SES Moored Instrument Data Set

The SES moored instrument data comprises a significant part of the SES data set. The experiment specification comprised a series of stations along two lines ('S' and 'N') that were to be occupied continuously by current meters, thermistor chains, transmissometers and fluorometers from March 1995 to September 1996. In addition, moorings were deployed to look at cascading off the shelf and to determine boundary conditions from the Tiree Passage.

Unfortunately, these stations were located in a major commercial fishery and losses were heavy. Nevertheless, over 250 series of moored instrument data were obtained as follows:

102	Aanderaa Current Meter Series
55	Thermistor Chain Series
18	Fluorometer Series
16	Moored ADCP Series
16	Transmissometer records
15	Temperature Probe Series
11	Bottom Pressure Records
9	EM Current Meter Series
5	Colour Sensor Series
3	Meteorological Buoy Records
2	STABLE Deployments
1	Waverider Record

Details of precise locations, times and instrument types may be found in either spreadsheet inventories supplied with the data or from the SES database.

The data are subdivided into two groups. The first of these are conventional time series where the instrument sampled at pre-set regular intervals of the order of several minutes to an hour. The second are burst recorded data where the instrument sampled at high frequency for a period of several minutes followed by a period of inactivity. This latter category is confined to the STABLE II lander deployments.

Conventional Time Series Data

The conventional time series data may be found in the subdirectories of the MOORINGS directory on Disk 2 of the SES CD-ROM set. These are:

ADCP	Moored ADCP data
FLTRANS	Fluorometer and transmissometer data
MET	Meteorological buoy and colour sensor data
RCM	Aanderaa current meter data
S4	S4 current meter data
SFPG	Seafloor pressure gauge data
TCHN	Thermistor chain data
TPROBE	Temperature probe data
WAVE	Waverider data

Users interested in transmissometer data should note that many of the Aanderaa current meters used during SES included a transmissometer in the fin.

A spreadsheet in ASCII comma separated variable format and *Excel* 8.0 format (MOORINV.CSV and MOORINV.XLS) is included in the MOORINGS directory that provides an index to the data files. The data filenames are of the form Bnnnnnnn.LST or Bnnnnnnn.QXF where nnnnnnnn is the BODC series reference number. This number is used to refer to the data in the file throughout the data documentation and may also be found in the MOORINDX table in the SES database. It is well worth making a note of it when using the data.

The data files are in one of two formats as indicated by their file extension. The .LST files are in a simple ASCII format, termed BODC Request Format Version 1.0. This format will be familiar to users who have received data from the BODC National Oceanographic Database. The .QXF files are in QXF format, a derivative of the NetCDF binary exchange format. The introduction of this format was necessary to handle both the data volume and structural complexity of moored ADCP and thermistor chain data. Both formats are handled transparently and output in a common grid format by the BODC Mooring Explorer software. It is strongly recommended that all users with access to a *Windows* system should use this program as the interface to the SES moored instrument data.

These data have been through the standard BODC moored instrument quality control procedures, during which data documentation has been compiled. This describes the instrumentation and data processing procedures applied to the data by the originators and BODC. The documentation also describes any problems or abnormalities with the data reported by the originator or

detected by BODC quality control. In some cases, vital information may only be found in the data documentation. **Therefore, ignore this document at your peril.**

Burst Recorded Data

Introduction

The STABLE II lander was deployed twice during SES, during Challenger cruises CH121A and CH125A. Both deployments were at site S200 (56° 27' N, 9° 3' W) in approximately 200 m of water. The instrument was fitted with a range of sensors and two data loggers. The mean data logger stored a cycle of averaged data once a minute. The data from this are included as part of the conventional time-series data set on the CD-ROM. The second data logger collected, approximately, 9500 scans at a frequency of 8 Hz once an hour. These data are documented here.

Data File Location

The burst recorded data files may be found in the CD-ROM directory MOORINGS\STABLE\STABURST. The data are located under the appropriate directory (CH121 or CH125). There are over 500 files from each cruise, each containing the data from a single burst.

Due to space constraints, the burst files have been compressed using the Unix 'zip' utility (using, zip –l to ensure PC-compatible record terminators). The files may be uncompressed using MS-Dos, UNIX or *Windows*-based software (e.g. Pkware). Note that if the UNIX 'unzip' command is used, the '-a' option must be specified to convert the PC record terminators to the UNIX form (unzip –a <*filename*>).

