

AN INVESTIGATION INTO THE PRESENCE
OF HIGH LEVELS OF CADMIUM IN SEA-WATER SAMPLES
FROM MOUNTS BAY, CORNWALL

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Summary

High cadmium concentrations were discovered in sea-water samples collected during an investigation into an algal bloom in Mounts Bay on the 5 and 7 August 1989.

In response to this the Tidal Waters Unit of National Rivers Authority, South West Region, investigated the problem on 10 August 1989. Cadmium inputs via the freshwater, crude sewage and storm water overflows were assessed, and the cadmium content of the sediments, shellfish and seawater of the inner bay evaluated.

All samples collected on 10 August, including sea-water samples, contained low levels of cadmium. No conclusive identification of the source of the cadmium originally found is possible, though it may be linked in some way to the algal bloom.

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1. Introduction

Mounts Bay is situated on the South Coast of Cornwall and the area concerned stretches from Albert Pier, Penzance to Marazion (Figs 1 and 2), a distance of some 3 miles. The coastal stretch receives the discharges from crude sewage outfalls serving an equivalent population of approximately 33,000, a number of storm overflows, private dwellings and the freshwater inputs from the Chyandour Stream, Ponsandane Brook and the Red River. The Marazion area contains numerous disused mines (1) from which Copper, Zinc, Lead, Iron, Tin and Silver Ores have been extracted in the past.

The major industries in the area are Tourism and Fishing. A small industrial estate exists between Chyandour and Long Rock, and an abattoir is in operation in Chyandour.

During an investigation into an algal bloom (2) of the dinoflagellate, Gyrodinium aureolum in Mounts Bay on 5 and 7 August 1989, high levels of cadmium were discovered. The Environmental Quality Standard (EQS) of 2.5 µg/l for cadmium in coastal waters was exceeded in three samples, see Table 1.

Cadmium is highly toxic, thus it was deemed necessary to establish the source of metal and the extent of the contamination. The Tidal Waters Unit (TWU) of the National Rivers Authority (NRA), South West Region investigated the problem on 10 August 1989.

2. Summary of Earlier Surveys

The algal bloom was first sampled on 5 August 1989 by employees of the National Rivers Authority (NRA), South West Region, at Marazion and again on 7 and 8 August 1989 at Long Rock/Chyandour area. Samples were collected in Polyethylene Terephthalate bottles (PET) and the analyses for a number of determinands e.g. nutrients, metals, E. Coli and the biological identification of the algae was undertaken.

3. Sampling Procedure, 10 August 1989

The TWU surveyed the area on 10 August 1989. The investigation included an assessment of the cadmium input to the inner bay (Penzance to Marazion) from the outfalls, overflows and streams, and an evaluation of the cadmium content in the sediments, biota and receiving coastal waters.

The major crude sewage inputs from Marazion, Chyandour and Albert Pier were sampled via manholes above the discharges, throughout the day between the times of high water and low water.

Spot samples were collected from the larger freshwater inputs to the inner bay at various times during the day. The storm overflows observed to be flowing were sampled at low tide.

Table 1. Cadmium Content of Seawater Samples During the Algal Bloom 5 - 8 August 1989

Sample Point	Site	NGR	Date Sampled	Cd µg/l (Dis)	Cd µg/l (Particulate)	Observations
Marazion RYA	U	SW51673054	5.8.89	17.8	1.1	Algal bloom present. First reported.
Sea Off S/O pipe. Long Rock/Chyand (at 0.6m depth)	N	SW48673081	7.8.89	0.25	<0.5	Presence of Algal bloom unknown.
As above(surface)	N	SW48673081	7.8.89	6.9	<0.5	Algal bloom present.
Sea off beach between Long Rock and Heliport	Near P	SW49003090	7.8.89	5.5	<0.5	Algal bloom present (not as apparent as at site N above)
Marazion RYA	U	SW51673054	7.8.89	0.175	<0.5	No algal bloom observed.
Marazion RYA	U	SW51673054	8.8.89	<0.125	<0.5	No algal bloom observed.
Off Longrock	Near Q	SW49793111	8.8.89	0.31	<0.5	No algal bloom observed.

Sediment and mussel samples were collected at low water and the seawater samples at both high and low water. The latter samples were taken from just below the surface in 0.6m of water approximately ten metres from the shore. The sites were chosen to correspond with the areas associated with the freshwater or crude inputs.

