

NRA-South West 429

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-St.Agnes Spore and Dye Survey-  
- 10/8/95-

-Tidal Water Quality-  
-November 1995-

TWO/95/16

Status: Draft

110



ENVIRONMENT AGENCY

**Information Services Unit**

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Due Date

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Author: Paul Salmon



0401

St. Agnes - Spore and Dye Survey - 10/8/95 - Spring Tide

### 1.0 Introduction

This survey was carried out as part of the NRA's assessment of the application by SWWSL to discharge sewage via a new outfall 600m west of the EC bathing water of Trevaunance Cove.

The main aim of the survey was to determine the dilutions available to an effluent discharge, between the new outfall location (NGR: SW 7154 5173) and the EC Bathing Water of Trevaunance Cove, on the flood tide. From SWWSL's site specific surveys (Ref 1) undertaken in September 1994, Trevaunance Cove bathing water could potentially be affected by effluent discharged on the early flood tide.

The survey work was defined by Tidal Water Quality and carried out by Cornwall Area Investigations in conjunction with Tidal Water Quality

### 2.0 Method

*B.globigii* spores were injected at the cliff base, in the immediate vicinity of the discharge point, together with intermittent dye dosing to indicate the general current flow and to mark the plume for sampling purposes.

This survey was undertaken on a spring tide with the predicted tidal times at Perranporth (4 km NE of St. Agnes) being:

10 August 1995		
	Time (BST)	Height (mAOD)
HW	05:30	6.8
LW	11:56	0.5
HW	17:43	7.2

Spore dosing began at 09:30 (HW+4), as a previous SWWSL survey of 28 September 1994 (Ref 1) indicated the flood tide could commence as early as this in the tidal cycle.

A buoyant spore solution was pumped down a long tube from the cliff top to the base of the cliffs at the outfall location. The end of the tube was weighted to ensure injection sub-surface, and supported approximately 0.75m above by a surface buoy. The dosing continued until 16:45 (HW-1).

Dye injection consisted of 2 litres of fluorescein (green) or rhodamine (red) diluted with fresh water to make up 20 litres of dye solution. Initially fluorescein was released at HW+4:05 (5 minutes after the *B.globigii* dosing started). A rhodamine release followed at 12:00 (LW): Due to the slow movement of the dye away from the discharge location no further dye releases were necessary.

Water sampling from a Rigid Inflatable Boat (RIB) was carried out from the visible dye patches and from a grid pattern within Trevaunance Cove. Position fixing was undertaken with the Global Positioning System. Raw positions were post-processed differentially utilising the NRA Manley house base station. This sampling was planned to be carried out over the flood tide and succeeding ebb. Temperature and salinity measurements were made concurrently with the water sampling from the RIB with a Hydrolab water quality probe. Water sampling from three locations on Trevaunance Cove Beach were planned to run for two full tidal cycles from the commencement of the *B.globigii* injection.

Photography was carried out from the cliff top to aid in the interpretation of the results.

### 3.0 Results and Discussion

Table 1 identifies each survey operation and its approximate timing.

Wind measurements and observations (Table 2) show strong easterly winds present throughout this survey in the offshore waters. In Trevaunance Cove a strong offshore wind prevailed and these conditions caused the survey to be curtailed early.

Sampling and measurement data from the boat and from the beach can be found in Appendices A and B respectively. Initial salinity measurements from the boat were thought to be suspect and the Hydrolab water quality probe was replaced, for salinity measuring, by a calibrated WTW salinometer which gave satisfactory results.

Figures 1 to 8 show dye patch progression and *B.globigii* concentrations at various times.

#### 3.1.1 Dye Patch Movement

Individual dye patch behaviour is discussed below.

##### *HW+4 Fluorescein Release*

This dye release initially moved east, hugging the cliffs, indicating that the flood tide was running. One hour later, at HW+5, the dye was observed to be heading west (Fig 2 and Plate 1).

By LW (Fig 3) the dye patch was still very visible, but elongated. The patch stretched several hundred metres from close to the dosing point along the base of the cliffs west. The furthest extent offshore the dye was visible was approximately 50m.

The fluorescein ceased moving west around LW. The dye subsequently made some progress eastwards (still close in to the cliffs) but only a small proportion of the still visible dye extended east of the dosing point at HW-4½ (Fig 5). Beyond HW-4 little progression was made easterly, against the strong winds. At no point did the dye encroach on the Trevaunance Cove Bathing Water. The strong easterly wind nullified any significant water movement eastwards in the surface layer. This produced a situation of minimal water movement around the discharge point leading to potentially poor dilution and dispersion in the hours immediately succeeding the dye release.

At approximately HW-4 the patch experienced strong westerly transport and headed off towards Newdowns Head (Fig 6).

### *LW Rhodamine Release*

A slow movement east was initially identified for this release. As with the HW+4 release eastward movement was noticeable up to approximately HW-4 when the dye became almost stationary making no headway against the wind. Plates 2 and 3 show the slow progression of the rhodamine eastwards between HW-4:40 and HW-3:40. After HW-4 the patch experienced some westerly movement, also becoming elongated, with dye still present as far east as Polberro Cove.

Plate 4 shows both of the dye patches heading west at HW-2:26.

### **3.1.2 B.Globigii Results**

A steady two litres/hour of the *B.globigii* solution was discharged between 9:30 and 16:45, at a measured concentration of  $2.67 \times 10^9$ /ml. This equates to a flux of  $1.48 \times 10^9$  *B.globigii*/second. Table 3 shows assumed faecal coliform fluxes from the proposed discharge assuming CAS treatment is employed giving a 1 log reduction in faecal coliforms. From Table 4 it can be seen that to equate the measured *B.globigii* concentrations in the water samples taken to potential faecal coliform concentrations the values must be multiplied by 0.3 - 0.72, depending on the scenario to be viewed.

The *B.globigii* distribution confirms the evidence from the dye that dispersion away from the discharge location was slow. Grid sampling from Trevaunance Cove shows several samples (Figs 3 and 5) with spore values up to 200,000/100ml. It is very likely that these large concentrations were due to either sampling and labelling error or gross contamination of the samples by an unknown mechanism. This conclusion is reached as no dye travelled further east than Polberro Cove and, the very high concentrations were higher than any other concentrations found bar one (which was within 50m of the discharge location).

#### 4.0 Conclusions

It is difficult to detect the onset of the flood tide and the subsequent ebb from the dye patch movements. The initial dye release at HW-4 changed direction frequently as shown below.

HW+4 movement East  
HW+5 movement West  
LW movement East  
HW-4 movement West

The strong easterly wind probably exerted a significant force on the surface waters even up to the point of overcoming flood tide transport, causing westerly surface transport to occur in favour of easterly, tidally induced movement. However, no one transport mechanism dominated, as can be seen by the fact that the dye changed direction often and over the 5½ hour observation period no dye was observed >500m from the dosing location.

The *B.globigii* concentrations can be enumerated to give faecal coliform equivalents. No meaningful numbers were present in or around Trevaunance Cove due to the minimal transport eastwards on this survey. The *B.globigii* samples from Trevaunance Cove with large spore concentrations present can be dismissed as suspect data.

The main aim of the survey was not achieved as no spores or dye reached Trevaunance Cove. Little movement away from the dosing site was experienced probably caused by the strong easterly wind field opposing any tidally induced westerly (flood) transport. The large residence time of any discharged effluent around the new outfall would lead to deposition of any solids in the immediate vicinity of the discharge. Under the environmental conditions experienced on this survey there would be no threat to the EC Bathing Water Directive at Trevaunance Cove but these conditions were in no way worst case.

#### 5.0 Reference

- 1) South West Water Services Ltd, St. Agnes Site Specific Study, November 1994.



