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National Marine Baseline Survey 1995

Survey Design & Objectives

ENVIRONMENT AGENCY

Report NC/MAR/016 Part 2 of 17
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Survey Design and Objectives

1. Introduction

This report provides an introduction to the 1995 NRA National Marine Baseline Survey. This survey consisted of four vessel campaigns in Winter, Spring, Summer and Autumn and two aircraft campaigns in Summer and Autumn. The four NRA coastal survey vessels were used to perform the boat work and a chartered light aircraft was used for the aerial surveillance work. The objective of this survey was to make measurements of background levels of contaminants to provide a baseline of water quality in the coastal zone.

The Spring and Autumn campaigns were timed to coincide with the two main phytoplankton bloom events of the year, when chlorophyll-*a* concentrations were likely to be at their highest. The summer campaigns provided a measure of the background levels of chlorophyll-*a* since they were at a time when natural nutrient levels were expected to be low. It was therefore expected to be possible to distinguish any raised levels that might have been linked with increased discharges, such as areas which have a seasonal increase in population due to an influx of holiday makers. The winter campaigns were carried out only by boat due to the low chlorophyll-*a* previously found in winter, the higher suspended matter in coastal waters in winter and problems associated with airborne surveillance at a time of year with much cloud cover. Winter boat campaigns do however provide important information on natural background nutrient levels around the coast, which are theoretically at their maxima during the winter and linked with the occurrence of phytoplankton blooms in the following Spring and Autumn.

2. Sampling strategy

Baseline sampling was carried out at 186 sites along the coast of England and Wales, between Berwick on Tweed and the Solway Firth. Following consultation with NRA Regional staff, sites were situated approximately 15 km apart, with some additional sites at major estuaries. The positions of the baseline sampling sites are shown in Appendix A.

Additional measurements were taken between the baseline sampling points using continuous monitoring systems while underway. These provided information on any changes in water mass between the baseline sampling points, thus placing the baseline results in context.

The remotely sensed data were collected on a series of 189 flight lines along the coast with a swath width sufficient to encompass the area within the three mile limit, the area which the NRA has the responsibility to monitor. These data allowed a description of the oceanography and spatial variations in water quality of the three nautical mile zone to be made, including for example, the presence of frontal systems which might differentiate areas of water quality.

3. Rationale for measurements made

3.1 Spot samples

At each of the identified sites, samples were taken for laboratory analysis ashore. These samples were prepared and stored on board prior to transfer to NRA laboratories for analysis for suites of determinands which included nutrients, metals and various organic chemicals. Appendix B includes a full listing of the determinands measured and the intervals at which the 3 different analysis suites were used.

Ten litre bottles were used to collect single samples which were then subdivided for the other analysis suites except that for organic compounds. Water samples for organics were collected directly into solvent cleaned glass bottles supplied by the laboratories. For dissolved metals, 250 ml samples were filtered into separate bottles and submitted to the laboratory. For total metals, well mixed sub-samples were placed directly into separate bottles. Samples for the measurement of suspended solids were transferred directly from the sampling container and then refrigerated. For chlorophyll-*a* the samples were filtered, the filter paper removed and wrapped in foil. These foil packages were frozen quickly and kept frozen until analysed in the laboratory. Finally, 250 ml samples to be analysed for nutrients were filtered through syringes, the filtered sample frozen immediately and transferred to the laboratory in this state.

Chlorophyll-a

The concentrations of chlorophyll-*a* were measured as means of assessing the level of primary phytoplankton productivity and the likelihood of eutrophication. The concentration of chlorophyll-*a* is linked to the concentration of phytoplankton due to the presence of chlorophyll-*a* in all phytoplankton species. Generally in the marine environment, chlorophyll-*a* concentrations vary with season, usually having a peak in Spring caused by a bloom in the phytoplankton population. Sometimes a second peak is seen in Autumn, due to the presence of an autumnal bloom. Generally, levels are lower during the Summer and Winter.

By means of the Urban Waste Water Treatment Directive (UWWTD), the European Union and the UK Department of the Environment have defined a number of parameters which signify that an area is subject to eutrophication. No single factor signifies a eutrophic area, but the presence of a number of these factors taken in geographical and historical context allows a scientific conclusion to be drawn concerning susceptibility to eutrophication.

Three of these factors are concerned with the concentration of phytoplankton. The presence of chlorophyll-*a* concentrations in excess of 10 μg/l signify the presence of an area of high phytoplankton productivity or bloom. If an algal bloom occurs in summer when it would be expected that chlorophyll-*a* concentrations would be lower, then this might suggest a eutrophic region. Other indicators such as dissolved oxygen and nutrient concentrations, in particular ortho-phosphate and nitrate, would support the suggestion. Finally, the presence of scum on the surface of the water and around the coast is another potential indicator of the likelihood of eutrophication.

Measurements of chlorophyll-*a* were therefore taken at four seasons in order to establish if the natural seasonal cycle was being affected by excessive inputs of nutrients.

Nutrients

Nutrients, particularly phosphorus and nitrogen, are essential for the growth of organisms such as phytoplankton in the aquatic environment. The levels of these nutrients also provide an indication of the probability of eutrophication as defined in the UWWTD.

