XBT Data Processing – LUTH 2008

XBT data were collected with Sippican MK21 software on the NOAA Ship David Starr Jordan (DSJ), 26 Aug 2008 through 21 Sep 2008. Typically, XBT drops were conducted every three hours during daylight operations. XBT drops were conducted several times per day with Sippican Deep Blue Expendable Bathythermograph (XBT) probes to measure the temperature of the water column to 760 m.

Raw data files were checked for date/time and position and then edited to remove erroneous temperature data. All valid and edited profiles were then combined into final files. The XBTCorrect file has depth and temperature corrections according to Cheng et al. (2016, Bull. American Meteorological Soc., June 2016, 923-933). The XBTArchive file has depths calculated with the fall rate equation of Hanawa et al. (1995, Deep-Sea Research I 42:1423-1451) and excludes incomplete profiles that do not extend through the thermocline. This file is for archiving and allows for optional correction of depth and temperature by users.

All data and programs are stored in sub-folders of P:\Surveys\Data\WestCoast\2008_Luth\Oceanographic\XBT\. The raw data files are in the sub-folder Raw. The programs used to process the data are stored in the sub-folder Current_Version\Programs. These programs read year-specific information from *.ini files, which are stored in the same folder as the programs. The intermediate files created during the processing steps are stored in the sub-folder Current_Version\Intermediate. The final processed data and documentation are stored in the sub-folder Current_Version\Final.

Raw Data Files

Raw File Summaries

Sippican raw (***.RDF**) and export (***.EDF**) data files were copied from file LUTH-data-insitu.zip on the DVD to

> P:\Surveys\Data\WestCoast\2008_LUTH\Oceanographic\XBT\Raw\DSJ\

There was a file from the DVD called **TD_00077orig.RDF**. There was no associated *.EDF, so the Sippican WinMK21 software was used to export the EDF. The EDF was then compared to **TD_00077.EDF** from the DVD. This showed that the longitude had been corrected at sea, and the "orig" file was the uncorrected file. Therefore, **TD_00077orig.RDF** was moved to the Original sub-folder and excluded from further processing.

The DVD has files **TD_00095.RDF** and **TD_00095.EDF**. However, drop 95 is not in the ELog. According to the lat/lon in the file, the drop was just outside of the mouth of San Francisco Bay, in approximately 20 m of water. Since it has some data, it was included in processing.

<u>Raw File Checks</u>

Perl program XBTRawFileInfo was used to review the raw data files. It noted that files **TD_00139.EDF** and **TD_00154.EDF** did not have corresponding *.RDF files. These RDF files were not found on the DVD. Since we only use the EDF files for processing, these two files were included in the processing.

It also noted that there were no files for drops 1, 10, 12, 51, 55, and 74. There is no mention of drops 1 or 10 in the ELog. The ELog specifically says the other drops were either bad and not recorded, or skipped.

NOTE: This step was re-done after the EDF's were updated from ELog. The results were the same, other than it now reported that all files were missing *.RDF's, since the *.RDF's had all been moved to the Raw\DSJ\Original folder.

Data Checks

<u>Position Check</u>

Station locations from the raw files were checked against edited TSG files by Perl program XBTPositionCheck. This program wrote comparisons between XBT stations and TSG positions to the files **XBTPositionCheck_2008_LUTH_DSJ.txt** and **XBTPositionCheck_2008_LUTH_DSJ.err** in

P:\Survey\Data\WestCoast\2008_LUTH\Oceanographic\XBT\Intermediate

The ***.txt** file has time and distance information between XBT and TSG. The ***.err** file has records that have more than 1 nautical mile between XBT and TSG based on time.

Results:

```
        194   XBT lines read from
P:\Surveys\Data\WestCoast\2008_LUTH\Oceanographic\XBT\Current_Version\I
ntermediate\XBTStation_2008_LUTH_DSJ.txt
          0   XBT lines started with an apostrophe, so were skipped
          1   XBT lines were headers, so were skipped
          0   were missing date, time, latitude, or longitude
          0   were not in a valid format
          1   did not have a TSG record within 120 seconds in
P:\Surveys\Data\WestCoast\2008_LUTH\Oceanographic\TSG\Current_Version\I
ntermediate\TSGTrackCheck_2008_LUTH_DSJ.dat

        192   lines were compared to TSG

   364.30550  Root-mean-square-error of distances
         30   Distances >= 1 nautical mile
  5061.79345  Max distance
```

These results show that the time and/or location information in the *.EDF files did not match very well with the TSG data. The time and location information in the ELog file was determined to be a much better match to the TSG data. So it was decided to change the EDF files to use the time and location information from the ELog.