**Table 2: Wind Record**

Filename: GPS.wk4

Time (BST)	Location	Speed (Force)	Direction (Deg)	Comments
09:30	Cliff Top	3	90	
10:05	Cliff Base	1 - 2	360	Gusty
10:10	Offshore	4 - 5	90	Gusty
11:15	Offshore	4	90	
12:10	Offshore	4 - 5	90	Gusty
12:40	Offshore	4 - 5	90	V.Gusty
13:10				Wind under cliffs is much weaker than offshore.
14:20	Offshore	1 - 4	90	Gusty
14:25	Trevaunance Cove	<4	180	Offshore
15:20	Offshore	4	90	Sheltered close to cliffs.
15:50	Cliff Top	4 - 5	90	
16:00	Trevaunance Cove	2 - 3	180	Offshore
17:15	Trevaunance Cove	Gusting 6	180	Offshore
17:20	Offshore	4	90	Steady
18:45	Cliff Top	5	90	

**Table 3: Predicted Coliform Fluxes**

Design Horison	Scenario	Predicted Flow (l/s) *	Effluent ** F. Coliform Concentration (no/100ml)	Effluent F. Coliform Flux (no/sec)
2001	Summer DWF	14.56	3.00E+06	4.37E+08
	Summer FTFT	27.54	3.00E+06	8.26E+08
2021	Summer DWF	17.29	3.00E+06	5.19E+08
	Summer FTFT	35.73	3.00E+06	1.07E+09

\* Ref: South West Water, St. Agnes Sewerage Scheme - Engineering Criteria Statement, 1994.

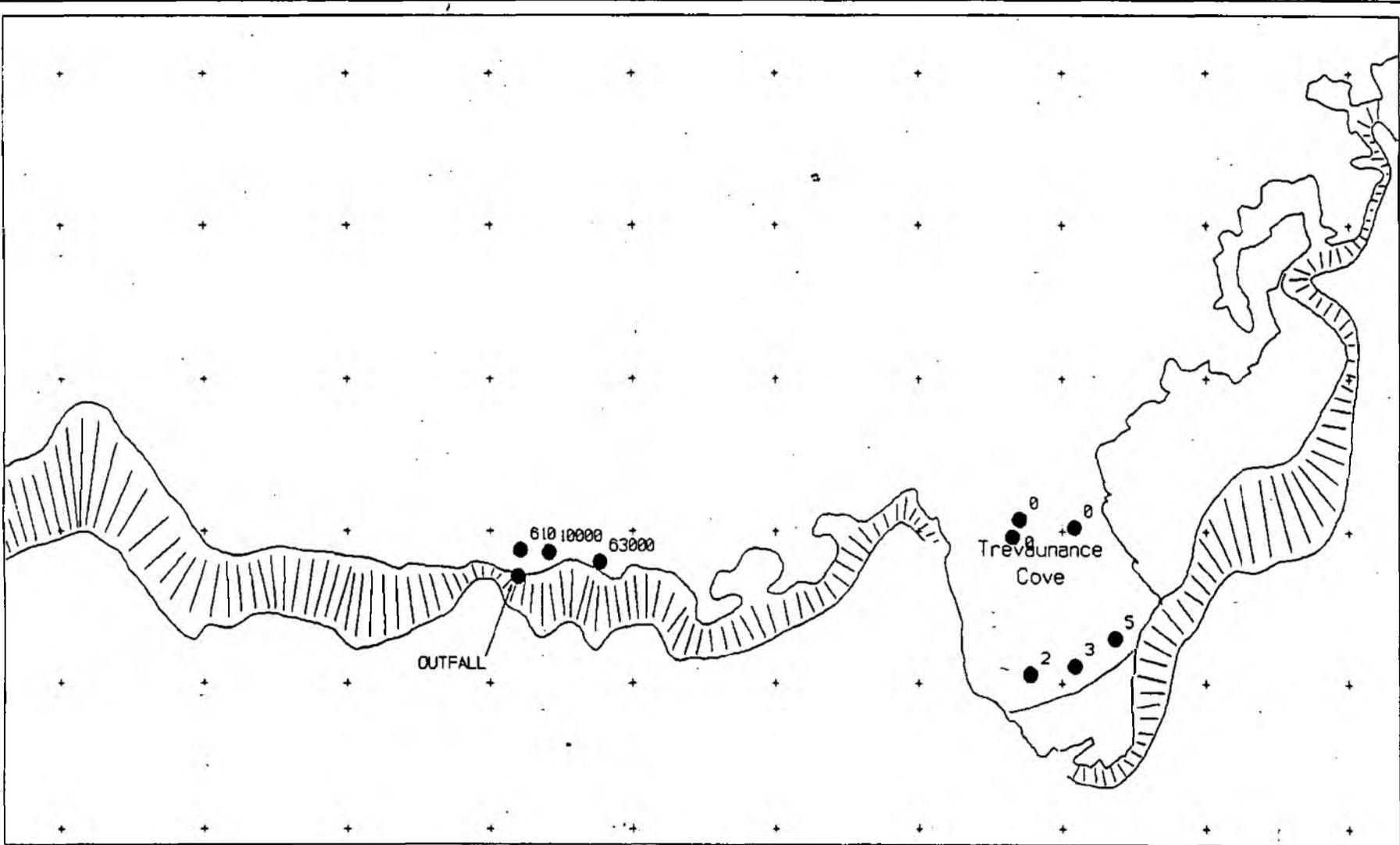
\*\*Assumes - 1) Crude Sewage F.Coliform Concentration of 3.00E+07/100ml

2) 1 Log Reduction in F.Coliforms via CAS Treatment Process

**Table 4: B.Globigii : F.Coliform Ratio**

Design Horison	Scenario	1 B.Globigii Equivalent To	
2001	Summer DWF	0.30	F.Coliforms
	Summer FTFT	0.56	F.Coliforms
2021	Summer DWF	0.35	F.Coliforms
	Summer FTFT	0.72	F.Coliforms

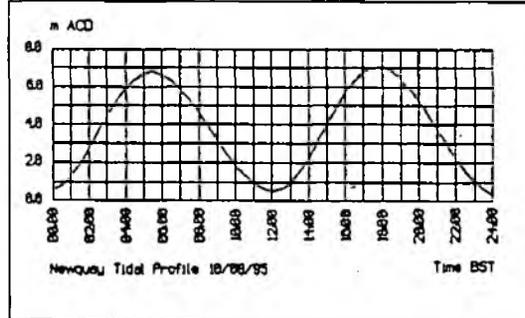
Assumes - B.Globigii Flux of 1.48E+09/sec (from Section 3.1.2).