Generally, nutrient concentrations in coastal surface waters are expected to be highest during Winter when the water column is well mixed. In early Spring, stratification occurs and phytoplankton thrive in the upper layer, or eutrophic zone, where high nutrient levels coincide with high light levels. This phytoplankton bloom causes a rapid decrease in nutrient levels over the order of one month. Concentrations are usually expected to remain low during summer, increasing again as the water column begins to mix once more in the Autumn.

Changes in nutrient levels in the coastal zone may be further complicated by inputs from anthropogenic sources such as agricultural run off and sewage effluent. These may increase concentrations being recorded during summer months, for example. Identification of these areas of high nutrient concentration or "hot spots" aids in the identification of areas which might be subject to eutrophication. The UWWTD specifies that nutrient concentrations, particularly nitrate and ortho-phosphate and their relative ratio, must be interpreted in geographical and historical context using expert knowledge of a particular zone or area.

Dissolved metals

A number of dissolved metals were measured at each baseline site. The complete list is shown at Appendix B. Trace metals occur naturally in the marine ecosystem. However, more are introduced as a result of industrial output and levels may even increase to such an extent as to be harmful to aquatic life. It was considered to be necessary to establish the background level of metals and to identify those areas which were "hot spots" to enable these to be linked with particular sources. Most sources of metals discharges were located at estuaries and it was anticipated that the highest concentrations would be found here.

The National Baseline Survey monitors various substances which are listed in the EU Dangerous Substances Directive and for which Environmental Quality Standards (EQS) have been adopted. The metals measured by the National Baseline Survey fall into two classes of this Directive. Mercury and cadmium are List I substances which have been identified as posing a threat to the aquatic environment on the basis of their toxicity, persistence and bioaccumulative properties. The requirement is for environmental concentrations of List I substances to be reduced. The other metals measured by the National Baseline Survey are List II substances which can have deleterious effects on the aquatic environment and should therefore be monitored. The reporting limit from the laboratories for the National Marine Baseline Survey has been set at 10% of the relevant EQS. The EQS levels for the metals measured during the baseline surveys are tabulated below.

Table 1
Environmental Quality Standards for Dissolved Metals

	EQS level µg/l	Reporting level µg/l
Dissolved Lead	25	2.5
Dissolved Mercury	0.3	0.03
Dissolved Cadmium	2.5	0.25
Dissolved Copper	5	0.5
Dissolved Chromium	15	1.5
Dissolved Nickel	30	3
Dissolved Arsenic	25	2.5
Dissolved Zinc	40	4

Suspended particulate matter

Measurements of total suspended particulate matter (SPM) were taken at every baseline site. Although often referred to as suspended sediment, SPM is made up of both inorganic sediment and organic particles such as phytoplankton cells. Additionally, it may have a component of sewage or any other particular matter which may be present in the water. The samples were analysed for total SPM at 105 °C and then heated to 500 °C to remove the organic component, so as to allow the organic/inorganic fraction to be determined.

Measurements of suspended particulate matter may be used in studies of sediment transport and dynamics. The transport of sediment has implications for beach erosion, the formation or removal of sand bars and other natural features which may be hazardous to shipping. In addition the movement of sediment away from areas, for example by erosion, may have implications for flood defences.

High concentrations of suspended matter considerably reduce light transfer through the water and hence limit the numbers of algae even in waters in which nutrients are readily available.

Total metals

Total metals concentrations were measured at every third Baseline site. In addition to providing information on the amount of metals in suspension, these also acted as a check on pre-treatment procedures carried out on the vessels.

Organic compounds

These compounds are mainly introduced to the marine ecosystem by anthropogenic sources. For example, DDT and HCH formerly used in pesticides and PCBs which are a byproduct of many industrial processes. These compounds are harmful to aquatic life and their effects may even be transferred up the food chain with associated risk to human health. Although many of these compounds are no longer in use, they tend to accumulate in the tissue of organisms and as sedimentary material. In these forms they are retained and may be released slowly over a large time scale. It is therefore necessary to monitor these compounds until a negligible level has been recorded for a number of years.

The Baseline Surveys included the measurement of various organic compounds, some of which are List I Dangerous Substances for which Environmental Quality Standards have been defined. Organic compounds were measured at sites of interest selected by the NRA regions as being possible sources of organic pollution. Other sites were selected at anticipated clean regions to establish a background level.

3.2 Underway monitoring and measurement

The coastal survey vessels each used 3 main groups of instruments to monitor water quality at and between the sampling points. Systems capable of measuring 7 parameters continuously were towed behind the vessels and 5 channel auto-analysers were used to measure nutrient concentrations at frequent intervals. When stopped at sampling points, 3 parameter probes were used to carry out profile measurements. Further details of these instrument systems are set out in the following paragraphs and Figure 1 illustrates how the various ship-borne measurement systems interacted and were logged on the Qubit navigational system.

The towfish systems were towed approximately 10 m behind the vessel at depths of 4 m to eliminate interference from the wake. These systems measured dissolved oxygen, salinity, temperature, pH and depth. In addition, fluorimeters and transmissometers were attached to the fish. The data were integrated with time, date and geographic position within the Qubit system and subsequently analysed at the National Centre for Instrumentation and Marine Surveillance.

