Provision of Statutory Shellfish Monitoring Services for Scotland- Chemical Contaminant Analysis of Shellfish from Classified Harvesting Areas (2023)

Report to Food Standards Scotland



June 2023 – Final report

Contract reference FSS008/271184341/C7714

Chemical Contaminant Analysis of Shellfish from Classified Harvesting Areas (2023)

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Document approved by Cefas:	M. Algoet	27/06/2023

Quality statement: All results were quality checked and approved prior to release to FSS. Information relating to the origin of the samples (place and date of collection) is as provided by sampling staff and has not undergone verification checks by Fera or Cefas.

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Glossary of Main Terms

Term or Acronym	General Meaning of Term
µg/kg	Microgram per kilogram (part per billion)
FAPAS	Food Analysis Proficiency Assurance Scheme
fat weight	Values based on the assessed fat content of the sample
FSA	Food Standards Agency
FSS	Food Standards Scotland
GC-HRMS	Gas chromatography - high resolution mass spectrometry
GC-MS	Gas chromatography –unit resolution mass spectrometry
ICP-MS	Inductively coupled plasma-mass spectrometry
LIMS	Laboratory Information Management System
LOD	Limit of Detection
LOQ	Limit of Quantification
Lower bound (LB)	Assumes values at less than the limit of detection are zero (e.g.<0.07 = 0)
mg/kg	Milligram per kilogram (part per million)
ng/kg	Nanogram per kilogram (part per trillion)
Non-ortho-PCB	Non-ortho-substituted PCB (co-planar)
Ortho-PCB	Ortho-substituted PCB (non planar)
PAH 4	Sum of 4 PAHs (benzo[a]pyrene, benzo[a]anthracene, benzo[b]fluoranthene, chrysene)
PAHs	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyl
PCDD/F	Polychlorinated dibenzo-*p*-dioxin/ polychlorinated dibenzofuran (dioxins)
PFAS	Polyfluorinated and perfluorinated alkyl substances
Sum of ICES 6	Sum of PCB28, PCB52, PCB101, PCB138, PCB153 and PCB180
TEF	Toxic Equivalency Factor – toxicity expressed for each dioxin-like compound relative to 2,3,7,8-TCDD (TEF = 1).
TEQ	Toxic Equivalence – product of the congener concentration and the TEF
Total TEQ	Total of the Sum of all the Toxic Equivalences (TEQs) for each group of compounds
Trace Element	An element in a sample that has an average concentration of less than 100 parts per million (< 100 mg/kg)
Upper bound (UB)	assumes values at less than the limit of detection is equal to the limit of detection (e.g. <0.07 = 0.07)
whole weight	Values based on the sample as received
WHO	World Health Organisation
WHO-TEQ 2005	TEQ based on TEF values set by World Health Organisation in 2005

Executive Summary

This study on chemical contaminants in shellfish from Scottish classified shellfish production areas fulfils the requirements of UK legislation to adopt appropriate monitoring measures and carry out compliance checks on shellfish produced for human consumption. Marine shellfish bio-accumulate environmental contaminants because of their inability to metabolise them to easily excreted compounds. 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 20 samples of shellfish including common mussels, Pacific oysters, native oysters, common cockles, surf clams and razor clams for polycyclic aromatic hydrocarbons (PAHs), trace elements, inorganic arsenic, polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), polychlorinated biphenyls (PCBs) and for the first time per and polyfluorinated alkyl substances (PFAS). The methodologies used for the analyses were UKAS accredited to the ISO 17025 standard (except PFAS) and follow retained European regulations for data quality criteria.

All measured analytes were below their maximum regulatory levels in the test samples. Contaminant profiles from the this study are similar to the previous year's (2022) data.

1. Background to Study

Marine shellfish are an excellent source of protein, are high in essential minerals and low in fat. In many parts of the UK and in Scotland in particular, the shellfish industry makes a significant contribution to the local economy. Shellfish have a recognised potential for bio-accumulating contaminants and some bivalve species such as mussels, are commonly used as early indicators of local pollution. Bivalves feed by filtering plankton from the surrounding water. This feeding mechanism leads to the bio-accumulation of pollutants of biogenic and anthropogenic origin from the surrounding waters. The bio-accumulation potential of the shellfish species used for food is particularly relevant in the case of environmental contaminants with long half-lives such as polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), polychlorinated biphenyls (PCBs). These contaminants have been the subject of several studies (Garraud et al 2007, Lee et al 2007, Fernandes et al 2009, Fernandes et al 2012) relating to the occurrence and bio-accumulation in marine species and the resulting potential for human exposure arising from the consumption of the edible species.

Due to potential food safety concerns, the European Union has defined limits for the control of these contaminants in a range of foods including shellfish. (European Commission 2006). The European Union (Withdrawal) Act as amended (HMSO 2018) converted directly applicable European legislation as it stood at the end of the transition period (11pm on 31 December 2020) into UK law.

PCDD/Fs and PCBs are recognised environmental and food contaminants that are known to bio-accumulate in fish and shellfish. The extent of this accumulation is evident by the levels of these contaminants detected in various studies. In the UK, Total Diet Studies (TDS) (e.g. FSA 2003) carried out over the last two decades; fish (including shellfish) has consistently been one of the highest PCDD/F and PCB containing food groups. Human dietary exposure can therefore be significantly influenced by the fish and shellfish component of the diet, particularly in high level consumers and low body-weight individuals. Although metabolised in many fish species, PAHs persist in shellfish as they are unable to break down these contaminants. Other than this bio-accumulation pathway, PAHs can also arise in fish and shellfish through some food preparation and processing methods – e.g. smoked fish are known to contain elevated levels of PAHs.

Some trace elements e.g. arsenic, cadmium, mercury and lead, are established toxic contaminants. Others, such as copper, chromium, selenium and zinc are essential to health but may be toxic at high levels of exposure. These elements may enter marine and aquatic environments and bio-accumulate in some species. Some potentially toxic elements occur naturally as part of the local geology, but others may also be found in the location of certain industries, as a result of unauthorised discharge, or as a result of other anthropogenic activity.

