XBT Data Processing – 2001 ORCAWALE MAC

XBT data were collected with SEAS software (Shipboard Environmental data Acquisition System, NOAA/AOML) on the NOAA Ship McArthur, Nov 16 through Dec 7, 2001. Typically, XBT drops were conducted daily at 0900, 1200, 1500 hours (local ship time), and after sunset. Sippican Deep Blue Expendable Bathythermograph (XBT) probes were used 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\2001_ORCAWALE\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

SEAS raw data files were converted to *.EDF files with Fortran program SEAS2EDF. No *.ini file is used by the SEAS2EDF program. These *.EDF file were moved to the same folder as the SEAS raw files, P:\Surveys\Data\WestCoast\2001_ORCAWALE\Oceanographic\XBT\Raw\MAC

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 MAC during ORCAWALE 2001, the CD labeled Vals_Data_July27_2002 appears to be the most complete, and the closest to the original data (based on the dates). These files were copied to P:\Surveys\Data\WestCoast\2001_ORCAWALE\Oceanographic\XBT\Raw\MAC\.

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 that all SEAS files had matching EDF Files, and vice versa.

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.

```
              95    EDF files read
               0    were missing date, time, latitude, or longitude
               0    were not in a valid format
               0    did not have a TSG record within 120 seconds in
P:\Surveys\Data\WestCoast\2001_ORCAWALE\Oceanographic\TSG\Current_Version\Inter
mediate\TSGTrackCheck_2001_ORCAWALE_MAC_Final.DAT

              95    lines were compared to TSG

         0.37199    Root-mean-square-error of distances
              14    Distances >= 1 nautical mile
         1.84393    Max distance
```

For 2001 ORCAWALE, fourteen XBT drops were greater than 1 nautical mile from TSG positions matched by time. However, none was greater than 2 nautical miles from TSG. It appears that the differences were because of slight time differences between TSG and XBT, so all were accepted.

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 2001 ORCAWALE, there were 95 drops, all using 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 XBTedit01m_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 $\leq$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

Perl program XBTEdit reads the editing codes entered by the reviewer, and creates edited output files. From its ini file, it reads: The location of the edit file (created in the previous step), the location of the time offsets file, the location of the raw XBT files, and the coefficients for the fall

rate equation. It creates output files with the editing codes applied. (e.g. Drops marked with RJ are excluded, depths marked with XD are removed, etc.)

Here is the output from program XBTEdit:

```
95      lines read from input file
        P:\Surveys\Data\WestCoast\2001_ORCAWALE\Oceanographic\XBT\Current_Versio
        n\Intermediate\XBTedit01m_PF.txt
0       lines started with an apostrophe, so were ignored
6       lines had an RJ code, so were ignored

89      records written to
        P:\Surveys\Data\WestCoast\2001_ORCAWALE\Oceanographic\XBT\Current_Versio
        n\Intermediate\XBTEdit_2001_ORCAWALE_MAC.dat

5       lines were not good enough for NODC, so their drop numbers were negated
84      records written to
        P:\Surveys\Data\WestCoast\2001_ORCAWALE\Oceanographic\XBT\Current_Versio
        n\Intermediate\XBTNODC_2001_ORCAWALE_MAC_6.691_0.00225.dat

7.57    Average temperature of all 83439 output points whose drops met the Min
        To Avg depth
14.02   Average temperature of all 12478 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
```

Correct Depth and Temperature

Perl program XBTCorrect adjusted temperatures and depths using the method described in P:\Surveys\Data_Processing_Resources\Oceanographic\XBT\CH XBT fall-rate method.pdf. Here is the 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\WestCoast\2001_ORCAWALE\Oceanographic\XBT\Current_Versi
        on\Intermediate\XBTEdit_2001_ORCAWALE_MAC.dat...
Deep Blue: Thermal Bias = 0.02920, A = 6.586, B = 0.00210, Offset = 1.703

90      lines read from
        'P:\Surveys\Data\WestCoast\2001_ORCAWALE\Oceanographic\XBT\Current_Vers
        ion\Intermediate\XBTEdit_2001_ORCAWALE_MAC.dat'
0       lines started with an apostrophe, so were ignored
89      records written to
        P:\Surveys\Data\WestCoast\2001_ORCAWALE\Oceanographic\XBT\Current_Versi
        on\Intermediate\XBTCorrect_2001_ORCAWALE_MAC_Deep Blue.dat

5       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_2001_ORCAWALE_MAC_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_2001_ORCAWALE_MAC_Deep Blue.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:

```
..., 0.3, 0.9, 1.6, 2.2, 2.9, 3.6, 4.2, 4.9, 5.5, 6.2, 6.9, 7.5, 8.2, 8.8,...
```

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