Cruise Report

RV Prince Madog, 6th-10th August 2001

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 second 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 objective of this particular cruise was to make measurements of the mass-specific optical properties in sediment dominant water (i.e. the Irish Sea) and determine how inorganic sediment affects marine reflectance.

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. Dave McKee (University of Strathclyde)
Dr. Susanne Craig (University of Strathclyde)
Caren Binding (School of Ocean Sciences, PhD student)
Dong H Shon (School of Ocean Sciences, PhD student)

Cruise Summary

Narrative

Table 1 summarises the station locations and Figure 1 displays a cruise track for the five days of the cruise. 22 stations were sampled for optical and suspended sediment measurements. The station positions were chosen in order to have a wide range of sediment concentrations, with high concentrations expected off Anglesey, Liverpool Bay and the Arklow Banks, and low concentrations in the centre of the Irish Sea.
An anticlockwise circuit of Liverpool Bay and the Irish Sea was carried out during the cruise. On Day 1, the Prince Madog departed north from Menai Bridge into Liverpool Bay. Three stations were sampled, working east from Anglesey towards Liverpool. An aircraft oveflight was to have taken place on Day 1 but had to be cancelled due to low cloud cover. The vessel anchored overnight west of the River Ribble (see Fig. 1). The weather was calm. On Day 2, five stations were sampled, working a transect west towards the Isle of Man. A major equipment failure occurred during Day 2, resulting in no measurements of absorption and scattering. The vessel anchored overnight in Castletown Bay, on the eastern coast of the Isle of Man (see Fig. 1). Five stations were sampled on Day 3, running southwest from the Isle of Man to Lambay Island. The CTD rosette system failed on the last station, so no temperature or salinity profiles could be made. An overnight anchor was made in Killiney Bay (see Fig. 1). On Day 4, the Prince Madog worked south along the Irish coast in an attempt to sample very high sediment concentrations. Measurements were made at 6 stations, mainly in the vicinity of the

Arklow Banks. The high sediment concentrations expected at these stations were not found. Once the 6th station had been sampled, the vessel steamed northeast to Anglesey, where an overnight anchor was made just south of Holy Island (see Fig. 1). Finally, on Day 5, three stations were sampled to the north of Anglesey whereupon the vessel returned to Menai Bridge to finish the cruise.

Table 1. Station Positions on RV Prince Madog cruise 6th to 10th August 2001

Station	Date	Time BST	Lat. Deg.	Lon. Deg.	Depth. (m)
1	06/08/01	1146	53.3337	4.0810	15
2	06/08/01	1442	53.3836	3.7503	17.8
3	06/08/01	1642	53.4514	3.4669	17.4
4	07/08/01	0830	53.6355	3.3061	18
6	07/08/01	1015	53.7175	3.5773	41
7	07/08/01	1226	53.7839	3.8670	43.7
8	07/08/01	1400	53.8845	4.1507	48
9	07/08/01	1527	53.9672	4.4184	54
11	08/08/01	0800	53.9015	4.9360	63
12	08/08/01	1015	53.7518	5.1682	73
13	08/08/01	1206	53.6671	5.4176	95
14	08/08/01	1420	53.5334	5.6673	90
15	08/08/01	1628	53.4159	5.9007	43
16	09/08/01	0800	53.1667	5.9504	42
17	09/08/01	1030	52.9515	5.8667	23
18	09/08/01	1224	52.6685	5.9269	38
19	09/08/01	1420	52.6001	6.0672	35
20	09/08/01	1614	52.8002	6.0025	19
21	09/08/01	1731	52.8782	5.9362	27
23	10/08/01	0800	53.5001	4.5835	47
24	10/08/01	0950	53.5003	4.3009	42
25	10/08/01	1134	53.3179	4.0827	10

Measurements Made

At each of the above 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, particle spectra, and nutrients.
4) – Deploy AC-9 absorption meter, Hydroscat-2 scattering meter and LISST-25 particle sizer package and profile as with 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 bed and repeat measurements made by PRR-600

Bottle samples were taken from the CTD rosette at each station for calibration of the CTD conductivity meter. Underway measurements of beam transmission and fluorescence were made throughout the cruise.

