Cruise Report PD09/02

RV Prince Madog, 2nd – 5th April 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”

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Objectives

The cruise was the fourth 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 twofold. Firstly, 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. Secondly, 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.

Personnel

The following scientists took part in the cruise

Dr. Sean Gaffney (School of Ocean Sciences, Scientist in Charge)
Dr. Alex Cunningham (University of Strathclyde)
Dr. D.G. Bowers (School of Ocean Sciences)
Dr. Dave McKee (University of Strathclyde)
Dr. Susanne Craig (University of Strathclyde)
Agnes Dudek (University of Strathclyde)
Dong H Shon (School of Ocean Sciences, PhD student)
Kathy Ellis (School of Ocean Sciences, PhD student)
Jenny Ullgren (School of Ocean Sciences, Undergraduate)

Cruise Summary

Narrative

Table 1 summarises the station locations and Figure 1 displays the station positions for the 4 days of the cruise. In total, 34 stations were sampled, 11 of those being the same station repeated over a 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 (~1ms^{-1}). The stations in the Western Irish Sea (Transects ‘A’,’B’ and ‘C’) were chosen to provide detailed spatial coverage on both sides of the region where the Western Irish Sea front is known to form. The final four stations (RW1 – RW4) were positioned off the north coast of

Anglesey to provide 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. This station was sampled 11 times over a tidal cycle, whereupon the RV Prince Madog anchored near Holyhead overnight.
On Day 2, the vessel arrived at station A6 at 0900 HRS. All stations on the 'A' Transect were sampled, working from east to west. Stations B2, B1 and C1 were also sampled, in that order. The RV Prince Madog anchored off Clogher Head overnight.
On Day 3, the remaining stations in Transect 'C' were sampled, whereupon the RV Prince Madog steamed to station B3. The remaining stations in Transect 'B' were then sampled, working west to east. The RV Prince Madog steamed east to Point Lynas and anchored overnight.
Finally, on Day 4, the RV Prince Madog sampled stations RW1 through RW4, arriving back in Menai Bridge during mid-afternoon.

Table 1. Station Positions on RV Prince Madog cruise 2nd – 5th April 2002

Station	Date	Time BST	Lat. Deg.	Lon. Deg.	Depth. (m)
T1	02/04/02	0800-2000	53.46468	-4.5345	40-50
A1	03/04/02	1500	53.95852	-5.64903	82
A2	03/04/02	1330	53.9082	-5.5336	112
A3	03/04/02	1230	53.86438	-5.45072	97
A4	03/04/02	1120	53.83187	-5.36515	95
A5	03/04/02	1015	53.7937	-5.28527	72
A6	03/04/02	0900	53.76255	-5.21122	70
B1	03/04/02	1715	53.93595	-5.85788	47
B2	03/040/2	1615	53.90833	-5.77515	60
B3	04/04/02	1330	53.86645	-5.68315	86
B4	04/04/02	1430	53.83365	-5.6162	97
B5	04/04/02	1540	53.79122	-5.54923	102
B6	04/04/02	1645	53.76678	-5.47415	103
B7	04/04/02	1805	53.7344	-5.41548	105
C1	03/04/02	1815	53.88068	-5.91155	44
C2	04/04/02	0800	53.85315	-5.8441	50
C3	04/04/02	0910	53.79763	-5.7485	71
C4	04/04/02	1000	53.7678	-5.68217	86
C5	04/04/02	1100	53.73178	-5.60715	95
C6	04/04/02	1150	53.7081	-5.53993	106
RW1	05/04/02	0840	53.47985	-4.3876	44
RW2	05/04/02	1015	53.46212	-4.27773	40
RW3	05/04/02	1140	53.37193	-4.1967	22
RW4	05/04/02	1245	53.34155	-4.05803	22.5

Measurements Made

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

1) – Lower CTD to just above seabed. Measure Secchi Depth and take surface water samples with bucket
2) – Return CTD to surface, taking 30 litres of water each of at two depths; depths to be chosen based on the CTD profile
3) – Filter water samples taken on rosette for SPM, chlorophyll, yellow substance and particle spectra.
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

When the data from station T1 was examined, variability in water column properties were found to exist over a tidal cycle. An example of this variability can be seen in Figure 2 which shows a record of diffuse attenuation (K) from 0800 HRS BST to 2000 HRS BST. The peak value of diffuse attenuation in all wavelengths occurs on or just before high water slack, with minima in all wavelengths occurring at half tides on both the flood and ebb. This data shows the nature of the underwater light field varies considerably over a tidal cycle and this needs to be considered when analysing satellite images of the water column.

