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**MONITORING OF ALGAL TOXINS IN SHELLFISH  
IN SCOTLAND  
1 APRIL 2001 to 31 MARCH 2002**

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## Report Information Sheet

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# **MONITORING OF ALGAL TOXINS IN SHELLFISH IN SCOTLAND 1 APRIL 2001 TO 31 MARCH 2002**

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## **SUMMARY**

Marine biotoxins produced by certain species of phytoplankton can be accumulated in the tissues of filter feeding bivalve molluscs. If these molluscs are then consumed by humans, toxin related illness may occur. United Kingdom and European Community food safety regulations stipulate the levels of toxin permitted in products placed on the market for human consumption, and also require that monitoring for the presence of toxins be undertaken to ensure that no potentially hazardous shellfish are placed on the market for human consumption. A monitoring and surveillance programme is undertaken in Scotland, and samples of bivalve molluscs are tested for the presence of Amnesic Shellfish Poisons (ASP), Diarrhetic Shellfish Poisons (DSP), and Paralytic Shellfish Poisons (PSP). The maximum toxin levels permitted are ASP: 20 µg/g flesh, DSP; No toxins permitted, PSP: 80 µg/100 g flesh.

Fisheries Research Services (FRS) has conducted an extensive monitoring and surveillance programme for marine biotoxins in bivalve mollusc flesh in Scotland since 1991, and for the causative phytoplankton since 1995. The monitoring programmes are operated to comply with the requirements of the shellfish hygiene directive, 91/492/EEC, and with the current UK implementing legislation, The Food Safety (Fishery Products and Live Shellfish) (Hygiene) Regulations 1998, as amended.

The programmes are undertaken on behalf of the Food Standards Agency (Scotland) (FSAS).

The monitoring is carried out on bivalve mollusc samples from classified harvesting areas, and from offshore scallop fishing grounds; sampling is undertaken throughout the year. The programme is based upon a sampling frequency of monthly during the period October to March, and weekly, fortnightly or monthly during the period April to September. The sampling frequency is based on a risk assessment of each site, which takes account of the shellfish production and the historical occurrence of toxins. Sampling frequency is increased if toxins are detected, and species other than bivalve molluscs may be tested.

In the period 1 April 2001 to 31 March 2002, shellfish from 56 primary inshore production areas, 56 secondary areas and 10 offshore fishing areas were examined. A total of 6,300 mollusc samples were analysed; 2,029 for PSP, 1,145 for DSP and 3,126 for ASP.

In the inshore production areas, PSP toxins were found in 80 samples from 32 sites, DSP toxins were found in 146 samples from 35 sites, and ASP toxins, above the Limit of Detection (LOD) were found in 96 samples from 18 sites. Voluntary Closure Agreements (VCAs) were made with affected aquaculture site operators, and warning notices erected where public access and harvesting could take place.

The site location and the result of samples with detected toxins above the permitted level, which resulted in harvesting restrictions being imposed, is shown below:

## Monitoring of Algal Toxins in Shellfish in Scotland

Site	Date	No of samples	Species	Toxin PSP ( $\mu\text{g STX}$ equiv/100g)	DSP	ASP ( $\mu\text{gDA/g}$ )	Action taken
St Abbs	May Aug-Sept	1 3	Mussels Mussels	142	Positive		Warning notices erected
Scapa Flow	May-June June-Nov	5 11	Mussels Mussels	88 -245	Positive		Restrictions imposed
Kirkwall	June Sept	1 1	Mussels Mussels	299	Positive		Restrictions imposed
Mill Sands	June	1	Cockles	152			Restrictions imposed
Whalefirth	Sept-Oct	2	Mussels		Positive		Closure order
Ura Firth	Sept	1	Scallop W			20	Closure order
Olna Firth	June July/Oct	1 2	Mussels Mussels	184	Positive		Closure order
Busta Voe	June	1	Mussels	163			Closure order
Clift Sound	October	1	Mussels		Positive		Closure order
Clousta Voe	May	1	Mussels	164			Closure order
East Burra Firth	Jul-Oct	5	Mussels		Positive		Closure order imposed
Linga Voe	May Jul/Oct	1 2	Mussels Mussels	211	Positive		Closure order imposed
Mid Yell Voe	May	1	Mussels	130			Closure order
Ronas Voe	May	1	Mussels	86			Closure order
Uyea Voe	Sept	1	Mussels		Positive		Closure order
Loch Eriboll	July-Oct	4	Mussels		Positive		Closure order
Loch Inchard	May-June July-Oct	2 11	Mussels Mussels	112, 277	Positive		Closure order
Loch Laxford	Aug - Oct	8	Mussels		Positive		Closure order
Kylesku	August	1	Mussels		Positive		Closure order
Loch Kirkaig	Sep/Mar	2	Mussels		Positive		Warning notices
Dornoch Firth	Sept-Oct	3	Mussels		Positive		Closure order
Little Loch Broom	Aug-Oct	5	Mussels		Positive		Closure order Imposed
Loch Broom	October	1	Mussels		Positive		Warning notice
Loch Ewe	Jun-Aug Apr-Mar 02	7 23 26	Mussels Scallop G Scallop W		Positive	LOD – 43 10 - >100	Closure orders Imposed
Loch Torridon	May-June Jun/Sept	4 6	Mussels Mussels	80- 220	Positive		Closure orders Imposed
Loch Toscaig	Sept	1	Mussels		Positive		Restrictions imposed
Loch Kishorn	Aug-Oct	4	Mussels		Positive		Closure order
Broadford Bay	Aug-Dec Jun-Sept May Aug-Sept	4 5 1 3	Mussels Queens Scallop G Scallop W		Positive Positive	27 43 - 67	Closure orders Imposed
Loch Ainort	October	1	Scallop W			>100	Restrictions imposed
Loch Sligachan	May-Dec Aug/Feb	8 2	Scallop G Scallop W			LOD- 64 29, >100	Closure orders imposed
Loch Greshornish	Jun-Jul Jul-Oct	2 5	Mussels Mussels	148, 122	Positive		Closure orders Imposed
Loch Dunvegan	June Oct-Nov	1 2	Mussels Mussels	405	Positive		Closure orders Imposed
Loch Harport	Jul/Oct	2	Mussels		Positive		Closure order
Loch Eishort	July	1	Mussels	89			Closure order

## Monitoring of Algal Toxins in Shellfish in Scotland

Site	Date	No of samples	Species	Toxin PSP (µg STX equiv/100g)	DSP	ASP (µgDA/g)	Action taken
Badicaul	Sep-Oct	2	Queens		Positive	27,26,38,23 26,70	Closure order and restrictions imposed
	July	1	Scallop W				
	May/Aug/	4	Scallop G				
	Dec/Feb June/Feb	2	Scallop W				
Loch Hourn	Jun-Jul Aug-Nov	3 10	Mussels	214 121, 98	Positive		Closure orders imposed
Loch Leven	May	1	Mussels		Positive		Closure order
Loch Roag	Jun-Jul	2	Mussels	101, 127	Positive	22	Closure orders imposed
	October	1	Mussels				
	Sept	1	Mussels				
Loch Creran	October	1	P.oyster		Positive		Closure order
Loch Crinan	Jun-Feb	6	Scallop W			56 - >100	Closure order
Loch Coalisport	Sept	2	Scallop W			>100	Closure order
Barmore	Aug/Oct- Nov	3	Queens		Positive		Closure orders imposed
Ardkinglass	Aug -Nov	5	Mussels		Positive		Closure order
Loch Striven	Aug/Oct- Nov	3	Mussels		Positive		Closure order
Loch Scridain	Jul/Sep	3	Mussels		Positive		Closure order
Fairlie	Aug-Oct	8	Mussels		Positive		Closure orders imposed
	December October	1	P.oyster				

In the offshore scallop fishing areas, PSP toxins were found in both scallop gonad and whole scallop samples in the East Coast, Moray Firth, Orkney, Shetland, Hebrides, and the North and South Minches. PSP toxins were found only in whole scallops in the Sound of Jura, and none were found in the Clyde or Irish Sea. DSP toxins were found, using the bioassay, in whole scallops in all areas except Shetland, while ASP toxins were found in both gonad tissue and whole animals in all areas. In Shetland, Clyde and Irish Sea areas, detected ASP levels in gonad tissue were below the action level.

For the offshore scallop fishing areas, PSP toxins at or above the action level were found in 18 (3%) gonad tissue samples, and 55 (10%) whole animals. DSP was found in 81 whole animal samples (47%) by bioassay. ASP toxins at or above the action level were found in 111 (10%) gonad tissue samples, and in 786 (71%) whole animal samples.

Fishing restrictions by means of a closure order under the Food and Environment Protection Act 1985 (FEPA) or shucking requirements (whereby only the processed adductor muscle and gonad are permitted to enter the marketplace) were imposed where appropriate.

**Abbreviations used in Text**

AOAC	Associations of Official Analytical Chemists
ASP	Amnesic Shellfish Poisons
AZA	Azaspiracid
DA	Domoic Acid
DSP	Diarrhetic Shellfish Poisons
DTX	Dinophysis Toxins
EHO	Environmental Health Officer
EU	European Union
FEPA	Food and Environment Protection Act 1985
FSAS	Food Standards Agency (Scotland)
FRS	Fisheries Research Services
FRS MLA	FRS Marine Laboratory
GTX	Gonauytoxins
HPLC	High Performance Liquid Chromatography
LC-MS	Liquid Chromatography – Mass Spectrometry
LOD	Limit of Detection
NSP	Neurotoxic Shellfish Poisons
OA	Okadaic Acid
PSP	Paralytic Shellfish Poisons
PTX	Pectenotoxins
SFFPA	Scottish Fisheries Protection Agency
STX	Saxitoxin
UKAS	United Kingdom Accreditation Service
VCA	Voluntary Closure Agreement
YTX	Yessotoxins

## INTRODUCTION

Phytoplankton is composed of a myriad of microscopic unicellular organisms that comprise the main primary producers in aquatic environments and hence plays an essential role in aquatic systems. The phytoplankton forms the primary food source for filter feeding marine animals such as the bivalve molluscs which include mussels, oysters, cockles, scallops and queens. These mollusc species are important components of the shellfish stocks exploited by commercial fisheries or cultivated in aquaculture units for human consumption. Phytoplankton is, for much of the time, beneficial to these operations, but, in certain circumstances, can have deleterious effects, causing economic losses to aquaculture, fisheries and tourism, and have major environmental impacts, and create human health hazards.

The term “microalgae” is, in the context of shellfish toxins, a more accurate description than “phytoplankton” since it includes species of benthic algae, such as *Prorocentrum* which can also produce problem toxins. The use of the term “algal bloom” is also inappropriate for many toxic events, as toxin problems can be caused by relatively low biomass levels (Hallegraff 1993).

Of the 5,000 species of marine microalgae, some 300 can, at times, occur in such dense concentrations as to discolour the sea surface, the so-called “red tides”, but of these only about 40 species have the capacity to produce toxins which can be assimilated into the food chain and find their way through fish and shellfish to humans. Filter feeding molluscs are the primary vector for various forms of shellfish poisoning such as Paralytic Shellfish Poisons (PSP), Diarrhetic Shellfish Poisons (DSP) and Amnesic Shellfish Poisons (ASP) (Hallegraeff, 1993; Shumway, 1990).