Preliminary Results

In general, the water column is well mixed, both in the shallow stations and the deep stations in the centre of the Irish Sea. An example of the mixed structure of the water column can be seen in Fig. 2, which shows the CTD profile taken at station 8, in a depth of 48m. The surface/bottom temperature difference at this station was only 0.002°C; with a depth mean temperature of 14.06°C (σ = 0.002°C). The salinity at station 8 ranged from 34.26 PSU (Practical Salinity Units) to 34.39 PSU; with a depth mean salinity of 34.39 PSU (σ = 0.02). The transmissometer profile (uncalibrated) shows only a very small variation in particle load with depth, indicating overall that particulates are distributed fairly uniformly throughout the water column. The fluorometer profile (uncalibrated) shows similar variability to that of the transmissometer. There is a sudden peak in the voltage, from 0.1302 to 0.2306 at 14m and then immediately back down again. This may indicate the presence of a thin layer of phytoplankton, but apart from this peak, the profile indicates a uniform spread of fluorescing material in the water column.

There are however, two stations that do show evidence of stratification. At station 12, there is a strong thermocline dropping from 15°C at 13m down to 12.8°C at 26m. The temperature remains constant from then on, down to the seabed. The profile of station 13 (Fig. 3) shows two interesting temperature features, a near-surface thermocline, which drops from 13.9°C at 3m to 12.9°C at 15m; and a deep cold water layer at 72m, where temperatures drop from 12.7°C to 10.5°C at the seabed. This temperature layer is mirrored by a corresponding decrease in the transmissometer signal, which suggests that the cold water layer may be trapping particulates near the seabed.

Along with the profiling information from the CTD, surface water quality was continually sampled using an underway monitoring system. Figure 4 displays the fluorescence and turbidity records from this system for the two transects carried out on 7th and 8th August (see Fig 1). The record in Fig. 4a (from Liverpool Bay to the Isle of Man) shows a decrease in turbidity and fluorescence away from the coast. This may be because chlorophyll levels are decreasing away from nutrient sources such as rivers, while the turbidity of the water column has decreased, possibly because the water depth has increased, making entrainment of sediment from the seabed less likely. A similar picture is visible in Figure 4b, which shows an increase in fluorescence and turbidity towards the Irish coast. However, the matching patterns in both datasets visible in Figure 4a are not apparent here.

Secchi Depth measurements were taken at each station in order to provide a fast estimate of turbidity. The changes in Secchi Depth from station to station over the five days of the cruise can be seen in Fig. 5. In general, the closer to the coast the station was, the lower the value of the Secchi Depth was. This overall pattern seems to corroborate the underway profiling data mentioned above. The lowest Secchi Depth reading was 4m at station 21 beside the Arklow Banks while the clearest water was found at station 9, southeast of the Isle of Man where a Secchi Depth of 9.5m was recorded.

Instrument Performance

All instruments worked well. However, on 7th August, the Wetlabs AC-9 absorption meter failed due to a connector problem. It was repaired but the instrument was inoperable for 1 full day. The CTD failed at station 14 due to a problem with the primary connector. This problem took the remainder of 8th August to fix, so no CTD data was gathered at station 15.