In the Western Irish Sea, a front was detected in the CTD temperature and salinity data. The stratified region covers all stations west of A6 and B6. The stratification is most marked in the temperature records. An example of this can be seen in Figure 3, which displays the temperature and salinity records from the CTD for station A1. Here, the surface/bottom temperature difference is 0.656°C while the surface/bottom salinity difference is 0.069 PSU. This contrasts with the data from the mixed region. An example of a station in the mixed region is station A6 (Figure 4). The mixed structure of the water column is clearly visible, with a surface/bottom temperature difference of 0.0011°C and a surface/bottom salinity difference of 0.0071 PSU.

Evidence for the presence of the Western Irish Sea front is also visible in subsurface reflectance and diffuse attenuation data measured throughout the cruise. Figure 5 shows a map of subsurface reflectance over the Western Irish Sea, constructed from *in-situ* measurements made during the cruise. There is a very sharp gradient on the eastern side of the study area, where the subsurface reflectance at 555nm (R(555)) increases from

0.03 (3%) to 0.07 (7%). This sharp gradient is located where the CTD data suggest the frontal boundary is located. Overall, the subsurface reflectance map shows a trend from low reflectance in the west to high reflectance in the east. Measurements of diffuse attenuation at 555nm taken in the Western Irish Sea during the cruise (Figure 6) also show a sharp gradient at the eastern edge of the study area, with an increase in K(555) from 0.14 m^{-1} to 0.22 m^{-1}. The map of diffuse attenuation follows a similar pattern to the map of subsurface reflectance, with lowest values in the west of the study area and highest values in the east. This indicates the clearest waters observed during the cruise were to be found in the west of the region that was sampled.

Instrument Performance

No underway monitoring data was gathered during this cruise as the pump for the flow-through system failed just before the start of the cruise. Also, on Day 1, from 1300 HRS, the CTD would not give accurate beam transmission or fluorometry data due to a wiring problem. This problem was partially fixed by Ray Wilton allowing beam transmission data to be gathered from the beginning of Day 2. However, it was still not possible to gather fluorometry data.

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

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

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 Ray Wilton for his hard work with the CTD, and all participating scientists for their efforts. This cruise was the third 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 for RV Prince Madog cruise 2/4 - 5/4/2002