Crude and freshwater inputs were collected in PET bottles whilst the seawater and sediment samples were taken in acid soaked poplypropylene bottles. All sampling sites were lettered from west to east (see Figs 1 and 2) and the samples numbered in chronological order.

4. Weather Conditions

The conditions during both the algal bloom and on the day of the investigation were calm with little cloud cover and no rain. However, the large storm water overflow at site M was observed to be flowing.

The algal bloom that was present on the 5 -7 August 1989 was not apparent on 10 August. The sea urchin tests observed on previous days (1) were again present in high numbers on 10 August.

5. Chemical Analyses

Samples collected on 5, 7 and 8 August 1989 as part of the algal bloom survey were analysed for a number of determinands including Cadmium. Samples collected on 10 August were analysed for cadmium only. The nature of the Cadmium analyses for each sample type is as follows:-

- (a) Inputs of Freshwater: Total cadmium.
and Crude Sewage
- (b) Seawater: Dissolved (<0.45µm) and particulate.
- (c) Sediments: Total metals (digested in aqua regia)
found in the total fraction i.e.
coarse and fine material.
- (d) Mussels: Cadmium concentration was determined
in the dry weight after freeze-drying
and homogenisation.

6. Results

All results and sample details for the investigation on 10 August 1989 are given in Table 2 and the sampling sites illustrated in Figures 1 and 2. The samples collected during this investigation did not reveal any significant levels of cadmium in the sediments, seawater, freshwater or crude discharges to the inner bay. The absence of elevated levels in the shellfish and sediments indicate that the high cadmium concentrations found during the algal bloom on 5, 7 and 8 August 1989 are not due to a long term problem.

Table 2a - Cadmium Values Found in Samples Collected on 10 August 1989

Sampling Point	Site	NGR	Discharge Ref No	Sample No	Sample Time	Lab Sample No	Cadmium Conc	Sample Type
Albert Pier Brick Culvert - South Outfall	A	SW47753038	48/21A/P/214	13 17	1353 1533	11609 11613	<7 µg/l <7 µg/l	Crude Sewage
Albert Pier Stone Culvert North Outfall	B	SW47743042	48/21A/P/213	14 16	1358 1523	11610 11612	<7 µg/l <7 µg/l	Crude Sewage
Albert Pier Small Outfall at Station South (Old Gas Work Outfall)	C	SW47683057	48/21A/P/211	15	1510	11611	<7 µg/l	Crude Sewage
Albert Pier (Area Off)	D	SW47753062 SW47753062 SW47753062		24 53	1700 1700 1700	11585 11619 11629	<0.125 µg/l <0.4 µg/g <1.3 µg/g	Saline Sample Sediment Shellfish (mussels)
Small Stream at End of Railway Station	E	SW47753078 SW47753078		23 52	1650 1650	11599 11618	<7 µg/l <0.4 µg/g	Freshwater Sediment
Off Chyandour River	F	SW47963090		59	1720 1720	11630 11630	<0.7 µg/g <1.9 µg/g	Sediment Shellfish

N.B. All Cadmium concentrations in shellfish are given as µg/g dry weight

Table 2b - Cadmium Values Found in Samples Collected on 10 August 1989

Sampling Point	Site	NGR	Discharge Ref No	Sample No	Sample Time	Lab Sample No	Cadmium Conc	Sample Type
Chyandour Outfall West of Square	G	SW47893100	48/21A/P/210	2	1135	11604	<7 µg/l	Crude Sewage (includes discharge from abattoir and urban)
				12	1345	11608	<7 µg/l	
				20	1553	11614	<7 µg/l	
Chyandour Outfall East of Square	H	SW47913103	48/21A/P/210	3	1140	11605	<7 µg/l	Crude Sewage (including discharge from Ind. Estate)
				10	1335	11607	<7 µg/l	
				19	1602	11615	<7 µg/l	
Chyandour River	I	SW47923098		4	1150	11593	<7 µg/l	Freshwater Freshwater Freshwater
				11	1340	11596	<7 µg/l	
				18	1550	11597	<7 µg/l	
Off Ponsandane Stream	J	SW48173095		58		11624	<0.4 µg/g	Sediment
Ponsandane Stream	K	SW48163110		7	1235	11594	<7 µg/l	Freshwater Freshwater Freshwater
				9	1325	11595	<7 µg/l	
				22	1640	11598	<7 µg/l	
30m East of Ponsandane Stream	L	SW48383105		31	1201	11589	<0.125 µg/l	Saline Sample Sediment
				56	1630	11622	<0.4 µg/g	

