NRA NORTH WEST 88

MSP-004

SEABURN SEWER SURVEY

05-07 August 1991

Marine and Special Projects Section
N.R.A. North West

September 1991

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INTRODUCTION

Seascale beach is a designated Bathing Water under European Community Directive 76/160/EEC. The beach has failed to comply with the 'mandatory' standards for indicator organisms. The principal sources of contamination are believed to be:

- the adjacent discharge of screened sewage from the North West Water plant serving Seascale,
- storm sewage contamination of Seascale stream.

Some 3 km to the north, domestic sewage from the British Nuclear Fuel Ltd (BNFL) Sellafield complex is discharged via an outfall known as the *Seaburn Sewer*, located at the confluence of the Rivers Ehen and Calder. The Seaburn Sewer conveys miscellaneous plant drainage as well as the treated sewage effluent which flows into the sewer close to its outfall. Although the sewage from BNFL receives secondary treatment (diffused air Activated Sludge plant), the population served is considerably greater than Seascale Village, and has reached 14,000 in the recent past.

OBJECTIVE

This survey was carried out in order to determine whether the discharge from the BNFL sewage treatment plant has a significant impact on the bacterial counts found at Seascale beach, thereby contributing to the failure of the beach to meet EC standards.

METHODOLOGY

Treated effluent from the BNFL sewage treatment plant connects into the Seaburn Sewer approximately 100 m from its

outfall to the Calder/Ehen. At a manhole just downstream of this junction, two 30 kg drums of rhodamine B dye, together with one litre of *B. globigii* spores were added at about 08:35 on August 6th, approximately 30 minutes after local high water. The dye emerged from the outfall into the mouth of the Calder at 09:00. (High water Liverpool was at 07:59 (7.7m) and at 20:41 h (7.9m)).

BNFL provided a semi-rigid inflatable boat to follow the initial movement of the tracers along the coast. Seascale beach was sampled at various times following the release of the tracers in the manhole. Figure 1 shows the boat sampling positions along the coast together with the beach sampling points. It should be noted that beach sampling for EC monitoring purposes occurs at station 8.0.

Using equation (1) below, it is possible to quantify beach total coliform levels originating from the Seaburn sewer, using *B. globigii* concentr tions recorded on the beach. The same procedure applies to quantify beach *E. coli* levels.

$$N_c = N_g * R * e^{-kt} \qquad \text{(equation 1)}$$

where: N_c = predicted number of total coliforms on the beach
N_g = *B. globigii* concentration on the beach
R = (total coliforms / *B. globigii*) at source
k = total coliforms decay constant, based on when 90% of the population has died (T_{90})
t = time in decimal hour.

Depending on environmental conditions, T_{90} varies between 0.75 and 24 hours. Within these T_{90} limits, and using equation (1), estimates can be made of the percentage contribution of the Sellafield sewage to the observed coliform levels at Seascale beach - station 8.

RESULTS

All raw data can be found in Appendix 1.

The Seaburn Sewer was sampled from the manhole over a three hour period in order to evaluate the variability in the bacterial content of the sewage effluent (Seaburn Sewer flow was 5 027 m^3 over 24 hours, starting 8:15 on August 6th).

While some variations in coliform concentrations can be observed (Figure 2), it can be assumed that the overall quality of the effluent was reasonably constant during the survey. The mean coliform concentrations in the manhole are summarised:

TABLE 1	N	M	Mean	St.Dev.	St.Err.
Total coliforms	16	5	$3.2 * 10^5$	$4.7 * 10^4$	$1.2 * 10^4$
E. coli	17	4	$2.7 * 10^5$	$3.9 * 10^4$	$0.9 * 10^4$

N = number of samples
M = removal of inconsistent data
St.Dev. = Standard deviation
St.Err. = Standard error about the mean
Units = counts / 100 ml

Figure 3 illustrates the dilution of coliforms away from the mouth of the Calder, and outlines the similar behaviour of the two tracers along the coast. In Figures 4 and 5, variability in *B. globigii* concentrations on Seascale beach are shown with respect to time and station respectively.

Whilst the tracer was observed to move initially to the north before tracking in a southerly direction (Figure 5), results also show that some *B. globigii* remained near the mouth of the estuary, e.g. at station 8.5. Figure 4 shows the migration of the tracer along the beach with time; *B. globigii* reached a maximum concentration of 200 counts/100ml at station 8.4 during the 19:00 h run.