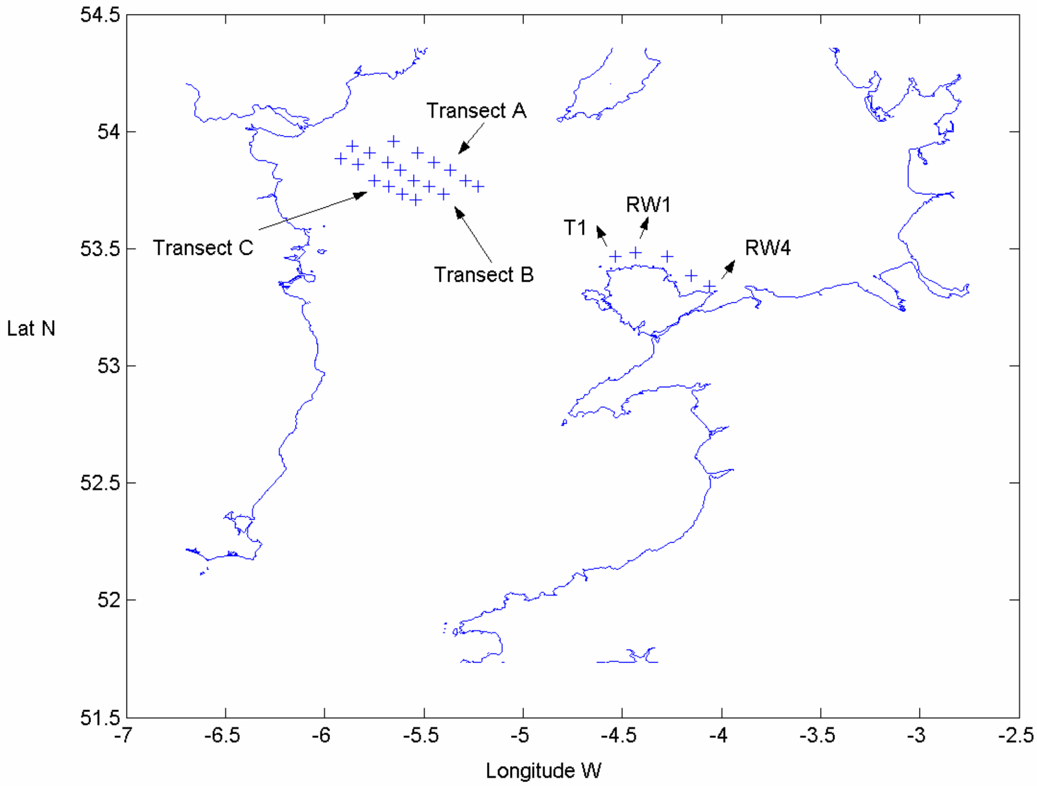
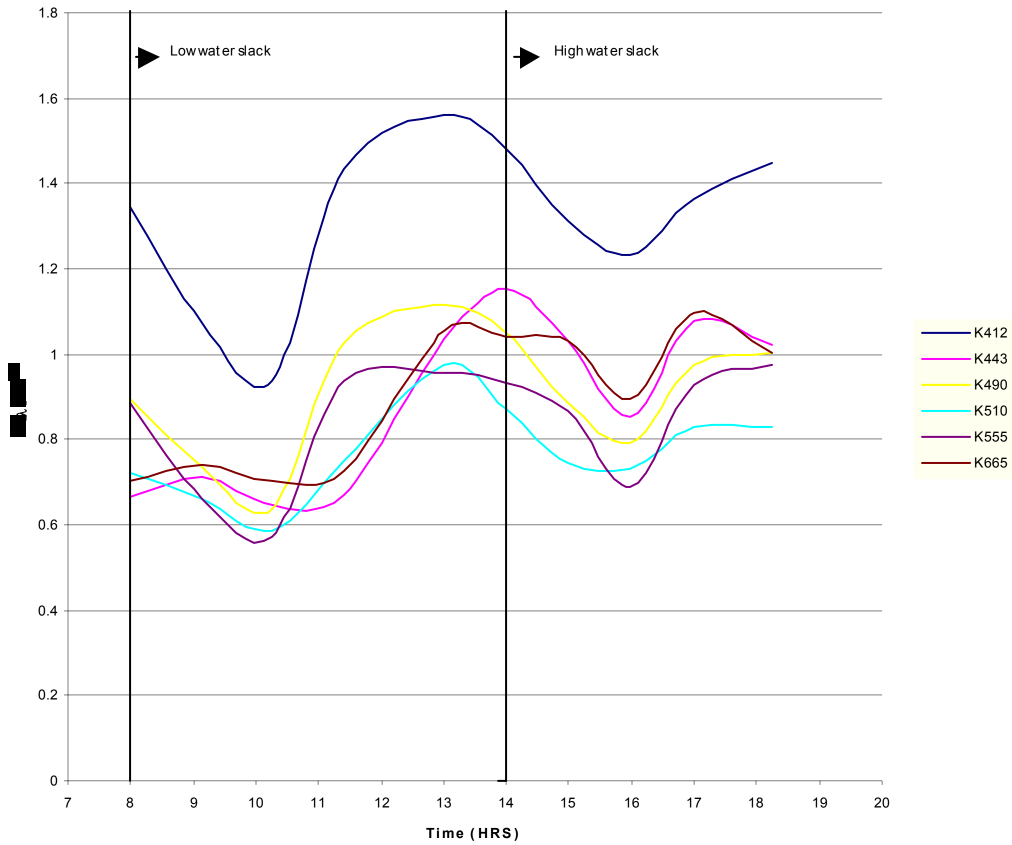


Figure 2. Plot of K(λ) m^{-1} against time at station T1, northwest of Anglesey over a tidal cycle, during a RV Prince Madog Cruise, 2-5 April 2002