Polyfluorinated alkyl and perfluorinated alkyl compounds, collectively known as PFAS were first developed in the 1940s. Due to their unique properties such as thermal and chemical stability, water resistance and low surface tension they find use within many consumer products and industrial applications. Examples are chrome plating, aqueous film forming foams (AFFF) used in fire fighting, water and stain proofing of textiles, emulsifiers in polymer production and cosmetics. Over 3000 different PFAS are currently on the global market. The properties that make PFAS useful also make them resistant to bio-transformation and environmental degradation. Due to their stability and extensive use, a wide range of PFAS have been detected in terrestrial and aquatic environments, wildlife and humans. The main source of dietary exposure are fish and other seafoods (EFSA CONTAM Panel 2022). Several PFAS are known to have toxic effects in humans, including immune suppression and endocrine disruption, while perfluorooctanoic acid (PFOA) is classed as possibly carcinogenic to humans (IARC 2016).

As part of its monitoring requirements in support of UK regulations, Food Standards Scotland (FSS) has overseen the collection of shellfish, 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.

Fera has generated environmental contaminant data on shellfish collected from new and existing shellfish production areas in Scotland since 2007. This report collates the results of the individual analyses for dioxins, PAHs, PFAS and trace elements in samples of shellfish collected from selected classified Scottish production areas in the first quarter of 2023.

2. Methods

2.1 Sample Collection and Preparation

Sampling officers 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 Science Limited (Fera). Twenty samples of shellfish, including species of common mussels (7 samples), Pacific oysters (4), native oysters (1), common cockles (5), razor clams (2) and surf clams (1) were collected between January and March 2023. The sampling period was timed to coincide with the period of optimal contaminant concentrations in the shellfish which relates to the period before annual spawning. Details on the locations, with descriptions of the samples and identification are given in Table 1.

On receipt at the laboratory each sample was given a unique laboratory reference number and the sample details were logged into a Nautilus LIMS database. The samples were stored frozen prior to analysis. Sample preparation consisted of shelling followed by thorough homogenisation. Aliquots were then taken for PAH, trace element, PFAS and dioxin analysis, in line with the monitoring plan determined by FSS. Dioxin sample aliquots underwent additional freeze-drying and were re-homogenised prior to analysis. Table 2 contains information on which analyses were performed on each sample.

2.2 Contaminants measured – Specific Analytes

The following analytes were determined; regulated contaminants are highlighted in **bold,** and summarised regulation limits are listed below:

Analytes	UK Maximum Regulatory Levels (MRL) relevant for live bivalve molluscs (whole weight)
Lead	1.5 mg/kg
Cadmium	1.0 mg/kg
Mercury	0.50 mg/kg
Dioxins and PCBs	Sum of dioxins (WHO PCDD/F-TEQ): 3.5 pg/g Sum of dioxins and dioxin-like PCBs (WHO PCDD/F-PCB-TEQ): 6.5 pg/g Sum of PCB28, PCB52, PCB101, PCB138, PCB153 and PCB180 (ICES 6 Indicator PCBs): 75 ng/g
PAHs	Benzo[a]pyrene: 5.0 µg/kg

	Sum of Benzo[a]pyrene, Benzo[a]anthracene, Benzo[b]fluoranthene and Chrysene): 30 µg/kg

No UK regulations exist for PFAS or inorganic arsenic. For the purpose of evaluating results from this study the proposed EU limits for inorganic arsenic are 0.090 mg/kg for all bivalve molluscs except clam species (i.e. common clams, surf clams) which have a proposed MRL of 0.35 mg/kg. Maximum levels for PFOS, PFOA, PFNAS and PFHxS in bivalve molluscs came into effect within the EU from 1st January 2023 and are given in Table 7 (European Commission 2022).

Dioxins **- all 17, 2,3,7,8-Cl substituted PCDDs and PCDFs.**

Dioxin-like PCBs **- IUPAC no. 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169 and 189.**

Non dioxin-like PCBs - IUPAC numbers 18, **28**, 31, 47, 49, 51, **52**, 99, **101**, 128, **138**, **153** and **180**.

PAHs - acenaphthene, acenaphthylene, fluorene, phenanthrene, anthracene, fluoranthene, benzo[c]fluorene, pyrene, benzo[e]pyrene, benzo[b]naptho[2,1-d]thiophene, anthanthrene, coronene, benzo[ghi]fluoranthene, **benzo[a]anthracene (BaA)**, **chrysene (Chr)**, **benzo[b]fluoranthene (BbF)**, benzo[j]fluoranthene, benzo[k]fluoranthene, **benzo[a]pyrene (BaP)**, cyclopenta[cd]pyrene, indeno[1,2,3-cd]pyrene, dibenzo[a,h]anthracene, benzo[ghi]perylene, dibenzo[a,l]pyrene, dibenzo[a,e]pyrene, dibenzo[a,i]pyrene, dibenzo[a,h]pyrene and the alkylated PAH, 5-methylchrysene.

Trace elements – chromium (Cr), manganese (Mn), cobalt (Co), nickel (Ni), copper (Cu), Zinc (Zn), total arsenic (As), inorganic arsenic (*i*-As), selenium (Se), silver (Ag), **cadmium (Cd), mercury (Hg), lead (Pb)**

PFAS – perfluoro-n-nonanoic acid (PFNA), perfluorohexanesulfonic acid (PFHxS), perfluorooctanesulfonic acid (PFOS), perfluoro-n-decanoic acid (PFDA), perfluoro-1-butanesulfonic acid (PFBS), perfluoro-n-dodecanoic acid (PFDoA), perfluoro-n-heptanoic acid (PFHpA), perflouoro-n-hexanoic acid (PFHxA), perfluoro-n-pentanoic acid (PFPeA), perfluoro-n-butanoic acid (PFBA), perfluoro-n-octanoic acid (PFOA)

2.3 PCDD/F and PCB - Analytical Methodology

(Fera SOPs FSG 401-414)

The method used for the preparation, extraction and analysis of samples has been reported previously (Fernandes et al 2004) and is part of the CEN EN16215:2012 standard. In brief, samples were fortified with ^{13}C-labelled analogues of target compounds and exhaustively extracted using mixed organic solvents. Ortho substituted PCBs were separated from non-ortho substituted PCBs and PCDD/Fs by fractionation on activated carbon. The two fractions were further purified using adsorption chromatography on alumina. Analytical measurement was carried out using GC-HRMS

All analyses were UKAS accredited to ISO17025 standards, with the inclusion of reference material (in-house reference material, LIMS No. S11-018695 crude cod liver oil) and method blanks which were evaluated prior to reporting. Quality control evaluation for the accompanying data follows the criteria specified for chlorinated dioxins and PCBs. In addition, as the National Reference Laboratory (NRL) for dioxins and halogenated contaminants, Fera participates in proficiency testing (PT) exercises and other inter-laboratory exercises organised by the European Union Reference Laboratory (EU-RL) and achieves consistently good results.

