SOLWAY FIRTH AND ADJACENT ESTUARIES

SUMMARY OF 1992 SURVEYS

Marine and Special Projects
EQ & PC
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Report: MSP-SOL-93-001

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SUMMARY OF 1992 SURVEYS

This report summarises the routine monitoring surveys carried out in the Solway Firth and adjacent estuaries during 1992. Refer to report MSP-SOL-001 for more information on the sampling requirements.

Since all data are archived and can be accessed fairly easily, no raw data listing is provided in this report.

INTERPRETATION

Figure 1 and Appendix 1 describe the location of stations. Overall mean concentrations for most of the parameters are listed in Table 1. In addition to the quarterly surveys, the Waver and Wampool were sampled monthly by pollution control at stations 1.

Most of the results are presented in a graph format which illustrates concentrations as a function of station and month distributions. The larger the star the higher the value. The minimum and maximum concentrations are indicated for each parameter and scaling of the size of the stars directly proportional.

Stars that are circled indicate levels exceeding their environmental quality standards (EQS). Remember: compliance with many EQSs is based on annual average values (Appendix 3).

PHYSICAL PARAMETERS - Figures 2 - 4.

Figure 2a. All baseline stations in the Esk, Eden, Waver and Wampool reflected the three salinity bands (0-10, 10-20, 20-30).

Figure 2b. Temperatures ranged between 0.5 and 19.5 °C, following seasonal variations. Highest levels were reached in August, and lowest temperatures in January.

The pH ranged between 6.9 and 9.5, thus exceeding the EQS of 7 - 8.5 in mainly in May and July.

Figure 3. Suspended solids averaged 199 mg/l, but reached 3600 mg/l in the Wampool (station 3) in October.

Figure 4. Dissolved oxygen levels averaged 91.8 %, but fluctuated between 42.0 and 158.8 % (4.4 to 15.7 mg/l). Seasonal variations showed the highest percentages in May.

Phaeophytin was only determined in October, levels ranging between 0.67 and 39.5 µg/l, with the maximum in the Wampool.

NUTRIENTS - Figures 5 and 6.

Figure 5. Ammonia ranged between 0.03 and 0.96 mg/l with maxima in May, but in general averaged 0.19 mg/l. Nitrate ranged between 0.03 and 7.30 mg/l. The profiles showed that the Wampool estuary contains the highest levels of nitrate, and the Solway the lowest. Also, seasonal variations were observed throughout the estuaries, with minimum concentrations in the summer.

Figure 6. Silicate was only determined in the Waver and the Wampool at stations 1. Levels ranged between 0.07 to 8.0 mg/l, with minimum concentrations reached during the summer. Phosphate ranged between 0.01 and 1.36 mg/l, with maxima in the Esk and Eden in August.

METALS - Figures 7 - 10.

With the exception of copper, all dissolved metals concentrations were below their EQSs. Lead levels averaged 1.9 µg/l, but reached 6.6 µg/l in August at station Wampool 3.

Figure 7. Copper distributions displayed temporal variations, with exceeding EQS levels at station 1 in the Esk (5.30 and 5.65 µg/l). Nickel concentrations where highest in the Wampool, with an overall range of 0.41 to 3.80 µg/l. Arsenic levels fluctuated between 0.21 and 2.25 µg/l, with maxima generally in the Wampool,

Figure 8. Cadmium levels ranged between 0.03 and 0.37 µg/l but generally averaged 0.07 µg/l. Zinc concentrations appeared to be highest in most estuaries at stations 1 (*i.e.* upstream). Levels ranged between 3.20 and 9.30 µg/l.

Figure 9. Boron concentrations ranged between 0.08 and 3.72 mg/l, with maxima in the Solway. Chromium levels fluctuated between 0.25 and 3.90 µg/l with maxima in January.

Figure 10. Dissolved mercury levels fluctuated between 0.01 and 0.132 µg/l and averaged 0.025 µg/l. Total mercury concentrations ranged between 0.015 - 0.280 µg/l, and generally averaged 0.070 µg/l.

ORGANICS

The majority of organic compounds analysed for were below their detection limit (refer to Appendix 2).

Carbon tetrachloride, hexachlorobutadeine and dieldrin exceeded their EQS at certain stations, mainly in August 1992. Also, PCB-28 (and other isomers) were found in various estuaries, at different months.

Hexachlorohexane-g (HCH-g) results should be treated with care as problems associated with HCH-g determinations have been found and are currently being investigated.

COMPARISON WITH OTHER ESTUARIES

Table 4 summarises concentration ranges for data collected in 1992 in 5 estuaries (refer to reports MSP-LUN-93-001, MSP-93-RIB-001, MSP-93-MER-001, and MSP-93-DUD-001 for further information on each estuary).

The Solway and adjacent estuaries display the widest ranges in pH (6.9 - 9.5), suspended solids (6 - 3600 mg/l) and dissolved oxygen (42.0 - 158.8 %). The data also show the highest levels of nitrate (7.30 mg/l) and dissolved lead (6.6 µg/l). Finally, most metal concentrations are lower than other estuaries.

CONCLUSION

This report briefly summarises routine data archived during the Solway and adjacent estuaries surveys in 1992. The report MSP-SOL-001 outlines all estuaries sampling points and requirements.

All baseline stations in the Esk, Eden, Waver and Wampool reflected the three salinity bands (0-10, 10-20, 20-30). The pH ranged between 6.9 and 9.5, thus exceeding the EQS of 7 - 8.5, mainly in May and July.

Nitrate profiles showed that the Wampool estuary contains the highest levels.

All dissolved metals concentrations in the Solway were below their EQS (except copper). Higher levels of nickel and arsenic were found in the Wampool.

The majority of organic compounds analysed for were below their detection limit. Carbon tetrachloride, hexachlorobutadeine and dieldrin exceeded their EQS at certain stations, mainly in August 1992.

Please pass on any comments, suggestions or questions on this report to Irene Gize at the Marine and Special Projects Section.

Table 1: Overall mean concentrations for most parameters, for the Solway Firth and adjacent estuaries, 1992.

	COND	TEMP	pH	DO	DO%	S.S.
N OF CASES	76	77	76	75	75	75
MINIMUM	191	0.5	6.9	4.4	42.0	4
MAXIMUM	47800	19.5	9.5	15.7	158.5	3600
MEAN	15746	10.5	7.8	9.7	91.8	199

N = Number
COND = Conductivity
TEMP = Temperature
DO = Dissolved oxygen
S.S. = Suspended solids

	Phaeo	NH3	PO4	SiO2	NO3	NO2
N OF CASES	12	76	76	22	76	76
MINIMUM	0.67	0.03	0.01	0.07	0.03	0.01
MAXIMUM	39.50	0.96	1.36	8.00	7.30	0.25
MEAN	14.52	0.19	0.19	5.72	2.13	0.04

PHAEO = Phaeophytin

Dissolved metals:

	As	Cd	Cr	Cu	Ni	Zn
N OF CASES	44	43	43	43	43	43
MINIMUM	0.21	0.03	0.25	0.70	0.41	3.20
MAXIMUM	2.25	0.37	3.90	5.65	3.80	9.30
MEAN	1.21	0.07	0.86	2.10	1.45	4.75

	Pb	Hg	Hg^t	B^t
N OF CASES	43	40	44	27
MINIMUM	1.4	0.010	0.015	0.08
MAXIMUM	6.6	0.132	0.280	3.72
MEAN	1.9	0.025	0.070	1.28

t = total

Table 2: Stations where organics exceeded their environmental quality standards, mainly in August 1992.

	CTC	HCB	Dldn	HCH-g	
Waver 1			0.021		
Waver 2			0.015		
Wampool 1		0.12			January
Wampool 1				0.040	
Wampool 2				0.045	
Wampool 3			0.012		
Eden 1		0.05	0.012		
Eden 2				0.042	
Eden 3		0.09			January
Esk 3		0.05			January
Esk 3	15				July
Esk 3				0.093	
Solway 7			0.03		
EQS	12	0.03	0.01	0.02	
Detection	<1	<.05	<.001	<0.003	

Units = µg/l
* = EQS for all 3 isomers
CTC = Carbon tetrachloride
HCB = Hexachlorobutadeine
Dldn = Dieldrin
HCH-g = Hexachlorocyclohexane-gamma

Table 3: Stations where PCBs were found to exceed their detection limits.

