

Cruise Report 18/02

RV Prince Madog, 13th – 20th July 2002

Project: NERC Research Programme GR3/12903 “Quantitative studies of the inherent optical properties of marine particle suspensions and their influence on remote sensing reflectance in Case 2 waters”

Sean Gaffney

School of Ocean Sciences, University of Wales Bangor

Objectives

The cruise was the fifth cruise carried out for the National Environment Research Council Programme GR3/12903 (see above). The main objective of the project is to conduct a survey of mass-specific inherent optical properties in coastal waters, using *in situ* measurements of absorption, beam attenuation and forward scattering and an indirect method to determine the volume scattering function. The results of the survey are to be used to evaluate the effect of strong variations in the optically dominant class of suspended particles on marine reflectance.

The objectives of this cruise were:

- To make measurements of the mass-specific optical properties of the water column on both sides of a front, in order to determine the difference that stratification and mixing make to the underwater light field.
- To make measurements of the mass-specific optical properties of the water column in waters with both low and high sediment concentration, in order to assess the influence sediment concentration has on the underwater optical signal.
- To take water samples and optical measurements hourly over a tidal cycle at one point, northwest of Anglesey. This was done in order to determine what level of variability in the underwater light field is due to tidal action and to what extent satellite monitoring of the water column needs to account for tidal action.
- To examine particle size distributions in the clear waters of the Celtic Sea and the turbid waters off Anglesey.
- To calibrate the transmissometer on the CTD rosette to provide data on sediment concentration.

Personnel

The following scientists took part in the cruise

Dr. Alex Cunningham (University of Strathclyde, Scientist in Charge)

Dr. Dave Bowers (School of Ocean Sciences)

Dr. Sarah Jones (School of Ocean Sciences)

Dr. Dave McKee (University of Strathclyde)

Dr. Susanne Craig (University of Strathclyde)

Dr. Oujin Jeong (National Oceanography Research Institute, Korea)

Agnes Dudek (University of Strathclyde)

Dong H Shon (School of Ocean Sciences, PhD student)

Kathy Ellis (School of Ocean Sciences, PhD student)

Ellie Bray (School of Ocean Sciences, Undergraduate)

Cruise Summary

Narrative

Table 1 summarises the station locations and Figure 1 displays the station positions for the 8 days of the cruise. In total, 49 stations were sampled, 15 of those being repeats of the same station, 12 of which occurred over 1 tidal cycle.

The station used for monitoring over a tidal cycle (T1) was positioned off the northwest coast of Anglesey, in an area known for very strong tidal currents ($\sim 1\text{ms}^{-1}$). The stations in the Celtic Sea were chosen to provide detailed spatial coverage on both sides of the region in which the Celtic Sea front is known to form. The final three stations were positioned at station T1 off the north coast of Anglesey to provide more high concentration sediment dominated water samples to contrast with the samples taken across the Western Irish Sea front.

On Day 1, the Prince Madog departed north from Menai Bridge and turned west along the coast of Anglesey, arriving at station T1 at low water slack tide (0810 HRS BST [All times in report are in BST unless indicated otherwise]). This station was sampled 12 times over a tidal cycle, whereupon the RV Prince Madog steamed south to station B7 overnight.

On Day 2, the vessel arrived at station B7 at 0915 HRS. Stations B7 through B2 were sampled throughout the day, working northeast back into the Irish Sea. The RV Prince Madog moored in Rosslare Harbour overnight.

On Day 3, the RV Prince Madog departed Rosslare Harbour and arrived at station A2 at 0800 HRS. Stations A2 through to A7 and station S1 were sampled throughout the day, working southwest into the Celtic Sea. The RV Prince Madog remained at sea throughout the night.

On Day 4, the RV Prince Madog arrived at station C7 at 0800 HRS. Stations C7 through C2 were sampled throughout the day, working northeast towards the Irish Sea. The RV Prince Madog remained at sea overnight.

On Day 5, the RV Prince Madog arrived at station E2 at 0820 HRS. Station E2 and station E1 were sampled and then the RV Prince Madog steamed to Milford Haven, arriving at 1400 HRS. The ship moored overnight here. Scientists Dr. Dave Bowers and Dr. Sarah Jones left the cruise here, while Dr. Oujin Jeong came aboard.

On Day 6, the RV Prince Madog left Milford Haven to arrive at station E3 at 1410 HRS. Stations E3 through E6 were sampled, working southwest into the Celtic Sea. On completion of station E6, the RV Prince Madog remained at sea overnight.