Data Documentation

STABLE II lander consisted of a large aluminium frame standing on tripod legs fitted with syntactic foam buoyancy, two Benthos transponding releases, mechanical releases and disposable ballast.

The frame carried a large number of sensors (Humphery and Moores, 1994a) measuring three-dimensional currents, acoustic backscatter, temperature and pressure.

The following sensors on the STABLE II platform were logged in burst mode:

> Three electromagnetic current meter arrays (Valeport 800 series), termed Array A (300 mm above seabed), Array B (602 mm above seabed) and Array C (899 mm above sea bed). Each array comprised two heads mounted on Y-shaped arms with a horizontal separation of

230 mm. The arrays were mounted such that the heads were at identical angles to port and starboard of the lander centre-line facing its bow (the reference point on the lander for the heading channel in the mean data set).

A Digiquartz pressure sensor (serial number SN36626) capable of operating at depths of up to 1400 m. This was mounted 1950 mm above the sea floor. Note that the mean data logger used a separate sensor.

The current sensors were calibrated prior to deployment (18 November 1993) in the high-velocity recirculating flume at the Liverpool University Mechanical Engineering Department that was capable of producing virtually non-turbulent flow. The instruments were calibrated for both horizontal and vertical currents. Due to flume size constraints, each sensor array was calibrated separately.

Further details of the instrumentation and sensor calibrations may be found in Humphery and Moores (1994b).

Challenger CH121A

The Challenger CH121A deployment was from 11 August 1995 until 06 September 1995. The data are stored in a simple zipped ASCII format. There are 558 files named 001.ZIP to 558.ZIP (uncompress to burst.001 to burst.558). Each file contains 9600 scans. These files **DO NOT** contain a header. The file README.TXT in the CH121 directory contains the start date and times of each burst file, which are in sequential order, every hour, starting at 18:59:58 UT on 07 August 1995.

The data are contained in 13 columns each containing decimal numbers separated by at least one blank (usually two). Columns 1 to 12 contain data for the Electromagnetic Current Meters (EMCM) and give velocity in meters per second.

Column	EMCM Array	Head	Flow Component
1	A	Port	Horizontal
2	A	Port	Vertical
3	A	Stbd	Horizontal
4	A	Stbd	Vertical
5	B	Port	Horizontal
6	B	Port	Vertical
7	B	Stbd	Horizontal
8	B	Stbd	Vertical
9	C	Port	Horizontal
10	C	Port	Vertical
11	C	Stbd	Horizontal
12	C	Stbd	Vertical

Column 13 contains wave induced pressure information in bars.

The 'ECM Array' designations are defined in the Data Documentation section above. Vertical currents are positive when flowing from the bottom of the head to the top. Horizontal currents are positive when flowing from left to right (viewing the sensor from the front).

Challenger CH125A

The winter deployment (Challenger cruise CH125A) was from 01 February 1996 to 22 February 1996. The data are stored in a simple zipped ASCII format. There are 504 files named 001.ZIP to 504.ZIP (uncompress to burst.001 to burst.504). Each file contains 9405 scans. File README.TXT in the CH125 directory contains the start date and times of each burst file, which are in sequential order, every hour, starting at 07:59:59 UT 1 February 1996. These files contain a header that appears as:

```
Rig:                        POP-UP STABLE2

Burst Number:               001

Start Date:          01:02:1996

Start Time (GMT):    07:59:59

Deployment reference:       SES_CH125

Logging Frequency:  8Hz

Column information:
Columns 1 to 12 contain data for the Electromagnetic Current Meters and
give velocity in metres per second.


Column      EMCM Array           Head         Flow Component
  1               A              Port         Horizontal
  2               A              Port         Vertical
  3               A              Stbd         Horizontal
  4               A              Stbd         Vertical
  5               B              Port         Horizontal
  6               B              Port         Vertical
  7               B              Stbd         Horizontal
  8               B              Stbd         Vertical
  9               C              Port         Horizontal
  10              C              Port         Vertical
  11              C              Stbd         Horizontal
  12              C              Stbd         Vertical

Columns 13 and 14 contain Thermistor probe temperature information.
```

9405 records follow the header, each containing 14 decimal numbers separated by at least one blank (usually two). The definitions of these numbers are defined in the header. The 'ECM Array' designations are defined in the Data Documentation section above. Vertical currents are positive when flowing from the bottom of the head to the top. Horizontal currents are positive when flowing from left to right (viewing the sensor from the front).