Nutrients were measured using a Skalar auto-analyser system on each vessel. These were continuous flow automated analyser systems, in which reagents were added to a flowing stream of sample and, after mixing and heating where required, the concentrations of various nutrients present in the sample were determined colorimetrically using flow-through cells. The system determined nitrite, total oxidised nitrogen, ammonia, ortho-phosphate and dissolved silica. Calibrations were carried out on board using concentrated standards diluted volumetrically to produce concentrations of a similar range to the samples being measured. Periodically, quality control samples consisting of standards diluted in low nutrient sea water were analysed. Data from the Skalar systems were integrated into files containing information on position, date and time and archived at the National Centre for Instrumentation and Marine Surveillance.

3.3 Remotely sensed data

Principles of operation

The NRA is responsible for monitoring the entire coastal zone as defined by the three nautical mile limit. An R & D project (Airborne Remote Sensing of Coastal Waters, published in R & D Report No.4) established the effectiveness of the combination of aerial remote sensing, continuous underway monitoring and sampling at selected fixed points. Laboratory analysis of samples from the baseline sites give high quality information on the chemical composition of the water sample taken. However, it is important to establish whether this water sample is representative of its surroundings. The underway data from the Qubit and Skalar systems record any changes in water mass along the baseline track. The image data add to this by showing changes in water mass off the survey track and across the three nautical mile zone.

To be apparent in remotely sensed imagery, changes in water quality of the coastal zone must in some way alter the electromagnetic signal reflected or radiated by the water. The two systems used by the NRA operate in two different parts of the electromagnetic spectrum, the visible and thermal bands.

Visible wavelength remote sensing provides information by measuring light reflected from the surface beneath the aircraft thereby obtaining information on the scattering and/or absorption of visible light. Clear ocean water returns little signal as the majority of light is absorbed. Waters of the coastal zone, however, contain large amounts of particulate matter which reflect and scatter light. In addition, the presence of organic matter such as phytoplankton causes selective absorption of some wavebands within the spectrum of the sunlight. It is the interaction of these two processes, scattering and absorption, on the incident sunlight which leads to the reflectance signal recorded at the sensor. The variation of this signal with wavelength may be used to determine the concentration of particulate matter and chlorophyll within the water mass.

Areas of high suspended particulate load may be seen to be associated with riverine inputs and these may account for high levels seen in the baseline survey results. In this way the visible wavelength remote sensing can explain features in the baseline data. Similarly, frontal systems may divide two water masses of different particulate composition and this can be seen in the airborne imagery.

Thermal wavelength remote sensing measures the temperature of the surface of the water. Radiation absorbed from sunlight and thermal discharges is re-emitted from this surface layer. Although this temperature is not necessarily representative of the entire water column, it is often able to show the presence of mixing zones around outfalls which have a temperature different to that of the surrounding water mass. This again allows the measurements from baseline sites to be interpreted in relation to surroundings.

Remotely sensed image data is collected from two sensors, the Compact Airborne Spectrographic Image (CASI) and the thermal video scanning system. Figure 2 illustrates how the various components of the aircraft data collection system interact.

