Centre for Environment Fisheries & Aquaculture Science

Cefas

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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 - 2018

February 2019

Annual report on the results of the *E. coli*, biotoxin, phytoplankton and chemical contaminants Official Control Monitoring Programmes for Scotland - 2018

FINAL report

76 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 2018. The programmes were delivered on behalf of Food Standards Scotland (FSS), the competent authority in Scotland 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 now, the results of each annual programme have been reported separately. At the request of FSS, the 2018 results have been combined into one single annual report.

A total of 3,975 shellfish samples and 1,305 water samples were collected for the purpose of the 2018 Scottish official control monitoring programmes. Samples collected between the 1st of January and 31st of March were collected by officers operating on behalf of several contractors appointed directly by FSS. 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 0.5% of the biotoxin samples, 0.7% of the water samples and 2.1% of *E. coli* samples were rejected as unsuitable for analysis on arrival at the laboratories. All chemical contaminants samples were suitable.

All analyses followed the approved methods layed 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 794 samples, lipophilic toxins (LT) in 1,858 samples and paralytic shellfish poisoning toxins (PSP) in 1,161 samples. 1,951 samples were tested for *E. coli*, 20 for heavy metals (lead, cadmium and mercury), 28 for PAHs and 13 for dioxins and PCBs.

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

- 96.5% of all toxin results were reported within 1 working day of sample receipt, 99.9% within 2 working days;

- 100% of phytoplankton results were reported within 3 days of sample receipt;
- 100% 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 2018.

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

- 254 samples breached the maximum permitted limits (MPL) for lipophilic toxins (OA/DTX/PTX group only) (see section 1.2);
- 21 samples 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% of the 1,946 analyses undertaken (see Table 19 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 2018.

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 1,950 bivalve shellfish samples from 87 inshore sampling locations (Figure 1) were submitted to Cefas for toxin analyses in the reporting period. They comprised of; common mussels (1,373), Pacific oysters (414), razors (80), common cockles (40), surf clams (32), and native oysters (11).

King scallop samples 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.

Eleven inshore samples (0.6% of those received) were rejected on arrival at the laboratory – six of these were submitted in error as testing was not required in these areas, two samples were submitted in error, two could not be analysed due to a lab error and one razor sample was collected by a harvester who did not have the relevant permissions to collect razors.

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

Phytoplankton monitoring

A total of 1,305 seawater samples from 44 inshore sampling locations (Figure 2) were submitted to SRSL for the identification and enumeration of potentially harmful algal species

during the reporting period and 1,301 were analysed. Four samples were collected in error and not analysed, due to the reduced winter sampling schedule.

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 eq./kg [shellfish flesh] or Yessotoxins, 3.75mg yessotoxin eq./kg [shellfish flesh] or Azaspiracids, 160µg azaspiracid eq./kg [shellfish flesh]
PSP	800µg saxitoxin eq./kg [shellfish flesh]

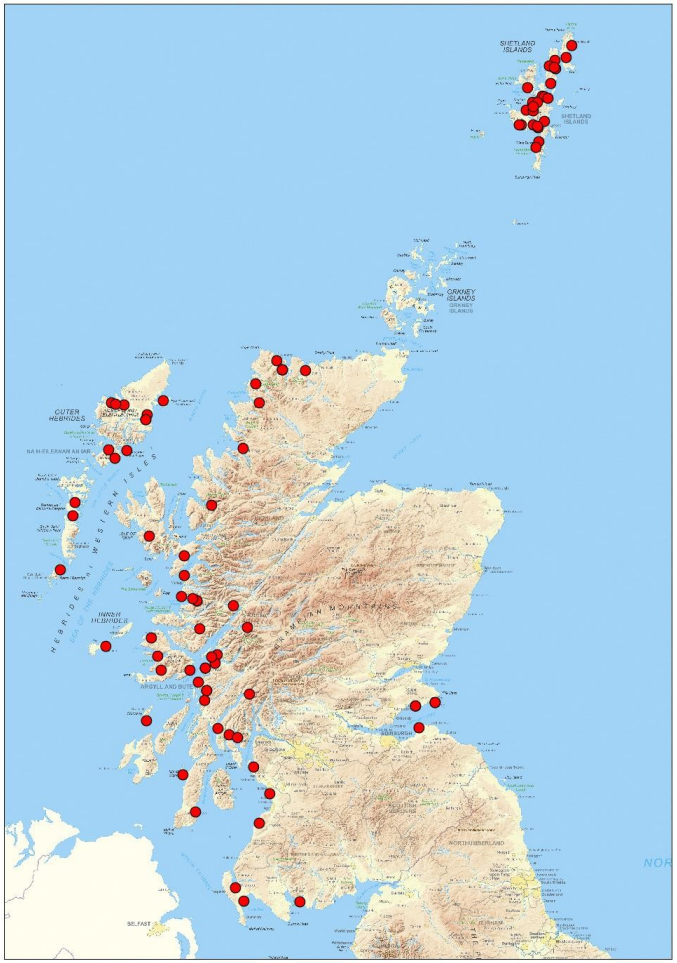


Figure 1. Scottish inshore shellfish sampling locations – Food Standards
Scotland biotoxin monitoring programme in 2018

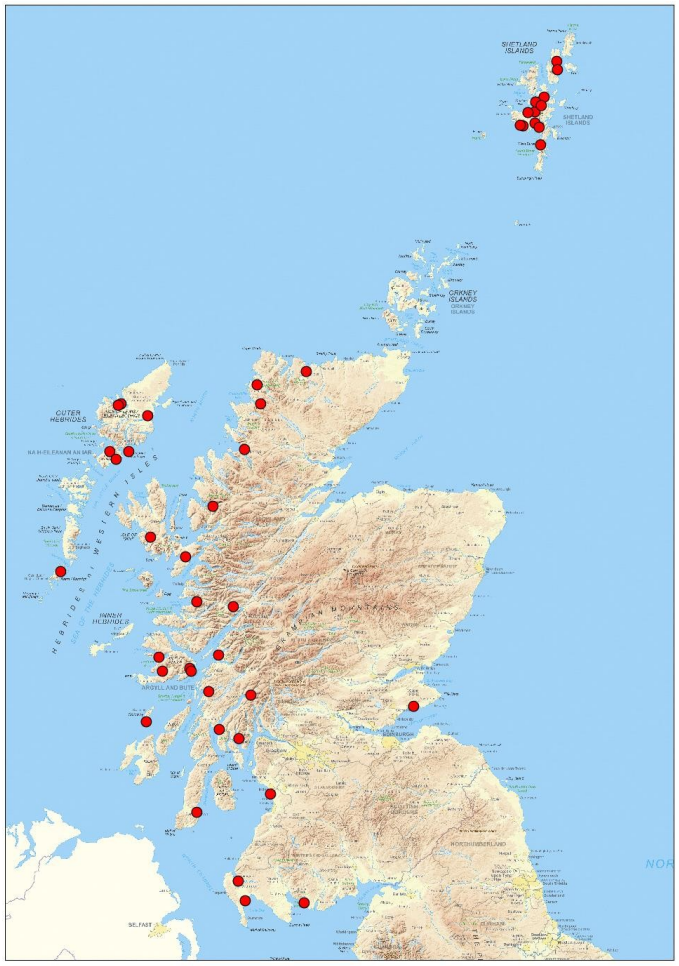


Figure 2. Scottish water sampling locations – Food Standards Scotland phytoplankton monitoring programme in 2018

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, 254 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.

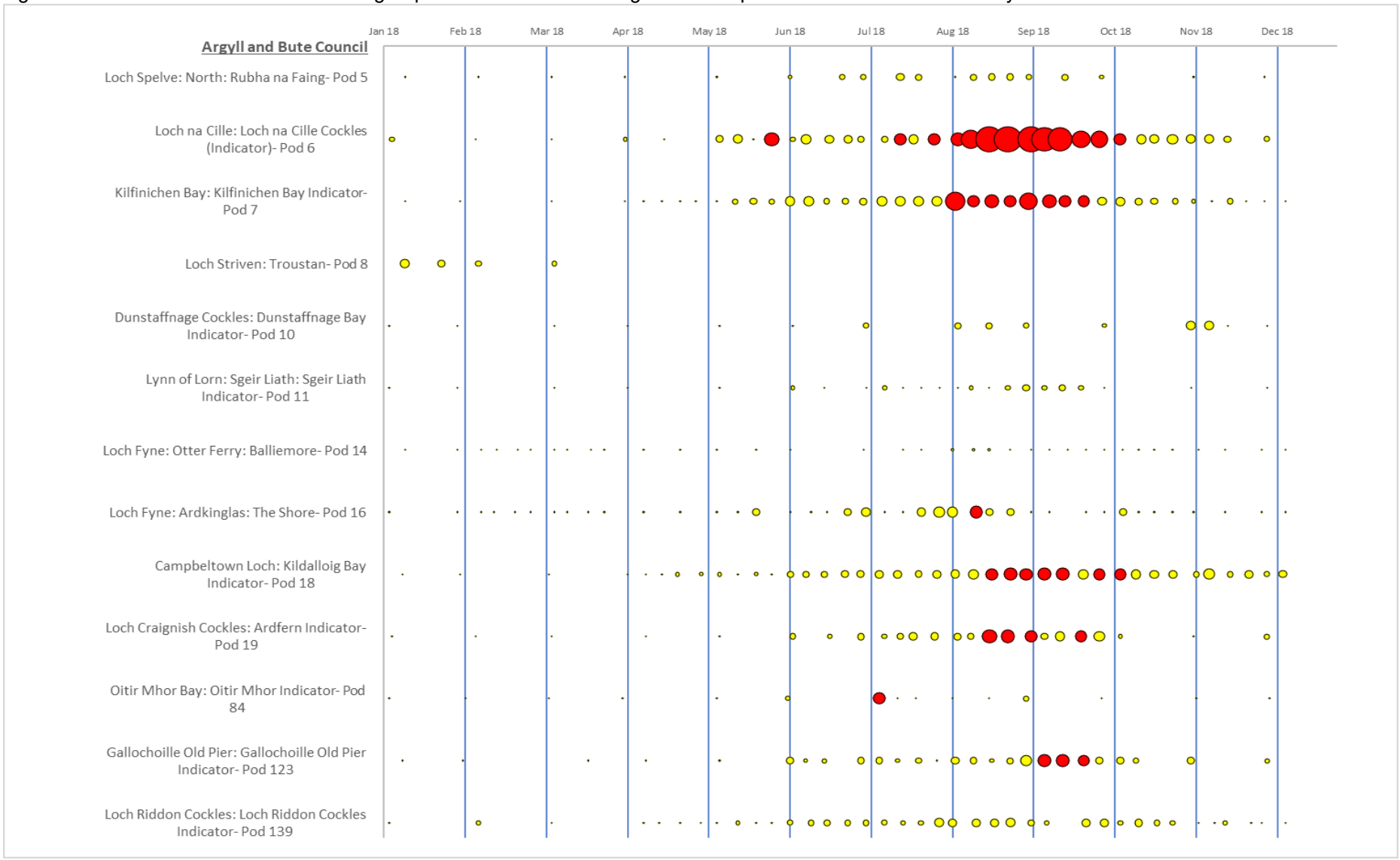
In total, lipophilic toxins analyses were performed on 1,857 samples from inshore locations and 1 verification sample collected from commercial establishments. Results are summarised below.

1.2.1 OA/DTX/PTX group

- OA/DTX/PTX group toxins were detected in 873 inshore samples, comprising of mussels (826 samples), Pacific oysters (28), cockles (2), razors (1) and surf clams (16).
- 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 November 2018 (776 samples).
- The distribution of OA/DTX/PTX toxins was widespread, affecting sites within all monitored local authority regions, with the exception of South Ayrshire.
- 254 samples comprising of mussels (248 samples), Pacific oysters (3) and Surf clams (3) from 36 sites (Figure 4) recorded results above the MPL. These were recorded between May and November 2018.
- The highest level recorded during 2018 was 3,971µg OA eq./kg, almost 25 times the regulatory limit, in a sample from Loch Beag (Highland Council: Lochaber) in mid July 2018. Levels of OA/DTX/PTX group toxins at this site had started to rise in early May, however a closure for PSP toxins during the weeks prior to this peak meant that OA/DTX/PTX monitoring was suspended from mid May to late June & early July. A sample taken on 26/06/2018 again recorded elevated levels of OA/DTX/PTXs but still within the regulatory limit, rising to 3,971µg OA eq./kg by the sample collected on 10/07/2018.

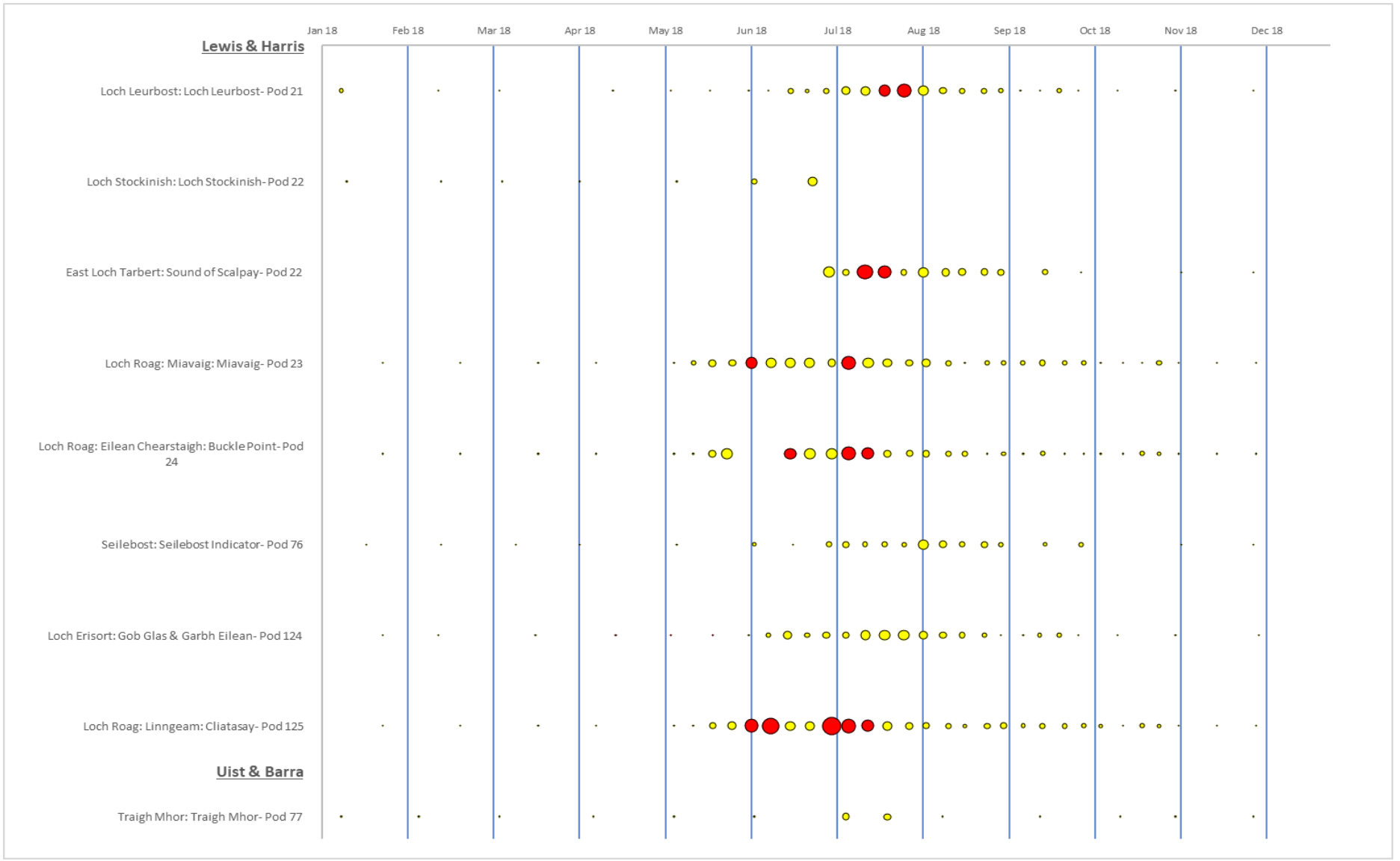
- Elsewhere, OA/DTX/PTX group toxins were detected below the MPL in a further 619 samples from 65 sites (Figure 5), between January and December 2018. This level of detection is comparable to previous years.
- No OA/DTX/PTX group toxins were detected in the king scallop verification sample received in 2018.

Figure 3. Concentrations of OA/DTX/PTX group toxins in sites recording results at quantifiable levels from January to December 2018



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 2018 (cont.)



