XBT Data Processing – STAR 1999 DSJ

XBT data were collected with Sippican MK21 software on the NOAA Ship David Starr Jordan, July 29 through Dec 9, 1999. Typically, XBT drops were conducted every three hours during daylight operations. Sippican T-7, T-10, and Deep Blue Expendable Bathythermograph (XBT) probes were used. T-10 probes measure the temperature of the water column to 200 m, and T-7 and Deep Blue 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\ETP\1999_STAR\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

Sippican raw (*.RDF) and export (*.EDF) data files are in P:\Surveys\Data\ETP\1999_STAR\Oceanographic\XBT\Raw\.

Raw File Summaries

The data collected on each survey were backed up on several DVD's. The DVDs were frequently created at the end of each leg. Sometimes data from each leg were backed up separately, while at other times the backups included all data collected (e.g., data collected on legs 1-3 were backed up at the end of leg 3) . Consequently, there can be a great deal of overlap among the DVDs.

For the data collected on the DSJ during STAR 1999, the DVD labeled DSJ_DS9905_Data_Disk_Lab_Copy_SCS was the most complete. However, this only had files through 10/27. These files were copied to P:\Surveys\Data\ETP\1999_STAR\Oceanographic\XBT\Raw\DSJ\. Files for the remaining days of the cruise were already on the network, in W:\Final_oceanographic\ETP\1999_STAR\Oceanographic\XBT\Raw\DSJ.

No XBT spreadsheets or Elog databases were created during the cruise.

Perl program XBTRawFileInfo was used to get a summary of the raw files. It showed several problems:

- Files T7_00111.RDF and T$20000.RDF appear to be test files, created before the cruise began. These files were both excluded from processing.
- There were files were named TD_-3261.*, and the drop number within the file was -32611. Per the ODL, these were corrected to 135.
- Drop 154's files had the incorrect time. The time was corrected in the EDF.
- Per the ODL, files for drops 263 and 264 were identical. This was confirmed, and 264 was excluded from processing. TD_00263.RDF said it was for drop 264. It was edited to say 263 using the Sippican software WinMk21, and expofted to create the EDF.
- Drops 263 and 277 had RDF files, but no EDF files. Sippican software WinMk21 was used to export the RDF's to create the EDF's.
- There were no files for drops 1, 37, 52, 72, 107, 254, 274, or 316. This was confirmed in the ODL.
- Drop 186 had no Latitude or Longitude. Per the ODL, the Sippican software did not record this information. However, the Latitude and Longitude were entered as a note in Sippican. Those coordinates were manually entered in the EDF file.

Data Checks

Position Check

Perl program XBTPositionCheck compares the positions and times of the XBT drops to positions and times in the final TSG "Track Check" file. The program reads the following information from its .ini file: the location of the EDF files, the location of the final TSG Track Check file, and the number of seconds to search the TSG file for a record that matches each XBT file's time. Positions for stations without corresponding TSG data are checked against the XBT Log and ODL.

For 1999 STAR DSJ, seven XBT drops were greater than 1 nautical mile of TSG positions matched by time.

- One was because the time in the file was incorrect. The RDF file was corrected using Sippican program WinMk21, then exported to re-create the EDF file.
- One was marked in the ODL as "bad - repeated", so was excluded from processing.
- Two had incorrect positions because of a bug in the Sippican software that prevented longitudes of 90 West from being recorded. The EDF's were manually corrected.
- Two had incorrect positions. The RDF's were edited using WinMk21, and exported to create the EDF.
- For the final one, the position in the files was better than the position in the ODL, so the files were left unchanged.

Station and Drop Lists

Perl program XBTStationAndDrops creates the Station and Drops files. From its ini file, it reads the location of the EDF files, and the location of the time offsets file. The Drop file is simply a list of the EDF Files. The Station file lists additional information for each drop: time and location, number of data points, probe type, start and end depths, and drop rate coefficients in the EDF file.
For 1999 STAR DSJ, there were 314 drops. 13 of these used T-10 probes, 17 used T-7, the remaining 284 used Deep Blue probes.

