EA-NCEDS Box 3

National Marine Baseline Survey 1995

Littoral Cell 6
Portland Bill to Lands End

ENVIRONMENT AGENCY

Report NC/MAR/016 Part 8 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.

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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.

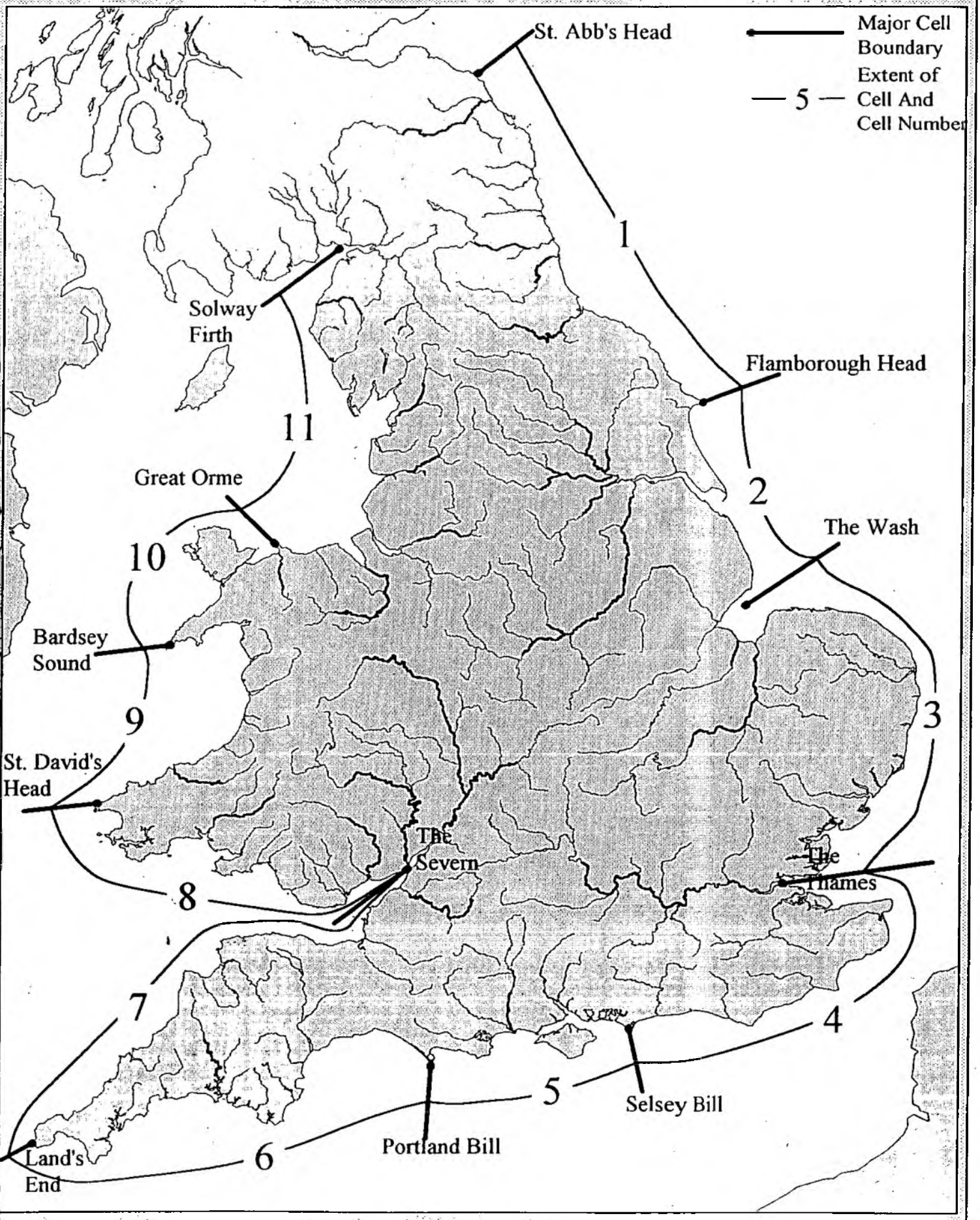
Consideration has been given to the position of the baseline sampling sites in relation to estuaries or major oceanographic features.

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 6: Portland Bill to Lands End

Executive Summary

This littoral cell extends from Portland Bill to Lands End. Water quality in the region is high, with little industrialisation. There is a general increase in quality with lower concentrations of determinands towards the west which marks the influence of open ocean water from the Atlantic.

Nutrient concentrations during Summer are higher than average, with the highest levels being found to the west of the cell. This may be due to rainfall runoff across agricultural land, or a results of the increased population during the tourist season. The fluorimeter data recorded a number of blooms in this area which are potentially caused by the nutrients. Copper concentrations are also high in comparison to other dissolved metals results. This is probably due to rainfall runoff across old copper workings, particularly in Cornwall.

The area is bounded to the east by a front off Portland Bill. Waters within this cell show generally lower concentrations of suspended solids than those in the eastern English Channel. To the west the boundary is Lands End. A front in water quality is again seen here, with generally lower water quality to the north of the headland. Coastal fronts are seen within the cell, with warmer more sediment laden water located close to the shore. This has potential implications on near shore water quality.

The spatial chlorophyll-*a* results show the concentration of chlorophyll-*a* to be low throughout the cell during summer. There is a geographical boundary, however, at Start Point between higher concentrations to the west and lower concentrations to the east.

The long sea outfall at Portland is shown in CASI data from both July and September. Other major outfalls in the region are not visible in the imagery, because they are discharging into the near coastal zone which has similar turbidity to the discharge.

1. Introduction

This littoral cell on the English Channel coast stretches from Portland Bill to Lands End. This represents approximately 2500 km^2 within the coastal zone for which Environment Agency has responsibility for controlled waters, of which 130 km^2 is estuarine. The region is illustrated in Figure 1.

Four vessel surveys were carried out in 1995 for the collection of water samples for laboratory analysis and continuous monitoring data. These were carried out by Vigilance and took place in early Spring (April), late Spring (May), Summer (July) and Autumn (September). Two aircraft surveys were conducted in July and September/October.

2. Water chemistry results

2.1 Background

This littoral cell extends from Portland Bill to Lands End, with a total of 22 baseline sampling sites, as shown in Figure 1. There are no major estuarine sources, with the key determinant of water quality being the increased influence of Atlantic water to the West of the cell.

2.2 Nutrients and chlorophyll-*a*

2.2.1 Total Oxidised Nitrogen (TON)

TON concentrations showed some seasonal cycle, with the highest concentrations found in Winter, with a maximum of 342 µg/l N at Bridport (77) and the lowest in Spring, when concentrations seldom exceed 10 µg/l N. The Summer results are however higher than those in Autumn, with a maximum TON concentration in Summer equal to 173 µg/l N at St. Antony Head (90). There is also a geographical pattern, with higher concentrations towards the East, except in Summer.

