460  -0.0124   23.8606   23.8507  1507.14  1507.13  1507.13 0.0000e+00
  3.024  4.119942  16.0472  4.118348  16.0454  260.686   3.000 -0.0018 -0.001594  32.5587
…..32.5461  -0.0126   23.8600   23.8508  1507.17  1507.14  1507.15 0.0000e+00
```

The output format for the down casts only is shown below.

```
PrDM      C1S/m      T190C   Sbeox0Mm/Kg    DepSM      Sal11  Sigma-é11    AvgsvCM      SvCM1
2.017   3.921694    14.3140    277.005      2.000    32.2112    23.9680    1501.28    1501.26
3.025   3.921662    14.3134    277.385      3.000    32.2110    23.9680    1501.28    1501.27
```

Column descriptions are as follows (only the bolded variables are included in the final downcast files):

a) **PrDM = Digiquartz pressure in decibars (db)**
b) C0S/m = Primary conductivity in Siemens per meter (S/m)
c) T090C = Primary temperature, in degrees Celsius (ºC), calculated using the ITS-90 standard
d) **C1S/m = Secondary conductivity in Siemens per meter (S/m)**
e) **T190C = Secondary temperature, in degrees Celsius (ºC), calculated using the ITS-90 standard**
f) **Sbeox0Mm/Kg = Oxygen, SBE 43 (µmol/Kg)**
g) **DepSM = Salt water depth in meters (m)**
h) T2-T190C = The difference between the primary and secondary temperature data, in degrees Celsius (ºC), calculated using the ITS-90 standard
i) C2-C1S/m = The difference between the primary and secondary conductivity data in Siemens per meter (S/m)

j) Sal00 = Salinity, in practical salinity units (psu), derived from the primary temperature and conductivity sensors

k) Sal11 = Salinity, in practical salinity units (psu), derived from the secondary temperature and conductivity sensors

l) SecS-priS = The difference between the salinity data derived from the primary and secondary sensors, in practical salinity units (psu)

m) Sigma-é00 = Density [sigma-theta], in kilograms per cubic meter (kg/m^3), calculated from the primary temperature sensor and the salinity data derived from the primary conductivity sensor

n) Sigma-é11 = Density [sigma-theta], in kilograms per cubic meter (kg/m^3), calculated from the secondary temperature sensor and the salinity data derived from the secondary conductivity sensor

o) SvCM = Chen-Millero's sound velocity in meters per second (m/s) calculated from the primary temperature sensor and the salinity data derived from the primary conductivity sensor

p) AvgsvCM = Chen-Millero's average sound velocity in meters per second (m/s) calculated from the primary temperature sensor and the salinity data derived from the primary conductivity sensor

q) SvCM1 = Chen-Millero's sound velocity in meters per second (m/s) calculated from the secondary temperature sensor and the salinity data derived from the secondary conductivity sensor

Perl program CTDPositionCheck was used to check the CTD cast date/times and positions recorded in the header files against the edited TSG file for STARLITE 2007. 189 of 190 files had matching TSG records; no corrections were necessary.

Paul Fiedler, 16 June 2021

Appendix 1. STARLITE 2007 MACII Sea-Bird Data Processing Configuration Files

STARLITE 2007 Cast 001.CON

```
Configuration report for SBE 911plus/917plus
       CTD
-----------------------------------------
Frequency channels suppressed : 0
Voltage words suppressed      : 2
Computer interface            : RS-232C
Deck unit                     : SBE11plus
       Firmware Version >= 5.0
Scans to average              : 1
NMEA position data added      : Yes
NMEA depth data added         : No
NMEA time added               : No
NMEA device connected to      : deck unit
Surface PAR voltage added     : No
Scan time added               : No

1) Frequency 0, Temperature

   Serial number : 4667
   Calibrated on : 06-Feb-07
   G             : 4.39719491e-003
   H             : 6.45869960e-004
   I             : 2.20888460e-005
   J             : 1.80099547e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity

   Serial number : 3201
   Calibrated on : 01-Feb-07
   G             : -1.01964638e+001
   H             : 1.44892962e+000
   I             : -2.71539166e-004
   J             : 7.98436056e-005
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00055080
   Offset        : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

   Serial number : 3001
   Calibrated on : 12-Feb-07
   C1            : -3.911989e+004
   C2            : -1.960405e+000
   C3            : 9.871570e-003
   D1            : 3.178100e-002
   D2            : 0.000000e+000
   T1            : 2.933918e+001
   T2            : -9.729668e-004
   T3            : 3.817570e-006
   T4            : 0.000000e+000
   T5            : 0.000000e+000
   Slope         : 0.99997000
   Offset        : 11.01800
   AD590M        : 1.135000e-002
   AD590B        : -8.643200e+000

4) Frequency 3, Temperature, 2

   Serial number : 4803
   Calibrated on : 22-Jun-07
   G             : 4.33039723e-003
   H             : 6.36521906e-004
   I             : 2.05998802e-005
   J             : 1.69730027e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