2.4 Polycyclic Aromatic Hydrocarbons (PAH) - Analytical Methodology

(Fera SOP FSG 410)

The analytical methodology for the PAHs has been reported before (Rose et al 2007) and is based on internal standardisation with GC-MS measurement. An aliquot of the homogenised sample was fortified with ^{13}C-labelled analogues of target compounds and saponified with methanolic potassium hydroxide. The extracted PAH solutions were purified in two stages with a dimethylformamide/cyclohexane partition followed by adsorption chromatography on activated silica. Purified extracts were sensitivity standardised and measured using GC-MS.

The analytical procedure for PAHs is UKAS accredited to ISO17025 and includes the assessment of method blanks and reference materials, (e.g. T0658, PAHs in cocoa butter) for compliance with the accreditation criteria. The methodology also meets the criteria required for evaluating data against the maximum permitted limits for benzo[a]pyrene as specified in retained Commission Regulations. Fera regularly participates in Food Analysis Proficiency Assurance Scheme (FAPAS) PT exercises for PAHs in food and achieves consistently good results.

2.5 Trace Elements - Analytical Methodology

(Fera SOP FSG 461 and 457)

Aliquots of the homogenised sample were weighed into allotted digestion vessels and a mixture (4:1) of nitric acid and hydrochloric acid added. The vessels were capped and the contents digested using a high-pressure microwave digestion system. Reagent blanks, certified reference materials and a spiked sample were also taken through the procedure. The resulting solutions were transferred to pre-marked acid-clean plastic test tubes and diluted to 10 ml with deionised water. The digest solutions together with a set of standards covering the expected concentration range, were internally standardised with indium and rhodium in dilute nitric acid (1 %v/v). Measurements were made using an Agilent 7700x ICP-MS with collision cell.

The analytical procedure is accredited to ISO17025. The criteria used to assess data included checks on instrument drift, spike recovery, replicate agreement, limits of detection and certified reference material (e.g. CE 278K mussel tissue) values. Regular, successful participation in FAPAS inter-comparison exercises provides further confidence in the data. In addition, as NRL for trace elements, Fera participates in PT exercises and other inter-laboratory exercises organised by the EU-RL and achieves consistently good results.

Inorganic arsenic was determined using In-house method FSG 456. In brief, aliquots of homogenised test sample were solubilised in hydrochloric acid. After reduction by hydrobromic acid and hydrazine sulphate, the inorganic arsenic was extracted into chloroform then back-extracted into dilute hydrochloric acid prior to quantification by ICP-MS with collision cell. Quality checks included blanks, spikes, and certified reference materials. The applied method will also extract mono methyl arsenic species (MMA). If MMA is present, an overestimate of the inorganic arsenic content will occur. The method is accredited to ISO17025.

2.6 Fat analysis

For samples requiring dioxin and PCB analysis, total fat was determined by the Werner-Schmidt method under UKAS accreditation, by Microsearch Laboratories Ltd.

2.7 Poly and Per-Fluorinated Alkyl Substances - Analytical Methodology

(not accredited to ISO17025)

Aliquots of homogenised test samples were spiked with isotope standards (internal standards) and extracted using methanol. The resulting solvent extracts were solvent exchanged into potassium hydroxide and passed through WAX SPE columns. WAX columns allow for the retention of both short and longer chain PFAS analytes due to the ionic exchange and reverse phase properties. Non-specific interferences were retained on the column whilst PFAS analytes were eluted using ammonia in methanol.

Samples were concentrated and reconstituted in 50:50 methanol:water and analysed by ultra-high performance liquid chromatography coupled to a tandem mass spectroscope (UHPLC-MS/MS) and quantified against calibration standards of known concentrations of the PFAS.

3. Results

Analyte concentrations are presented in Tables 3 to 7. The limits of quantification (LOQ, quoted as "<") for dioxins, PCBs and PAHs are estimated as a dynamic parameter and therefore represent the limits of determination that prevail during the measurement. Data on the reference materials that were analysed concurrently with the samples, were within established acceptable limits, and are available if required. Measurement uncertainty (MU) was calculated and applied to data following guidelines and principals set out in "Measurement Uncertainty For Persistent Organic Pollutants By Isotope-Dilution Mass Spectrometry" (Eppe et al 2014). MU and reference material data can be made available if required.

Nine samples were tested for PCDD/Fs and PCBs. All samples contained PCDD/Fs and PCBs above the LOQ but well within the regulatory limits. Concentrations of individual congeners on a whole and fat weight basis are given in Table 4. The dioxin-like toxicity of the samples arising from PCDD/Fs and dioxin-like PCBs has also been reported as a toxic equivalent (WHO-TEQ), which is calculated by multiplying the concentration of each congener of interest by its toxicity equivalency factor (WHO-TEF). The TEQs are presented in Tables 3a and 3b in terms of the 2005 TEFs (van den Berg et al 2006) on a whole and fat weight basis respectively. Additionally, the sum of the ICES-6 Marker PCBs is also provided (Tables 3a and 3b). The regulations for shellfish are based on whole weight concentrations; however, in keeping with previous reports to Food Standards Scotland, the results for PCDD/Fs and PCBs have also been reported on a fat weight basis.

The range for total TEQ (PCDD/F + PCB) on a whole weight, upper bound basis (UB) was 0.05 ng TEQ/kg to 0.15 ng TEQ/kg.
The concentration of ICES-6 PCBs on a whole weight basis (UB) ranged from 0.10 µg/kg to 0.53 µg/kg. PCB101, PCB138 and PCB153 were found above LOQ in all samples. The highest TEQ and ICES6 concentrations were measured in razor clams from North Berwick Razors (S23-001566).

PAHs were detected in all 9 samples analysed. All samples showed levels below MRL for BaP (5 µg/kg) and PAH4 (30 µg/kg). BaP was only found above LOQ in 3 samples. Sum of PAH4 concentrations (UB) ranged from 0.45 µg/kg to 7.52 µg/kg. The samples with the highest PAH4 were razor clams from North Berwick (S23-001566). In general, PAH4 concentrations were higher in razor clams than in the other species tested. The results from PAH analysis are given in Table 5.