Some non-toxic species may cause problems, particularly in the fin-fish aquaculture sector; exceptional concentrations may result in anoxia when the microalgae die and decay, sheer numbers may clog fish gills, and species with siliceous spines can damage delicate gill membranes.

Algal blooms are a natural phenomena, and have occurred throughout recorded history, however in the past two to three decades, their occurrence and impact on public health and fishery economics appears to have increased in frequency, intensity, and geographic distribution. Four explanations for this apparent increase have been proposed: increased scientific awareness of toxic species; increased utilisation of coastal waters for aquaculture; stimulation of plankton blooms by cultural eutrophication and/or unusual climatic conditions; and transport of dinoflagellate resting cysts from one geographic area to another, either in ships ballast water, or by the translocation of shellfish stocks (Hallegraeff, 1993).

One group of microalgae, the dinoflagellates, are most commonly associated with shellfish toxins; in Scotland, the dinoflagellate species *Alexandrium* and *Dinophysis* are associated with the production of PSP and DSP toxins, while the diatom *Pseudo-nitzschia* spp. is associated with the production of ASP toxins. These species are regularly identified in seawater samples collected for microalgae analysis.

As well as a motile phase, *Alexandrium* spp. produce cysts as part of their reproductive strategy. The cysts rest in the sediments on the sea bed until suitable conditions occur when they again form the motile stage. The cysts are themselves toxic, and can be ingested by other benthic organisms, causing those species to become toxic.



There does not appear to be a straightforward relationship between the concentration of microalgae in the water, and the amount of toxin present. Dinoflagellate species such as *Alexandrium* and *Dinophysis* can contaminate bivalve molluscs with toxins at very low algal concentrations, while conversely, large numbers of these species can occur with no toxin production (Shumway, 1990). This means that while monitoring for the causative organisms in the water column is useful, and can give an indication of potential toxin problems in shellfish, its use as a predictive tool can be somewhat limited.

PSP is caused by the ingestion of shellfish which have been contaminated by potent neurotoxins produced by certain species of dinoflagellate. Over 20 toxins may be involved in PSP including saxitoxin, gonyautoxins and their analogues. The toxins block sodium channels in mammalian nerve cells, thus interfering with nerve transmission (Gallacher and Birkbeck, 1995). The toxins are heat stable, particularly in acid conditions, and are not destroyed by cooking. The onset of PSP symptoms can occur 30 minutes after ingestion; at low dosages, a sensation of numbness around the lips and tongue may be experienced, spreading to the face, and neck, accompanied by "pins and needles" in the fingertips, headache, nausea and vomiting. At higher dosages, muscular paralysis can be experienced leading to respiratory paralysis and death within 2-24 hours. There is no antidote.

Prior to 1968, only sporadic cases of PSP had been recorded in the United Kingdom, including some fatalities. However, in 1968 a severe outbreak in north-east England resulted in some 75 cases necessitating hospital treatment (Ayres and Cullum, 1978).

There have been no reported cases of PSP intoxication in the UK since then, however, some 2,000 cases are reported annually worldwide, 15% of which are fatal.

In Scotland, PSP toxins have been detected in shellfish in most years since 1968, and since 1990, have caused considerable disruption to the aquaculture sector, and in some years to the offshore east coast scallop fishery. PSP toxins can also be found in crustaceans, particularly when high levels are found in bivalve molluscs.

In addition to affecting humans, PSP toxins may occasionally result in the deaths of marine mammals and sea birds.

The toxins associated with DSP include okadaic acid and the dinophysistoxins which are lipid soluble. DSP intoxication causes vomiting, severe abdominal pains and diarrhoea; onset of the symptoms, which may be confused with those associated with bacterial gastric infections, occurs between 30 minutes and 12 hours after ingestion, and can last up to three days. A number of cases of DSP have been reported in the UK since 1992, usually as a result of consuming shellfish harvested illegally from unclassified harvesting areas, or from areas closed because of the presence of the toxins.

In Scotland, prior to 1995, DSP toxins were detected only sporadically and in isolated occurrences but since then they have been found over wide areas, and bivalve molluscs have been affected for several months.

ASP, associated with the diatom *Pseudo-nitzschia* spp. was first identified in 1987 in Canada following an outbreak of shellfish toxicity and human poisoning, including two fatalities. The toxin was identified as domoic acid, a neurotoxin. Subsequently, isomers of domoic acid, iso-domoic acid A, B and C, have also been found. Ingestion of the toxins results in nausea, vomiting, diarrhoea, confusion and short-term memory loss which may be permanent.

*Pseudo-nitzschia* spp. are very common in Scottish waters, but prior to 1996, ASP had not been detected. Since then it has caused considerable problems, particularly in the offshore scallop fishery.

Monitoring the marine environment for the presence of marine biotoxin producing microalgae, and the testing of shellfish flesh for the presence of toxins is a requirement of Council Directive 91/492/EEC and Council Directive 97/61/EEC which lay down health conditions for the production and placing on the market of live bivalve molluscs. Council Directive 91/493/EEC makes provision for the safety of fishery products. The directive requirements are implemented by UK legislation: The Food Safety (Fishery Products and Live Shellfish) (Hygiene) Regulations 1998 as amended. In Scotland, the monitoring of microalgae, and the monitoring of toxins in shellfish flesh is undertaken by FRS on behalf of FSAS. The monitoring of microalgae is the subject of a separate report. The current legislation states that bivalve molluscs placed on sale for human consumption, shall not contain more than 80 µg STX equiv/100 g tissue in the case of PSP, no detectable DSP toxins, and not more than 20 µg DA/g tissue for ASP.

Recent EU DSP Working Group decisions have recommended changes to the DSP toxin group, splitting it into okadaic acid and DTX toxins, Azaspiracid, Pectenotoxins and Yessotoxins. Further it recommends the imposition of statutory permitted levels of these toxins in shellfish. The DSP WG recommendation for permitted levels would introduce a maximum level of 16 µgOA/100 g, 15 µgPTX/100 g, 8 µgAZA/100 g, and 100 µgYTX/100 g.

During the calendar year 1 January to 31 December 2001, the quantity of bivalve molluscs produced in Scotland, by aquaculture was: mussels 2,988 tonnes, oysters (both Native and Pacific) 287 tonnes and pectenids (scallops and queens) 47 tonnes, with a total value of some £4 million (Anon, 2002a).

In the same period, the offshore scallop fishery landed some 9,800 tonnes valued at £17 million together with a further 5,500 tonnes of queens worth £2.3 million. Landings of other exploited bivalves (cockles, mussels, razor fish etc) were some 1,000 tonnes valued at £0.37 million (Anon, 2002b).

### Methodology

Samples of bivalve molluscs were collected from inshore and offshore sampling sites throughout the year, 1 April 2001 to 31 March 2002. Fifty-six inshore sites were identified, an increase over the 38 primary sites monitored the previous year, the increase being due to an increase in the number of bivalve mollusc production areas classified under 91/492/EEC. Additionally, three unclassified east-coast sites were also monitored, these areas having a history of toxin occurrences. Samples of bivalve molluscs were collected by shellfish farmers, Environmental Health Officers and officers of the Scottish Fishery Protection Agency, depending upon the area concerned. Most samples were supplied by members of the aquaculture industry, but in some areas, or where additional samples were required, then EHOs were involved. In non-classified areas, samples were provided by SFPA. Sampling frequency is based on a risk assessment of the area, in area judged to be at high risk, a minimum sampling frequency of fortnightly during the period April to September, and monthly thereafter was the target.

The samplers were provided with a sampling schedule, sampling kits and instructions. Samples were posted to FRS ML by first class mail, in containers with pre-paid labels provided by FRS ML.

The results of sample analyses were sent to the FSAS daily; FSAS then disseminated the results to interested parties weekly. If results are above the permitted levels, FSAS took immediate action to ensure public safety was protected.

The collection of scallop samples from offshore fishing areas was a more complex operation. FSAS invited tenders from fishing vessels interested in being chartered once a month to obtain samples of scallops, *Pecten maximus* L, from specified fishing areas. Forty vessels were successful in their applications, and charter sampling commenced in June 2001 for all Scottish scallop fishing areas. Scallop samples were landed at different ports, and transported to FRS ML by courier in cool boxes provided by FRS ML.

On arrival at FRS ML, all samples were logged, and then prepared for the different toxin analyses. The analysis of samples for PSP toxins was carried out in accordance with the method described by AOAC, 1990, for DSP the analysis was undertaken in accordance with Yasumoto *et al.* (1978, 1984), and for ASP, the HPLC method of Quilliam *et al.* (1995) was used. The ASP assay is UKAS accredited; the PSP and DSP assays will be accredited during 2002, following a recent assessment visit.

Calibrations for the PSP bioassay were undertaken at regular intervals throughout the year, and a calibration factor in the range 0.15 to 0.19 used in the calculation of the results. In addition, some DSP samples were further analysed by LC-MS in order to identify the particular toxins present. The chemical assay for DSP is a accredited technique.

## RESULTS

During the period of this report, 6,300 bivalve mollusc samples from 56 primary inshore sites, 56 secondary inshore sites, and from 10 offshore scallop fishing areas were examined. A total of 2,029 samples were analysed for PSP, 1,145 for DSP, and 3,126 for ASP. Of these, 992, PSP samples, 990, DSP samples and 955, ASP samples were collected from primary and secondary inshore sites. A further 591 samples were analysed chemically for DSP.

A summary of the results obtained for the primary inshore sites is given in Table 1.

As a result of either the detection of toxins at a primary site, or because phytoplankton levels triggered reactive sampling, flesh sampling was initiated at a number of secondary inshore sites; a summary of these results is given in Table 2. The results of analyses of scallop samples from offshore fishing areas are shown in Table 3.

The results of chemical analyses for DSP toxins from aquaculture sites are shown in Table 4, and those from offshore fishing areas in Tables 5 and 6.

In the inshore areas, PSP toxins were found in 80 samples from 32 areas. Of the samples found to contain PSP toxins, 29 (3% of inshore samples) were at or above the action level of 80 µg STX/100 g. DSP toxins were found in 146 samples (15% of inshore samples) in 35 areas, and ASP toxins in 96 samples from 18 areas; of those, 59 (6% of inshore samples) were at or above the action level of 20 µg DA/g.

The results of chemical analyses for DSP showed that the closure of some areas was due to the presence of DTX2, rather than okadaic acid.

A map showing the location of the primary inshore sites is given in Figure 1, while offshore fishing grounds are shown in Figure 2.

The primary inshore site results for PSP, DSP, and ASP are illustrated in Figures 3, 4 and 5.

## CONCLUSIONS

Shellfish toxins affected both the aquaculture and fishing sectors of the shellfish industry. The aquaculture sector was affected by PSP toxins, and VCAs were imposed on 19 occasions, however, these were generally of relatively short duration, but DSP toxins were more widespread and longer lasting, VCAs being imposed on 55 occasions. VCAs for ASP were imposed on seven occasions.