Figure 1

QUBIT NAVIGATION SYSTEM

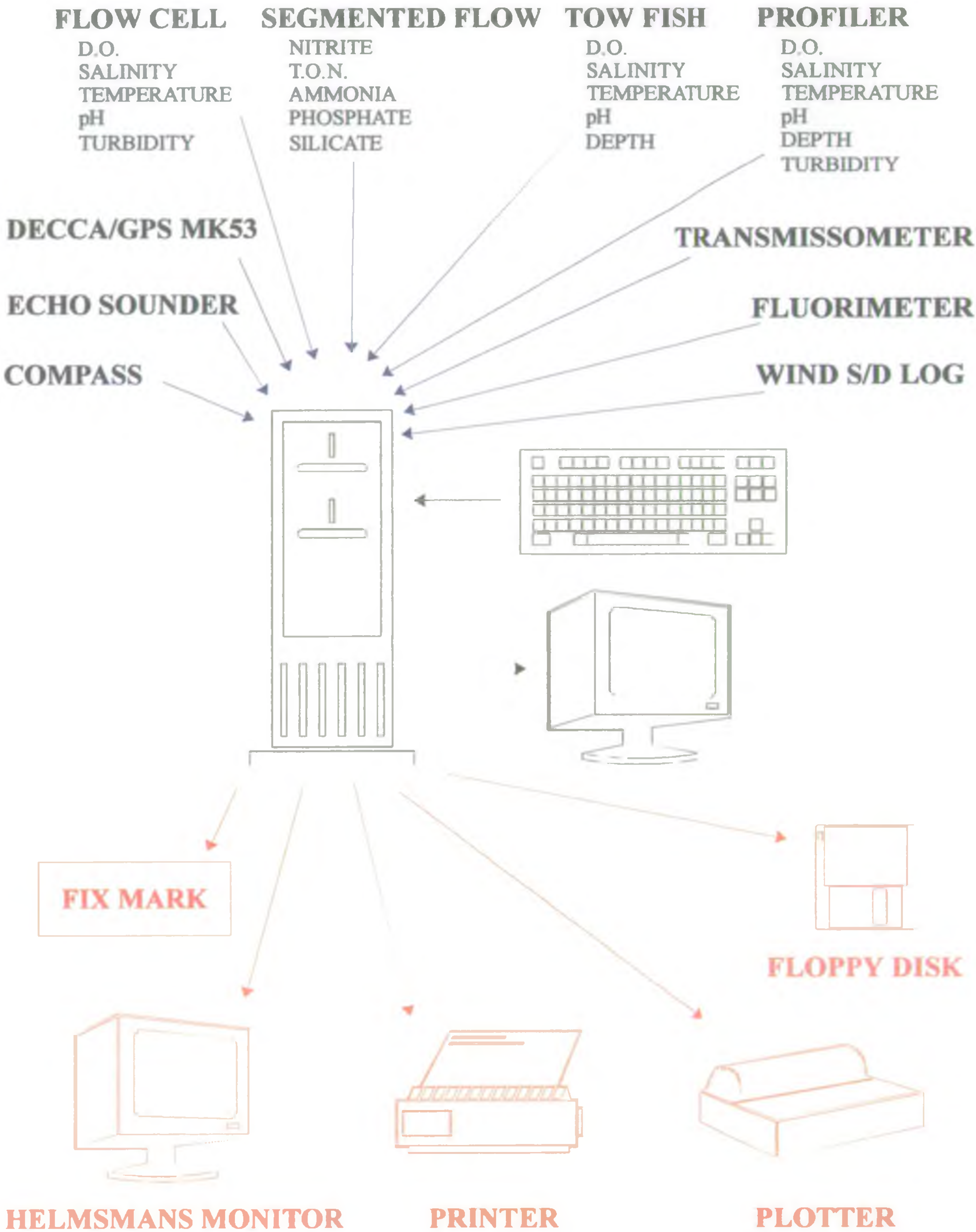
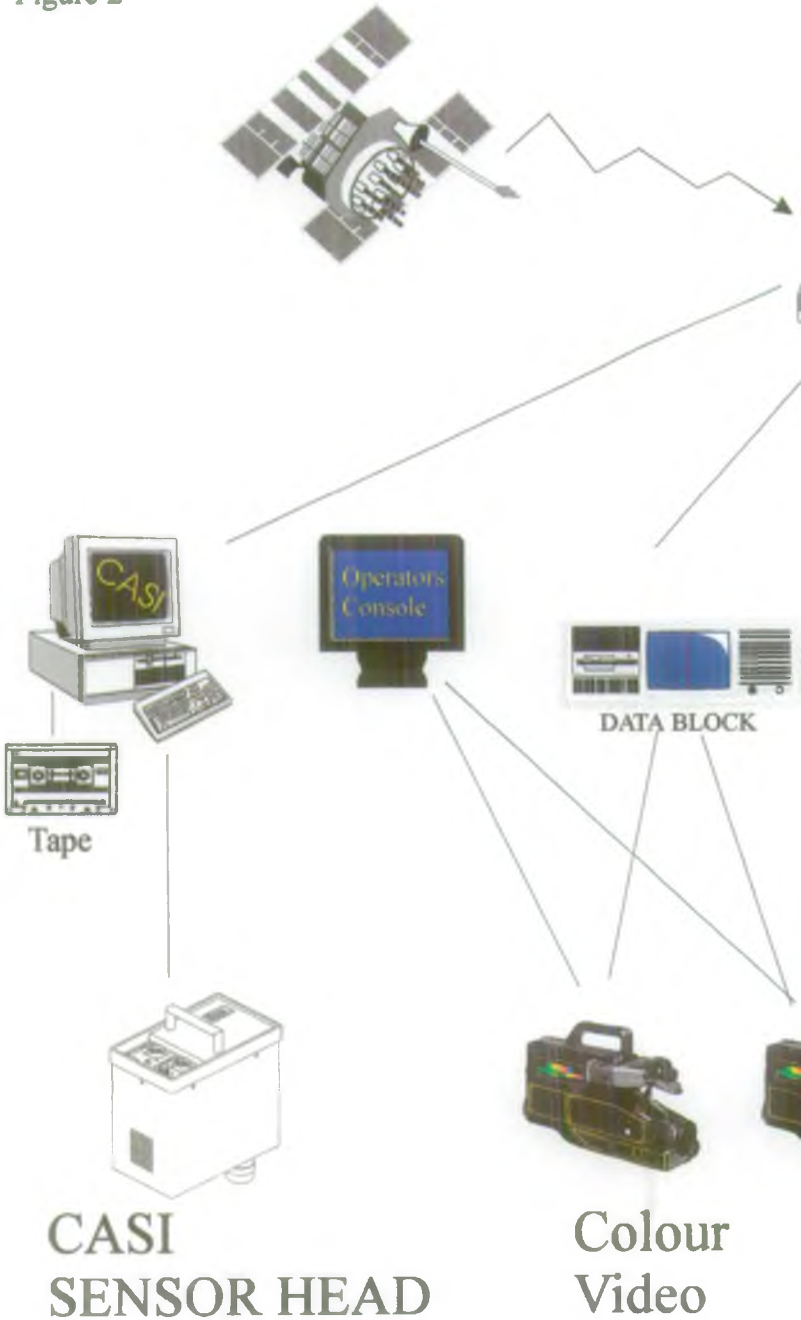
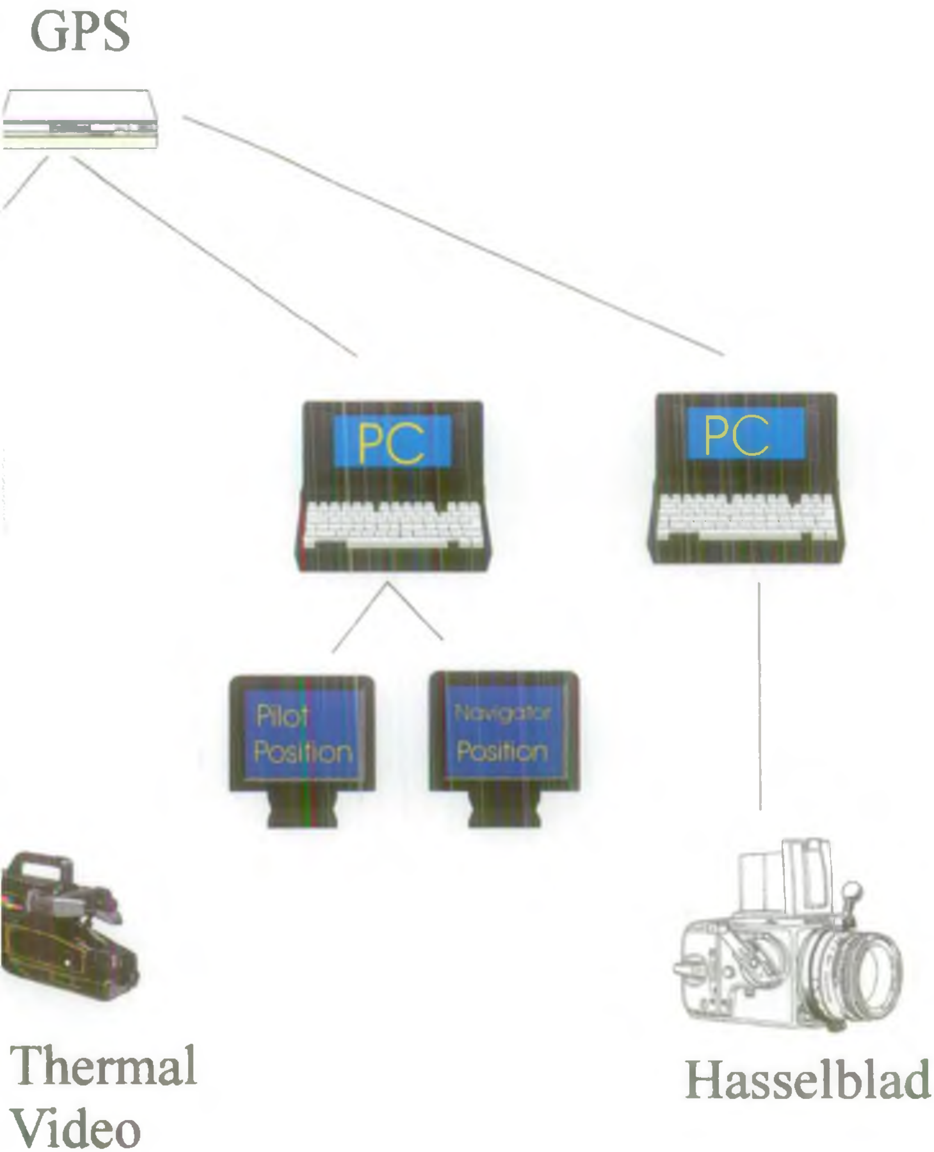


