Centre for Environment Fisheries & Aquaculture Science

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Cefas contract reports: C7711 to C7715

FSS References: FSS00003, FSS00004, FSS00006, FSS00008, FSS00009

Annual report on the results of the Shellfish Official Control Monitoring Programmes for Scotland - 2019

February 2020

Annual report on the results of the *E. coli*, biotoxin, phytoplankton and chemical contaminants Official Control Monitoring Programmes for Scotland - 2019

Final Report

75 pages

Not to be quoted without prior reference to the authors

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Quality statement: This report is a compilation of the information included on the reports provided to FSS and showing the results of the E. coli, chemical contaminants, phytoplankton and toxin analyses undertaken on samples submitted via the Official Control programme. All results were quality checked and approved prior to release to FSS and the results compiled in this report have been further checked against a copy of the original reports held on a central database. Information relating to the origin of the samples (place (including co-ordinates), date and time of collection) is as provided by contracted sampling staff and has not undergone verification checks by the laboratories.

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Abbreviations used in the text

AHA	Associated Harvesting Area
AOAC	AOAC International
ASP	Amnesic Shellfish Poisoning
AZA	Azaspiracid
AZP	Azaspiracid Poisoning
CI	Cyclic Imines
DA	Domoic Acid
DSP	Diarrhetic Shellfish Poisoning
DTX	Dinophysistoxin
dcSTX	decarbamoyl saxitoxin
EC	European Commission
EU	European Union
EURL	European Union Reference Laboratory for Marine Biotoxins
EHO	Environmental Health Officer
EPT	End product test
Fera	Fera Science Limited
FSS	Food Standards Scotland
GTX	Gonyautoxin
HPLC	High Performance Liquid Chromatography
LA	Local Authority
LC-MS/MS	Liquid Chromatography with tandem Mass Spectrometry
LOD	Limit of detection
LOQ	Limit of quantitation
LT(s)	Lipophilic Toxin(s)
MPL	Maximum Permitted Level
ND	Not Detected
UKNRL	UK National Reference Laboratory for Marine Biotoxins
OA	Okadaic Acid
PAHs	Polycyclic aromatic hydrocarbons
PAH4	Sum of 4 PAHs (benzo[*a*]pyrene; (BaP), benz[a]anthracene; (BaA), benzo[b]fluoranthene; (BbF), chrysene; (Chr))
PCB	Ortho-substituted PCB (non planar)
PCDD/F	Polychlorinated dibenzo-*p*-dioxin/ polychlorinated dibenzofuran (dioxins)
PSP	Paralytic Shellfish Poisoning
PST(s)	Paralytic Shellfish Toxin(s)
PTX	Pectenotoxin
PTX2	Pectenotoxin 2
PTX2sa	Pectenotoxin 2 seco-acid
RL	Reporting limit
RMP	Representative Monitoring Point
SAMS	The Scottish Association for Marine Science
SRSL	SAMS Research Services Ltd
SSQC	SSQC Ltd
SOP(s)	Standard Operating Procedure(s)
STX	Saxitoxin
YTX	Yessotoxin

Summary

This report describes the results of the Scottish Official Control Monitoring Programmes delivered by the Centre for Environment, Fisheries and Aquaculture Science (Cefas) and partners for the period 1st January to 31st December 2019. The programmes were delivered on behalf of Food Standards Scotland (FSS), the national competent authority for food safety and were aimed at delivering the testing required for the statutory monitoring of biotoxins, *E.coli* and chemical contaminants in shellfish and for the identification and enumeration of potentially harmful algal species in selected shellfish harvesting areas, as described in EC Regulations 854/2004, 882/2004, 1881/2006 and 2074/2005.

The co-ordination of the programme, its logistics, toxin analyses and the majority of *E. coli* analyses were conducted by Cefas, whilst phytoplankton analyses were performed by SAMS Research Services Ltd. (SRSL) in Oban, chemical contaminants analyses by Fera Science Ltd (Fera) in York and *E. coli* analyses for Shetland only by SSQC Ltd in Scalloway. These laboratories were contracted by Cefas under the scope of the 'Shellfish Partnership'.

An overview of these programmes and their results are presented in the following sections of this report:

- Section 1: Toxin and phytoplankton monitoring programme
- Section 2: *E. coli* monitoring programme
- Section 3: Chemical contaminants monitoring programme

The Shellfish Partnership has been responsible for the delivery of these programmes since 2012. Until 2017, the results of each annual programme have been reported separately. Since 2018, at the request of FSS, the results of the annual monitoring programmes are combined into one single annual report. The first one was released in June 2019 for the 2018 results.

A total of 4,118 shellfish samples and 1,311 water samples were collected for the purpose of the 2019 Scottish official control monitoring programmes. Since the 1st of April 2018, sampling officers from Hall Mark Meat Hygiene (HMMH) have collected or arranged collection for all samples from all geographic locations, under a new contract arrangement with Cefas.

Only 0.2% of the biotoxin samples and 2% of *E. coli* samples were rejected as unsuitable for analysis on arrival at the laboratories. All water and chemical contaminants samples were suitable.

All analyses followed the approved methods laid out in EU legislation and specified by FSS for the purpose of this programme. All methods were accredited to ISO17025:2005 standards at the testing laboratories. Amnesic shellfish poisoning toxins (ASP) were monitored in 916 samples, lipophilic toxins (LT) in 1,956 samples and paralytic shellfish poisoning toxins (PSP) in 1,272 samples. 2,010 samples were tested for *E. coli*, 28 for heavy metals (lead, cadmium and mercury), 28 for PAHs and 1 for dioxins and PCBs.

All results were reported to FSS' specifications and met the required FSS turnaround times. Specifically:

- 98.9% of all toxin results were reported within 1 working day of sample receipt, 100% within 2 working days;

- 100% of phytoplankton results were reported within 3 days of sample receipt;
- 99% of *E. coli* actionable results ('outwith') were reported within 3 working days of onset of analysis;
- 100% *of E. coli* non-actionable results were reported within 5 working days of onset of analysis;
- Chemical contaminant report produced by end May 2019.

The results of the monitoring programme are presented in each section of this report. In summary:

- 68 samples breached the maximum permitted limits (MPL) for lipophilic toxins (OA/DTX/PTX group only) (see section 1.2);
- 1 sample breached the MPL for PSP toxins (see section 1.3);
- No sample breached the MPL for ASP toxins (see section 1.4);
- Outwith *E. coli* results were reported in 6.5% of the 2019 analyses undertaken (see Table 31 for details);
- All chemical contaminants results were below the regulatory maximum limits (see section 3).

Section 1. Toxin and Phytoplankton

1.1 Summary

This report describes the results of the Official Control Biotoxin and Phytoplankton Monitoring Programmes for Scotland for the period 1st January to 31st December 2019.

The laboratory analysis for biotoxins in shellfish, co-ordination of the programme and its logistics were conducted by the Centre for Environment, Fisheries and Aquaculture Science (Cefas) Weymouth Laboratory, whilst the laboratory phytoplankton analysis, co-ordination of the programme and its logistics were performed by SAMS Research Services Ltd. (SRSL) in Oban, under the scope of the contracted Shellfish Partnership.

The programmes were delivered on behalf of Food Standards Scotland (FSS), the national competent authority for food safety and are aimed at delivering the testing required for the statutory monitoring of biotoxins in shellfish and for identification and enumeration of potentially harmful algal species in selected shellfish harvesting areas, as described in EC Regulations 854/2004, 882/2004 and 2074/2005.

Toxin monitoring

A total of 2,009 bivalve shellfish samples from 81 inshore sampling locations (Figure 1) were submitted to Cefas for toxin analyses in the reporting period. They comprised of; common mussels (1,352), Pacific oysters (442), razors (132), common cockles (38), surf clams (32), and native oysters (13).

Nine samples of king and queen scallops were also collected from commercial establishments under the scope of the FSS official control verification programme and were submitted for toxin analysis during the reporting period.

Three inshore samples (<0.2% of those received) were rejected on arrival at the laboratory – two of these were submitted in error as testing was not required in these areas, the other sample was not collected according to the sampling schedule.

All samples received and assessed as suitable for testing provided sufficient material to perform all the required analyses.

Phytoplankton monitoring

A total of 1,311 seawater samples from 48 inshore sampling locations (Figure 2) were submitted to SRSL for the identification and enumeration of potentially harmful algal species during the reporting period.

Results of the FSS toxin and phytoplankton monitoring programmes are available on the FSS website. For results for individual RMPs (Representative Monitoring Points), please visit the Scotland's Aquaculture website at the following links:

- Biotoxin monitoring
- Phytoplankton monitoring

All results are compared to the maximum permitted levels (MPL) (Table 1) as stipulated in EC regulation 853/2004 (Section VII, Chapter V: Health standards for live bivalve molluscs). Toxin test results must not exceed these limits in either whole body or any edible part separately:

Table 1. Maximum Permitted Limits of toxins in shellfish flesh

Toxin group	**Maximum Permitted Limits**
ASP	20 mg Domoic/epi-domoic acid/kg [shellfish flesh]
LTs	Diarrhetic shellfish poisoning (DSP) toxins and pectenotoxins (PTXs) together, 160µg okadaic acid (OA) eq./kg [shellfish flesh] or Yessotoxins, 3.75mg yessotoxin (YTX) eq./kg [shellfish flesh] or Azaspiracids, 160µg azaspiracid (AZA) eq./kg [shellfish flesh]
PSP	800µg saxitoxin (STX) eq./kg [shellfish flesh]

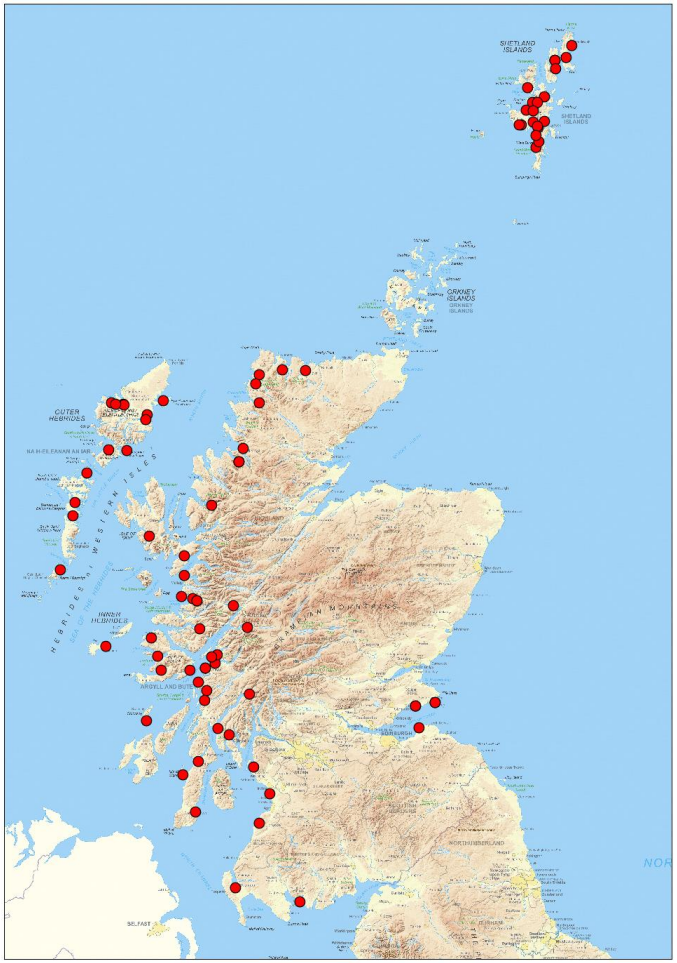


Figure 1. Scottish inshore shellfish sampling locations – Food Standards Scotland biotoxin monitoring programme in 2019

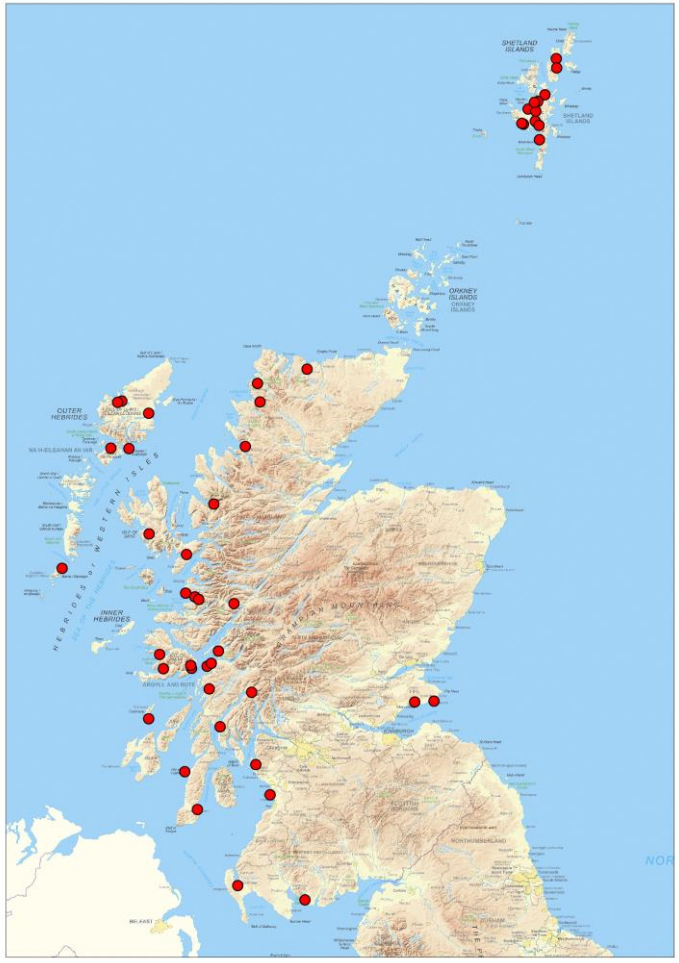


Figure 2. Scottish water sampling locations – Food Standards Scotland phytoplankton monitoring programme in 2019

1.2 Monitoring for lipophilic toxins

Monitoring for lipophilic toxins (LTs) was conducted using a liquid chromatography with tandem mass spectrometry (LC-MS/MS) method (see Section 2.7 for details). The method is able to characterise and quantify the following LT groups:

- Okadaic Acid (OA)/Dinophysis Toxins (DTXs) and Pectenotoxins (PTXs) – reported as µg OA equivalent (eq.)/kg shellfish flesh
- Azaspiracid toxins (AZAs) – reported as µg AZA1 eq./kg shellfish flesh
- Yessotoxins (YTXs) reported as mg YTX eq./kg shellfish flesh.

During this reporting period, 68 inshore samples breached the MPL for lipophilic toxins (Table 1). As highlighted in previous annual reports, where the MPL for lipophilic toxins had been exceeded and sampling had occurred in the previous two to three weeks, the LC-MS method provided an early warning, detecting low toxin levels prior to closure in the majority of cases This indicates the methods performance and advantage as an early warning mechanism, when applied to risk management practices such as the FSS "traffic light" guidance.

In total, lipophilic toxins analyses were performed on 1,947 samples from inshore locations and 9 verification samples collected from commercial establishments. Results are summarised below.

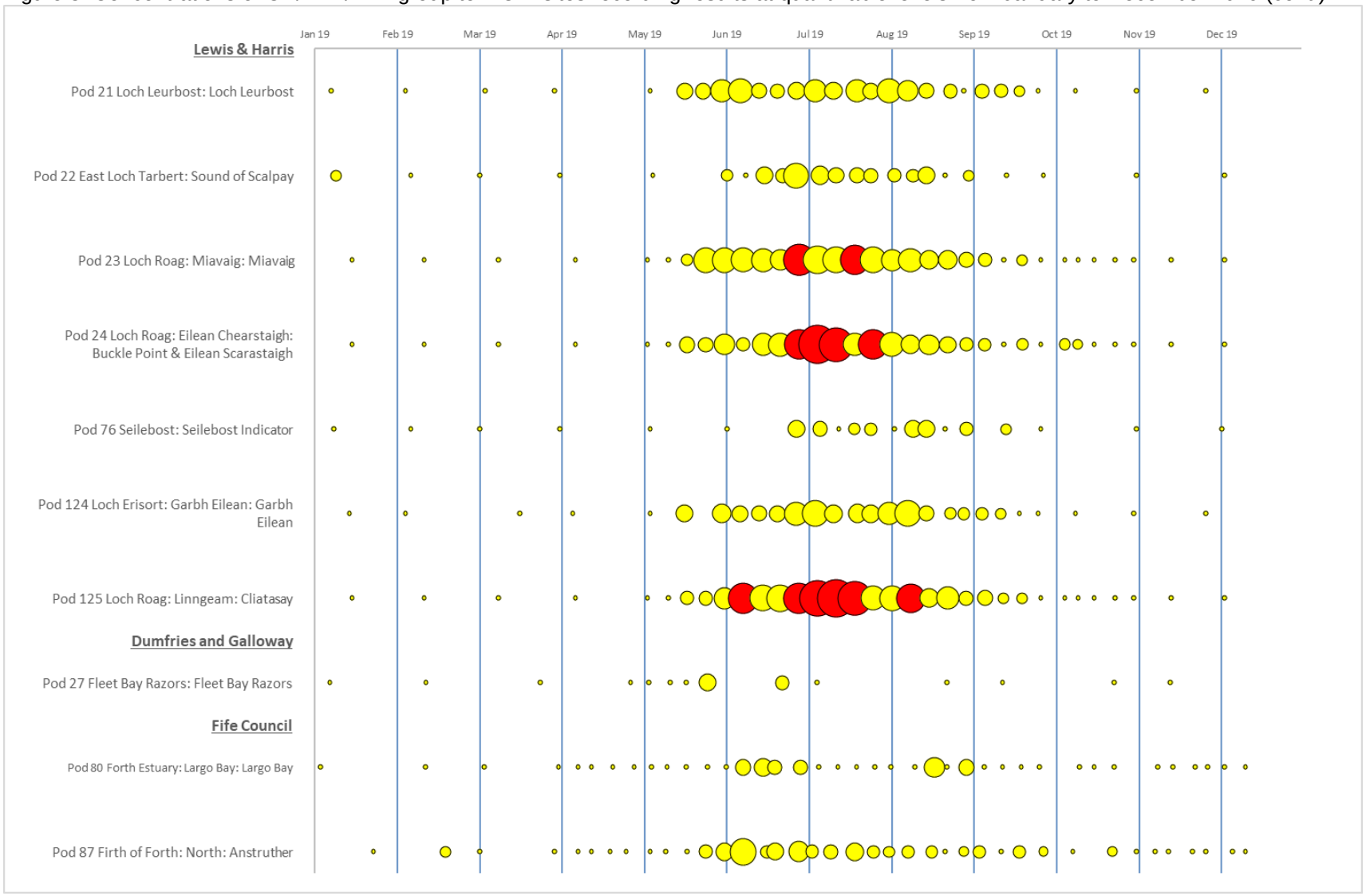
1.2.1 OA/DTX/PTX group

- OA/DTX/PTX group toxins were detected in 653 inshore samples, comprising of mussels (623 samples), Pacific oysters (7), razors (5) and surf clams (18).
- OA/DTX/PTX group toxins were detected in all months throughout the reporting period (Figure 3), with the majority of recorded results occurring between June and October 2019 (542 samples).
- The distribution of OA/DTX/PTX toxins was widespread, affecting sites within the majority of monitored local authority regions, with the exception of Uist and Barra and North and South Ayrshire.
- Only 68 samples comprising of mussels (67 samples) and Pacific oysters (1) from 19 sites (Figure 4) recorded results above the MPL in 2019. These results were recorded between June and September 2019. Overall, 2019 was a quiet year in terms of LT closures, similar to2017 (when only 46 results >MPL were recorded). 254 results >MPL had been recorded in 2018.
- The highest level recorded during 2019 was 680µg OA eq./kg, over 4 times the regulatory limit, in a sample from Loch Eishort (Highland Council: Skye and Lochalsh) in early July 2019. Levels of OA/DTX/PTX group toxins at this site had started to rise in late April. Levels remained at less than half the action level through May and June. Then following an increase in *Dinophysis* species in late June, levels rose to exceed the MPL.
- Elsewhere, OA/DTX/PTX group toxins were detected below the MPL in a further 585 samples from 48 sites (Figure 5), between January and December 2019.
- No OA/DTX/PTX group toxins were detected in the Scallop verification samples received in 2019.

