LOIS SES Underway Data Documentation Index

The SES underway data documentation contains one document file for each underway data file. These contain data from either a cruise leg or an entire cruise. The following documents are included:

1995 Cruises

RRS Charles Darwin	CD91A	02 Mar 1995 to 22 Mar 1995
RRS Charles Darwin	CD91B	22 Mar 1995 to 02 Apr 1995
RRS Charles Darwin	CD92A	06 Apr 1995 to 12 Apr 1995
RRS Charles Darwin	CD92B	13 Apr 1995 to 01 May 1995
RRS Charles Darwin	CD93A	07 May 1995 to 16 May 1995
RRS Charles Darwin	CD93B	16 May 1995 to 30 May 1995
RRS Challenger	CH121A	10 Aug 1995 to 18 Aug 1995
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RRS Challenger	CH121C	01 Sep 1995 to 08 Sep 1995
RRS Challenger	CH123A	15 Nov 1995 to 29 Nov 1995
RRS Challenger	CH123B	01 Dec 1995 to 15 Dec 1995

1996 Cruises

RRS Challenger	CH125A	31 Jan 1996 to 11 Feb 1996
RRS Challenger	CH125B	13 Feb 1996 to 02 Mar 1996
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RRS Challenger	CH126B	27 Apr 1996 to 11 May 1996
RRS Challenger	CH128A	10 Jul 1996 to 25 Jul 1996
RRS Challenger	CH128B	27 Jul 1996 to 07 Aug 1996

<TIP> The hot links to the individual cruise documents are the BODC cruise mnemonics. These are used throughout the database to label data as belonging to that cruise.

Surface Underway Data for Cruise Charles Darwin CD91A (2nd March to 22nd March 1995)

1) Components of the Underway Data Set

The underway data set for cruise Charles Darwin 91A contains the following data channels. The single character following each channel is the appropriate channel identifier in the binary merge file.

Navigation:	Latitude (°N)	A
	Longitude (°E)	B
	Distance along track	K
	Carter corrected Bathymetric depth (m)	J
	Ship's Velocity North (knots)	#
	Ship's Velocity East (knots)	(
	Ship's Heading (°)	)

Note that the additional navigation channels have been included in this file to satisfy the requirement that a binary merge file should contain at least seven data channels.

2) Methodology Overview

2.1) Data acquisition

Data logging and initial data processing were handled by the RVS ABC logging system. The Level A sampling microcomputer digitised input voltages, applied a time stamp and transferred the data via the Level B disk buffer onto the Level C (a Sun OS Workstation) where the data records were assembled into files.

The Level C includes a suite of processing software that was used to apply initial calibrations to convert raw ADC counts into engineering units. At the end of the cruise, the Level C disk base was transferred to BODC for further processing.

2.2) BODC data processing procedures

Data from the underway files were merged into a common file (the binary merge file) using time as the primary linking key.

Each data channel was inspected on a graphics workstation and any spikes or periods of dubious data were flagged. Whenever possible, comparative screening checks between channels were employed.

3) Data Processing, Correction and Calibration Procedures

3.1) Navigation

GPS was the primary navigation system used on this cruise. At BODC a program was run which locates any null values in the latitude and longitude channels and checks to ensure that the ship's speed does not exceed 15 knots. Any speed anomalies were investigated and the offending position fixes were removed from the record. As far as possible, gaps were filled manually using entries from the bridge log. Any remaining gaps were filled by linear interpolation. The largest gap interpolated on this cruise was 10 minutes, commencing 15:07 on 11th March 1995.

Bathymetric depth was logged by the ABC system from an EA500 echo sounder. The data were Carter's table corrected and screened on a graphics workstation.

4) Data Warnings

For much of this cruise, SWATH multibeam bathymetry was switched on, and there were also two tows of a Side-scan sonar instrument. As a result, the bathymetry record from the echo sounder in the binary merge file provides incomplete coverage for the cruise.

In fact, only 10 minutes of data were logged. The only practical use of the binary merge file for this cruise is therefore to provide a full record of the cruise track covered.

Surface Underway Data for Cruise Charles Darwin CD91B (22nd March to 2nd April 1995)

1) Components of the Underway Data Set

The underway data set for cruise Charles Darwin 91B contains the following data channels. The single character following each channel is the appropriate channel identifier in the binary merge file.

Navigation:	Latitude (°N)	A
	Longitude (°E)	B
	Distance along track (km)	K
	Carter corrected Bathymetric depth (m)	J
	Ship's Velocity North (knots)	#
	Ship's Velocity East (knots)	(
	Ship's Heading (°)	)

Note that the additional navigation channels have been included in this file to satisfy the requirement that a binary merge file should contain at least seven data channels.

2) Methodology Overview

2.1) Data acquisition

Data logging and initial data processing were handled by the RVS ABC logging system. The Level A sampling microcomputer digitised input voltages, applied a time stamp and transferred the data via the Level B disk buffer onto the Level C (a Sun OS Workstation) where the data records were assembled into files.

The Level C includes a suite of processing software that was used to apply initial calibrations to convert raw ADC counts into engineering units. At the end of the cruise, the Level C disk base was transferred to BODC for further processing.

2.2) BODC data processing procedures

Data from the underway files were merged into a common file (the binary merge file) using time as the primary linking key.

Each data channel was inspected on a graphics workstation and any spikes or periods of dubious data were flagged. Whenever possible, comparative screening checks between channels were employed.

3) Data Processing, Correction and Calibration Procedures

3.1) Navigation

GPS was the primary navigation system used on this cruise. At BODC a program was run which locates any null values in the latitude and longitude channels and checks to ensure that the ship's speed does not exceed 15 knots. Any speed anomalies were investigated and the offending position fixes were removed from the record. As far as possible, gaps were filled manually using entries from the bridge log. Any remaining gaps were filled by linear interpolation. The largest gap interpolated on this cruise was 7 minutes, commencing 08:01 on 2nd April 1995.

Bathymetric depth was logged by the ABC system from an EA500 echo sounder. The data were Carter's table corrected and screened on a graphics workstation.

The echo sounder record for this cruise suffered from interference from the depth sounding pinger deployed on the CTD frame, and seems to exhibit a ranging problem. Suspicious segments of depth data were compared with BGS contour maps of the region and flagged accordingly.

4) Data Warnings

None.

Surface Underway Data for Cruise Charles Darwin CD92A (6th April to 12th April 1995)

1) Components of the Underway Data Set

The underway data set for cruise Charles Darwin 92A contains the following data channels. The single character following each channel is the appropriate channel identifier in the binary merge file.

Navigation:	Latitude (°N)	A
	Longitude (°E)	B
	Distance along track (km)	K
	Carter corrected Bathymetric depth (m)	J
	Ship’s Velocity North (knots)	#
	Ship’s Velocity East (knots)	(
	Ship’s Heading (°)	)

Note that the additional navigation channels have been included in this file to satisfy the requirement that a binary merge file should contain at least seven data channels.

2) Methodology Overview

2.1) Data acquisition

Data logging and initial data processing were handled by the RVS ABC logging system. The Level A sampling microcomputer digitised input voltages, applied a time stamp and transferred the data via the Level B disk buffer onto the Level C (a Sun OS Workstation) where the data records were assembled into files.

The Level C includes a suite of processing software that was used to apply initial calibrations to convert raw ADC counts into engineering units. At the end of the cruise, the Level C disk base was transferred to BODC for further processing.

2.2) BODC data processing procedures

Data from the underway files were merged into a common file (the binary merge file) using time as the primary linking key.

Each data channel was inspected on a graphics workstation and any spikes or periods of dubious data were flagged. Whenever possible, comparative screening checks between channels were employed.

3) Data Processing, Correction and Calibration Procedures

3.1) Navigation

GPS was the primary navigation system used on this cruise. At BODC a program was run which locates any null values in the latitude and longitude channels and checks to ensure that the ship's speed does not exceed 15 knots. Any speed anomalies were investigated and the offending position fixes identified as the cause were removed from the record. As far as possible, gaps were filled manually using entries from the bridge log. Any remaining gaps were filled by linear interpolation. The largest gap interpolated on this cruise was 1 minute, commencing 02:01 on 8th April 1995.

Bathymetric depth was logged by the ABC system from a PES fish deployed from the side of the ship. The data were Carter's table corrected and screened on a graphics workstation.

There was some loss of depth data during deployments of the multicorer due to interference from the bottom ranging pinger employed on the frame.

4) Data Warnings

None.

Surface Underway Data for Cruise Charles Darwin CD92B (13th April to 1st May 1995)

1) Components of the Underway Data Set

The underway data set for cruise Charles Darwin 92B contains the following data channels. The single character following each channel is the appropriate channel identifier in the binary merge file.

Navigation:	Latitude (°N)	A
	Longitude (°E)	B
	Distance along track (km)	K

Note that there are four additional channels in the file (labelled C, J, (, and #). These are dummy channels (filled with null values) that have been included to satisfy the requirement that a binary merge file should contain at least seven data channels.

2) Methodology Overview

2.1) Data acquisition

Data logging and initial data processing were handled by the RVS ABC logging system. The Level A sampling microcomputer digitised input voltages, applied a time stamp and transferred the data via the Level B disk buffer onto the Level C (a Sun OS Workstation) where the data records were assembled into files.

The Level C includes a suite of processing software that was used to apply initial calibrations to convert raw ADC counts into engineering units. At the end of the cruise, the Level C disk base was transferred to BODC for further processing.

2.2) BODC data processing procedures

Data from the underway files were merged into a common file (the binary merge file) using time as the primary linking key.

Each data channel was inspected on a graphics workstation and any spikes or periods of dubious data were flagged. Whenever possible, comparative screening checks between channels were employed.

3) Data Processing, Correction and Calibration Procedures

3.1) Navigation

GPS was the primary navigation system used on this cruise. At BODC a program was run which locates any null values in the latitude and longitude channels and checks to ensure that the ship's speed does not exceed 15 knots. Any speed anomalies were investigated and the offending position fixes identified as the cause were removed from the record. As far as possible, gaps were filled manually using entries from the bridge log. Any remaining gaps were filled by linear interpolation.

4) Data Warnings

None.

Surface Underway Data for Cruise
Charles Darwin CD93A (7th May to 16th May 1995)

1) Components of the Underway Data Set

The underway data set for cruise Charles Darwin 93A contains the following data channels. The single character following each channel is the appropriate channel identifier in the binary merge file.

Navigation:	Latitude (°N)	A
	Longitude (°E)	B
	Carter corrected bathymetric depth (m)	J
Physics:	Temperature (°C)	C
	Optical attenuance (m^{-1})	I
Meteorology:	Photosynthetically Available Radiation (W m^{-2})	L
Biology:	Chelsea Instruments fluorescence (V)	?
	Chelsea Instruments chlorophyll (mg m^{-3})	!

2) Methodology Overview

2.1) Plumbing

Sea water was continually pumped from the hull of the ship (at a depth of about 2.5m) through the various underway sensors on-deck. This is known as the ship's non-toxic supply. An outlet from this, situated in the ship's wet laboratory, was used to collect the calibration samples for the underway sensors.

2.2) Data acquisition

Data logging and initial data processing were handled by the RVS ABC logging system. The Level A sampling microcomputer digitised an input voltage, applied a time stamp and transferred the data via the Level B disk buffer onto the Level C (a Sun OS Workstation) where the data records were assembled into files.

The Level C includes a suite of processing software that was used to apply initial calibrations to convert raw ADC counts into engineering units. At the end of the cruise, the Level C disk base was transferred to BODC for further processing.

2.3) BODC data processing procedures

Data from the underway files were merged into a common file (the binary merge file) using time as the primary linking key. Data logged as voltages (e.g. PAR) were converted to scientific units.

Each data channel was inspected on a graphics workstation and any spikes or periods of dubious data were flagged. Whenever possible, comparative screening checks between channels were employed.

3) Data Processing, Correction and Calibration Procedures

3.1) Navigation

GPS was the primary navigation system used on this cruise. At BODC a program was run which located any null values in the latitude and longitude channels and checked to ensure that the ship's speed did not exceed 15 knots. Any speed anomalies were investigated and the offending position fixes identified as the cause were removed from the record. As far as possible, gaps were filled manually using entries from the bridge log. Any remaining gaps were filled by linear interpolation. The largest gap interpolated on this cruise was 3 minutes, commencing 21:30 on 11th May 1995.

Bathymetric depth was logged by the ABC system from an RD200A echo sounder. The data were Carter's table corrected and screened on a graphics workstation. Inspection of the data revealed the record to be of generally good quality with relatively few spikes. The only problem with the data was that a large number of gaps, filled with either total garbage or pinger interference, were observed. All data in these gaps have been flagged suspect.

3.2) Physics

Temperature and Salinity

Temperature and salinity were measured using an improvised thermosalinograph based on SeaBird CTD components fitted into the non-toxic supply. The temperature sensor was a thermistor mounted in the water inlet manifold. Conductivity was measured by a unit in the ship's wet lab which included a second thermistor to provide temperature for the computation of salinity.

The raw ADC counts were processed into conductivity and two temperature channels based upon laboratory calibrations by RVS. Salinity was computed from the housing temperature and conductivity using the UNESCO 1978 Practical Salinity Scale (Fofonoff and Millard, 1982).

The thermosalinograph was calibrated against surface values taken from the calibrated CTD data set for this cruise. The salinity data had obvious problems (value range 27 to 29 PSU) and they have been deleted from the data set. Temperature, however, exhibited a constant offset from the CTD throughout the cruise and was corrected as follows:

$$T_{cal} = T - 0.00852$$

Inspection of the temperature channel revealed an exceptionally clean record with just a small number of obvious spikes to be flagged.

Optical Attenuance

Optical attenuance was measured using a SeaTech red light (661nm) transmissometer with a 25cm optical path length mounted in a light-tight box fed from the non-toxic supply.

A transmission air reading (4.778 V) taken during the cruise was used to correct the transmissometer voltage to the manufacturer's specified voltage (4.823 V) by ratio. The voltages were then converted to attenuance eliminating the influence of path length using the equation:

$$\text{Attenuance} = -4.0 * \log_e (\text{voltage} / 5.0)$$

The data were then screened. The record was exceptionally clean, with virtually no 'bubble spikes'. In general there was good correspondence with the fluorometer record. However, there were a number of examples in the record where peaks in the fluorometer trace produced no reaction from the transmissometer.

3.3) Meteorology

Photosynthetically Available Radiation

PAR (scalar irradiance) was measured using PML 2π PAR sensors mounted on gimballed supports on each side of the ship's monkey island. This arrangement attempted to ensure that when one sensor was in shadow, the other was not.

The PAR meters were logged as voltages and converted to W m^{-2} by BODC using coefficients determined in February 1990 supplied by RVS. The equations used were:

Port (#4): $PAR(W\ m^{-2}) = \exp(5.139*volts + 7.2376)/100$
Starboard (#9): $PAR(W\ m^{-2}) = \exp(5.052*volts + 6.7874)/100$

After spikes had been flagged, taking the greater of the port and starboard values produced a merged PAR channel. This reduced shading artefacts to a minimum.

3.4) Biology

Chlorophyll

Chlorophyll was measured by a Chelsea Instruments Aquatracka fluorometer immersed in a light-tight box.

The fluorometer voltages were converted to chlorophyll concentrations by linear regression of the natural logarithm of discrete chlorophyll concentrations (fluorometrically analysed filtered non-toxic supply samples) against corresponding fluorometer voltages. The following equation resulted and was used to generate the chlorophyll channel in the binary merge file.

$$\text{Chlorophyll (mg m}^{-3}) = \exp(2.10 * \text{volts} - 3.59) \quad (R^2 = 66.6\%)$$

4) Data Warnings

The salinity data from this cruise could not be realistically calibrated (data values in the range 27-29 PSU that showed no systematic relationship to the CTD data set) and have been deleted from the data set.

