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Project Number	S01007
Full Report Title	Monitoring of Toxin Producing Phytoplankton in Scottish Coastal Waters 01 April 2002 – 31 March 2003
Length in pages (each part separately)	53 plus appendices
Agency contact name for further information	Lorna Murray
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Project Abstract for Food Standards News (approximately 150 words)	The phytoplankton monitoring programme in Scotland fulfils the requirements of the EU directive 91/492/EEC, which requires member states to monitor their coastal water for the presence of toxin producing cells. This report presents the results from the phytoplankton monitoring programme in Scotland obtained from 1st April 2002 – 31st March 2003. During this time 506 samples were analysed by light microscopy for the presence of toxin producing cells. 100 samples were also analysed using transmission electron microscopy to identify the *Pseudo-nitzschia* cells present to species level. Nine different species were observed in Scottish waters, seven of which are potential toxin producers. These were *P. australis, P. cf. delicatissima, P. fraudulenta, P. multiseries, P. pungens, P. cf. pseudodelicatissima* and P. *seriata var. obtusa.*
Any additional information or instructions	

S01007

FISHERIES RESEARCH SERVICES | CONTRACT REPORT

Fisheries Research Services Contract Report No 14/03

MONITORING PROGRAMME FOR TOXIC PHYTOPLANKTON IN SCOTTISH COASTAL WATERS

1 APRIL 2002 – 31 MARCH 2003

Project Code: SO1007

E Bresnan

Fisheries Research Services Contract Report No 14/03

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Project Code: SO1007

E Bresnan

December 2003

Fisheries Research Services
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REPORT INFORMATION SHEET

Title: Monitoring Programme for Toxic Phytoplankton in Scottish Waters: 1 April 2002 – 31 March 2003

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MONITORING PROGRAMME FOR TOXIC PHYTOPLANKTON IN SCOTTISH COASTAL WATERS 1 APRIL 2002 – 31 MARCH 2003

Project Code: SO1007

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SECTION 1: SUMMARY

This report contains the results of the monitoring programme for toxic phytoplankton in Scottish coastal waters, 1 April 2002 – 31 March 2003, funded by the Food Standards Agency, Scotland (FSAS) in fulfilment of the EU Shellfish Hygiene Directive 91/492/EEC.

Fourteen coastal sites and eight offshore sites were initially selected to participate in the monitoring programme with coastal sites requested to supply water samples for light microscope analysis (LM) on, typically, a weekly basis during the summer and monthly during the winter (see Section 4 for details). Offshore sites were requested to be sampled fortnightly during the summer and monthly during the winter. A variable sample return rate was observed from coastal sites, with only 371 samples received in FRS instead of the requested 512. The percentage sample return *per* site varied from 17–100%. Bad weather and alternative sampling priorities meant that the sampling frequency of the targeted offshore boxes was particularly low with only 53 samples returned out of a requested 152. In order to supplement this low sample return in FRS, 82 extra samples for LM analysis were requested from an additional 45 offshore sites, bringing the total number of coastal and offshore LM samples analysed during the year to 506 (final number requested: 746).

A summary of the cell maxima data light microscope (LM) results is given in Table 1.1

TABLE 1.1

Summary of LM results from 2002–2003

Species Observed	Cell maxima Cells/l	Site	Date
Coastal Sites			
Alexandrium spp.	4,240	Scapa Bay	27 Mar 03
Dinophysis spp.	1,740	Stonehaven	05 Aug 02
Pseudo-nitzschia spp.	1,096,260	Loch Spelve	27 Sep 02
Prorocentrum lima	720	Scapa Bay	27 Jun 02
Protoceratium reticulatum	120	Loch Eishort	19 Aug 02
Lingulodinium polyedrum	80	Scalloway	11 Aug 02
Protoperidinium spp.	1,120	Loch Roag	24 Sep 02
Offshore sites			
Alexandrium spp.	160	O19	15 Apr 02
Dinophysis spp.	3,020	E21	26 Aug 02
Pseudo-nitzschia spp.	921,080	NM16	25 May 02
Prorocentrum lima	nd	nd	nd
Protoceratium reticulatum	60	E28	6 May 02
Lingulodinium polyedrum	20	NM16	24 June 02
Protoperidinium spp.	1,960	S14	03 Sep 02

nd: not detected

One hundred samples from 27 sites around the Scottish coast and offshore areas were analysed using Transmission Electron Microscopy (TEM) to identify *Pseudo-nitzschia* cells present to species level. Nine species were identified including *P. americana*, *P. australis*, *P cf. heimii*, *P. fraudulenta*, *P. cf. multiseries*, *P. pungens*, *P cf. pseudodelicatissima* and *P. cf. seriata*. Species which are underlined are potential amnesic shellfish toxin (AST) producers.

Results from the Scottish Executive funded project 'Investigations into the causative organism of Amnesic Shellfish Toxin (AST) in shellfish harvested from Scottish waters' (Project code: AE1159), are also presented in this report. FSAS supported this project by allowing phytoplankton samples to be taken in offshore scallop fishing grounds on their charter vessels and by funding the TEM analysis of *Pseudo-nitzschia* spp. cells.

SECTION 2: INTRODUCTION

The monitoring programme for toxic phytoplankton in Scottish coastal waters fulfils the requirements of the EU directive 91/492/EEC. This programme has been in operation since 1996 and has been funded by the Food Standards Agency, Scotland (FSAS) since 2001.

In Scotland at least three types of shellfish toxin are known to occur:

1. Paralytic Shellfish Toxin (PST) which may be associated with dinoflagellates of the genus *Alexandrium.*

2. Diarrhetic shellfish toxin (DST) which can be associated with the dinoflagellate *Dinophysis* and the benthic *Prorocentrum lima* (the latter being difficult to monitor in routine samples).

3. Amnesic shellfish toxin (AST) which may be associated with the diatom *Pseudo-nitzschia* species.

The phytoplankton monitoring programme examines water samples from around the Scottish coast for the presence of these cells and other toxin producers. Light microscopy (LM) methods were used to both identify and quantify any potential toxin producing species present. In addition 100 samples were also analysed using transmission electron microscopy (TEM) to identify *Pseudo-nitzschia* cells present to species level.

Fourteen sites around the Scottish coast were selected to take part in the monitoring programme during 2002/2003. Eight offshore sites, chosen on the basis of historic levels of AST in scallops, were also targeted for sampling. When the sample numbers returned from these sites was observed to be low an additional 45 offshore sites were also sampled in order to supplement the number of LM samples received at FRS.

The success of the phytoplankton-monitoring programme is largely due to the extensive effort of shellfish farmers, Fisheries Officers, Environmental Health Officers and others who take considerable time and apply a lot of effort to voluntarily collect and send in samples on a regular basis.

This report presents the data obtained under this programme from samples collected between 1 April 2002 – 31 March 2003. In addition, this report also presents data collected under the Scottish Executive project 'Investigations into the causative organism of AST in shellfish harvested from Scottish waters (Project code AE1159)' which received considerable support from the FSAS.

SECTION 3: METHODOLOGY

3.1 Sampling Sites

The 14 coastal sites around Scotland selected to participate in the monitoring programme (Fig. 3.1) were chosen on the basis of their location in relation to shellfish harvesting areas and also geographic position around the Scottish coastline.

The eight offshore sites targeted for water collection (Fig. 3.2) were chosen on the basis of historic AST levels in king scallops (*Pecten maximus*). An additional 45 offshore sites were sampled during the year in order to increase the number of LM samples received by FRS. Details of these sites are given in Table 4.3.

3.2 Sampling Protocol

The sampling method described in Kelly and Fraser (1998) was used to take water samples for the identification and enumeration of potential toxin producing cells. Integrated water samples were taken using a 10 m tube sampler, one-litre of which was preserved with Lugol's iodine and sent to FRS for analysis. Samples were collected monthly in winter (November–March) and weekly during the summer (April–October).

Four sites, Stonehaven, Scapa, Scalloway and Isle of Ewe were sampled weekly throughout the year as these sites also participate in an FRS climate change project. Two sites, Dhoon and Loch Ryan, were sampled monthly due to the limited availability of the collectors.

3.3 Light Microscopy

A 50 ml subsample of the preserved sample was examined using the Ütermohl technique (Throndsen, 1995) for the presence of toxin producing cells. This method has a sensitivity of 20 cells *per* litre. The target species monitored and their associated toxin are presented in Table 3.1.

3.4 Transmission Electron Microscopy

Samples with relatively high *Pseudo-nitzschia* spp. numbers (>20,000 cells *per* litre) determined by LM, were selected for analysis by transmission electron microscopy (TEM). The cells in a 900 ml aliquot of sample were allowed to settle and the top 850 ml gently siphoned off. The remaining 50ml was concentrated to a volume of 5ml by centrifuging at 2500 rpm for 15-20 minutes and the supernatant discarded. The diatoms were then cleaned using the method of Christensen (1988). Cleaned samples were rinsed and concentrated using centrifugation to a volume of 1–2 ml in distilled water. Samples were mounted on a 150 or 200 mesh formvar-coated TEM grid using a Pasteur pipette and left overnight to air-dry. The samples were then analysed using a Phillips 301 TEM at the Electron Microscope Unit, University of Aberdeen.

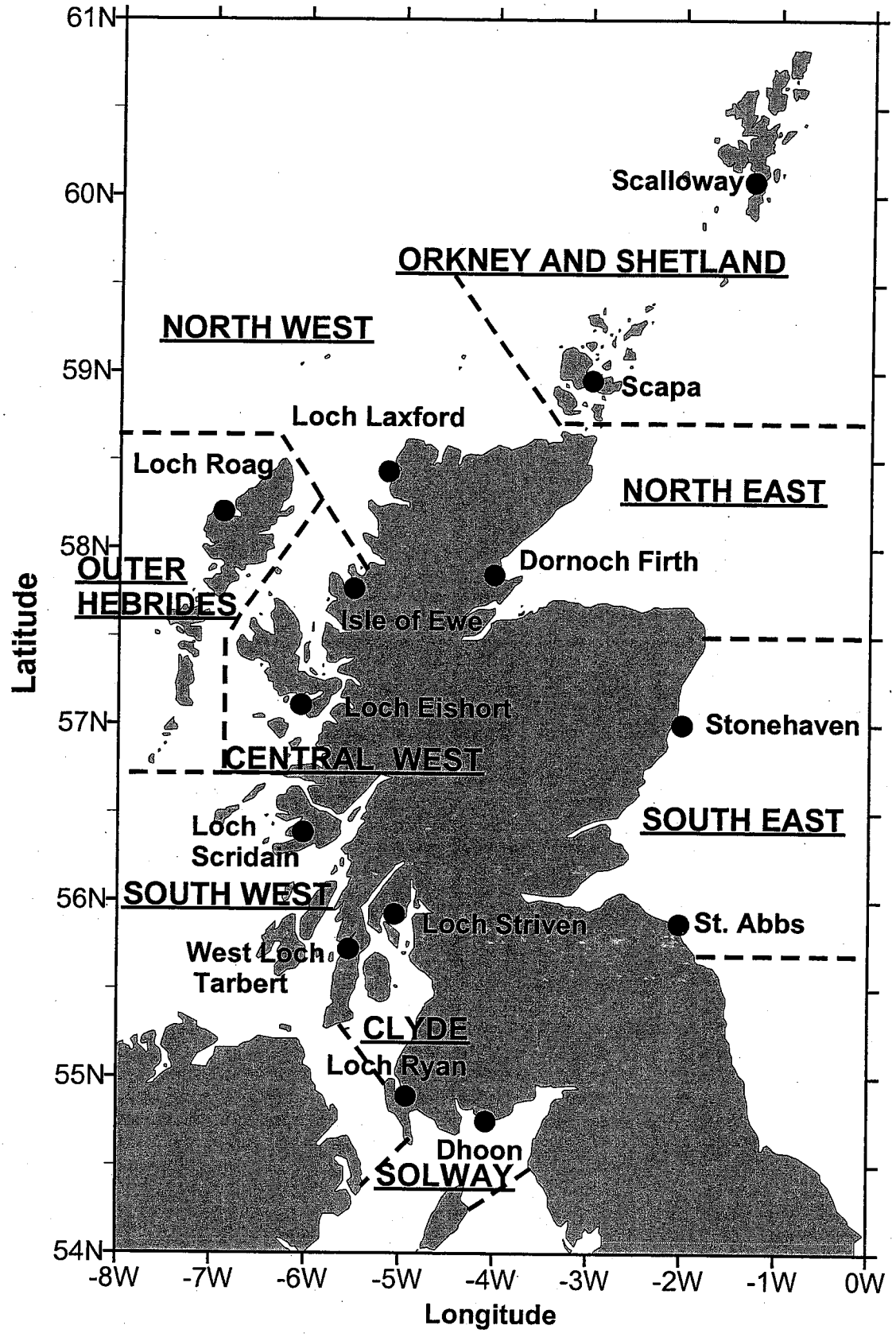

Figure 3.1 Location of coastal sites selected for inclusion in the monitoring programme during 2002/2003.

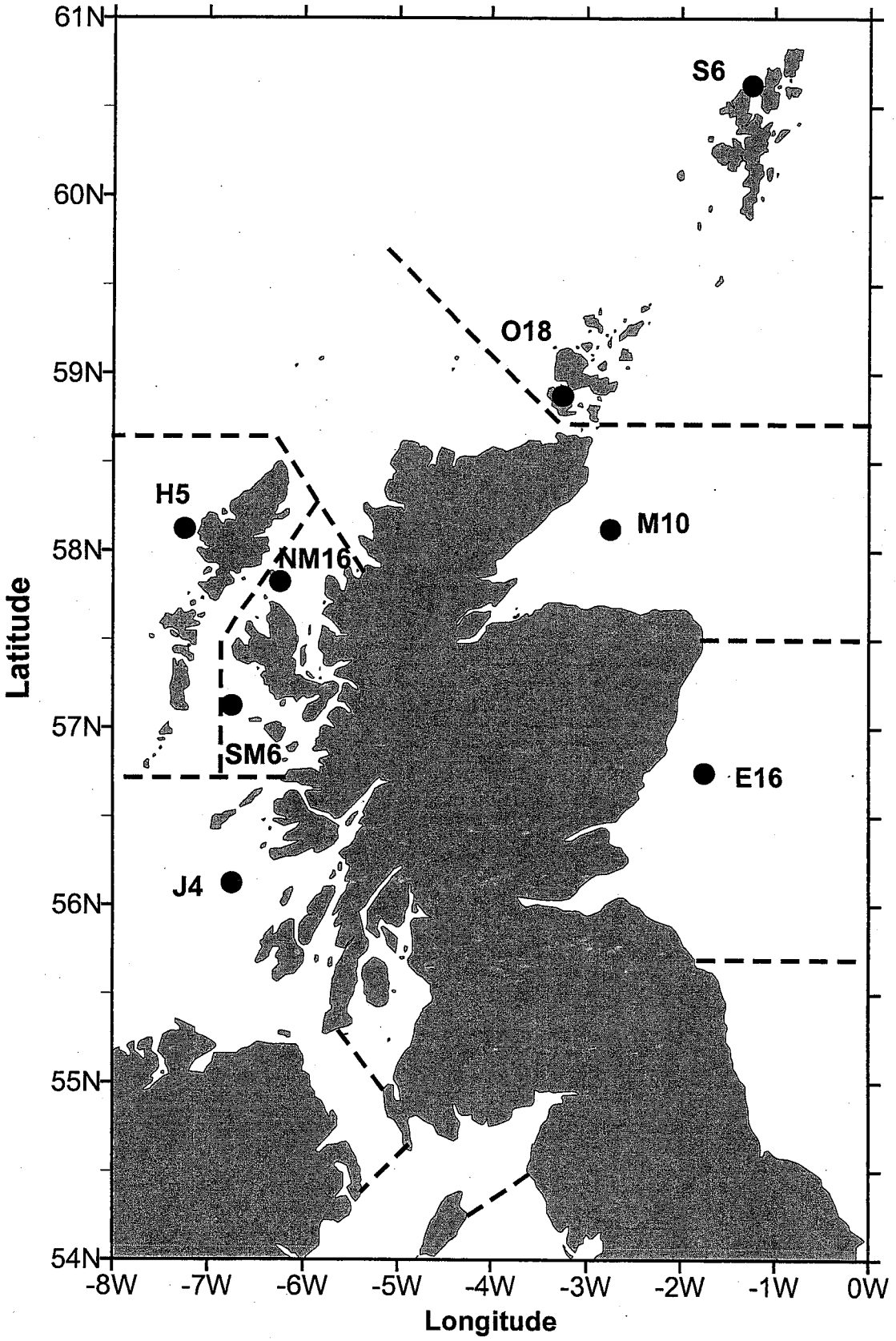

Figure 3.2 Offshore sites initially targeted for monitoring during 2002/2003. The box numbers (E16, M10, O18, S6, H5, NM16, SM6 and J4) correspond to the numbering used in the shellfish flesh monitoring programme with E representing East Coast, M - Moray, O - Orkney, S - Shetland, H - Hebrides, NM – North Minch, SM – South Minch, J – Jura.

TABLE 3.1

Phytoplankton species and associated toxin monitored by the phytoplankton monitoring programme during 2002/2003.

Species	Toxin
Alexandrium spp.	PST (paralytic shellfish toxin)
Dinophysis acuminata	DST (diarrhetic shellfish toxin)
D. acuta	DST (diarrhetic shellfish toxin)
D. norvegica	DST (diarrhetic shellfish toxin)
D. dens	DST (diarrhetic shellfish toxin)
Prorocentrum lima	DST (diarrhetic shellfish toxin)
Lingulodinium polyedrum	Yessotoxin (YTX)
Protoceratium reticulatum	Yessotoxin (YTX)
Pseudo-nitzschia spp.	Amnesic shellfish toxin (AST)
Protoperidinium spp.	Potential Azaspiracid producers (AZA)

SECTION 4: RESULTS

4.1 Sample Return

A variable sample return rate was observed from a number of sites participating in the monitoring programme this year. Of the 664 samples requested from the coastal and offshore sites initially selected to participate in the programme, only 424 were received in FRS. In order to supplement this low sample number, an additional 82 samples were collected from an extra 45 offshore sites. In total, 506 samples (371 coastal, 135 offshore) were received out of a final requested number of 746.

Table 4.1 shows a variable sample return rate for coastal sites participating the monitoring programme. Although not selected by the monitoring programme, ten samples were received from Loch Etive during the year. The % return rate from coastal sites ranged from 17–100. While some sites, such as Isle of Ewe, Scapa and Loch Roag had a sample return of >90%, a third of the sites had a sample return rate of < 60%.

Table 4.2 shows the sample return rate from the offshore sites initially targeted. Due to bad weather and alternative sampling priorities, this sample return was extremely low, with the return rate varying from 21–56%. In order to increase the total sample number received at FRS, additional offshore sites were sampled. Details of these samples are given in Table 4.3. With the exception of two sites, E2 and O19, the sample return rate of these additional offshore sites was <5 samples *per* year.

TABLE 4.1

Sample information for water samples from coastal sites received 1 April 2002 – 31 March 2003

Site	Samples requested	Samples received	% return	collector
St Abbs	35	6	17	EHO
Dornoch Firth	35	13	37	Highland Council
Loch Laxford	35	20	57	Shellfish Farmer
Loch Roag	35	32	91	Shellfish Farmer
Loch Scridain/Spelve	35	30	85	Shellfish Farmer
Loch Eishort	35	26	86	Shellfish Farmer
Loch Striven	35	13	37	Shellfish Farmer
West Loch Tarbert	35	17	48	Shellfish Farmer
Scalloway	52	38	73	North Atlantic/ Fishery College
Scapa Bay	52	49	92	Orkney Council
Isle of Ewe	52	53	>100	Shellfish Farmer/FRS
Stonehaven	52	42	80	FRS
Loch Ryan	12	11	91	EHO
Dhoon	12	11	91	EHO
Loch Etive	-	-	10	Shellfish Farmer
Total		**512**		**371**

TABLE 4.2

Sample information for water samples from offshore sites received 1 April 2002 – 31 March 2003

Site	Samples requested	Samples received	% return	Collector
Targeted sites				
E16	19	4	21	FSA charter vessels
M10	19	4	21	FSA charter vessels
O18	19	10	52	FSA charter vessels
S6	19	3	16	FSA charter vessels
H5	19	11	56	FSA charter vessels
NM16	19	10	53	FSA charter vessels
SM6	19	7	37	FSA charter vessels
J4	19	4	21	FSA charter vessels
Total	**152**		**53**	

TABLE 4.3

Sample information for water samples from additional offshore sites targeted due to low sample return from 1 April 2002 – 31 March 2003

Site	Number of samples requested	Site	Number of samples requested
East Coast		**West Coast**	
E2	7	NM9	2
E3	1	NM12	3
E11	1	NM17	1
E17	2	NM19	2
E21	1	SM1	1
E22	1	SM2	1
E28	4	SM6	1
E33	1	SM7	1
M1	1	SM10	1
M9	2	SM11	1
M11	1	SM15	1
M16	1	SM16	1
M18	1	H3	1
M19	1	H9	1
M28	1	H10	2
O11	1	J1	4
O12	2	J2	3
O19	11	J3	1
O25	1	J5	1
O27	1	J7	2
S2	1		
S4	1		
S7	1		
S10	2		
S14	4		
Total number of samples			**82**
Total number of sites			**45**

4.2 Light Microscope Analysis

4.2.1 Coastal sites

Three hundred and seventy one samples from coastal sites were analysed by LM for the presence of toxin producing species. The maximum values of *Alexandrium* spp., *Dinophysis* spp., *Pseudo-nitzschia* spp., *P. lima*, *P. reticulatum*, *L. polyedrum* and *Protoperidinium* spp. recorded from each of the coastal sites from 1 April 2002 to 31 March 2003 are summarised in Table 4.4. This data is also presented in pictorially (Figs 4.1-4.7). The complete results for these sites are given in Appendix I.

4.2.2 Offshore sites

One hundred and thirty five samples from a final total of 53 offshore samples were analysed by LM for the presence of toxin producing species. A summary of these results is shown in Table 4.5. Full details of the results are given in Appendix I.

TABLE 4.4

Summary of LM analysis from coastal sites 2002/2003

Site	Max no of *Alexandrium* spp. (date observed)	Max no of *Dinophysis* spp. (date observed)	Max no of *Pseudo-nitzschia* spp. (date observed)	Max no of *P. lima* (date observed)	Max no *P. reticulatum* (date observed)	Max no *L. polyedrum* (date observed)	Max no *Protoperidinium* spp. (date observed)
South East							
St Abbs	60 17 Sep 02	1,660 17 Sep 02	320 24 Jun 02	nd nd	nd nd	nd nd	100 24 June 02
Stonehaven	120 15 May 02	1,740 05 Aug 02	202,250 12 Aug 02	40 29 Nov 02	40 1 Jul 02	nd nd	480 9 Jul 02
North East							
Dornoch	180 1 May 02	220 16 Jul 02	169,480 22 May 02	nd nd	nd nd	nd nd	40 8 Aug 02
Scapa	4,240 27 Mar 03	1,520 5 Jul 02	589,206 27 May 02	720 27 Jun 02	40 22 Apr 02	20 27 May 02	340 7 Oct 02
Scalloway	380 31 Aug 02	100 26 Jul 02	226,280 16 Aug 02	120 16 Aug 02	nd nd	80 11 Aug 02	440 3 Jun 02
North West							
Loch Laxford	60 24 Jul 02	1,040 06 Jul 02	61,180 08 Oct 02	20 5 Sep 02	nd nd	nd nd	340 2 Jun 02
Outer Hebrides							
Loch Roag	80 26 Aug 02	240 2 Sep 02	280,658 30 Sep 02	40 26 Aug 02	nd nd	20 26 Aug 02	1,120 24 Sep 02

nd: not detected

Central West							
Isle of Ewe	440 12 Aug 02	840 17 Jun 02	105,520 17 Jun 02	20 20 May 02	40 3 Jun 02	20 22 Jul 02	780 20 May 02
Loch Eishort	260 2 Apr 02	720 24 Jun 02	360,720 16 Sep 02	nd nd	120 19 Aug 02	20 27 May 02	320 20 May 02
South West							
Loch Etive	nd nd	20 03 Jun 02	9,980 15 Apr 02	nd nd	nd nd	nd nd	nd nd
Scridain/Spelve	260 15 Apr 02	80 29 Jul 02	1,096,260 27 Sep 02	20 22 Jul 02	nd nd	nd nd	240 22 Jul 02
W/L Tarbert	40 16 Sep 02	20 29 Apr 02	6,600 29 Apr 02	40 29 Jul 02	nd nd	nd nd	60 16 Sep 02
Clyde							
Loch Striven	80 22 May 02	1,640 05 Jun 02	191,904 05 Jun 02	nd nd	nd nd	nd nd	680 5 Jun 02
Solway							
Loch Ryan	nd nd	60 25 Jun 02	25,904 22 Jul 02	nd nd	nd nd	nd nd	60 17 Jul 02
Dhoon	20 03 Apr 02	20 30 Sep 02	560 30 Sep 02	nd nd	nd nd	nd nd	nd nd

nd: not detected

TABLE 4.5

Summary of LM results from Offshore Sites 2002–2003

Species	Cell maxima	Site	Date Observed
Offshore sites			
Alexandrium spp.	160	O19	15 Apr 02
Dinophysis spp.	3,020	E21	26 Aug 02
Pseudo-nitzschia spp.	921,080	NM16	25 May 02
Prorocentrum lima	nd	nd	nd
Protoceratium reticulatum	60	E28	6 May 02
Lingulodinium polyedrum	20	NM16	24 June 02
Protoperidinium spp.	1,960	S14	3 Sep 02

nd: not detected

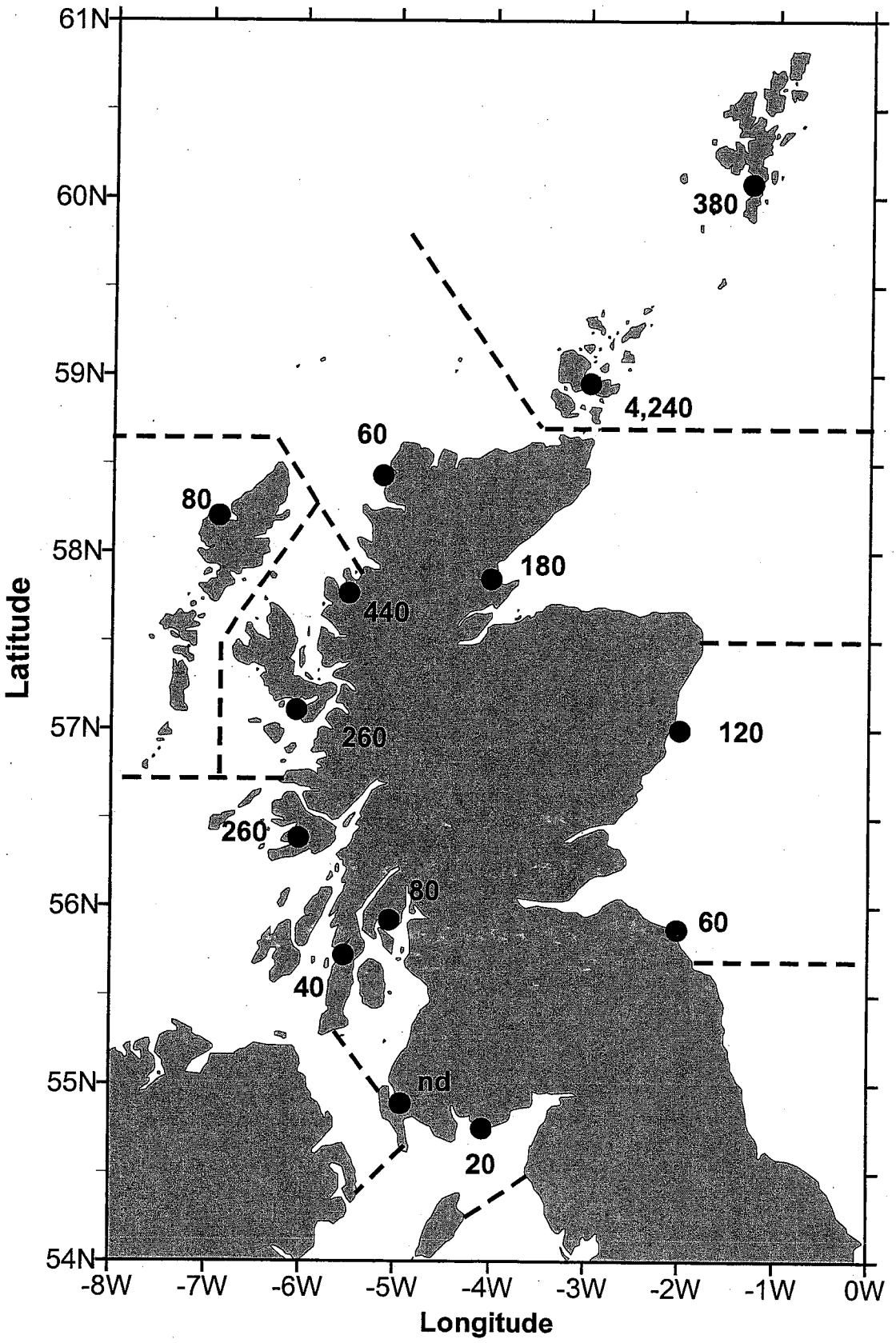

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Figure 4.1 Maximum number of *Alexandrium* cells *per* litre observed at each coastal site during 2002/2003.