Whilst ASP toxins had a relatively small impact on the aquaculture sector, they had a major impact on the fishing sector, as restrictions, either by FEPA closure order or shucking requirements, affected all fishing areas. In all, 26 FEPA orders were made.

In the aquaculture sector, PSP toxins only affected mussel growers, but DSP toxins affected growers of mussels, queens and Pacific oysters. ASP toxins affected scallops in both the aquaculture and fishing sectors, the latter also being affected by PSP and DSP toxins.

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Monitoring of Algal Toxins in Shellfish in Scotland

**TABLE 1**

Summary of results from primary inshore sites

Location and Production Area	No. samples and toxin analysed	Toxin levels detected	Comments
Berwickshire: St Abbs	PSP - 10 mussel samples DSP - 12 mussel samples ASP - 10 mussel samples	142, 31, 71µg STX/100 g DSP detected in 3 samples No toxicity detected or LOD	May to July August and September Warning notices posted
Fife: Elie	PSP - 9 mussel samples DSP - 12 mussel samples ASP - 8 mussel samples	32 µg STX/100 g No toxicity detected No toxicity detected or LOD	May Warning notices posted
Angus: Montrose	PSP - 12 mussel samples DSP - 12 mussel samples ASP - 11 mussel samples	No toxicity detected No toxicity detected No toxicity detected or LOD	
Orkney: Scapa Flow	PSP - 48 mussel samples  DSP - 47 mussel samples ASP - 48 mussel samples	42, 114, 145, 75, 245, 88, 185, 52, 38, 32, 36 µg STX/100 g DSP detected in 11 samples No toxicity detected or LOD	May to June  June to November. Closure orders imposed
Kirkwall	PSP - 12 mussel samples DSP - 10 mussel samples ASP - 12 mussel samples	299, 31µg STX/100 g DSP detected in one sample No toxicity detected or LOD	June and July September. Closure orders imposed
Shetland: Whalefirth	PSP - 8 mussel samples DSP - 12 mussel samples ASP - 7 mussel samples	54, 41 µg STX/100 g DSP detected in two samples No toxicity detected or LOD	May and June Sept and October. Closure orders imposed
Basta Voe	PSP - 8 mussel samples DSP - 8 mussel samples ASP - 6 mussel samples	58, 49, 33µg STX/100g No toxicity detected No toxicity detected or LOD	May to July
Ura Firth	PSP - 2 queen samples PSP - 1 scallop sample DSP - 2 queen samples ASP - 2 queen samples ASP - 1 whole scallop sample	62, 31µg STX/100g No toxicity detected No toxicity detected No toxicity detected ASP at 20 µgDA/g	May to July  September
Olna Firth	PSP - 11 mussels samples DSP - 8 mussel samples ASP - 11 mussel samples	184 µg STX/100 g DSP detected in two samples No toxicity or LOD	June July and October. Closure orders imposed
Busta Voe	PSP - 7 mussel samples DSP - 9 mussel samples ASP - 7 mussel samples	163 µg STX/100 g No toxicity detected No toxicity detected or LOD	June
Vementry Voe	PSP - 6 mussel samples DSP - 6 mussel samples ASP - 6 mussel samples	No toxicity detected No toxicity detected No toxicity detected	
Vaila Sound	PSP - 13 mussel samples DSP - 14 mussels samples ASP - 13 mussel samples	29, 35 µg STX/100 g No toxicity detected No toxicity detected of LOD	May and August
Sutherland: Kyle of Tongue	PSP - 3 Pacific oyster samples DSP - 4 Pacific oyster samples ASP - 3 Pacific oyster samples	No toxicity detected  No toxicity detected  No toxicity detected or LOD	
Loch Eriboll	PSP - 8 mussel samples DSP - 9 mussel samples ASP - 7 mussel samples	33µg STX/100 g DSP detected in four samples No toxicity detected or LOD	June July to October. Closure orders imposed
Loch Inchard	PSP - 17 mussel samples DSP - 24 mussel samples ASP - 18 mussel samples	69, 112,277µg STX/100 g DSP detected in 11 samples No toxicity detected or LOD	May and June July to November Closure orders imposed
Loch Laxford	PSP - 10 mussel samples DSP - 13 mussel samples ASP - 11 mussel samples	No toxicity detected DSP detected in 8 samples No toxicity detected or LOD	August to October. Closure orders imposed

## Monitoring of Algal Toxins in Shellfish in Scotland

Location and Production Area	No. samples and toxin analysed	Toxin levels detected	Comments
Ross and Cromarty: Dornoch Firth	PSP - 12 mussel samples DSP - 13 mussel samples ASP - 12 mussel samples	No toxicity detected DSP detected in 3 samples No toxicity detected or LOD	September and October. Closure orders imposed
Little Loch Broom	PSP - 4 mussel samples PSP - 1 scallop gonad sample DSP - 5 mussel samples ASP - 4 mussel samples ASP - 1 scallop gonad sample ASP - 1 whole scallop sample	No toxicity detected No toxicity detected  DSP detected in 5 samples No toxicity detected or LOD LOD  ASP at 12 µgDA/g	August to October Closure orders imposed   December
Loch Ewe	PSP - 28 mussel samples PSP - 21 scallop gonad samples PSP - 22 whole scallop samples DSP - 33 mussel samples DSP - 9 whole scallop samples ASP - 26 mussel samples ASP - 28 scallop gonad samples  ASP - 31 whole scallop samples	No toxicity detected No toxicity detected  No toxicity detected  DSP detected in 7 samples No toxicity detected  No toxicity detected or LOD ASP detected in all samples in the range LOD to 43 µgDA/g ASP detected in all samples in the range 10 to >100 µgDA/g	June to August     April 2001 to March 2002 Closure orders imposed
Loch Torridon	PSP - 18 mussel samples  DSP - 18 mussel samples ASP - 17 mussel samples	80, 69, 164, 220, 123, 71, 72, 29 µgSTX/100 g DSP detected in 6 samples No toxicity detected or LOD	May to July  June and September Closure orders imposed
Loch Kishorn	PSP - 5 mussel samples PSP - 2 Pacific oyster samples DSP - 7 mussel samples ASP - 5 mussel samples ASP - 2 Pacific oyster samples	No toxicity detected No toxicity detected  DSP detected in 4 samples No toxicity detected or LOD No toxicity detected	August to October Closure orders imposed.
Skye and Lochalsh : Broadford Bay/Scalpay	PSP - 5 mussel samples PSP - 12 queen samples PSP - 2 scallop gonad samples PSP - 5 whole scallop samples DSP - 6 mussel samples DSP - 12 queen samples DSP - 1 scallop gonad sample DSP - 3 whole scallop samples ASP - 5 mussel samples ASP - 13 queen samples ASP - 2 scallop gonad samples ASP - 5 whole scallop samples	34µgSTX/100 g 33µgSTX/100 g No toxicity detected  32, 38µgSTX/100 g  DSP detected in 4 samples DSP detected in 5 samples No toxicity detected No toxicity detected  ASP at 5 µgDA/g ASP at 4, 6, 3, 4 µgDA/g ASP at 27, 10 µgDA/g ASP at 9, 5, 43, 61, 67 µgDA/g	June June  June  Aug, Sept, Nov, Dec. June to Sept.  September August and Oct. May and June June, August and Sept. Closure orders imposed

## Monitoring of Algal Toxins in Shellfish in Scotland

Location and Production Area	No. samples and toxin analysed	Toxin levels detected	Comments
Loch Ainort	PSP - 1 queen sample PSP - 1 scallop gonad sample PSP - 1 whole scallop sample PSP - 2 cockle samples DSP - 1 queen sample DSP - 2 cockle samples ASP - 1 queen sample ASP - 1 whole scallop sample ASP - 2 cockle samples	No toxicity detected No toxicity detected No toxicity detected No toxicity detected No toxicity detected No toxicity detected LOD ASP at >100 µgDA/g LOD	October
Loch Sligachan	PSP - 2 scallop gonad samples PSP - 2 whole scallop samples ASP - 8 scallop gonad samples ASP - 2 whole scallop samples	No toxicity detected No toxicity detected ASP detected in all samples range LOD to 64 µgDA/g ASP detected at 29, >100 µgDA/g	May and June; Sept to Dec  August and February 2001 Closure orders imposed
Loch Greshornish	PSP - 17 mussel samples DSP - 21 mussel samples ASP - 18 mussel samples	148, 122, 52 µgSTX/100g DSP detected in 5 samples ASP at LOD and 5 µgDA/g	June and July July, Aug and Oct. August. Closure orders imposed
Loch Dunvegan	PSP - 9 mussel samples DSP - 9 mussel samples ASP - 9 mussel samples	31, 405 µgSTX/100 g DSP detected in two samples No toxicity detected or LOD	May and June October and Nov Closure orders imposed
Loch Bracadale	PSP - 1 Pacific oyster sample PSP - 1 mussel sample DSP - 1 mussel sample ASP - 1 Pacific oyster sample ASP - 1 mussel sample	No toxicity detected No toxicity detected No toxicity detected No toxicity detected	
Loch Harport	PSP - 2 Pacific oyster samples PSP - 2 mussel samples DSP - 1 Pacific oyster sample DSP - 2 mussel samples ASP - 1 Pacific oyster sample ASP - 2 mussel samples	No toxicity detected 35µgSTX/100g No toxicity detected DSP detected in two samples No toxicity detected No toxicity detected or LOD	June July and October. Closure orders imposed
Loch Eishort	PSP - 29 mussel samples DSP - 27 mussel samples ASP - 29 mussel samples	32, 46, 89 µgSTX/100 g No toxicity detected No toxicity detected or LOD	May and July
Kyle/Badical	PSP - 7 queen samples PSP - 8 scallop gonad samples PSP - 7 whole scallop samples DSP - 7 queen samples DSP - 5 whole scallop samples ASP - 7 queen samples ASP - 11 scallop gonad samples ASP - 7 whole scallop samples	No toxicity detected 34, 35 µgSTX/100 g 33, 32 µgSTX/100 g DSP detected in two samples DSP detected in one sample No toxicity detected or LOD ASP at LOD 38 µgDA/g ASP at 26, 6, 12, 70 µgDA/g	June and August June and August Sept. and Oct. July May to February June, July and February Restrictions imposed
Loch Hourn	PSP - 22 mussel samples DSP - 25 mussel samples ASP - 22 mussel samples	214, 121, 61, 98 µgSTX/100g DSP detected in 10 samples ASP at LOD and 3 µgDA/g	June and July August to November July. Closure orders imposed