2

The original *.RDF and *.EDF files were moved to folder:

> P:\Surveys\Data\WestCoast\2008_LUTH\Oceanographic\XBT\Raw\DSJ\Original

The date/time and latitude/longitude information was extracted from the ELog. Perl program **XBTEDFUpdate.pl** was run to create files updated with the ELog information in folder

> P:\Surveys\Data\WestCoast\2008_LUTH\Oceanographic\XBT\Raw\DSJ

Note that there is no entry for files **TD_00095.*** in ELog, so it was not possible to update the EDF file for that drop. So it was not moved or modified during this process.

The updated results were:

```
      193   EDF files read
        0   were missing date, time, latitude, or longitude
        0   were not in a valid format
        1   did not have a TSG record within 120 seconds in
P:\Surveys\Data\WestCoast\2008_LUTH\Oceanographic\TSG\Current_Version\Interme
diate\TSGTrackCheck_2008_LUTH_DSJ.dat

      192   lines were compared to TSG

  0.08299   Root-mean-square-error of distances
        1   Distances >= 1 nautical mile
  1.15721   Max distance
```

Note that the drastic improvements in the final stats. There was only one drop that differs by more than 1 nautical mile from TSG, and that is only 1.15721 nmi. All other drops are within .03 nmi. That is acceptable.

Station and Drop Lists

Program **XBTStationAndDrops** was run to create the "Drops" and "Station" files. The "Drops" file is just an alphabetical list of all *.EDF files The "Station" file has a single line per drop, with date, time, and position data. Those files are **XBTDrops_2008_LUTH_DSJ.txt** and **XBTStation_2008_LUTH_DSJ.txt**, respectively. They were both saved to

> P:\Surveys\Data\WestCoast\2008_LUTH\Oceanographic\XBT\Current_Version\Interme
> diate\

All stations had date, time, latitude and longitude. All drops were done using Deep Blue XBT, with fall rate equation coefficients 6.472 and 0.00216.

Profile Review and Edit

XBT temperature vs depth profiles were examined by Dan Prosperi (Database Manager), and checked by Paul Fiedler (Senior Oceanographer) using the Visual Basic program ProfileViewer, which is located in

> P:\Surveys\Data_Processing_Resources\Oceanographic\XBT\ProfileViewer

> The reviewer decided what edits need to be made, and recorded that information in file P:\Surveys\Data\WestCoast\2008_LUTH\Oceanographic\XBT\Current_Version\Intermediate**XBTDrops_2008_LUTH_MACII.txt**

Each XBT drop has a line in that file, with the EDF file name. If the profile requires any editing, the reviewer added codes to each line to tell what edits need to be made. Codes are based on Bailey et al. (Quality Control Cookbook for XBT Data, CSIRO Marine Laboratories Report 221, 1994). The Quality Control Cookbook can be found in P:\Surveys\Data_Processing_Resources\Oceanographic\XBT\. Codes are as follows, where ddd.d is the depth exactly as recorded in the .edf file:

>FT ddd.d	False trigger, data recorded before the probe entered the water. Reject all data above ddd.d and change the depth at ddd.d to 0.7m, which is the starting depth for all drops (and then increment the depth estimates per Hanawa et al. 1995).
>ST ddd.d	Surface transient, identified by warming or cooling as the probe temperature equilibrates. Reject data before depth ddd.d. If the profile also contains an FT error, ddd.d is an integer that indicates the number of records after the FT correction that should be rejected.
>XD ddd.d ddd.d	Bad data within the profile. Reject data from the first to the second depth.
>BD ddd	Bad data at the end of the profile (i.e., the drop was not as deep as the cast file makes it appear) due to wire break (indicated in the comments by wb), wire stretch (indicated in the comments by ws), the probe hitting the bottom (indicated in the comments by hb), or insulation penetration (indicated in the comments for this error or XD by ip). Reject data deeper than the specified depth.
>NN	The profile is too noisy for NODC, but suitable for deriving mixed layer depth and thermocline variables for protected species assessments.
>RJ	Reject profile.