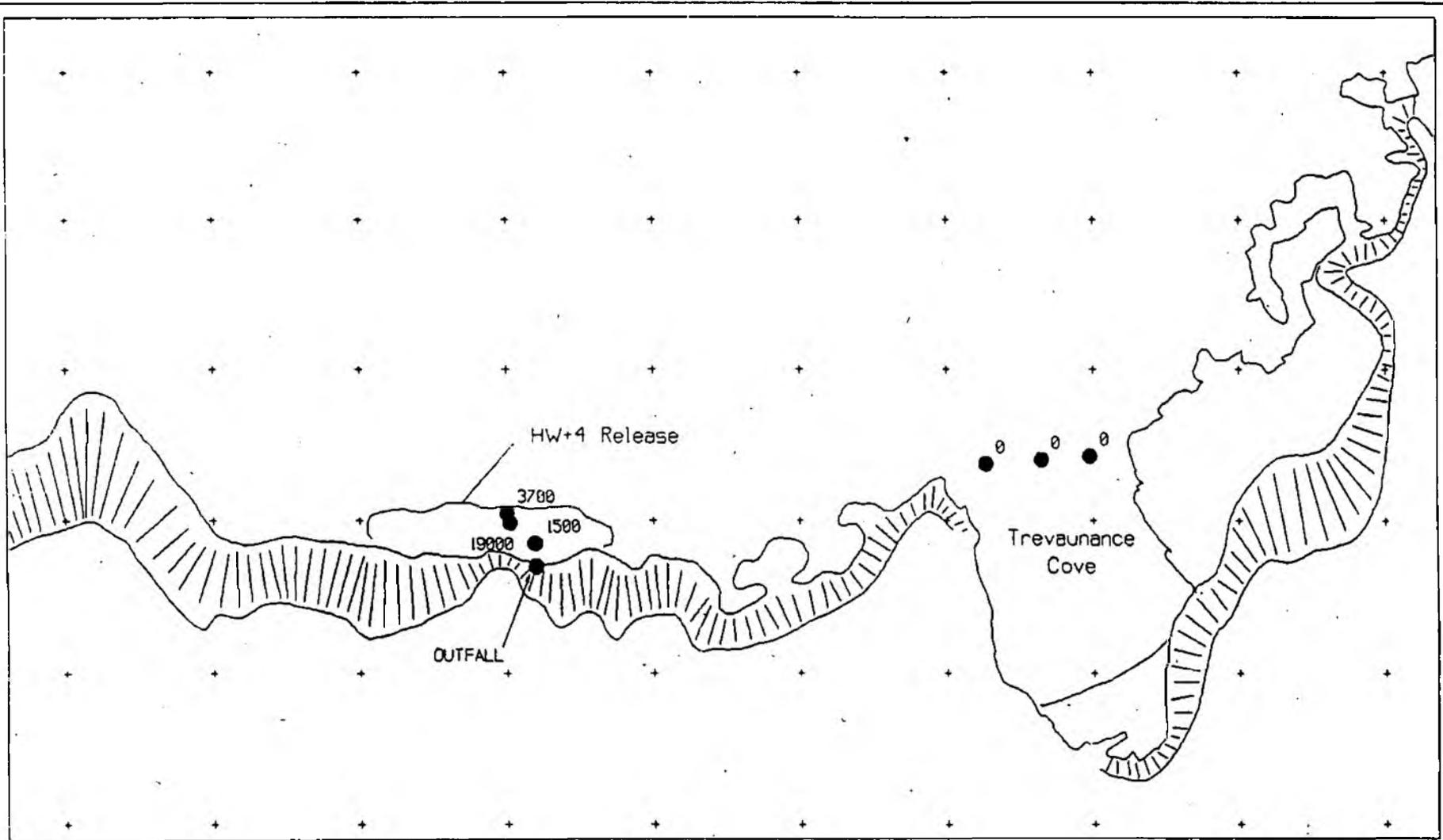


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Figure: 1

St Agnes  
Bacillus Globigii Survey  
10th August 1995  
10:00 to 10:28 BST  
HW+4:30 to HW+4:58

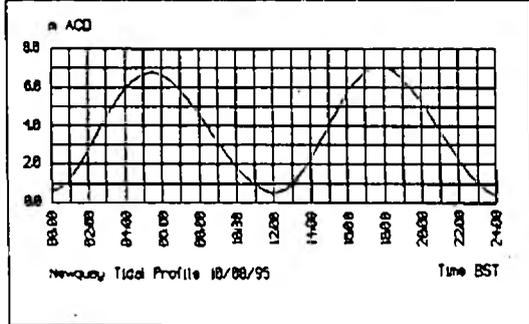




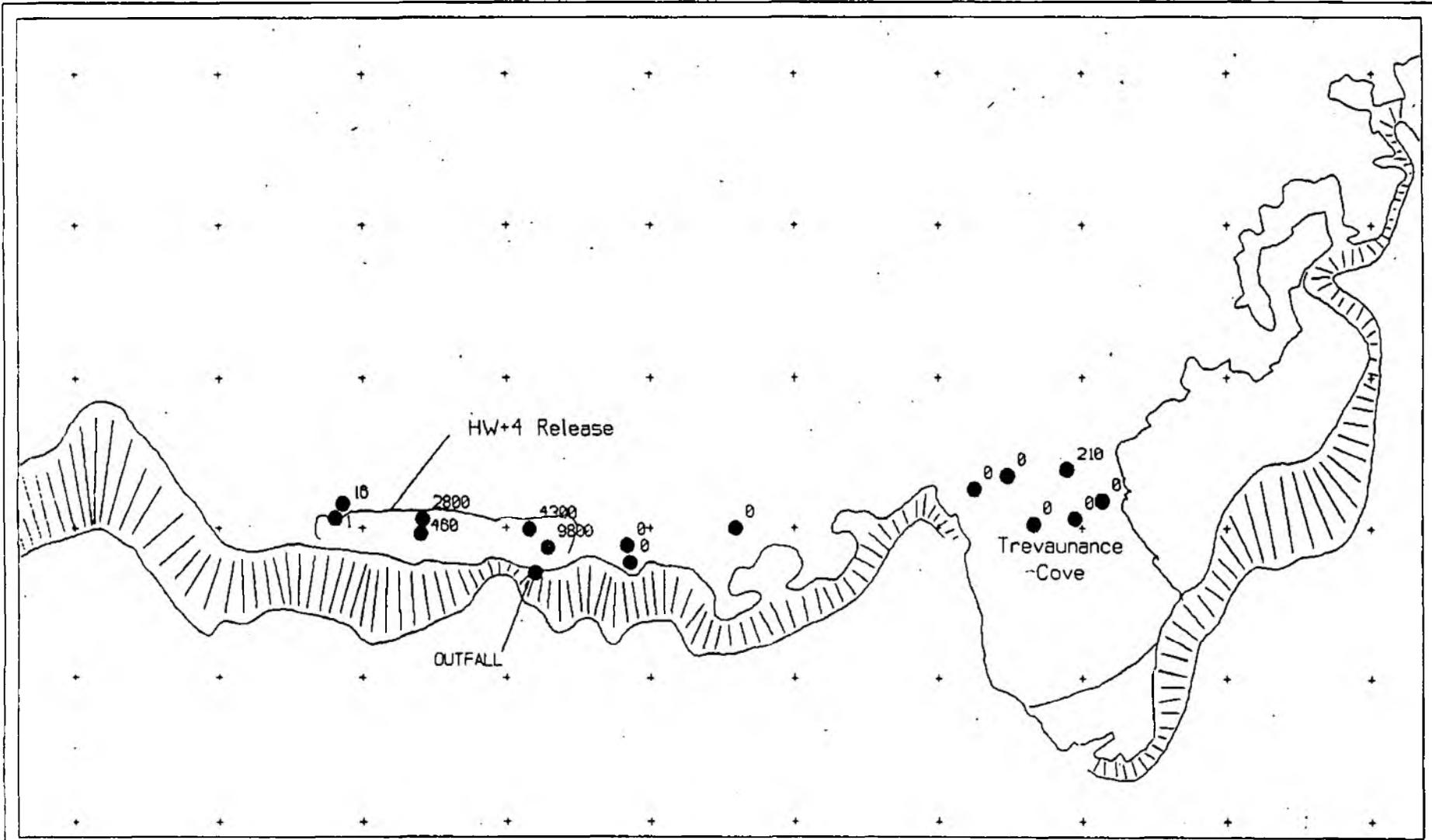
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TIDAL WATER QUALITY

Figure: 2

St Agnes  
Bacillus Globigii Survey  
10th August 1995  
10:45 to 11:15 BST  
HW+5:14 to HW+5:44



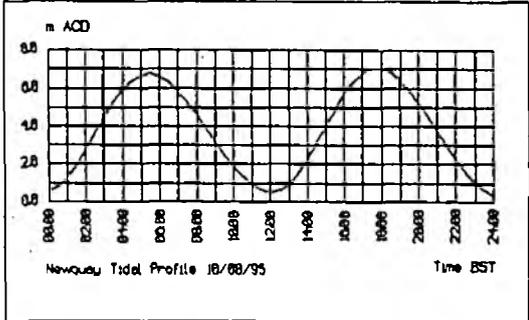
●<sup>0</sup> B.Globigii / 100ml  
Patch delimited  
by DGPS