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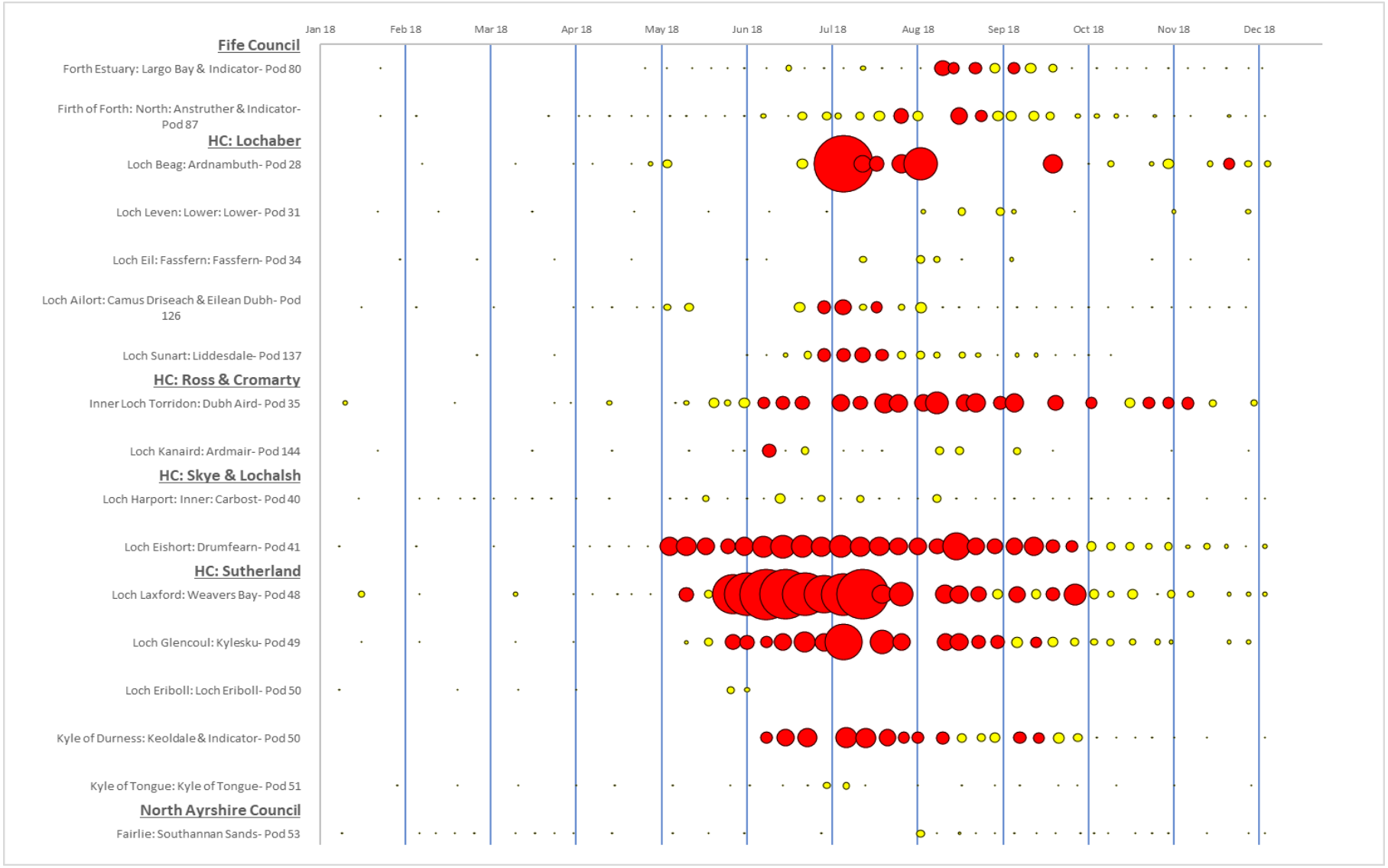
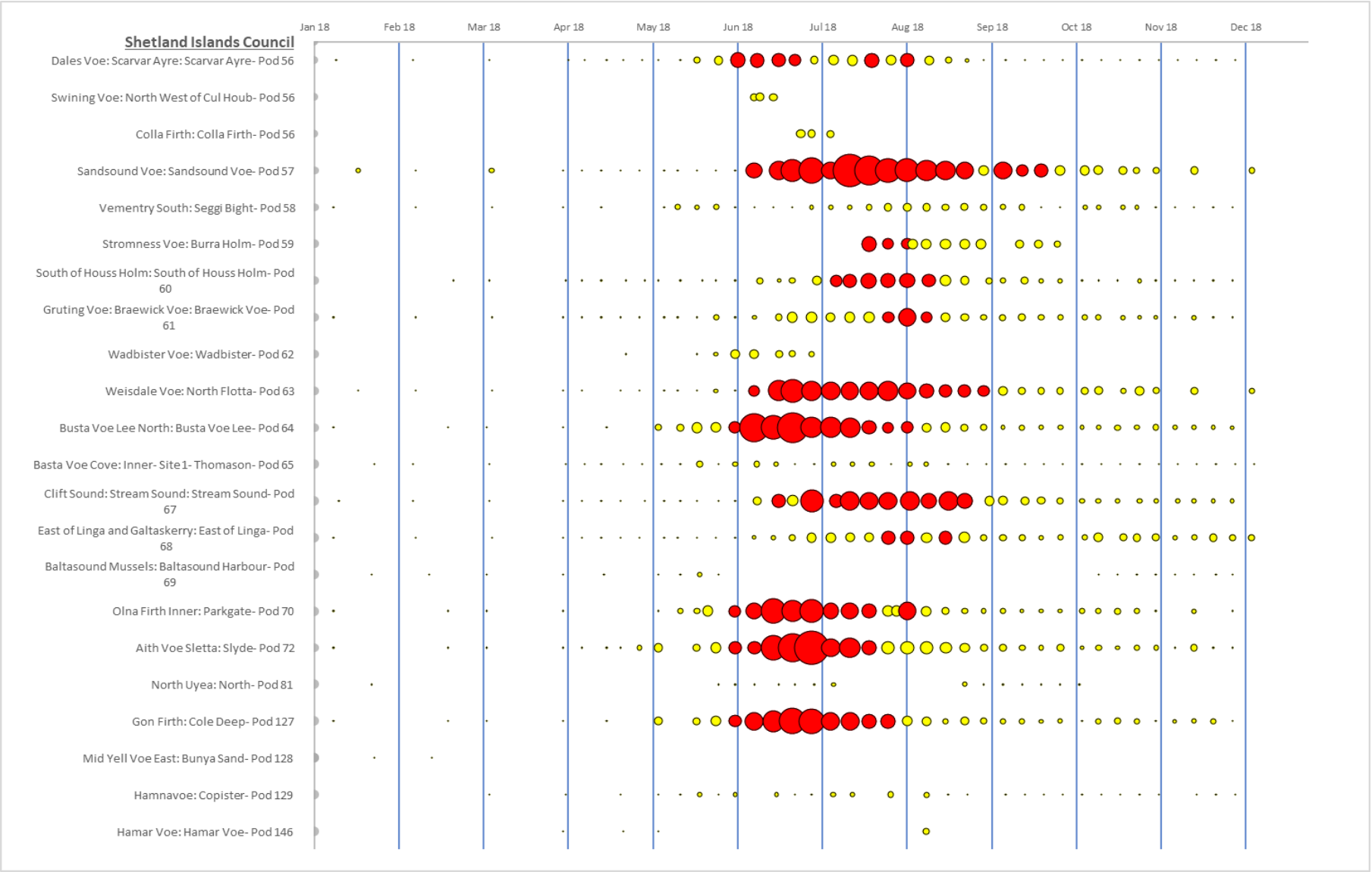


Concentration of OA/DTX/PTX toxins: Red = Toxins above MPL Yellow = Toxins below MPL Not detected = ●
(Bubble size is proportional to toxin concentration)

Figure 3. Concentrations of OA/DTX/PTX group toxins in sites recording results at quantifiable levels from January to December 2018 (cont.)



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

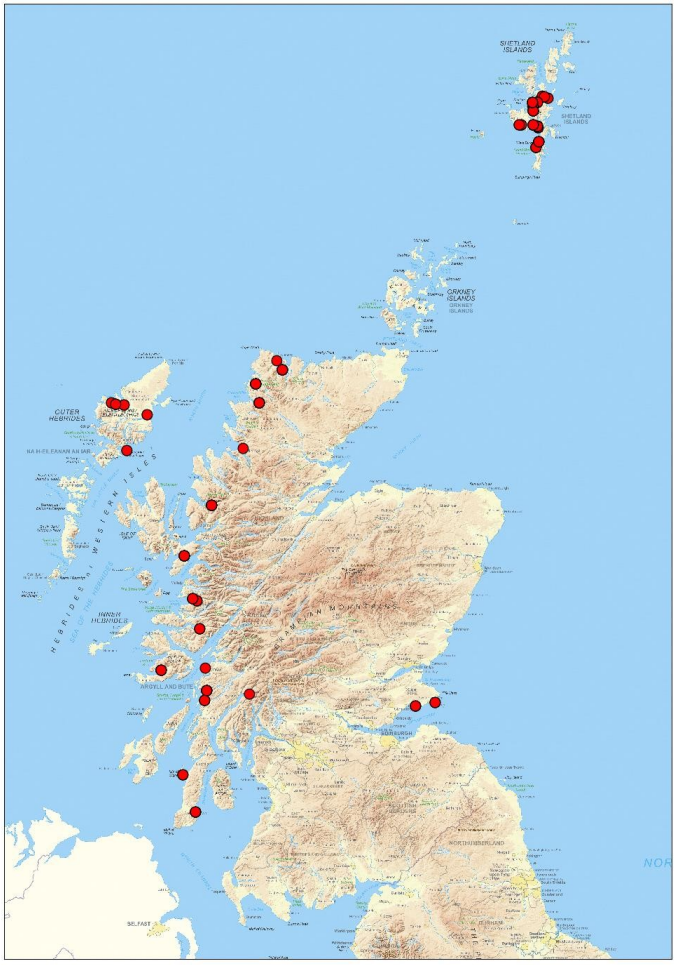


Figure 4. Inshore locations recording OA/DTX/PTX group results above the maximum permitted limit (>160µg OA eq./kg) in 2018

Figure 5. Inshore locations where toxins of OA/DTX/PTX group were detected below the maximum permitted limit (≤160µg OA eq./kg) in 2018

1.2.2 AZA group

AZAs below the MPL were detected in two samples in 2018. Both samples were mussels collected from Pod 28 – Loch Beag at 97 & 27µg AZA eq./kg (Figure 6), in November 2018.

1.2.3 YTX group

YTXs below the MPL were detected in 13 inshore samples from 3 monitoring points in Argyll and Bute, Lochaber and Lewis & Harris areas (Figure 7) during the reported period. All results were equal to or below 1mg YTXeq/kg and were recorded between May and September 2018.

Figure 6. Inshore locations where AZA group toxins were detected in 2018 (all below the maximum permitted level (≤160µg AZA eq./kg))

Figure 7. Inshore locations where YTX group toxins were detected in 2018 (all below the maximum permitted level (≤3.75mg YTX eq./kg))

1.2.4 Phytoplankton associated with the production of lipophilic toxins

- *Dinophysis* spp.* were present in 627 (48.2%) of the 1,301 samples analysed during 2018 and were detected from March to October (Figure 9). They were observed at or above trigger level (set at 100 cells/L) in 290 samples (22.3%) between April and October. The majority of *Dinophysis* spp. blooms** occurred around the Scottish coast in June and July, with 51.2% of the samples exceeding threshold counts in June (Figure 8). The percentage of samples with *Dinophysis* spp. counts above trigger level in late spring/early summer (May-June) was higher than in previous years.
- The earliest bloom reaching trigger level was recorded at Kyle of Tongue (Highland: Sutherland) on 11th April. As in 2016 and 2017, dense blooms of *Dinophysis* spp. were observed at Loch Fyne: Ardkinglas in summer 2018 (Figure 9), with the highest cell density reaching 59,812 cells/L on 1st August. An exceptionally late bloom of 19,400 cells/L also occurred at this site on 22nd October. These 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* spp. at concentrations rarely exceeding threshold.
- *Dinophysis* spp. blooms were widespread around most of the Highland region between May and July, with cell counts at Loch Laxford (Highland: Sutherland) reaching 167,625 cells/L on 10th July (Figure 10). Blooms were also reported around the Shetland Islands at the same time, with densities of 42,801 cells/L recorded in Dales Voe on 5th June, and 23,500 cells/L in Busta Voe on 11th June.
- The total percentage of *Dinophysis* spp. at or exceeding trigger level during the current reporting period (22.3%) was the highest since 2013 (27.5%) and frequently resulted in DSP toxins above regulatory level, particularly in common mussels.

*references to *Dinophysis* spp. 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.

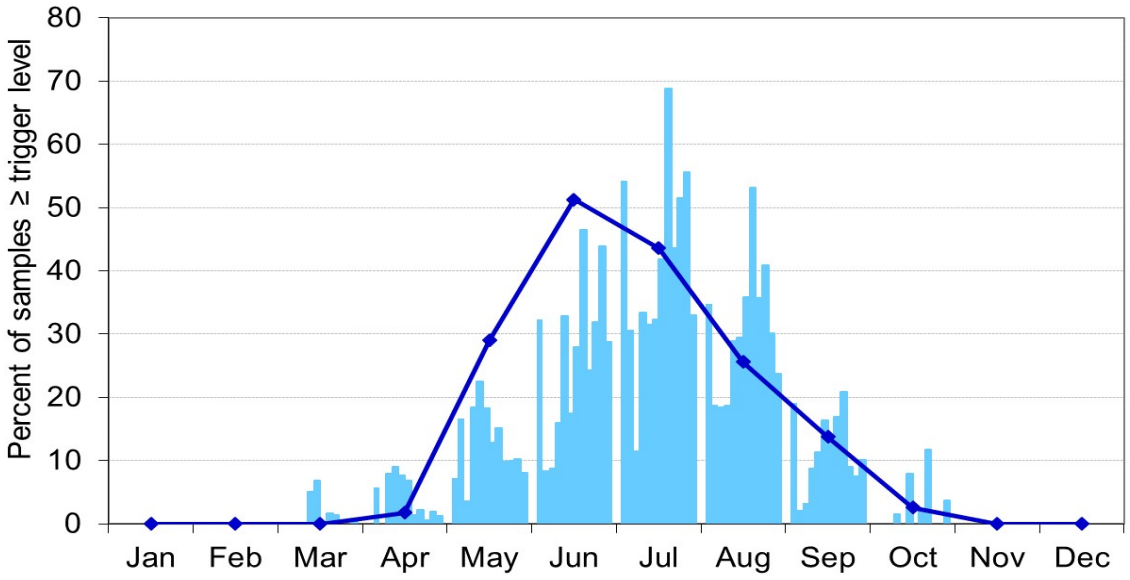
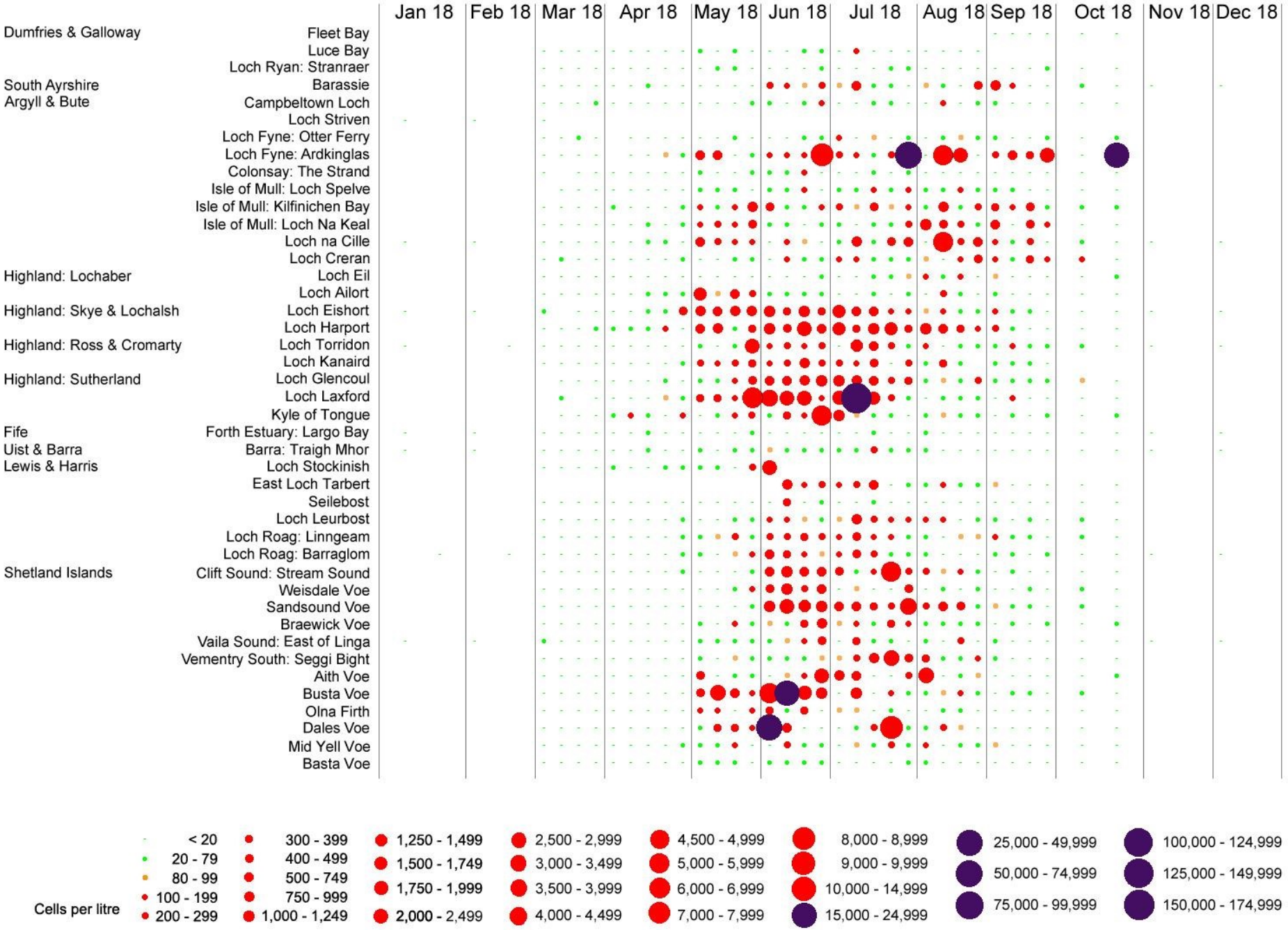


Figure 8. The percentage of samples in which *Dinophysis* spp. equalled or exceeded the trigger level of 100 cells/L in 2018 is indicated by the line. (For comparison, the bars show the percentage of samples in which *Dinophysis* cells equalled or exceeded the trigger level between 2006 and 2017).