5) Reference

Fofonoff, N.P. and Millard Jr., R.C. (1983). Algorithms for Computation of Fundamental Properties of Seawater. ***UNESCO Technical Papers in Marine Science*** 44.

Surface Underway Data for Cruise
Charles Darwin CD93B (16th May to 30th May 1995)

1) Components of the Underway Data Set

The underway data set for cruise Charles Darwin 93B contains the following data channels. The single character following each channel is the appropriate channel identifier in the binary merge file.

Navigation:	Latitude (°N)	A
	Longitude (°E)	B
	Carter corrected bathymetric depth (m)	J
Physics:	Temperature (°C)	C
	Salinity (PSU)	F
	Optical attenuance (m^{-1})	I
Meteorology:	Photosynthetically available radiation ($W\ m^{-2}$)	L
Biology:	Chelsea Instruments fluorescence (V)	?
	Chelsea Instruments chlorophyll ($mg\ m^{-3}$)	!

2) Methodology Overview

2.1) Plumbing

Seawater was continually pumped from the hull of the ship (at a depth of about 2.5m) through the various underway sensors on-deck. This is known as the ship's non-toxic supply. An outlet from this, situated in the ship's wet laboratory, was used to collect the calibration samples for the underway sensors.

2.2) Data acquisition

Data logging and initial data processing were handled by the RVS ABC logging system. The Level A sampling microcomputer digitised an input voltage, applied a time stamp and transferred the data via the Level B disk buffer onto the Level C (a Sun OS Workstation) where the data records were assembled into files.

The Level C includes a suite of processing software that was used to apply initial calibrations to convert raw ADC counts into engineering units. At the

end of the cruise, the Level C disk base was transferred to BODC for further processing.

2.3) BODC data processing procedures

Data from the underway files were merged into a common file (the binary merge file) using time as the primary linking key. Data logged as voltages (e.g. PAR) were converted to scientific units.

Each data channel was inspected on a graphics workstation and any spikes or periods of dubious data were flagged. Whenever possible, comparative screening checks between channels were employed.

3) Data Processing, Correction and Calibration Procedures

3.1) Navigation and Bathymetry

GPS was the primary navigation system used on this cruise. At BODC a program was run which located any null values in the latitude and longitude channels and checked to ensure that the ship's speed did not exceed 15 knots. Any speed anomalies were investigated and the offending position fixes were removed from the record. As far as possible, gaps were filled manually using entries from the bridge log. Any remaining gaps were filled by linear interpolation. The largest gap interpolated on this cruise was 2 minutes, commencing 10:01 on 26th May 1995.

Bathymetric depth was logged by the ABC system from an RD200A echo sounder. The data were Carter's table corrected and screened on a graphics workstation. The bathymetry record was mostly clean but did contain some noisy patches and obvious interference from pingers. These have been flagged as suspect.

The depth record whilst the ship was on station in some 1500m of water between 18:00 on 25/05/1995 and 14:00 on 26/06/1995 is somewhat curious. There were repeated bursts of noisy data that seemed to form a regular pattern. It was unclear whether these represented the ship drifting repeatedly over a real uneven feature or a recurring artefact. These data have been left unflagged.

3.2) Physics

<u>Temperature and Salinity</u>

Temperature and salinity were measured using an improvised thermosalinograph based on SeaBird CTD components fitted into the non-toxic supply. The temperature sensor was a thermistor mounted in the water inlet manifold. Conductivity was measured by a unit in the ship's wet laboratory that included a second thermistor to provide temperature for the computation of salinity.

The raw ADC counts were processed into conductivity and two temperature channels based upon laboratory calibrations by RVS. Salinity was computed from the housing temperature and conductivity using the UNESCO 1978 Practical Salinity Scale (Fofonoff and Millard, 1982).

The thermosalinograph was calibrated against surface values taken from the calibrated CTD data set for this cruise. Both channels exhibited an offset from the calibrated CTD data and were corrected as follows:

$$T_{cal} = T - 0.00987$$
$$S_{cal} = S + 0.01932$$

Visual examination of the salinity data revealed a number of occurrences of low (by up to 0.5 PSU) salinity water in the SES area. Some of these were obviously real phenomena that were corroborated by CTD, salinity and attenuance data. However, one event between 18:45 on 20/05/1995 and 00:40 on 21/05/1995 showed no correlation with temperature and attenuance and was absent from the CTD data. Consequently, the event has been labelled as an instrumental artefact and the data from this interval have all been flagged suspect.

Inspection of the temperature channel showed the signal to be generally low noise but with a number of large spikes, usually 1-2 degrees low. However, these were easy to identify with confidence and they have been flagged suspect. There are a number of periods during the record where the noise level increases significantly. These have been attributed to the presence of a shallow thermocline and have been left unflagged.

Optical Attenuance and Sediment Load

Optical attenuance was measured using a SeaTech red light (661nm) transmissometer with a 25cm optical path length mounted in a light-tight box on the starboard deck fed from the non-toxic supply.

A transmission air reading taken during the cruise (4.778 V) was used to correct the transmissometer voltage to the manufacturer’s specified voltage (4.823 V) by ratio. The voltages were then converted to attenuance eliminating the influence of path length on transmission using the equation:

$$\text{Attenuance} = -4.0 * \log_e (\text{voltage} / 5.0)$$

The data were then screened and any spikes flagged. The attenuance record was virtually free from the characteristic 'bubble spikes' but included a large number of obvious single-cycle spikes. These have all been flagged as suspect. There is good agreement in the forms of the fluorometer and transmissometer records.

3.3) Meteorology

Photosynthetically Available Radiation

PAR was measured using PML 2π PAR sensors mounted on gimballed supports on each side of the ship's monkey island. This arrangement attempted to ensure that when one sensor was in shadow, the other was not.

The PAR meters were logged as voltages and converted to W m^{-2} by BODC using coefficients determined in February 1990 supplied by RVS. The equations used were:

Port (#4): PAR(W m^{-2}) = exp (5.139*volts + 7.2376)/100
Starboard (#9): PAR(W m^{-2}) = exp (5.052*volts + 6.7874)/100

After spikes had been flagged, taking the greater of the port and starboard values produced a merged PAR channel. This reduced shading artefacts to a minimum.

3.4) Biology

Chlorophyll

Chlorophyll was measured by a Chelsea Instruments Aquatracka fluorometer immersed in a light-tight box.

The fluorometer voltages were converted to chlorophyll concentrations by linear regression of the natural logarithm of discrete chlorophyll concentrations (fluorometrically analysed filtered non-toxic supply samples) against corresponding fluorometer voltages. The following equation resulted and was used to generate the chlorophyll channel in the binary merge file.

$$\text{Chlorophyll (mg m}^{-3}\text{)} = \exp(2.12 * \text{volts} - 3.59) \quad (R^2 = 66.6\%)$$

4) Data Warnings

None.

5) Reference

Fofonoff, N.P. and Millard Jr., R.C. (1983). Algorithms for Computation of Fundamental Properties of Seawater. ***UNESCO Technical Papers in Marine Science*** 44.

Surface Underway Data for Cruise Challenger CH121A (10th August to 18th August 1995)

1) Components of the Underway Data Set

The underway data set for cruise Challenger 121A contains the following data channels. The single character following each channel is the appropriate channel identifier in the binary merge file.

Navigation:	Latitude (°N)	A
	Longitude (°E)	B
	Carter corrected Bathymetric depth (m)	J
Physics:	Temperature (°C)	C
	Salinity (PSU)	F
	Optical Attenuance (m^{-1})	I
Meteorology:	Photosynthetically Available Radiation (W m^{-2})	L
	Solar radiation (W m^{-2})	O
Biology:	Aquatracka fluorometer output (V)	?
	Aquatracka chlorophyll (mg m^{-3})	!

2) Methodology Overview

2.1) Plumbing

Seawater was continually pumped from the hull of the ship (at a depth of about 4m) through the various underway sensors on-deck. This is known as the ship's non-toxic supply. An outlet of this, situated in the ship's wet lab, was used to collect the calibration samples for the underway sensors.

2.2) Data acquisition

Data logging and initial data processing were handled by the RVS ABC logging system. The Level A sampling microcomputer digitised input voltages, applied a time stamp and transferred the data via the Level B disk buffer onto the Level C (a Sun OS Workstation) where the data records were assembled into files.

The Level C includes a suite of processing software that was used to apply initial calibrations to convert raw ADC counts into engineering units. At the

end of the cruise, the Level C disk base was transferred to BODC for further processing.

2.3) BODC data processing procedures

Data from the underway files were merged into a common file (the binary merge file) using time as the primary linking key. Data logged as voltages (e.g. PAR) were converted to engineering units.

Each data channel was inspected on a graphics workstation and any spikes or periods of dubious data were flagged. Whenever possible, comparative screening checks between channels were employed.

3) Data Processing, Correction and Calibration Procedures

3.1) Navigation

GPS was the primary navigation system used on this cruise. At BODC a program was run which located any null values in the latitude and longitude channels and checked to ensure that the ship's speed did not exceed 15 knots. Any speed anomalies were investigated and the offending position fixes were removed from the record. As far as possible, gaps were filled manually using entries from the bridge log. Any remaining gaps were filled by linear interpolation.

The largest gap interpolated on this cruise was 22 minutes, commencing 10:35 on 12th August 1995. There were no speed check failures.

Bathymetric depth was logged by the ABC system from an RD200A echo sounder. The data were Carter's table corrected and screened on a graphics workstation. Visual inspection revealed the data to be of exceptionally good quality.

3.2) Physics

<u>Temperature and Salinity</u>

Temperature and salinity were measured using an autoranging TSG103 thermosalinograph. The temperature sensor was a thermistor in the non-toxic supply inlet manifold. Conductivity was measured by a unit in the ship's wet laboratory that included a second thermistor to provide temperature for the computation of salinity.

The raw ADC counts were processed into conductivity and two temperature channels based upon laboratory calculations by RVS. Salinity was computed from the housing temperature and conductivity using the UNESCO 1978 Practical Salinity Scale (Fofonoff and Millard, 1982).

The thermosalinograph was calibrated against surface values taken from the calibrated CTD data set for this cruise. Both channels exhibited an offset from the calibrated CTD data set and were corrected as follows:

$$T_{cal} = T - 0.036$$
$$S_{cal} = S + 0.041$$

Optical Attenuance

Optical attenuance was measured using a SeaTech red light (661nm) transmissometer with a 25cm optical path length mounted in a light-tight box on the starboard deck fed from the non-toxic supply.

A transmission air reading taken during the cruise (4.780 V) was used to correct the transmissometer voltage to the manufacturer’s specified voltage (4.806) by ratio. The voltages were then converted to attenuance eliminating the influence of path length on transmission using the equation:

$$\text{Attenuance} = -4.0 * \log_e (\text{voltage} / 5.0)$$

The data were then screened and any spikes flagged. This procedure revealed that the instrument didn't start to record sensible data until 12:00 on 12/08/1995. The signal between this time and 06:30 on 13/08/1995 comprises sensible data with some strange features, obviously associated with instrument malfunction. Whilst the obviously erroneous data have been flagged suspect, it is advised that all data prior to 06:30 on 13/08/1995 be used with caution. After this time, the problems with the instrument had obviously been resolved providing an unusually clean signal with just a small number of isolated 'bubble spikes'.

The attenuance signal closely follows the form of the fluorometer signal throughout the cruise.

3.3) Meteorology

Photosynthetically Available Radiation

PAR was measured using PML 2π PAR sensors mounted on gimballed supports on each side of the ship’s monkey island. This arrangement attempts to ensure that when one sensor is in shadow, the other is not.

The PAR meters were logged as voltages and converted to W m^{-2} by BODC using coefficients determined in August 1995 supplied by RVS. The equations used were:

Port (#5): $PAR(W\ m^{-2}) = \exp(4.910*volts + 6.952)/100$
Starboard (#3): $PAR(W\ m^{-2}) = \exp(4.970*volts + 6.526)/100$

After spikes had been flagged, a merged PAR channel was produced containing the larger of the port and starboard values to eliminate shading effects.

Solar Radiation

Two Kipp and Zonen instruments mounted on the same platforms as the PAR sensors measured solar radiation. These are unique in as much as they are connected to a data integrator that converted the instrument voltages into W/m^2 and integrated the values to produce 10 minute and running total integrations in kJ/m^2. A Level A logged the output from the integrator at the end of each integration period.

At BODC, the 10 minute integrations were merged into the underway file by a custom program that divided the integrated energy by the integration interval to give an averaged irradiance value. The time stamp was also adjusted to the mid-point of the averaging interval by subtracting 5 minutes.

A merged solar radiation channel was produced, after spikes were flagged out, by taking the maximum of the port and starboard values to eliminate shading effects.

3.4) Biology

Chlorophyll

Chlorophyll was measured by a Chelsea Instruments Aquatracka fluorometer immersed in a light-tight box.

The fluorometer voltages were converted to chlorophyll concentrations by linear regression of the natural logarithm of discrete chlorophyll concentrations (fluorometrically analysed filtered non-toxic supply samples) against corresponding fluorometer voltages. The following equation resulted and was used to generate the chlorophyll channel in the binary merge file.

$$\text{Chlorophyll (mg m}^{-3}\text{)} = \exp(0.795 * \text{volts} - 2.58) \qquad (n=17;\ R^2 = 77.4\%)$$

Visual inspection of the chlorophyll data revealed that the fluorometer didn't start to return sensible data until 09:45 on 12/08/1995. A couple of small (0.1 mg/m^3) upwards steps in the calibrated signal were observed following instrument maintenance at 06:25 on 13/08/1995 and 19:20 on 15/08/1995.

4) Data Warnings

Transmissometer data prior to 06:30 on 13/08/1995 should be used with caution.

The fluorometer didn't start to return sensible data until 09:45 on 12/08/1995. A couple of small (0.1 mg/m^3) upwards steps in the calibrated signal were observed following instrument maintenance at 06:25 on 13/08/1995 and 19:20 on 15/08/1995.

5) Reference

Fofonoff, N.P. and Millard Jr., R.C. (1983). Algorithms for Computation of Fundamental Properties of Seawater. ***UNESCO Technical Papers in Marine Science*** 44.

Surface Underway Data for Cruise Challenger CH121B (18th August to 1st September 1995)

1) Components of the Underway Data Set

The underway data set for cruise Challenger 121B contains the following data channels. The single character following each channel is the appropriate channel identifier in the binary merge file.

Navigation:	Latitude (°N)	A
	Longitude (°E)	B
	Carter corrected Bathymetric depth (m)	J
Physics:	Temperature (°C)	C
	Salinity (PSU)	F
	Optical Attenuance (m^{-1})	I
Meteorology:	Photosynthetically Available Radiation (W m^{-2})	L
	Solar radiation (W m^{-2})	O
Biology:	Aquatracka fluorometer output (V)	?
	Aquatracka chlorophyll (mg m^{-3})	!

2) Methodology Overview

2.1) Plumbing

Seawater was continually pumped from the hull of the ship (at a depth of about 4m) through the various underway sensors on-deck. This is known as the ship's non-toxic supply. An outlet of this, situated in the ship's wet lab, was used to collect the calibration samples for the underway sensors.

2.2) Data acquisition

The RVS ABC logging system handled data logging and initial data processing. The Level A sampling microcomputer digitised an input voltage, applied a time stamp and transferred the data via the Level B disk buffer onto the Level C (a Sun OS Workstation) where the data records were assembled into files.

The Level C includes a suite of processing software that was used to apply initial calibrations to convert raw ADC counts into engineering units. At the

end of the cruise, the Level C disk base was transferred to BODC for further processing.

2.3) BODC data processing procedures

Data from the underway files were merged into a common file (the binary merge file) using time as the primary linking key. Data logged as voltages (e.g. PAR) were converted to engineering units.