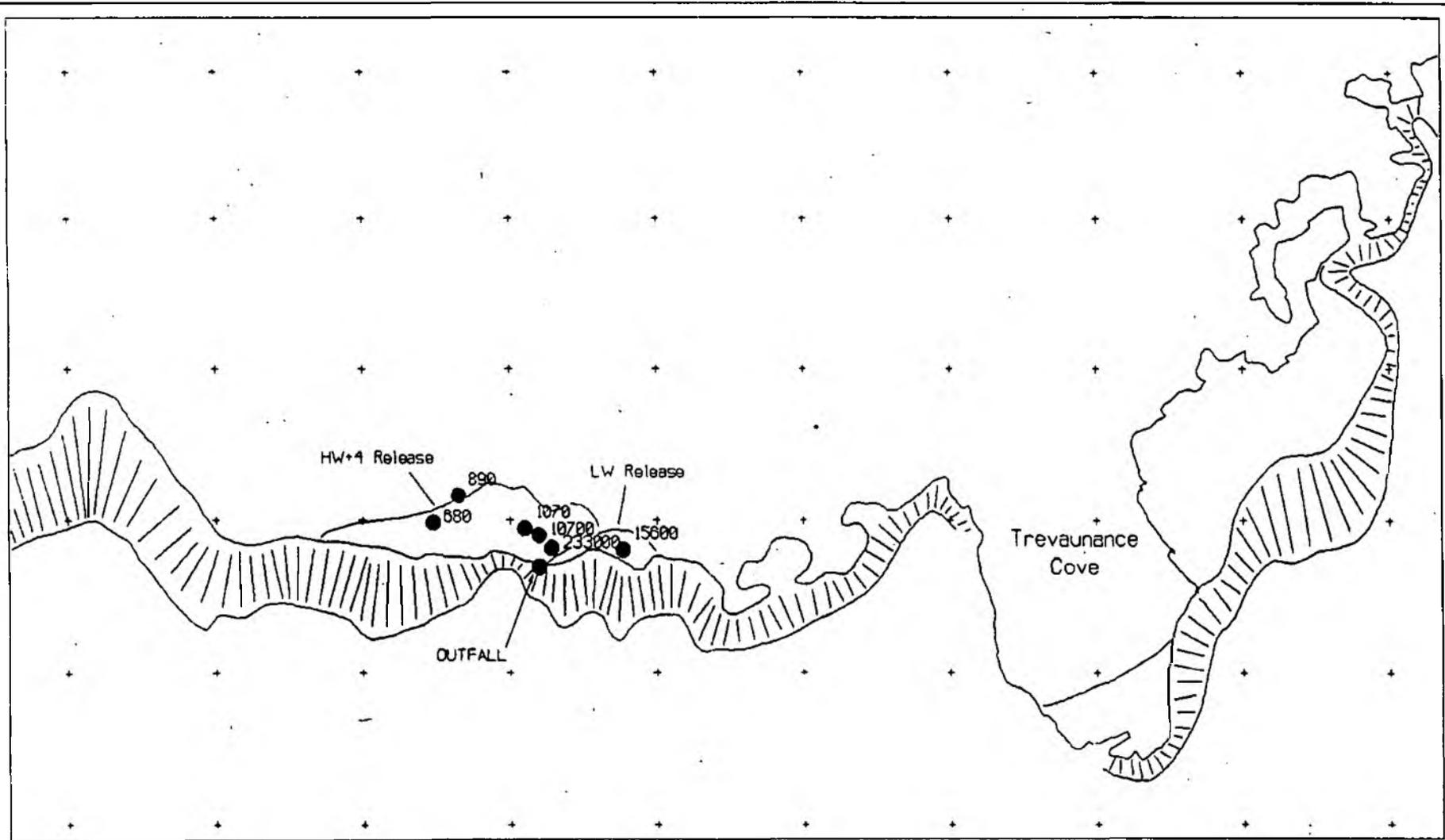
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TOTAL WATER QUALITY

Figure: 3

St Agnes  
Bacillus Globigii Survey  
10th August 1995  
12:00 to 12:36 BST  
HW+6:30 to HW-5:07

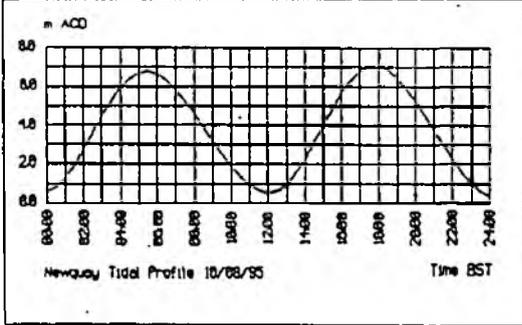


● B.Globigii / 100ml  
Patch delimited  
by DGPS



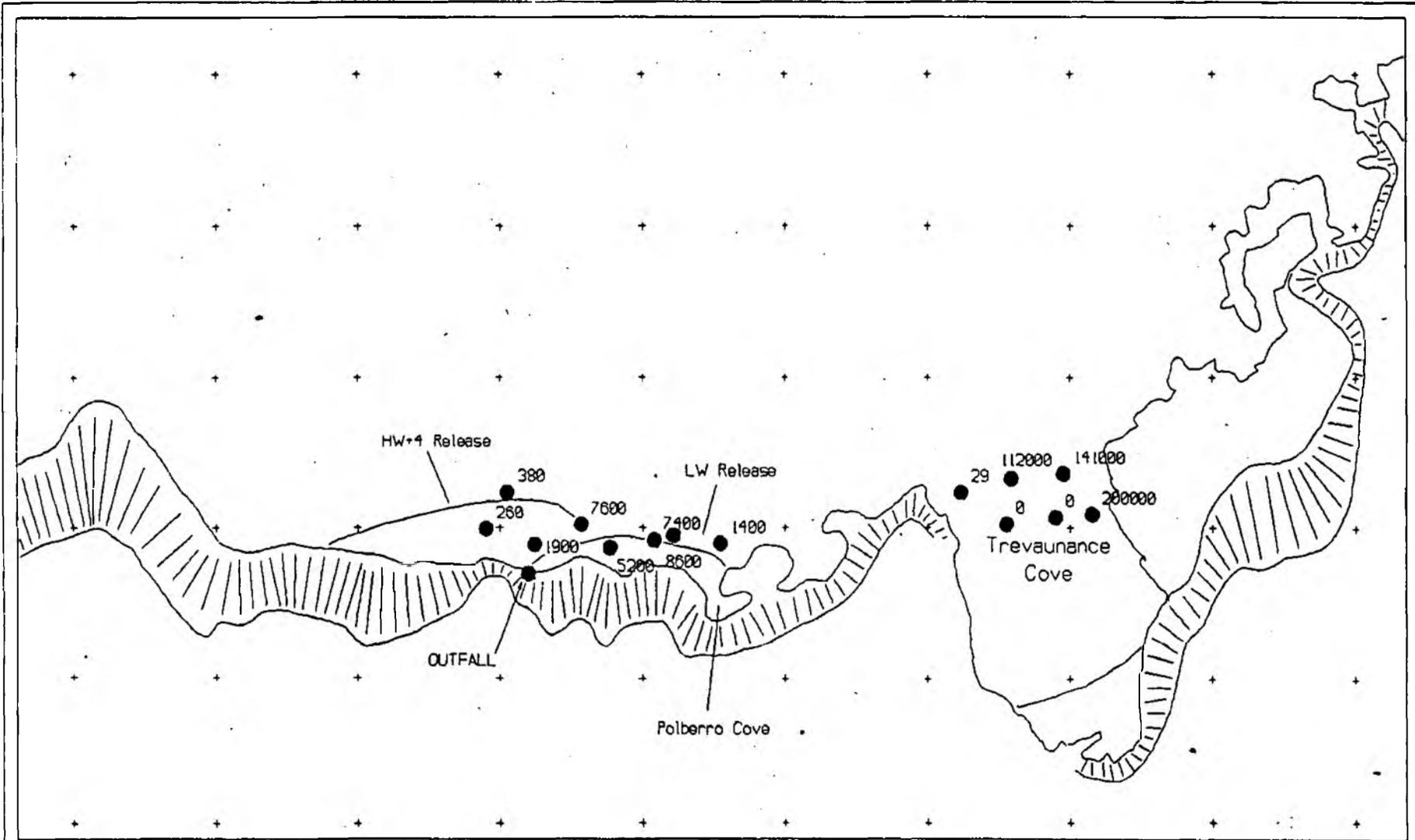
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 TIDAL WATER QUALITY