DISCUSSION

To calculate the 'R' parameter in equation 1, a ratio for coliforms / B. globigii at the source is needed, based on a system that is well mixed. It was assumed that the system was well mixed but still concentrated when the effluent/tracers reached the mouth of the Calder (Table 2). It is also reasonable to assume that no other coliform sources were present in the area.

TABLE 2	Manhole	Boat♦	Dilution
Total coliforms	$3.2 * 10^5$	60 000	5.3 : 1
E. coli	$2.7 * 10^5$	40 000	6.7 : 1

♦ = mean concentration (positions 2 to 4)
Units = counts / 100 ml

Using measurements taken from the semi-rigid inflatable boat at positions 2 to 4 (Figure 3), mean source concentrations have been calculated and ratios between total coliforms and B. globigii can be estimated at 1.41:1, and between E. coli and B. globigii at 0.94:1 (Table 3 below).

TABLE 3	N	Mean	St.Err.	% St.Err.
Total coliforms	3	60 000	20 000	33
E. coli	3	40 000	30 022	75
B. globigii	3	42 667	4 055	9
Rhodamine B	3	312	103	33

N = number of samples
St.Err. = Standard error about the mean
Units = all in counts / 100 ml, except for rhodamine in µg / l

Since the objective of the survey was to concentrate on the EC monitoring station, the following discussion will concentrate on station 8. The maximum B. globigii concentration at station 8 reached 110 counts / 100 ml at

22:30 h on the 6th August, i.e. 13.5 hours following the discharge (Figure 5).

Using the available data and equation 1, the following Table can be compiled:

TABLE 4

		Total coliforms			E. coli		
T_{90}	k	Exp.	Obs.♦	%	Exp.	Obs.♦	%
0.75	3.01	< 0.01	1000	<0.01	< 0.01	620	<0.01
12	0.19	11.90	1000	1.19	7.93	620	1.28
24	0.10	40.10	1000	4.01	26.76	620	4.31

Units = counts / 100 ml
T^{90} = in decimal hour from the time of discharge
k = decay constant
Exp. = Expected concentration
Obs. = Observed concentration
% = (Exp. / Obs.) * 100
♦ = concentration at station 8 at 22:30 h on 6th August, where B. globigii level is at its maximum

It is clear from Table 4 that for a T_{90} of up to 24 hours, the derived Seaburn discharge total coliforms and E. coli levels reaching station 8 represent only a very small percentage of the observed beach coliform concentrations.

CONCLUSIONS

1. The sample taken at the EC monitoring point on Seascale beach at 10:36 h on the 6th August failed the mandatory standards of the EC bathing directive:

TABLE 5

	Observed	Standard
Total coliforms	11 000	10 000
E. coli	3 400	2 000

Units = counts / 100 ml

2. The survey demonstrated that although under the environmental conditions existing on the 6th August, sewage from the Seaburn discharge did reach Seascale beach., However its impact was limited to less than 5 % of the observed total coliform / E. coli concentrations at station 8.

3. The Seaburn survey was carried out during a neap tide, and so it is recommended that a similar exercise be conducted during a spring tide, where greater water movements are to be expected.