. Figure 9. Phytoplankton concentrations of *Dinophysis* spp. observed between January and December 2018



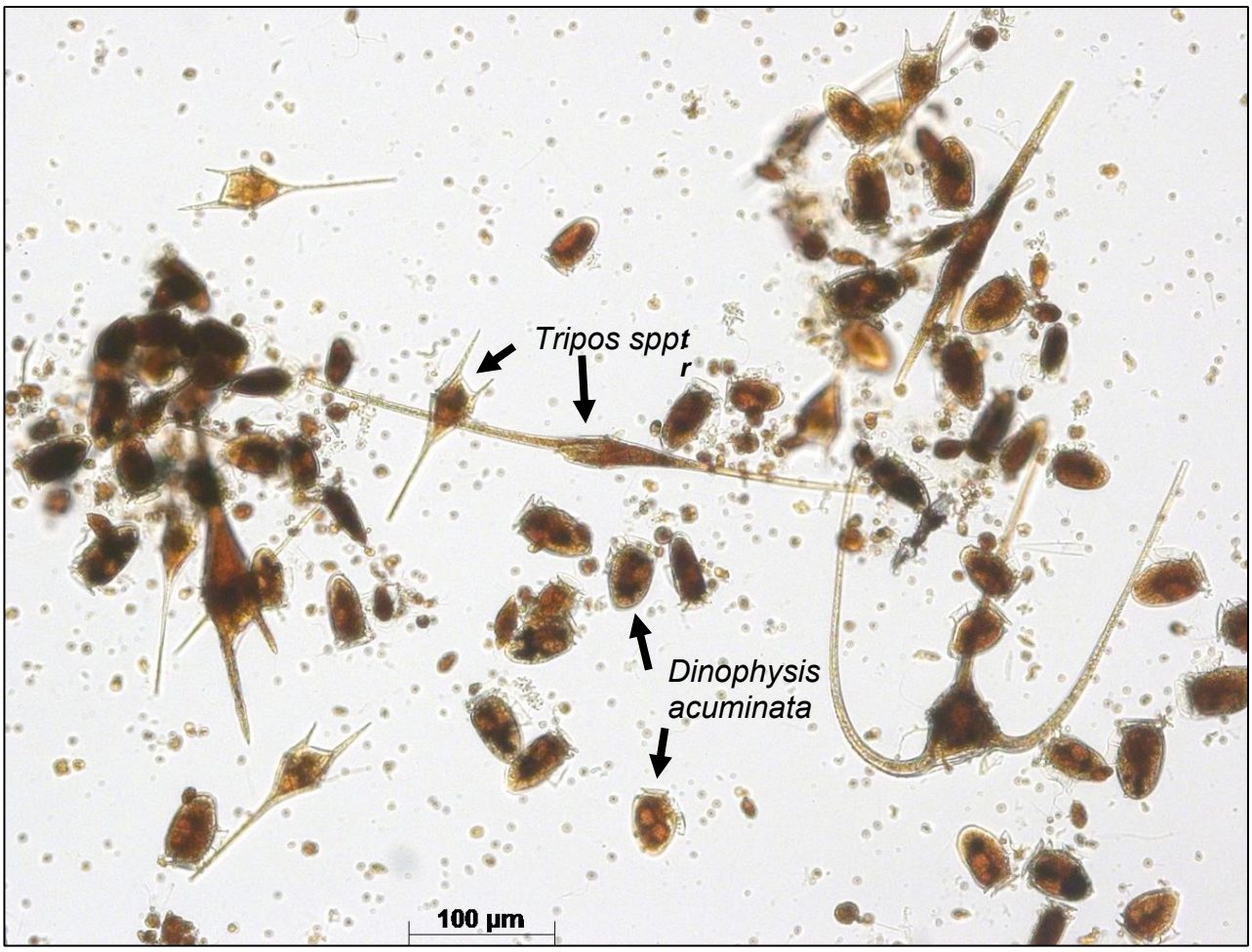


Figure 10. An exceptionally dense bloom of *Dinophysis* (167,625 cells/L) was observed on 10th July in Loch Laxford (Highland: Sutherland). The phytoplankton community was dominated by dinoflagellates, including several species of *Tripos*.

- The benthic dinoflagellate *Prorocentrum lima* (Figure 11) was present in 325 samples (25.0%) analysed during 2018. It was recorded from March to November and was reported at or above the trigger level (set at 100 cells/L) in 69 samples (5.3%), collected between April and October, and was most abundant in July and August. 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. A bloom of *P. lima* at a cell density of 2,440 cells/L was recorded at Colonsay (Argyll & Bute) on 25th June, but in 2018 *P. lima* was notably more abundant around the Shetland Islands, particularly in Basta Voe Cove, Dales Voe, Vaila Sound and Weisdale Voe. This is most likely due to a change in the method of sample collection at most Shetland Islands sites between April and July, from the use of a tube sampler to obtain an integrated water column sample to one collected from the shore by bucket. One exception to this was Basta Voe Cove where the sampling location was moved to the pier near the head of the voe and samples continued to be collected using the tube sampler. The change in location was associated with a conspicuous increase in the abundance of *P. lima*, with maximum cell counts of 12,080 cells/L and 12,040 cells/L reached on 24th July and 4th September, respectively.

- The dinoflagellate *Protoceratium reticulatum* (Figure 12) was detected in 38 samples (2.9%) between April and August and was most abundant between May and July. It was widespread around the coast and observed at low density in more than half of all the sites monitored. The densest bloom occurred in Argyll & Bute, with 180 cells/L recorded in Kilfinichen Bay (Loch Scridain, Isle of Mull, Argyll & Bute) on 17th July. No trigger level has been set for *Protoceratium reticulatum*.

- The dinoflagellate *Lingulodinium polyedra* (Figure 13) is rarely abundant in Scottish coastal waters but was detected on 22 occasions (1.7 % of samples) between April and October, mainly around Argyll & Bute, but with one observation recorded in Stream Sound (Shetland Islands) in April, and one in Loch Leurbost (Lewis & Harris) in June. It was recorded on several occasions in Kilfinichen Bay (3 occassions), Loch Creran (10) and Loch na Cille (6), and once in Loch Spelve (Argyll & Bute). The maximum bloom density of 560 cells/L was observed in Loch Creran on 3rd September, where it appears to bloom annually. No trigger level has been set for *Lingulodinium polyedra*.

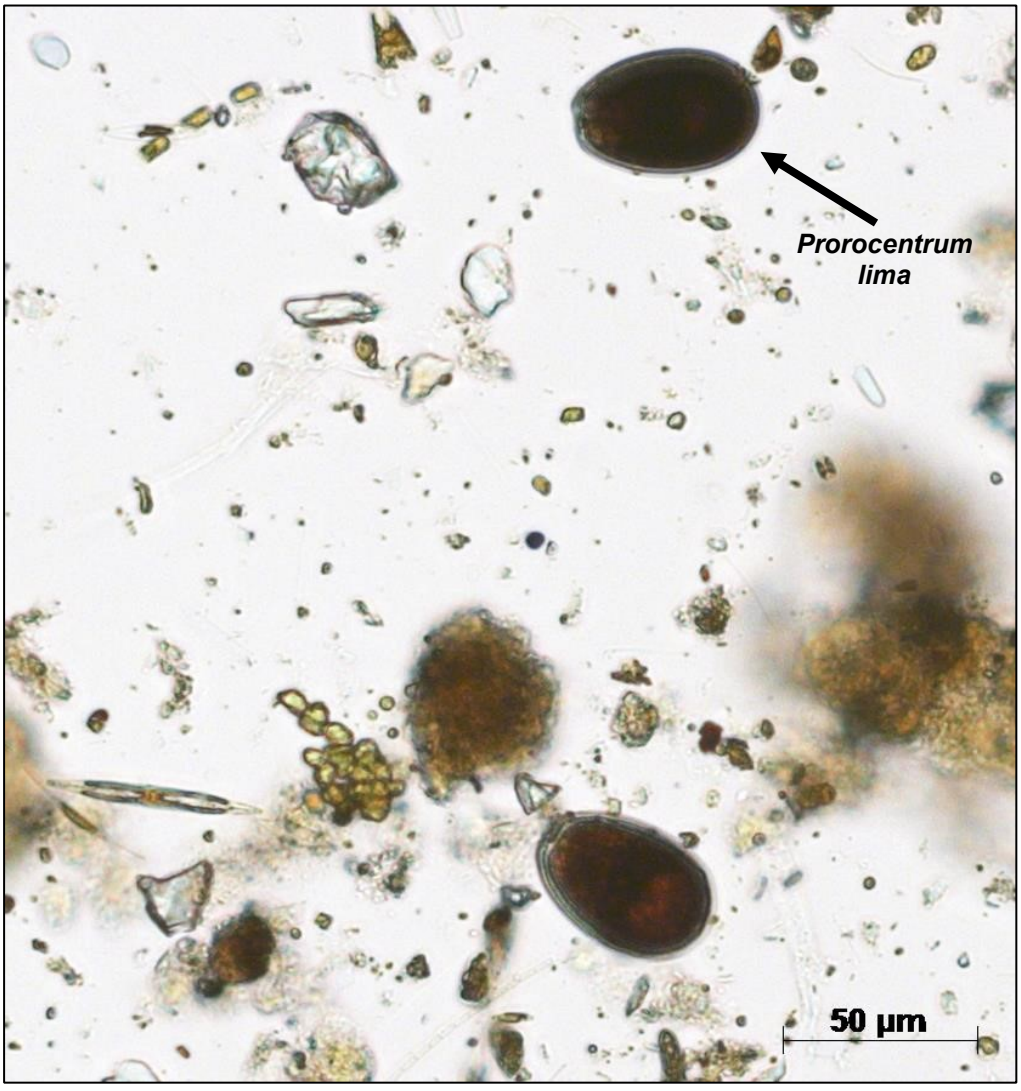


Figure 11. *Prorocentrum lima* observed at Basta Voe Cove (Shetland Islands) on 3rd July at a concentration of 2,280 cells/L.

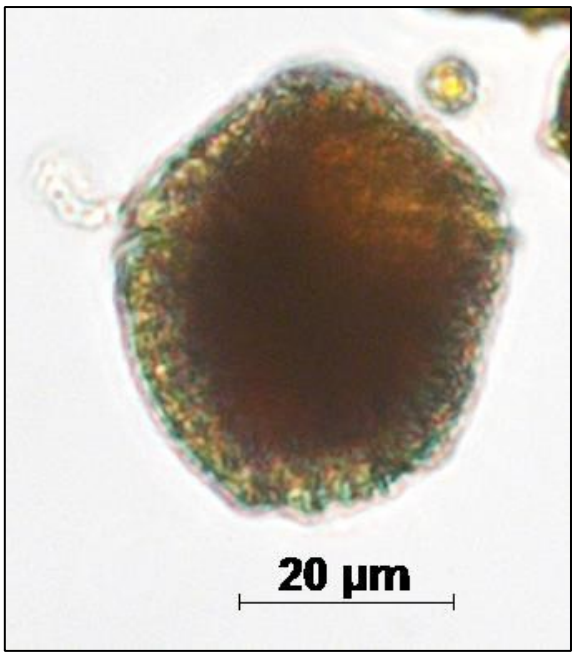


Figure 12. *Protoceratium reticulatum* from Loch na Cille (Argyll & Bute) on 2nd July.

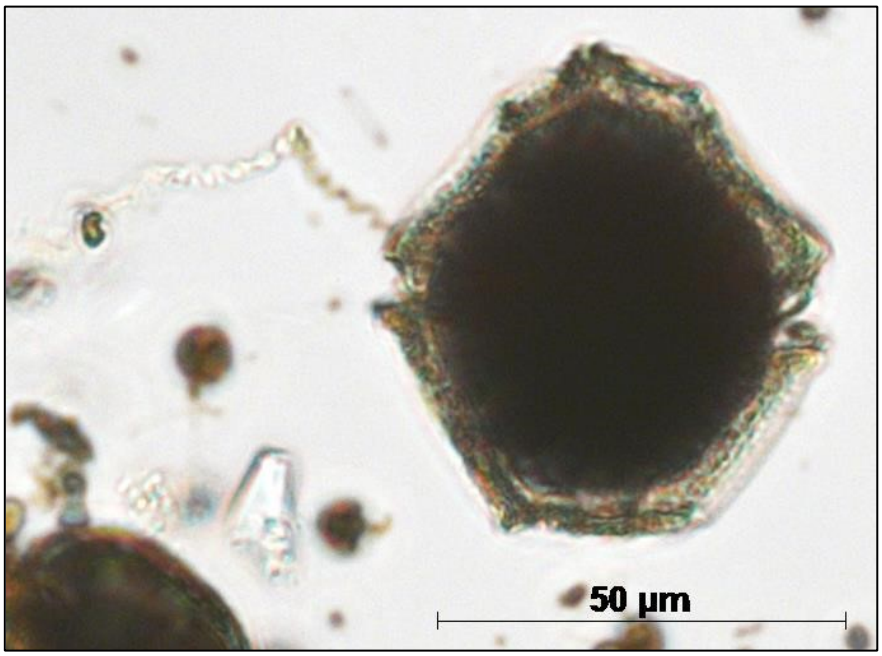


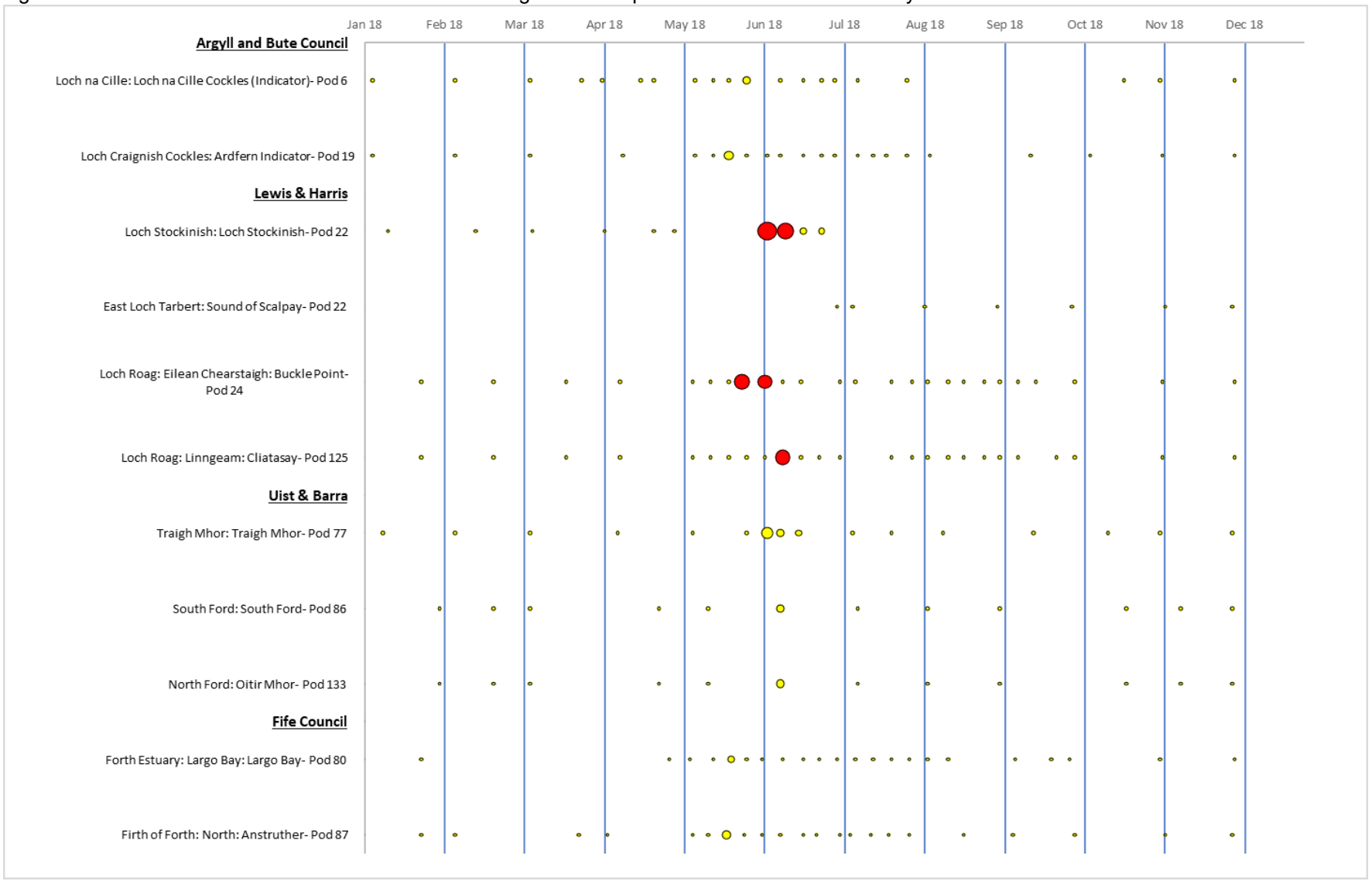
Figure 13. *Lingulodinium polyedra* from Loch na Cille (Argyll & Bute) on 13th August.

1.3 Monitoring for PSP toxins

A total of 1,160 samples from inshore locations and one king 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 are summarised below.