St Agnes  
 Bacillus Globigii Survey  
 10th August 1995  
 13:00 to 13:12 BST  
 HW-4:43 to HW-4:31



● 15600  
 B.Globigii / 100ml  
 Approximate Patch  
 Positions Only

Figure: 4

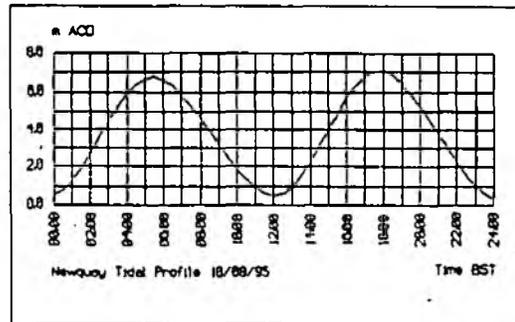


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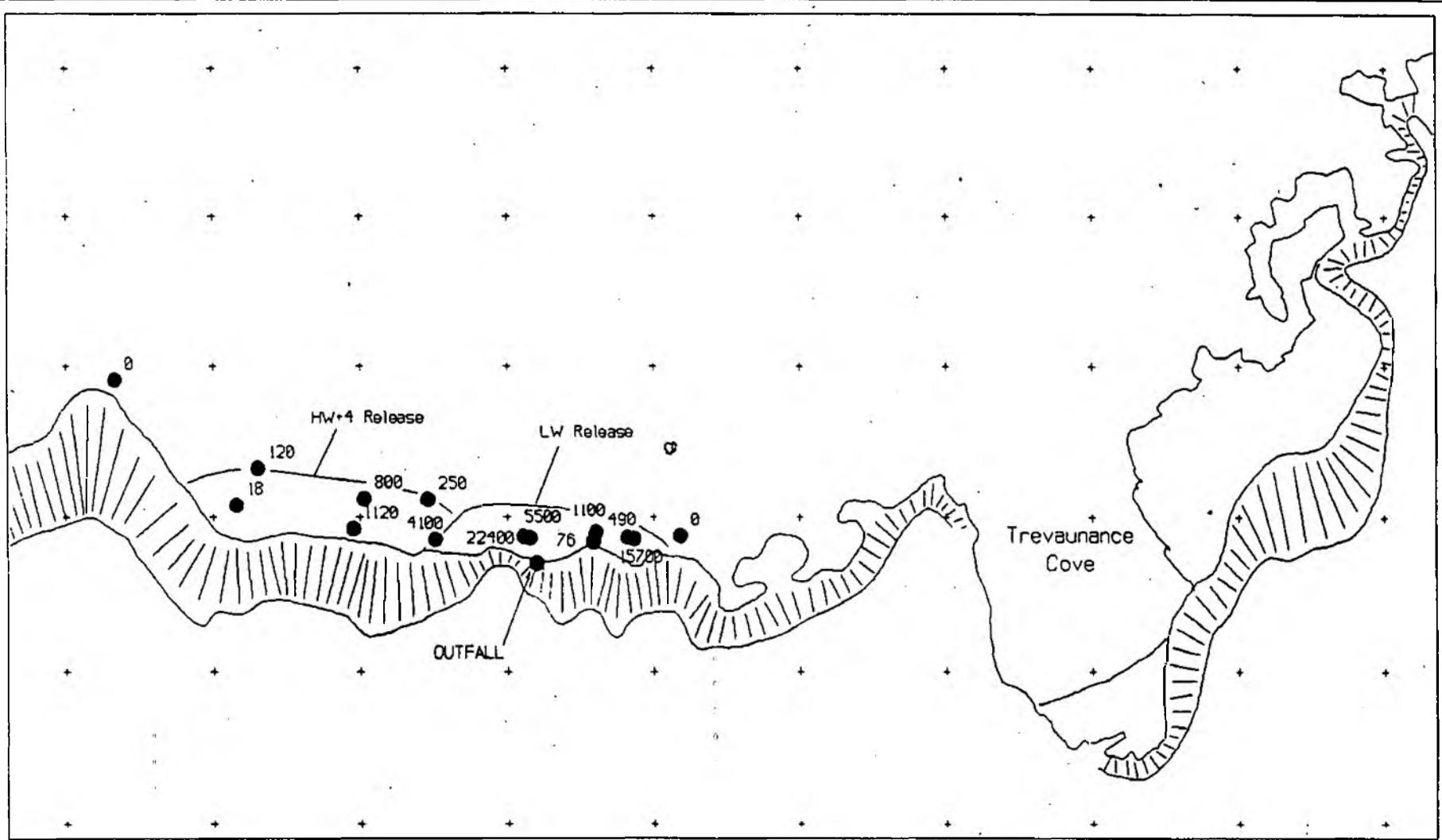
Figure: 5

