

Chapter 5 Underway Data Formats

WOCE underway data are a fundamental part of the Hydrographic Programme (WHP). High quality, underway measurements have both direct and indirect scientific and operational applications. Among the benefits are the identification, movement and mixing of water masses, fluxes of fresh water, heat and momentum through the sea surface, and the high-resolution cross sections of hydrographic frontal structures. These measurements are also of importance in the recognition of possible aliasing effects in WHP sections. WHP underway measurements, particularly from ships cruising away from general shipping lanes in otherwise data sparse areas, also supplement routine measurements aboard ships-of-opportunity participating in the Integrated Global Ocean Services System (IGOSS) and the World Weather Watch (WWW).

Until recently, the fate of WHP underway data (surface salinity, XBT/XCTDs, bathymetry, meteorology, currents (ADCP) and gases) was not clearly addressed within the WHP nor within the WOCE Data Management System. Arrangements have now been made to assemble and preserve these data in existing or new Data Assembly Centres (DACs) or, in the case of ADCP data, by the responsible PIs. Underway measurements of dissolved and atmospheric gases are, however, considered the responsibility of JGOFS and are not addressed further in this manual.

The WHP Planning Committee has decided that for purposes of data tracking, underway data (except XBT/XCTD) for which a DAC exists should be submitted to the WHPO with the hydrographic data. The **chief scientist** has the responsibility of submitting this data. Methods for submission of data to the WHPO are described in Section 1.6 of this manual. The WHPO will then forward the underway data to the appropriate DAC and post relevant information on OCEANIC.

Following are formats for each type of measurement. Postal and electronic addresses for all DACs and SACs are given in Appendix A. Summaries of the availability of data from the DACs will be posted on OCEANIC and included in the WOCE Data Handbook (contact DIU for copy).

5.1 Acoustic Doppler Current Profiler Data

No arrangements have been made to quality control and assemble acoustic Doppler current profiler (ADCP) data. The WOCE Scientific Steering Group agrees with the WOCE Implementation Plan, and with International Council for the Exploration of the Sea (ICES) that it is premature to store all ADCP data in data centres. ICES has a set of proposed guidelines for the management of shipborne ADCP data which are suggested for WOCE use and reproduced here. The SSG has recommended that a small group of experts be requested to develop guidelines for sampling strategy, ADCP setup and quality control. This group is presently being formed by IPO and is expected to report to SSG in October 1994. DIU has been

requested to ensure that all ADCP projects are tracked and the WHPO will provide them with that information for all WHP cruises. The bottom line is that PIs are expected to retain their data, or continue to follow their national practices, document their projects, and to share their data within the WOCE data sharing guidelines. Once the experts have completed their study, a new approach may be taken.

ICES Proposed Guidelines for the Management of Shipborne ADCP

(Reprinted from Annex 2 of the ICES Working Group on Marine Data Management, C.M. 1992/C:5 Ref D. Hydrography Committee)

It is felt premature to store all ADCP data in data centres. Each institute should store their own data and send an inventory of these data with an estimate of their quality to the appropriate data centre. Data could then be submitted to the data center on request.

All parameters collected should be stored (that is, two horizontal components of velocity, vertical velocity, error velocity, percent good and automatic gain control (AGC). Navigation should also be submitted, either merged with the data or as a separate file which can be linked to the ADCP data file using date and time.

The data should be fully checked for quality and pre-edited or flagged for erroneous values such as spikes, gaps, etc. an explicit statement should be made of the checks and edits applied to the data.

Sufficient self-explanatory series header 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 their original collection, processing and quality control. These are described in more detail below.

Data can be exchanged in the IOC standard format GF3, but it is equally acceptable to exchange data as ASCII files provided a format description accompanies the data.

ADCP data files

1. Series header information should include the following:
 - 1.1 Project, ship, cruise identifier (EXPOCODE for WHP cruises)
 - 1.2 Country, organization
 - 1.3 Date, time, latitude, longitude, (error of GPS), water depth for each profile.