Figure 2


CASI
Operators Console
Tape
DATA BLOCK
CASI
SENSOR HEAD
Colour
Video

AIRCRAFT SYSTEM



The Compact Airborne Spectrographic Image (CASI)

The CASI is an imaging spectrometer designed and built by Itres Ltd of Calgary, Canada. In use by the NRA, it is flown over the coastal waters in a leased aircraft.

It works on the principle of a series of lines of charged coupled devices (CCDs) which each produce an electrical charge dependant upon the amount of light energy falling upon them. These are packed together into a 3 dimensional array made up of 288 x 512 CCDs. Upwelling light radiation from beneath the aircraft is focused onto the array by a compound lens.

Light entering the system is split into a number of wavebands, each registering on a different CCD or row of CCDs. As the aircraft travels forward, light reflected from a succession of small areas fall onto the array and is split into its wavebands. The minimum size (pixel size) of the areas recorded in the routine coastal surveys was 8 m^2. Other pixel sizes can be recorded by altering height, speed and the focal length of the lens.

The CASI can be operated continuously in 2 modes and intermittently in a third. The spatial mode was used in the coastal surveys. In this mode the CASI records data in up to 19 selected spectral channels from all the pixels across the swath. Waveband channels appropriate for the observation of chlorophyll-*a*, solids in suspension and vegetation in the coastal fringe were selected and the CASI system was modified by the addition of a supplementary wide angle lens to cover the three nautical mile coastal zone in a single pass. The CASI can also be used in the spectral mode, recording data from across the whole spectrum over 288 wavebands but only for a limited number of pixels across the swath. This mode also allows the collection of spatial mode data in a single waveband to aid in the location of the spectral data.

Finally, the CASI can also be used in short bursts in an enhanced spectral mode to record up to 74 channels over a 300 pixel wide swath. This acts as a middle ground between spectral and spatial modes.

