

THE IDENTIFICATION AND INVESTIGATION OF A
DINOFLAGELLATE BLOOM IN MOUNTS BAY,
CORNWALL.

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R. GRANTHAM
TIDAL WATERS UNIT
NATIONAL RIVERS AUTHORITY
SOUTH WEST REGION
MANLEY HOUSE
EXETER EX2 7LQ

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SUMMARY

On Thursday 3/8/1989 Penwith District Council Environmental Health Department received reports of large numbers of dead sea urchins and lugworm on the shore at Long Rock/Marazion in Cornwall and that this appeared to be associated with a reddish-brown discolouration of the sea. The South West Water Rivers Unit (SWWRU) was informed on the afternoon of Saturday 5/8/1989 and consequently visited the area that evening. Staff from the Rivers Unit and Scientific Services of South West Water worked throughout the weekend to assess the water quality of inputs to the bay and the receiving waters, and to establish the nature of the discolouration.

The Tidal Waters Unit of the SWWRU visited the area and the adjacent beaches of Newlyn, Praa Sands, Perran Sands and Penzance Harbour on 7/8/1989 and again on 8/8/1989. The 'red tide' on 7/8/1989 could only be seen in the waters at the extreme north of Mounts Bay and affected an area that stretched from Penzance Harbour to the Long Rock/Marazion beaches. The waters concerned were highly turbid, of a red clay colouration and occurred to a depth of at least one metre. A large number of dead sea urchins (Echinocardium caudatum) were present, ragworm species' (Nereis and Nephtys) and a few lugworm were found to be under stress. Samples were collected to verify those results obtained from the samples taken on the Saturday.

Close collaborative work with the Plymouth Marine Laboratories identified a predominance of the Dinoflagellate species Gyrodinium aureolum. South West Water Scientific Laboratories' algologists also identified the presence of the algae, Glenodinium. The dominant species has been known to bloom in the area in the past, giving the observed reddish/brown discolouration and mortalities of benthic species. Dinoflagellates are algae type micro-organisms that bloom under favourable conditions including elevated temperature, high illumination and the supply of limiting materials. A prolonged dry spell and settled conditions prior to the bloom are likely to be the primary causative factors for the predominance of Gyrodinium aureolum. However, the growth of the algae could be enhanced by the presence by additional factors of low dispersion within Mounts Bay and/or high inputs from the crude discharges and run off from the neighbouring agricultural land.

The Chemical analyses of the inputs and waters within the bay showed levels in the order that would be expected of the various water types within the region.



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1. Introduction

On Saturday 5/8/1989 South West Water Rivers Unit (SWWRU) were informed by Penwith District Council Environmental Health Department of reports first received by them on the previous Thursday, of dead and dying marine species (lugworm, ragworm and sea urchins) on the foreshore, and a red/brown discolouration of the sea at Mounts Bay, Cornwall. Algae were suspected of being the causative organism because the observations showed a marked similarity with those recorded in previous incidents along the south Cornish coast (1-3) and throughout the British Isles (4-8).

Pollution staff of the SWWRU (later to become the National Rivers Authority, South West Region) visited the area on the Saturday evening and collected samples from the freshwater and crude inputs to the bay, and from areas within the bay that were affected by the 'red tide'. Staff of the Rivers Unit and Scientific Services worked throughout the weekend to establish the biological nature of the discolouration, and the bacteriological and chemical quality of the inputs and inshore waters.