On Day 7, the RV Prince Madog began sampling at station D7 at 0750 HRS. Stations D7 through D-END were sampled, steaming northeast back into the Irish Sea. On completing station D-END, the RV Prince Madog steamed north towards Holyhead overnight.

Finally, **on Day 8**, the RV Prince Madog carried out three repeats of station T1, from 0750-0940, arriving back in Menai Bridge to finish the cruise during mid-afternoon.

Table 1. Station Positions on RV Prince Madog cruise 13th – 20th July 2002

| Station | Date | Time BST | Lat. (°) | Lon. (°) | Depth. (m) |
|---------|----------|-------------|-------------|-------------|---------------|
| T1 | 13/07/02 | 0800-2030 | 53.46848 | -4.53674 | 45-60m |
| B7 | 14/07/02 | 0915 | 51.62527 | -6.5612 | 79 |
| B6 | 14/07/02 | 1110 | 51.75432 | -6.40135 | 72 |
| B5 | 14/07/02 | 1235 | 51.88337 | -6.23122 | 86 |
| B4 | 14/07/02 | 1415 | 51.00817 | -6.0666 | 88 |
| B3 | 14/07/02 | 1600 | 52.13128 | -5.90007 | 90 |
| B2 | 14/07/02 | 1815 | 52.26923 | -5.72752 | 88 |
| A2 | 15/07/02 | 0800 | 52.2381 | -5.92508 | 84 |
| A3 | 15/07/02 | 0950 | 52.20187 | -6.11423 | 71 |
| A4 | 15/07/02 | 1140 | 52.07537 | -6.27773 | 68 |
| A5 | 15/07/02 | 1330 | 51.954 | -6.45 | 65 |
| A6 | 15/07/02 | 1520 | 51.81605 | -6.62077 | 64 |
| A7 | 15/07/02 | 1700 | 51.68583 | -6.8 | 67 |
| S1 | 15/07/02 | 2015 | 51.34135 | -6.64452 | 87.5 |
| C7 | 16/07/02 | 0800 | 51.52893 | -6.33355 | 100 |
| C6 | 16/07/02 | 0940 | 51.64895 | -6.23712 | 103 |
| C5 | 16/07/02 | 1130 | 51.78272 | -6.05538 | 115 |
| C4 | 16/07/02 | 1325 | 51.91503 | -5.89453 | 105 |
| C3 | 16/07/02 | 1515 | 52.03802 | -5.726 | 104 |
| C2 | 16/07/02 | 1700 | 52.1635 | -5.56167 | 93 |
| E2 | 17/07/02 | 0820 | 51.55363 | -5.75058 | 88 |
| E1 | 17/07/02 | 1010 | 51.6771 | -5.5818 | 66 |
| E3 | 18/07/02 | 1410 | 51.41748 | -5.92182 | 94 |
| E4 | 18/07/02 | 1630 | 51.29163 | -6.09388 | 101 |
| E5 | 18/07/02 | 1805 | 51.1485 | -6.27522 | 100 |
| E6 | 18/07/02 | 1930 | 51.01597 | -6.44588 | 98 |
| D7 | 19/07/02 | 0750 | 51.4539 | -6.17702 | 108 |
| D6 | 19/07/02 | 0930 | 51.58613 | -6.01157 | 109 |
| D5 | 19/07/02 | 1110 | 51.70663 | -5.83927 | 124 |
| D4 | 19/07/02 | 1250 | 51.84045 | -5.66775 | 99 |
| D3 | 19/07/02 | 1440 | 51.83458 | -5.49875 | 75 |
| D2 | 19/07/02 | 1620 | 52.09167 | -5.33068 | 67 |
| D1 | 19/07/02 | 1735 | 52.22493 | -5.16487 | 61 |
| D0 | 19/07/02 | 1849 | 52.35202 | -5.00275 | 58 |
| D-END | 19/07/02 | 2010 | 52.46308 | -4.83837 | 53 |
| T1 | 20/07/02 | 0750-0940 | 53.46848 | -4.53674 | 43-45m |

Measurements Made

At each of the sampling stations, the following measurements were made:

