National Marine Baseline Survey 1995

Littoral Cell 9
St. David's Head to Bardsey Sound

ENVIRONMENT AGENCY

Report NC/MAR/016 Part 11 of 17

National Centre for Environmental Monitoring and Surveillance
Rivers House
Lower Bristol Road
Twerton
Bath
BA2 9ES

Dr. Alison Matthews, Oceanographer
Alastair Duncan, Data Officer

Foreword

In recent years we have carried out National Baseline Surveys of the coastal zone which have involved analysis of samples taken at specific locations in coastal waters around England and Wales for a wide range of determinants. These data have been supplemented by further continuous analysis from the Coastal Survey Vessels and by spatial data from airborne remote sensing operations.

The dissemination of information from these data in an easily digestible form has proved to be a difficult task. To try to overcome this problem the data for the 1995 surveys have been distilled into a summary for each littoral cell.

The information in these summaries is meant to reflect the main features of the littoral cell. More extensive data as well as data collected in previous surveys are held at the National Centre and can be made available on request.

David Palmer

DAVID PALMER
MANAGER, NATIONAL CENTRE

Introduction

The object of this report is to present an overview of the results of the four 1995 surveys in a compact form. The report is accompanied by the full laboratory analysis results and a catalogue of image data stored on CD-ROM and video. In total there are seventeen parts to the report, and those parts included in this pack are listed at the end of this section.

The coastline has been divided into coastal cells, known as littoral cells using the procedure developed by HR Wallingford (Motyka and Brampton, Report SR 328, January 1993). A map of the divisions between these cells is shown in Figure (i). The rationale of these cells means that any changes within a cell should not affect adjacent cells. In addition each cell has a significantly different character to adjacent cells, in terms of geology or biology. The divisions were defined principally for coastal defence construction, but the position of boundaries have implications on water quality variations. For example, effects from effluent outfalls should not be transferred across boundaries.

The water chemistry results for each cell have been reviewed for each season. In particular the nutrient results have been investigated for high concentrations in Summer which may be linked to anthropogenic sources, and which may result in eutrophic waters. In parallel with this the chlorophyll-*a* concentrations have been studied for any increases which are linked to high nutrient values, by two techniques. Firstly, the individual samples have been investigated, and secondly, maps of the entire coastal zone have been produced to allow spatial estimates of eutrophic waters to be made.

The absolute concentration of chlorophyll-*a* is compared with a concentration of 10 µg/l. This is the level suggested as representative of a bloom event by the Department of the Environment in their document "Criteria and Procedures for Identifying Sensitive Areas and Less Sensitive Areas" which was produced as a response to the EC Urban Waste Water Treatment Directive. Although this level signifies the presence of a phytoplankton bloom, it must be associated with other indicators to show that waters are effected by eutrophication.

Dissolved metals concentrations have been investigated in terms of their relation to the Environmental Quality Standard (EQS) levels. These levels are established in response to the EC Dangerous Substances Directive. The definition of the EQS level is as an annual mean. This has been calculated for any sites in which an individual sample exceeds the EQS. Organic contaminants have also been compared with EQS levels where they exist.

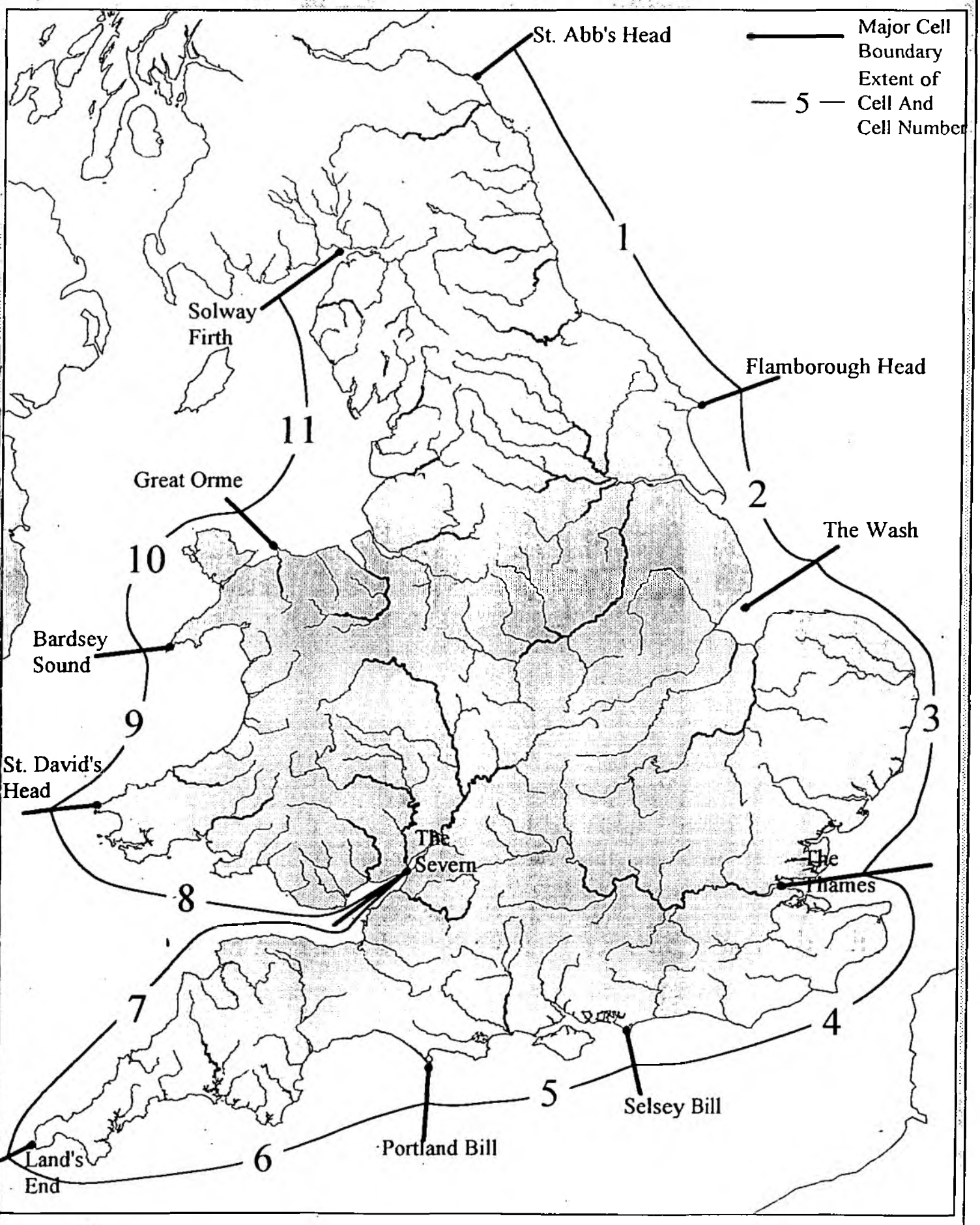
Consideration has been given to the position of the baseline sampling sites in relation to estuaries or major oceanographic features.

The image data and underway data have been investigated for major oceanographic features and changes in water quality. These may be manifested in the image data in two ways. Features are seen in the CASI imagery if they result in an alteration in the ocean colour signal. This usually requires a change in the amount of light scattered or absorbed by particles in the water column. Features such as estuarine plumes have higher particulate matter loading which increases the ocean colour sighal. Phytoplankton blooms increase the absorption of light in selected wavebands and moreover result in fluorescence being detected in other wavebands. Some features do not record a CASI signal but have a difference in water temperature. The thermal video systems used in the baseline survey record only the surface temperature of the water, but clearly show features such as effluent discharges and outfalls from power station cooling systems, in addition to river plumes.