Figure 3. Concentrations of OA/DTX/PTX group toxins in sites recording results at quantifiable levels from January to December 2019

Concentration of OA/DTX/PTX toxins: Red = Toxins above MPL Yellow = Toxins below MPL Not detected = ●
(Bubble size is proportional to toxin concentration)

Figure 3. Concentrations of OA/DTX/PTX group toxins in sites recording results at quantifiable levels from January to December 2019 (cont.)



Concentration of OA/DTX/PTX toxins: Red = Toxins above MPL Yellow = Toxins below MPL Not detected = ●
(Bubble size is proportional to toxin concentration)

Figure 3. Concentrations of OA/DTX/PTX group toxins in sites recording results at quantifiable levels from January to December 2019 (cont.)

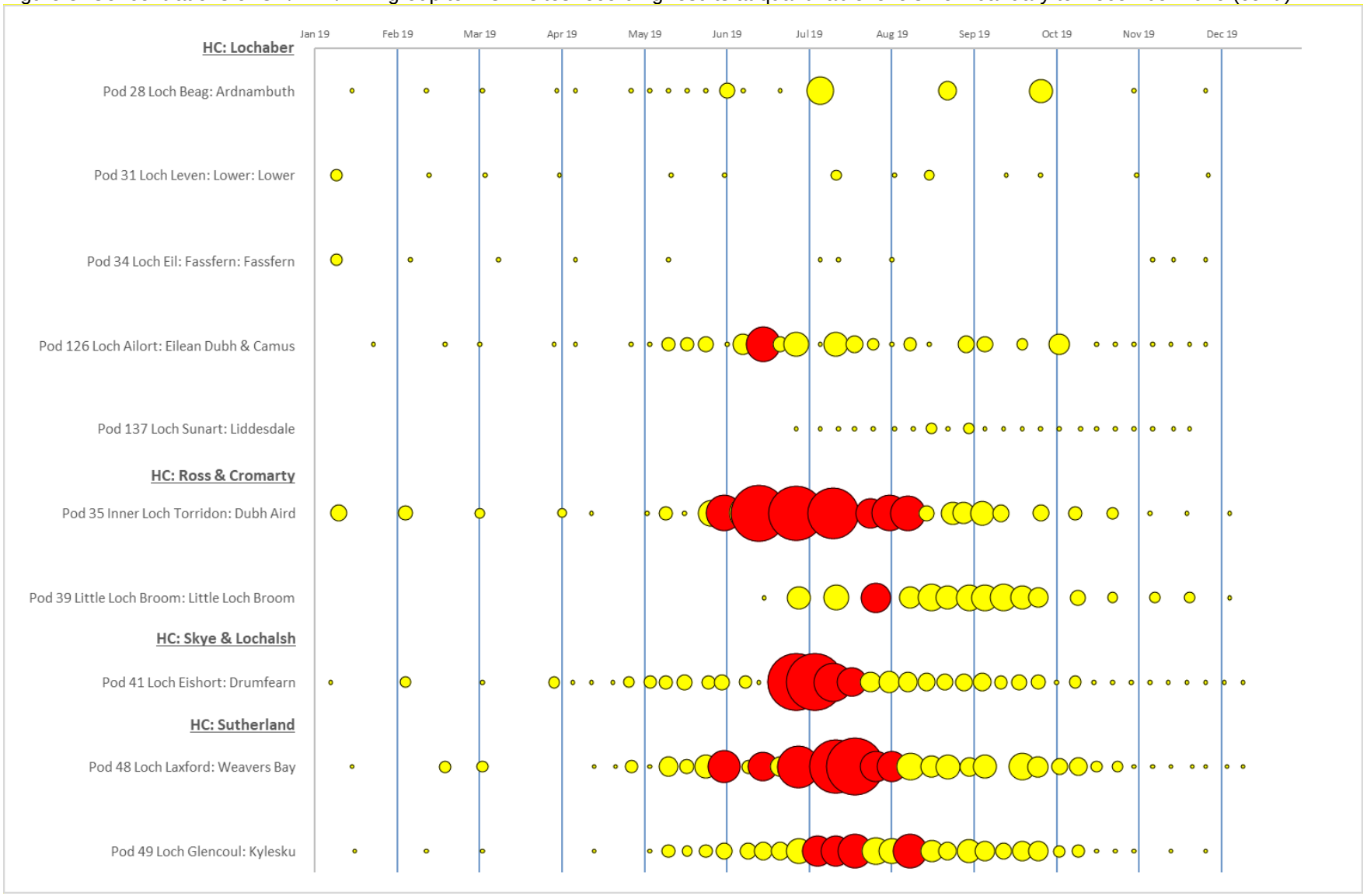
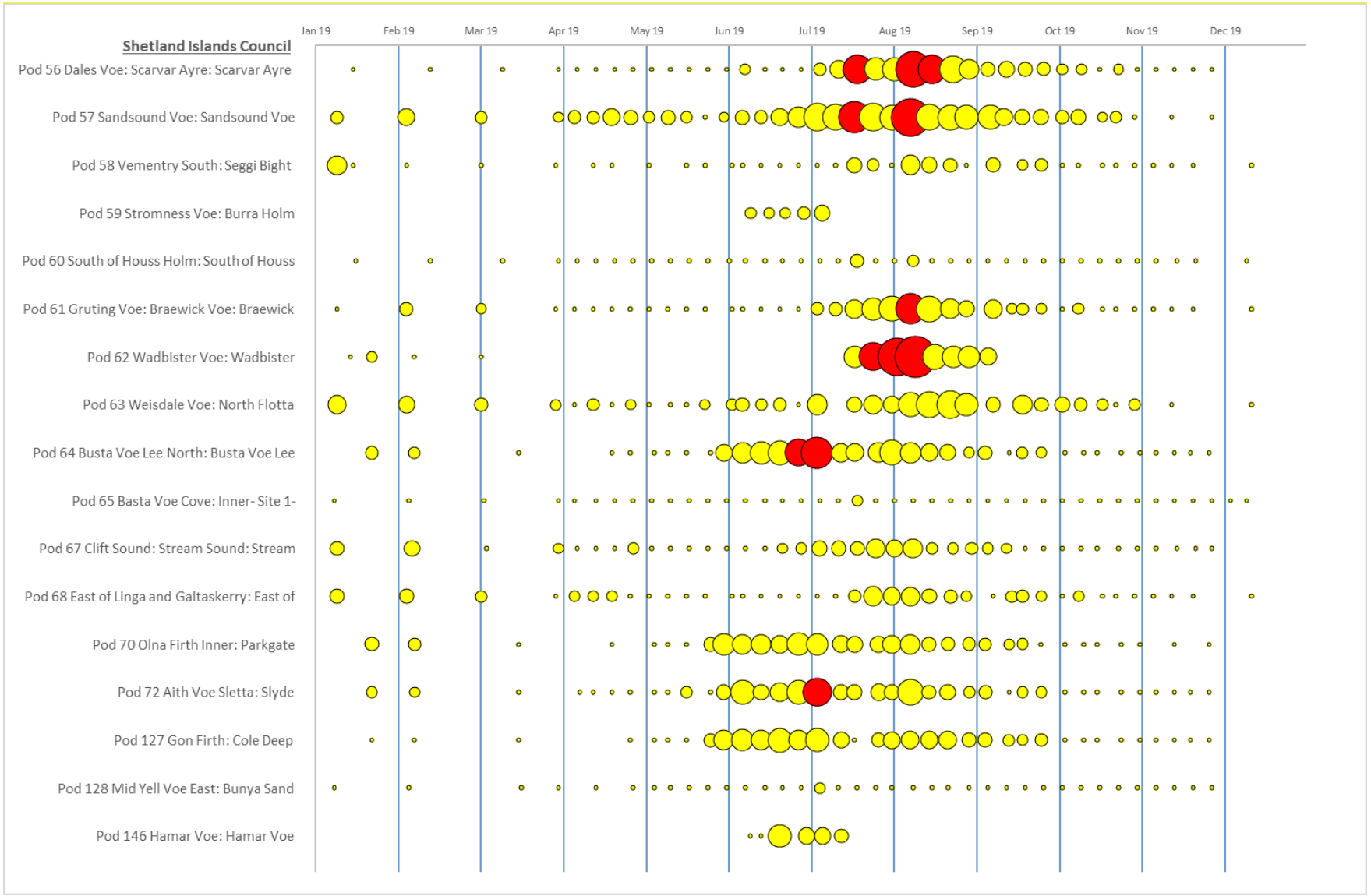


Figure 3. Concentrations of OA/DTX/PTX group toxins in sites recording results at quantifiable levels from January to December 2019 (cont.)



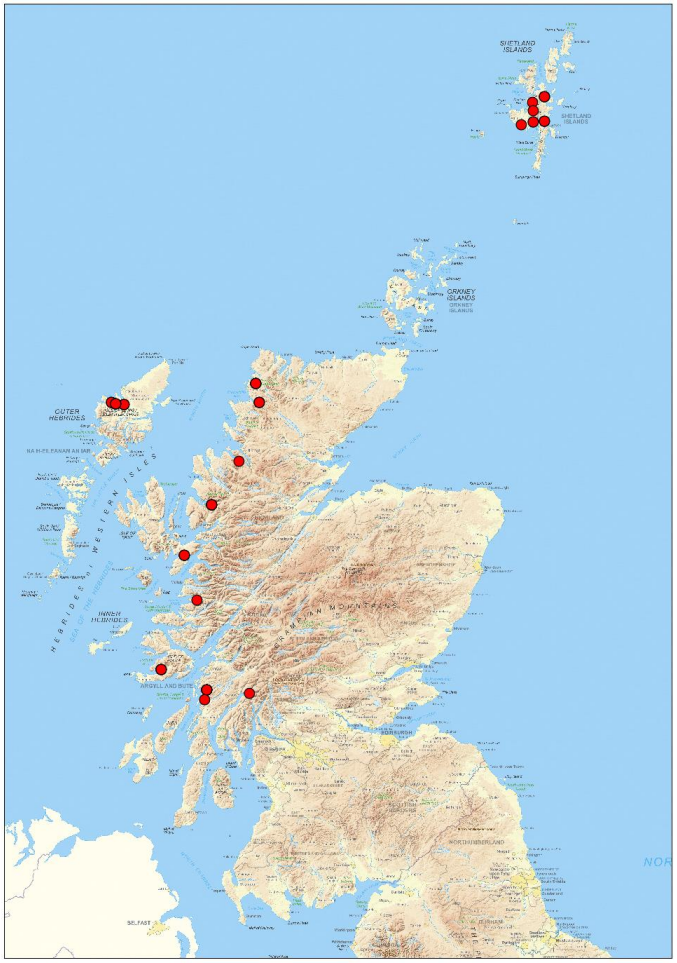


Figure 4. Inshore locations recording OA/DTX/PTX group results above the maximum permitted limit (>160µg OA eq./kg) in 2019

Figure 5. Inshore locations where toxins of OA/DTX/PTX group were detected below the maximum permitted limit (≤160µg OA eq./kg) in 2019

1.2.2 AZA group

AZAs below the MPL were detected in 13 samples in 2019. This toxin group was predominantly detected in mussels (11 samples) but also in cockles (1) and Pacific oyster samples (1). Toxins were detected between September and October 2019 in the north west of Scotland and the Western Isles. The highest result was recorded in mussels collected from Pod 124 – Loch Erisort at 76 µg AZA eq./kg (Figure 6), in October 2019.

1.2.3 YTX group

YTXs below the MPL were detected in one inshore sample from Pod 6 - Argyll and Bute, Loch na Cille (Table 7) in February 2019 (0.2 mg YTXeq/kg).

Figure 6. Inshore locations where AZA group toxins were detected in 2019 (all below the maximum permitted level (≤160µg AZA eq./kg))

Figure 7. Inshore locations where YTX group toxins were detected in 2019 (all below the maximum permitted level (≤3.75mg YTX eq./kg))

1.2.4 Phytoplankton associated with the production of lipophilic toxins

Dinophysis species* (Figure 8) were present in 552 (42.1%) of the 1,312 samples analysed during 2019 and were detected in every month of the year (

- 9). They were observed at or above trigger level (set at 100 cells/L) in 208 samples (15.8%) between April and September. The majority of *Dinophysis* blooms** occurred around the Scottish coast from June to August, with 36.7% of the samples collected in July exceeding threshold counts (Figure 9).
- The earliest blooms reaching trigger level were recorded in Loch Ailort (Highland: Lochaber), Loch Harport (Highland: Skye & Lochalsh) and Loch Fyne: Otter Ferry (Argyll & Bute), all in the fourth week of April 2019. As in 2016, 2017 and 2018, dense blooms of *Dinophysis* were observed at Loch Fyne: Ardkinglas (Argyll & Bute) during the summer of 2019 (Figure 8), with the highest cell density reaching 26,280 cells/L on 5th June and a further bloom of density 3,020 cells/L on 21st August. These dense blooms appeared to be confined to upper Loch Fyne, with samples obtained from lower Loch Fyne: Otter Ferry during the same time period containing *Dinophysis* at lower concentrations.
- *Dinophysis* blooms were widespread around most of the Highland region between May and July, with cell counts of 1,460 cells/L recorded at Kyle of Tongue (Highland: Sutherland), 2,260 cells/L in Loch Torridon (Highland: Ross & Cromarty) and 2,200 cells/L in Loch Harport (Highland: Skye & Lochalsh) on 15th May, 30th May and 22nd July, respectively. In Argyll & Bute, blooms were observed on the west coast of the Isle of Mull: 2,540 cells/L at Ulva: Loch na Keal West on 4th June, and 1,800 cells/L at Kilfinichen Bay on 20th August.
- The total percentage of *Dinophysis* at or exceeding trigger level during the 2019 reporting period (15.8%) was lower than in 2018 (22.3%), but similar to 2009 (14.6%) and 2017 (13.8%).

*references to *Dinophysis* species in this report also include *Phalacroma rotundatum* (synonym *Dinophysis rotundata*)

** blooms are denoted as cell counts at or exceeding trigger level, where appropriate for individual species/genera.

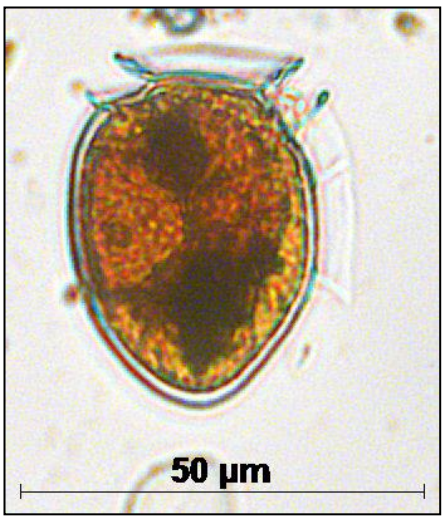
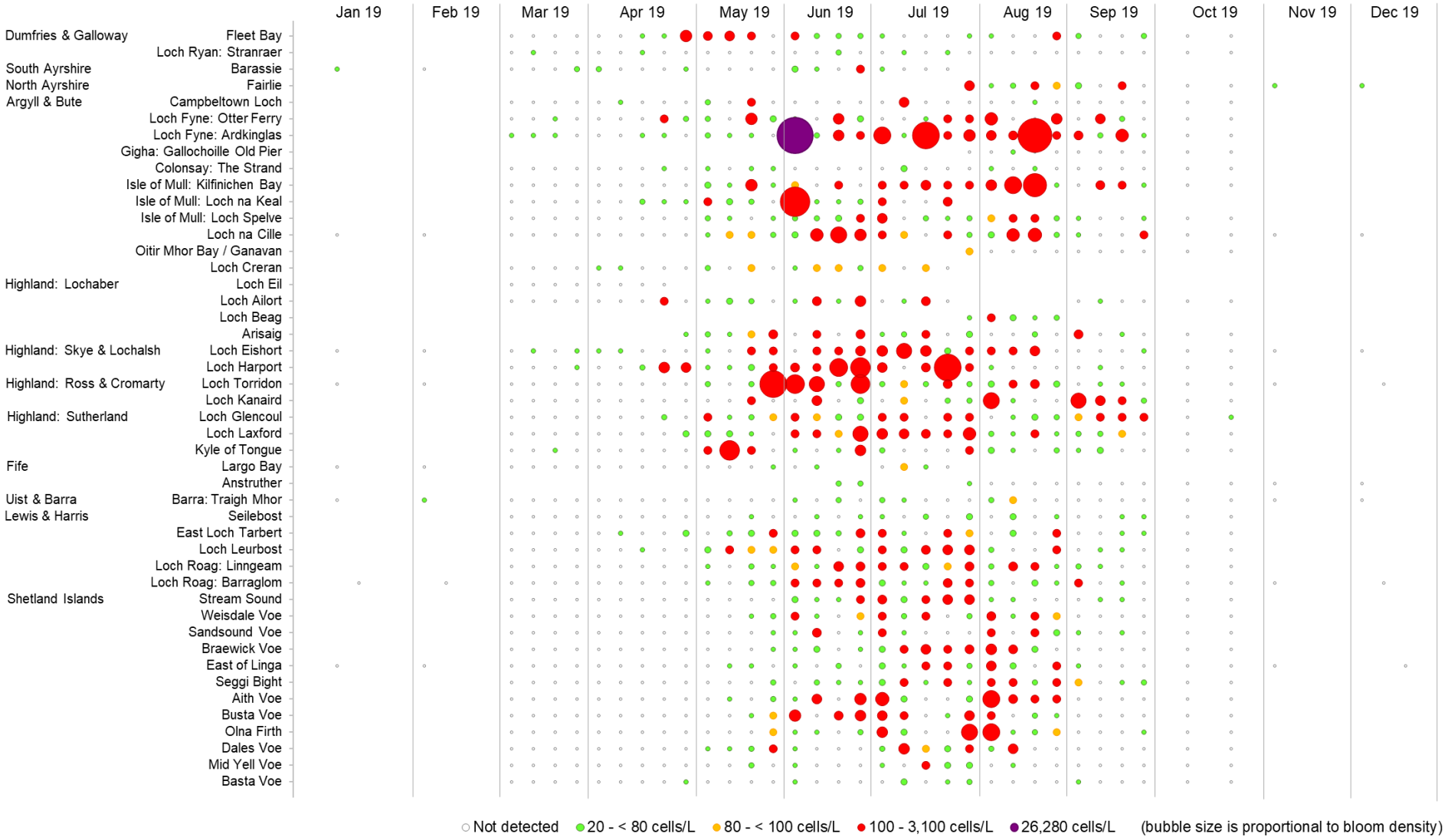


Figure 8. *Dinophysis acuminata* from the Isle of Colonsay (Argyll & Bute) on 27th May 2019.