Each data channel was inspected on a graphics workstation and any spikes or periods of dubious data were flagged. Whenever possible, comparative screening checks between channels were employed.

3) Data Processing, Correction and Calibration Procedures

3.1) Navigation

GPS was the primary navigation system used on this cruise. At BODC a program was run which locates any null values in the latitude and longitude channels and checks to ensure that the ship's speed does not exceed 15 knots. Any speed anomalies were investigated and the offending position fixes were removed from the record. As far as possible, gaps were filled manually using entries from the bridge log. Any remaining gaps were filled by linear interpolation.

There were no speed check failures. The largest gap interpolated on this cruise was 31 minutes, commencing 10:25 on 31st August 1995.

Bathymetric depth was logged by the ABC system from an RD200A echo sounder. The data were Carter's table corrected and screened on a graphics workstation. Visual inspection of the data revealed them to be of higher than usual quality with relatively few spikes and data dropout.

3.2) Physics

<u>Temperature and Salinity</u>

Temperature and salinity were measured using an autoranging TSG103 thermosalinograph. The temperature sensor was a thermistor in the non-toxic supply inlet manifold. Conductivity was measured by a unit in the ship's wet laboratory that included a second thermistor to provide temperature for the computation of salinity.

The raw ADC counts were processed into conductivity and two temperature channels based upon laboratory calculations by RVS. Salinity was computed from the housing temperature and conductivity using the UNESCO 1978 Practical Salinity Scale (Fofonoff and Millard, 1982).

The thermosalinograph was calibrated against surface values taken from the calibrated CTD data set for this cruise.

The salinity calibration revealed a worrying feature in the salinity data from this cruise. A number of low salinity features could be identified in the record. Where these coincided with CTD casts the evidence from the CTD was that these features simply did not exist. The most spectacular of these occurred between 22:50 on 26/08/1995 and 06:00 on 28/08/1995 where the thermosalinograph salinity oscillated between 34.85 and 35.33 whereas CTD surface salinities for this period ranged between 35.234 and 35.338. Further, less dramatic low salinity features, at least one of which was discredited by CTD evidence, were identified between the break in the record at 03:20 on 21/08/1995 and the dramatic feature documented above.

The conclusion of the salinity quality control for this leg was that low salinity features in the data were artefacts. During the following cruise leg, low salinity features of similar amplitude were present that were corroborated by CTD evidence and are believed to be real. Users concerned about the development of low salinity surface water on the shelf break are invited to re-examine the evidence to see if they come to the same conclusions.

The action taken was to flag out any low salinity features unsupported by CTD evidence. **However, users are strongly advised to use any of the thermosalinograph salinity data, whether flagged or not, between 03:20 on 21/08/1995 and 06:00 on 28/08/1995 with extreme caution.** The data before and especially after this period appear to be of acceptable quality.

Separate calibrations were determined for data prior to the 'problem period', the 'problem period' itself and for data following it. The corrections obtained, and subsequently applied to the data, were:

18/08/1995 15:02 to 21/08/1995 03:20	$S_{cal} = S + 0.044$
21/08/1995 03:20 to 28/08/1995 06:00	$S_{cal} = S + 0.054$
28/08/1995 06:00 to 01/09/1995 07:14	$S_{cal} = S + 0.071$

The temperature record was particularly noisy, especially prior to 21/08/1995. Much of the noise may be attributed to the development of shallow uneven thermoclines associated with strong solar heating and calm seas. Another possible source of intermittent noise was electrical interference from a faulty item of equipment in the engine room identified on a later SES cruise. Where possible, obvious artefact noise spikes have been flagged suspect. However, this procedure ran into problems where it was difficult to distinguish signal from noise.

The presence of high noise levels in the thermosalinograph temperature signal makes accurate calibration against CTD data difficult. As a result, users who require a data quality standard where individual data points are more accurate than 0.25 °C should use the temperature data with caution.

However, the quality of the data should prove adequate for most oceanographic purposes.

The temperature record contained a number of obvious small steps (of the order 0.1 °C). The calibration was subdivided into segments between these steps giving rise to a series of temperature corrections as follows:

18/08/95 15:02:00 to 22/08/95 04:55:00	$T_{cal} = T + 0.123$
22/08/95 04:55:30 to 22/08/95 06:29:30	$T_{cal} = T - 0.027$
22/08/95 06:30:00 to 22/08/95 12:19:00	$T_{cal} = T + 0.123$
22/08/95 12:19:30 to 22/08/95 12:37:00	$T_{cal} = T + 0.038$
22/08/95 12:37:30 to 30/08/95 21:50:30	$T_{cal} = T + 0.123$
30/08/95 21:51:00 to 30/08/95 22:26:00	$T_{cal} = T - 0.027$
30/08/95 22:26:30 to 31/08/95 01:54:00	$T_{cal} = T + 0.123$
31/08/95 01:54:30 to 31/08/95 02:27:30	$T_{cal} = T - 0.027$
31/08/95 02:28:00 to 31/08/95 04:07:00	$T_{cal} = T + 0.123$
31/08/95 04:07:30 to 31/08/95 04:48:00	$T_{cal} = T - 0.047$
31/08/95 04:48:30 to 31/08/95 06:46:30	$T_{cal} = T + 0.123$
31/08/95 06:47:00 to 31/08/95 07:43:30	$T_{cal} = T - 0.022$
31/08/95 07:44:00 to 01/09/95 07:14:00	$T_{cal} = T + 0.123$

<u>Optical Attenuance</u>

Optical attenuance was measured using a SeaTech red light (661nm) transmissometer with a 25cm optical path length mounted in a light-tight box on the starboard deck fed from the non-toxic supply.

Transmission air readings taken during the cruise (4.780 V) were used to correct the transmissometer voltage to the manufacturer's specified voltage (4.806 V) by ratio. The voltages were then converted to attenuance eliminating the influence of path length on transmission using the equation:

$$\text{Attenuance} = -4.0 * \log_e (\text{voltage} / 5.0)$$

The calibrated data were quality controlled using an interactive graphical editor. Examination of the record revealed that the data at the start of the cruise were exceptionally clean, indicating calm seas. This provides supporting evidence that the temperature noise at the start of the thermosalinograph was due to a shallow thermocline. Serious noise from bubble spikes was encountered from 02:00 to 07:00 on 23/08/1995 and 22:45 on 26/08/1995 until 00:00 on 28/08/1995 where segments of data up to two hours duration had to be flagged completely. Isolated bubble spikes occurred elsewhere in the record and these have all been flagged.

In addition to the bubble spikes, there was evidence of other problems. The measured attenuance between 12:30 and 15:00 on 22/08/1995 was anomalously low bounded by periods of severe noise. All affected data were flagged suspect. There is a corresponding problem with the fluorometer data.

As both instruments were mounted in the same box this problem was probably due to an interruption in its water supply.

At 15:20 on 30/08/1995 there was a burst of severe noise followed by a marked downward step in attenuance. The data continued low, with no corresponding upward step, until the end of the cruise. This problem was 'fixed' by applying a correction of 0.362 per m to all data after 15:23 on 30/08/1995. This correction was simply the value required to remove the step from the data. There is a possibility that the data following the 'step' were correct and that all the preceding data were, in fact, too high. However, this is not believed to be the case.

3.3) Meteorology

Photosynthetically Available Radiation

PAR was measured using PML 2π PAR sensors mounted on gimballed supports on each side of the ship's monkey island. This arrangement attempts to ensure that when one sensor is in shadow, the other is not.

The PAR meters were logged as voltages and converted to W m^{-2} by BODC using coefficients determined in August 1995 supplied by RVS. The equations used were:

Port (#5): PAR(W m^{-2}) = exp (4.910*volts + 6.952)/100
Starboard (#3): PAR(W m^{-2}) = exp (4.970*volts + 6.526)/100

After spikes had been flagged, a merged PAR channel was produced containing the larger of the port and starboard values to eliminate shading effects.

Solar Radiation

Two Kipp and Zonen instruments mounted on the same platforms as the PAR sensors measured solar radiation. These are unique in as much as they are connected to a data integrator that converted the instrument voltages into W/m^2 and integrated the values to produce 10 minute and running total integrations in kJ/m^2. A Level A logged the output from the integrator at the end of each integration period.

At BODC, the 10 minute integrations were merged into the underway file by a custom program that divided the integrated energy by the integration interval to give an averaged irradiance value. The time stamp was also adjusted to the mid-point of the averaging interval by subtracting 5 minutes.

A merged solar radiation channel was produced, after spikes were flagged out, by taking the maximum of the port and starboard values to eliminate shading effects.

3.4) Biology

Chlorophyll

Chlorophyll was measured by a Chelsea Instruments Aquatracka fluorometer immersed in a light-tight box.

The fluorometer voltages were converted to chlorophyll concentrations by linear regression of the natural logarithm of discrete extracted chlorophyll concentrations (fluorometrically analysed filtered non-toxic supply samples) against corresponding fluorometer voltages. The following equation resulted and was used to generate the chlorophyll channel in the binary merge file.

Chlorophyll (mg m^{-3}) = exp (0.985 * volts - 3.58) (n=60; R^2 = 57%)

4) Data Warnings

The thermosalinograph salinity data between 03:20 on 21/08/1995 and 06:00 on 28/08/1995 contain numerous low salinity features that are unsupported by CTD data. It is recommended that the salinity data from this period are used with extreme caution.

The thermosalinograph temperatures at the start of the cruise were exceptionally noisy but this is believed to be a real phenomenon.

An empirical correction was applied to the attenuance data after 15:23 on 30/08/1995 to remove a step artefact from the data.

5) Reference

Fofonoff, N.P. and Millard Jr., R.C. (1983). Algorithms for Computation of Fundamental Properties of Seawater. ***UNESCO Technical Papers in Marine Science*** 44.

Surface Underway Data for Cruise Challenger CH121C (1st September to 8th September 1995)

1) Components of the Underway Data Set

The underway data set for cruise Challenger 121C contains the following data channels. The single character following each channel is the appropriate channel identifier in the binary merge file.

Navigation:	Latitude (°N)	A
	Longitude (°E)	B
	Carter corrected Bathymetric depth (m)	J
Physics:	Temperature (°C)	C
	Salinity (PSU)	F
	Optical Attenuance (m^{-1})	I
Meteorology:	Photosynthetically Available Radiation (W m^{-2})	L
	Solar radiation (W m^{-2})	O
Biology:	Aquatracka fluorometer output (V)	?
	Aquatracka chlorophyll (mg m^{-3})	!

2) Methodology Overview

2.1) Plumbing

Seawater was continually pumped from the hull of the ship (at a depth of about 4m) through the various underway sensors on-deck. This is known as the ship's non-toxic supply. An outlet of this, situated in the ship's wet lab, was used to collect the calibration samples for the underway sensors.

2.2) Data acquisition

The RVS ABC logging system handled data logging and initial data processing. The Level A sampling microcomputer digitised input voltages, applied a time stamp and transferred the data via the Level B disk buffer onto the Level C (a Sun OS Workstation) where the data records were assembled into files.

The Level C includes a suite of processing software that was used to apply initial calibrations to convert raw ADC counts into engineering units. At the

end of the cruise, the Level C disk base was transferred to BODC for further processing.

2.3) BODC data processing procedures

Data from the underway files were merged into a common file (the binary merge file) using time as the primary linking key. Data logged as voltages (e.g. PAR) were converted to engineering units.

Each data channel was inspected on a graphics workstation and any spikes or periods of dubious data were flagged. Whenever possible, comparative screening checks between channels were employed.

3) Data Processing, Correction and Calibration Procedures

3.1) Navigation

GPS was the primary navigation system used on this cruise. At BODC a program was run which located any null values in the latitude and longitude channels and checked to ensure that the ship's speed did not exceed 15 knots.

A total of 8 speed check failures were identified (in the range 15-16 knots) and the offending position fixes were identified and replaced by interpolated values.

A single gap, of 3 minutes duration commencing 09:28 on 2nd September 1995, was filled by interpolation.

Bathymetric depth was logged by the ABC system from an RD200A echo sounder. The data were Carter's table corrected and screened on a graphics workstation.

Examination of the data showed them to be exceptionally clean for the entire duration of the cruise except for two periods (09:25 to 14:10 on 04/09/1995 and 12:30 to 23:30 on 06/09/1995) when the signal deteriorated to total garbage. All affected data have been flagged suspect.

3.2) Physics

<u>Temperature and Salinity</u>

Temperature and salinity were measured using an autoranging TSG103 thermosalinograph. The temperature sensor was a thermistor in the non-toxic supply inlet manifold. Conductivity was measured by a unit in the ship's wet laboratory that included a second thermistor to provide temperature for the computation of salinity.

The raw ADC counts were processed into conductivity and two temperature channels based upon laboratory calculations by RVS. Salinity was computed from the housing temperature and conductivity using the UNESCO 1978 Practical Salinity Scale (Fofonoff and Millard, 1982).

The thermosalinograph was calibrated against surface values taken from the calibrated CTD data set for this cruise. The salinity data were subdivided into clear segments, bounded by either gaps or steps in the data. Each of these was calibrated separately to give the following corrections:

01/09/1995 15:01 to 02/09/1995 00:31	$S_{cal} = S - 0.088$
02/09/1995 00:31 to 02/09/1995 08:29	$S_{cal} = S + 0.042$
02/09/1995 08:29 to 02/09/1995 11:09	$S_{cal} = S + 0.102$
02/09/1995 11:09 to 08/09/1995 07:40	$S_{cal} = S + 0.042$

A constant offset was identified for the temperature data, except for a short (approximately 40 minute) interval where the data were obviously anomalous. This was corrected through the application of the following calibrations:

01/09/1995 15:01 to 02/09/1995 00:31	$T_{cal} = T - 0.006$
02/09/1995 00:31 to 02/09/1995 01:09	$T_{cal} = T + 0.194$
02/09/1995 01:09 to 08/09/1995 07:40	$T_{cal} = T - 0.006$

The calibrated data were screened using an interactive graphical editor. The overall conclusion was that both thermosalinograph data channels were generally free from noise except for a scattering of low value flags on the temperature channel. These have been flagged suspect.

The salinity data exhibited a number of low salinity features on the shelf break. During the previous cruise leg, a number of low salinity features were identified as artefacts and flagged suspect. However, the low salinity data for this cruise were believed to be real for three reasons. First, they were bounded by clear fronts. Secondly, these fronts were present in both the temperature and salinity channels. Thirdly, and most significantly, there was corroborating evidence from the CTD data.

Optical Attenuance

Optical attenuance was measured using a SeaTech red light (661nm) transmissometer with a 25cm optical path length mounted in a light-tight box on the starboard deck fed from the non-toxic supply.

A transmission air reading (4.780 V) taken during the cruise was used to correct the transmissometer voltage to the manufacturer's specified voltage (4.806 V) by ratio. The voltages were then converted to attenuance eliminating the influence of path length on transmission using the equation:

$$\text{Attenuance} = -4.0 * \log_e (\text{voltage} / 5.0)$$

The data were then screened using an interactive graphics editor. The signal was generally clean except for isolated 'bubble spikes' that have been flagged suspect. No evidence of steps in the signal, indicative of transmissometer malfunction, could be ascertained.

3.3) Meteorology

<u>Photosynthetically Available Radiation</u>

PAR was measured using PML 2π PAR sensors mounted on gimballed supports on each side of the ship's monkey island. This arrangement attempts to ensure that when one sensor is in shadow, the other is not.

The PAR meters were logged as voltages and converted to W m^{-2} by BODC using coefficients determined in August 1995 supplied by RVS. The equations used were:

Port (#5): PAR(W m^{-2}) = exp (4.910*volts + 6.952)/100
Starboard (#3): PAR(W m^{-2}) = exp (4.970*volts + 6.526)/100

After spikes had been flagged, a merged PAR channel was produced containing the larger of the port and starboard values to eliminate shading effects.