	Mth	28	52	101	118	138	153	180
Waver 1	10	0.01		0.02	0.02	0.02	0.02	0.02
Waver 2	10	0.02		0.02	0.02	0.02	0.02	0.02
Wamp. 1	1	0.01						
Wamp. 1	10	0.03						
Wamp. 2	8	0.01				0.01		0.01
Wamp. 2	10	0.03						
Wamp. 3	8	0.02		0.01	0.01	0.02	0.01	0.02
Wamp. 3	10	0.03						
Esk 2	1							0.01
Esk 2	5		0.12	0.05				0.09
Esk 3	1	0.04						
Esk 3	8	0.01						
Solw. 1	8	0.01						
Solw. 6	8	0.01						
Detection lmt		<.01	<.04	<.01	<.01	<.01	<.01	<.01

Mth = Month
Wamp. = Wampool

TABLE 4: Summary of results for the 1992 baseline estuarine surveys. (Limited data for the Lune and the Duddon)

	Conductivity µS/cm	pH	Temperature °C	Suspended solids mg/l	Dissolved oxygen %
Solway	191 - 47800	6.9 - 9.5	0.5 - 19.5	6 - 3600	42.0 - 158.8
Duddon	198 - 47900	7.1 - 8.8	6.0 - 20.9	7 - 225	67.5 - 154.4
Lune	6890 - 46900	8.2 - 9.1	13.4 - 18.0	6 - 88	71.5 - 171.0
Ribble	1650 - 50200	7.5 - 8.3	4.7 - 17.5	2 - 300	45.5 - 111.0
Mersey	502 - 50600	7.0 - 8.6	3.8 - 18.6	3 - 1600	15.5 - 125.5

mg/l	NH_3	PO_4	SiO_2	NO_3	NO_2
Solway	0.03 - 0.96	0.01 - 1.36	0.07 - 8.00	0.03 - 7.30	0.01 - 0.25
Duddon	0.08 - 1.58	0.01 - 1.68	0.01 - 8.89	0.05 - 2.88	0.01 - 0.06
Lune	0.03 - 0.36	0.03 - 0.28		0.03 - 0.98	0.01 - 0.04
Ribble	0.03 - 1.26	0.03 - 0.70		0.06 - 5.10	0.01 - 0.32
Mersey	0.03 - 6.40	0.03 - 1.40	0.13 - 19.2	0.03 - 4.22	0.01 - 0.88

µg/l	As diss.	Cd diss.	Cr diss.	Cu diss.	Ni diss.
Solway	0.21 - 2.25	0.05 - 0.37	0.25 - 3.90	0.70 - 5.65	0.41 - 3.80
Duddon	1.28 - 2.39	0.04 - 0.31	0.26 - 4.48	0.57 - 42.0	0.35 - 2.07
Lune	0.10 - 1.70	<0.05 - 0.09	0.39 - 1.45	1.20 - 8.50	0.60 - 0.95
Ribble	1.45 - 4.15	0.03 - 4.30	0.30 - 3.60	1.10 - 24.5	0.65 - 3.55
Mersey	1.95 - 14.4	0.03 - 0.21	0.28 - 21.5	1.12 - 13.4	0.47 - 9.60

µg/l	Zn diss.	Pb diss.	Hg diss.	Hg total	Boron mg/l
Solway	3.20 - 9.30	<2.5 - 6.6	<0.02 - 0.13	0.01 - 0.28	0.08 - 3.72
Duddon	< 2 - 15.4	1.4 - <3	<0.02 - 0.08	0.02 - 0.11	0.81 - 4.71
Lune	<15	<2.5	<0.02 - 0.07	0.02 - 0.74	
Ribble	3.70 - 27.5	<2.5	0.01 - 0.14	0.03 - 0.43	0.31 - 4.69
Mersey	4.90 - 29.0		0.01 - 0.12	0.11 - 2.40	0.21 - 4.65