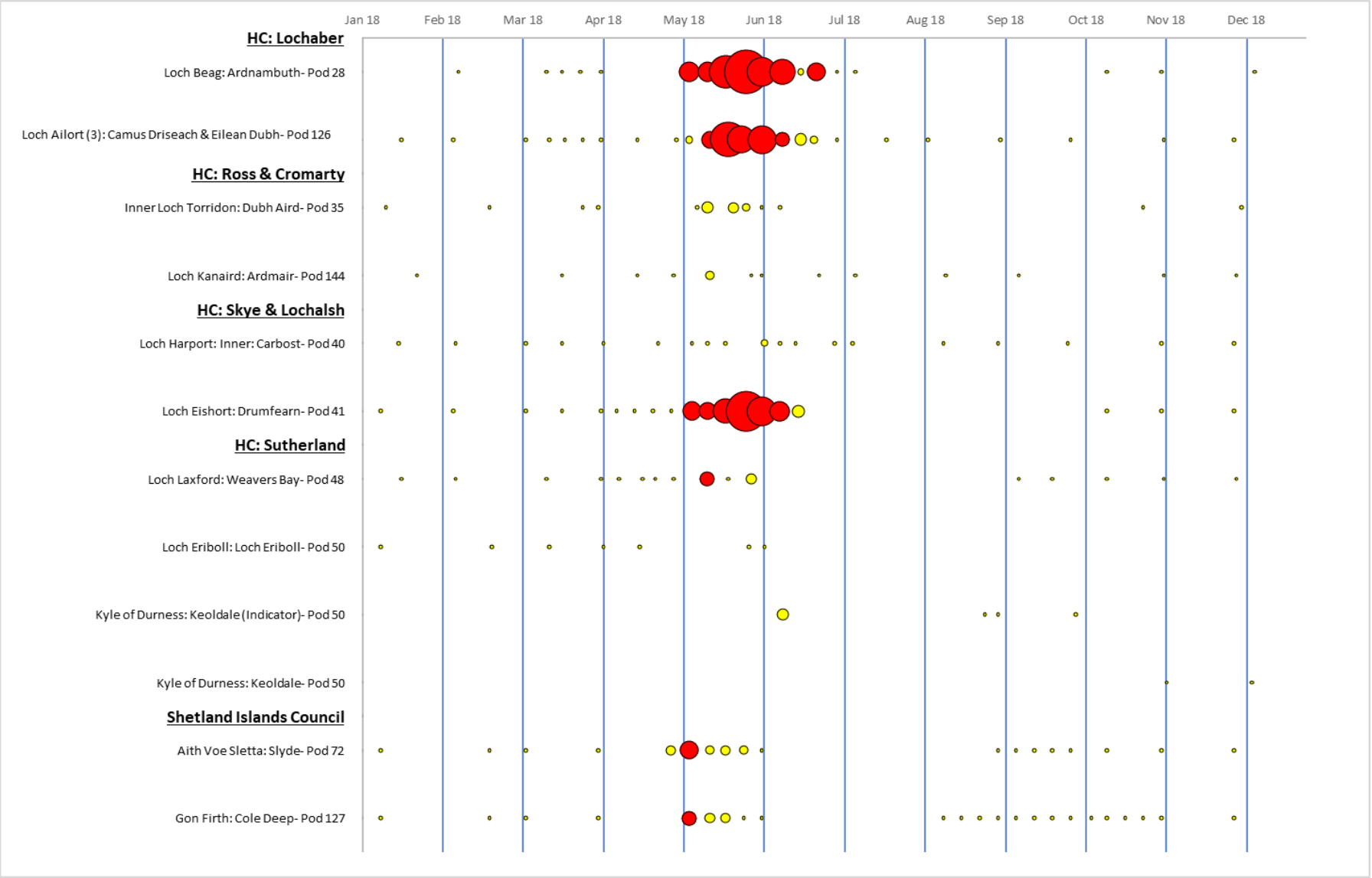
- 26 mussel samples from 10 sites (9 pods, 2 sites within pod 126) were found to contain PSP toxins above the MPL of 800µg STX eq./kg shellfish flesh between late April and June (Figure 15). The highest level recorded was 8,428 µg/kg, over ten times the regulatory limit in a mussel sample from Loch Beag: Ardnambuth collected in late May.
- PSP toxins above reporting levels, but below the MPL were detected in a further 29 samples comprising of mussels (21 samples), Pacific oysters (2), cockles (5) and Surf clams (1) (Figure 16). All occurrences were recorded between late April and June 2018 (Figure 14).
- A range of PSP toxins were quantified during 2018, the majority of samples were mussels (47 samples), although 2 Pacific oyster samples, several cockle samples and a surf clam were also subjected to a quantitation test. The profiles predominantly consisted of the toxins Saxitoxin (STX), Gonyauxtoxins (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. The surf clam sample differed in profile and was characterised by the decarbamoyl toxins dcNEO, dcSTX and dcGTX2&3.
- No quantifiable levels of PSP toxins were detected in the king scallop verification samples.

Figure 14. Concentrations of PSP toxins in sites recording results at quantifiable levels from January to December 2018



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

Figure 14. Concentrations of PSP toxins in sites recording results at quantifiable levels from January to December 2018 (cont.)



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

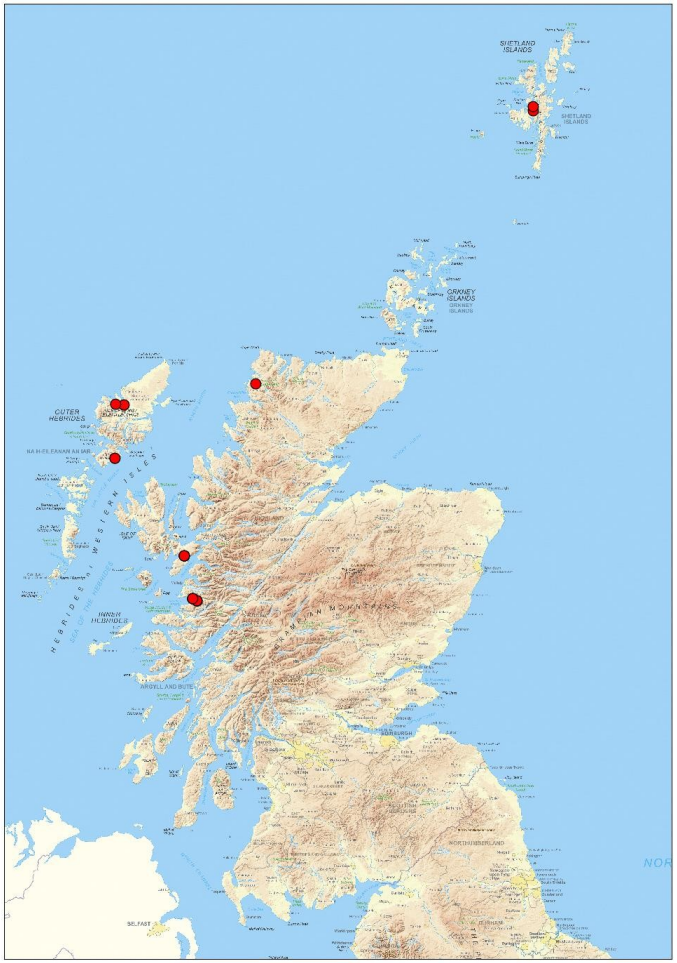


Figure 15. Inshore locations recording PSP toxin results above the maximum permitted limit (>800µg STX eq./kg) in 2018

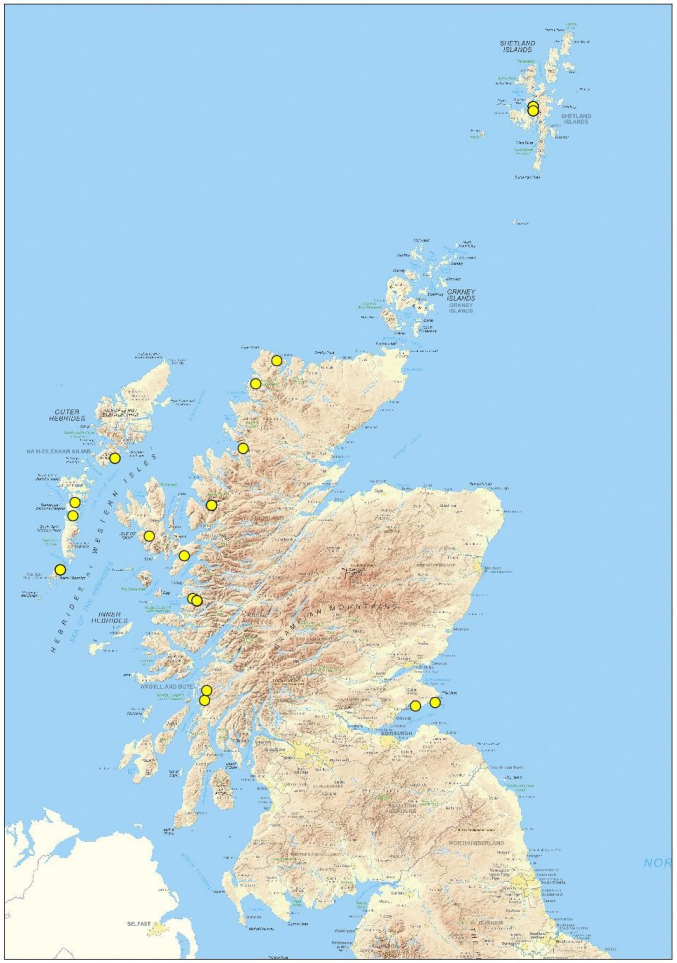
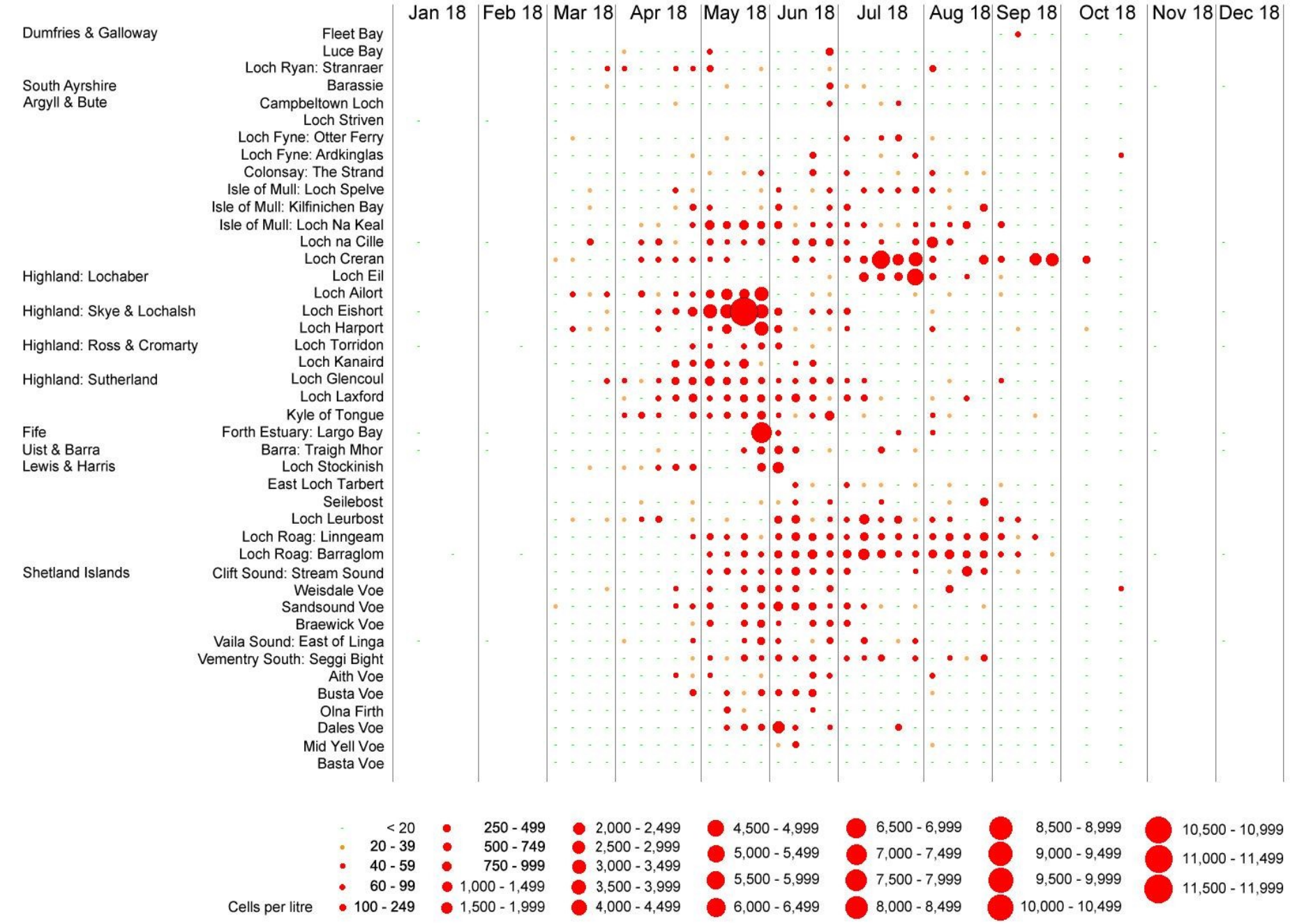


Figure 16. Inshore locations recording PSP toxin results below the maximum permitted limit (≤800µg STX eq./kg) in 2018

1.3.1 Phytoplankton associated with the production of PSP toxins

- Dinoflagellates belonging to the genus *Alexandrium* were observed between March and October (Figure 17) and were detected in 436 (33.5%) of the 1,301 samples analysed during 2018. They were reported at or above the trigger level (set at 40 cells/L) in 322 samples (24.7%). Over 50% of the samples analysed from June were recorded at or exceeded the trigger level (Figure 18).
- The earliest *Alexandrium* spp. bloom of 2018 that breached trigger level was recorded in Loch Harport (Highland: Skye & Lochalsh) on 13th March. Blooms were detected in other areas around the Highland region and in Argyll & Bute during spring (March and April), and also around Lewis & Harris and the Shetland Islands in late April. The blooms in the Loch Roag monitoring sites at Linngeam and Barraglom (Lewis & Harris) were extended in duration, lasting from early May into mid September, with PSP toxins in shellfish above reporting levels in early June, associated with *Alexandrium* spp. counts of a few hundred cells/L.
- A bloom of *Alexandrium* spp. at a concentration of 60 cells/L was observed in Loch Eishort (Skye & Lochalsh) on 16th April. This bloom continued to increase in density for the following five weeks, reaching a maximum of 11,540 cells/L on 21st May (Figure 19), with PSP toxins in common mussels exceeding the regulatory limit by 8th May, when the bloom had reached a density of 3,480 cells/L.
- Relatively dense blooms were also noted at other sites including the Forth Estuary: Largo Bay (Fife), Loch Creran (Argyll & Bute), and Loch Eil (Highland: Lochaber). Cell counts were recorded at 7,200 cells/L, 5,680 cells/L and 4,660 cells/L at these sites on 29th May, 17th July and 31st July, respectively. The Loch Creran and Loch Eil blooms did not appear to be associated with any PSP toxicity in shellfish.
- Overall, the percentage of samples with *Alexandrium* spp. counts at or above trigger level was higher in May and June (at 47.3% and 50.6%) compared with the average value of approximately 31% for both of these months between 2006 and 2017. However, the total percentage of *Alexandrium* spp. at or exceeding trigger level during the whole of 2018 (24.7%) was below the annual average of 28.1% for the period 2006 to 2017.

Figure 17. Phytoplankton concentrations of *Alexandrium* spp. observed between January and December 2018



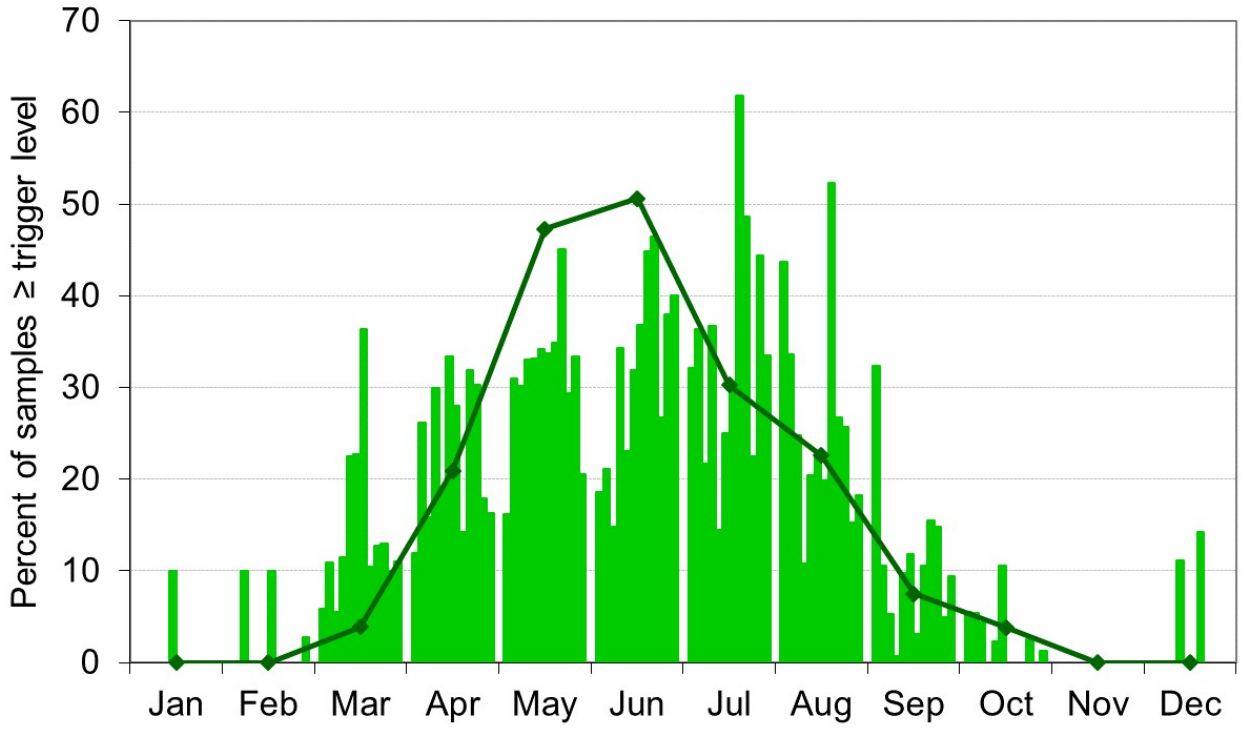


Figure 18. The percentage of samples in which *Alexandrium* spp. equalled or exceeded the trigger level of 40 cells/L in 2018 is indicated by the line. (For comparison, the bars show the percentage of samples in which *Alexandrium* spp. equalled or exceeded the trigger level between 2006 and 2017. NOTE: Data collected prior to July 2014 have been adjusted to the revised trigger level of 40 cells/L for comparative purposes).