<u>Solar Radiation</u>

Two Kipp and Zonen instruments mounted on the same platforms as the PAR sensors measured solar radiation. These are unique in as much as they are connected to a data integrator that converted the instrument voltages into W/m^2 and integrated the values to produce 10 minute and running total integrations in kJ/m^2. A Level A logged the output from the integrator at the end of each integration period.

At BODC, the 10 minute integrations were merged into the underway file by a custom program that divided the integrated energy by the integration interval to give an averaged irradiance value. The time stamp was also adjusted to the mid-point of the averaging interval by subtracting 5 minutes.

A merged solar radiation channel was produced, after spikes were flagged out, by taking the maximum of the port and starboard values to eliminate shading effects.

3.4) Biology

<u>Chlorophyll</u>

Chlorophyll was measured by a Chelsea Instruments Aquatracka fluorometer immersed in a light-tight box.

The fluorometer voltages were converted to chlorophyll concentrations by linear regression of the natural logarithm of discrete chlorophyll concentrations (fluorometrically analysed filtered non-toxic supply samples plus surface CTD bottle samples) against corresponding fluorometer voltages. The following equation resulted and was used to generate the chlorophyll channel in the binary merge file.

$$\text{Chlorophyll (mg m}^{-3}\text{)} = \exp(1.59 * \text{volts} - 4.83) \quad (n = 48, R^2 = 61\%)$$

4) Data Warnings

None.

5) Reference

Fofonoff, N.P. and Millard Jr., R.C. (1983). Algorithms for Computation of Fundamental Properties of Seawater. ***UNESCO Technical Papers in Marine Science*** 44.

Surface Underway Data for Cruise Challenger CH123A (15th November to 29th November 1995)

1) Components of the Underway Data Set

The underway data set for cruise Challenger 123A contains the following data channels. The single character following each channel is the appropriate channel identifier in the binary merge file.

Navigation:	Latitude (°N)	A
	Longitude (°E)	B
	Carter corrected Bathymetric depth (m)	J
Physics:	Temperature (°C)	C
	Salinity (PSU)	F
	Optical Attenuance (m^{-1})	I
Meteorology:	Photosynthetically Available Radiation ($W\ m^{-2}$)	L
	Solar radiation ($W\ m^{-2}$)	O
Biology:	Aquatracka fluorometer output (V)	?

2) Methodology Overview

2.1) Plumbing

Sea water was continually pumped from the hull of the ship (at a depth of about 4m) through the various underway sensors on-deck. This is known as the ship's non-toxic supply. An outlet from this, situated in the ship's wet lab, was used to collect the calibration samples for the underway sensors.

2.2) Data acquisition

The RVS ABC logging system handled data logging and initial data processing. The Level A sampling microcomputer digitised input voltages, applied a time stamp and transferred the data via the Level B disk buffer onto the Level C (a Sun OS Workstation) where the data records were assembled into files.

The Level C includes a suite of processing software that was used to apply initial calibrations to convert raw ADC counts into engineering units. At the end of the cruise, the Level C disk base was transferred to BODC for further processing.

2.3) BODC data processing procedures

Data from the underway files were merged into a common file (the binary merge file) using time as the primary linking key. Data logged as voltages (e.g. PAR) were converted to engineering units.

Each data channel was inspected on a graphics workstation and any spikes or periods of dubious data were flagged. Whenever possible, comparative screening checks between channels were employed.

3) Data Processing, Correction and Calibration Procedures

3.1) Navigation

GPS was the primary navigation system used on this cruise. At BODC a program was run which locates any null values in the latitude and longitude channels and checks to ensure that the ship's speed does not exceed 15 knots. Any speed anomalies were investigated and the offending position fixes were removed from the record. As far as possible, gaps were filled manually using entries from the bridge log. Any remaining gaps were filled by linear interpolation. The largest gap interpolated on this cruise was 7 minutes, commencing 13:50 on 15th November 1995.

Bathymetric depth was logged by the ABC system from an RD200A echo sounder. The data were Carter's table corrected and screened on a graphics workstation.

3.2) Physics

Temperature and Salinity

Temperature and salinity were measured using an autoranging TSG103 thermosalinograph. The temperature sensor was a thermistor in the non-toxic supply inlet manifold. Conductivity was measured by a unit in the ship's wet lab which included a second thermistor to provide temperature data for the computation of salinity.

The raw ADC counts were processed into conductivity and two temperature channels based upon laboratory calibrations by RVS. Salinity was computed from the housing temperature and conductivity using the UNESCO 1978 Practical Salinity Scale (Fofonoff and Millard, 1982).

The thermosalinograph was calibrated against surface values taken from the calibrated CTD data set for this cruise. Both channels exhibited an offset from the calibrated CTD data set and were corrected as follows:

$$T_{cal} = T + 0.027$$
$$S_{cal} = S + 0.044$$

The temperature data were unusually noisy. The signal frequently spiked to approximately 0.2 °C low. This was possibly due to the incorporation of cold air bubbles into the non-toxic supply. Heavy flagging, at times up to 50 per cent of the data, was required to reduce the level of noise.

Optical Attenuance

Optical attenuance was measured using a SeaTech red light (661nm) transmissometer with a 25cm optical path length mounted in a light-tight box on the starboard deck fed from the non-toxic supply.

Transmission air readings taken during the cruise (4.753 V) were used to correct the transmissometer voltage to the manufacturer's specified air voltage (4.823 V) by ratio. The voltages were then converted to attenuance eliminating the influence of path length on transmission using the equation:

$$\text{Attenuance} = -4.0 * \log_e (\text{voltage} / 5.0)$$

On screening the data, it could be seen that the record was extremely noisy in parts, due to the incorporation of bubbles in the non-toxic supply during bad weather.

The data from the beginning of the cruise until 18:00 on 17/11/1995 are particularly bad. However, during this period the ship was on passage from Southampton through to the Irish Sea. Whilst best efforts have been made to improve the signal to noise through flagging, qualitative use of the data from this period should be undertaken with caution.

From 18:00 on 17/11/1995 until 16:00 on 22/11/1995 the data quality was much improved. Although bubble spikes did occur, they were isolated, readily identifiable and therefore easily taken out by flagging.

From 16:00 on 22/11/1995 until 07:00 on 23/11/1995 data quality deteriorates dramatically. Over 90% of the data from this interval have been flagged out and the degree to which the remaining data are affected by bubbles is open to question.

The data from 07:00 on 23/11/1995 until 06:00 on 28/11/1995, mostly collected whilst the ship was sheltering off Northern Ireland or Islay, are once more of reasonable quality due to the successful flagging out of bubble spikes.

The data from 06:00 on 28/11/1995 until 20:00 on the same day were so bad that they have been flagged out completely. The data following this period appear reasonable.

3.3) Meteorology

Photosynthetically Available Radiation

PAR was measured using PML 2π PAR sensors mounted on gimballed supports on each side of the ship's monkey island. This arrangement attempts to ensure that when one sensor is in shadow, the other is not.

The PAR meters were logged as voltages and converted to W m^{-2} by BODC using coefficients determined in August 1995 supplied by RVS. The equations used were:

Starboard (#5): PAR(W m^{-2}) = exp (4.910*volts + 6.952)/100
Port (#3): PAR(W m^{-2}) = exp (4.970*volts + 6.526)/100

After spikes had been flagged, a merged PAR channel was produced containing the larger of the port and starboard values to eliminate shading effects.

Note that an empirical calibration is available for these instruments to convert the units to $\mu E/m^2/s$ that simply involves multiplying the data by 3.75.

Solar Radiation

Two Kipp and Zonen instruments mounted on the same platforms as the PAR sensors measured solar radiation. These are unique in as much as they are connected to a data integrator that converted the instrument voltages into W/m^2 and integrated the values to produce 10 minute and running total integrations in kJ/m^2. A Level A logged the output from the integrator at the end of each integration period.

At BODC, the 10 minute integrations were merged into the underway file by a custom program that divided the integrated energy by the integration interval to give an averaged irradiance value. The time stamp was also adjusted to the mid-point of the averaging interval by subtracting 5 minutes.

A merged solar radiation channel was produced, after spikes were flagged out, by taking the maximum of the port and starboard values to eliminate shading effects.

3.4) Biology

Chlorophyll

Chlorophyll was measured by a Chelsea Instruments Aquatracka fluorometer immersed in a light-tight box plumbed into the non-toxic supply. Routine practice is to calibrate this instrument by regression against the natural log of extracted chlorophyll data. However, for both legs of this cruise, no significant correlation could be obtained. Consequently, the data file includes the raw voltages as logged but no calibrated chlorophyll channel. It is strongly suspected that the underway fluorometer used on this cruise was malfunctioning.

4) Data Warnings

The temperature data were unusually noisy.

The transmissometer record is severely affected by noise in parts due to bubble formation during bad weather.

It is strongly suspected that the fluorometer was malfunctioning on this cruise and no chlorophyll calibration has proved possible.

5) Reference

Fofonoff, N.P. and Millard Jr., R.C. (1983). Algorithms for Computation of Fundamental Properties of Seawater. ***UNESCO Technical Papers in Marine Science*** 44.

Surface Underway Data for Cruise Challenger CH123B (1st December to 15th December 1995)

1) Components of the Underway Data Set

The underway data set for cruise Challenger 123B contains the following data channels. The single character following each channel is the appropriate channel identifier in the binary merge file.

Navigation:	Latitude (°N)	A
	Longitude (°E)	B
	Carter corrected Bathymetric depth (m)	J
Physics:	Temperature (°C)	C
	Salinity (PSU)	F
	Optical Attenuance (m^{-1})	I
Meteorology:	Photosynthetically Available Radiation ($W\ m^{-2}$)	L
	Solar radiation ($W\ m^{-2}$)	O
Biology:	Aquatracka fluorometer output (V)	?

2) Methodology Overview

2.1) Plumbing

Seawater was continually pumped from the hull of the ship (at a depth of about 4m) through the various underway sensors on-deck. This is known as the ship's non-toxic supply. An outlet from this, situated in the ship's wet lab, was used to collect the calibration samples for the underway sensors.

2.2) Data acquisition

The RVS ABC logging system handled data logging and initial data processing. The Level A sampling microcomputer digitised input voltages, applied a time stamp and transferred the data via the Level B disk buffer onto the Level C (a Sun OS Workstation) where the data records were assembled into files.

The Level C includes a suite of processing software that was used to apply initial calibrations to convert raw ADC counts into engineering units. At the end of the cruise, the Level C disk base was transferred to BODC for further processing.

2.3) BODC data processing procedures

Data from the underway files were merged into a common file (the binary merge file) using time as the primary linking key. Data logged as voltages (e.g. PAR) were converted to engineering units.

Each data channel was inspected on a graphics workstation and any spikes or periods of dubious data were flagged. Whenever possible, comparative screening checks between channels were employed.

3) Data Processing, Correction and Calibration Procedures

3.1) Navigation

GPS was the primary navigation system used on this cruise. At BODC a program was run which locates any null values in the latitude and longitude channels and checks to ensure that the ship's speed does not exceed 15 knots. Any speed anomalies were investigated and the offending position fixes were removed from the record. As far as possible, gaps were filled manually using entries from the bridge log. Any remaining gaps were filled by linear interpolation. Two long gaps were interpolated for this cruise: 75 minutes from 06:45 on 05/12/95 and 86 minutes from 08:00 on 05/12/95.

Bathymetric depth was logged by the ABC system from an RD200A echo sounder. The data were Carter's table corrected and screened on a graphics workstation.

3.2) Physics

Temperature and Salinity

Temperature and salinity were measured using an autoranging TSG103 thermosalinograph. The temperature sensor was a thermistor in the non-toxic supply inlet manifold. Conductivity was measured by a unit in the ship's wet laboratory that included a second thermistor to provide temperature for the computation of salinity.

The raw ADC counts were processed into conductivity and two temperature channels based upon laboratory calculations by RVS. Salinity was computed from the housing temperature and conductivity using the UNESCO 1978 Practical Salinity Scale (Fofonoff and Millard, 1982).

The thermosalinograph was calibrated against surface values taken from the calibrated CTD data set for this cruise. Both channels exhibited an offset from the calibrated CTD data set and were corrected as follows:

$$T_{cal} = T + 0.1769$$
$$S_{cal} = S + 0.0660$$

Optical Attenuance

Optical attenuance was measured using a SeaTech red light (661nm) transmissometer with a 25cm optical path length mounted in a light-tight box on the starboard deck fed from the non-toxic supply.

Transmission air readings taken during the cruise were used to correct the transmissometer voltage (4.753 V) to the manufacturer's specified air voltage (4.823 V) by ratio. The voltages were then converted to attenuance eliminating the influence of path length on transmission using the equation:

$$\text{Attenuance} = -4.0 * \log_e (\text{voltage} / 5.0)$$

The data were then screened and any spikes flagged. 'Bubble spikes' affect the entire record. These were particularly bad between 09:00 and 17:00 on 09/12/1995. However, the spikes have been effectively flagged out.

3.3) Meteorology

Photosynthetically Available Radiation

PAR was measured using PML 2π PAR sensors mounted on gimballed supports on each side of the ship's monkey island. This arrangement attempts to ensure that when one sensor is in shadow, the other is not.

The PAR meters were logged as voltages and converted to W m^{-2} by BODC using coefficients determined in August 1995 supplied by RVS. The equations used were:

Starboard (#5): $PAR(W\ m^{-2}) = \exp(4.910*volts + 6.952)/100$
Port (#3): $PAR(W\ m^{-2}) = \exp(4.970*volts + 6.526)/100$

After spikes had been flagged, a merged PAR channel was produced containing the larger of the port and starboard values to eliminate shading effects.

Note that an empirical calibration is available for these instruments to convert the units to $\mu E/m^2/s$ that simply involves multiplying the data by 3.75.

Solar Radiation

Two Kipp and Zonen instruments mounted on the same platforms as the PAR sensors measured solar radiation. These are unique in as much as they are connected to a data integrator that converted the instrument voltages into W/m^2 and integrated the values to produce 10 minute and running total integrations in kJ/m^2. A Level A logged the output from the integrator at the end of each integration period.

At BODC, the 10 minute integrations were merged into the underway file by a custom program that divided the integrated energy by the integration interval to give an averaged irradiance value. The time stamp was also adjusted to the mid-point of the averaging interval by subtracting 5 minutes.

A merged solar radiation channel was produced, after spikes were flagged out, by taking the maximum of the port and starboard values to eliminate shading effects.

3.4) Biology

Chlorophyll

Chlorophyll was measured by a Chelsea Instruments Aquatracka fluorometer immersed in a light-tight box plumbed into the non-toxic supply. Routine practice is to calibrate this instrument by regression against the natural log of extracted chlorophyll data. However, for both legs of this cruise, no significant correlation could be obtained. Consequently, the data file includes the raw voltages as logged but no calibrated chlorophyll channel. It is strongly suspected that the underway fluorometer used on this cruise was malfunctioning.

4) Data Warnings

It is strongly suspected that the fluorometer was malfunctioning on this cruise and no chlorophyll calibration has proved possible.

5) Reference

Fofonoff, N.P. and Millard Jr., R.C. (1983). Algorithms for Computation of Fundamental Properties of Seawater. ***UNESCO Technical Papers in Marine Science*** 44.

Surface Underway Data for Cruise Challenger CH125A (31st January to 11th February 1996)

1) Components of the Underway Data Set

The underway data set for cruise Challenger 125A contains the following data channels. The single character following each channel is the appropriate channel identifier in the binary merge file.

Navigation:	Latitude (°N)	A
	Longitude (°E)	B
	Carter corrected Bathymetric depth (m)	J
Physics:	Temperature (°C)	C
	Salinity (PSU)	F
	Optical Attenuance (m^{-1})	I
Meteorology:	Photosynthetically Available Radiation ($W\ m^{-2}$)	L
	Solar radiation ($W\ m^{-2}$)	O
Biology:	Aquatracka fluorometer output (V)	?
	Aquatracka Chlorophyll ($mg\ m^{-3}$)	!