- 1) – Lower CTD with LISST-100 particle sizer bolted to CTD frame, to just above seabed. Measure Secchi Depth and take surface water samples with bucket
- 2) – Return CTD to surface, taking 30 litres of water at each of two depths; depths to be chosen based on the CTD profile. One water bottle on rosette to contain stainless steel sleeve for Galai Ci 100 particle size analyser.
- 3) – Filter water samples taken on rosette for SPM, chlorophyll, yellow substance, particle spectra and particle size.
- 4) – Deploy AC-9 absorption meter, Hydroscat-2 scattering meter and LISST-25 particle sizer package and profile as for CTD
- 5) – Deploy PRR-600 multiband radiometer, profile to just above bed and measure upwelling and downwelling radiance and irradiance at SeaWiFS wavelengths
- 6) – Deploy SPMR-7 freefalling multiband radiometer, profile to just above the bed and repeat measurements made by PRR-600
- 7) – ADCP running to obtain current data for each station

Bottle samples were taken from the CTD rosette at each station for calibration of the CTD conductivity meter.

Preliminary Results

In the Celtic Sea, a thermal front was detected in the CTD temperature data. The stratified region covers a region south of a line running from Carnsore Pt. in Ireland to Skomer Island on the Pembrokeshire coast (see Fig. 2). There is also a central tongue of stratified water extending into St. Georges Channel. However, there is no front visible in the salinity data obtained during the cruise (Fig. 3). The level of thermal stratification present in the front can be seen in a map of the surface/bottom temperature difference in the Celtic Sea constructed using CTD records from the cruise (Fig. 4). The plot clearly shows mixed water present in St. Georges Channel, a sharp frontal boundary along the Carnsore Pt. / Skomer Island line, and a steadily increasing level of stratification out into the Celtic Sea. Examples of the difference between the mixed and stratified regions can be seen in Figs. 5 and 6. Fig. 5. displays the temperature and salinity records from the CTD for station D2. Here, the surface/bottom temperature difference is 0.1991°C (Fig. 5a) while the surface/bottom salinity difference is 0.0347 (Fig. 5b). This contrasts with the data from the stratified region. An example of a station in the stratified region is station A7 (Figure 6). The thermal stratification of the water column is clearly visible, with a surface/bottom temperature difference of 5.4508°C (Fig. 6a) and a surface/bottom salinity difference of 0.0339 (Fig. 6b).

Water clarity data were measured throughout the cruise but did not show any evidence of the front visible in Figure 2. Figure shows a map of water column transparency indicated by Secchi Depth for the Celtic Sea, constructed from in-situ measurements made during the cruise. The most turbid water, recorded at stations C4 and C5 where the Secchi Depth

was 6.5m, is concentrated in the centre of the study area. The region of high turbidity extends eastwards towards the Welsh coast. There is a suggestion from the plot that the source of the turbid water may be outflow from the Bristol Channel and Severn Estuary. The clearest water measured during the cruise was found in the south of the study area, at stations E4 and E6, where the Secchi Depth was 15m.

Instrument Performance

All instruments functioned perfectly during the cruise.

Summary of achievements

- i) High quality optical measurements to provide data on evaluating the effect of fronts and stratification on marine reflectance and the underwater light field.
- ii) High quality optical measurements such as in situ measurements of absorption, beam attenuation and forward scattering, in order to determine the mass-specific inherent optical properties of stratified Case II waters.
- iii) Collection of a suspended sediment dataset to use in determining the mass-specific inherent optical properties of sediment dominant coastal waters; also to be used in the development of an algorithm relating remote sensing reflectance measured by SeaWiFS to sediment load and in the calibration of the CTD transmissometer.
- iv) Collection of chlorophyll samples (to be analysed fluorometrically and by high performance liquid chromatography) for use in development of an algorithm relating remote sensing reflectance measured by SeaWiFS to plankton species types
- v) Collection of particle size information for both turbid and clear waters in the Irish and Celtic Seas.

Acknowledgements

I would like to thank the Captain and crew of the RV Prince Madog for their hard work and enthusiasm during the cruise. This enabled all cruise objectives to be met. I would like to thank Anne Hammerstein for her work with the CTD, and all participating scientists for their efforts. This cruise was the fifth in a series funded under NERC Programme GR3/12903 “Quantitative studies of the inherent optical properties of marine particle suspensions and their influence on remote sensing reflectance in Case 2 waters”. I would like to thank the Irish Government for granting permission for the RV Prince Madog to work in Irish waters.

