DY033 CTD processing report

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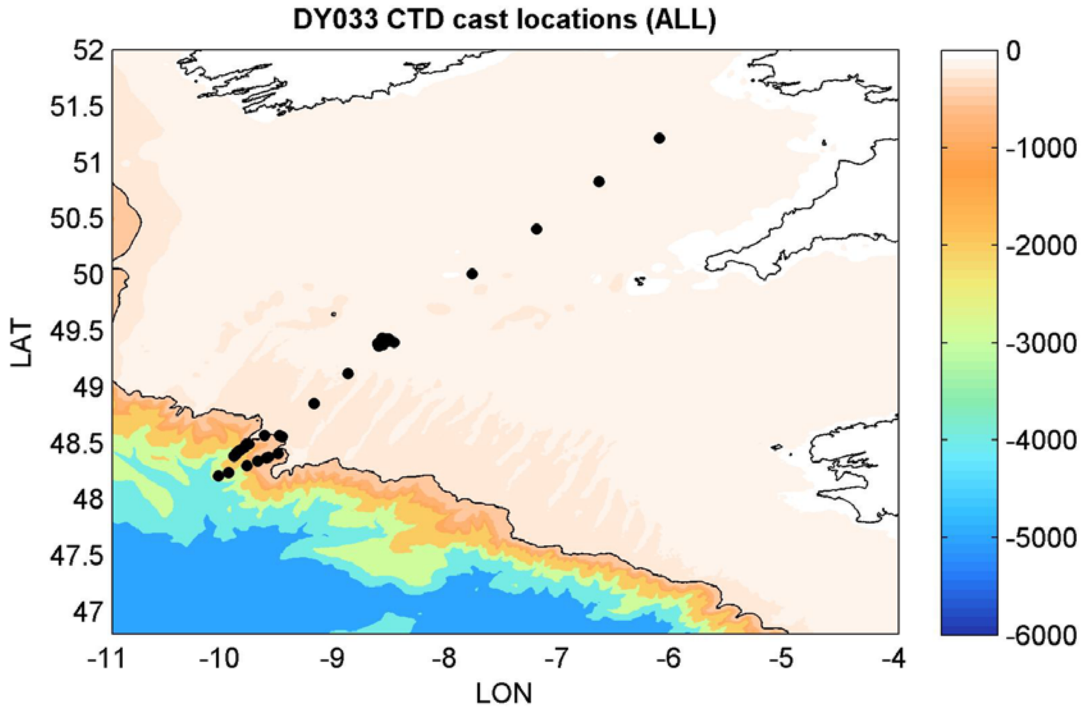
A total of 47 useable casts with the stainless steel frame and 41 useable casts with the titanium CTD frame were completed. See technical reports for sensor serial numbers and channels.

Map of CTD cast locations



Raw data files:

The following raw data files were generated:

DY033_001.bl (a record of bottle firing locations)
DY033_001.hdr (header file)
DY033_001.hex (raw data file)
DY033_001.con (configuration file)

Where _001 is the cast number (not STNNBR)

Files generated by the titanium CTD frame have a suffix 'T', e.g DY033_007T.bl etc

SBEDataProcessing steps

The following processing routines were run in the SBEDataProcessing software (Seasave Version 7.23.2):

1. **DatCnv:** A conversion routine to read in the raw CTD data file (.hex) containing data in engineering units output by the CTD hardware. Calibrations as appropriate though the instrument configuration file (.CON) are applied.

Data Setup options were set to the following:

Process scans to end of file: yes
Scans to skip: 0
Output format: ascii
Convert data from: upcast & downcast
Create file types: both bottle and data
Source of scan range data: bottle log .BL file
Scan range offset: -2.5 seconds for stainless, -1 second for titanium
Scan range duration: 5 seconds for stainless, 1 second for titanium
Merge separate header file: No
Apply oxygen hysteresis correction: yes (2 second window)
Apply oxygen Tau correction: yes

Selected output variables:

- Time [seconds]
- Pressure [db]
- Temperature [ITS-90, °C] and Temperature 2 [ITS-90, °C], referring to primary and secondary sensors)
- Conductivity and Conductivity 2 [S/m]
- Salinity and salinity 2 [PSU, PSS-78]
- Oxygen raw, SBE 43 [V]
- Oxygen, SBE 43 [µmol/l]
- Beam attenuation [1/m]
- Fluorescence [µg/l]
- PAR/irradiance, downwelling [W m^2]
- Turbidity [m^{-1} sr^{-1}]
- Altimeter [m]
- Voltage channel 2: Light scattering Wetlabs BBRTD *[Stainless]*; Upwelling Irradiance sensor (UWIRR) *[Titanium]*
- Voltage channel 3: Altimeter *[Stainless]*; Downwelling Irradiance sensor (DWIRR) *[Titanium]*
- Voltage channel 4: Fluorometer *[Stainless]*; Altimeter *[Titanium]*
- Voltage channel 5: Transmissometer *[Stainless]*; Light scattering Wetlabs BBRTD *[Titanium]*
- Voltage channel 6: Downwelling Irradiance sensor (DWIRR) [*Stainless]*; Transmissometer *[Titanium]*
- Voltage channel 7: Upwelling Irradiance sensor (UWIRR) *[Stainless]*; Fluorometer *[Titanium]*

2. **Bottle Summary** was run to create a .BTL file containing the average, standard deviation, min and max values at bottle firings. .ROS files were placed in the same directory as the .bl files during this routine to ensure that bottle rosette position was captured in the .btl file.

   Output saved to DY033_001.btl (DY033_007T.btl)

3. **Wild Edit:** Removal of pressure spikes

   Standard deviations for pass 1: 2
   Standard deviations for pass 2: 20
   Scans per black: 100
   Keep data within this distance of the mean: 0
   Exclude scans marked as bad: yes

4. **Filter:** Run on the pressure channel to smooth out high frequency data

   Low pass filter time B: 0.15 seconds

5. **AlignCTD:** Based on examination of different casts a 3 second advance was chosen for alignment of the oxygen sensor on the stainless steel CTD and 3 seconds for the titanium casts. This alignment is a function of the temperature and the state of the oxygen sensor membrane. The colder (deeper) the water the greater the advance needed. The above alignments were chosen as a compromise between results in deep (cold) and shallow (warmer) waters.

6. **CellTM:** Removes the effect of thermal inertia on the conductivity cells. Alpha = 0.03 (thermal anomaly amplitude) and 1/beta = 7 (thermal anomaly time constant) for both cells.

   Output of steps 1-6 above saved in DY033_001.cnv (24 Hz resolution) (DY033_007T.cnv)

7. **Derive:** Variables selected are
   Salinity and Salinty 2 [PSU, PSS-78]
   Oxygen SBE43 [µmol/l]
   Oxygen Tau correction: yes (2 second window)

   Output saved to DY033_001_derive.cnv (24 Hz resolution) (DY033_007T_derive.cnv)

8. **BinAverage:** Average into 2Hz (0.5 seconds),
   Exclude bad scans: yes
   Scans to skip over: 0
   Casts to process: Up and down

9. **Strip:** Remove salinity and oxygen channels from the 2 Hz file that were originally created by DatCnv, but then later regenerated by Derive.

   Output saved to DY033_001_derive_2Hz.cnv (DY033_007T_derive_2Hz.cnv)

Matlab processing steps
The following processing steps were performed in MATLAB:

(1) Create a .mat file of meta data extracted from the cruise Event Log with the following variables:

   CRUISECODE e.g. DY033
   STNNBR (as per BODC data management guidance for the Shelf Sea Biogeochemistry programme)
   DATE and TIME of the cast at the bottom of the profile (when known)
   LAT and LON when the CTD was at the bottom of the profile (when known)
   DEPTH (nominal water depth in metres from echo sounder)
   CAST (CTD cast number, e.g. 001)