Data Quality

The times of the first and last bursts from both cruises may be influenced by deployment/recovery operations and should be ignored. Furthermore, the Challenger CH121A record shows a disturbance in the bottom set of EMCM heads at the end of the record. The Challenger CH125A rig recovery damaged the EMCM spare. Thus, the data record shows the final readings to be useless for some of the equipment. Table 1 describes the good data for each deployment and instruments.

The pressure sensor used on deployment CH121A was useless as it was uncalibrated and details were lost.

Each of the EMCM heads have a "warm up" time. This means that the first 20 seconds of every burst on both deployments are suspect.

Table 1: Good data from STABLE deployments S200 1995 & 1996.

Deployment	**Sensor**	**Good Data**	**Time of Good Data**
CH121	EMCM arrays	Bursts 82-480	11/08/95 03:59 to 27/08/95 17:59
CH121	Pressure	NONE	
CH125	EMCM arrays	Bursts 2-489	01/02/96 08:59 to 21/02/96 15:59
CH125	Thermistor probes	Bursts 2-489	01/02/96 08:59 to 21/02/96 15:59

References

Humphery J.D. and Moores S.P. 1994a. STABLE II – An improved benthic lander for the study of turbulent wave-current-bed interactions and associated sediment transport. p170-174 *in* ***Sixth International Conference on Electronic Engineering in Oceanography***, 19-21 July 1994, Cambridge, UK. London: Institute of Electrical Engineers. 188 pp.

Humphery J.D. and Moores S.P. 1994b. Description and interpretation of data recorded by STABLE II during RRS Charles Darwin cruise 84, OMEX, Goban Spur, January 1994. ***Proudman Oceanographic Laboratory Report*****,** 37, 45 pp.

BODC Request Format
Version 1.0

This is a generalised output format to handle most types of data held in the BODC National Oceanographic Database.

The following is an example of a file listed in the format:

```
BODC Request Format Std. V1.0           Headers=  15 Data Cycles=   1247 BODC QC (a)
Series:   12050 Inv: CMD  1008           Produced:1993/07/07                     (b)
Id:   048/0           United Kingdom    Scottish Office Agric. & Fisheries Dept. (c)
 57d18.1mN001d54.6mW                     Start:19700831095800 End:19701022075800 (d)
Depth: floor  22.0  sensor  18.0         Nom. sample int.:   3600        secs    (e)
    2 Parameters included:                                                      (f)
Parameter  f  P  Q     Absent Data Value  Minimum Value  Maximum Value     Units
LCDAEL01   Y 30 37                 -1.00           0.00         359.70     deg T (g)
Horizontal Current Direction             Eulerian method
LCSAEL01   Y 40 47                 -1.00           0.14          72.07    cm/sec
Horizontal Current Speed                 Eulerian method
    1 FORTRAN format record:                                                    (h)
(I7,A20,A1,1X,F8.2,A1,1X,F8.2,A1)
  Cycle    Date      Time    LCDAEL01  LCSAEL01                                 (i)
 Number yyyy mm dd hh mi ssf         f         f
      1 1970/08/31 09.58.00    228.26     18.63                                (j)
      2 1970/08/31 10.58.00    209.69     36.14
      3 1970/08/31 11.58.00    206.74     44.23
      4 1970/08/31 12.58.00    204.33     40.06
      5 1970/08/31 13.58.00    207.48     27.95
```

Notes:

(a) The first record contains general information regarding the file. Std. indicates Standard format and V1.0 indicates version 1.0 of the format. Headers and Data Cycles are counts of the number of header records and data cycles in the file. BODC QC indicates that the data has been through BODC quality control procedures; this field is blank if this is not the case.

(b) Record two indicates the BODC series reference number and any inventory reference numbers by which the series is also known (in this case the inventory is the Moored Time Series Inventory that was originally known as the Current Meter Inventory: hence the mnemonic). A reference to a second inventory may occur on this line. If a series has not yet been allocated a BODC reference number this record will start with 'File:' followed by the full BODC file name. This record also indicates the date on which the output was produced (yyyy/mm/dd).

(c) Record three gives the data originator's identifier for the series, the source country and the source laboratory. If this information is not available the record will state 'Series header information not available' and the next two records will be blank.