2) Methodology Overview

2.1) Plumbing

Seawater was continually pumped from the hull of the ship (at a depth of about 4m) through the various underway sensors on-deck. This is known as the ship's non-toxic supply. An outlet of this, situated in the ship's wet laboratory, was used to collect the calibration samples for the underway sensors.

2.2) Data acquisition

The RVS ABC logging system handled data logging and initial data processing. The Level A sampling microcomputer digitised input voltages, applied a time stamp and transferred the data via the Level B disk buffer onto the Level C (a Sun OS Workstation) where the data records were assembled into files.

The Level C includes a suite of processing software that was used to apply initial calibrations to convert raw ADC counts into engineering units. At the

end of the cruise, the Level C disk base was transferred to BODC for further processing.

2.3) BODC data processing procedures

Data from the underway files were merged into a common file (the binary merge file) using time as the primary linking key. Data logged as voltages (e.g. PAR) were converted to engineering units.

Each data channel was inspected on a graphics workstation and any spikes or periods of dubious data were flagged. Whenever possible, comparative screening checks between channels were employed.

3) Data Processing, Correction and Calibration Procedures

3.1) Navigation

GPS was the primary navigation system used on this cruise. At BODC a program was run which locates any null values in the latitude and longitude channels and checks to ensure that the ship’s speed does not exceed 15 knots. No gaps were found in the navigation record for this cruise. However, a total of 45 speed check failures were noted. The offending spikes in the navigation channels were identified and smoothed out by linear interpolation.

Bathymetric depth was logged by the ABC system from an RD200A echo sounder. The data were Carter’s table corrected and screened on a graphics workstation. The bathymetry record from this cruise contains a large number of strange looking 'V' shaped features. These were the result of interference from pingers fitted to either the CTD frame or corers with the echo sounder. These data have been flagged suspect and it is therefore important that the flags are taken into account when these data are used.

3.2) Physics

<u>Temperature and Salinity</u>

Temperature and salinity were measured using an autoranging TSG103 thermosalinograph. The temperature sensor was a thermistor in the non-toxic supply inlet manifold. Conductivity was measured by a unit in the ship’s wet laboratory that included a second thermistor to provide temperature for the computation of salinity.

The raw ADC counts were processed into conductivity and two temperature channels based upon laboratory calculations by RVS. Salinity was computed from the housing temperature and conductivity using the UNESCO 1978 Practical Salinity Scale (Fofonoff and Millard, 1982).

The thermosalinograph was calibrated against surface values taken from the calibrated CTD data set for this cruise. A consistent offset from the CTD data set was identified for salinity. The error in the temperature channel showed significant drift with time (correlation 0.68) from the start of the cruise until 13:43 on 10/02/1996. After this time, the offset was constant. The boundary between the corrections was marked by a dramatic (0.37 °C) downward step in the raw temperature record.

The following corrections have been applied:

T_{cal} = T + (cycle_number*0.000003) + 0.0790	(start to 13:43 on 10/02/1996)
T_{cal} = T + 0.012	(13:43 on 10/02/1996 to end)
S_{cal} = S +0.046	(whole cruise)

Optical Attenuance

Optical attenuance was measured using a SeaTech red light (661nm) transmissometer with a 25cm optical path length mounted in a light-tight box on the starboard deck fed from the non-toxic supply.

The instrument used on this cruise (SN104D) had a very chequered history since 1994. Between March 1994 and September 1996 it was returned to the manufacturer for repair on no less than four occasions. In all cases the problem was that the air readings determined by RVS significantly exceeded the manufacturer's calibration value. If the instrument was functioning normally, this simply should not happen: the air voltage should progressively reduce as the light source deteriorates.

An initial inspection of the raw voltages revealed that the instrument was not functioning according to specification. The primary evidence for this was a number of discrete steps in the data, the most dramatic of which occurred at 11:24 on 05/02/1996. The following strategy was adopted to produce the optimum data set from the instrument.

An air reading was taken on the cruise of 4.81 Volts and a post-cruise reading of 4.783 Volts. The manufacturer's calibrated voltage after the instrument was returned from repair on 05/09/1995 was 4.655 Volts.

The first processing run assumed that the reading of 4.81 was valid for the whole cruise and a ratio correction was applied to all measured voltages. The voltages were converted to attenuance eliminating the influence of path length on transmission using the equation:

$$\text{Attenuance} = -4.0 * \log_e (\text{voltage} / 5.0)$$

The result showed the attenuance values in the SES box to be reasonable (when compared to data from cruise CH123B: another winter SES cruise) between the jump on 11:24 on 05/02/1996 and when the ship temporarily left blue water to shelter from bad weather on 07/02/1996. Before this time, they were obviously high and slightly high when the ship returned to the SES box on 10/02/1997.

The latter problem was adequately corrected by using the post-cruise air reading. However, an empirical approach was required to correct the data from the start of the cruise to equalise values before and after the jump on 05/02/1996. This yielded an air 'reading' of 4.5 V.

In summary, the air values used for this cruise to determine corrections based on a manufacturer's value of 4.655 V were:

08:11:30 on 31/01/1996 to 11:24:30 on 05/02/1996	4.500 V
11:25:00 on 05/02/1996 to 18:15:00 on 07/02/1996	4.810 V
18:15:30 on 07/02/1996 to 16:45:00 on 11/02/1996	4.783 V

Screening of the data revealed the usual crop of spikes due to bubbles in the non-toxic sea water supply plus a number of very strange bursts of data attributed to instrument malfunction. These have all been flagged. The data quality was so poor for the following periods that all points have been flagged:

14:55 on 04/02/1996 to 19:20 on 04/02/1996
08:00 on 05/02/1996 to 13:00 on 05/02/1996
18:00 on 07/02/1996 to 03:00 on 08/02/1996
09:00 on 10/02/1996 to 13:00 on 10/02/1996
16:30 on 10/02/1996 to 19:15 on 10/02/1996

An upward step of 0.05 per m remains in the final data set at 02:25 on 03/02/1996. No defensible strategy to correct this could be devised.

The resulting attenuance data set is believed to be accurate within 0.1 per m. However, this conclusion is critically dependent on the assumption that the surface attenuance in the SES box was unchanged between December 1995 and February 1996. **This should be taken into account when making use of the data.**

3.3) Meteorology

Photosynthetically Available Radiation

PAR was measured using PML 2π PAR sensors mounted on gimballed supports on each side of the ship’s monkey island. This arrangement attempts to ensure that when one sensor is in shadow, the other is not.

The PAR meters were logged as voltages and converted to W m^{-2} by BODC using coefficients determined in August 1995 supplied by RVS. The equations used were:

Starboard (#5): PAR(W m^{-2}) = exp (4.910*volts + 6.952)/100
Port (#3): PAR(W m^{-2}) = exp (4.970*volts + 6.526)/100

After spikes had been flagged, a merged PAR channel was produced containing the larger of the port and starboard values to eliminate shading effects.

Solar Radiation

Two Kipp and Zonen instruments mounted on the same platforms as the PAR sensors measured solar radiation. These are unique in as much as they are connected to a data integrator that converted the instrument voltages into W/m^2 and integrated the values to produce 10 minute and running total integrations in kJ/m^2. A Level A logged the output from the integrator at the end of each integration period.

At BODC, the 10 minute integrations were merged into the underway file by a custom program that divided the integrated energy by the integration interval to give an averaged irradiance value. The time stamp was also adjusted to the mid-point of the averaging interval by subtracting 5 minutes.

A merged solar radiation channel was produced, after spikes were flagged out, by taking the maximum of the port and starboard values to eliminate shading effects.

3.4) Biology

Chlorophyll

Chlorophyll was measured by a Chelsea Instruments Aquatracka fluorometer immersed in a light-tight box plumbed into the non-toxic supply.

The fluorometer voltages were converted to chlorophyll concentrations by linear regression of the natural logarithm of extracted chlorophyll data (GF/F filtered, acetone extracted, and fluorometrically assayed non-toxic supply samples) against corresponding fluorometer voltages. The following equation resulted and was used to generate the chlorophyll channel in the binary merge file.

Chlorophyll (mg m^{-3}) = exp (1.93 * volts - 4.02) (n=33; R^2 = 64.0%)

4) Data Warnings

The attenuance data required empirical corrections to overcome instrument malfunctions. Further details are given above. Caution is recommended when using these data.

5) Reference

Fofonoff, N.P. and Millard Jr., R.C. (1983). Algorithms for Computation of Fundamental Properties of Sea water. ***UNESCO Technical Papers in Marine Science*** 44.

Surface Underway Data for Cruise Challenger CH125B (13th February to 2nd March 1996)

1) Components of the Underway Data Set

The underway data set for cruise Challenger 125B contains the following data channels. The single character following each channel is the appropriate channel identifier in the binary merge file.

Navigation:	Latitude (°N)	A
	Longitude (°E)	B
	Carter corrected Bathymetric depth (m)	J
Physics:	Temperature (°C)	C
	Salinity (PSU)	F
	Optical Attenuance (m^{-1})	I
Meteorology:	Photosynthetically Available Radiation (W m^{-2})	L
	Solar radiation (W m^{-2})	O
Biology:	Aquatracka fluorometer output (V)	?
	Aquatracka Chlorophyll (mg m^{-3})	!

2) Methodology Overview

2.1) Plumbing

Seawater was continually pumped from the hull of the ship (at a depth of about 4m) through the various underway sensors on-deck. This is known as the ship's non-toxic supply. An outlet of this, situated in the ship's wet laboratory, was used to collect the calibration samples for the underway sensors.

2.2) Data acquisition

The RVS ABC logging system handled data logging and initial data processing. The Level A sampling microcomputer digitised input voltages, applied a time stamp and transferred the data via the Level B disk buffer onto the Level C (a Sun OS Workstation) where the data records were assembled into files.

The Level C includes a suite of processing software that was used to apply initial calibrations to convert raw ADC counts into engineering units. At the

end of the cruise, the Level C disk base was transferred to BODC for further processing.

2.3) BODC data processing procedures

Data from the underway files were merged into a common file (the binary merge file) using time as the primary linking key. Data logged as voltages (e.g. PAR) were converted to engineering units.

Each data channel was inspected on a graphics workstation and any spikes or periods of dubious data were flagged. Whenever possible, comparative screening checks between channels were employed.

3) Data Processing, Correction and Calibration Procedures

3.1) Navigation

GPS was the primary navigation system used on this cruise. At BODC a program was run which locates any null values in the latitude and longitude channels and checks to ensure that the ship's speed does not exceed 15 knots. A single gap of 31 minutes duration from 19:30 on 29/02/1996 was detected and filled by linear interpolation. There were no speed check failures.

Bathymetric depth was logged by the ABC system from an RD200A echo sounder. The data were Carter's table corrected and screened on a graphics workstation.

The quality of the bathymetry data from this cruise was extremely variable. It ranged from a totally clean signal, through isolated spikes and extremely noisy data requiring heavy flagging to data in which there was no discernible signal. This latter category has been completely flagged out.

Data from the following periods were noted as particularly bad.

16:00 on 14/02/1996 to 12:10 on 15/02/1996
18:00 on 19/02/1996 to 22:45 on 19/02/1996
08:45 on 20/02/1996 to 14:20 on 20/02/1996
03:00 on 21/02/1996 to 04:00 on 21/02/1996
08:00 on 22/02/1996 to 03:00 on 23/02/1996
08:00 on 29/02/1996 to 13:15 on 29/02/1996

3.2) Physics

Temperature and Salinity

Temperature and salinity were measured using an auto-ranging TSG103 thermosalinograph. The temperature sensor was a thermistor in the non-toxic supply inlet manifold. Conductivity was measured by a unit in the ship's wet laboratory that included a second thermistor to provide temperature for the computation of salinity.

The raw ADC counts were processed into conductivity and two temperature channels based upon laboratory calculations by RVS. Salinity was computed from the housing temperature and conductivity using the UNESCO 1978 Practical Salinity Scale (Fofonoff and Millard, 1982).

Initial inspection of the data revealed that the temperature data were exceptionally noisy to the extent that calibration accuracy would be severely compromised. Correction of the data through flagging was deemed impossible, as it was extremely difficult to distinguish between signal and noise. Consequently, the exceptional step of smoothing the data using a three-datacycle rolling average was taken prior to calibration.

The thermosalinograph was calibrated against surface values taken from the calibrated CTD data set. The calibrations required for both temperature and salinity were unusually complex as summarised below.

A linear drift model was used to correct temperature with the calibrations of the form:

Corrected temperature = Raw Temperature + (slope*cycle_number) + offset

The following slopes and offsets were determined:

13/02/1996 12:05:30 to 17/02/1996 09:51:30	slope = 0.0 offset = 0.127
17/02/1996 09:52:00 to 19/02/1996 01:35:00	slope = 0.0 offset = 0.064
19/02/1996 01:35:30 to 24/02/1996 22:17:30	slope = 0.0 offset = 0.130
24/02/1996 22:18:00 to 25/02/1996 14:39:00	slope = -0000441691 offset = 1.526
25/02/1996 14:39:30 to 25/02/1996 21:27:00	slope = 0.0 offset = 0.080
25/02/1996 21:27:30 to 26/02/1996 11:51:00	slope = 0.0 offset = -0.024
26/02/1996 11:51:30 to 28/02/1996 04:04:30	slope = 0.0 offset = 0.061
28/02/1996 04:05:00 to 28/02/1996 12:26:30	slope = 0.0 offset = -0.029

28/02/1996 12:27:00 to 28/02/1996 20:30:30	slope = 0.0 offset = 0.036
28/02/1996 20:31:00 to 29/02/1996 08:45:30	slope = 0.0 offset = -0.047
29/02/1996 08:46:00 to 02/03/1996 17:00:30	slope = 0.0 offset = 0.071

A simple offset model was used to calibrate salinity such that:

Corrected salinity = Raw salinity + offset

The following offsets were determined:

13/02/1996 12:05:30 to 19/02/1996 17:53:30	offset = 0.044
19/02/1996 17:54:00 to 19/02/1996 20:01:00	offset = -0.004
19/02/1996 20:01:30 to 19/02/1996 22:55:00	offset = 0.030
19/02/1996 22:55:30 to 23/02/1996 13:34:00	offset = 0.052
23/02/1996 13:34:30 to 25/02/1996 07:52:00	offset = 0.066
25/02/1996 07:52:30 to 27/02/1996 04:31:00	offset = 0.013
27/02/1996 04:31:30 to 27/02/1996 10:14:30	offset = 0.067
27/02/1996 10:15:00 to 27/02/1996 16:25:00	offset = 0.033
27/02/1996 16:25:30 to 27/02/1996 21:20:30	offset = -0.002
27/02/1996 21:21:00 to 28/02/1996 03:57:30	offset = -0.079
28/02/1996 03:58:00 to 02/03/1996 17:00:30	offset = 0.064

All of these corrections have been applied to the data.

From these calibrations it may be seen that the initial data set was characterised by a series of obvious discrete steps that have been eliminated through the calibration process. However, there were two periods when the salinity data were obviously offset but no correction could be determined due to insufficient calibration data. These periods were:

23/02/1996 13:34:00 to 25/02/1996 01:32:00
28/02/1996 03:58:00 to 28/02/1996 13:10:00

All salinity data from these periods have been flagged suspect.

Optical Attenuance and Sediment Load

Optical attenuance was measured using a SeaTech red light (661nm) transmissometer with a 25cm optical path length mounted in a light-tight box on the starboard deck fed from the non-toxic supply.