   File created: DY033_metadata.mat

(2) Extract data from 2Hz averaged files (e.g. DY033_001_derive_2Hz.cnv), merge with metadata and save into a matlab structure for each cast. Each file (DY033_001_derive_2Hz.mat) contains the following <u>un-calibrated</u> channels.

```
CTD001 =

           CRUISE: 'DY033'
             CAST: 1.00
           STNNBR: 3.00
```

```
                 DATE: '13/07/2015'
                 TIME: '06:47'
                  LAT: 49.43
                  LON: -8.59
                DEPTH: 144.00                [m]
              CTDtime: [4276x1 double]     [seconds]
              CTDpres: [4276x1 double]     [db]
             CTDtemp1: [4276x1 double]     [°C]
             CTDtemp2: [4276x1 double]     [°C]
             CTDcond1: [4276x1 double]     [S/m]
             CTDcond2: [4276x1 double]     [S/m]
           CTDoxy_raw: [4276x1 double]     [V]
               CTDatt: [4276x1 double]     [1/m]
             CTDfluor: [4276x1 double]     [µg/l]
               CTDpar: [4276x1 double]     [Wm2]
              CTDturb: [4276x1 double]     [m-1 sr-1]
               CTDalt: [4276x1 double]     [m]
          CTDturb_raw: [4276x1 double]     [V]
           CTDalt_raw: [4276x1 double]     [V]
         CTDfluor_raw: [4276x1 double]     [V]
           CTDatt_raw: [4276x1 double]     [V]
        CTDpar_dn_raw: [4276x1 double]     [V]
        CTDpar_up_raw: [4276x1 double]     [V]
              CTDsal1: [4276x1 double]     [PSU]
              CTDsal2: [4276x1 double]     [PSU]
         CTDoxy_umoll: [4276x1 double]     [µmol/l]
              CTDflag: [4276x1 double]
```

(3) Extract data from 24Hz files (e.g. DY033_001_derive.cnv), merge with metadata and save into a matlab structure for each cast. Each file (DY008_001_derive.mat) contains the following <u>un-calibrated</u> channels.

```
CTD001 =

             CRUISE: 'DY033'
               CAST: 1.00
             STNNBR: 3.00
               DATE: '13/07/2015'
               TIME: '06:47'
                LAT: 49.43
                LON: -8.59
              DEPTH: 144.00                 [m]
            CTDtime: [51306x1 double]     [seconds]
            CTDpres: [51306x1 double]     [db]
           CTDtemp1: [51306x1 double]     [°C]
           CTDtemp2: [51306x1 double]     [°C]
           CTDcond1: [51306x1 double]     [S/m]
           CTDcond2: [51306x1 double]     [S/m]
          CTDsal1_1: [51306x1 double]     [PSU]
          CTDsal2_1: [51306x1 double]     [PSU]
         CTDoxy_raw: [51306x1 double]     [V]
    CTD_oxy_umoll_1: [51306x1 double]     [µmol/l]
             CTDatt: [51306x1 double]     [1/m]
           CTDfluor: [51306x1 double]     [µg/l]
             CTDpar: [51306x1 double]     [Wm2]
```

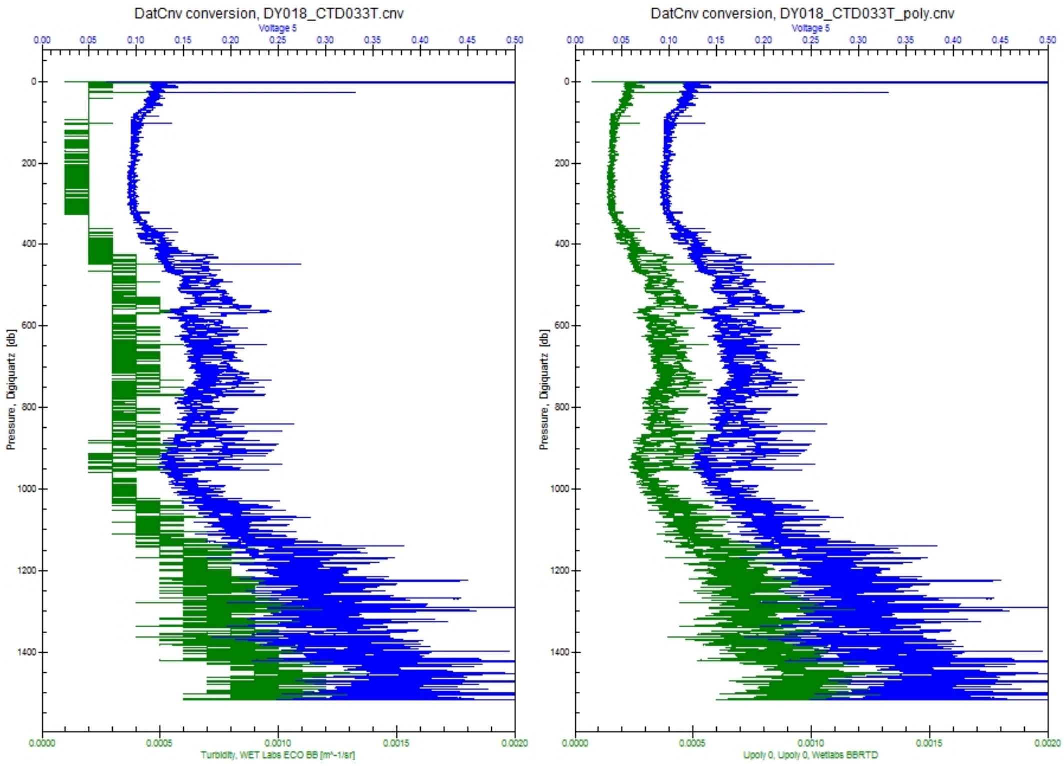
```
     CTDturb: [51306x1 double]    [m-1 sr-1]
      CTDalt: [51306x1 double]    [m]
 CTDturb_raw: [51306x1 double]    [V]
  CTDalt_raw: [51306x1 double]    [V]
CTDfluor_raw: [51306x1 double]    [V]
  CTDatt_raw: [51306x1 double]    [V]
CTDpar_dn_raw: [51306x1 double]   [V]
CTDpar_up_raw: [51306x1 double]   [V]
     CTDsal1: [51306x1 double]    [PSU]
     CTDsal2: [51306x1 double]    [PSU]
 CTDoxy_umoll: [51306x1 double]   [μmol/l]
     CTDflag: [51306x1 double]
```

Note that ‘_1’ for the first instances of salinity and oxygen in this file are variables before re-derivation in the SeaBird Processing routines.

Inspection of the turbidity channel (CTDturb) and comparison to the original raw voltage (CTDturb_raw) reveals a bug in the SeaBird DatCnv conversion module whereby the converted ECO-BB output is reported to a fixed precision. This has been confirmed by SeaBird (see email chain at the end of cruise DY018). It is demonstrated below (left) where the raw voltage channel (blue) is compared to the SeaBird DatCnv output (green). Direct conversion using the scale factor (SF) and dark counts (DC) supplied in the manufacturer’s calibration appears to rectify this problem (right plot). We therefore replace the original turbidity channel in the .cnv files with a corrected version using:

CTDturb = CTDturb_raw .* SF - (SF x DC);

This appears to reinstate the original resolution.



(4) Manual identification of the surface soak (while waiting for pumps to turn on) and the end of the downcast using the 2Hz files. Times to crop were saved to DY033_stainless_castcrop_times.mat and DY033_titanium_castcrop_times.mat

```
     CAST: [48x6 char]
   STNNBR: [48x1 double]
 CTDstart: [48x1 double] [seconds]
  CTDstop: [48x1 double] [seconds]
```

This was then used to crop both the 2Hz and 24Hz files and output (i.e. just the downcast recordings) saved to DY033_CTD001_derive_2Hz_cropped.mat and DY033_CTD001_derive_cropped.mat respectively.

(5) De-spiking of downcast 24 Hz data. The salinity, conductivity, temperature, oxygen, attenuation, turbidity and fluorescence channels were all de-spiked. The worst spikes were identified using an automated routine (similar to WildEdit) where the data was scanned twice and points falling outside a threshold of *nstd* x standard deviations from the mean within a set window size were removed (turned into NaNs).

Window size (#scans) and number of standard deviations from the mean (nstd) used for each channel.

Channel	*Pass 1 window*	*Pass 1 nstd*	*Pass 2 window*	*Pass 2 nstd*
Temperature, conductivity, fluorescence	100	3	200	3
Salinity, turbidity	200	2	200	3
Oxygen	100	2	200	3

Auto-despiking saved to DY033_CTD001_derived_cropped_autospike.mat

Large 'spikes' were often observed in the CT sensors lasting a few seconds, predominantly in the thermocline. This is a persistent problem in shallow water with strong property gradients (e.g. see for example D352, D376); particularly where a large CTD package carrying large volume bottles is used. The spikes coincide with a decrease in the decent rate of the CTD package and are therefore likely associated with inefficient flushing of water around the sensors. It is caused by the pitch and roll of the boat, so is accentuated in rough weather. As the decent rate of the CTD package slows on the downcast 'old' water (from above and therefore typically warmer) is pushed back passed the sensors. As the decent rate increases again 'new' water is flushed past the sensors. A similar problem can occur if the veer rate on the CTD winch varies (as was the case on CD173).

The largest and most significant warm anomalies identified in the primary and secondary CT sensors were removed. This was at times up to 5 m of the profile. The impact of smaller scale anomalies that were not removed is mostly minimised during the averaging processes, but care should be taken when interpreting smaller scale features, particularly through the thermocline. The casts are more than good enough for looking at large scale trends and anomalies but should probably not be used for Thorpe scale analysis and interpretation of fine scale structures. To achieve this in a shelf sea environment free fall profiling techniques are more suitable.

