EA-NCEDS BOX 4

# National Marine Baseline Survey 1995

# Littoral Cell 8
# Severn Estuary to St. David's Head

ENVIRONMENT
AGENCY

Report NC/MAR/016 Part 10 of 17
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## 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.

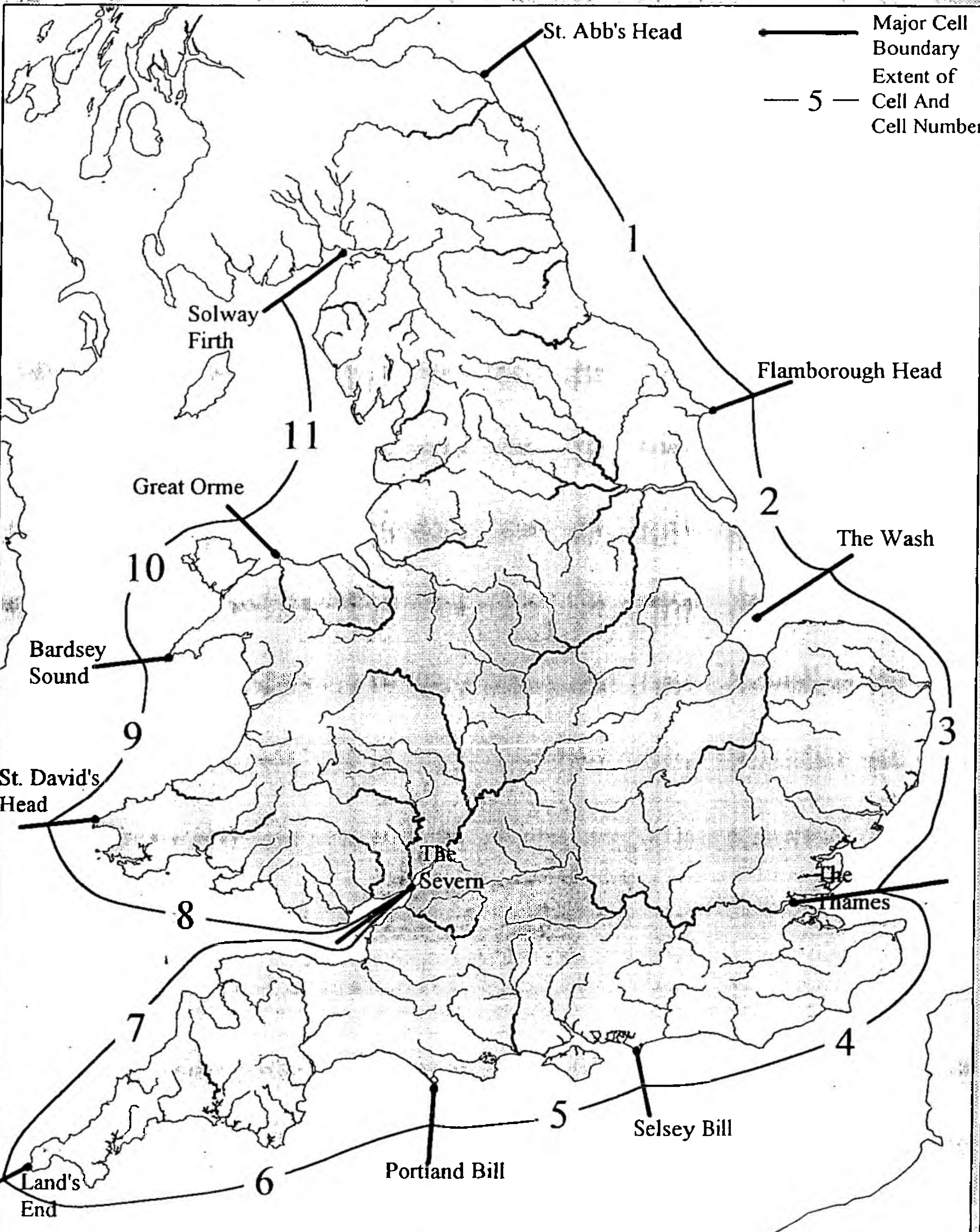
Consideration has been given to the position of the baseline sampling sites in relation to estuaries or major oceanographic features.

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 8: Severn Estuary to St David's Head


## Executive Summary

This littoral cell extends from the Severn Estuary to St David's Headland. The water quality is influenced by the complex inputs around the Upper Bristol Channel and by further industrial regions, in particular Milford Haven.

No baseline sampling sites recorded concentrations in excess of the Environmental Quality Standards for dissolved metals. The Newport Deep sampling station recorded high winter nutrient concentrations, for example TON equal to 3241 μg/l, with corresponding elevated concentrations of chlorophyll-*a*, up to 5 μg/l. Other regions which showed high nutrient concentrations, for example the Mumbles, did not show high chlorophyll-*a* concentrations. Most sites show concentrations of γ-HCH above 0.001 μg/l, but the total HCH value does not exceed the EQS.

Spatial chlorophyll-*a* results showed that the region has some areas of high chlorophyll-*a* concentration, specifically at Burry Port and St Ann's Head at the time of the Summer survey. Concentrations at Burry Port exceeded 10 μg/l. There were no corresponding high nutrient concentrations in this region in any of the surveys.

CASI imagery reveals circulation of suspended sediment within the Upper Bristol Channel, which is influenced by the presence of sand and mud banks. There is evidence of possible algal growth on the mudflats to the south of the Second Severn Crossing. The power stations located along this coast are shown to have varying influence on the thermal characteristics of the surrounding waters.

A discharge of effluent from the Mumbles sewage outfall is shown in both the CASI and thermal video imagery in July. The timing of this discharge at Low Water might result in ponding of effluent around the Mumbles Headland. The plume of estuarine water from Milford Haven is shown to have potential implications on the water quality of surrounding waters.


## 1. Introduction

This littoral cell extends from the Severn Estuary to St David's Head, as illustrated in Figure 1. This represents a total of 3700 km$^2$ of waters within the coastal zone for which the Environment Agency has responsibility for controlled waters. Of this, approximately 980 km$^2$ are estuarine waters, if all the Severn Estuary is considered to be within this cell.

Four vessel surveys were conducted in 1995 to collect water samples for laboratory analysis of chemical determinands, and to continuously monitor temperature, salinity, dissolved oxygen, fluorescence and transmission. Data for this cell were collected by Vigilance in each of the surveys. These took place in early Spring (April), late Spring (May), Summer (July) and Autumn (September). Aircraft surveys were carried out with the CASI and thermal video systems in July and September / October.

## 2. Water chemistry results

### 2.1 Background

This littoral cell extends from the Severn Estuary to St David's Head, and includes 21 baseline sampling sites. The major influence of water quality is from the industrialised region of the Upper Bristol Channel.

### 2.2 Nutrients and chlorophyll-*a*

#### *2.2.1 Total Oxidised Nitrogen (TON)*

TON concentrations in early Spring decreased from Newport Deep (120), equal to 3241µg/l N to Old Castle Head (135), equal to 240 µg/l N. The Mumbles (128) and Oxwich (129) sampling points recorded locally high concentrations of 1595 µg/l N and 1578 µg/l N respectively. Concentrations showed a further increase once more around St Ann's (138). The maximum concentration in late Spring was 1560 µg/l N at Newport Deep (120) once more, and the minimum was 38 µg/l N at Carmarthen. Summer and Autumn concentrations were slightly higher than those seen in late Spring, with an increase towards the Upper Bristol Channel.

#### *2.2.2 Silicate*

Silicate concentrations were maximum at Newport Deep (120), with a sharp decrease in concentration in the vicinity of Lavernock (122) in all surveys. Early Spring concentrations showed a maximum of 1644 µg/l Si at Newport Deep (120), with a further local peak in concentration at Mumbles (128), equal to 756 µg/l Si. Late Spring concentrations were lower, with a maximum of 892 µg/l Si at Newport Deep (120) and a minimum of 28 µg/l Si at Nash point and a further increase at St Ann's (138). In Summer, sites to the west of Worms Head (130) recorded concentrations below 1 µg/l Si, until St Ann's (138), where the concentration rose slightly. In Autumn the maximum concentration of 799 µg/l Si was again recorded at Newport Deep (120).

#### *2.2.3 Orthophosphate*

The maximum early Spring an orthophosphate concentration of 113 µg/l P was recorded at Newport Deep (120), with the minimum at Old Castle Head, and a further slight peak at Mumbles (128). In late Spring the concentration fell to less than 5 µg/l P to the west of Port Talbot (127). Summer concentrations showed a gradual decrease to the west, but with a peak at Port Talbot (127), equal to 127 µg/l P. Autumn concentrations showed a maximum at Newport Deep (120) falling to a minimum at Port Talbot (127), with the Oxwich (129) sampling site showing a slight peak.

#### *2.2.4 Total Ammoniacal Nitrogen (Ammonia)*

Ammonia concentrations showed a maximum in early Spring of 66 µg/l N at Lavernock (122). All other sites showed concentrations between 44 and 54 µg/l N with no geographical pattern. Concentrations were very low in late Spring, with only those sites between Porthcawl (125) and the Mumbles (128) recording results above the minimum reporting value (MRV) of 6 µg/l N, and a maximum of 8.6 µg/l N at Port Talbot (127). Summer concentrations showed a maximum of 37 µg/l N at Mumbles (128), and a minimum of 17 µg/l N at Caldey Island (134) and Newport Deep (120). Autumn concentrations were highest from Oxwich (129) to Burry Port (132), with the maximum at Burry of 23 µg/l N.