The underway data illustrates changes in temperature, salinity, dissolved oxygen, transmission and fluorescence. The longitudinal profiles from the underway systems have been investigated for major changes which may be associated with estuarine inputs or fronts between different water bodies. Data from the Skalar continuous monitoring nutrient analyser have been investigated to determine the geographical extent of elevated samples in the laboratory analyses.

Summaries have been produced for each littoral cell which provide a statement on the water quality of the region recorded by the baseline survey. The key local oceanographic features are also summarised.

Figure i. The Major Littoral Cells of England and Wales, After Motyka and Brampton; 1993.



* Motyka, J.M. and Brampton, A.H. (1993), "Coastal Management, Mapping of Littoral Cells", HR Wallingford.

Littoral Cell 9: St David's Head to Bardsey Sound

Executive Summary

This cell, on the west coast of Wales, stretches from St David's Head in the south to Bardsey Sound off the Lleyn Peninsula in the north. There are no major industrial regions within this cell, which results in a homogeneous water quality for most determinands.

No sites recorded dissolved metals concentrations in excess of any individual Environmental Quality Standard (EQS). Organic contaminants were below the minimum reporting value for all sites. Two sites showed elevated concentrations of total oxidised nitrogen (TON) in Summer, at Pwllheli (154) equal to 393.6 µg/l and Shell Island (153) equal to 294 µg/l. The laboratory sample from the Pwllheli (154) site did not show exceptionally high chlorophyll-*a* concentration, although there was an increase in the underway fluorescence data.

Spatial chlorophyll-*a* results showed that this region had chlorophyll-*a* concentrations between 2 and 6 µg/l in July. This means that this region showed no large scale phytoplankton blooms which may be caused by eutrophication. A restricted phytoplankton bloom was seen off Pwllheli in the individual Fluorescence Line Height imagery, in the area shown above.

The CASI data revealed a large estuarine plume from Aberdovey. This plume is tidally dependent and may have implications on the water quality measurements in local waters. There was a clear decrease in suspended solids concentration perpendicular to the coast throughout the cell, resulting in a strong variation in ocean colour signal. This was broken in places by plumes from rivers and gyres at headlands, which promote mixing of the nearshore waters offshore.

The imagery did not reveal the presence of any effluent outfalls, which is probably due to most discharges being within the highly turbid coastal zone. In particular there is no obvious explanation for the high concentrations of nutrients found in Summer at Pwllheli and Shell Island.

1. Introduction

This littoral cell extends from St David's Head on the Dyfed coast to Bardsey Sound off the coastline of Gwynedd. This represents approximately 2000 km^2 within the coastal zone for which the Environment Agency has responsibility for controlled waters, of which only 50 km^2 are estuarine, the remainder being open waters.

Four vessel surveys were conducted by Coastal Guardian in this region during 1995, in Winter (February), Spring (June), Summer (July) and Autumn (October). Water samples were collected for analysis for water chemistry and underway monitoring system were used to measure salinity, temperature, dissolved oxygen, fluorescence and transmission. Two aircraft surveys took place, in July and September / October.

2. Water chemistry results

2.1 Background

This littoral cell extends from St David's Head to Bardsey Sound, as illustrated in Figure 1. There are eighteen sampling sites in total.

2.2 Nutrients and chlorophyll-*a*

2.2.1 Total Oxidised Nitrogen (TON)

TON concentrations were generally highest in Winter, but with the maximum single sample concentration found in Summer at Pwllheli (154). Winter concentrations were generally between 100 and 200 µg/l N, with a maximum of 233.4 µg/l N at Cardigan Island (145). Spring concentrations were low, with a minimum of 4.8 µg/l N at Barmouth (152), and a maximum of only 82.9 µg/l N at South Bishop (140). Although Summer concentrations were generally low in Summer, two sites show very high concentrations; at Pwllheli (154) equal to 393.6 µg/l N and Shell Island (153) equal to 294 µg/l N. Autumn results were moderate, with a maximum of 92.8 µg/l at Fishguard (143).

2.2.2 Silicate

Silicate concentrations in Winter were high, with a maximum of 305.2 µg/l Si at Porthmadog (153.1). Spring results were lower, with a maximum of 89.7 µg/l Si at Strumble Head (142), decreasing further in Summer with a maximum of only 52.3 µg/l Si at Porth Ceiriad (155). Concentrations rose again in Autumn, with maximum of 169.1 µg/l Si at Pwllheli (154).

2.2.3 Orthophosphate

Orthophosphate concentrations were between 15 and 20 µg/l P for all sites. Concentrations were lower and more variable in Spring, and lower again in Summer. In Autumn results returned to slightly higher values, with maximum of 13.9 µg/l P at Abereiddy (141).

2.2.4 Total Ammoniacal Nitrogen (Ammonia)

Ammonia concentrations were low in Winter, with a maximum of 11 µg/l N at Newquay Head (147). Spring concentrations were higher, with a maximum concentration of 39 µg/l N at Shell Island (153). In Summer concentrations were variable, with a maximum of 38 µg/l N at Abereiddy (141) and a minimum of less than the MRV of 1 µg/l N at Newquay Head (147). The maximum and minimum concentrations for Autumn are both recorded at Fishguard (143), equal to 45 µg/l N and 5 µg/l N respectively, which reflects the tidal state at time of sampling.

2.2.5 Nitrite

Nitrite concentrations were low throughout the cell. In Winter the maximum concentration was only 2.9 µg/l N at Porth Ceiriad (155). Concentrations were more variable in Spring, with a maximum of 5.1 µg/l N at South Bishop (140), and values less than the MRV of 3 µg/l N from Pwll Coch (144) to Barmouth (152). Summer concentrations showed a similar range, with again very low concentrations towards the centre of the cell. There highest concentrations occurred in Autumn, with a maximum of 10.5 µg/l N at Cardigan Island (145).

2.2.6 Chlorophyll-a

Chlorophyll-*a* concentrations were not high relative to national averages at any time during the four surveys. In Winter the maximum concentration was 2.3 µg/l at Barmouth (152), with a minimum concentration of 0.5 µg/l. The Spring survey does not record the presence of a Spring phytoplankton bloom, which has probably passed its maximum concentration by the date of the survey, 13th June. In Summer there were no concentrations above 3 µg/l, and as such there are clearly no sites which are subject to eutrophication. In Autumn, there were some signs of an Autumnal bloom, with concentrations equal to 6.6 µg/l at Aberdovey (150).

2.2.7 Nutrients/chlorophyll-a Summary

Nutrient concentrations were generally low in this littoral cell, with peaks in concentration mainly associated with estuarine sources. Pwllheli (154) and Shell Island (153) showed very high TON concentrations in Summer but did not show high chlorophyll-*a* in the laboratory results. The image data did, however, record the presence of a bloom at Pwllheli (154) on 21st July, some 5 days before the vessel survey, and the underway fluorimeter showed enhanced levels of chlorophyll-*a*.

2.3 Suspended Solids

Suspended solids concentrations were low throughout this cell, which reflects the absence of any major estuarine sources. The maximum concentrations were clearly associated at each season with estuarine plumes, for example a concentration of 31 mg/l is found at Aberdovey (150) in Winter when many sites record concentrations of less than 2 mg/l. A general seasonal pattern was seen, with the lowest concentrations found in Spring and Summer, when many sites recorded concentrations less than 2 mg/l. The highest concentrations generally were seen in Autumn, but with some Winter peaks. This may be due to the date of the two surveys, with the Autumn survey being carried out in October, when riverine inputs and agitation of bottom sediments had increased.