Figure 1. Station Positions. RV Prince Madog cruise, 13-20 July 2002

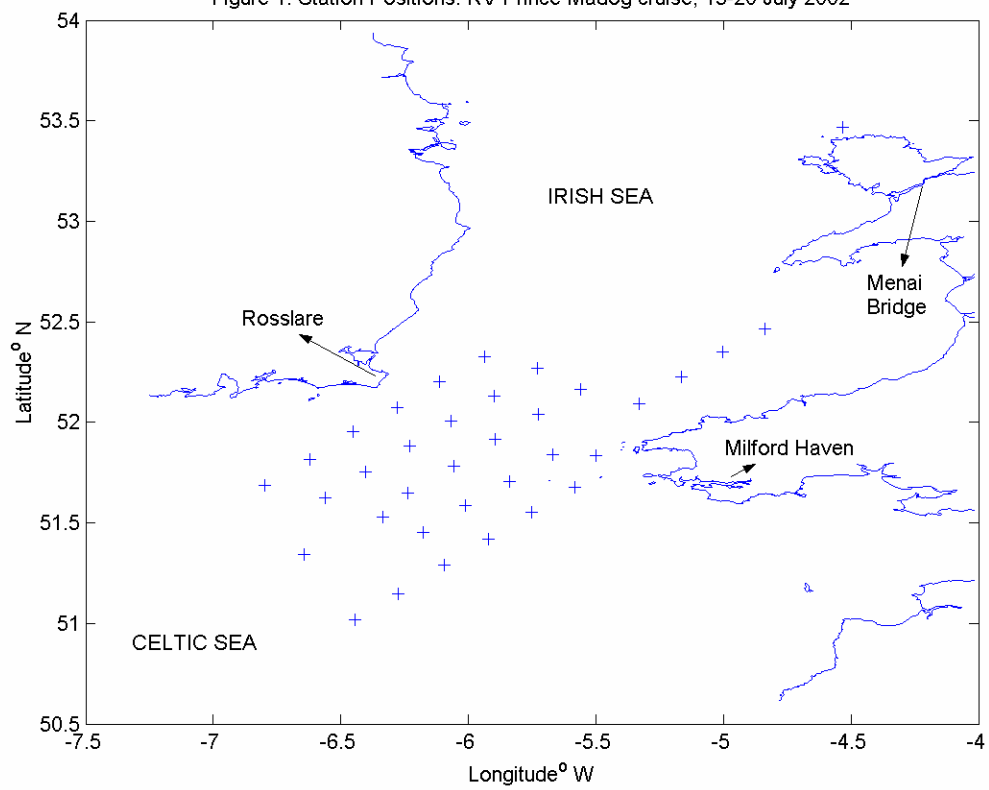


Figure 2.

Surface water column temperature (deg C) variation in the Celtic Sea.
Result obtained from CTD measurements on R.V. Prince Madog cruise,
13 - 20 July 2002