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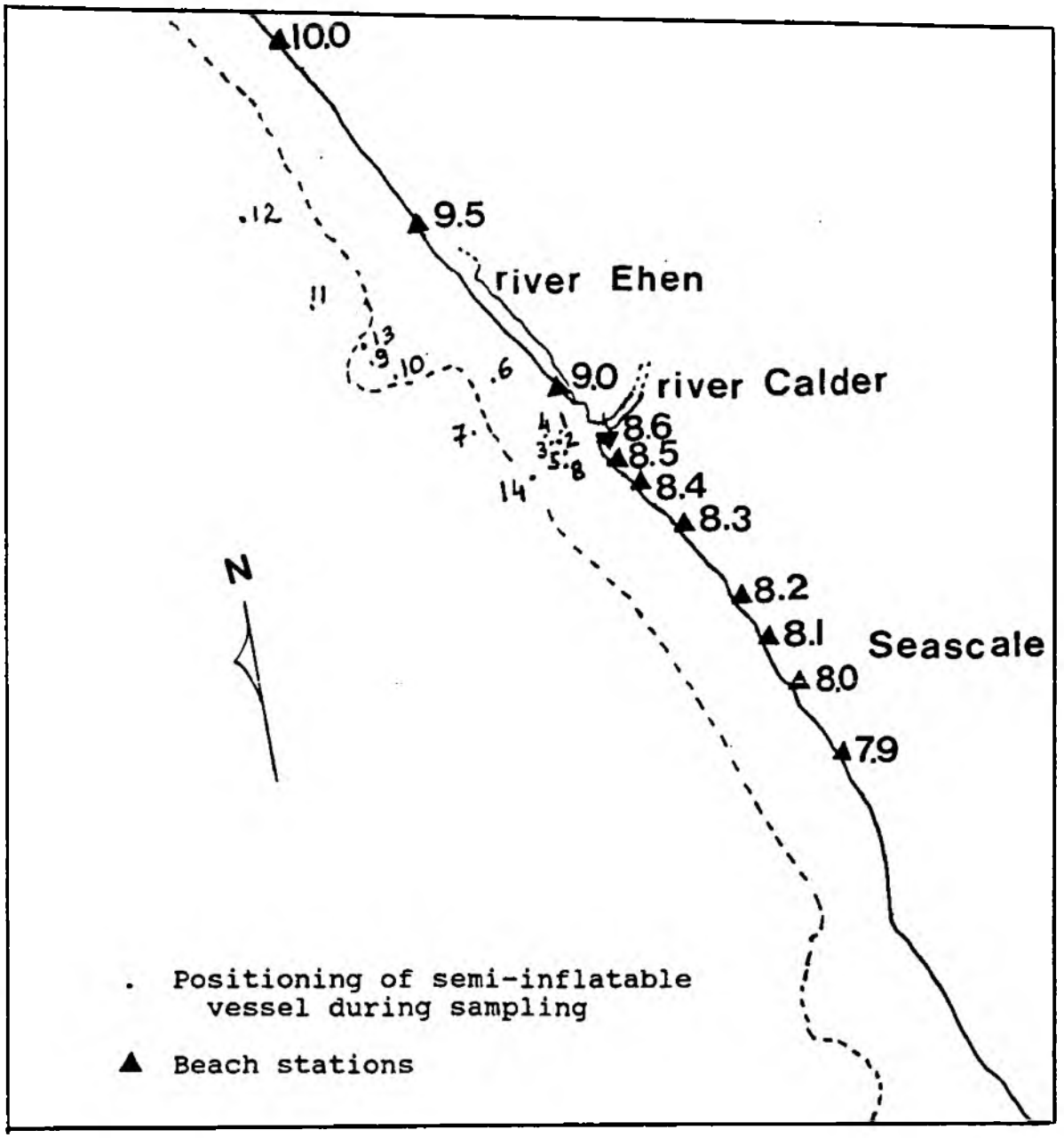


Figure 1: Sampling sites along the coast and on the beach during the Seaburn sewer survey, 05-07 August'91.