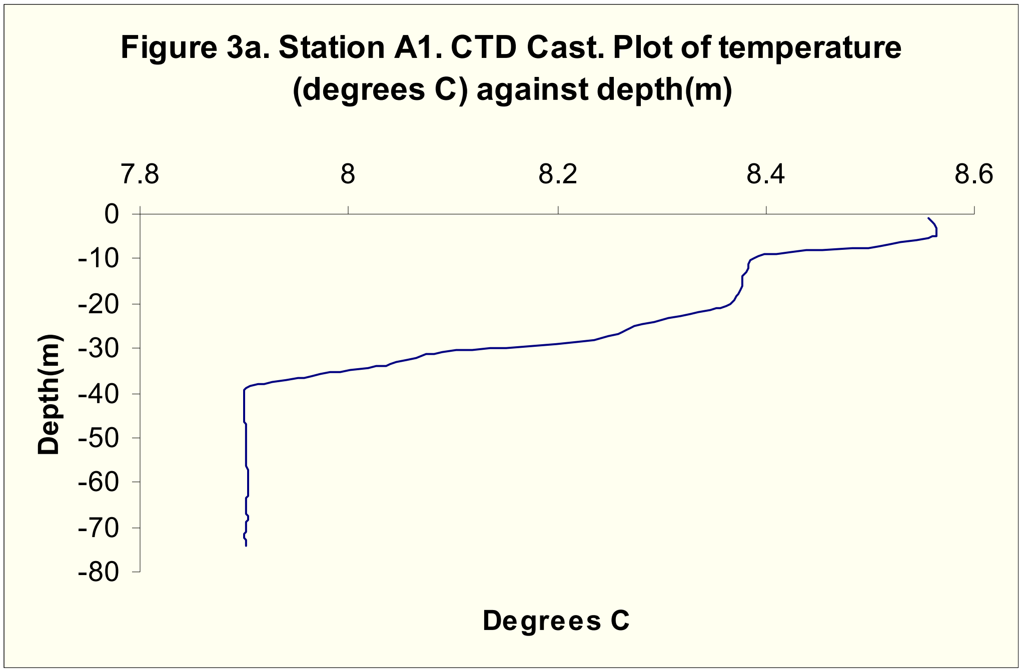


Figure 3a. Station A1. CTD Cast. Plot of temperature (degrees C) against depth(m)
7.8
8
8.2
8.4
8.6
0
-10
-20
-30
-40
-50
-60
-70
-80
Depth(m)
Degrees C