2.2.2 Silicate

Silicate concentrations were highest in Winter and Autumn. Winter concentrations ranged from a maximum of 133 µg/l Si at Exmouth (80) to a minimum of 87 µg/l Si at Runnel Stone (96). Spring concentrations were very low, seldom exceeding the laboratory minimum reporting value (MRV) of 25 µg/l Si. In Summer the concentrations showed a similar geographical pattern to those of TON elevated values towards the centre of the cell, with a maximum of 19 µg/l Si at St. Antony Head (90).

2.2.3 Orthophosphate

Orthophosphate concentrations were low and variable in Winter, with an increase towards Lands End, with the maximum of 41 µg/l P at Mullion (94). In Spring the concentrations were all below the laboratory MRV of 5 µg/l P. In Summer the maximum concentration of 27 µg/l P was again recorded at the centre of the cell at East Looe (87). Autumn results were low relative to national average concentrations, with a maximum concentration of 12.2 µg/l P found at Exmouth (80).

2.2.4 Total Ammoniacal Nitrogen (Ammonia)

Ammonia concentrations recorded a maximum of 178 µg/l N at Mullion (94). All concentrations in Spring were below the laboratory MRV of 6 µg/l N with one exception. A concentration of 7.1 µg/l N was measured at Portland Bill (75) which may be associated with the long sea outfall here. The peak concentration in Summer was again located towards the centre of the cell, with the maximum concentration of 21µg/l N found at Dartmouth (82). All Autumn concentrations were low, with a maximum of 5.4 µg/l N at Sidmouth (79).

2.2.5 Nitrite

Nitrite concentrations showed a steady decrease in concentration towards Land End in the Winter, with results less than 3 µg/l N at Runnel Stone (96). The Spring results were all below the MRV of 3 µg/l N, except for the Portland Bill (75) site which recorded a concentration of 12.1 µg/l N.

2.2.6 Chlorophyll-a

Chlorophyll-*a* concentrations were low during the early Spring survey with all results less than 2 µg/l, and maximum of 1.92 µg/l seen at Exmouth (80). In Spring the maximum concentration recorded was 4.82 µg/l at Dartmouth (82). There was some geographical pattern, with a peak seen from Exmouth (80) to Dartmouth (82) and a further peak at Mullion (94). The summer concentrations were generally low, as would be expected in July, but with two key exceptions. At Fowey (88) the concentration of chlorophyll-*a* was 8.57 µg/l and at Mullion (94) it was 28.69 µg/l. The Fowey (88) site is close to the region which showed elevated concentrations of nutrients in Summer. The high concentration at Mullion (94) was not associated with any high nutrient concentrations. In Autumn all concentrations were low, with a maximum of 2.05 µg/l at Exmouth (80).

2.2.7 Nutrients/chlorophyll-a Summary

Nutrient levels showed elevated concentrations towards the centre of the cell in Summer. It is possible that this was linked to the increase in population in this region due to tourism, or equally may be due to rainfall runoff across agricultural land. The source could be investigated further with reference to the position of large effluent outfalls. Whether these elevated concentrations are of concern may partially be assessed by investigation of the chlorophyll-*a* results to see if the increased nutrients are resulting in exceptional phytoplankton blooms. The Portland Bill sampling site recorded higher concentrations of nitrite and ammonia than neighbouring sites which may be linked to the Weymouth and Portland long sea outfall.

The chlorophyll-*a* results showed some geographical pattern. Exmouth (80) showed high concentrations in early Spring, late Spring and Autumn. This region has recorded high chlorophyll-*a* concentrations in the past, which could be due to the input of highly productive waters from the River Exe. The Mullion (94) site showed elevated concentrations in Spring and Summer, relative to both national average figures and neighbouring sites. The elevated concentration at Fowey may be linked to the elevated nutrient concentrations seen in this area, whereas that at Mullion may point to some other factor, for example the effects of more productive Atlantic waters.

2.3 Suspended Solids

Suspended solids concentrations were low throughout this littoral cell relative to national average concentrations. In Winter all concentrations were less than 3 mg/l. Spring concentrations were highest at Salcombe (84), Seaton (78) and Mullion (94), with the maximum being 15 mg/l at Salcombe (84). In Summer a maximum concentration of 14 mg/l was found at Falmouth (91). In Autumn the peak concentration was 5.2 mg/l at Bridport (77). The maximum concentrations were related to tidal inputs from estuaries. The magnitude of these inputs could be assessed by recourse to hydrometric data extracted from the regions.

2.4 Metals

2.4.1 Total Mercury

Dissolved mercury concentrations were low throughout the surveys, with many site less than the laboratory MRV of 0.008 µg/l Hg. The maximum concentration was found to be 0.01 µg/l Hg at Penzance (95) in late Spring. This is only one third of the Environmental

Quality Standard (EQS).

2.4.2 Dissolved Cadmium

Dissolved cadmium concentrations were also very low, seldom exceeding the laboratory MRV of 0.042 µg/l Cd. The maximum recorded concentration was 0.318 µg/l Cd at Sidmouth (79) in Autumn, compared to an EQS level of 2.5 µg/l Cd.

2.4.3 Dissolved Copper

The national survey maximum dissolved copper concentration was recorded at Runnel Stone (96) in early Spring, equal to 7.01 µg/l Cu compared to an EQS level of 5 µg/l Cu. This site did not record a high concentration at nay other season. Furthermore, the copper concentrations were generally high within this cell compared to other regions of the coastline, with no samples being less than the laboratory MRV of 0.051 µg/l Cu.

2.4.4 Dissolved Lead

Dissolved lead concentrations were low throughout the cell, generally less than 0.5 µg/l Pb compared with an EQS of 25 µg/l Pb. The maximum concentration recorded was 0.294 µg/l Pb at Bigbury Bay (85) in Summer.

2.4.5 Dissolved Arsenic

No samples recorded concentrations of dissolved arsenic above the laboratory MRV of 2 µg/l As.

2.4.6 Dissolved Zinc

Dissolved zinc concentrations showed a maximum concentration at Penzance (95) in Summer of 40.9 µg/l Zn, which slightly exceeds the EQS level of 40 µg/l Zn. The annual mean concentration calculated from the four samples from this site was not greater than the EQS level. Concentrations in general were lower than 50% of the EQS .

2.4.7 Dissolved Chromium

Results for dissolved chromium showed the survey maximum in early Spring to be located at Dodman Point, equal to 6.51 µg/l Cr. This is less than 50% of the EQS level. Dartmouth (82) recorded a concentration of 8 µg/l Cr in Summer, which is high compared to surrounding sites.

2.4.8 Dissolved Nickel

Dissolved nickel concentrations showed the survey maximum concentration in Autumn at Chesil (76), equal to 6.2 µg/l Ni. This is not in excess of the EQS level of 30 µg/l Ni, but is clearly high in comparison to its neighbouring sites. Concentrations of dissolved nickel were generally low, with many sites less than 1 µg/l Ni.

2.4.9 Metals Summary

Dissolved metals concentrations are in cases the highest recorded in the survey. Although there is no heavy industry in this region, there are many old mine working across which rainfall runoff passes before entering the coastal zone, which may result in these elevated concentrations.

2.5 Organic Determinands

Water samples were analysed for twenty three trace organic determinands at four baseline sites within this littoral cell, at Seaton (78), Torbay (81), Plymouth (86) and Falmouth (91). 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.