## Monitoring of Algal Toxins in Shellfish in Scotland

Location and Production Area	No. samples and toxin analysed	Toxin levels detected	Comments
Lochaber : Loch Nevis	PSP - 5 mussel samples DSP - 4 mussel samples ASP - 5 mussel samples	30 µgSTX/100 g No toxicity detected No toxicity detected or LOD	May
Loch Ailort	PSP - 3 mussel samples PSP - 3 clam samples DSP - 4 mussel samples DSP - 2 clam samples ASP - 4 mussel samples ASP - 2 clam samples	31 µgSTX/100 g No toxicity detected No toxicity detected No toxicity detected No toxicity detected or LOD ASP at LOD and 4 µgDA/g	May    July
Loch Moidart	PSP - 2 Pacific oyster samples DSP - 2 Pacific oyster samples ASP - 3 Pacific oyster samples	No toxicity detected  No toxicity detected or LOD	
Ardtoe	PSP - 3 Native oyster samples PSP - 1 scallop gonad sample ASP - 3 Native oyster samples ASP - 1 scallop gonad sample	No toxicity detected  No toxicity detected or LOD ASP at 8 µgDA/g	April
Loch Teacuis	PSP - 5 mussel samples DSP - 6 mussel samples ASP - 6 mussel samples	No toxicity detected No toxicity detected No toxicity detected or LOD	
Loch Leven	PSP - 27 mussel samples DSP - 27 mussel samples ASP - 17 mussel samples	No toxicity detected DSP detected in one sample No toxicity detected or LOD	May
Western Isles: Loch Roag Complex	PSP - 49 mussel samples  DSP - 46 mussel samples ASP - 46 mussel samples	34, 100, 56, 47, 46, 127, 42 µgSTX/100 g DSP in one sample ASP at LOD, 22, 8 µgDA/g	June and July  October Sept and Oct. Closure orders imposed
Seilebost	PSP - 4 cockle samples DSP - 1 cockle sample ASP - 4 cockle samples	No toxicity detected No toxicity detected ASP at LOD and 4, 3µgDA/g	June
Loch Leurbost	PSP - 15 mussel samples DSP - 10 mussel samples ASP - 13 mussel samples	No toxicity detected No toxicity detected No toxicity detected or LOD	
Loch Carnan	PSP - 10 mussel samples DSP - 8 mussel samples ASP - 10 mussel samples	No toxicity detected No toxicity detected No toxicity detected or LOD	
Barra	DSP - 1 cockle sample	No toxicity detected	
Argyll and Bute: Loch Linnhe	PSP - 4 mussel samples PSP - 5 Pacific oyster samples DSP - 2 mussel samples DSP - 5 Pacific oyster samples ASP - 2 mussel samples ASP - 5 Pacific oyster samples	No toxicity detected No toxicity detected  No toxicity detected No toxicity detected or LOD	
Loch Creran	PSP - 14 mussel samples PSP - 22 Pacific oyster samples DSP - 13 mussel samples DSP - 24 Pacific oyster samples ASP - 14 mussel samples ASP - 15 Pacific oyster samples	No toxicity detected No toxicity detected  No toxicity detected DSP in one sample  No toxicity detected or LOD ASP at LOD and 3 µgDA/g	October    July



## Monitoring of Algal Toxins in Shellfish in Scotland

Location and Production Area	No. samples and toxin analysed	Toxin levels detected	Comments
Loch Etive	PSP - 16 mussel samples DSP 16 mussel samples ASP - 16 mussel samples	No toxicity detected No toxicity detected No toxicity detected or LOD	
Seil Sound	PSP - 2 Pacific oyster samples DSP - 4 Pacific oyster samples ASP - 2 Pacific oyster samples	No toxicity detected No toxicity detected No toxicity detected or LOD	
West Loch Tarbert	PSP - 14 Pacific oyster samples DSP - 10 Pacific oyster samples ASP - 8 Pacific oyster samples	No toxicity detected No toxicity detected No toxicity detected or LOD	
Loch Fyne/Barmore	PSP - 18 Queen samples DSP - 20 Queen sample ASP - 17 Queen samples	No toxicity detected DSP in 3 Queen samples No toxicity detected or LOD	Aug, Oct and Nov. Closure orders imposed
Loch Fyne/ Ardkinglass	PSP - 19 mussel samples PSP - 9 Pacific oyster sample DSP - 19 mussel samples DSP - 17 Pacific oyster samples ASP - 20 mussel samples ASP - 13 Pacific oyster samples	No toxicity detected No toxicity detected DSP in 5 mussel samples No toxicity detected No toxicity detected or LOD No toxicity detected or LOD	August to November. Closure orders imposed
Loch Striven	PSP - 19 mussel samples DSP - 21 mussel samples ASP - 19 mussel samples	No toxicity detected DSP detected in 3 samples No toxicity detected or LOD	August, Oct. and November. Closure orders imposed
Loch Spelve	PSP - 14 mussel samples DSP - 14 mussel samples ASP - 13 mussel samples	No toxicity detected No toxicity detected ASP at LOD and 5 µgDA/g	July
Loch Scridain	PSP - 15 mussel samples DSP - 15 mussel samples ASP - 14 mussel samples	79 µgSTX/100 g DSP detected in 3 samples No toxicity detected or LOD	June July and Sept. Closure orders imposed.
Ulva Sound	PSP - 10 mussel samples PSP - 1 Pacific oyster sample DSP - 10 mussel samples DSP - 1 Pacific oyster sample ASP - 10 mussel samples ASP - 1 Pacific oyster sample	No toxicity detected No toxicity detected No toxicity detected No toxicity detected or LOD No toxicity detected	
North Ayrshire : Fairlie	PSP - 24 mussel samples PSP - 11 Pacific oyster samples DSP - 30 mussel samples DSP - 13 Pacific oyster samples ASP - 21 mussel samples ASP - 10 Pacific oyster samples	No toxicity detected No toxicity detected DSP in eight samples DSP in 1 sample No toxicity detected or LOD No toxicity detected	Aug. to October, and December October. Closure orders imposed

## Monitoring of Algal Toxins in Shellfish in Scotland

Location and Production Area	No. samples and toxin analysed	Toxin levels detected	Comments
Dumfries and Galloway : Loch Ryan	PSP - 8 mussel samples PSP - 3 Native oyster samples DSP - 7 mussel samples DSP - 1 Native oyster sample ASP - 7 mussel samples ASP - 3 Native oyster samples	No toxicity detected No toxicity detected No toxicity detected No toxicity detected No toxicity detected or LOD No toxicity detected	
Kirkcubright	PSP - 16 mussel samples PSP - 1 cockle sample DSP - 12 mussel samples ASP - 16 mussel samples ASP - 1 cockle sample	No toxicity detected No toxicity detected No toxicity detected No toxicity detected or LOD LOD	

Monitoring of Algal Toxins in Shellfish in Scotland

**TABLE 2**

Summary of results from secondary inshore sites.

Location and Production Area	No. samples and toxin analysed	Toxin levels detected	Comments
Fife: Burnt Island	PSP – 1 cockle sample DSP – 1 cockle sample ASP – 1 cockle sample	No toxicity detected No toxicity detected No toxicity detected	
Orkney: Stromness	PSP – 1 cockle sample DSP – 1 cockle sample ASP – 1 cockle sample	No toxicity detected No toxicity detected LOD	
Houton	PSP – 1 Queen sample DSP – 1 Queen sample ASP – 1 Queen sample	No toxicity detected No toxicity detected LOD	
Lyness	PSP – 1 Queen sample DSP – 1 Queen sample ASP – 1 Queen sample	No toxicity detected No toxicity detected LOD	
Cava	PSP – 2 Queen samples DSP – 2 Queen samples ASP – 2 Queen samples	32, 58 µgSTX/100 g No toxicity detected LOD	July
Echnaloch Bay	PSP – 1 cockle sample DSP – 1 cockle sample ASP – 1 cockle sample	No toxicity detected No toxicity detected No toxicity detected	
Bay of Firth	PSP – 4 Pacific oyster samples DSP – 2 Pacific oyster samples ASP – 4 Pacific oyster samples	No toxicity detected No toxicity detected No toxicity detected	
Inganess	PSP – 4 cockle samples DSP – 3 cockle samples ASP – 1 cockle samples	No toxicity detected No toxicity detected No toxicity detected	
Mill Sands	PSP – 6 cockle samples DSP – 5 cockle samples ASP – 6 cockle samples	152, 45µgSTX/100g No toxicity detected No toxicity detected or LOD	June
Shetland: Balta Sound	PSP – 1 mussel sample DSP – 2 mussel samples ASP – 2 mussel samples	No toxicity detected No toxicity detected No toxicity detected	
Braewick Voe	PSP – 6 mussel samples DSP – 6 mussel samples ASP – 6 mussel samples	No toxicity detected No toxicity detected No toxicity detected	
Browland Voe	PSP – 6 mussel samples DSP – 7 mussel samples ASP – 5 mussel samples	No toxicity detected No toxicity detected No toxicity detected	
Clift Sound	PSP – 2 mussel samples DSP – 2 mussel samples ASP – 1 mussel sample	No toxicity detected DSP in 1 sample No toxicity detected	October
Clousta Voe	PSP – 6 mussel samples DSP – 7 mussel samples ASP – 7 mussel samples	164µgSTX/100g No toxicity detected No toxicity detected or LOD	May.
Dales Voe (Scarvar Ayre	PSP – 6 mussel samples DSP – 8 mussel samples ASP – 5 mussel samples	No toxicity detected No toxicity detected No toxicity detected or LOD	
Dales Voe	PSP – 3 mussel samples DSP – 3 mussel samples ASP – 3 mussel samples	No toxicity detected No toxicity detected No toxicity detected	
East Burra Firth	PSP – 7 mussel samples DSP – 9 mussel samples ASP – 8 mussel samples	No toxicity detected DSP in 5 samples No toxicity detected or LOD	July to October. Closure order imposed
Lea Cray Voe	PSP – 1 Queen sample DSP – 1 Queen sample ASP – 1 Queen sample	No toxicity detected No toxicity detected No toxicity detected	