The instrument used on this cruise (SN104D) had a very chequered history since 1994. Between March 1994 and September 1996 it was returned to the manufacturer for repair on no less than four occasions. In all cases the problem was that the air readings determined by RVS significantly exceeded the manufacturer's calibration value. If the instrument was functioning normally, this simply should not happen: the air voltage should progressively reduce as the light source deteriorates.

Inspection of the raw data revealed that the data from this cruise were free from the steps and obvious periods of malfunction observed during the previous cruise (CH125A). Consequently, normal processing procedures were applied as follows.

A transmission air reading taken during the cruise (4.800 V) was used to correct the transmissometer voltage to the manufacturer's specified voltage (4.655 V) by ratio. The voltages were then converted to attenuance eliminating the influence of path length on transmission using the equation:

$$\text{Attenuance} = -4.0 * \log_e (\text{voltage} / 5.0)$$

The result gave attenuance values in the SES box that were comparable with those obtained on other winter SES cruises (CH123B and CH125A) and so there is reasonable confidence that the data are accurate. However, the high air readings and known problems with SN104D require that the data be used with an element of caution.

The data were then screened and any spikes flagged. The flagged data were attributed to either instrument maintenance or the result of bubbles in the non-toxic sea water supply. With the exception of one four hour period (17:25 to 21:30 on 22/02/1996), the bubble spikes were either isolated events or grouped into relatively short periods of 1-1.5 hours duration.

3.3) Meteorology

Photosynthetically Available Radiation

PAR was measured using PML 2π PAR sensors mounted on gimballed supports on each side of the ship's monkey island. This arrangement attempts to ensure that when one sensor is in shadow, the other is not.

The PAR meters were logged as voltages and converted to W m^{-2} by BODC using coefficients determined in August 1995 supplied by RVS. The equations used were:

Starboard (#5): PAR(W m^{-2}) = exp (4.910*volts + 6.952)/100
Port (#3): PAR(W m^{-2}) = exp (4.970*volts + 6.526)/100

After spikes had been flagged, a merged PAR channel was produced containing the larger of the port and starboard values to eliminate shading effects.

Solar Radiation

Two Kipp and Zonen instruments mounted on the same platforms as the PAR sensors measured solar radiation. These are unique in as much as they are connected to a data integrator that converted the instrument voltages into W/m^2 and integrated the values to produce 10 minute and running total integrations in kJ/m^2. A Level A logged the output from the integrator at the end of each integration period.

At BODC, the 10 minute integrations were merged into the underway file by a custom program that divided the integrated energy by the integration interval to give an averaged irradiance value. The time stamp was also adjusted to the mid-point of the averaging interval by subtracting 5 minutes.

A merged solar radiation channel was produced, after spikes were flagged out, by taking the maximum of the port and starboard values to eliminate shading effects.

3.4) Biology

Chlorophyll

Chlorophyll was measured by a Chelsea Instruments Aquatracka fluorometer immersed in a light-tight box plumbed into the non-toxic supply.

The fluorometer voltages were converted to chlorophyll concentrations by linear regression of the natural logarithm of extracted chlorophyll data (GF/F filtered, acetone extracted, and fluorometrically assayed non-toxic supply samples) against corresponding fluorometer voltages. The following equation resulted and was used to generate the chlorophyll channel in the binary merge file.

$$\text{Chlorophyll (mg m}^{-3}\text{)} = \exp(1.74 * \text{volts} - 3.69) \quad (n=111;\ R^2 = 55.0\%)$$

Visual inspection of the data revealed an unusually high level of noise in the signal. This could not be eliminated through flagging without excessive data loss. Consequently, flagging has been limited to obvious outliers.

4) Data Warnings

The transmissometer on this cruise (SN104D) has been identified as a troublesome instrument and returned an air value significantly in excess of the calibration value on this cruise. Although the data seem credible and no obvious evidence of malfunction could be identified, users of the attenuance data should bear these problems in mind.

5) Reference

Fofonoff, N.P. and Millard Jr., R.C. (1983). Algorithms for Computation of Fundamental Properties of Seawater. ***UNESCO Technical Papers in Marine Science*** 44.

Surface Underway Data for Cruise Challenger CH126A (11th April to 26th April 1996)

1) Components of the Underway Data Set

The underway data set for cruise Challenger 126A contains the following data channels. The single character following each channel is the appropriate channel identifier in the binary merge file.

Navigation:	Latitude (°N)	A
	Longitude (°E)	B
	Carter corrected Bathymetric depth (m)	J
Physics:	Temperature (°C)	C
	Salinity (PSU)	F
	Optical Attenuance (m^{-1})	I
Meteorology:	Photosynthetically Available Radiation (W m^{-2})	L
	Solar radiation (W m^{-2})	O
Biology:	Aquatracka fluorometer output (V)	?
	Aquatracka Chlorophyll (mg m^{-3})	!

2) Methodology Overview

2.1) Plumbing

Seawater was continually pumped from the hull of the ship (at a depth of about 4m) through the various underway sensors on-deck. This is known as the ship's non-toxic supply. An outlet from this, situated in the ship's wet lab, was used to collect the calibration samples for the underway sensors.

2.2) Data acquisition

The RVS ABC logging system handled data logging and initial data processing. The Level A sampling microcomputer digitised input voltages, applied a time stamp and transferred the data via the Level B disk buffer onto the Level C (a Sun OS Workstation) where the data records were assembled into files.

The Level C includes a suite of processing software that was used to apply initial calibrations to convert raw ADC counts into engineering units. At the

end of the cruise, the Level C disk base was transferred to BODC for further processing.

2.3) BODC data processing procedures

Data from the underway files were merged into a common file (the binary merge file) using time as the primary linking key. Data logged as voltages (e.g. PAR) were converted to engineering units.

Each data channel was inspected on a graphics workstation and any spikes or periods of dubious data were flagged. Whenever possible, comparative screening checks between channels were employed.

3) Data Processing, Correction and Calibration Procedures

3.1) Navigation

GPS was the primary navigation system used on this cruise. At BODC a program was run which locates any null values in the latitude and longitude channels and checks to ensure that the ship's speed does not exceed 15 knots. No speed check failures were encountered. A single gap of 2 minutes duration was filled by linear interpolation.

Bathymetric depth was logged by the ABC system from an RD200A echo sounder. The data were Carter's table corrected and screened on a graphics workstation.

3.2) Physics

Temperature and Salinity

Temperature and salinity were measured using an autoranging TSG103 thermosalinograph. The temperature sensor was a thermistor in the non-toxic supply inlet manifold. Conductivity was measured by a unit in the ship's wet lab which included a second thermistor to provide temperature data for the computation of salinity.

The raw ADC counts were processed into conductivity and two temperature channels based upon laboratory calibrations by RVS. Salinity was computed from the housing temperature and conductivity using the UNESCO 1978 Practical Salinity Scale (Fofonoff and Millard, 1982).

The thermosalinograph was calibrated against surface values taken from the calibrated CTD data set. The salinity offset drifted linearly until 06:30 on 26/04/1996, after which it was constant. The error in the temperature channel showed linear drift with time.

The following corrections have been applied:

T_{cal} = T + (cycle_number*-0.000002) + 0.02 (whole cruise)
S_{cal} = S + (cycle_number*0.000005) - 0.257 (until 06:30 on 26/04/1996)
S_{cal} = S - 0.121 (after 06:30 on 26/04/1996)

Optical Attenuance

Optical attenuance was measured using a SeaTech red light (661nm) transmissometer with a 25cm optical path length mounted in a light-tight box on the starboard deck fed from the non-toxic supply.

Transmission air readings taken during the cruise (4.740V) were used to correct the transmissometer voltage to the manufacturer's specified air voltage (4.744 V) by ratio. The voltages were then converted to attenuance eliminating the influence of path length on transmission using the equation:

$$\text{Attenuance} = -4.0 * \log_e (\text{voltage} / 5.0)$$

The attenuance signal was generally clean except for isolated spikes caused by bubbles in the non-toxic supply. Flagging the affected data as suspect has eliminated these. A good general correspondence between the transmissometer and fluorometer signals could be discerned. However, during the following short periods the bubble spikes coalesced to the extent that the background signal might have been artificially elevated:

18:00 - 22:00 on 15/04/1996
05:00 - 09:30 on 16/04/1996
06:30 - 09:30 on 19/04/1996
16:00 - 22:30 on 22/04/1996

3.3) Meteorology

Photosynthetically Available Radiation

PAR was measured using PML 2π PAR sensors mounted on gimballed supports on each side of the ship's monkey island. This arrangement attempts to ensure that when one sensor is in shadow, the other is not.

The PAR meters were logged as voltages and converted to W m^{-2} by BODC using coefficients determined in August 1995 supplied by RVS. The equations used were:

Starboard (#5): PAR(W m^{-2}) = exp (4.910*volts + 6.952)/100
Port (#3): PAR(W m^{-2}) = exp (4.970*volts + 6.526)/100

After spikes had been flagged, a merged PAR channel was produced containing the larger of the port and starboard values to eliminate shading effects.

Note that an empirical calibration is available for these instruments to convert the units to $\mu E/m^2/s$ that simply involves multiplying the data by 3.75.

Solar Radiation

Two Kipp and Zonen instruments mounted on the same platforms as the PAR sensors measured solar radiation. These are unique in as much as they are connected to a data integrator that converted the instrument voltages into W/m^2 and integrated the values to produce 10 minute and running total integrations in kJ/m^2. A Level A logged the output from the integrator at the end of each integration period.

At BODC, the 10 minute integrations were merged into the underway file by a custom program that divided the integrated energy by the integration interval to give an averaged irradiance value. The time stamp was also adjusted to the mid-point of the averaging interval by subtracting 5 minutes.

It is usual BODC practice to merge the data from the two instruments, taking the maximum reading to eliminate shading artefacts. However, on this cruise, the starboard instrument was inoperative throughout. Consequently, the 'merged' solar radiation channel only contains data from the port sensor which, fortunately, is the less prone to shading.

3.4) Biology

Chlorophyll

Chlorophyll was measured by a Chelsea Instruments Aquatracka fluorometer immersed in a light-tight box plumbed into the non-toxic supply.

The fluorometer voltages were converted to chlorophyll concentrations by linear regression of the natural logarithm of discrete extracted chlorophyll data (GF/F filtered, acetone extracted, and fluorometrically assayed non-toxic supply samples) against corresponding fluorometer voltages.

The following equation resulted and was used to generate the chlorophyll channel in the binary merge file.

$$\text{Chlorophyll (mg m}^{-3}) = \exp(1.22 * \text{volts} - 2.44) \quad (n = 43;\ R^2 = 84.1\%)$$

4) Data Warnings

Several short periods of the transmissometer record is severely affected by noise due to bubble formation during bad weather.

5) Reference

Fofonoff, N.P. and Millard Jr., R.C. (1983). Algorithms for Computation of Fundamental Properties of Seawater. ***UNESCO Technical Papers in Marine Science*** 44.

Surface Underway Data for Cruise Challenger CH126B (27th April to 11th May 1996)

1) Components of the Underway Data Set

The underway data set for cruise Challenger 126B contains the following data channels. The single character following each channel is the appropriate channel identifier in the binary merge file.

Navigation:	Latitude (°N)	A
	Longitude (°E)	B
	Carter corrected Bathymetric depth (m)	J
Physics:	Temperature (°C)	C
	Salinity (PSU)	F
	Optical Attenuance (m^{-1})	I
Meteorology:	Photosynthetically Available Radiation (W m^{-2})	L
Biology:	Aquatracka fluorometer output (V)	?
	Aquatracka Chlorophyll (mg m^{-3})	!

2) Methodology Overview

2.1) Plumbing

Seawater was continually pumped from the hull of the ship (at a depth of about 4m) through the various underway sensors on-deck. This is known as the ship's non-toxic supply. An outlet from this, situated in the ship's wet lab, was used to collect the calibration samples for the underway sensors.

2.2) Data acquisition

The RVS ABC logging system handled data logging and initial data processing. The Level A sampling microcomputer digitised input voltages, applied a time stamp and transferred the data via the Level B disk buffer onto the Level C (a Sun OS Workstation) where the data records were assembled into files.

The Level C includes a suite of processing software that was used to apply initial calibrations to convert raw ADC counts into engineering units. At the end of the cruise, the Level C disk base was transferred to BODC for further processing.

2.3) BODC data processing procedures

Data from the underway files were merged into a common file (the binary merge file) using time as the primary linking key. Data logged as voltages (e.g. PAR) were converted to engineering units.

Each data channel was inspected on a graphics workstation and any spikes or periods of dubious data were flagged. Whenever possible, comparative screening checks between channels were employed.

3) Data Processing, Correction and Calibration Procedures

3.1) Navigation

GPS was the primary navigation system used on this cruise. At BODC a program was run which locates any null values in the latitude and longitude channels and checks to ensure that the ship's speed does not exceed 15 knots. No speed check failures were encountered. A single gap of 2 minutes duration was filled by linear interpolation.

Bathymetric depth was logged by the ABC system from an RD200A echo sounder. The data were Carter's table corrected and screened on a graphics workstation. Data quality was generally good.

3.2) Physics

<u>Temperature and Salinity</u>

Temperature and salinity were measured using an autoranging TSG103 thermosalinograph. The temperature sensor was a thermistor in the non-toxic supply inlet manifold. Conductivity was measured by a unit in the ship's wet laboratory that included a second thermistor to provide temperature data for the computation of salinity.

The raw ADC counts were processed into conductivity and two temperature channels based upon laboratory calibrations by RVS. Salinity was computed from the housing temperature and conductivity using the UNESCO 1978 Practical Salinity Scale (Fofonoff and Millard, 1982).

Initial visual inspection of the data revealed that the temperature data were exceptionally noisy. Further investigation revealed that this noise had two origins. On some days, the temperature became noisy in the early afternoon. This has been attributed to the formation of a shallow, uneven thermocline by diurnal heating: a real phenomenon. The other source of noise, a rapid oscillation with a magnitude of approximately 0.2 degrees that generally occurred at night, was subsequently found to be due to a poorly earthed oil heater only switched on when the engine room was on automatic operation.

As the noise was partially real and partially due to an artefact, elimination through pre-calibration averaging was deemed unjustifiable. An attempt was made to reduce the effect of the noise through flagging, but this was, at best, a partial success.

The thermosalinograph was calibrated against surface values taken from the calibrated CTD data set. The salinity offset was initially constant but drifted linearly after 16:41 on 01/05/1996. A constant temperature offset was determined for the whole cruise.

The following corrections have been applied:

$T_{cal} = T + 0.153$	(whole cruise)
$S_{cal} = S + 0.059$	(until 16:41 on 01/05/1996)
$S_{cal} = S + (0.000002*cycle\_number + 0.034)$	(after16:41 on 01/05/1996)

There were two periods when the salinity data were obviously offset but no correction could be determined due to insufficient calibration data. These periods were:

29/04/1996 13:45:00 to 30/04/1996 19:00:00
01/05/1996 16:40:00 to 01/05/1996 21:25:00

All salinity data from these periods have been flagged suspect.

<u>Optical Attenuance</u>

Optical attenuance was measured using a SeaTech red light (661nm) transmissometer with a 25cm optical path length mounted in a light-tight box on the starboard deck fed from the non-toxic supply.

Transmission air readings taken during the cruise (4.740V) were used to correct the transmissometer voltage to the manufacturer's specified air voltage (4.744 V) by ratio. The voltages were then converted to attenuance eliminating the influence of path length on transmission using the equation:

$$\text{Attenuance} = -4.0 * \log_e (\text{voltage} / 5.0)$$

The attenuance signal was generally clean except for isolated spikes caused by bubbles in the non-toxic supply and these were relatively sparse compared with what is expected for North Atlantic cruises. Flagging the affected data suspect has eliminated all spikes. A good general correspondence between the transmissometer and fluorometer signals was observed.