CASI data from the surveys were processed, enhanced and interpreted at the National Centre for Instrumentation and Marine Surveillance using the PCI image processing package which reads and displays CASI data directly in full 16 bit resolution to produce high resolution images.

The thermal video system

The thermal imaging system consists of four parts: the scanning head, the cooling system, the processing electronics/control unit and VTR/monitor. The system operates in the 8-13 micron spectral range. The resultant signals are processed to professional video format with the addition of a data block containing information on date, time, position and heading.

This system constitutes an inexpensive means of acquiring thermal data and provides a useful means of identifying the location and extent of frontal structures, mixing zones and discharge footprints. However, it is uncalibrated and can determine only relative and not absolute temperatures. Also, because it produces analogue pictorial information, the outputs from the system cannot be merged with the digital data from the CASI or be geocorrected to overlay precisely onto maps or other data. The practicalities of obtaining thermal data in digital form and combining it with the CASI, GPS and aircraft attitude data are being explored.

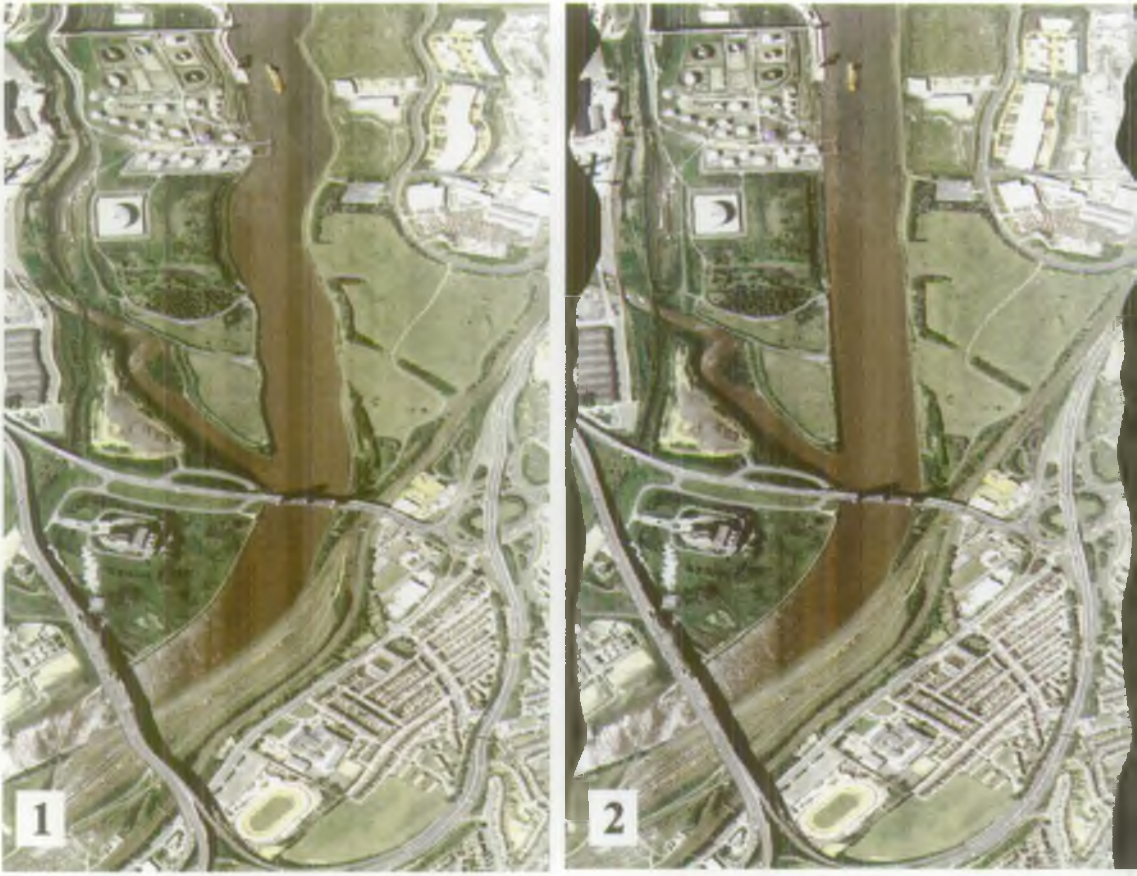
Geometric correction procedure

In addition to progressing along their tracks, aircraft move relative to the ground in pitch and roll motions. Geometric correction procedures eliminate errors in the images caused by the movements of the plane and relate the image coordinates to known geographic coordinates. The resultant images can be overlaid directly onto maps and are of greater use for identifying the location of features. Geometric correction of all survey data will allow changes over time to be accurately mapped and scaled. Images derived from 1995 and future surveys will all be geocorrected.

The geometric correction procedure used by the National Centre for Instrumentation and Marine Surveillance uses the auxiliary data collected by the aircraft during the CASI flights. This data gives information on aircraft motion and geographic location using a Global Positioning System (GPS). Plate 1 shows an image from the 1995 survey of the Tees estuary with the two possible correction procedures which may be used.

The first figure is the raw image derived from the uncorrected data. In the second figure the raw image is corrected for the roll of the aircraft. This removes any visual differences, for example straightening the river in the upper half of the image. The image still has an incorrect geometric orientation with the sports stadium in the lower half of the image appearing as a collapsed shape. This is clearly corrected when the full geocorrection procedure is applied, as shown in the final image. Furthermore, geographical coordinates of features of interest may be extracted from the image.