Table 2c - Cadmium Values Found in Samples Collected on 10 August 1989

Sampling Point	Site	NGR	Discharge Ref No	Sample No	Sample Time	Lab Sample No	Cadmium Conc	Sample Type
Large Outfall Pipe	M	SW48683091		21 51	1620 1620	11616	<7 µg/l <0.55 µg/g	Freshwater Sediment
Sea Off M	N	SW48673081		21A	1620	11584	<0.125 µg/l	Saline Sample
30m West of M	O	SW48583105		32	1222		<0.125 µg/l	Saline Sample.
Equi-Distant Between Long Rock Overflow and M	P	SW49343109		33	1232	11591	<0.125 µg/l	Saline Sample.
Long Rock Surface Water Overflow	Q	SW49793111	48/21A/P/209	25 54	1740 1740	11600 11620	<7 µg/l <0.4 µg/g	Freshwater Sediment
Long Rock Pump Station Overflow	R	SW50093117	48/21A/P/208	26	1750	11601	<7 µg/l	Freshwater
Marazion Station Car Park (Sea Off)	S	SW50683112		28 55	1810 1810	11587 11621	<0.125 µg/l <0.4 µg/g	Saline Sample Sediment
Red River	T	SW51383087		27 510	1851 1815	11602 11626	<7 µg/l 1.1 µg/g	Freshwater Sediment

Table 2d - Cadmium Values Found in Samples Collected on 10 August 1989

Sampling Point	Site	NGR	Discharge Ref No	Sample No	Sample Time	Lab Sample No	Cadmium Conc	Sample Type
Marazion - Opp RYA Slip	U	SW51673054		29	1810	11623	<0.75 µg/g	Sediment
As above	V	SW51583048		30	1126	11587	<0.125 µg/l <0.125 µg/l	Saline Sample Saline Sample
Marazion - The Gwelva Outfall	W	SW51833055	48/21A/P/205	1 8	1120 1250	11603 11606	<7 µg/l <7 µg/l	Crude Sewage Crude Sewage
Causeway, Marazion (W Side)	X	SW51643029			1805	11628	<1.5 µg/g	Shellfish

All Cadmium concentrations in shellfish are given as µg/g dry weight.

7. Discussion

It is possible that cadmium may be present in the ores of the old mines, and thus with sufficient rainfall will discharge to the sea, resulting in the concentrations of cadmium that were found during the algal bloom. However, the weather conditions at the time and the past records of cadmium levels in the streams and rivers do not substantiate this theory. In addition to this, those samples with high cadmium levels did not contain elevated levels of other metals which would be expected in mine discharges.

There is no heavy industry in the area that could be suspected of discharging cadmium. A small industrial estate exists at Long Rock which upon inspection showed little of concern.

Contamination from sample bottles was considered, because sampling for metals in seawater is normally undertaken using acid soaked polypropylene bottles. The samples collected on the 5, 7 and 8 August were taken in PET bottles because the investigation on these dates were not concerned with cadmium problems but the algal bloom. The contamination tests that have been run on these bottles have so far proved negative. However, problems have been encountered with contamination from other metals.

The results obtained throughout the period 5 - 10 August imply that a correlation exists between the cadmium levels and the presence of the algal bloom. The cadmium levels appeared to decrease as the bloom lessened and the greater concentrations of cadmium were found near the surface where the algae would be expected in greatest numbers. However, if cadmium was a component of the bloom, high concentrations would be expected in the particulates and not in the dissolved fraction, since dinoflagellates have diameters approximately 100 times the filter size.

8. Conclusions

There are no clear conclusions as to the source of the Cadmium. The high levels appear to have been transitory, although further sampling on a regular basis would be necessary to confirm this. There is a high correlation between the elevated Cadmium levels and the algal bloom, but any Cadmium accumulated within the bloom would be expected to have been found in the particulate fraction. It is possible that some unknown mechanism caused the Cadmium to be released to the dissolved fraction.

9. Recommendations

It is recommended that:-

- (a) The seawater at points within the inner bay, be monitored for cadmium in the near future to ensure that the problem no longer exists. One seawater sample to be collected at the RYA Marazion once a month until November 1989.