Figure 9. Phytoplankton concentrations of *Dinophysis* spp. observed between January and December 2019



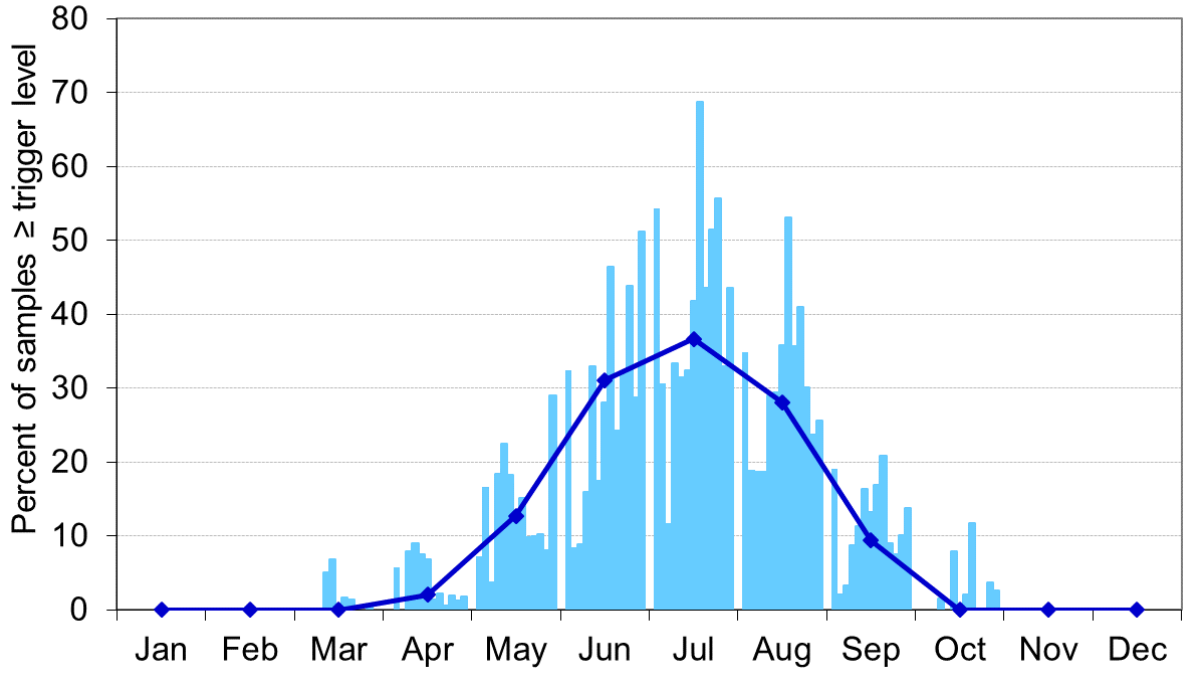


Figure 10. The percentage of samples in which *Dinophysis* equalled or exceeded the trigger level of 100 cells/L in 2019 is indicated by the line. (For comparison, the bars show the percentage of samples in which *Dinophysis* equalled or exceeded the trigger level between 2006 and 2018).

- The benthic dinoflagellate *Prorocentrum lima* (Figure 11) was present in 234 samples (17.8%) analysed during 2019. It was recorded from February to October and was most abundant between June and August. *Prorocentrum lima* was reported at or above the trigger level (set at 100 cells/L) in 35 samples (2.7%), collected between April and September. This species is generally detected more often in the sandy sediments of shallow bays where oyster cultivation takes place, although it can also grow epiphytically. The densest blooms of 2019 were observed in the Shetland Islands, with 1,580 cells/L recorded in Busta Voe on 10th June, and 1,180 cells/L in Dales Voe on 6th August. *Prorocentrum lima* was also frequently observed in Basta Voe Cove, similar to 2018. Elsewhere in Scotland, blooms were noted at Kyle of Tongue (Highland: Sutherland) and Colonsay: The Strand (Argyll & Bute), with maximum densities of 1,160 cells/L on 12th June and 820 cells/L on 1st July, respectively. It was present in almost 60% of the Colonsay samples analysed.

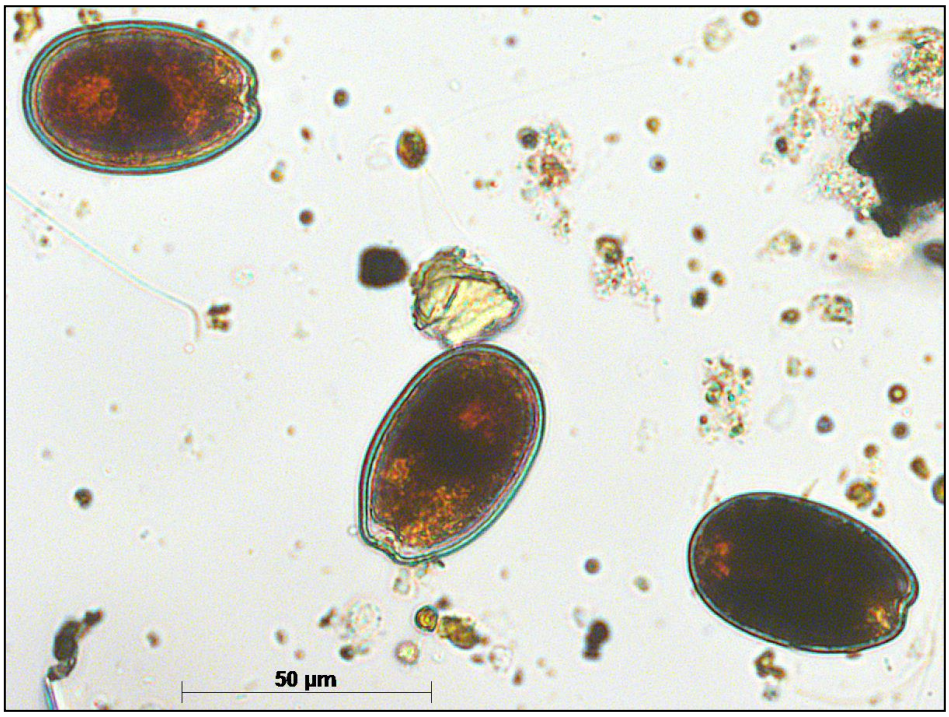


Figure 11. *Prorocentrum lima* observed at Basta Voe Cove (Shetland Islands) on 4th June 2019 at a concentration of 800 cells/L.

- The dinoflagellate *Protoceratium reticulatum* (Figure 11) was detected in 32 samples (2.4%) between March and August and was most abundant between May and July. It was most frequently observed at sites in Argyll & Bute and around the Highland region, but not present at all in the Shetland Islands during 2019. The densest bloom occurred in Loch Laxford (Highland: Sutherland), with 440 cells/L recorded on 13th June. No trigger level has been set for *Protoceratium reticulatum*.

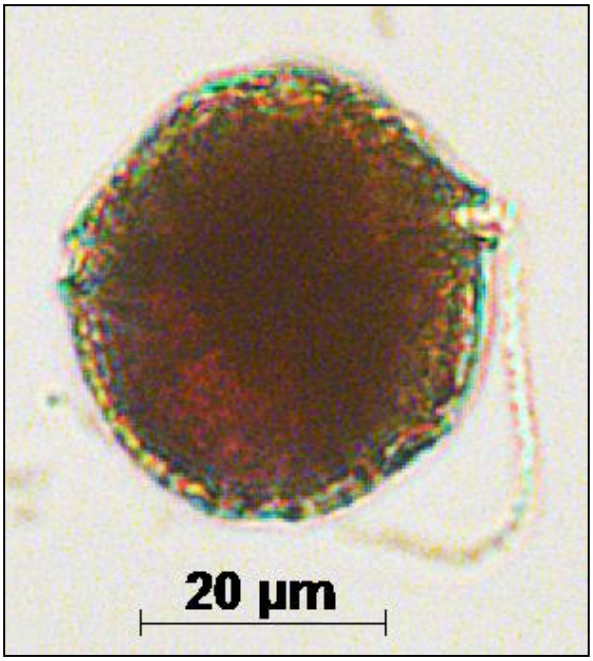


Figure 12. *Protoceratium reticulatum* from Loch Fyne: Otter Ferry (Argyll & Bute) on 20th May 2019.

- The dinoflagellate *Lingulodinium polyedra* (Figure 13) is rarely abundant in Scottish coastal waters and was only found on six occasions (0.5 % of samples) and in two regions, Argyll & Bute and Dumfries & Galloway. It was detected between July and September, reaching a maximum bloom density of 240 cells/L in Fleet Bay (Dumfries & Galloway) on 10th September. Samples were not collected from Loch Creran after mid July, so it is not known whether this species was present in late summer, when it tends to bloom at this site. No trigger level has been set for *Lingulodinium polyedra*.

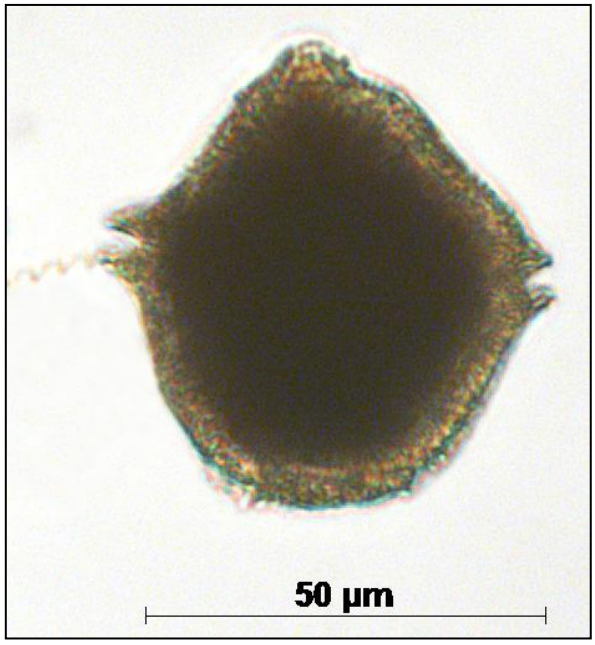


Figure 13. *Lingulodinium polyedra* from Loch Creran (Argyll & Bute) on 9th July 2019.

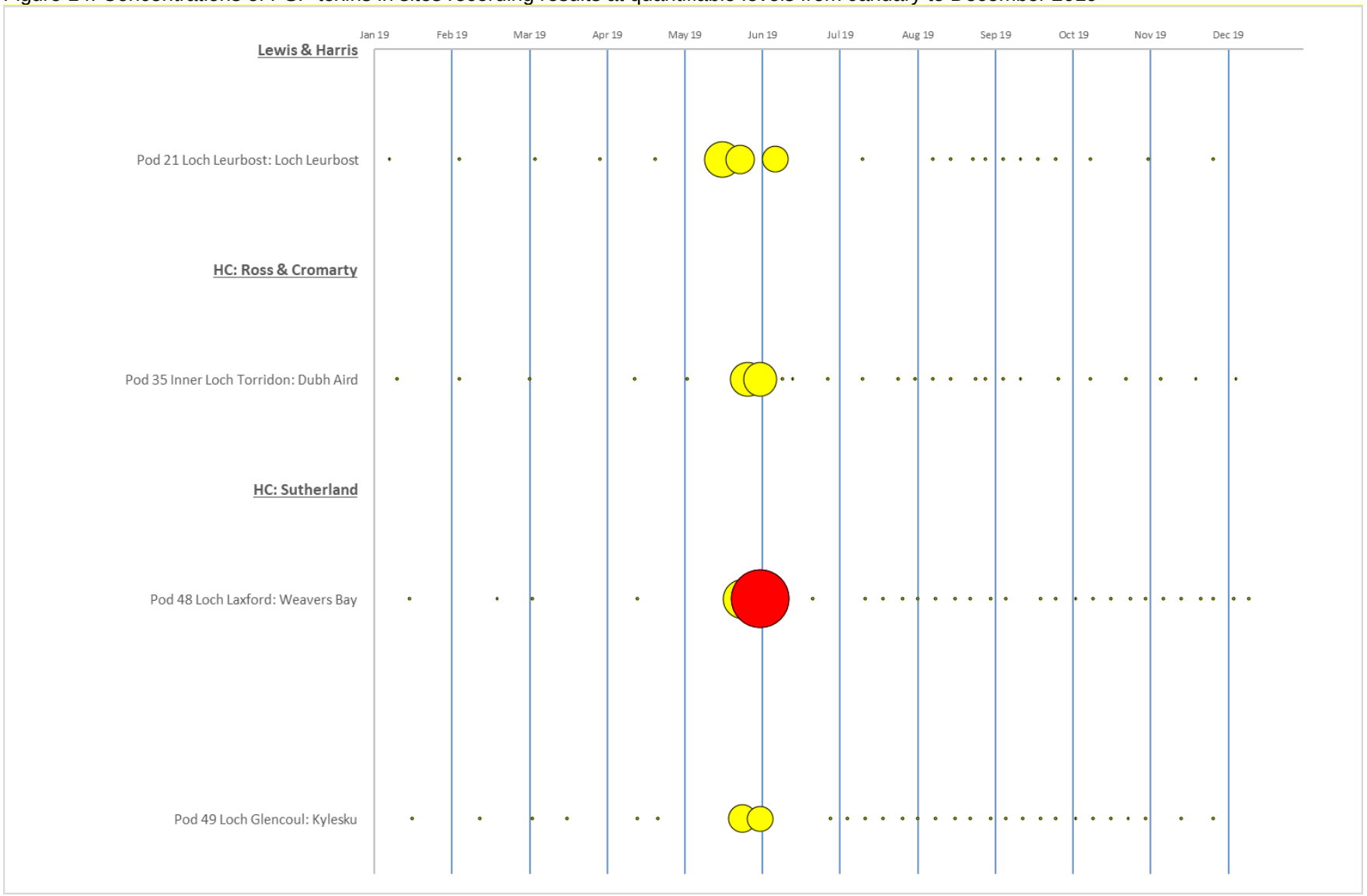
1.3 Monitoring for PSP toxins

A total of 1,263 samples from inshore locations and 9 king & queen scallop verification samples collected from commercial establishments were tested for paralytic shellfish poisoning (PSP) toxins. All samples were tested by a high-performance liquid chromatography (HPLC) method (see section 1.7 for details) and results are summarised below.

- One mussel sample from Pod 48 - Loch Laxford in the Sutherland region was found to contain PSP toxins above the MPL of 800µg STX eq./kg shellfish flesh in early June (Figure 13 & Figure 14). The level recorded was 1,436 µg/kg. PSP toxins were detected above the trigger level (400 µg/kg) in the week prior to the closure result.
- PSP toxins above reporting levels, but below the MPL were detected in a further 8 samples of mussels from 4 separate pods (Pod 21 – Loch Leurbost, Pod 35 - Inner Loch Torridonm Pod 48 – Loch Laxford, and Pod 49 – Loch Glencoul). All occurrences were recorded between late May and mid June 2019 (Figure 15).

- A range of PSP toxins were quantified during 2019. Nine samples of mussels were quantified and recorded toxin results above the reporting limit (160ug STXeq/kg). A further 13 samples (12 mussels and one razor) were subjected to full quantitative analysis but returned results below the reporting limit for the test. The profiles predominantly consisted of the toxins Saxitoxin (STX), Gonyautoxins (GTX) 2&3, GTX1&4, Neosaxitoxin and C toxins 1&2 (data not shown). Lower concentrations of GTX5 and dcSTX were also detected in some shellfish samples. Proportions of each toxin varied considerably, but the profiles were consistent with previous years, and similar to those expected from shellfish contaminated with *Alexandrium* as documented in Turner et al, 2014., with profiles dominated by GTX1&4, GTX2&3 and STX. No quantifiable levels of PSP toxins were detected in the scallop verification samples.
- 2019 saw the lowest occurrence of PSP toxins in Scotland since 2010.

Figure 14. Concentrations of PSP toxins in sites recording results at quantifiable levels from January to December 2019



Concentration of PSP toxins: Red = Toxins above MPL Yellow = Toxins below MPL Not detected =
(Bubble size is proportional to toxin concentration)

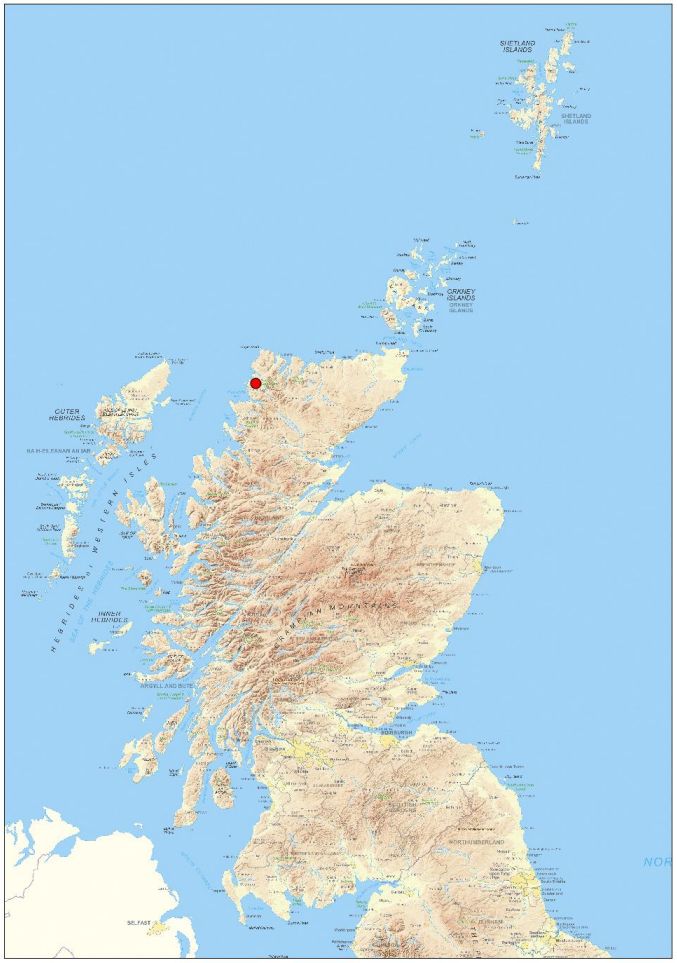


Figure 15. Inshore locations recording PSP toxin results above the maximum permitted limit (>800µg STX eq./kg) in 2019

Figure 16. Inshore locations recording PSP toxin results below the maximum permitted limit (≤800µg STX eq./kg) in 2019

1.3.1 Phytoplankton associated with the production of PSP toxins

- Dinoflagellates belonging to the genus *Alexandrium* (Figure 17) were observed in January and between March and October (Figure 18) and were detected in 336 (25.7%) of the 1,312 samples analysed during 2019. They were reported at or above the trigger level (set at 40 cells/L) in 203 samples (15.6%). Blooms were most frequently recorded between May and August, and 28.6% of the samples analysed in June breached the *Alexandrium* trigger level (Figure 19).
- The earliest *Alexandrium* blooms of 2019 were observed on 5th March at Ulva: Loch na Keal (Argyll & Bute) and Loch Roag: Linngeam (Lewis & Harris). Blooms were detected at other sites in Argyll & Bute and around the Highland region during spring (March/April). *Alexandrium* was observed at several sites around the Shetland Islands in June, but was most frequently recorded around Lewis & Harris from May to August.
- Toxin-producing *Alexandrium* appeared to be most prevalent in late May and early June. A bloom of 200 cells/L on 20th May in Loch Leurbost (east coast of the Isle of Lewis) was associated with PSP toxins at more the half the regulatory limit in mussels, with a further period of toxicity on 10th June, associated with *Alexandrium* at 180 cells/L. *Alexandrium* was present in Loch Laxford (Highland: Sutherland) on 21st May at a concentration of 40 cells/L, two weeks prior to mussels exceeding the regulatory limit for PSP toxins. *Alexandrium* at a density of 340 cells/L in Loch Torridon (Highland: Ross & Cromarty) was coincident with PSP toxins at more the half the maximum permitted level in mussels on 30th May. Toxic *Alexandrium* was also present in Loch Glencoul (Highland: Sutherland) throughout May and into June. The densest *Alexandrium* bloom of 2019 was observed in Loch Creran (Argyll & Bute) on 27th May, where a concentration of 4,280 cells/L was recorded.
- The percentage of samples with *Alexandrium* counts at or above trigger level in 2019 (15.6%) was lower than in 2018 (24.7%).

