# Underway navigation, meteorology and surface hydrography data series for cruise Challenger CH140 (20 October to 9 November 1998)

## Cruise Principal Scientist

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## Data Originators

British Oceanographic Data Centre (BODC), POL, Merseyside, UK.
Research Vessels Services (RVS), SOC, Southampton, UK.

## Content of data series

| Parameter | Unit | Parameter code | Comments |
|---|---|---|---|
| Latitude | deg. N | A | none |
| Longitude | deg. E | B | none |
| Ship's Heading | deg. | u | none |
| Ship's EW velocity | knot | 6 | computed |
| Ship's NS velocity | knot | 7 | computed |
| Distance along track | km | g | none |
| Water depth | m | J | no record after 03/11/98 12:00 |
| Sea temperature | deg. C | C | none |
| Salinity | PSU | F | none |
| Raw fluorescence | mV | G | starts on 25/10/98 |
| Chlorophyll *a* | µg $l^{-1}$ | D | calibrated from fluorescence |
| Attenuance (660 nm) | per m | I | none |
| Atmospheric pressure | mbar | z | none |
| Dry bulb air temperature | deg. C | n | none |
| Relative humidity | percent | { | none |
| Relative wind speed | knots | l | none |
| Relative wind direction | degree | m | gap in record between 25/10/98 11:09 and 31/10/98 10:38 |
| Absolute wind speed | knots | Y | computed |
| Absolute wind direction | degree | V | computed (260 degree vane correction applied) |
| PAR vector irradiance | W $m^{-2}$ | t | computed |

## Sampling strategy

Navigation and meteorological data were recorded for the duration of the cruise from 21 October 1998 13:30 GMT, shortly after the ship left Greenock in the Clyde estuary until 8 November 1998 15:00, shortly before entering the Tyne estuary where the scientific party debarked (Fig. 1). The record for the surface underway data was usually shorter because the pump of the non-toxic sampling system is typically switched off close to coastal area. The cruise was divided into two legs with a mid-cruise port-call at Peterhead (East coast Scotland) on 30th October. Logging of underway data was stopped from 7:30 on 30th to 10:30 on 31st October while the ship was in Peterhead.

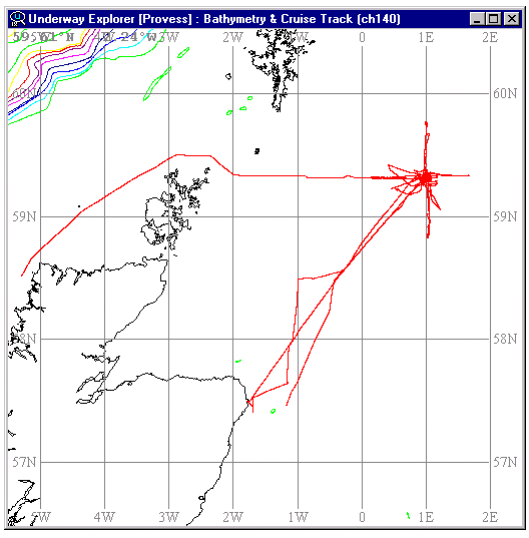


Fig. 1. Cruise track of cruise Challenger CH140.

## Instrumentation and data processing by originator

**Instruments and data acquisition:**
The underway data acquisition system was an ABC-system (NERC, Research Vessel Services, UK). It handled the logging and initial data processing from the following instruments:

- Simrad EA-500 echosounder for water depth.
- Chelsea Instruments Aqua-flow system: seawater was continually pumped from the hull of the ship (at a depth of about 4m) through the various underway sensors on-deck (known as 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. The sensors consisted of an FSI integrated thermosalinograph for temperature and salinity, Turner Design WetStar fluorometer WS3S-134 (linear signal), Wet Labs C-Star red-light transmissometer CST-113R (661 nm, 25cm pathlength).
- RVS met system comprising port and starboard Didcot PAR sensors DRP-5, Vaisala HMP44L humidity and temperature sensor and Vaisala PTB100A barometer.
- Global Positioning System, Gyro compass and EM. Speedlog for navigation data.

Initial manufacturer's calibrations were applied to convert raw ADC counts into engineering units. The raw ADC counts from the thermosalinograph were processed into conductivity and two temperature channels (one from the thermistor located in the non-toxic supply inlet manifold and one located in the conductivity cell unit located in the ship's lab) 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).

Data were then supplied to BODC for further processing.

## BODC post-cruise processing and screening

**Reformatting:**
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. Fluorescence was left as voltage.

**Screening:**
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.

**Data processing, correction and calibration procedures:**

- Navigation: 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. Two gaps of 1 min and 13 min respectively were located in the record and 382 speed checks failed. These were investigated using the in-house graphics editor SERPLO. Overlay of the ship's track with GEBCO bathymetry indicated that the ship's trajectory was wrong relative to the islands on the west coast of Scotland at the beginning of the cruise (20 to 23 October). Navigation errors were also observed up until 23/10/1998 03:36:30. As a result, the file was cropped and all channels made to start on 23 October 1998 03:37:00.
- Temperature and salinity: Underway sea surface temperature (SST) and salinity (SAL) were calibrated against surface values taken from the calibrated CTD data set and averaged between 3 and 6 db (excluding flagged data points). The temperature offset was not constant throughout the cruise: a stepwise increase of the TSG temperature signal was observed on 6/11/98 between 23:15 and 23:35. Temperature records during this period were flagged as suspect. Before and after this date the offset between TSG temperature and CTD temperature was constant and the following calibrations were applied to the TSG temperature data:

From start to 06/11/98 23:15:00: $T_{cal}$ = T -0.3 (standard deviation: ±0.04 deg. C)
From 06/11/98 23:15:30 to end: $T_{cal}$ = T -0.5 (standard deviation: ±0.04 deg. C)

The salinity offset was constant throughout the cruise and the calibration applied was as follows:

$S_{cal}$ = S – 0.29 (standard deviation: < ±0.005 , n= 41)

The calibrated data were then checked against 18 surface bottle salinity samples obtained from the ship's non-toxic supply (Dave Teare, RVS). The difference between the two was not significantly different from zero indicating that no further calibration was necessary.