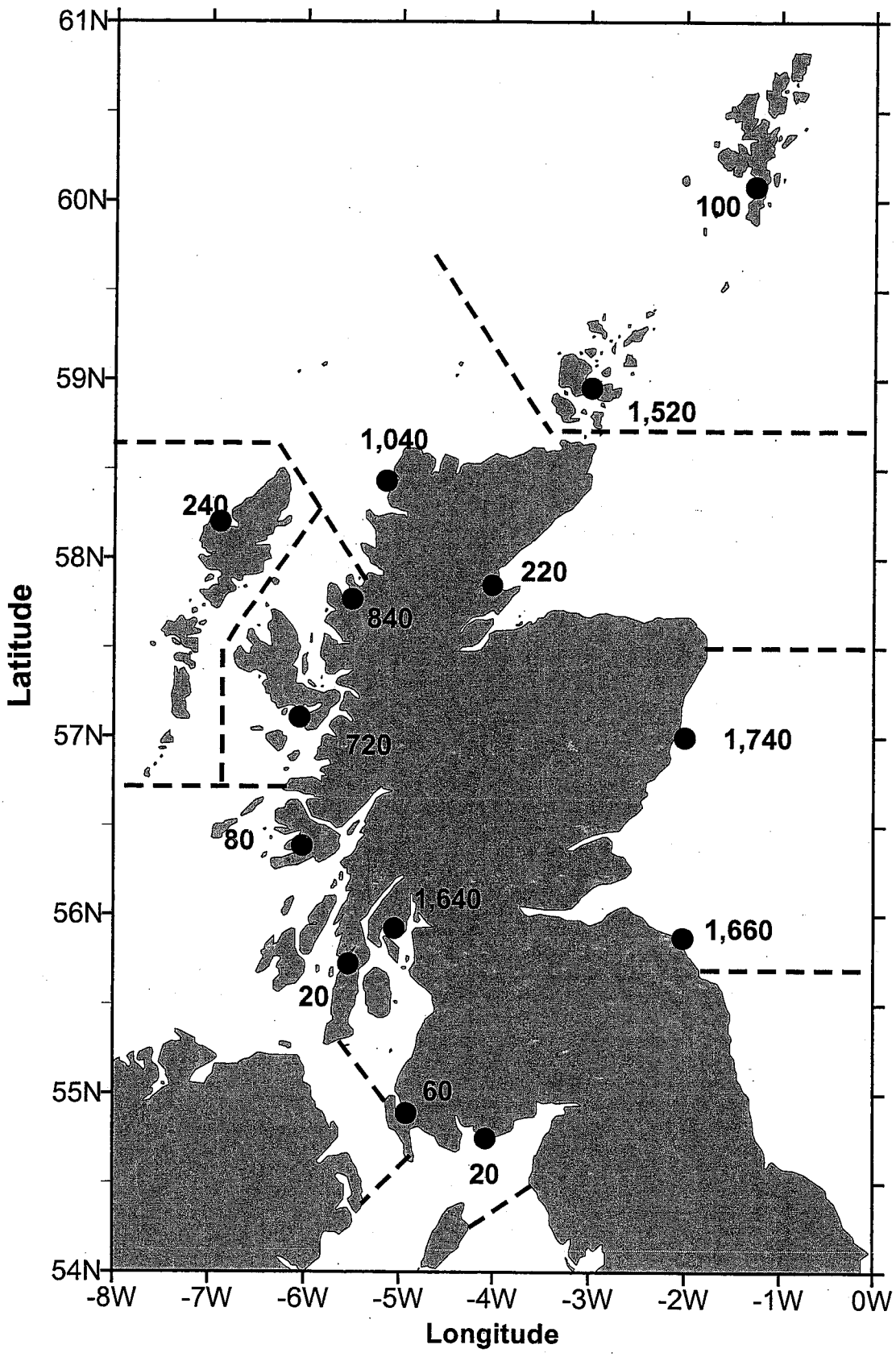

Figure 4.2 Maximum number of *Dinophysis* cells observed at each coastal site during 2002/2003.

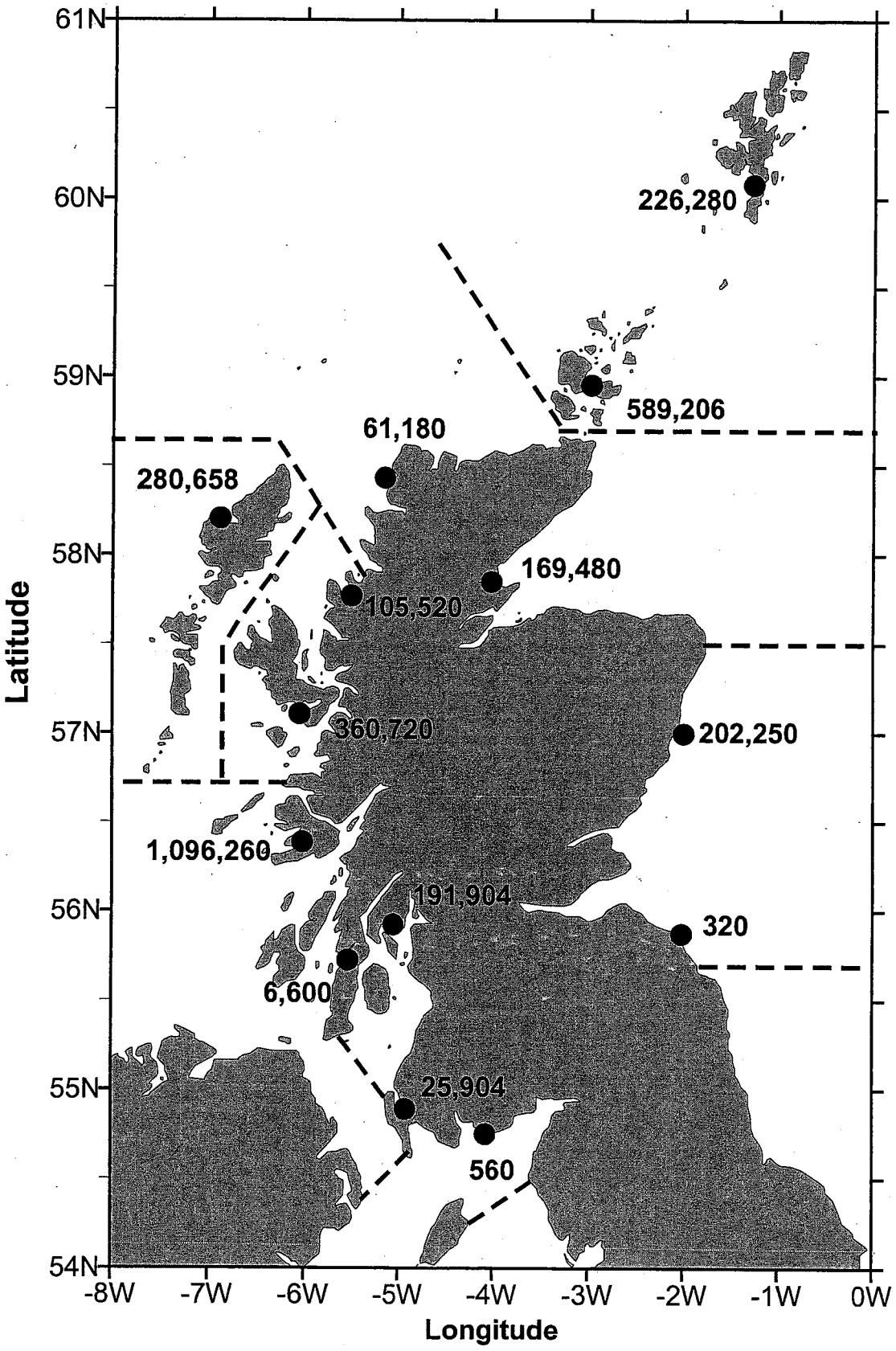

Figure 4.3 Maximum numbers of *Pseudo-nitzschia* cells observed at each coastal monitoring site during 2002/2003.

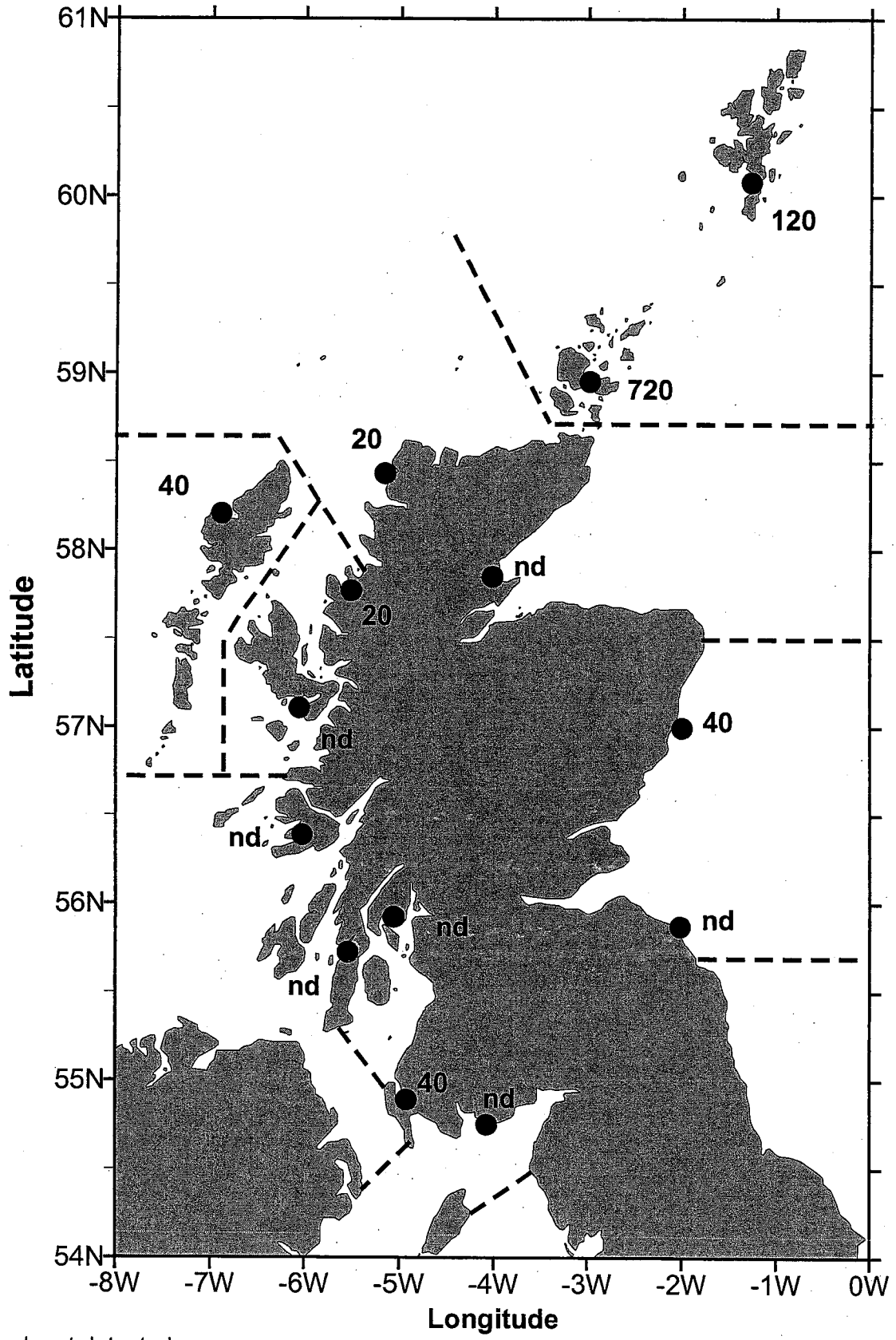

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Figure 4.4 Maximum numbers of *P. lima* cells observed at each coastal monitoring site during 2002/2003.

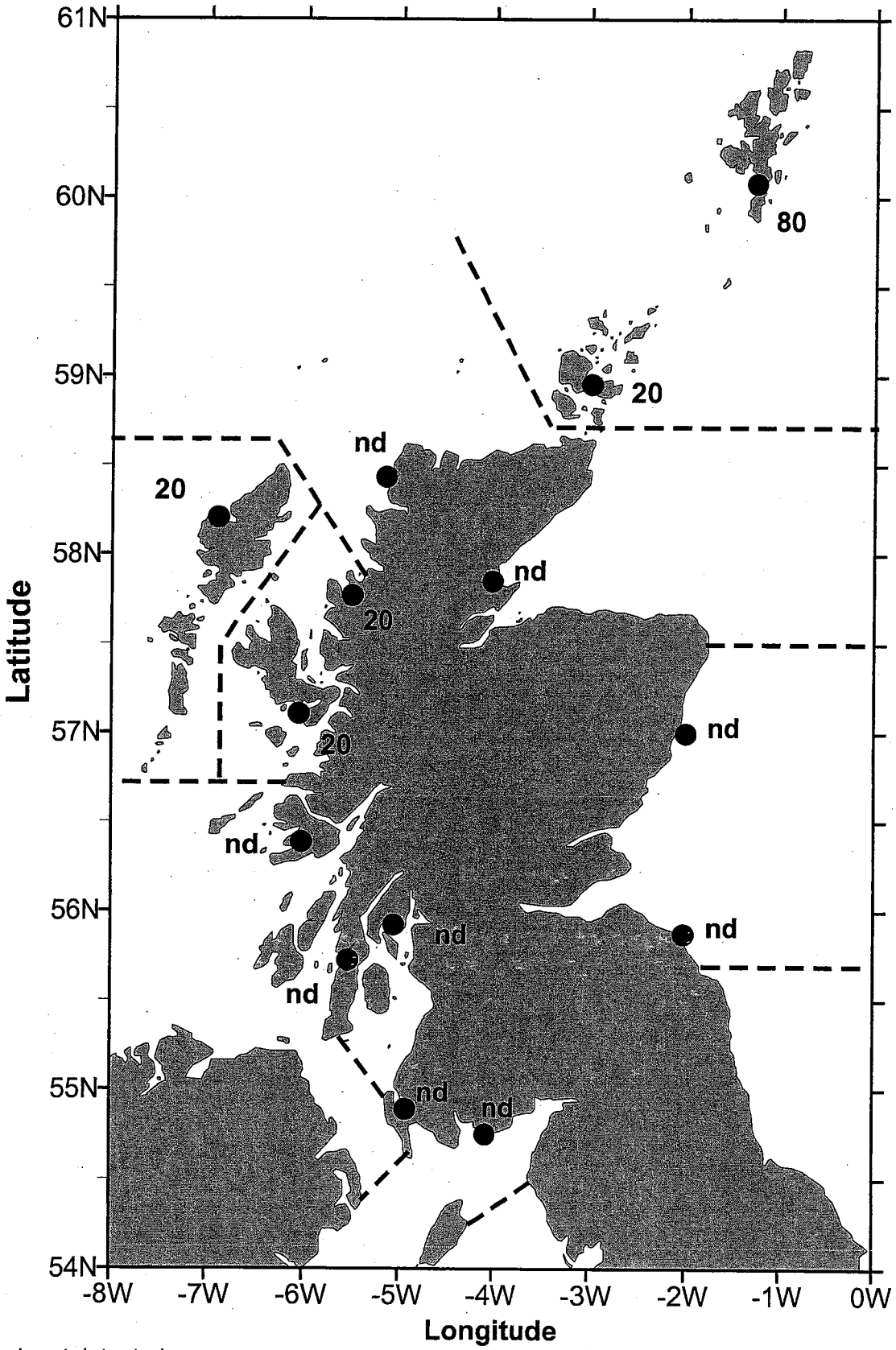

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Figure 4.5 Maximum numbers of *L.. polyedrum* cells observed at each coastal monitoring site during 2002/2003.

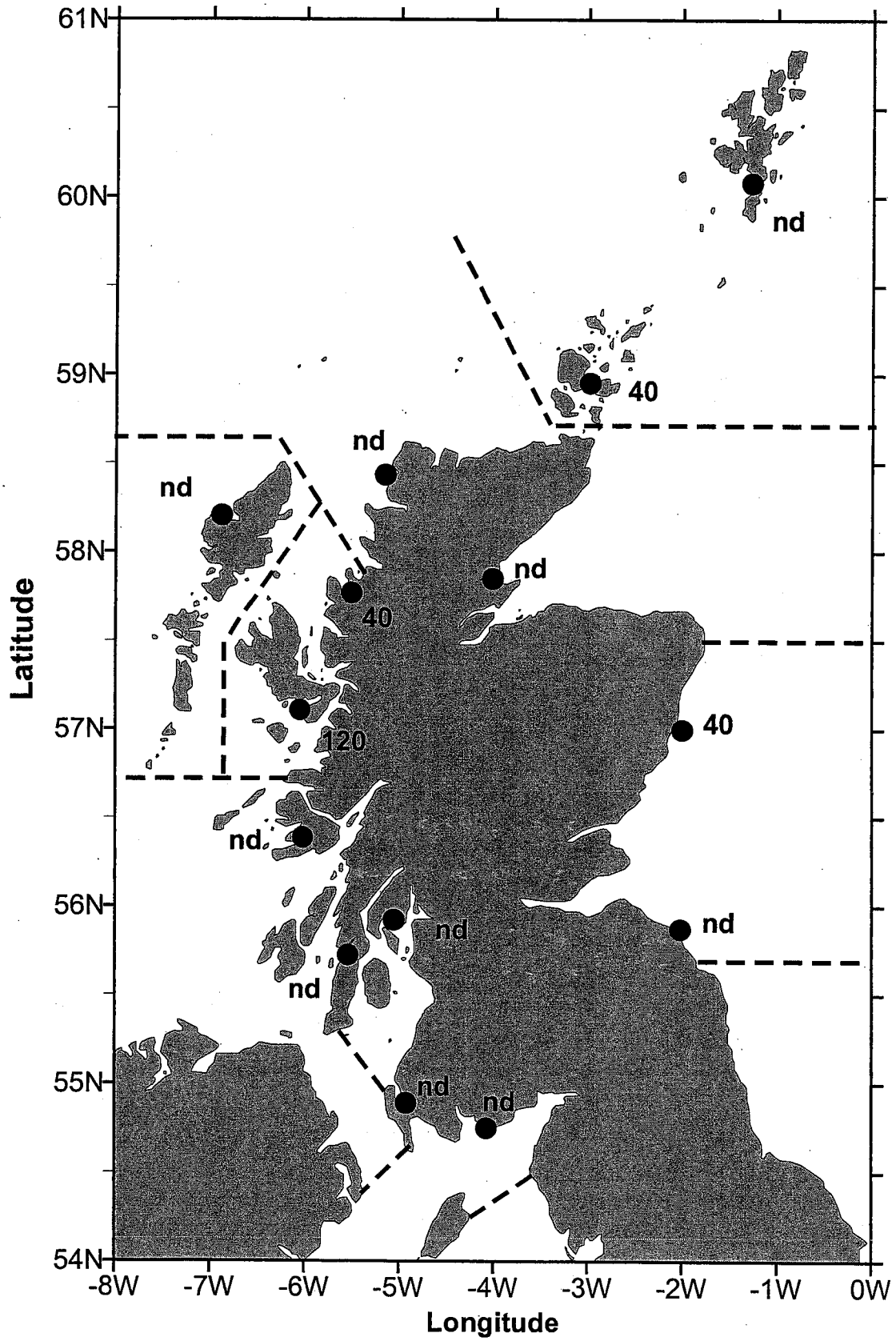

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Figure 4.6 Map showing maximum numbers of *P. reticulatum* cells observed at each coastal monitoring site during 2002/2003.

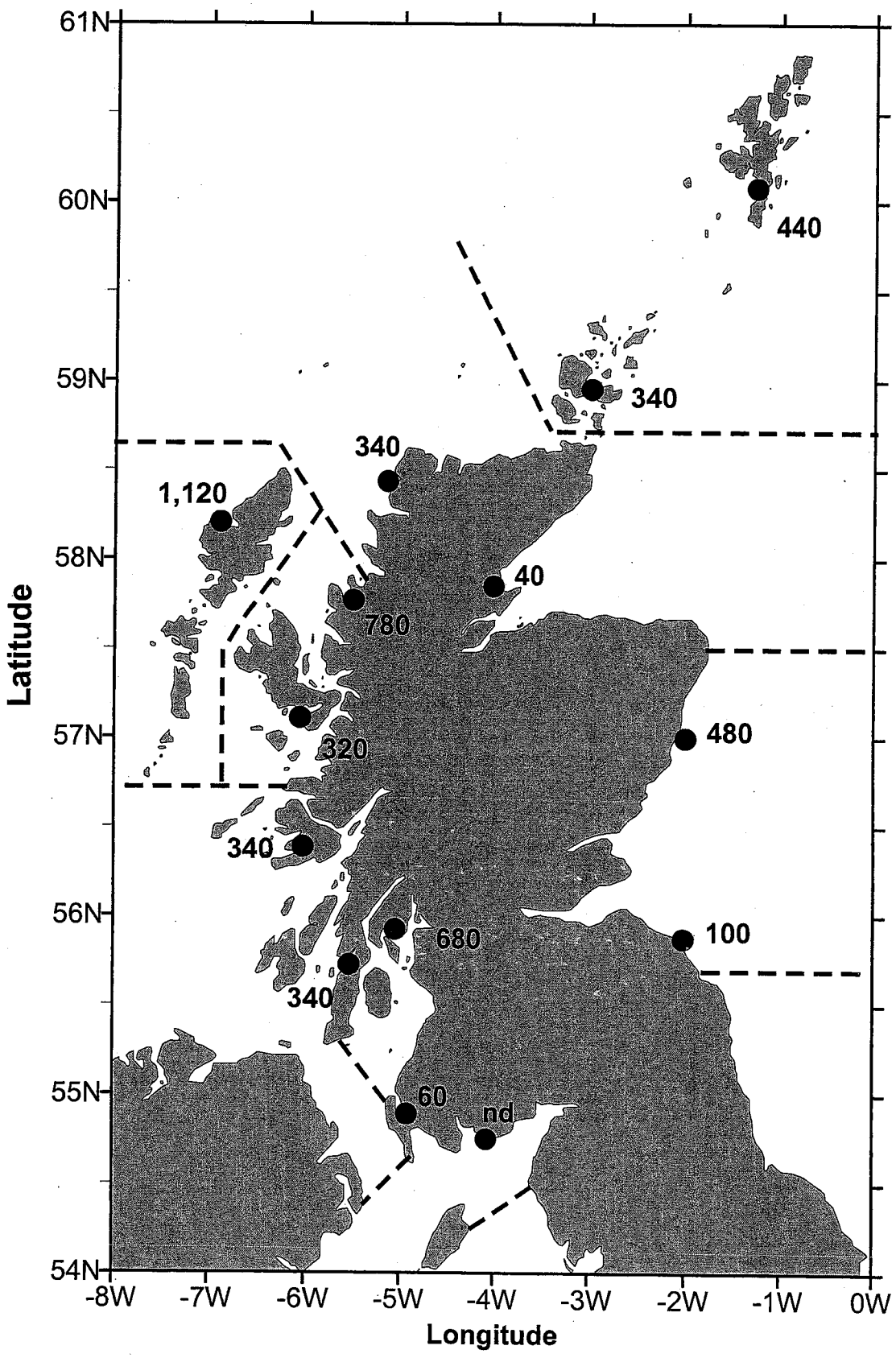

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Figure 4.7 Maximum numbers of *Protoperidinium spp.* cells observed at coastal monitoring sites during 2002/2003.

4.3 Relationship Between Phytoplankton Cells and Shellfish Toxicity: Coastal Sites

The relationship between phytoplankton cell number and toxin concentrations in shellfish was examined at three coastal sites. For continuity, the same sites were examined as in the 2002 Toxic Phytoplankton Monitoring Report (Bresnan, 2002). These sites were chosen because of their geographic location and represent the East Coast (St Abbs – replacing Elie Harbour which is no longer participating in the monitoring programme), the West Coast, (Loch Striven) and the Outer Hebrides (Loch Roag).

4.3.1 Relationship between *Alexandrium* spp. and PST in mussels (*Mytilus edulis*)

St Abbs: Historically, PST concentrations in *M. edulis* above the closure limit of 80 µg STX eq/100 g have been recorded at St Abbs (Kelly and Fraser, 1998). During 2002/2003, only six samples were returned from this site. Of these, only one contained measurable numbers of *Alexandrium* spp. (60 cells/l; Fig. 4.8). Only two samples of *M. edulis* were obtained during the year, one of which contained PSTs (30 µg STX eq/100 g flesh; Fig. 4.8). The low numbers of samples, coupled with the low cell numbers, preclude the possibility of assessing whether or not any relationship may exist between *Alexandrium* spp. and PST in mussels.

Loch Striven: During 2001/2002 low levels of *Alexandrium* spp. (20 cells/l) and no PST in *M. edulis* were recorded at this site. This pattern was again observed during 2002/2003 with maximum values of 80 *Alexandrium* spp. cells/l observed. No PST was recorded in *M. edulis* from Loch Striven during this year (Fig. 4.9).