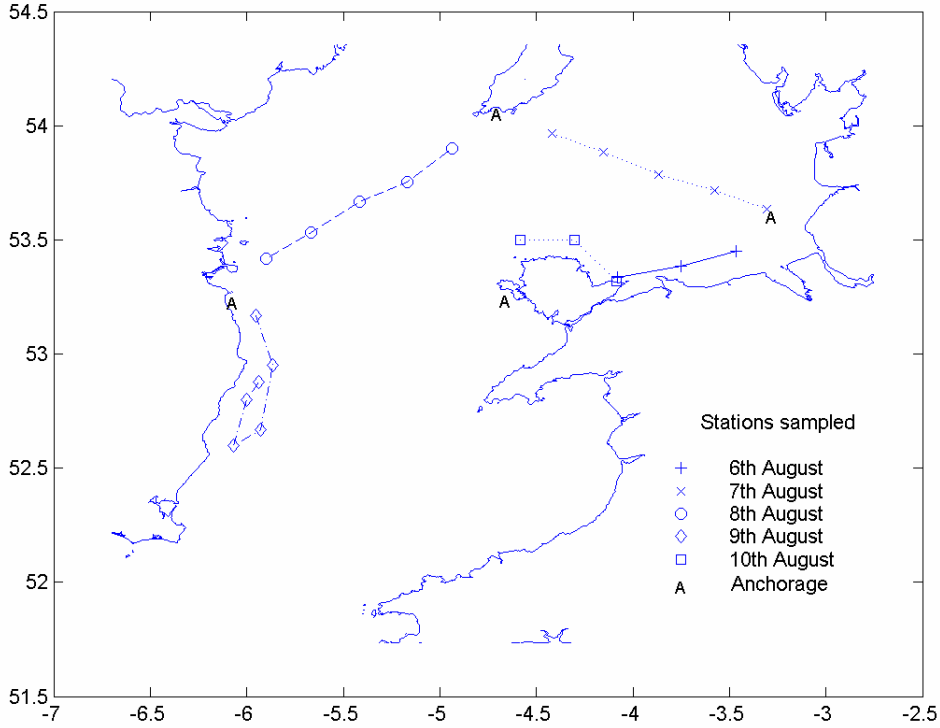
Summary of achievements

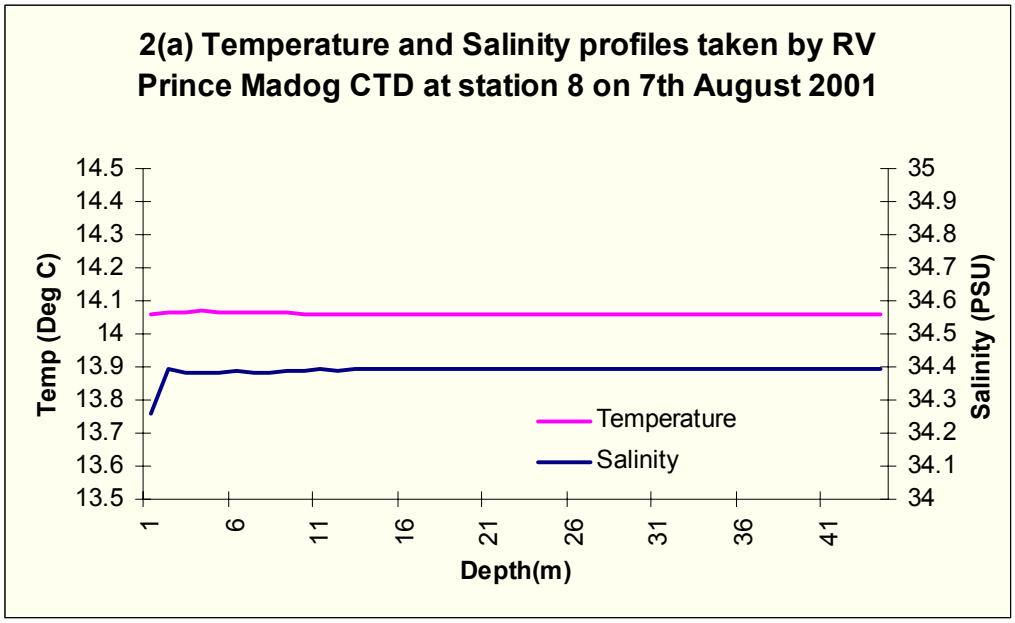
i) High quality optical measurements to provide data on evaluating the effect of strong variations in the optically dominant class of suspended particles on marine reflectance.
ii) High quality optical measurements such as *in situ* measurements of absorption, beam attenuation and forward scattering, in order to determine the mass-specific inherent optical properties of sediment dominant coastal 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 chlorophyll concentration