2. Accompanying information
 - 2.1 Details of the instrument (for example manufacturer, model number, instrument configuration and any modifications carried out)
 - 2.2 Data collection: description of operational procedures including time interval over which ensemble averages are performed, bin size, number of binds, bottom tracking on/off, pitch and roll on/off, methods of position fixing
 - 2.3 Data calibration, quality and processing: brief description of procedures including
 - (a) whether horizontal components of velocity are N and E components or are components relative to the ship
 - (b) criteria used for flagging or rejecting data (for example threshold values of error velocity and/or per cent good)
 - (c) method used for correction of profiles for ship speed (that is, bottom tracking, navigation or reference level of no motion)

- (d) calibrations carried out to correct for transducer misalignment
 - (e) problems of contamination of the data due to bubbles in rough weather, high ship speed (propeller noise), change in ship direction or ship speed zero and how dealt with
 - (f) estimate of final accuracy in the data
- 2.4 Gyro information, manufacturer, model number, and adjustments made for latitude and speed throughout the cruise. Also, any gyro errors that were detected.
 - 2.5 Gyro corrections made using utilising heading information from 3-D GPS systems along with details of the 3-D GPS equipment.
 - 2.6 Method of calculating sound speed should be stated. If a constant value is employed state what it is and how it might vary along the cruise track. If temperature and a fixed salinity were used to estimate sound speed state what the latter value is and where temperature data are stored.
 - 2.7 There should be specific mention of bottom tracked velocities. These are valuable in the shallow sections of the cruise for calibration information.
 - 2.8 Applied units in which the data are expressed should be clearly stated.
 - 2.9 Any additional information of use to secondary users which may have affected the data or have bearing on its subsequent use.

5.2 Bathymetry

The National Geophysical Data Center (NGDC) in Boulder, Colorado, has been named the Data Assembly Center (DAC) for bathymetry for WOCE cruises. NGDC maintains the International Council of Scientific Unions (ICSU) World Data Center A for Marine Geology and Geophysics and the International Hydrographic Organization Data Center for Digital Bathymetry. Maximum benefits to scientists and researchers worldwide accrue from the parallel and collocated operation of these Centers.

WOCE principal investigators should submit all acquired bathymetric data with their hydrographic data to the WOCE Hydrographic Program (WHP) office. The WHP Office will then forward the bathymetric data to NGDC for public dissemination worldwide.

Format

NGDC normally uses "The Marine Geophysical Data Exchange Format - 'MGD77'" (Hittelman and others, 1989) for exchange and storage. However, data submitted in any other format are acceptable provided that the format is well documented. Documentation on MGD77 is available from NGDC by mail or via ftp from the WHP SAC (see Appendix A).

If data are provided in a format other than MGD77, please provide specific cruise information by completing either:

- (1) the MGD77 Header Coding Form, or
- (2) header information as described in the next section.

Header information (metadata) is used to complement the data records and can be used, for example, to estimate data accuracy or determine what correctors have been applied to the depth values.

Generally, depth values and position should be recorded at least every 5 minutes. When a depth value is not acquired at the same time as a vessel position is determined, some institutions estimate (interpolate) a depth for that position. NGDC prefers to receive depths acquired at a given position rather than an interpolated depth. However, if interpolated depths

are included with the data, please identify with a "flag" for each depth whether it is observed or interpolated. Also, if possible, identify for each position whether it is an observed or interpolated (dead reckoning) position. See the MGD77 data record format, POSITION and BATHYMETRIC TYPE CODE, for additional information.

Header Information for WOCE Cruises

An essential part of any digital data series is the documentation describing how the data were acquired and processed, the instrumentation used, the reference datum, the methods used for acquiring the data, etc. It is strongly recommended that such documentation be stored in computer compatible form together with the data.

In lieu of completing the MGD77 Header Coding Form, the following information should be submitted with the data:

EXPOCODE

Cruise Identifier (8 characters long)

Contributing Institution

Country

Vessel Name

Chief Scientist

Navigational Instrumentation

(e.g., GPS)

Position Determination Method

(e.g., interpolation over 3 three minutes between fixes)

Bathymetric Instrumentation

(for example, echo sounder, beam width, frequency, etc.)