5) Frequency 4, Conductivity, 2

   Serial number : 3353
   Calibrated on : 06-Jul-07
   G             : -9.73266143e+000
   H             : 1.49230971e+000
   I             : -2.15421025e-003
   J             : 2.54964559e-004
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00046190
   Offset        : 0.00000

6) A/D voltage 0, Free

7) A/D voltage 1, Free

8) A/D voltage 2, Oxygen, SBE 43

   Serial number : 1294
   Calibrated on : 31-Jul-07
   Equation      : Owens-Millard
   Soc           : 4.4440e-001
   Boc           : 0.0000
   Offset        : -0.4769
   Tcor          : 0.0017
   Pcor          : 1.35e-004
   Tau           : 0.0

9) A/D voltage 3, Free

Scan length                   : 31
```

STARLITE 2007 Casts 002_020.CON

```
Configuration report for SBE 911plus/917plus
       CTD
-----------------------------------------

Frequency channels suppressed : 0
Voltage words suppressed      : 3
Computer interface            : RS-232C
Deck unit                     : SBE11plus
       Firmware Version >= 5.0
Scans to average              : 1
NMEA position data added      : Yes
NMEA depth data added         : No
NMEA time added               : No
NMEA device connected to      : deck unit
Surface PAR voltage added     : No
Scan time added               : No

1) Frequency 0, Temperature

   Serial number : 4667
   Calibrated on : 06-Feb-07
   G             : 4.39719491e-003
   H             : 6.45869960e-004
   I             : 2.20888460e-005
   J             : 1.80099547e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity

   Serial number : 3201
   Calibrated on : 01-Feb-07
   G             : -1.01964638e+001
   H             : 1.44892962e+000
   I             : -2.71539166e-004
   J             : 7.98436056e-005
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00055080
   Offset        : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

   Serial number : 3001
   Calibrated on : 12-Feb-07
   C1            : -3.911989e+004
   C2            : -1.960405e+000
   C3            : 9.871570e-003
   D1            : 3.178100e-002
   D2            : 0.000000e+000
   T1            : 2.933918e+001
   T2            : -9.729668e-004
   T3            : 3.817570e-006
   T4            : 0.000000e+000
   T5            : 0.000000e+000
   Slope         : 0.99997000
   Offset        : 11.01800
   AD590M        : 1.135000e-002
   AD590B        : -8.643200e+000

4) Frequency 3, Temperature, 2

   Serial number : 4803
   Calibrated on : 22-Jun-07
   G             : 4.33039723e-003
   H             : 6.36521906e-004
   I             : 2.05998802e-005
   J             : 1.69730027e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

5) Frequency 4, Conductivity, 2

   Serial number : 3353
   Calibrated on : 06-Jul-07
   G             : -9.73266143e+000
   H             : 1.49230971e+000
   I             : -2.15421025e-003
   J             : 2.54964559e-004
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00046190
   Offset        : 0.00000

6) A/D voltage 0, Oxygen, SBE 43

   Serial number : 1294
   Calibrated on : 31-Jul-07
   Equation      : Owens-Millard
   Soc           : 4.4440e-001
   Boc           : 0.0000
   Offset        : -0.4769
   Tcor          : 0.0017
   Pcor          : 1.35e-004
   Tau           : 0.0

7) A/D voltage 1, Free

Scan length                   : 28
```

STARLITE 2007 Casts 021-030 200-211.CON

```
Configuration report for SBE 911plus/917plus
       CTD
-----------------------------------------

Frequency channels suppressed : 0
Voltage words suppressed      : 4
Computer interface            : RS-232C
Deck unit                     : SBE11plus
       Firmware Version >= 5.0
Scans to average              : 1
NMEA position data added      : Yes
NMEA depth data added         : No
NMEA time added               : No
NMEA device connected to      : deck unit
Surface PAR voltage added     : No
Scan time added               : No

1) Frequency 0, Temperature

   Serial number : 4667
   Calibrated on : 06-Feb-07
   G             : 4.39719491e-003
   H             : 6.45869960e-004
   I             : 2.20888460e-005
   J             : 1.80099547e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity

   Serial number : 3201
   Calibrated on : 01-Feb-07
   G             : -1.01964638e+001
   H             : 1.44892962e+000
   I             : -2.71539166e-004
   J             : 7.98436056e-005
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00055080
   Offset        : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

   Serial number : 3001
   Calibrated on : 12-Feb-07
   C1            : -3.911989e+004
   C2            : -1.960405e+000
   C3            : 9.871570e-003
   D1            : 3.178100e-002
   D2            : 0.000000e+000
   T1            : 2.933918e+001
   T2            : -9.729668e-004
   T3            : 3.817570e-006
   T4            : 0.000000e+000
   T5            : 0.000000e+000
   Slope         : 0.99997000
   Offset        : 11.01800
   AD590M        : 1.135000e-002
   AD590B        : -8.643200e+000