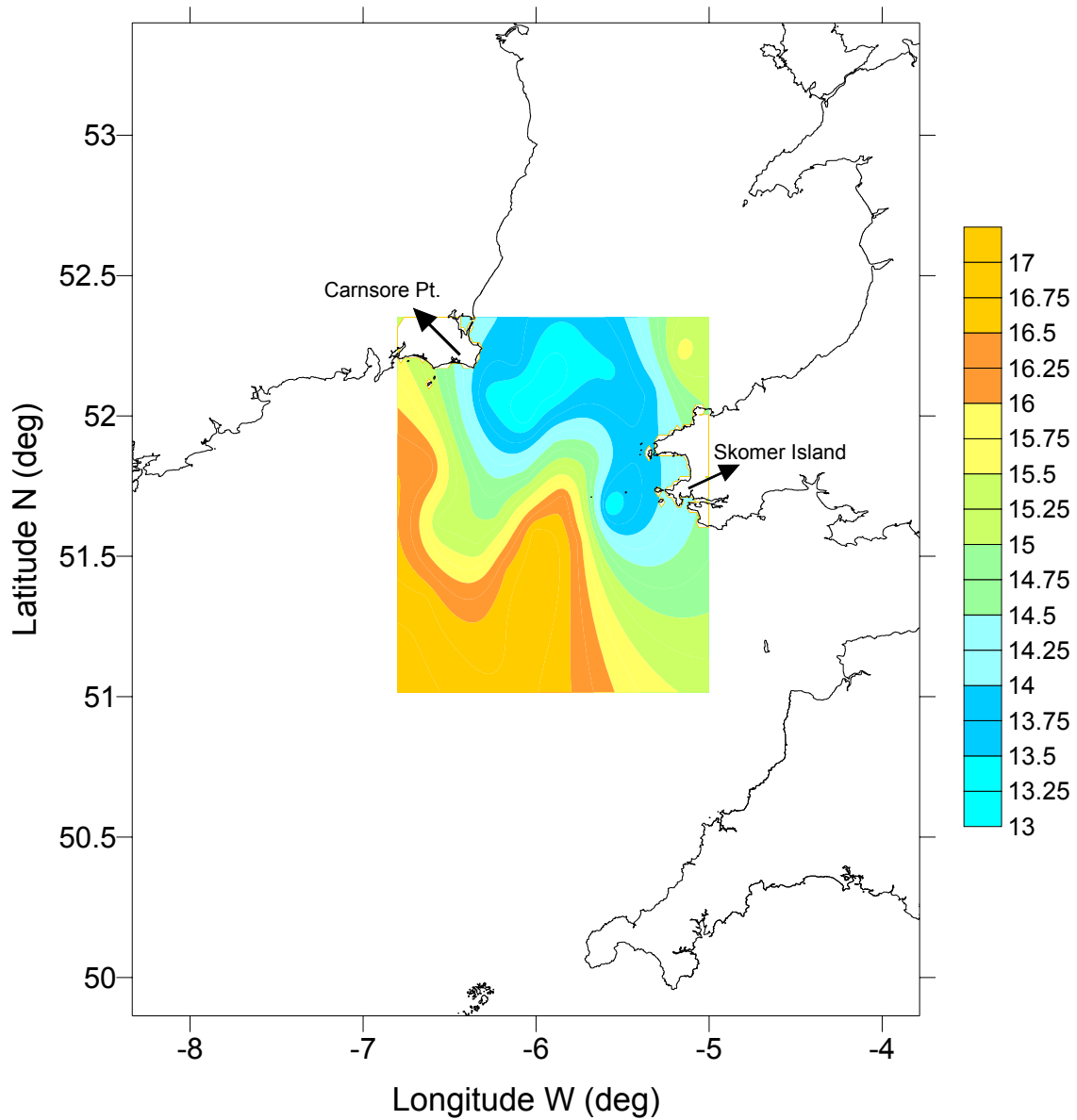


Figure 3.
Surface water column salinity (PSU) variation in the Celtic Sea.
Result obtained from CTD measurements on R.V. Prince Madog cruise,
13 - 20 July 2002

