ICES
Guidelines for XBT Data

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The Expendable Bathythermograph (XBT) has been used by oceanographers for many years to obtain information on the temperature structure of the ocean to depths of up to 1500 meters. The XBT probe is typically launched from a steaming ship. During the probes descent, it measures the water temperature. Two very small wires transmit the temperature data to a ship computer where it is recorded for later analysis. The probe is designed to fall at a constant rate, so that the depth of the probe can be inferred from the time since it was launched.

1.0 RECEIVING DATA

The Data Centres require the following information to be supplied by the data supplier together with the data. When receiving data, the Data Centres of the ICES community shall strive to meet the following guidelines.

1.1 Data Standard

An overview of the instrument, data logging practices, data transmission in real-time (low resolution), and the overall data management practices for high resolution data in a continuously managed database is provided in Annex A.

All parameters must be clearly specified and described. If parameter codes are to be used, then the source data dictionary must be specified. Parameter units must be clearly stated. Parameter scales must be noted where applicable. If computed values are included, the equations used in the computations should be stated.

All relevant calibrations should be applied to the data including laboratory and field calibrations. Instrument calibration data should be included in the data file. The data should be fully checked for quality and flagged for erroneous values such as spikes, gaps, etc. An explicit statement should be made of the checks and edits applied to the data. If any data values have been removed, the times of the removed values should be noted.

Sufficient self-explanatory information and documentation should accompany the data so that they are adequately qualified and can be used with confidence by scientists/engineers other than those responsible for its original collection, processing and quality control.

The data supplier should ensure that the following be provided with the XBT data submission:

- Metadata information about the instruments (XBT manufacturer, probe model, probe recording rate)
- Metadata information about the data precision and final accuracy

- The fall rate equation used
- Metadata information about the calibration and processing techniques used for the particular XBT data set
- All data values should be expressed in oceanographic terms, in SI units, which should be clearly stated
- Time reported in UTC is strongly recommended
- The units used for the measured parameters should be clearly described and consistent
- Any ancillary meteorological information should be included

1.2 Format Description

Low-resolution XBT data, transmitted in real-time over the Global Telecommunications System free of charge, are coded into the WMO BATHY report format JJVV (the previous format was JJYY. Changes to JJYY that produced JJVV may be found at http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/gts-smt/index-eng.htm) (see also Annex B).

Coding of the messages can be done either manually or automatically via automated data collection platforms, such as the US Shipboard Environmental Acquisition System SEAS at http://www.aoml.noaa.gov/phod/goos/seas/seas.php, via GOES or INMARSAT satellites or using the French Service ARGOS.

The coded message is typically made up of inflection points from the profile. Various algorithms exist for determining these inflection points (e.g. Rual, 1989).

The originator data formats for the exchange of high resolution XBT data may vary. However, data should be supplied in a fully documented ASCII format. Individual fields, units, etc. should be clearly defined and time zone stated. Time reported in UTC is strongly recommended. Ideally all of the data from the instrument should be stored in a single file. The contents of the data and ancillary information should adhere to the Formatting Guidelines for Oceanographic Data Exchange (http://ocean.ices.dk/formats/GETADE_Guidelines.aspx) prepared by the IOC's Group of Experts on the Technical Aspects of Data Exchange (GETADE) and available from RNODC Formats.

The high resolution XBT data set must include:

- A full description of the format used.
- All XBT profiles collected from a single platform can be in the same file, or one file can be used for each XBT profile.
- The files must be homogeneous (i.e. each piece of information must always be in the same place in the file).
- Data should be reported at 1 m resolution

1.3 Collection Details

Other pertinent information to be included in the data transfer to the Data Centre includes:

- Platform name
- Station number
- Country, organisation
- Date and time of the start of each profile
- Sounding (specify method, e.g. chart, constant speed of sound, etc.)
- Latitude and longitude of each station, method of position fix (e.g. GPS, DGPS)
- calibration reference temperature and the method used to determine the calibration

Any additional information of use to secondary users which may have affected the data or have a bearing on its subsequent use. An example deployment log sheet is provided in Annex C.

2.0 VALUE ADDED SERVICE

When processing and quality controlling data, the Data Centres of the ICES community shall strive to meet the following guidelines.