Although 'old' water would also have been flushed back past the auxiliary sensors (turbidity, oxygen, chlorophyll, attenuation) the coincident measurements in these channels were (a) not always anomalous and/or (b) any associated anomaly did not always exactly coincide (or could even be confidently identified, especially for oxygen). As such removal of data from auxiliary channels using scans flagged as bad in the primary/secondary CT channels was not always appropriate or did not improve data quality. The worst individual spikes within these channels however were manually identified and removed (NaN'd).

Output saved to DY033_CTD001_derived_cropped_autospike_manualspike.mat

Additional channels added into this file:

Vectors of 0's and 1's indicating data that has been NaN'd (=1). Outputs depend on channels loaded and viewed so each column may have variable meaning and is saved for processing archive purposes only.

```
Pindex: [18900x3 double]
Sindex: [18900x3 double]
Aindex: [18900x4 double]
```

(6) Average 24Hz (cropped and de-spiked data) into 1 db. Linear interpolation used when no data available for averaging.

Files for each cast were created: DY033_CTD001_1db_dn.mat

All the 1 db profiles (except PAR and fluor) are then further smoothed with a 5 m running median window. To help preserve fine scale structure through the SCM a 3 m window was used for the fluorescence. Note that all non-smoothed (24 Hz) data is available on request.

File output: DY033_CTD001_1db_dn_smth.mat

(7) Application of calibrations to salinity, chlorophyll and oxygen in 1db smoothed downcasts. Calibrated files saved to DY033_001_1db_dn_smth_calib.mat.

Sigma theta (σ_θ) (relative to 0 pressure) is also calculated at this stage using the matlab function `sw_pden-1000` from the `SEAWATER` toolkit.

```
CTD001 =

      CRUISE: 'DY033'
        CAST: 1.00
      STNNBR: 3.00
        DATE: '13/07/2015'
        TIME: '06:47'
         LAT: 49.43
         LON: -8.59
       DEPTH: 144
        pres: [140x1 double] [db]
        time: [140x1 double] [seconds]
       temp1: [140x1 double] [°C]
       temp2: [140x1 double] [°C]
        sal1: [140x1 double] [PSU] - calibrated
        sal2: [140x1 double] [PSU] - calibrated
       cond1: [140x1 double] [S/m] – not calibrated
       cond2: [140x1 double] [S/m] – not calibrated
   oxy_umoll: [140x1 double] [µmol/l] – calibrated
```

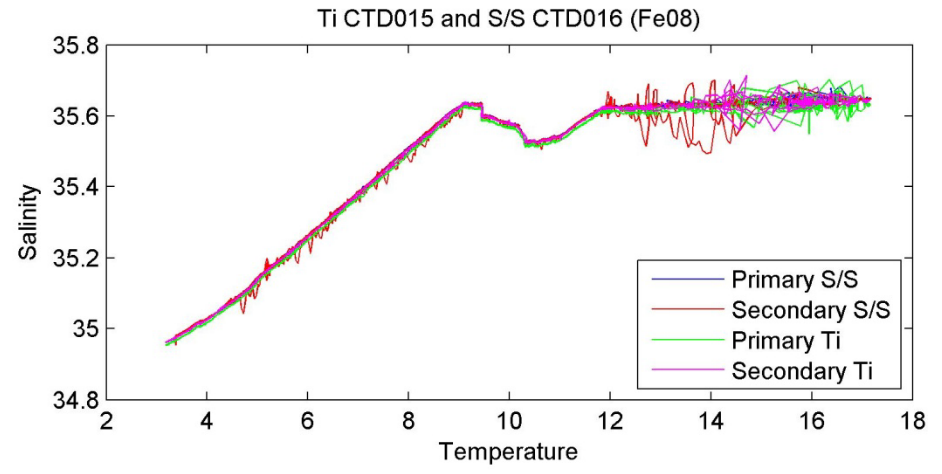
```
         fluor: [140x1 double] [μg/l] – calibrated
           par: [140x1 double] [Wm2]
          turb: [140x1 double] [m-1 sr-1]
           att: [140x1 double] [1/m]
   sigma_theta: [140x1 double]
```

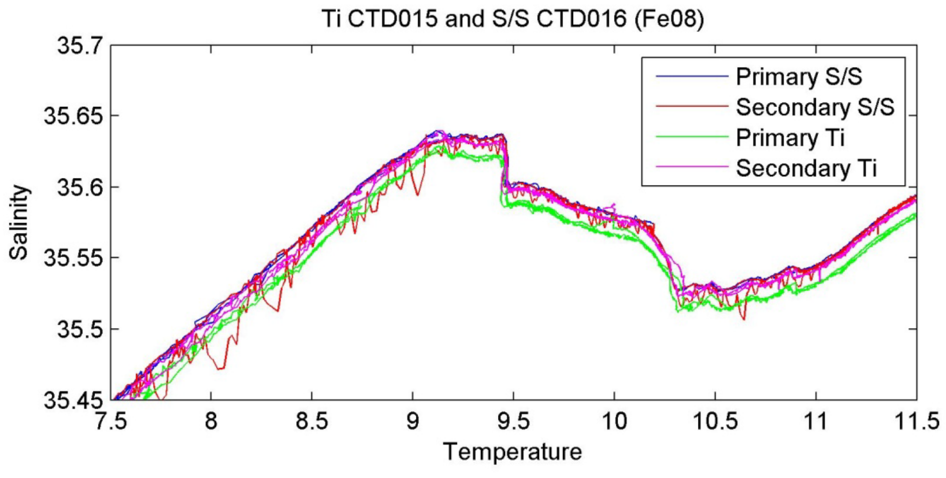
The calibrations were also applied to the 24 Hz data (cropped and de-spiked) and output to .mat files DY033_001_derive_cropped_autospike_manualspike_calib.mat containing the same variables as above.

(8) Application of salinity, chlorophyll and oxygen calibrations to bottle firing data. A new file, DY033_stainless_btl_calib.mat/ DY033_titanium_btl_calib.mat, with variables CTDsal1_cal, CTDsal2_cal, CTDoxy_umoll_cal and CTDfluor_cal was created.

Notes:

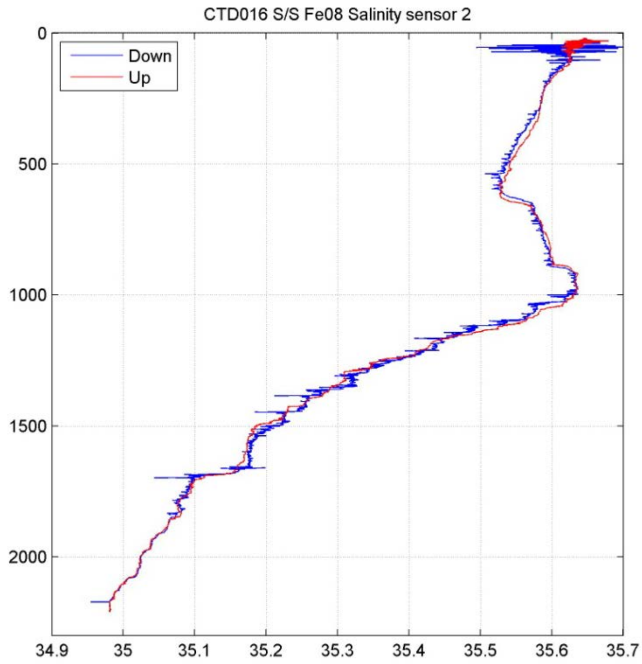
(a) CTD014T hit the bottom (approx. 2500m). The primary titanium conductivity cell was subsequently offset and salinities too low. The primary to secondary salinity offset increased from 0.001 to 0.01 PSU. The primary conductivity sensor was changed after cast CTD019T (SN 04-4138 to SN 04-2571). CTD021T is the first cast with the new sensor. Separate calibrations will be required.





T-S plots of CTD015T (Ti) and CTD016 (S/S) demonstrating the salinity offset in the primary titanium sensor after collision with the seabed.

(b) The secondary conductivity on the downcast of CTD016 (S/S) is very noisy. There was probably something stuck in the cell. It cleared for the upcast.



Up and downcast salinity from CTD016 (S/S)

(c) Stainless casts 1- 44 were recorded with incorrect calibration coefficients entered for the SBE43 oxygen sensor. A new master configuration file was therefore created (DY033_ss_oxy_final_cal_NMEA.XMLCON) and all casts up to CTD075 were processed in the SeaBird software using this new file (as opposed to the individual ones generated for each cast).