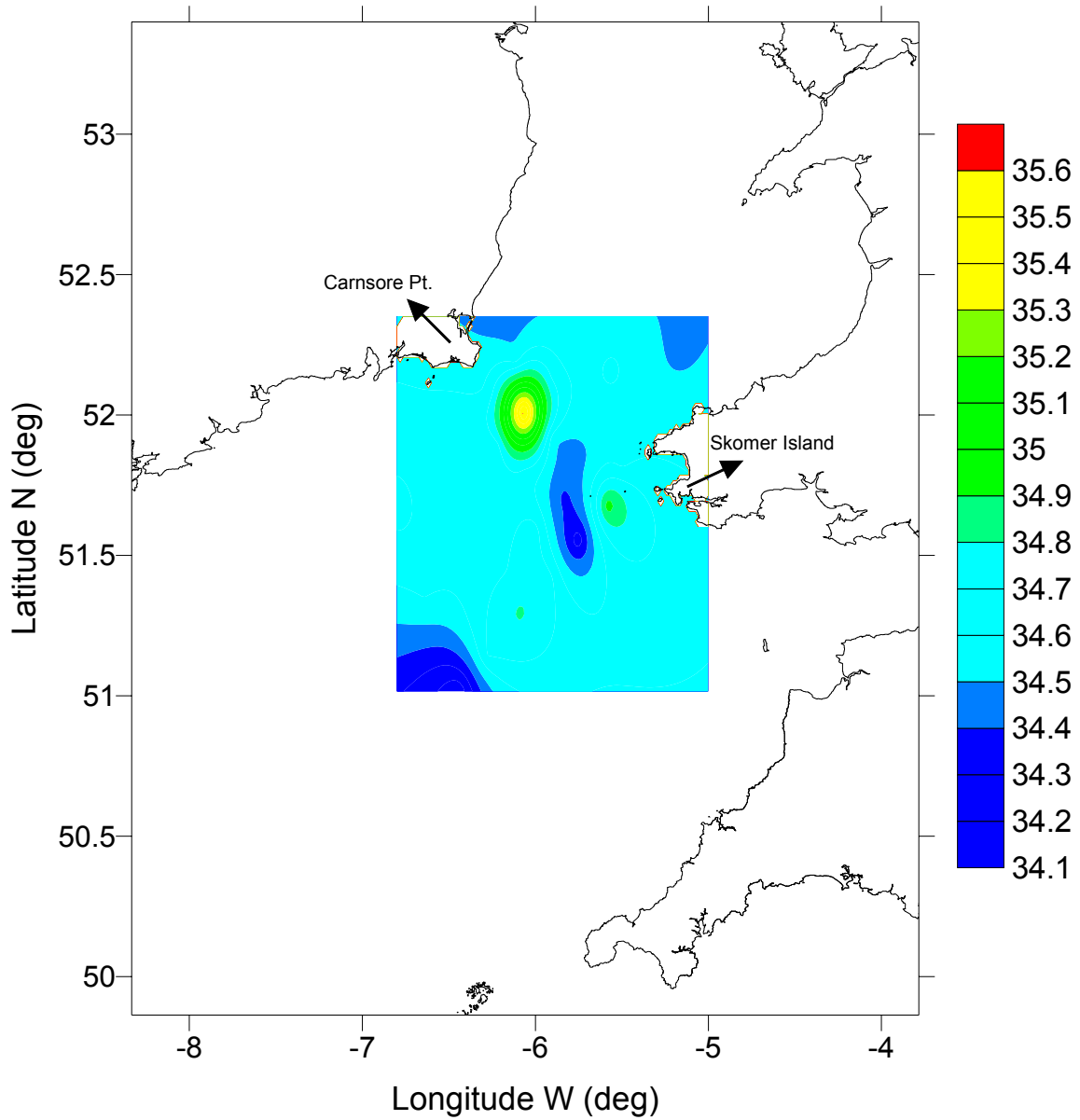


Figure 4.
Surface/Bottom temperature difference (degrees C) in the Celtic Sea,
measured during R.V Prince Madog cruise, 13 - 20 July 2002