4) Frequency 3, Temperature, 2

   Serial number : 4803
   Calibrated on : 22-Jun-07
   G             : 4.33039723e-003
   H             : 6.36521906e-004
   I             : 2.05998802e-005
   J             : 1.69730027e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

5) Frequency 4, Conductivity, 2

   Serial number : 3353
   Calibrated on : 06-Jul-07
   G             : -9.73266143e+000
   H             : 1.49230971e+000
   I             : -2.15421025e-003
   J             : 2.54964559e-004
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00046190
   Offset        : 0.00000

Scan length                   : 25
```

STARLITE 2007 Cast 031.CON

```
Configuration report for SBE 911plus/917plus
CTD
-----------------------------------------
----

Frequency channels suppressed : 0
Voltage words suppressed      : 3
Computer interface            : RS-232C
Deck unit                     : SBE11plus
Firmware Version >= 5.0
Scans to average              : 1
NMEA position data added      : Yes
NMEA depth data added         : No
NMEA time added               : No
NMEA device connected to      : deck unit
Surface PAR voltage added     : No
Scan time added               : No

1) Frequency 0, Temperature

   Serial number : 4667
   Calibrated on : 06-Feb-07
   G             : 4.39719491e-003
   H             : 6.45869960e-004
   I             : 2.20888460e-005
   J             : 1.80099547e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity

   Serial number : 3201
   Calibrated on : 01-Feb-07
   G             : -1.01964638e+001
   H             : 1.44892962e+000
   I             : -2.71539166e-004
   J             : 7.98436056e-005
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00055080
   Offset        : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

   Serial number : 3001
   Calibrated on : 12-Feb-07
   C1            : -3.911989e+004
   C2            : -1.960405e+000
   C3            : 9.871570e-003
   D1            : 3.178100e-002
   D2            : 0.000000e+000
   T1            : 2.933918e+001
   T2            : -9.729668e-004
   T3            : 3.817570e-006
   T4            : 0.000000e+000
   T5            : 0.000000e+000
   Slope         : 0.99997000
   Offset        : 11.01800
   AD590M        : 1.135000e-002
   AD590B        : -8.643200e+000

4) Frequency 3, Temperature, 2

   Serial number : 4803
   Calibrated on : 22-Jun-07
   G             : 4.33039723e-003
   H             : 6.36521906e-004
   I             : 2.05998802e-005
   J             : 1.69730027e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

5) Frequency 4, Conductivity, 2

   Serial number : 3353
   Calibrated on : 06-Jul-07
   G             : -9.73266143e+000
   H             : 1.49230971e+000
   I             : -2.15421025e-003
   J             : 2.54964559e-004
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00063890
   Offset        : 0.00000

6) A/D voltage 0, Oxygen, SBE 43

   Serial number : 1295
   Calibrated on : 31 Jul 07
   Equation      : Owens-Millard
   Soc           : 3.9450e-001
   Boc           : 0.0000
   Offset        : -0.5003
   Tcor          : 0.0023
   Pcor          : 1.35e-004
   Tau           : 0.0

7) A/D voltage 1, Free

Scan length                   : 28
```

STARLITE 2007 Casts 032-063 300-314.CON

```
Configuration report for SBE 911plus/917plus
CTD
-----------------------------------------

Frequency channels suppressed : 0
Voltage words suppressed      : 0
Computer interface            : RS-232C
Deck unit                     : SBE11plus
Firmware Version >= 5.0
Scans to average              : 1
NMEA position data added      : Yes
NMEA depth data added         : No
NMEA time added               : No
NMEA device connected to      : deck unit
Surface PAR voltage added     : No
Scan time added               : No

1) Frequency 0, Temperature

   Serial number : 4667
   Calibrated on : 06-Feb-07
   G             : 4.39719491e-003
   H             : 6.45869960e-004
   I             : 2.20888460e-005
   J             : 1.80099547e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity

   Serial number : 3201
   Calibrated on : 01-Feb-07
   G             : -1.01964638e+001
   H             : 1.44892962e+000
   I             : -2.71539166e-004
   J             : 7.98436056e-005
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00055080
   Offset        : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

   Serial number : 3001
   Calibrated on : 12-Feb-07
   C1            : -3.911989e+004
   C2            : -1.960405e+000
   C3            : 9.871570e-003
   D1            : 3.178100e-002
   D2            : 0.000000e+000
   T1            : 2.933918e+001
   T2            : -9.729668e-004
   T3            : 3.817570e-006
   T4            : 0.000000e+000
   T5            : 0.000000e+000
   Slope         : 0.99997000
   Offset        : 11.01800
   AD590M        : 1.135000e-002
   AD590B        : -8.643200e+000