(d) The PAR sensor was taken off the titanium CTD from cast 14 onwards (only rated to 500 m). The stainless PAR sensors were deep rated and cosine response rather than hemispherical. The PAR sensor was reattached on cast CTD58T. The PAR channel in the final calibrated files has been NaNd when no sensor was attached.

(e) Casts 38T and 39T were aborted due to termination failure. Usable data was collected from CTD038T but not from CTD039T.

(f) On CTD057 (S/S) the wire was caught in the sheave and damaged (new termination required). No data is available for this cast.

(g) The BBRTD cable on the stainless frame developed a leak and the connector slowly dissolved. There are drop outs in preceding casts but large sections of the turbidity in casts 40-44 is entirely un-usable. These sections have been removed but the remainder of the profile should still be treated with caution. The connection was changed after cast 44.

(h) On CTD074 the stainless oxygen sensor started reading unrealistically low values (~160 umol/kg). This problem persisted in cast CTD075. The SBE43 SN0709 was subsequently replaced with SBE43 SN0619 (casts CTD076 onwards). A new config. file was created (DY033_SS_new_oxy_0619.xmlcon) and used for casts CTD076 onwards. Oxygen from casts 74 and 75 has been removed from the final files.

(i) The new S/S oxygen sensor (SN 0691) looked to be faulty on cast CTD078 – potential cable problem? Oxygen samples were taken to allow a profile to be constructed from discrete data points. Oxygen from casts 78 and 90 has been removed from the final files.

(j) On cast CTD021T there was some confusion around bottle firing order and position. For clarification, the following bottles (ROSPOS) were on the frame and closed: 1, 2, 3, 4, 5, 6, 7 (depth 895-400 m) and then 13, 14 (30 and 20 m depth). Positions 8-12 were fired but no samples collected because these positions did not have bottles mounted.

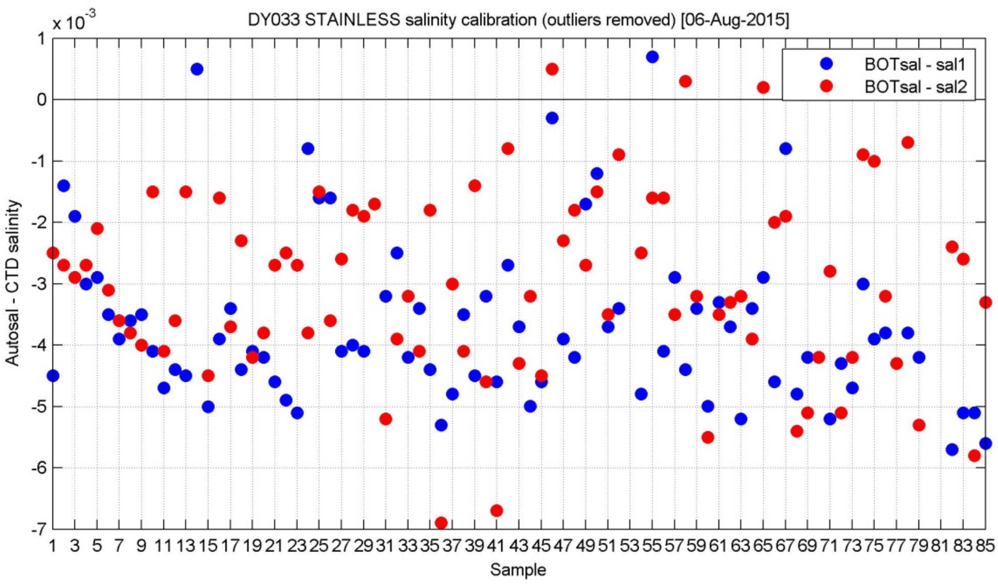
Calibrations

Salinity

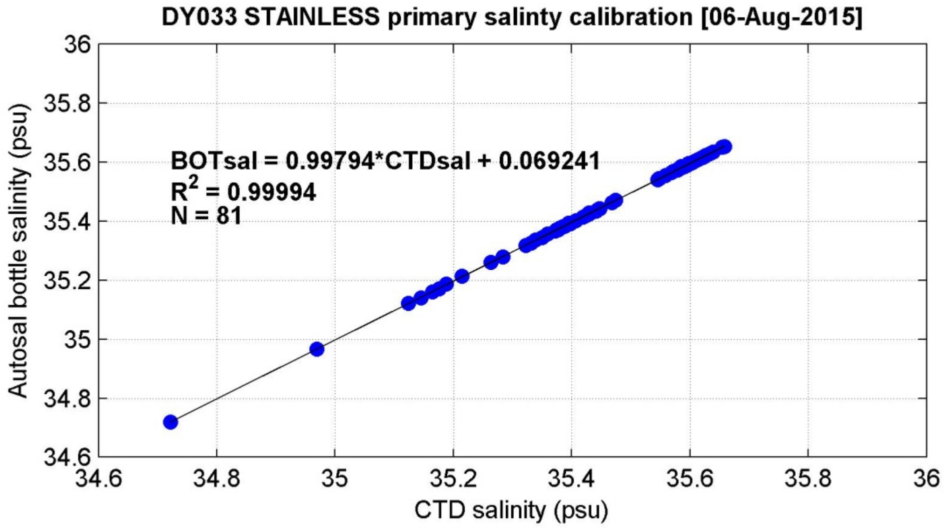
139 salinity samples (93 stainless, 46 titanium) were taken for analysis on a Guildline 8400B (s/n 71185). 8 samples from the stainless bottles and 4 samples from the titanium however could not be matched against a cast and bottle position from the logs so are not useable.

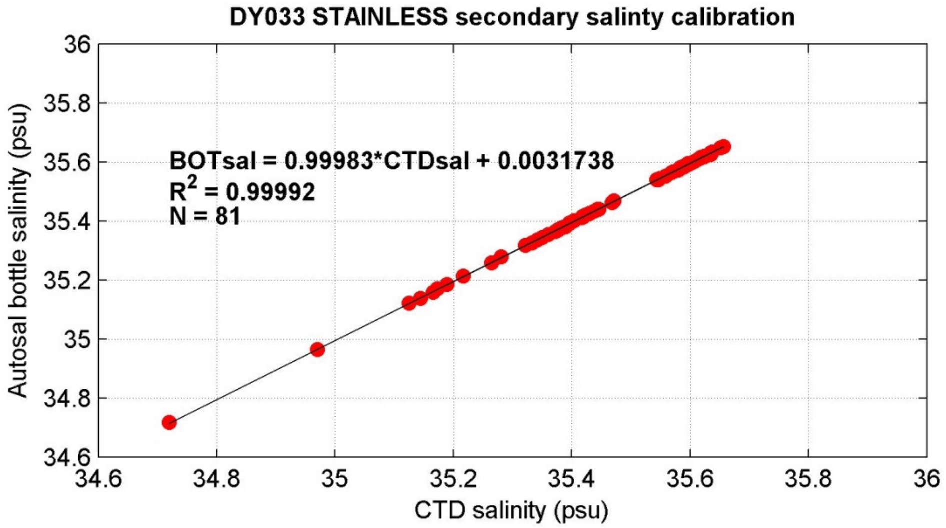
Stainless

Using all samples the mean and standard deviation of residuals from the primary and secondary sensors were 0.0012859 ± 0.047523 and 0.0018212 ± 0.047426 respectively. After removal of outliers where the difference between Autosal and CTD values was greater than 1 standard deviation and/or > 0.002, the mean ± standard deviations for the primary and secondary sensors was reduced to -0.0036901 ± 0.0013353 and -0.0030173± 0.001501 respectively.



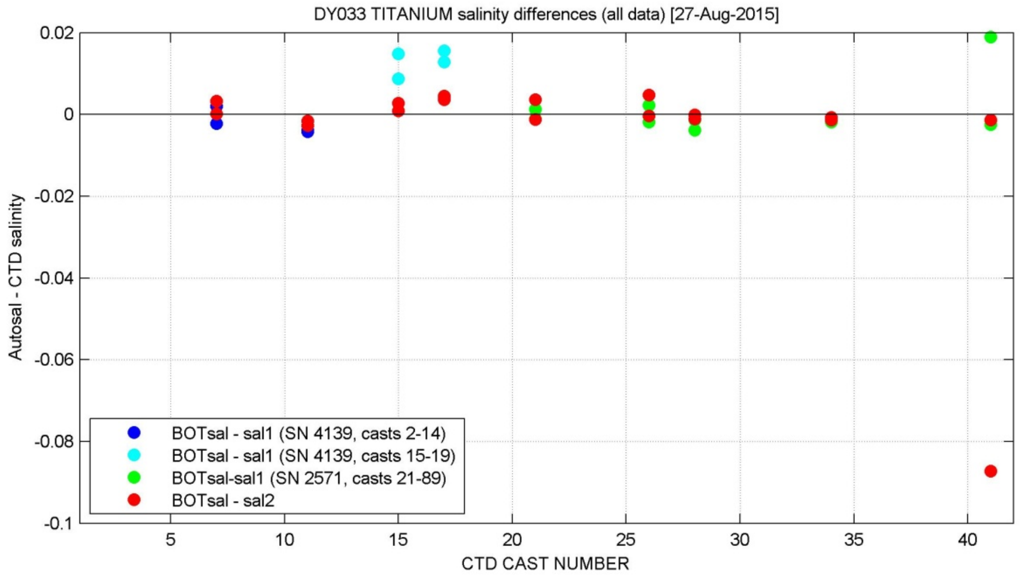
The following regressions were applied to the profiles.