St Agnes  
Bacillus Globigii Survey

10th August 1995  
14:00 to 14:20 BST  
HW-3:43 to HW-3:23

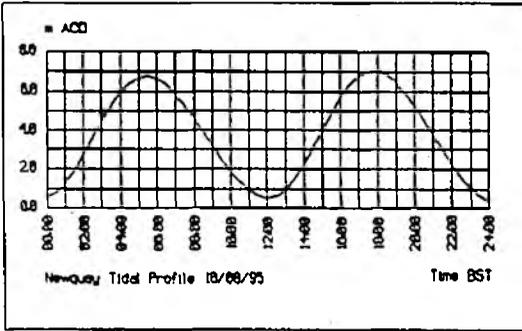


●<sup>29</sup> B.Globigii / 100ml  
Approximate Patch  
Positions Only



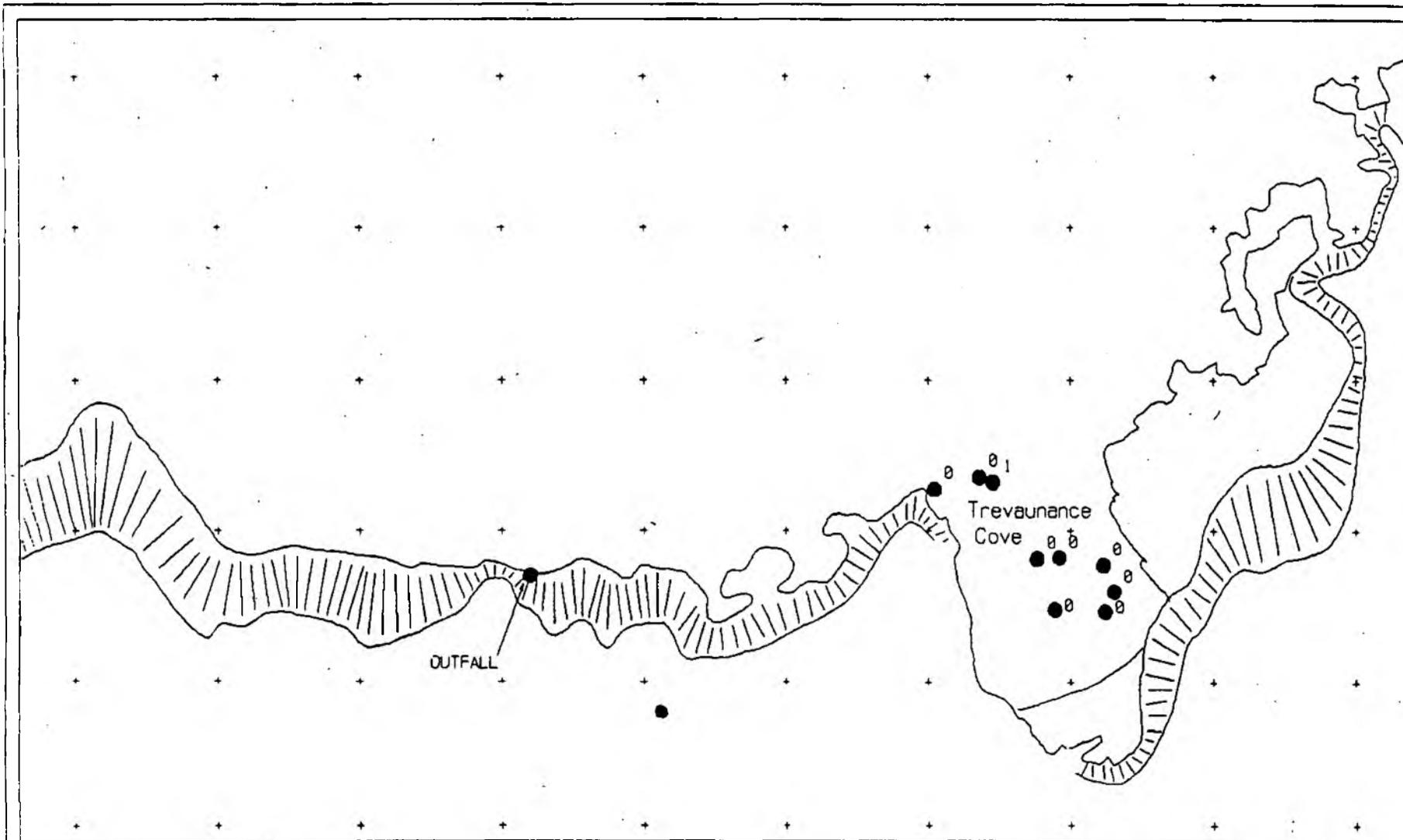
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South Western Region  
TIDAL WATER QUALITY

St Agnes  
Bacillus Globigii Survey  
10th August 1995  
15:00 to 15:25 BST  
HW-2:43 to HW-2:18



● 120  
B. Globigii / 100ml  
Approximate Patch  
Positions Only

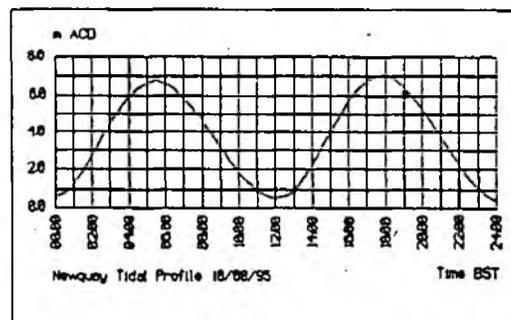
Figure: 6



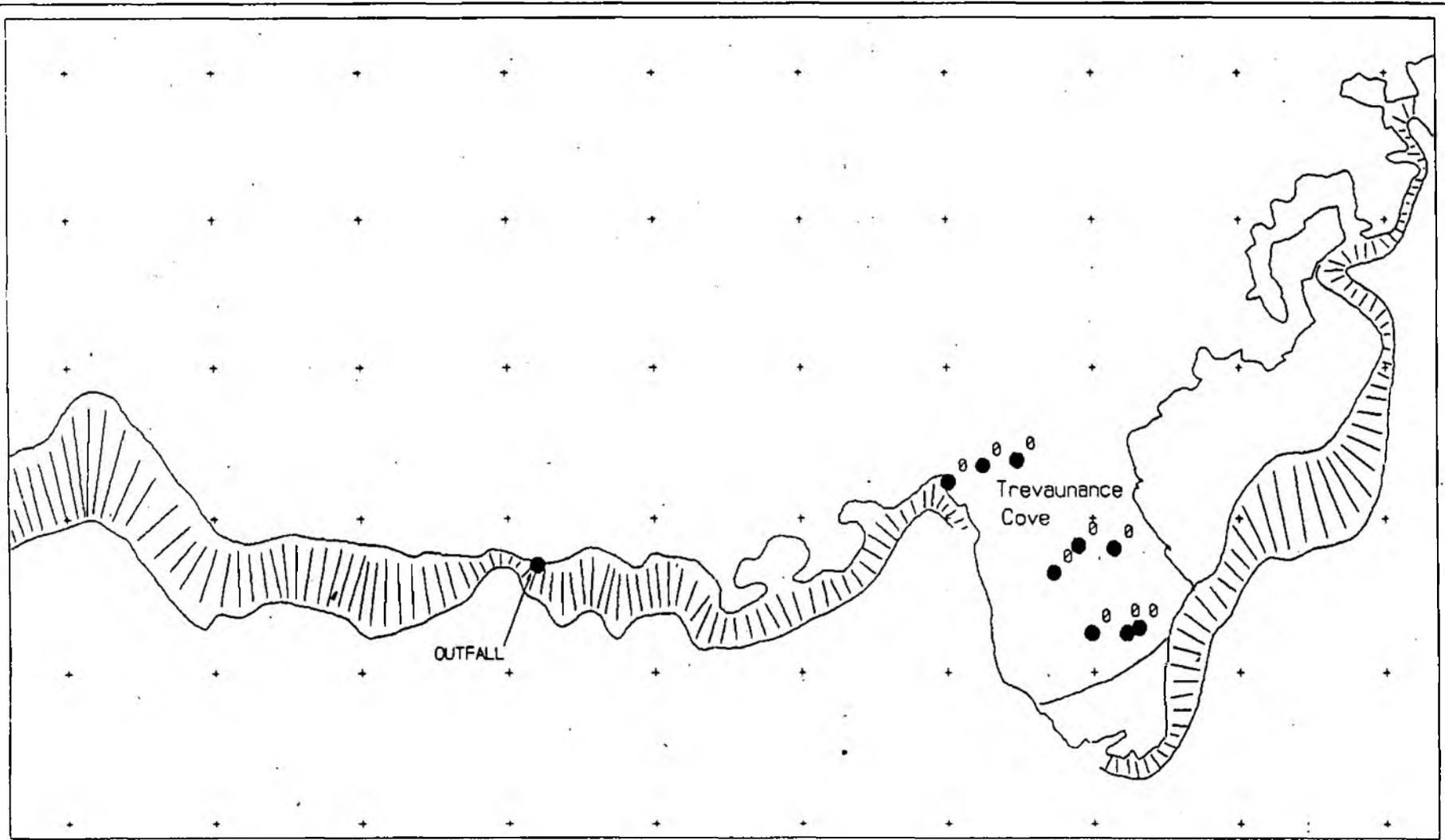
**NRA**  
National Rivers Authority  
South Western Region  
TIDAL WATER QUALITY

Figure: 7

St Agnes  
Bacillus Globigii Survey  
10th August 1995  
16:00 to 16:15 BST  
HW-1:43 to HW-1:28