General Digitizing Rate of Bathymetry in Minutes

(time between recorded depths)

General Sampling Rate of Bathymetry

(instrument dependent, for example, 1 ping/second)

Corrected for Transducer Depth (yes or no)

(if no, what is draft)

Vertical Datum

(none applied, mean lower low water, etc.)

Horizontal Datum

(geoid; for example, WGS84)

Interpolation Scheme (if interpolated depths are included)

Assumed Sound Velocity (normally 1500 m/s on WHP cruises)

Sound Velocity Correction

01-55 Matthew's Zone

59 Matthew's corrections used but zones unspecified
in data record

60 S. Kuwahara Formula

61 Wilson Formula

62 Del Grosso Formula

63 Carter's Tables

88 Other (describe under Additional Documentation)

blank No correction made

Additional Documentation

Data Records

Each data record should include, at a minimum, the data, UTC time, latitude, longitude, and depth. Five-minute time intervals are the desired resolution for discrete systems. As stated previously in the "Format" section, any well documented format is acceptable.

The data should be stored in character format (ASCII or EBCDIC) in fixed-length records with fields in integer or fixed point format (or alphanumeric format for flags) in fixed positions within the record. It is recommended that the data be arranged in ascending sequence of date/time rather than as a spatial progression of positions and their associated depths as the time information provides for the possibility of valuable quality control checks. However, NGDC operates on the basis that the prime responsibility for quality control of the data rests with the collector or custodian of the raw data.

Data Submission and Retrieval

Submission of data to the WHPO is discussed in Section 1.6 of this manual. If bathymetric data submitted to the WHPO requires a proprietary-hold period please inform NGDC through the WHPO. NGDC will not distribute such data until the hold period is over.

Through exchange agreements with WOCE, WOCE participants, upon request can obtain copies free of charge of the WOCE bathymetric data maintained at NGDC. Other marine data and products are available from NGDC for a nominal fee, or free of charge for active data exchange partners. Organizations or institutions are able to become data exchange partners when they contribute data holdings to NGDC. Any data received is in the international public domain, readily available globally to any interested individual or group.

Digital data can be distributed on 9-track magnetic tape, 8-mm tape (for example, Exabyte), floppy disk (file size permitting), by direct file transfer over various networks, or specially agreed upon transfer media. The data are stored in the marine geophysical data base in the MGD77 data exchange format.

Submitting Other Types of Geophysical Data

NGDC also accepts magnetic, gravimetric, and seismic reflection data for entry into the Global Marine Geophysical Data Base (GEODAS). Header (cruise) information must be forwarded with this data also. See Appendix 2 of the "Marine Geophysical Data Exchange Format -'MGD77'" description for information.

5.3 Gases

The WHP Planning Committee has decided that responsibility for **underway** atmospheric and dissolved gas measurements be vested in the JGOFS community.

5.4 Meteorological Data

Florida State University (FSU) is now the underway meteorology DAC. FSU collects, checks, archives, and distributes all surface meteorological data from WOCE vessels and moored and drifting buoys. The FSU operation is a combined DAC/SAC, which means that it

also has a mandate to generate and issue fields and uncertainty estimates of surface fluxes of heat and momentum to serve as surface boundary conditions for numerical ocean models and to be validation tools for other flux products.

Introduction

Surface meteorological observations are valuable to several of the WOCE objectives. Either individually or jointly (in order to estimate surface heat and momentum fluxes), these data can be employed for verifying satellite and ship of opportunity data; determining surface boundary conditions for atmosphere and ocean models; validating results from atmospheric and ocean general circulation models; and analyzing variability of the marine boundary layer and upper ocean. More about these uses as well as relevant discussion of measurement precision, etc. are detailed in Taylor, 1989.

The procedure for contributing surface meteorological data to the WOCE program is given below. An overview of the data flow is also presented here that gives a broad picture of the data path; from the collection phase to final availability to the WOCE community. The need for supporting documentation in the —.DOC file is emphasized.