Plate 1



True colour CASI data. River Tees, Middlesborough.
Date: 14 June 1995, Time: 15:45GMT, Alt.: 2100ft.

1 Raw CASI data showing errors due to roll and pitch.

2 Roll corrected CASI data showing visually correct imagery but with the wrong geometric orientation.

3 Geo-corrected CASI data showing corrections for heading and geometrically square pixels.


3

APPENDIX A

Base	Site name	Easting	Northing
1	Berwick	401443	652107
2	Castlehead Rocks	413450	644616
3	Shoreston Outcars	421779	633985
4	Craster	426513	620379
5	Warkworth	427260	606770
6	Brig Head	430730	594089
7	Blyth	434352	579260
8	Tyne (North)	438454	569686
9	Tyne (Middle)	438895	569078
10	Tyne (South)	439317	568451
11	Marsden	440937	566073
12	Wear (North)	442341	559707
13	Wear (Middle)	442402	558854
14	Wear (South)	442433	557927
15	Pincushon Rock	443338	551556
16	Blackhall	449679	538324
17	Tees (North)	455462	530528
18	Tees (Middle)	456231	529147
19	Tees (South)	459667	527892
20	Skinningrove	472910	521798
21	Sandsend	486288	515059
22	Robin Hoods Bay	497341	505265
23	Scarborough Outfall	504454	492103
24	Filey Brigg	514516	481769
25	Flamborough (North)	524552	472901
26	Bridlington	520418	466428
27	Hornsea	520801	451653
28	Beacon Hill	528006	438358
29	Withernsea	536920	426310
30	Spurn Head	546422	414537
31	Haile Sand Flat	547030	405650
32	Theddlethorpe	552061	390130
33	Chapel St. Leonards	558791	374579
34	Outer Dogs Head	560595	357290
35	Wash	568866	346069
36	Overy, Staithe	585400	349600
37	Cley, Lookout	605700	347800
38	Sheringham	617400	345300
39	Mundesley	632100	339700
40	Lessingham	642300	331000
41	Winterton	652700	319400
42	Gorleston	656000	303600
43	Kessingland	656200	287300
44	Dunwich Cliffs	651400	271400
45	Thorpeness	649000	257600

46	Shingle Street	638759	242982
47	Felixstowe	630400	231200
48	Walton	627500	220000
49	Jaywick	616000	210600
50	Maplin Bank	613300	192600
51	Medway Buoy	600023	179518
52	Shiveringsand Buoy	614810	173220
53	East Margate	632640	172140
54	East Brake Buoy	642560	164290
55	Goodwin Fork Buoy	640780	152520
56	South Foreland	637420	142840
57	Sandgate Bay	623350	133160
58	Dungeness	610960	115460
59	Rye Bay	593690	111730
60	Bexhill	576710	103760
61	Beachy Head	560440	92640
62	Newhaven	541170	97470
63	Brighton	531560	101530
64	Worthing	514840	98340
65	Middleton-on-Sea	499850	95140
66	Selsey Bill	486600	89740
67	Nab Tower	477220	89080
68.1	East Brambles	454500	99090
68.2	Calshot	449950	102320
68.3	Dockhead	442954	109622
68.4	West Princessa	467490	89410
69	St. Catherines	449780	74450
70	The Needles	427320	83450
71	Hengistbury Head	417670	88880
72	Anvil Point	404752	77529
73	St. Aldhelms	391444	74806
74	Weymouth Bay	374897	77068
75	Portland Bill	366887	68905
76	Chesil	357708	80056
77	Bridport	344060	88033
78	Seaton	327371	85782
79	Sidmouth	314357	81023
80	Exmouth	298768	73910
81	Torbay	296654	57937
82	Dartmouth	292251	45010
83	Start Point	282855	34413
84	Salcombe	271484	31174
85	Bigbury Bay	260244	41176
86	Plymouth	246016	46192
87	East Looe	232461	50530
88	Fowey	216744	48055
89	Dodman Point	203301	38283
90	St. Antony Head	191045	31497
91	Falmouth	183960	26360

92	Black Head	183110	15940
93	Lizard	171990	9880
94	Mullion	163430	15910
95	Penzence	151330	23980
96	Runnel Stone	137160	18980
97	Cape Cornwall	132110	31440
98	The Carracks	141640	42920
99	Godrevy Island	156000	45800
100	St. Agnes	168780	52800
101	Newquay	179500	63850
102	Trevose	182760	77920
103	Padstow	191671	79737
104	Port Isaac	194930	86330
105	Boscastle	207848	93942
106	Bude	217387	104811
107	Morewenstowe	218976	118706
108	Hartland Point	222623	132318
109	Bideford	237456	133833
110	Bull Point	244082	147356
111	Combe Martin	258542	150774
112	Foreland	272883	153182
113	Porlock	287856	150676
114	Minehead	302829	147589
115	Bridgwater Bar	315221	149213
116	Weston-super-Mare	328422	160435
117	Clevedon	337342	171688
118	Avonmouth	350046	178825
119	No. 1 Beacon	351230	184940
120	Newport Deep	330560	178100
121	Cardiff Road	323990	174200
122	Lavernock	319740	166990
123	Aberthaw	304980	163990
124	Nash Point	291470	167040
125	Porthcawl	279540	175580
126	Kenfig	275210	180890
127	Port Talbot	271670	187250
128	Mumbles	264920	185970
129	Oxwich	251470	183060
130	Worms Head	237680	186370
131	Llanelli	236580	193880
132	Burry Port	232570	199170
133	Carmarthen	225390	201800
134	Caldey Island	219540	197440
135.1	Old Castle Head (Inner)	206575	187970
135.2	Old Castle Head (Off)	207020	193620
136.1	St. Govans (Inner)	192260	184790
136.2	St. Govans (Off)	192490	190400
137	Turbot Bank	184870	194230
138	St. Anns	180565	201679