Apply Profile Edits

Program XBTEdit was used to apply the editing codes. It reported the following:

```
193    lines read from input file
       P:\Surveys\Data\WestCoast\2008_LUTH\Oceanographic\XBT\Current_Version\Intermediate\X
       BTDrops_2008_LUTH_DSJ_Final_PF.txt
0      lines started with an apostrophe, so were ignored
8      lines had an RJ code, so were ignored

185    records written to
       P:\Surveys\Data\WestCoast\2008_LUTH\Oceanographic\XBT\Current_Version\Intermediate\X
       BTEdit_2008_LUTH_DSJ.txt

2      lines were not good enough for NODC, so their drop numbers were negated
183    records written to
       P:\Surveys\Data\WestCoast\2008_LUTH\Oceanographic\XBT\Current_Version\Intermediate\X
       BTNODC_2008_LUTH_DSJ_6.691_0.00225.dat

7.18   Average temperature of all 148349 output points whose drops met the Min To Avg depth
12.26  Average temperature of all 22329 output points <= 100 m whose drops met the Min To
       Avg depth
       Note that this is based on depths calculated using the Hanawa et al 1995 formula
```

The average temperature values were used in the fall rate equations below.

Correct Depth and Temperature

Perl program **XBTCorrect.pl** was used to correct depths and temperatures. It follows the methods described in Cheng et al 2014, as described in
      P:\Surveys\Data_Processing_Resources\Oceanographic\XBT\Fall rate**XBT Depth Errors Due to Changing Fall Rates.pdf**.

Here is the output from XBTCorrect:
```
Reading XBTCorrect.ini...
Reading CH14 table 'P:\Surveys\Data_Processing_Resources\Oceanographic\XBT\Fall
     rate\CH14_table1.txt'...
Reading CH14 table 'P:\Surveys\Data_Processing_Resources\Oceanographic\XBT\Fall
     rate\CH14_table2.txt'...
Processing
     P:\Surveys\Data\WestCoast\2008_LUTH\Oceanographic\XBT\Current_Version\Int
     ermediate\XBTEdit_2008_LUTH_DSJ.txt...
Deep Blue: Thermal Bias = 0.04045, A = 6.612, B = 0.00228, Offset = 1.868

186    lines read from
       'P:\Surveys\Data\WestCoast\2008_LUTH\Oceanographic\XBT\Current_Version\In
       termediate\XBTEdit_2008_LUTH_DSJ.txt'
0      lines started with an apostrophe, so were ignored
185    records written to
       P:\Surveys\Data\WestCoast\2008_LUTH\Oceanographic\XBT\Current_Version\Int
       ermediate\XBTCorrect_2008_LUTH_DSJ_Deep Blue.txt

2      had negative drop numbers, which means their data was not good enough for
       NODC
```

Final data files

The NODC file created in the XBTEdit step was copied to \Final and was renamed as:
      XBTArchive_2008_LUTH_DSJ_Deep Blue.dat

Each drop record in a XBTArchive file starts with fields under the following column headers:

```
UTC Date, UTC Time, Time Offset, Local Date, Local Time, Latitude, Longitude,
Drop #, Probe Type, # Points, H95 FRE Coefficients...
```

The column headers after that are depths (m), based on the Hanawa et al 1995 fall rate equation, e.g:

```
..., 0.7, 1.3, 2.0, 2.7, 3.3, 4.0, 4.7, 5.4, 6.0, 6.7, 7.4, 8.0, 8.7,...
```

The drop records data in those columns are temperatures (ºC) at those depths. Missing data (e.g., surface transients) are blank.

The file that had depth and temperature corrected based on Cheng et al was also copied to \Final. This file is:
      XBTCorrect_2008_LUTH_DSJ_Deep Blue.txt

Each drop record in a XBTCorrect file starts with fields under the following column headers:

```
UTC Date, UTC Time, Time Offset, Local Date, Local Time, Latitude, Longitude,
Drop #, Probe Type, CH14 Values, # Points...
```

The column headers after that are depths (m), based on the Cheng et al fall rate correction, e.g:

```
..., 0.1, 0.8, 1.4, 2.1, 2.8, 3.4, 4.1, 4.7, 5.4, 6.1, 6.7, 7.4, 8.0, 8.7,...
```

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Dan Prosperi
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