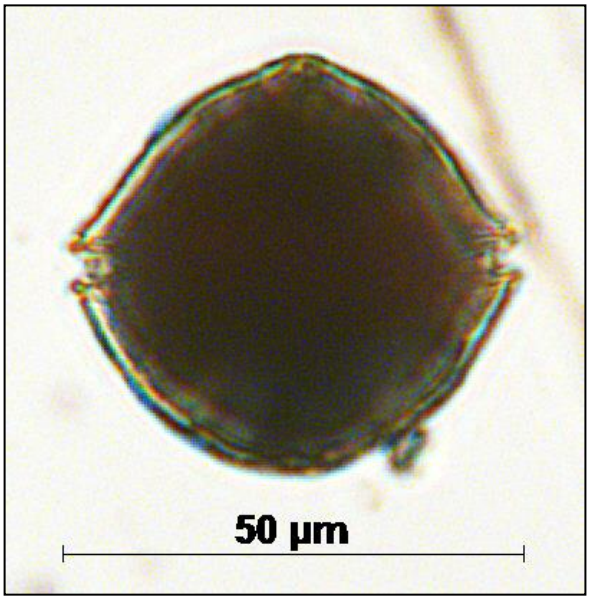
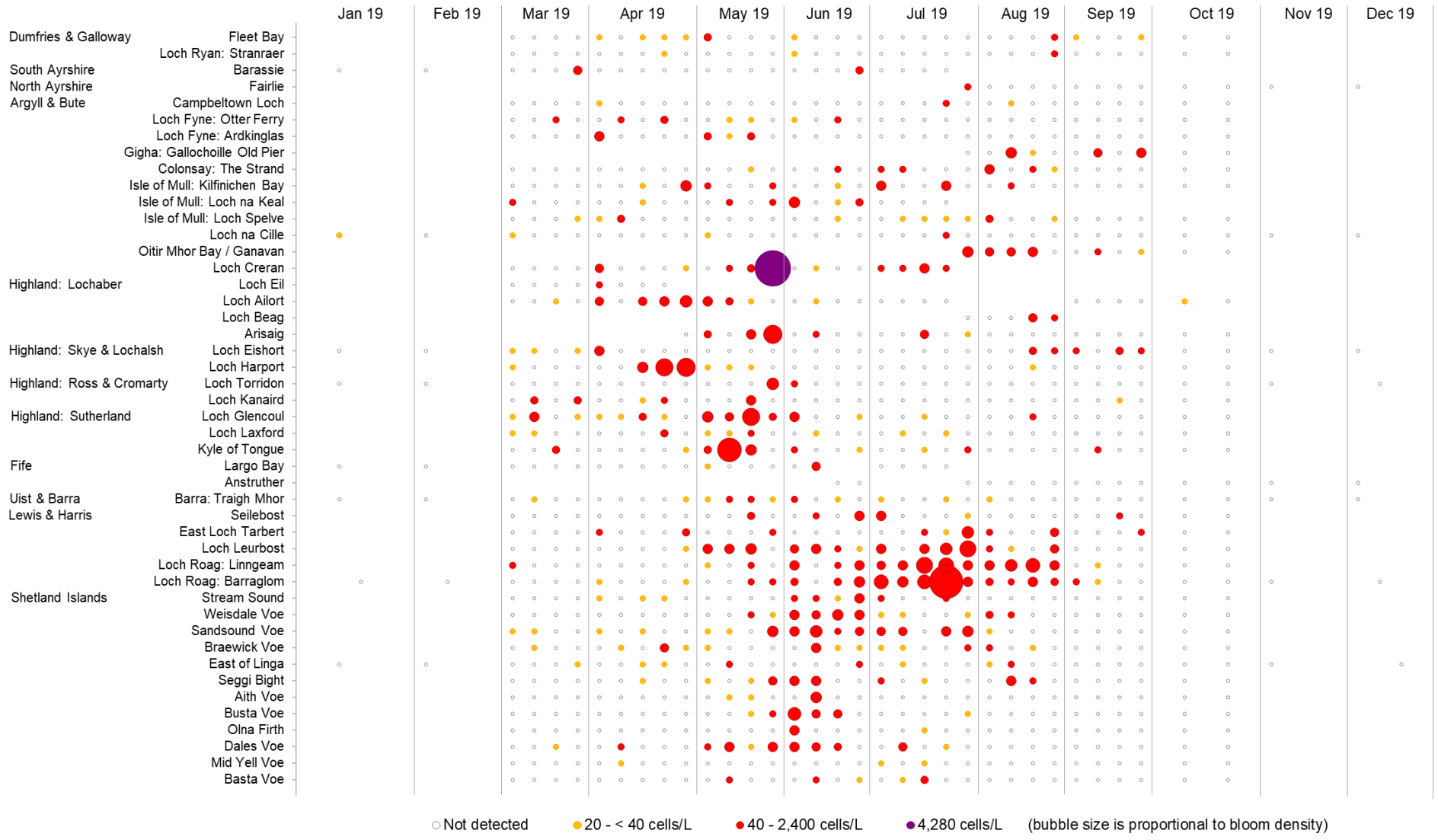


Figure 17. *Alexandrium* species from Loch Kanaird (Highland: Ross & Cromarty) on 26th March 2019.

Figure 18. Phytoplankton concentrations of *Alexandrium* observed between January and December 2019.



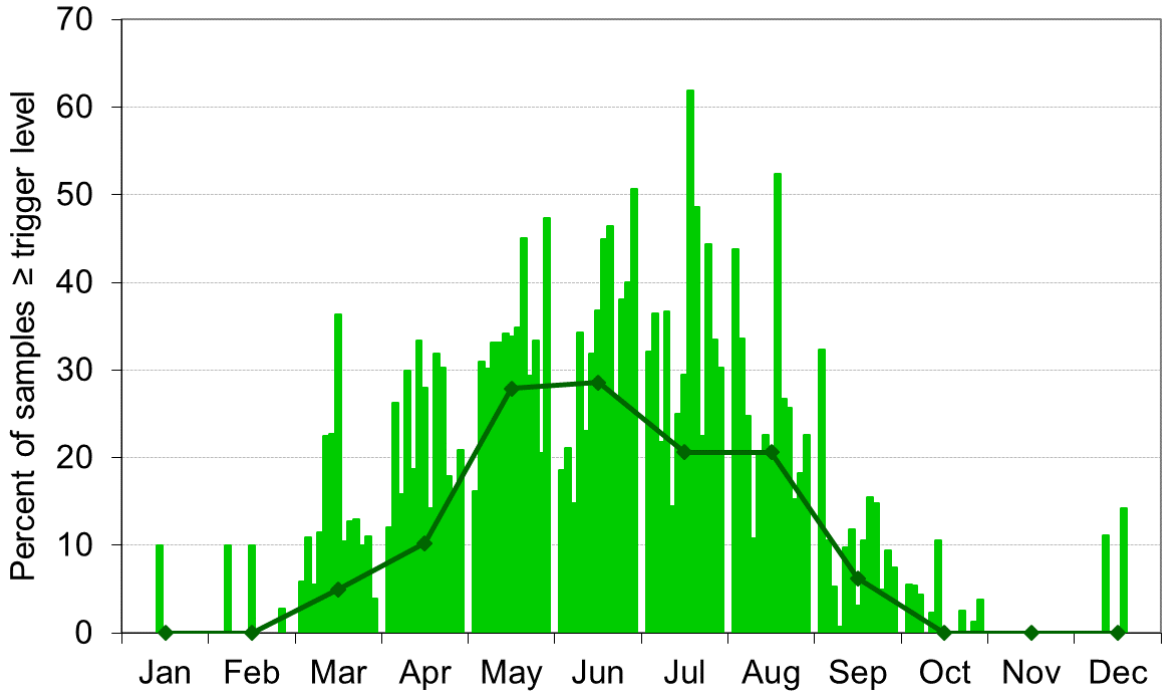


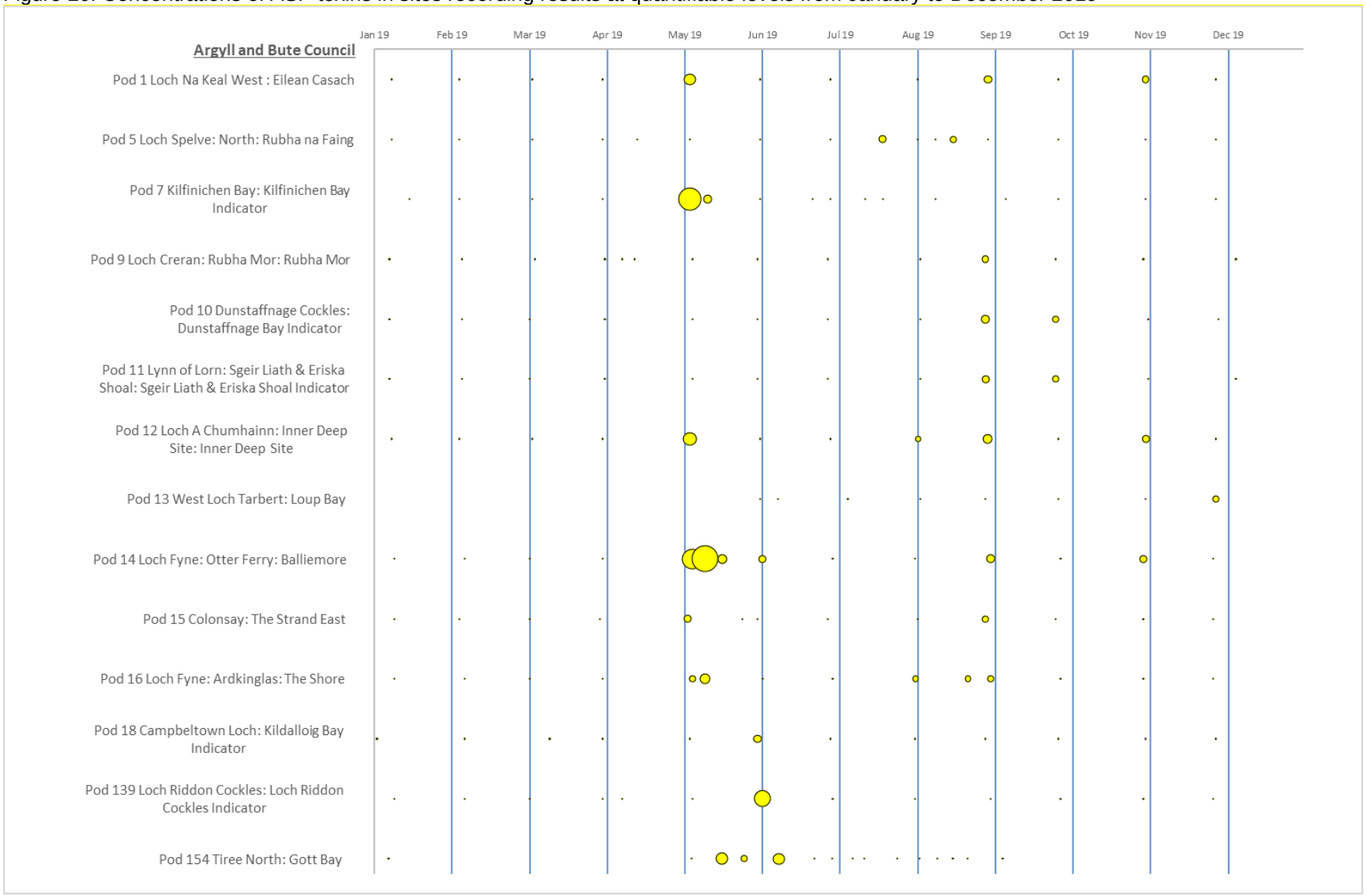
Figure 19. The percentage of samples in which *Alexandrium* equalled or exceeded the trigger level of 40 cells/L in 2019 is indicated by the line. (For comparison, the bars show the percentage of samples in which *Alexandrium* equalled or exceeded the trigger level between 2006 and 2018. NOTE: Data collected prior to July 2014 have been adjusted to the revised trigger level of 40 cells/L for comparative purposes).

1.4 Monitoring for ASP toxins

Analyses for amnesic shellfish poisoning (ASP) toxin were conducted on 907 samples and 9 king and queen scallop verification samples collected from a commercial establishment. All samples were analysed by an HPLC method (see section 1.7 for details). Results are summarised below.

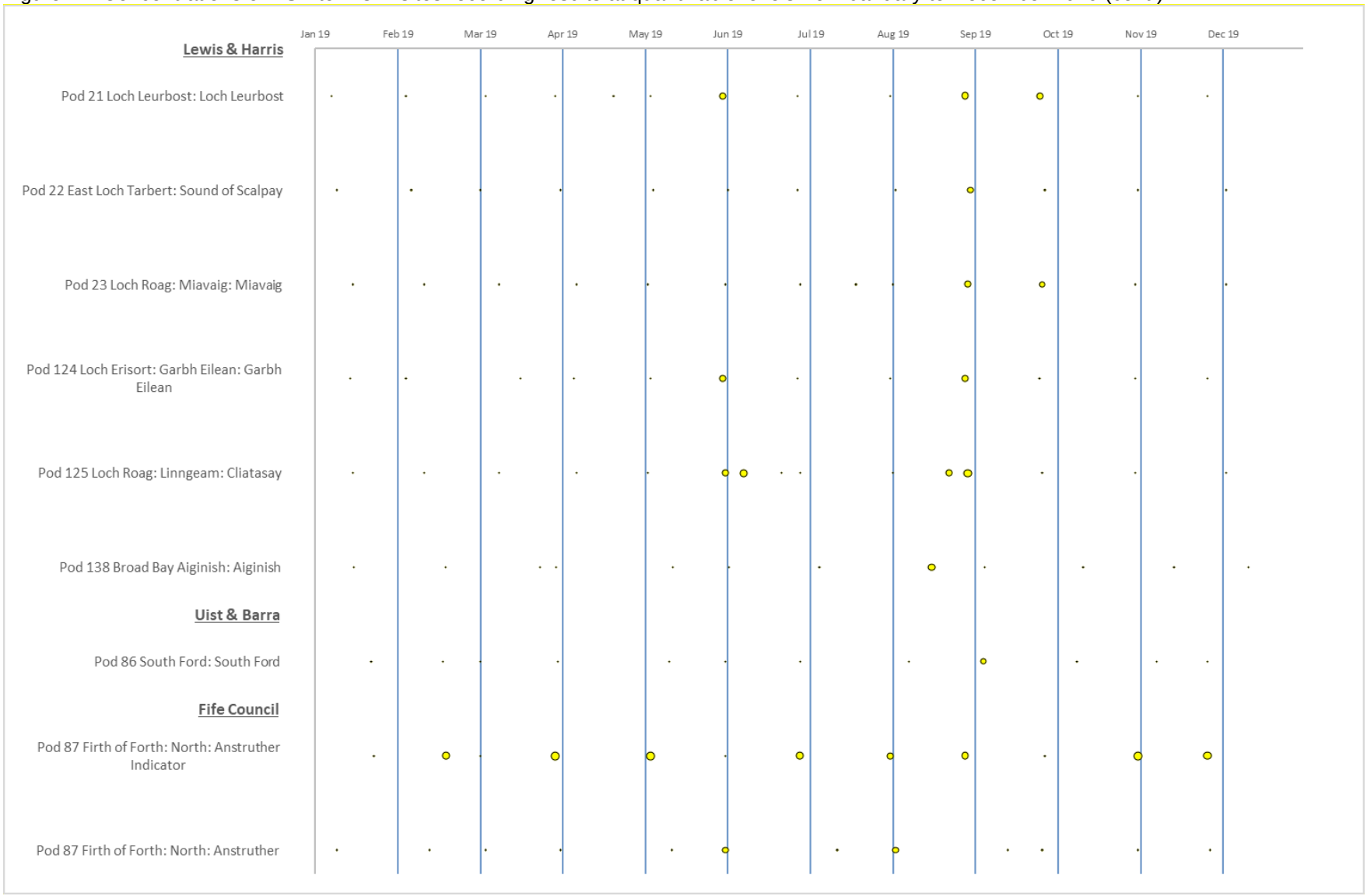
- ASP was detected in 94 inshore samples comprising of: common mussels (40 samples), razors (9), Pacific oysters (36), common cockles (1) and surf clams (8). These samples originated from 42 sites.
- Low concentrations were recorded throughout 2019 (Figure 20). The peak period occurring between May & September, during which time ASP was detected in 72 samples (Figure 20)
- No inshore samples exceeded the MPL of 20mg [domoic/epi domoic acid] (DA)/kg shellfish flesh (Figure 20). The highest level recorded was 18 mg/kg in a Pacific oyster sample collected in May 2019**,** originating from Loch Fyne, Otter Ferry.
- ASP was detected (below the MPL) in one scallop verification sample received in September 2019.

Figure 20. Concentrations of ASP toxins in sites recording results at quantifiable levels from January to December 2019



Concentration of ASP toxins:
Red = Toxins above MPL Yellow = Toxins below MPL Not Detected = ● (Bubble size is proportional to toxin concentration)

Figure 21. Concentrations of ASP toxins in sites recording results at quantifiable levels from January to December 2019 (cont.)



Concentration of ASP toxins:

Red = Toxins above MPL Yellow = Toxins below MPL Not Detected = ● (Bubble size is proportional to toxin concentration)

Figure 21. Concentrations of ASP toxins in sites recording results at quantifiable levels from January to December 2019 (cont.)