*2.2.5 Nitrite*
In early Spring, the nitrite concentration was maximum at Newport Deep (120), equal to 7.3 µg/l N, with no apparent geographical pattern between the other sites. Concentrations in late Spring only exceeded the MRV at a few sites, with the maximum at Lavernock (122) equal to 4 µg/l N. In Summer the maximum concentration was recorded at Aberthaw (123), equal to 21.2 µg/l N, with generally higher values towards Newport. Autumn results were high, with the maximum concentration of 60 µg/l N found at Port Talbot (127) and Worms Head (130) and concentrations to the West of Nash Point (124) generally high.

*2.2.6 Chlorophyll-a*
Chlorophyll-*a* concentrations in early Spring were generally low, with many sites recording concentrations less than 0.2 µg/l. At Newport Deep (120), however, there was a concentration of 5 µg/l, which may have been caused by the excessive nutrients in the region promoting an early growth of phytoplankton. Late Spring concentrations were low in comparison to national averages, with the maximum concentration found at Cardiff Roads (121) equal to 7.85 µg/l. Most sites in Summer showed low values, with only two sites having concentrations above 5 µg/l: the concentration at Burry Port (132) is greater than 10 µg/l. This region did not, however, show elevated nutrient concentrations. In Autumn all sites recorded low concentrations, with the maximum at Llanelli (131) equal to 4.6 µg/l.

*2.2.7 Nutrients/chlorophyll-a Summary*
Thus the sites which showed elevated nutrient concentrations in early Spring around the Mumbles (128) did not apparently result in high concentrations of chlorophyll-*a* during the baseline surveys. Similarly, the high concentration of chlorophyll-*a* in Summer at Burry Port (132) was not accompanied by high nutrient values, with this region not showing high nutrient concentrations at any season. The Newport Deep (120) site does showed a link between nutrients and chlorophyll-*a*. This site recorded high concentrations of all nutrients except ammonia and showed elevated early Spring concentrations of chlorophyll-*a*. This suggests that the late Spring phytoplankton bloom may have been stimulated to arrive early by some anthropogenic source.

## 2.3 Suspended solids

Suspended solids concentrations exhibited the same geographical pattern in each of the four surveys, with highest concentrations at the upper end of the Bristol Channel. The change between those sites recording the high concentration of Severn Estuary sediment and those which were influenced by the open ocean water occurred between Port Talbot (127) and Oxwich (129) depending on seasonal and tidal influences.

Early Spring concentrations were greatest for those sites away from the Upper Bristol Channel, although the maximum concentration was recorded in the late Spring survey, equal to 595 mg/l at Newport Deep (120).

## 2.4 Metals

*2.4.1 Total Mercury*
Total mercury concentrations were generally less than the laboratory MRV of 0.008 µg/l

Hg in each survey. The Newport Deep (120) sampling site showed concentrations above this throughout the year, representing the higher suspended solids loading in this area. No samples were in excess of the EQS level of 0.3 µg/l Hg.

*2.4.2 Dissolved Cadmium*
Dissolved cadmium concentrations were low throughout the surveys, with a maximum value of 0.793 µg/l Cd being recorded during Autumn at Newport Deep (120), compared with an EQS level of 2.5 µg/l. This was the maximum concentration found nationally during this survey. The concentrations show a further increase to the west of the cell.

*2.4.3 Dissolved Copper*
Dissolved copper concentrations showed a geographical pattern of two peaks in concentration, with maximum values found near to the Newport Deep (120) or Cardiff Roads (121) sampling sites, but with a further increase from approximately Caldey Island (134) onwards. No sites recorded concentrations above the Environmental Quality Standard of 5 µg/l. The concentration of 3.55 µg/l Cu found at Llanelli (131) in Autumn was the maximum for that survey.

*2.4.4 Dissolved Lead*
Dissolved lead concentrations were low in comparison with the EQS value of 25 µg/l Pb, with maximum concentrations generally recorded around St Ann's (138) to South Bishop (140). Concentrations were all less than 1 µg/l Pb, with a maximum of 0.99 µg/l Pb at St Ann's in early Spring.

*2.4.5 Dissolved Arsenic*
Dissolved arsenic concentrations did not exceed the laboratory MRV of 2 µg/l As for any sites.

*2.4.6 Dissolved Zinc*
Dissolved zinc concentrations showed two concentration peaks located at the Upper Bristol Channel and around Milford Haven during the early and late Spring surveys. Early Spring concentrations were generally low, with a maximum of 13.9 µg/l Zn at St Ann's (138). The Spring maximum concentration of 24 µg/l Zn was found at Old Castle Head. In Summer the peak concentration was found at Newport, but with a further high concentration at Burry Port (132). In Autumn, concentrations were high from Newport Deep (120) to Oxwich (129), with a rapid decrease after this.

*2.4.7 Dissolved Chromium*
Dissolved chromium concentrations were geographically variable between seasons, and low in comparison to the EQS level of 15 µg/l Cr. The maximum concentration was recorded in Autumn at Old Castle Head (135) equal to 1.4 µg/l Cr.

*2.4.8 Dissolved Nickel*
Dissolved nickel concentrations showed a westerly decrease from the Upper Bristol Channel. All results were low in comparison to the EQS level of 30 µg/l Ni. In Autumn high concentrations were found at Llanelli (131) and Oxwich (129) equal to 1.17 and 1.18 µg/l Ni respectively.

*2.4.9 Metals Summary*

Many dissolved metals ie. cadmium, copper and zinc showed a pattern of two peaks in concentration. Where absolute concentrations were lower, the pattern was less clearly defined with mercury and nickel showing a slight westerly decrease and dissolved lead a slight easterly decrease. Dissolved chromium had maximum concentrations in the Mumbles (128) and Oxwich (129) region.

## 2.5 Organic determinands

Water samples were analysed for twenty three trace organic determinands at ten baseline sites within this littoral cell. 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.

Concentrations of γ-HCH were generally above the MRV of 0.001 µg/l, with some sites also showing positive concentrations of α-HCH. The concentration of total HCH did not exceed the EQS level of 0.02 µg/l for any site.

## 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 figure is incomplete as no data collection was possible during the July survey for much of this cell, due to the activity of military firing ranges. Additionally data are missing for the Upper Bristol Channel as the high suspended solids concentrations effect the action of the algorithm. For the remainder of the cell, the concentration is less than 6 µg/l, with the lowest concentrations around Oxwich (129), being less than 2 µg/l.

These low concentrations are also found in the calibrated fluorimeter data as shown in Figure 3. This data also shows a number of peak concentrations. To the north of Worms Head (130) concentrations exceed 10 µg/l, which corresponds to the laboratory maximum of 10.8 µg/l at Burry Port (132). There is a further high concentration at St Ann's (138), which is again shown in the laboratory data equal to 6.2 µg/l.

Thus calibration of the fluorimeter data provides a full picture of the variation in chlorophyll-*a* concentration along the vessel track. This data has been interpolated across track to produce the spatial view shown. The CASI data would provide the added benefit of full spatial data, this advantage being shown in descriptions of other littoral cells.

## 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 below, 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. Sandbanks in the Severn
2. Swansea Bay
3. Mumbles headland
4. Power station outfalls
5. Milford Haven

### 4.1 Sandbanks in the Severn

The Severn Estuary and Upper Bristol Channel are populated by sandbanks which mainly run parallel to the main channel, from north-east to south-west. To the upper end these banks are mainly emergent, but further to the west the banks are mainly submerged.

CASI imagery from both campaigns was collected close to Low Water at the upper end of the Bristol Channel, as shown in Plate 1. Of particular interest is the area marked A which shows a region of mud which has been potentially populated by algae, as shown by the green coloration of the image. This region is high in nutrient concentrations as shown by the laboratory results. This algal growth may therefore be promoted by the excess nutrients. The second image shows a greater level of exposure overall due to the tidal state being Low Water Springs.

Further to the west, CASI imagery from both July and September shows the presence of Nash Sand located off Nash Point (Plate 2). Again, the second image shows the maximum level of exposure due to the image being collected close to Low Water Spring Tides. The level of exposure may be assessed by observation of the breaking waves across the westerly extension of the banks. The imagery from July was taken two days after Spring tides, and as such the sandbank is not so exposed.

This July image, however, shows the transport path of sediment in this region clearly. The tidal flow of sediment at this time is towards the west. Water high in suspended sediment, and thus having a higher ocean colour signal divides around the position of the bank. A flow of high suspended solids water is seen to be deflected onto the coast to the north of Nash Point. This water may be high in chemical determinands, given its source in the Severn Estuary, and as such may lead to pollution of the coastline at this point.

### 4.2 Swansea Bay

Plate 3 shows CASI imagery from Swansea Bay collected in July and October. Both images were collected at Low Water Spring tides, which is shown by the exposure of mud and sand. The two images show differing directions of flow for the main channel from Swansea harbour, marked on the imagery. In July the direction of the channel is directly to the south, whereas in October the channel is deflected to the east. In addition there is greater variability in the October image, with generally higher suspended solids concentrations as shown by the higher ocean colour signal.