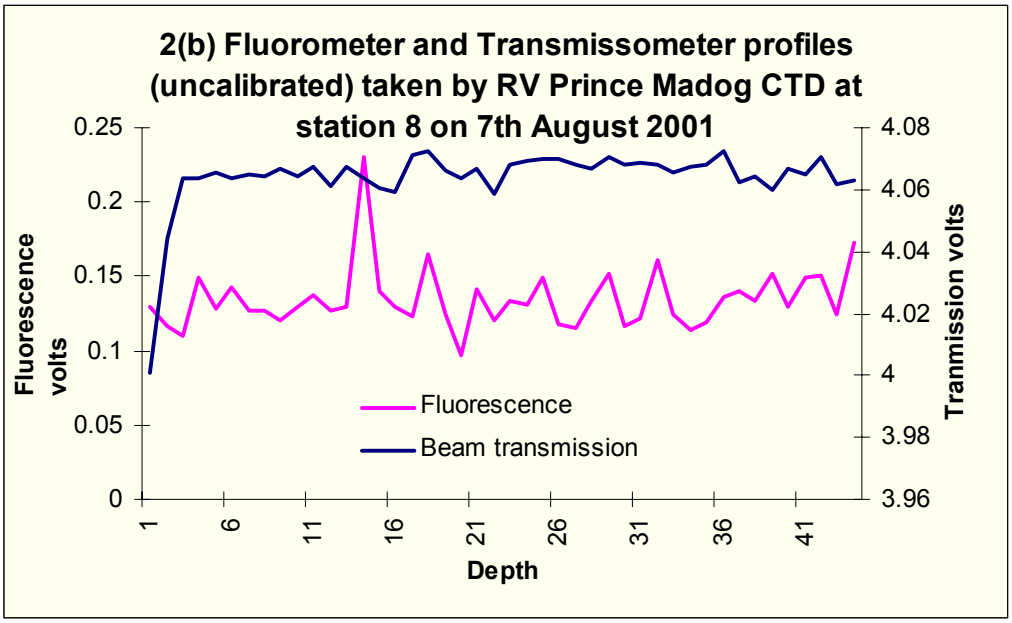
Acknowledgements

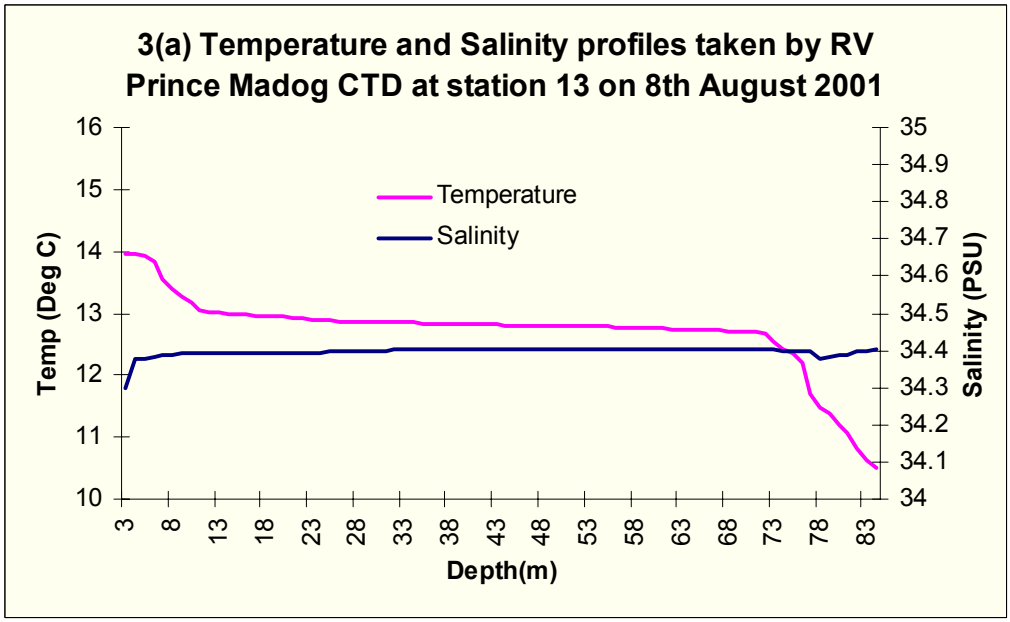
I would like to thank the Captain and crew of the RV Prince Madog for their hard work and enthusiasm during the cruise. This enabled all cruise objectives to be met. I would like to thank the technical staff from the School of Ocean Sciences for their hard work with the CTD, and all participating scientists for their efforts. This cruise was the second 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 also like to thank the Irish Government for granting permission for the RV Prince Madog to work in Irish waters.