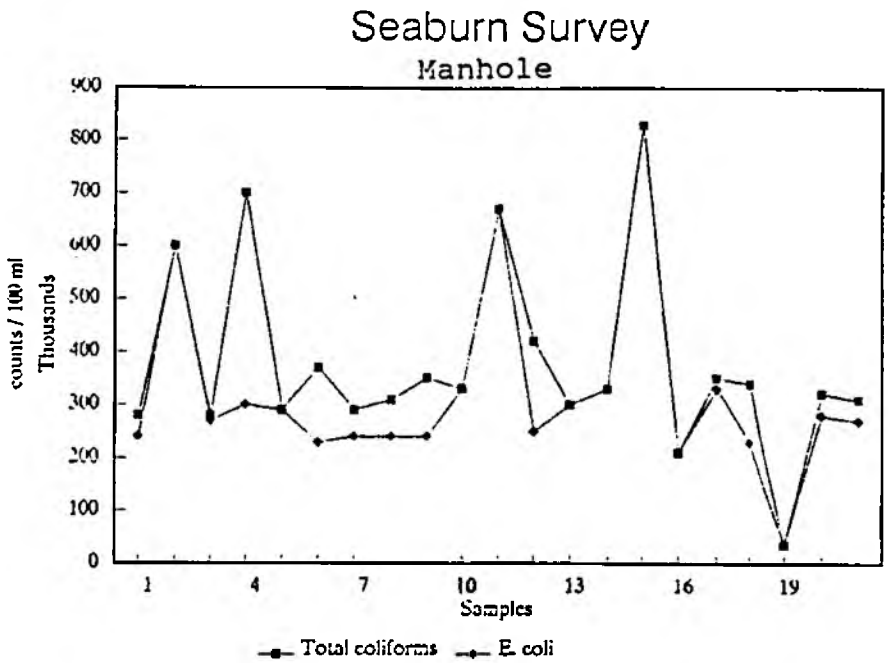
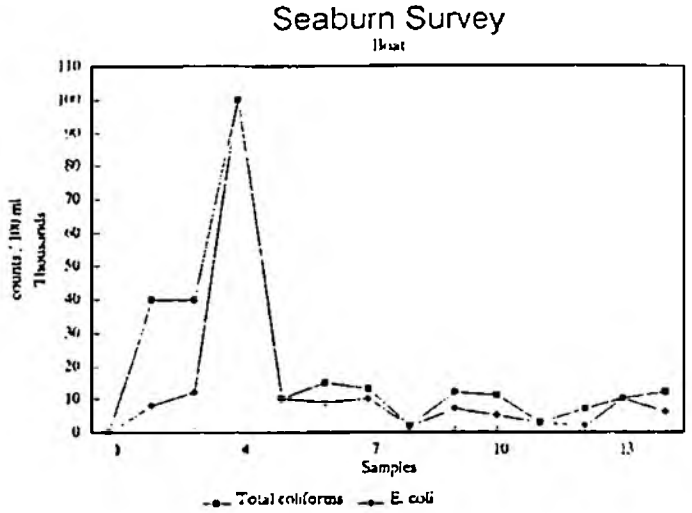
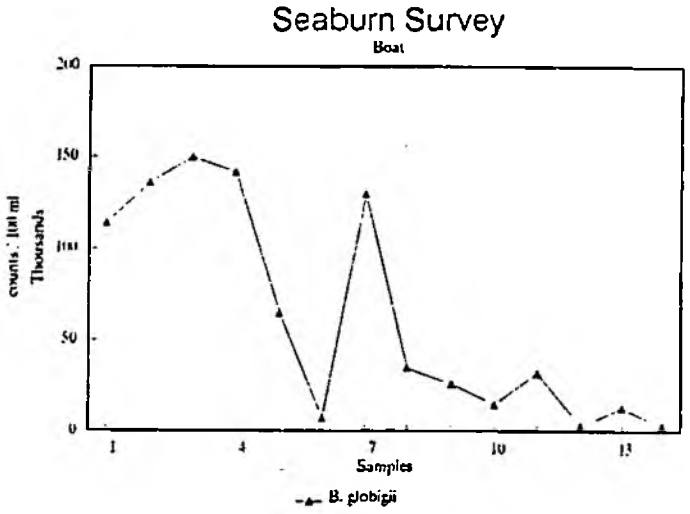


Figure 2: Seaburn effluent content at the manhole, where the tracers were introduced on the survey day.