Titanium
After the CTD frame hit the bottom on CTD014T, a much larger offset was introduced to the primary conductivity sensor (for casts 15, 17 and 19). See notes above. The primary titanium conductivity sensor was replaced from cast CTD021T onwards. Three separate calibrations are therefore necessary for the primary sensor:

SN 04-4138 Casts 2-14 (STNNBRs 6-64)
SN 04-4138 Casts 15-19 (STNNBRs 65-71)
SN 04-2571 Casts 21-89 (STNNBRs 73-280)



Autosal – CTD salinity for all samples (titanium)

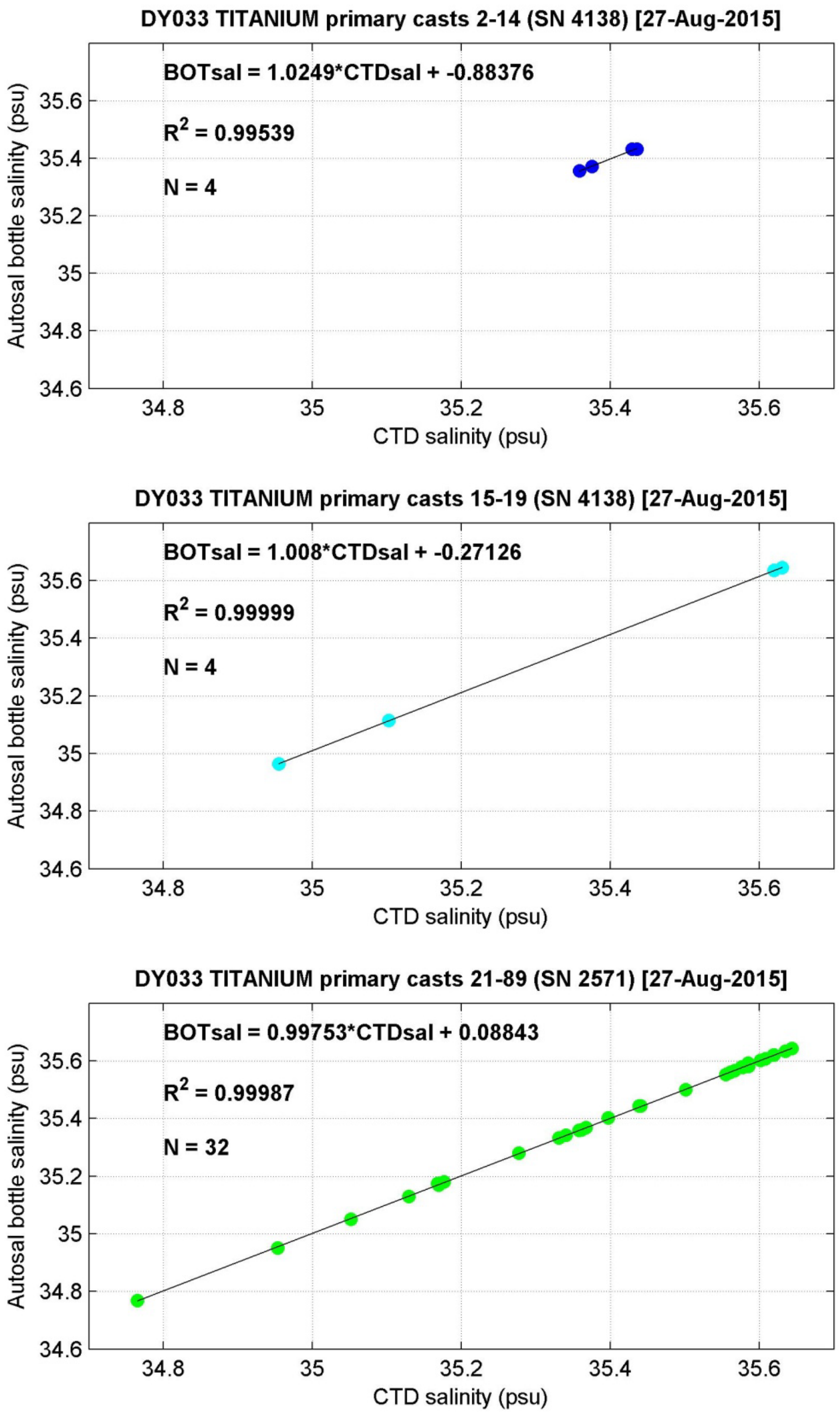
Using all samples the mean and standard deviation of residuals from the primary and secondary sensors were:

Primary casts 2-14 (SN 4138): -0.002075 ± 0.0028558 (mean ± std)
Primary casts 15-19 (SN 4138): 0.012975 ± 0.0030837
Primary casts 21-89 (SN 2571): 0.0017941 ± 0.0042938
Secondary: -0.00090476 ± 0.013903

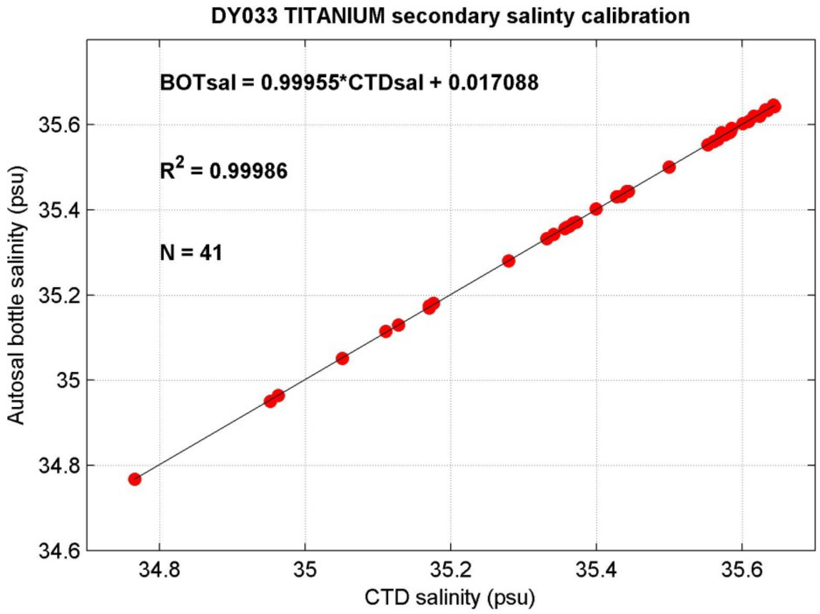
After removal of outliers in the replacement primary sensor (SN2571) and in the secondary sensor where the difference between Autosal and CTD values was greater than 1.5 standard deviations the mean ± standard deviations reduced to:

Primary casts 21-89 (SN 2571): 0.00096562 ± 0.0025739
Secondary: 0.0012024 ± 0.0026419

The following regressions were applied:



Linear regressions applied to the primary titanium salinity



Linear regression applied to the secondary titanium salinity

After calibration the means and standard deviations are reduced to the following:

Primary casts 2-14 (SN 4138): 0 ± 0.0026895
Primary casts 15-19 (SN 4138): 7.1054e-15 ± 0.0012602
Primary casts 21-89 (SN 2571): -4.6629e-15 ± 0.0025135
Secondary: 0 ± 0.00264