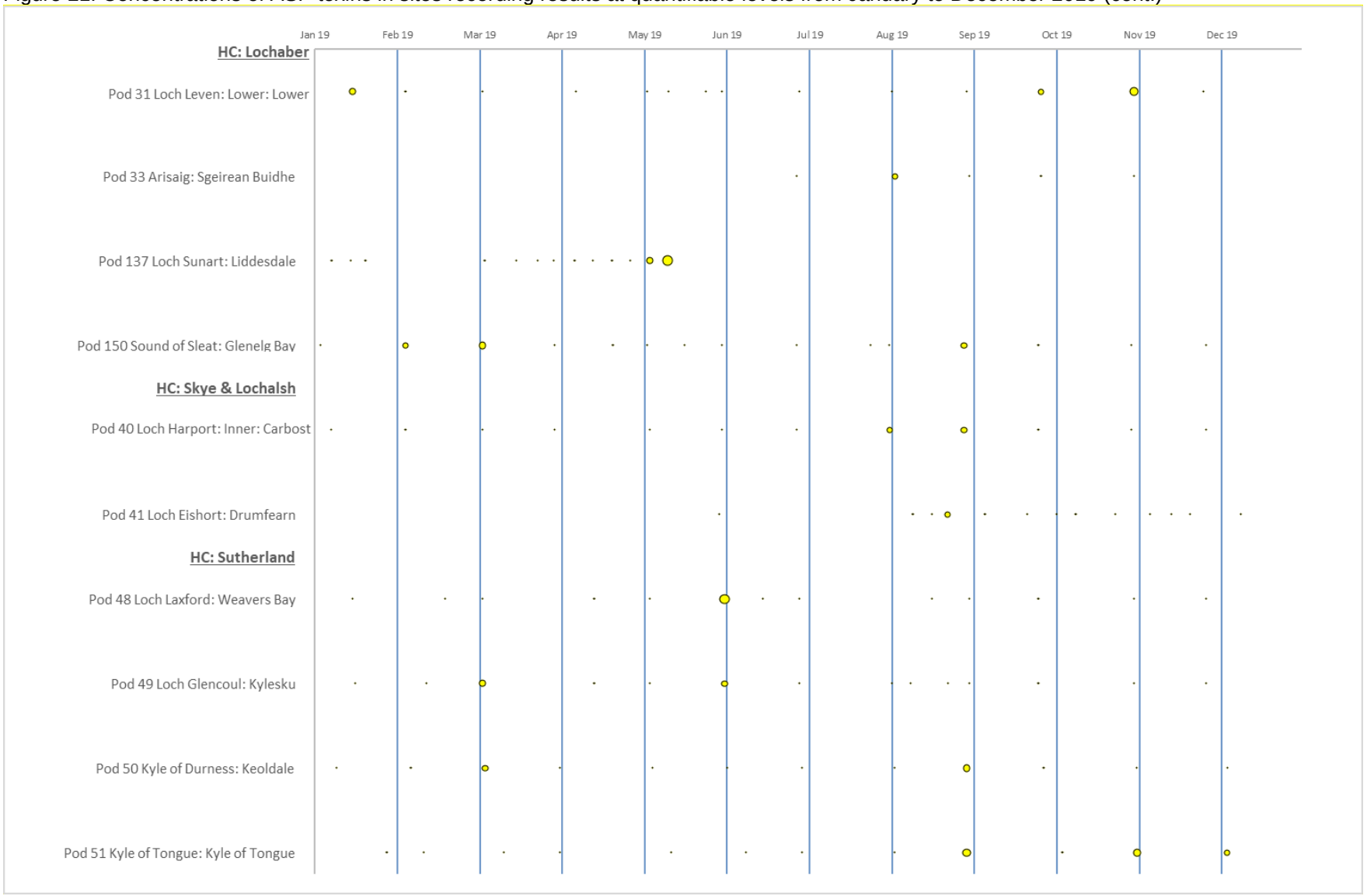


Figure 21. Concentrations of ASP toxins in sites recording results at quantifiable levels from January to December 2019 (cont.)

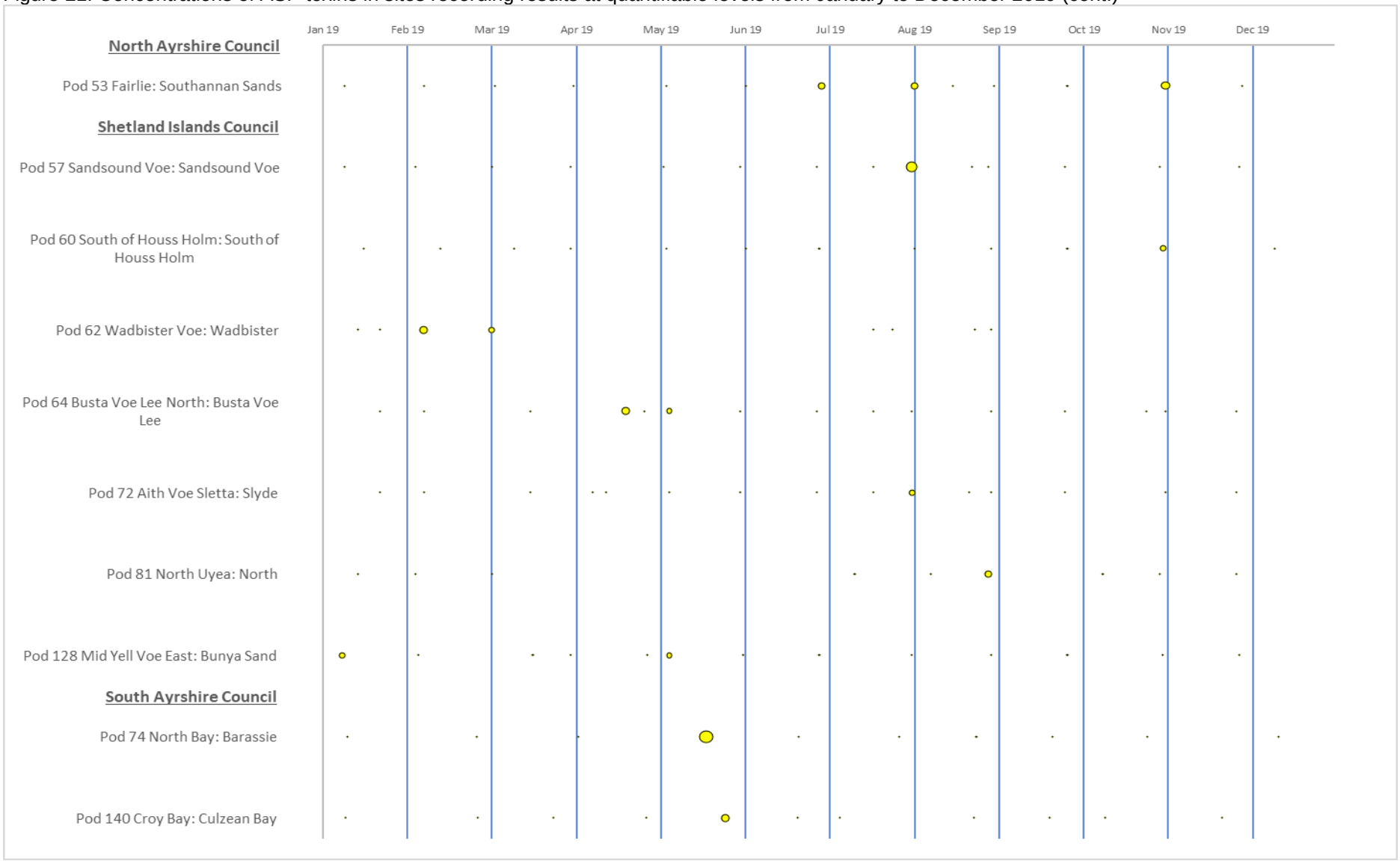


Figure 21. Inshore locations where ASP toxins were detected in 2019 (all below the maximum permitted limit (<20mg/kg))

1.4.1 Phytoplankton associated with the production of ASP toxins

- Diatoms belonging to the genus *Pseudo-nitzschia* (Figure 22) were detected in every month in 2019 (Figure 23) and were present in 1,211 (92.4%) of the 1,311 samples analysed. Blooms (here referred to as cell densities exceeding 50,000 cells/L) were detected between March and October and were most frequently observed in August.
- *Pseudo-nitzschia* counts at or above the trigger level (set at 50,000 cells/L) were recorded in 70 samples (5.3%), with 10.6% of the samples analysed in August exceeding this level (Figure 23). The earliest bloom of 2019 was recorded in Olna Firth (Shetland Islands) on 5th March, with an abundance of 52,735 cells/L. *Pseudo-nitzschia* abundance did not exceed trigger level again in the Shetland Islands until June, and a dense bloom of 355,811 cells/L was recorded at Clift Sound on 18th June. The latest bloom of 2019 occurred at another site in the Shetland Islands, Busta Voe, with a cell count of 80,846 cells/L reported on 21st October.
- Elsewhere around the Scottish coast, *Pseudo-nitzschia* blooms were observed in the Highland: Lochaber region and around Argyll & Bute in April/May. A bloom of *Pseudo-nitzschia seriata* group cells at a density of 179,840 cells/L at Loch Fyne: Ardkinglas (Argyll & Bute) on 8th May was associated with a low-level of ASP toxicity in Pacific oysters. Slightly further south at Loch Fyne: Otter Ferry, blooms of 74,787 cells/L and 64,540 cells/L (also *Pseudo-nitzschia seriata* group) occurred on the 8th May and 13th May, respectively. These blooms resulted in ASP toxins exceeding half the maximum permitted levels in Pacific oysters.
- The densest *Pseudo-nitzschia* bloom of 2019 was recorded in Loch Glencoul (Highland: Sutherland) on 6th August, where cell counts reached 508,124 cells/L.
- Since 2006 (when SAMS began monitoring), the percentage of samples in which *Pseudo-nitzschia* exceeded trigger level has varied from a high value of 17.2% in 2011 to a low value of 4.5% in 2018. The value for 2019 (5.3%) is more similar to that of the preceding six years.

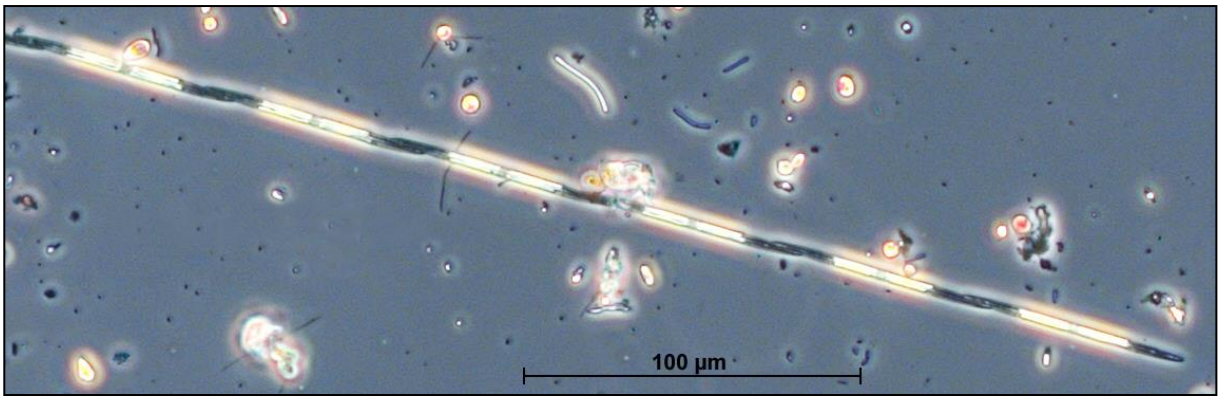


Figure 22. Chain of six *Pseudo-nitzschia delicatissima* group cells observed in Loch Harport (Highland: Skye & Lochalsh) on 15th April 2019.

Figure 23. Phytoplankton concentrations of *Pseudo-nitzschia* spp. observed between January and December 2019

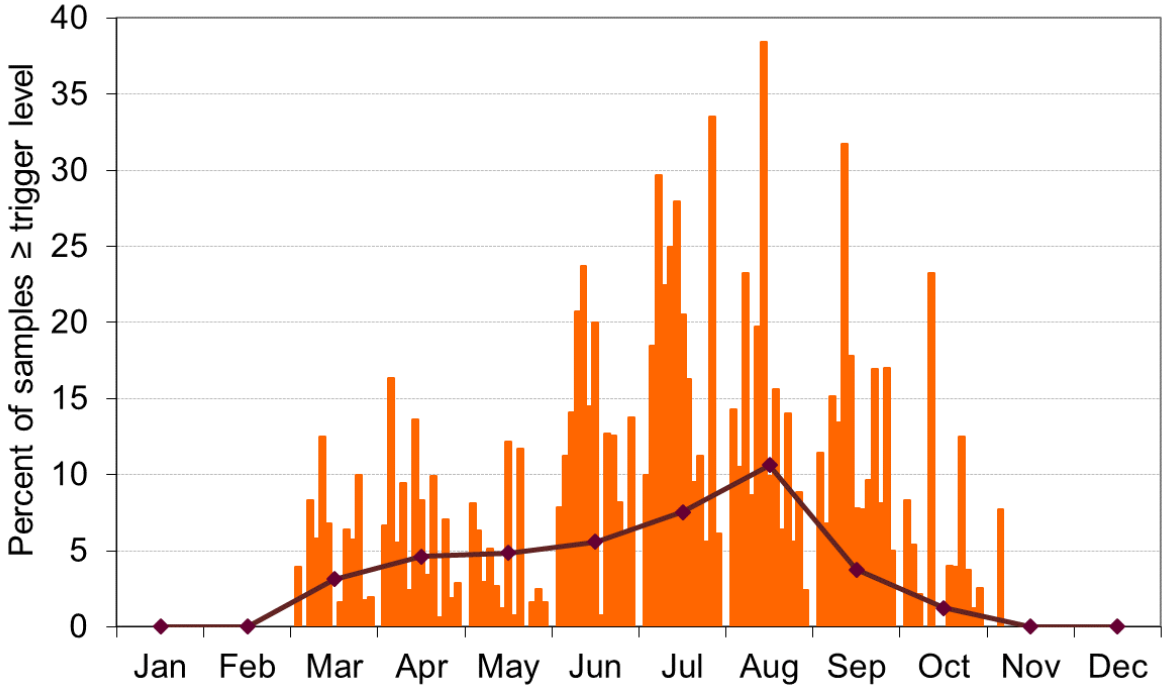


Figure 24. The percentage of samples in which *Pseudo-nitzschia* equalled or exceeded the trigger level of 50,000 cells/L in 2019 is indicated by the line. (For comparison, the bars show the percentage of samples in which *Pseudo-nitzschia* equalled or exceeded the trigger level between 2006 and 2018).

1.5 Other potentially harmful phytoplankton

The dinoflagellate *Prorocentrum cordatum* (Figure 25) was detected in 627 samples analysed in 2019 (47.8%). It was observed in January and from March through to November, typically at densities below 10,000 cells/L. It was most frequently recorded between April and July and was present in 87.9% of the May samples. *Prorocentrum cordatum* was widespread around the Scottish coast, but the densest blooms occurred around the Shetland Islands from May to July, with concentrations of 610,188 cells/L recorded in Clift Sound on 25th June, 597,253 cells/L in Vaila Sound and 631,468 cells/L in Sandsound Voe, both on 1st July. No trigger level has been set for this species.

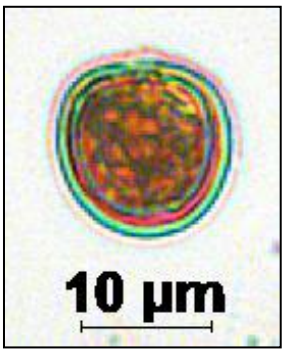


Figure 25. *Prorocentrum cordatum* from the Isle of Colonsay (Argyll & Bute) on 27th May 2019.

The potentially problematic dinoflagellate *Karenia mikimotoi* (Figure 26) was found in 206 (15.7%) of the samples analysed. It was present between March and November, but most frequently observed in August and September, being detected in 36.3% and 30.0% of the samples collected in these months, respectively. This species is not an issue in terms of shellfish harvesting, as it does not produce biotoxins that are harmful to human health, although it may negatively impact aquaculture. It produces ichthyotoxins that can kill finfish, and dense blooms of the order of several million cells/L may result in both fish and invertebrate mortality due to hypoxia. Cell counts were relatively higher than in 2018, with a maximum density of 2,574,796 cells/L recorded at Arisaig (Highland: Lochaber) on 27th August. Bloom densities of 807,089 cells/L were observed in Loch Kanaird (Highland: Ross & Cromarty) on 4th September, and 181,081 cells/L at Traigh Mhor (Uist & Barra) on 26th August.

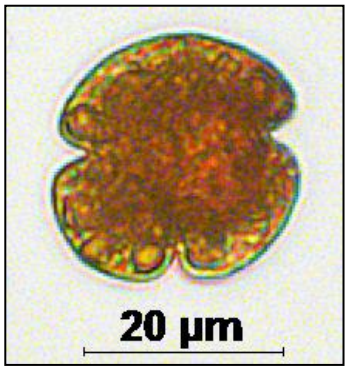


Figure 26. *Karenia mikimotoi* from Loch Fyne: Otter Ferry (Argyll & Bute) on 20th May 2019.

1.6 Results of the wild pectinidae onshore verification programme

ASP, PSP and LTs analyses were performed on nine samples from establishments in the South Ayrshire and Dumfries and Galloway regions received via the wild pectinidae onshore verification programme. All samples received were of processed king scallop (adductor and roe (8 samples)) and processed queen scallops (adductor and roe (1)). The origin of harvest for the scallop samples received during the reporting period is indicated by the shaded labels in Figure 27.

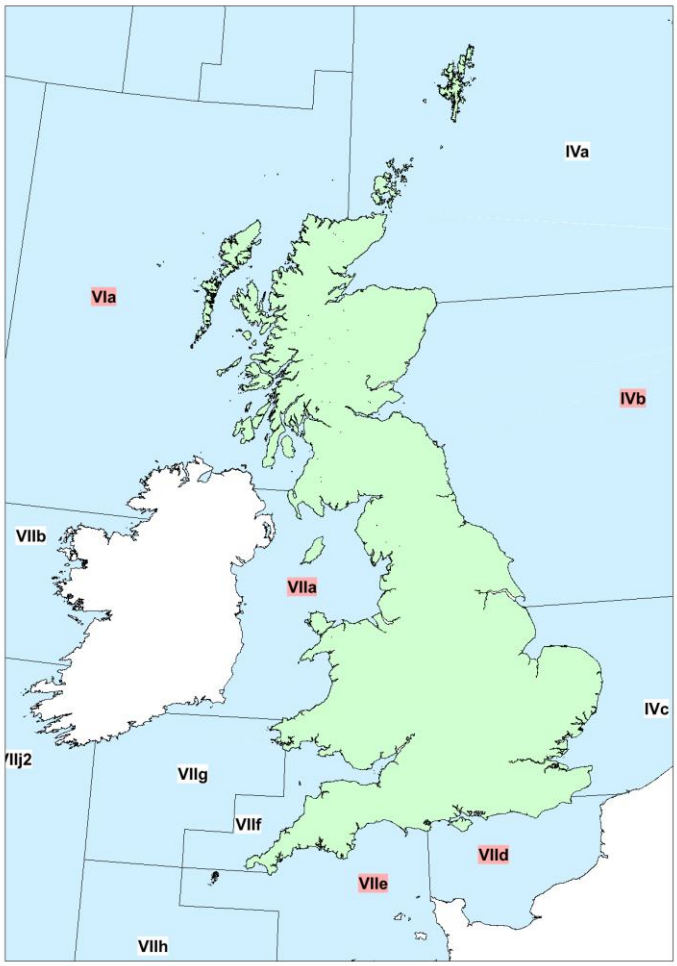


Figure 27. Origin of the wild pectinidae sample received via the FSS onshore official control verification programme in 2019

Low levels of ASP toxins (2.9 mg/kg) were detected in the sample of processed king scallops collected from the South Ayrshire region (region VIa, Figure 27) in September 2019. No other quantifiable levels of toxins were recorded.

1.7 Biotoxin Methodology

1.7.1 Shellfish collection

Inshore Monitoring Programme (classified shellfish production areas):

For the monitoring period of 1st January to 31st December 2019, 2,009 bivalve shellfish samples from 81 inshore sampling locations were submitted for toxin analyses. These sampling locations covered 76 pods within 9 Local Authority regions (13 regional offices).

The inshore samples received by Cefas during the reporting period comprised of mussels (*Mytilus* spp.) (1,352 samples – 67.3% of all samples), Pacific oysters (*Crassostrea gigas*) (442 – 22.0%), razors (*Ensis* spp.) (132 – 6.6%), common cockles (*Cerastoderma edule*) (38 – 1.9%), surf clams (*Spisula solida*) (32 – 1.6%) and native oysters (*Ostrea edulis*) (13 - 0.6%).