All 20 samples were analysed for heavy metals, of which 11 were also analysed for inorganic arsenic. The results of are detailed in Table 6. Concentrations of the regulated heavy metals (Cd, Hg, Pb) were all below the regulatory limit. The concentration ranges for Cd, Hg and Pb were 0.023 mg/kg to 0.227 mg/kg, <0.007 mg/kg to 0.031 mg/kg and 0.028 mg/kg to 1.08 mg/kg respectively. All samples contained quantifiable levels of Cd and Pb. The highest concentration of Cd was found in a sample of native oysters from Loch Ryan (S23-001979) which also contained the highest levels of Zn and Cu. The highest concentration of Pb was found in a sample of common mussels (S23-017181 Camas a Chuilinn: Loch Linnhe). Mercury was detected above LOQ in 65% of samples. No Hg was found above LOQ in samples originating from Shetland Islands (5 common mussels). Across all samples the 3 most abundant heavy metals were Zn, Mn and Cu, with Zn present at the highest concentration.
Inorganic arsenic concentrations (shown as "*i*- As" in Table 6) ranged from 0.03 mg/kg to 0.21 mg/kg, with a mean of 0.06 mg/kg. The highest concentration was found in surf clams from Forth Estuary (S23-001106), which was at least 3 times higher than the other samples tested. When expressed as a percentage of total arsenic, this sample was significantly higher (13%) than those with similar total arsenic concentrations (typically 3%). This may be an over-estimate due to interference from monomethyl arsenic.

In general, the patterns of the contaminant classes were consistent with those recorded last year.

All 20 samples were analysed for PFAS. This is the first time that PFAS has been analysed as part of the FSS surveillance programme. The range of Sum EU PFAS 4 concentrations on an upper bound basis were 0.232 µg/kg to 0.39 µg/kg whole weight. The detection (>LOQ) frequencies for the main compounds were PFNA (95%), PFOS (90%), PFDA (55%), PFHpA (50%), PFOA (50%). PFHxS was not found above LOQ in any sample. The highest concentration for an individual PFAS was PFHpA. (0.323 µg/kg in S23-019598, Pacific oyster, North Bay Oysters - Hoy). Data for PFAS can be found in Table 7, with the current EU MPL included for comparison. Results are reported as the mean of 2 replicate analyses. Typically CVs were less than or equal to 25% for all analytes in all samples; where this is not the case the result is marked as indicative.

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Table 1: Overview of all Samples*

Local Authority	Production Area	Site Name	Site Identification Number	Grid Reference	Species	Date Sample Taken	Date Received at Fera	FERA LIMS No.
Argyll and Bute	Eriska Shoal	Eriska Shoal Cockles	AB-490-907-04	NM 89456 42123	Common Cockles	23/02/2023	22/02/2023	S23-017631
Argyll and Bute	Kerrera East	Ardantrive	AB-894-1513-04	NM 84039 29909	Common Cockles	21/02/2023	20/02/2023	S23-017504
Argyll and Bute	Loch Craignish Cockles	Ardfern	AB-786-2028-04	MN 82075 05229	Common Cockles	26/01/2023	25/01/2023	S23-001759
Argyll and Bute	Loch Linnhe	Loch Linnhe	AB-172-047-13	MN 8761 4548	Pacific Oysters	26/01/2023	25/01/2023	S23-001760
Argyll and Bute	Lynn of Lorn: Sgeir Liath	Sgeir Liath	AB-318-068-13	NM 87163 38895	Pacific Oysters	07/02/2023	06/02/2023	S23-002400
Argyll and Bute	Oitir Mhor Bay	Oitir Mhor	AB-308-701-13	MN 82400 30018	Pacific Oysters	24/01/2023	23/01/2023	S23-001448
Argyll and Bute	Seil Sound East	East of Balvicar	AB-897-703-08	NM 7778 1661	Common Mussels	27/02/2023	28/02/2023	S23-018125
Comhairle nan Eilean Siar: Lewis & Harris	Seilebost	Seilebost	LH-249-129-04	NG 0829 9772	Common Cockles	27/03/2023	29/03/2023	S23-027831
Comhairle nan Eilean Siar: Uist & Barra	South Ford	South Ford	UB-259-162-04	NF 8041 4728	Common Cockles	09/03/2023	07/03/2023	S23-020440
Dumfries and Galloway	Loch Ryan	Leffnoll Point	DG-191-174-12	NX 07100 65711	Native Oysters	31/01/2023	30/01/2023	S23-001979
East Lothian	North Berwick Razors	North Berwick Razors	EL-736-1707-16	NT 50050 86551	Razors	25/01/2023	23/01/2023	S23-001566
Fife	Forth Estuary Surf Clams	Shell Bay	FF-772-1975-19	NO 4518 0071	Surf Clams	18/01/2023	16/01/2023	S23-001106

Local Authority	Production Area	Site Name	Site Identification Number	Grid Reference	Species	Date Sample Taken	Date Received at Fera	FERA LIMS No.
Highland: Lochaber	Camas a Chuilinn: Loch Linnhe	Camas a Chuilinn: Loch Linnhe	HL-875-2386-08	NN 0481 6929	Common Mussels	15/02/2023	14/02/2023	S23-017181
Orkney Islands	North Bay Oysters - Hoy	North Bay Oysters - Hoy	OI-865-2349-13	ND 2811 9100	Pacific Oysters	01/03/2023	28/02/2023	S23-019598
Shetland Islands	Mid Yell Voe East	Bunya Sand	SI-797-2083-08	HU 5245 9094	Common Mussels	15/02/2023	14/02/2023	S23-017182
Shetland Islands	Papa Little Voe	Millburn	SI-235-1350-08	HU 3479 6056	Common Mussels	16/02/2023	14/02/2023	S23-017281
Shetland Islands	Uyea Sound	Cow Head	SI-441-845-08	HU 30731 60332	Common Mussels	16/02/2023	14/02/2023	S23-017282
Shetland Islands	Vaila Sound: Riskaness	Riskaness	SI-289-458-08	HU 2311 4820	Common Mussels	22/03/2023	20/03/2023	S23-021174
Shetland Islands	Weisdale Voe Upper	Olligarth	SI-378-1521-08	HU 3824 4774	Common Mussels	10/03/2023	08/03/2023	S23-020507
South Ayrshire	Heads of Ayr	Heads of Ayre Razors	SA-866-2362-16	NS 28363 19484	Razors	01/03/2023	27/02/2023	S23-019599