2.4 Metals

2.4.1 Total Mercury

Total mercury concentrations were governed by the suspended solids concentrations, with the highest overall results found in autumn. The maximum Winter concentration 0.008 µg/l Hg was at Aberdovey (150), which is clearly associated with the maximum suspended solids measurement here of 31 mg/l.

2.4.2 Dissolved Cadmium

Dissolved cadmium concentrations were low in all surveys, with many concentrations less than the laboratory MRV of 0.042 µg/l Cd. The highest concentrations were in Winter, equal to 0.25 µg/l Cd at Newquay Head (147) and Aberdovey (150). This is only 10% of the EQS level of 2.5 µg/l Cd.

2.4.3 Dissolved Copper

Dissolved copper concentrations were generally low, with the majority of sites recording concentrations less than 25% of the EQS of 5 µg/l Cu at all seasons. Pwll Coch (144)

recorded a concentration of 2.57 µg/l Cu in Spring which is greater than 50% of the EQS.

2.4.4 Dissolved Lead

Dissolved lead concentrations were low throughout, with most sites less than 0.25 µg/l Pb compared with an EQS level of 25 µg/l Pb. The maximum concentration of 0.31 µg/l Pb was recorded at Peny-Badell (148) in Winter.

2.4.5 Dissolved Arsenic

Concentrations of dissolved arsenic were less than the laboratory MRV of 2 µg/l As in each season.

2.4.6 Dissolved Zinc

Dissolved zinc concentrations were higher in comparison to the EQS value of 40 µg/l Zn. In Winter there was a maximum of 27.8 µg/l Zn at Pen Pigyn (148), with a Spring maximum of 19.3 µg/l Zn at South Bishop (140). In Summer and Autumn the results were lower.

2.4.7 Dissolved Chromium

Dissolved chromium concentrations were low, seldom exceeding the laboratory MRV of 2 µg/l Cr. The maximum concentration of 4.66 µg/l Cr, recorded at Cardigan Island (145) in Winter is less than the EQS of 15 µg/l Cr.

2.4.8 Dissolved Nickel

Dissolved nickel were low, with many samples less than the laboratory MRV of 0.25 µg/l Ni. The maximum recorded concentration, at Fishguard in Summer, was 0.644 µg/l Ni compared with a EQS of 30 µg/l Ni.

2.4.9 Metals Summary

Dissolved metals concentrations were low, with no samples in excess of the Environmental Quality Standard for any metal. Moreover there is little geographical pattern to the results, suggesting that there are no major point sources within this region. Some metals recorded higher concentrations associated with estuarine plumes.

2.5 Organic Determinands

Water samples were analysed for twenty three trace organic determinands at four baseline sites within this littoral cell. In the national survey, with the exception of a few PCBs, only γ-HCH and α-HCH gave positive analyses. The other 22 determinands were not detected at their laboratory MRVs of 0.001 µg/l for the entire survey.

No samples recorded positive analyses for any organic determinand within this cell.

3. Spatial chlorophyll-*a* results

The CASI imagery has been used in combination with the laboratory baseline samples and the underway fluorimeter to produce maps of chlorophyll-*a* concentration of the coastal zone. The technique used involves calculation of the Fluorescence Line Height (FLH) of the imagery and correlation of the three measuring techniques.

Figure 2 shows the calibrated CASI Fluorescence Line Height data for this littoral cell. The gaps in the data are due to the activity of military firing ranges in the area. The FLH map shows all chlorophyll-*a* concentrations to be between 2 and 4 µg/l. This is in accordance with the laboratory samples which record the concentrations as being between 1 and 3 µg/l.

Figure 3 shows the calibrated fluorimeter reading from the vessel, which has been extrapolated to represent a spatial view. Again the majority of this littoral cell records a concentration of between 2 and 4 µg/l. However, there are two regions which record concentrations between 4 and 6 µg/l, one to the south of Cardigan and the other around Pwllheli. These regions showed enhanced fluorescence readings, although the laboratory samples were not high. This suggests a problem with the comparison of the different techniques, with in particular a difference in the depth of sampling causing calibration problems.

These two techniques allow assessment of those waters which are potentially subject to eutrophication. Chlorophyll-*a* concentrations in this littoral cell are not high with respect to national averages and to the 10 µg/l limit. The underway fluorimeter data shows two keys areas of higher concentration at Pwllheli and between Fishguard and Cardigan.

4. Local oceanographic descriptions

Underway measurements have been investigated in order to show which areas within this littoral cell show most variability in the underway parameters measured, namely temperature, salinity, fluorescence, transmission and dissolved oxygen. In addition the imagery has been studied for variation in ocean colour signal and temperature signal, or where discrete bathymetric and oceanographic features are visible during either July or September.

These areas will be discussed in more detail, in terms of results from remote sensing imagery, laboratory sampling and underway measurements. This will provide an overview of the results for this section of coastline. The areas are as follows.

1. Aberdovey estuarine plume
2. Pwllheli phytoplankton bloom
3. Sediment transport off Newquay Head
4. Shell Island nutrient levels

4.1 Aberdovey

The major estuarine source to the coastal zone revealed within the CASI imagery for this cell is the River Dovey at Aberdovey. CASI imagery from September and October is illustrated in Plate 1. The July imagery did not reveal any structures due to the presence of cloud in the data. Estuarine water is generally higher in suspended solids loading than the receiving coastal waters. This results in enhanced scattering of sunlight to the CASI system, which is shown in a higher ocean colour signal.

Plate 1(i), collected on the 29th September at 11:01 GMT shows little outflow of water from the estuary, with more sediment transport visible in Plate 1(ii) taken one hour later. These images are taken at one and two hours after High Water at Aberdovey respectively, such that some ebb tide would be expected.

In Plate 2 a strong outflow of water is seen forming a plume structure from the estuary. The estuarine plume is complex, with the outer area having an enhanced ocean colour signal, suggesting higher solids, but with the inner section having a low signal. In addition, there is an area of very high signal, which is caused by breaking waves over the Aberdovey Bar sandbank within the estuary mouth. This image was taken four hours after High Water at Aberdovey, when there would be a strong ebb flow. The tidal stream is close to slack water, with a slight southerly flow, resulting in the shape of the plume.

Underway data from Coastal Guardian shows the presence of the estuarine plume in July, with low transmission signifying high suspended solids concentration. The data was collected one hour before Low Water, which is in accordance with a large outflow from the estuary. The position of this plume will have implications on the results from the Aberdovey (150) baseline sampling site, the position of which is shown on Figure 1 and Plates 1 and 2. In Winter, the suspended solids result is 31 mg/l which clearly shows that the site is within the plume influence. This site also shows enhanced concentrations of nutrients and some dissolved metals, which are associated with an estuarine output.

Plate 2 shows a further feature having a high ocean colour signal off Tonfanou headland to the north of the Aberdovey estuary. This represents the outflow from the River Dysynni, which enters the coastal zone through the marsh of Broad Water. The source of suspended solids is clearly different from that in the River Dovey as the spectral signature of the outflow is different. Again, results from the baseline sampling site located here, shown in both Figure 1 and Plates 1 and 2, would be effected by the magnitude and direction of this plume.

4.2 Phytoplankton bloom at Pwllheli

CASI imagery from Pwllheli on July 21st shows the presence of high levels of chlorophyll-*a* shown as the fluorescent green structures in Plate 3. This region shows an enhanced signal in the Fluorescence Line Height image, as shown in Plate 4. The FLH image allows the full extent of the bloom to be assessed. The main centre of this feature is seen to be located offshore, with a secondary feature towards the coast.