Oxygen

Stainless

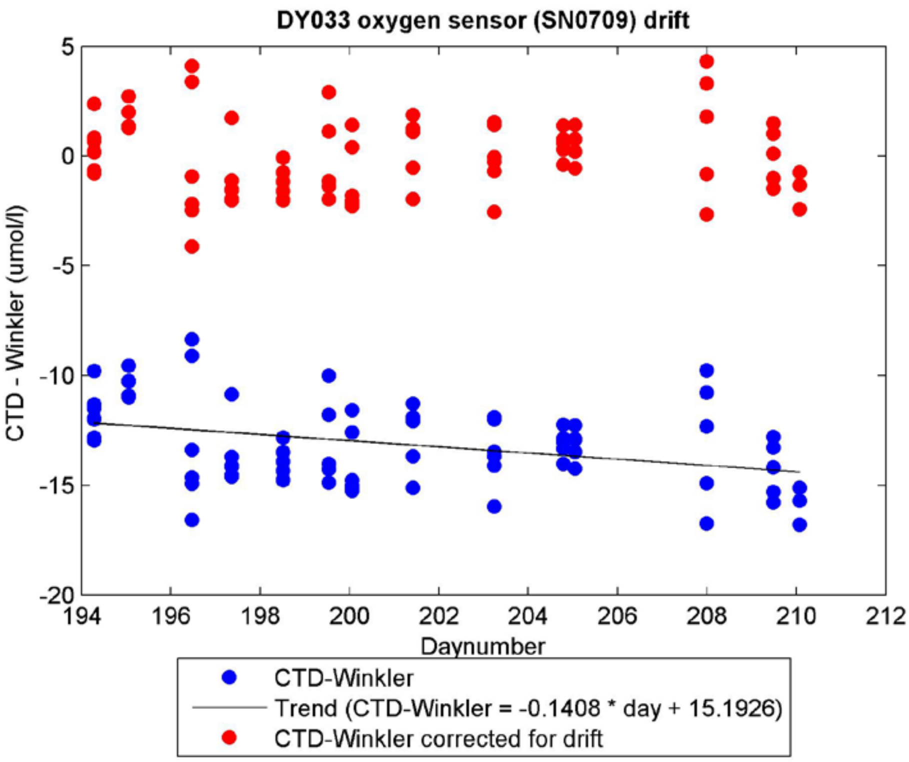
The oxygen sensor on the stainless frame was clearly giving suspect readings on casts 74 and 75 and subsequently changed from cast 76 onwards. Casts 1-70 are therefore used to calibrate the original sensor (SN0709). As the performance of the sensor deteriorated there is firstly a significant (p-value < 0.05) linear temporal drift that requires correction based on the daynumber of the CTD cast.

CTD profiles are therefore first corrected according to the following:

CTDoxyt = CTDoxy – ([slope * daynumber] + intercept),

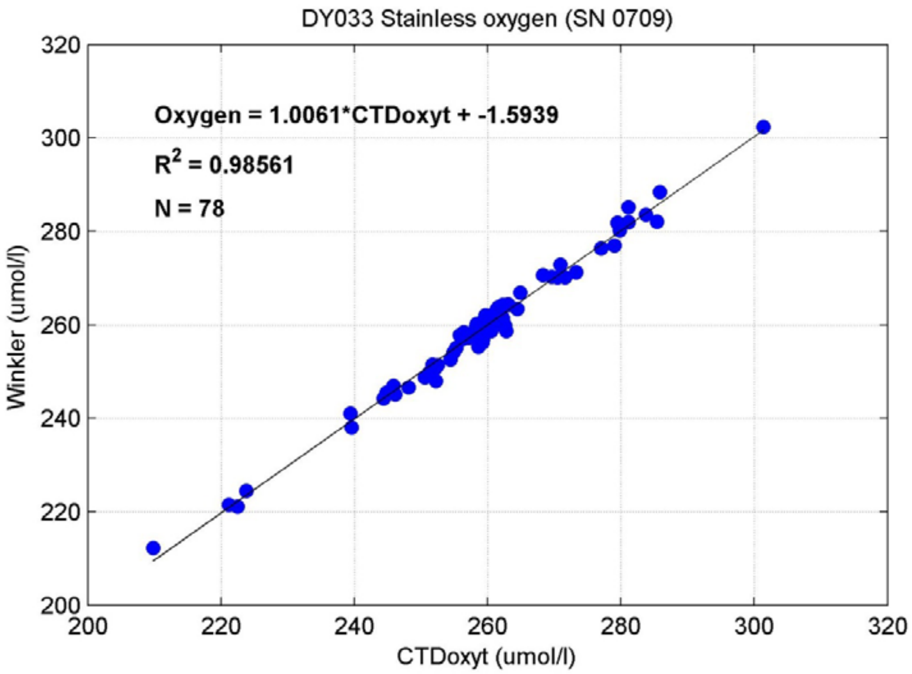
where

slope = -0.1408
intercpet = 15.1926

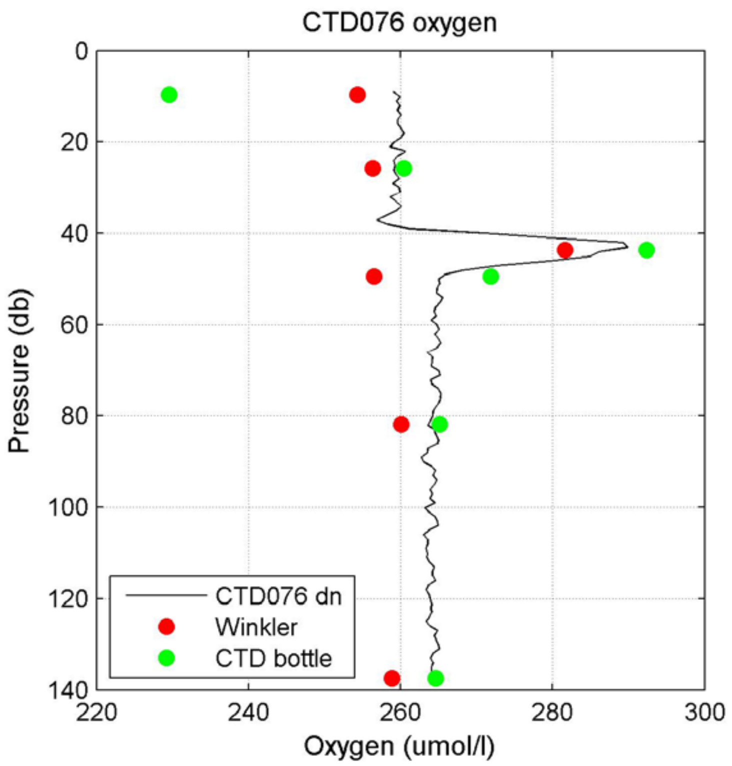


Linear regression against day number for stainless oxygen (casts 1-70). CTD readings that differed from the winkler analysis by more than 17 umol/l were removed.

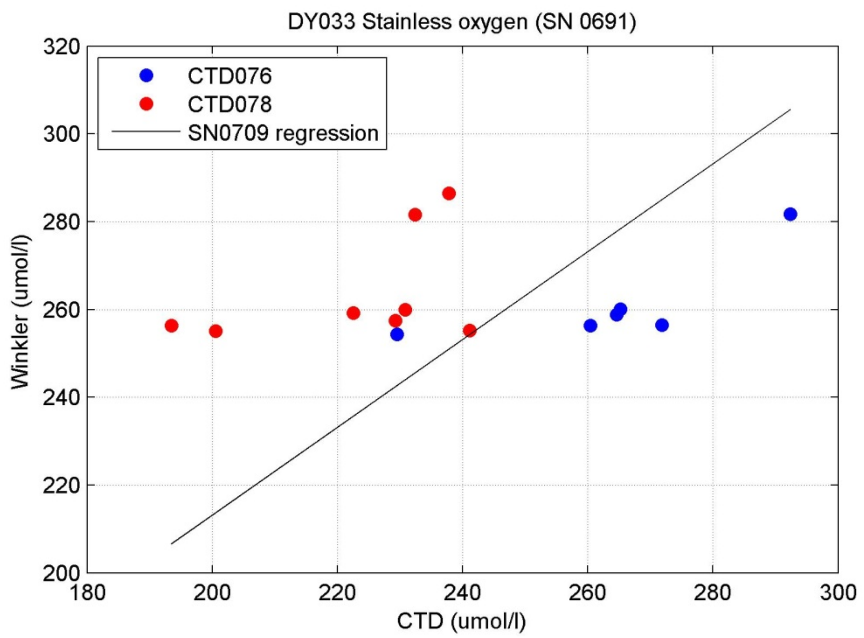
The following regression (winkler vs CTDoxyt) was then applied up to and including cast 70.