Thermal video imagery from this area is shown in Plate 4. This image from July shows the surface temperature of the water, which is shown to be more highly variable than the CASI imagery. This is probably due to the complex series of inputs to the region from both riverine sources and industrial outfalls. Many of these sources will have a thermal signature, but may not alter the ocean colour signal.

All images show the presence of an anomalous area, marked A. The area has a warm temperature signal, and a dark ocean colour signal. Although this region is shown on Admiralty charts to have a similar depth to surrounding areas, these characteristics clearly suggest an emergent feature. In addition the spectral signature of the region is not consistent with the mud and sand of which this area is built up. Investigations to date have not established the reason for this anomaly and are continuing.

### 4.3 Mumbles Headland

Plate 5 shows CASI imagery from the Mumbles headland and Oxwich Bay. In October there is a clear front off the Mumbles, with water higher in suspended solids located close to the shore, and waters lower in suspended solids offshore. The source of the high suspended solids water is Swansea Bay, which may have implications on water quality in the region to the west of the Mumbles. The imagery shows that this region of higher suspended solids disperses over a scale of approximately 7 km, and thus under these conditions only bays within this distance would be directly affected by sediment transport mechanisms.

In the July imagery there is less clearly marked front off the Mumbles, but there is again a difference in suspended solids concentrations between offshore and inshore waters. Moreover, this image shows the position of the Mumbles sewage outfall, which has a greenish yellow signal in the CASI imagery. The CASI imagery at this resolution does not clearly show the dispersion characteristics of the plume.

The thermal video imagery illustrates the characteristics of this plume more clearly. Plate 6 shows data coincident with the two CASI overpasses. In October, the simple frontal structure is clearly illustrated, with warmer water close to the shore, and cooler water offshore. There are no apparent discharges within this area.

In July the area is more complex. The frontal structure is still evident, but there are two further features. Firstly, there is a warmer region offshore. In addition there is a thermal signature associated with the position of the sewage outfall. The shape of the feature implies that the sewage is travelling towards the shore. This may have implications on the water quality of this region of coast. In addition, there is an indication of further flow along the coast.

The July image was collected at Low Water at Mumbles. The tidal flow direction was in process of reversing at this time from a weak westerly flow to the weak easterly flow. Thus effluent from this outfall would not quickly disperse from the point of discharge. In October the image was collected at 3 hours after High Water. At this time there was a stronger westerly flow of water. Thus if effluent has been discharged at High Water, it had by this time dispersed from the area. The timing of effluent discharge in the July imagery is therefore a matter which may warrant further investigation.

The baseline sampling sites located at the Mumbles (128) and Oxwich (129) are marked on the CASI imagery. The Mumbles site is outside the influence of water from Swansea Bay in both July and October. Similarly, the Oxwich (129) site is within clear water in July, although there is a slight sediment movement off the headland in October. Both sites record high nutrient concentrations during the early Spring baseline survey, which are indicative of being within the influence of a sewage outfall. For example a concentration of 1595 μg/l for TON is recorded at Mumbles (128).

Skalar continuous nutrient analyser data for Spring, Summer and Autumn 1995 are shown in Figures 4, 5 and 6 respectively. The scales for these figures are determined from national average concentrations which allows national comparisons to be made. It is immediately apparent that nutrient concentrations in the Mumbles area were not high in comparison to national concentrations in any of the three surveys, except for the silicate concentrations in Spring, which are high for this entire area of Welsh coast.

Phosphate concentrations, however, showed a local maximum off the Mumbles headland in Autumn and Summer, with no data available for this region in Spring. It is not possible to state whether these elevated concentrations were a result of the sewage discharge or from more diffuse sources without further information.

### 4.4 Power station outfalls

There are a number of power stations within this littoral cell, including those at Aberthaw, Burry Port and Pwllcrochran in Milford Haven. Thermal video imagery offers the potential to assess the influence of the discharges from these power stations into the coastal zone.

Plate 7 illustrates thermal video imagery from each of these areas. The Aberthaw power station (Plate 7(i)) shows a large outfall of warmer than ambient temperature water which is seen to extend along the coast to the west, although the extent of influence is difficult to assess, as the outfall has similar temperature to the coast. Imagery from Burry Port is shown in Plate 7(ii), shows no obvious thermal plume from this. Imagery from Milford Haven shows a small outfall of cooler than ambient temperature from the Pwllcrochran power station (Plate 7(iii)). The geographical extent of this feature is obviously small at this time. This may, however, be due to the time of flight, and it would therefore be necessary to collect data at differing tidal states to assess whether this size of plume is typical.

## 4.5 Milford Haven

Imagery was only collected from the flightline from St Ann's Head to Skomer in October (see Plate 8). This area of coastline was not sampled in July due to the constraints of military firing ranges.

The CASI imagery shows a northerly flow of suspended sediment from each of the headlands, with the plume of water from Milford Haven also being deflected northwards. This water is higher in suspended solids, and thus has a higher ocean colour signal. The direction of flow of the plume is in accordance with the tidal stream at the time of measurement, which is weakly to the north. The flow is out from Milford Haven, with the image being collected four hours after High Water here.

As Milford Haven is a highly industrialised region, the position and extent of the plume would have implications on the water quality of the shoreline to the north and south of the Haven. In the scenario illustrated here, beaches to the north are potentially under the influence of the plume from Milford Haven.

The baseline sampling sites in this region are located as marked on the imagery. The St Ann's (138) sampling site is located within the plume from Milford Haven in this image, whereas the Skomer (139) site is away from this influence. If the tidal stream were reversed or had a stronger magnitude the Skomer (139) sampling site could potentially be within the influence of the plume.

Laboratory analysis of baseline sampling data during 1995 shows high concentrations in many determinands at these sites. The results show that the northerly sampling sites more often record high concentrations. This is probably because the sites to the south are located in more open water where mixing of the waters from Milford Haven is stronger.

Thermal data of this region shows minor outfalls within Milford Haven, including a small outfall of cooling waters from Pwllcrochran power station (see Plate 6). The plume of water from the Haven seen in the CASI imagery is not visible on the thermal imagery from this flightline, and as such must have a similar temperature to the receiving waters.

The spatial chlorophyll-*a* data for this section of the coastline (see Figures 2 and 3) shows high concentrations of chlorophyll-*a* between St Ann's Head and Skomer to the north of Milford Haven. This phytoplankton population is potentially being maintained by high nutrient levels held within the Milford Haven plume.

## 5. Conclusions

The water quality of this littoral cell in 1995 was influenced by the major estuarine source of the River Severn and by further areas of industry, in particular Milford Haven. Concentrations of chemical determinands in these regions were often some of the highest recorded nationally in each survey, with the intermediate sites recording very low levels.

However, there were no sites which recorded concentrations in excess of the

Environmental Quality Standards for any particular determinand. The Newport Deep (120) sampling station recorded high nutrient concentrations in early Spring with corresponding elevated concentrations of chlorophyll-*a* equal to 5 μg/l. Other regions which showed high nutrient concentrations, for example the Mumbles (128), did not show high chlorophyll-*a* concentrations. Most sites showed concentrations of γ-HCH above the MRV, but not at high levels in comparison to the EQS.

The sand and mud banks within the River Severn influence the circulation patterns of suspended sediment. In addition there is some growth of algae evident on the mudflats to the south of the Second Severn Crossing.

The power stations located along this coast are shown to have varying influence on the thermal characteristics of the surrounding waters. If these outfalls were considered to have an environmental impact on the surrounding coastline, collection of thermal data over full tidal cycles would show the geographical extent of the influence.

The Mumbles sewage outfall is shown to be discharging in the July imagery. The timing of this discharge at Low Water might result in ponding of effluent around the Mumbles Headland. The plume of estuarine water from Milford Haven is shown to have potential implications on the water quality of surrounding waters.