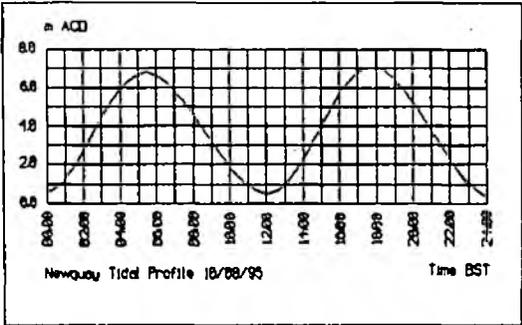
● B.Globigii / 100ml



**NRA**  
National Rivers Authority  
South Western Region  
TOTAL WATER QUALITY

**St Agnes  
Bacillus Globigii Survey**

10th August 1995  
17:00 to 17:15 BST  
HW-0:43 to HW-0:28



● *B.Globigii* / 100ml

Figure: 8

APPENDIX A: BOAT DATA

Filename: GPS.wk4

Time (GPS)			NGR		Site Name	Time (BST)	Depth (m)	Salinity (ppt)	Temperature (Deg C)	B.Globigii (no/100ml)
H	M	S	E	N						
9	0	30	171443.33	51774.44	1/1	10:00	0.1 1.0	28.5 28.6	17.12 17.07	610
9	2	50	171483.20	51771.58	1/2	10:03	0.1 1.0	28.6 28.6	17.06 17.07	10000
9	6	30	171554.27	51759.00	1/3	10:06	0.1 1.0	28.7 28.6	16.98 17.00	63000
9	20	50	172130.72	51792.72	1/4	10:21	0.1 1.0	35.4 35.4	17.32 17.23	0
9	26	10	172140.55	51816.23	1/5	10:26	0.1 1.0	35.3 35.4	17.36 17.36	0
9	28	30	172216.59	51805.75	1/6	10:28	0.1 1.0	34.6 35.2	17.87 17.41	0
9	39	0	172053.73	51874.75	1/7	10:39	0.1 1.0		17.2 17.1	0
9	40	30	172129.41	51880.63	1/8	10:40	0.1 1.0		17.6 17.3	0
9	42	0	172195.39	51885.39	1/9	10:42	0.1 1.0		17.3 17.1	0
10	2	30	171400.23	51809.75	1/10	11:02	0.1 1.0	34.8 35.0	17.5 17.4	3700
10	3	30	171404.66	51797.02	1/11	11:03	0.1 1.0	35.0 35.0	17.4 17.3	19000
10	5	10	171438.42	51770.08	1/12	11:05	0.1 1.0	35.0 35.0	17.4 17.3	1500
11	0	50	171457.39	51774.44	1/13	12:01	0.1 1.0	34.9 35.0	17.5 17.5	9800
11	1	50	171432.29	51798.87	1/14	12:02	0.1 1.0	35.0 35.0	17.6 17.4	4300
11	7	40	171284.09	51812.11	1/15	12:07	0.1 1.0	35.0 35.0	17.5 17.5	2800
11	8	40	171280.92	51792.48	1/16	12:08	0.1 1.0	35.0 35.1	17.5 17.5	460
11	10	50	171173.17	51826.42	1/17	12:11	0.1 1.0	35.0 35.0	17.4 17.4	16
11	11	50	171162.67	51813.56	1/18	12:12	0.1 1.0	35.0 35.0	17.5 17.5	1
11	22	50	171567.78	51776.67	1/19	12:23	0.1 1.0	34.9 35.0	17.5 17.5	0
11	24	50	171572.03	51753.66	1/20	12:25	0.1 1.0	34.9 35.0	17.5 17.4	0
11	25	30	171718.33	51798.86	1/21	12:25	0.1 1.0	34.9 35.0	17.3 17.2	0

## APPENDIX A: BOAT DATA

Filename: GPS.wk4

H	Time (GPS)			NGR		Site Name	Time (BST)	Depth (m)	Salinity (ppt)	Temperature (Deg C)	B.Globigii (no/100ml)
	M	S	E	N							
11	30	50	172050.67	51851.67	1/22	12:31	0.1 1.0	34.9 34.9	17.7 17.7	0	
11	32	0	172096.53	51869.47	1/23	12:32	0.1 1.0	34.9 35.0	17.7 17.5	0	
11	33	0	172178.98	51877.72	1/24	12:33	0.1 1.0	35.0 35.0	17.8 17.4	210	
11	34	20	172228.00	51836.44	1/25	12:34	0.1 1.0	34.8 34.9	18.4 17.7	0	
11	35	30	172190.19	51812.58	1/26	12:35	0.1 1.0	35.0 35.0	17.6 17.4	0	
11	36	30	172133.09	51805.16	1/27	12:36	0.1 1.0	35.0 35.1	17.5 17.4	0	
12	1	0	171420.13	51789.13	2/1	13:01	0.1 1.0	34.9 35.0	17.7 17.6	1070	
12	2	0	171439.02	51780.31	2/2	13:02	0.1 1.0	35.0 35.0	17.7 17.6	10700	
12	4	40	171329.98	51832.56	2/3	13:04	0.1 1.0	35.0 35.0	17.5 17.5	890	
12	6	0	171295.58	51797.16	2/4	13:06	0.1 1.0	35.1 35.1	17.6 17.6	680	
12	11	10	171553.59	51761.69	2/5	13:11	0.1 1.0	34.8 34.9	17.7 17.6	15600	
12	12	30	171456.03	51763.75	2/6	13:12	0.1 1.0	35.0 35.0	17.5 17.5	233000	
13	0	30	171709.14	51778.94	2/10	14:00	0.1 1.0	34.9 34.9	17.7 17.7	1400	
13	2	10	171643.11	51789.39	2/11	14:02	0.1 1.0	35.0 34.9	17.7 17.7	8600	
13	3	10	171616.06	51783.33	2/12	14:03	0.1 1.0	34.7 34.9	17.7 17.6	7400	
13	4	40	171554.02	51773.83	2/13	14:04	0.1 1.0	34.8 35.0	17.8 17.7	5200	
13	6	0	171513.86	51804.47	2/14	14:06	0.1 1.0	35.0 35.0	17.8 17.7	7600	
13	7	30	171448.52	51778.39	2/15	14:07	0.1 1.0	35.1 35.1	17.9 17.8	1900	
13	9	0	171380.50	51798.81	2/16	14:09	0.1 1.0	35.0 35.0	17.7 17.7	260	
13	10	30	171410.42	51846.97	2/17	14:10	0.1 1.0	35.0 35.1	17.7 17.5	380	
13	14	40	172047.13	51847.27	2/18	14:14	0.1	35.0	17.7	29	

## APPENDIX A: BOAT DATA

Filename: GPS.wk4

Time (GPS)			NGR		Site Name	Time (BST)	Depth (m)	Salinity (ppt)	Temperature (Deg C)	B.Globigii (no/100ml)
H	M	S	E	N						
							1.0	35.0	17.6	
13	15	50	172117.38	51865.55	2/19	14:16	0.1	35.1	17.5	112000
							1.0	35.1	17.5	
13	16	50	172190.50	51871.91	2/20	14:17	0.1	35.1	17.5	141000
							1.0	35.1	17.5	
13	18	10	172230.80	51818.44	2/21	14:18	0.1	35.1	17.6	200000
							1.0	35.1	17.5	
13	19	20	172179.91	51814.55	2/22	14:19	0.1	35.1	17.5	0
							1.0	35.1	17.5	
13	20	20	172110.98	51805.36	2/23	14:20	0.1	34.8	18.2	0
							1.0	34.8	18.1	
13	59	50	171637.09	51775.58	2/24	15:00	0.1	34.9	17.9	0
							1.0	35.0	17.8	
14	1	50	171572.20	51771.53	2/25	15:02	0.1	34.9	17.7	15700
							1.0	35.0	17.5	
14	3	20	171563.52	51773.05	2/26	15:03	0.1	35.0	17.8	490
							1.0	35.0	17.8	
14	5	20	171520.55	51780.22	2/27	15:05	0.1	35.0	17.7	1100
							1.0	35.0	17.7	
14	6	30	171516.78	51767.84	2/28	15:06	0.1	35.1	17.7	76
							1.0	35.1	17.7	
14	8	10	171430.50	51772.70	2/29	15:08	0.1	35.0	17.7	5500
							1.0	35.1	17.7	
14	9	40	171421.67	51774.23	2/30	15:09	0.1	35.0	17.7	22400
							1.0	35.0	17.7	
14	13	0	171302.03	51771.03	2/31	15:13	0.1	35.0	17.7	4100
							1.0	35.0	17.7	
14	15	0	171292.38	51824.30	2/32	15:15	0.1	35.2	17.7	250
							1.0	35.1	17.6	
14	16	30	171191.30	51784.56	2/33	15:16	0.1	35.1	17.7	1120
							1.0	35.1	17.7	
14	17	50	171205.70	51823.11	2/34	15:18	0.1	35.1	17.6	800
							1.0	35.1	17.6	
14	19	20	171031.83	51816.56	2/35	15:19	0.1	35.1	17.6	18
							1.0	35.1	17.7	
14	21	10	171060.95	51865.11	2/36	15:21	0.1	35.1	17.7	120
							1.0	35.1	17.7	
14	22	50	170847.31	51958.78	2/37	15:23	0.1	35.1	17.5	0
							1.0	35.1	17.5	
15	0	0	172153.25	51762.45	2/38	16:00	0.1	35.0	18.9	0
							1.0	34.8	18.5	