4) Frequency 3, Temperature, 2

   Serial number : 4803
   Calibrated on : 22-Jun-07
   G             : 4.33039723e-003
   H             : 6.36521906e-004
   I             : 2.05998802e-005
   J             : 1.69730027e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

5) Frequency 4, Conductivity, 2

   Serial number : 3353
   Calibrated on : 06-Jul-07
   G             : -9.73266143e+000
   H             : 1.49230971e+000
   I             : -2.15421025e-003
   J             : 2.54964559e-004
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00063890
   Offset        : 0.00000

6) A/D voltage 0, Free

7) A/D voltage 1, Free

8) A/D voltage 2, Free

9) A/D voltage 3, Free

10) A/D voltage 4, Oxygen, SBE 43

    Serial number : 1295
    Calibrated on : 31-July-07
    Equation      : Owens-Millard
    Soc           : 3.9450e-001
    Boc           : 0.0000
    Offset        : -0.5003
    Tcor          : 0.0023
    Pcor          : 1.35e-004
    Tau           : 0.0

11) A/D voltage 5, Free

12) A/D voltage 6, Free

13) A/D voltage 7, Free

Scan length                   : 37
```

STARLITE 2007 Casts 064_075.CON

```
Configuration report for SBE 911plus/917plus
CTD
-----------------------------------------

Frequency channels suppressed : 0
Voltage words suppressed      : 0
Computer interface            : RS-232C
Deck unit                     : SBE11plus
Firmware Version >= 5.0
Scans to average              : 1
NMEA position data added      : Yes
NMEA depth data added         : No
NMEA time added               : No
NMEA device connected to      : deck unit
Surface PAR voltage added     : No
Scan time added               : No

1) Frequency 0, Temperature

   Serial number : 4667
   Calibrated on : 06-Feb-07
   G             : 4.39719491e-003
   H             : 6.45869960e-004
   I             : 2.20888460e-005
   J             : 1.80099547e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity

   Serial number : 3201
   Calibrated on : 01-Feb-07
   G             : -1.01964638e+001
   H             : 1.44892962e+000
   I             : -2.71539166e-004
   J             : 7.98436056e-005
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00055080
   Offset        : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

   Serial number : 0405
   Calibrated on : 29-Jan-08
   C1            : -4.505278e+004
   C2            : -9.372496e-001
   C3            : 1.416440e-002
   D1            : 3.852400e-002
   D2            : 0.000000e+000
   T1            : 3.024202e+001
   T2            : -5.890827e-004
   T3            : 4.036660e-006
   T4            : 2.914400e-009
   T5            : 0.000000e+000
   Slope         : 0.99986000
   Offset        : -0.61300
   AD590M        : 1.111000e-002
   AD590B        : -8.834520e+000

4) Frequency 3, Temperature, 2

   Serial number : 4803
   Calibrated on : 22-Jun-07
   G             : 4.33039723e-003
   H             : 6.36521906e-004
   I             : 2.05998802e-005
   J             : 1.69730027e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

5) Frequency 4, Conductivity, 2

   Serial number : 3353
   Calibrated on : 06-Jul-07
   G             : -9.73266143e+000
   H             : 1.49230971e+000
   I             : -2.15421025e-003
   J             : 2.54964559e-004
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00082360
   Offset        : 0.00000

6) A/D voltage 0, Free

7) A/D voltage 1, Free

8) A/D voltage 2, Free

9) A/D voltage 3, Free

10) A/D voltage 4, Oxygen, SBE 43

    Serial number : 1295
    Calibrated on : 31-July-07
    Equation      : Owens-Millard
    Soc           : 3.9450e-001
    Boc           : 0.0000
    Offset        : -0.5003
    Tcor          : 0.0023
    Pcor          : 1.35e-004
    Tau           : 0.0

11) A/D voltage 5, Free

12) A/D voltage 6, Free

13) A/D voltage 7, Free

Scan length                   : 37
```

STARLITE 2007 Casts 076-094 400-413.CON

```
Configuration report for SBE 911plus/917plus
CTD
-----------------------------------------

Frequency channels suppressed : 0
Voltage words suppressed      : 0
Computer interface            : RS-232C
Deck unit                     : SBE11plus
Firmware Version >= 5.0
Scans to average              : 1
NMEA position data added      : Yes
NMEA depth data added         : No
NMEA time added               : No
NMEA device connected to      : deck unit
Surface PAR voltage added     : No
Scan time added               : No

1) Frequency 0, Temperature

   Serial number : 4667
   Calibrated on : 06-Feb-07
   G             : 4.39719491e-003
   H             : 6.45869960e-004
   I             : 2.20888460e-005
   J             : 1.80099547e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity

   Serial number : 3201
   Calibrated on : 01-Feb-07
   G             : -1.01964638e+001
   H             : 1.44892962e+000
   I             : -2.71539166e-004
   J             : 7.98436056e-005
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00055080
   Offset        : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