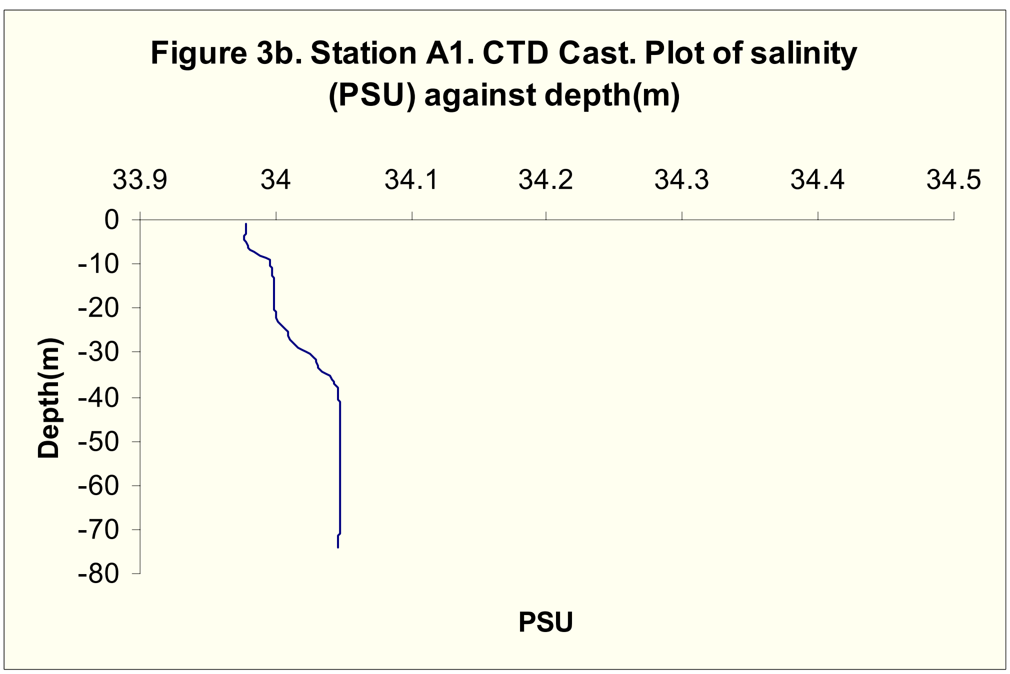


Figure 3b. Station A1. CTD Cast. Plot of salinity (PSU) against depth(m)
33.9
34
34.1
34.2
34.3
34.4
34.5
0
-10
-20
-30
-40
-50
-60
-70
-80
Depth(m)
PSU

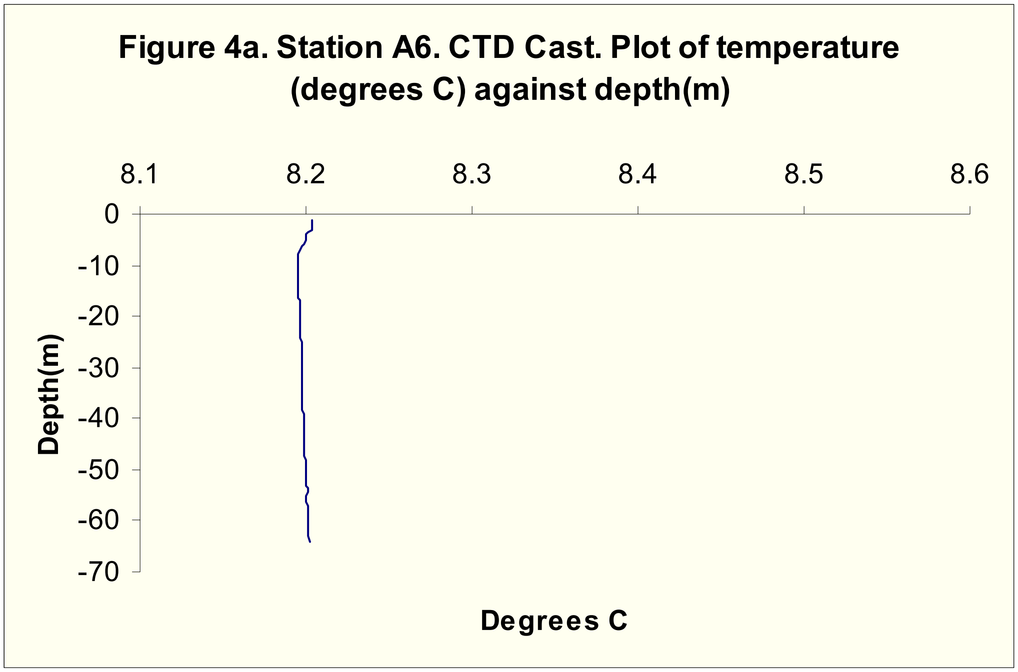


Figure 4a. Station A6. CTD Cast. Plot of temperature (degrees C) against depth(m)
8.1
8.2
8.3
8.4
8.5
8.6
0
-10
-20
-30
-40
-50
-60
-70
Depth(m)
Degrees C