This area does not show high concentrations of chlorophyll-*a* in the laboratory data from July 1995. Samples were collected on both 25th and 26th July, and concentrations were 2.3 µg/l and 2.7 µg/l respectively. These concentrations are slightly higher than surrounding sites, but are not indicative of a bloom event. The underway fluorimeter shows an increase in fluorescence in this region (see Figure 4). The water samples do, however, show that concentrations of TON are high in this region, with a concentration of 393.6 µg/l recorded on the 26th July. Such levels of nutrients would be sufficient to promote a phytoplankton bloom at this time.

The difference in the chlorophyll-*a* concentrations recorded between the laboratory samples and the underway fluorimeter may be due to a different sampling depth. A phytoplankton bloom would result in a CASI signal even if it were located at depth as the CASI integrates the signal from the upper water layer. Similarly, the position of the baseline sampling site is to the west of the phytoplankton bloom in this image, and would not in this scenario have recorded high concentrations.

4.3 Sediment transport off Newquay Head

CASI imagery from September and October shows clear sediment transport close to Newquay Head. There are two key features in this imagery, the gyre off Newquay Head, and the river plume at Aberaeron.

The river plume at Aberaeron is shown in Plate 5 (i) to be strongly deflected to the north. This is due to a strong tidal stream in this direction. In Plate 5(ii) the tidal stream is weakly to the south. This has resulted in little deflection of the plume as shown. This riverine plume would result in increased nutrients within this area. This is not reflected in the laboratory data as the closet sampling site is at Newquay Head (147) as shown on the image.

In Plate 5(i) there is a clear gyre off Newquay Head, which is caused by the slack water in the lee of the headland. The situation is more complex in Plate 5(ii), where a small gyre feature is located to the south of the headland. The position of this gyre would have clear implications on the water quality results from the Newquay Head (147) sampling site (see Plate 5.1), with this site recording higher results than neighbouring sites which are located in clear offshore waters.

Underway data from the Winter and Spring surveys record variations in %transmission around Newquay Head, which reflects the varying position of the plume. In Winter and Autumn the plume is located to the north of the headland, and in Spring to the south. In Summer there is no variation in %transmission which reflects the lower suspended solids concentrations at this time of year.

4.4 Shell Island nutrient levels

The Shell Island (153) baseline sampling site marked on Figure 1 shows very high concentrations of TON in July, with corresponding high levels of ammonia and nitrite. The site does not show high concentrations at any other season. It is therefore probable that the measurement from July coincides with a point source.

CASI and thermal imagery has been investigated in order to identify the presence of any point sources of effluent in this region. Both types of imagery revealed a northerly flow of sediment, held close to the coast in July 1995 (see Plate 6(i)). The imagery from October (Plate 6(ii)) shows an outflow of higher suspended solids from Barmouth to the south, and a further minor outflow from the River Glasyn to the north. In both of the images there is little activity around the Shell Island site which is marked in the plate.

The imagery does not reveal any point sources of effluent. The position of the sampling site is shown in both images to be in offshore water, away from near coastal influences. Thus the imagery does not reveal the cause of these high nutrient levels to be linked to any land based source.

5. Conclusions

The water quality of this section of coastline was high during the 1995 survey. There were no sites which recorded concentrations of dissolved metals in excess of the Environmental Quality Standards. In addition, there were no sites which recorded concentrations of organic determinands in excess of the minimum reporting value.

Nutrient concentrations were not high in comparison to average values from the entire coastline. In July there were enhanced concentrations at Shell Island (153) and Pwllheli (154). These did not directly result in high chlorophyll-*a* concentrations, although a phytoplankton bloom was revealed in the CASI imagery one week earlier.

Spatial chlorophyll-*a* results showed that this coast has a moderate concentration of chlorophyll-*a* between 2 and 6 µg/l. This means that the area is not subject to eutrophication in terms of its chlorophyll-*a* concentration at the time of survey.

In general there is a flow of suspended solids along the coast which is held close to the coast. Transport across this region into the clearer waters occurs only at estuarine inputs and when gyres develop by the interaction of headlands. Neither the CASI or the thermal imagery reveal the presence of any major effluent outfalls in this region. This is probably due to the position of the majority of outfalls within the highly turbid coastal zone. However, the presence of this coastal flow of sediment means that outfalls to this zone will not easily disperse into the coastal waters.

The major estuarine input to this region is the River Dovey, which is shown to have a large

plume, the extent and direction of which is tidally dependent. This plume may have implications on water quality measurements in the region. There are a number of further riverine inputs, many of which are also shown to have a thermal signature. Although some of these inputs are not high in suspended solids they may contain dissolved nutrients. The gyre off Newquay Head has implications on the reliability of interpretation of water quality samples from this site.

Figure 1.

Littoral Cell 9*, From St. David's Head to Bardsey Sound.

*After Motyka, J.M. and Brampton, A.H. (1993), "Coastal Management, Mapping of Littoral Cells", HR Wallingford.