## Monitoring of Algal Toxins in Shellfish in Scotland

Location and Production Area	No. samples and toxin analysed	Toxin levels detected	Comments
Linga Voe	PSP – 7 mussel samples DSP – 7 mussel samples ASP – 7 mussel samples	211 µgSTX/100g DSP in 2 samples No toxicity detected or LOD	May July and October. Closure orders imposed
Maraness	PSP – 1 mussel sample DSP – 1 mussel sample ASP – 1 mussel sample	No toxicity detected No toxicity detected No toxicity detected	
Mid Yell Voe	PSP – 4 mussel samples DSP – 3 mussel samples ASP – 4 mussel samples	130 µgSTX/100 g No toxicity detected No toxicity detected or LOD	May. Closure order imposed
Quilse Voe	PSP – 1 mussel sample DSP – 1 mussel sample ASP – 1 mussel sample	No toxicity detected No toxicity detected No toxicity detected	
Ronas Voe	PSP – 6 mussel samples DSP – 6 mussel samples ASP – 6 mussel samples	86 µgSTX/100 g No toxicity detected No toxicity detected or LOD	May
Seli Voe	PSP – 1 mussel sample DSP – 2 mussel samples ASP – 2 mussel samples	No toxicity detected No toxicity detected No toxicity detected	
Stromness Voe	PSP – 4 mussel samples DSP – 3 mussel samples ASP – 2 mussel samples	No toxicity detected No toxicity detected No toxicity detected or LOD	
Uyea Voe	PSP – 3 mussel samples DSP – 2 mussel samples ASP – 3 mussel samples	No toxicity detected DSP in one sample No toxicity detected	Sept. Closure order imposed
Wadbister Voe	PSP – 4 mussel samples DSP – 4 mussel samples ASP – 4 mussel samples	No toxicity detected No toxicity detected No toxicity detected or LOD	
Sutherland: Kylesku	PSP – 3 mussel samples DSP – 4 mussel samples ASP – 4 mussel samples	No toxicity detected DSP in one sample No toxicity detected or LOD	August Closure order imposed
Loch Kirkaig	PSP – 5 mussel samples DSP – 4 mussel samples ASP – 4 mussel samples	No toxicity detected DSP in two samples No toxicity detected or LOD	Sept and March 02 Warning notices erected
Ross and Cromarty: Udale Bay	PSP – 1 mussel sample DSP – 1 mussel sample ASP – 1 mussel sample	No toxicity detected No toxicity detected LOD	
Loch Broom	PSP – 5 mussel samples DSP – 5 mussel samples ASP – 5 mussel samples	No toxicity detected DSP in one sample No toxicity detected	October Warning notices
Enard Bay	PSP – 1 Pacific oyster sample DSP – 2 Pacific oyster samples	No toxicity detected No toxicity detected	
Loch Toscaig	PSP – 4 mussel samples DSP – 5 mussel samples ASP – 3 mussel samples	No toxicity detected DSP in one sample No toxicity detected or LOD	Sept. Restrictions imposed
Skye and Lochalsh: Portree	PSP – 1 cockle sample DSP – 1 cockle sample ASP – 1 cockle sample	No toxicity detected No toxicity detected No toxicity detected	
Loch Snizort	DSP – 1 Pacific oyster sample	No toxicity detected	
Erbusaig	ASP – 1 scallop gonad sample	ASP at 16 µgDA/g	May
Lochaber: Loch Eil	PSP – 5 mussel samples DSP – 4 mussel samples ASP – 4 mussel samples	No toxicity detected No toxicity detected No toxicity detected or LOD	

## Monitoring of Algal Toxins in Shellfish in Scotland

Location and Production Area	No. samples and toxin analysed	Toxin levels detected	Comments
Glenuig Bay	PSP – 2 mussel samples DSP – 4 mussel samples ASP – 3 mussel samples	No toxicity detected No toxicity detected No toxicity detected or LOD	
Loch Beag	PSP – 4 mussel samples DSP – 6 mussel samples ASP – 4 mussel samples	56 µgSTX/100 g DSP detected in 3 samples LOD	June Aug – Sept. Closure order imposed
Fascadale Bay	PSP – 1 whole scallop sample DSP – 1 whole scallop sample ASP – 1 whole scallop sample	No toxicity detected No toxicity detected ASP at 18µgDA/g	June
Western Isles: Liernish	PSP – 1 mussel sample DSP – 1 mussel sample ASP – 1 mussel sample	No toxicity detected No toxicity detected No toxicity detected	
Loch Ceann Dibig	PSP – 1 mussel sample DSP – 1 mussel sample ASP – 1 mussel sample	No toxicity detected No toxicity detected No toxicity detected	
Loch Tananavay	PSP – 1 mussel sample	39µgSTX/100g	
Sandavaig	DSP – 1 mussel sample	No toxicity detected	
Loch Seaforth	PSP - 1 mussel sample	No toxicity detected	
Loch Stockinish	PSP – 2 mussel samples DSP – 2 mussel samples ASP – 1 mussel sample	No toxicity detected No toxicity detected ASP at 7µgDA/g	September
East Loch Tarbert	PSP – 1 mussel sample DSP – 1 mussel sample ASP – 1 mussel sample	No toxicity detected No toxicity detected No toxicity detected	
Loch Eynort	PSP – 3 mussel samples DSP – 4 mussel samples ASP – 3 mussel samples	No toxicity detected No toxicity detected No toxicity detected or LOD	
Loch Eport	PSP – 1 mussel sample DSP – 1 mussel sample ASP – 1 mussel sample	No toxicity detected No toxicity detected No toxicity detected	
Argyll and Bute: Loch Melfort	PSP – 2 mussel samples DSP – 1 mussel sample ASP – 2 mussel samples	No toxicity detected No toxicity detected LOD	
Loch Crinan	PSP – 7 scallop gonad samples PSP – 4 whole scallop samples DSP – 3 whole scallop samples ASP – 6 scallop gonad samples ASP – 7 whole scallop samples	No toxicity detected No toxicity detected No toxicity detected LOD, 3, 47, 13, 12, 6 µgDA/g 56, 12, >100, >100, >100, >100, 63µgDA/g	Closure orders imposed July - Sept, Dec and Feb 02 June – Sept. Nov, Dec, and Feb 02
Loch Coalisport	PSP – 3 scallop gonad samples PSP – 2 whole scallop samples ASP – 1 scallop gonad samples ASP – 2 whole scallop samples	No toxicity detected No toxicity detected ASP at 12 µgDA/g ASP at >100, >100 µgDA/g	November September Closure orders imposed
Loch Fyne/Otter Ferry	PSP – 1 Pacific oyster sample PSP – 2 Native oyster samples DSP – 2 Pacific oyster samples DSP 1 Native oyster sample ASP – 1 Pacific oyster sample ASP – 1 Native oyster sample	No toxicity detected No toxicity detected No toxicity detected No toxicity detected No toxicity detected	
Loch a Chumhainn	PSP – 2 Pacific oyster samples ASP – 2 Pacific oyster samples	No toxicity detected No toxicity detected	
Sound of Mull	PSP – 1 Pacific oyster sample ASP – 1 Pacific oyster sample	No toxicity detected No toxicity detected	

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Location and Production Area	No. samples and toxin analysed	Toxin levels detected	Comments
Colonsay	PSP – 3 Pacific oyster sample PSP – 3 Native oyster samples DSP – 5 Pacific oyster samples	No toxicity detected No toxicity detected No toxicity detected or LOD	
Loch Gruinart	PSP – 3 Pacific oyster sample PSP – 5 Native oyster samples DSP – 3 Pacific oyster samples	No toxicity detected No toxicity detected No toxicity detected or LOD	
Inverclyde : Parklea	PSP – 2 mussel samples DSP – 1 mussel sample ASP – 1 mussel sample	No toxicity detected No toxicity detected No toxicity detected	
Greenock	DSP – 1 mussel sample ASP – 1 mussel sample	No toxicity detected No toxicity detected	
Lunderstone Bay	PSP – 1 mussel sample ASP – 1 mussel sample	No toxicity detected No toxicity detected	
North Ayrshire: Pinmill, Arran	PSP – 1 Razor fish sample DSP – 1 Razor fish sample ASP – 1 Razor fish sample	No toxicity detected No toxicity detected No toxicity detected	
Dumfries and Galloway: Mersehead	PSP- 2 cockle samples DSP – 2 cockle samples ASP – 2 cockle samples	No toxicity detected No toxicity detected No toxicity detected	
Priestside	PSP- 1 cockle sample DSP – 1 cockle sample ASP – 1 cockle sample	No toxicity detected No toxicity detected No toxicity detected	

Monitoring of Algal Toxins in Shellfish in Scotland

**TABLE 3**

Summary of results from offshore scallop fishing grounds.

Location and Production Area	No. samples and toxin analysed	Toxin levels detected	Comments
East Coast (EC)	PSP – 48 scallop gonad samples PSP – 51 whole scallop samples  DSP – 12 whole scallop samples ASP – 137 – scallop gonad samples ASP – 132 whole scallop samples	37, 42, 49, 60 µg/100 g  34 , 41, 42, 44, 48, 63, 64, 108,143 µg/100 g  DSP detected in 11 samples ASP detected in range LOD – 20 µg/g ASP detected in range LOD – 80 µg/g	Fishing and shucking restrictions imposed
Moray Firth (MF)	PSP – 82 scallop gonad samples PSP – 75 whole scallop samples  DSP – 15 whole scallop samples ASP – 167 – scallop gonad samples ASP – 170 whole scallop samples	PSP detected in 22 samples, range 31 - 248 µg/100 g PSP detected in 38 samples, range 36 - 314 µg/100 g DSP detected in 8 samples  ASP detected in range LOD – 20µg/g ASP detected in range LOD – 149 µg/g	Fishing and shucking restrictions imposed
Orkney (O)	PSP – 135 scallop gonad samples PSP – 128 whole scallop samples  DSP – 51 whole scallop samples ASP – 195 – scallop gonad samples ASP – 181 whole scallop samples	PSP detected in 51 samples, range 30 - 222 µg/100 g PSP detected in 85 samples, range 32 – 1,752 µg/100 g DSP detected in 24 samples  ASP detected in range LOD – 72 µg/g ASP detected in range LOD – 326 µg/g	Fishing and shucking restrictions imposed
Shetland (S)	PSP – 10 scallop gonad samples PSP – 11 whole scallop samples  DSP – 1 whole scallop samples ASP – 15 – scallop gonad samples ASP – 16 whole scallop samples	36, 41 µg/100 g  42,52 µg/100 g  No toxicity detected ASP detected at LOD  ASP detected in range LOD – 26 µg/g	Shucking restrictions imposed
Hebrides (H)	PSP – 24 scallop gonad samples PSP – 24 whole scallop samples  DSP – 3 whole scallop samples ASP – 59 scallop gonad samples ASP – 56 whole scallop samples	60 µg/100 g  35, 40, 47, 64 µg/100 g  DSP detected in 2 samples  ASP detected in range LOD – 60µg/g ASP detected in range 12 – 420 µg/g	Fishing and shucking restrictions imposed

## Monitoring of Algal Toxins in Shellfish in Scotland

North Minch (NM)	<p>PSP – 41 scallop gonad samples PSP – 43 whole scallop samples</p> <p>DSP – 15 whole scallop samples</p> <p>ASP – 104 – scallop gonad samples ASP – 102 whole scallop samples</p>	<p>PSP detected in 10 samples, range 34 – 55 µg/100 g PSP detected in 16 samples, range 33 – 1384 µg/100 g DSP detected in 9 samples</p> <p>ASP detected in range LOD – 71 µg/g ASP detected in range 12 – 340 µg/g</p>	Fishing and shucking restrictions imposed
South Minch (SM)	<p>PSP – 75 scallop gonad samples PSP – 74 whole scallop samples</p> <p>DSP – 24 whole scallop samples</p> <p>ASP – 186 – scallop gonad samples ASP – 182 whole scallop samples</p>	<p>PSP detected in 1 sample, 80 µg/100 g PSP detected in 13 samples, range 30 – 554 µg/100 g DSP detected in 10 samples</p> <p>ASP detected in range LOD – 54 µg/g ASP detected in range 16 – 315 µg/g</p>	Fishing and shucking restrictions imposed
Sound of Jura (J)	<p>PSP – 77 scallop gonad samples PSP – 75 whole scallop samples</p> <p>DSP – 15 whole scallop samples</p> <p>ASP – 179 – scallop gonad samples ASP – 178 whole scallop samples</p>	<p>No toxins detected</p> <p>31, 35 67 µg/100 g</p> <p>DSP detected in 5 samples</p> <p>ASP detected in range LOD – 67 µg/g ASP detected in range 5 – 552 µg/g</p>	Fishing and shucking restrictions imposed
Clyde (C)	<p>PSP – 15 scallop gonad samples PSP – 16 whole scallop samples</p> <p>DSP – 2 whole scallop samples</p> <p>ASP – 34 – scallop gonad samples ASP – 34 whole scallop samples</p>	<p>No toxins detected</p> <p>No toxins detected</p> <p>DSP in 1 sample</p> <p>LOD</p> <p>ASP detected in range LOD – 39 µg/g</p>	Shucking restrictions imposed
Irish Sea (IS)	<p>PSP – 14 scallop gonad samples PSP – 13 whole scallop samples</p> <p>DSP – 5 whole scallop samples</p> <p>ASP – 18 – scallop gonad samples ASP – 15 whole scallop samples</p>	<p>No toxins detected</p> <p>No toxins detected</p> <p>DSP detected in 1 sample</p> <p>ASP detected in range LOD – 10 µg/g ASP detected in range LOD – 23 µg/g</p>	



Monitoring of Algal Toxins in Shellfish in Scotland

**TABLE 4**

Summary of results of LC-MS analyses for DSP toxins of samples from aquaculture sites.