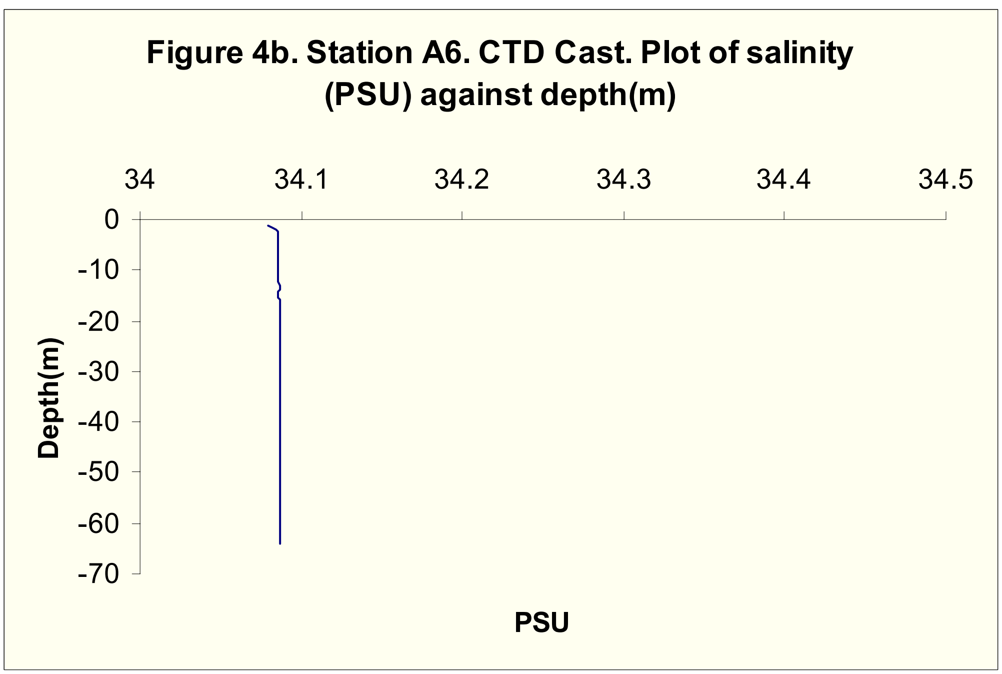


Figure 4b. Station A6. CTD Cast. Plot of salinity (PSU) against depth(m)
34
34.1
34.2
34.3
34.4
34.5
0
-10
-20
-30
-40
-50
-60
-70
Depth(m)
PSU