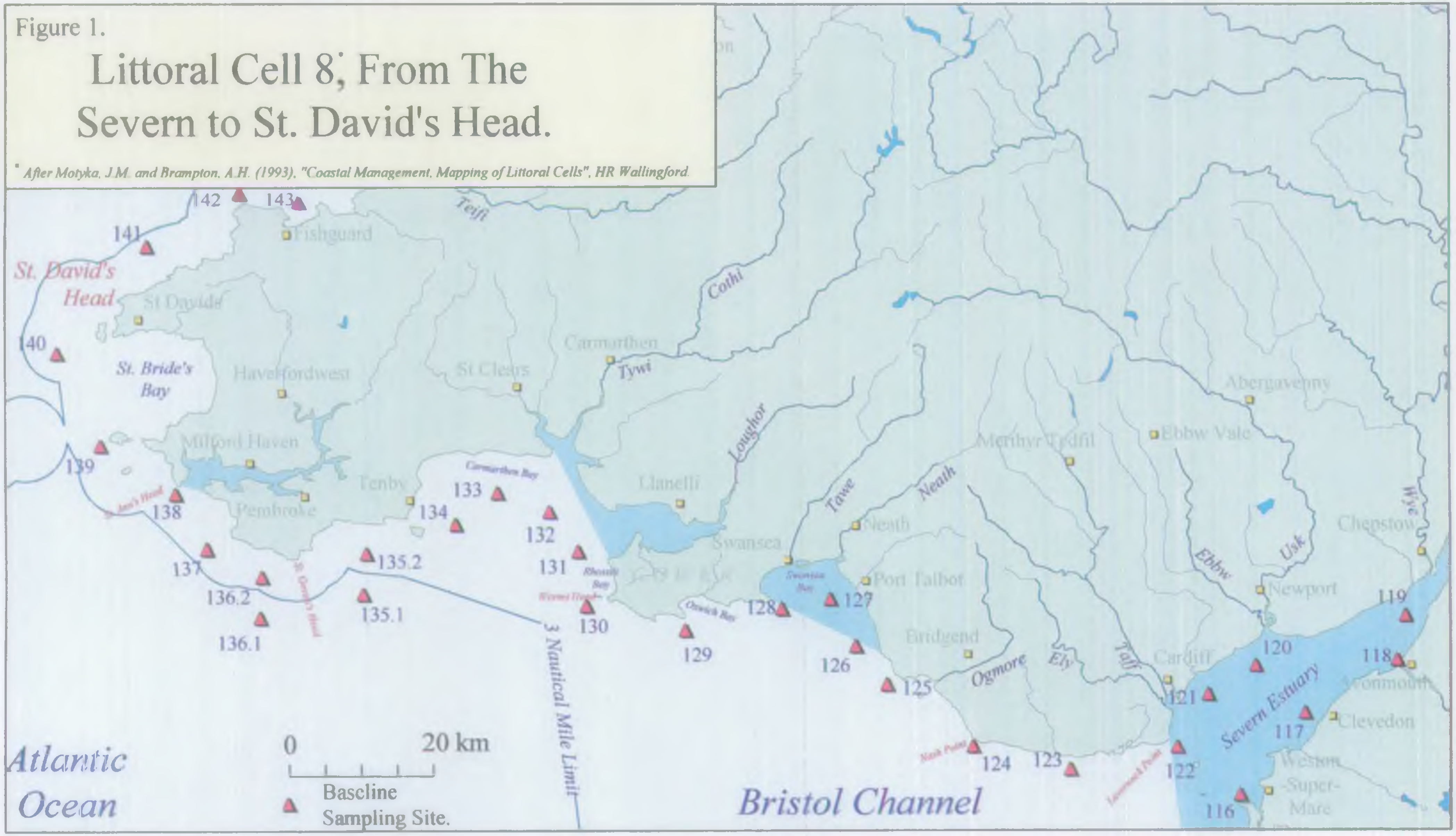



Figure 1.

## Littoral Cell 8*, From The Severn to St. David's Head.

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

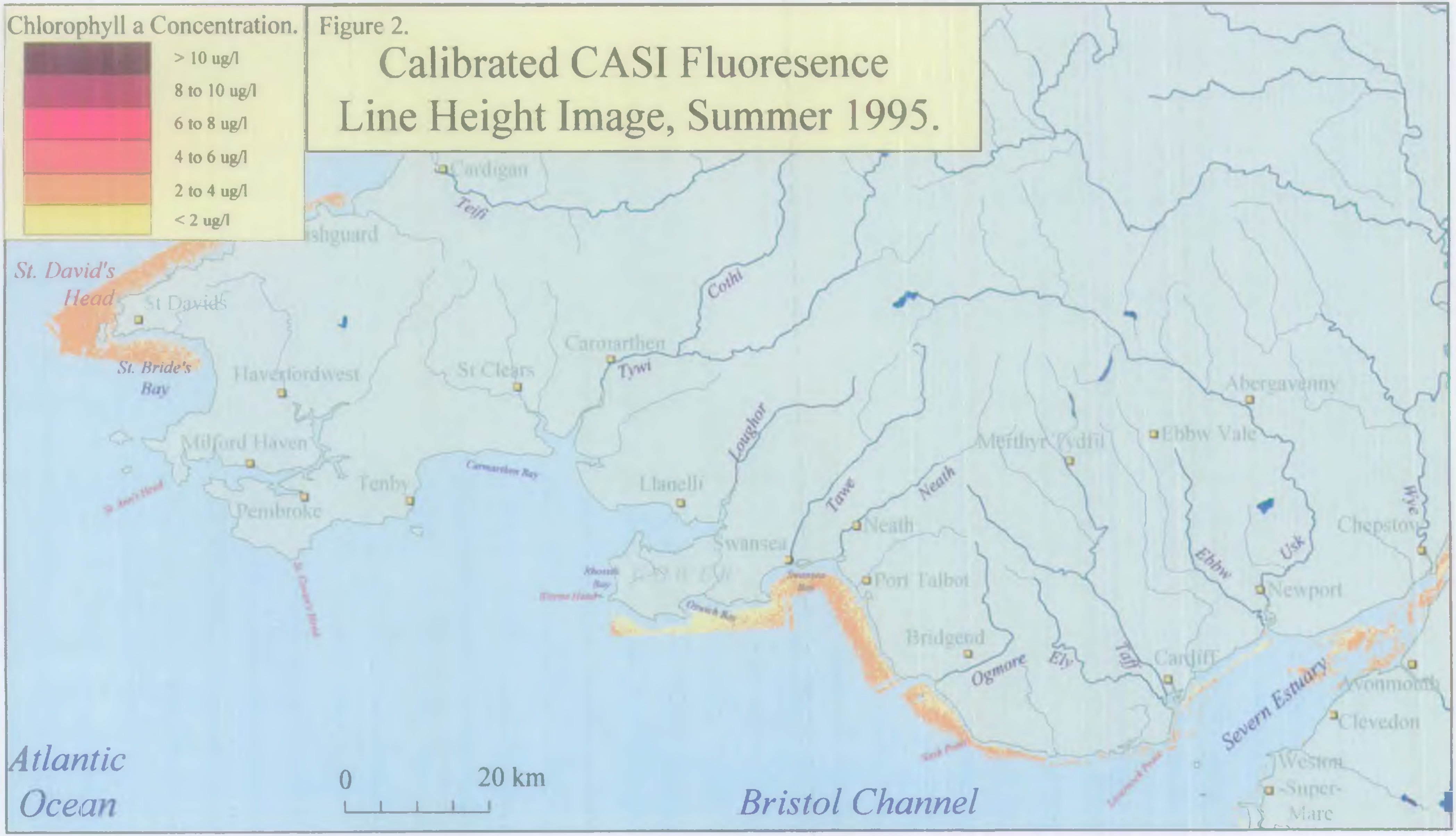



Figure 2.
Calibrated CASI Fluoresence Line Height Image, Summer 1995.

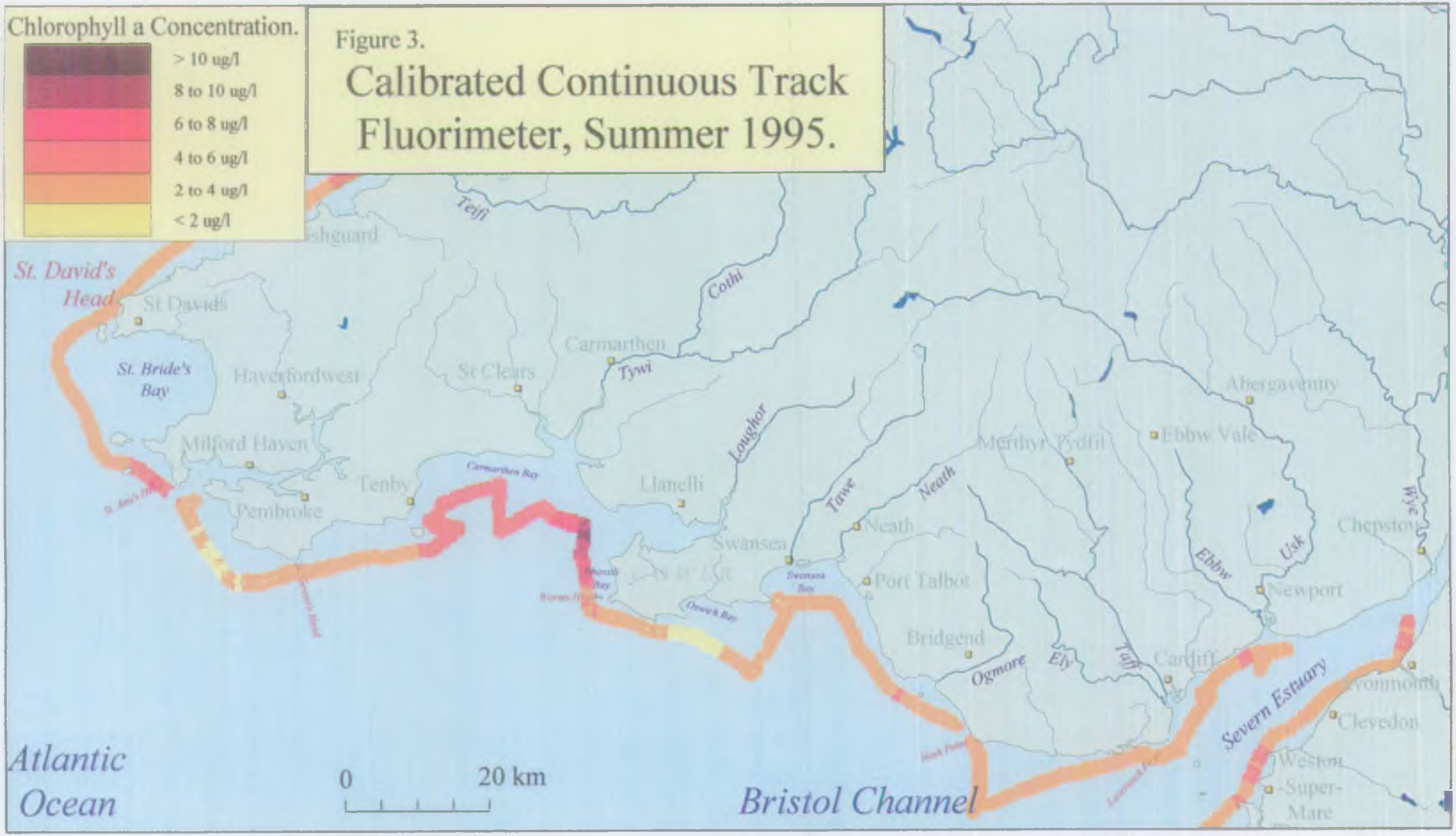


Figure 3.
Calibrated Continuous Track Fluorimeter, Summer 1995.