Loch Roag: A good rate of sample return was obtained for Loch Roag with a total of 32 out of a requested 35 samples being returned to FRS. In contrast to 2001/2002, when high numbers of *Alexandrium* spp. (3,100 cells/l) were recorded coincidentally with high PST concentrations (maximum value 127 µg STX eq/100 g) above the closure limit (80 µg STX eq/100 g), lower levels were recorded during 2002/2003 (maximum no of *Alexandrium* spp.; 80 cells/l and no PST in *M. edulis,* Fig. 4.10).

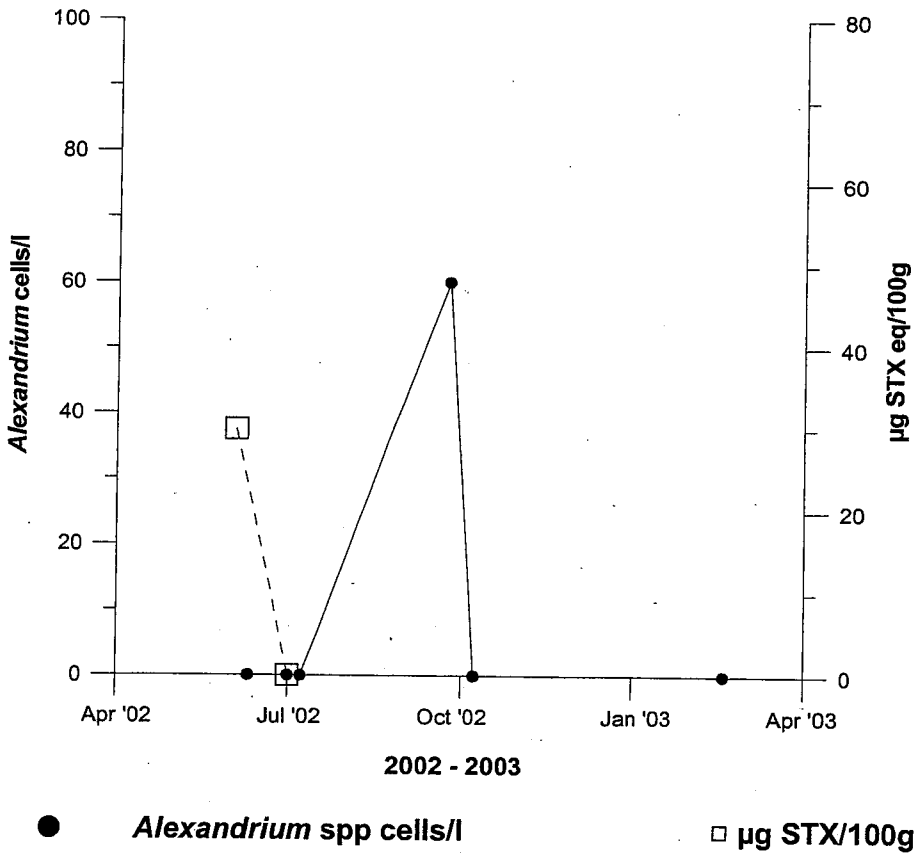


Figure 4.8 Graph showing *Alexandrium* spp cells and PST in *M. edulis* measured at St Abbs between 1 April 2002 – 31 March 2003.

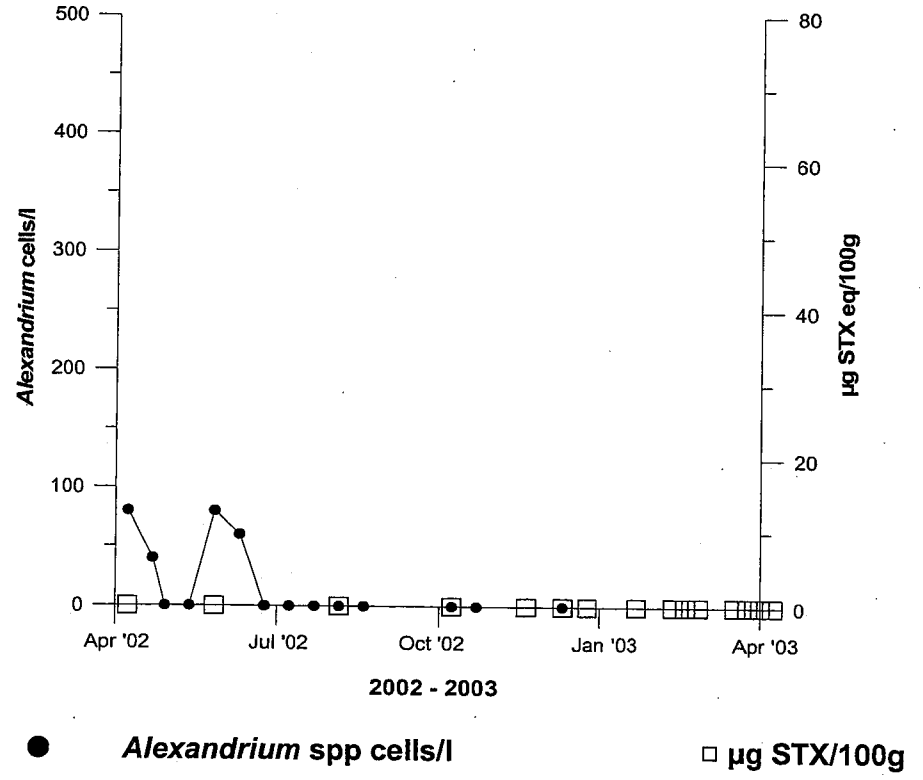


Figure 4.9 Graph showing *Alexandrium* spp cells and PST in *M. edulis* measured at Loch Striven between 1 April 2002 – 31 March 2003.

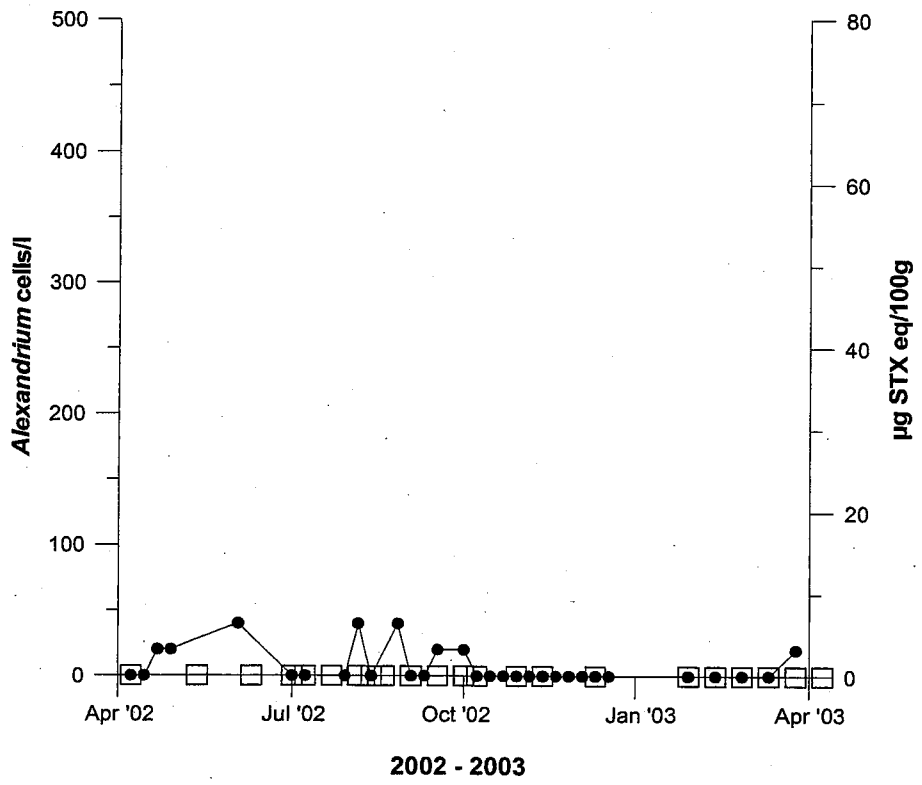


Figure 4.10 Graph showing *Alexandrium* spp cells and PST in *M. edulis* measured at Loch Roag between 1 April 2002 – 31 March 2003.

4.3.2 Relationship between *Dinophysis* spp and DST in mussels (*Mytilus edulis*)

St Abbs: Although there was a very low sample return from this site during 2002/2003, the data show high numbers of *Dinophysis* observed on two occasions during the year. The first peak occurred at the same time as a positive bioassay result indicating the presence of DST in *M. edulis* flesh. However, the low sample return does not allow any further examination of the relationship between the occurrence of *Dinophysis* spp. and DST in shellfish to be made (Fig. 4.11).

Loch Striven: High numbers of *Dinophysis* spp. and DST in *M. edulis* flesh were recorded during 2002. A mussel sample was received prior to the measured maximum, but at the same time as the numbers of *Dinophysis* spp. were increasing. This mussel sample was negative for DST. The next mussel sample was not obtained until 30 July, nearly two months after the measured maximum and when a slight increase in cell numbers was noted relative to the previous sample. This sample gave a positive DST result as did the next six mussel samples collected during October and November. Although the trend in *Dinophysis* cell counts was downward following the minor maximum in August (Fig. 4.12), the sample resolution is such that a third peak may have been missed and so it is not possible to say if the positive DST results are a carry over from the earlier *Dinophysis* events or not.

Loch Roag: Historically, low numbers of both *Dinophysis* spp. and DST concentration in *M. edulis* flesh have been recorded at this site. This was again observed during 2002/2003 with a maximum number of only 240 *Dinophysis* spp. cells observed during the year and no positive DST samples recorded (Fig. 4.13).

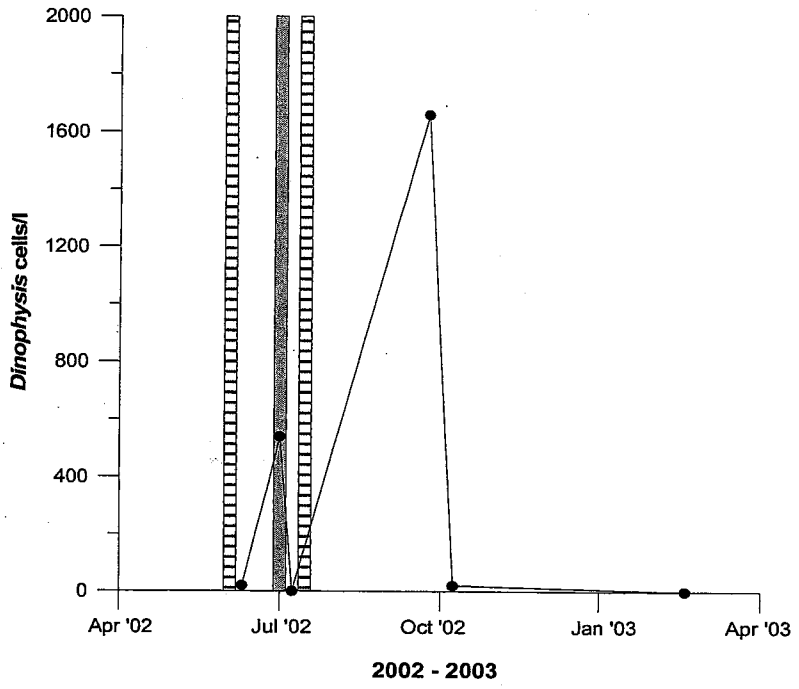


Figure 4.11 Graph showing *Dinophysis* spp cells and DST positive and negative bioassay results for *M. edulis* measured at St Abbs between 1 April 2002 – 31 March 2003. The circles represent *Dinophysis* cells/l, the filled bars represent DST positive samples and the striped bars represent DST negative samples.

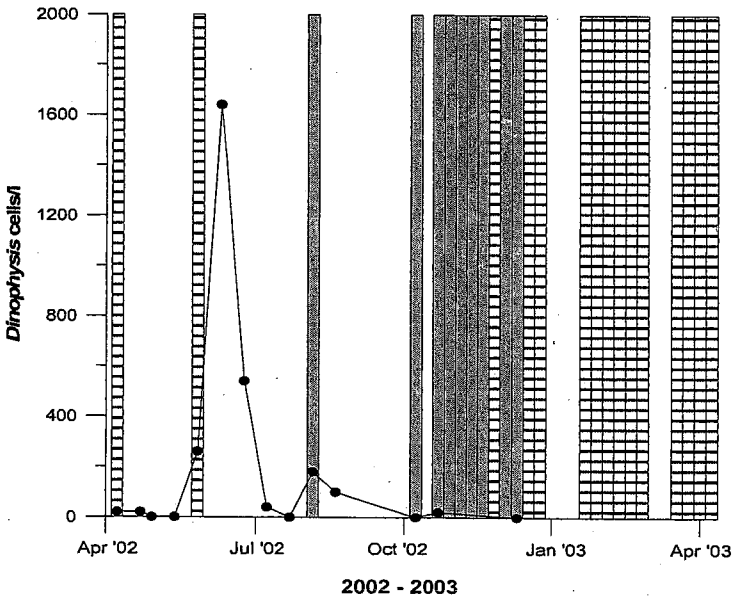


Figure 4.12 Graph showing *Dinophysis* spp cells and DST positive and negative bioassay results for *M. edulis* measured at Loch Striven between 1 April 2002 – 31 March 2003. The circles represent *Dinophysis* cells/l, the filled bars represent DST positive samples and the striped bars represent DST negative samples.

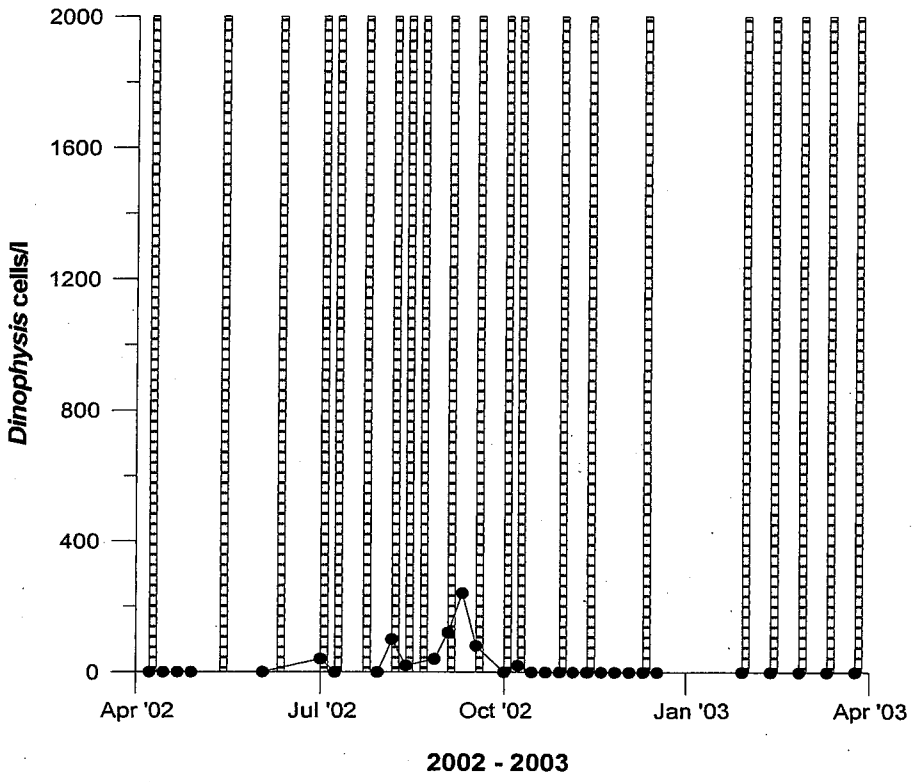


Figure 4.13 Graph showing *Dinophysis* spp cells and DST positive and negative bioassay results for *M. edulis* measured at Loch Roag between 1 April 2002 – 31 March 2003. The circles represent *Dinophysis* cells/l, the filled bars represent DST positive samples and the striped bars represent DST negative samples.

4.3.3 Relationship between *Pseudo-nitzschia* spp and AST in mussels (*Mytilus edulis*)

St Abbs: The relationship between *Pseudo-nitzschia* spp cells and AST in *M. edulis* is difficult to examine due to the low number of samples that were returned. Only two shellfish and six phytoplankton samples were returned during 2002/2003 which prevents any interpretation of occurrence of *Pseudo-nitzschia* spp and AST in *M. edulis* flesh (Fig. 4.14).

Loch Striven: In contrast to 2001/2002 when only 11,680 cells/l were recorded, high numbers of *Pseudo-nitzschia* cells (191,904 cells/l) were recorded during this year. The effect of this increase in cell number on the AST concentrations on shellfish flesh cannot be determined due to the 9 week gap before the next shellfish flesh sample was returned. *M. edulis* show a very fast depuration rate (*FRS, unpublished data*) and it is possible that some ASTs did accumulate in *M. edulis* flesh and depurated before the next sample was sent in. Low cell numbers and AST levels were recorded throughout the rest of the year at this site (Fig. 4.15).

Loch Roag: High numbers of *Pseudo-nitzschia* cells (280,685 cells/l) were again recorded at this site. AST was detected in *M. edulis* flesh as cells numbers began to increase, but only low levels of this toxin (< the closure level of 20 µg domoic acid/g) were recorded in flesh samples, even when cell numbers were at their maximum. (Fig. 4.16).

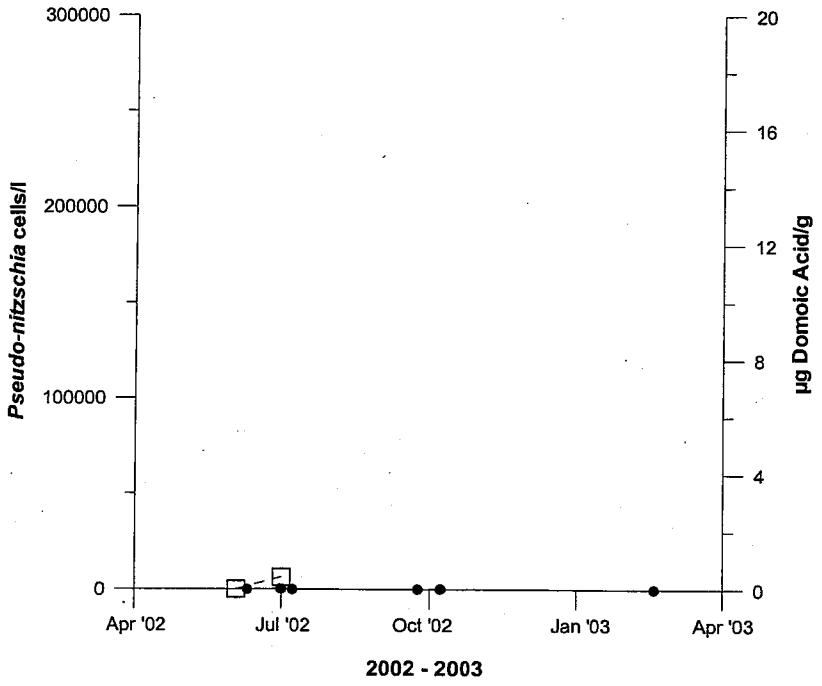


Figure 4.14 Graph showing *Pseudo-nitzschia* spp cells and AST in *M. edulis* measured at Loch Striven between 1 April 2002 – 31 March 2003.

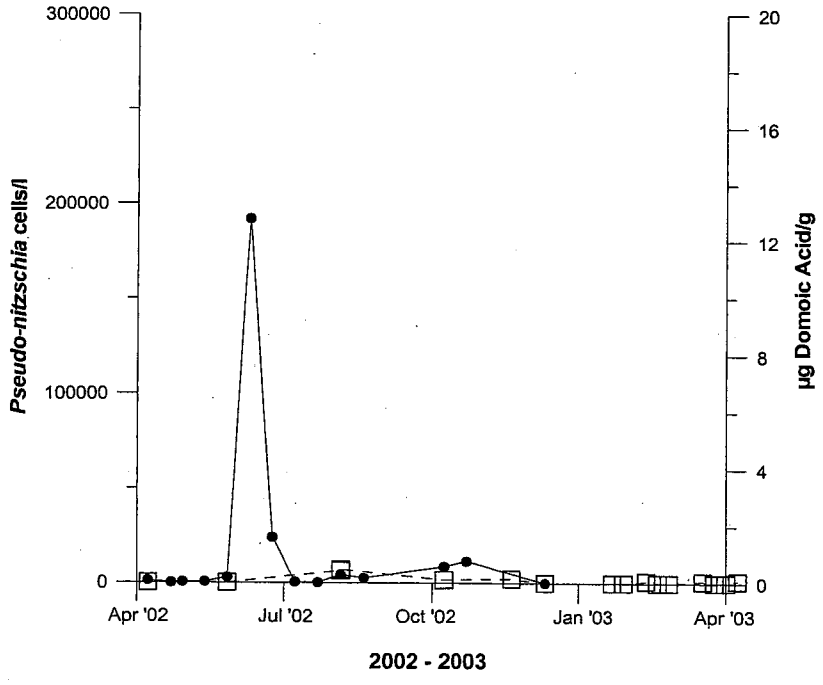


Figure 4.15 Graph showing *Pseudo-nitzschia* spp cells and AST in *M. edulis* measured at Loch Striven between 1 April 2002 – 31 March 2003.

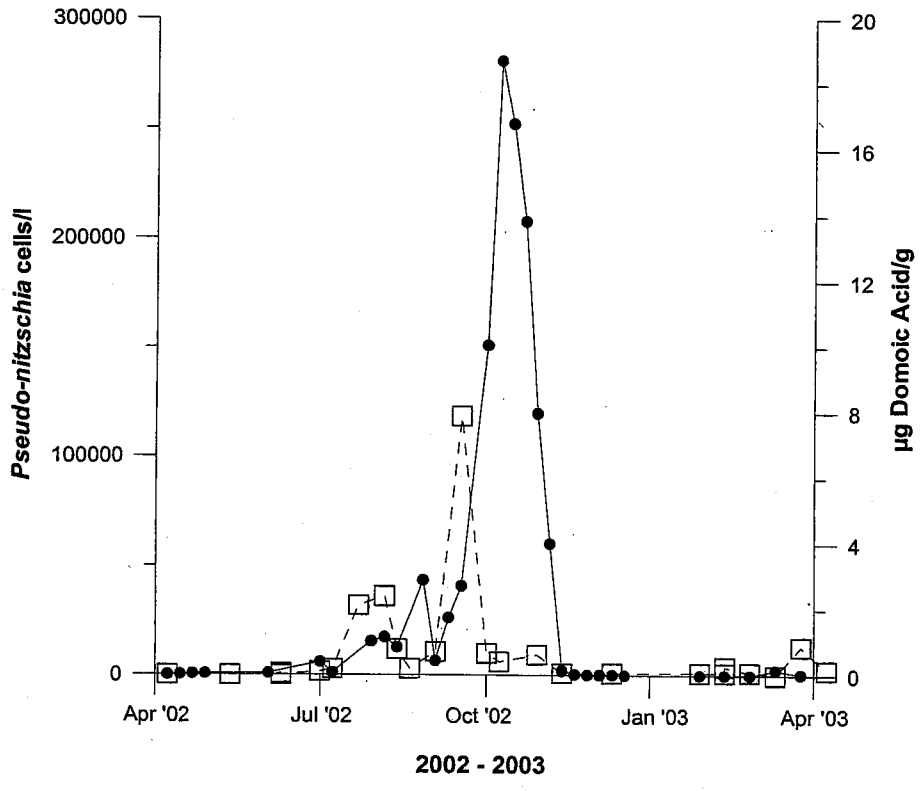


Figure 4.16 Graph showing *Pseudo-nitzschia* spp cells and AST in *M. edulis* measured at Loch Roag between 1 April 2002 – 31 March 2003.

4.4 Investigations into the causative agent of AST harvested from Scottish Waters

The FSAS has provided support to a Scottish Executive project examining 'The causative agent of AST in shellfish harvested from Scottish waters'. One of the main outputs from this project is a time series charting the numbers of *Pseudo-nitzschia* spp from 1 April 2000 – 31 March 2003 for both coastal and offshore waters. FSAS allowed phytoplankton samples to be taken from their offshore charter vessels and also funded TEM analysis of 10 samples from 2001 (Bresnan, 2002) and 100 samples from the 2002/2003 monitoring programme to identify *Pseudo-nitzschia* cells present to species level.

4.4.1 *Pseudo-nitzschia* spp. at coastal sites

Plots showing coastal sites sampled for *Pseudo-nitzschia* spp. are shown in Figures 4.17, 4.19 and 4.21. The results of the LM time series are plotted in relation to latitude in Figures 4.18, 4.20 and 4.22. Care must be taken in interpreting these plots to avoid bias as a result of the sampling frequency. These plots show that a number of blooms occur during the year. Observation has shown the earlier blooms to comprise mainly *P. delicatissima 'type'* cells (diameter <5 µm), while those occurring July and August are dominated by *P. seriata 'type'* cells (diameter >5 µm).

4.4.2 *Pseudo-nitzschia* spp. at offshore sites

Plots of the offshore sampling sites are shown in Figures 4.23–4.25. The LM time series obtained from offshore sites is presented in Figures 4.26–4.28. The sampling frequency from these sites is very low which makes any pattern or trend difficult to interpret. The practicalities of obtaining a regular supply of offshore samples during this project were highlighted. During 2000–2001, FRS research cruises were used to obtain samples. These were collected sporadically and there was little continuity between sample sites. Insufficient samples were collected from offshore areas in 2000 to generate a meaningful contour plot (Fig. 4.26). From 2001 FSAS charter vessels were used to collect samples, however bad weather and alternative sampling priorities meant that a low sample number was still obtained from these regions.

4.4.3 AST in *Pecten maximus* from offshore areas

AST levels in *P. maximus* gonad tissue is plotted in samples 4.29–4.31. More flesh samples were analysed for the presence of AST, but the low phytoplankton sample numbers make the relationship between cell number and toxin concentration difficult to interpret. However the data shows that high levels of AST were recorded in *P. maximus* gonads during the time period when high numbers of *Pseudo-nitzschia* spp. were likely to be found in the watercolumn.

The low sampling frequency makes the relationship between *Pseudo*-nitzschia and AST in scallop flesh difficult to interpret. Data from an FSA, UK project currently being carried out at FRS shows that fortnightly sampling is insufficient to adequately monitor *Pseudo-nitzschia* spp numbers in the water-column (*FRS, unpublished data*). This is highlighted in Figures 4.32 and 4.33, which present the *Pseudo-nitzschia* cell numbers and AST levels in *P. maximus* gonad tissue from offshore scallop fishing boxes NM16 and SM6. These graphs show that while it is possible that a relationship does exist between the number of *Pseudo-nitzschia* spp. cells in the water column and AST in the gonad tissue, the low sampling frequency make it impossible to examine this relationship with any statistical power. This indicates that our ability to use cells numbers in the water column as an indicator of toxin levels in shellfish will only be reliable if an appropriate sampling frequency is observed.