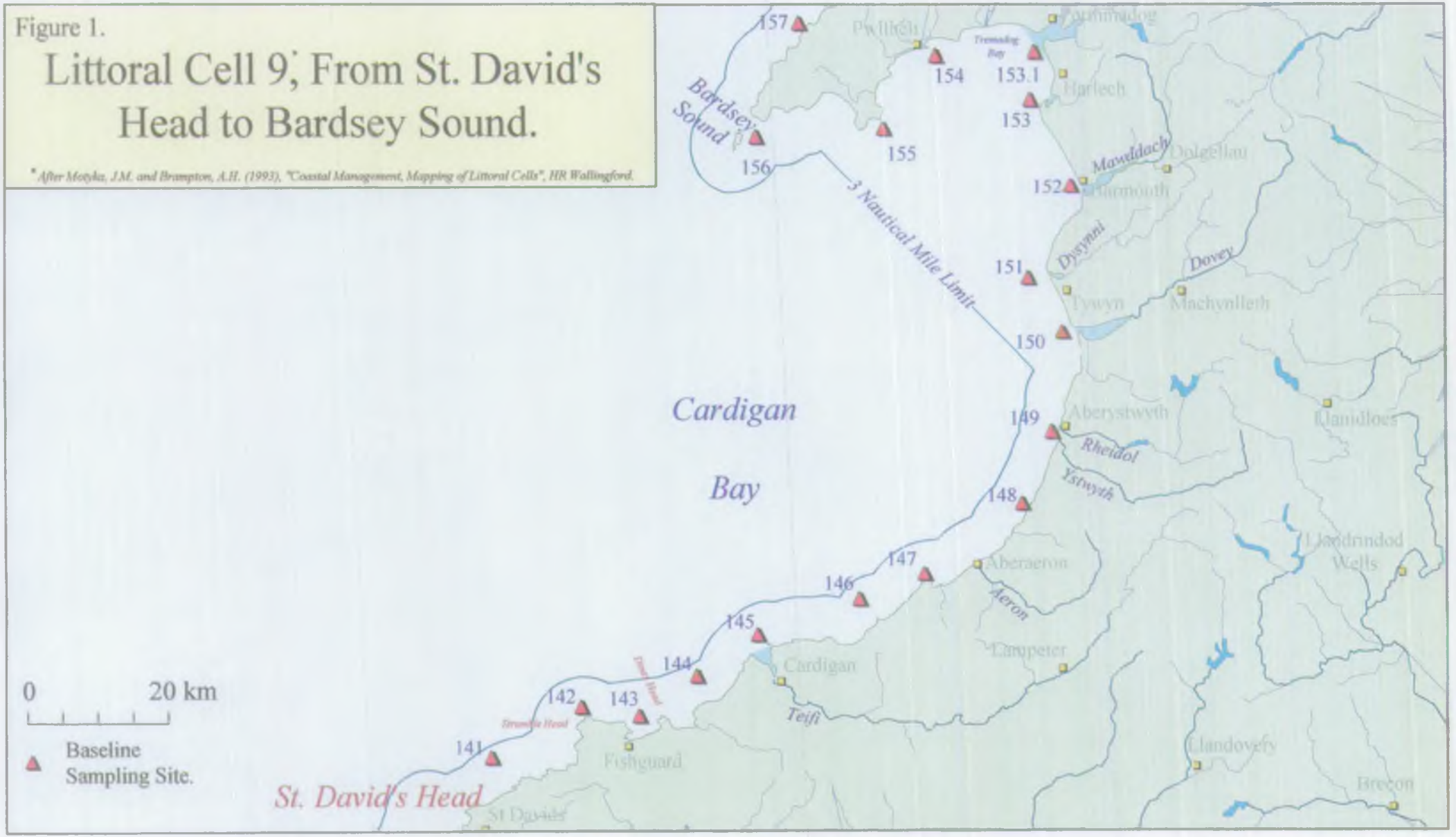


Figure 2.

Calibrated CASI Fluoresence Line Height Image, Summer 1995.

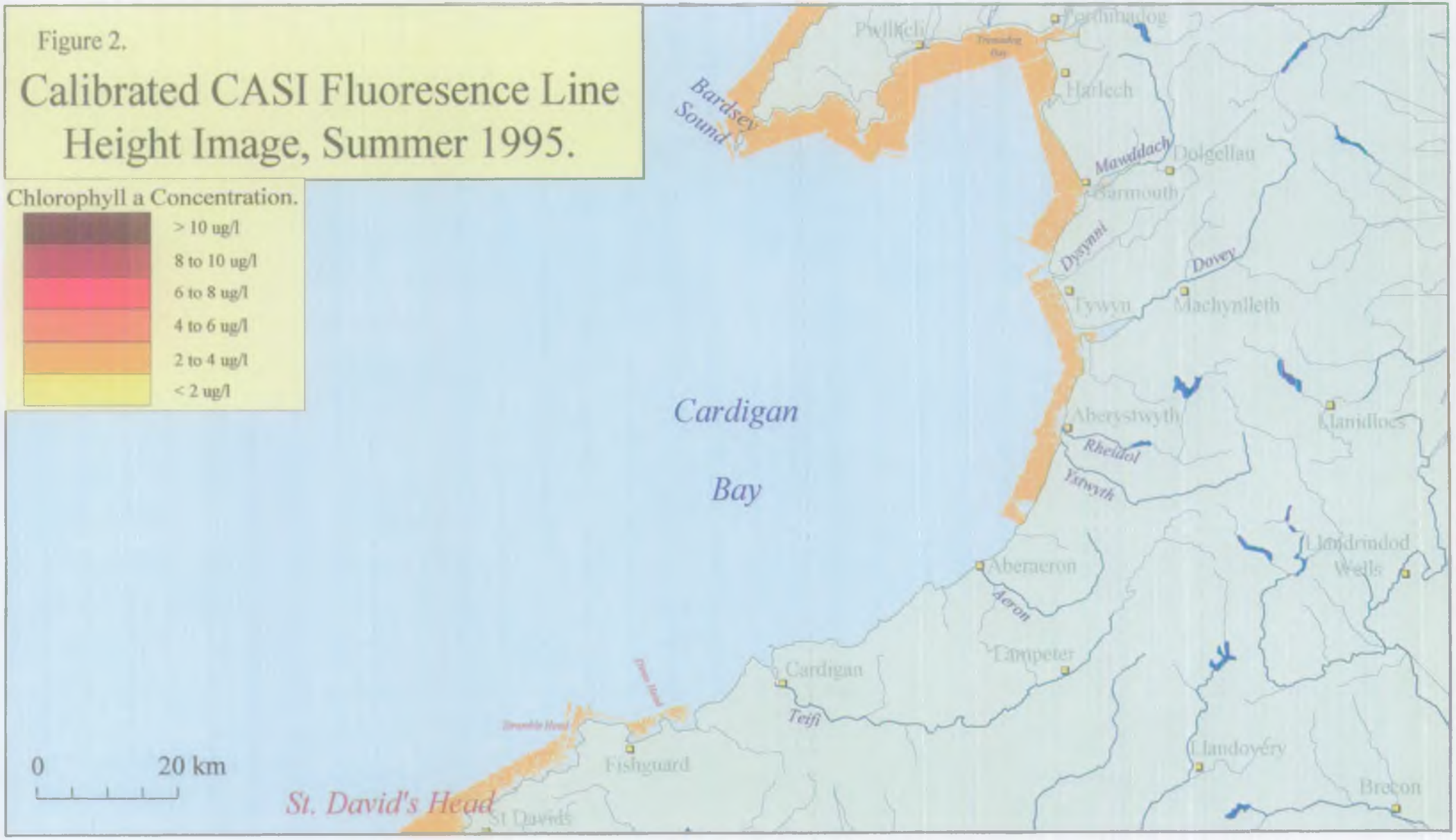


Figure 3.

Calibrated Continuous Track Fluorimeter, Summer 1995.