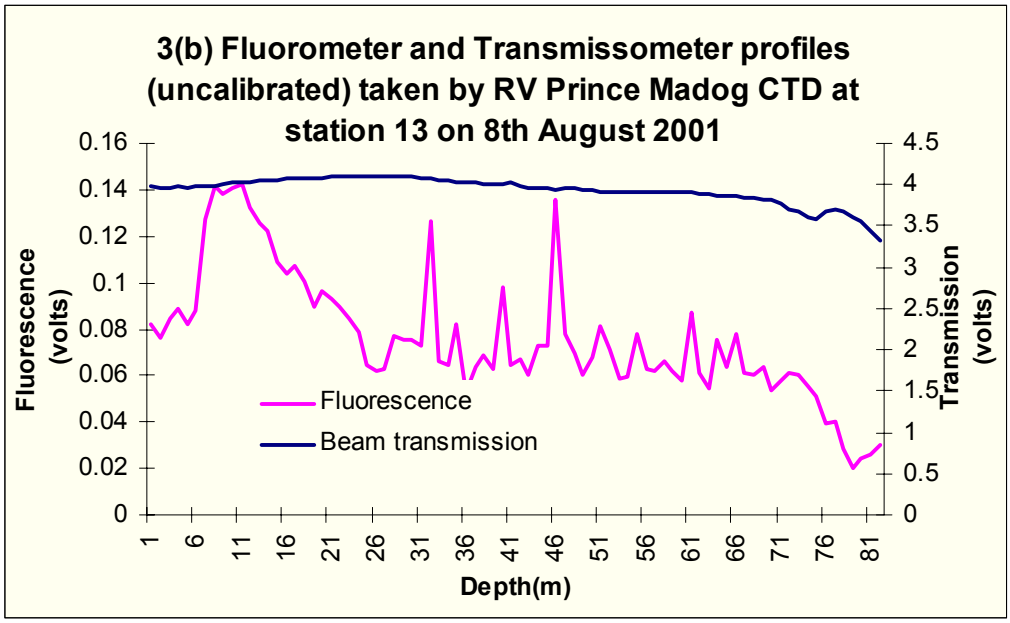
Figure 1. Cruise Track for RV Prince Madog. 6th - 10th August 2001