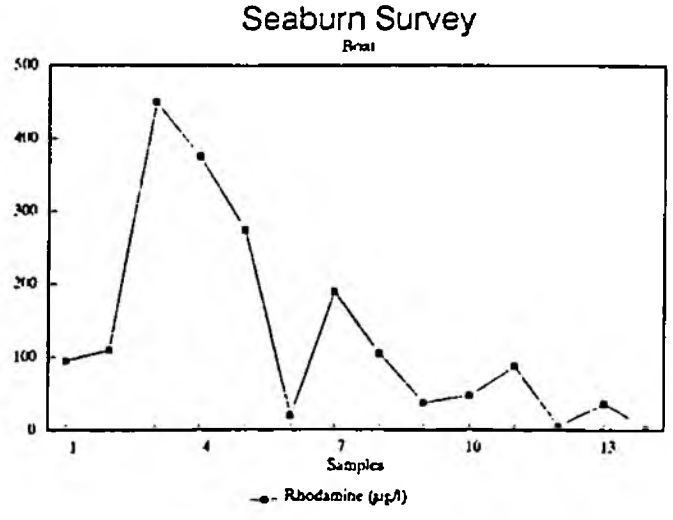


Figure 3: Samples taken from the semi-rigid inflatable

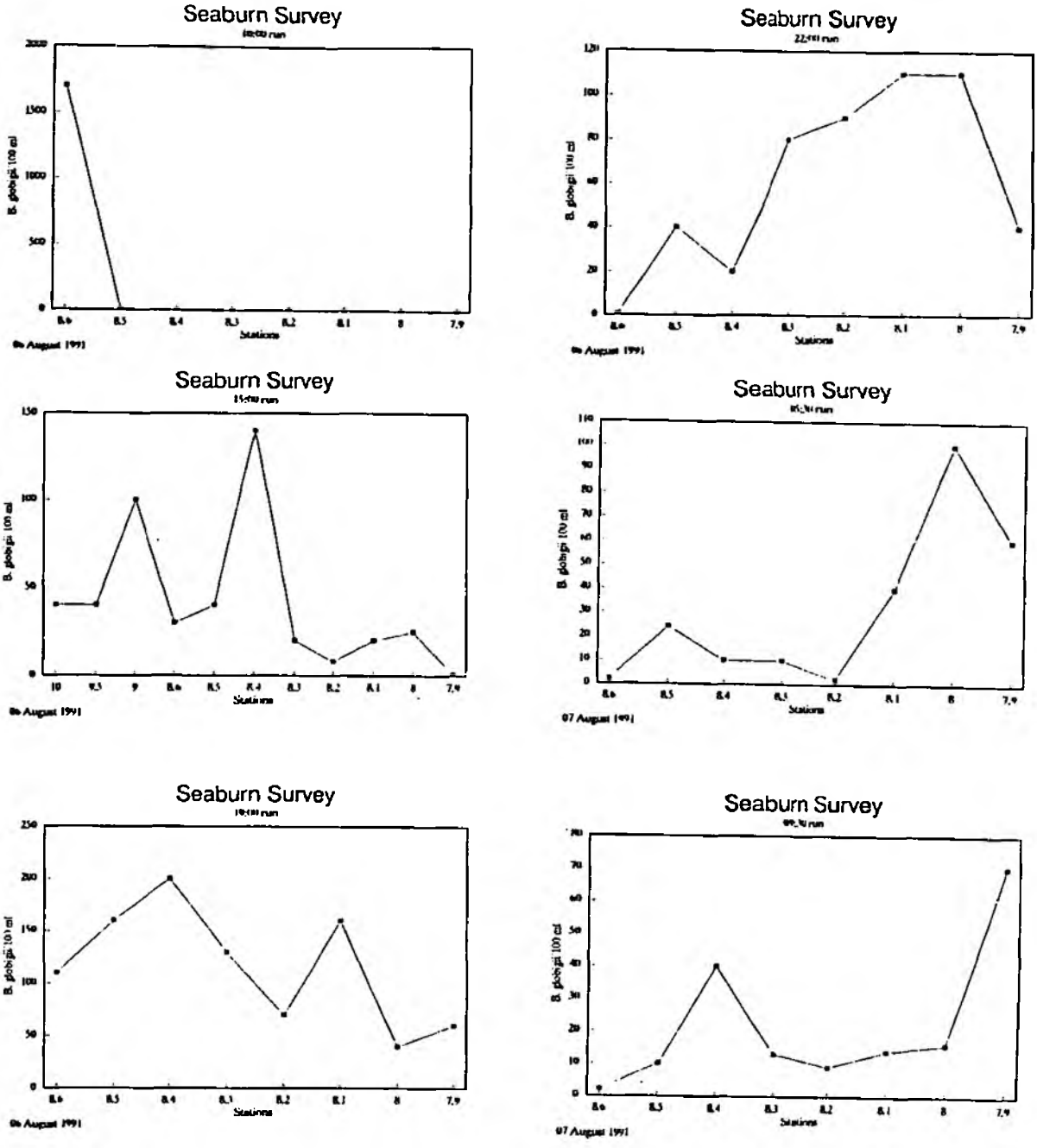


Figure 4: B globigii concentrations along the beach, at various times following the tracer's release into the manhole.