Overview of data path

All observations, as well as all documentation describing the methods used to record the observations, are considered essential parts of the data system. Documentation facilitates better quality control as well as a more comprehensive distribution and final archival value.

Meteorological data recorded during each cruise and the associated metadata should be forwarded to the WOCE Hydrographic Programme Office (WHPO) nominally within six months after the cruise.

After receipt by the DAC, the data will be subjected to extensive quality-control checks. The original data, corrections, and quality flags as well as all supporting documentation will be available in final form from the meteorology DAC. The data will be made available to WOCE SACs (Special Analysis Centers) for synthesis and further analyses.

All data reported to the WHPO will be subject to the WOCE data sharing policy described in Section 1.5 on page 9. The meteorology DAC will honor the WOCE data sharing policy, but will encourage data contributors to waive the required waiting period and push for the quick dissemination of data since some of it are already passed into the public domain via other means, for example, the GTS - Global Telecommunications System.

Reporting Details

Content, form, and submission instructions are presented here and it is requested that the chief scientists and PI's follow these when assembling the data.

The mission of the surface meteorology DAC is focused on WOCE sponsored cruises. However, that should not be interpreted as precluding the transmission of data from cruises that are not WOCE. We will gladly accept and process all surface meteorological data from research vessels participating in WOCE or affiliated programs, for example, JGOFS, TOGA, etc.

There are two categories of data that are of prime importance, both of which are relevant to the overall WOCE data strategy. The first are the actual surface meteorological data. This includes all routine measurements of the standard surface conditions, as listed below, as well as other supporting weather-related information. The second category is metadata; that is

information that describes in some detail all aspects of how the data were collected. Examples of information that should be included in the —.DOC file include listings of instrumentation specifics, their configuration, data collection methods, calibration efforts, etc. Data submission to the WHPO is described in Section 1.6.

Meteorological Documentation Requirements (—.DOC file)

There are a vast number of instrument possibilities and configurations, each of which have individual response characteristics. Thus a detailed list of instruments used to record the meteorological data as well as a description of the instrument configuration, for example, location of each instrument, data logging system, averaging techniques and period, etc., are requested in order to facilitate the complete quality-control process. Flags and corrections for reporting differences may be necessary. Thus, environmental factors should be reported. For example, possible shading of the radiometers, or anemometers that were obstructed by upwind superstructure.

Additionally, all calibration information should be reported. That includes the pertinent conversion parameters for raw-data to geophysical parameters as well as the results and date of calibration tests.

Meteorological Data Reporting

Many research vessels have automated systems to record routine surface meteorological data, for example, IMET, Multimet. Other ships rely on observations recorded manually by the crew or scientific staff. When both manual and automatic systems are aboard, it is desirable that observations from both be reported for the purpose of confirming the observations as well as monitoring the performance of the instruments and recording systems. Thus, all surface meteorological data that are recorded, either manually or automatically, should be formatted following the guidelines given here.

Automated System Measurements

It is assumed automated systems can generate digital files that consist of the data plus some identifying information generally found in an initial data record or header. The header for each submitted data file should include (at a minimum) the WOCE expedition code (EXPOCODE) and scientist(s) responsible for the meteorological data. The data should be organized such that the ship location and time (UTC) are associated with each observation record. Information regarding ship heading and speed are also necessary for calculating corrected winds. Table 5.1 lists typical measurements, required accuracies, and reporting units. All data should be reported in SI units. Additions, for example, precipitation rate, to the list given in Table 5.1 are possible and welcome within the scope of the mission of the surface meteorological DAC.

Data from automated systems are often subject to sampling, averaging, or filtering. If any of these techniques are used prior to the delivery of the data to the WHPO, specifics need to be given in the —.DOC file. If the meteorological data are simultaneously recorded along with other underway data, for example, bathymetry, it is *not* necessary to explicitly extract the meteorological data.