## APPENDIX A: BOAT DATA

Filename: GPS.wk4

Time (GPS)			NGR		Site Name	Time (BST)	Depth (m)	Salinity (ppt)	Temperature (Deg C)	B.Globigii (no/100ml)
H	M	S	E	N						
15	1	10	172184.06	51763.80	2/39	16:01	0.1 1.0	35.1 34.8	18.4 19.0	0
15	2	30	172245.80	51754.30	2/40	16:02	0.1 1.0	34.6 34.6	19.8 18.6	0
15	3	50	172261.09	51718.64	2/41	16:04	0.1 1.0	34.6 34.7	18.8 18.7	0
15	4	50	172248.17	51692.20	2/42	16:05	0.1 1.0	34.8 34.9	17.8 17.7	0
15	6	30	172177.92	51694.08	2/43	16:06	0.1 1.0	35.0 35.1	17.8 17.7	0
15	11	10	172091.59	51864.38	2/44	16:11	0.1 1.0	35.1 34.9	18.2 17.7	1
15	12	20	172072.28	51871.28	2/45	16:12	0.1 1.0	35.0 35.1	18.4 18.3	0
15	13	20	172009.17	51855.38	2/46	16:13	0.1 1.0	35.1 35.1	17.7 17.6	0
16	0	20	172262.09	51657.38	2/47	17:00	0.1 1.0	34.8 34.9	18.0 17.7	0
16	1	40	172246.09	51650.84	2/48	17:01	0.1 1.0	35.0 35.0	17.8 17.7	0
16	2	40	172197.63	51650.64	2/49	17:02	0.1 1.0	35.0 35.0	17.8 17.7	0
16	3	50	172145.78	51728.92	2/50	17:04	0.1 1.0	35.0 35.0	17.8 17.8	0
16	5	20	172179.97	51764.34	3/1	17:04	0.1 1.0	35.0 35.0	17.7 17.7	0
16	7	40	172228.66	51760.73	3/2	17:07	0.1 1.0	35.0 35.0	17.9 17.9	0
16	9	40	172095.98	51877.11	3/3	17:09	0.1 1.0	35.0 35.0	17.8 17.8	0
16	10	30	172049.22	51869.63	3/4	17:10	0.1 1.0	35.1 35.1	17.6 17.6	0
16	11	20	172002.16	51848.08	3/5	17:11	0.1 1.0	35.1 35.1	17.5 17.5	0

**APPENDIX B: BEACH DATA**

Time (BST)	West			Centre			East		
	Temp (Deg C)	Salinity (ppt)	Globigii (no/100ml)	Temp (Deg C)	Salinity (ppt)	Globigii (no/100ml)	Temp (Deg C)	Salinity (ppt)	Globigii (no/100ml)
10:02	17.3	35.6	2	17.4	35.1	3	17.5	35.5	5
10:32	17.6	35.5	1	17.6	35.2	1	17.8	35.5	0
11:32	18.3		0	17.9	35.4	0	18.2	35.4	0
12:47	18.7		0	19.2		0	17.9		0
13:47	19.5	33.3	0	19.2	33.2	0	19.9	33.5	0
14:47	18.4	34.1	0	21	33.2	0	20.5	33.7	0
15:47	18.3	33.7	0	18.4	34	1	18.9	34.1	0
16:47	18	34	0	18	34.7	0	18	34	0
17:50	18	34	2	18	34.1	0	18	34	0



Plate 1: Initial dye release (HW+4) heading west at 10:55 BST (HW+5:25). Photo taken from directly above the discharge location looking west



**Plate 2:** LW rhodamine release at 13:04 BST  
(HW-4-39) taken from above the discharge  
location looking east



**Plate 3:** LW rhodamine release at 14 05 BST (HW-3.38) taken from above the discharge location looking east. Some fluorescence from the HW-4 release can be seen to the left of the rhodamine.

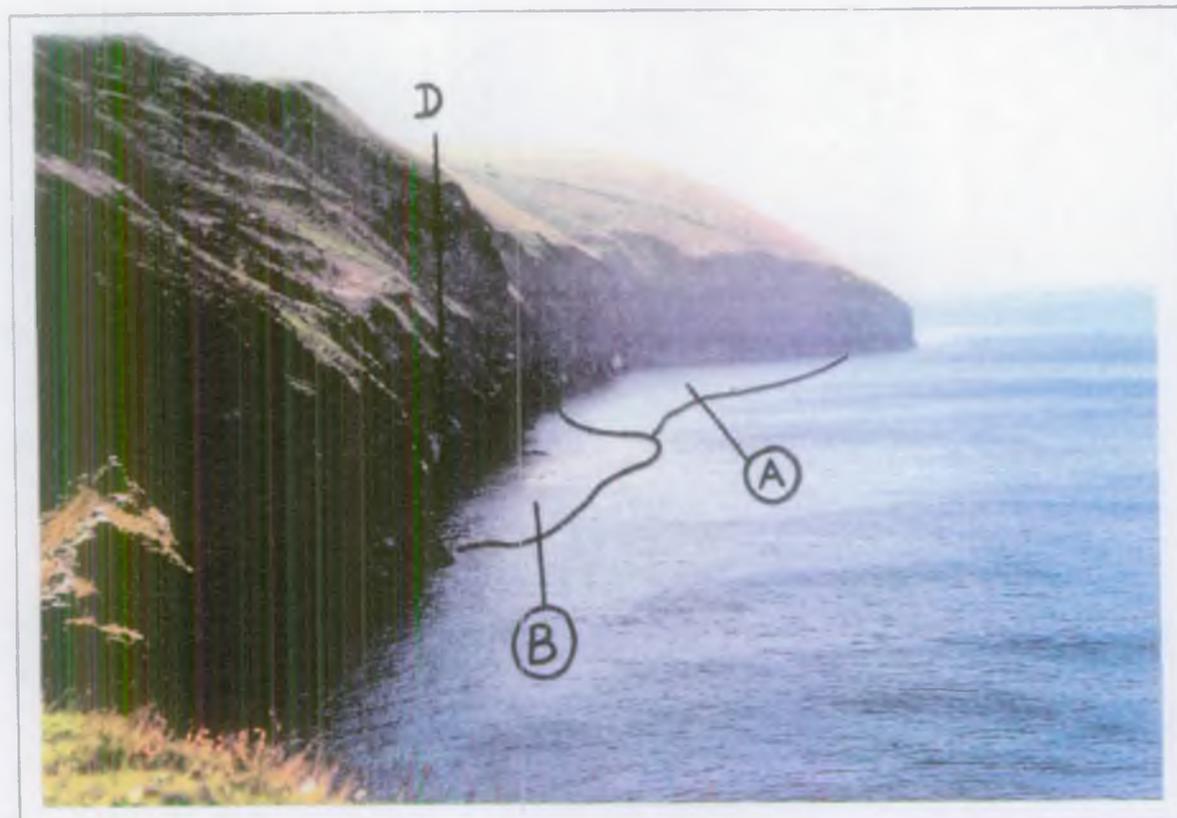


Plate 4: HW-4 fluorescein patch (area 'A') and LW rhodamine patch (area 'B') heading west at 15:17 (HW-2:26). Discharge location marked 'D'.