Figure 4.

# Skalar Nutrient Data from the Swansea Bay Area, Spring 1995.

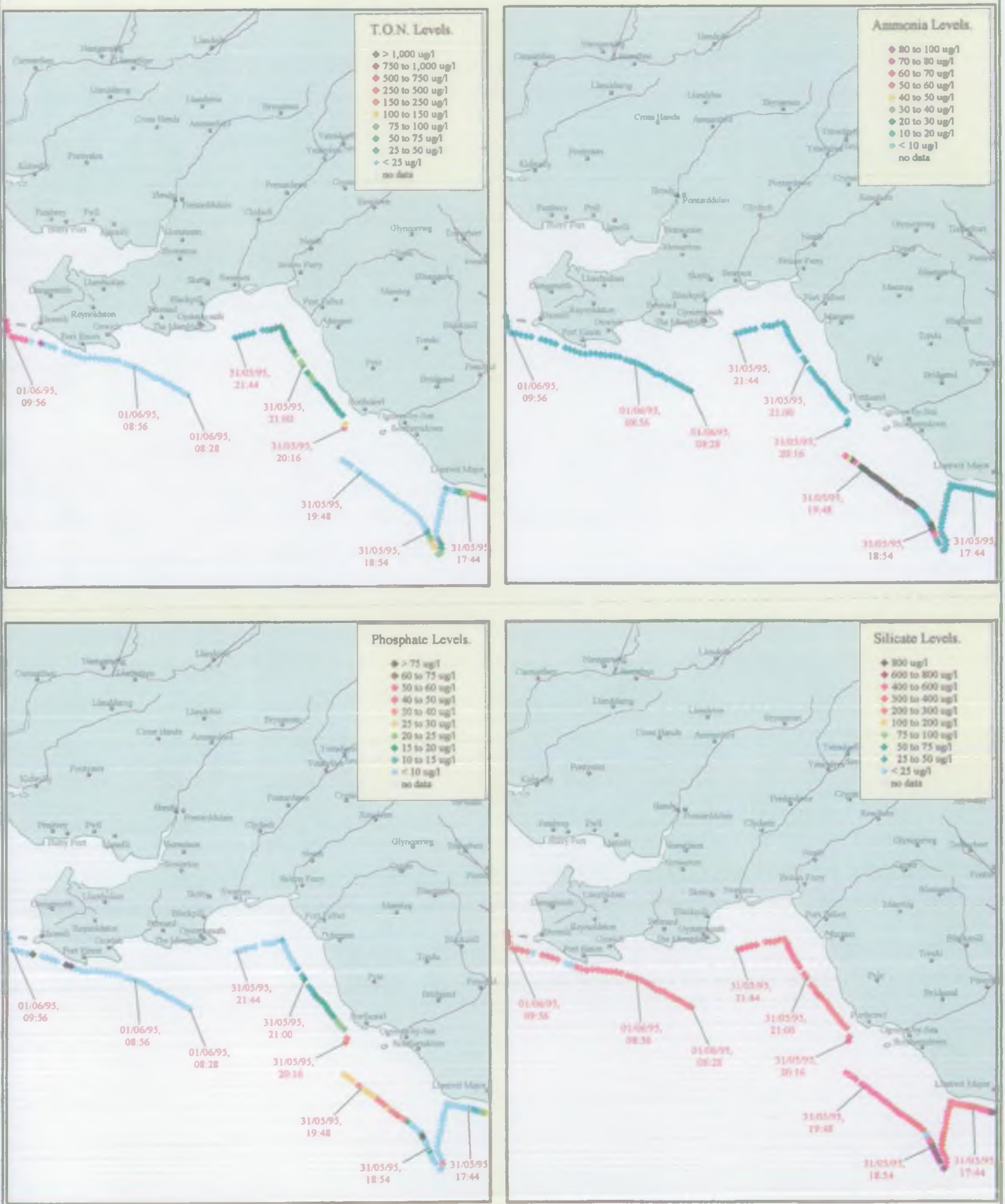


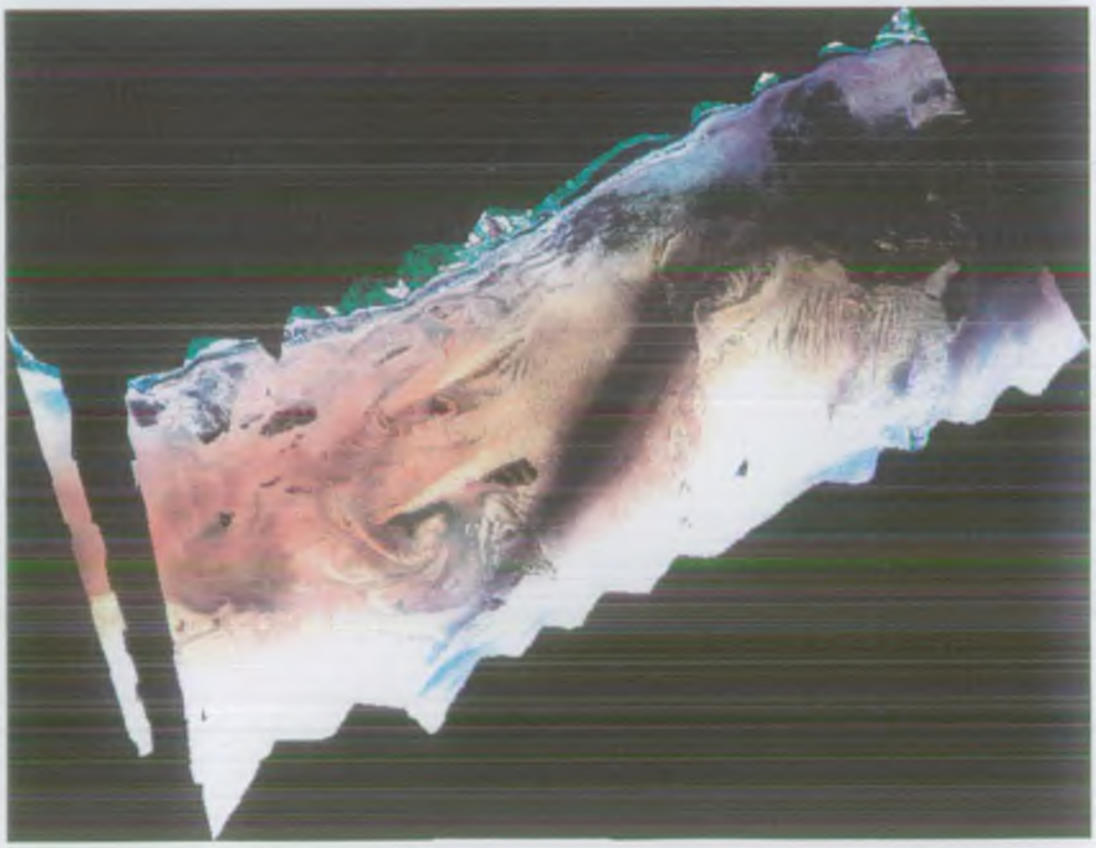
Figure 5.

# Skalar Nutrient Data from the Swansea Bay Area, Summer 1995.

Figure 6.