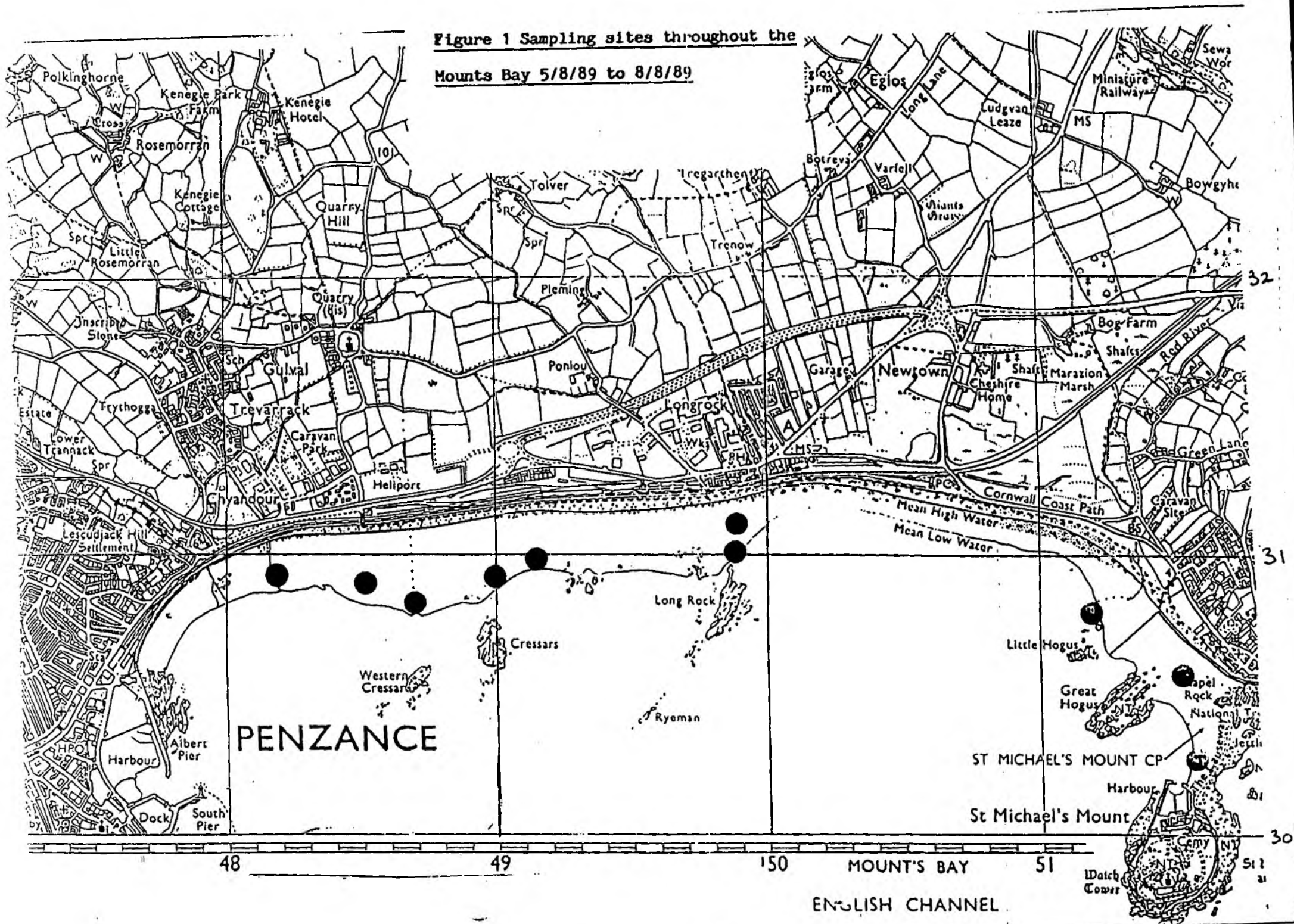
The Tidal Waters Unit (TWU) of the SWWRU visited the area on the following Monday and Tuesday (7-8/8/1989) to evaluate the extent of the red tide, to verify the results from the previous Sunday, and to identify any abnormal chemical or bacteriological phenomena present in the coastal waters.

The investigation concerned the extreme North of Mounts Bay from Newlyn to Praa Sands. The major industries in the area are Agriculture, Tourism and Fishing. These coastal waters receive the discharges from 12 crude sewage outfalls serving an equivalent population of over 40,000, at least nine storm overflows, and a number of private dwellings.

2. Sampling Procedure

Samples were collected for bacteriological and chemical (organic and inorganic) analysis throughout the inner bay from Albert Pier, Penzance to Marazion on Saturday 5/8/89 and from sites in the same area on the following Monday and Tuesday, see Figure 1. All samples except for those required for organic analysis were collected in polyethylene terephthalate bottles. Organic samples were collected in prewashed glass bottles. A Dissolved Oxygen probe was used just below the surface at Marazion and in the Long Rock area on Monday 7/8/89.