2.1 Quality Control

Details on the quality control of XBT profile data are described in IOC MANUALS AND GUIDES No. 22
http://www.iode.org/index.php?option=com_oe&task=viewDocumentRecord&docID=269

Although the Manual is intended for the quality control of real-time profiles, the same principles apply to high-resolution data. Along with other relevant information, the Guide provides specific details on quality flagging, quality control tests, duplicates management, implementation details, as well as additional references on the treatment of XBT data by other data centres. The UKHO (1999) guide and Bailey et al. (1994) are also excellent references related to processing raw XBT data from a variety of source instruments.

There are three main components to the quality control of XBT profile data. All three components are used at the ICES data centres to quality control the XBT datasets.

The first component examines the characteristics of the platform track looking to identify errors in either position or time.

The second component examines the various profiles of observations to identify values that appear to be in error. Knowledge of the different types of real and erroneous features is critical. This knowledge, when combined with a local knowledge of water mass structure, statistics of data anomalies, thermocline characteristics, and cross validation with climatological data, ensures a data set of the best possible quality.

The third component is software to identify duplicate profiles. Duplicate profiles occur either by having received the data more than once, or because data of lower resolution (such as a real-time

BATHY message) typically arrive before the delayed-mode data on which the real-time message was based.

Quality control findings for the original data set are shared with the data originator to maintain consistency and uniqueness of the mutual data set and improve its overall quality.

2.2 Problem Resolution

The quality control procedures followed by the Data Centres will typically identify problems with the data and/or metadata. The Data Centre will resolve these problems through consultation with the originating Principal Investigator (PI) or data supplier. Other experts in the field or other Data Centres may also be consulted.

2.3 History Documentation

All quality control procedures applied to a dataset are fully documented by the Data Centre. As well, all quality control applied to a dataset should accompany that dataset. All problems and resulting resolutions will also be documented with the aim to help all parties involved; the Collectors, Data Centre, and Users. A history record will be produced detailing any data changes (including dates of the changes) that the Data Centre may make.

3.0 PROVIDING DATA AND INFORMATION PRODUCTS

When addressing a request for information and/or data from the User Community, the Data Centres of the ICES community shall strive to provide well-defined data and products. To meet this objective, the Data Centres will follow these guidelines.

3.1 Data Description

The Data Centre shall aim to provide well-defined data or products to its clients. If digital data are provided, the Data Centre will provide sufficient self-explanatory information and documentation to accompany the data so that they are adequately qualified and can be used with confidence by scientists/engineers other than those responsible for their original collection, processing and quality control.

- A data format description fully detailing the format in which the data will be supplied
- Any ancillary parameters (e.g. meteorological data)
- Parameter and unit definitions, and scales of reference
- Definition of flagging scheme, if flags are used
- Relevant information included in the data file (e.g. ship, cruise, project, start and end dates, etc.)
- Data history document (as described in 3.2 below)

3.2 Data History

A data history document will be supplied with the data to include the following:

- A description of data collection and processing procedures as supplied by the data collector (as specified in Section 1.1 and 1.3)
- Quality control procedures used to check the data (as specified in Section 2.1, see below)
- Any problems encountered with the data and their resolution
- Any changes made to the data and the date of the change

Any additional information of use to secondary users which may have affected the data or have a bearing on its subsequent use should also be included.

3.3 Referral Service

ICES member research and operational data centres produce a variety of data analysis products and referral service. By dividing ocean areas into regions of responsibility, and by developing mutually agreed guidelines on the format, data quality and content of the products, better coverage is obtained. By having the scientific experts work in ocean areas with which they are familiar, the necessary local knowledge finds its way into the products. Data and information products are disseminated as widely as possible and via a number of media including mail, electronic mail and bulletin boards.

If the Data Centre is unable to fulfil the client's needs, it will endeavour to provide the client with the name of an organisation and/or person who may be able to assist. In particular, assistance from the network of Data Centres within the ICES Community will be sought.

REFERENCES

Bailey, R., A. Gronell, H. Phillips, G. Meyers and E. Tanner, 1994: CSIRO Cookbook for Quality Control of Expendable Bathythermograph (XBT) Data. CSIRO Marine Laboratories Report, 221, 75 pp.