**Quality statement: Information relating to the origin of the samples (place, date of collection and GR/NGR details) is as provided by sampling staff and has not undergone verification checks by Fera or Cefas*

Table 2: Samples: Chemical contaminant monitoring plan

FERA LIMS No.	Production Area	Sample Site Name	Species	Trace Elements	*i*-As	PAHs	DXN/ PCBs	PFAS
S23-017631	Eriska Shoal	Eriska Shoal Cockles	Common Cockles	X	-	-	-	X
S23-017504	Kerrera East	Ardantrive	Common Cockles	X	-	-	-	X
S23-001759	Loch Craignish Cockles	Ardfern	Common Cockles	X	-	-	-	X
S23-001760	Loch Linnhe	Loch Linnhe	Pacific Oysters	X	X	-	-	X
S23-002400	Lynn of Lorn: Sgeir Liath	Sgeir Liath	Pacific Oysters	X	-	-	-	X
S23-001448	Oitir Mhor Bay	Oitir Mhor	Pacific Oysters	X	X	-	-	X
S23-018125	Seil Sound East	East of Balvicar	Common Mussels	X	-	-	-	X
S23-027831	Seilebost	Seilebost	Common Cockles	X	X	-	-	X
S23-020440	South Ford	South Ford	Common Cockles	X	-	-	-	X
S23-001979	Loch Ryan	Leffnoll Point	Native Oysters	X	X	-	-	X
S23-001566	North Berwick Razors	North Berwick Razors	Razors	X	X	X	X	X
S23-001106	Forth Estuary Surf Clams	Shell Bay	Surf Clams	X	X	-	-	X
S23-017181	Camas a Chuilinn: Loch Linnhe	Camas a Chuilinn: Loch Linnhe	Common Mussels	X	X	X	X	X
S23-019598	North Bay Oysters - Hoy	North Bay Oysters - Hoy	Pacific Oysters	X	X	X	X	X
S23-017182	Mid Yell Voe East	Bunya Sand	Common Mussels	X	X	X	X	X
S23-017281	Papa Little Voe	Millburn	Common Mussels	X	X	X	X	X
S23-017282	Uyea Sound	Cow Head	Common Mussels	X	-	X	X	X
S23-021174	Vaila Sound: Riskaness	Riskaness	Common Mussels	X	-	X	X	X
S23-020507	Weisdale Voe Upper	Olligarth	Common Mussels	X	-	X	X	X
S23-019599	Heads of Ayr	Heads of Ayre Razors	Razors	X	X	X	X	X

Table 3a: PCDD/Fs and PCB - TEQ and ICES6 summary, Whole weight

FERA LIMS No.	S23-001566	S23-017181	S23-019598	S23-017182	S23-017281
Description	Razors, North Berwick Razors, North Berwick Razors	Common Mussels, Camas a Chuilinn: Loch Linnhe, Camas a Chuilinn: Loch Linnhe	Pacific Oysters, North Bay Oysters - Hoy, North Bay Oysters - Hoy	Common Mussels, Mid Yell Voe East, Bunya Sand	Common Mussels, Papa Little Voe, Millburn
PCDD/F TEQ LB (ng/kg)	0.07	0.04	0.07	0.03	0.03
PCDD/F TEQ UB (ng/kg)	0.08	0.05	0.08	0.05	0.04
PCB TEQ LB (ng/kg)	0.06	0.02	0.04	0.03	0.01
PCB TEQ UB (ng/kg)	0.07	0.02	0.04	0.03	0.01
PCDD/F + PCB WHO-TEQ LB (ng/kg)	0.13	0.06	0.11	0.06	0.04
PCDD/F + PCB WHO-TEQ UB (ng/kg)	0.15	0.07	0.12	0.08	0.05
SUM ICES 6 LB (µg/kg)	0.52	0.09	0.18	0.19	0.07
SUM ICES 6 UB (µg/kg)	0.53	0.12	0.21	0.21	0.1

FERA LIMS No.	S23-017282	S23-020507	S23-021174	S23-019599
Description	Common Mussels, Uyea Sound, Cow Head	Common Mussels, Weisdale Voe Upper, Olligarth	Common Mussels, Vaila Sound: Riskaness, Riskaness	Razors, Heads of Ayr, Heads of Ayre Razors
PCDD/F TEQ LB (ng/kg)	0.02	0.05	0.01	0.05
PCDD/F TEQ UB (ng/kg)	0.05	0.07	0.04	0.06
PCB TEQ LB (ng/kg)	0.02	0.04	0.01	0.04
PCB TEQ UB (ng/kg)	0.02	0.04	0.01	0.05

FERA LIMS No.	S23-017282	S23-020507	S23-021174	S23-019599
Description	Common Mussels, Uyea Sound, Cow Head	Common Mussels, Weisdale Voe Upper, Olligarth	Common Mussels, Vaila Sound: Riskaness, Riskaness	Razors, Heads of Ayr, Heads of Ayre Razors
PCDD/F + PCB WHO-TEQ LB (ng/kg)	0.04	0.09	0.02	0.09
PCDD/F + PCB WHO-TEQ UB (ng/kg)	0.07	0.11	0.05	0.11
SUM ICES 6 LB (µg/kg)	0.08	0.24	0.11	0.44
SUM ICES 6 UB (µg/kg)	0.11	0.27	0.14	0.45

Table 3b: PCDD/Fs and PCB - TEQ and ICES6 summary, Fat weight

FERA LIMS No.	S23-001566	S23-017181	S23-019598	S23-017182	S23-017281
Description	Razors, North Berwick Razors, North Berwick Razors	Common Mussels, Camas a Chuilinn: Loch Linnhe, Camas a Chuilinn: Loch Linnhe	Pacific Oysters, North Bay Oysters - Hoy, North Bay Oysters - Hoy	Common Mussels, Mid Yell Voe East, Bunya Sand	Common Mussels, Papa Little Voe, Millburn
Fat %	1.39	0.81	0.94	0.78	0.8
PCDD/F TEQ LB (ng/kg)	5.28	5.75	8.58	5.65	4.03
PCDD/F TEQ UB (ng/kg)	5.31	5.77	8.6	5.67	4.04
PCB TEQ LB (ng/kg)	4.54	2.42	4.83	3.75	1.69
PCB TEQ UB (ng/kg)	4.54	2.42	4.83	3.75	1.69
PCDD/F + PCB WHO-TEQ LB (ng/kg)	9.82	8.17	13.41	9.4	5.72
PCDD/F + PCB WHO-TEQ UB (ng/kg)	9.85	8.19	13.43	9.42	5.73