**Figure 1 Sampling sites throughout the
Mounts Bay 5/8/89 to 8/8/89**



3. Observations

The weather throughout the summer of 1989 was unusually hot and settled with near drought conditions reported throughout the South West. However, the surface overflows (S/O) at Long Rock and near Site C were observed to be flowing with the Long Rock S/O exuding an odour characteristic of sewage. The red tide was observed on the 5/8/89 at Marazion and from aerial photographs taken on the 6/8/89 (see Dinoflagellate Bloom file, TWU) was seen to stretch from Marazion to Newlyn. The affected areas were highly turbid and of a red clay colouration. A large number of sea urchin tests of Echinocardium caudatum were observed and ragworms of genus Nereis and Nephtys were found to be under stress. Large numbers of seagulls were seen in the areas where the worms could be found.

4. Biological Analysis

An aliquot of the sample collected from Marazion (Site I) on 5/8/1989 was sent to the Plymouth Marine Laboratories (PML) and to Laboratories of South West Water, for the identification of the organism that had caused the red tide. Initial investigations indicated the Dinoflagellate genus Peridinium but a second opinion identified Glenodinium. However, close collaborative work with PML subsequently confirmed (Tuesday a.m.) that although the Glenodinium was present the predominant organism was the Dinoflagellate, Gyrodinium aureolum.

5. Bacteriological Analysis

The bacteriological analysis included the presumptive counts for Total Coliforms, E.Coli and faecal streptococci, and are given in Appendix I. The bacterial counts showed little of significance, with levels in the order that would be expected in these particular inshore waters. An exception is the high streptococci values at site E and I which could be explained by the presence of large amounts of bird faeces from the vast number of seagulls in the area.

6. Chemical Analysis

The samples collected from the inputs on the 5/8/89 were analysed for metals and sanitary parameters (e.g. nutrients, suspended solids and pesticides). The results did not reveal anything uncharacteristic. However, chemical analysis of the seawater sample collected at Site I (see Appendix II) indicated high cadmium levels.

The chemical analyses undertaken on the samples of the 7/8/89 included the determination of saline nutrients (Ammonia, Orthophosphate, Total Oxidised Nitrogen and Reactive Silicate), metals (Lead, Cadmium, Copper, Zinc, Chromium and Nickel), suspended solids and salinities. Metal results for the samples collected on the 7/8/89 and 8/8/89 are given in Appendix III and the nutrients, suspended solids and salinities given in Appendix IV. The only determinand that was present at elevated levels appeared to be cadmium. These high cadmium values and the elevated level at Marazion on the previous Saturday were later investigated and are discussed in a separate report(9).

The results not presented in this report can be obtained from the National Rivers Authority, South West Region after quoting reference: RPL/21A.

7. Discussion

Dinoflagellates are algae type micro-organisms that are capable of manufacturing their own food by photosynthesis(8). However, many species require additional preformed organic substances for growth and reproduction. Under the optimum conditions of temperature, salinity, illumination, and pH, along with the various growth factors and trace elements in the water, dinoflagellates may reach bloom proportions.

It is likely that the long hot spell prior to this investigation aided the optimisation of the conditions for the growth of Gyrodinium aureolum. The results given in this report are inconclusive, but it is possible that high anthropogenic inputs from the crude discharges and run off from agricultural land to Mounts Bay supplied the limiting materials that encouraged the algal bloom. The low dispersion found within the bay could also enhance the accumulation of the limiting materials.

7. Discussion (continued)

There have been many reports prior to this investigation of dinoflagellates causing mortalities among benthic species, shellfish, fish and, occasionally through ingestion of shellfish, to man. The deaths in humans have been caused by Paralytic Shellfish Poisoning resulting from the consumption of shellfish that had been feeding on poisonous species of dinoflagellates (10) e.g Pyridinium (8). However, it is not known whether the sea urchin deaths in Mounts Bay were caused by ingestion of toxins found within the dinoflagellates, suffocation, or by other means. Algae liberate oxygen during photosynthesis and thus could cause the saturation of the surrounding waters (as indicated by the dissolved oxygen readings on 7/8/1989) during the day but respiration of algae at night may deoxygenate the waters sufficiently to cause suffocation of benthic species. An alternative method of suffocation can arise through the death and decay of algae and the subsequent settling of the humus upon the seabed (1,5).