   Serial number : 0311
   Calibrated on : 12-Apr-07
   C1            : -4.123560e+004
   C2            : 1.043267e+000
   C3            : 1.330030e-002
   D1            : 4.018400e-002
   D2            : 0.000000e+000
   T1            : 3.020637e+001
   T2            : 4.924132e-005
   T3            : 3.833950e-006
   T4            : 6.451910e-009
   T5            : 0.000000e+000
   Slope         : 0.99987000
   Offset        : -5.25150
   AD590M        : 1.167000e-002
   AD590B        : -8.165620e+000

4) Frequency 3, Temperature, 2

   Serial number : 4803
   Calibrated on : 22-Jun-07
   G             : 4.33039723e-003
   H             : 6.36521906e-004
   I             : 2.05998802e-005
   J             : 1.69730027e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

5) Frequency 4, Conductivity, 2

   Serial number : 3353
   Calibrated on : 06-Jul-07
   G             : -9.73266143e+000
   H             : 1.49230971e+000
   I             : -2.15421025e-003
   J             : 2.54964559e-004
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00082360
   Offset        : 0.00000

6) A/D voltage 0, Free

7) A/D voltage 1, Free

8) A/D voltage 2, Free

9) A/D voltage 3, Free

10) A/D voltage 4, Oxygen, SBE 43

    Serial number : 1295
    Calibrated on : 31-July-07
    Equation      : Owens-Millard
    Soc           : 3.9450e-001
    Boc           : 0.0000
    Offset        : -0.5003
    Tcor          : 0.0023
    Pcor          : 1.35e-004
    Tau           : 0.0

11) A/D voltage 5, Free

12) A/D voltage 6, Free

13) A/D voltage 7, Free

Scan length                   : 37
```

STARLITE 2007 Casts 095-131 500-511.CON

```
Configuration report for SBE 911plus/917plus
CTD
-----------------------------------------

Frequency channels suppressed : 0
Voltage words suppressed      : 0
Computer interface            : RS-232C
Deck unit                     : SBE11plus
Firmware Version >= 5.0
Scans to average              : 1
NMEA position data added      : Yes
NMEA depth data added         : No
NMEA time added               : No
NMEA device connected to      : deck unit
Surface PAR voltage added     : No
Scan time added               : No

1) Frequency 0, Temperature

   Serial number : 4667
   Calibrated on : 06-Feb-07
   G             : 4.39719491e-003
   H             : 6.45869960e-004
   I             : 2.20888460e-005
   J             : 1.80099547e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity

   Serial number : 3201
   Calibrated on : 01-Feb-07
   G             : -1.01964638e+001
   H             : 1.44892962e+000
   I             : -2.71539166e-004
   J             : 7.98436056e-005
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00055080
   Offset        : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

   Serial number : 0311
   Calibrated on : 12-Apr-07
   C1            : -4.123560e+004
   C2            : 1.043267e+000
   C3            : 1.330030e-002
   D1            : 4.018400e-002
   D2            : 0.000000e+000
   T1            : 3.020637e+001
   T2            : 4.924132e-005
   T3            : 3.833950e-006
   T4            : 6.451910e-009
   T5            : 0.000000e+000
   Slope         : 0.99987000
   Offset        : -5.25150
   AD590M        : 1.167000e-002
   AD590B        : -8.165600e+000

4) Frequency 3, Temperature, 2

   Serial number : 4803
   Calibrated on : 22-Jun-07
   G             : 4.33039723e-003
   H             : 6.36521906e-004
   I             : 2.05998802e-005
   J             : 1.69730027e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

5) Frequency 4, Conductivity, 2

   Serial number : 3353
   Calibrated on : 06-Jul-07
   G             : -9.73266143e+000
   H             : 1.49230971e+000
   I             : -2.15421025e-003
   J             : 2.54964559e-004
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00100840
   Offset        : 0.00000

6) A/D voltage 0, Free

7) A/D voltage 1, Free

8) A/D voltage 2, Free

9) A/D voltage 3, Free

10) A/D voltage 4, Oxygen, SBE 43

    Serial number : 1295
    Calibrated on : 31-Jul-07
    Equation      : Owens-Millard
    Soc           : 3.9450e-001
    Boc           : 0.0000
    Offset        : -0.5003
    Tcor          : 0.0023
    Pcor          : 1.35e-004
    Tau           : 0.0

11) A/D voltage 5, Free

12) A/D voltage 6, Free

13) A/D voltage 7, Free

Scan length                   : 37
```

STARLITE 2007 Cast 132.con

```
Configuration report for SBE 911plus/917plus
CTD
-----------------------------------------

Frequency channels suppressed : 0
Voltage words suppressed      : 0
Computer interface            : RS-232C
Deck unit                     : SBE11plus
Firmware Version >= 5.0
Scans to average              : 1
NMEA position data added      : Yes
NMEA depth data added         : No
NMEA time added               : No
NMEA device connected to      : deck unit
Surface PAR voltage added     : No
Scan time added               : No