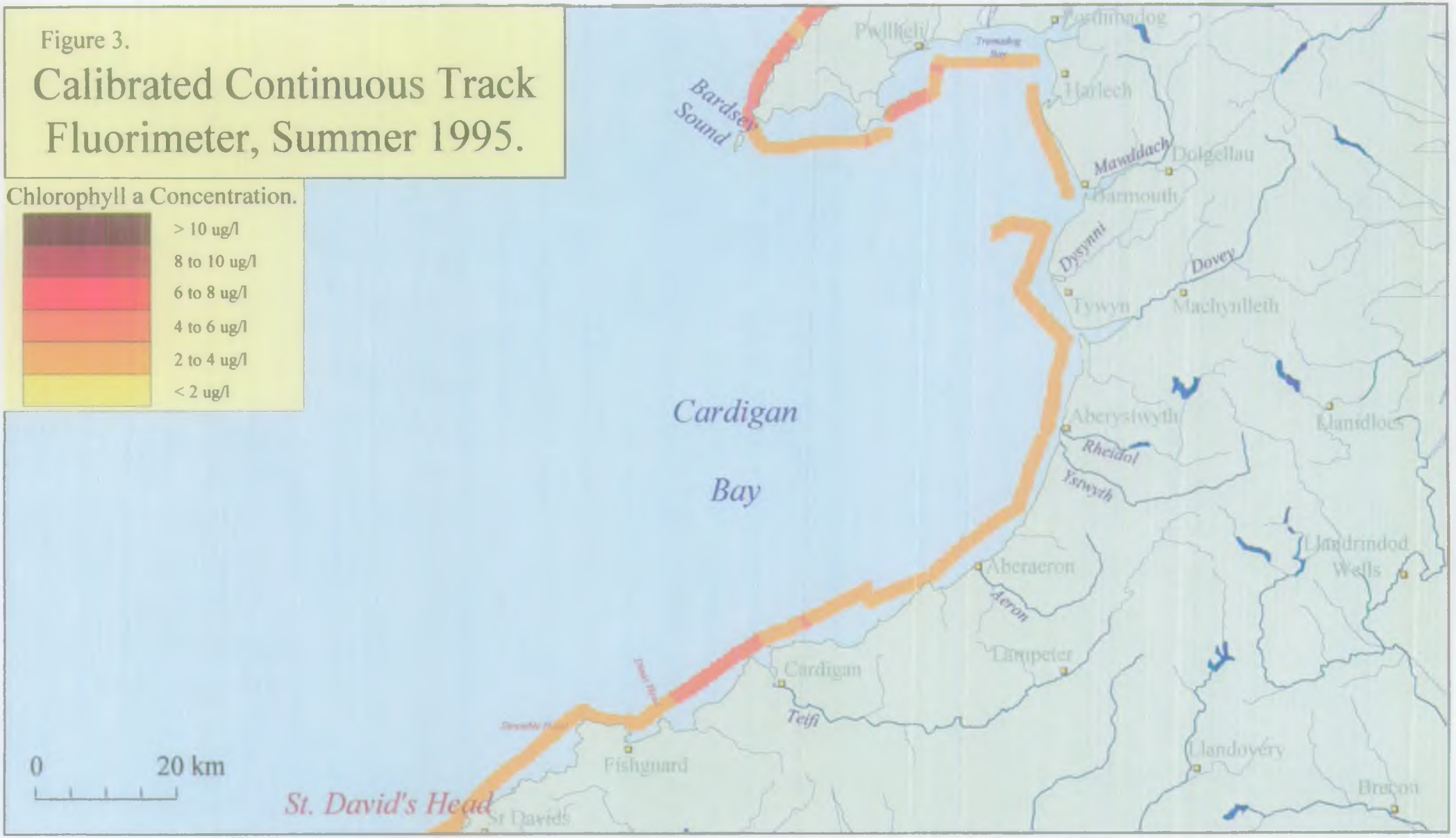
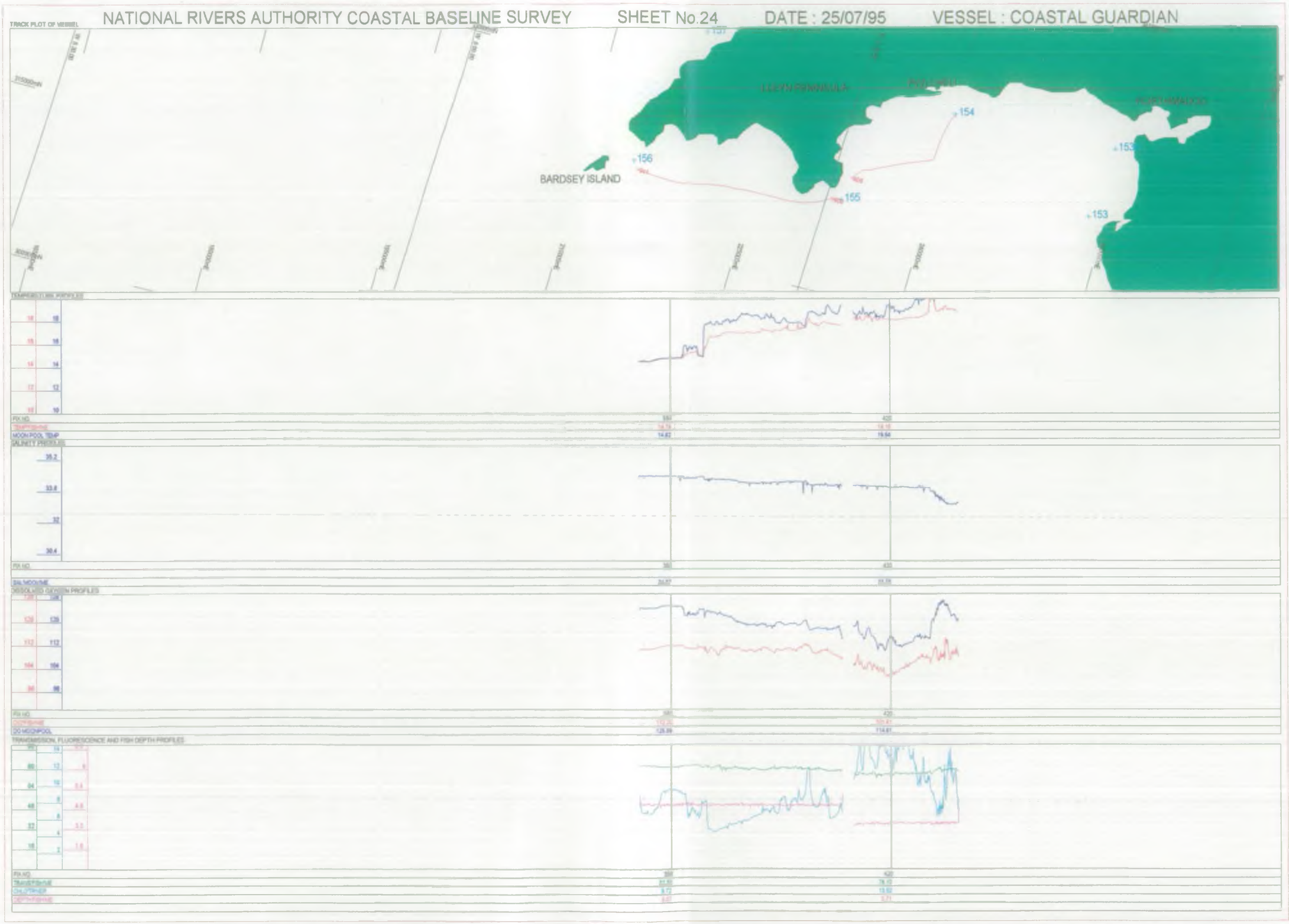