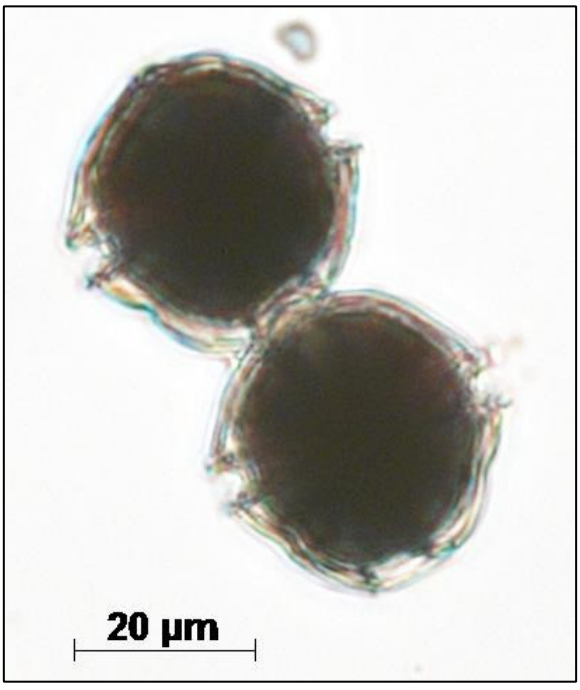


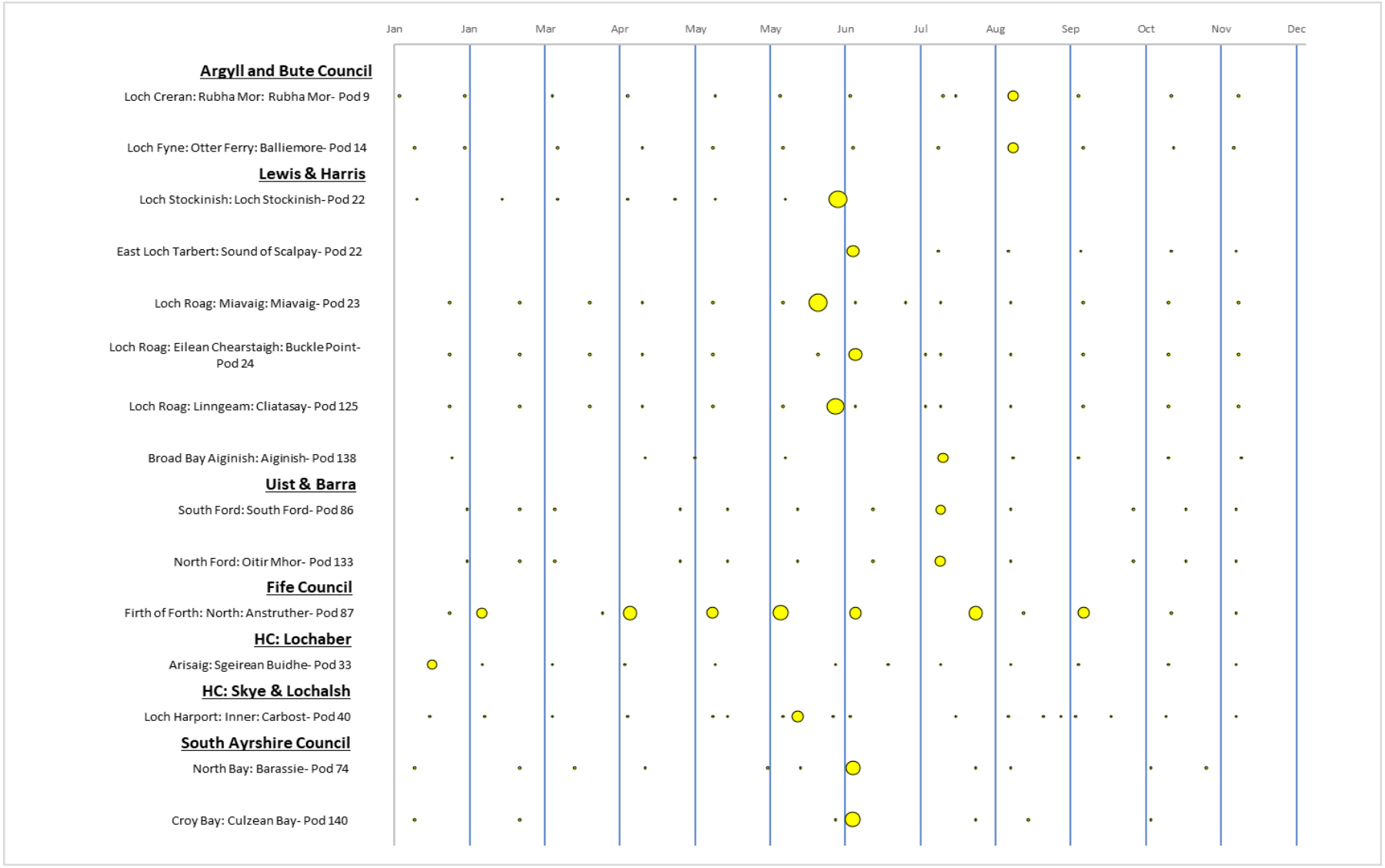
Figure 19. A chain of *Alexandrium* spp. in a bloom of density 11,540 cells/L, observed at Loch Eishort (Highland: Skye & Lochalsh) on 21st May.

1.4 Monitoring for ASP toxins

Analyses for amnesic shellfish poisoning (ASP) toxin were conducted on 793 samples from 86 inshore locations and 1 king scallop verification sample 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 21 inshore samples comprising of: common mussels (5 samples), razors (3), Pacific oysters (4), common cockles (2) and surf clams (7).
- These samples originated from 15 sites. Low concentrations were recorded from January through to October 2018 (Figure 20). The peak period occurring between May & September, during which time, ASP was detected in 17 samples (Figure 20).
- No inshore samples exceeded the MPL of 20mg [domoic/epi domoic acid] (DA)/kg shellfish flesh (Figure 21). The highest level recorded was 3.1mg/kg in a mussel sample collected in June 2018**,** originating from Loch Roag: Miavaig (mussels, Comhairle nan Eilean Siar - Lewis & Harris).
- ASP was not detected in the king scallop verification sample**.**

Figure 20. Concentrations of ASP toxins in sites recording results at quantifiable levels from January to December 2018


Jan
Jan
Mar
Apr
May
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Argyll and Bute Council
Loch Creran: Rubha Mor: Rubha Mor- Pod 9
Loch Fyne: Otter Ferry: Balliemore- Pod 14
Lewis & Harris
Loch Stockinish: Loch Stockinish- Pod 22
East Loch Tarbert: Sound of Scalpay- Pod 22
Loch Roag: Miavaig: Miavaig- Pod 23
Loch Roag: Eilean Chearstaigh: Buckle Point- Pod 24
Loch Roag: Linngeam: Cliatasay- Pod 125
Broad Bay Aiginish: Aiginish- Pod 138
Uist & Barra
South Ford: South Ford- Pod 86
North Ford: Oitir Mhor- Pod 133
Fife Council
Firth of Forth: North: Anstruther- Pod 87
HC: Lochaber
Arisaig: Sgeirean Buidhe- Pod 33
HC: Skye & Lochalsh
Loch Harport: Inner: Carbost- Pod 40
South Ayrshire Council
North Bay: Barassie- Pod 74
Croy Bay: Culzean Bay- Pod 140

Concentration of ASP toxins:

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

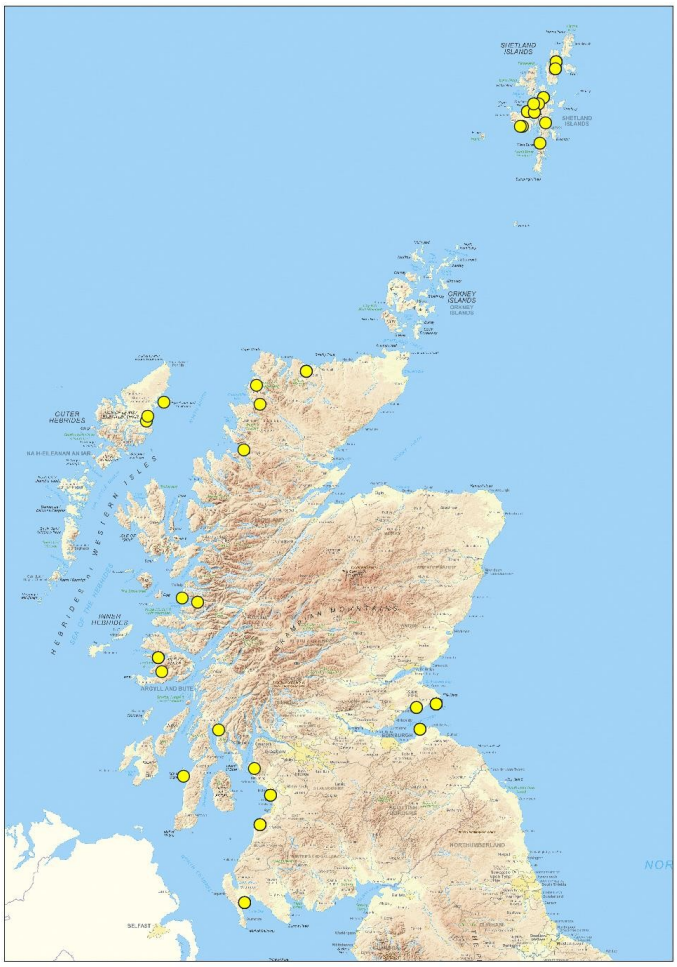


Figure 21. Inshore locations where ASP toxins were detected in 2018 (all below the maximum permitted limit (<20mg/kg))

1.4.1 Phytoplankton associated with the production of ASP toxins

- Diatoms belonging to the genus *Pseudo-nitzschia* were detected in every month in 2018 (Figure 24) and were present in 1,189 (91.4%) of the 1,301 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 June (Figure 22).
- *Pseudo-nitzschia* spp. counts at or above the trigger level (set at 50,000 cells/L) were recorded in 59 samples (4.5%), with 13.7% of the samples analysed in June exceeding this level (Figure 22). The earliest bloom was recorded in Loch Glencoul (Highland: Sutherland) on 13th March, with an abundance of 52,760 cells/L. The latest bloom of 2018 occurred in Kilfinichen Bay, as was the case for this site in 2017, with a cell count of 152,778 cells/L reported on 22nd October.

- *Pseudo-nitzschia* spp. blooms were occasionally observed around the Shetland Islands (Braewick Voe, Aith Voe and Busta Voe) in March and early April, but in stark contrast to 2017, cell counts mostly remained below trigger level throughout the whole summer in the region. When they did occur, blooms were of short duration and fairly localized, either on the east coast of Yell, (north-east Shetland Islands) in June, or on the south-west coast of mainland Shetland (Clift Sound, Sandsound Voe, Braewick Voe and Vaila Sound) in late July, with a further bloom period in Sandsound Voe during September (Figure 24).
- Denser *Pseudo-nitzschia* spp. blooms were recorded elsewhere around the Scottish coast, notably in Loch Harport and Loch Eishort (Highland: Skye & Lochalsh) in mid June, where cell counts of 910,355 cells/L and 928,422 cells/L were reported at these sites on 11th June and 18th June, respectively. Coincident with the bloom peak, a low level of ASP toxicity was detected in Pacific oysters from Loch Harport, but ASP testing was not performed on shellfish from Loch Eishort because of a site closure due to DSP toxins present above regulatory limit in common mussels.
- The densest *Pseudo-nitzschia* spp. bloom of 2018 was recorded in East Loch Tarbert (Lewis & Harris) on 27th June, where cell counts reached 1,528,134 cells/L (Figure 23). ASP testing was not performed on shellfish during the week of the bloom maxima, but toxins were found to be present in common mussels in the following week.
- Overall, the percentage of *Pseudo-nitzschia* spp. exceeding trigger level during 2018 (4.5%) was below the annual average of 10.5% for the period 2006 to 2017.

Figure 22. Phytoplankton concentrations of *Pseudo-nitzschia* spp. observed between January and December 2018

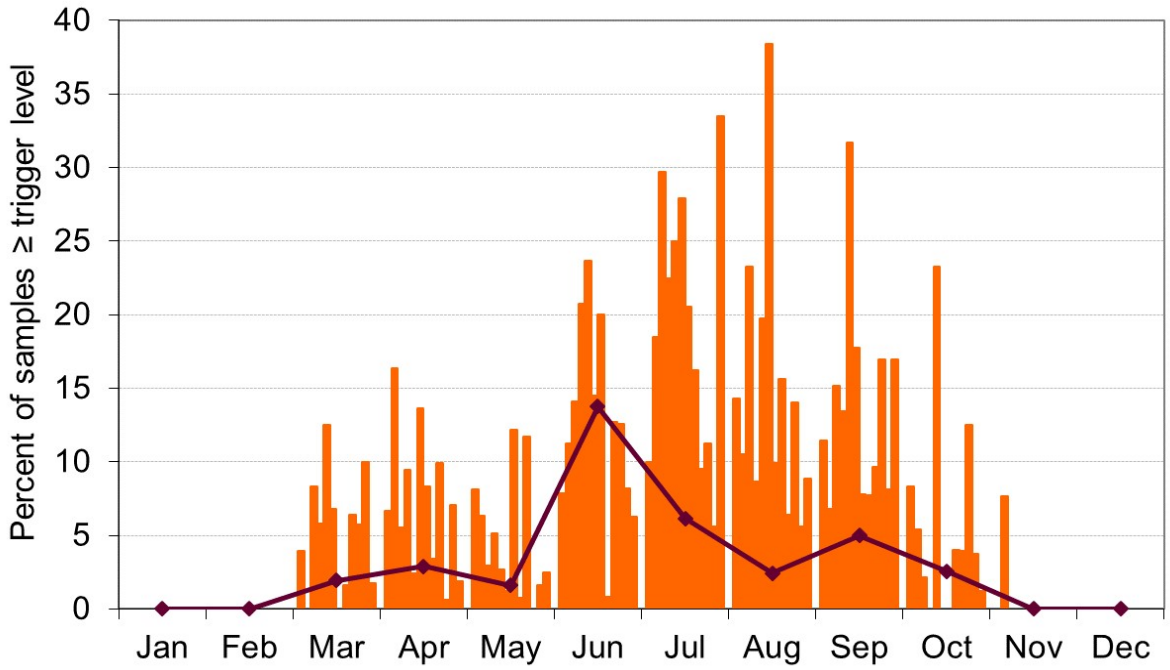


Figure 23. The percentage of samples in which *Pseudo-nitzschia* spp. equalled or exceeded the trigger level of 50,000 cells/L in 2018 is indicated by the line. (For comparison, the bars show the percentage of samples in which *Pseudo-nitzschia* spp. equalled or exceeded the trigger level between 2006 and 2017).

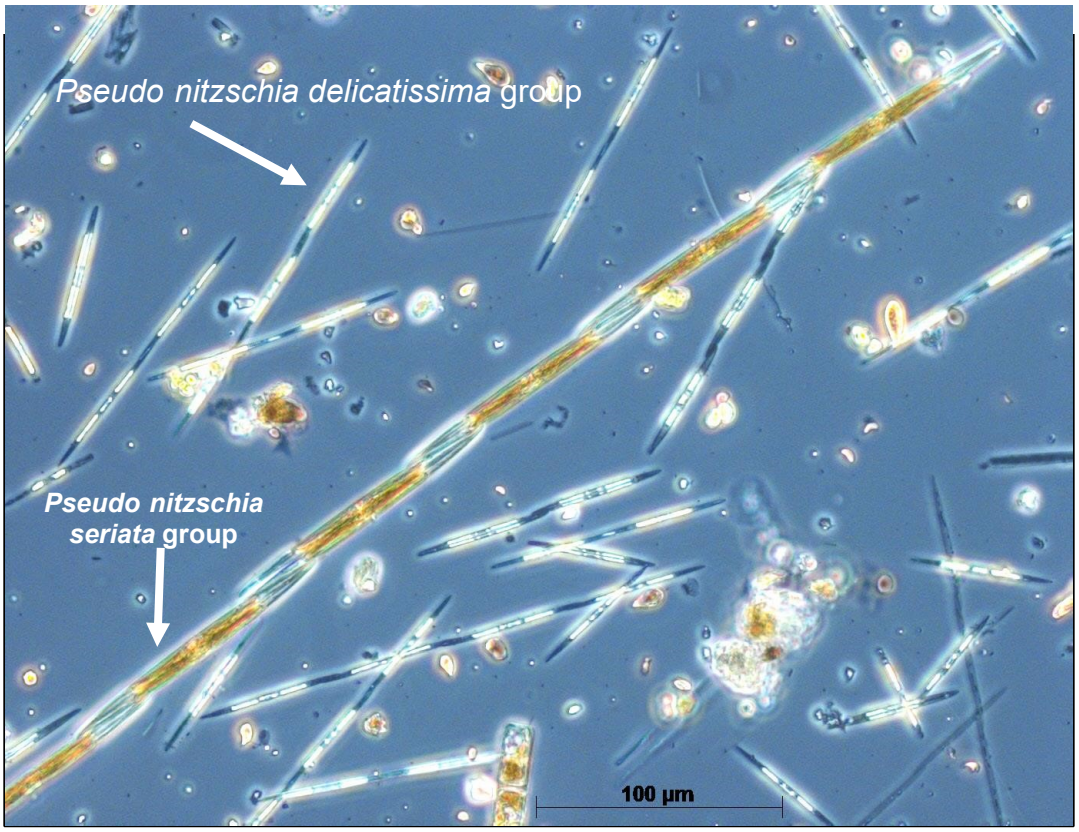


Figure 24. Chains of *Pseudo-nitzschia* spp. observed in Loch Tarbert (Lewis & Harris) on 27th June. The bloom was composed of approximately 98% *Pseudo-nitzschia delicatissima* group cells and the density exceeded 1.5 million cells/L.