- (b) PET bottles should no longer be used for sea-water metal samples.
- (c) Should high cadmium values be found in the future then it is advisable, in addition to repeating the work done in this investigation, to collect:-
 - (i) Samples throughout the sea of the inner bay.
 - (ii) Samples from the outlying area i.e. east of St Michaels Mount and to the west of Albert Pier.

10. References

- 1. The Metalliferous Mining Region of South West England, Vol I. Her Majestys Stationery Officer 1956.
- 2. Dinoflagellate Bloom in the Mounts Bay, Cornwall 1989. Report No. NRA SW TQU/89/004.

M Harris
9 September 1989

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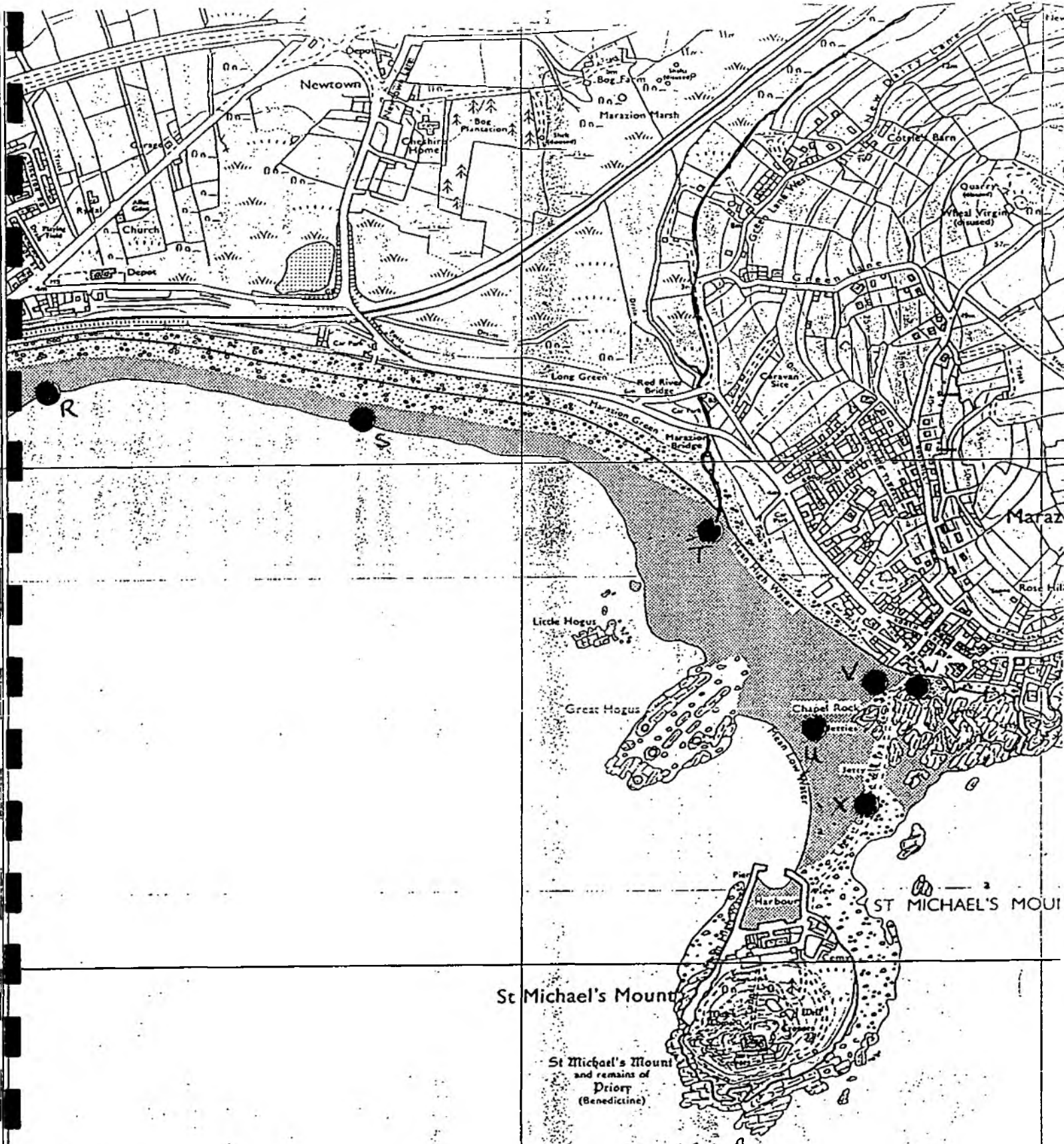