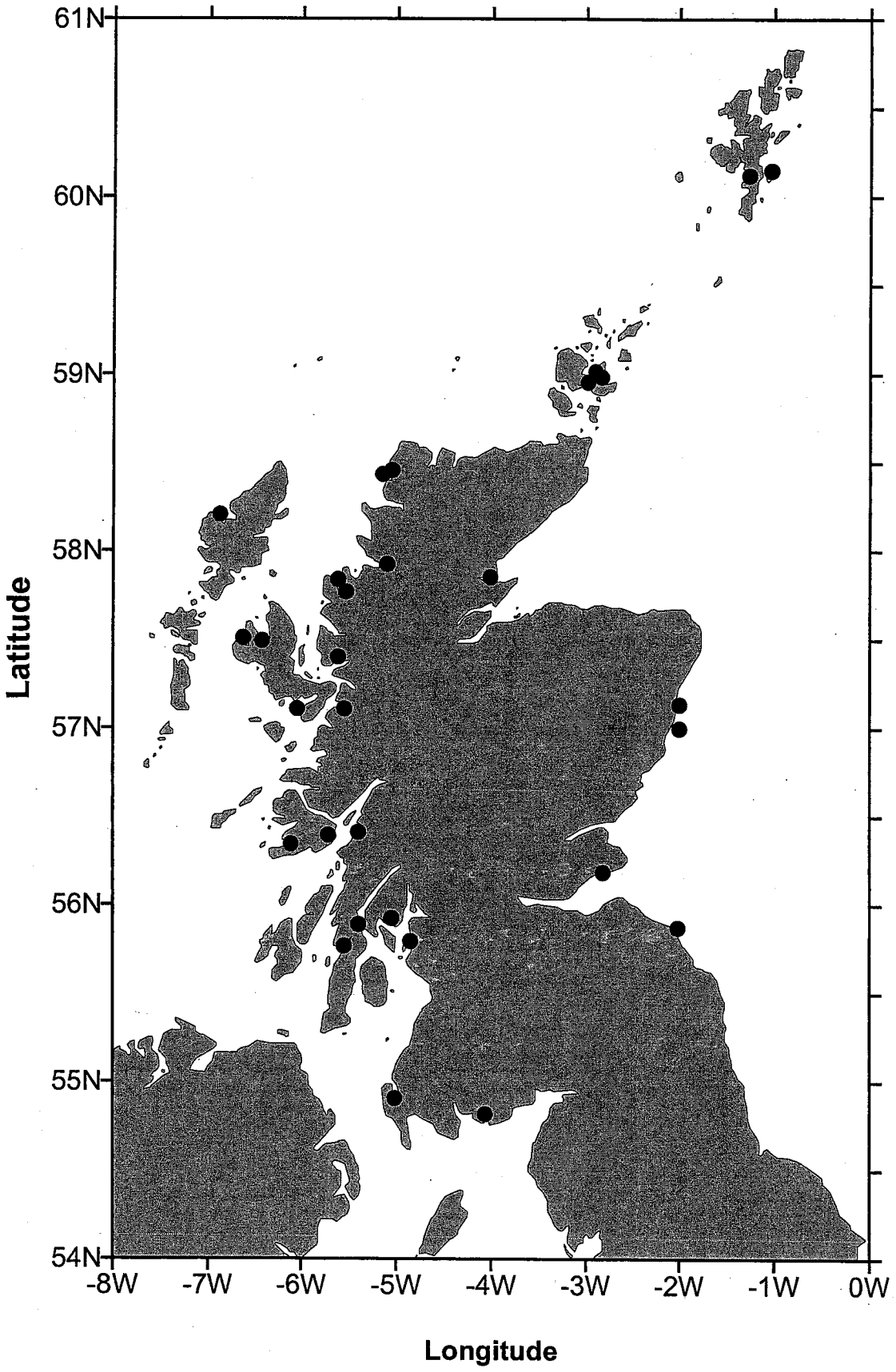
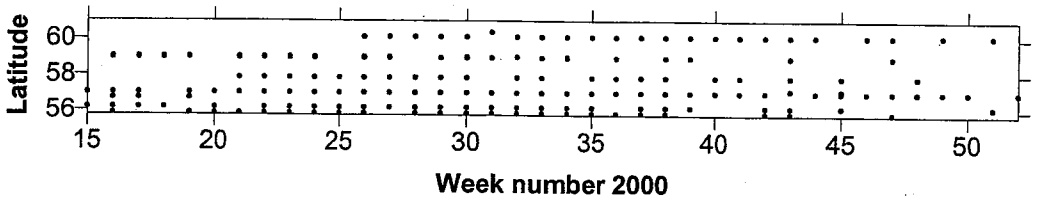


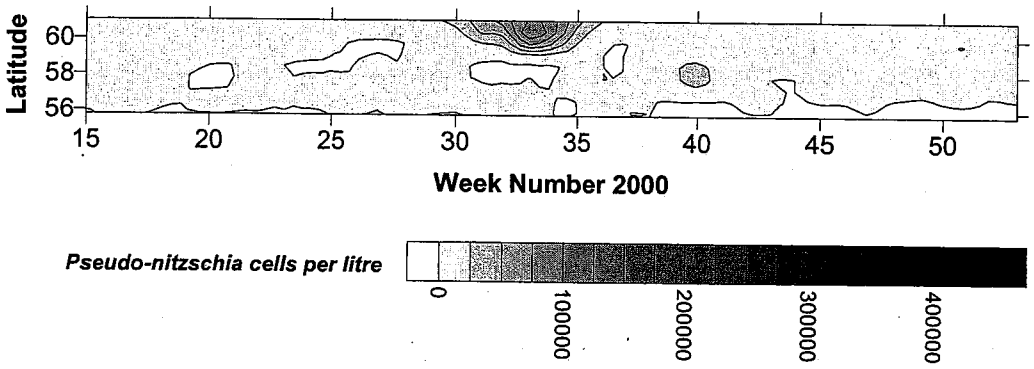
Figure 4.17 Map showing location of coastal sites sampled for *Pseudo-nitzschia* spp. during 2000.

COASTAL - EAST COAST 2000

Sampling Frequency

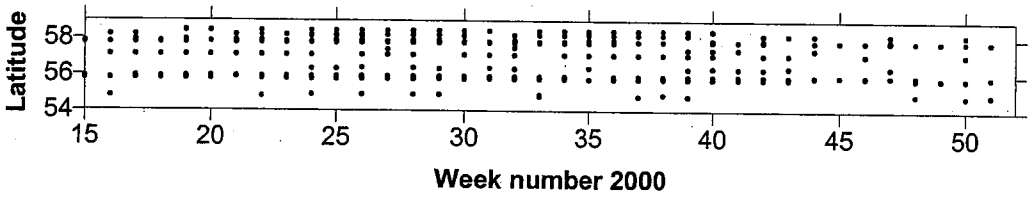


Pseudo-nitzchia cells



COASTAL - WEST COAST 2000

Sampling Frequency



Pseudo-nitzchia cells

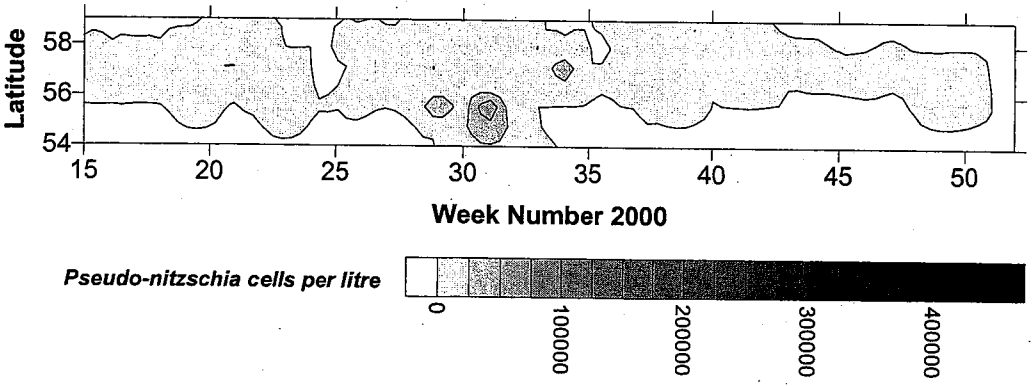


Figure 4.18 Dot plots showing the sampling frequency and contour plots showing *Pseudo-nitzschia* spp. from coastal sampling sites in relation to latitude on the east and west coast of Scotland during 2000.

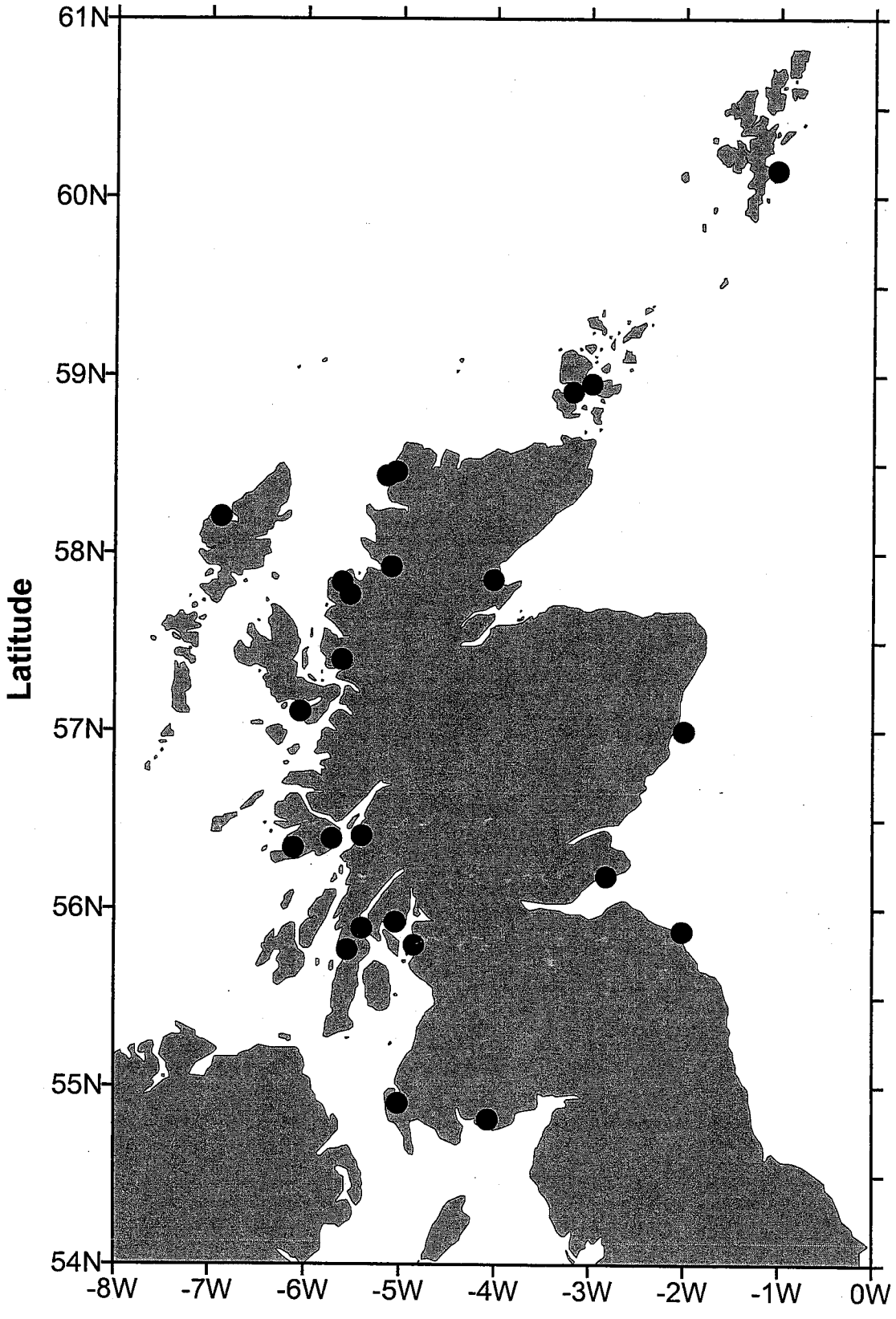
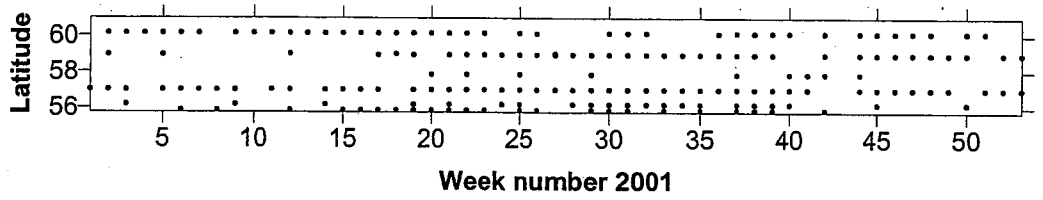


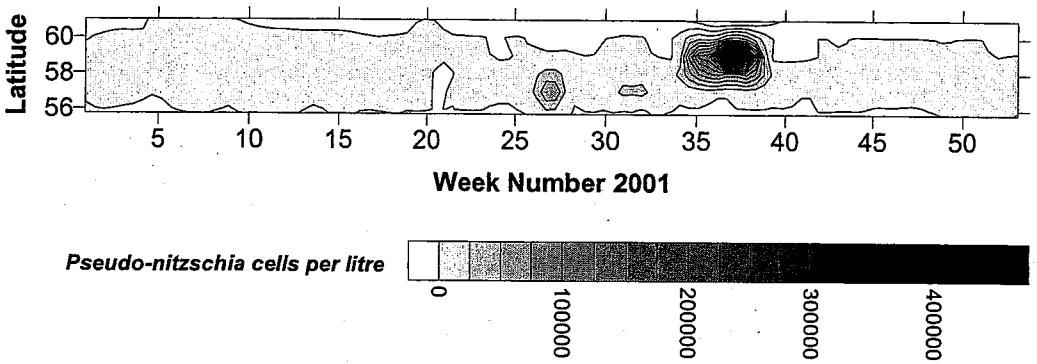
Figure 4.19 Map showing location of coastal sites sampled for *Pseudo-nitzschia* spp. during 2001.

COASTAL - EAST COAST 2001

Sampling Frequency

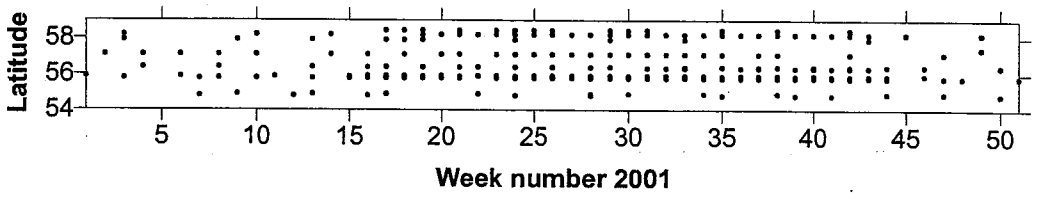


Pseudo-nitzchia cells



COASTAL - WEST COAST 2001

Sampling Frequency



Pseudo-nitzchia cells

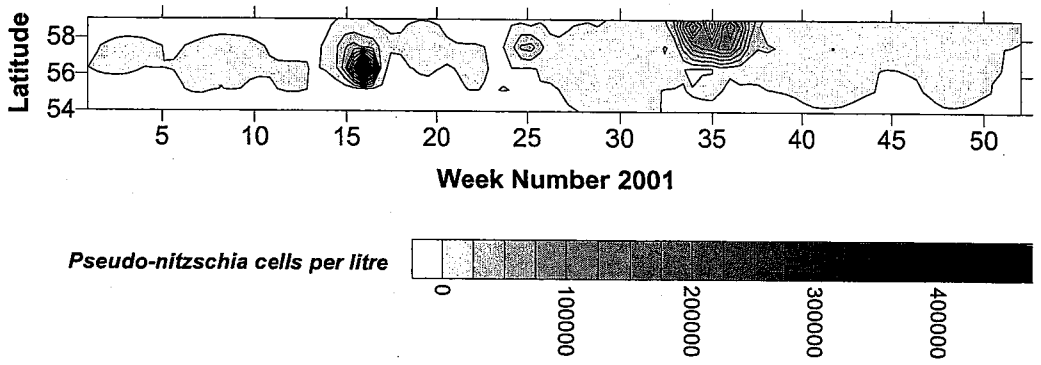


Figure 4.20 Dot plots showing the sampling frequency and contour plots showing *Pseudo-nitzschia* spp. from coastal sampling sites in relation to latitude on the east and west coast of Scotland during 2001.

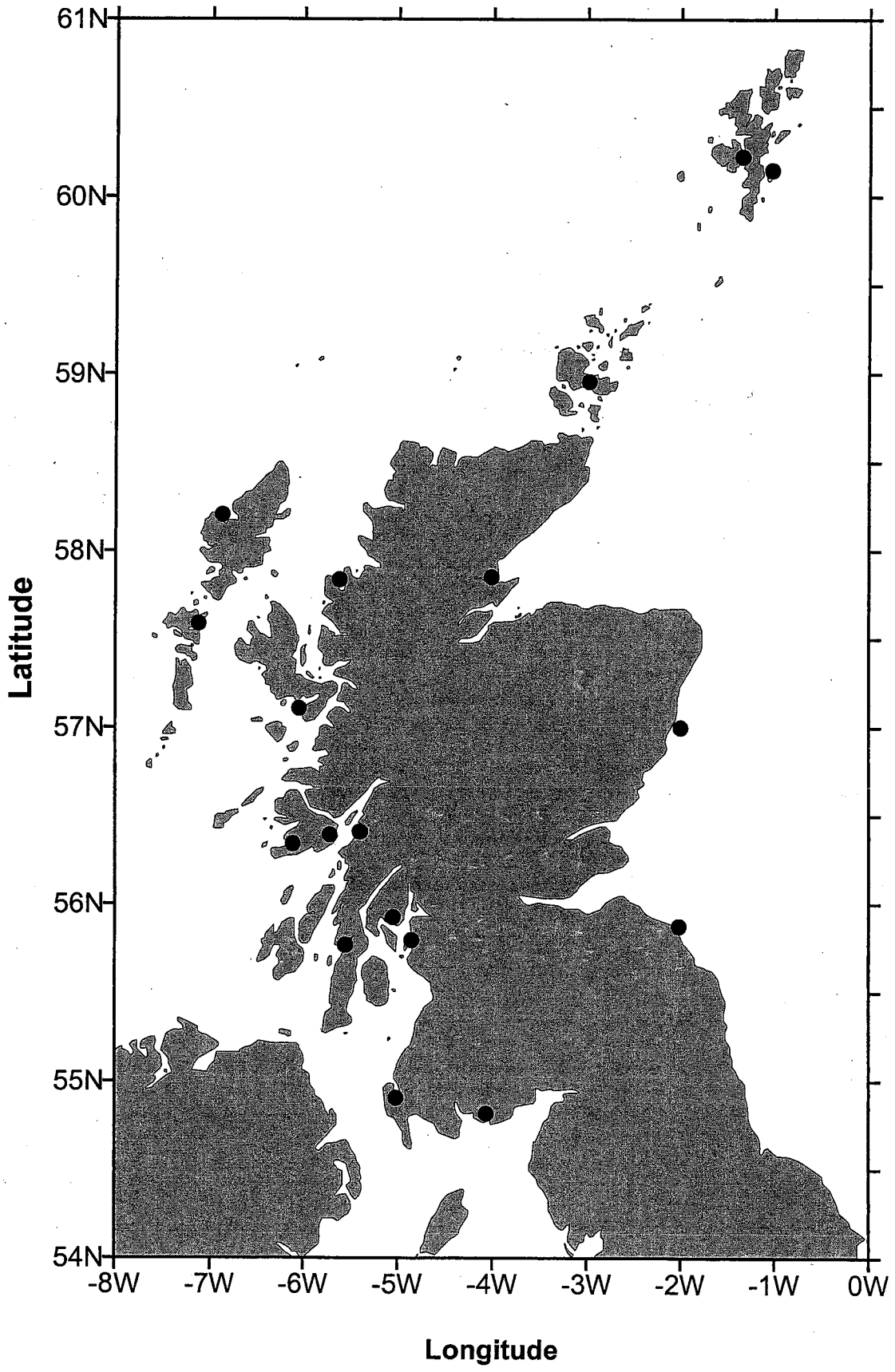
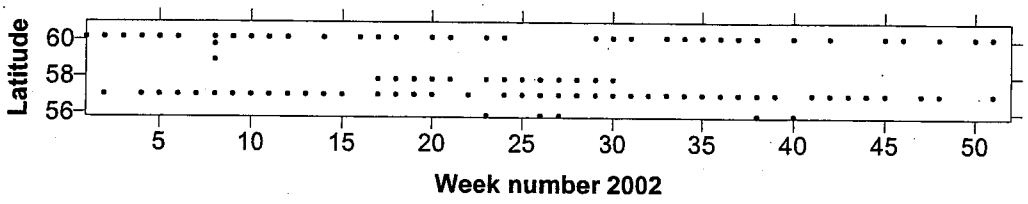


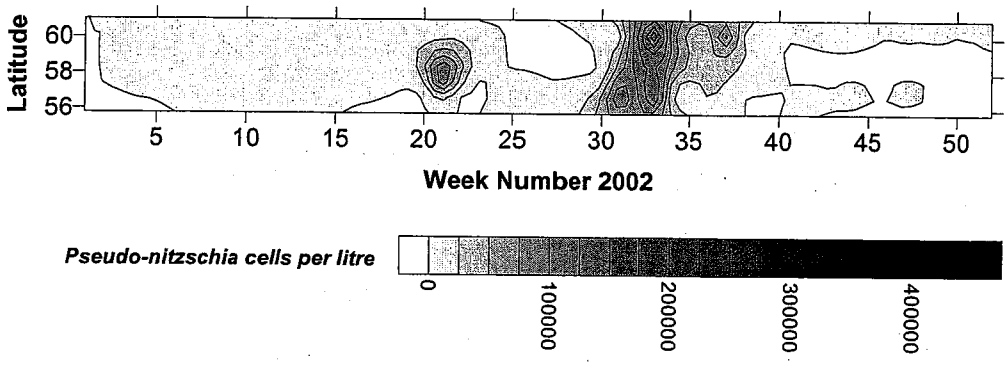
Figure 4.21 Map showing location of coastal sites sampled for *Pseudo-nitzschia* spp. during 2002.

COASTAL - EAST COAST 2002

Sampling Frequency

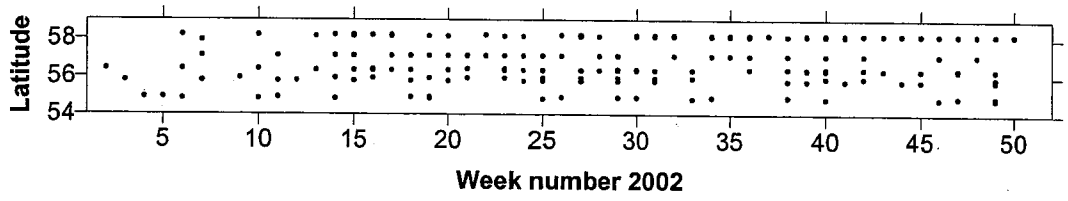


Pseudo-nitzchia cells



COASTAL - WEST COAST 2002

Sampling Frequency



Pseudo-nitzchia cells

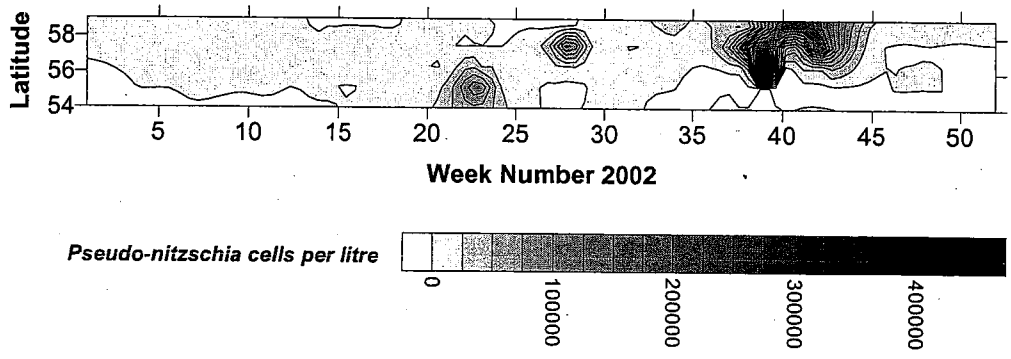
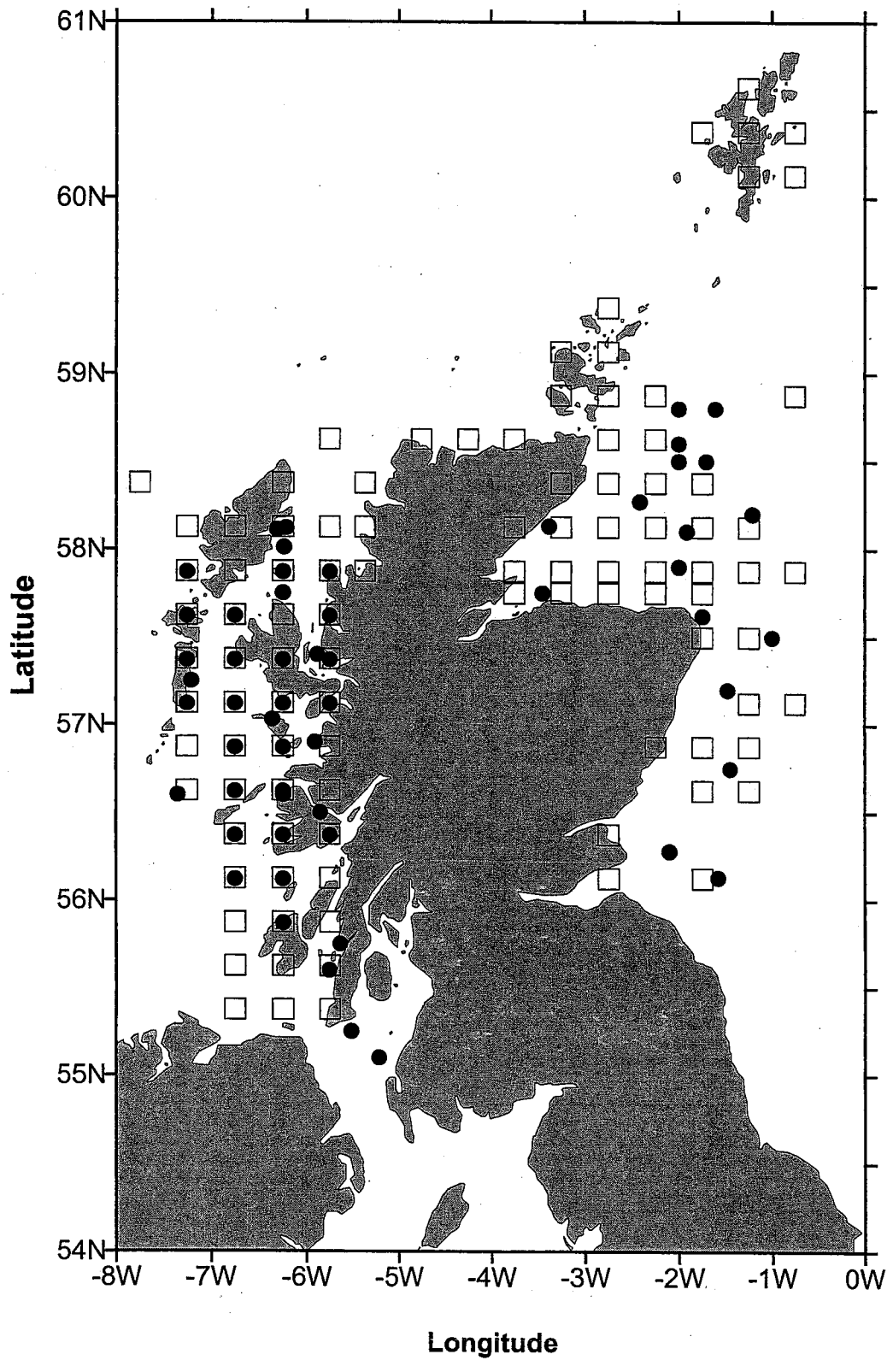


Figure 4.22 Dot plots showing the sampling frequency and contour plots showing *Pseudo-nitzschia* spp. from coastal sampling sites in relation to latitude on the east and west coast of Scotland during 2002.