Figure 4

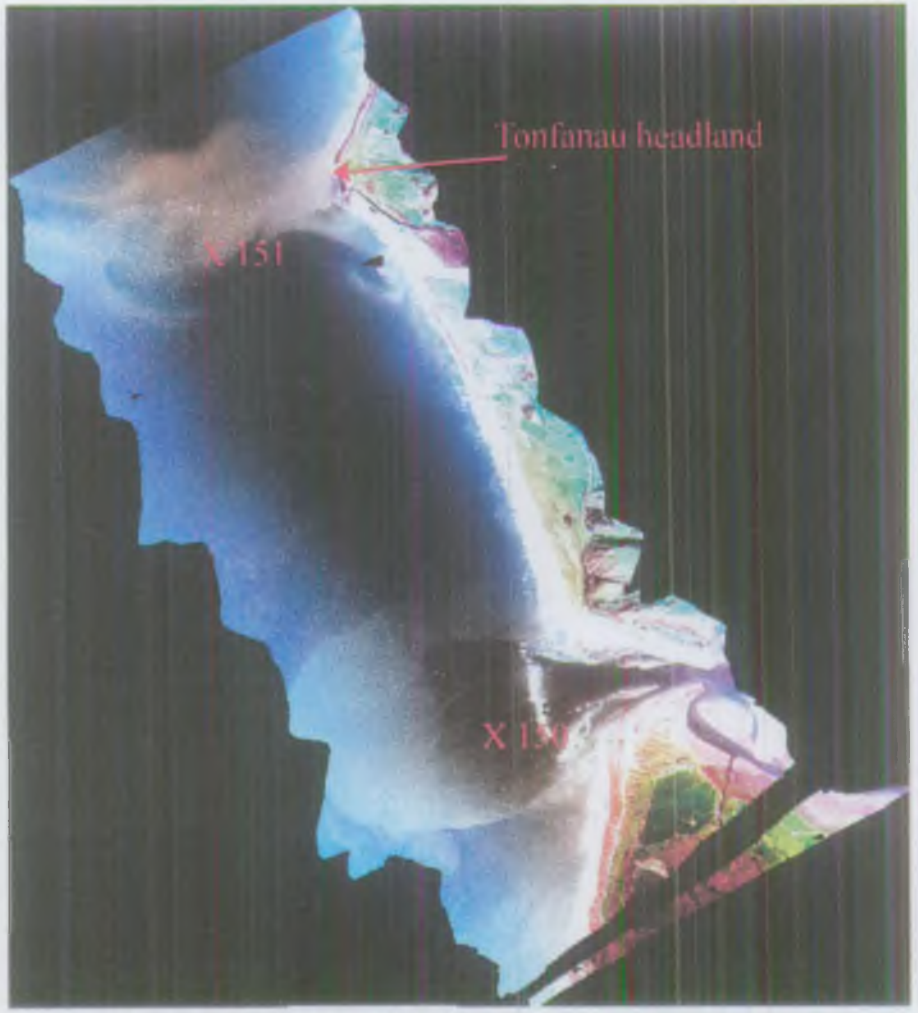


NATIONAL CENTRE FOR INSTRUMENTATION AND MARINE SURVEILLANCE, RIVERS HOUSE, LOWER BRISTOL ROAD, BATH, BA2 9ES.

(i) 29th September 1995, 11:01 GMT

(ii) 29th September 1995, 11:53 GMT

Plate 1: Aberdovey
CASI enhanced true colour composite images
Baseline sampling sites are marked as red crosses



8th October 1995, 11:08 GMT

Plate 2: Aberdovey
CASI enhanced true colour composite image
Baseline sampling sites are marked as red crosses

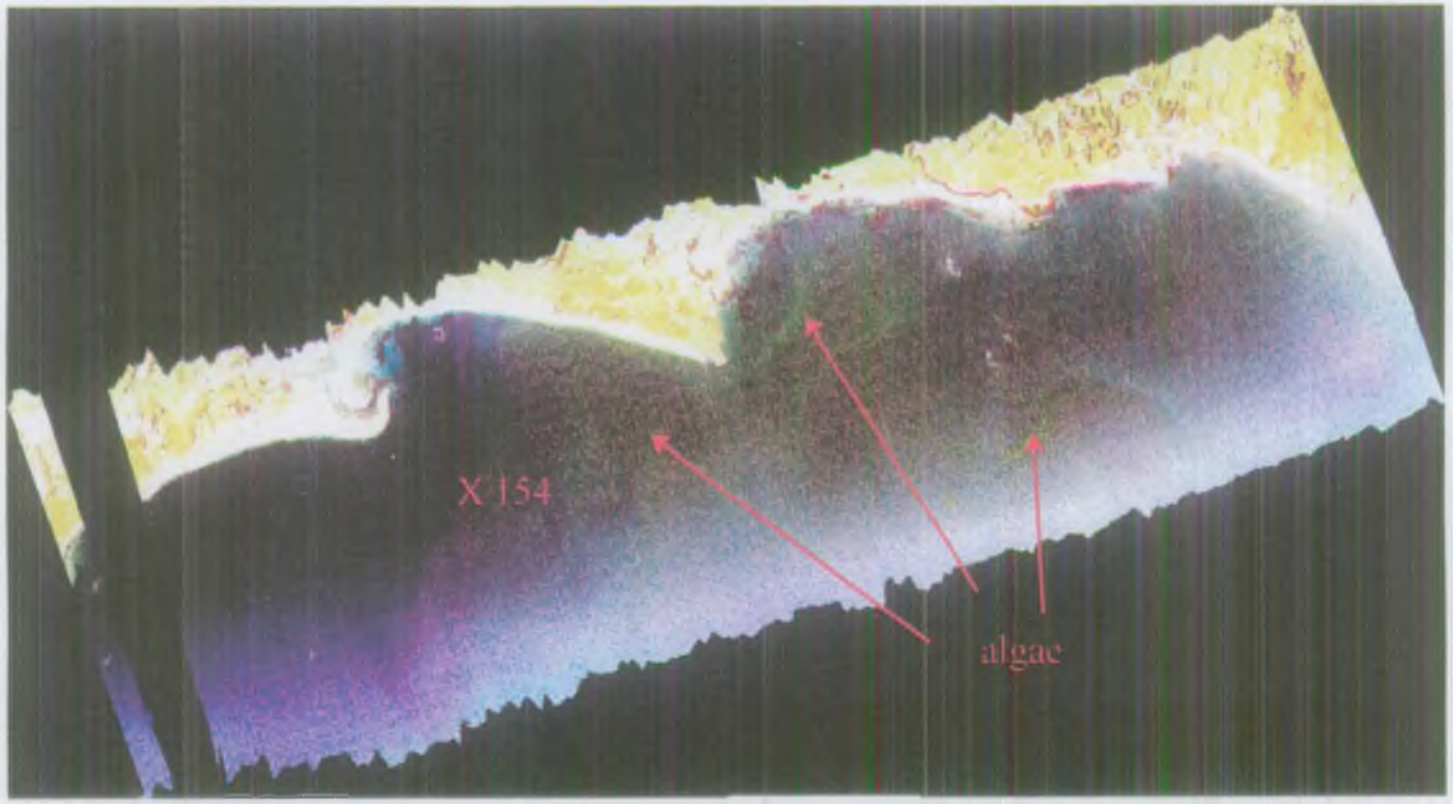
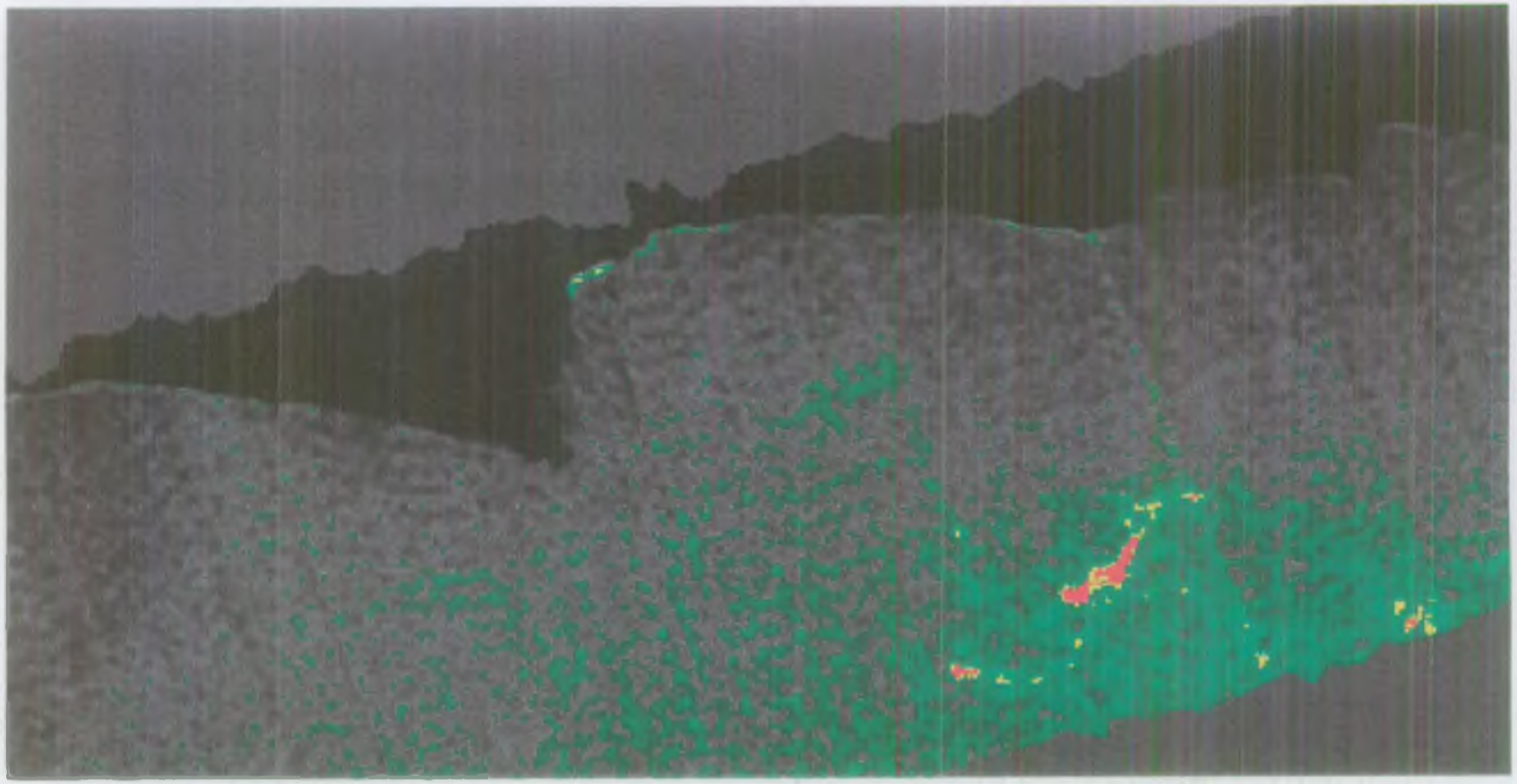