8. Conclusions

The red tide was identified as being due to an algal bloom caused by a predominance of the dinoflagellate, Gyrodinium aureolum. It was not possible to identify the reason for the dinoflagellate bloom using the chemical and bacteriological analysis obtained for this report.

Dinoflagellate blooms of Gyrodinium aureolum had previously been reported in waters off the south Cornish coast(1-3) and are recorded as being responsible for the mortalities of benthic fauna.

9. References

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APPENDIX 1 - BACTERIAL COUNTS OF SAMPLES COLLECTED FROM MOUNTS BAY ON 5, 7 AND 8 AUGUST 1989

Sampling pt. Description	Site	NGR	Date Sampled	Red tide Observed	Bacterial Counts No/100 ml		
					Total Coliforms	E.Coli	F. Strept
Sea off Ponsadane Brook	A	4818 3090	5/8/89	Yes	2300	700	82
Long Rock B.R. W. End	B	4850 3089	5/8/89	Yes	34	32	3
Long Rock at B.R. B.R. Depot	E	4910 3100	5/8/89	Yes	2100	2900	16000
Sea Off Long Rock Overflow	F	4981 3110	8/8/89	No.	620	230	37
Long Rock Overflow	G	4978 3100	8/8/89	No.	>50000	18900	1400
Sea Off Red River Car Park	H	5120 3072	5/8/89	Yes	30	14	82
Off the Slipway RYA, Marazion	I	5167 3054	5/8/89	Yes	6200	1300	23200
West of Causeway, Marazion	J	5154 3044	8/8/89	No	8	2	8

APPENDIX II The chemical analysis of the sample collected at
RYA, Marazion on 5/8/89

DETERMINAND AND UNITS	RESULTS OF ANALYSIS	VALUE
SALINE LEAD (PARTICULATE) as ug/l Pb		<5.0
SALINE LEAD (DISSOLVED) as ug/l Pb		<2.5
SALINE pH as pH units		8.1
SALINE B.O.D. (5 DAY TOTAL - ATU) as mg/l O		>10.
SALINE CADMIUM (DISSOLVED) as ug/l Cd		17.8
SALINE CADMIUM (PARTICULATE) as ug/l Cd		1.1
AMMONIACAL NITROGEN as mg/l N		.03
SALINE TOTAL OXIDISED NITROGEN as mg/l N		.011
NITRITE as ug/l N		11.
SALINE SOLIDS SUSPENDED at 105 C as mg/l		282.
SALINE SOLIDS SUSPENDED (ASH) at 500 C as mg/l		233.
SALINE ORTHOPHOSPHATE (TOTAL) as ug/l P		.04
SALINE SILICATE REACTIVE DISSOLVED as mg/l SiO ₂		.137
ALDRIN (TOTAL) as ng/l		<1.
HCH(BHC) ALPHA (TOTAL) as ng/l		<1.
HCH(BHC) BETA (TOTAL) as ng/l		<2.
HCH(BHC) DELTA (TOTAL) as ng/l		<1.
HCH(BHC) GAMMA (TOTAL) as ng/l		<1.
DIELDRIN (TOTAL) as ng/l		<3.
HEPTACHLOR (TOTAL) as ng/l		<1.
HEPTACHLOR EPOXIDE (TOTAL) as ng/l		<3.
MALATHION (TOTAL) as ng/l		<5.
op DDT (TOTAL) as ng/l		<12.
PARATHION (TOTAL) as ng/l		<10.
PHORATE (TOTAL) as ng/l		<40.
pp DDE (TOTAL) as ng/l		<3.
pp DDT (TOTAL) as ng/l		<5.
pp TDE (TOTAL) as ng/l		<3.
ENDRIN (TOTAL) as ng/l		<3.
E. OSULPHAN A (TOTAL) as ng/l		<7.
ENDOSULPHAN B (TOTAL) as ng/l		<7.
op TDE (TOTAL) as ng/l		<12.
CHLORDANE ALPHA (TOTAL) as ng/l		<4.
op DDE (TOTAL) as ng/l		<6.
DIAZINON (TOTAL) as ng/l		<40.
SALINITY as gm/kg T.D.S.		34.1
Unidentified peaks on packed GC pesticide scan		0.
SALINE COPPER (DISSOLVED) as ug/l Cu		4.6
SALINE COPPER (PARTICULATE) as ug/l Cu		<5.0
SALINE ZINC (DISSOLVED) as ug/l Zn		12.1
SALINE ZINC (PARTICULATE) as ug/l Zn		21.2
SALINE CHROMIUM (PARTICULATE) as ug/l Cr		<5.0
SALINE NICKEL (DISSOLVED) as ug/l Ni		<3.0
SALINE NICKEL (PARTICULATE) as ug/l Ni		<5.0
DISULFOTON (TOTAL) ng/l.		<40.
CHLORPYRIPHOS (TOTAL) as ng/l.		<2.
ETHION (TOTAL) as ng/l.		<10.
TRIFLURALIN (TOTAL) as ng/l		<1.