1) Frequency 0, Temperature

   Serial number : 4667
   Calibrated on : 06-Feb-07
   G             : 4.39719491e-003
   H             : 6.45869960e-004
   I             : 2.20888460e-005
   J             : 1.80099547e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity

   Serial number : 3201
   Calibrated on : 01-Feb-07
   G             : -1.01964638e+001
   H             : 1.44892962e+000
   I             : -2.71539166e-004
   J             : 7.98436056e-005
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00055080
   Offset        : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

   Serial number : 0311
   Calibrated on : 12-Apr-07
   C1            : -4.123560e+004
   C2            : 1.043267e+000
   C3            : 1.330030e-002
   D1            : 4.018400e-002
   D2            : 0.000000e+000
   T1            : 3.020637e+001
   T2            : 4.924132e-005
   T3            : 3.833950e-006
   T4            : 6.451910e-009
   T5            : 0.000000e+000
   Slope         : 0.99987000
   Offset        : -5.25150
   AD590M        : 1.167000e-002
   AD590B        : -8.165620e+000

4) Frequency 3, Temperature, 2

   Serial number : 4803
   Calibrated on : 22-Jun-07
   G             : 4.33039723e-003
   H             : 6.36521906e-004
   I             : 2.05998802e-005
   J             : 1.69730027e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

5) Frequency 4, Conductivity, 2

   Serial number : 3353
   Calibrated on : 06-Jul-07
   G             : -9.73266143e+000
   H             : 1.49230971e+000
   I             : -2.15421025e-003
   J             : 2.54964559e-004
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00100840
   Offset        : 0.00000

6) A/D voltage 0, Free

7) A/D voltage 1, Free

8) A/D voltage 2, Free

9) A/D voltage 3, Free

10) A/D voltage 4, Oxygen, SBE 43

    Serial number : 1294
    Calibrated on : 31-Jul-07
    Equation      : Owens-Millard
    Soc           : 4.4440e-001
    Boc           : 0.0000
    Offset        : -0.4769
    Tcor          : 0.0017
    Pcor          : 1.35e-004
    Tau           : 0.0