(d) This record specifies one or two geographic positions; if a second position is given its purpose will be described in the accompanying documentation. Start date and end date

(if available) are given in the format yyyymmddhhmiss (24 hour clock and GMT). If time is unavailable hhmiss will be blank.

(e) This record gives the sea floor depth and the sensor depth. If a second (greater) sensor depth is given the two sensor depths specify the range of depths over which measurements were made. The second half of this record gives the nominal sampling interval and units.

(f) This record and the following title record start the parameter section. There are two records per parameter present.

(g) The parameter information record gives the BODC parameter name, whether the channel has been flagged with quality control indicators (Y/N), byte pointers (P and Q) to the start and end of the parameter within each datacycle record, the absent data value, minimum and maximum values of the parameter within the series and parameter storage units. The next record gives the full parameter name and the sampling method.

(h) This line indicates the number of following records which together form the FORTRAN format used to write each data cycle record.

(i) This and the next record are the data cycle title lines. 'f' indicates a flag channel.

(j) Data cycles are listed one per line. The first seven characters are always a data cycle count. One of the following quality control flags may appear against an individual data value (if the remark 'BODC QC' is present in record 1, then a blank flag indicates that the value is good):

Flag	Description
	Unqualified
<	Below detection limit
>	In excess of quoted value
B	Beginning of CTD downcast
D	Thermometric depth
E	End of CTD downcast
K	Uncertain/suspect value
L	Improbable value - originator's quality control
M	Improbable value - BODC quality control
N	Null value
P	Trace/calm
Q	Indeterminate
R	Replacement value
S	Estimated value
T	Interpolated value
W	Control value
X	Excessive difference

QXF Format

Introduction

QXF is a binary format developed within BODC to handle multidimensional data such as wave spectra, ADCP data and thermistor chains. A concise definition of multidimensional data is those data that have more than one independent variable. For example, for a thermistor chain temperature to make any sense, it must be labelled with both its date/time and sensor depth. Due to the overheads involved in software maintenance, it is proposed that QXF will become the standard BODC binary format. It will replace PXF and its ASCII analogue (BODC Request Format) that has previously been used by BODC for the distribution of time series data. For operational reasons, the SES CD-ROM represents a transitional stage and includes data in both QXF and BODC Request Format.

QXF is a customisation of Network Common Data Form (NetCDF) that was developed for data exchange within the atmospheric research community in the USA. Its purpose is to provide a vehicle for the platform-independent exchange of binary data. The format is well supported by the Unidata Program Center, managed by the University Corporation of Atmospheric Research on behalf of the US National Science Foundation. Interface software written in both C and FORTRAN is freely available on the Web. Users wishing to know more about NetCDF or wishing to write applications against QXF should consult the UCAR Web site (www.unidata.ucar.edu). Further support, in the form of C++ methods, is available to those wishing to program against QXF from BODC.

NetCDF Concepts and Terminology

NetCDF considers data to consist of a series of multidimensional arrays, each of which stores the values for a specified variable. Some arrays will have values for all dimensions, whilst other arrays have a lower number of dimensions. These may pertain to one or more dimensions of the multidimensional arrays. One of the dimensions, usually time, is unlimited in that the file may grow along that dimension. Fixed storage is allocated for the other dimensions.

Initially, this is a difficult concept to understand. The following example may help. Consider thermistor chain data where temperature is measured at a number of depths along a common time base. The minimum number of arrays required to store these data is three: temperature, time_stamp and sensor_depth. The temperature array is 2-dimensional (time, depth), time_stamp is 1-dimensional (time) and sensor_depth is also 1-dimensional

but this time the dimension is depth. The time dimension is set to be unlimited, whilst the depth dimension is fixed at the number of sensors on the thermistor chain.

In addition to the data arrays, NetCDF also stores attributes. These may be either global or variable-specific. Global attributes are used to store metadata that pertains to the entire data set. Variable-specific attributes are used to store such items as variables' names, absent data values, formats, minimum and maximum data values, etc.

Mapping Between QXF and NetCDF

The first consideration is the global attributes. The following global attributes have been included in QXF:

SERIDN	Series identifier
GOODFL	Flag character used to signify good data
NULLFL	Flag character used to signify null data
STOROP	Currently unused (set zero)
NSCHAN	Number of channels in the series
NSOFDA	Offset of free space within the series array
HEADSZ	Storage required besides data arrays
CYCLSZ	Storage required for one datacycle

The primary reason these variables are stored in the QXF file is that they are required by the BODC Series Class (see below). They may therefore be safely ignored by programmers developing applications outside the Series Class unless the information they contain proves useful.