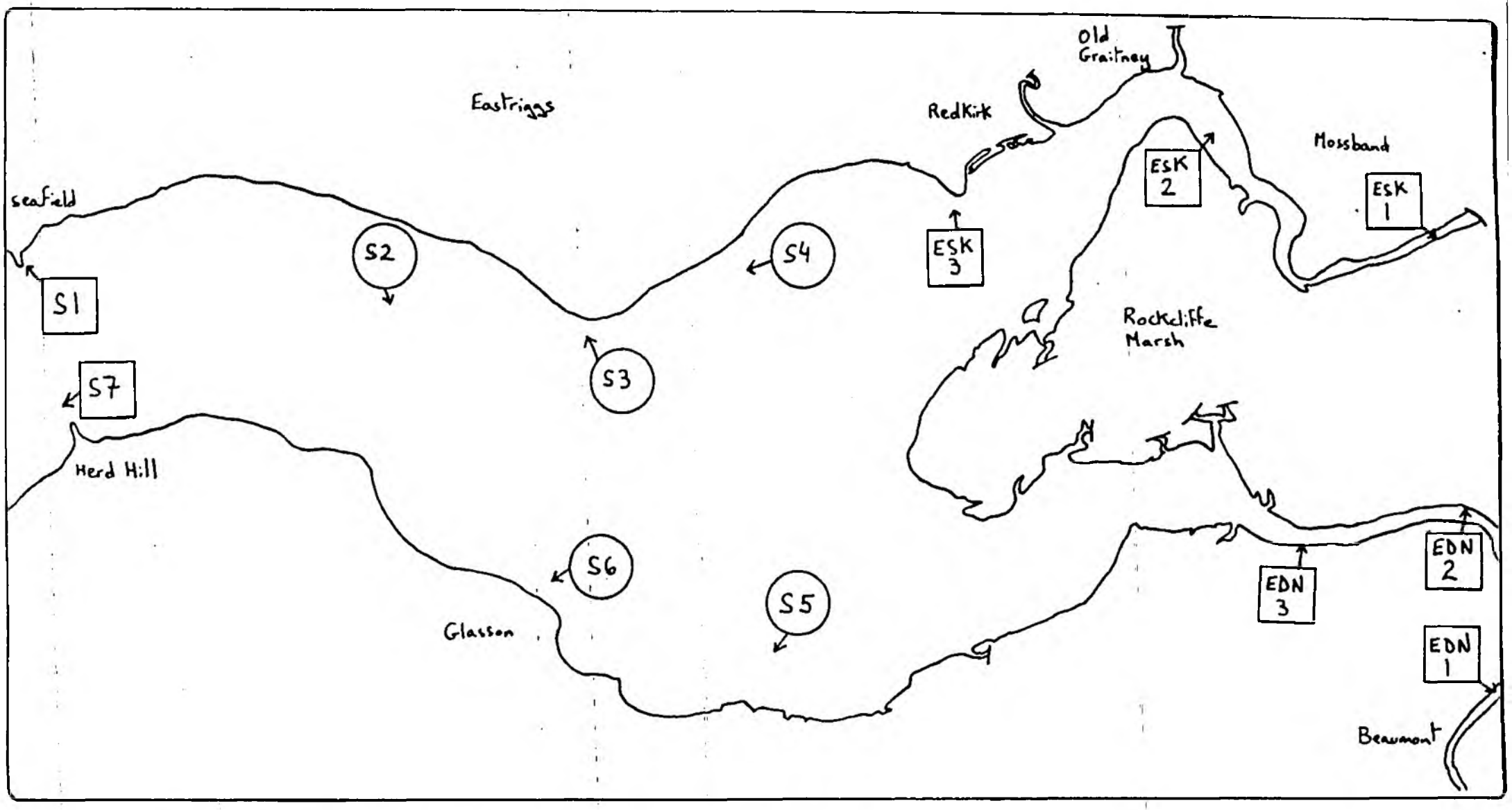


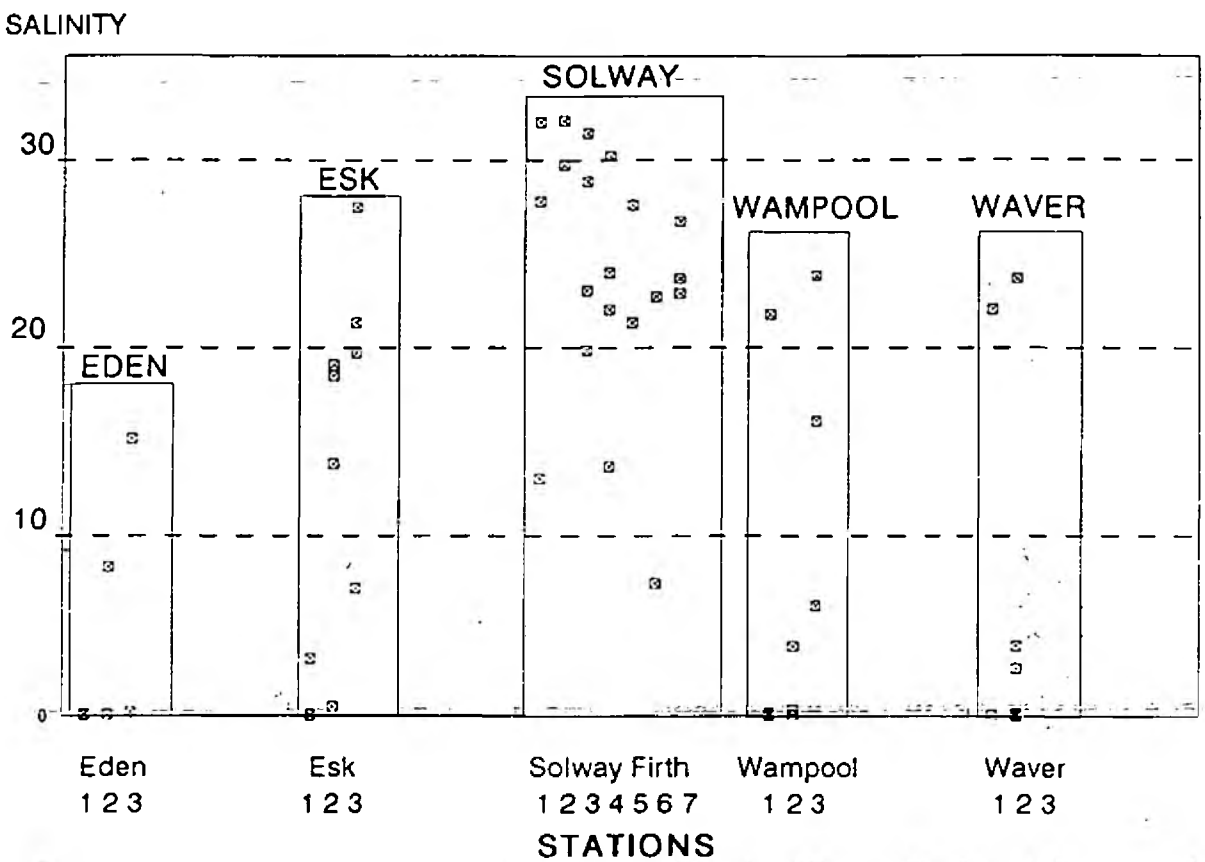
Figure 1: Schematic representation of the Solway Fith, including the Esk and the Eden estuaries, showing the sampling sites.

= Baseline monitoring stations

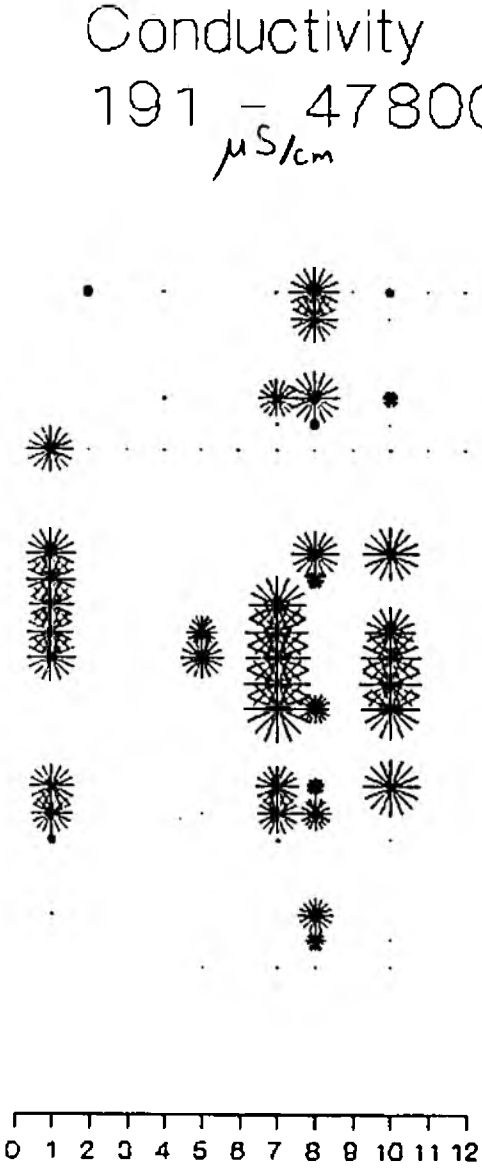
FIGURE 20:

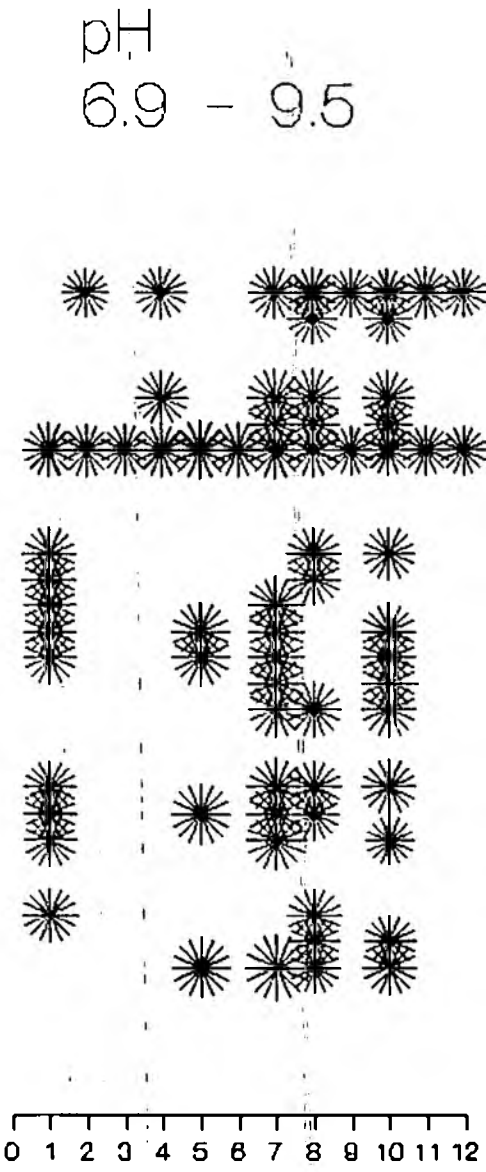
SOLWAY FIRTH AND ADJACENT ESTUARIES

1992 SURVEYS



FIGURE


Conductivity
191 - 47800
µS/cm
0 1 2 3 4 5 6 7 8 9 10 11 12
January to December 1992


pH
6.9 - 9.5
0 1 2 3 4 5 6 7 8 9 10 11 12
January to December 1992

2b:

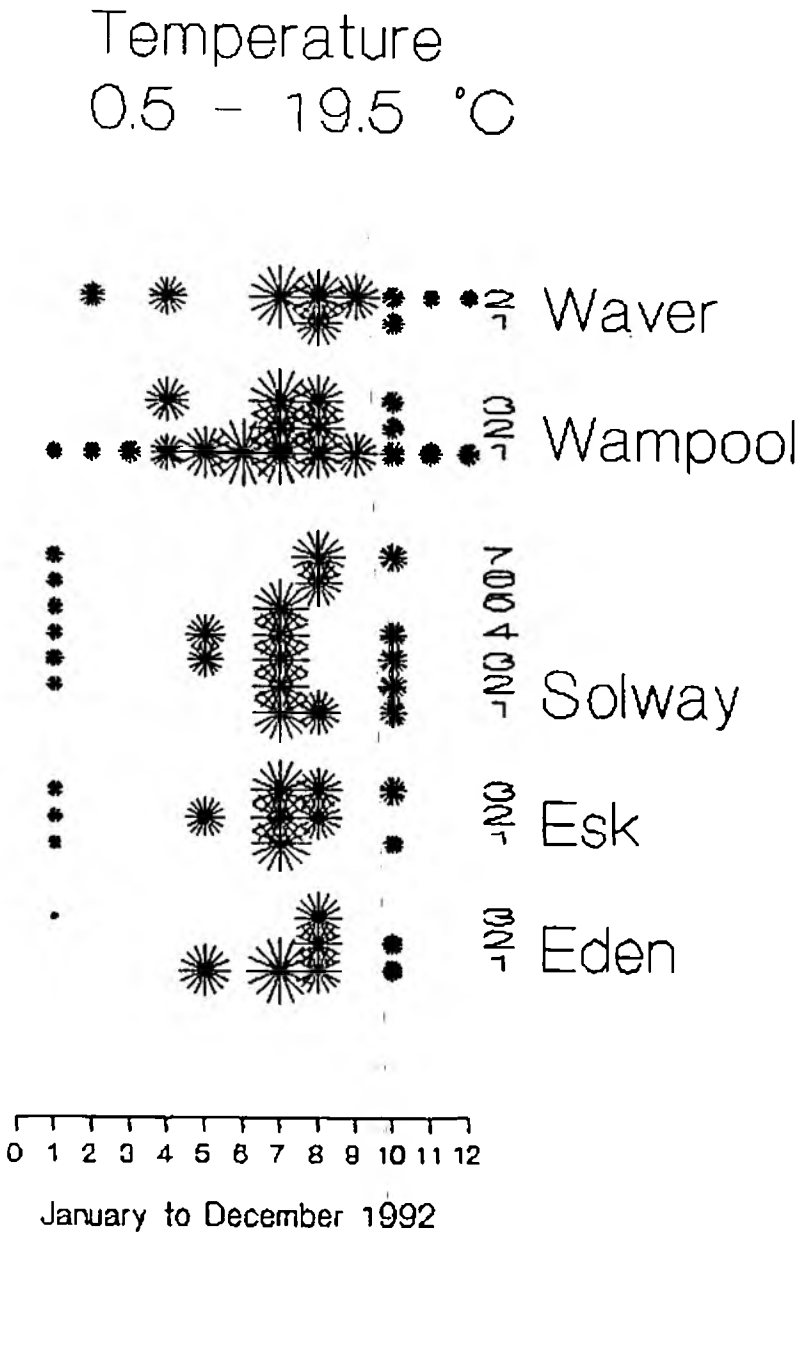

Temperature
0.5 - 19.5 °C
Waver
Wampool
Solway
Esk
Eden
0 1 2 3 4 5 6 7 8 9 10 11 12
January to December 1992

FIGURE 3:

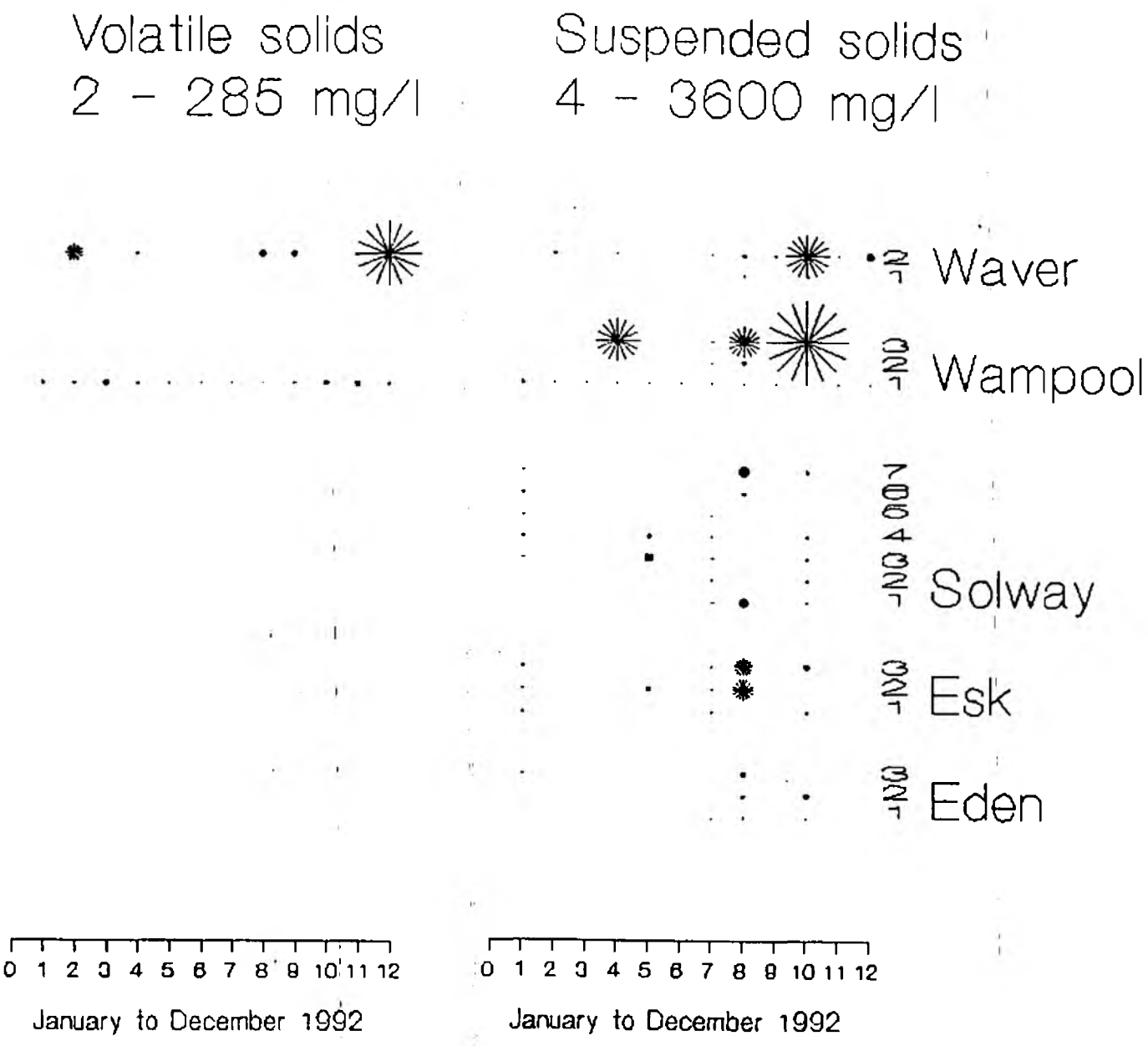

Volatile solids
2 - 285 mg/l
Suspended solids
4 - 3600 mg/l
Waver
Wampool
Solway
Esk
Eden
0 1 2 3 4 5 6 7 8 9 10 11 12
January to December 1992
0 1 2 3 4 5 6 7 8 9 10 11 12
January to December 1992

FIGURE 4:

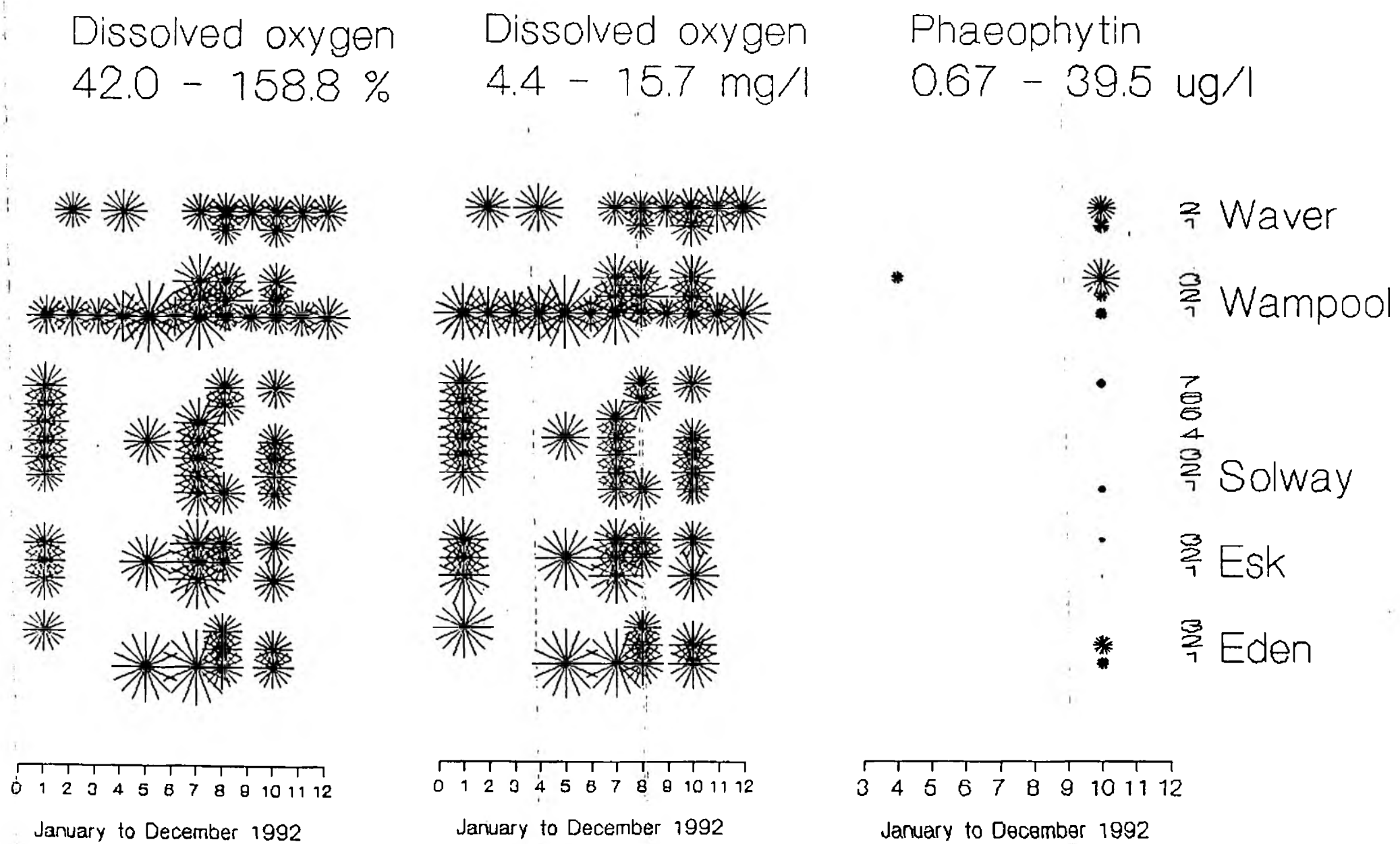
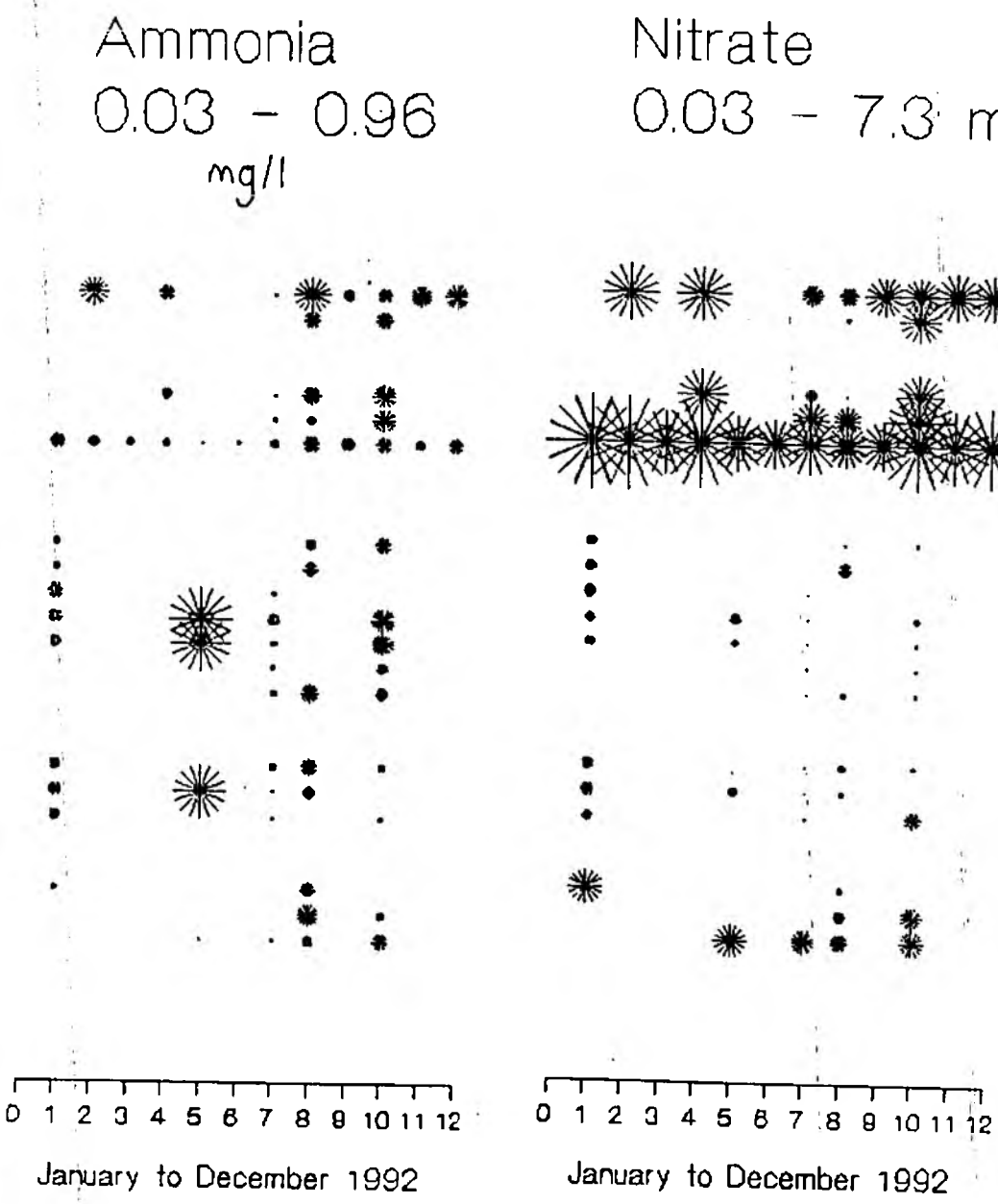

Dissolved oxygen
42.0 - 158.8 %
Dissolved oxygen
4.4 - 15.7 mg/l
Phaeophytin
0.67 - 39.5 ug/l
Waver
Wampool
Solway
Esk
Eden
0 1 2 3 4 5 6 7 8 9 10 11 12
January to December 1992
0 1 2 3 4 5 6 7 8 9 10 11 12
January to December 1992
3 4 5 6 7 8 9 10 11 12
January to December 1992

FIGURE 5:


Ammonia
0.03 - 0.96
mg/l
Nitrate
0.03 - 7.3 mg/l
0 1 2 3 4 5 6 7 8 9 10 11 12
January to December 1992
0 1 2 3 4 5 6 7 8 9 10 11 12
January to December 1992

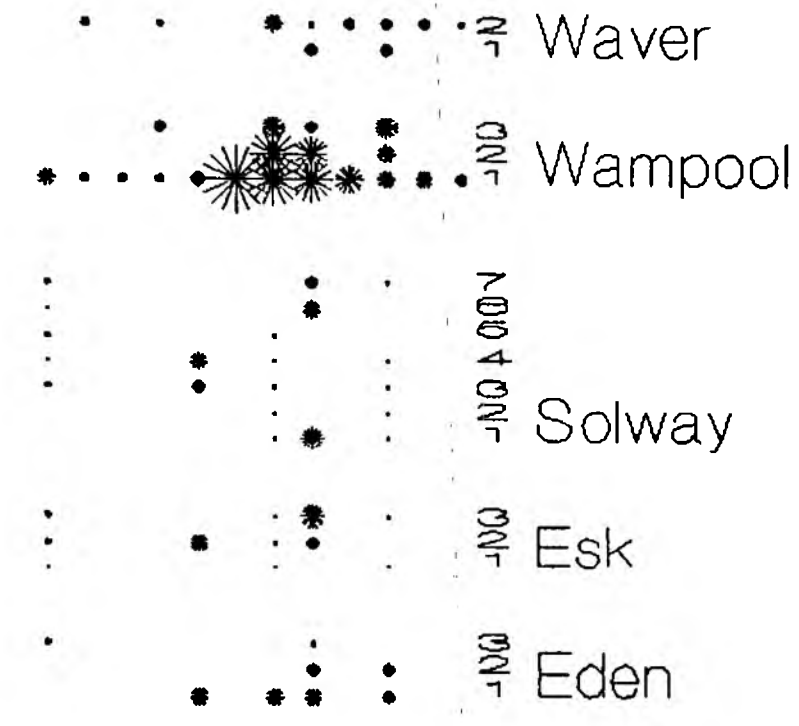

Nitrite
0.01 - 0.25 mg/l
Waver
Wampool
Solway
Esk
Eden
0 1 2 3 4 5 6 7 8 9 10 11 12
January to December 1992

FIGURE 6:

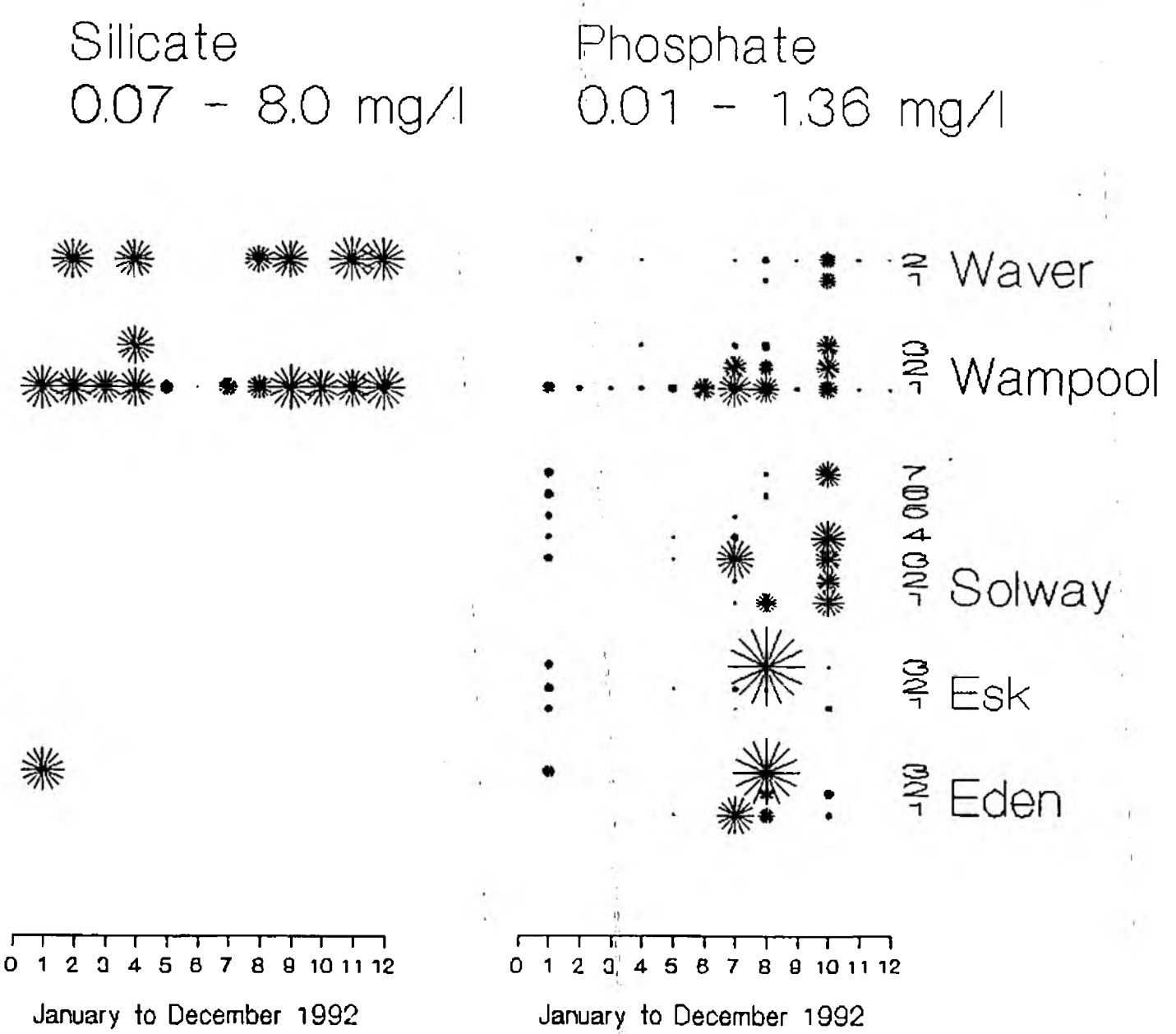

Silicate
0.07 - 8.0 mg/l
Phosphate
0.01 - 1.36 mg/l
Waver
Wampool
Solway
Esk
Eden
0 1 2 3 4 5 6 7 8 9 10 11 12
January to December 1992
0 1 2 3 4 5 6 7 8 9 10 11 12
January to December 1992

FIGURE 7:

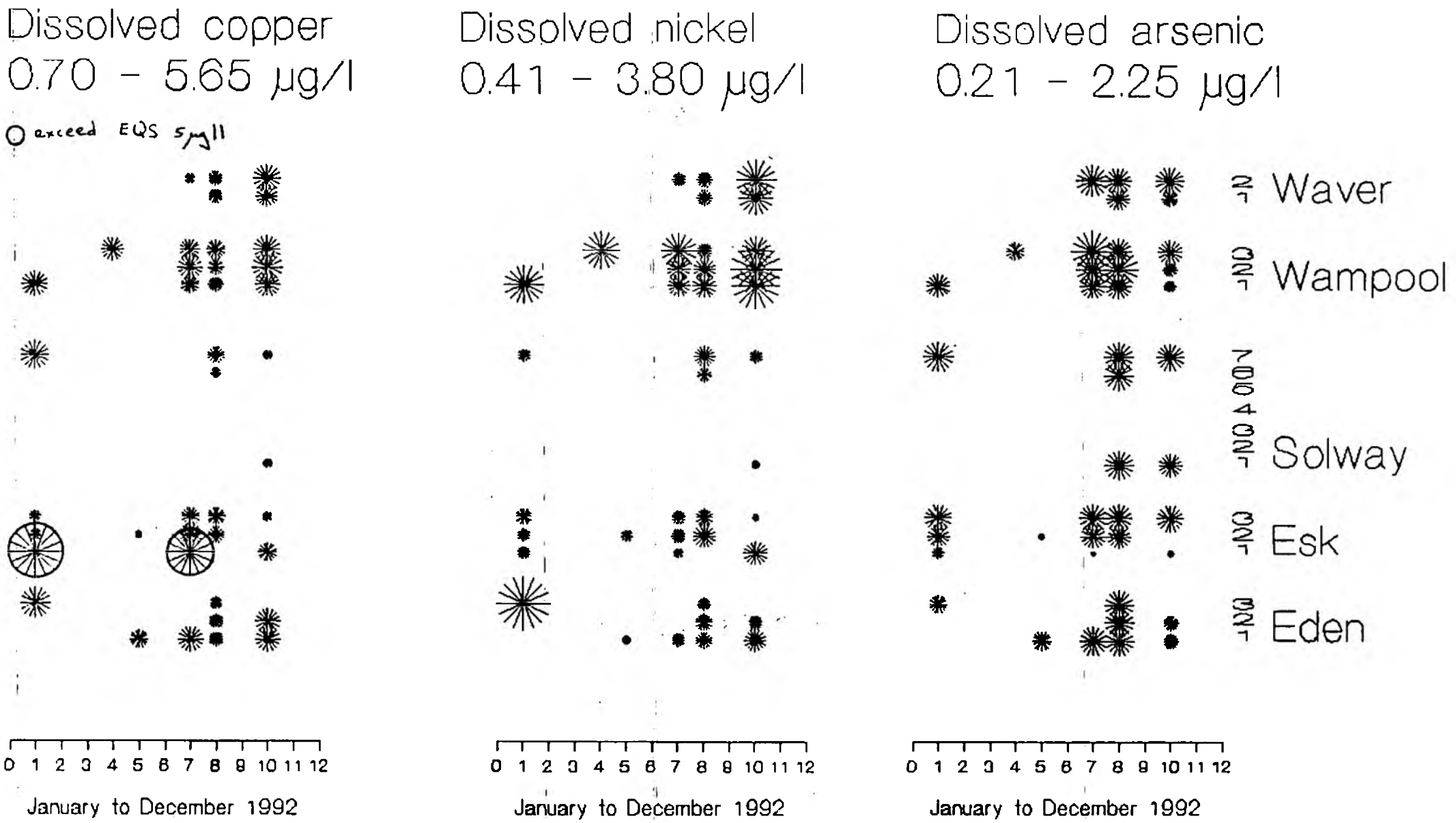

Dissolved copper
0.70 - 5.65 µg/l
○ exceed EQS 5µg/l
Dissolved nickel
0.41 - 3.80 µg/l
Dissolved arsenic
0.21 - 2.25 µg/l
Waver
Wampool
Solway
Esk
Eden
0 1 2 3 4 5 6 7 8 9 10 11 12
January to December 1992
0 1 2 3 4 5 6 7 8 9 10 11 12
January to December 1992
0 1 2 3 4 5 6 7 8 9 10 11 12
January to December 1992

FIGURE 8:

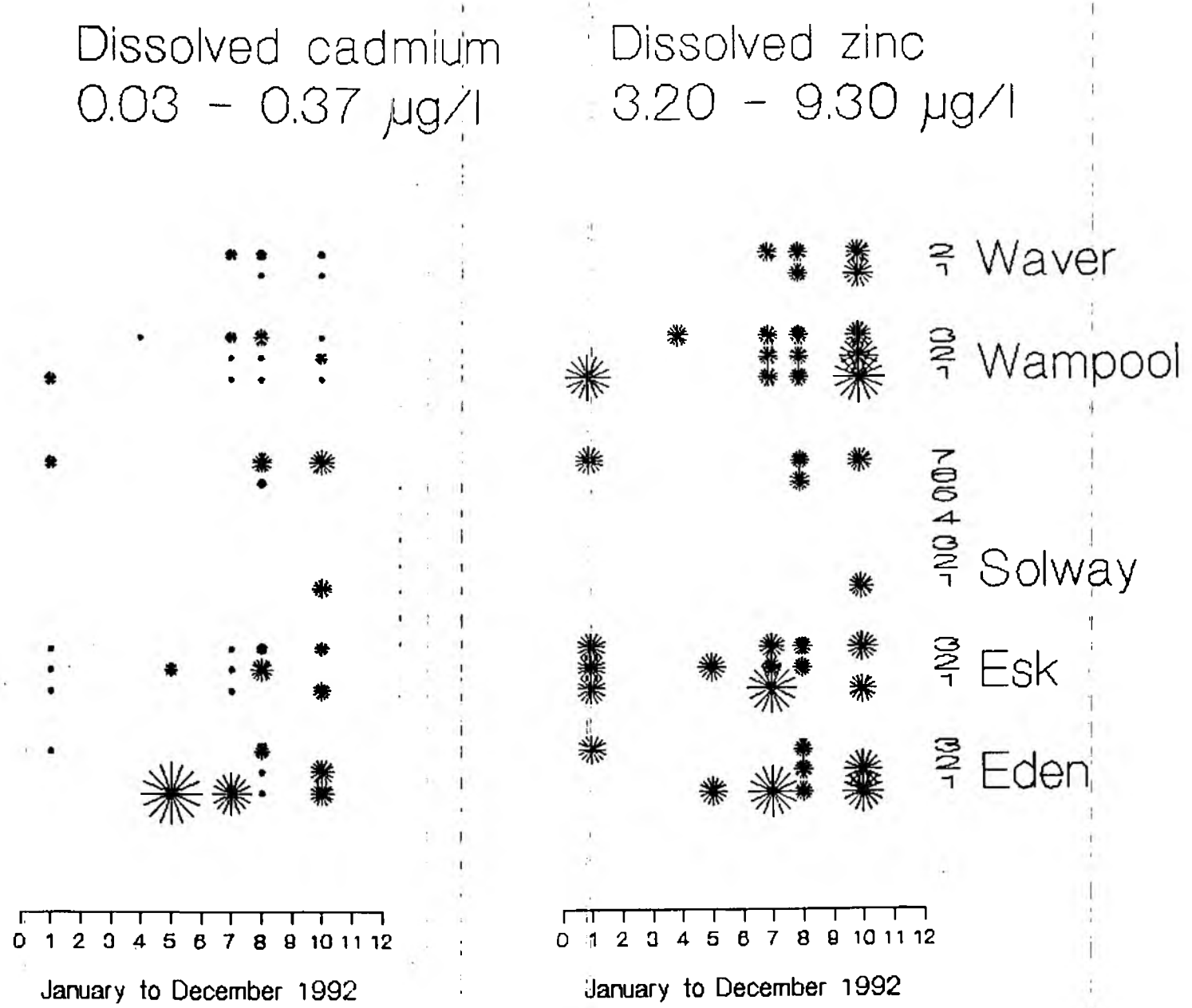
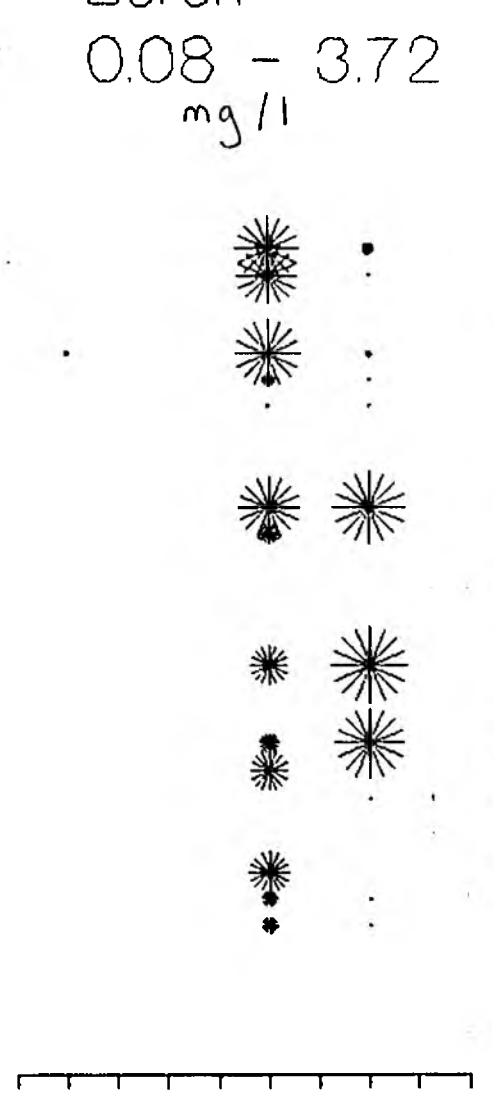
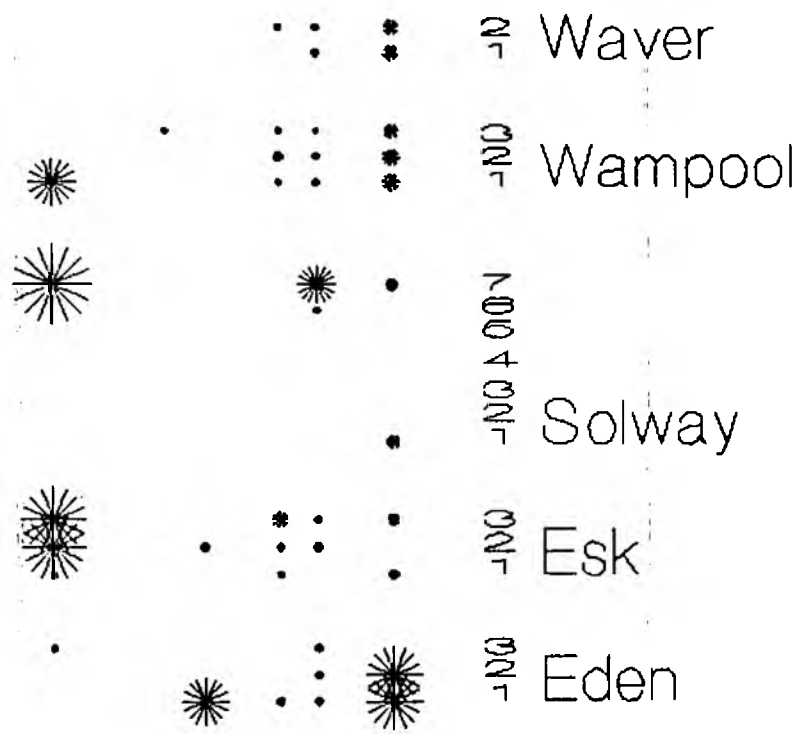
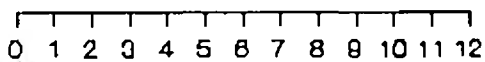

Dissolved cadmium
0.03 - 0.37 µg/l
Dissolved zinc
3.20 - 9.30 µg/l
Waver
Wampool
Solway
Esk
Eden
0 1 2 3 4 5 6 7 8 9 10 11 12
January to December 1992
0 1 2 3 4 5 6 7 8 9 10 11 12
January to December 1992

FIGURE 9 :