In early Spring, all sites recorded a concentration of γ-HCH and α-HCH of 0.001µg/l. In late Spring the site at Falmouth (91) recorded a γ-HCH concentration of 0.0023µg/l, with no α-HCH concentration. In Summer and Autumn, all sites recorded positive analyses for γ-HCH, with a concentration of 0.002 µg/l in Summer and 0.001 µg/l in early Spring. No sites exceeded the EQS level for total HCH.

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 chlorophyll-*a* concentration during Summer 1995 for this littoral cell derived from the CASI imagery. The chlorophyll-*a* concentration is generally low for this cell, varying from 0 - 6 µg/l. There is a distinct geographical pattern, however, with the lowest concentrations, between 0 and 2 µg/l being located to the east of Start Point. Chlorophyll-*a* concentrations also increase to the east of Portland Bill. To the west of Start Point there are areas which show higher offshore concentrations.

Figure 3 shows the continuous track fluorimeter data for this cell, which has been calibrated using the laboratory samples. This map shows the same geographical pattern as the FLH imagery, with higher concentrations to the west. There is, however, more detail in this figure, for example the phytoplankton blooms noted in the laboratory data at Fowey and Dodman Point are shown (see Section 4.6). The probable reason for this is the difference in timing of the vessel and aircraft survey, which varied by up to one week.

This littoral cell has two clear areas of varying chlorophyll-*a* concentration with lower concentrations to the east of the cell. No areas within this region show chlorophyll-*a* concentrations greater than 10 µg/l at the time of this survey, indicating that these waters are not subject to eutrophication at this time.

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. Weymouth and Portland long sea outfall
2. Sediment flow around Beer Head
3. Circulation features in Torbay
4. Coastal front in St Austell Bay
5. Phytoplankton bloom off Manacle Point
6. Phytoplankton blooms in Summer

4.1 Weymouth and Portland long sea outfall

CASI imagery from both July and September shows the presence of the Weymouth and Portland long sea outfall to the west of Portland Bill off Chesil beach. In July, a single point source is seen (see Plate 1), whereas in the September image there are three individual areas of discharge from the outfall (see Plate 2). This represents either three separate risers in operation or three pulses of flow from the discharge.

For an outfall to be seen in CASI imagery the effluent must effect the ocean colour signal, by for example increasing the scattering of light back to the sensor. In many cases such outfalls are not visible in CASI imagery due to the high particulate loading of the receiving water mass, or alternatively due to the timing of the imagery away from the time of discharge. This region of coastline shows suspended solids concentrations less than 3 mg/l during all four vessels campaigns in 1995. Thus the effluent is increasing the CASI signal.

The Portland Bill (75) baseline sampling station is located close to the position of the outfall, as shown in the figures. This sampling site shows elevated concentrations of ammonia and nitrite in Spring. The ammonia concentration is not exceptionally high, being 7.1 µg/l compared to concentrations at neighbouring sites of less than 6 µg/l. The nitrite concentration, however, is 12.1 µg/l compared with less than 3 µg/l at all other sites within this cell.

These elevated nutrient concentrations did not result in higher chlorophyll-*a* concentrations at this site during the baseline survey, with the concentrations during Spring being only 1.92 µg/l. Thus the presence of the outfall does not seem to be causing eutrophic conditions. This is probably due to circulation patterns resulting in a fast exchange of waters offshore.

4.2 Sediment flow patterns around Beer Head

Plate 3 shows data from the CASI flightline extending from Lyme Regis to Sidmouth, from October 1995. This image shows a band of high suspended sediment close to the

coast, with clearer water offshore. The suspended sediment in the water column increases the scattering of sunlight back to the sensor and thus results in a higher ocean colour signal. The red coloration of this sediment in a true colour composite image is due to erosion of the red sandstone cliffs in this region.

Sediment to the west of Beer Head is flowing westwards, which is the direction of the tidal stream at this time. However, to the east of Beer Head the sediment close to the shore appears to be flowing to the east before being deflected back to the west. This suggests that a secondary current exists close to the shore. The easterly flow direction is the residual littoral flow direction, and this may be the explanation.

Thermal video imagery from this area is shown in Plate 4. In the first image, from July, a flow of cooler water is seen around Beer Head, shown light in the imagery. This is probably caused by the outflow of the Axe located to the north of Beer Head, which may have a cooler temperature than the receiving waters at this time of year. There is a further feature which is warmer in temperature marked on the image. In the second image, from September, this flow of warmer water around the headland is more pronounced and appears to be dispersing in two directions, both around the headland and towards the Axe. There is no clear source of this water, which appears to be coming from beneath the rocks on the headland. The nearest outfall of effluent is located on the southern side of Beer Head and is shown not to have any signal in either the CASI or thermal imagery.

4.3 Sediment patterns in Torbay

CASI imagery from both July and September shows distinct ocean colour patterns within Torbay and off Berry Head (see Plate 5). In both images the features do not have a distinctive coloration. As such they could be due to phytoplankton which absorbs sunlight in addition to scattering. The Fluorescence Line Height images for this region do not, however, show there to be elevated chlorophyll-*a* concentrations in either July and September. Thus it is probable that the patterns are due to sediment, possibly of a white coloration.

In July there is a high sediment concentration off Berry Head with a general southerly flow. This was the tidal flow direction at this time. Moreover this flow may be enhanced by the strong southwesterly wind which was blowing at this time. In September, the tidal stream direction is also to the south west but the sediment flow patterns are more complex. The interaction of the headlands at the north and south of Torbay are resulting in the formation of eddy structures within the bay itself.

This could have implications on water quality within the bay if discharges from the towns of Torquay, Brixham and Paignton were to be entrapped within the bay. The two major outfalls for this region are, however, located on the headlands at Hopes Nose and Sharkham Point. Thus it is unlikely that the water quality would be adversely affected. This is shown in water quality results for the Torbay (81) sampling site which show low concentrations of all determinands relative to neighbouring sites.

4.4 St Austell Bay

CASI imagery from October 1995 shows the presence of a marked coastal front across St Austell Bay. The bay is located at the intersection of two CASI flightlines as shown in Plate 6. A clear banding is seen in ocean colour signal away from the coast. The highest values close to the coast are likely to represent bathymetry, with the underlying sand causing increased reflection of light to the sensor.

There is then a further band which is seen to have a complex interface with the offshore water. To the east of the bay it is interlaced with the offshore water. The front does not extend past Gribbin Head. To the west, the higher suspended solids water appears to extend further down the coast with the front extending across Mevagissey Bay to Chapel Point.

Imagery from the thermal video system is shown in Plate 7. The front between offshore waters and high suspended solids waters is not seen in this thermal data. However, an area of warm water is seen to correspond with the area of shallow water which is shown yellow in colour imagery. This is caused by solar warming of the shallow water. This warming is particularly intense for this season due to the time of collection of imagery at 15:06 GMT. However, as the thermal video is not calibrated it is not possible to assess the extent of warming.