Location and Production Area	No. samples analysed	Toxin detected <sup>a</sup>		
		OA	DTX1	DTX2
Elie	1 mussel sample	ND	N	N
Scapa Flow	4 mussel samples	0.074 <sup>b</sup>	N	Y
Kirkwall	2 mussel samples	LOD	N	N
Whalefirth	2 mussel samples	LOD	N	Y
Olna Firth	1 mussel sample	ND	N	Y
Vaila Sound	1 mussel sample	ND	N	N
East Burra Firth	1 mussel sample	0.053	N	Y
Linga Voe	1 mussel sample	ND	N	Y
Uyea Firth	1 mussel sample	LOD	N	Y
Kyle of Tongue	1 mussel sample	LOD	N	Y
Loch Eriboll	1 mussel sample	0.064	N	Y
Loch Inchard	10 mussel samples	0.33	N	Y
Loch Laxford	7 mussel samples	0.149	N	Y
Loch Inver ?	1 mussel sample	ND	N	Y
Dornoch Firth	3 mussel samples	LOD	N	Y
Loch Broom	1 mussel sample	LOD	N	Y
Little Loch Broom	2 mussel samples	0.142	N	Y
	1 scallop sample	ND	N	N
Loch Ewe	5 mussel samples	0.041	N	Y
	10 scallop samples	ND	N	N
Loch Torridon	8 mussel samples	0.107	N	Y
Loch Kishorn	1 mussel sample	ND	N	Y
Scalpay	3 mussel samples	0.289	N	Y
	2 queen samples	ND	N	N
Loch Sligachan	1 scallop sample	ND	N	N
Loch Ainort	1 mussel sample	0.067	N	N
	2 cockle samples	ND	N	N
Loch Greshornish	2 mussel samples	LOD	N	Y
Loch Dunvegan	4 mussel samples	0.408	N	Y
Loch Harport	1 mussel sample	ND	N	N
Loch Eishort	4 mussel samples	LOD	N	N
Badicaul	1 queen sample	LOD	N	N
	3 scallop samples	ND	N	N
Loch Hourn	7 mussel samples	0.138	N	Y
Loch Nevis	1 mussel sample	LOD	N	N
Loch Ailort	1 mussel sample	ND	N	N
Loch Moidart	2 mussel samples	ND	N	N
Ardtoe	1 Native oyster sample	ND	N	N
Loch Teacuis	1 mussel sample	ND	N	N
Loch Leven	2 mussel samples	LOD	N	N
Loch Roag	5 mussel samples	ND	N	N
Loch Leurbost	1 mussel sample	ND	N	N
Loch Creran	1 mussel sample	ND	N	N
	1 Pacific oyster sample	ND	N	N
Loch Etive	3 mussel samples	LOD	N	N
Loch Spelve	1 mussel sample	ND	N	N
Loch Scridain	1 mussel sample	0.056	N	Y
Barmore	3 queen samples	LOD	N	Y
Ardkinglass	2 mussel samples	LOD	N	Y
Loch Striven	5 mussel samples	0.187	N	Y
Fairlie	3 mussel samples	LOD	N	Y
	2 Pacific oyster samples	ND	N	Y
Loch Ryan	1 mussel sample	LOD	N	N
Kirkcudbright	1 mussel sample	LOD	N	N

<sup>a</sup>ND = Not detected; LOD = Limit of detection; Y = present, ND = Not present

<sup>b</sup>Highest level detected (µg/g)

**TABLE 5**

Summary of results of LC-MS analyses for DSP toxins in scallop samples from offshore fishing grounds.

Location and Production Area	No. of Samples Analysed	Toxin <sup>a</sup>		
		OA	DTX1	DTX2
East Coast	28 whole scallop samples	LOD	N	N
	28 scallop gonad samples	LOD	N	Y
Moray Firth	23 whole scallop samples	0.111	N	N
	45 scallop gonad sample	LOD	N	N
Orkney	40 whole scallop samples	0.069 <sup>b</sup>	N	N
	67 scallop gonad samples	LOD	N	N
Shetland	4 whole scallop samples	ND	N	N
	4 scallop gonad samples	ND	N	N
Hebrides	11 whole scallop samples	LOD	N	N
	13 scallop gonad samples	LOD	N	N
North Minch	16 whole scallop samples	0.145	N	Y
	19 scallop gonad samples	LOD	N	N
South Minch	30 whole scallop samples	LOD	N	N
	34 scallop gonad samples	LOD	N	N
Sound of Jura	27 whole scallop samples	LOD	N	N
	48 scallop gonad samples	LOD	N	N
Clyde	7 whole scallop samples	0.035	N	N
	6 scallop gonad samples	ND	N	N
Irish Sea	8 whole scallop samples	ND	N	N
	7 scallop gonad samples	ND	N	N

<sup>a</sup>ND = Not detected; LOD = Limit of detection; Y = present, ND = Not present

<sup>b</sup>Highest level detected ( $\mu\text{g/g}$ )

Monitoring of Algal Toxins in Shellfish in Scotland

**TABLE 6**

Summary of results from offshore fishing grounds – other species

Location and Production Area	No. samples and toxin analysed	Toxin levels detected	Comments
Moray Firth	PSP – 1 <i>Chamelea</i> sample DSP – 1 <i>Chamelea</i> sample ASP – 1 <i>Chamelea</i> sample	No toxins detected No toxins detected No toxins detected	
Orkney	PSP – 14 Queen samples PSP – 9 Razor fish samples PSP – 3 Horse mussel samples DSP – 11 Queen samples DSP – 8 Razor fish samples DSP – 4 Horse mussel samples ASP – 18 Queen samples  ASP – 9 Razor fish samples ASP – 2 Horse mussel samples	48, 80, 82 µg/100 g 35, 36 µg/100 g 32 µg/100 g  DSP detected in 3 samples No toxins detected  DSP in 3 samples ASP detected in range LOD – 21µg/g LOD LOD	Restrictions imposed July  July, September
North Minch	PSP – 3 Razor fish samples DSP – 3 Razor fish samples ASP – 3 Razor fish samples	34 µg/100 g No toxins detected LOD - 5 µg/g	
Irish Sea	PSP – 1 Queen sample PSP – 1 Razor fish sample DSP – 1 Razor fish sample ASP – 1 Razor fish sample	No toxins detected No toxins detected No toxins detected No toxins detected	

## ANNEX 1

### ALGAL TOXIN MONITORING AND SURVEILLANCE PROGRAMME 2000-2001

Site Number	Area and sample collector	Location	Contact Name Tel and Fax	OS Grid Ref	Species	Toxin	Start Date	Sampling Frequency
<b>Inshore Shellfish Beds</b>								
1	South East SFPA Eyemouth	St Abbs	Mr R Hunter T: 01890 750203 F: 01890 751387	NT 920 675	Mussels <i>M. edulis</i>	PSP PSP ASP and DSP	3 April 4 Oct. 3 April	Weekly to 29 September Monthly to 30 March Monthly to 30 March
2	South East SFPA Pittenweem	Elie	Mr P Gibson T: 01333 311555 F: 01333 311320	NT 490 955	Mussels	PSP PSP ASP and DSP	3 April 4 Oct. 3 April	Weekly to 29 September Monthly to 30 March Monthly to 30 March
3	South East Montrose	Montrose	Mr G Smith T: 01674 677070 F: 01674 672674	NO 720 570	Mussels	PSP PSP ASP and DSP	3 April 4 Oct. 3 April	Weekly to 29 September Monthly to 30 March Monthly to 30 March
4	North East Highland Council: Tain	Dornoch Firth	Mr J Bromham T: 01463 702510 F:	NH 800 865	Mussels	PSP PSP ASP and DSP	3 April 4 Oct. 3 April	Weekly to 29 September Monthly to 30 March Monthly to 30 March
5	Orkney Orkney Islands Council	Scapa Flow	Mr A Simpson T: 01856 876070 F: 01856 872274	HY 400 000	Mussels	PSP PSP ASP and DSP	3 April 4 Oct. 3 April	Weekly to 29 September Monthly to 30 March Monthly to 30 March
6	Orkney Orkney Islands Council	Kirkwall	Mr A Simpson T: 01856 876070 F: 01856 872274	HY450 130	Mussels	PSP PSP ASP and DSP	3 April 4 Oct. 3 April	Weekly to 29 September Monthly to 30 March Monthly to 30 March
7	Orkney Orkney Islands Council	Orkney North Isles	Mr A Simpson T: 01856 876070 F: 01856 872274		Scallops <i>Pecten</i>	PSP PSP ASP and DSP	3 April 4 Oct. 3 April	Weekly to 29 September Monthly to 30 March Monthly to 30 March
8	Shetland	Sullom Voe	Ms A Hawick	HU 380 740	Mussels	PSP	3 April	Weekly to 29 September
	Shetland Islands Council		T: 01595 744800			PSP	4 Oct.	Monthly to 30 March