FERA LIMS No.	S23-001566	S23-017181	S23-019598	S23-017182	S23-017281
Description	Razors, North Berwick Razors, North Berwick Razors	Common Mussels, Camas a Chuilinn: Loch Linnhe, Camas a Chuilinn: Loch Linnhe	Pacific Oysters, North Bay Oysters - Hoy, North Bay Oysters - Hoy	Common Mussels, Mid Yell Voe East, Bunya Sand	Common Mussels, Papa Little Voe, Millburn
SUM ICES 6 LB (µg/kg)	37.25	12.34	20.47	26.4	8.55
SUM ICES 6 UB (µg/kg)	37.25	12.34	20.47	26.4	8.55

FERA LIMS No.	S23-017282	S23-020507	S23-021174	S23-019599
Description	Common Mussels, Uyea Sound, Cow Head	Common Mussels, Weisdale Voe Upper, Olligarth	Common Mussels, Vaila Sound: Riskaness, Riskaness	Razors, Heads of Ayr, Heads of Ayre Razors
Fat %	0.7	0.97	0.38	1.11
PCDD/F TEQ LB (ng/kg)	4.93	5.93	5.49	5.4
PCDD/F TEQ UB (ng/kg)	4.95	5.94	5.51	5.44
PCB TEQ LB (ng/kg)	2.36	3.86	3.99	3.53
PCB TEQ UB (ng/kg)	2.36	3.86	3.99	3.54
PCDD/F + PCB WHO-TEQ LB (ng/kg)	7.29	9.79	9.48	8.93
PCDD/F + PCB WHO-TEQ UB (ng/kg)	7.31	9.80	9.50	8.98
SUM ICES 6 LB (µg/kg)	11.72	26.43	32.58	39.37
SUM ICES 6 UB (µg/kg)	11.72	26.43	32.58	39.37

Table 4: PCDD/F & PCB concentrations

	FERA LIMS No.	S23-001566		S23-017181	
	Description	Razors, North Berwick Razors, North Berwick Razors		Common Mussels, Camas a Chuilinn: Loch Linnhe, Camas a Chuilinn: Loch Linnhe	
	Units	Whole	Fat (1.39%)	Whole	Fat (0.81%)
2,3,7,8-TCDD	ng/kg	<0.01	0.57	<0.01	0.55
1,2,3,7,8-PeCDD	ng/kg	0.02	1.13	0.01	1.59
1,2,3,4,7,8-HxCDD	ng/kg	0.01	0.81	0.01	1.23
1,2,3,6,7,8-HxCDD	ng/kg	0.02	1.42	0.02	1.87
1,2,3,7,8,9-HxCDD	ng/kg	0.02	1.68	0.01	1.19
1,2,3,4,6,7,8-HpCDD	ng/kg	0.28	20.05	0.08	9.99
OCDD	ng/kg	1.02	73.32	0.29	35.85
2,3,7,8-TCDF	ng/kg	0.17	12.27	0.07	8.93
1,2,3,7,8-PeCDF	ng/kg	0.01	0.85	0.02	2.45
2,3,4,7,8-PeCDF	ng/kg	0.05	3.92	0.04	5.48
1,2,3,4,7,8-HxCDF	ng/kg	0.04	2.74	<0.01	1.13
1,2,3,6,7,8-HxCDF	ng/kg	0.01	0.85	<0.01	1.09
1,2,3,7,8,9-HxCDF	ng/kg	<0.01	<0.22	<0.01	<0.13
2,3,4,6,7,8-HxCDF	ng/kg	0.02	1.29	0.02	2.09
1,2,3,4,6,7,8-HpCDF	ng/kg	0.07	4.92	0.02	2.84
1,2,3,4,7,8,9-HpCDF	ng/kg	<0.01	<0.28	<0.01	0.35
OCDF	ng/kg	0.05	3.92	0.02	2.54
PCB 77	ng/kg	6.18	443.16	0.58	70.88
PCB 81	ng/kg	0.5	35.79	0.04	5.14
PCB 126	ng/kg	0.55	39.38	0.17	20.82
PCB 169	ng/kg	0.12	8.79	0.07	8.25
PCB 105	µg/kg	0.03	2.17	<0.01	0.48
PCB 114	µg/kg	<0.01	0.12	<0.01	0.03
PCB 118	µg/kg	0.08	5.92	0.01	1.68
PCB 123	µg/kg	<0.01	<0.05	<0.01	<0.02
PCB 156	µg/kg	<0.01	0.38	<0.01	0.18
PCB 157	µg/kg	<0.01	0.18	<0.01	0.07
PCB 167	µg/kg	<0.01	0.38	<0.01	0.16
PCB 189	µg/kg	<0.01	0.04	<0.01	0.02
PCB 28	µg/kg	0.04	2.54	<0.01	0.27
PCB 52	µg/kg	0.04	3.02	<0.01	0.53
PCB 101	µg/kg	0.1	7.26	0.01	1.76
PCB 138	µg/kg	0.16	11.51	0.04	4.72
PCB 153	µg/kg	0.18	12.59	0.04	4.71
PCB 180	µg/kg	<0.01	0.33	<0.01	0.35
PCB 18	µg/kg	<0.01	0.33	<0.01	0.09
PCB 31	µg/kg	0.03	2.01	<0.01	0.22
PCB 47	µg/kg	0.02	1.56	<0.01	0.3
PCB 49	µg/kg	0.03	2.2	<0.01	0.3
PCB 51	µg/kg	<0.01	0.1	<0.01	0.02
PCB 99	µg/kg	0.05	3.58	<0.01	1.12
PCB 128	µg/kg	0.02	1.53	<0.01	0.49