• ***Pseudo-nitzschia* spp.** □ ***P. maximus***

Figure 4.23 Map showing location of offshore scallop fishing boxes sampled for *Pseudo-nitzschia* spp. and *P. maximus* during 2000.

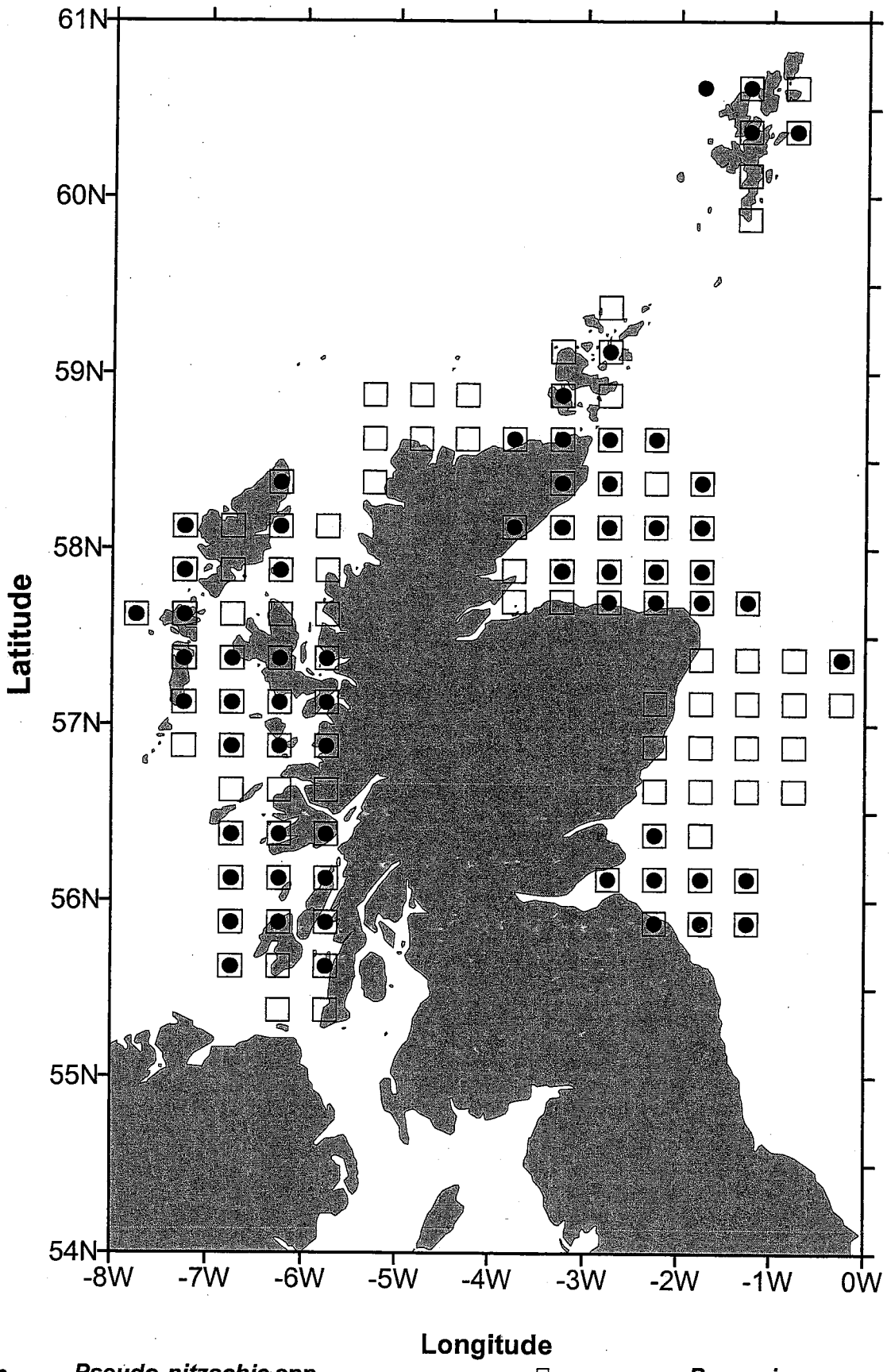


Figure 4.24 Map showing location of offshore scallop fishing boxes sampled for *Pseudo-nitzschia* spp. and *P. maximus* during 2001.

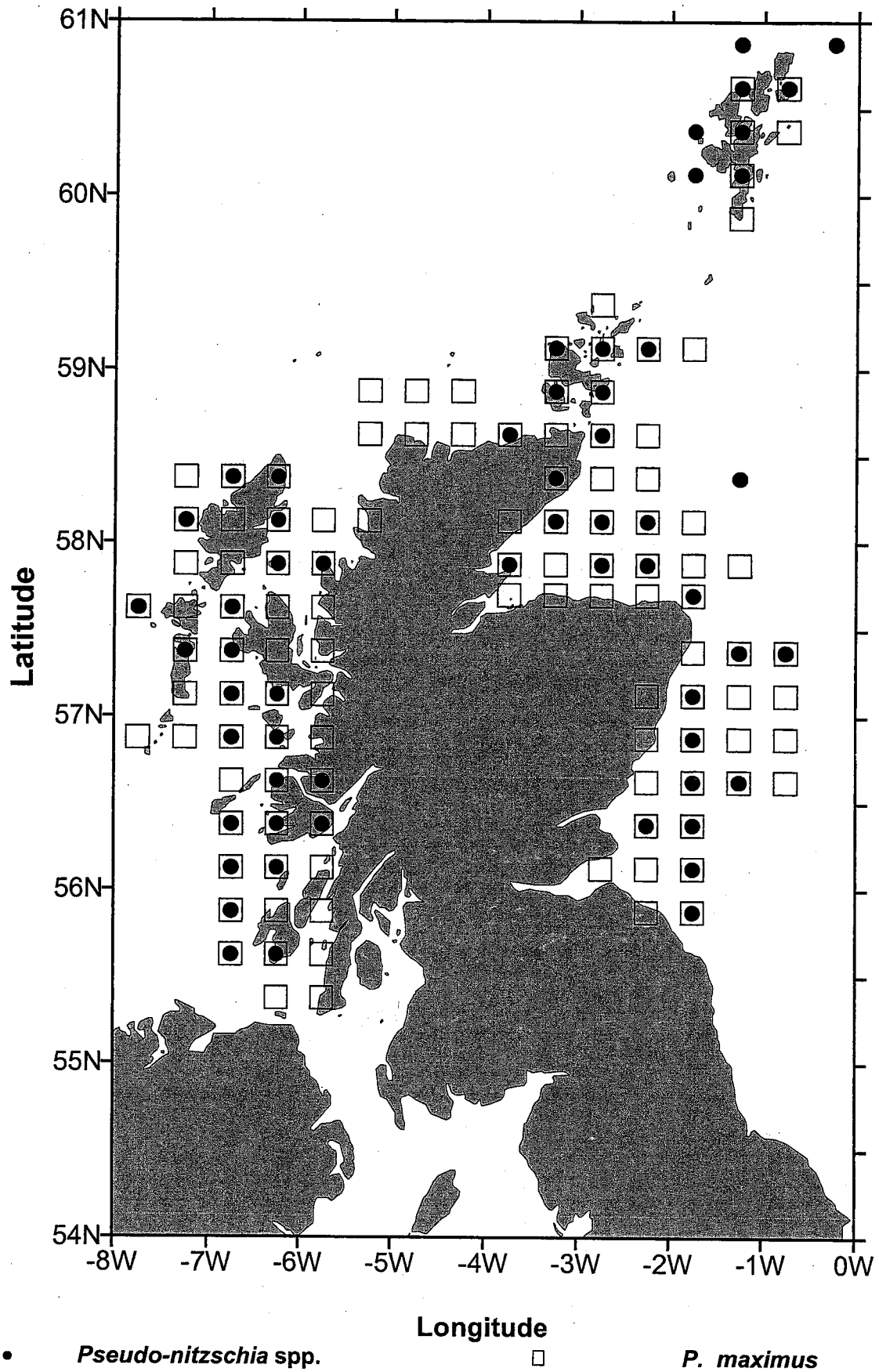
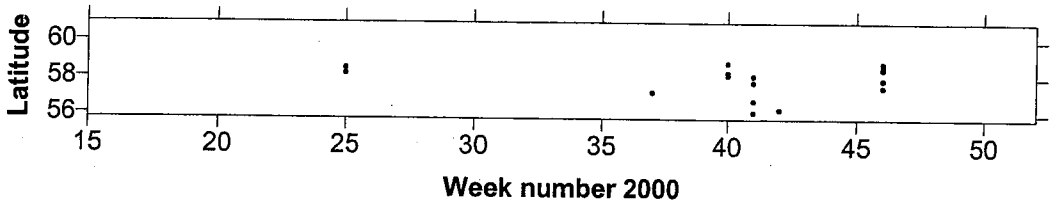


Figure 4.25 Map showing location of offshore scallop fishing boxes sampled for *Pseudo-nitzschia* spp. and *P. maximus* during 2002.

OFFSHORE - EAST COAST 2000

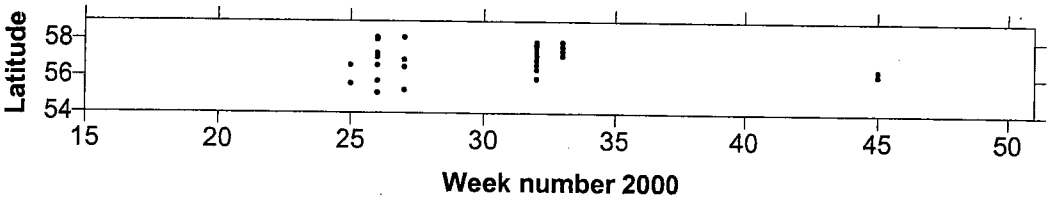
Sampling Frequency



Insufficient data was collected to generate a significant contour plot.

OFFSHORE - WEST COAST 2000

Sampling Frequency

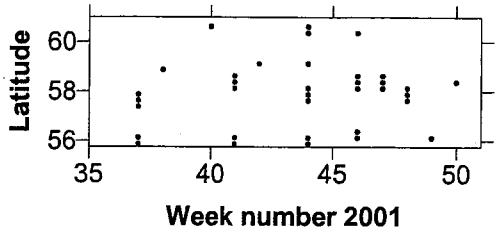


Insufficient data was collected to generate a significant contour plot.

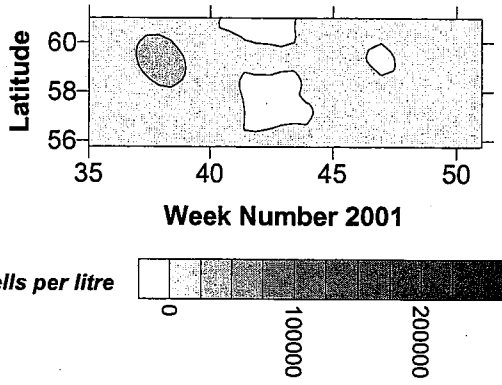
Figure 4.26 Dot plots showing the sampling frequency from offshore sampling sites in relation to latitude on the east and west coast of Scotland during 2000. Insufficient samples were collected to generate a significant contour plot.

OFFSHORE - EAST COAST 2001

Sampling Frequency

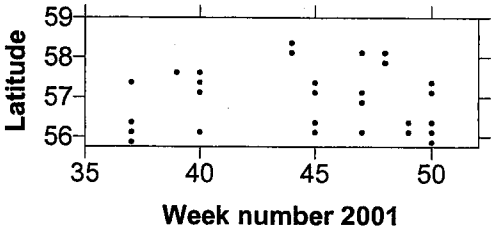


Pseudo-nitzchia cells



OFFSHORE - WEST COAST 2001

Sampling Frequency



Pseudo-nitzchia cells

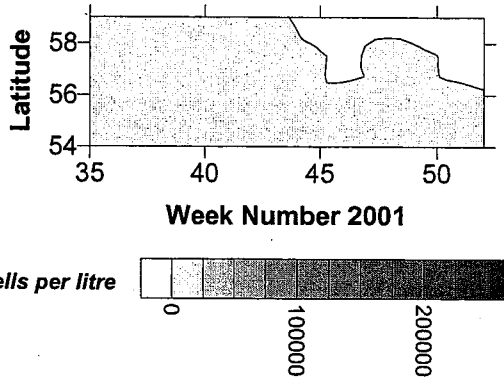
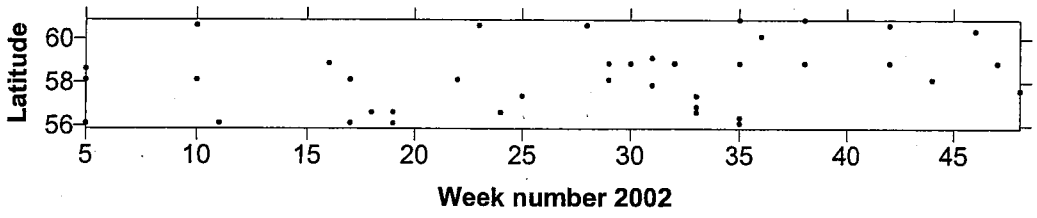


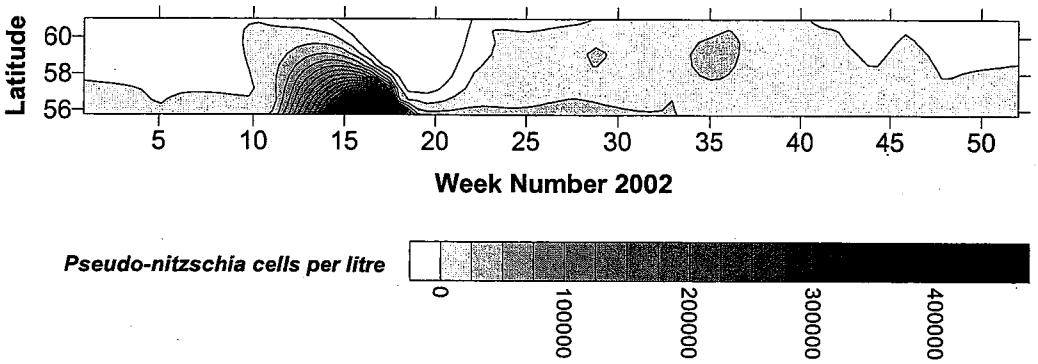
Figure 4.27 Dot plots showing the sampling frequency and contour plots showing *Pseudo-nitzschia* spp. from offshore sampling sites in relation to latitude on the east and west coast of Scotland during 2001.

OFFSHORE - EAST COAST 2002

Sampling Frequency

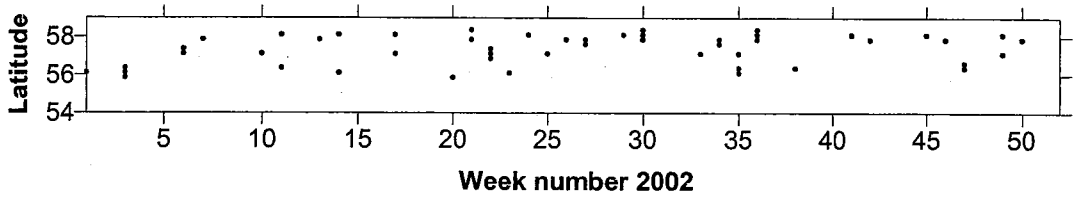


Pseudo-nitzchia cells



OFFSHORE - WEST COAST 2002

Sampling Frequency



Pseudo-nitzchia cells

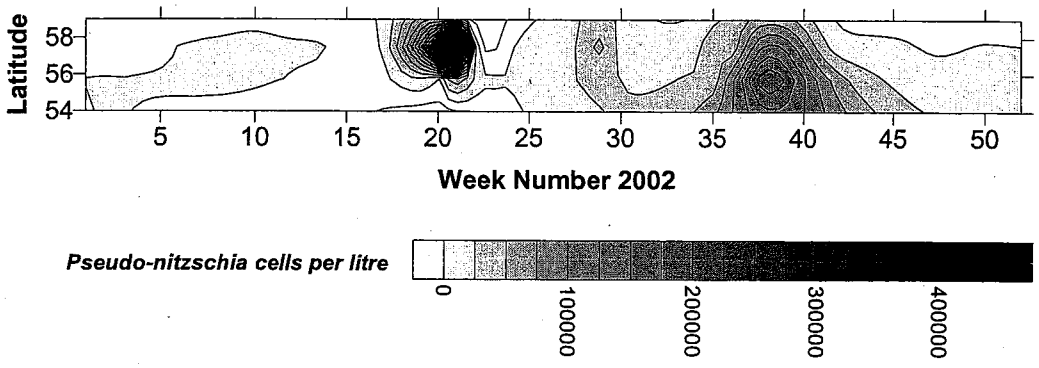
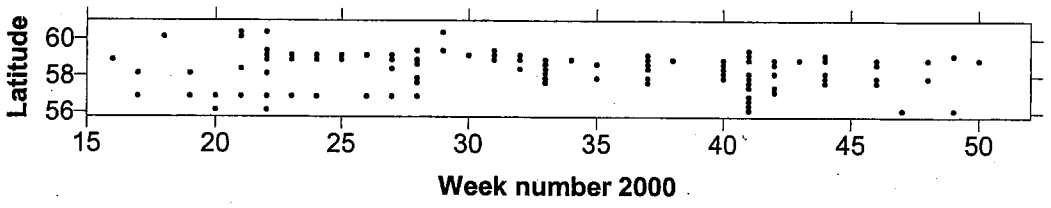


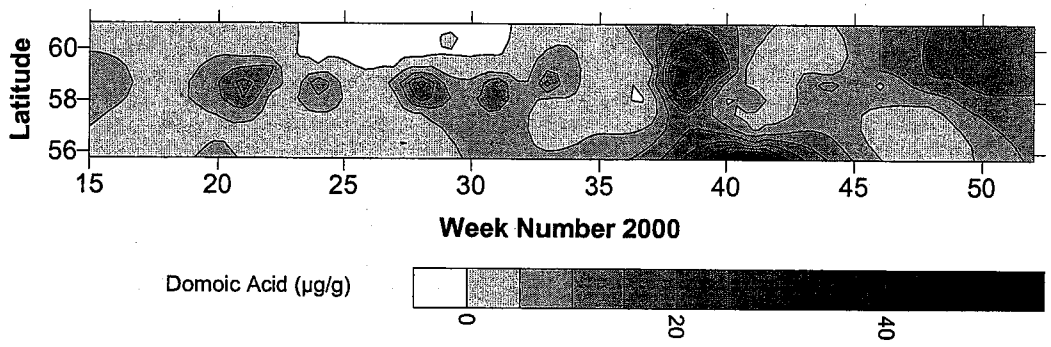
Figure 4.28 Dot plots showing the sampling frequency and contour plots showing *Pseudo-nitzschia* spp. from offshore sampling sites in relation to latitude on the east and west coast of Scotland during 2002.

OFFSHORE - EAST COAST 2000

Sampling Frequency

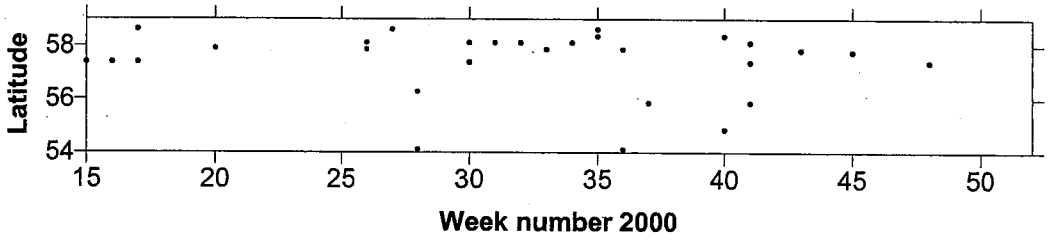


Domoic Acid (µg/g P. maximus gonad)



OFFSHORE - WEST COAST 2000

Sampling Frequency



Domoic Acid (µg/g P. maximus gonad)

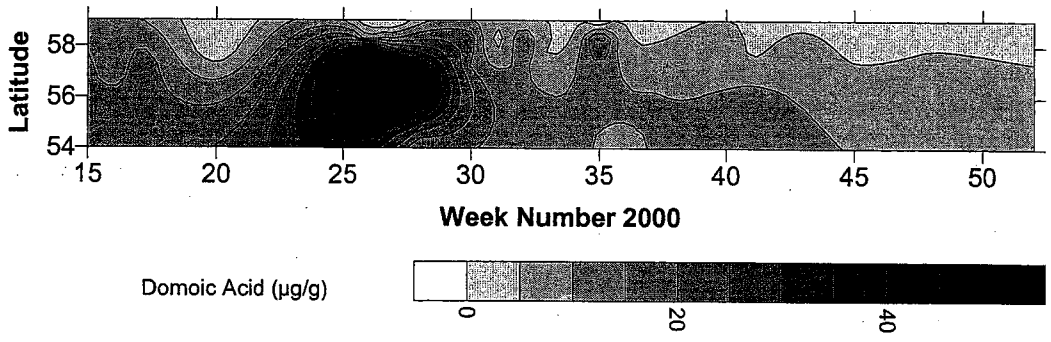
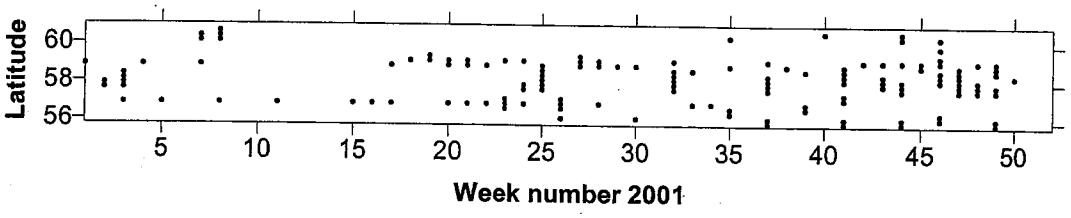


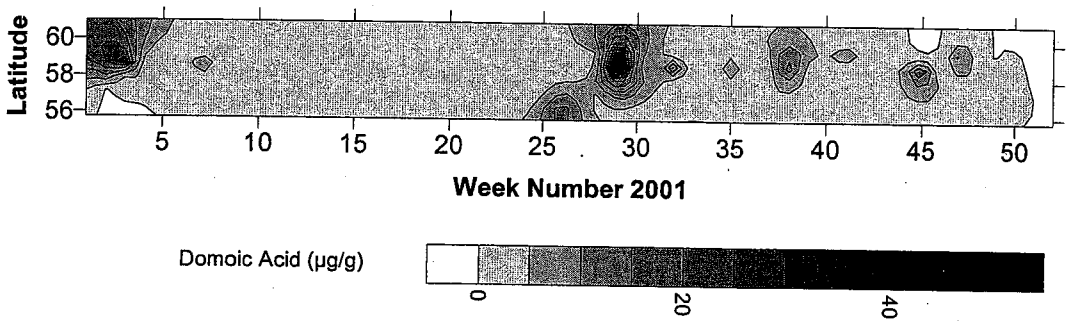
Figure 4.29 Dot plots showing the sampling frequency and contour plots showing domoic acid (µg/g *P. maximus* gonad) from offshore sampling sites in relation to latitude on the east and west coast of Scotland during 2000.

OFFSHORE - EAST COAST 2001

Sampling Frequency

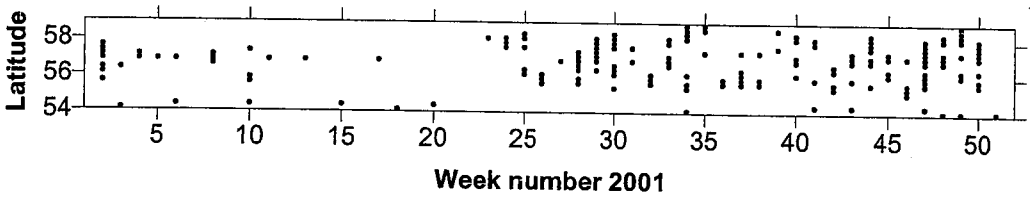


Domoic Acid (µg/g P. maximus gonad)



OFFSHORE - WEST COAST 2001

Sampling Frequency



Domoic Acid (µg/g P. maximus gonad)

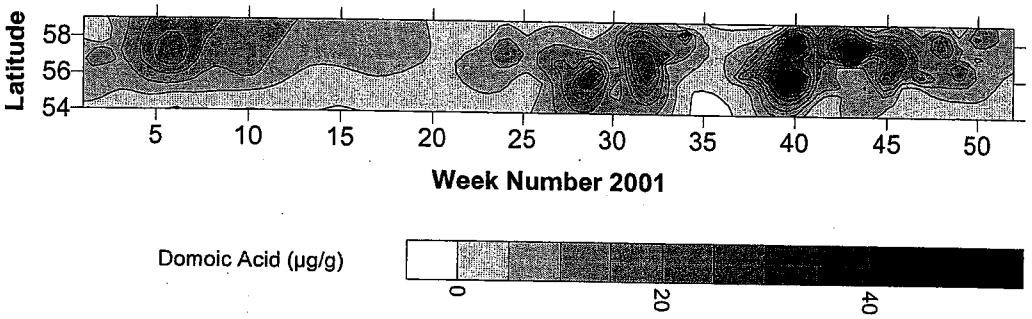
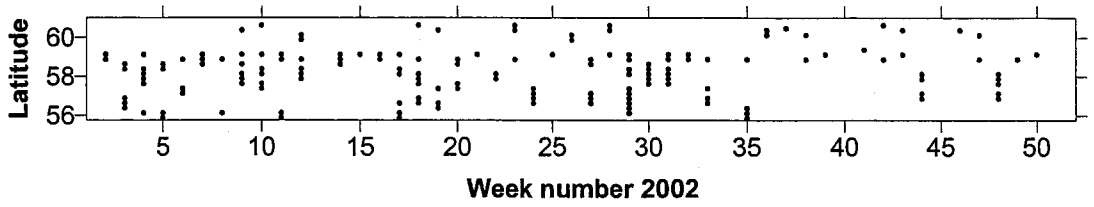


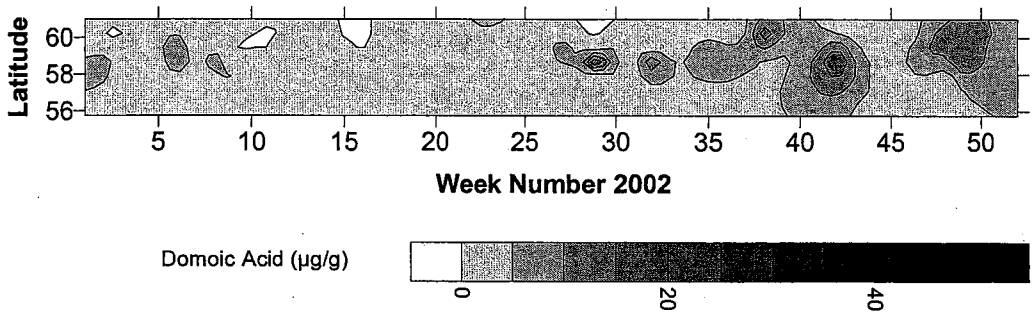
Figure 4.30 Dot plots showing the sampling frequency and contour plots showing domoic acid (µg/g *P. maximus* gonad) from offshore sampling sites in relation to latitude on the east and west coast of Scotland during 2001.