Since the 1st of April 2018, sampling officers from Hall Mark Meat Hygiene (HMMH) have collected or arranged collection for all samples from all geographic locations, under contract arrangement with Cefas. A further breakdown of sampling is provided in Table 2. For the purpose of this report and in line with FSS protocol, a 'verified' shellfish sample is defined as a sample collected from the agreed monitoring point by an authorised sampling officer. Samples 'verified from shore' are defined as samples collected by harvesters under the supervision of the authorised sampling officer. Such arrangements are implemented when sampling officers are unable to accompany the harvester to the location of the monitoring point and the collection, from the site, of shellfish by the harvester can be witnessed from shore by the sampling officer. Where collection from the shellfish bed cannot be witnessed from the shore by the sampling officer (due to the remoteness of the shellfish bed or the lack of suitable and accessible vantage point), the samples are recorded as 'unverified'.

During this reporting period, 7.9% (n=158) of the samples received were of unverified origin. Numbers however, varied significantly between Local Authority regions. A further breakdown of samples received (by species and fishery type) is provided in Table 3.

Table 2. Number of verified and unverified inshore biotoxin samples collected during the reporting period by Local Authority region

Local Authority	No. samples received	No. verified or verified from shore samples received & percentage		No. unverified samples received & percentage	
Argyll & Bute Council	548	536	97.8%	12	2.2%
Comhairle nan Eilean Siar: Lewis & Harris	218	207	95.0%	11	5.0%
Comhairle nan Eilean Siar: Uist & Barra	45	44	97.8%	1	2.2%
Dumfries & Galloway Council	27	19	70.4%	8	29.6%
East Lothian Council	9	2	22.2%	7	77.8%
Fife Council	78	42	53.8%	36	46.2%
Highland Council: Lochaber	153	140	91.5%	13	8.5%
Highland Council: Ross & Cromarty	63	62	98.4%	1	1.6%
Highland Council: Skye & Lochalsh	95	83	87.4%	12	12.6%
Highland Council: Sutherland	130	99	76.2%	31	23.8%
North Ayrshire Council	35	35	100.0%	0	0.0%
Shetland Islands Council	587	581	99.0%	6	1.0%
South Ayrshire Council	21	1	4.8%	20	95.2%
Total	**2009**	**1,851**	92.1%	**158**	7.9%

Table 3. Number of unverified inshore biotoxin samples collected during the reporting period by species and fishery type.

Species	Fishery type	No. of samples received	No. unverified samples received	Proportion of unverified samples received per species
Common cockles	Wild harvest	38	0	0.0%
Common mussels	Aquaculture	1352	40	3.0%
Common mussels	Wild harvest	0	0	
Pacific oysters	Aquaculture	442	0	0.0%
Razors	Wild harvest	132	96	72.7%
Surf clams	Wild harvest	32	20	62.5%
Native oysters	Wild harvest	13	2	15.4%

Shellfish were collected and packaged in accordance with the Shellfish Partnership sampling and transport protocol, itself based upon UKNRL guidance and sent to the Cefas Weymouth laboratory for analyses. All samples were posted using Royal Mail next day delivery service. The majority of samples (~99%) arrived at the laboratory within one or two working days of sample collection (~79 and ~20%, respectively) (
Table 4). When delays occurred, these were generally attributed to the time at which the samples were collected, thus missing the routine post office collection deadline or to other events outside of the laboratory or sampling officers' control, such as inclement weather or transport network problems.

Table 4 Number of inshore biotoxin samples received from each Local Authority region and time taken between collection and receipt at Cefas in 2019

Local Authority	No. samples received	No. received 1 working day post collection	No. received 2 working days post collection	No. received 3 working days post collection
Argyll and Bute Council	548	458	87	3
Comhairle nan Eilean Siar - Lewis & Harris	218	187	26	5
Comhairle nan Eilean Siar - Uist & Barra	45	36	7	2
Dumfries and Galloway Council	27	13	14	0
East Lothian Council	9	2	7	0
Fife Council	78	43	35	0
Highland Council: Lochaber	153	126	25	2
Highland Council: Ross & Cromarty	63	54	8	1
Highland Council: Skye & Lochalsh	95	74	19	2
Highland Council: Sutherland	130	114	15	1
North Ayrshire Council	35	33	2	0
Shetland Islands Council	587	441	141	5
South Ayrshire Council	21	8	13	0
Totals (percent)	**2009**	**1589 79.1%**	**399 19.9%**	**21 1.0%**

Careful programme management, training and liaison with sampling officers minimised the occurrence and impact of delays on the programme, with only <1% of samples (n=21) being received three working days post collection throughout this reporting period. No samples were received more than 3 working days post collection in 2019. None of the samples received more than one working day post collection were rejected as unsuitable for analyses (see section 1.4.2).

Wild pectinidae – Onshore Surveillance Programme:

Eight king scallop samples and one queen scallop sample (all comprising of adductor and roe only) were collected by authorised officers from the Dumfries and Galloway and South Ayrshire regions during the reporting period and submitted to Cefas for toxin analyses.

These samples originated from several of the ICES regions around the coast of the UK, with the majority (5 samples) originating from the Channel (ICES regions VIId and VIIe). All samples arrived one day post collection from the premises and results were available the following working day, with the exception of one sample which arrived after the sample receipt cut off time in September. This sample was processed the following day and results were available the day after.

1.7.2 Shellfish analysis

Assessment of suitability of the samples for analysis

On arrival at the laboratory, all samples were assigned a unique laboratory number and assessed for their suitability for analysis.

Shellfish which failed to respond to a percussion test, and/or did not exhibit the correct organoleptic characteristics associated with freshness or were accompanied by incorrect or missing paperwork were rejected and reported as unsuitable for analyses. A summary of the number of samples assessed as unsuitable during the reporting period is given in Table 5. Overall, only 3 inshore samples were rejected in 2019. All scallop verification samples were suitable for analysis. Therefore ~99.5% of all samples received were assessed as suitable for analysis and tested in 2019.

Table 5. Summary of inshore biotoxin samples found unsuitable for analyses, by Local Authority region.

Local Authority	No. samples received	No. rejected due to unsatisfactory quality or provenance	No. rejected due to other reasons (e.g.: arrived late or unscheduled sample)
Argyll & Bute Council	548	0	0
Comhairle nan Eilean Siar: Lewis & Harris	218	0	0
Comhairle nan Eilean Siar: Uist & Barra	45	0	0
Dumfries & Galloway Council	27	0	0
East Lothian Council	9	0	1
Fife Council	78	0	0
Highland Council: Lochaber	153	0	0
Highland Council: Ross & Cromarty	63	0	0
Highland Council: Skye & Lochalsh	95	0	0
Highland Council: Sutherland	130	0	0
North Ayrshire Council	35	0	0
Shetland Islands Council	587	0	2
South Ayrshire Council	21	0	0
Total (percent)	**2009**	**0 (0%)**	**3 (0.1%)**

Insufficient samples

Samples which were assessed as suitable for analysis were then prepared for ASP, LTs and/or PSP analyses (as required by the FSS testing regime for the relevant pod). The analyses to be conducted on each batch of samples were defined by the current risk assessment and co-ordinated by Cefas. All samples assessed as suitable for analyses yielded sufficient material for the required tests.

1.7.3 Methodology of shellfish analysis

The methods used for routine toxin analysis of shellfish were those specified by the FSA and involved the application of a range of analytical methods. These included liquid chromatography (LC) with Ultra-violet (UV) or fluorescence (FLD) detection or LC with tandem mass spectrometry (MS/MS) for either, a semi-quantitative screen or full toxin quantitation of samples. The methods used for toxin testing were as follows:

ASP testing

- Shellfish species received in the reporting period were tested by LC-UV analysis following extraction with 50% aqueous methanol and filtration of the crude extracts. The quantitative method was applied to all shellfish species and is based on the method of Quilliam et al., 1995.
- ASP results are reported as mg/kg of domoic and epi-domoic acid combined.

PSP testing

- Shellfish species received in the reporting period have all been validated at Cefas for the use of a refined LC-FLD method based on AOAC 2005.06. Samples were all extracted with 1% acetic acid and forwarded for semi-quantitation by LC-FLD. Any sample returning a semi-quantitative total toxicity of >400 µg STX eq/kg were then forwarded for full quantitation by LC-FLD.
- Screen positive samples under this limit were reported as <400 µg STX eq/kg.
- Quantitation was conducted following the fully quantitative AOAC 2005.06 method, with final results reported as total toxicities in µg STX eq/kg.

Lipophilic toxins testing

- All shellfish species were analysed by LC-MS/MS for the quantitation of all EU regulated lipophilic toxins. The method used was validated at Cefas and conforms to the performance characteristics and conditions stipulated by the EU Reference Laboratory (EU RL) for Marine Biotoxins.
- Results are reported as total toxicities in µg eq/kg for the OA, AZA and YTX groups separately.

Table 6 summarises the methods of analysis used throughout this reporting period. All methods are accredited to ISO17025:2017 standard. Table 7.7 summarises the toxin levels and cell concentrations used in the reporting period to trigger additional monitoring should these levels be breached.

Table 6. List of toxin analytical methods used, by species, in 2019

Toxin group	Methods employed	Species tested	Dates
ASP	LC-UV	All species	1st January to 31st December 2019
PSP	LC-FLD (screen, semi-quantitative screen & full quantitation)	All species	1st January to 31st December 2019
Lipophilic toxins	LC-MS/MS	All species	1st January to 31st December 2019

Table 7. Flesh and phytoplankton trigger levels

Toxin group	Levels of toxin or cell concentrations triggering additional monitoring if breached
ASP	≥10mg domoic/epi-domoic acid/kg shellfish flesh and/or *Pseudo-nitzschia* spp. ≥ 50,000 cells/L
LTs	OA/DTX/PTX group: ≥80 µg OA eq/kg shellfish flesh AZA group: ≥80 µg AZA1eq./kg shellfish flesh YTX group: ≥1.8mg/kg shellfish flesh and/or *Prorocentrum lima*/*Dinophysis* spp. ≥ 100 cells/L
PSP	≥400µg STX eq./kg shellfish flesh and/or *Alexandrium* spp. presence (40 cells/L)

1.7.4 Reporting of results

Upon completion of the required analyses, the results were collated and quality control checked prior to submission to FSS.

Results were reported on a daily basis. During this reporting period, Cefas were able to report individual results from 98.9% of all tests carried out within one working day of receipt and 100% within two working days (Table 8).

Of the 50 samples results which were reported after one working day of receipt, 22 samples (44%) required additional PSP LC-FLD quantitative analyses, thus incurring a delay in the reporting timeframe.

For reference, the turnaround times agreed with FSS and required from Cefas during the reporting period were as follows:

Table 8. Biotoxin sample turnaround times (from sample receipt) specified by FSS and achieved by the laboratory

Toxin and analysis method	FSS specified targets	Laboratory statistics in the reporting period (all results combined)
ASP by HPLC	90% within 1 working day 98% within 3 working days	98.9% within 1 working day 100% within 2 working days
Lipophilic toxins by LC-MS	90% within 1 working day 98% within 3 working days	
PSP by HPLC (screen)	90% within 1 working day 98% within 3 working days	
PSP by HPLC (quantitation)	90% within 2 working days 98% within 4 working days	

Required turnaround times were therefore all met and for all analyses, delivery by the laboratory exceeded the targets agreed with FSS.

In addition to daily reports, all results from samples received between Monday and Friday the previous week were collated and reported in a weekly results sheet to FSS, released by the following Tuesday.

A summary of results turnaround times, for inshore samples from day of receipt to completion of all required analyses for the period 1st January to 31st December 2019 is given in Table 9.

Table 9. Turnaround times, by Local Authority region, for biotoxin samples received from inshore areas in 2019

Local Authority	**No. samples received**	**No. of tests carried out**	**No. completed results reported within one working day of receipt of sample**	**No. completed results reported two working days after receipt of sample**
Argyll & Bute Council	548	1073	1065	8
Comhairle nan Eilean Siar: Lewis & Harris	218	463	449	14
Comhairle nan Eilean Siar: Uist & Barra	45	131	131	
Dumfries & Galloway Council	27	70	67	3
East Lothian Council	9	24	24	
Fife Council	78	146	145	1
Highland Council: Lochaber	153	331	331	
Highland Council: Ross & Cromarty	63	129	127	2
Highland Council: Skye & Lochalsh	95	187	182	5
Highland Council: Sutherland	130	266	261	5
North Ayrshire Council	35	61	61	
Shetland Islands Council	587	1195	1183	12
South Ayrshire Council	21	63	63	
Totals (percent)	**2009**	**4139**	**4089 (98.8%)**	**50 (1.2%)**

(Note, of the 50 samples reported by 2 days, 22 were due to PSP quantitative analysis which requires an additional 24 hours)

As agreed with FSS, toxin monitoring was suspended for 2 weeks over the Christmas period, the last toxin samples being accepted on Thursday 19th of December 2019 and last results reported on Friday 20th of December.

1.8 Phytoplankton Methodology

1.8.1 Water collection

For the monitoring period 1st January to 31st December 2019, a total of 1,311 seawater samples were collected from 48 sampling locations (46 Pods) within eight Local Authority regions (Table 10). As for shellfish samples, the majority of seawater samples were collected by officers operating on behalf of the sampling contractor, Hall Mark Meat Hygiene. At some sites, seawater samples were collected by harvesters, with the sampling procedure verified from the shore by the sampling officer (where possible).

Samples were collected and packaged in accordance with SRSL's guidance and protocols and sent to the SRSL Oban laboratory for analysis. All samples received were assessed and considered suitable for testing.

The sampling protocol used by appointed officers followed that described by the UKNRL SOP for the collection of water samples for toxic phytoplankton analysis (UK-NRL Phytoplankton WG, 2006). The aim of this method is to collect samples of phytoplankton that are representative of the community in the water body. The water sample is taken as close to the shellfish bed as possible and at the same location from where shellfish samples for tissue analysis are collected. Alternative sampling locations may be used with prior agreement from the competent authority. The sampling method used depends on the depth of water at the site, and water samples are collected with either a PVC sample tube (the preferred method) or a bucket, as appropriate. A well-mixed 500 mL sub-sample of this water is then preserved using Lugol's iodine and returned (usually by post) to SRSL for analysis.

The majority of samples (97.6%) arrived at the laboratory within one or two working days of sample collection, 84.5% and 13.1%, respectively (Table 10). Of the samples taking more than one working day to arrive, 86.2% were from remote areas. Of the 31 samples taking more than two working days to arrive, eleven of these were from the Isle of Colonsay (Argyll & Bute), fifteen from the Shetland Islands, four from the Western Isles, and one from Fife.

Table 10. Number of seawater samples collected during the reporting period by local authority and region, and time taken between collection and receipt at SRSL in 2019.

Local Authority	Region	Number of samples received in 2019	Number received 1 working day post collection	Number received 2 working days post collection	Number received 3 working days post collection	Number received ≥ 4 working days post collection
Argyll & Bute		292	265	16	3	8
Comhairle nan Eilean Siar	Lewis & Harris	164	136	26	2	0
Comhairle nan Eilean Siar	Uist & Barra	36	28	6	2	0
Dumfries & Galloway		64	49	15	0	0
Fife		36	30	6	0	0
Highland	Lochaber	64	64	0	0	0
Highland	Ross & Cromarty	68	63	4	1	0
Highland	Skye & Lochalsh	68	58	10	0	0
Highland	Sutherland	96	93	3	0	0
North Ayrshire		12	12	0	0	0
Shetland Islands		388	294	79	15	0
South Ayrshire		23	16	7	0	0
TOTAL (percent)		**1,311**	**1,108 (84.5%)**	**172 (13.1%)**	**23 (1.8%)**	**8 (0.6%)**

1.8.2 Phytoplankton analysis

Assessment of suitability of the samples for analysis

On arrival at the laboratory, all samples were assigned a unique laboratory number and assessed for their suitability for analysis. No samples were rejected in 2019.

Methodology

The UKNRL protocol for the identification and enumeration of potential toxin-producing phytoplankton was used to analyse all water samples (UK-NRL Phytoplankton WG, 2008). In the laboratory, a sub-sample of 50 mL is routinely settled (Figure 28), but if the amount of sediment present in the sub-sample is excessive, 25 mL or 10 mL sub-samples may be used.

Figure 28. Phytoplankton cells in a 50 mL sub sample of Lugol's-fixed seawater are allowed to settle onto the base plate of the chamber prior to analysis

The phytoplankton cells within the sub-sample are allowed to sink onto the base of a settling chamber for a minimum period of 20 hours (for a 50 mL sub-sample) before analysis. The cells are then identified and enumerated using an inverted light microscope. Final cell densities are calculated to express phytoplankton concentration as the number of cells per litre (cells/L) of sample. The method is accredited to ISO17025:2017 standard.

Test outcome

"Trigger" levels for toxic phytoplankton concentrations in the water column have been determined historically by comparing phytoplankton count data with the presence of biotoxins in shellfish tissue. However, sufficient data are not always available to allow trigger levels to be set for all the target harmful algal species. Trigger levels remained at the same cell concentrations as used since 2015 (Table 7).

1.8.3 Reporting of results

Upon completion of analyses, results were collated and quality control checked prior to submission to the FSS. During 2018, SRSL was able to report all results within three working days of sample receipt. This turnaround time is in full compliance with the targets specified by the FSS (98% of results reported within 3 working days of sample receipt).

In addition to the daily reporting schedule, all results from samples received the previous week were collated and reported in a weekly results sheet to FSS, released by the following Tuesday.

1.9 Monitoring programme review & recommendations:

1.9.1 Toxin monitoring

Sampling and testing frequencies for toxin and phytoplankton monitoring are defined by FSS, as the competent authority, based on the results of risk assessments which FSS commissioned in 2004 (Holtrop & Horgan), 2008 (Holtrop) and 2016 (Holtrop et al.). The recommendations of the 2016 risk assessment led to testing frequencies been defined and implemented for each site separately. The aim of the review conducted for this report was to look at toxin occurrence over the last couple of years (based on the resuls of the FSS official monitoring alone as industry data was not available) and identify sites where the set testing frequency may need adjustment, as a result of a recent change to toxin incidence and levels at these sites.

During 2019, the detection rates of toxins were relatively low compared with previous year. All toxins occurrences occurred within periods of elevated testing for that toxin group. The only point for consideration occurred in Pod 21 Loch Leurbost, where PSP weekly monitoring had ceased at the end of May and PSP toxins were still detected on the 10th of June. The high level 124 ug STXeq/kg recorded in this sample was the highest level recorded in this event which commenced in mid May.
Recommendation: *Consider the extension of weekly or fortnightly sampling/testing for PSP in June for Pod 21.*

1.9.2 Phytoplankton monitoring

The phytoplankton monitoring points used in 2019 were reviewed following the 2018 annual report. The suggested RMP changes in Table 11 below were implemented in in July 2019 following the resolution of practical issues such as site access and sampling methods. Due to the delay in implementation and the lower rate of detection of toxins in 2019, the impact of these changes is difficult to assess. However, all sites where toxins were detected, algae from the relevant species were detected at or before the time of toxin detection.

Table 11. Recommended changes to phytoplankton monitoring RMPs

Previous phytoplankton RMP	New (from July 2019) phytoplankton RMP
Pod 74 – North Bay: Barassie	Pod 53 Fairlie: Southannan Sands
Pod 1- Loch na Keal West: Eilean Casach	Pod 123 – Gallochoille Pier: Gallochoille Pier Indicator
Pod 9 – Loch Creran: Rubha Mor	Pod 84 – Oitir Mhor Bay: Oitir Mhor Bay Indicator
Pod 126 – Loch Ailort: Eilean Dubh	Pod 28 - Loch Beag: Ardnambuth
Pod 80 – Forth Estuary: Largo Bay: Largo Bay	Pod 87 – Forth Estuary: Anstruther

Section 2. *E. coli*

2.1 Introduction

Bivalve molluscan shellfish (referred to hereafter as shellfish) can accumulate bacteria and other contaminants, including pathogens associated with faeces, through the natural process of filter feeding. This in turn can pose a potential risk of illness to consumers, who may eat shellfish raw or lightly cooked.