APPENDIX III - METAL CONTENT* OF SEAWATER SAMPLES COLLECTED ON 7/8 AUGUST 1989

Sampling pt Description	Site	NGR	Date Sampled	Metal Results mg/l											
				Pb		Cu		Cd		N		Zn		Cr	
				Dis	Part	Dis	Part	Dis	Part	Dis	Part	Dis	Part	Dis	Part
Sea off lge S/O	C	4867 3081	7/8/89	<2.5	<5.0	2.6	<5.0	6.9	<0.5	<3.0	<5.0	11.3	<5.0	N/A	<5.0
Between Long Rock and B.R. Bridge	D	4900 3092	7/8/89	<2.5	<5.0	2.3	<5.0	5.5	<0.5	<3.0	<5.0	12.0	7.4	N/A	<5.0
Sea Off Marazion	I	5167 3054	7/8/89	<2.5	<5.0	0.87	<5.0	0.175	<0.5	<3.0	<5.0	7.2	<5.0	N/A	<5.0
Penzance Harbour	not marked on map	-	7/8/89	<2.5	<5.0	1.9	<5.0	<0.125	<0.5	<3.0	<5.0	11.3	<5.0	N/A	<5.0
Sea off Long Rock	F	4981 3110	8/8/89	<2.5	<5.0	0.78	<5.0	0.31	<0.5	<3.0	<5.0	6.9	<5.0	N/A	<5.0
West of Causeway Marazion	J	5154 3044	8/8/89	<2.5	<5.0	0.62	<5.0	<0.125	<0.5	<3.0	<5.0	5.9	<5.0	N/A	<5.0

* The dissolved and particulate values are given for Lead, Copper, Cadmium, Nickel, and Zinc. Chromium concentrations are only given for the particulate fraction.

APPENDIX IV - CHEMICAL ANALYSIS OF THE SAMPLES COLLECTED - 7 AUGUST 1989

Sampling pt Description	Site	NGR	Date Sampled	Time of Sampling	Diss. Oxygen %	Red Tide present	Saline Nutrients				Salinity S	S.S. at 105°C mg/l	S.S. (Ash) mg/l
							T.O.N. ¹ ug/l	SiO ₄ ² ug/l	NH ₄ ³ ug/l	PO ₄ ⁴ ug/l			
Sea Off Ige s/o pipe	C	4867 3081	7.8.89	1610	130%	Yes	<5	25	10	20	33.8	26	20
Between Long Rock and B.R bridge	D	4900 3092	7.8.89	1540	130%	Yes	8	31	10	40	N/A	N/A	N/A
Sea off slipway RYA, Marazion	I	5167 3054	7.8.89	1730	120%	No	<5	13	10	20	N/A	N/A	N/A

1 T.O.N. - Total oxidised Nitrogen

2 SiO₄ - Reactive Silicate

3 NH₄ - Ammonia (filtered)

4 PO₄ - Orthophosphate