- Fluorescence: a total of 20 extracted chlorophyll *a* measurements from samples collected from the ship's non-toxic supply outlet was available for the calibration of the fluorometer voltage output. However, the range of variation of the surface chlorophyll concentration (0.33 to 0.54 µg $l^{-1}$) was too small to establish a significant relationship between fluorometer voltages and chlorophyll *a* concentrations. A first attempt was made to apply the manufacturer's calibration equation to the fluorometer voltages.

Manufacturer's calibration equation:

$$\text{Chlorophyll (mg m}^{-3}) = (V_{sample} - V_{blank}) * \text{Scale Factor}$$

where:

Vsample = *in situ* output of the WETStar (volts)
Vblank = clean water blank voltage output (volts) = 0.0777
Manufacturer's Scale Factor = Chlorophyll concentration / ($V_{copro}$ - $V_{blank}$)
Manufacturer's Scale Factor = 50 / (2.9218 - 0.0777) = 17.58

However, the scale factor derived from using equivalent chlorophyll concentration based on coproporphyrin tetramethyl ester sample gave unrealistically high chlorophyll concentrations. Alternatively the average extracted chlorophyll concentration (0.45 ± 0.05 µg $l^{-1}$, n=20) and the average corresponding fluorometer voltages (669.51 ± 34.47 mVolts, n=20) were used to derive a field calibration scale factor.

Field Scale Factor = avg extracted chlorophyll concentration / (avg$V_{sample}$ - $V_{blank}$)
Field Scale Factor = 0.45 / (0.66951 - 0.0777) = 0.76

The following calibration equation was therefore applied to generate the chlorophyll channel in the binary merge file:

$$\text{Chlorophyll (µg l}^{-1}) = 0.00076 \times (\text{mVolts}) - 0.059$$

This calibration resulted in predicted chlorophyll concentrations being within ± 0.06 µg $l^{-1}$ of the extracted value (95% confidence interval) and residuals ranging between -0.10 and 0.13 µg $l^{-1}$.

- Attenuance: transmission air reading ($CV_{air}$ = 4.915V) and blocked path reading ($CV_{blocked}$ = 0.0564V) taken at the end of the cruise were used to correct the transmissometer voltage to the manufacturer's specified air voltage ($V_{air}$ = 4.976V) by ratio:

$$V_{ref} = V_{cw} * (CV_{air} - CV_{blocked}) / (V_{air} - V_{dark}),$$

where $V_{cw}$, $V_{air}$ and $V_{dark}$ are measurements carried out by the manufacturer. $V_{ref}$ is the output voltage of the instrument in clean water; $V_{air}$ is the output voltage in the air; $V_{dark}$ is the instrumental offset and is the output voltage with the instrument path blocked.

Percent transmission was then calculated using the formula:

$$\text{trans} = (V - CV_{blocked}) / (V_{ref} - V_{dark}).$$

Transmission was converted to attenuance using standard formula but included an offset correction factor of 0.364 in order to obtain attenuance values in clear water comparable to that typically recorded by WetStar transmissometers.

$$\text{Attenuance} = -(1 / 0.25) * \log_e (\text{trans}) + 0.364.$$

- PAR radiance: the two Didcot DRP-5 cosine-collector PAR sensors were mounted on the port and starboard sides of the ship's foremast. The data were logged as voltages which were later converted to W $m^{-2}$ by BODC using coefficients determined by the manufacturer after the cruise in February 1999.

The calibrations applied were:

Port (S/N2273): PAR (W $m^{-2}$ ) = Volts x 1000 x 1000/13.63
Starboard (S/N2274): PAR (W $m^{-2}$ ) = Volts x 1000 x 1000/13.59

The data were then screened and spikes were flagged as suspect using the in-house graphic editor Serplo. A merged PAR channel was then produced from the 'clean' data by taking the maximum of the port and starboard values to minimise shading effect.

- Wind speed and direction: the anenometer used on this cruise was a conventional Vaisala cup and vane anemometer. The instrument was mounted on the meteorological package platform on the foremast (approximately 12 m above sea level). The anemometer generated relative wind speed in m/s and relative wind direction in degrees. 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 second 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 were flagged. The ship's heading was added to the relative wind direction and 260 degrees subtracted to correct for the vane orientation. It was noted that the 90 degree vane orientation correction initially applied to the data gave erroneous data. As a result the correction for the vane orientation had to be determined by trying several correction angles and choosing the best fit visually. Successive vane orientation corrections were applied and the data were examined graphically alongside ship's heading until the effect of ship's heading on corrected wind speed was minimised. The wind direction did not function between 25/10/98 11:09 and 31/10/98 10:38, and as a result, there are no relative wind direction or absolute wind speed and direction data available for this period.

Note that the wind data were not corrected to a standard height but represent the wind at the height of the instrument.

## Comments on data quality

See above: 'BODC post-cruise processing and screening'.

## Reference

Fofonoff NP, Millard RC (1983) Algorithms for computation of fundamental properties of seawater. Unesco technical papers in marine science No. 44, 53 pp.