Two outfalls are located within St Austell Bay which serve a population equivalent of more than 2000 people. There is no CASI signal from either of these outfalls. The outfall at Porthpean may be causing the patch of even warmer water marked A, as the effluent would probably have warmer temperature than the receiving waters. The presence of a strong front across the bay may have implications on the dispersal of effluent from these outfalls. Baseline water quality measurements are not taken within the bay with the nearest sampling sites being located at Fowey and Dodman Point. The Fowey (88) sampling site shows elevated concentrations of chlorophyll-*a* in Summer but there is no evidence from the imagery collected of flow from St Austell towards Fowey. If this were to be considered a possible cause of the chlorophyll-*a* maximum at Fowey further imagery would need to be investigated from differing tidal states and in differing weather conditions.

4.5 Phytoplankton bloom off Manacle Point

CASI data from the July survey shows a feature off Manacle Point having high ocean colour signal. This feature, shown in Plate 8, has the appearance of a phytoplankton bloom, with some substance being seen on the surface which is accompanied by a feature within the water column.

The feature does not record a high Fluorescence Line Height signal in the CASI data. This technique measures the *in-vivo* fluorescence of chlorophyll-*a* within the phytoplankton. The image data was collected on 31st July 1995, approximately one week after the collection of water samples by Vigilance. The water samples and continuous monitoring data showed areas of high chlorophyll-*a* concentration marking the position of blooms at various place along the coastline, but with the majority to the east of this

measuring site.

This feature may represent a phytoplankton bloom which has decayed and therefore would not have any active fluorescence emission. Thus no signal would be recorded by the CASI. The surface signal seen by the CASI would indicate a scum of dead phytoplankton which are also located within the water column. This would agree with water samples which showed high chlorophyll-*a* concentrations to be to the east, as there is a general easterly progression of phytoplankton development along the English Channel. Alternatively, this bloom may be made up of non-fluorescing species.

4.6 Phytoplankton blooms in Summer

The laboratory water samples and underway fluorimeter data indicate the position of a number of phytoplankton blooms in the east of this cell during the July survey. Specifically, laboratory data shows high chlorophyll-*a* concentrations at Fowey and Mullion and Runnel Stone (96). The fluorimeter data shows elevated concentrations between Salcombe and Plymouth, at East Looe, Fowey, St Antony Head, off the Lizard and around Lands End as shown in Figure 4.

Many of these elevated concentrations are associated with high concentrations of nutrients. In particular, the sampling site at St. Antony Head (90) shows exceptional concentrations of TON, phosphate, nitrite and ammonia. The high concentrations of nutrients around this coast during summer might to be due to the increased population during the tourist season resulting in higher effluent discharge. Alternatively, they may be due to rainfall runoff over agricultural land upon which fertilisers are used. Although in places these appear to be resulting in elevated chlorophyll-*a* concentrations, the highest concentrations found in the laboratory data is not accompanied by elevated nutrient concentrations.

The link here is therefore not fully established. Further investigation would be required if these phytoplankton blooms were considered to be a nuisance.

5. Conclusions

The water quality in this region was generally good with a steady increase in quality represented by lower concentrations of determinands found to the west of the cell.

Nutrient concentrations in summer were high for this season to the west of the cell, which may be due to rainfall runoff over agricultural land, or may potentially be due to increased effluent discharge during the tourist season. Chlorophyll-*a* concentrations were also high in this region, although there are no laboratory sampling sites which show a direct link between chlorophyll-*a* and nutrients.

The spatial chlorophyll-*a* results from July 1995 showed a distinct geographical pattern with higher concentrations to the west of the cell, which is supported by laboratory samples.

Two individual samples recorded metals concentrations above the Environmental Quality Standard levels. In early Spring the concentration of dissolved copper at Runnel Stone (96) is 7.01 µg/l compared to an EQS level of 5 µg/l. In Summer the dissolved zinc concentration at Penzance (95) equals 40.9 µg/l compared to an EQS of 40 µg/l. The annual mean concentrations, calculated from the four samples, are not in excess of the EQS. These sites may, however, be worthy of further investigation.

The cell is bounded by a front off Portland Bill to the east, with lower suspended solids found within the cell compared to the eastern English Channel. There is also a front off Lands End, with higher water quality to the south. A minor thermal front is seen in some surveys off the Lizard. CASI data shows that in many embayments a coastal front exists between warmer more sediment laden water in shore and offshore waters. This may have implications on nearshore water quality.

CASI data also shows the presence of the Weymouth and Portland long sea outfall off Chesil Beach, which shows up in the imagery due to the low suspended sediment loading in the receiving waters. This discharge is into deep water and is not resulting in increased chlorophyll-*a* concentrations.

Figure 1.

Littoral Cell 6,* From Portland Bill to Land's End.