The variable attributes stored are the absent data value (ABS), the minimum data value (MIN) and the maximum data value (MAX). Note that data units are not explicitly stored. The variable names used in QXF are BODC parameter codes. This implicitly specifies the storage unit because it is part of the parameter code definition. These definitions may be found in the SES Database or in the moored instrument data documentation.

QXF also includes quality control flag variables in addition to the data variables. These may be recognised and linked to their related data variable through their variable name. This is 9 bytes long instead of 8. The first byte is always 'F' and the other 8 bytes are the name of the associated data channel.

The QXF data on the SES CD-ROM have two dimensions specified: primary and secondary. The primary dimension is unlimited in size and represents time. The secondary dimension is limited to the number of measurement depths and represents measurement depth. Note that temperature probes

have been implemented in QXF as if they were single-bead thermistor chains.

One final complication requires some explanation. The time stamp in QXF is implemented as two variables rather than one to reflect the way in which date and time are handled within BODC. The first variable, AADYAA01, defines the date in terms of what is known locally as a Loch day number. This is the number of days that have elapsed since the start of the Gregorian calendar. Source code (FORTRAN and Pascal) is provided in the Underway Data Set section of this manual, which converts a Loch day number into year month and day. The second variable, AAFDZZ01, stores time as a floating-point day fraction (06:00 = 0.25, 12:00 = 0.5 etc.).

The BODC Series Class

Within BODC, QXF data files are interfaced through a C++ class known as the BODC Series Class. This concept, plus the associated class library, will be of great interest to anyone wishing to develop C++ applications against QXF files. Those who wish to know more are invited to contact BODC for further information (e-mail: bodcmail@ccms.uk.ac).

Making use of data in QXF

The first message to users who have access to a *Windows* system is that the easiest way to use the QXF data on the SES CD-ROM is via the BODC Moorings Explorer program. This handles both moored instrument data formats present on the CD-ROM with equal ease.

Users on other platforms will generally need to develop software if they wish to use the QXF data on the CD-ROM. Note that this is not restricted to conventional language programming: NetCDF data may be imported directly into packages such as *MatLab* and then manipulated through command language macros.

Another relatively simple route into the data is through the ‘ncdump’ utility. This general-purpose NetCDF to ASCII conversion utility is freely available for UNIX platforms.

BODC Mooring Explorer Software

The BODC Mooring Explorer is a *Windows* application that allows the moored instrument files on the CD-ROM to be plotted as stacked time series. The data may also be listed in a grid format that may be exported to other applications, such as spreadsheets. The mooring position may also be displayed overlaid on a map of GEBCO bathymetry.

The program has been tested successfully under *Windows95, Windows98* and *Windows NT 4.0*. It contains on-line help, including functional descriptions of all the menu options and control buttons. However, a brief description of how to get started is included here.

When the program is launched through either the BODC entry in the Start menu, a shortcut or *Windows Explorer*, a splash screen is briefly displayed followed by the opening of the program control window. The following actions are then required to display data.

- Select the Open Project option from the File menu and choose the project appropriate to the CD-ROM currently loaded.

- Click on the Select menu to open the Selection Dialog, which allows the series of interest to be specified. The form is in three parts. The top, 'Primary data selection criteria', allows various selection criteria to be specified. The result of this is to restrict the choices available in the other two sections to entries matching the selection. The selection may be refined, if desired through the 'Secondary data selection criterion' section. Once the number of series displayed in the bottom section of the form has been reduced to a manageable number, the series of interest may be chosen by a mouse left-click. Note that more than one series may be chosen at this stage.

- Press 'OK' to open the View Dialog. This controls the series, or part of a series, which is to be plotted or listed. The time interval, data channels and quality control flag values may all be used to restrict what is displayed. If you don't like working with parameter codes, right click in the Parameters Available window to get plain language definitions. This dialog may be opened at any time to update the selection criteria by selecting the Moorings option from the View menu.

- Click on one or more of the three large control buttons to open the plot window, data grid or mooring location map. The icons on the buttons clearly indicate which button does what.

This is all you need to do to access the data. Control over how the data are presented is provided through both the menus and the toolbar buttons. Consult the on-line help or simply experiment to discover what these can do.