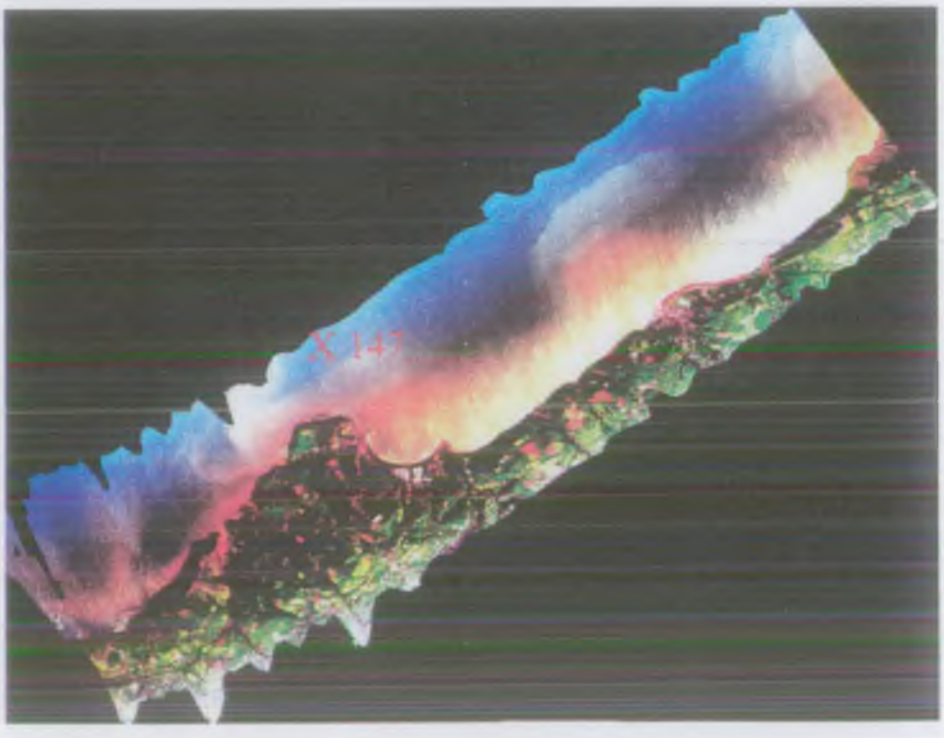
Plate 3: Pwllheli
CASI enhanced true colour composite image
21st July 1995, 16:21 GMT
The baseline sampling site is marked as a red cross



21 July 1995, 16:21 GMT

Plate 4: Pwllheli Area
Enhanced CASI image showing algae activity

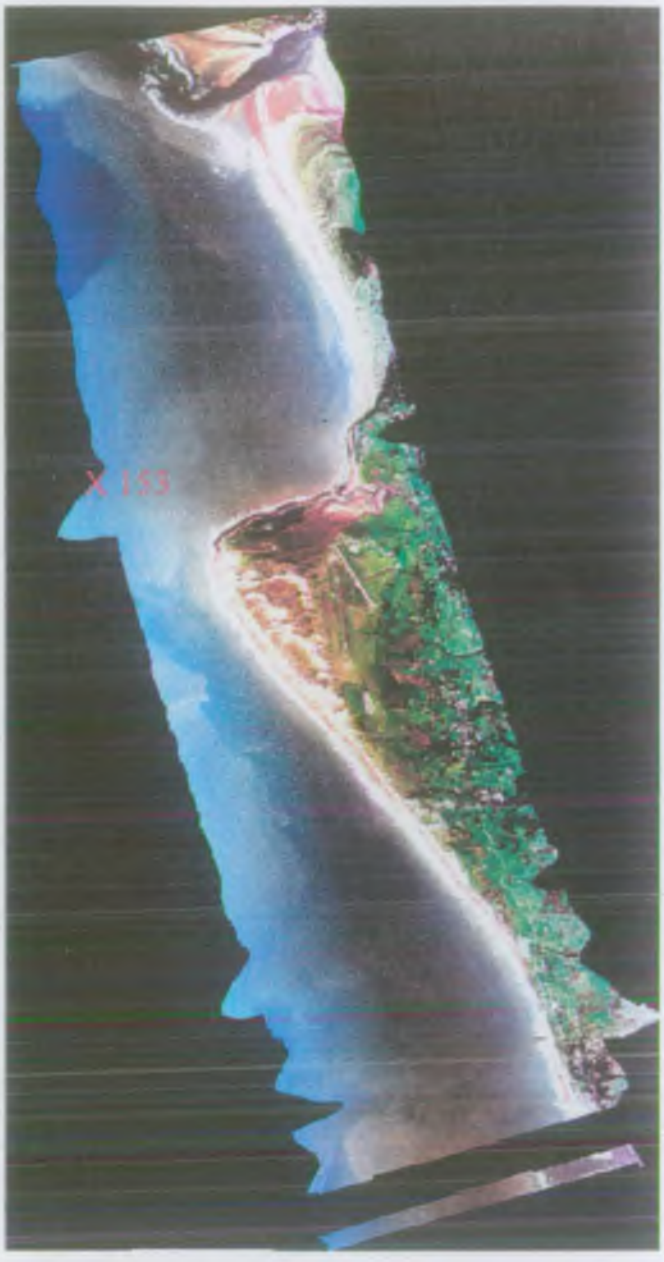
(i) 29th September 1995, 11:19 GMT



(ii) 8th October 1995, 10:41 GMT

Plate 5: Newquay Head
CASI enhanced true colour composite images
The baseline sampling site is marked as a red cross

(i) 29th July 1995, 12:19 GMT



(ii) 8th October 1995, 11:23 GMT

Plate 6: Shell Island
CASI enhanced true colour composite images
The baseline sampling site is marked as a red cross