Figure 1. Sampling sites for the East side of the inner bay, 10 August 1989

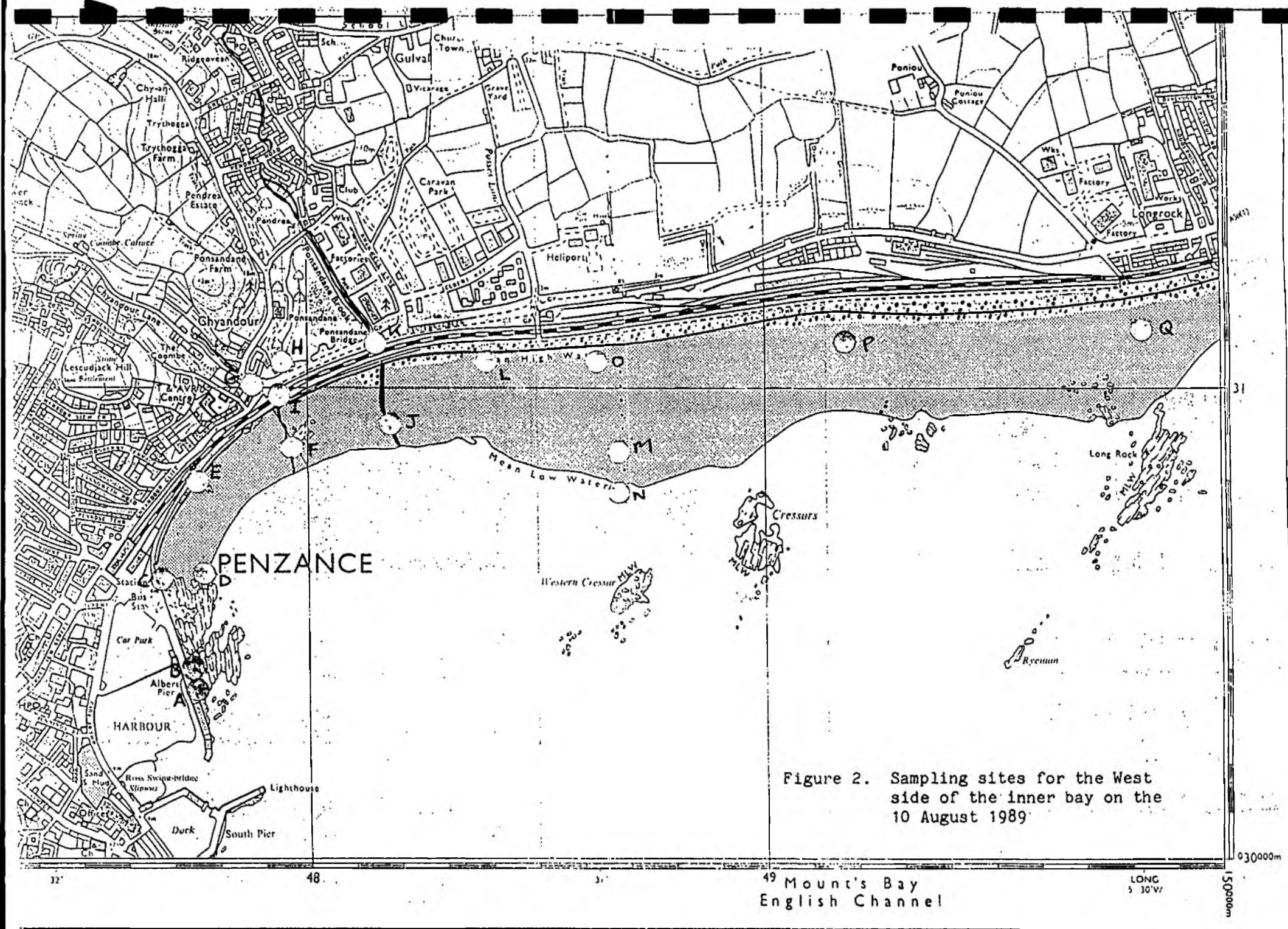


Figure 2. Sampling sites for the West side of the inner bay on the 10 August 1989

SW 43 SE