# Skalar Nutrient Data from the Swansea Bay Area, Autumn 1995.

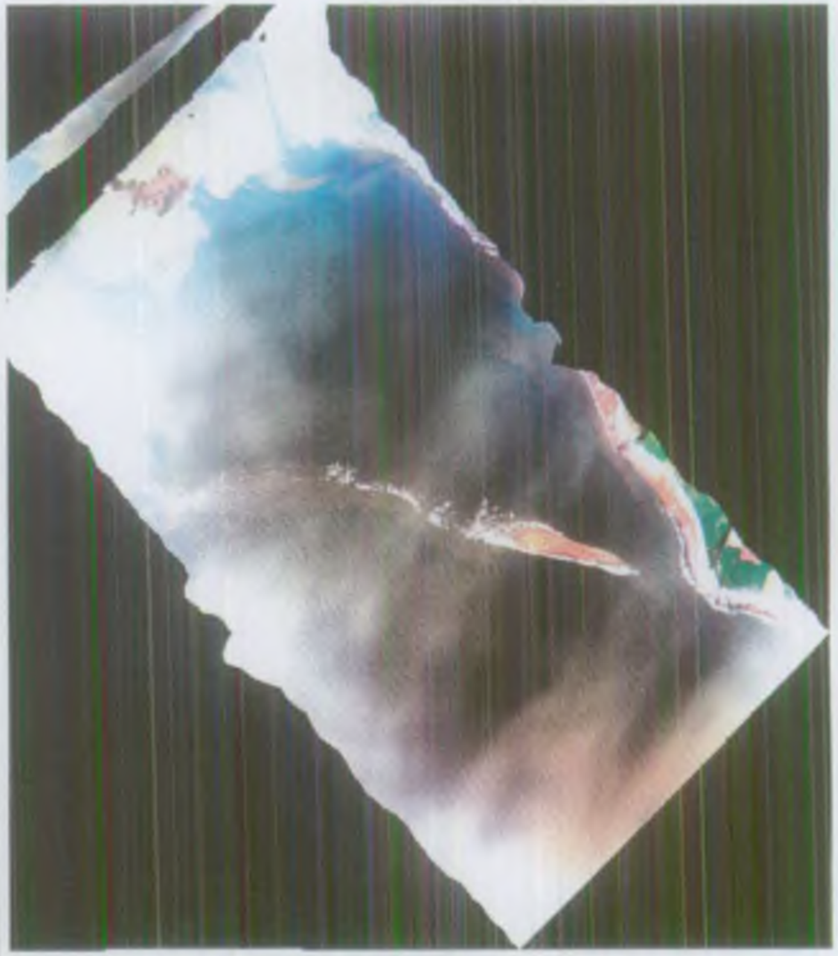

25th July 1995, 11:03 GMT



10th October 1995, 14:23 GMT

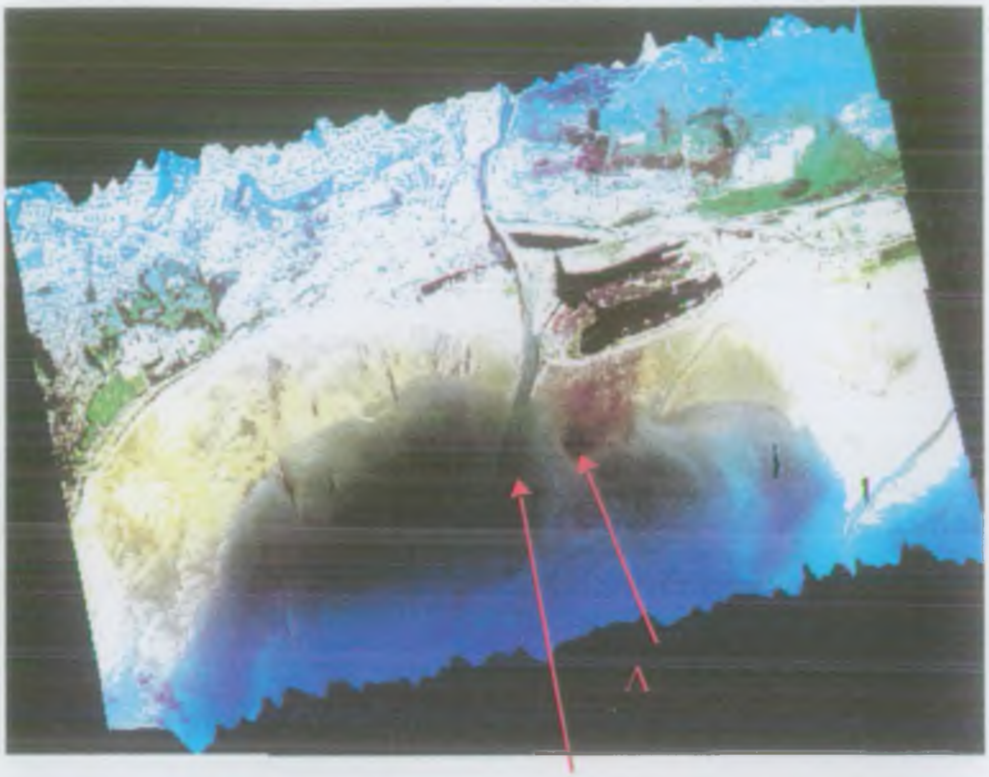
Plate 1: Severn Estuary
CASI enhanced true colour composite images