	FERA LIMS No.	S23-019598		S23-017182	
	Description	Pacific Oysters, North Bay Oysters - Hoy, North Bay Oysters - Hoy		Common Mussels, Mid Yell Voe East, Bunya Sand	
	Units	Whole	Fat (0.94%)	Whole	Fat (0.78%)
2,3,7,8-TCDD	ng/kg	0.01	1.11	<0.01	0.46
1,2,3,7,8-PeCDD	ng/kg	0.02	2.53	0.01	1.64
1,2,3,4,7,8-HxCDD	ng/kg	<0.01	0.53	<0.01	0.7
1,2,3,6,7,8-HxCDD	ng/kg	0.01	1.34	0.01	1.52
1,2,3,7,8,9-HxCDD	ng/kg	<0.01	0.89	<0.01	1.02
1,2,3,4,6,7,8-HpCDD	ng/kg	0.02	2.42	0.04	5.51
OCDD	ng/kg	0.09	9.15	0.12	15.24
2,3,7,8-TCDF	ng/kg	0.24	25.79	0.09	11.56
1,2,3,7,8-PeCDF	ng/kg	0.02	2.1	0.01	1.77
2,3,4,7,8-PeCDF	ng/kg	0.06	5.97	0.04	5.58
1,2,3,4,7,8-HxCDF	ng/kg	<0.01	<0.14	<0.01	0.75
1,2,3,6,7,8-HxCDF	ng/kg	<0.01	0.66	<0.01	0.47
1,2,3,7,8,9-HxCDF	ng/kg	<0.01	<0.06	<0.01	<0.17
2,3,4,6,7,8-HxCDF	ng/kg	0.01	1.28	0.01	1.46
1,2,3,4,6,7,8-HpCDF	ng/kg	<0.01	0.76	0.01	1.48
1,2,3,4,7,8,9-HpCDF	ng/kg	<0.01	<0.09	<0.01	<0.16
OCDF	ng/kg	0.01	0.76	0.01	1.51
PCB 77	ng/kg	1.36	145.01	1.39	178.04
PCB 81	ng/kg	0.09	9.61	0.07	9.3
PCB 126	ng/kg	0.42	44.72	0.25	32.64
PCB 169	ng/kg	0.07	7.01	0.06	7.91
PCB 105	µg/kg	<0.01	0.75	0.01	1.41
PCB 114	µg/kg	<0.01	0.03	<0.01	0.05
PCB 118	µg/kg	0.03	2.95	0.04	5.22
PCB 123	µg/kg	<0.01	<0.03	<0.01	0.05
PCB 156	µg/kg	<0.01	0.11	<0.01	0.35
PCB 157	µg/kg	<0.01	0.11	<0.01	0.16
PCB 167	µg/kg	<0.01	0.26	<0.01	0.3
PCB 189	µg/kg	<0.01	<0.01	<0.01	0.03
PCB 28	µg/kg	<0.01	0.52	<0.01	0.68
PCB 52	µg/kg	<0.01	0.94	0.01	1.69
PCB 101	µg/kg	0.03	2.89	0.04	5.08
PCB 138	µg/kg	0.06	5.91	0.07	9.48
PCB 153	µg/kg	0.09	9.57	0.07	8.94
PCB 180	µg/kg	<0.01	0.64	<0.01	0.53
PCB 18	µg/kg	<0.01	<0.23	<0.01	0.2
PCB 31	µg/kg	<0.01	0.42	<0.01	0.52
PCB 47	µg/kg	<0.01	0.54	<0.01	0.82
PCB 49	µg/kg	<0.01	0.59	<0.01	1.13
PCB 51	µg/kg	<0.01	0.05	<0.01	0.02
PCB 99	µg/kg	0.02	1.83	0.02	3.06
PCB 128	µg/kg	<0.01	0.49	<0.01	1.21

	FERA LIMS No.	S23-017281		S23-017282	
	Description	Common Mussels, Papa Little Voe, Millburn		Common Mussels, Uyea Sound, Cow Head	
	Units	Whole	Fat (0.80%)	Whole	Fat (0.70%)
2,3,7,8-TCDD	ng/kg	<0.01	0.21	<0.01	0.42
1,2,3,7,8-PeCDD	ng/kg	0.01	1.39	<0.01	1.4
1,2,3,4,7,8-HxCDD	ng/kg	<0.01	0.48	<0.01	0.56
1,2,3,6,7,8-HxCDD	ng/kg	<0.01	1.08	<0.01	1.36
1,2,3,7,8,9-HxCDD	ng/kg	<0.01	0.59	<0.01	0.81
1,2,3,4,6,7,8-HpCDD	ng/kg	0.04	4.64	0.04	6.10
OCDD	ng/kg	0.12	15.26	0.15	21.7
2,3,7,8-TCDF	ng/kg	0.05	5.88	0.06	8.83
1,2,3,7,8-PeCDF	ng/kg	0.01	1.38	0.01	1.53
2,3,4,7,8-PeCDF	ng/kg	0.03	4.22	0.04	5.23
1,2,3,4,7,8-HxCDF	ng/kg	<0.01	0.5	<0.01	0.51
1,2,3,6,7,8-HxCDF	ng/kg	<0.01	0.62	<0.01	0.56
1,2,3,7,8,9-HxCDF	ng/kg	<0.01	<0.15	<0.01	<0.18
2,3,4,6,7,8-HxCDF	ng/kg	0.01	1.38	0.01	1.49
1,2,3,4,6,7,8-HpCDF	ng/kg	0.01	1.42	<0.01	1.40
1,2,3,4,7,8,9-HpCDF	ng/kg	<0.01	0.22	<0.01	<0.22
OCDF	ng/kg	0.01	1.68	0.01	1.71
PCB 77	ng/kg	0.34	41.93	0.39	55.27
PCB 81	ng/kg	0.02	2.81	0.03	3.6
PCB 126	ng/kg	0.12	14.68	0.15	20.81
PCB 169	ng/kg	0.04	5.33	0.05	6.86
PCB 105	µg/kg	<0.01	0.36	<0.01	0.44
PCB 114	µg/kg	<0.01	0.01	<0.01	0.02
PCB 118	µg/kg	0.01	1.32	0.01	1.57
PCB 123	µg/kg	<0.01	<0.01	<0.01	<0.02
PCB 156	µg/kg	<0.01	0.11	<0.01	0.14
PCB 157	µg/kg	<0.01	0.05	<0.01	0.06
PCB 167	µg/kg	<0.01	0.11	<0.01	0.14
PCB 189	µg/kg	<0.01	<0.01	<0.01	<0.02
PCB 28	µg/kg	<0.01	0.2	<0.01	0.23
PCB 52	µg/kg	<0.01	0.39	<0.01	0.48
PCB 101	µg/kg	0.01	1.27	0.01	1.53
PCB 138	µg/kg	0.03	3.17	0.03	4.07
PCB 153	µg/kg	0.03	3.35	0.04	5.18
PCB 180	µg/kg	<0.01	0.17	<0.01	0.23
PCB 18	µg/kg	<0.01	0.09	<0.01	0.1
PCB 31	µg/kg	<0.01	0.2	<0.01	0.23
PCB 47	µg/kg	<0.01	0.17	<0.01	0.21
PCB 49	µg/kg	<0.01	0.24	<0.01	0.26
PCB 51	µg/kg	<0.01	<0.01	<0.01	<0.01
PCB 99	µg/kg	<0.01	0.73	<0.01	0.93
PCB 128	µg/kg	<0.01	0.36	<0.01	0.44

