Seasoar Data for Cruise Discovery 192  
(9 June - 27 June 1990)

1) INSTRUMENTATION

The Seasoar is a hydrodynamic fish towed behind a ship travelling at 8-9 knots linked by a faired cable. The unit has two stub wings whose angle of attack may be set by hydraulic servo motors. Thus the fish is able to climb or dive under the control of command signals from the ship or, more usually, by automatic command signals driven by the on-board pressure sensor.

On this cruise, the Seasoar cable was approximately 500 metres in length, enabling the fish to 'fly' between the surface and a depth of 300m. The unit was programmed to ascend and descend at approximately 1 m/s which, assuming a towing speed of 8.5 knots, gave a complete oscillation from surface to 300m and back to the surface for every 2.7 km travelled.

The Seasoar contained a Neil Brown Systems Mk3B CTD incorporating a pressure sensor, conductivity cell, platinum resistance thermometer and a Beckmann dissolved oxygen sensor. The unit was mounted horizontally along the body of the fish. A Chelsea Instruments Aquatracka fluorometer was mounted in the nose of the fish sampling through a window facing downwards at an angle of 45 degrees.

The instrument was also fitted with an array of upwelling and downwelling irradiance sensors covering a range of spectral bands. Data from these were not made available for the CD-ROM deadline.

2) DATA ACQUISITION

CTD data were sampled at a frequency of 32 Hz. Data reduction was in real time, converting the 32 Hz data to a 1-second time-series (done by the RVS Level A system) which was then passed through an Analogue-Digital Converter and logged as digital counts on the Level C.

Due to the limitations of the Level A hardware available at the time, two parallel systems were used, one to log the hydrographic data whilst the other logged the optical data. Synchronisation of the time channels proved to be a real problem which was largely responsible for the non-availability of the optical data.

3) ON-BOARD DATA PROCESSING

Much of the Seasoar data processing was undertaken in close to real time. Data were logged for four hours and processed during the following four hours whilst the next four-hour segment of data was being logged.

The raw data were passed from the Level C onto a second Sun workstation running the P-EXEC suite of data processing software. Standard procedures were then used to convert the raw counts into engineering units (pressure (db), salinity (PSU), temperature (C), oxygen (ml/l), nominal chlorophyll (mg/m$^3$)). Salinity was computed from conductivity using the algorithms given in Fofonoff and Millard (1982).

The objectives of the real time data processing were the elimination of spikes and the correction of salinity offsets due to biological fouling. The latter is a problem to which Seasoar is
particularly susceptible, because the fish travels through the water at well over 10 knots and inevitably collides with animals whose remains become lodged in the conductivity cell.

The quality control procedure was to plot out temperature/salinity diagrams for each upcast and downcast, and a time series plot for the segment. These were used to identify spikes and quantify any salinity offsets. Spikes were eliminated (set to null values) and offsets corrected using the editing programs included in the P-EXEC package.

Inevitably, most of the available time was spent cleaning up the salinity channel. Any rare problems in the temperature channel were apparent from the T/S plots. However, it is quite conceivable for spikes in the chlorophyll or oxygen channels to have passed unnoticed.

The individual four-hour data files were merged into survey leg files and the near surface salinities calibrated from bottle samples taken from the non-toxic supply shortly before the Seasoar reached the surface. These samples were timed such that the Seasoar passed through the water sampled.

This gave the equation below which has been applied to the data:

$$
\text{Scorr} = \text{Sobs} + 0.0545
$$

Dissolved oxygen was computed using a nominal calibration.

No meaningful chlorophyll calibration was possible during the cruise due to the severe malfunctioning of the Turner Designs bench fluorometer.

The calibrated data were interpolated onto a regular grid with cells 4km long by 8m deep using the P-EXEC program PGRID, based upon UNIRAS interpolation algorithms. These gridded files form the basis for the data set on the CD-ROM. The full 1Hz data (in GF3 format) have been archived by BODC.

4) POST-CRUISE PROCESSING

The gridded data files were loaded directly into Oracle tables by a one-off program written for the purpose. This extracted header information for each column in the grid from the underway data file and then loaded the datacycles into a table used for calibrated CTD data. Thus, each column of the gridded data files has been treated as if it were a CTD cast with each profile containing data from 1.5 to 2 (depending on the depth attained) oscillations of the Seasoar.

A set of surface water samples corresponding to Seasoar arrivals at the surface was taken, filtered through GF/F filter papers and frozen. These were extracted into 90% acetone back in the laboratory and assayed fluorometrically.

This data set was used to calibrate the fluorometer as follows. First, surface bin values corresponding to the sampling times were obtained and compared against the extracted chlorophyll values. The result showed a weak but significant correlation ($r=0.69$). Bringing the irradiance from the underway sensor into the calibration significantly increased the correlation ($r=0.81$). This may partially result from the log transforms used in the regression, but a subsequent analysis of the magnitude of the residuals at midday showed a marked improvement when PAR was considered.

The calibration equation derived was:
chl (mg/m³) = exp (0.000735*PAR + 0.670*log(nominal chlorophyll) - 0.536) \( (r^2=65.8\%) \)

No PAR channel was available for the Seasoar data. This problem was overcome by using CTD data to determine the following empirical relationship between the surface underway PAR and the PAR at depth:

\[
\text{PAR} = \exp(\log(\text{surface PAR}) - 0.085*(\text{pressure}-6))
\]

These two equations were combined to generate recalibrated chlorophyll data from the binned nominal chlorophyll data set. Comparisons of the calibrated chlorophyll values with the extracted chlorophyll data set and the data from the underway Turner Designs instrument were most encouraging.

Dissolved oxygen was converted from ml/l to µM by multiplying the values by 44.66. Surface bin values were then regressed against contemporaneous samples determined following the methods of Carpenter (1965) as modified by Williams and Jenkinson (1982).

Empirical analysis of the data showed that for the first three legs of the Seasoar survey (until 08:00 on June 13th) the following equation could be derived:

\[
\text{Ocorr} = \text{Oobs} \times 0.962 + 29.3 \ (r^2=86.8\%)
\]

The resulting calibrated data showed good agreement with the underway Endeco dissolved oxygen data. For the rest of the Seasoar survey, the equation below was derived:

\[
\text{Ocorr} = \text{Oobs} \times 0.387 + 167 \ (r^2=29.0\%)
\]

The statistics of this calibration are very poor and the good agreement with the Endeco data observed for the first three legs of the survey breaks down. Consequently, users are advised to use the oxygen data from the latter part of the survey with extreme caution.

Oxygen saturations were computed using the equations of Benson and Krause (1984).

All the calibrations described above have been applied to the data.

5) DATA WARNINGS

Salinity accuracy is not known but the data are believed to be of good quality. In general, good quality Seasoar data have a salinity accuracy of the order of 0.02 PSU. Users concerned about the third decimal place in salinity are warned that these data may not be sufficiently accurate.

The dissolved oxygen data after 08:00 on 13th June 1990 are of poor quality and are best ignored.

6) BIBLIOGRAPHY

The concentration and isotopic fractionation of oxygen dissolved in fresh water and sea water in equilibrium with the atmosphere. Limnol. Oceanogr. 29: 620-632.

The Chesapeake Bay Institute techniques for the Winkler dissolved oxygen method. Limnology and Oceanography 10: 141-143.