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

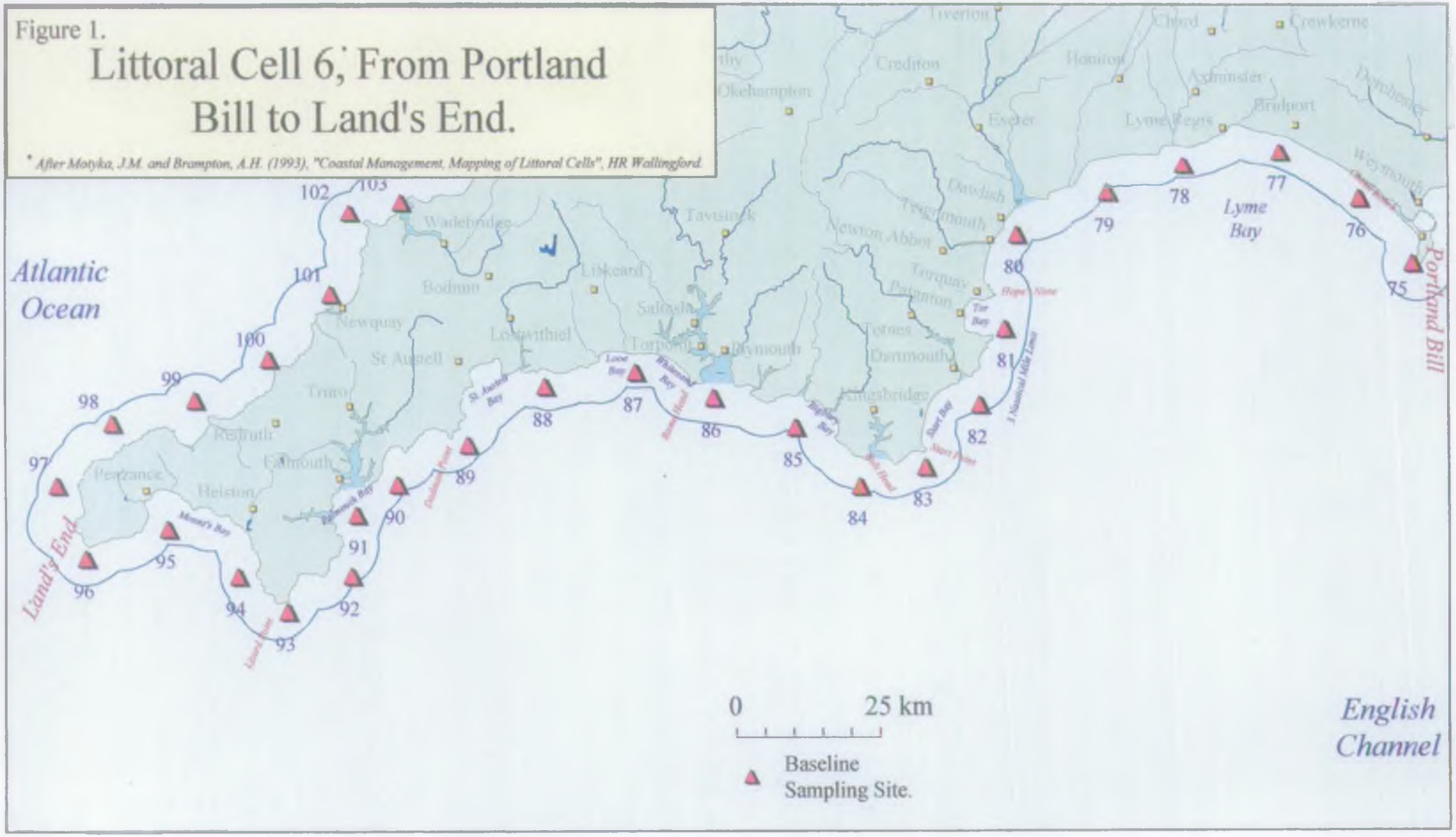


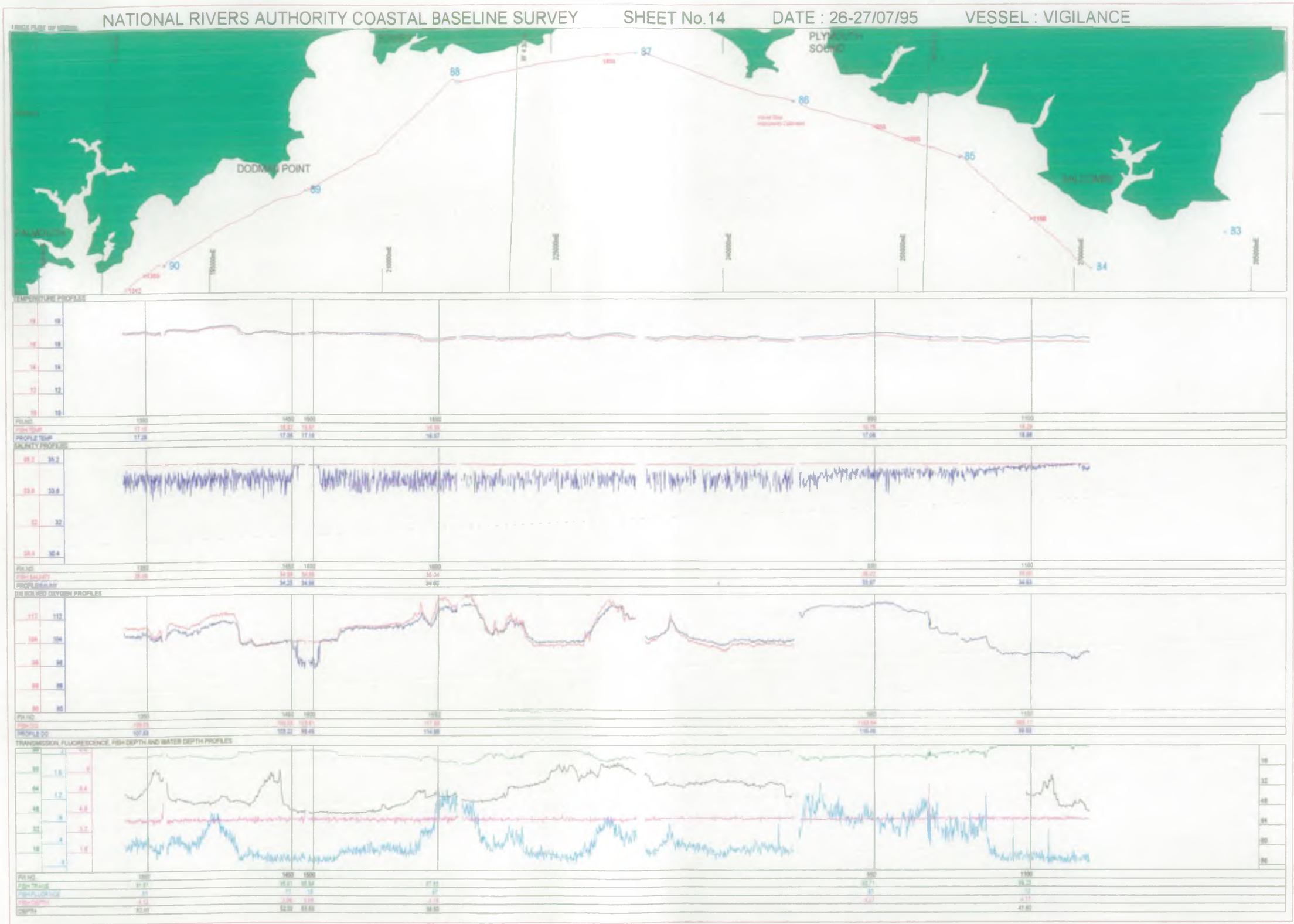
Figure 2.

Calibrated CASI Fluoresence Line Height Image, Summer 1995.

Figure 3.

Calibrated Continuous Track Fluorimeter, Summer 1995.

Figure 4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SHEET No.14
DATE : 26-27/07/95
VESSEL : VIGILANCE
DODMAN POINT
PLYMOUTH SOUND
87
88
86
85
89
90
84
83
TEMPERATURE PROFILES
DISSOLVED OXYGEN PROFILES
TRANSMISSION, FLUORESCENCE, FISH DEPTH AND WATER DEPTH PROFILES

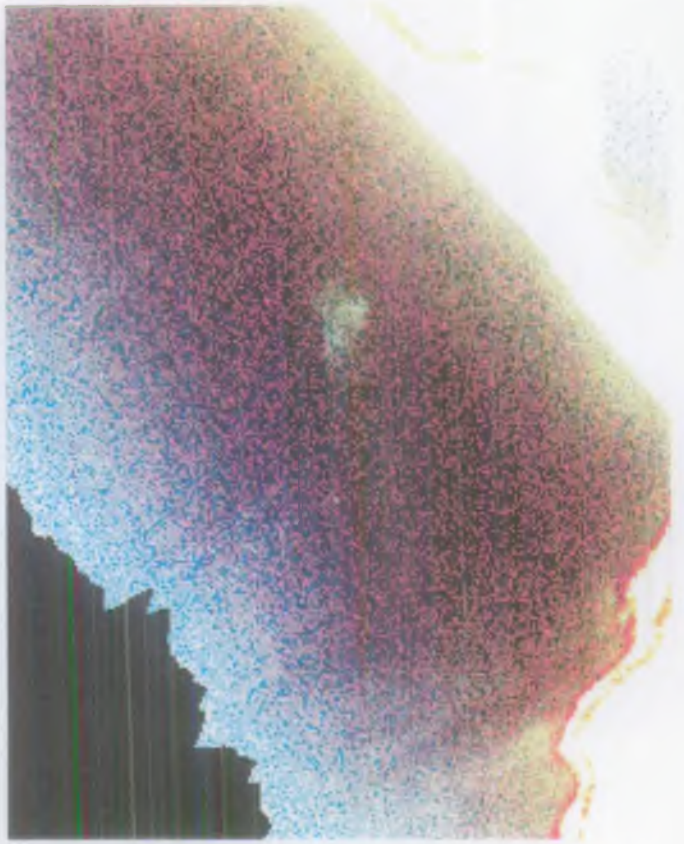


Plate 1: Portland Bill

24th July 1995, 09:24 GMT
CASI enhanced true colour composite images
Baseline sampling sites are marked as red crosses