3.3) Meteorology

Photosynthetically Available Radiation

PAR was measured using PML 2π PAR sensors mounted on gimballed supports on each side of the ship’s monkey island. This arrangement attempts to ensure that when one sensor is in shadow, the other is not.

The PAR meters were logged as voltages and converted to W m^{-2} by BODC using coefficients determined in August 1995 supplied by RVS. The equations used were:

Starboard (#5): PAR(W m^{-2}) = exp (4.910*volts + 6.952)/100
Port (#3): PAR(W m^{-2}) = exp (4.970*volts + 6.526)/100

After spikes had been flagged, a merged PAR channel was produced by taking the maximum of the port and starboard values to eliminate shading effects. However, the starboard instrument failed at 13:15 on 08/05/1996. Consequently, the 'merged' channel only contains data from the port instrument after this time, increasing the possibility that shading artefacts are present in the data.

Note that an empirical calibration is available for these instruments to convert the units to $\mu E/m^2/s$ that simply involves multiplying the data by 3.75.

Solar Radiation

Two Kipp and Zonen instruments mounted on the same platforms as the PAR sensors measured solar radiation. However, both instruments malfunctioned throughout this cruise.

3.4) Biology

Chlorophyll

Chlorophyll was measured by a Chelsea Instruments Aquatracka fluorometer immersed in a light-tight box plumbed into the non-toxic supply.

The fluorometer voltages were converted to chlorophyll concentrations by linear regression of the natural logarithm of discrete extracted chlorophyll data (GF/F filtered, acetone extracted, and fluorometrically assayed non-toxic supply samples) against corresponding fluorometer voltages.

The following equation resulted and was used to generate the chlorophyll channel in the binary merge file.

Chlorophyll (mg m^{-3}) = exp (1.13 * volts - 2.33) (n = 109; R^2 = 51.0%)

4) Data Warnings

None

5) Reference

Fofonoff, N.P. and Millard Jr., R.C. (1983). Algorithms for Computation of Fundamental Properties of Seawater. ***UNESCO Technical Papers in Marine Science*** 44.

Surface Underway Data for Cruise Challenger CH128A (10th July to 25th July 1996)

1) Components of the Underway Data Set

The underway data set for cruise Challenger 128A contains the following data channels. The single character following each channel is the appropriate channel identifier in the binary merge file.

Navigation:	Latitude (°N)	A
	Longitude (°E)	B
	Carter corrected Bathymetric depth (m)	J
Physics:	Temperature (°C)	C
	Salinity (PSU)	F
	Optical Attenuance (m^{-1})	I
Meteorology:	Photosynthetically Available Radiation: scalar ($W\ m^{-2}$)	L
	Photosynthetically Available Radiation: vector ($W\ m^{-2}$)	t
	Dry bulb air temperature (°C)	a
	Wet bulb air temperature (°C)	b
	Relative humidity (%)	d
	Absolute wind speed (knots)	Y
	Absolute wind direction (degrees blowing from)	Z
	Vertical wind velocity (knots +ve up)	q
	Barometric pressure (mb)	1
Biology:	Aquatracka fluorometer output (V)	?
	Aquatracka Chlorophyll ($mg\ m^{-3}$)	!

2) Methodology Overview

2.1) Plumbing

Seawater was continually pumped from the hull of the ship (at a depth of about 4m) through the various underway sensors on-deck. This is known as the ship's non-toxic supply. An outlet from this, situated in the ship's wet lab, was used to collect the calibration samples for the underway sensors.

2.2) Data acquisition

The RVS ABC logging system handled data logging and initial data processing. The Level A sampling microcomputer digitised input voltages, applied a time stamp and transferred the data via the Level B disk buffer onto the Level C (a Sun OS Workstation) where the data records were assembled into files.

The Level C includes a suite of processing software that was used to apply initial calibrations to convert raw ADC counts into engineering units. At the end of the cruise, the Level C disk base was transferred to BODC for further processing.

2.3) BODC data processing procedures

Data from the underway files were merged into a common file (the binary merge file) using time as the primary linking key. Data logged as voltages (e.g. PAR) were converted to engineering units.

Each data channel was inspected on a graphics workstation and any spikes or periods of dubious data were flagged. Whenever possible, comparative screening checks between channels were employed.

3) Data Processing, Correction and Calibration Procedures

3.1) Navigation

GPS was the primary navigation system used on this cruise. At BODC a program was run which locates any null values in the latitude and longitude channels and checks to ensure that the ship's speed does not exceed 15 knots. No speed check failures or gaps were encountered.

Bathymetric depth was logged by the ABC system from an RD200A echo sounder. The data were Carter's table corrected and screened on a graphics workstation. This visual inspection revealed the data to be of generally good quality with very few spikes. From time to time the data included a high proportion of null values (approximately four out of five values null) and some data were lost due to interference from pingers on winch-deployed instruments.

3.2) Physics

<u>Temperature and Salinity</u>

Temperature and salinity were measured using an autoranging TSG103 thermosalinograph. The temperature sensor was a thermistor in the non-toxic supply inlet manifold. Conductivity was measured by a unit in the ship's wet lab which included a second thermistor to provide temperature data for the computation of salinity.

The raw ADC counts were processed into conductivity and two temperature channels based upon laboratory calibrations by RVS. Salinity was computed from the housing temperature and conductivity using the UNESCO 1978 Practical Salinity Scale (Fofonoff and Millard, 1982).

The thermosalinograph was calibrated against surface values taken from the calibrated CTD data set. Both salinity and temperature exhibited constant offsets from the CTD that were corrected by applying the following calibrations:

$$T_{cal} = T + 0.158$$
$$S_{cal} = S + 0.063$$

Visual inspection of the data revealed periods of temperature noise with amplitude of up to a couple of degrees. These have been attributed to the formation of shallow diurnal thermoclines and consequently the data have not been flagged suspect. The salinity record was generally clean except for isolated spikes that have been flagged.

Optical Attenuance

Optical attenuance was measured using a SeaTech red light (661nm) transmissometer with a 25cm optical path length mounted in a light-tight box on the starboard deck fed from the non-toxic supply.

Transmission air readings taken during the cruise (4.685V) were used to correct the transmissometer voltage to the manufacturer's specified air voltage (4.789 V) by ratio. The voltages were then converted to attenuance eliminating the influence of path length on transmission using the equation:

$$\text{Attenuance} = -4.0 * \log_e (\text{voltage} / 5.0)$$

The attenuance signal was generally clean except for isolated spikes caused by bubbles in the non-toxic supply. Flagging the affected data suspect has eliminated these. A good general correspondence between the transmissometer and fluorometer signals could be discerned. However, during the following short periods the bubble spikes coalesced to the extent that the background signal might have been artificially elevated:

21:00 on 10/07/1996 to 05:00 on 11/07/1996
04:00 on 13/07/1996 to 06:00 on 13/07/1996

3.3) Meteorology

<u>Barometric Pressure</u>

The meteorological package included a Vaisala aneroid barometer mounted on the foremast platform. The instrument output data in millibars which were logged every 5 seconds by a PC Level A. These data were reduced by averaging to 30 seconds sampling at BODC and examined on a graphics workstation. For this cruise, the barometric pressure record was perfectly clean and no data points required flagging.

No correction has been applied for the height of the instrument above sea level.

<u>Radiation</u>

Challenger was equipped for this cruise with a total of six radiation sensors. PML designed 2-pi PAR scalar irradiance meters and Kipp and Zonen solar radiation meters were mounted in pairs in gimballed housings on the port and starboard side of the 'Monkey Island' above the scientific plot. The starboard location is far from ideal due to a large satellite communication radome that frequently shades the instruments. Two planar PAR sensors were mounted on the meteorological package platform on the port and starboard sides of the foremast.

The 2-pi PAR and Kipp and Zonen instruments have been in operation since 1988 but were overhauled and recalibrated in July 1995. The planar PAR sensors were new instruments fitted in May 1995.

Data from the solar radiation meters were not logged during this cruise.

The PML 2-pi PAR sensors were logged as voltages every 30 seconds on an RVS Level A and were calibrated in W/m^2 by BODC using coefficients determined in July 1995. The calibration equations used were:

Port (sensor 3):	PAR = exp(Volts*4.97 + 6.526)/100
Starboard (sensor 5):	PAR = exp(Volts*4.91 + 6.952)/100

A merged PAR channel was produced, after spikes were flagged out, by taking the maximum of the port and starboard values to eliminate shading effects.

It has been determined by empirical calibration that the PAR values in W/m^2 measured by the PML 2-pi PAR sensors may be converted to $\mu E/m^2/s$ by multiplying by 3.75.

It must be emphasised that these instruments have hemispherical domed collectors, and therefore measure scalar irradiance. Consequently, simple comparisons between data from these instruments and other equipment with differing geometry must not be attempted.

The planar PAR sensors were logged every 5 seconds as a voltage by the meteorological package PC Level A and the voltages were converted to W/m^2 from volts on the Level C using the following manufacturer's calibrations:

Port (SN2273):	$W/m^2 = (V*1000*1000)/16.3$
Starboard(SN2274):	$W/m^2 = (V*1000*1000)/16.75$

The data were reduced to 30 seconds sampling at BODC by averaging and any spikes found in the port and starboard channels were flagged as suspect. A merged PAR channel was produced containing the larger of the port and starboard values to eliminate shading effects.

Air Temperature and Humidity

The Metpac fitted to Challenger for this cruise included two Vector Instruments psychrometers fitted to the port and starboard sides of the foremast together with a Vaisala low grade temperature and humidity sensor mounted between them. These were brand new instruments fitted in May 1996. The Vaisala generated output in scientific units (C and %) whilst the psychrometers output voltages which were converted to temperatures using the manufacturer's calibrations thus:

Port Instrument (SN2003)

Dry bulb = $7.648506E\text{-}11(mV)^3 + 1.839413E\text{-}6(mV)^2 + 0.0384022(mV) - 10.36550$
Wet bulb = $1.303252E\text{-}10(mV)^3 + 1.630955E\text{-}6(mV)^2 + 0.0386373(mV) - 10.19036$

Starboard Instrument (SN2002)

Dry bulb = $1.305221E\text{-}10(mV)^3 + 1.721910E\text{-}6(mV)^2 + 0.0384830(mV) - 10.39138$
Wet bulb = $2.793227E\text{-}10(mV)^3 + 1.400990E\text{-}6(mV)^2 + 0.0387425(mV) - 10.19583$

The data were logged on a PC Level A every 5 seconds and the calibrations given above were applied on the Level C. The four psychrometer channels plus the two channels from the Vaisala were averaged to 30 seconds and merged into the BODC underway file.

A first pass inspection on a graphics workstation was done to flag out any obvious problems affecting one of the psychrometers but not the other. The Vaisala temperature channel was inspected in conjunction as an independent check on the psychrometers. In general, the agreement between the temperature sensors was very good (usually within 0.1C with occasional differences up to 0.5C) except for the Vaisala temperature sensor which was obviously not functioning correctly. The data from this instrument were discarded.

Averaging the data from the port and starboard instruments generated combined dry and wet bulb temperature channels. The merged channels were then inspected on a graphics workstation. A number of noisy high temperature events affecting all sensors were identified in the record. These were attributed to stack thermal pollution and all temperature and humidity channels were flagged as suspect, even if the dramatic indication was only in the dry bulb temperature channel.

Please note that the Vaisala humidity channel has been included in the final data set as a convenient direct source of humidity data. It is, however, from a low grade instrument and readings (not spikes) of up to 102 per cent reveal possible accuracy limitations. Humidity may be computed from the wet and dry bulb temperature data as an alternative if required.

Wind Velocity

Two types of anemometer were included in the meteorological package on Challenger**,** a conventional Vaisala cup and vane anemometer and a sonic anemometer operated by Southampton Oceanography Centre (SOC).

The instruments were mounted on the meteorological package platform on the foremast (approximately 12m above sea level) with the sonic anemometer central and forward of the conventional anemometer, which had the cup to port and the vane to starboard. The cup and vane were at the same height as the mid-point of the sonic instrument. Both instruments were new in May 1996. The Vaisala vane was mounted with zero to starboard and the sonic anemometer was mounted with a 30 degree offset to port (i.e. if 180 degrees were the relative wind direction for wind blowing directly over the bows of the ship, then the v component would be +ve from 150 through 330 degrees and the u component would be +ve when the wind is between 60 and 240 degrees). A comparison of the relative directions from the two instruments for the previous cruise (CH127) indicated that the offset between the zero points of the two instruments was 110 degrees instead of the expected value of 120 degrees.

The objective of the data processing was to generate definitive wind speed and wind direction channels. These have been generated from the conventional anemometer to ensure comparability with other cruises where the sonic instrument may not be carried. However, the sonic data were temporarily merged into the data file to allow comparative screening of the relative wind speeds and the additional information it provided (vertical wind velocity) was retained.

The cup anemometer generated relative wind speed in m/s and relative wind direction in degrees. These were logged every 5 seconds by the PC Level A and the wind speed was converted to knots on the Level C by multiplying by 1.94. At BODC the wind speed was reduced to 30 seconds sampling by averaging and spot wind direction values were taken every 30 seconds from the 5-second stream. The merged file also included spot values of ship's heading taken every 30 seconds and averaged ship’s velocity over the ground (from data logged every 30 seconds). All these data channels were examined on a graphics workstation and suspect values flagged.

The ship's heading was added to the relative wind direction and 260 degrees subtracted to correct for the vane orientation. Note that this assumes that it was the sonic instrument that was correctly oriented due to its more robust mechanical mounting. The resulting value was constrained to the range 0-359 by adding or subtracting 360 as appropriate. The ship's velocity over the ground was then subtracted from the relative wind velocity to give the absolute wind velocity. Note that as the two velocities have opposite sign conventions, this is effectively an addition of the velocities converted to uniform sign convention.

The data were again screened on a workstation. Comparative screening checks were made to ensure that the absolute wind velocity was truly independent of the ship's velocity and heading. This proved to be the case except for spikes (usually in absolute direction but occasionally in speed as well) coinciding with times when the ship was accelerating or decelerating. These have been attributed to the mismatch in the sampling rates of the navigation and meteorology and have been flagged suspect.

The sonic anemometer provided three wind component velocities (port/starboard, fore/aft and vertical) as voltages such that (manufacturer’s calibration):

0V	Full scale negative
2.5V	Zero
5V	Full scale positive

The jumper settings in the instrument were set to give a full scale reading of 30 m/s. Voltages were logged every 5 seconds by the PC Level A. On the Level C the voltages were converted to velocities in knots using the equation:

$$\text{Velocity} = \text{Volts}*23.28 - 58.2$$

The 5-second data were reduced to 30 seconds sampling at BODC by averaging. Comparison of the raw wind speeds from the two instruments showed good agreement. No comparisons on the raw wind direction were undertaken.

The vertical wind velocity from the sonic instrument was inspected on a graphics workstation and a small number of obvious spikes were flagged suspect.

No attempt has been made to correct the data to a standard height of 10m.

3.4) Biology

Chlorophyll

Chlorophyll was measured by a Chelsea Instruments Aquatracka fluorometer immersed in a light-tight box plumbed into the non-toxic supply.

The fluorometer voltages were converted to chlorophyll concentrations by linear regression of the natural logarithm of discrete extracted chlorophyll data (GF/F filtered, acetone extracted, and fluorometrically assayed non-toxic supply samples) against corresponding fluorometer voltages.

The following equation resulted and was used to generate the chlorophyll channel in the binary merge file.

$$\text{Chlorophyll (mg m}^{-3}\text{)} = \exp(0.701 * \text{volts} - 1.73) \qquad (n = 72;\ R^2 = 70.8\%)$$

4) Data Warnings

None.

5) Reference

Fofonoff, N.P. and Millard Jr., R.C. (1983). Algorithms for Computation of Fundamental Properties of Seawater. ***UNESCO Technical Papers in Marine Science*** 44.