OFFSHORE - EAST COAST 2002

Sampling Frequency

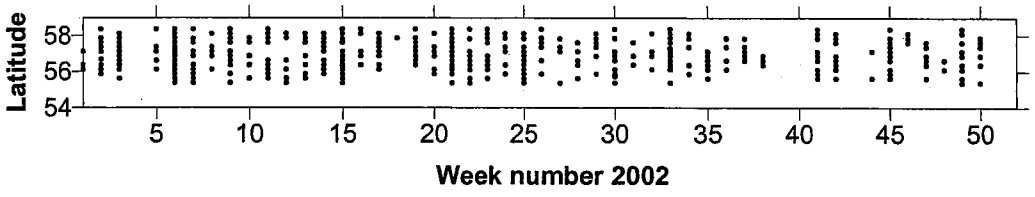


Domoic Acid (µg/g P. maximus gonad)



OFFSHORE - WEST COAST 2002

Sampling Frequency



Domoic Acid (µg/g P. maximus gonad)

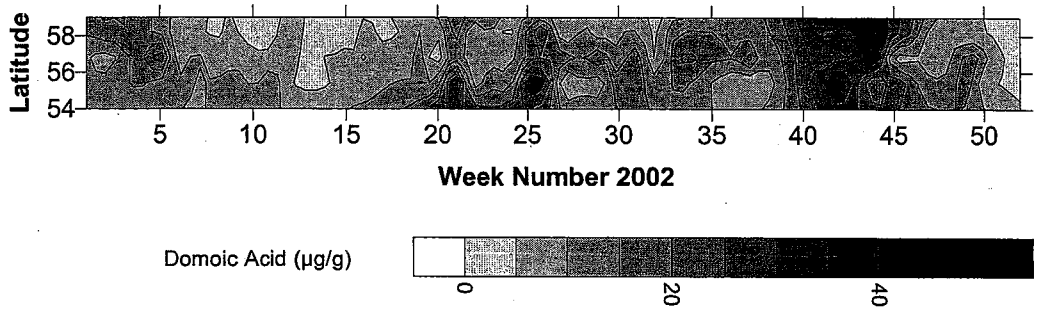
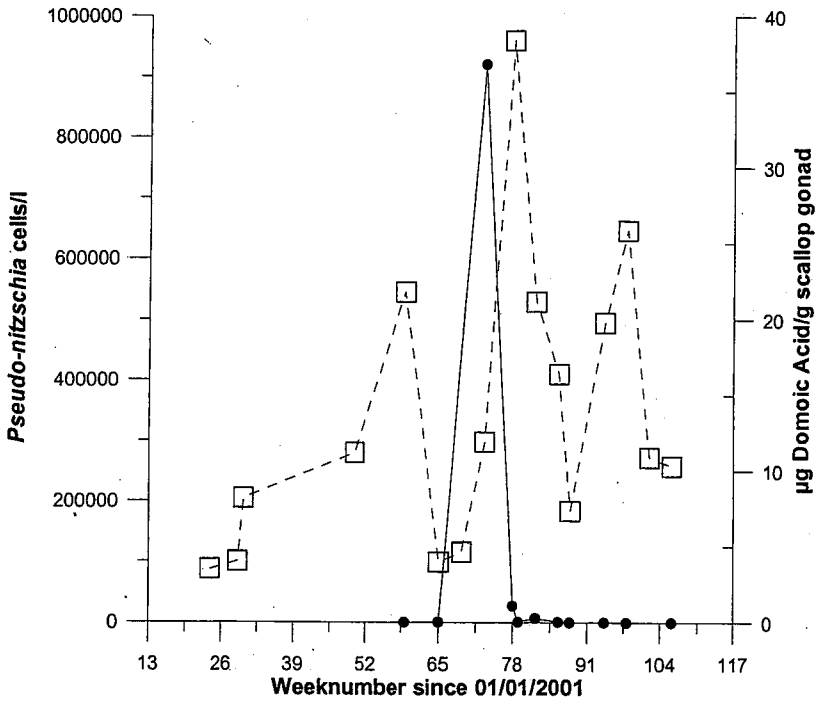
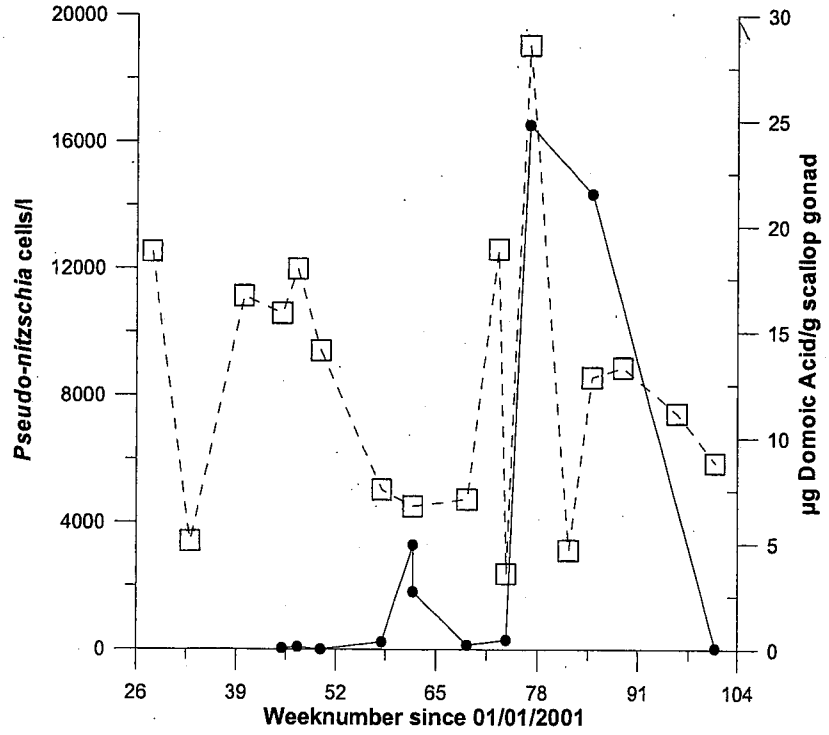


Figure 4.31 Dot plots showing the sampling frequency and contour plots showing domoic acid (µg/g *P. maximus* gonad) from offshore sampling sites in relation to latitude on the east and west coast of Scotland during 2002.



● ***Pseudo-nitzschia* spp cells/l** □ **µg Domoic Acid/g**

Figure 4.32 Graph showing *Pseudo-nitzschia* spp cells and AST in *M. edulis* measured NM16 between 1 April 2002 – 31 March 2003.



● ***Pseudo-nitzschia* spp cells/l** □ **µg Domoic Acid/g**

Figure 4.33 Graph showing *Pseudo-nitzschia* spp cells and AST in *M. edulis* measured SM6 between 1 April 2002 – 31 March 2003.

4.4.4 TEM Analysis

Pseudo-nitzschia cells in 100 samples from 27 sites around the Scottish Coast were analysed using TEM techniques. Owing to the high number of *Pseudo-nitzschia* cells that are required to obtain a reading using the TEM, only samples with a *Pseudo-nitzschia* cell count of >20,000 cells/l were used. Figure 4.34 shows the sites from which samples were used for TEM analysis. It must be stressed that these samples are qualitative only. They are also slightly biased in that only samples with high cell counts were analysed. The grids examined of samples with LM cell counts < 20,000 cells/l contained no *Pseudo-nitzschia* cells when examined on the TEM.

Nine species were identified in these 100 samples. These were *P. americana, P. australis, P. cf. delicatissima, P. fraudulenta, P. cf heimii, P. cf multiseries, P. pungens, P. cf pseudo-delicatissima* and *P. cf. seriata*. No studies were performed to determine which, if any, of these species produced toxins in Scottish waters, however with the exception of *P. americana* and *P. cf. heimii* the remainder of the species observed have been recorded as potential AST producers in the scientific literature.

Full details of the results are given in Appendix II, however maps summarising the location of samples where the four most dominant species (*P. australis, P. fraudulenta, P. pungens* and *P. cf pseudodelicatissima*) were detected are given in Figures 4.35–4.38.

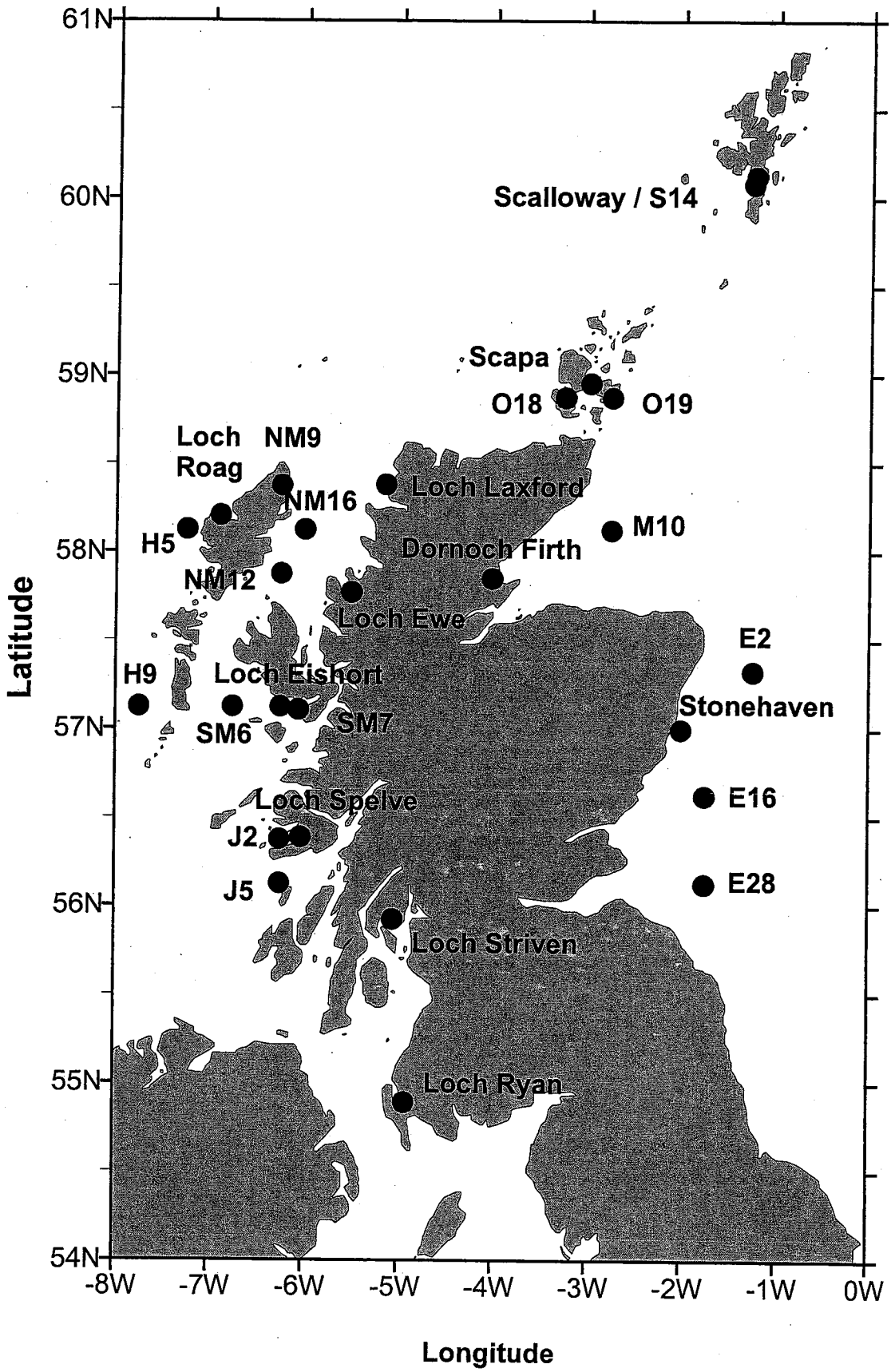


Figure 4.34 Sites from where phytoplankton samples were selected for TEM analysis.

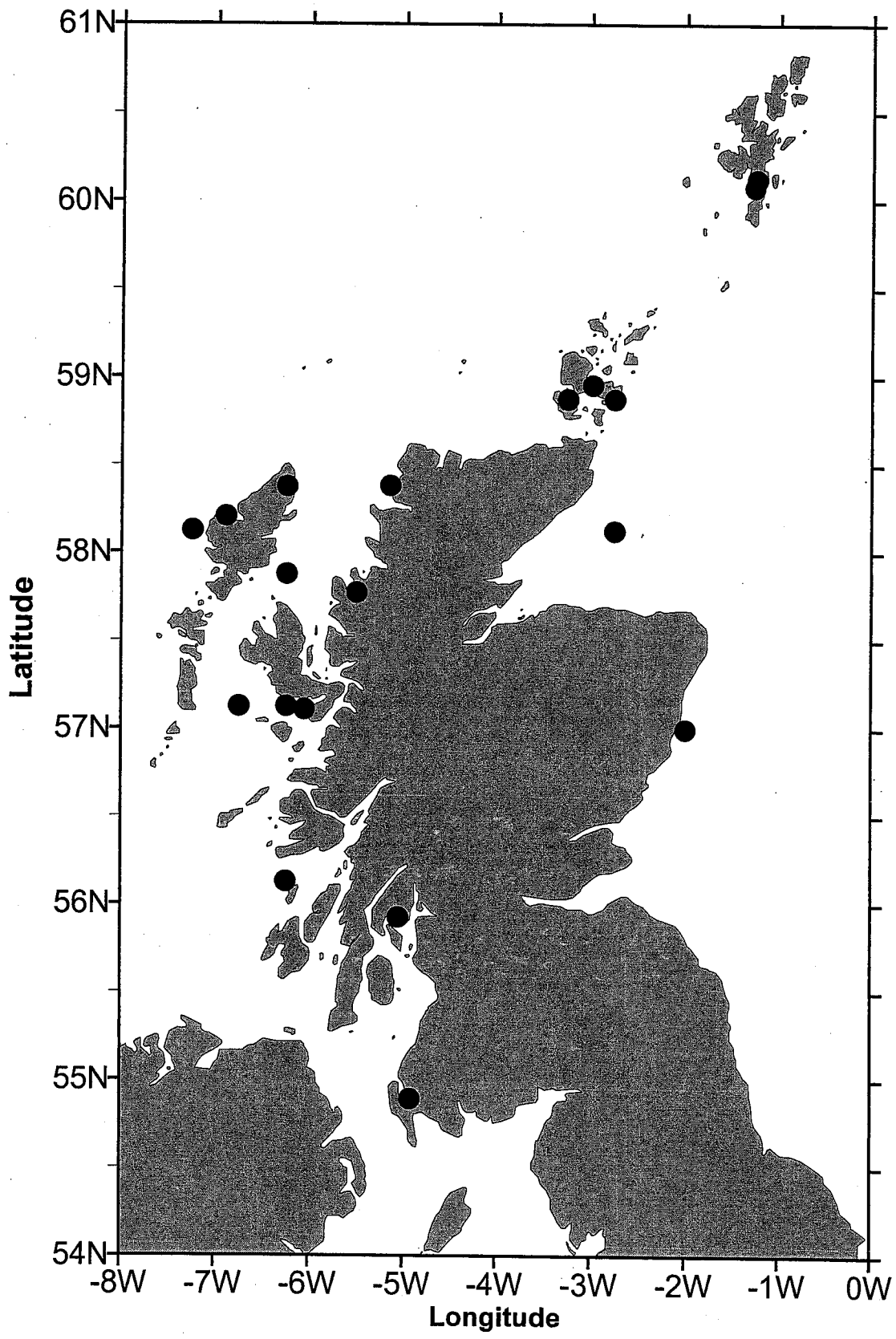


Figure 4.35 Sites where *P. australis* cells were observed during 2002/2003.

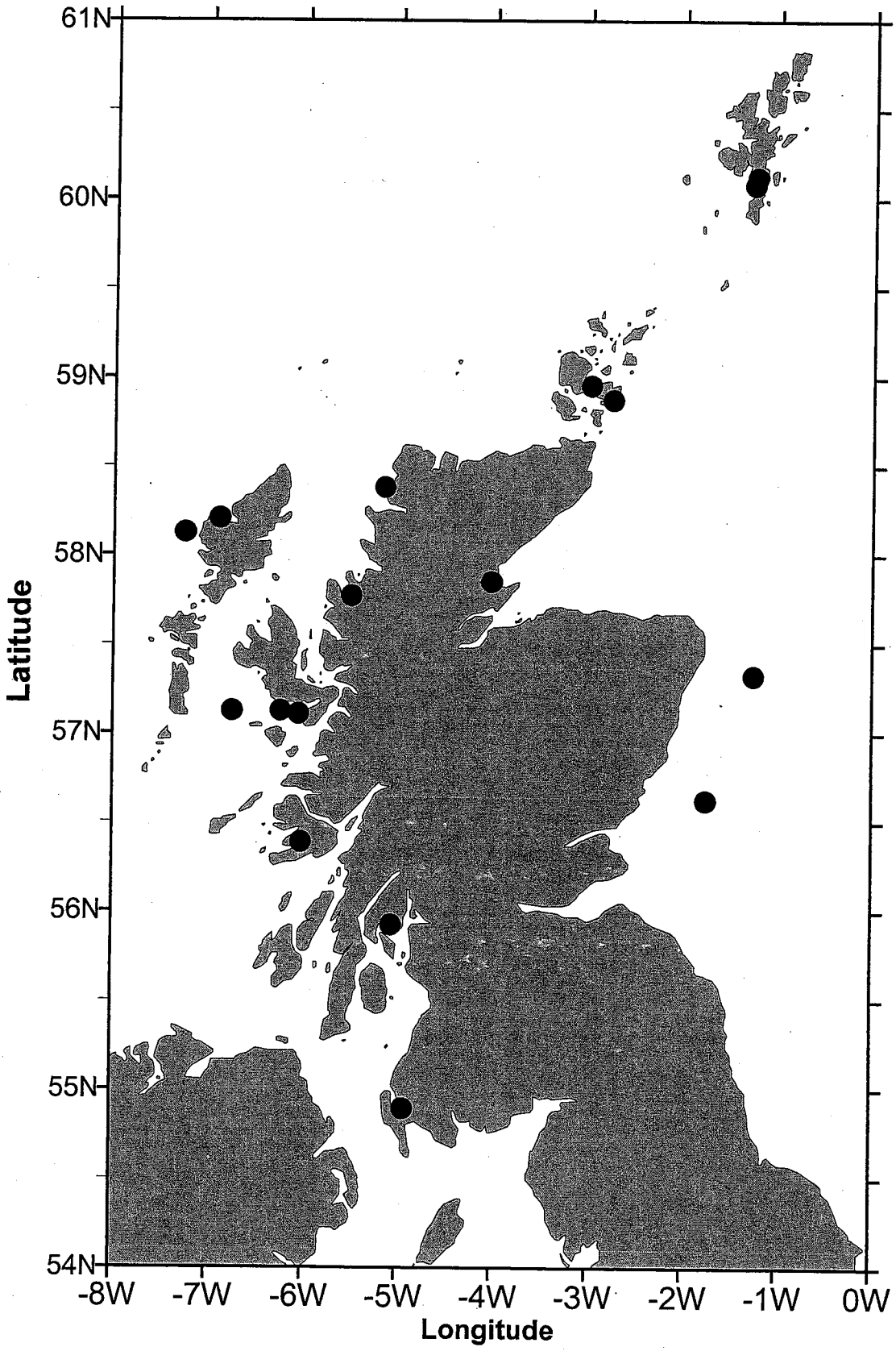


Figure 4.36 Sites where *P. fraudulenta* cells were observed during 2002/2003.

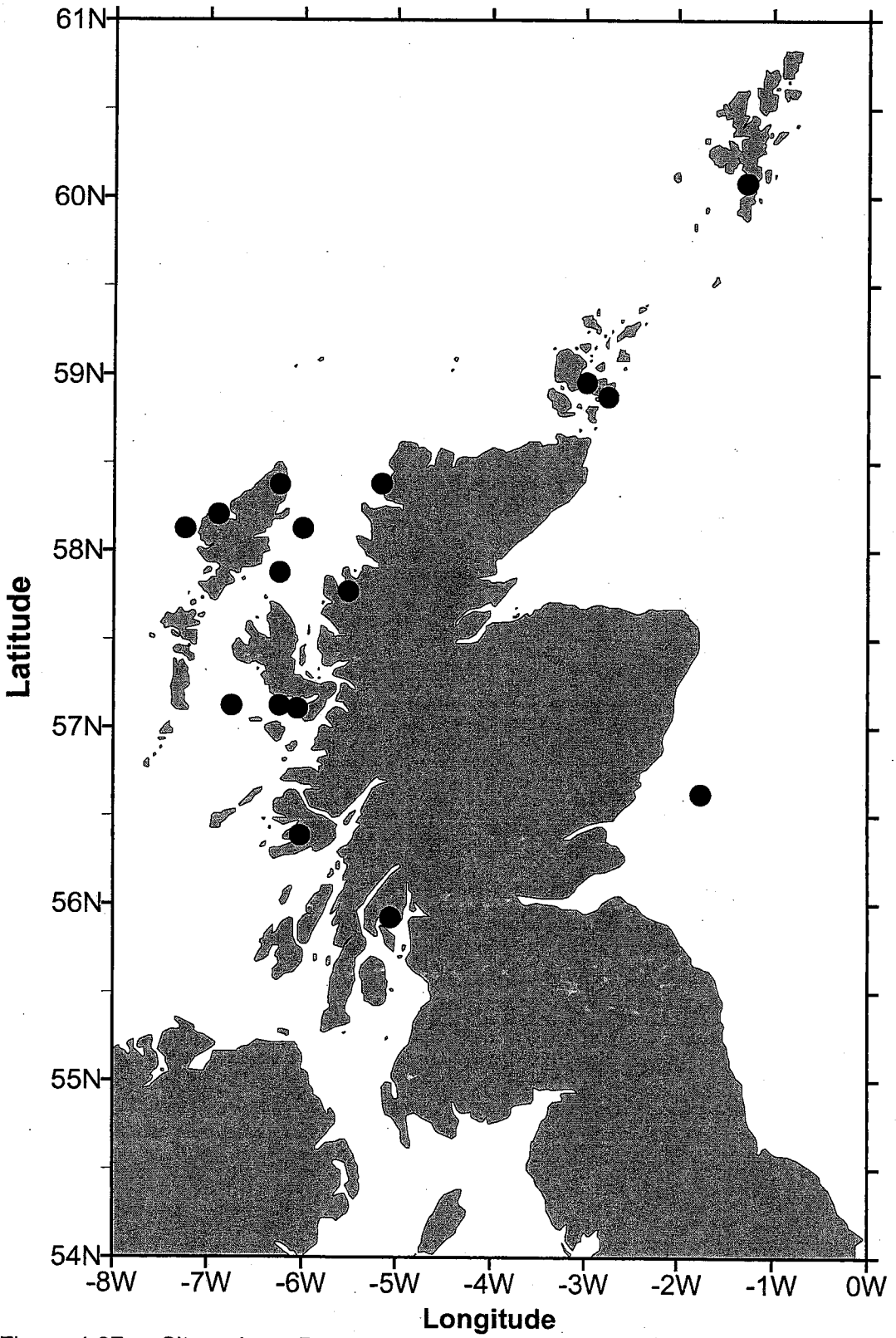


Figure 4.37. Sites where *P. pungens* were observed during 2002/2003

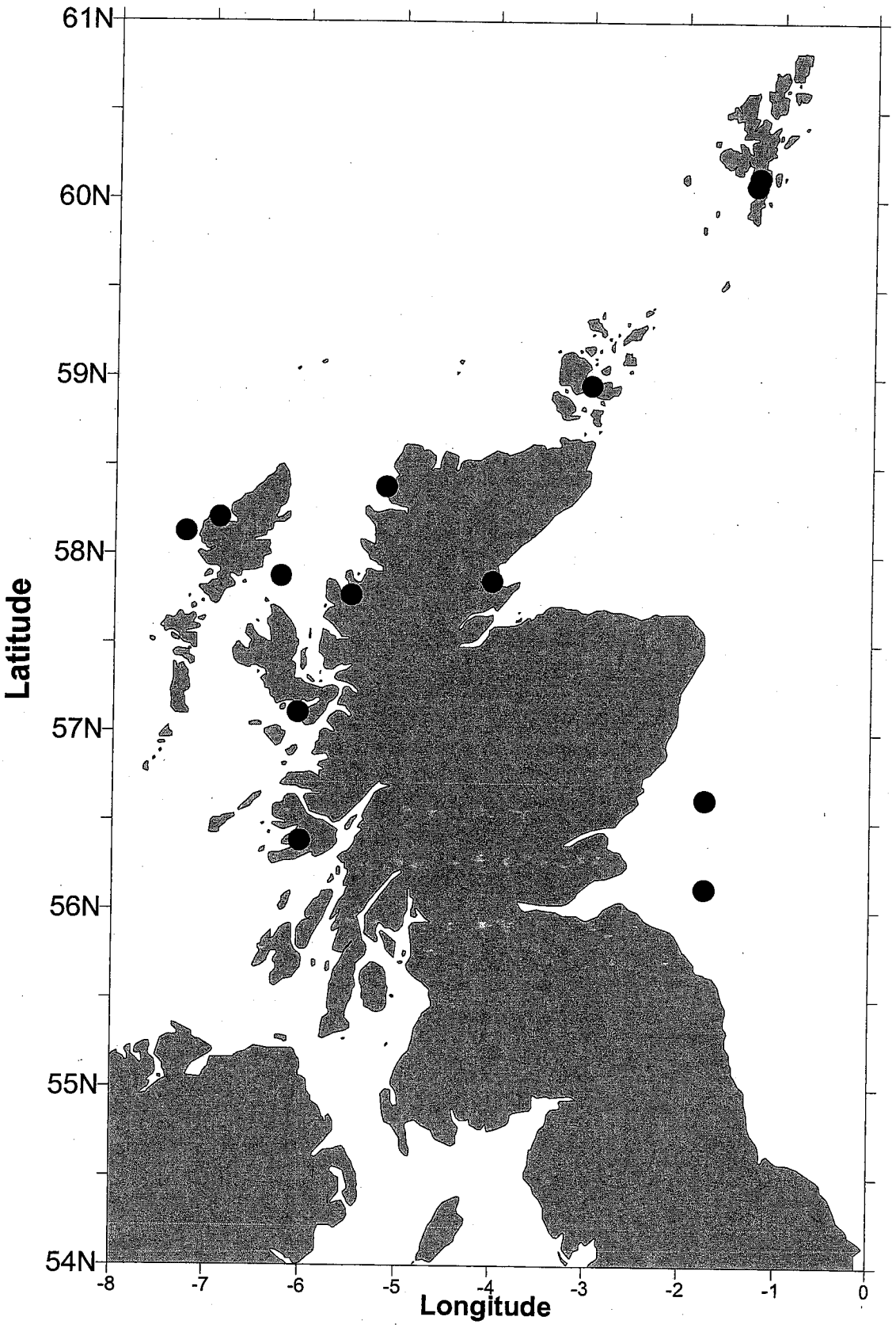


Figure 4.38 Sites where *P. cf. pseudodelicatissima* were observed during 2002/2003.