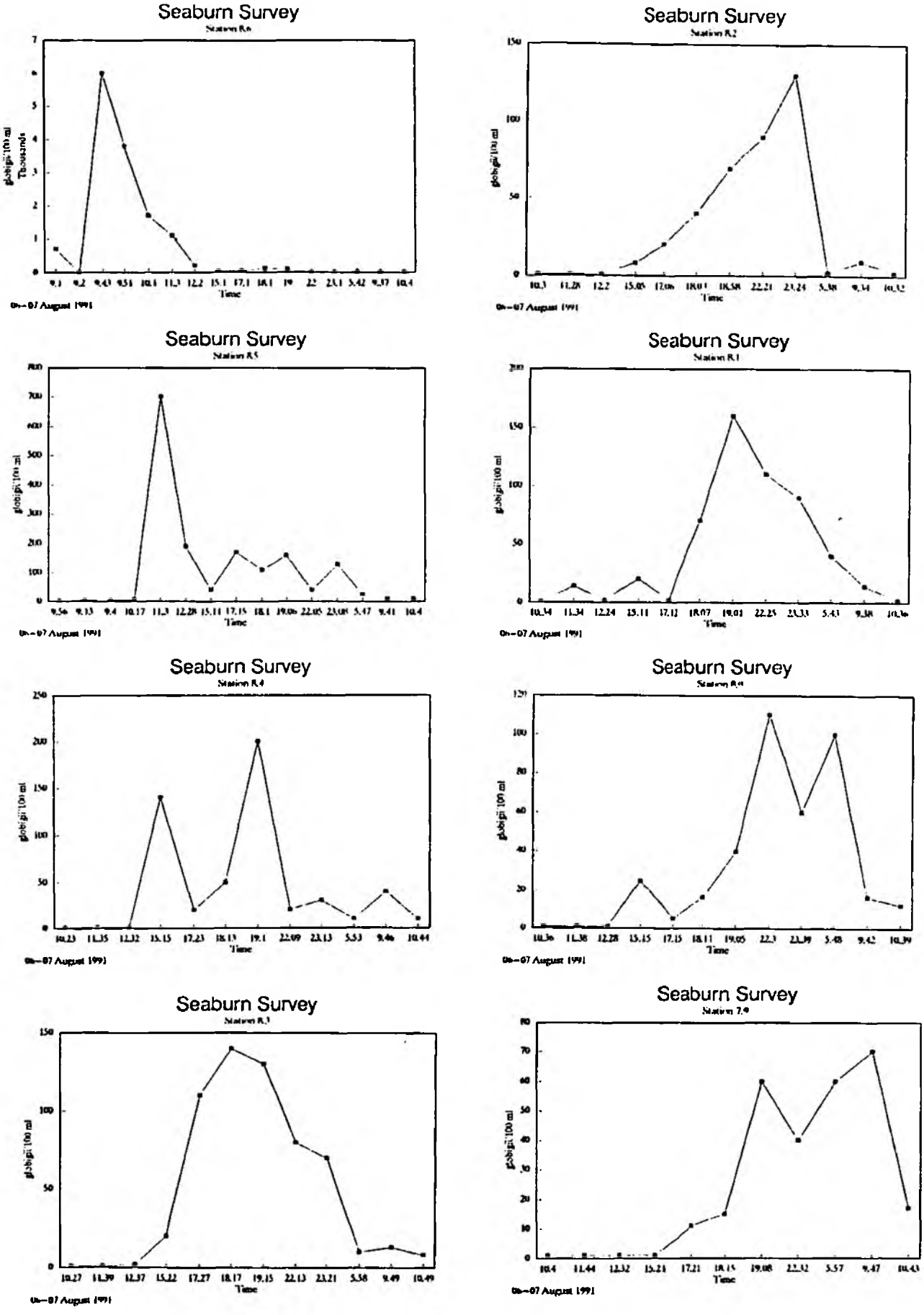


Figure 5: B globigii concentrations with time per station.

APPENDIX 1

RAW DATA

KEY:

TOT.COL.	Total coliforms
RHODA.	Rhodamine
STATIONS	Manhole = 101 to 121
	Boat = 201 to 214
	Beach = 7.9 to 10.0

UNITS:

Total coliforms in counts / 100 ml

E. coli in counts / 100 ml

B. globigii in counts / 100 ml

Rhodamine in µg/l

ROW	STATION	DATE	TIME	TOT.COL.	E. coli	globigii	RHODA.
1	8.60	910805	15:47	*	*	1	*
2	8.50	910805	15:52	*	*	1	*
3	8.40	910805	15:58	*	*	2	*
4	8.30	910805	16:02	*	*	12	*
5	8.20	910805	16:06	*	*	1	*
6	8.10	910805	16:12	*	*	1	*
7	8.00	910805	16:16	*	*	1	*
8	7.90	910805	16:22	*	*	1	*
9	101.00	910806	8:35	280000	240000	*	*
10	102.00	910806	8:55	600000	600000	*	*
11	103.00	910806	9:05	280000	270000	*	*
12	104.00	910806	9:15	700000	300000	*	*
13	105.00	910806	9:25	290000	290000	*	*
14	106.00	910806	9:35	370000	230000	*	*
15	107.00	910806	9:45	290000	240000	*	*
16	108.00	910806	9:55	310000	240000	*	*
17	109.00	910806	10:05	350000	240000	*	*
18	110.00	910806	10:15	330000	330000	*	*
19	111.00	910806	10:25	670000	670000	*	*
20	112.00	910806	10:35	420000	250000	*	*
21	113.00	910806	10:45	300000	300000	*	*
22	114.00	910806	10:55	330000	330000	*	*
23	115.00	910806	11:05	830000	830000	*	*
24	116.00	910806	11:15	210000	210000	*	*
25	117.00	910806	11:25	350000	330000	*	*
26	118.00	910806	11:35	340000	230000	*	*
27	119.00	910806	11:45	36000	36000	*	*
28	120.00	910806	11:55	320000	280000	*	*
29	121.00	910806	12:05	310000	270000	*	*
30	201.00	910806	9:00	7	7	114000	95.000
31	202.00	910806	9:05	40000	8000	136000	110.000
32	203.00	910806	9:07	40000	12000	150000	450.000
33	204.00	910806	9:15	100000	100000	142000	375.000
34	205.00	910806	9:25	10000	10000	65000	275.000
35	206.00	910806	9:30	15000	9000	7000	20.000
36	207.00	910806	9:34	13000	10000	130000	190.000
37	208.00	910806	9:47	2000	1800	35000	105.000
38	209.00	910806	10:02	12000	7000	26000	37.000
39	210.00	910806	10:35	11000	5000	15000	48.000
40	211.00	910806	10:52	3000	3000	32000	88.000
41	212.00	910806	11:00	7000	2000	3600	5.800
42	213.00	910806	11:07	10000	10000	13000	36.000
43	214.00	910806	11:13	12000	6000	3300	2.300
44	8.60	910806	9:10	10000	10000	700	2.000

45	8.50	910806	9:13	10000	3700	2	0.100
46	8.60	910806	9:20	2000	600	1	0.025
47	8.55	910806	9:30	2000	2000	440	2.100
48	8.55	910806	9:35	1000	1000	2100	9.000
49	8.50	910806	9:40	900	300	1	0.035
50	8.60	910806	9:43	1300	1000	6000	23.500
51	8.55	910806	9:45	1100	900	4100	17.000
52	8.60	910806	9:51	1000	400	3800	18.000
53	8.50	910806	9:56	200	100	1	0.035
54	8.60	910806	10:08	2000	100	1700	2.200
55	8.50	910806	10:17	300	270	7	0.040
56	8.40	910806	10:23	1000	500	1	0.020
57	8.30	910806	10:27	1000	200	1	0.020
58	8.20	910806	10:30	1000	200	1	0.020
59	8.10	910806	10:34	2000	700	1	0.020
60	8.00	910806	10:36	11000	3400	1	0.020
61	7.90	910806	10:40	70	70	1	0.015
62	8.60	910806	11:27	19000	5100	1100	0.400
63	8.20	910806	11:28	130	130	1	0.020
64	8.50	910806	11:30	3000	600	700	2.800
65	8.10	910806	11:34	6000	1100	14	0.020
66	8.40	910806	11:35	500	160	1	0.020
67	8.00	910806	11:38	1100	300	1	0.010
68	8.30	910806	11:39	100	100	1	0.015
69	7.90	910806	11:44	100	*	1	0.020
70	8.20	910806	12:20	150	150	1	0.020
71	8.60	910806	12:23	24000	6200	200	0.210
72	8.10	910806	12:24	3000	1100	2	0.015
73	8.50	910806	12:28	1400	1300	190	0.160
74	8.00	910806	12:28	1900	300	1	0.015
75	7.90	910806	12:32	600	100	1	0.015
76	8.40	910806	12:32	500	100	1	0.040
77	8.30	910806	12:37	400	100	2	0.020
78	8.20	910806	15:05	200	60	8	0.020
79	8.60	910806	15:07	16000	6300	30	0.060
80	8.10	910806	15:11	400	180	20	0.030
81	8.50	910806	15:11	2000	400	40	0.165
82	8.00	910806	15:15	1800	900	25	0.030
83	8.40	910806	15:15	400	240	140	0.150
84	7.90	910806	15:21	200	80	1	0.015
85	8.30	910806	15:22	140	140	20	0.025
86	10.00	910806	15:35	1400	200	40	0.020
87	9.50	910806	15:50	2000	300	40	0.020
88	9.00	910806	16:10	1400	200	100	0.055
89	8.20	910806	17:06	300	130	20	0.025
90	8.60	910806	17:10	18000	3000	50	0.055