Rual, Pierre. 1989. For a Better XBT Bathy-message: Onboard Quality Control, plus a New Data Reduction Method, Proceedings of the Western Pacific International Meeting and Workshop on TOGA COARE, Edited by Joel Picaut, Roger Lukas and Thierry Delcroix, Centre ORSTIM de Noumea, New Caledonia, May 24-30, 1989.

UKHO, 1999. XBT Data Processing User Guide, UK Hydrographic Office, June 1999.

Annex A

An XBT probe consists of a small projectile with a leaded nose and a plastic casing that contains a spool of fine copper wire. As the probe descends through the water column, the wire self-spools and transmits the temperature from a thermistor in the nose to a recorder on deck. Corresponding depths are computed from an empirically derived, second order fall rate equation given by the manufacturer of the probe. Historically, a continuous analog chart was used to record XBT temperature-depth readings, which were subsequently digitised. More recently digital recorders have replaced these analog charts.

The probes are generally launched by research ships, naval vessels, and by the crew aboard volunteer merchant ships that transit regular shipping routes. Sippican Inc. http://www.sippican.com/seaair/xbt.php has prepared an XBT User's Guide that gives practical advice and hints on how to successfully store and deploy XBTs. The guide is based on deployment experiences with XBTs over many years.

The term high-resolution is used for profiles that are sampled usually at 1 or 2 metre depth resolution, require maximum calibration and quality control, and hence are normally available in delayed mode. Low-resolution messages are those profiles that have been reduced by some process such as selecting inflection points to reproduce the trace to specific tolerances (Rual, 1989). Some data centres maintain archives of only the reduced profiles. As well, the reduction tolerances may vary from agency to agency. Some of these messages are transmitted and available in real-time (less than one month, usually within days of observation). Delayed mode high resolution data are more useful to scientists but generally it is a matter of months to years before the high-resolution data are submitted to data centres.

Requirements for the collection and exchange of low-resolution XBT messages for real-time operations differ from those of an oceanographic data archive centre for high-resolution, fully calibrated and quality controlled XBT data. For example, although XBTs have been used for some time, it is only in the last few years that errors have been detected and corrected in the fall-rate equation coefficients and with the thermistors. Problems have also been detected in shipboard XBT recorders. For these reasons, there is a higher requirement for metadata information such as instrument type and the associated calibration information along with the original recordings.

To manage XBT data, it is recommended that a Continuously Managed Database (CMD) system is implemented. As data are acquired in both real-time and delayed mode they are added to the database. Calibrated and quality controlled delayed mode data replaces the messages obtained in near real-time. The CMD therefore holds the most current and highest quality data set at all times. The database is continuously refined as additional quality checks are undertaken. Observations that have passed quality control and entered the database are not removed but are flagged to indicate that a higher quality version of the observation exists in the database.

Annex B

HOW TO PREPARE A JJVV BATHY REPORT WITH NEW COEFFICIENTS

As of May 3, 2000 the WMO bathy report format JJYY was replaced with the format JJVV shown below.

Code Table A lists codes for IxIxIx and Code Table B lists codes for XrXr.

Example: On November 29, 1995, at 13:45 GMT, a vessel underway deploys an XBT using a Sippican T-7 probe with coefficients a=6.691 and b=-2.25 (the new coefficients have been programmed into the shipboard software) and a Sippican MK-9 recorder. The probe was deployed at 45 25'N and 150 37'W. The depth-temperature inflection points are selected automatically by the recorder.

BATHY Code:

Section 1

MiMiMjMj	YYMMJ	Gggg/	QcLaLaLaLaLa	LoLoLoLoLoLo
JJVV	29115	1345/	74525	15037

Section 2

8888k1	IxIxIxXrXr	ZoZoToToTo	.....	ZnZnTnTnTn
88887	04203			

CODE INPUT:

1. MiMiMjMj represents the report and version, JJVV, denoting a BATHY report encoded after 3 May 2000.

2. Date and time are given in GMT (YYMMJ and Gggg/).

3. Qc = 7 = quadrant of the glove; from Table 3333 of WMO No. 306.

4. Latitude and longitude given in tenths, hundredths and thousandths of a degree, depending on the capability of the positioning system. When the position is in tenths of a degree, the position group shall be encoded as $Q_cL_aL_aL_a$// or $L_oL_oL_oL_o$//. When the position is in hundredths of a degree, the latitude position group shall be encoded as $Q_cL_aL_aL_aL_a$/ or $L_oL_oL_oL_oL_o$/; iudff and 4SnTTT are optional fields for wind direction and speed and air temperature.