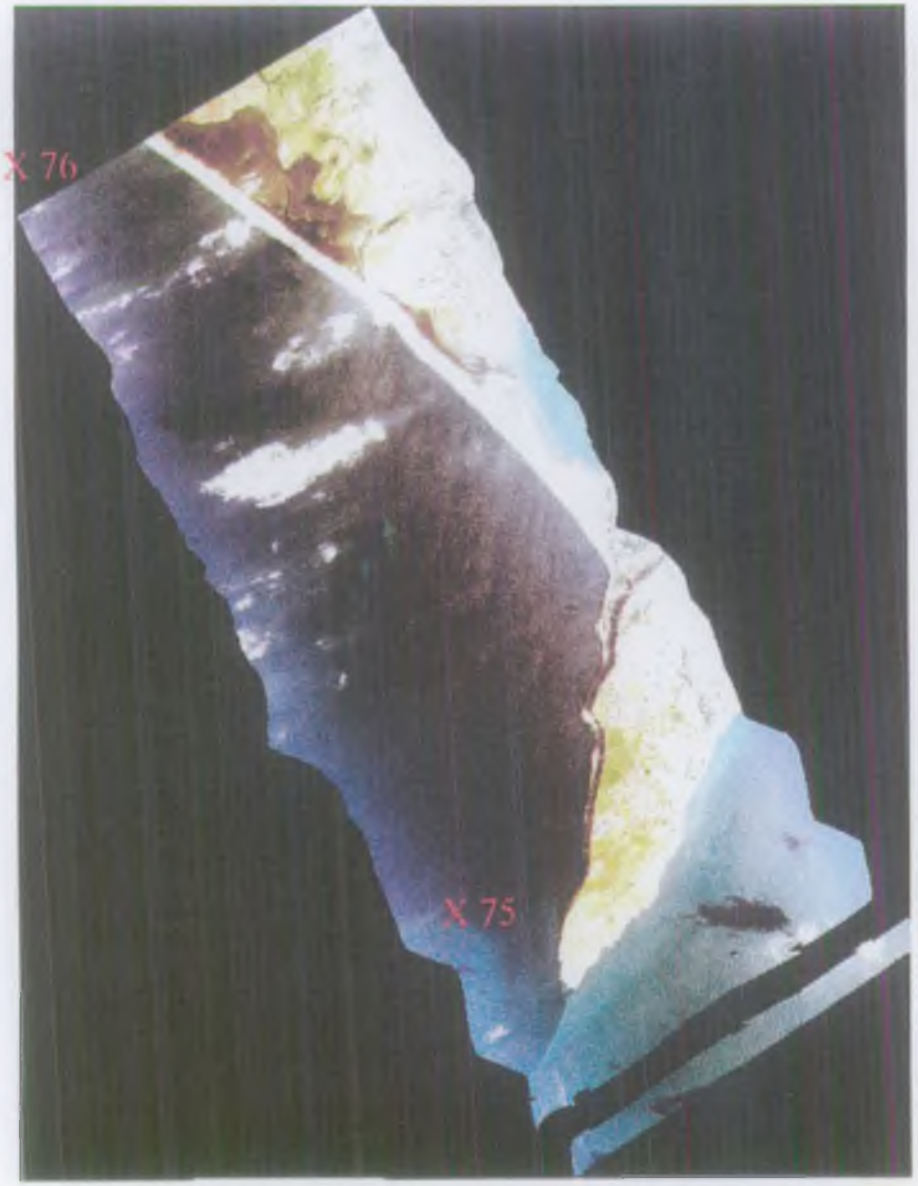


Plate 2: Portland Bill

20th September 1995, 09:28 GMT

CASI enhanced true colour composite image

Baseline sampling sites as marked as red crosses

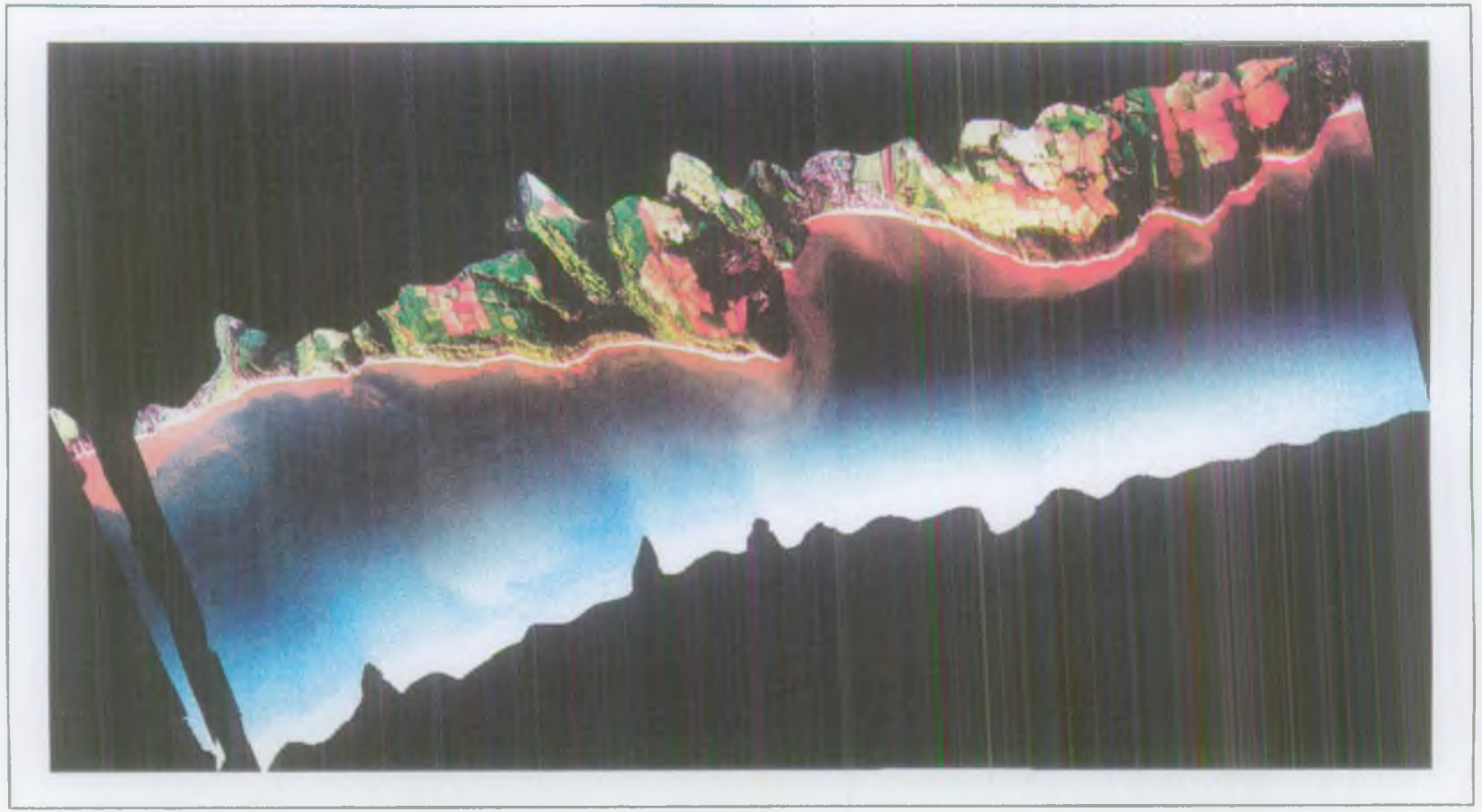
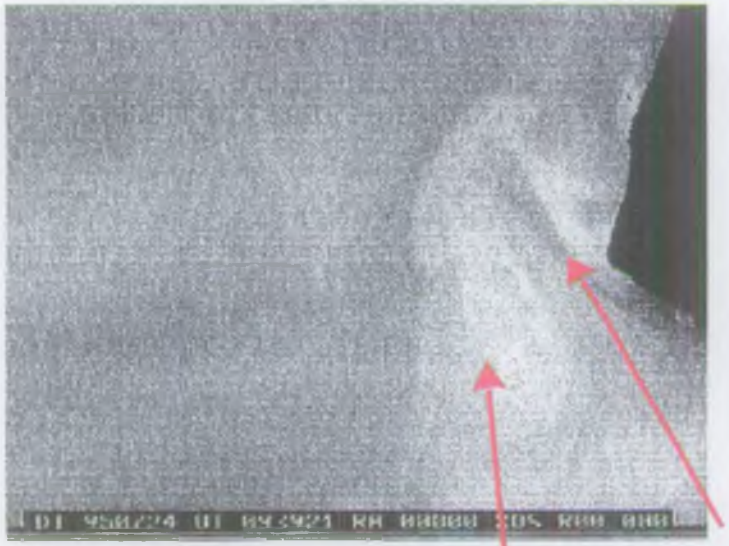


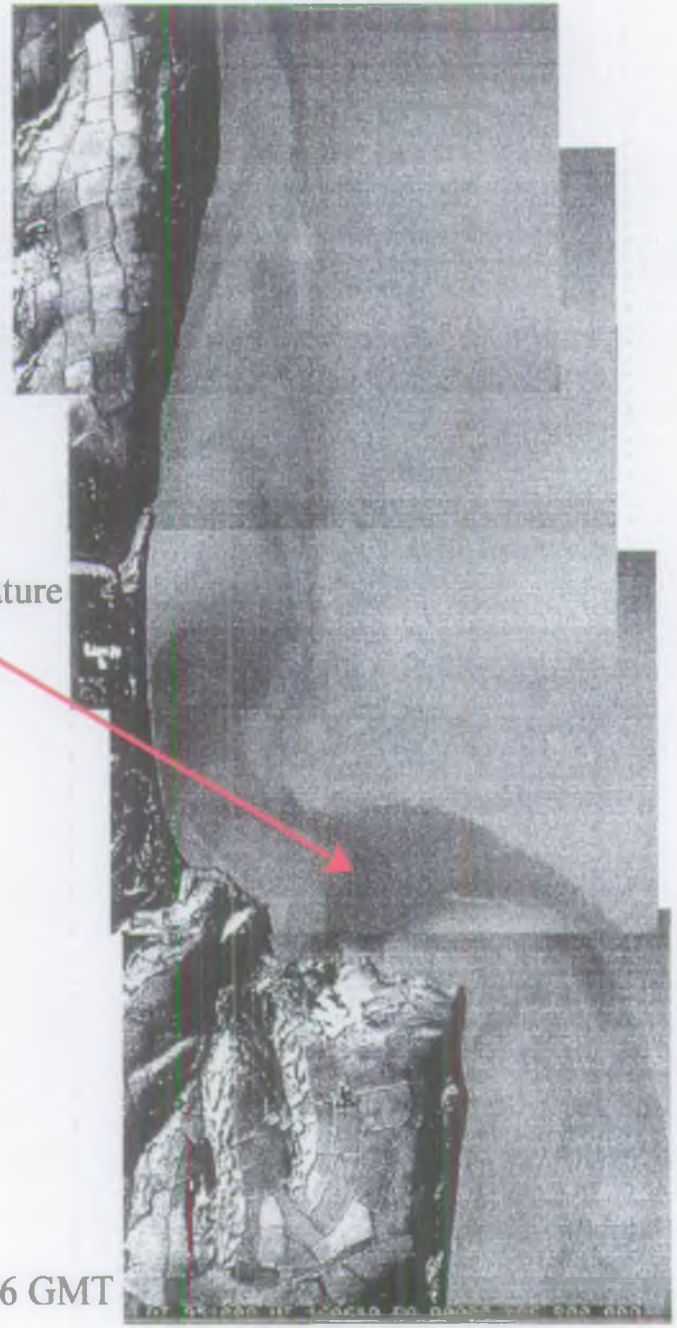
Plate 3: Beer Head
8th October 1995, 16:03 GMT
CASI enhanced true colour composite image



24th July 1995, 09:39 GMT

warmer feature

cooler water



8th October 1995, 16:06 GMT

Plate 4: Beer Head
Thermal video composite images

24th July 1995, 10:16 GMT

20th September 1995, 09:59 GMT

Plate 5: Torbay
CASI enhanced true colour composite images
Baseline sampling site is marked as a red cross