Site Number	Area and sample collector	Location	Contact Name Tel and Fax	OS Grid Ref	Species	Toxin	Start Date	Sampling Frequency
			F: 01595 692605			ASP and DSP	3 April	Monthly to 30 March
<b>Inshore Shellfish Beds</b>								
9	Shetland	Olna Firth	Ms A Hawick	HU 370 645	Mussels	PSP	3 April	Weekly to 29 September
	Shetland Islands Council	Voe	T: 01595 744800 F: 01595 692605			PSP ASP and DSP	4 Oct. 3 April	Monthly to 30 March Monthly to 30 March
10	Shetland	Scalloway	Ms A Hawick	HU 400 370	Mussels	PSP	3 April	Weekly to 29 September
	Shetland Islands Council		T: 01595 744800 F: 01595 692605			PSP ASP and DSP	4 Oct 3 April	Monthly to 30 March Monthly to 30 March
11	North West	Loch Eriboll	Mr J Mather	NC 419 592	Mussels	PSP	3 April	Weekly to 29 September
			T: 01971 511365 No Fax			PSP ASP and DSP	4 Oct. 3 April	Monthly to 30 March Monthly to 30 March
12	North West	Loch Inchard	Mr C Steventon	NC 229 555	Mussels	PSP	3 April	Weekly to 29 September
	Kinlochbervie		T: 01971 521286 F: 01971 521286			PSP ASP and DSP	4 Oct. 3 April	Monthly to 30 March Monthly to 30 March
13	North West	Loch Laxford	Mr J Ross	NC 205 495	Mussels	PSP	3 April	Weekly to 29 September
			T: 01971 502209 F: 01971 502209			PSP ASP and DSP	4 Oct. 3 April	Monthly to 30 March Monthly to 30 March
14	North West	Loch Kirkaig	Mr W McConnachie	NC 070 195	Mussels	PSP	3 April	Weekly to 29 September
	SFPA Lochinver		T: 01571 844486			PSP	4 Oct.	Monthly to 30 March
15	North West	Ullapool	Mr I Hepburn	NH 120 940	Mussels	PSP	3 April	Weekly to 29 September
	SFPA Ullapool	Loch Broom	T: 01854 612704 F: 01854 612868			PSP ASP and DSP	4 Oct. 3 April	Monthly to 30 March Monthly to 30 March
16	North West	Little Loch Broom	Mr M Bush	NH 050 910	Mussels	PSP	3 April	Weekly to 29 September
			T: 01854 633376 No Fax			PSP ASP and DSP	4 Oct. 3 April	Monthly to 30 March Monthly to 30 March
17	Outer Hebrides	Loch Roag	Mr P MacLeod	NB 130 340	Mussels	PSP	3 April	Weekly to 29 September
	Hebridean Seafoods		T: 01851 672325			PSP	4 Oct.	Monthly to 30 March

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Site Number	Area and sample collector	Location	Contact Name Tel and Fax F: 01851 672393	OS Grid Ref	Species	Toxin ASP and DSP	Start Date 3 April	Sampling Frequency Monthly to 30 March
<b>Inshore Shellfish Beds</b>								
18	Outer Hebrides Raven Rock	Loch Leurbost	Mr M MacLeod T: 01851 860228 F: 01851 260228	NB 390 245	Mussels	PSP PSP ASP and DSP	3 April 4 Oct. 3 April	Weekly to 29 September Monthly to 30 March Monthly to 30 March
19	Central West MLA	Loch Ewe	Mr P MacLaughlan T: 01445 731437 F: 01445 731441	NG 840 840	Mussels	PSP PSP ASP and DSP	3 April 4 Oct. 3 April	Weekly to 29 September Monthly to 30 March Monthly to 30 March
20	Central West	Loch Torridon	Mr J MacDonald T: 01445 741273 F: 01445 741273	NG 840 560	Mussels	PSP PSP ASP and DSP	3 April 4 Oct. 3 April	Weekly to 29 September Monthly to 30 March Monthly to 30 March
21	Central West Seafield Centre	Loch Kishorn	Mr M Stark T: 01520 733300 F: 01520 733262	NG 820 390	Mussels	PSP PSP ASP and DSP	3 April 4 Oct. 3 April	Weekly to 29 September Monthly to 30 March Monthly to 30 March
22a	Central West	Scalpay	Mr S Birch T: 01471 822539 F: 01471 822539	NG 640 290	Queens Chlamys	PSP PSP ASP and DSP	3 April 4 Oct. 3 April	Weekly to 29 September Monthly to 30 March Monthly to 30 March
22b		Broadford Bay	Mr R Parry T: 01471 822498 F: 01471 822498		Scallops	PSP PSP ASP and DSP	3 April 4 Oct. 3 April	Weekly to 29 September Monthly to 30 March Monthly to 30 March
22c		L. Sligachan	Mr D Oakes T: 01478 650304 F: 01478 650304		Scallops	PSP PSP ASP and DSP	3 April 4 Oct. 3 April	Weekly to 29 September Monthly to 30 March Monthly to 30 March
23	Central West Greshornish Mussels	Loch Greshornish	Mr C Dickson T: 01470 582266 F: 01470 582345	NG 345 540	Mussels	PSP PSP ASP and DSP	3 April 4 Oct. 3 April	Weekly to 29 September Monthly to 30 March Monthly to 30 March
24	Central West	Loch Eishort	Mr P MacAskill	NG 620 150	Mussels	PSP	3 April	Weekly to 29 September

Site Number	Area and sample collector	Location	Contact Name Tel and Fax	OS Grid Ref	Species	Toxin	Start Date	Sampling Frequency
	Loch Eishort Mussel Farms		T: 01471 822309 F: 01471 822309			PSP ASP and DSP	4 Oct. 3 April	Monthly to 30 March Monthly to 30 March
<b>Inshore Shellfish Beds</b>								
25	Central West	Loch Hourn	Mr M Simpson T: 01687 462843 F: 01687 820120	NG 860 060	Mussels	PSP PSP ASP and DSP	3 April 4 Oct. 3 April	Weekly to 29 September Monthly to 30 March Monthly to 30 March
26	Central West	L. Dunvegan Ob Dubh	Mr P J MacSween T: 01470 521 710 F:	NG 230 485	Mussels	PSP PSP ASP and DSP	3 April 4 Oct. 3 April	Weekly to 29 September Monthly to 30 March Monthly to 30 March
27	Central West	Ardtoe L.Cean Traigh	Mr J MacMillan T: 01967 431324 F: 01967 431324	NM 620 705	Mussels	PSP PSP ASP and DSP	3 April 4 Oct. 3 April	Weekly to 29 September Monthly to 30 March Monthly to 30 March
28	South West	Loch Creran	Mr R Thwaites T: 01631 720216 F: 01631 720650	NM 918 405	Mussels	PSP PSP ASP and DSP	3 April 4 Oct. 3 April	Weekly to 29 September Monthly to 30 March Monthly to 30 March
29	South West Celtic Sea	Loch Spelve	Mr J Turner T: 01681 704245 F: 01680 814218	NM 700 290	Mussels	PSP PSP ASP and DSP	3 April 4 Oct. 3 April	Weekly to 29 September Monthly to 30 March Monthly to 30 March
30	South West Celtic Sea Ltd	Loch Scridain	T: 01680 704000 F: 01680 814208	NM 450 250	Mussels	PSP PSP ASP and DSP	3 April 4 Oct. 3 April	Weekly to 29 September Monthly to 30 March Monthly to 30 March
31	South West	Ulva Sound/ Loch na Keal	Mr N Mawhinney T: 01688 500250 F: 01688 500250	NM 460 380	Mussels	PSP PSP ASP and DSP	3 April 4 Oct. 3 April	Weekly to 29 September Monthly to 30 March Monthly to 30 March
32	South West	West Loch Tarbert	Mr N Duncan T: 01880 820583 F: 01880 820042	NR 800 615	Mussels	PSP PSP ASP and DSP	3 April 4 Oct. 3 April	Weekly to 29 September Monthly to 30 March Monthly to 30 March

Site Number	Area and sample collector	Location	Contact Name Tel and Fax	OS Grid Ref	Species	Toxin	Start Date	Sampling Frequency
33	Clyde	Loch Fyne Barmore	Mr G Goldsworthy	NR 870 720	Queens	PSP	3 April	Weekly to 29 September
			T: 01880 820100			PSP	4 Oct.	Monthly to 30 March
			F: 01880 801001			ASP and DSP	3 April	Monthly to 30 March
<b>Inshore Shellfish Beds</b>								
34	Clyde	Loch Fyne Ardkinglas	Mr D A Attwood	NN 160 100	Mussels	PSP	3 April	Weekly to 29 September
			T:01499 600264			PSP	4 Oct.	Monthly to 30 March
			F:			ASP and DSP	3 April	Monthly to 30 March
35	Clyde	Loch Striven	Mr D Scott	NS 080 760	Mussels	PSP	3 April	Weekly to 29 September
			T: 01786 832248			PSP	4 Oct.	Monthly to 30 March
			F: 01786 832248			ASP and DSP	3 April	Monthly to 30 March
36	Clyde North Ayrshire Council	Fairlie Southannan	Mr K McMunn	NS 200 545	Mussels	PSP	3 April	Weekly to 29 September
			T: 01294 324300			PSP	4 Oct.	Monthly to 30 March
			F: 01294 324360			ASP and DSP	3 April	Monthly to 30 March
37	Clyde Dumfries & Galloway Council	Loch Ryan	Ms H Hightet	NX 055 645	Mussels	PSP	3 April	Weekly to 29 September
			T: 01776 702151			PSP	4 Oct.	Monthly to 30 March
			F: 01776 704819			ASP and DSP	3 April	Monthly to 30 March
38	Solway Dumfries & Galloway Council	Kirkcudbright	Mr G Naismith	NX 660 480	Mussels	PSP	3 April	Weekly to 29 September
			T: 01557 330291			PSP	4 Oct.	Monthly to 30 March
			F: 01557 331982			ASP and DSP	3 April	Monthly to 30 March
<b>Inshore Shellfish Beds Offshore Scallop Beds</b>								
S1	East Coast	E Squares	SFPA Pittenweem	01333 311555	Scallops	PSP, DSP, ASP	April 2000	As landings permit
S2	Moray Firth	M Squares	SFPA Peterhead	01779 472254	Scallops	PSP, DSP, ASP	April 2000	As landings permit
S3		M Squares	SFPA Buckie	01542 832187	Scallops	PSP, DSP, ASP	April 2000	As landings permit
S4	Orkney	O Squares	SFPA Kirkwall/OIC	01856 875834	Scallops	PSP, DSP, ASP	April 2000	As landings permit
S5	Shetland	S Squares	SFPA Lerwick/SIC	01595 692007	Scallops	PSP, DSP, ASP	April 2000	As landings permit
S6	North Minch	NM Squares	SFPA Lochinver	01571 844486	Scallops	PSP, DSP, ASP	April 2000	As landings permit

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Site Number	Area and sample collector	Location	Contact Name Tel and Fax	OS Grid Ref	Species	Toxin	Start Date	Sampling Frequency
S7		NM Squares	SFPA Kinlochbervie	01971 521375	Scallops	PSP, DSP, ASP	April 2000	As landings permit
S8	South Minch	SM Squares	SFPA Oban	01631 566583	Scallops	PSP, DSP, ASP	April 2000	As landings permit
S9		SM Squares	SFPA Mallaig	01687 462155	Scallops	PSP, DSP, ASP	April 2000	As landings permit
S10	Outer Hebrides	H Squares	SFPA Stornoway	01851 703291	Scallops	PSP, DSP, ASP	April 2000	As landings permit
S11	Sound of Jura	J Squares	SFPA Campbeltown	01586 552251	Scallops	PSP, DSP, ASP	April 2000	As landings permit
S12	Clyde	C Squares	SFPA Campbeltown	01586 552251	Scallops	PSP, DSP, ASP	April 2000	As landings permit
S13	Solway/Irish Sea	IS Squares	SFPA Ayr	01292 610177	Scallops	PSP, DSP, ASP	April 2000	As landings permit

## ANNEX 2

Fisheries Research Services  
Marine Laboratory, PO Box 101, Victoria Road  
Aberdeen, AB11 9DB

April 2001

### ALGAL TOXIN MONITORING AND SURVEILLANCE PROGRAMME SHELLFISH SAMPLE COLLECTION PROTOCOL

1. Shellfish samples should be collected from identified sites at the stated frequency.
2. The sites and collection frequency may change depending upon the prevalence of algal toxins, but any changes will be notified beforehand.
3. Shellfish samples should ideally be collected on Monday or Tuesday of each week and posted to the Algal Toxin Unit, Rowett Institute so that results are available by the Thursday at the latest.
4. Sample size should be such that 100 g of meat can be extracted for each assay (PSP, DSP, ASP).