In accordance with EU regulation, shellfish harvesting areas are classified by Food Standards Scotland (FSS) according to the level of faecal contamination that they are exposed to. This is determined in part through monitoring of *Escherichia coli* in shellfish flesh and intra-valvular fluid. In this context, *E. coli* is used as an indicator of faecal contamination. Subsequent treatment processes (e.g. depuration, heat treatment) are prescribed according to the classification status of the area. The classification categories are set out in Table 12.

Table 12. Criteria for the classification of bivalve shellfish harvesting areas

Classification category	**Microbiological standard[1]**	**Post-harvest treatment required**
Class A	Samples of live bivalve molluscs from these areas must not exceed, in 80 % of samples collected during the review period, 230 *E. coli* per 100 g of flesh and intra-valvular liquid The remaining 20 % of samples must not exceed 700 *E. coli* per 100 g of flesh and intra-valvular liquid[2]	None – live bivalve molluscs can be harvested for direct human consumption if the end product standard requirements are met
Class B	Live bivalve molluscs from these areas must not exceed, in 90 % of the samples, 4 600 MPN *E. coli* per 100 g of flesh and intra-valvular liquid. In the remaining 10 % of samples, live bivalve molluscs must not exceed 46 000 MPN *E. coli* per 100 g of flesh and intra-valvular liquid[3]	Purification in an approved establishment, or Re-laying for at least one month in an approved Class A relaying area, or An EC approved heat treatment process
Class C	Live bivalve molluscs from these areas must not exceed 46 000 *E. coli* MPN per 100 g of flesh and intra-valvular liquid[4]	Relaying for at least two months in an approved Class B re-laying area followed by treatment in an approved purification centre, or Relaying for at least two months in an approved Class A relaying area, or After an EC approved heat treatment process
Prohibited	>46,000 *E. coli* MPN/100g[5]	Harvesting not permitted

[1] The reference method for analysis of E. coli is the detection and Most Probably Number (MPN) technique specified in EN/ISO 16649-3. Alternative methods may be used if they are validated against this reference method in accordance with the criteria in EN/ISO 16140 (Regulation (EC) 854/2004 as amended by Regulation (EC) 2285/2015).

[2] Regulation (EC) 854/2004 as amended by Regulation (EC) 2285/2015.

[3] Regulation (EC) 854/2004 as amended by Regulation (EC) 1021/2008

[4] Regulation (EC) 854/2004

[5] This level is not specifically given in the Regulation but does not comply with classes A, B or C. The competent authority has the power to prohibit any production and harvesting of bivalve molluscs in areas considered unsuitable for health reasons.

This is the basis of policy for the monitoring and classification of shellfish harvesting areas in Scotland. The FSS protocol for classification and management is available on the FSS' website.

Cefas is contracted by FSS to deliver microbiological testing of monitoring samples for *E. coli* for all Scottish shellfish production areas. Samples are collected and sent to the laboratory by sampling officers according to an agreed schedule and protocol. Samples are transported under controlled time and temperature specifications (Appendix I) to Cefas Weymouth Laboratory or, for Shetland samples only, to SSQC Ltd, Shetland.

Cefas collates all results and forwards them to FSS weekly, or in real time in the event of results exceeding the upper maximum for the prescribed classification category (described as 'outwith' results) as per agreed laboratory reporting procedures.

All data generated under the Scottish shellfish harvesting classification programme for the last 10 years are available on the Cefas website. *E.coli* results are also available on the Scotland's Aquaculture website and on FSS' website.

This report presents summary data for the microbiological monitoring for Scotland generated between January 1st and December 31st 2019.

2.2 Methodology

2.2.1 Shellfish collection

For the monitoring period of 1st January to 31st December 2019, 2,072 bivalve shellfish samples from 173 Representative Monitoring Points (RMP) were submitted for microbiological analyses (SSQC *n*= 683; Cefas *n*=1,389). These sampling locations covered classified production areas within 9 Local Authority regions (13 regional offices).

The samples received by the testing laboratories during the reporting period comprised of Common mussels (*Mytilus* spp.) (1,028 samples – 49.6% of all samples), Pacific oysters (*Crassostrea gigas*) (423 –20.4%), Common cockles (*Cerastoderma edule*) (298 – 14.4%), Razor clams (*Ensis* spp.) (258 – 12.5%), Surf clams (*Spisula solida*) (39 – 1.9%), Native oysters (*Ostrea edulis*) (12 – 0.6%), Sand gapers (*Mya arenaria*) (10 - 0.5%) and Carpet clams (*Venerupis pullastra*) (4 - 0.2%)

Since the 1st April 2018, sampling officers from Hall Mark Meat Hygiene (HMMH) have collected or arranged collection for all samples from all geographic locations, under contract with Cefas. A further breakdown of sampling is provided in Table 14. For the purpose of this report and in line with FSS protocol, a 'verified' shellfish sample is defined as a sample collected from the agreed monitoring point by an authorised sampling officer. Samples 'verified from shore' are defined as samples collected by harvesters under the supervision of the authorised sampling officer. Such arrangements are implemented when sampling officers are unable to

accompany the harvester to the location of the monitoring point and the collection, from the site, of shellfish by the harvester can be witnessed from shore by the sampling officer. Where collection from the shellfish bed cannot be witnessed from the shore by the sampling officer (due to the remoteness of the shellfish bed or the lack of suitable and accessible vantage point), the samples are recorded as 'unverified'.

During this reporting period, 15.2% of the samples received were of unverified origin. Numbers however, varied significantly between Local Authority regions. A further breakdown of samples received (by species and fishery type) is provided in Table 13

Table 13. Number of verified and unverified *E. coli* samples collected during the reporting period by Local Authority region and by sampling contractor

Local Authority	No. samples received	No. verified and verified from shore samples received & percentage		No. unverified samples received & percentage	
Argyll & Bute Council	614	509	82.9%	105	17.1%
Comhairle nan Eilean Siar: Lewis & Harris	224	212	94.6%	12	5.4%
Comhairle nan Eilean Siar: Uist & Barra	91	90	98.9%	1	1.1%
Dumfries & Galloway Council	45	22	48.9%	23	51.1%
East Lothian Council	21	2	9.5%	19	90.5%
Fife Council	51	6	11.8%	45	88.2%
Highland Council: Lochaber	136	136	100.0%	0	0.0%
Highland Council: Ross & Cromarty	34	34	100.0%	0	0.0%
Highland Council: Skye & Lochalsh	45	35	77.8%	10	22.2%
Highland Council: Sutherland	53	39	73.6%	14	26.4%
North Ayrshire Council	23	14	60.9%	9	39.1%
Shetland Islands Council	683	663	97.1%	20	2.9%
South Ayrshire Council	52	1	1.9%	51	98.1%
Total	**2072**	**1763**	**85.1%**	**309**	**14.9%**

Shellfish were collected and packaged in accordance with the Shellfish Partnership sampling and transport protocol, itself based upon UKNRL guidance, and sent to the laboratories for analyses. Samples posted to Cefas were sent using Royal Mail next day delivery service. The majority of samples (98%) arrived at the laboratory within 48h of sample collection (Table 14). When delays occurred, these were generally attributed to the time at which the samples were collected, thus missing the routine post office collection deadline or to other events outside of the laboratory or sampling officers' control, such as inclement weather or transport network problems. Samples were examined if they passed the time and temperature criteria.

Table 14. Number of *E. coli* samples received from each Local Authority region and time taken between collection and receipt at the laboratories in 2019

Local Authority	No. samples received	No. received within 48h of collection	No. received more than 48h post collection
Argyll and Bute Council	**614**	**598**	**16**
Comhairle nan Eilean Siar - Lewis & Harris	**225**	**216**	**9**
Comhairle nan Eilean Siar - Uist & Barra	**91**	**87**	**4**
Dumfries and Galloway Council	**45**	**45**	**0**
East Lothian Council	**21**	**17**	**4**
Fife Council	**51**	**47**	**4**
Highland Council: Lochaber	**136**	**132**	**4**
Highland Council: Ross & Cromarty	**34**	**34**	**0**
Highland Council: Skye & Lochalsh	**45**	**45**	**0**
Highland Council: Sutherland	**53**	**53**	**0**
North Ayrshire Council	**23**	**23**	**0**
Shetland Islands Council	**682**	**682**	**0**
South Ayrshire Council	**52**	**52**	**0**
Totals (percent)	**2072**	**2031 (98.0%)**	**41 (2.0%)**

Careful programme management, training and liaison with sampling officers minimised the occurrence and impact of delays on the programme, with 2% of samples (n=41) being received more than 48h post collection throughout this reporting period.

2.2.2 Receipt and analysis of shellfish

The proportion of samples rejected on arrival at the laboratory was 3.0% (*n*=62). The majority of rejections were due to exceedance of the time/temperature criteria as follows:

- Time between sample collection and arrival at the laboratory exceeded 48 hours only (n=18)
- Sample receipting temperature at the laboratory exceeded 10°C only (n=2)
- Samples exceeded both time and temperature criteria (n=23)

The remaining 19 samples were rejected for the following reasons:

- Duplicate samples collected from same zone (n=2)
- Collected outside classified area (n=11)
- Collected within less than seven days of the previous sample (n=1)
- Incubator failure (n=3)
- Sample not required (n=1)
- Wrong species collected (n=1)

A further 2 samples were accepted for testing; however the result returned an improbable number combination and as such the results were void.

Analysis of samples assessed as suitable was initiated within 48h of sample collection 100% of the time (FSS target = 98% of all sample analysis initiated within 48h of sample collection).

The EU reference method followed for enumeration of *E. coli* in shellfish was the ISO 16649-3:2015 method specified by FSS (ISO, 2015). Initial preparation of shellfish samples is described in ISO 6887-3 (ISO 2003) and derivation of MPN results is described in ISO 7218 (ISO 2007).

This procedure is transcribed in Cefas SOPs 1172, 1175 and SSQC SOP BM018. Both Cefas and SSQC laboratories hold method-specific accreditation to ISO/IEC 17025 standard.

A total of 2010 tests were undertaken between January 1st and December 31st 2019. The number of samples received and analysed by local authority is presented in Table 15. Two samples tested returned an invalid result.

Table 15. Numbers of *E. coli* samples received, and results reported in 2019

Local Authority area	**No. of samples received**	**No. of samples tested**	**% tested**
Argyll and Bute Council	614	594	96.7%
Comhairle nan Eilean Siar: Lewis and Harris	224	213	95.1%
Comhairle nan Eilean Siar: Uist and Barra	91	87	95.6%
Dumfries and Galloway Council	45	45	100.0%
East Lothian Council	21	12	57.1%
Fife Council	51	46	90.2%
Highland Council: Lochaber	136	132	97.1%
Highland Council: Ross and Cromarty	34	33	97.1%
Highland Council: Skye and Lochalsh	45	45	100.0%
Highland Council: Sutherland	53	51	96.2%
North Ayrshire Council	23	23	100.0%
Shetland Islands Council	682	677	99.3%
South Ayrshire Council	52	52	100.0%
Total	**2072**	**2010***	97.1%

*Including samples which returned an improbable number combination

A summary of samples received from each local authority by month is given in Table 16. The breakdown of samples by month was based on the number of samples submitted and in accordance with schedules determined by FSS. Therefore, some samples received and analysed in November were attributed to December.

Table 16. Breakdown of samples received from Local Authorities by month in 2019

Local Authority Area	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Argyll and Bute Councill	48	50	53	64	50	50	54	55	45	46	75	24
Comhairle nan Eilean Siar: Lewis and Harris	18	22	18	18	18	18	19	18	18	20	18	20
Comhairle nan Eilean Siar: Uist and Barra	6	6	6	8	8	9	13	7	7	7	13	1
Dumfries and Galloway Council	4	4	4	4	4	4	4	4	4	4	4	1
East Lothian Council	4	3	2	0	2	4	2	2	2	0	0	0
Fife Council	4	6	4	4	4	5	4	4	4	4	4	4
Highland Council: Lochaber	11	14	11	11	11	11	11	11	11	11	16	7
Highland Council: Ross and Cromarty	3	3	3	1	3	3	3	3	1	5	5	1
Highland Council: Skye and Lochalsh	4	3	4	6	2	3	3	4	4	4	7	1
Highland Council: Sutherland	4	4	4	4	4	4	4	5	4	6	5	5
North Ayrshire Council	2	2	2	2	2	2	2	2	2	2	1	2
Shetland Islands Council	56	57	56	69	49	59	57	56	54	59	85	25
South Ayrshire Council	5	5	2	5	5	5	5	5	3	5	3	4

2.2.3 Reporting of results

Upon completion of analyses, the results were collated, and quality control checked prior to submission to FSS. All results were reported in accordance with the agreed laboratory reporting procedures and laboratory turnaround times detailed below (Table 17). Actionable results were reported as soon as available and all weekly results fully reported every Tuesday.

Table 17. *E. coli* sample turnaround times (from sample receipt) specified by FSS and achieved by the laboratory

Type of result	FSS specified targets	Laboratory statistics in the reporting period
E. coli actionable result	98% reported within 3 working days of onset of analysis	99%
E. coli non-actionable result	98% reported within 5 working days of onset of analysis	100%

Required turnaround times were therefore all met and delivery by the laboratories exceeded the targets agreed with FSS.

As agreed with FSS, microbiological monitoring was suspended for 2 weeks over the Christmas period, the last sample being accepted on 19th December and the last result reported on 21st December 2019.

2.3 Samples received by production area

Summaries of samples received, rejected and providing results outwith of their classification are shown in Tables 18-30 for each classified production area in each local authority.

2.3.1 Argyll & Bute Council

Table 18. *E. coli* samples received from Argyll & Bute Council area

Production Area	Site Name	Site	Sample Species	Samples received	Outwiths	Rejected samples
Ardencaple	Ardencaple cockles	AB 818 2146 04	Common cockles	12		
Campbeltown Loch	Kildalloig Bay	AB 029 008 04	Common cockles	13		
Castle Stalker	Port Appin	AB 492 909 04	Common cockles	12	2	
Coll Razors	Crossapol Bay	AB 837 2246 16	Razors	2		
Colonsay	The Strand (West)	AB 041 009 13	Pacific oysters	1		
Colonsay	The Strand (East)	AB 041 1199 13	Pacific oysters	12		2
Colonsay East of the Strand	Islands of Colonsay and Oransay	AB 774 1987 16	Razors	5		
Dunstaffnage Cockles	Dunstaffnage Bay	AB 696 1511 04	Common cockles	12		
East Tarbert Bay	Isle of Gigha	AB 541 972 13	Pacific oysters	12	1	
Eriska Shoal	Eriska Shoal Cockles	AB 490 907 04	Common cockles	12	1	
Eriska Shoal Carpet Clams	Eriska Shoal Carpet Clams	AB 547 1006 02	Carpet Clams	4		
Gallochoille Old Pier	Gallochoille Old Pier	AB 699 1519 13	Pacific oysters	12	1	
Ganavan Cockles	Ganavan	AB 697 1512 04	Common cockles	13	1	
Islay	Loch Gruinart Craigens	AB 094 011 13	Pacific oysters	11	1	
Kerrera East	Ardantrive	AB 697 1513 04	Common cockles	13	1	1
Kerrera West	Oitir Mhor	AB 697 1514 04	Common cockles	14		1
Kilbrannan Sound	Kilbrannan Sound Gapers	AB 849 2287 18	Sand Gapers	10		
Kilfinichen Bay	Kilfinichen Bay	AB 695 1507 04	Common cockles	12		
Loch A Chumhainn: Inner Deep Site	Inner Deep Site	AB 112 017 13	Pacific oysters	12	2	
Loch A Chumhainn: Outer	Outer	AB 113 018 13	Pacific oysters	12	1	
Loch Craignish Cockles	Ardfern	AB 786 2028 04	Common cockles	14	3	
Loch Creran Cockles	Loch Creran Cockles	AB 729 1685 04	Common cockles	12	1	
Loch Creran Upper Oysters	East - Barrington	AB 129 021 13	Pacific oysters	12		
Loch Creran: Rubha Mor	Rubha Mor	AB 130 022 13	Pacific oysters	12	1	
Loch Fyne: Ardkinglas Oysters	The Shore	AB 147 036 13	Pacific oysters	12	2	
Loch Fyne: Otter Ferry	Balliemore	AB 151 039 13	Pacific oysters	12	1	
Loch Fyne: Otter Point	Otter Point	AB 714 1659 04	Common cockles	13	2	
Loch Fyne: Stonefield Oysters	North Bay Oysters	AB 435 840 13	Pacific oysters	10	1	1
Loch Gair	Loch Gair Common Cockles	AB 863 2347 04	Common cockles	8		1

Loch Linnhe	Loch Linnhe	AB 172 047 13	Pacific oysters	12	1	
Loch na Cille	Loch na Cille Cockles	AB 617 1204 04	Common cockles	13	2	
Loch Na Keal	Eilean Liath	AB 284 080 13	Pacific oysters	12	1	
Loch Na Keal West	Eilean Casach	AB 286 082 13	Pacific oysters	12		
Loch Riddon Cockles	Loch Riddon Cockles	AB 656 1409 04	Common cockles	14	1	
Loch Spelve Cockles	North West Spelve	AB 767 1963 04	Common cockles	12		
Loch Spelve Croggan Pier	Croggan Pier	AB 199 055 13	Pacific oysters	12		
Loch Spelve North	Ardura	AB 200 1915 08	Common mussels	12	2	
Lynn of Lorn Sgeir Liath	Sgeir Liath	AB 318 068 13	Pacific oysters	12		
North Connel Cockles	Ledaig Point Cockles	AB 758 1909 04	Common cockles	12		
Oitir Mhor Bay	Oitir Mhor	AB 308 701 13	Mussels	1		1
Oitir Mhor Bay	Oitir Mhor	AB 308 701 13	Pacific oysters	13		1
Seil Point	Poll a' Bhrochain (Cyster)	AB 245 070 13	Pacific oysters	13	1	
Seil Sound East	East of Balvicar	AB 247 703 08	Common mussels	11		1
Seil Sound North	Balvicar North	AB 247 735 13	Pacific oysters	11		1
Seil Sound: Balvicar	Rubha nan Ron South	AB 247 728 13	Pacific oysters	12		
Sound of Gigha	Sound Of Gigha Razors 2	AB 515 1250 16	Razors	13		1
Sound of Gigha 3	Cretshengan	AB 857 2310 16	Razors	8		1
Sound of Gigha 4	North	AB 855 2307 16	Razors	8		1
Sound of Gigha 5	Leim	AB 856 2309 16	Razors	8		1
Sound of Gigha Cretrshengan	Cretshengan	AB 857 2310 16	Razors	2		1
Sound of Gigha Leim	Leim	AB 856 2309 16	Razors	8		1
Sound of Gigha Muasdale	Sound of Gigha Muasdale	AB 854 2305 16	Razors	16		3
Sound of Gigha North	North	AB 855 2307 16	Razors	6		
Sound of GighaCretrshengan	Cretshengan	AB 857 2310 16	Razors	5		1
Tiree North	Gott Bay	AB 835 2244 16	Razors	6		
Traigh Bhan	Traigh Bhan Oysters	AB 859 2315 13	Pacific oysters	17	1	
West Jura Razors	Jura	AB 482 805 16	Razors	5		
West Loch Tarbert	Loup Bay	AB 299 084 13	Pacific oysters	17	3	