1.5 Other potentially harmful phytoplankton

The dinoflagellate *Prorocentrum cordatum* (Figure 25) was detected in 689 samples analysed in 2018 (53.0%). It was observed from March through to December and was most abundant in April, May and June, being recorded in 77.3%, 79.0% and 76.2% of the samples analysed during these months, respectively. The densest blooms of 2018 occurred around the Shetland Islands on 4th June, with concentrations of 528,578 cells/L recorded in Vaila Sound and 191,092 cells/L in Busta Voe. In south-west Scotland, blooms of maximum density 344,782 cells/L were reported in Loch Ryan (Dumfries & Galloway) on 7th May, and 72,116 cells/L at Barassie (South Ayrshire) on 14th May. *Prorocentrum cordatum* was mostly observed below 10,000 cells/L at other monitoring sites around the Scottish coast. No trigger level has been set for this species.

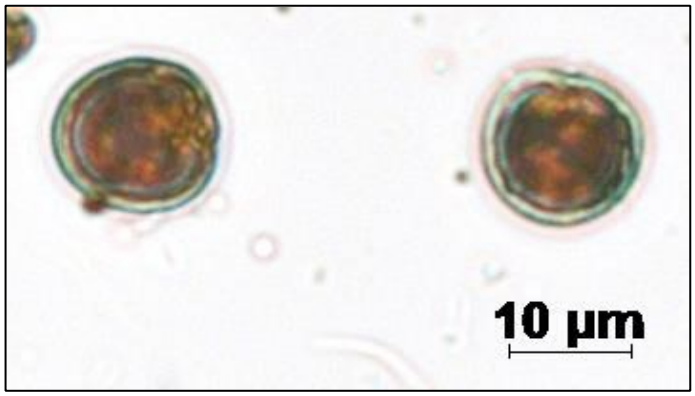


Figure 25. *Prorocentrum cordatum* observed in Olna Firth (Shetland Islands) on 16th May.

The potentially problematic dinoflagellate *Karenia mikimotoi* (Figure 26) was not observed in densities likely to negatively impact aquaculture during 2018 but was detected in 198 (15.2%) of the samples analysed. This species is not an issue in terms of shellfish harvesting, as it does not produce biotoxins that are harmful to human health. However, it does produce 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 low in 2018, with a maximum density of 1,240 cells/L recorded at Kyle of Tongue (Highland: Sutherland) on 27th June.

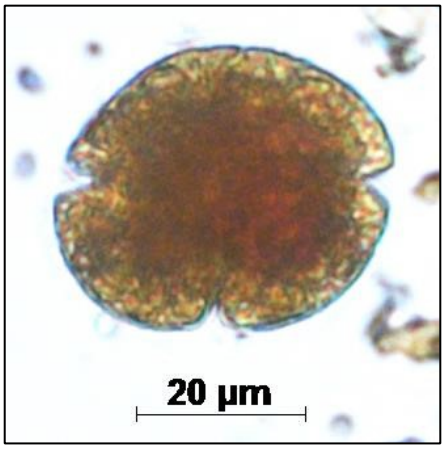


Figure 26. *Karenia mikimotoi* in Loch Stockinish (Lewis & Harris) on 18th April.

1.6 Results of the wild pectinidae onshore verification programme

ASP, PSP and LTs analyses were performed on one sample from an establishment in the South Ayrshire region received via the wild pectinidae onshore verification programme. The origin of harvest for the scallop sample received during the reporting period is indicated by the shaded cells in Figure 27.

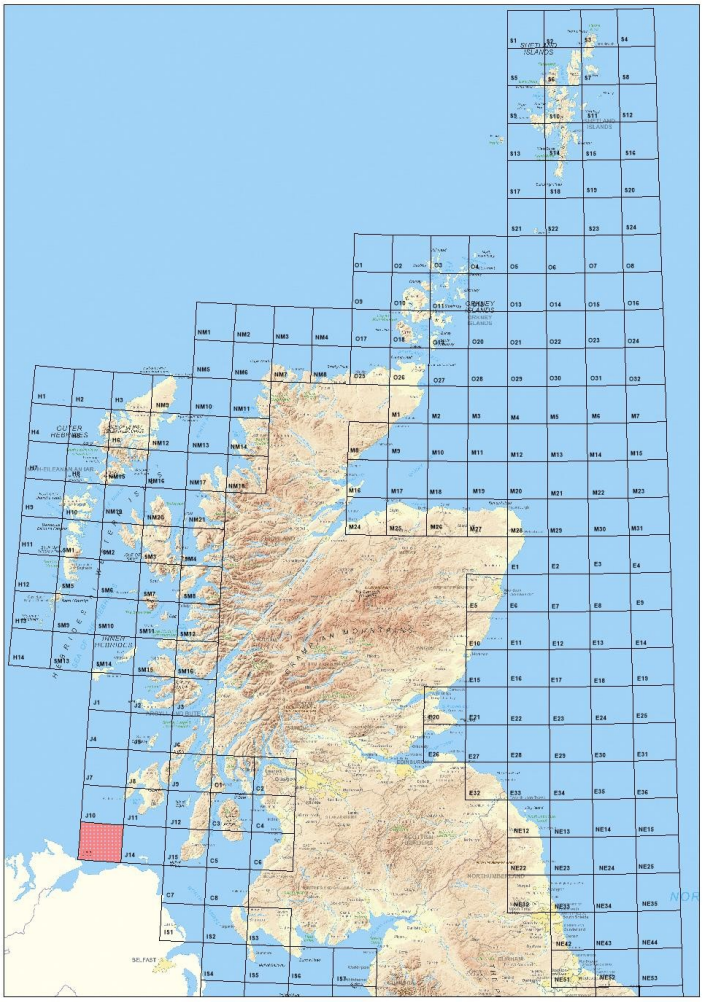


Figure 27. Origin of the wild pectinidae sample received via the FSS onshore official control verification programme in 2018

No toxins were detected in this scallop sample.

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 2018, 1,950 bivalve shellfish samples from 87 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.) (1,373 samples – 70.4% of all samples), Pacific oysters (*Crassostrea gigas*) (414 – 21.2%), razors (*Ensis* spp.) (80 – 4.1%), common cockles (*Cerastoderma edule*) (40 – 2.0%), surf clams (*Spisula solida*) (32 – 1.6%) and native oysters (*Ostrea edulis*) (11 - 0.6%).

Samples collected between the 1st of January and 31st of March were collected by officers operating on behalf of several contractors appointed directly by FSS. 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. 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, 18.9% 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 and by sampling contractor

Local Authority	**Sampling contractors from 1st January to 31st March 2018**	**Sampling contractor from 1st April 2018**	**No. samples received**	**No. verified samples received & percentage**		**No. unverified samples received & percentage**	
Argyll & Bute Council	Argyll & Bute Council	Hall Mark Meat Hygiene	520	516	99.2%	4	0.8%
Comhairle nan Eilean Siar: Lewis & Harris	Hall Mark Meat Hygiene		217	191	88.0%	26	12.0%
Comhairle nan Eilean Siar: Uist & Barra	Hall Mark Meat Hygiene		40	40	100.0%	0	0.0%
Dumfries & Galloway Council	FSS Operations		22	3	13.6%	19	86.4%
East Lothian Council	Hall Mark Meat Hygiene		9	0	0.0%	9	100.0%
Fife Council	Hall Mark Meat Hygiene		74	21	28.4%	53	71.6%
Highland Council: Lochaber	Highland Council		161	115	71.4%	46	28.6%
Highland Council: Ross & Cromarty	Highland Council		51	51	100.0%	0	0.0%
Highland Council: Skye & Lochalsh	Highland Council		83	77	92.8%	6	7.2%
Highland Council: Sutherland	Highland Council		131	100	76.3%	31	23.7%
North Ayrshire Council	FSS Operations		33	33	100.0%	0	0.0%
Shetland Islands Council	Hall Mark Meat Hygiene		588	433	73.6%	155	26.4%
South Ayrshire Council	FSS Operations		21	1	4.8%	20	95.2%
Totals			**1,950**	**1,581**	**81.1%**	**369**	**18.9%**

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	40	0	0.0%
Common mussels	Aquaculture	1373	254	18.5%
Common mussels	Wild harvest	0	0	
Pacific oysters	Aquaculture	414	0	0.0%
Razors	Wild harvest	80	76	95.0%
Surf clams	Wild harvest	32	31	96.9%
Native oysters	Wild harvest	11	8	72.7%

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 (~76 and ~23%, 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. No samples had perished during extended periods of transit, to the point where a sample was rejected.

Table 4. Number of inshore biotoxin samples received from each Local Authority region and time taken between collection and receipt at Cefas in 2018

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	No. received 4 or more working days post collection
Argyll and Bute Council	520	426	89	3	2
Comhairle nan Eilean Siar - Lewis & Harris	217	190	26	1	
Comhairle nan Eilean Siar - Uist & Barra	40	33	7		
Dumfries and Galloway Council	22	14	7	1	
East Lothian Council	9	4	5		
Fife Council	74	41	31	2	
Highland Council: Lochaber	161	117	40	3	1
Highland Council: Ross & Cromarty	51	41	10		
Highland Council: Skye & Lochalsh	83	58	25		
Highland Council: Sutherland	131	111	20		
North Ayrshire Council	33	27	6		
Shetland Islands Council	588	410	176	1	1
South Ayrshire Council	21	13	8		
Totals (percent)	**1950**	**1485 (76.1%)**	**450 (23.1%)**	**11 (0.6%)**	**4 (0.2%)**

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=15)

being received three or more working days post collection throughout this reporting period. None of these late samples were rejected as unsuitable for analyses (see section 1.4.2).

Wild pectinidae – Onshore Surveillance Programme:

One king scallop sample (comprising of adductor and roe only) was collected by an authorised officer from the South Ayrshire region during the reporting period and submitted to Cefas for toxin analyses.

The sample was originally harvested from the Jura offshore scallop ground (J13), the sample arrived one day post collection from the premises and results were available the following day.

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, 11 inshore samples were rejected in 2018. The king scallop verification samples was suitable for analysis. Therefore ~99.5% of all samples received were assessed as suitable for analysis and tested in 2018.

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	520	0	2
Comhairle nan Eilean Siar: Lewis & Harris	217	0	1
Comhairle nan Eilean Siar: Uist & Barra	40	0	0
Dumfries & Galloway Council	22	0	1
East Lothian Council	9	0	0
Fife Council	74	1	1
Highland Council: Lochaber	161	0	0
Highland Council: Ross & Cromarty	51	1	0
Highland Council: Skye & Lochalsh	83	0	0
Highland Council: Sutherland	131	0	2
North Ayrshire Council	33	0	0
Shetland Islands Council	588	0	2
South Ayrshire Council	21	0	0
Totals (percent)	**1950**	**2 (0.1%)**	**9 (0.5%)**

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 ISO17025:2005 standard. Table 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 2018

Toxin group	Methods employed	Species tested	Dates
ASP	LC-UV	All species	1st January to 31st December 2018
PSP	LC-FLD (screen, semi-quantitative screen & full quantitation)	All species	1st January to 31st December 2018
Lipophilic toxins	LC-MS/MS	All species	1st January to 31st December 2018

Table 7. Flesh and phytoplankton trigger levels

Toxin group	Levels of toxin or cell concentrations triggering additional monitoring if breached
ASP	and/or *Pseudo-nitzschia* spp. ≥ 50,000 cells/L
LTs	OA/DTX/PTX group: ≥80 µg OA ≥10mg domoic/epi-domoic acid/kg shellfish flesh 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 (40 and/or *Alexandrium* spp. 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 96.5% of all tests carried out within one working day of receipt and 99.9% within two working days (Table 8).

Of the 135 samples results which were reported after one working day of receipt, 78 samples (57.7%) 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	96.5% within 1 working day 99.9% within 2 working days 100% within 3 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 2018 is given in Table 9.

Table 9. Turnaround times, by Local Authority region, for biotoxin samples received from inshore areas in 2018

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	No. completed results reported three working days after receipt of sample
Argyll & Bute Council	520	1023	1010	13	0
Comhairle nan Eilean Siar: Lewis & Harris	217	468	449	19	0
Comhairle nan Eilean Siar: Uist & Barra	40	118	112	6	0
Dumfries & Galloway Council	22	59	59	0	0
East Lothian Council	9	27	27	0	0
Fife Council	74	144	140	4	0
Highland Council: Lochaber	161	325	308	16	1
Highland Council: Ross & Cromarty	51	100	91	7	2
Highland Council: Skye & Lochalsh	83	154	141	13	0
Highland Council: Sutherland	131	232	225	7	0
North Ayrshire Council	33	59	58	1	0
Shetland Islands Council	588	1123	1093	30	0
South Ayrshire Council	21	54	53	1	0
Totals	**1950**	**3886**	**3766**	**117**	**3**

(Note, of the 120 samples reported between 2 and 3 days, 78 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 Wednesday 12th of December and last results reported on Thursday 13th of December.

1.8 Phytoplankton Methodology

1.8.1 Water collection

For the monitoring period 1st January to 31st December 2018, a total of 1,305 seawater samples were collected from 43 sampling locations within seven Local Authority regions (eleven local offices) (Table 10). As for shellfish samples, seawater samples were collected by officers operating on behalf of several contractors appointed by the FSS up until 31st March 2018, after which the sampling contractor for all areas was Hall Mark Meat Hygiene.

Table 10. Number of water samples collected during the reporting period by Local Authority region and by sampling contractor.

Local Authority	Sampling contractor	No. samples received	No. samples rejected
Argyll & Bute Council	Argyll & Bute Council	39	
Argyll & Bute Council	Hall Mark Meat Hygiene	253	1
Comhairle nan Eilean Siar: Lewis & Harris	Hall Mark Meat Hygiene	167	3
Comhairle nan Eilean Siar: Uist & Barra	Hall Mark Meat Hygiene	36	
Dumfries & Galloway Council	FSS Operations	8	
Dumfries & Galloway Council	Hall Mark Meat Hygiene	56	
Fife Council	Hall Mark Meat Hygiene	36	
Highland Council: Lochaber	Highland Council	8	
Highland Council: Lochaber	Hall Mark Meat Hygiene	56	
Highland Council: Ross & Cromarty	Highland Council	10	
Highland Council: Ross & Cromarty	Hall Mark Meat Hygiene	55	
Highland Council: Skye & Lochalsh	Highland Council	9	
Highland Council: Skye & Lochalsh	Hall Mark Meat Hygiene	58	
Highland Council: Sutherland	Highland Council	8	
Highland Council: Sutherland	Hall Mark Meat Hygiene	84	
Shetland Islands Council	Hall Mark Meat Hygiene	388	
South Ayrshire Council	FSS Operations	4	
South Ayrshire Council	Hall Mark Meat Hygiene	30	
TOTALS		1305	4

Samples were collected and packaged in accordance with SRSL's guidance and protocols and sent to the SRSL Oban laboratory for analysis. Four samples were collected in error and were not analysed, due to the reduced winter sampling schedule. Eleven samples were not received due to either adverse weather (6 samples), not being scheduled on the weekly sampling plan (3 samples) or were collected but never arrived at the laboratory (2 samples). This resulted in a total of 1,301 samples being analysed between 1st January and 31st December 2018.

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. 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 wellmixed 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 (98.0%) arrived at the laboratory within one or two working days of sample collection, 86.6% and 11.4%, respectively (Table 11). Of the samples taking more than one working day to arrive, 85.7% were from remote areas. Of the 26 samples taking more than two days to arrive, 15 of these were from the island of Colonsay (Argyll & Bute) and the remainder from the Shetland Islands.

Table 11. Number of phytoplankton samples received from each Local Authority region and time taken between collection and receipt at SRSL in 2018.

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	No. received ≥4 working days post collection
Argyll & Bute Council	292	256	21	6	9
Comhairle nan Eilean Siar: Lewis & Harris	167	149	18	0	0
Comhairle nan Eilean Siar: Uist & Barra	36	34	2	0	0
Dumfries & Galloway Council	64	50	14	0	0
Fife Council	36	34	2	0	0
Highland Council: Lochaber	64	63	1	0	0
Highland Council: Ross & Cromarty	65	60	5	0	0
Highland Council: Skye & Lochalsh	67	55	12	0	0
Highland Council: Sutherland	92	86	6	0	0
Shetland Islands Council	388	318	59	11	0
South Ayrshire Council	34	25	9	0	0
TOTAL (percent)	**1305**	**1130 (86.6%)**	**149 (11.4%)**	**17 (1.3%)**	**9 (0.7%)**

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.