91	8.10	910806	17:12	200	200	2	0.025
92	8.00	910806	17:15	1600	400	5	0.020
93	8.50	910806	17:15	14000	5600	170	0.130
94	7.90	910806	17:21	200	60	11	0.030
95	8.40	910806	17:23	30	30	20	0.030
96	8.30	910806	17:27	1500	300	110	0.075
97	8.20	910806	18:03	400	140	40	0.040
98	8.10	910806	18:07	300	200	70	0.035
99	8.60	910806	18:07	15000	4800	120	0.050
100	8.50	910806	18:10	6000	2700	110	0.130
101	8.00	910806	18:11	800	80	16	0.025
102	8.40	910806	18:13	2000	1800	50	0.110
103	7.90	910806	18:15	600	150	15	0.025
104	8.30	910806	18:17	600	400	140	0.125
105	8.20	910806	18:58	1000	700	70	0.080
106	8.60	910806	19:00	16000	5000	110	0.055
107	8.10	910806	19:01	400	400	160	0.045
108	8.00	910806	19:05	500	200	40	0.045
109	8.50	910806	19:06	12000	3400	160	0.230
110	7.90	910806	19:08	400	200	60	0.025
111	8.40	910806	19:10	1500	1400	200	0.110
112	8.30	910806	19:15	600	600	130	0.100
113	8.60	910806	22:00	5000	2600	1	0.040
114	8.50	910806	22:05	1600	1000	40	0.060
115	8.40	910806	22:09	1100	750	20	0.040
116	8.30	910806	22:13	800	360	80	0.065
117	8.20	910806	22:21	1200	600	90	0.080
118	8.10	910806	22:25	600	570	110	0.095
119	8.00	910806	22:30	1000	620	110	0.070
120	7.90	910806	22:32	28000	3500	40	0.055
121	8.60	910806	23:05	6000	2700	1	0.045
122	8.50	910806	23:08	16000	4300	130	0.070
123	8.40	910806	23:13	2000	800	30	0.055
124	8.30	910806	23:21	900	500	70	0.050
125	8.20	910806	23:24	800	360	130	0.050
126	8.10	910806	23:33	1300	200	90	0.090
127	8.00	910806	23:39	8000	530	60	0.055
128	7.90	910806	*	*	*	*	*
129	8.20	910807	5:38	15000	280	2	0.040
130	8.60	910807	5:42	11000	650	2	0.050
131	8.10	910807	5:43	5000	160	40	0.030
132	8.50	910807	5:47	16000	4400	24	0.090
133	8.00	910807	5:48	7000	80	100	0.030
134	8.40	910807	5:53	10000	140	10	0.030
135	7.90	910807	5:57	4000	10	60	0.025
136	8.30	910807	5:58	16000	70	10	0.055
137	8.20	910807	9:34	2700	700	9	0.030
138	8.60	910807	9:37	7000	6000	2	0.050
139	8.10	910807	9:38	6400	6400	14	0.020
140	8.50	910807	9:41	23000	8700	10	0.035
141	8.00	910807	9:42	4100	1500	16	0.020
142	8.40	910807	9:46	8000	2700	40	0.035
143	7.90	910807	9:47	8000	2700	70	0.030
144	8.30	910807	9:49	2700	300	13	0.020
145	8.20	910807	10:32	4000	300	2	0.030
146	8.60	910807	10:35	8000	5300	7	0.045
147	8.10	910807	10:36	3000	1100	2	0.030
148	8.00	910807	10:39	2300	800	12	0.025
149	8.50	910807	10:40	2000	600	11	0.030
150	7.90	910807	10:43	23000	15000	17	0.030
151	8.40	910807	10:44	4400	2600	10	0.030
152	8.30	910807	10:49	2400	1400	8	0.030