This is usually achieved by the following numbers of animals:

Mussels	Full box
Oysters	10 – 12
Cockles	100-150
Queens	15 – 20
Scallops	10 – 20
Razorfish	6-8
Periwinkles ( <i>Littorina</i> spp.)	50-100
Whelks ( <i>Buccinum</i> spp.)	5-10
Lobster	Single animals
Nephrops	6-12
Brown crabs	Single animals
Green crabs	6
Velvet crabs	6

5. Shellfish must be placed inside two of the polythene bag provided, the bags tied and labelled with:
  - Date of collection
  - Site of collection/Offshore position/Catch rectangle
  - Name of collector
  - Any other relevant data eg state of tide; water temperature; weather conditions
  - Number of boxes remaining
6. The bagged samples will then be placed in the plastic containers provided, the box lids should be securely taped with adhesive tape to prevent leakage, and the whole placed in the cardboard boxes which should then be posted using the prepaid labels, to the FRS, Algal Toxin Unit, Rowett Research Institute, Greenburn Road, Bucksburn, Aberdeen, AB21 9SB.

7. Any queries or problems may be referred to:

**Godfrey Howard/Margaret McCann at the Marine Laboratory Aberdeen**

**Phone: 01224 876544; Fax: 01224 295511**

**e-mail: [howardfg@marlab.ac.uk](mailto:howardfg@marlab.ac.uk); [mccannm@marlab.ac.uk](mailto:mccannm@marlab.ac.uk)**

## ANNEX 3

### PARALYTIC SHELLFISH POISONING - (PSP) ANALYSIS TECHNIQUE

Ref:- AOAC Official Methods of Analysis (1990) 959.08.

#### Sample Preparation

1. Thoroughly clean the outside of the shellfish with potable water
2. Open by cutting the adductor muscles
3. Remove the meat from within the shell by separating the adductor muscle and tissue connections at the hinge
4. Transfer the meats to a sieve and drain
5. Mix using a food processor until homogenous

#### Toxin Extraction Technique

1. Weigh 100 grams of the homogenate into a plastic screw topped container
2. Add 100 millilitres of 0.1 molar hydrochloric acid, mix by shaking for 1 minute pH to between 2.0 and 4.0. Adjust if out with this range using 5 molar hydrochloric acid dropwise whilst mixing to lower the pH or 0.1 molar sodium hydroxide dropwise while mixing to raise the pH.
3. Place the mixture in a boiling water bath and boil for 5 minutes timing from when the water restarts boiling. Remove the samples and cool to room temperature.
4. Adjust the pH of the cooled mixture to 2.8-3.2 as in step 2.
5. Centrifuge a subsample of the supernatant at 12,000 rpm for 5 minutes.
6. Filter supernatant from the centrifuge tube through a 113V filter into a 30 ml Sterlin bottle. The supernatant is used for the bioassay.

#### Bioassay

1. Inject 1 ml sample of the extract intra peritoneally into a white out-bred female mouse.
2. Weighing between 17.5 and 23.4 grams.
3. The toxicity of the sample is determined using the death time of the mouse (mouse observed for 20 minutes), the weight of the mouse, the correction factor ascertained from calibration samples and a dilution factor if required. For samples that cause the mouse to die in less than 5 minutes the extract is diluted and the sample re-tested in order to attain a more accurate result.

## ANNEX 3

### DIARRHETIC SHELLFISH POISONING - (DSP) ANALYSIS TECHNIQUE

Ref:- Yasumoto *et al.*, (Modified) Bull. Jap. Soc. Fish 1978 44(11) pp1249-1255

#### Sample Preparation

1. Thoroughly clean the outside of the shellfish with potable water
2. Open by cutting the adductor muscles
3. Remove the meat from within the shell by separating the adductor muscle and tissue connections at the hinge
4. Transfer the meats to a sieve and drain
5. Mix using a food processor until homogenous

#### Toxin Extraction Technique

1. Weigh 75 grams of the homogenate.
2. Extract the sample three times with 75 mls of acetone. Filter through a 320 mm 113 V filter paper into a plastic screw topped container. Evaporate the filtered liquid using a rotary evaporator. Suspend the round bottomed flask containing the liquid in the water bath at 45°C until distillation stops. The rotary evaporator should be placed in a fume cupboard.
3. Measure the volume of the remaining aqueous suspension in a measuring cylinder and place in a separating funnel add an equal volume of ether. Shake until mixed, loosen lid to release the pressure and support the funnel on a stand. Run off the bottom layer into the round bottomed flask. Pour the top ether layer into a 100 ml conical flask. Wash the bottom layer again with the same volume of ether as before discarding bottom layer this time. Pour the ether layer from the conical flask into the separating funnel to combine both extracts.
4. The combined ether extract is back-washed twice with 5 mls of distilled water (keep top layer, discard bottom layer). The ether extract is transferred to a 100 ml florentine flask and evaporated to dryness using the rotary evaporator.
5. The residue in the florentine flask is suspended in 3 mls of 1% Tween 60 using an ultrasonic bath and transferred to glass universal for testing.

#### Bioassay

1. Inject 1 ml sample of the extract intra peritoneally into two white out-bred mice weighing between 15.5 and 18.4 grams.
2. The test is positive if 1 or 2 mice die within five hours.

## ANNEX 3

### ASP ANALYSIS OF SHELLFISH USING HPLC WITH PHOTO DIODE ARRAY DETECTION

#### Preparation of Samples

1. An aliquot of 4 g ( $\pm 1$  g) of shellfish homogenate is placed in a 50 ml centrifuge tube.
2. Methanol-water solution (1:1, 16 mls) is added to the tissue and the sample is extracted using an Ultraturrax (13000 rpm, 1 minute).
3. The resulting suspension is then centrifuged (3000 rpm, 12 minutes) and the supernatant transferred to a 30 ml universal container. The supernatant is mixed thoroughly using a vortex mixer.
4. Methanol (6 mls) and methanol-water solution (1:1, 3 mls) are used to condition strong anion exchange cartridges (Waters QMA Accell 500 mg 6cc) on a vacuum manifold.
5. An aliquot of 2.5 mls of the sample extract is loaded onto the cartridge. The cartridge is washed with acetonitrile-water solution (1:9, 5 mls) and 0.3 mls of citrate buffer (pH 3.2) is loaded on to the cartridge and discarded.
6. Sample collection tubes (5 ml) are placed in the rack of the vacuum manifold. Citrate buffer (pH 3.2, 5 mls) is used to elute the compound of interest from the cartridge. Exactly 5 mls of eluent is collected in the tubes by checking the meniscus of the elution solvent.
7. The tubes are mixed on a vortex mixer and the contents transferred to borosilicate vials for analysis.

#### Analysis

The samples are analysed using high performance liquid chromatography with photo diode array detection. Conditions for the analysis of samples are given in Table 1.

**TABLE 1**

HPLC Conditions for the Analysis of Domoic Acid

Column	Vydac 201TP54 250 x 4.6 mm 5 $\mu$ m (Separation Products, Hysperia, USA)
Injection volume	10 $\mu$ l
Mobile phase	0.1 % (v/v) trifluoroacetic acid in 10 % (v/v) acetonitrile
Flow rate	1.5 ml min <sup>-1</sup>
Scanning wavelengths	200-360 nm
Quantification wavelength	242 nm

Quality control and calibration standards for domoic acid are analysed (0.25, 0.5, 1, 2, 5, 10  $\mu$ g ml<sup>-1</sup> domoic acid) along with the samples. The samples are calculated using a linear calibration curve model and the identity of domoic acid is confirmed using the similarity index of the sample when compared to a standard.

## Reference

Quilliam, M.A., Xie, M. and Hardstaff, W.R. 1995. Rapid extraction and cleanup for liquid chromatographic determination of domoic acid in unsalted seafood. *J. AOAC International*, **78**(2), 543-554.

## ANNEX 4

### CLINICAL SYMPTOMS OF VARIOUS TYPES OF FISH AND SHELLFISH POISONING

Paralytic Shellfish Poisoning (PSP)	Diarrhetic Shellfish Poisoning (PSP)	Amnesic Shellfish Poisoning (ASP)	Ciguatera Toxin Poisoning (CTX)
Causative Organisms			
<i>Alexandrium catenella</i> <i>Alexandrium minutum</i> <i>Alexandrium tamarense</i> <i>Gymnodinium catenatum</i> <i>Pyrodinium bahamense</i>	<i>Dinophysis acuta</i> <i>Dinophysis acuminata</i> <i>Dinophysis norvegica</i> <i>Dinophysis fortii</i> <i>Prorocentrum lima</i>	<i>Pseudo-nitzschia</i> spp.	<i>Gambierdiscus toxicus</i> <i>Osteopsis siamensis</i> <i>Prorocentrum</i> spp.
Symptoms			
Mild case: Within 30 mins. Tingling sensation or numbness around lips, gradually spreading to face and neck; prickly sensation in fingertips, toes; headache, dizziness, nausea, vomiting, diarrhoea.  Extreme case: Muscular paralysis, pronounced respiratory difficulty; choking sensation, death through respiratory paralysis may occur with 2 – 12hrs of ingestion.	After 30 min. to several hours, (seldom exceeding 12 hrs) , diarrhoea, vomiting, abdominal pain. Symptoms may persist for up to 3 days.  Chronic exposure may promote tumour formation in the digestive system.	After 3-5 hours, nausea, vomiting diarrhoea, abdominal cramps.  Decreased reaction to pain, dizziness, hallucinations, confusion and short term memory loss, seizures, death.	Symptoms develop within 12-24 hrs of eating fish. Gastrointestinal symptoms: diarrhoea, abdominal pain, nausea, vomiting.  Neurological symptoms : numbness and tingling of hands and feet; cold objects feel hot to touch, difficulty in maintaining balance; low heart rate and blood pressure; rashes. In extreme cases, death through respiratory failure.
Treatment			
Patient has stomach pumped and is given artificial respiration. No lasting effects.	Natural recovery after 3 days, irrespective of medical treatment.	Patient has stomach pumped and is given artificial respiration	No antitoxin or specific treatment available. Neurological symptoms may last for months or years. Calcium and mannitol may help relieve symptoms.