31st July 1995, 14:14 GMT



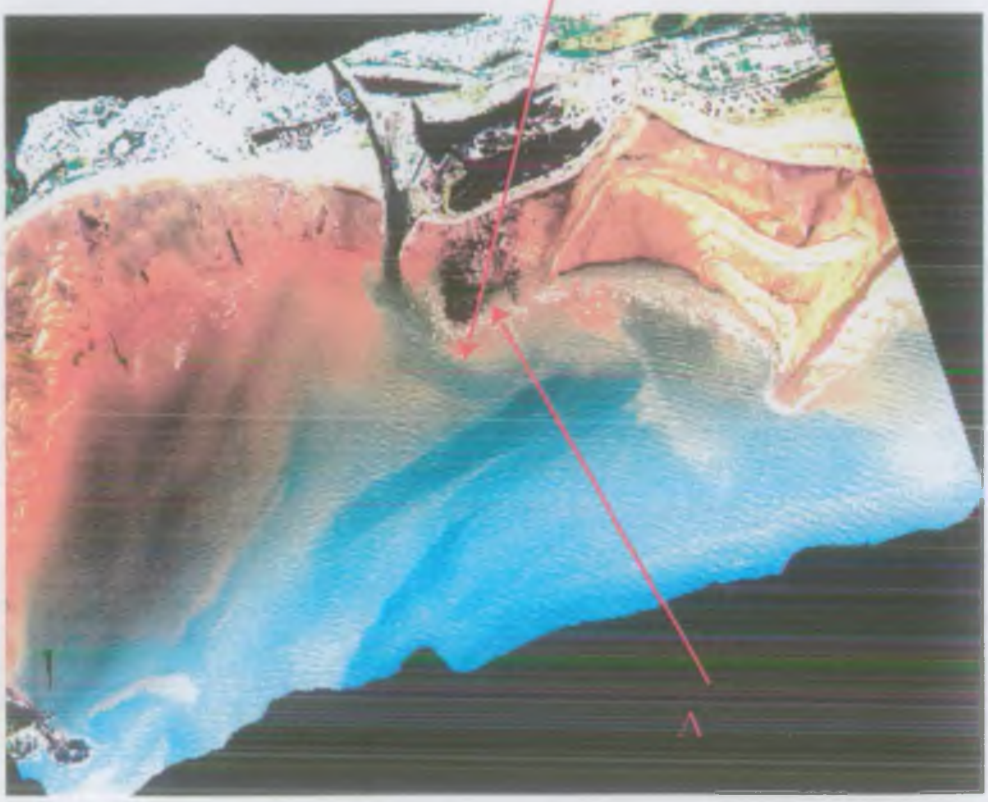
10th October 1995, 13:51 GMT

Plate 2: Nash Sands
CASI enhanced true colour composite images




31st July 1995, 14:27 GMT

varying channel position




10th October 1995, 13:34 GMT

Plate 3: Swansea Bay
CASI enhanced true colour composite images

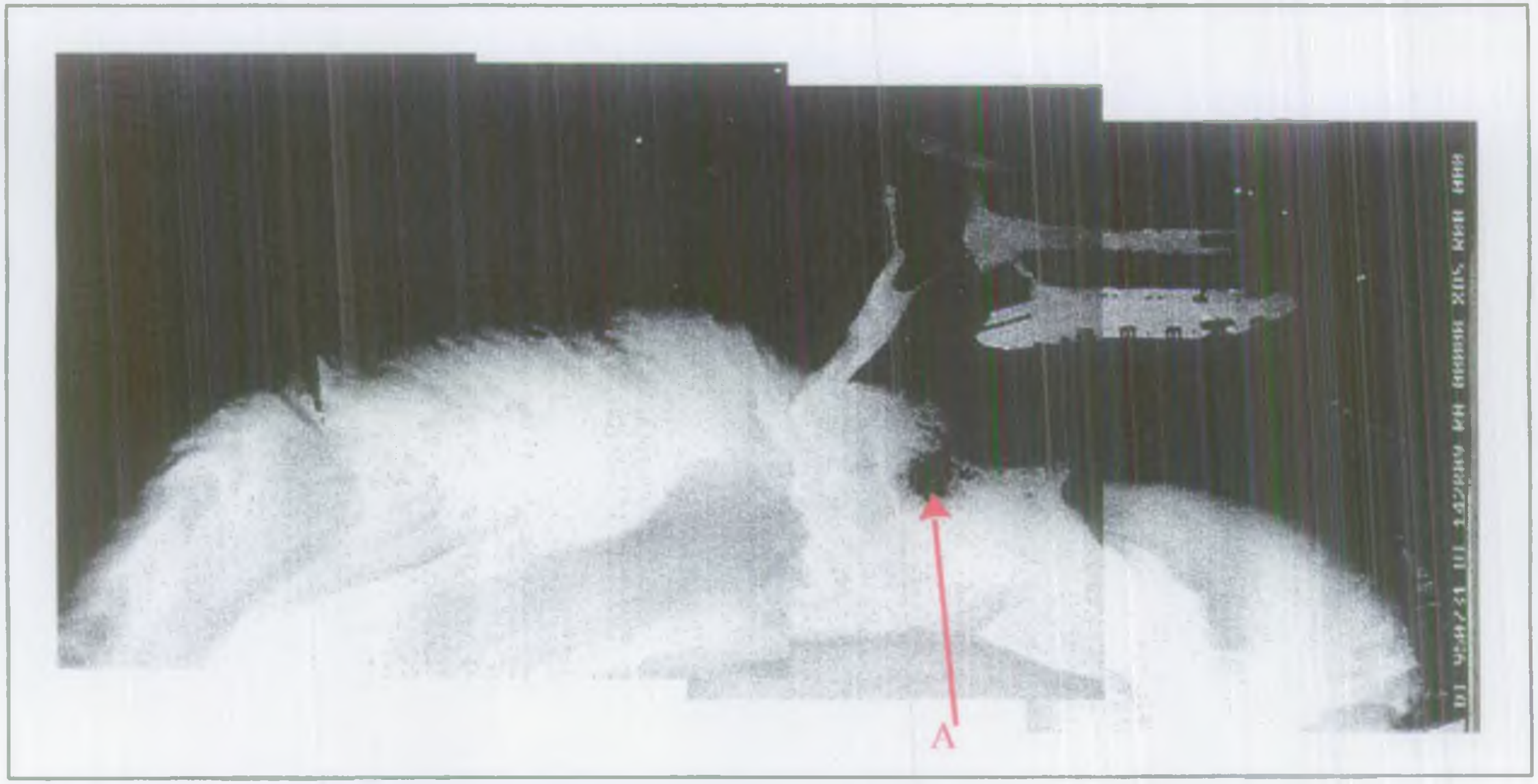
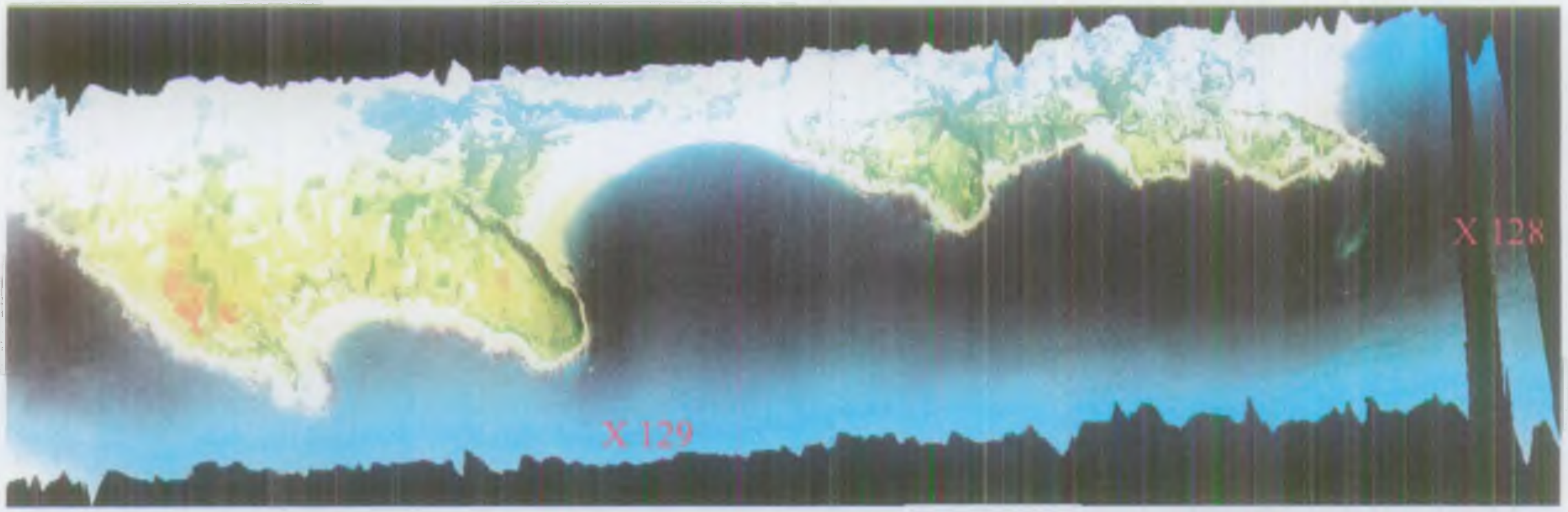
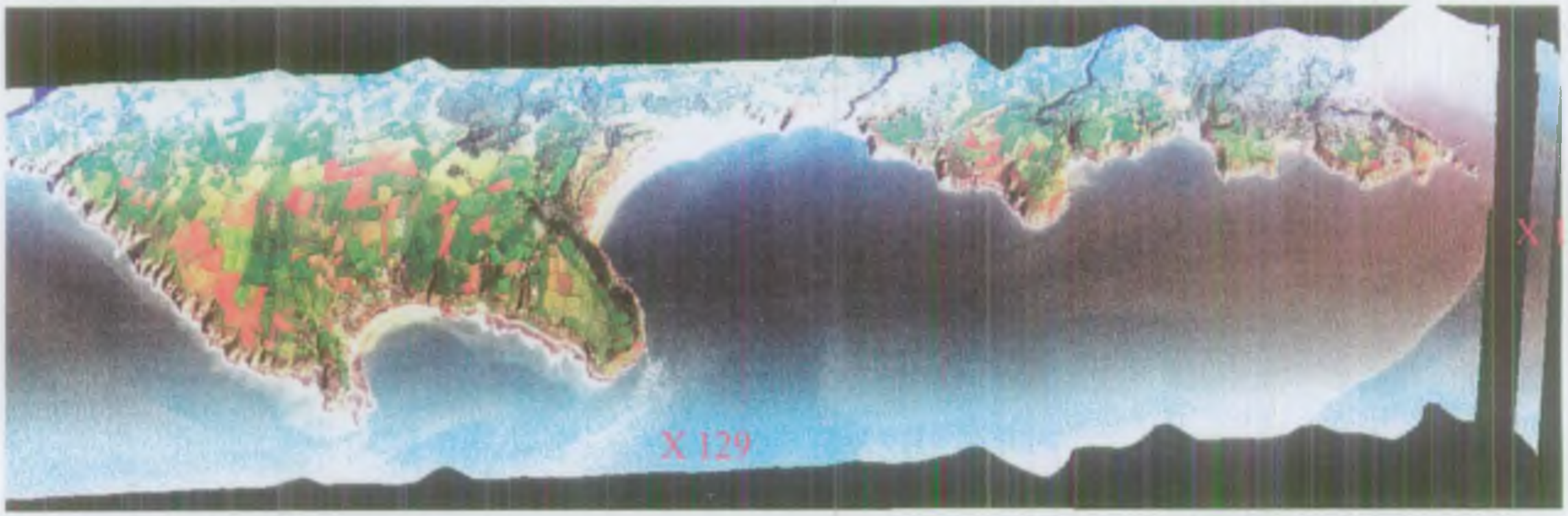