Profile Review and Edit

At the lab, profiles were examined by Paul Fiedler using the Visual Basic program ProfileViewer, which is located in P:\Surveys\Data_Processing_Resources\Oceanographic\XBT\ProfileViewer. The reviewer decides what edits need to be made, and records that information in file XBTDrops_1999_STAR_DSJ PF.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 for the edits to be applied. 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:

>RJ	Reject profile.
>NN	The profile is not suitable for submission to the NCEI World Ocean Database, but is good enough for deriving surface temperature and mixed layer depth, and perhaps thermocline variables, for MMTD purposes.
>XD ddd.d ddd.d	Exclude data within the profile. Reject data between the first and second specified depths.
>BD ddd.d	Exclude data at the bottom end of the profile. Reject data deeper than ddd.d.
>FT ddd.d	False trigger, data recorded before the probe entered the water. This error is rare. 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. All temperatures at depths ≤4.0 m are rejected to routinely dismiss surface transients, so this flag is only effective if a depth >4.0 m is indicated. 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.

Profile rejections and data exclusions are usually explained in a comment following an apostrophe (‘): wb = wire break, ws = wire stretch, hb = the probe hit the bottom, ip = insulation penetration.

Apply Profile Edits

Here is the output from program XBTEdit:

```
314     lines read from input file
        P:\Surveys\Data\ETP\1999_STAR\Oceanographic\XBT\Current_Version\Interme
        diate\XBTDrops_1999_STAR_DSJ PF.txt
0       lines started with an apostrophe, so were ignored
13      lines had an RJ code, so were ignored

301     records written to
        P:\Surveys\Data\ETP\1999_STAR\Oceanographic\XBT\Current_Version\Interme
        diate\XBTEdit_1999_STAR_DSJ.dat

2       lines were not good enough for NODC, so their drop numbers were negated
13      records written to
        P:\Surveys\Data\ETP\1999_STAR\Oceanographic\XBT\Current_Version\Interme
        diate\XBTNODC_1999_STAR_DSJ_6.301_0.00216.dat
286     records written to
        P:\Surveys\Data\ETP\1999_STAR\Oceanographic\XBT\Current_Version\Interme
        diate\XBTNODC_1999_STAR_DSJ_6.691_0.00225.dat

10.53   Average temperature of all 287965 output points whose drops met the Min
        To Avg depth
19.83   Average temperature of all 42400 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
```

Depth and Temperature Corrections

Perl program XBTCorrect was used to correct depths and temperatures, using the method described in P:\Surveys\Data_Processing_Resources\Oceanographic\XBT\CH XBT fall-rate method.pdf. Here is its output:

```
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\ETP\1999_STAR\Oceanographic\XBT\Current_Version\Intermed
       iate\XBTEdit_1999_STAR_DSJ.dat...
```

```
Deep Blue: Thermal Bias = 0.02584, A = 6.621, B = 0.00235, Offset = 1.926
T-10: Thermal Bias = 0.11139, A = 6.503, B = 0.00137, Offset = 0.376
T-7: Thermal Bias = 0.02584, A = 6.621, B = 0.00235, Offset = 1.926

302     lines read from
        'P:\Surveys\Data\ETP\1999_STAR\Oceanographic\XBT\Current_Version\Interme
        diate\XBTEdit_1999_STAR_DSJ.dat'
0       lines started with an apostrophe, so were ignored
17      records written to
        P:\Surveys\Data\ETP\1999_STAR\Oceanographic\XBT\Current_Version\Intermed
        iate\XBTCorrect_1999_STAR_DSJ_T-7.dat
13      records written to
        P:\Surveys\Data\ETP\1999_STAR\Oceanographic\XBT\Current_Version\Intermed
        iate\XBTCorrect_1999_STAR_DSJ_T-10.dat
271     records written to
        P:\Surveys\Data\ETP\1999_STAR\Oceanographic\XBT\Current_Version\Intermed
        iate\XBTCorrect_1999_STAR_DSJ_Deep Blue.dat

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

Final data files

The NODC files created in the XBTEdit step were copied to \Final and were renamed as:

XBTArchive_1999_STAR_DSJ_T-7_Deep Blue.dat
XBTArchive_1999_STAR_DSJ_T-10.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_1999_STAR_DSJ_Deep Blue.dat
XBTCorrect_1999_STAR_DSJ_T-7.dat
XBTCorrect_1999_STAR_DSJ_T-10.dat

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, 0.7, 1.4, 2.0, 2.7, 3.4, 4.0, 4.7, 5.4, 6.0, 6.7, 7.3, 8.0, 8.7,...
```

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