SECTION 5: DISCUSSION

The ability of the toxic phytoplankton monitoring programme to adequately monitor the dynamics of toxin producing cells was considerably reduced during 2002/2003 by the low sample return. A third of the coastal sampling sites and all of the offshore sites initially targeted had a sample return of < 60%. This can reduce phytoplankton monitoring to a mere counting exercise, which has little power to act as an early warning system to trigger shellfish flesh testing. This is particularly relevant in monitoring *Pseudo-nitzschia* cells and AST in offshore scallop boxes. It also has a number of practical implications for the running of the programme, as the resource available to operate the programme effectively is determined by the number of samples returned each year.

2002/2003 was a particularly quiet year for toxic dinoflagellates and the cell maxima observed at many sites for *Alexandrium* and *Dinophysis* species were lower in 2002 than in previous years. This is in contrast to early 2003 when the highest number of *Alexandrium* spp (4,240 cells/l) recorded since the beginning of the monitoring programme in 1996 was observed in Scapa Bay at the end of March. High *Pseudo-nitzschia* numbers (>200,000 cells/l) were again recorded at a number of coastal sites during the year.

The TEM results provided valuable information relating to *Pseudo-nitzschia* dynamics in Scottish waters and have identified seven potential toxin producing *Pseudo-nitzschia* species from around the Scottish Coast and offshore areas. Some samples were also found to consist of up to six potentially toxic species co-occurring at the same time. Some of these potentially toxic species (*P. australis P. pungens* and *P. fraudulenta*) were observed throughout most of the year.

The generation of contour plots of *Pseudo-nitzschia* spp. numbers from coastal and offshore areas and AST levels in *P. maximus* gonad tissue show that although sample frequency is low, AST was recorded in the shellfish flesh at the time that *Pseudo-nitzschia* spp. was likely to occur in the water column. Time series data from offshore sites was at too low a frequency to allow for statistical examination of the data.

The relevance of performing 100 TEM samples in the coming year was discussed with the FSAS and this analysis has been reduced to 10 samples during 2003/2004. The resource that this frees will allow five extra coastal sites to participate in the monitoring programme and increase coverage of areas of interest e.g. Shetland. In addition some of the targeted offshore sites will be changed in an effort to receive a more regular supply of samples.

ACKNOWLEDGEMENTS

We are extremely grateful to the following collectors for their co-operation during 2002 and 2003.

Without their help this programme would not be possible.

Mr Kevin MacKenzie, EM Unit, University of Aberdeen
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Highland Regional Council
Loch Eishort Mussel Culture
Mr N Etherson and Mrs J Church
Ms J Grant
Mull Scallops/Celtic Sea
North Atlantic Fisheries College, Shetland
North Ayrshire Council
Orkney Islands Council
Mr J Ross
Mr D Scott
Seacroft Oysters
SFPA, Eyemouth
Shetland Islands Council
Mr Chris Steventon
FSAS Charter Vessel Skippers

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Christensen, T. 1988). *Alger i naturen og i laboratoriet.* Københavens Universitat. Institute for sproreplanter. 137pp.

Kelly, M. C. and Fraser, S. 1998. Toxic Phytoplankton Monitoring in Scotland, 1 January to 31 December 1997. *Fisheries Research Services Report 6/98.*

Throndsen, J. 1995. Estimating cell numbers, in Holograph, G.M., Anderson, D.M. and Cembella, A.D. (Eds.), *Manual on Harmful Marine Microalgae, IOC annuals and guides no. 33*, 1st Paris UNESCO Press, France, p 63-80.

APPENDIX I

LM RESULTS

		Alexandrium/l	*Dinophysis/l*	*Pseudo-nitzschia/l*	*Protoperidinium/l*	*P. reticulatum/l*	*Prorocentrum lima/l*	*L. polyedrum/l*
St. Abbs	5-Jun-02	0	20	0	0	0	0	0
St. Abbs	24-Jun-02	0	540	320	100	0	0	0
St. Abbs	4-Jul-02	0	0	0	0	0	0	0
St. Abbs	17-Sep-02	60	1660	60	40	0	0	0
St. Abbs	3-Oct-02	0	20	160	0	0	0	0
St. Abbs	13-Feb-03	0	0	0	0	0	0	0

		Alexandrium/l	*Dinophysis/l*	*Pseudo-nitzschia/l*	*Protoperidinium/l*	*P. reticulatum/l*	*Prorocentrum lima/l*	*L. polyedrum/l*
2-Apr-02	Stonehaven	0	0	260	0	0	0	0
8-Apr-02	Stonehaven	60	0	2160	0	0	0	0
23-Apr-02	Stonehaven	40	0	1780	0	0	0	0
29-Apr-02	Stonehaven	0	20	1440	0	0	0	0
7-May-02	Stonehaven	60	20	1180	140	0	0	0
15-May-02	Stonehaven	120	40	580	230	40	0	0
30-May-02	Stonehaven	20	40	620	160	0	0	0
11-Jun-02	Stonehaven	20	80	2900	300	0	0	0
20-Jun-02	Stonehaven	0	0	15380	60	0	0	0
24-Jun-02	Stonehaven	0	460	7480	220	0	0	0
1-Jul-02	Stonehaven	0	320	1480	160	40	0	0
9-Jul-02	Stonehaven	0	1100	2620	480	0	0	0
15-Jul-02	Stonehaven	0	280	12960	20	0	0	0
22-Jul-02	Stonehaven	20	940	40640	120	0	0	0
30-Jul-02	Stonehaven	0	380	144200	40	0	0	0
5-Aug-02	Stonehaven	0	1740	58400	200	0	0	0
12-Aug-02	Stonehaven	0	880	202250.4	40	0	0	0
20-Aug-02	Stonehaven	0	420	7220	0	0	0	0
26-Aug-02	Stonehaven	0	1140	6940	100	0	0	0
3-Sep-02	Stonehaven	0	940	30400	60	0	0	0
9-Sep-02	Stonehaven	0	20	21680	40	0	0	0
16-Sep-02	Stonehaven	0	40	200	40	0	0	0
24-Sep-02	Stonehaven	0	0	340	0	0	0	0
30-Sep-02	Stonehaven	0	0	1580	40	0	0	0
7-Oct-02	Stonehaven	0	0	600	20	0	0	0
16-Oct-02	Stonehaven	0	0	400	60	0	0	0
28-Oct-02	Stonehaven	0	0	280	0	0	0	0
5-Nov-02	Stonehaven	0	0	60	0	0	0	0
18-Nov-02	Stonehaven	0	0	200	0	0	0	0
29-Nov-02	Stonehaven	0	0	80	0	0	40	0
17-Dec-02	Stonehaven	0	0	0	0	0	0	0
6-Jan-03	Stonehaven	0	0	80	0	0	0	0
13-Jan-03	Stonehaven	0	0	520	0	0	0	0
21-Jan-03	Stonehaven	0	0	560	0	0	0	0
3-Feb-03	Stonehaven	0	0	320	0	0	0	0
11-Feb-03	Stonehaven	0	0	840	0	0	0	0
17-Feb-03	Stonehaven	0	0	280	0	0	0	0
24-Feb-03	Stonehaven	0	0	1840	0	0	0	0
3-Mar-03	Stonehaven	20	0	1460	0	0	0	0
13-Mar-03	Stonehaven	0	0	7720	0	0	0	0
17-Mar-03	Stonehaven	0	0	8900	0	0	0	0
24-Mar-03	Stonehaven	20	0	9920	20	0	0	0

	Alexandrium/l	*Dinophysis/l*	*Pseudo-nitzschia/l*	*Protoperidinium/l*	*P. reticulatum/l*	*Prorocentrum lima/l*	*L. polyedrum/l*
23-Apr-02 Dornoch Firth	20	20	200	0	0	0	0
01-May-02 Dornoch Firth	180	100	4640	40	0	0	0
08-May-02 Dornoch Firth	0	80	2600	20	0	0	0
15-May-02 Dornoch Firth	0	20	30360	0	0	0	0
22-May-02 Dornoch Firth	0	0	169480	40	0	0	0
05-Jun-02 Dornoch Firth	0	40	240	0	0	0	0
12-Jun-02 Dornoch Firth	0	80	3520	20	0	0	0
17-Jun-02 Dornoch Firth	0	100	80	0	0	0	0
24-Jun-02 Dornoch Firth	0	160	380	0	0	0	0
01-Jul-02 Dornoch Firth	0	40	120	0	0	0	0
08-Jul-02 Dornoch Firth	20	220	440	40	0	0	0
16-Jul-02 Dornoch Firth	0	220	60	0	0	0	0
22-Jul-02 Dornoch Firth	0	0	0	0	0	0	0

		Alexandrium/l	*Dinophysis/l*	*Pseudo-nitzschia/l*	*Protoperidinium/l*	*P. reticulatum/l*	*Prorocentrum lima/l*	*L. polyedrum/l*
8-Apr-02	Loch Laxford	0	0	8660	0	0	0	0
26-Apr-02	Loch Laxford	0	0	80	0	0	0	0
7-May-02	Loch Laxford	0	0	160	0	0	0	0
16-May-02	Loch Laxford	0	0	6240	20	0	0	0
2-Jun-02	Loch Laxford	40	80	5320	340	0	0	0
13-Jun-02	Loch Laxford	60	300	260	40	0	0	0
1-Jul-02	Loch Laxford	0	0	0	0	0	0	0
6-Jul-02	Loch Laxford	0	1040	280	0	0	20	0
8-Jul-02	Loch Laxford	0	20	9540	100	0	0	0
24-Jul-02	Loch Laxford	60	0	7540	0	0	20	0
29-Jul-02	Loch Laxford	0	200	0	20	0	0	0
3-Aug-02	Loch Laxford	0	0	0	0	0	0	0
7-Aug-02	Loch Laxford	40	0	880	60	0	0	0
19-Aug-02	Loch Laxford	20	0	8620	0	0	0	0
27-Aug-02	Loch Laxford	0	60	1220	0	0	0	0
5-Sep-02	Loch Laxford	0	0	39540	100	0	20	0
16-Sep-02	Loch Laxford	0	0	1620	60	0	0	0
25-Sep-02	Loch Laxford	0	0	10420	0	0	0	0
2-Oct-02	Loch Laxford	0	0	29960	0	0	0	0
8-Oct-02	Loch Laxford	0	0	61180	0	0	0	0

		Alexandrium/l	*Dinophysis/l*	*Pseudo-nitzschia/l*	*Protoperidinium/l*	*P. reticulatum/l*	*Prorocentrum lima/l*	*L. polyedrum/l*
01-Apr-02	Loch Ewe - Isle Ewe	40	0	26080	60	0	0	0
08-Apr-02	Loch Ewe - Isle Ewe	0	0	1320	40	0	0	0
15-Apr-02	Loch Ewe - Isle Ewe	20	0	860	40	0	0	0
22-Apr-02	Loch Ewe - Isle Ewe	40	0	6680	0	0	0	0
29-Apr-02	Loch Ewe - Isle Ewe	20	80	17440	60	0	0	0
06-May-02	Loch Ewe - Isle Ewe	0	0	2780	0	0	0	0
13-May-02	Loch Ewe - Isle Ewe	0	60	14940	180	0	0	0
20-May-02	Loch Ewe - Isle Ewe	80	80	26820	780	0	20	0
27-May-02	Loch Ewe - Isle Ewe	20	160	13220	580	0	0	0
03-Jun-02	Loch Ewe - Isle Ewe	160	220	4200	600	40	0	0
10-Jun-02	Loch Ewe - Isle Ewe	40	320	6400	560	0	0	0
17-Jun-02	Loch Ewe - Isle Ewe	0	840	105520	100	20	20	0
24-Jun-02	Loch Ewe - Isle Ewe	0	200	6960	380	0	0	0
01-Jul-02	Loch Ewe - Isle Ewe	0	120	6540	200	20	0	0
08-Jul-02	Loch Ewe - Isle Ewe	0	440	36340	200	0	0	0
15-Jul-02	Loch Ewe - Isle Ewe	0	140	12900	40	0	0	0
22-Jul-02	Loch Ewe - Isle Ewe	0	500	11360	360	0	0	20
29-Jul-02	Loch Ewe - Isle Ewe	0	260	4440	100	0	0	0
05-Aug-02	Loch Ewe - Isle Ewe	0	140	260	100	0	0	0
12-Aug-02	Loch Ewe - Isle Ewe	440	300	3500	220	0	0	20
19-Aug-02	Loch Ewe - Isle Ewe	40	160	105500	100	0	0	0
26-Aug-02	Loch Ewe - Isle Ewe	0	60	46300	20	0	0	0
02-Sep-02	Loch Ewe - Isle Ewe	0	100	17200	40	0	0	0
09-Sep-02	Loch Ewe - Isle Ewe	0	0	10360	60	0	0	0
16-Sep-02	Loch Ewe - Isle Ewe	0	0	11000	20	0	0	0
23-Sep-02	Loch Ewe - Isle Ewe	0	0	8420	60	0	0	20
30-Sep-02	Loch Ewe - Isle Ewe	0	20	10720	180	0	0	0
07-Oct-02	Loch Ewe - Isle Ewe	0	100	14320	440	0	0	0
14-Oct-02	Loch Ewe - Isle Ewe	0	0	16580	40	0	0	0
21-Oct-02	Loch Ewe - Isle Ewe	0	40	22280	100	0	0	0
28-Oct-02	Loch Ewe - Isle Ewe	0	0	10360	0	0	0	0
04-Nov-02	Loch Ewe - Isle Ewe	0	0	2160	20	0	0	0
11-Nov-02	Loch Ewe - Isle Ewe	0	0	3800	140	0	0	0
18-Nov-02	Loch Ewe - Isle Ewe	0	0	1800	0	0	0	0
25-Nov-02	Loch Ewe - Isle Ewe	0	0	740	0	0	0	0
02-Dec-02	Loch Ewe - Isle Ewe	0	0	840	0	0	0	0
09-Dec-02	Loch Ewe - Isle Ewe	0	0	1920	0	0	0	0
16-Dec-02	Loch Ewe - Isle Ewe	0	0	1240	0	0	0	0
23-Dec-02	Loch Ewe - Isle Ewe	0	0	3020	0	0	0	0
30-Dec-02	Loch Ewe - Isle Ewe	0	0	1320	0	0	0	0
06-Jan-03	Loch Ewe - Isle Ewe	0	0	360	0	0	0	0
13-Jan-03	Loch Ewe - Isle Ewe	0	0	1860	0	0	0	0
20-Jan-03	Loch Ewe - Isle Ewe	0	0	760	0	0	0	0
27-Jan-03	Loch Ewe - Isle Ewe	0	0	220	0	0	0	0
03-Feb-03	Loch Ewe - Isle Ewe	0	0	240	0	0	0	0
10-Feb-03	Loch Ewe - Isle Ewe	0	0	360	0	0	0	0
17-Feb-03	Loch Ewe - Isle Ewe	0	0	2280	0	0	0	0
24-Feb-03	Loch Ewe - Isle Ewe	0	0	3600	20	0	0	0
03-Mar-03	Loch Ewe - Isle Ewe	0	0	5640	0	0	0	0
10-Mar-03	Loch Ewe - Isle Ewe	0	0	5220	40	0	0	0
17-Mar-03	Loch Ewe - Isle Ewe	0	20	2080	0	0	0	0
24-Mar-03	Loch Ewe - Isle Ewe	20	20	81190	0	0	0	0
31-Mar-03	Loch Ewe - Isle Ewe	0	20	71764	200	0	0	0

	Alexandrium/l	*Dinophysis/l*	*Pseudo-nitzschia/l*	*Protoperidinium/l*	*P. reticulatum/l*	*Prorocentrum lima/l*	*L. polyedrum/l*
01-Apr-02 Loch Roag - Miavaig	0	0	0				
08-Apr-02 Loch Roag - Miavaig	0	0	140	0	0	0	0
15-Apr-02 Loch Roag - Miavaig	20	0	460	0	0	0	0
22-Apr-02 Loch Roag - Miavaig	20	0	540	0	0	0	0
27-May-02 Loch Roag - Miavaig	40	0	780	0	0	0	0
25-Jun-02 Loch Roag - Miavaig	0	40	5920	0	0	0	0
02-Jul-02 Loch Roag - Miavaig	0	0	1140	20	0	0	0
22-Jul-02 Loch Roag - Miavaig	0	0	15400	160	0	0	0
28-Jul-02 Loch Roag - Miavaig	40	100	17320	0	0	0	0
06-Aug-02 Loch Roag - Miavaig	0	20	12800	100	0	0	0
20-Aug-02 Loch Roag - Miavaig	40	40	43480	0	0	0	0
26-Aug-02 Loch Roag - Miavaig	0	120	6520	40	0	40	20
02-Sep-02 Loch Roag - Miavaig	0	240	26300	20	0	0	0
10-Sep-02 Loch Roag - Miavaig	20	80	40820	20	0	0	0
24-Sep-02 Loch Roag - Miavaig	20	0	150920	1120	0	0	0
30-Sep-02 Loch Roag - Miavaig	0	20	280658	0	0	0	0
08-Oct-02 Loch Roag - Miavaig	0	0	251880	120	0	0	0
15-Oct-02 Loch Roag - Miavaig	0	0	207540	40	0	0	0
21-Oct-02 Loch Roag - Miavaig	0	0	119680	140	0	0	0
28-Oct-02 Loch Roag - Miavaig	0	0	60244.8	0	0	0	0
04-Nov-02 Loch Roag - Miavaig	0	0	2000	20	0	0	0
04-Nov-02 Loch Roag - Miavaig	0	0	2360	0	0	0	0
11-Nov-02 Loch Roag - Miavaig	0	0	460	0	0	0	0
18-Nov-02 Loch Roag - Miavaig	0	0	180	0	0	0	0
25-Nov-02 Loch Roag - Miavaig	0	0	180	0	0	0	0
02-Dec-02 Loch Roag - Miavaig	0	0	220	0	0	0	0
09-Dec-02 Loch Roag - Miavaig	0	0	0	0	0	0	0
22-Jan-03 Loch Roag - Miavaig	0	0	0	0	0	0	0
03-Feb-03 Loch Roag - Miavaig	0	0	0	0	0	0	0
18-Feb-03 Loch Roag - Miavaig	0	0	0	0	0	0	0
04-Mar-03 Loch Roag - Miavaig	0	0	2360	0	0	0	0
18-Mar-03 Loch Roag - Miavaig	20	0	500	0	0	0	0

	Alexandrium/l	*Dinophysis/l*	*Pseudo-nitzschia/l*	*Protoperidinium/l*	*P. reticulatum/l*	*Prorocentrum lima/l*	*L. polyedrum/l*
01-Apr-02 Loch Eishort	0	0	0				
08-Apr-02 Loch Eishort	0	0	2080	0	0	0	0
22-Apr-02 Loch Eishort	40	0	2300	20	0	0	0
29-Apr-02 Loch Eishort	260	20	1320	120	0	0	0
07-May-02 Loch Eishort	20	100	1840	20	0	0	0
13-May-02 Loch Eishort	20	80	3600	20	0	0	0
20-May-02 Loch Eishort	20	440	3060	320	80	0	0
27-May-02 Loch Eishort	60	160	60	260	20	0	20
04-Jun-02 Loch Eishort	80	380	100	120	40	0	0
10-Jun-02 Loch Eishort	20	400	680	240	0	0	0
17-Jun-02 Loch Eishort	0	640	3280	0	0	0	0
24-Jun-02 Loch Eishort	0	720	18040	0	0	0	0
08-Jul-02 Loch Eishort	0	560	286656	80	0	0	0
15-Jul-02 Loch Eishort	0	320	21100	0	0	0	0
05-Aug-02 Loch Eishort	0	60	840	0	0	0	0
19-Aug-02 Loch Eishort	0	220	12420	120	120	0	0
26-Aug-02 Loch Eishort	0	320	6640	0	0	0	0
02-Sep-02 Loch Eishort	40	60	11020	120	0	0	0
16-Sep-02 Loch Eishort	0	0	360720	0	0	0	0
29-Sep-02 Loch Eishort	0	20	130434	0	0	0	0
14-Oct-02 Loch Eishort	0	0	328200	160	0	0	0
11-Nov-02 Loch Eishort	0	0	340	0	0	0	0
26-Nov-02 Loch Eishort	0	0	280	0	0	0	0
13-Jan-03 Loch Eishort	0	0	0	0	0	0	0
03-Mar-03 Loch Eishort	20	0	560	0	0	0	0
31-Mar-03 Loch Eishort	120	20	300	0	0	0	0

	Alexandrium/l	*Dinophysis/l*	*Pseudo-nitzschia/l*	*Protoperidinium/l*	*P. reticulatum/l*	*Prorocentrum lima/l*	*L. polyedrum/l*
08-Apr-02 Loch Scridain	0	0	200	20	0	0	0
15-Apr-02 Loch Scridain	260	0	9820	240	0	0	0
22-Apr-02 Loch Scridain	0	20	4660	20	0	0	0
29-Apr-02 Loch Scridain	0	0	1220	40	0	0	0
13-May-02 Loch Scridain	120	0	660	120	0	0	0
04-Jun-02 Loch Spelve	0	0	380	0	0	0	0
04-Jun-02 Loch Scridain	0	0	180	0	0	0	0
11-Jun-02 Loch Scridain	0	60	14560	0	0	0	0
18-Jun-02 Loch Scridain	0	20	6280	0	0	0	0
02-Jul-02 Loch Scridain	0	0	360	0	0	0	0
08-Jul-02 Loch Scridain	0	20	760	20	0	0	0
16-Jul-02 Loch Scridain	0	0	860	0	0	0	0
16-Jul-02 Loch Spelve	0	20	14300	0	0	0	0
22-Jul-02 Loch Scridain	0	0	500	0	0	20	0
22-Jul-02 Loch Spelve	0	20	27980	340	0	0	0
29-Jul-02 Loch Scridain	0	80	3500	140	0	0	0
13-Aug-02 Loch Scridain	0	0	2620	0	0	0	0
27-Sep-02 Loch Scridain	0	0	375080	0	0	0	0
27-Sep-02 Loch Spelve	0	0	1096260	320	0	0	0
30-Sep-02 Loch Scridain	0	0	19980	0	0	0	0
21-Oct-02 Loch Scridain	0	0	47300	160	0	0	0
04-Nov-02 Loch Scridain	0	0	3620	0	0	0	0
18-Nov-02 Loch Scridain	0	0	660	0	0	0	0
02-Dec-02 Loch Scridain	0	0	0	0	0	0	0
07-Jan-03 Loch Scridain	0	0	0	0	0	0	0
21-Jan-03 Loch Scridain	0	0	0	0	0	0	0
03-Feb-03 Loch Scridain	0	0	0	0	0	0	0
24-Feb-03 Loch Scridain	0	0	0	0	0	0	0
18-Mar-03 Loch Scridain	0	0	0	0	0	0	0
31-Mar-03 Loch Scridain	0	0	0	0	0	0	0

	Alexandrium/l	*Dinophysis/l*	*Pseudo-nitzschia/l*	*Protoperidinium/l*	*P. reticulatum/l*	*Prorocentrum lima/l*	*L. polyedrum/l*
15-Apr-02 Loch Etive	0	0	9980	0	0	0	0
21-May-02 Loch Etive	0	0	0	0	0	0	0
3-Jun-02 Loch Etive	0	20	0	40	0	0	0
3-Sep-02 Loch Etive	0	0	960	0	0	0	0
16-Sep-02 Loch Etive	0	0	40	20	0	0	0
2-Oct-02 Loch Etive	0	0	360	0	0	0	0
18-Oct-02 Loch Etive	0	0	160	40	0	0	0
18-Nov-02 Loch Etive	0	0	0	0	0	0	0
4-Mar-03 Loch Etive	0	0	0	0	0	0	0
30-Mar-03 Loch Etive	40	0	100	0	0	0	0

		Alexandrium/l	*Dinophysis/l*	*Pseudo-nitzschi*	*Protoperidinium*	*P. reticulatum/l*	*Prorocentrum lii*	*L. polyedrum/l*
8-Apr-02	West Loch Tarbert - Loup Bay	1	0	520	0	0	0	0
29-Apr-02	West Loch Tarbert - Loup Bay	0	20	6600	0	0	0	0
13-May-02	West Loch Tarbert - Loup Bay	0	0	1960	0	0	0	0
11-Jun-02	West Loch Tarbert - Loup Bay	0	0	100	0	0	0	0
17-Jun-02	West Loch Tarbert - Loup Bay	0	0	4320	0	0	0	0
2-Jul-02	West Loch Tarbert - Loup Bay	0	0	5500	0	0	0	0
15-Jul-02	West Loch Tarbert - Loup Bay	0	0	520	0	0	0	0
29-Jul-02	West Loch Tarbert - Loup Bay	0	0	740	0	0	40	0
16-Sep-02	West Loch Tarbert - Loup Bay	2	0	1620	60	0	0	0
23-Sep-02	West Loch Tarbert - Loup Bay	0	0	1080	20	0	0	0
7-Oct-02	West Loch Tarbert - Loup Bay	0	0	440	0	0	0	0
28-Oct-02	West Loch Tarbert - Loup Bay	0	0	6260	40	0	0	0
4-Nov-02	West Loch Tarbert - Loup Bay	0	0	180	0	0	0	0
2-Dec-02	West Loch Tarbert - Loup Bay	0	0	0	0	0	0	0
20-Jan-03	West Loch Tarbert - Loup Bay	0	0	0	0	0	0	0
17-Feb-03	West Loch Tarbert - Loup Bay	1	0	2040	0	0	0	0
17-Mar-03	West Loch Tarbert - Loup Bay	1	0	140	0	0	20	0

	Alexandrium/l	*Dinophysis/l*	*Pseudo-nitzschia/l*	*Protoperidinium/l*	*P. reticulatum/l*	*Prorocentrum lima/l*	*L. polyedrum/l*
04-Apr-02 Loch Striven	80	20	1220	220	0	0	0
15-Apr-02 Loch Striven	40	20	0	20	0	0	0
24-Apr-02 Loch Striven	0	0	360	0	0	0	0
07-May-02 Loch Striven	0	0	500	0	0	0	0
22-May-02 Loch Striven	80	260	2840	220	0	0	0
05-Jun-02 Loch Striven	60	1640	191904	680	0	0	0
19-Jun-02 Loch Striven	0	540	24000	160	0	0	0
02-Jul-02 Loch Striven	0	40	380	40	0	0	0
18-Jul-02 Loch Striven	0	0	140	0	0	0	0
30-Jul-02 Loch Striven	0	180	4280	280	0	0	0
16-Aug-02 Loch Striven	0	100	2620	0	0	0	0
01-Oct-02 Loch Striven	0	0	8600	0	0	0	0
14-Oct-02 Loch Striven	0	20	11480	220	0	0	0