Surface Underway Data for Cruise Challenger CH128B (27th July to 7th August 1996)

1) Components of the Underway Data Set

The underway data set for cruise Challenger 128B contains the following data channels. The single character following each channel is the appropriate channel identifier in the binary merge file.

Navigation:	Latitude (°N)	A
	Longitude (°E)	B
	Carter corrected Bathymetric depth (m)	J
Physics:	Temperature (°C)	C
	Salinity (PSU)	F
	Optical Attenuance (m^{-1})	I
Meteorology:	Photosynthetically Available Radiation: scalar (W m^{-2})	L
	Photosynthetically Available Radiation: vector (W m^{-2})	t
	Solar radiation	O
	Dry bulb air temperature (°C)	a
	Wet bulb air temperature (°C)	b
	Relative humidity (%)	d
	Absolute wind speed (knots)	Y
	Absolute wind direction (degrees blowing from)	Z
	Vertical wind velocity (knots +ve up)	q
	Barometric pressure (mb)	1
Biology:	Aquatracka fluorometer output (V)	?
	Aquatracka Chlorophyll (mg m^{-3})	!

2) Methodology Overview

2.1) Plumbing

Seawater was continually pumped from the hull of the ship (at a depth of about 4m) through the various underway sensors on-deck. This is known as the ship's non-toxic supply. An outlet from this, situated in the ship's wet lab, was used to collect the calibration samples for the underway sensors.

2.2) Data acquisition

The RVS ABC logging system handled data logging and initial data processing. The Level A sampling microcomputer digitised input voltages, applied a time stamp and transferred the data via the Level B disk buffer onto the Level C (a Sun OS Workstation) where the data records were assembled into files.

The Level C includes a suite of processing software that was used to apply initial calibrations to convert raw ADC counts into engineering units. At the end of the cruise, the Level C disk base was transferred to BODC for further processing.

2.3) BODC data processing procedures

Data from the underway files were merged into a common file (the binary merge file) using time as the primary linking key. Data logged as voltages (e.g. PAR) were converted to engineering units.

Each data channel was inspected on a graphics workstation and any spikes or periods of dubious data were flagged. Whenever possible, comparative screening checks between channels were employed.

3) Data Processing, Correction and Calibration Procedures

3.1) Navigation

GPS was the primary navigation system used on this cruise. At BODC a program was run which locates any null values in the latitude and longitude channels and checks to ensure that the ship's speed does not exceed 15 knots. No speed check failures or gaps were encountered.

Bathymetric depth was logged by the ABC system from an RD200A echo sounder. The data were Carter's table corrected and screened on a graphics workstation. This visual inspection revealed the data present to be of generally good quality with very few spikes. However, the record contains a significant number of gaps containing no data, complete garbage or interference from pingers on winch-deployed instruments. All data in these gaps have been flagged either null or suspect.

3.2) Physics

<u>Temperature and Salinity</u>

Temperature and salinity were measured using an autoranging TSG103 thermosalinograph. The temperature sensor was a thermistor in the non-toxic supply inlet manifold. Conductivity was measured by a unit in the ship's wet laboratory that included a second thermistor to provide temperature data for the computation of salinity.

The raw ADC counts were processed into conductivity and two temperature channels based upon laboratory calibrations by RVS. Salinity was computed from the housing temperature and conductivity using the UNESCO 1978 Practical Salinity Scale (Fofonoff and Millard, 1982).

The thermosalinograph was calibrated against surface values taken from the calibrated CTD data set. The best fit for salinity was obtained using a linear drift model conforming to the following equation:

$$S_{cal} = S + (cycle\_number*0.000001) + 0.0774$$

Temperature exhibited a constant offset from the CTD that were corrected by applying the following calibrations:

$$T_{cal} = T + 0.016$$

Visual inspection of the data revealed a worrying feature in the salinity data. There was a dramatic low salinity (0.4 PSU drop) event present in the record from 13:05 to 23:52 on 31/07/1996. This coincided with a storm (50-knot winds) and consequently there were no CTD casts during the event to confirm or refute it. The event occurred whilst the ship was steaming steadily north-west into open ocean. When the ship returned along a track slightly to the north the following day, there was no sign of this low salinity water. There was a low temperature event but this lagged the salinity event by some 12 hours and probably represented mixing by the storm. On the basis of this evidence it has been concluded that this low salinity event was an artefact and the data have been flagged suspect. A later, less dramatic (0.1 PSU) low salinity event is supported by CTD data and is believed to be real.

Optical Attenuance

Optical attenuance was measured using a SeaTech red light (661nm) transmissometer with a 25cm optical path length mounted in a light-tight box on the starboard deck fed from the non-toxic supply.

Transmission air readings taken during the cruise (4.685V) were used to correct the transmissometer voltage to the manufacturer's specified air voltage (4.789 V) by ratio. The voltages were then converted to attenuance eliminating the influence of path length on transmission using the equation:

$$\text{Attenuance} = -4.0 * \log_e (\text{voltage} / 5.0)$$

The attenuance signal was generally clean except for isolated spikes caused by bubbles in the non-toxic supply. Flagging the affected data suspect has eliminated these. A good general correspondence between the transmissometer and fluorometer signals could be discerned. However, during the following short period the bubble spikes coalesced to the extent that the background signal might have been artificially elevated:

15:00 to 23:30 on 31/07/1996

3.3) Meteorology

Barometric Pressure

The meteorological package included a Vaisala aneroid barometer mounted on the foremast platform. The instrument output data in millibars which were logged every 5 seconds by a PC Level A. These data were reduced by averaging to 30 seconds sampling at BODC and examined on a graphics workstation. There was some evidence of noise with amplitude of approximately 0.5 mbar at times in the record. However, this was difficult to clean through flagging, as the 'noise' points could not be identified. The data have therefore been left unflagged.

No correction has been applied for the height of the instrument above sea level.

Radiation

Challenger was equipped for this cruise with a total of six radiation sensors. PML designed 2-pi PAR scalar irradiance meters and Kipp and Zonen solar radiation meters were mounted in pairs in gimballed housings on the port and starboard side of the 'Monkey Island' above the scientific plot. The starboard location is far from ideal due to a large satellite communication radome, which frequently shades the instruments. Two planar PAR sensors were mounted on the meteorological package platform on the port and starboard sides of the foremast.

The 2-pi PAR and Kipp and Zonen instruments have been in operation since 1988 but were overhauled and recalibrated in July 1995. The planar PAR sensors were new instruments fitted in May 1995.

The PML 2-pi PAR sensors were logged as voltages every 30 seconds on an RVS Level A. These were calibrated in W/m^2 by BODC using coefficients determined in July 1995. The calibration equations used were:

Port (sensor 3):	PAR = exp(Volts*4.97 + 6.526)/100
Starboard (sensor 5):	PAR = exp(Volts*4.91 + 6.952)/100

A merged PAR channel was produced, after spikes were flagged out, by taking the maximum of the port and starboard values to eliminate shading effects.

It has been determined by empirical calibration that the PAR values in W/m^2 measured by the PML 2-pi PAR sensors may be converted to $\mu E/m^2/s$ by multiplying by 3.75.

It must be emphasised that these instruments have hemispherical domed collectors, and therefore measure scalar irradiance. Consequently, simple comparisons between data from these instruments and other equipment with differing geometry must not be attempted.

The planar PAR sensors were logged every 5 seconds as a voltage by the meteorological package PC Level A. The voltages were converted to W/m^2 from volts on the Level C using the following manufacturer’s calibrations:

Port (SN2273):	$W/m^2 = (V*1000*1000)/16.3$
Starboard (SN2274):	$W/m^2 = (V*1000*1000)/16.75$

The data were reduced to 30 seconds sampling at BODC by averaging and any spikes found in the port and starboard channels were flagged as suspect. A merged PAR channel was produced containing the larger of the port and starboard values to eliminate shading effects.

The Kipp and Zonen instruments on Challenger are unique in as much as they are connected to a data integrator. This converted the instrument voltages into W/m^2 and integrated the values producing 10 minute and running total integrations in kJ/m^2. A Level A logged the output from the integrator at the end of each integration period.

At BODC, the 10 minute integrations were merged into the underway file by a custom program that divided the integrated energy by the integration interval to give an averaged irradiance value. The time stamp was also adjusted to the mid-point of the averaging interval by subtracting 5 minutes.

Visual observation of the data revealed an obvious problem. The values were much too small, with a maximum value of 250 W/m^2 recorded during the cruise, whereas a value of nearer 1000 W/m^2 would be expected. This is the first cruise where this phenomenon was observed, but it has been present on every subsequent Challenger cruise handled by BODC. Communications with RVS on the subject have failed to produce either an explanation or a cure. The integrator is the prime suspect as a cause and the most likely explanation is that the integration period has changed.

When compared to the other radiometer data, the instruments are obviously functioning perfectly. It's just the absolute values that are wrong. Rather than jettison the data, an empirical scaling 'correction' of 4 has been applied. This factor was obtained by comparing data from CH127 and CH133. It is believed to give a result within 5% of the true value.

A merged solar radiation channel was produced, after spikes were flagged out, by taking the maximum of the port and starboard values to eliminate shading effects.

Air Temperature and Humidity

The Metpac fitted to Challenger for this cruise included two Vector Instruments psychrometers fitted to the port and starboard sides of the foremast together with a Vaisala low grade temperature and humidity sensor mounted between them. These were brand new instruments fitted in May 1996. The Vaisala generated output in scientific units (C and %) whilst the psychrometers output voltages which were converted to temperatures using the manufacturer's calibrations thus:

Port Instrument (SN2003)

Dry bulb = 7.648506E-11(mV)^3 + 1.839413E-6(mV)^2 + 0.0384022(mV) - 10.36550
Wet bulb = 1.303252E-10(mV)^3 + 1.630955E-6(mV)^2 + 0.0386373(mV) - 10.19036

Starboard Instrument (SN2002)

Dry bulb = 1.305221E-10(mV)^3 + 1.721910E-6(mV)^2 + 0.0384830(mV) - 10.39138
Wet bulb = 2.793227E-10(mV)^3 + 1.400990E-6(mV)^2 + 0.0387425(mV) - 10.19583

The data were logged on a PC Level A every 5 seconds and the calibrations given above were applied on the Level C. The four psychrometer channels plus the two channels from the Vaisala were averaged to 30 seconds and merged into the BODC underway file.

A first pass inspection on a graphics workstation was done to flag out any obvious problems affecting one of the psychrometers but not the other. The Vaisala temperature channel was inspected in conjunction as an independent check on the psychrometers. In general, the agreement between the temperature sensors was very good (usually within 0.1C with occasional differences up to 0.5C) except for the Vaisala temperature sensor which was obviously not functioning correctly. The data from this instrument were discarded.

Averaging the data from the port and starboard instruments generated combined dry and wet bulb temperature channels. The merged channels were then inspected on a graphics workstation. A number of noisy high temperature events affecting all sensors were identified in the record. These were attributed to stack thermal pollution and all temperature and humidity channels were flagged as suspect, even if the dramatic indication was only in the dry bulb temperature channel.

Please note that the Vaisala humidity channel has been included in the final data set as a convenient direct source of humidity data. It is, however, from a low grade instrument and readings (not spikes) of up to 101 per cent reveal possible accuracy limitations. Humidity may be computed from the wet and dry bulb temperature data as an alternative if required.

Wind Velocity

Two types of anemometer were included in the meteorological package on Challenger, a conventional Vaisala cup and vane anemometer and a sonic anemometer operated by Southampton Oceanography Centre (SOC).

The instruments were mounted on the meteorological package platform on the foremast (approximately 12m above sea level) with the sonic anemometer central and forward of the conventional anemometer, which had the cup to port and the vane to starboard. The cup and vane were at the same height as the mid-point of the sonic instrument. Both instruments were new in May 1996. The Vaisala vane was mounted with zero to starboard and the sonic anemometer was mounted with a 30 degree offset to port (i.e. if 180 degrees were the relative wind direction for wind blowing directly over the bows of the ship, then the v component would be +ve from 150 through 330 degrees and the u component would be +ve when the wind is between 60 and 240 degrees). A comparison of the relative directions from the two instruments for the previous cruise (CH127) indicated that the offset between the zero points of the two instruments was 110 degrees instead of the expected value of 120 degrees.

The objective of the data processing was to generate definitive wind speed and wind direction channels. These have been generated from the conventional anemometer to ensure comparability with other cruises where the sonic instrument may not be carried. However, the sonic data were temporarily merged into the data file to allow comparative screening of the relative wind speeds and the additional information it provided (vertical wind velocity) was retained.

The cup anemometer generated relative wind speed in m/s and relative wind direction in degrees. These were logged every 5 seconds by the PC Level A and the wind speed was converted to knots on the Level C by multiplying by 1.94. At BODC the wind speed was reduced to 30 seconds sampling by averaging and spot wind direction values were taken every 30 seconds from the 5-second stream. The merged file also included spot values of ship’s heading taken every 30 seconds and averaged ship’s velocity over the ground (from data logged every 30 seconds). All these data channels were examined on a graphics workstation and suspect values flagged.

The ship's heading was added to the relative wind direction and 260 degrees subtracted to correct for the vane orientation. Note that this assumes that it was the sonic instrument that was correctly oriented due to its more robust mechanical mounting. The resulting value was constrained to the range 0-359 by adding or subtracting 360 as appropriate. The ship's velocity over the ground was then subtracted from the relative wind velocity to give the absolute wind velocity. Note that as the two velocities have opposite sign conventions, this is effectively an addition of the velocities converted to uniform sign convention.

The data were again screened on a workstation. Comparative screening checks were made to ensure that the absolute wind velocity was truly independent of the ship's velocity and heading. This proved to be the case except for spikes (usually in absolute direction but occasionally in speed as well) coinciding with times when the ship was accelerating or decelerating. These have been attributed to the mismatch in the sampling rates of the navigation and meteorology and have been flagged suspect.

The sonic anemometer provided three wind component velocities (port/starboard, fore/aft and vertical) as voltages such that (manufacturer’s calibration):

0V	Full scale negative
2.5V	Zero
5V	Full scale positive

The jumper settings in the instrument were set to give a full scale reading of 30 m/s. Voltages were logged every 5 seconds by the PC Level A. On the Level C the voltages were converted to velocities in knots using the equation:

$$\text{Velocity} = \text{Volts}*23.28 - 58.2$$

The 5-second data were reduced to 30 seconds sampling at BODC by averaging. Comparison of the raw wind speeds from the two instruments showed good agreement. No comparisons on the raw wind direction were undertaken.

The vertical wind velocity from the sonic instrument was inspected on a graphics workstation. No data were flagged.

No attempt has been made to correct the data to a standard height of 10m.

3.4) Biology

Chlorophyll

Chlorophyll was measured by a Chelsea Instruments Aquatracka fluorometer immersed in a light-tight box plumbed into the non-toxic supply.

The fluorometer voltages were converted to chlorophyll concentrations by linear regression of the natural logarithm of discrete extracted chlorophyll data (GF/F filtered, acetone extracted, fluorometrically assayed non-toxic supply samples) against corresponding fluorometer voltages.

The following equation resulted and was used to generate the chlorophyll channel in the binary merge file.

$$\text{Chlorophyll (mg m}^{-3}\text{)} = \exp(1.29 * \text{volts} - 3.51) \quad (n = 26;\ R^2 = 63\%)$$

4) Data Warnings

The thermosalinograph indicated a dramatic low salinity event on 31/07/1996 which has been interpreted as an artefact and flagged suspect.

An empirical scaling factor based on data comparison between two cruises was required to obtain reasonable values for the solarimeter data.

5) Reference

Fofonoff, N.P. and Millard Jr., R.C. (1983). Algorithms for Computation of Fundamental Properties of Seawater. ***UNESCO Technical Papers in Marine Science*** 44.