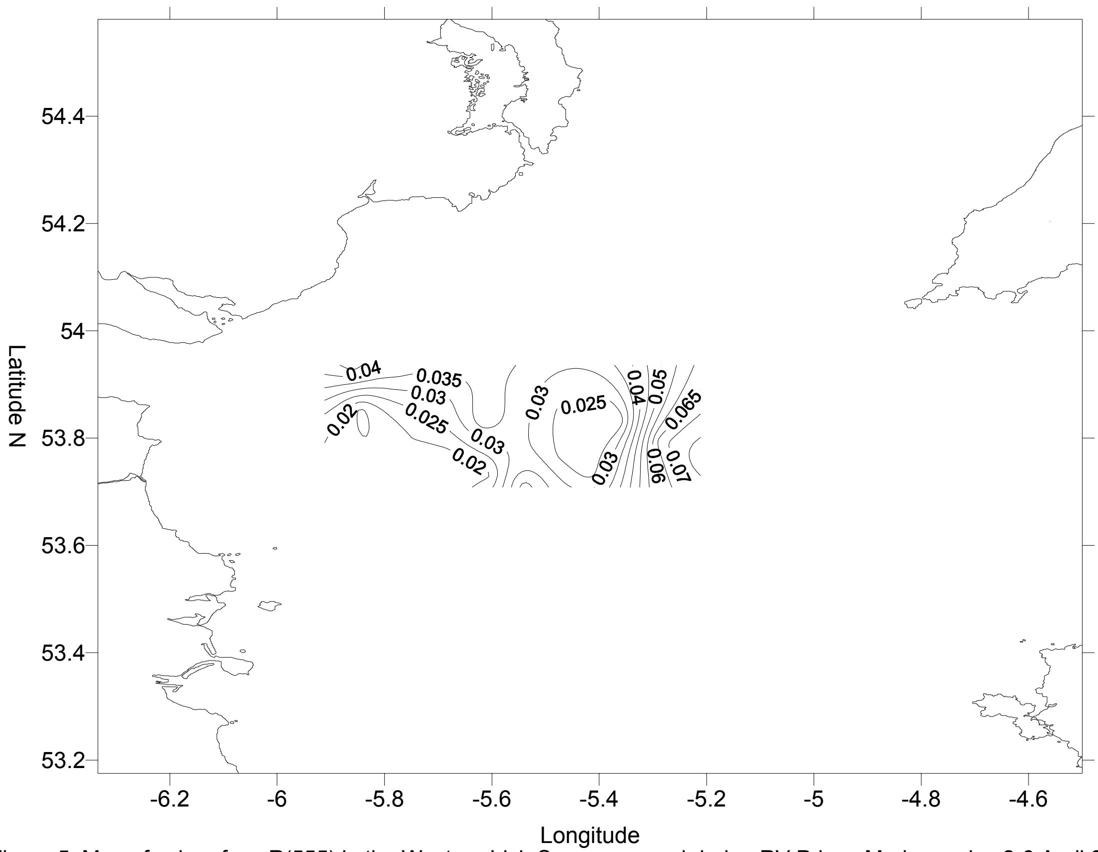


Figure 5. Map of subsurface R(555) in the Western Irish Sea, measured during RV Prince Madog cruise 2-6 April 2002

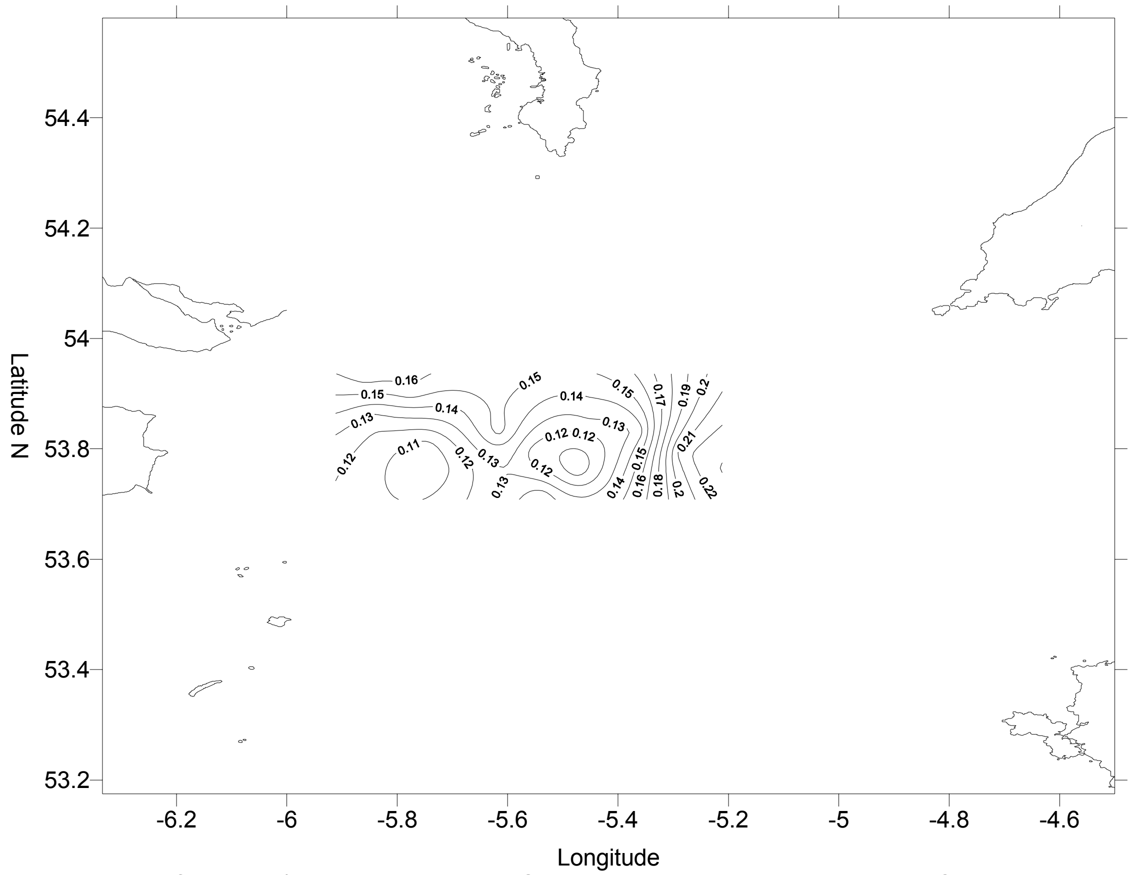


Figure 6. Map of K(555) m^-1 in the Western Irish Sea, measured during RV Prince Madog Cruise, 2-6 April 2002