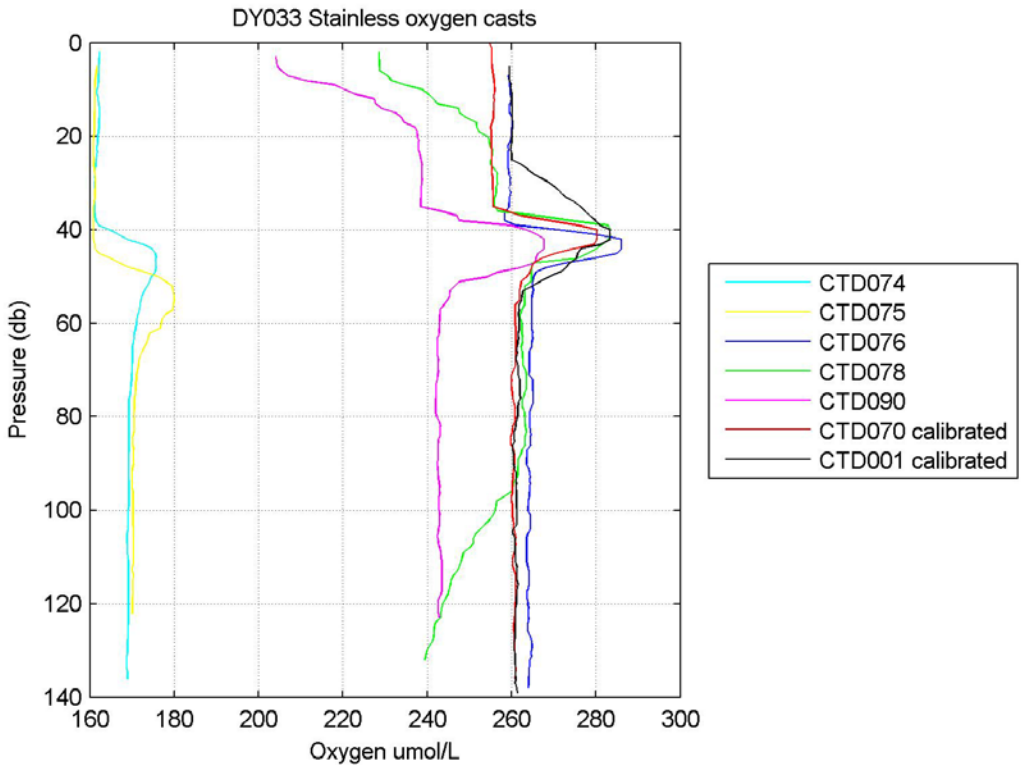
One potentially useable cast with the replacement oxygen sensor (SN0691) was completed (CTD076). Six samples were taken for calibration, although the CTD measurement at the time of firing the surface bottle is clearly far too low. With only 5 samples remaining that do not generate a robust regression no calibration is applied. Winkler samples were also taken from CTD078 but CTD readings below 90 m and above 30 m reinforce a problem with this new sensor.



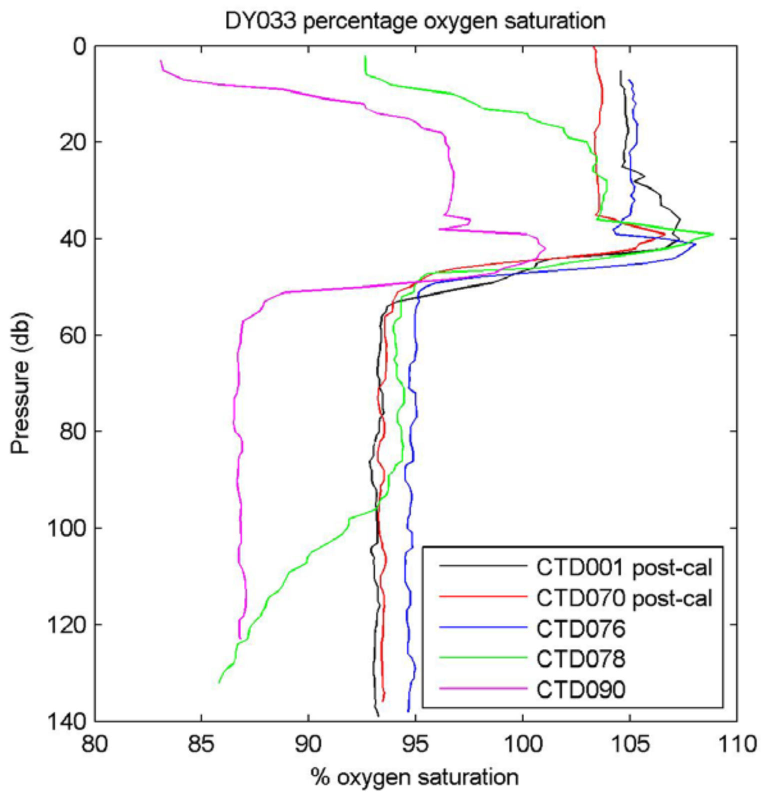
Downcast profile from CTD076 together with the winkler and CTD bottle values from the upcast



CTD vs winkler oxygen for casts CTD076 and CTD078. No sensible regression for sensor SN 0691 is possible.



Oxygen proifiles from all casts with SN 0691 (CTD076-CTD090). Calibrated profiles from CTD001 and CTD070. Profiles CTD074 and CTD075 with SN 0709 indicated sensor failure.



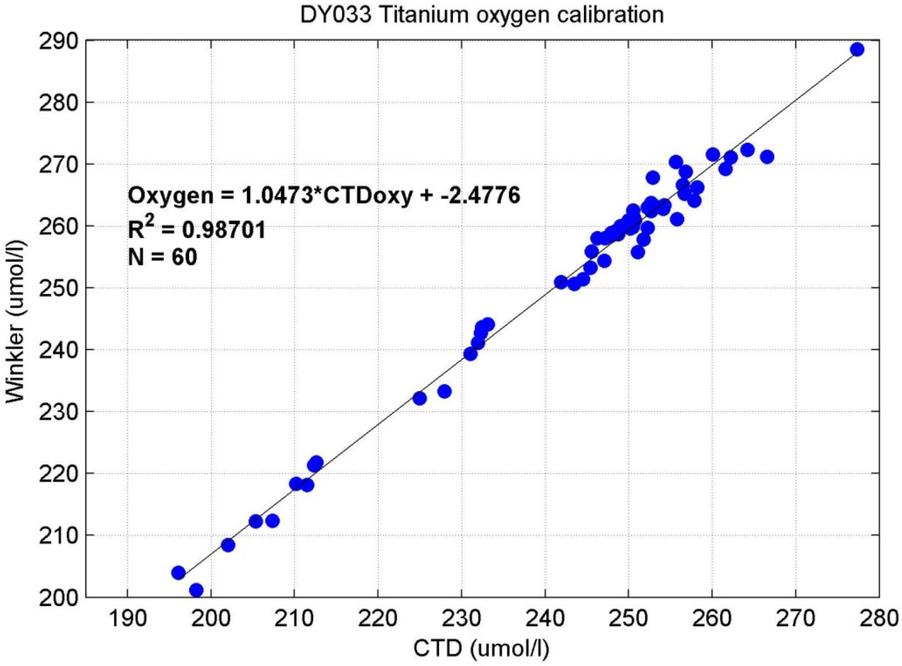
Percentage saturation for casts CTD001 and CTD070 (SN 0709) and casts CTD076, CTD078 and CTD090 (SN 0691)

In summary:

Oxygen on casts CTD001-CTD070 has been calibrated.
Oxygen from CTD074 and CTD075 has been removed
Oxygen on CTD076 is retained but is uncalibrated and should be treated as unreliable
Oxygen from casts CTD078 and CTD090 has been removed

Titanium

CTD readings that differed from the winkler analysis by more than 17 umol/l were removed. There is not a signficant temporal drift that needs correction therefore the following regresion is applied.



Chlorophyll

A total of 362 samples were taken for calibration of the CTD chlorophyll fluoresence (stainless+titanium). Samples taken during daylight hours at depths shallower than 30 m were removed. Outliers from sampling and/or recording errors were also discarded.