2.3.2 Comhairle Nan Eilean Siar: Lewis & Harris

Table 19. *E. coli* samples received from Comhairle Nan Eilean Siar: Lewis & Harris

Production Area	Site Name	Site	Sample Species	Samples received	Outwiths	Rejected samples
Broad Bay Aiginish	Aiginish	LH 743 1740 16	Razors	12	1	2
East Loch Tarbert	Sound of Scalpay	LH 057 106 08	Common mussels	14	3	1
Loch Erisort: Garbh Eilean	Garbh Eilean	LH 357 747 08	Common mussels	13	4	1
Loch Erisort: Gob Glas	Gob Glas	LH 357 711 08	Common mussels	13	2	1
Loch Leurbost	Loch Leurbost	LH 168 114 08	Common mussels	13	1	2
Loch Leurbost: Crosbost	Site 1 Crosbost	LH 339 795 13	Pacific oysters	13	4	

Loch Roag - Gob Sgrithir	Gob Sgrithir	LH 829 2215 08	Common mussels	3		
Loch Roag: Barraglom	Loch Barraglom	LH 185 120 08	Common mussels	12		
Loch Roag: Ceabhagh	Keava	LH 381 772 08	Common mussels	12		
Loch Roag: Drovinish	Loch Drovinish	LH 186 121 08	Common mussels	12		
Loch Roag: Eilean Chearstaigh	Eilean Scarastaigh	LH 344 697 08	Common mussels	4		
Loch Roag: Eilean Chearstaigh	Buckle Point	LH 344 791 08	Common mussels	8		
Loch Roag: Eilean Teinish	Eilean Teinish	LH 338 720 08	Common mussels	12		
Loch Roag: Linngeam	Linngeam	LH 187 122 08	Common mussels	12		
Loch Roag: Miavaig	Miavaig	LH 188 123 08	Common mussels	12		
Loch Roag: Torranish	Loch Torranish	LH 189 124 08	Common mussels	12		
Loch Seaforth	Loch Seaforth	LH 193 126 08	Common mussels	12		
Seilebost	Seilebost	LH 249 129 04	Common cockles	12	4	3
Tong Sands	Tong Sands Cockles	LH 605 1100 04	Common cockles	13		1
West Loch Roag - Gob Sgrithir	Gob Sgrithir	LH 829 2215 08	Common mussels	10		11

2.3.3 Comhairle Nan Eilean Siar: Uist & Barra

Table 20. *E. coli* samples received from Comhairle Nan Eilean Siar: Uist & Barra

Production Area	Site Name	Site	Sample Species	Samples received	Outwiths	Rejected samples
Caolas Bhearnaraigh	Caolas Bhearnaraigh	UB 735 1706 16	Razors	16		1
Cidhe Eolaigearraidh	Sound Of Barra: Pacific Oysters	UB 427 830 13	Pacific oysters	13	1	
Garbh Lingeigh	Garbh Lingeigh	UB 713 1622 13	Pacific oysters	12	1	
North Ford	Oitir Mhor	UB 493 852 04	Common cockles	12		
South Ford	South Ford	UB 259 162 04	Common cockles	12		1
Traigh Cille Bharra Cockles	Traigh Cille Bharra Cockles	UB 392 790 04	Common cockles	13	2	1
Traigh Mhor	Traigh Mhor	UB 282 165 04	Common cockles	13	3	4

2.3.4 Dumfries & Galloway Council

Table 21. *E. coli* samples received from Dufries & Galloway Council area

Production Area	Site Name	Site	Sample Species	Samples received	Outwiths	Rejected samples
Fleet Bay Razors	Fleet Bay Razors	DG 752 1880 16	Razors	11	1	
Kirkcudbright Bay Razors	Kirkcudbright Bay Razors	DG 809 2132 16	Razors	11		
Loch Ryan	Leffnoll Point	DG 191 174 12	Native oysters	12	1	
Wigtown Bay: Islands of Fleet	Wigtown Bay	DG 305 182 16	Razors	11		

2.3.5 East Lothian

Table 22. *E. coli* samples received from East Lothian

Production Area	Site Name	Site	Sample Species	Samples received	Outwiths	Rejected samples
Gullane Point North	Gullane North	EL 601 1087 16	Razors	11		5
Gullane Point South	Gullane South	EL 703 1525 16	Razors	10		9

2.3.6 Fife Council

Table 23. *E. coli* samples received from Fife Council area

Production Area	Site Name	Site	Sample Species	Samples received	Outwiths	Rejected samples
Fife Ness Surf Clams	Kingsbarns	FF 771 1974 19	Surf Clams	13		2
Firth of Forth: North	Anstruther	FF 068 184 19	Surf Clams	13		2
Forth Estuary Surf Clams	Shell Bay	FF 772 1975 19	Surf Clams	13		
Forth Estuary: Largo Bay	Largo Bay	FF 072 188 16	Razors	12	2	5

2.3.7 Highland Council: Lochaber

Table 24. *E. coli* samples received from Highland Council: Lochaber area

Production Area	Site Name	Site	Sample Species	Samples received	Outwiths	Rejected samples
Arisaig	Sgeirean Buidhe	HL 004 202 13	Pacific oysters	14	3	2
Loch Ailort	Eilean Dubh	HL 114 937 08	Common mussels	12	1	
Loch Ailort 1	Loch Ailort 1	HL 114 214 08	Common mussels	12	1	1
Loch Ailort 3	Camus Driseach	HL 114 207 13	Pacific oysters	13	2	
Loch Beag	Ardnambuth	HL 118 215 08	Common mussels	12		
Loch Eil	Duisky	HL 134 216 08	Common mussels	12	1	
Loch Eil: Fassfern	Fassfern	HL 136 219 08	Common mussels	12		
Loch Leven: Lower	Lower	HL 170 222 08	Common mussels	12	1	
Loch Leven: Upper	Upper	HL 171 223 08	Common mussels	12	1	1
Loch Moidart	South Channel	HL 179 227 13	Pacific oysters	13	3	
Loch Sunart	Liddisdale	HL 206 1237 08	Common mussels	12	2	4

2.3.8 Highland Council: Ross and Cromarty

Table 25. *E. coli* samples received from Highland Council: Ross and Cromarty area

Production Area	Site Name	Site	Sample Species	Samples received	Outwiths	Rejected samples
Inner Loch Torridon	Dubh Aird	RC 090 1616 08	Common mussels	12	1	
Little Loch Broom	Little Loch Broom	RC 805 2122 13	Pacific oysters	11		
Loch Kanaird	Ardmair	RC 625 1233 13	Pacific oysters	11	1	1

2.3.9 Highland Council: Skye and Lochalsh

Table 26. *E. coli* samples received from Highland Council: Skye and Lochalsh area

Production Area	Site Name	Site	Sample Species	Samples received	Outwiths	Rejected samples
Loch Eishort	Drumfearn	SL 137 281 08	Common mussels	12		
Loch Harport Inner Cockles	Carbost	SL 159 286 04	Common cockles	12		
Loch Harport: Inner	Carbost	SL 159 286 13	Pacific oysters	12	1	
Sound of Sleat	Gleneig Bay	SL 833 2242 16	Razors	9		

2.3.10 Highland Council: Sutherland

Table 27. *E. coli* samples received from Highland Council: Sutherland area

Production Area	Site Name	Site	Sample Species	Samples received	Outwiths	Rejected samples
Kyle of Durness	Keoldale	HS 773 1984 13	Pacific oysters	13		1
Kyle of Tongue	Kyle of Tongue	HS 103 303 13	Pacific oysters	13	2	
Loch Glencoul	Kylesku	HS 157 310 08	Common mussels	13	1	
Loch Inchard	Loch Inchard - Site 1 - D. Ross	HS 162 311 08	Common mussels	2		
Loch Laxford	Weavers Bay	HS 167 320 08	Common mussels	12	1	2

2.3.11 North Ayrshire Council

Table 28. *E. coli* samples received from North Ayrshire Council area

Production Area	Site Name	Site	Sample Species	Samples received	Outwiths	Rejected samples
Fairlie	Southannan Sands	NA 065 332 13	Pacific oysters	12	2	
Stevenston Sands Razors	Stevenston Sands Razors	NA 825 2169 16	Razors	11		

2.3.12 Shetland Islands

Table 29. *E. coli* samples received from the Shetland Islands

Production Area	Site Name	Site	Sample Species	Samples received	Outwiths	Rejected samples
Aith Voe Sletta	Slyde	SI 326 733 08	Common mussels	12	1	
Baltasound Mussels	Baltasound Harbour	SI 010 395 08	Common mussels	14	2	
Basta Voe Cove	Inner - Site 1 - Thomason	SI 324 399 08	Common mussels	12	2	
Basta Voe Outer	Outer	SI 323 403 08	Common mussels	13	2	
Brindister Voe	Brindister Voe	SI 023 406 08	Common mussels	12		1
Busta Voe Lee North	Busta Voe Lee	SI 327 410 08	Common mussels	1		
Busta Voe Lee North	Hevden Ness	SI 327 755 08	Common mussels	12		
Busta Voe Lee South	Greentaing	SI 328 767 08	Common mussels	12		
Catfirth	Catfirth	SI 032 412 08	Common mussels	12		
Catfirth Mussels 1	East of Little Holm	SI 816 2144 08	Common mussels	12		
Catfirth Mussels 2	East of Brunt Hamarsland	SI 817 2147 08	Common mussels	12		
Clift Sound Houss	Clift Sound Houss	SI 633 1270 08	Common mussels	12		
Clift Sound: Booth	Booth	SI 036 413 08	Common mussels	12		
Clift Sound: Stream Sound	East Hogaland	SI 035 414 08	Common mussels	12	1	
Clift Sound: Whal Wick	Wester Quarff	SI 038 1522 08	Common mussels	12		
Colla Firth	Colla Firth	SI 040 417 08	Common mussels	12		
Dales Voe - Fora Ness	West Taing	SI 502 869 08	Common mussels	12	1	
Dales Voe: Muckle Ayre	Muckle Ayre	SI 049 419 08	Common mussels	12		
Dales Voe: Scarvar Ayre	Scarvar Ayre	SI 050 420 08	Common mussels	12	2	
Gon Firth	Cole Deep	SI 076 1338 08	Common mussels	12	2	
Gruting Voe: Braewick Voe	Braewick Voe	SI 080 424 08	Common mussels	12		
Gruting Voe: Browland Voe	Browland Voe	SI 081 425 08	Common mussels	12		
Gruting Voe: Quilse	Quilse	SI 083 427 08	Common mussels	12		1
Gruting Voe: Seli Voe	Seli Voe	SI 084 428 08	Common mussels	13	2	
Hamar Voe	Hamar Voe	SI 655 1404 08	Common mussels	12		
Hamnavoe	Copister	SI 348 736 08	Common mussels	12	1	
Lang Sound	Lang Sound	SI 107 429 08	Common mussels	12		1
Laxfirth	Northwest of Skerby Ayre	SI 814 2142 08	Common mussels	12	1	2
Mid Yell Voe	Camb	SI 216 430 08	Common mussels	2		
Mid Yell Voe	Seafield	SI 216 432 08	Common mussels	16		
Mid Yell Voe East	Bunya Sands	SI 797 2083 08	Common mussels	12	1	
Muckle Roe	Pobies Geo	SI 221 433 08	Common mussels	12		
North Uyea	North	SI 230 453 08	Common mussels	12	1	
Olna Firth Inner	Inner	SI 232 435 08	Common mussels	12	1	

Olna Firth Outer	Foula Wick	SI 232 434 08	Common mussels	12		
Papa Little Voe	Millburn	SI 235 1350 08	Common mussels	12	2	
Ronas Voe East	Clifts	SI 523 919 08	Common mussels	11		
Ronas Voe Mussels 2	West Of Black Well	SI 522 918 08	Common mussels	11	1	
Sandsound Voe	Sandsound Voe	SI 242 443 08	Common mussels	12		
Seli Voe	Garderhouse	SI 815 2143 08	Common mussels	11		
South of Houss Holm	South of Houss Holm	SI 261 444 08	Common mussels	12	2	
South Voe Mussels	South Voe Mussels	SI 421 825 08	Common mussels	12	2	
Stream Sound: Ux Ness	Easterdale	SI 373 1096 08	Common mussels	12		
Stromness Voe	Burra Holm	SI 273 467 08	Common mussels	12		
Swining Voe	North West of Cul Houb	SI 820 2156 08	Common mussels	12		
The Rona	Aith Ness	SI 517 944 08	Common mussels	12	1	
Uyea Sound	Cow Head	SI 441 845 08	Common mussels	11		
Vaila Sound - East Ward	Brandy Ayre	SI 858 2312 08	Common mussels	18		
Vaila Sound Linga	Linga	SI 288 457 08	Common mussels	12	3	
Vaila Sound: East of Linga and Galtaskerry	Whitesness	SI 288 1061 08	Common mussels	12		
Vaila Sound: Riskaness	Riskaness	SI 289 458 08	Common mussels	12		
Vementry North	Suthra Voe West	SI 322 464 08	Common mussels	12		
Vementry South	Clousta Voe - Noonsbrough	SI 321 459 08	Common mussels	12	1	
Wadbister Voe	Wadbister Voe	SI 294 466 08	Common mussels	11		
Weisdale Voe	North Flotta	SI 297 469 08	Common mussels	12		
Weisdale Voe Upper	Olligarth	SI 378 1521 08	Common mussels	11		
West of Langa	Scalloway	SI 822 2160 08	Common mussels	12		
West of Lunna	Cul Ness	SI 380 770 08	Common mussels	12		6

2.3.13 South Ayrshire Council

Table 30. *E. coli* samples received from South Ayrshire Council area

Production Area	Site Name	Site	Sample Species	Samples received	Outwiths	Rejected samples
Ayr Bay	Ayr Bay Razors	SA 841 2263 16	Razors	10	1	
Croy Bay	Culzean Bay	SA 681 1482 16	Razors	11	2	
North Bay	Barassie	SA 337 719 16	Razors	10	1	
Prestwick Shore	Prestwick Shore Razors	SA 840 2262 16	Razors	11	1	
Troon South Beach	Troon South Beach Razors	SA 843 2267 16	Razors	10	2	

2.4 2019 outwith results

The number of outwith results i.e. those which exceeded the upper *E. coli* MPN/100g for the extant classification status are reported for all classified production areas by local authority in Table 31.

Table 31. Outwith results between 1st January and 31st December 2019

Local Authority	No. of valid results reported	No. of Outwith results	% outwith
Argyll and Bute Council	**593**	**34**	**5.7%**
Comhairle nan Eilean Siar: Lewis & Harris	**212**	**19**	**9.0%**
Comhairle nan Eilean Siar: Uist & Barra	**87**	**7**	**8.0%**
Dumfries and Galloway Council	**45**	**2**	**4.4%**
East Lothian	**12**	**0**	**0.0%**
Fife Council	**46**	**2**	**4.3%**
Highland Council: Lochaber	**132**	**15**	**11.4%**
Highland Council: Ross & Cromarty	**33**	**2**	**6.1%**
Highland Council: Skye & Lochalsh	**45**	**1**	**2.2%**
Highland Council: Sutherland	**51**	**4**	**7.8%**
North Ayrshire Council	**23**	**2**	**8.7%**
Shetland Islands Council	**677**	**32**	**4.7%**
South Ayrshire Council	**52**	**7**	**13.5%**
Total	**2008**	**127**	**6.3%**

Appendix I: Rejection criteria for samples for *E. coli* analysis[6]

- All samples must be appropriately labelled so as to enable accurate identification of individual samples;
- If multiple samples are packed in a single coolbox each sample must be contained within an intact sample bag (so as not to leak and cause potential contamination of other samples in the coolbox);
- Shellfish must not be immersed in water or mud/sand.
- No more than 48 hours[7] should have elapsed between sample collection[8] and the start of testing[9];
- Sample temperature –
    - *Where the time elapsed between sample collection and receipt at the laboratory is **more than** 4 hours:* the sample temperature (or water sample, if measured) should be between 1°C and 10°C. Where the temperature exceeds >10°C samples should be rejected;
    - *Where the time elapsed between sample collection and receipt at the laboratory is **less than** 4 hours:* the sample temperature (or water sample, if measured) should be less than the temperature at the time of sampling, or between 1°C and 10°C;
    - Samples should not be frozen.
- No analysis can be undertaken on less than 10 individual live shellfish per sample.

[6] Sample rejection criteria are derived from recommendations of the UK NRL for the laboratory testing of bivalve molluscs for the classification of bivalve mollusc harvesting areas under Regulation (EC) 854/2004 https://www.cefas.co.uk/nrl/
[7] Cut off point for rejected samples 48 hours and 29 minutes.
[8] Sample collection is the time at which shellfish are removed from the bed.
[9] Start of testing is defined as the time at which opening and homogenising (shucking) of shellfish begins.

Section 3. Chemical contaminants

This section provides a short summary of the chemical contaminants monitoring undertaken in Scottish shellfish under the FSS programme between January and February 2019. A full copy of the report produced and published in May 2019 is available on FSS' website.

As part of its monitoring requirements in support of EU regulations, Food Standards Scotland (FSS) has overseen the collection of shellfish each year, from classified shellfish production areas within relevant local authority areas. Shellfish from classified production areas are monitored, with the edible tissues analysed for the contaminants described above, and specified for dioxins, dioxin-like PCBs and non-dioxin-like PCBs for certain foodstuffs in Commission Regulation (EC) 589/2014. Sampling officers from Scotland were required to obtain suitable shellfish samples from designated sampling points within classified shellfish production areas, as defined by the FSS. The collection of shellfish and transport logistics were co-ordinated by Cefas. Samples were taken and live shellfish sent to Fera, with the edible tissues analysed for the contaminants described above. The analyses are carried out at Fera Science Limited in York.

Twenty-eight samples of shellfish, including species of common mussels (13 samples), Pacific oysters (3), native oysters (1), common cockles (3), surf clams (1), and razor clams (7). The sampling schedule was timed to coincide with the period before annual spawning. This point in the annual cycle contaminant levels would likely be at their highest for optimum detection.

This study on chemical contaminants in shellfish from Scottish classified shellfish production areas, fulfils part of the requirements of EU member states (EU Regulations (EC) 1881/2006 and (EC) 854/2004) to adopt appropriate monitoring measures and carry out compliance checks on shellfish produced for human consumption. In comparison to earlier years, the scope of this study was widened to include production areas that had not been tested before. Marine shellfish bio-accumulate environmental contaminants because of their inability to metabolise these during feeding. The study determines concentrations of regulated environmental contaminants in the flesh of edible species with a view to determine current levels of occurrence and to allow estimation of consumer exposure.

Only one sample of mussels was analysed for polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs, dioxins), polychlorinated biphenyls (PCBs). All 28 samples were tested for polycyclic aromatic hydrocarbons (PAHs) and heavy metals/trace elements. The methodologies used for the analyses were UKAS accredited to ISO 17025 standard and followed EU commission regulations for data quality criteria.

PAHs were detected in all 28 samples analysed but all samples showed levels below the maximum limits for BaP benzo[a]pyrene and for the total sum of the PAH4 compounds of 5 µg/kg (BaP) and 30 µg/kg (PAH4 Sum) respectively.

The sample tested for PCDD/Fs and PCBs returned contaminant concentrations all below the regulatory maximum levels.

Heavy metals were detected in all samples but concentrations of the regulated heavy metals (mercury, cadmium and lead) were all below the set maximum limits.

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