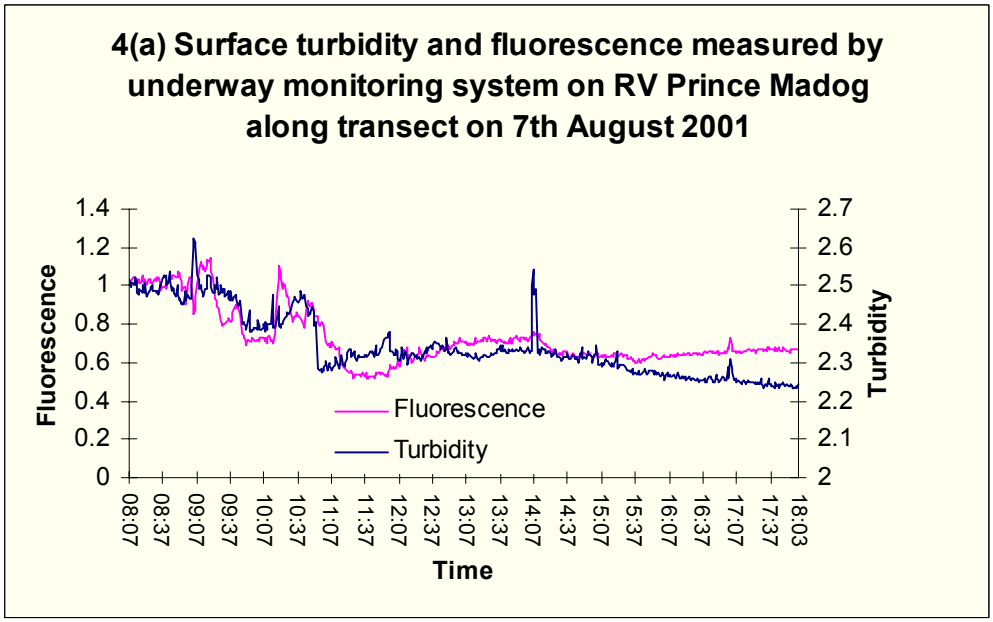





2(b) Fluorometer and Transmissometer profiles (uncalibrated) taken by RV Prince Madog CTD at station 8 on 7th August 2001
Fluorescence volts
Tranmission volts
Depth
Fluorescence
Beam transmission
0.25
0.2
0.15
0.1
0.05
0
4.08
4.06
4.04
4.02
4
3.98
3.96
1
6
11
16
21
26
31
36
41


3(a) Temperature and Salinity profiles taken by RV Prince Madog CTD at station 13 on 8th August 2001
Temp (Deg C)
Salinity (PSU)
Depth(m)
Temperature
Salinity
16
15
14
13
12
11
10
35
34.9
34.8
34.7
34.6
34.5
34.4
34.3
34.2
34.1
34
3
8
13
18
23
28
33
38
43
48
53
58
63
68
73
78
83


3(b) Fluorometer and Transmissometer profiles (uncalibrated) taken by RV Prince Madog CTD at station 13 on 8th August 2001
Fluorescence (volts)
Transmission (volts)
Depth(m)
Fluorescence
Beam transmission
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1
6
11
16
21
26
31
36
41
46
51
56
61
66
71
76
81


4(a) Surface turbidity and fluorescence measured by underway monitoring system on RV Prince Madog along transect on 7th August 2001
Fluorescence
Turbidity
Time
Fluorescence
Turbidity
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
08:07
08:37
09:07
09:37
10:07
10:37
11:07
11:37
12:07
12:37
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15:37
16:07
16:37
17:07
17:37
18:03

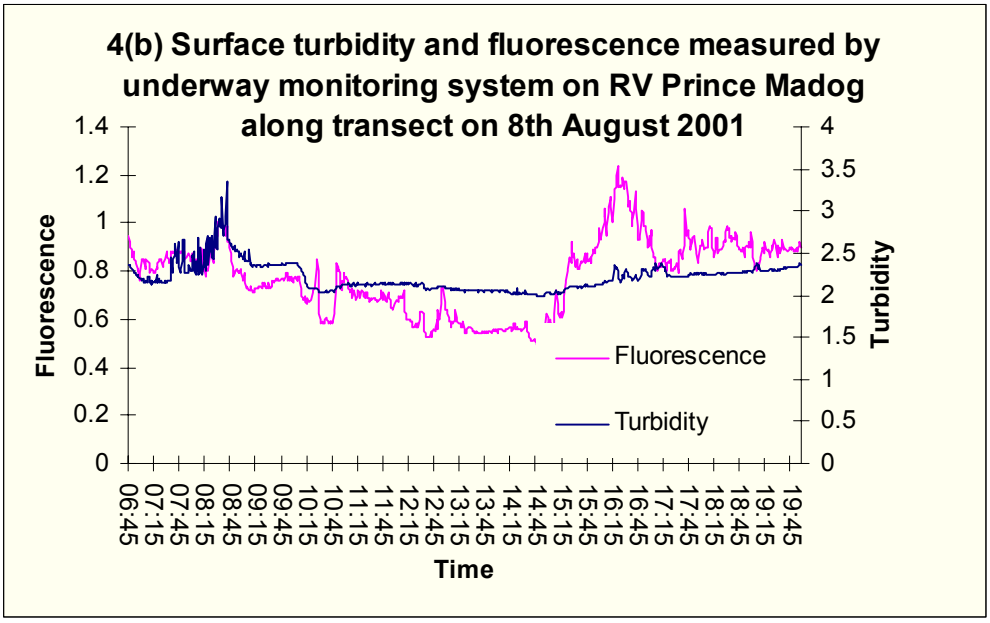

Figure 5. Changes in Secchi Depth throughout August 2001 RV Prince Madog cruise