5. 8888 indicates data on Instrumentation and Temperatures at either significant or selected depths follow.

6. k1 = 7; from table 2262 of WMO No. 306 (auto-selection of data points).

7. IxIxIx = 042 (Sippican T-7,6.691,-2.25);from Code Table A below.

8. XrXr = 03 (Sippican MK-9 recorder); from Code Table B below.

9. ZoZo.......ZnZn = significant depths, in metres, starting with the surface.

10. ToTo.......TnTnTn = temperatures, to tenths of a degree Celsius, starting at the surface.

CODE TABLE A for IxIxIx - Instrument Type for XBT with fall rate equation coefficients.

Code	Instrument, equation coefficients a, and b
001	Sippican T-4, 6.472,-2.16
002	Sippican T-4, 6.691,-2.25
011	Sippican T-5, 6.828,-1.82
021	Sippican Fast Deep, 6.346,-1.82
031	Sippican T-6, 6.472,-2.16
032	Sippican T-6, 6.691,-2.25
041	Sippican T-7, 6.472,-2.16
042	Sippican T-7, 6.691,-2.25
051	Sippican Deep Blue, 6.472,-2.16
052	Sippican Deep Blue, 6.691,-2.25
061	Sippican T-10, 6.3301,-2.16
071	Sippican T-11, 1.779,-0.255
201	TSK T-4, 6.472,-2.16
202	TSK T-4, 6.691,-2.25
211	TSK T-6, 6.472,-2.16
212	TSK T-6, 6.691,-2.25
221	TSK T-7, 6.472,-2.16
222	TSK T-7, 6.691,-2.25
401	Spartan XBT-1, 6.301,-2.16
411	Spartan XBT-3, 5.861,-0.0904
421	Spartan XBT-4, 6.472,-2.16
431	Spartan XBT-5, 6.828,-1.82
441	Spartan XBT-5DB, 6.828,-1.82
451	Spartan XBT-6,6.472,-2.16
461	Spartan XBT-7,6.472,-2.16
471	Spartan XBT-7DB, 6.472,-2.16
481	Spartan XBT-10, 6.301,-2.16
491	Spartan XBT-20, 6.472,-2.16

501	Spartan XBT-20DB,6.472,-2.16
800	Mechanical BT
810	Hydrocast
820	Thermistor Chain
830	CTD

Notes:

(1) The depth is claculated from coefficients a and b and the time, t, as follows: z = at + 10-3bt2.

(2) All unassigned numbers are reserved.

CODE TABLE B for XrXr - Recorder Types

This table encodes the various recorders used to log temperatures from the instruments listed.

Code	Recorder
01	Sippican StripChart Recorder
02	Sippican MK2A/SSQ-61
03	Sippican MK-9
04	Sippican AN/BHQ-7/MK8
05	Spiican MK-12
10	Spartan SOC BT/SV Processor Model 100
20	Argos XBT-ST
21	CLS-AGROS/Protecno XBT-ST model 1
22	CLS-ARGOS/Protecno XBT-ST model 2
30	BATHY Systems SA-810
31	Scripps Metrobyte controller
32	Murayama Denki Z-60-16 IIIjMj
33	Murayama Denki Z-60-16 II
34	Protecno ETSM2
35	Nautilus Marine Service NMS-XBT
40	TSK MK-2A
41	TSK MK-2S
42	TSK MK-30
43	TSK MK-30N
99	Unknown

Annex C
Example XBT Deployment Log Sheet

XBT Deployment Log Sheet

Country:____________ Organisation:______________ Platform:____________
Date:_______________

Event Number	Latitude dd mm.mm	Longitude dd mm.mm	Time (GMT)	Sounding	Filename	Initials