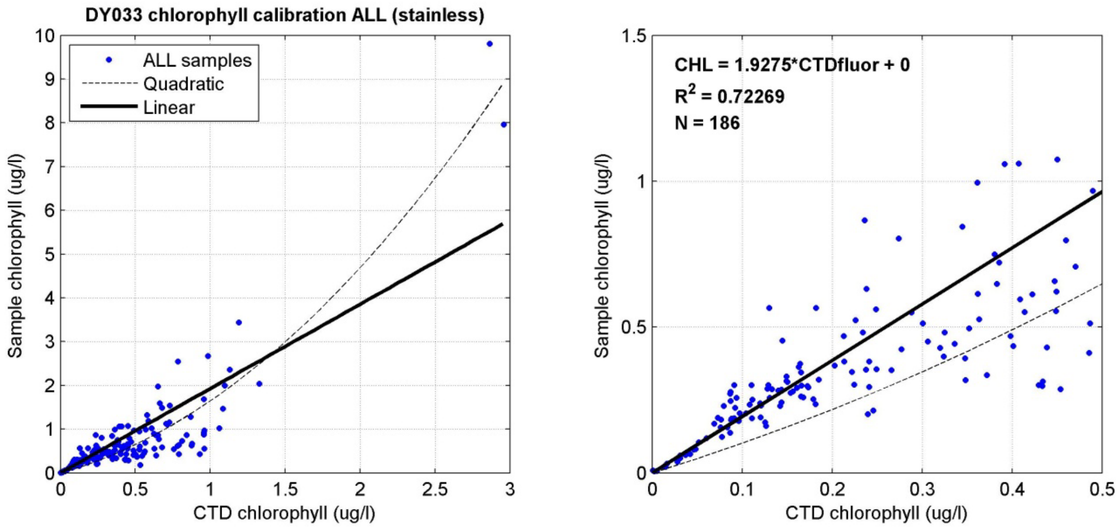
For both the stainless and titanium sensor a linear trend was fitted using ALL the samples. This however is a simplification of the more complicated relationship between the extracted chlorophyll and that reported by the CTD. There are clear regional differences (e.g. on-shelf vs off-shelf) and separate calibrations could be applied to regional subsets. Examples are provided below. Defining these regions however is subjective and in realitity there are likely to be gradients between them. There are also probably vertical and horizontal gradients in physiology (e.g. taxonomy, light, other environmental factors...) that account for some of the remaining scatter. To maintain consistency across all SSB cruises a linear trend was fitted to all the data.

Stainless

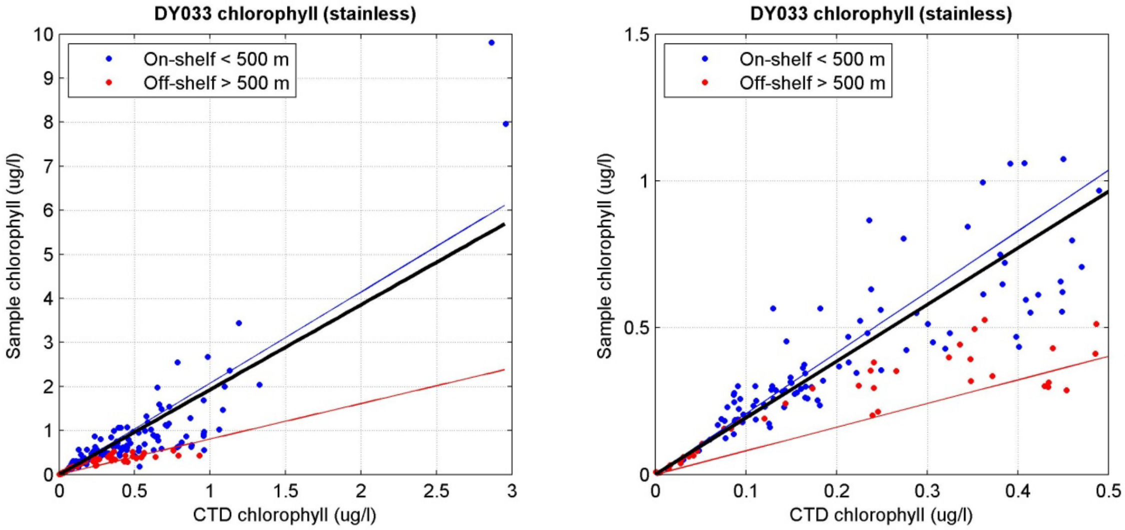
The following regression was applied (forced through origin):

CHL= 1.9275 * CTDfluor + 0 [ug/l]

For low chlorophyll concentrations this regression is reasonable but is less suitable at higher concentrations. Peak values will be under-reported. A quadratic regression (see below) would calibrate the chorophyll peaks much more satisfcatorliy but (a) performs poorly at lower concentrations (CTD < 0.5 umol/l) and (b) is not justified by any mechanistic reason.



Linear chlorophyll calibration (thick black line) applied to ALL stainless CTDs.



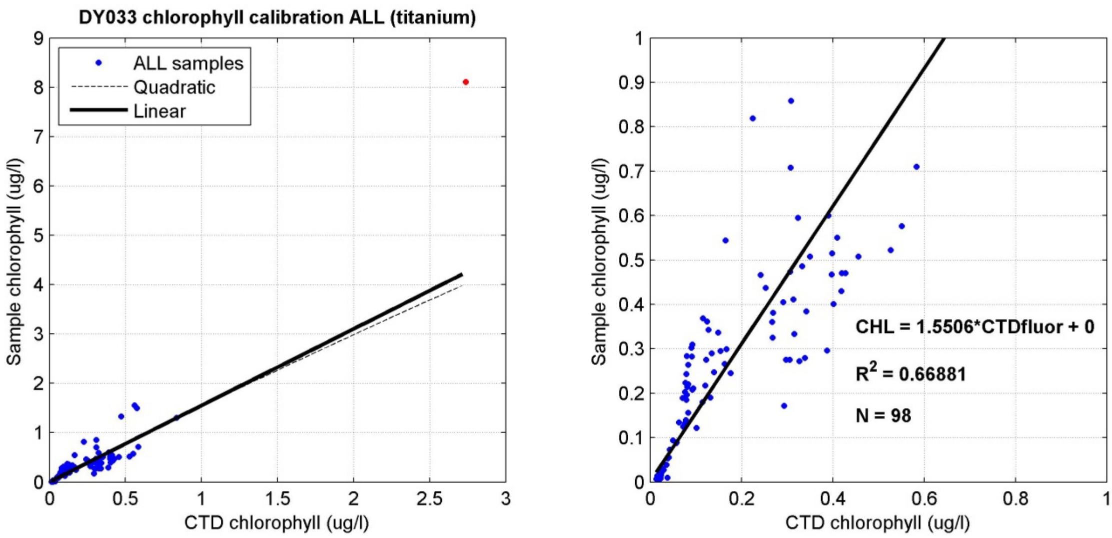
Example of regional differences in CTD vs extracted chlorophyll relationship (stainless).On-shelf is nominally defined as depths < 500 so includes the slope. Off-shelf is defined as depths > 500 m. A 3rd shelf-edge /slope region could be defined if desired. Thick black line is the regression applied here.

Titanium

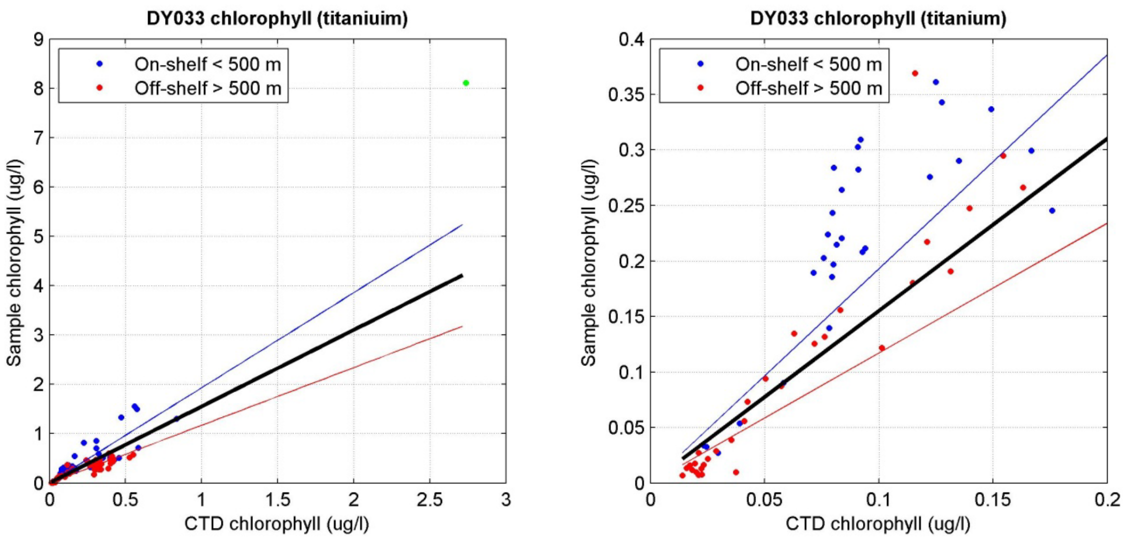
The following regression was applied (forced through origin):

CHL= 1.5506 * CTDfluor + 0 [ug/l]

As for the stainless sensor, for low chlorophyll concentrations this regression is reasonable but is less suitable at higher concentrations. Peak values will be under-reported.



Linear chlorophyll calibration (thick black line) applied to ALL titanium CTDs. Note that the high concentration sample (red dot) was removed to improve the fit at lower concentrations (CTD < 1 ug/l)



Example of regional differences in CTD vs extracted chlorophyll relationship (titanium).On-shelf is nominally defined as depths < 500 so includes the slope. Off-shelf is defined as depths > 500 m. A 3rd shelf-edge /slope region could be defined if desired. Thick black line is the regression applied here.