Manual Weather Observations

The requirements for manual observations are the same as those for automated systems, but the frequency of observations will be considerably less. The standard for the Volunteer Observing Ship (VOS) program requests observations be taken every 6 hours, that is at each of

TABLE 5.1: Table of accuracies and reporting units for surface meteorological data for WOCE (adopted from Taylor and Weller, 1991)

Measurement	Target Accuracies	Reporting Units
Wind speed	larger of 2% or 0.2 m s ⁻¹	m s ⁻¹
Wind direction	2.8°	compass degrees N = 0°, E = 90°, S = 180°, W = 270°
Air temperature	0.25°C	°C
Sea-surface temperature (SST)	0.25°C	°C
Specific humidity	0.25 g kg ⁻¹	g kg ⁻¹
Relative Humidity	1.7%	%
Dew Point Temperature	0.3°C	°C
Shortwave Radiation	5 W m ⁻²	W m ⁻²
Longwave Radiation	5 W m ⁻²	W m ⁻²
Barometric Pressure	0.3 mbar	mbar
Precipitation	1 cm month ⁻¹	cm

the main synoptic hours (0000, 0600, 1200, 1800 GMT). More frequent observations would be welcome. Manually observed data are subject to a larger uncertainty due, in part, to the variety of techniques used in making the observation. Thus, the documentation should describe in considerable detail the techniques employed in determining the data values in order to enable corrections. The method for determining each type of observation, wind, temperature, etc., should be described with as much detail as possible. For example, wind observations should be described as either being based on an anemometer, fixed or hand-held, or on a scale defined by sea-state (Beaufort scale) with some notation in the report regarding the averaging period, for example, was the reading averaged over 10 minutes, instantaneous, etc.

5.5 Surface Temperature and Salinity Measurements

The DAC for thermosalinograph (TSG) data is in Brest, France, and is collocated with the Global Upper Ocean Thermal DAC. They collect all salinity and related products including summaries of data holdings, climatologies and data location plots. Data are checked and returned to the PI together with standardized anomalies of individual observations.

DAC requirements

The minimum requirements for the sea surface temperature and salinity data set to be put in the data base are the following:

Format and Data Transfer

The format of the data set must be a single, standard ASCII file (one observation per line). It is recommended that each cruise constitutes a single file. Data transfer to the WHPO is described in Section 1.6.

Content of master (or header)

Each file must contain the following identifying information:

- EXPOCODE
- Ship
- WHP section number
- Type of instrument used (bucket, thermosalinograph, other)
- Calibrations
- Other relevant information can be added as text in the file or included in the —.DOC file.

Data

Each individual observation must contain:

- date and time (month, day, year, hour, minute)
- position (latitude and longitude in degrees and decimal minutes, or decimal degrees)
- salinity (PSS-78)
- temperature (ITS₉₀)

Resolution

- salinity resolution must be 0.1 or higher
- for thermosalinograph data the recommended time resolution is 1 hour. For regions of large scale variability the time resolution can be increased, but should not exceed 1 sample per minute.

Accuracy

Thermosalinograph measurements should have been calibrated prior to the data set shipment. No recalibration will be performed by the DAC.

5.6 Expendable Bathythermograph and CTD Data

Expendable bathythermograph (XBT) and expendable CTD (XCTD) data should *not* be sent to the WHPO. We suggest that normal IGOSS BATHY messages be used for initial submission and that delayed mode versions of the data be sent to national data centres who automatically forward XBT/XCTD data to other National and International centres, and thereby to the WOCE Upper Ocean Thermal DACs.

The procedures for submitting XBT data are long standing within the IOC's IGOSS system with well defined procedures and active WOCE DACs are in operation. PIs should therefore follow the IGOSS procedures for both near-real time and delayed mode data submissions. Guides¹ are available on the collection and exchange of XBT/XCTD data from the IGOSS operations officer who operates out of the Intergovernmental Oceanographic Commission (IOC) in Paris.

5.7 Submission of Underway Data from Past Cruises

Many PIs have reported that underway measurements were carried out on past cruises but we have little information on the fate of these data. We urge all PIs holding underway data to contact either the WHPO or the appropriate DAC directly to make arrangements for data transfer. As stated above, data from ongoing and future cruises should be sent to the WHPO, and we will forward it to the DACs.

1. See IOC references.

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