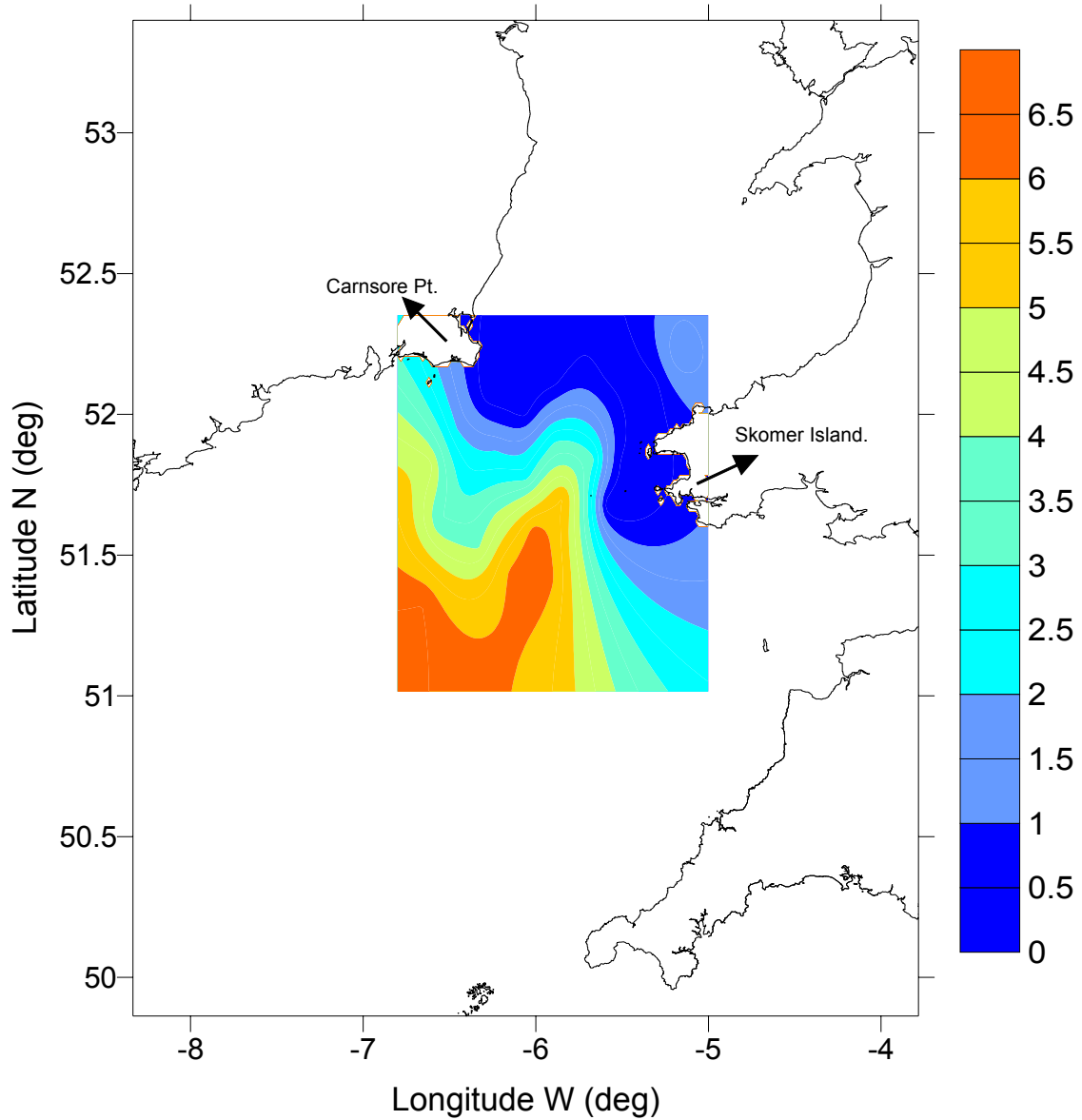


Fig. 5a. Water column temperature recorded by CTD at station D2 in the Celtic Sea, during RV Prince Madog cruise, 13-20 July 2002

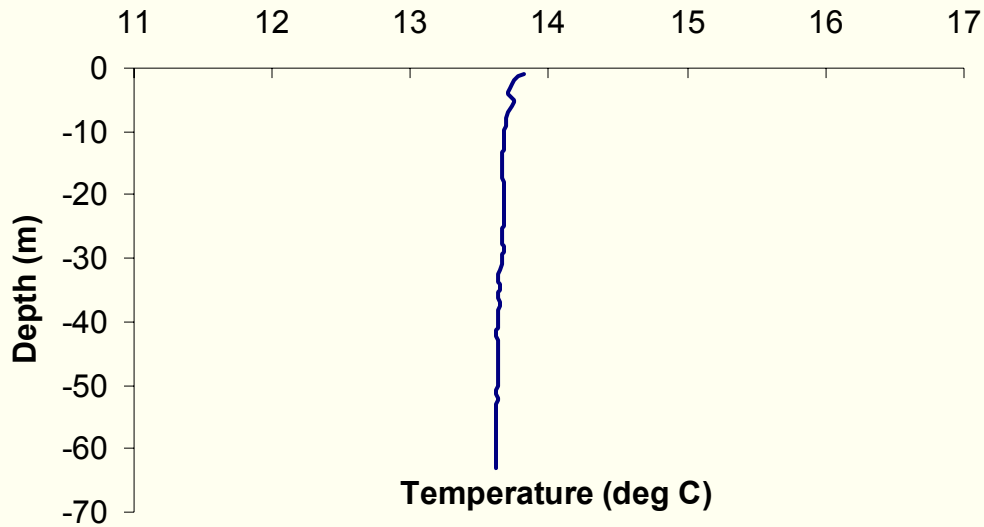


Fig. 5b. Water column salinity recorded by CTD at station D2 in the Celtic Sea, during RV Prince Madog cruise, 13-20 July 2002