11) A/D voltage 5, Free

12) A/D voltage 6, Free

13) A/D voltage 7, Free

Scan length                   : 37
```

Appendix 2. Bottle Salinity Analyses

Bottle salinity samples were analyzed to detect evidence of Niskin bottle leakage and to help validate CTD sensor calibration. Samples were collected from bottles tripped at depth and analyzed with a Guildline PortaSal salinometer using standard methods. The raw salinity data from the PortaSal and CTD can be found in /Oceanographic/Salinity. The results summarized below can be found in the spreadsheet STARLITE 2007 Salts.xls located in the /Documents folder.

Conductivity Ratio Adjustment for Bottle Salinities

When analyzing samples on the Portasal, the initial salinity standard reading should be equal to 2x the actual conductivity ratio of the standard (K_{15} on the ampule label) after correct initialization of the instrument. Referencing sample conductivity ratios to the initial standard reading may not give the best results for several reasons; for example, the initial standard reading may be erroneous (e.g., the Portasal was not sufficiently warmed up with standard water before samples are read) or the sensitivity of the Portasal may drift during the run. If the initial and final standard readings differ, then adjusting the reference for sample conductivity ratios will change both the mean and the standard deviation of Bottle - CTD salinity differences. Selection of an adjustment alternative should be based on minimizing the mean and standard deviation.

CR2SAL calculates four alternative salinity values from sample conductivity ratios adjusted relative to:

(0) the initial standard reading (no adjustment),
(1) the final standard reading,
(2) the average of the initial and final readings, and
(3) a standard reading interpolated between the initial and final readings.

Salinities calculated from sample conductivity ratios adjusted by method (1) resulted in bottle–CTD differences with the smallest means (biases) and standard deviations (RMSE) overall:

	Mean (Bottle – CTD)		St. dev. (Bottle – CTD)	
Adjustment	primary	secondary	primary	secondary
None:	-0.002352	-0.013679	0.008404	**0.008707**
(1):	**-0.001963**	**-0.013290**	**0.008266**	0.008947
(2):	-0.002158	-0.013484	0.008314	0.008808
(3):	-0.002130	+0.013457	0.008369	0.008813

Therefore, bottle salinities calculated from sample conductivity ratios adjusted by method (1) were used in subsequent analyses.

Precision of Replicates

Three replicate samples were collected from 10 deep bottles on selected CTD casts to assess the precision of our bottle salinity sampling and analysis methods (see Replicates worksheet in STARLITE 2007 Salts.xls). An ANOVA gives a "mean squares within" of 5.2391e-06, which is equivalent to the variance of replicate salinity values within bottles. The square root of this value gives a precision of ±0.0023 psu, approximately equal to the accuracy of ±0.003 specified by Guildline.

The standard deviation of Bottle - CTD salinity differences for all samples was between 0.0083 and 0.0089 (above table), more than three times greater than the precision of bottle salinity replicates. A larger error is expected because of the additional errors of the CTD sensors and the mismatch of waters pumped through CTD sensors and sampled by Niskin bottles.