		Alexandrium/l	*Dinophysis/l*	*Pseudo-nitzschia/l*	*Protoperidinium/l*	*P. reticulatum/l*	*Prorocentrum lima/l*	*L. polyedrum/l*
29-Apr-02	Loch Ryan	0	0	80	0	0	0	0
7-May-02	Loch Ryan	0	0	0	40	0	0	0
25-Jun-02	Loch Ryan	0	60	840	40	0	0	0
17-Jul-02	Loch Ryan	0	0	80	60	0	0	0
22-Jul-02	Loch Ryan	0	0	25940	60	0	0	0
19-Aug-02	Loch Ryan	0	0	520	0	0	0	0
17-Sep-02	Loch Ryan	0	0	0	0	0	0	0
18-Nov-02	Loch Ryan	0	0	40	0	0	0	0
3-Dec-02	Loch Ryan	0	0	0	0	0	0	0
6-Jan-03	Loch Ryan	0	0	160	0	0	0	0
25-Mar-03	Loch Ryan	0	0	100	40	0	0	0

		Alexandrium/l	*Dinophysis/l*	*Pseudo-nitzschia/l*	*Protoperidinium/l*	*P. reticulatum/l*	*Prorocentrum lima/l*	*L. polyedrum/l*
03-Apr-02	Dhoon Bay	20	0	40	0	0	0	0
07-May-02	Dhoon Bay	0	0	80	0	0	0	0
19-Jun-02	Dhoon Bay	0	0	40	0	0	0	0
17-Jul-02	Dhoon Bay	0	0	80	0	0	0	0
13-Aug-02	Dhoon Bay	0	0	0	0	0	0	0
30-Sep-02	Dhoon Bay	0	20	560	0	0	0	0
11-Nov-02	Dhoon Bay	0	0	0	0	0	0	0
02-Dec-02	Dhoon Bay	0	0	0	0	0	0	0
07-Jan-03	Dhoon Bay	0	0	0	0	0	0	0
24-Feb-03	Dhoon Bay	0	0	0	0	0	0	0
10-Mar-03	Dhoon Bay	0	0	0	0	0	0	0

		Alexandrium/l	*Dinophysis/l*	*Pseudo-nitzschia/l*	*Protoperidinium/l*	*P. reticulatum/l*	*Prorocentrum lima/l*	*L. polyedrum/l*
4-Apr-02	Scapa Flow/Scapa Bay	200	20	9480	220	0	0	0
8-Apr-02	Scapa Flow/Scapa Bay	400	20	7680	140	0	0	0
15-Apr-02	Scapa Flow/Scapa Bay	120	0	980	0	0	0	0
22-Apr-02	Scapa Flow/Scapa Bay	460	40	5020	120	40	0	0
29-Apr-02	Scapa Flow/Scapa Bay	520	20	6540	120	0	0	0
7-May-02	Scapa Flow/Scapa Bay	20	0	110780	0	0	0	0
13-May-02	Scapa Flow/Scapa Bay	40	0	112440	40	0	0	0
20-May-02	Scapa Flow/Scapa Bay	60	0	375240	40	0	20	0
27-May-02	Scapa Flow/Scapa Bay	0	0	589206	160	40	0	20
7-Jun-02	Scapa Flow/Scapa Bay	0	40	560	80	0	0	0
10-Jun-02	Scapa Flow/Scapa Bay	0	20	280	0	0	0	0
21-Jun-02	Scapa Flow/Scapa Bay	0	60	0	40	0	380	0
27-Jun-02	Scapa Flow/Scapa Bay	120	20	0	0	0	720	0
5-Jul-02	Scapa Flow/Scapa Bay	0	1520	3200	0	0	0	0
12-Jul-02	Scapa Flow/Scapa Bay	20	20	3900	60	0	0	0
18-Jul-02	Scapa Flow/Scapa Bay	0	920	7960	140	0	60	0
26-Jul-02	Scapa Flow/Scapa Bay	0	340	9660	40	0	100	0
31-Jul-02	Scapa Flow/Scapa Bay	20	260	35180	80	0	120	0
6-Aug-02	Scapa Flow/Scapa Bay	0	40	5200	0	0	60	0
13-Aug-02	Scapa Flow/Scapa Bay	20	60	1580	0	0	0	0
19-Aug-02	Scapa Flow/Scapa Bay	0	220	1160	0	0	180	0
26-Aug-02	Scapa Flow/Scapa Bay	0	0	1820	0	0	460	0
2-Sep-02	Scapa Flow/Scapa Bay	20	620	6080	160	0	160	0
9-Sep-02	Scapa Flow/Scapa Bay	0	200	13880	0	0	0	0
16-Sep-02	Scapa Flow/Scapa Bay	0	60	3080	80	0	180	0
23-Sep-02	Scapa Flow/Scapa Bay	0	80	15060	0	0	60	0
30-Sep-02	Scapa Flow/Scapa Bay	0	40	6060	0	0	40	0
7-Oct-02	Scapa Flow/Scapa Bay	80	20	19360	340	0	140	0
21-Oct-02	Scapa Flow/Scapa Bay	0	0	4100	0	0	0	0
29-Oct-02	Scapa Flow/Scapa Bay	0	0	940	0	0	40	0
4-Nov-02	Scapa Flow/Scapa Bay	0	0	420	0	0	40	0
11-Nov-02	Scapa Flow/Scapa Bay	0	0	80	0	0	0	0
18-Nov-02	Scapa Flow/Scapa Bay	0	0	580	0	0	0	0
25-Nov-02	Scapa Flow/Scapa Bay	0	0	160	0	0	20	0
2-Dec-02	Scapa Flow/Scapa Bay	0	0	0	0	0	0	0
10-Dec-02	Scapa Flow/Scapa Bay	0	0	540	0	0	0	0
17-Dec-02	Scapa Flow/Scapa Bay	0	0	260	0	0	0	0
6-Jan-03	Scapa Flow/Scapa Bay	0	0	2460	0	0	0	0
13-Jan-03	Scapa Flow/Scapa Bay	0	0	500	0	0	0	0
20-Jan-03	Scapa Flow/Scapa Bay	0	0	2020	0	0	0	0
27-Jan-03	Scapa Flow/Scapa Bay	0	0	640	0	0	0	0
5-Feb-03	Scapa Flow/Scapa Bay	0	0	2520	0	0	0	0
10-Feb-03	Scapa Flow/Scapa Bay	0	0	1640	0	0	0	0
21-Feb-03	Scapa Flow/Scapa Bay	40	0	9960	0	0	0	0
28-Feb-03	Scapa Flow/Scapa Bay	0	0	9640	0	0	0	0
7-Mar-03	Scapa Flow/Scapa Bay	20	0	8120	0	0	0	0
13-Mar-03	Scapa Flow/Scapa Bay	20	0	7040	80	20	0	0
19-Mar-03	Scapa Flow/Scapa Bay	100	0	98677	60	0	0	0
27-Mar-03	Scapa Flow/Scapa Bay	4240	0	137447	20	0	0	20

	Alexandrium/l	*Dinophysis/l*	*Pseudo-nitzschia/l*	*Protoperidinium/l*	*P. reticulatum/l*	*Prorocentrum lima/l*	*L. polyedrum/l*
4-Apr-02 Scalloway - Noss Sound	60	0	340	20	0	0	0
12-Apr-02 Scalloway - Noss Sound	40	0	2260	40	0	0	0
19-Apr-02 Scalloway - Noss Sound	20	0	40	200	0	0	0
26-Apr-02 Scalloway - Noss Sound	60	0	0	60	0	0	0
3-May-02 Scalloway - Noss Sound	0	20	7860	20	0	0	0
13-May-02 Scalloway - Noss Sound	20	20	9700	80	0	0	0
17-May-02 Scalloway - Noss Sound	0	0	7600	20	0	0	0
24-May-02 Scalloway - Noss Sound	0	40	11500	0	0	0	0
3-Jun-02 Scalloway - Noss Sound	20	0	2880	440	0	0	0
10-Jun-02 Scalloway - Noss Sound	120	0	1940	0	0	0	0
16-Jul-02 Scalloway - Noss Sound	20	0	1360	0	0	0	0
26-Jul-02 Scalloway - Noss Sound	40	100	5340	40	0	80	0
2-Aug-02 Scalloway - Noss Sound	0	0	7940	160	0	0	0
11-Aug-02 Scalloway - Noss Sound	40	0	159360	60	0	0	80
16-Aug-02 Scalloway - Noss Sound	220	60	226280	320	0	120	0
23-Aug-02 Scalloway - Noss Sound	140	0	88280	80	0	20	0
31-Aug-02 Scalloway - Noss Sound	380	0	37560	60	0	0	0
6-Sep-02 Scalloway - Noss Sound	20	0	31520	200	0	0	0
13-Sep-02 Scalloway - Noss Sound	0	0	110360	0	0	0	0
20-Sep-02 Scalloway - Noss Sound	40	0	108700	300	0	0	0
27-Sep-02 Scalloway - Noss Sound	0	0	57240	200	0	0	0
3-Oct-02 Scalloway - Noss Sound	20	20	460	40	0	0	0
14-Oct-02 Scalloway - Noss Sound	0	0	1220	0	0	0	0
18-Oct-02 Scalloway - Noss Sound	0	0	1720	40	0	0	0
8-Nov-02 Scalloway - Noss Sound	0	0	260	0	0	0	0
15-Nov-02 Scalloway - Noss Sound	0	0	0	0	0	0	0
24-Nov-02 Scalloway - Noss Sound	0	0	40	0	0	0	0
13-Dec-02 Scalloway - Noss Sound	0	0	0	0	0	0	0
20-Dec-02 Scalloway - Noss Sound	0	0	40	0	0	0	0
3-Jan-03 Scalloway - Noss Sound	0	0	340	20	0	0	0
10-Jan-03 Scalloway - Noss Sound	0	0	580	0	0	0	0
24-Jan-03 Scalloway - Noss Sound	0	0	220	0	0	0	0
31-Jan-03 Scalloway - Noss Sound	0	0	940	0	0	0	0
8-Feb-03 Scalloway - Noss Sound	0	0	420	0	0	0	0
14-Feb-03 Scalloway - Noss Sound	0	0	2860	0	0	20	0
28-Feb-03 Scalloway - Noss Sound	0	0	3660	0	0	0	0
7-Mar-03 Scalloway - Noss Sound	20	0	1060	20	0	0	0
14-Mar-03 Scalloway - Noss Sound	0	0	2440	0	0	0	0

		Alexandrium/l	*Dinophysis/l*	*Pseudo-nitzschia/l*	*Protoperidinium/l*	*P. reticulatum/l*	*Prorocentrum lima/l*	*L. polyedrum/l*
16-Aug-02	E11	20	140	5040	20	0	0	0
16-Aug-02	E16	0	140	25720	0	0	0	0
10-Jun-02	E16	0	0	15300	60	0	0	0
30-Jun-02	E16	0	0	840	460	0	0	0
7-May-02	E16	60	20	120	20	40	0	0
9-Jun-02	E17	0	580	1080	20	0	0	0
29-Apr-02	E17	40	20	1480	0	0	0	0
17-Aug-02	E2	0	400	9180	40	0	0	0
16-Jun-02	E2	20	880	5140	340	0	0	0
16-Jun-02	E2	0	400	9180	140	0	0	0
16-Jun-02	E2	20	720	4180	420	0	0	0
16-Jun-02	E2	0	280	1760	340	0	0	0
23-Mar-03	E2	0	0	3800	0	0	0	0
24-Mar-03	E2	20	0	6140	0	0	0	0
26-Aug-02	E21	0	3020	8380	120	0	0	0
26-Aug-02	E22	0	40	680	20	0	0	0
6-May-02	E28	60	60	300	20	60	0	0
23-Apr-02	E28	20	0	651260	80	0	0	0
26-Aug-02	E28	0	60	3780	0	0	0	0
21-Feb-03	E28	0	0	3720	0	0	0	0
17-Aug-02	E3	0	80	3240	0	0	0	0
26-Aug-02	E33	0	40	10420	40	0	0	0
20-May-02	H3	60	0	2620	80	0	0	0
1-Apr-02	H5	0	0	280	40	0	0	0
1-Apr-02	H5	0	0	200	0	0	0	0
27-Apr-02	H5	80	0	1660	260	0	0	0
7-Nov-02	H5	0	0	0	0	0	0	0
9-Jun-02	H5	0	0	620	0	0	0	0
14-Jan-03	H5	0	0	140	0	0	0	0
15-Jul-02	H5	0	0	82180	0	0	0	0
8-Oct-02	H5	0	0	16000	0	0	0	0
10-Mar-03	H5	20	0	80	0	0	0	0
2-Dec-02	H5	0	0	0	0	0	0	0
6-Feb-03	H5	0	0	80	0	0	0	0
1-Jul-02	H9	0	0	10380	0	0	0	0
31-Mar-03	J1	0	0	14260	0	0	0	0
18-Nov-02	J1	0	0	580	0	0	0	0
11-Jan-03	J1	0	0	40	0	0	0	0
15-Sep-02	J1	0	0	223740	0	0	0	0
17-Mar-03	J10	0	0	540	0	0	0	0
18-Mar-03	J11	0	0	160	0	0	0	0
26-Aug-02	J2	60	0	69940	0	0	0	0
18-Nov-02	J2	0	0	320	0	0	0	0
15-Sep-02	J2	0	0	135900	0	0	0	0
19-Nov-02	J3	0	0	320	0	0	0	0
18-Jan-03	J4	0	0	0	0	0	0	0
8-Jun-02	J4	80	220	6840	140	0	0	0
30-Mar-03	J4	0	0	14220	0	0	0	0
3-Apr-02	J4	0	0	0	0	0	0	0
26-Aug-02	J5	0	0	23840	20	0	0	0
15-May-02	J7	0	0	280	0	0	0	0
30-Mar-03	J7	20	0	8640	20	0	0	0
19-Jan-03	M1	0	0	0	0	0	0	0
27-May-02	M10	0	0	180	0	0	0	0
25-Apr-02	M10	100	0	1440	140	0	0	0
14-Jul-02	M10	0	20	15260	0	0	0	0
29-Oct-02	M10	0	0	40	0	0	0	0
21-Feb-03	M11	0	0	60	0	0	0	0
29-Jul-02	M16	0	80	11340	60	0	0	0
29-Jul-02	M18	0	20	6940	60	0	0	0
30-Jul-02	M19	0	20	7140	40	0	0	0
26-Nov-02	M28	0	0	0	0	0	0	0
24-Mar-03	M9	0	0	420	0	0	0	0
23-Mar-03	M9	0	0	40	0	0	0	0
3-Sep-02	NM12	0	0	340	40	0	0	0
27-Apr-02	NM12	0	0	3420	0	0	0	0
22-Jul-02	NM12	0	40	13740	40	0	0	0
25-May-02	NM16	40	120	921080	0	0	0	0
19-Mar-03	NM16	0	0	80	0	0	0	0
21-Jul-02	NM16	0	20	7080	40	0	0	0
30-Jun-02	NM16	0	0	840	80	0	0	0
24-Jun-02	NM16	0	60	27460	80	20	0	20
19-Aug-02	NM16	20	180	940	40	20	0	0
7-Jan-03	NM16	0	0	0	0	0	0	0
11-Nov-02	NM16	0	0	0	0	0	0	0
3-Sep-02	NM16	20	0	0	20	0	0	0
14-Oct-02	NM16	0	0	280	0	0	0	0
8-Dec-02	NM17	0	0	140	0	0	0	0
5-Feb-03	NM19	0	0	0	0	0	0	0
19-Aug-02	NM19	0	180	3480	80	0	0	0
3-Sep-02	NM9	0	20	42200	0	0	0	0
22-Jul-02	NM9	20	140	14540	260	0	0	0
30-Jul-02	O11	20	80	2940	120	0	0	0
30-Jul-02	O12	20	40	580	600	0	0	0
15-Feb-03	O12	0	0	0	0	0	0	0
8-Mar-03	O18	60	0	31900	40	0	0	0
15-Apr-02	O18	100	0	8540	120	0	0	0
17-Nov-02	O18	0	0	360	0	0	0	0
16-Jul-02	O18	0	180	38660	20	0	0	0
15-Apr-02	O18	160	0	4740	40	0	0	0
6-Aug-02	O18	120	300	12880	500	0	0	0
25-Jul-02	O18	60	340	9700	180	0	0	0

28-Aug-02	O18	0	120	45720	0	0	0	0
19-Oct-02	O18	0	0	880	20	0	0	0
16-Sep-02	O18	0	20	1860	0	0	0	0
6-Aug-02	O19	20	100	4660	120	0	0	0
17-Jul-02	O19	0	180	21180	0	0	0	0
25-Jul-02	O19	0	160	12620	60	0	0	0
15-Sep-02	O19	0	0	280	0	0	0	0
26-Aug-02	O19	60	20	5460	0	0	0	0
15-Apr-02	O19	100	0	1080	120	0	0	0
15-Apr-02	O19	160	0	1520	120	0	0	0
17-Nov-02	O19	0	0	200	0	0	0	0
9-Jan-03	O19	0	0	1080	0	0	0	0
28-Aug-02	O19	0	80	13600	0	0	0	0
5-Feb-03	O19	0	0	1540	0	0	0	0
26-Jan-03	O25	0	0	40	0	0	0	0
15-Feb-03	O27	0	0	160	0	0	0	0
16-Nov-02	S10	0	0	140	0	0	0	0
12-Mar-03	S14	0	0	3040	0	0	0	0
3-Sep-02	S14	0	0	31960	1960	0	0	0
20-Mar-03	S14	0	0	0	0	0	0	0
12-Aug-02	S2	0	40	4700	20	0	0	0
12-Sep-02	S2	0	40	0	0	0	0	0
16-Sep-02	S4	0	0	8980	0	0	0	0
19-Oct-02	S6	0	0	0	0	0	0	0
4-Jun-02	S6	0	0	40	20	0	0	0
20-Mar-03	S6	0	0	0	0	0	0	0
8-Jul-02	S7	0	0	0	0	0	0	0
27-Aug-02	SM 2	0	40	4700	40	0	0	0
11-Feb-03	SM1	0	0	0	0	0	0	0
27-May-02	SM10	0	0	420	0	0	0	0
11-Mar-03	SM11	0	0	0	0	0	0	0
15-Feb-03	SM15	0	0	180	0	0	0	0
18-Nov-02	SM16	0	0	100	0	0	0	0
28-May-02	SM2	20	20	660	60	0	0	0
11-Feb-03	SM2	0	0	60	0	0	0	0
17-Jun-02	SM6	0	0	16540	0	0	0	0
28-May-02	SM6	20	20	300	80	20	0	0
12-Aug-02	SM6	0	20	14360	20	0	0	0
8-Jan-03	SM6	0	0	80	0	0	0	0
22-Apr-02	SM6	0	0	140	0	0	0	0
3-Dec-02	SM6	0	0	40	0	0	0	0
30-Mar-03	SM6	60	0	846098	220	0	0	0
27-Aug-02	SM7	0	0	75660	0	0	0	0

APPENDIX II

TEM RESULTS

TEM results

Sample Type	Site	Date	sample no	species
Coastal Sites				
	Stonehaven	30-Jul-02	02/572	*P. australis*
		3-Sep-02	02/709	*P. cf. seriata*
	Dornoch Firth	22-May-02	02/326	*P. fraudulenta*
				P. pseudodelicatissima
	Scapa Bay	8-Apr-02	02/164	*P. fraudulenta*
		20-May-02	02/309	*P. cf. pseudodelicatissima*
		12-Jul-02	02/556	Too much precipitate to identify cells
		22-Jul-02	02/547	*P. australis*
				P. fraudulenta
				P. pungens
		23-Aug-02	02/683	*P. pungens*
				P. americana
				P. australis
		9-Sep-02	02/792	*P. pungens*
				P. americana
		23-Sep-02	02/831	*P. pungens*
		7-Oct-02	02/888	*P. pungens*
	Scalloway	24-May-02	02/327	*P. australis*
				P. fraudulenta
				P. cf. pseudodelicatissima
				P. cf. delicatissima
		11-Aug-02	02/645	*P. australis*
				P. fraudulenta
				P. cf. pseudodelicatissima
		16-Aug-02	02/653	*P. australis*
				P. cf. pseudodelicatissima
				P. fraudulenta
		23-Aug-02	02/678	*P. australis*
				P. fraudulenta
				P. seriata
				P. pungens
				P. cf. pseudodelicatissima
		31-Aug-02	02/708	*P. australis*
		6-Sep-02	02/728	*P. australis*
				P. cf. pseudodelicatissima
				P. australis
		13-Sep-02	02/770	*P. australis*
				P. fraudulenta
				P. cf. pseudodelicatissima
				P. pungens
		20-Sep-02	02/813	*P.australis*
				P. fraudulenta
				P. pungens
		27-Sep-02	02/816	*P.australis*
				P. fraudulenta
	Loch Laxford	27-Aug-02	02/706	Too much precipitation to identify cells
		5-Sep-02	02/730	*P. americana*
				P. australis

			P. cf. delicatissima
			P. fraudulenta
			P. pungens
			P. cf pseudodelicatissima
	16-Sep-02	02/785	Too much precipitate to identify cells
			P. americana
			P. australis
			P. fraudulenta
			P. pseudodelicatissima
			P. pungens
	2-Oct-02	02/843	*P. australis*
	8-Oct-02	02/863	*Pseudo-nitzschia spp.*
Loch Roag	6-Aug-02	02/618	*P. pungens*
	2-Sep-02	02/710	*P. americana*
			P. australis
			P cf. pseudodelicatissima
	10-Sep-02	02/761	*P. australis*
			P. fraudulenta
			P. pungens
	24-Sep-02	02/812	*P. australis*
			P. fraudulenta
	30-Sep-02	02/825	*P. australis*
			P. fraudulenta
	8-Oct-02	02/860	Too much precipitate to identify cells
	15-Oct-02	02/893	*P australis*
			P . fraudulenta
			P. pungens
	21-Oct-02	02/913	*P. australis*
Isle of Ewe	1-Apr-02	02/136	*P. cf. delicatissima*
			P. fraudulenta
	1-Apr-02	02/134	*P. cf. pseudodelicatissima*
			P. cf. delicatissima
			P. fraudulenta
			P. seriata
			Pseudo-nitzschia spp.
	22-Apr-02	02/209	Too much precipitation to identify cells
	25-Apr-02	02/223	*P. seriata*
	20-May-02	02/323	*P. cf. australis*
	23-May-02	02/340	Too much precipitation to identify cells
	27-May-02	02/334	*P. australis*
	13-Jun-02	02/446	*P. australis*
	17-Jun-02	02/452	*P. australis*
			P. fraudulenta
	19-Jun-02	02/390	*P. australis*
			P cf. delicatissima
	25-Jul-02	02/602	*P. australis*
			P. fraudulenta
			P. pungens
	12-Aug-02	02/636	*P. australis*
			P. pungens
			P. cf. pseudodelicatissima
	19-Aug-02	02/666	*P. australis*
	19-Aug-02	02/666	*P. pungens*
	26-Aug-02	02/701	Too much precipitation to identify cells

		22-Aug-02	02/751	*P. australis*
				P. fraudulenta
				P. cf. pseudodelicatissima
				P. pungens
		23-Sep-02	02/806	*P. americana*
		26-Sep-02	02/818	*P. australis*
				P. pungens
		3-Oct-02	02/857	*P. australis*
				P. fraudulenta
				P. cf. pseudodelicatissima
				Pseudonitzschia spp
				P. pungens
		31-Oct-02	02/959	*P. americana*
				P australis
				P pungens
		14-Nov-02	02/992	*P. cf australis*
		5-Dec-02	02/1066	*No cells on grid*
		23-Dec-02	02/1105	*No cells on grid*
		9-Jan-03	03/024	*No cells on grid*
	Loch Eishort	15-Jul-02	02/520	*P. australis*
				P. cf. pseudodelicatissima fragment
				P. pungens
				P. cf. pseudodelicatissima
		16-Sep-02	02/764	*P. cf. pseudodelicatissima*
				P. fraudulenta
		29-Sep-02	02/824	Too much precipitation to identify cells
		14-Oct-02	02/895	*P. fraudulenta*
		14-Oct-02	02/895	*P.pungens*
	Loch Scridain	27-Sep-02	02/862	*P. cf.pseudodelicatissima*
				P. fraudulenta
		30-Sep-02	02/840	*P. fraudulenta*
		21-Oct-02	02/914	*P. fraudulenta*
				P. cf. pseudodelicatissima
				P. pungens
	Loch Spelve	7-May-02	02/270	Too much precipitation to identify cells
		22-Jul-02	02/558	Too much precipitation to identify cells
	Loch Striven	5-Jun-02	02/378	*P. australis*
				P. fraudulenta
				P. seriata
		14-Oct-02	02/894	*P. australis*
				P. pungens
	Loch Ryan	22-Jul-02	02/540	*P. australis*
Offshore sites	**E 28**	23-Apr-02	02/204	*P. pseudodelicatissima*
	E16	16-Aug-02	02/661	*P. fraudulenta*
				P. pungens
	E16	10-Jun-02	02/399	*P. cf pseudodelicatissima*
				P. cf delicatissima
				P.pungens
	E2	17-Aug-02	02/658	*P. fraudulenta*

H5	8-Oct-02	02/861	*P. fraudulenta*
	15-Jul-02	02/502	*P. australis*
			P. cf. pseudodelicatissima
			P. pungens
			Pseudo-nitzschia spp.
H9	1-Jul-02	02/489	Too much precipitation to identify cells
J2	26-Aug-02	02/694	Too much precipitation to identify cells
J5	26-Aug-02	02/693	*P. australis*
M10	14-Jul-02	02/501	*P. australis*
NM12	22-Jul-02	02/560	*P. pungens*
NM16	24-Jun-02	02/439	*P. americana*
			P. australis
			P.pungens
			P. cf. pseudodelicatissima fragment
	25-May-02	02/344	Too much precipitation to identify cells
NM9	3-Sep-02	02/724	*P. australis*
			P. pungens
			P fraudulenta
	22-Jul-02	02/561	*P. australis fragment*
	22-Jul-02	02/561	*P. pungens fragment*
O18	16-Jul-02	02/563	*P. cf. australis*
O19	17-Jul-02	02/564	Too much precipitation to identify cells
	26-Aug-02	02/695	*P. australis*
			P. fraudulenta
			P. pungens
	17-Jul-02	02/564	*P.pungens*
			P. australis
S14	3-Sep-02	02/727	*P . australis*
			P. fraudulenta
			P. cf. pseudodelicatissima
SM6	17-Jun-02	02/422	*P. australis*
			P. fraudulenta
SM7	27-Aug-02	02/703	*P. australis*
			P. fraudulenta
			P. pungens