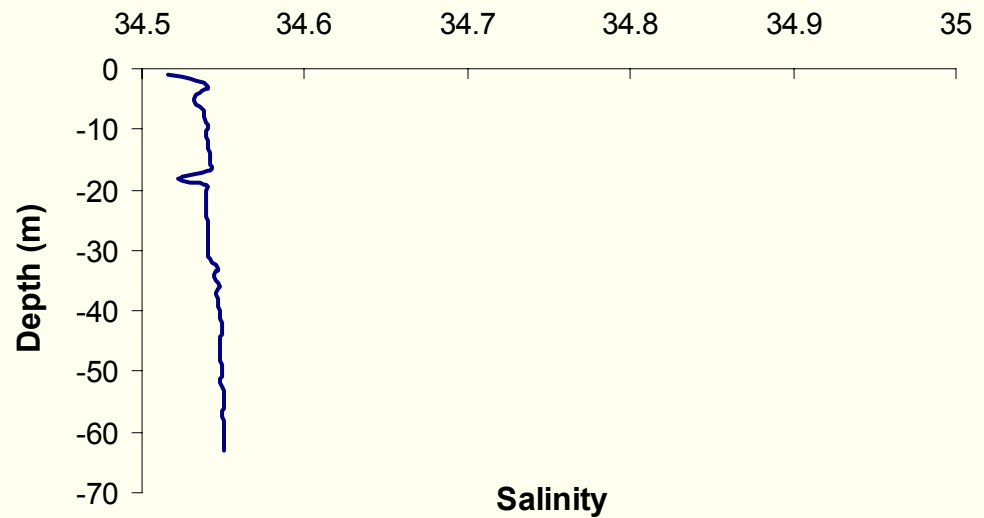


Figure 6a. Water column temperature recorded by CTD at station A7 in the Celtic Sea, during RV Prince Madog cruise, 13-20 July 2002

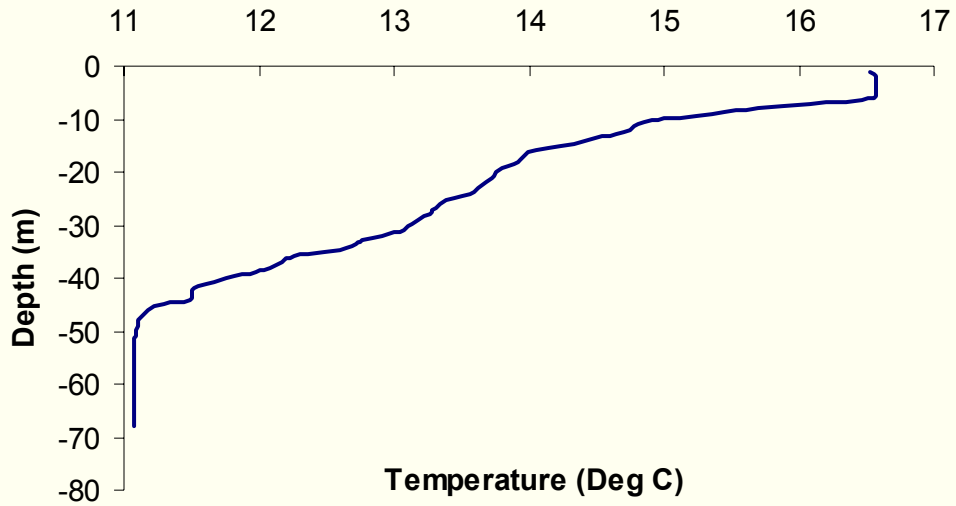


Figure 6b. Water column salinity recorded by CTD at station A7 in the Celtic Sea, during RV Prince Madog cruise, 13-20 July 2002

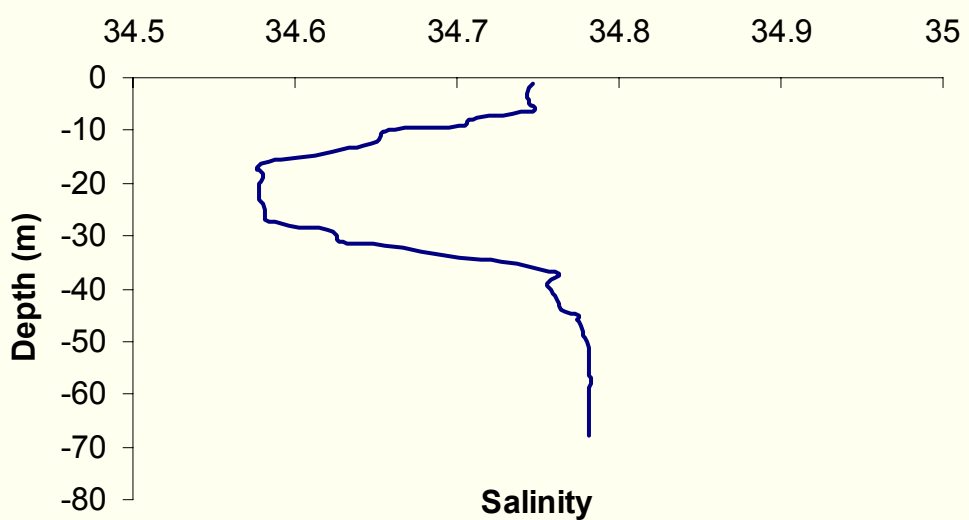


Figure 7.
Water column transparency indicated by Secchi Depth(m) in the Celtic Sea.
Measurements made during R.V. Prince Madog cruise, 13 -20 July 2002.