Test Cast Bottle vs. CTD Salinities

The following table summarizes bottle salinities and corresponding CTD salinities (mean ±sd) from the four test casts. Although values are listed to four decimal places, the precision of the salinometer is ±0.003 and the precision of the CTD sensors is ±0.0004 psu.

	CTD S1	CTD S2	Bottle
Leg 1	34.5832 ±0.0003	34.5903 ±0.0003	34.5819 ±0.0040
Leg 2	34.5762 ±0.0001	34.5910 ±0.0002	34.5706 ±0.0033
Leg 3	34.6224 ±0.0235	34.5800 ±0.0006	34.5650 ±0.0085
Leg 4	34.5840 ±0.0005	34.5953 ±0.0006	34.5731 ±0.0016

The salinity of the samples collected when the bottles were tripped sequentially at the same depth (column labeled "Bottle" above) vary more than the precision of replicates (i.e., ±0.0023 psu) and the precision of the salinometer. A larger variability is expected because there may be real salinity differences between bottles.

Salinities derived from primary and secondary CTD sensors (S1 and S2), after temperature and conductivity calibration adjustments, are plotted as deviations from the PortaSal bottle salinities in Figure 3 and mean values are shown in Figure 4 and the table below.

The Leg 3 test cast was conducted with CTD Pressure Sensor and Fish P0405-61183.This CTD was also used for casts 064-075. The excessively high variability of CTD S1 in the table and large S1-P salinity differences in Figure 3 indicate that there was a problem with the primary conductivity sensor on these casts, likely related to its mounting or connection with the CTD fish.

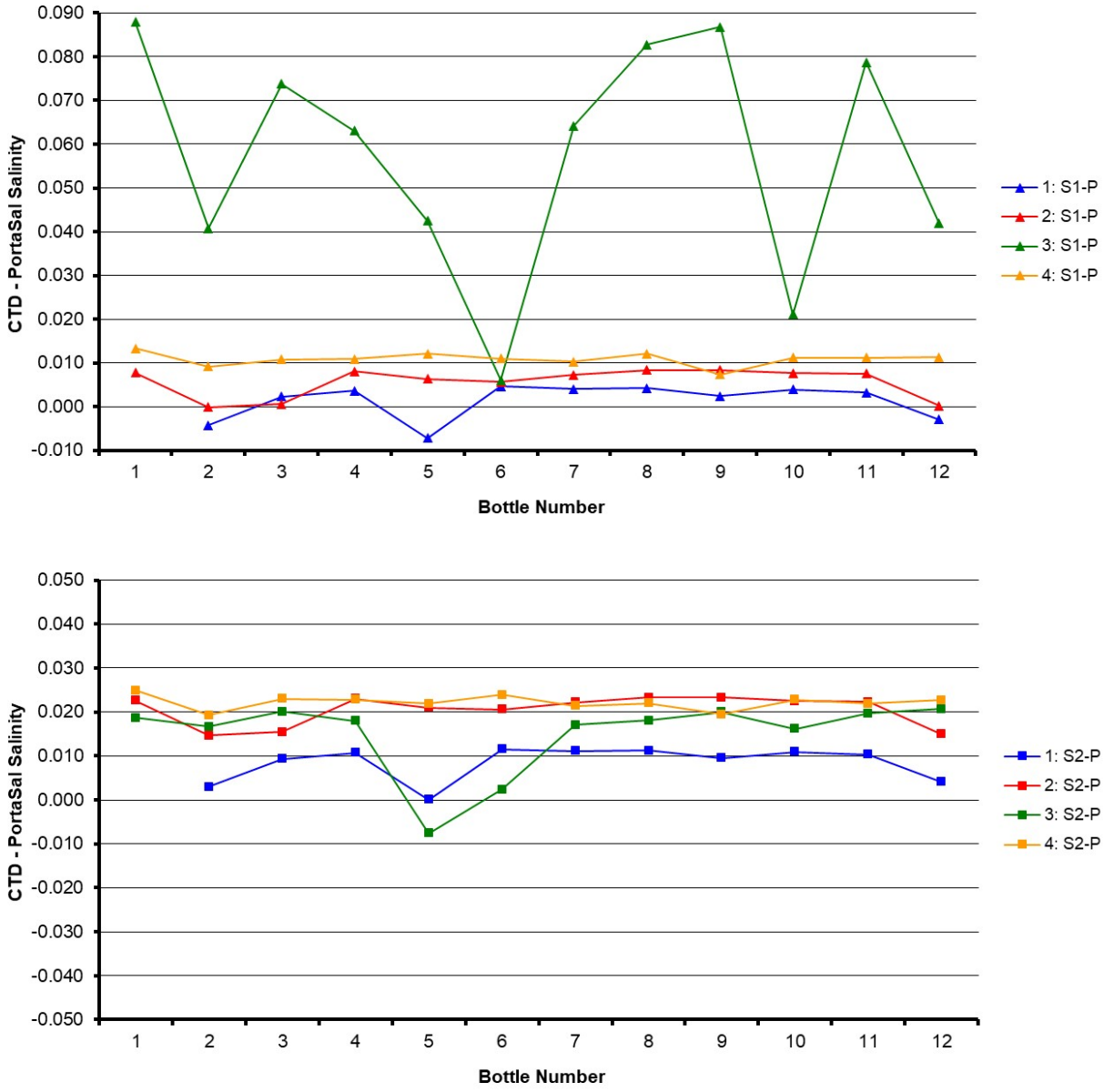


Figure 3. Deviations of CTD salinities, derived from primary (S0) and secondary (S1) sensor data, from bottle salinities measured with the PortaSal salinometer (P), for test casts on Legs 1-4.

Deviations of CTD salinities, derived from primary and secondary sensor data, from bottle salinities measured with the PortaSal salinometer are greater than the precision of the instruments, suggesting calibration error. There are no bottles with consistently greater deviations that might indicate Niskin bottle leakage.

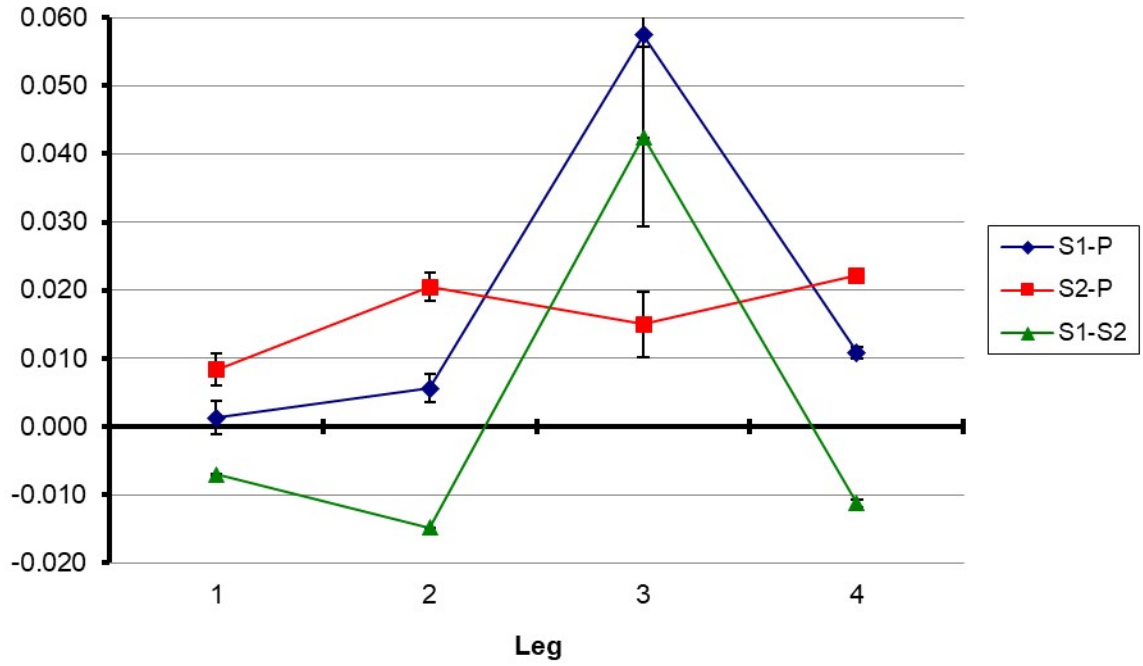


Figure 4. Mean deviations (psu, with 95% confidence limits) of CTD salinities, derived from the primary (S0) and secondary (S1) conductivity sensors, from bottle salinities measured with the PortaSal salinometer (P), for test casts on Legs 1-4.

	S1 - bottle	**S2 - bottle**	**S1 – S2**
Leg 1	+0.0013 ±0.0024	+0.0083 ±0.0024	-0.0071 ±0.0000
Leg 2	+0.0056 ±0.0020	+0.0205 ±0.0020	-0.0148 ±0.0000
Leg 3	+0.0574 ±0.0152	+0.0150 ±0.0049	+0.0425 ±0.0132
Leg 4	+0.0109 ±0.0008	+0.0222 ±0.0009	-0.0113 ±0.0006

It was shown above that temperatures from the primary and secondary temperature sensors were not significantly different (Fig. 1). The deviations between the CTD and Portasal salinities indicate that the primary conductivity sensor was more accurate than the secondary conductivity sensor. For the final data files, we will use temperature and salinity values from the primary sensors, except for casts 064-075 (use secondary sensors).