Plate 4: Swansea Bay
Thermal video image composite
31st July 1995, 14:28 GMT



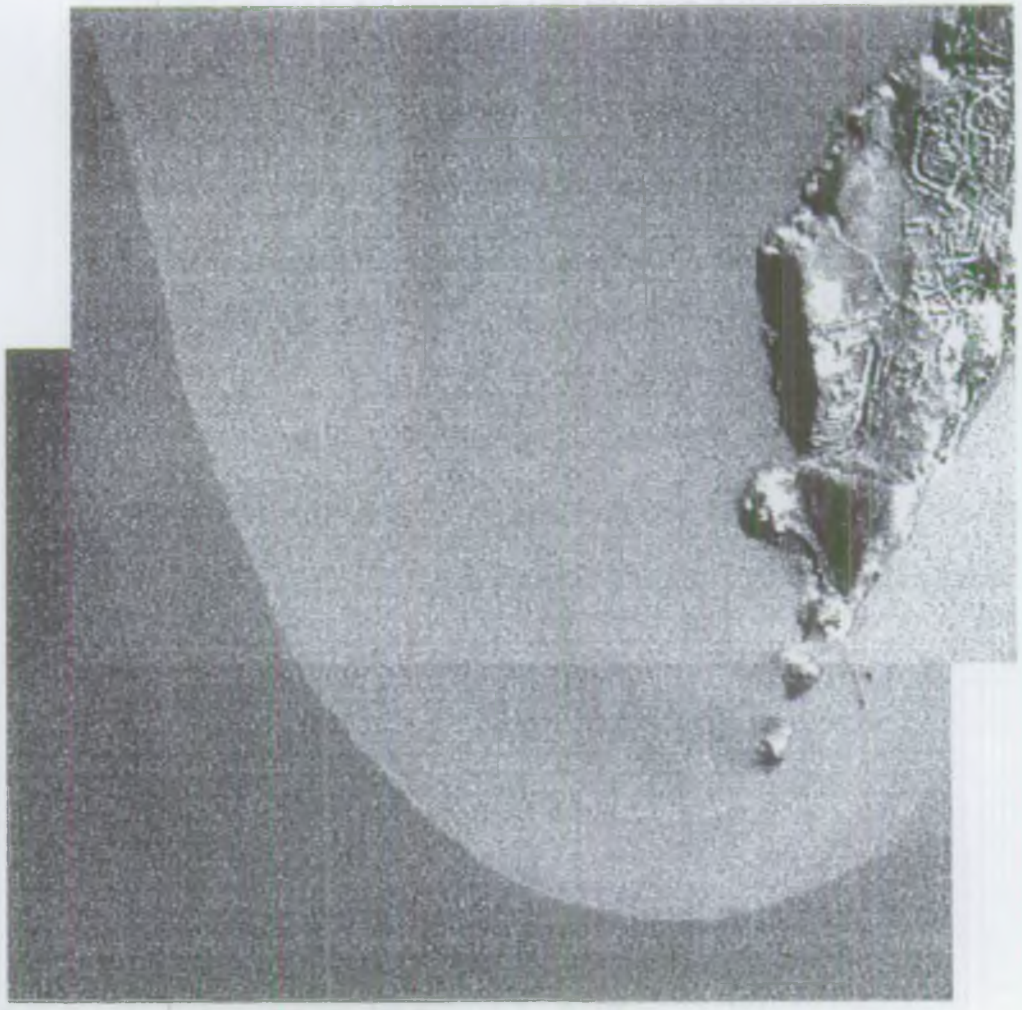

31st July 1995, 14:33 GMT




8th October 1995, 08:10 GMT

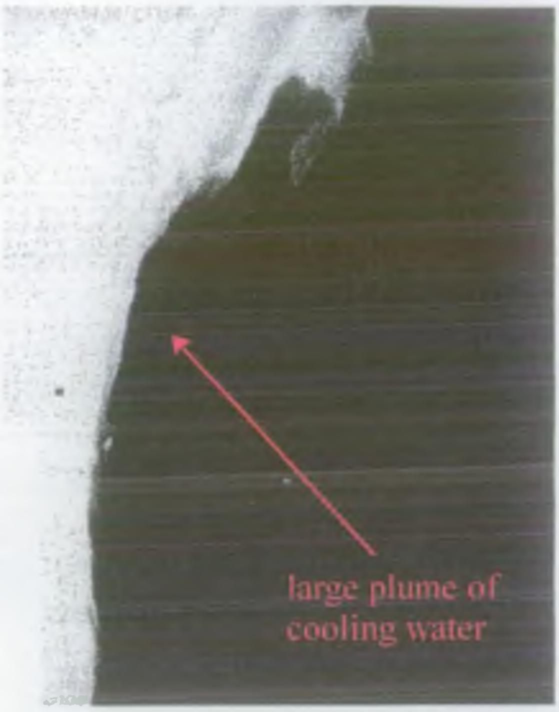
Plate 5: Mumbles and Oxwich
CASI enhanced true colour composite images
The baseline sampling sites are marked as red crosses

31st July 14:300 GMT



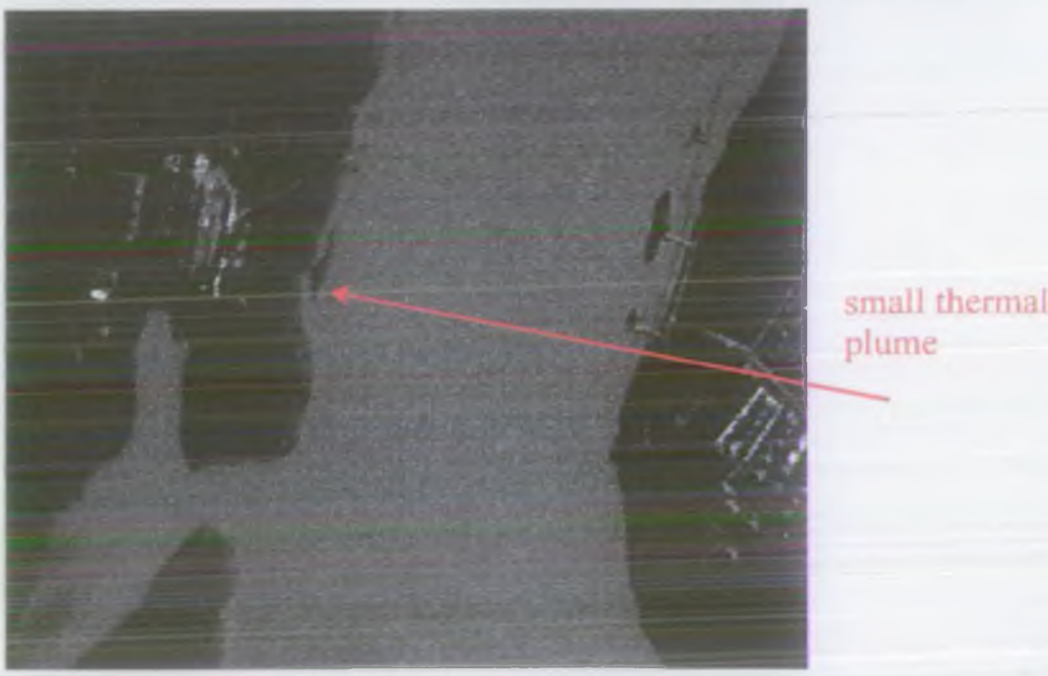
8th October 1995, 08:33 GMT

Plate 6: The Mumbles
Thermal video composite images




(i) Aberthaw power station

(ii) Burry Port power station




(iii) Pwllcrochran power station

Plate 7: Power station outfalls
Thermal video image composites

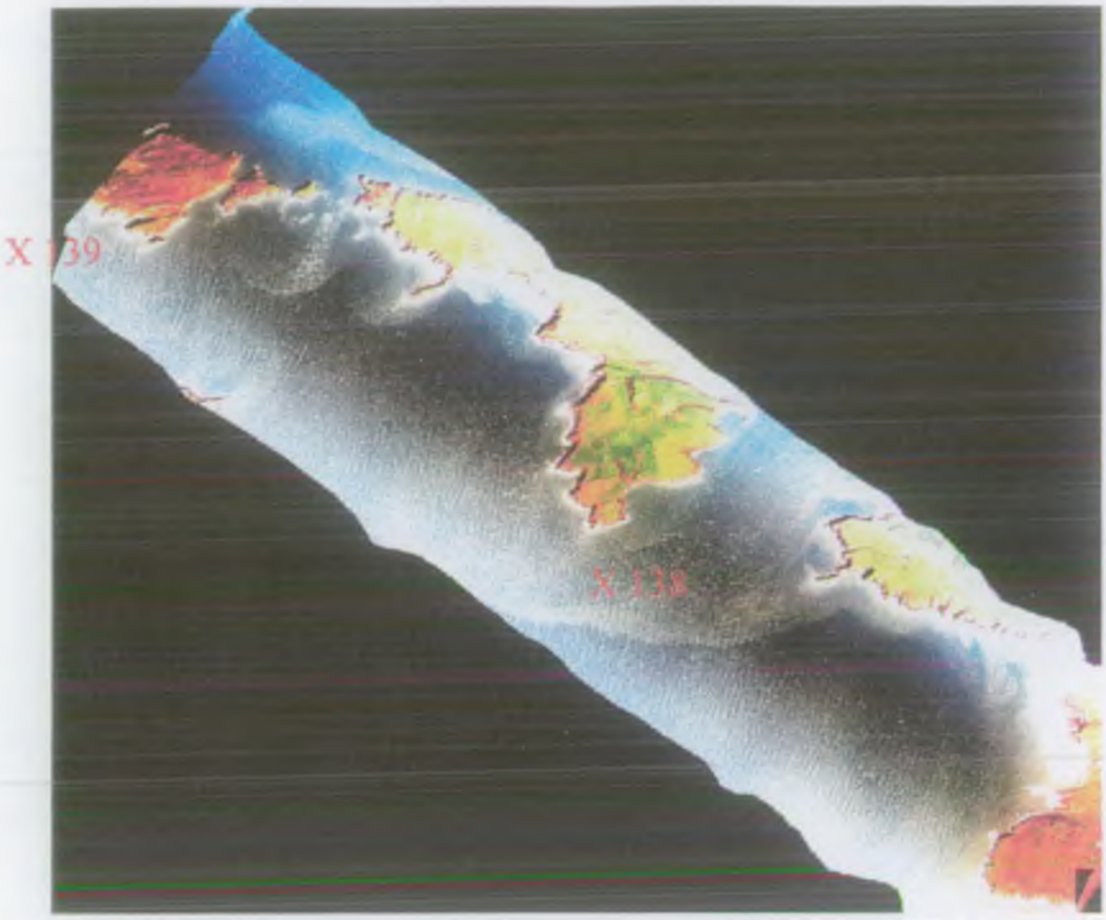



Plate 8: St Ann's Head to Skomer
CASI enhanced true colour composite image
8th October 1995, 09:36 GMT
The baseline sampling sites are marked as red crosses