139	Skomer	170162	208214
140	South Bishop	164072	220936
141	Abereiddy	176570	235494
142	Strumble Head	189368	242641
143	Fishguard	197672	241368
144	Pwll-Coch	205900	246887
145	Cardigan Island	214591	252771
146	Penly-Badell	229134	257723
147	New Quay Head	238369	261216
148	Pen Pigyn	252332	270982
149	Aberystwyth	256604	281058
150	Aberdovey	258140	294925
151	Pen-Bwch Point	253277	302489
152	Barmouth	259294	315297
153	Shell Island	253581	327524
154	Pwllheli	240180	333514
155	Porth Ceiriad	232708	323561
156	Bardsey	214489	322368
157	Penrhyn Colmon	220695	337909
158	Dinuaen	227616	343224
159	Dylan	241352	352029
160	Aberffraw	232901	366233
161	Penrhos	222588	376813
162	Holyhead	225804	385602
163	Middle Mouse	239518	396995
164	Red Wharf	255740	384043
165	Great Orme	275785	386259
166	Llanddulas	289027	383149
167	Chester Flat	302955	385626
168	Welsh Channel	311290	386391
169	He 1 Buoy	319146	391814
170	North Wirral	321644	395462
171	Formby Point	323261	408435
172	Gut	325516	423234
173	Blackpool	327725	438035
174	Shell Wharf	329673	450801
175	Hilpsford	317047	460468
176	Duddon	311551	471698
177	Selker	304434	486678
178	Calder Hall	297170	501675
179	Whitehaven	292652	516620
180	Workington	297151	531356
181	Solway Buoy	303426	543740
182	Medway Buoy	298653	546533
183	Balcarry	283026	546912
184	Abbey Head	271290	541294
185	Meggerland	258289	545024
186	St. Ninians	250301	536374

APPENDIX B

Determinand	Properties	Units	Limit of Detection
Group 1 - measured at every baseline site			
(Mercury Dissolved)	Dissolved	ug/l	0.03
Mercury Total	Total	ug/l	0.03
Cadmium Dissolved	Dissolved	ug/l	0.25
Suspended Solids 105°C		mg/l	5
Suspended Solids 500°C		mg/l	5
Ortho-phosphate	Filtered	ug/l P	5.0
Chlorophyll a	Total	ug/l	0.2
Ammonia	Filtered	ug/l N	6.0
Nitrite	Filtered	ug/l N	2.0
Silicate	Saline Filtered	mg/l	0.025
Copper Dissolved	Dissolved Saline ppb	ug/l	0.5
Lead Dissolved	Dissolved Saline	ug/l	2.5
Zinc Dissolved	Dissolved Saline ppb	ug/l	4.0
Arsenic Dissolved	Dissolved ppb	ug/l	2.5
Chromium Dissolved	Dissolved Saline ppb	ug/l	1.5
Nickel Dissolved	Dissolved Saline ppb	ug/l	3.0
Total Oxidised Nitrogen	Saline Filtered	mg/l N	0.010
Group 2 - measured at approximately every third baseline site			
Cadmium Total	Total	ug/l	0.25
Copper Total	Total Saline ppb	ug/l	0.5
Lead Total	Total Saline	ug/l	2.5
Zinc Total	Total Saline ppb	ug/l	5.0
Arsenic Total	Total ppb	ug/l	2.5
Chromium Total	Total Saline ppb	ug/l	2
Nickel Total	Total Saline ppb	ug/l	3.0
Group 3 - measured at occasional sites of interest			
Isodrin	Total	ng/l	2.5
Aldrin		ng/l	2.5
Dieldrin		ng/l	2.5
Endrin		ng/l	2.5
Hexachloro-Benzene	Total	ng/l	1.0
Hexachloro-Butadiene	Total	ng/l	1.0
PCB 28		ng/l	1.0
PCB 52		ng/l	1.0

PCB 101	ng/l	1.0
PCB 118	ng/l	1.0
PCB 138	ng/l	1.0
PCB 153	ng/l	1.0
PCB 180	ng/l	1.0
DDE-PP'	ng/l	1.0
DDE-OP'	ng/l	2.0
DDT-OP'	ng/l	1.0
DDT-PP'	ng/l	1.0
HCH-Alpha	ng/l	1.0
HCH-Beta	ng/l	1.0
HCH-Delta	ng/l	1.0
HCH-Gamma	ng/l	1.0
TDE-OP'	ng/l	2.0
TDE-PP'	ng/l	1.0