Methodology

The UKNRL protocol for the identification and enumeration of potential toxinproducing 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 ISO 17025 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:

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. The highlights of the review are summarised below, together with recommendations for future monitoring.

1.9.1 Toxin monitoring

Pod 144 – Loch Kanaird: Ardmair (Pacific oyster)

This pod has been monitored for toxins since September 2014 and from its induction into the biotoxin monitoring programme, the RMP location and species have remained the same. The pod is located in the north west region of mainland Scotland.

Prior to 2017, only a few toxic events had been recorded in this pod. PSP had not been recorded at quantifiable levels and low levels of OA/DTX/PTXs (highest concentration 85µg OA eq./kg in October 2014) and ASP (highest concentration 2.4mg [domoic/epi domoic acid] (DA)/kg) in May 2016. The current testing regime, as defined by FSS, is highlighted in Figure 29 (blue cells indicate the required test).

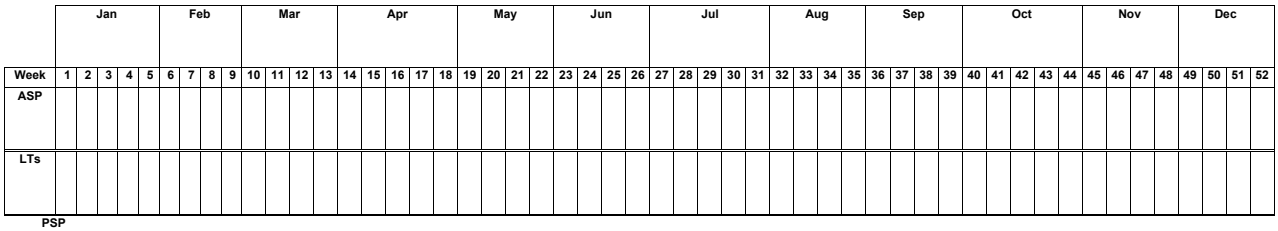


Figure 29. Testing frequencies of Pod 144

In 2017, the RMP recorded its first closure level results for OA/DTX/PTXs, with 2 separate events leading to closure of the pod. The first in late July with a highest

concentration of 181µg OA eq./kg and the second in September/October with a highest result of of 286µg OA eq./kg. In 2018, a further result exceeding the MPL for OA/DTX/PTXs was recorded in mid June (high result of 230µg OA eq./kg). Furthermore, PSP toxins were also recorded at quantifiable levels in mid May (high result of 402µg STX eq./kg), therefore exceeding the trigger level.

Recommendation: *Consider the extension of weekly sampling/testing for OA/DTX/PTXs from June until the end of September. Additionally, the introduction of fortnightly sampling for PSP in April and May should also be given consideration.*

1.9.2 Phytoplankton monitoring

The review of the phytoplankton monitoring points suggested that several monitoring points could be amended, with the current sampling locations dropped in favour of new sites. The list is provided in Table 12 below.

Table 12. Recommended changes to phytoplankton monitoring RMPs

Current phytoplankton RMP	Recommended 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 (FIL). 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 13.

Table 13. 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 intravalvular 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 intravalvular 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) No. 854/2004 as amended by Regulation (EU) 2015/2285).

[2] Regulation (EC) No 854/2004 as amended by Regulation (EU) 2015/2285.

[3] Regulation (EC) No. 854/2004 as amended by Regulation (EC) No 1021/2008

[4] Regulation (EC) No. 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 2018.

2.2 Methodology

2.2.1 Shellfish collection

For the monitoring period of 1st January to 31st December 2018, 1,994 bivalve shellfish samples from 181 Representative Monitoring Points (RMP) were submitted for microbiological analyses (SSQC *n*= 663; Cefas *n*=1331). 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 mussels (*Mytilus* spp.) (1033 samples – 51.8% of all samples), Pacific oysters (*Crassostrea gigas*) (381 –19.1%), common cockles (*Cerastoderma edule*) (285 – 14.3%),(Ensis spp.) (244 – 12.2%), surf clams (*Spisula solida*) (32 – 1.6%), native oysters (*Ostrea edulis*) (18 – 1.0%), and sand gapers (*Mya arenaria*) (1 – 0.1%).

Samples collected between the 1st of January and 31st of March were collected by officers operating on behalf of several contractors appointed directly by FSS. 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. 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, 25.6% 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 14.

Table 14. Number of verified and unverified *E. coli* samples collected during the reporting period by Local Authority region and by sampling contractor

Local Authority	**Sampling contractors from 1st January to 31st March 2018**	**Sampling contractor from 1st April 2018**	**No. samples received**	**No. verified samples received & percentage**		**No. unverified samples received & percentage**	
Argyll & Bute Council	Argyll & Bute Council	Hall Mark Meat Hygiene	539	470	87.2	69	12.8
Angus Council	Hall Mark Meat Hygiene		0	0	N/A	0	N/A
Comhairle nan Eilean Siar: Lewis & Harris	Hall Mark Meat Hygiene		224	210	93.7	14	6.3
Comhairle nan Eilean Siar: Uist & Barra	Hall Mark Meat Hygiene		84	82	97.6	2	2.4
Dumfries & Galloway Council	FSS Operations		49	13	26.6	36	73.4
East Lothian Council	Hall Mark Meat Hygiene		19	2	10.5	17	89.5
Fife Council	Hall Mark Meat Hygiene		42	6	14.3	36	85.7
Highland Council: Lochaber	Highland Council		132	98	74.2	34	25.8
Highland Council: Ross & Cromarty	Highland Council		44	43	97.7	1	2.3
Highland Council: Skye & Lochalsh	Highland Council		57	40	70.2	17	29.8
Highland Council: Sutherland	Highland Council		63	47	74.6	16	25.4
North Ayrshire Council	FSS Operations		24	13	54.2	11	45.8
Orkney Council	Hall Mark Meat Hygiene		0	0	N/A	0	N/A
Shetland Islands Council	Hall Mark Meat Hygiene		663	447	67.4	216	32.6
South Ayrshire Council	FSS Operations		54	13	24.1	41	75.9
Totals			**1**994	**1484**	**74.4**	**510**	**25.6**

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 (~99%) arrived at the laboratory within 48h of sample collection (Table 15). 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 acceptance criteria.

Table 15. Number of *E. coli* samples received from each Local Authority region and time taken between collection and receipt at the laboratories in 2018

Local Authority	**No. samples received**	**No. received within 48h of collection**	**No. received more than 48h post collection**
Argyll and Bute Council	539	531	8
Angus Council	0	0	0
Comhairle nan Eilean Siar - Lewis & Harris	224	224	0
Comhairle nan Eilean Siar - Uist & Barra	84	82	2
Dumfries and Galloway Council	49	46	3
East Lothian Council	19	19	0
Fife Council	42	39	3
Highland Council: Lochaber	132	126	6
Highland Council: Ross & Cromarty	44	43	1
Highland Council: Skye & Lochalsh	57	55	2
Highland Council: Sutherland	63	63	0

North Ayrshire Council	24	24	0
Orkney Council	0	0	0
Shetland Islands Council	663	663	0
South Ayrshire Council	54	54	0
Totals (percent)	**1**994	**1969 (98.7%)**	**25 (1.3%)**

Careful programme management, training and liaison with sampling officers minimised the occurrence and impact of delays on the programme, with <1.5% of samples (n=25) being received more than 48h post collection throughout this reporting period.

2.2.2 Receipt and analysis of shellfish

2.1% (*n*=43) were rejected on arrival at the laboratory. Sample rejection was due to exceedances of time and/or temperature criteria; i.e. the time between sample collection and arrival at the laboratory exceeded 48 hours (n=25) and/or sample receipting temperature at the laboratory exceeded 10°C (n=12). A further, 3 samples were rejected due to improper collection method, (1) discrepancy on sample submitted/received, (1) insufficient flesh yielded from sample, and (1) incorrect sample collected. Five samples were rejected following submission of results to FSS, the samples having been collected outside of the RMP boundaries.
Analysis of samples assessed as suitable was always initiated within 48h of sample collection (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). The entire method is published as the UK NRL SOP, which is downloadable at: https://www.cefas.co.uk/nrl/methods/

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 1951 tests were undertaken between January 1st and December 31st 2018. The number of samples received and analysed by local authority is presented in Table 16. All samples tested returned valid results. Interruption to the supply of some of the prepared media (MMGB) used in the microbiological examinations occurred from January to March. This was due to failure to ship from the supplier, Thermo Scientific (Oxoid), during that period. No clear reasons for the failure were identified by Thermo. Cefas sourced the necessary components and produced this media in house until shipments from Thermo Scientific resumed. A quality alert was raised for this period to note the substitution.

Table 16. Numbers of *E. coli* samples received, and results reported in 2018

Local Authority area	**No. of samples received**	**No. of samples tested**	**% tested**
Argyll and Bute Council	539	530	98
Angus Council	0	0	N/A

Comhairle nan Eilean Siar: Lewis and Harris	224	222	99
Comhairle nan Eilean Siar: Uist and Barra	84	79	94
Dumfries and Galloway Council	49	41	84
East Lothian Council	19	19	100
Fife Council	42	39	93
Highland Council: Lochaber	132	126	96
Highland Council: Ross and Cromarty	44	40	91
Highland Council: Skye and Lochalsh	57	53	92
Highland Council: Sutherland	63	61	97
North Ayrshire Council	24	24	100
Orkney Council	0	0	N/A
Shetland Islands Council	663	663	100
South Ayrshire Council	54	54	100
Total	**1994**	**1951**	

A summary of samples received from each local authority by month is given in Table 17. 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 17. Breakdown of samples received from Local Authorities by month in 2018

Local Authority Area	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Argyll and Bute Councill	46	35	43	50	32	52	47	42	51	52	70	19
Comhairle nan Eilean Siar: Lewis and Harris	18	17	16	23	21	19	19	19	18	18	19	17
Comhairle nan Eilean Siar: Uist and Barra	10	8	8	9	3	6	6	9	6	7	6	6
Dumfries and Galloway Council	6	1	4	1	1	3	7	3	4	7	8	4
East Lothian Council	0	0	0	2	2	2	2	2	2	4	2	1
Fife Council	0	4	3	7	1	4	4	5	4	5	1	4
Highland Council: Lochaber	8	13	11	16	7	11	11	11	11	14	13	6
Highland Council: Ross and Cromarty	1	1	4	5	4	4	5	4	5	2	6	3
Highland Council: Skye and Lochalsh	3	3	4	5	1	6	5	4	7	8	7	4
Highland Council: Sutherland	6	6	6	6	6	6	4	6	5	4	4	4
North Ayrshire Council	3	2	3	2	2	2	2	1	2	2	2	1
Shetland Islands Council	57	57	55	67	45	55	55	55	55	53	104	5
South Ayrshire Council	2	2	2	2	2	5	17	8	8	5	1	0

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. Actionable results were reported as soon as available and all weekly results fully reported every Tuesday.

Table 18. *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	100%
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 2018.

2.3 Samples received by production area

Summaries of samples for each classified production area follow by local authority.

2.3.1 Argyll & Bute Council

Table 19. *E. coli s*amples received from Argyll & Bute Council area

Production Area	Species	Site Identification No.	Samples Received	Outwiths	Rejected samples
Ardencaple	Common cockles	AB-818-2146-04 (Ardencaple Cockles)	12	0	0
Campbeltown Loch	Common cockles	AB-029-008-04 (Kildalloig Bay)	14	4	0
Carradale Bay Gapers	Sand gapers	AB-848-2282-18 (Carradale Bay Gapers)	1	0	0
Carradale Bay	Razors	AB-511-930-16 (Carradale Bay Razors)	2	0	0
Castle Stalker	Common cockles	AB-492-909-04 (Port Appin)	12	2	0
Coll Razors	Razors	AB-837-2246-16 (Crossapol Bay)	14	0	2
Colonsay	Pacific oysters	AB-041-1199-13 (The Strand East)	12	0	0
Colonsay East of the Strand	Razors	AB-774-1987-16 (Islands of Colonsay and Oronsay)	11	1	1
Dunstaffnage Cockles	Common cockles	AB-696-1511-04 (Dunstaffnage Bay)	13	4	0
East Tarbert Bay	Pacific oysters	AB-541-972-13 (Isle of Gigha)	11	1	0
Eriska Shoal	Common cockles	AB-490-907-04 (Eriska Shoal Cockles)	12	1	0
Gallochoille Old Pier	Pacific oysters	AB-699-1519-13 (Gallochoille Old Pier)	12	3	0

Ganavan Cockles	Common cockles	AB-697-1512-04 (Ganavan)	13	2	0
Islay	Pacific oysters	AB-094-011-13 (Loch Gruinart Craigens)	11	1	2
Kerrera East	Common cockles	AB-697-1513-04 (Ardantrive)	14	2	0
Kerrera West	Common cockles	AB-697-1514-04 (Oitir Mhor)	12	2	0
Kilfinichen Bay	Common cockles	AB-695-1507-04 (Kilfinichen Bay)	12	4	0
Loch A Chumhainn: Inner Deep Site	Pacific oysters	AB-112-017-13 (Inner Deep Site)	13	4	0
Loch A Chumhainn: Outer	Pacific oysters	AB-113-018-13 (Outer)	12	0	0
Loch Craignish Cockles	Common cockles	AB-786-2028-04 (Ardfern)	12	0	0
Loch Creran Cockles	Common cockles	AB-729-1685-04 (Loch Creran Cockles)	12	1	0
Loch Creran Upper Oysters	Pacific oysters	AB-129-021-13 (East - Barrington)	12	1	0
Loch Creran: Rubha Mor	Pacific oysters	AB-130-022-13 (Rubha Mor)	12	3	0
Loch Fyne: Ardkinglas Oysters	Pacific oysters	AB-147-036-13 (The Shore)	11	0	0
Loch Fyne: Otter Ferry	Pacific oysters	AB-151-039-13 (Balliemore)	12	1	0
Loch Fyne: Otter Point	Common cockles	AB-714-1659-04 (Otter Point)	12	2	0
Loch Fyne: Stonefield Oysters	Pacific oysters	AB-435-840-13 (North Bay Oysters)	11	1	0
Loch Linnhe	Pacific oysters	AB-172-047-13 (Loch Linnhe)	11	2	0
Production Area	**Species**	**Site Identification No.**	**Samples Received**	**Outwiths**	**Rejected samples**
Loch na Cille	Common cockles	AB-617-1204-04 (Loch na Cille Cockles)	12	0	0
Loch Na Keal	Pacific oysters	AB-284-080-13 (Eilean Liath)	11	0	0
Loch Na Keal West	Pacific oysters	AB-286-082-13 (Eilean Casach)	12	0	0
Loch Riddon Cockles)	Common cockles	AB-656-1409-04 (Loch Riddon Cockles)	13	3	0
Loch Spelve Cockles	Common cockles	AB-767-1963-04 (North West Spelve)	12	7	0
Loch Spelve: Croggan Pier	Pacific oysters	AB-199-055-13 (Croggan Pier)	12	1	0
Loch Spelve: North	Common mussels	AB-200-1915-08 (Ardura)	12	0	0
Loch Striven	Common mussels	AB-205-063-08 (Troustan)	3	1	0
Lynn of Lorn: Sgeir Liath	Pacific oysters	AB-318-068-13 (Sgeir Liath)	12	3	0
Machrie Bay	Razors	AB-510-929-16 (Machrie Bay Razors)	2	0	0
North Connel Cockles	Common cockles	AB-758-1909-04 (Ledaig Point Cockles)	12	2	0
Oitir Mhor Bay	Pacific oysters	AB-308-701-13 (Oitir Mhor)	13	1	1
Peninver Razors	Razors	AB-766-1962-16 (Peninver Razors)	2	0	0
Saddell Bay	Razors	AB-512-931-16 (Saddell Bay Razors)	2	0	0

Seil Point	Pacific oysters	AB-245-070-13 (Poll a' Bhrochain Cyster)	12	0	0
Seil Sound East	Common mussels	AB-247-703-08 (East of Balvicar)	11	2	0
Seil Sound North	Pacific oysters	AB-247-735-13 (Balvicar North)	11	0	0
Seil Sound: Balvicar	Pacific oysters	AB-247-728-13 (Rubha nan Ron South)	12	0	0
Sound of Gigha Cretshengan	Razors	AB-857-2310-16 (Sound of Gigha Cretshengan)	2	0	0
Sound of Gigha Leim	Razors	AB-856-2309-16 (Sound of Gigha Leim)	2	0	0
Sound of Gigha North	Razors	AB-855-2307-16 (Sound of Gigha North)	2	0	0
Sound of Gigha	Razors	AB-515-1250-16 (Sound Of Gigha Razors 2)	10	0	0
Tiree North	Razors	AB-835-2244-16 (Gott Bay)	14	0	2
Tiree South	Razors	AB-836-2245-16 (Hynish Bay)	4	0	0
West Jura	Razors	AB-482-805-16 (Jura)	11	0	1

2.3.2 Comhairle Nan Eilean Siar: Lewis And Harris

Table 20. *E. coli* samples received from Comhairle Nan Eilean Siar: Lewis and Harris