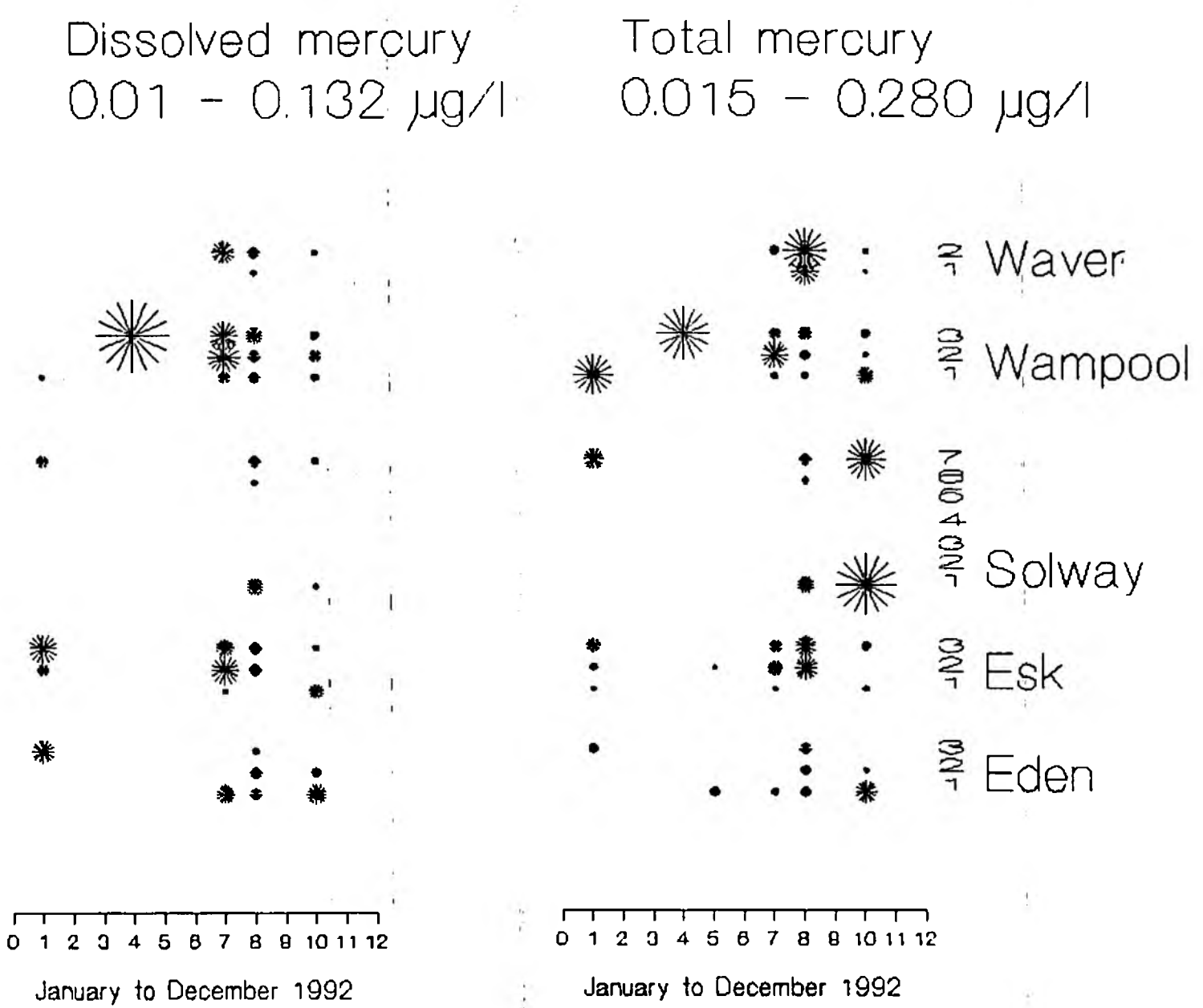
Dissolved chromium
0.25 - 3.90 µg/l





January to December 1992

FIGURE 10:


Dissolved mercury
0.01 - 0.132 µg/l
Total mercury
0.015 - 0.280 µg/l
Waver
Wampool
Solway
Esk
Eden
0 1 2 3 4 5 6 7 8 9 10 11 12
January to December 1992
0 1 2 3 4 5 6 7 8 9 10 11 12
January to December 1992

APPENDIX 1

DESCRIPTION OF SAMPLING SITES

SOLWAY

	STATION	DESCRIPTION		S.P.N.
***	1.	lat 54 57.69	long 03 14.13	709870
	2.	lat 54 57.96	long 03 10.63	709849
	3.	lat 54 57.69	long 03 09.06	709842
	4.	lat 54 58.08	long 03 07.40	709839
	5.	lat 54 56.11	long 03 07.12	3136
	6.	lat 54 56.41	long 03 09.34	709845
***	7.	lat 54 57.37	long 03 13.93	709871

lat=latitude long=longitude

ESK

***	1.	Esk (border) estuary railway bridge dowstream Metal bridge	3133
***	2.	Esk (border) estuary between Gretna and Sarkfoot point	3134
***	3.	Esk (border) estuary at Redkirk point	3135

EDEN

***	1.	Eden near Cargohill	3130
***	2.	Eden between Castletown House and Rockcliffe	3131
***	3.	River Eden at Sandsfield	609741

WAVER

***	1.	Waver estuary at the railway cutting	509231
***	2.	Waver estuary at Winding Banks	509232

WAMPOOL

***	1.	Wampool at Haythes	509300
***	2.	Wampool estuary at Whitrigg bridge	3132
***	3.	Wampool estuary at Anthorn	509311

S.P.N. = Sampling Point Number

*** BASELINE MONITORING STATION

APPENDIX 2

ENVIRONMENTAL QUALITY OBJECTIVES AND STANDARDS

FOR ESTUARIES AND COASTAL WATERS

(Information Dated January 1993)

QUALITY STANDARDS
Protection of salt water life

Arsenic	25 µg/l	annual mean, dissolved
Boron	7000 µg/l	annual mean, total
Chromium	15 µg/l	annual mean, dissolved
Copper	5 µg/l	annual mean, dissolved
Cyfluthrin	0.001 µg/l	total, 95%
Flucofuron	1 µg/l	total, 95%
Iron	1000 µg/l	annual mean, dissolved
Lead	25 µg/l	annual mean, dissolved
Nickel	30 µg/l	annual mean, dissolved
PCSDs	0.05 µg/l	total, 95%
Permethrin	0.01 µg/l	total, 95%
pH	6 - 8.5	95%
Sulcofuron	25 µg/l	total, 95%
Tributyltin	0.002 µg/l	maximum, total
Triphenyltin	0.008 µg/l	maximum, total
Vanadium	100 µg/l	annual mean, total
Zinc	40 µg/l	annual mean, dissolved

QUALITY STANDARDS - endorsed
annual mean

Total "drins"	0.03 µg/l	until 1994
Aldrin	0.01 µg/l	from 1.1.94
Dieldrin	0.01 µg/l	from 1.1.94
Endrin	0.005 µg/l	
Isodrin	0.005 µg/l	from 1.1.94
Cadmium	2.5 µg/l	dissolved
Carbon tetrachloride (CTC)	12 µg/l	
Chloroform	12 µg/l	
DDT	0.01 µg/l	para-para-DDT
DDT total	0.025 µg/l	
1,2-Dichloroethane (EDC)	10 µg/l	
Hexachlorobenzene (HCB)	0.03 µg/l	
Hexachlorobutadiene (HCBD)	0.1 µg/l	
Hexachlorocyclohexane (HCH)	0.02 µg/l	total of all 3 isomers
Mercury	0.3 µg/l	dissolved
Pentachlorophenol (PCP)	2 µg/l	
Trichlorobenzene (TCB)	0.4 µg/l	
Trichloroethylene (TRI)	10 µg/l	
Tetrachloroethylene (PER)	10 µg/l	

APPENDIX 3

DETECTION LIMITS

Dissolved oxygen	0.2	mg/l
Boron	0.12	mg/l
Chlorophyll a	0.1	µg/l
Particulate solids (105 °C) surface	2	mg/l
Ammonia (range 0 - 60 µg/l)	1	µg/l
Nitrate (range 0 - 600 µg/l)	5	µg/l
Nitrite (range 0 - 60 µg/l)	1	µg/l
Phosphate (range 0 - 30 µg/l)	1	µg/l
Silicate (range 0 - 900 µg/l)	10	µg/l
Lead dissolved, total	2.5	µg/l
Mercury dissolved, total	0.02	µg/l
Cadmium dissolved, total	0.05	µg/l
Copper dissolved, total	0.5	µg/l
Zinc dissolved, total	5.0	µg/l
Arsenic dissolved, total	0.2	µg/l
Chromium dissolved, total	0.5	µg/l
Nickel dissolved, total	0.75	µg/l
Aldrin	0.001	µg/l
Endrin	0.003	µg/l
Dieldrin	0.001	µg/l
Hexachlorobenzene	0.05	µg/l
Hexachlorobutadiene	0.05	µg/l
HCH - alpha	0.05	µg/l
HCH - beta	0.05	µg/l
HCH - gamma	0.003	µg/l
PCB - 28, 101, 118, 138, 153, 180	0.01	µg/l
PCB 52	0.04	µg/l
PCB - total	0.1	µg/l
DDTop, TDEpp, DDEop	0.006	µg/l
DDTpp	0.001	µg/l
DDEpp	0.002	µg/l
Atrazine	1	µg/l
Simazine	1	µg/l
Pentachlorophenol	0.1	µg/l
Carbon tetrachloride	1	µg/l
Chloroform	1	µg/l
Trichlorobenzene	1	µg/l
1,2 Dichloroethane	1	µg/l
Trichloroethane	1	µg/l
Tetrachloroethane	1	µg/l