Plate 6: St Austell Bay

8th October 1995, 15:00 GMT
CASI enhanced true colour composite images

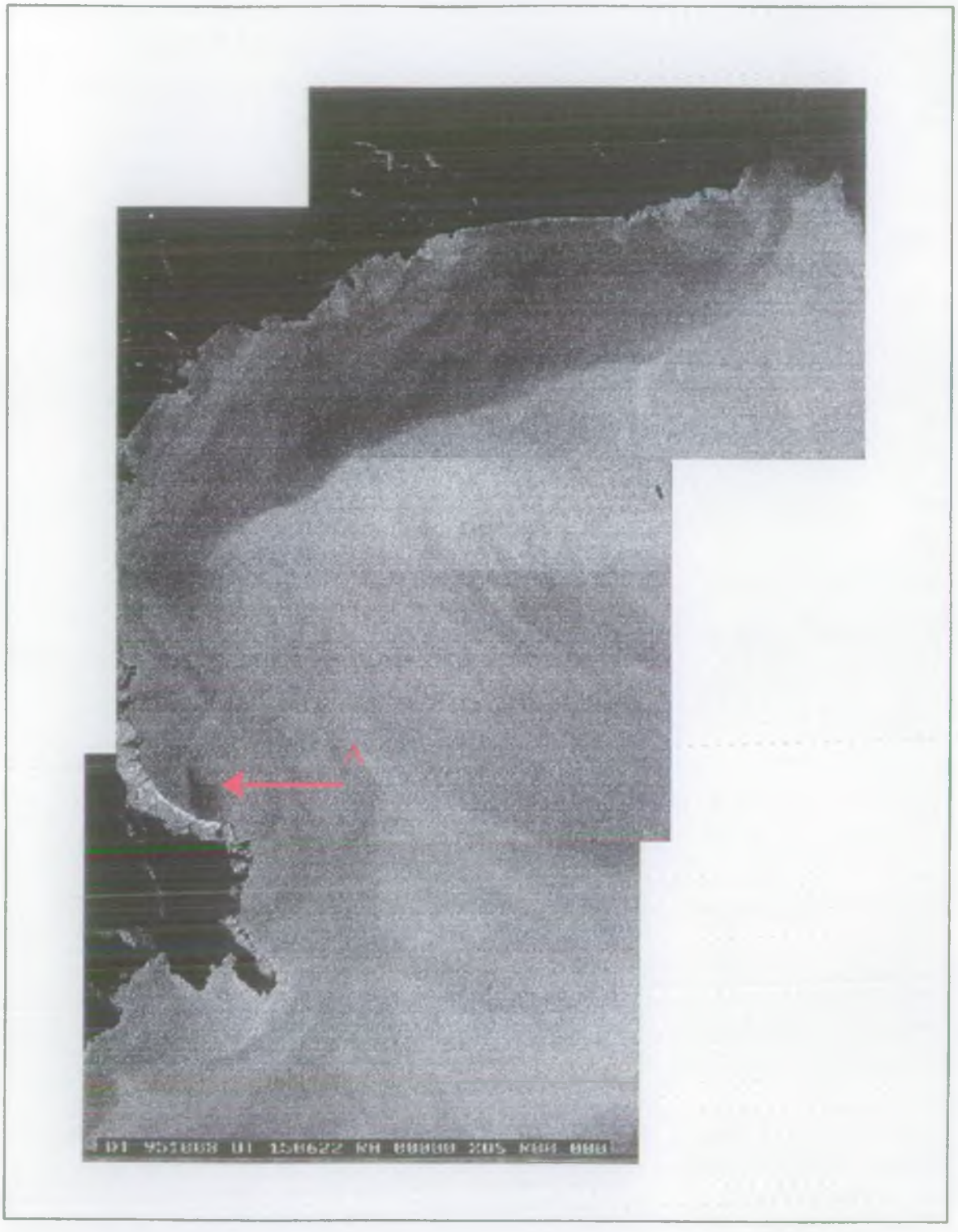


Plate 7: St Austell Bay
Thermal video composite image
8th October 1995, 15:06 GMT

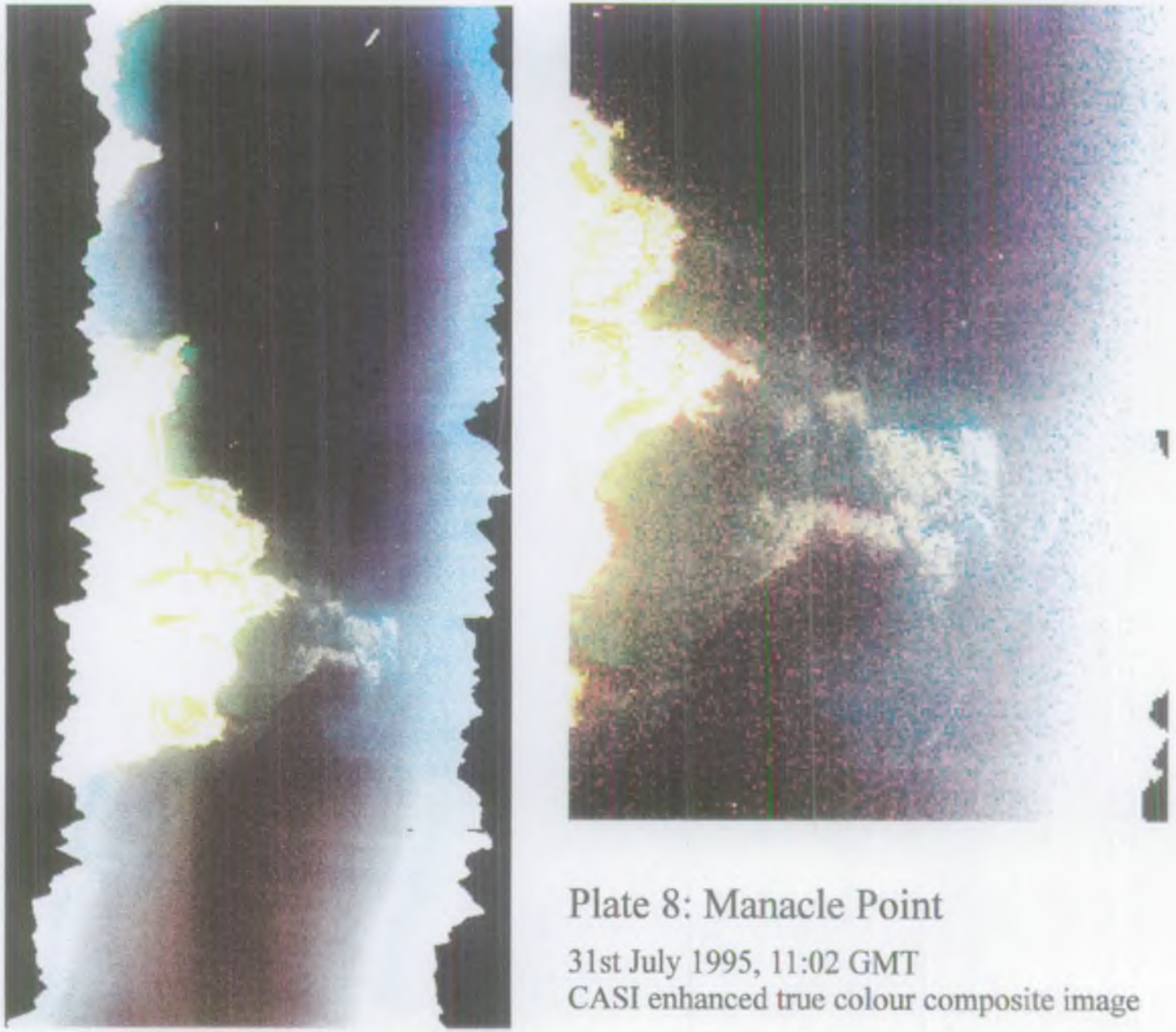


Plate 8: Manacle Point

31st July 1995, 11:02 GMT
CASI enhanced true colour composite image