Production Area	Species	Site	Samples Received	Outwiths	Rejected samples
Broad Bay Aiginish	Razors	LH-743-1740-16 (Aiginish)	10	0	0
East Loch Tarbert	Common mussels	LH-057-106-08 (Sound of Scalpay)	12	1	0
Loch Erisort: Garbh Eilean	Common mussels	LH-357-747-08 (Garbh Eilean)	12	0	0
Loch Erisort: Gob Glas	Common mussels	LH-357-711-08 (Gob Glas)	12	0	0
Loch Leurbost	Common mussels	LH-168-114-08 (Loch Leurbost)	12	1	0
Loch Leurbost: Crosbost	Pacific oysters	LH-339-795-13 (Site 1 Crosbost)	12	3	0
Loch Roag: Barraglom	Common mussels	LH-185-120-08 (Loch Barraglom)	12	0	0
Loch Roag: Ceabhagh	Common mussels	LH-381-772-08 (Keava)	12	1	0
Loch Roag: Drovinish	Common mussels	LH-186-121-08 (Loch Drovinish)	12	1	0
Loch Roag: Eilean Chearstaigh	Common mussels	LH-344-791-08 (Buckle Point)	12	0	0
Loch Roag: Eilean Teinish	Common mussels	LH-338-720-08 (Eilean Teinish)	12	2	0
Loch Roag: Linngeam	Common mussels	LH-187-122-08 (Linngeam)	12	1	0
Loch Roag: Miavaig	Common mussels	LH-188-123-08 (Miavaig)	12	1	0
Loch Roag: Torranish	Common mussels	LH-189-124-08 (Loch Torranish)	12	1	0
Loch Seaforth	Common mussels	LH-193-126-08 (Loch Seaforth)	13	0	1
Loch Stockinish	Common mussels	LH-203-127-08 (Loch Stockinish)	5	0	0

Seilebost	Common cockles	LH-249-129-04 (Seilebost)	13	3	1
Tong Sands	Common cockles	LH-605-1100-04 (Tong Sands Cockles)	11	1	0
West Loch Roag - Gob Sgrithir	Common mussels	LH-829-2215-08 (Gob Sgrithir)	16	0	0

2.3.3 Comhairle Nan Eilean Siar: Uist & Barra

Table 21. *E. coli* samples received from Comhairle Nan Eilean Siar: Uist & Barra

Production Area	Species	Site	Samples Received	Outwiths	Rejected samples
Cidhe Eolaigearraidh	Pacific oysters	UB-427-830-13 (Sound Of Barra: Pacific Oysters)	13	2	1
Garbh Lingeigh	Pacific oysters	UB-713-1622-13 (Garbh Lingeigh)	13	0	2
North Ford	Common cockles	UB-493-852-04 (Oitir Mhor)	12	1	0
North Uist	Common mussels	UB-540-969-08 (Lochmaddy)	3	0	0
Oitir Mhor Razors	Razors	UB-683-1484-16 (Rubha nan Eun)	1	0	0
South Ford	Common cockles	UB-259-162-04 (South Ford)	12	0	0
South Uist	Common mussels	UB-537-966-08 (Loch Skipport East)	3	1	0
Traigh Cille Bharra Cockles	Common cockles	UB-392-790-04 (Traigh Cille Bharra Cockles)	13	1	1
Traigh Cille Razors	Razors	UB-711-1574-16 (Traigh Cille Razors)	1	0	0
Traigh Mhor	Common cockles	UB-282-165-04 (Traigh Mhor)	13	1	1

2.3.4 Dumfries And Galloway Council

Table 22. *E. coli* samples received from Dufries and Galloway Council area

Production Area	Species	Site	Samples Received	Outwiths	Rejected samples
Fleet Bay Razors	Razors	DG-752-1880-16 (Fleet Bay Razors)	13	0	2
Kirkcudbright Bay Razors	Razors	DG-809-2132-16 (Kirkcudbright Bay Razors)	11	0	2
Loch Ryan	Native oysters	DG-191-174-12 (Leffnoll Point)	8	0	0
Luce Bay Drummore	Razors	DG-751-1824-16 (Drummore Razors)	3	0	1
Luce Bay Razors	Razors	DG-499-865-16 (Luce Sands Razors)	3	0	1
Wigtown Bay: Islands of Fleet	Razors	DG-305-182-16 (Wigtown Bay)	11	0	2

2.3.5 East Lothian

Table 23. *E. coli* samples received from East Lothian

Production Area	Species	Site	Samples Received	Outwiths	Rejected samples
Gullane Point North	Razors	EL-601-1087-16 (Gullane North)	10	1	0
Gullane Point South	Razors	EL-703-1525-16 (Gullane South)	9	0	0

2.3.6 Fife Council

Table 24. *E. coli* samples received from Fife Council area

Production Area	Species	Site	Samples Received	Outwiths	Rejected samples
Fife Ness Surf Clams	Surf clams	FF-771-1974-19 (Kingsbarns)	10	1	1
Firth of Forth: North	Surf clams	FF-068-184-19 (Anstruther)	11	0	1
Forth Estuary: Largo Bay	Razors	FF-072-188-16 (Largo Bay)	10	1	0
Forth Estuary Surf Clams	Surf clams	FF-772-1975-19 (Shell Bay)	11	0	1

2.3.7 Highland Council: Lochaber

Table 25. *E. coli* samples received from Highland Council: Lochaber area

Production Area	Species	Site	Samples Received	Outwiths	Rejected samples
Arisaig	Pacific oysters	HL-004-202-13 (Sgeirean Buidhe)	13	0	1
Loch Ailort	Common mussels	HL-114-937-08 (Eilean Dubh)	11	0	1
Loch Ailort	Common mussels	HL-114-214-08 (Site 1)	11	0	1
Loch Ailort 3	Pacific oysters	HL-114-207-13 (Camus Driseach)	13	1	1
Loch Beag	Common mussels	HL-118-215-08 (Ardnambuth)	11	0	1
Loch Eil	Common mussels	HL-134-216-08 (Duisky)	12	2	0
Loch Eil: Fassfern	Common mussels	HL-136-219-08 (Fassfern)	12	2	0
Loch Leven: Lower	Common mussels	HL-170-222-08 (Lower)	12	0	0
Loch Leven: Upper	Common mussels	HL-171-223-08 (Upper)	12	0	0
Loch Moidart	Pacific oysters	HL-179-227-13 (South Channel)	13	0	1
Loch Sunart	Common mussels	HL-206-1237-08 (Liddesdale)	12	1	0

2.3.8 Highland Council: Ross and Cromarty

Table 26. *E. coli* samples received from Highland Council: Ross and Cromarty area

Production Area	Species	Site	Samples Received	Outwiths	Rejected samples
Inner Loch Torridon	Common mussels	RC-090-1616-08 (Dubh Aird)	14	1	2
Little Loch Broom Native Oysters	Native oysters	RC-807-2123-12 (Little Loch Broom Native Oysters)	[10]	0	1
Little Loch Broom Pacific Oysters	Pacific oysters	RC-805-2122-13 (Little Loch Broom Pacific Oysters)	10	0	0
Loch Kanaird	Pacific oysters	RC-625-1233-13 (Ardmair)	10	0	1

2.3.9 Highland Council: Skye and Lochalsh

Table 27. *E. coli* samples received from Highland Council: Skye and Lochalsh area

Production Area	Species	Site	Samples Received	Outwiths	Rejected samples
Loch Eishort	Common mussels	SL-137-281-08 (Drumfearn)	15	0	3
Loch Harport: Inner	Pacific oysters	SL-159-286-13 (Carbost)	12	1	0
Loch Harport Inner Cockles	Common cockles	SL-159-286-04 (Carbost)	12	0	0
Sound Of Sleat	Razors	SL-833-2242-16 (Gleneig Bay)	18	0	6

2.3.10 Highland Council: Sutherland

Table 28. *E. coli* samples received from Highland Council: Sutherland area

Production Area	Species	Site	Samples Received	Outwiths	Rejected samples
Kyle of Durness	Pacific oysters	HS-773-1984-13 (Keoldale)	12	1	0
Kyle of Tongue	Pacific oysters	HS-103-303-13 (Kyle of Tongue)	13	0	1
Loch Eriboll	Common mussels	HS-139-307-08 (Loch Eriboll – MacLennan)	8	0	0
Loch Glencoul	Common mussels	HS-157-310-08 (Kylesku)	12	2	0
Loch Inchard	Common mussels	HS-162-311-08 (Site 1 - D. Ross)	6	0	1
Loch Laxford	Common mussels	HS-167-320-08 (Weavers Bay)	12	1	0

2.3.11 North Ayrshire Council

Table 29. *E. coli* samples received from North Ayrshire Council area

Production Area	Species	Site	Samples Received	Outwiths	Rejected samples
Arran: Pirnmill	Razors	NA-008-330-16 (Pirnmill)	2	0	0
Fairlie	Pacific oysters	NA-065-332-13 (Southannan Sands)	12	0	0
Stevenston Sands Razors	Razors	NA-825-2169-16 (Stevenston Sands Razors)	10	2	0

2.3.12 Shetland Islands

Table 30. *E. coli* samples received from the Shetland Islands

Production Area	Species	Site	Samples Received	Outwiths	Rejected samples
Aith Voe Sletta	Common mussels	SI-326-733-08 (Slyde)	12	0	0
Baltasound Mussels	Common mussels	SI-010-395-08 (Baltasound Harbour)	12	0	0
Basta Voe Cove	Common mussels	SI-324-399-08 (Inner - Site 1 - Thomason)	13	2	0
Basta Voe Outer	Common mussels	SI-323-403-08 (Outer)	13	0	0
Brindister Voe	Common mussels	SI-023-406-08 (Brindister Voe)	12	1	0

Busta Voe Lee North	Common mussels	SI-327-755-08 (Hevden Ness)	12	1	0
Busta Voe Lee South	Common mussels	SI-328-767-08 (Greentaing)	12	0	0
Catfirth	Common mussels	SI-032-412-08 (Catfirth)	12	0	0
Catfirth Mussels 1	Common mussels	SI-816-2144-08 (East of Little Holm)	12	0	0
Catfirth Mussels 2	Common mussels	SI-817-2147-08 (East of Brunt Hamarsland)	12	0	0
Clift Sound: Booth	Common mussels	SI-036-413-08 (Booth)	12	1	0
Clift Sound Houss	Common mussels	SI-633-1270-08 (Clift Sound Houss)	12	0	0
Clift Sound: Stream Sound	Common mussels	SI-035-414-08 (East Hogaland)	12	0	0
Clift Sound: Whal Wick	Common mussels	SI-038-1522-08 (Wester Quarff)	12	0	0
Colla Firth	Common mussels	SI-040-417-08 (Colla Firth)	12	0	0
Dales Voe - Fora Ness	Common mussels	SI-502-869-08 (West Taing)	12	0	0
Dales Voe: Muckle Ayre	Common mussels	SI-049-419-08 (Muckle Ayre)	11	0	0
Dales Voe: Scarvar Ayre	Common mussels	SI-050-420-08 (Scarvar Ayre)	12	0	0
Gon Firth	Common Mussels	SI-076-1338-08 (Cole Deep)	3	0	0
Gon Firth	Common mussels	SI-076-423-08 (Cole Ness)	9	0	0
Gruting Voe: Braewick Voe	Common mussels	SI-080-424-08 (Braewick Voe)	12	0	0
Gruting Voe: Browland Voe	Common mussels	SI-081-425-08 (Browland Voe)	12	1	0
Gruting Voe: Quilse	Common mussels	SI-083-427-08 (Quilse)	12	0	0
Gruting Voe: Seli Voe	Common mussels	SI-084-428-08 (Seli Voe)	14	1	0
Hamar Voe	Common mussels	SI-655-1404-08 (Hamar Voe)	12	1	0
Hamnavoe	Common mussels	SI-348-736-08 (Copister)	11	1	0
Lang Sound	Common mussels	SI-107-429-08 (Lang Sound)	12	1	0
Laxfirth	Common mussels	SI-814-2142-08 (North West of Skerby Ayre)	12	1	0
Lee of Vollister	Common mussels	SI-760-1920-08 (Whale Firth)	4	0	0
Mid Yell Voe	Common mussels	SI-216-432-08 (Seafield)	2	0	0
Mid Yell Voe East	Common mussels	SI-797-2083-08 (Bunya Sand)	12	3	0
Muckle Roe	Common mussels	SI-221-433-08 (Pobies Geo)	12	0	0
Production Area	**Species**	**Site**	**Samples Received**	**Outwiths**	**Rejected samples**
North Uyea	Common mussels	SI-230-453-08 (North)	12	0	0
Olna Firth Inner	Common mussels	SI-232-435-08 (Inner)	12	0	0
Olna Firth Outer	Common mussels	SI-232-434-08 (Foula Wick)	12	0	0
Papa Little Voe	Common mussels	SI-235-1350-08 (Millburn)	12	0	0
Ronas Voe East	Common mussels	SI-523-919-08 (Clifts)	12	0	0
Ronas Voe Mussels 2	Common mussels	SI-522-918-08 (West Of Black Well)	12	1	0

Sandsound Voe	Common mussels	SI-242-443-08 (Sandsound Voe)	12	0	0
Seli Voe	Common mussels	SI-815-2143-08 (Garderhouse)	10	0	0
South of Houss Holm	Common mussels	SI-261-444-08 (South of Houss Holm)	12	1	0
South Uyea	Common mussels	SI-263-454-08 (South)	9	0	0
South Voe Mussels	Common mussels	SI-421-825-08 (South Voe Mussels)	12	0	0
Stream Sound: Ux Ness	Common mussels	SI-373-1096-08 (Easterdale)	12	0	0
Stromness Voe	Common mussels	SI-273-467-08 (Burra Holm)	12	0	0
Swining Voe	Common mussels	SI-820-2156-08 (North West of Cul Houb)	12	0	0
The Rona	Common mussels	SI-517-944-08 (Aith Ness)	12	0	0
Uyea Sound	Common mussels	SI-441-845-08 (Cow Head)	12	0	0
Vaila Sound Linga	Common mussels	SI-288-457-08 (Linga)	12	0	0
Vaila Sound: East of Linga and Galtaskerry	Common mussels	SI-288-1061-08 (Whitesness)	12	0	0
Vaila Sound: Riskaness)	Common mussels	SI-289-458-08 (Riskaness)	12	0	0
Valia Sound - East Ward	Common mussels	SI-858-2312-08 (Brandy Ayre)	1	0	0
Vementry North	Common mussels	SI-322-464-08 (Suthra Voe West)	12	0	0
Vementry South	Common mussels	SI-321-459-08 (Clousta Voe - Noonsbrough)	12	0	0
Wadbister Voe	Common mussels	SI-294-466-08 (Wadbister Voe)	12	0	0
Weisdale Voe	Common mussels	SI-297-469-08 (North Flotta)	12	0	0
Weisdale Voe Upper	Common mussels	SI-378-1521-08 (Olligarth)	12	0	0
West of Langa	Common mussels	SI-822-2160-08 (Scalloway)	11	1	0
West of Lunna	Common mussels	SI-380-770-08 (Cul Ness)	12	0	0

2.3.13 South Ayrshire Council

Table 31. *E. coli* samples received from South Ayrshire Council area

Production Area	Species	Site	Samples Received	Outwiths	Rejected samples
Ayr Bay	Razors	SA-841-2263-16 (Ayr Bay Razors)	11	0	0
Croy bay	Razors	SA-681-1482-16 (Culzean Bay)	10	2	0
North Bay	Razors	SA-337-719-16 (Barassie)	11	1	0
Prestwick Shore	Razors	SA-840-2262-16 (Prestwick Shore Razors)	11	0	0
Troon South Beach Razors	Razors	SA-843-2267-16 (Troon South Beach Razors)	11	0	0

2.4 2018 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 32.

Table 32. Outwith results between 1st January and 31st December 2018

Local Authority area	No. of valid results reported	No. of outwith results	% outwith
Argyll and Bute Council	530	62	11
Comhairle nan Eilean Siar: Lewis and Harris	222	16	7
Comhairle nan Eilean Siar: Uist and Barra	79	6	8
Dumfries and Galloway	41	0	0
East Lothian Council	19	1	5
Fife Council	39	2	5
Highland Council: Lochaber	126	6	5
Highland Council: Ross and Cromarty	40	1	3
Highland Council: Skye and Lochalsh	48	1	2
Highland Council: Sutherland	61	4	7
North Ayrshire Council	24	2	8
Shetland Islands Council	663	17	3
South Ayrshire Council	54	3	6
Total	**1946**	**121**	**6**

2.5 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 –

[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) No. 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.

- *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.

Section 3. Chemical contaminants

This section provides a short summary of the monitoring undertaken between January and March 2018. A full copy of the report produced and published in May 2018 is available below and on FSS' website.

C7714 - FSS
Shellfish chem conta

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 (EU) No 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 analysis is carried out at Fera Science Limited in York.

31 samples of shellfish, including species of common mussels, Pacific oysters, Native oysters, common cockles, surf clams, and razor clams were collected during January to March 2018. 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) No.1881/2006 and (EC) No. 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.

The study analysed 13 composite samples of shellfish including Common mussels, Pacific oysters, Common cockles, and Razor clams for polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs, dioxins), polychlorinated biphenyls (PCBs). There were 28 samples tested for polycyclic aromatic hydrocarbons (PAHs), and 20 samples that include the aforementioned species as well as Surf clams and Native Oysters tested for heavy metals/trace elements. The methodologies used for the analyses were UKAS accredited to the ISO 17025 standard and follow EU commission regulations for data quality criteria.

The highest PAH values measured for benzo[a]pyrene (BaP) and for the total sum of the PAH4 compounds in the 28 samples as tested, all fall below the maximum permitted levels (MPL), of 5 µg/kg (BaP) and 30 µg/kg (PAH4 Sum) respectively. (Regulation (EC) No. 1881/2006 as amended) [3].

In the case of PCDD/Fs and PCBs in particular, contaminant concentrations were all below the regulatory maximum levels [3].

Concentrations of the regulated heavy metals, mercury, cadmium and lead were all below the set maximum limits [3].

Contaminant profiles from the 2018 study are similar to the previous year's data in 2017.

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