	FERA LIMS No.	S23-020507		S23-021174	
	Decription	Common Mussels, Weisdale Voe Upper, Olligarth		Common Mussels, Vaila Sound: Riskaness, Riskaness	
	Units	Whole	Fat (0.97%)	Whole	Fat (0.38%)
2,3,7,8-TCDD	ng/kg	<0.01	0.54	<0.01	0.57
1,2,3,7,8-PeCDD	ng/kg	0.02	1.63	<0.01	1.49
1,2,3,4,7,8-HxCDD	ng/kg	<0.01	0.56	<0.01	0.55
1,2,3,6,7,8-HxCDD	ng/kg	0.02	1.66	<0.01	1.21
1,2,3,7,8,9-HxCDD	ng/kg	0.01	1.05	<0.01	0.89
1,2,3,4,6,7,8-HpCDD	ng/kg	0.08	8.68	0.02	5.39
OCDD	ng/kg	0.24	24.33	0.06	15.12
2,3,7,8-TCDF	ng/kg	0.12	12.28	0.05	12.45
1,2,3,7,8-PeCDF	ng/kg	0.02	2.1	<0.01	1.92
2,3,4,7,8-PeCDF	ng/kg	0.05	5.4	0.02	5.05
1,2,3,4,7,8-HxCDF	ng/kg	<0.01	0.99	<0.01	0.65
1,2,3,6,7,8-HxCDF	ng/kg	<0.01	0.94	<0.01	0.66
1,2,3,7,8,9-HxCDF	ng/kg	<0.01	<0.14	<0.01	<0.22
2,3,4,6,7,8-HxCDF	ng/kg	0.02	1.93	<0.01	1.35
1,2,3,4,6,7,8-HpCDF	ng/kg	0.04	3.7	<0.01	1.87
1,2,3,4,7,8,9-HpCDF	ng/kg	<0.01	0.35	<0.01	<0.20
OCDF	ng/kg	0.03	3.49	<0.01	1.58
PCB 77	ng/kg	1.12	114.65	0.4	105.06
PCB 81	ng/kg	0.06	6.57	0.02	6.4
PCB 126	ng/kg	0.33	33.92	0.13	35.27
PCB 169	ng/kg	0.09	9.15	0.04	9.33
PCB 105	µg/kg	0.01	1.12	<0.01	1.02
PCB 114	µg/kg	<0.01	0.03	<0.01	0.04
PCB 118	µg/kg	0.04	3.98	0.01	3.83
PCB 123	µg/kg	<0.01	0.03	<0.01	0.04
PCB 156	µg/kg	<0.01	0.28	<0.01	0.27
PCB 157	µg/kg	<0.01	0.14	<0.01	0.13
PCB 167	µg/kg	<0.01	0.26	<0.01	0.28
PCB 189	µg/kg	<0.01	0.03	<0.01	0.04
PCB 28	µg/kg	<0.01	0.36	<0.01	0.41
PCB 52	µg/kg	<0.01	0.85	<0.01	0.9
PCB 101	µg/kg	0.03	3.53	0.01	3.67
PCB 138	µg/kg	0.07	7.03	0.03	8.05
PCB 153	µg/kg	0.14	14.2	0.07	19.05
PCB 180	µg/kg	<0.01	0.46	<0.01	0.5
PCB 18	µg/kg	<0.01	0.12	<0.01	0.14
PCB 31	µg/kg	<0.01	0.31	<0.01	0.36
PCB 47	µg/kg	<0.01	0.36	<0.01	0.44
PCB 49	µg/kg	<0.01	0.52	<0.01	0.52
PCB 51	µg/kg	<0.01	0.02	<0.01	<0.02
PCB 99	µg/kg	0.02	1.87	<0.01	2.38
PCB 128	µg/kg	<0.01	0.96	<0.01	0.94

	FERA LIMS No.	S23-019599	
	Description	Razors, Heads of Ayr, Heads of Ayre Razors	
	Units	Whole	Fat (1.11%)
2,3,7,8-TCDD	ng/kg	<0.01	0.58
1,2,3,7,8-PeCDD	ng/kg	0.01	0.98
1,2,3,4,7,8-HxCDD	ng/kg	<0.01	0.49
1,2,3,6,7,8-HxCDD	ng/kg	0.01	1.27
1,2,3,7,8,9-HxCDD	ng/kg	<0.01	0.73
1,2,3,4,6,7,8-HpCDD	ng/kg	0.12	10.41
OCDD	ng/kg	0.86	76.89
2,3,7,8-TCDF	ng/kg	0.19	17.25
1,2,3,7,8-PeCDF	ng/kg	0.02	1.45
2,3,4,7,8-PeCDF	ng/kg	0.05	4.39
1,2,3,4,7,8-HxCDF	ng/kg	0.01	1.27
1,2,3,6,7,8-HxCDF	ng/kg	<0.01	0.86
1,2,3,7,8,9-HxCDF	ng/kg	<0.01	<0.44
2,3,4,6,7,8-HxCDF	ng/kg	0.01	1.24
1,2,3,4,6,7,8-HpCDF	ng/kg	0.04	3.68
1,2,3,4,7,8,9-HpCDF	ng/kg	<0.01	0.24
OCDF	ng/kg	0.04	3.18
PCB 77	ng/kg	5.29	475.33
PCB 81	ng/kg	0.22	19.67
PCB 126	ng/kg	0.33	30.1
PCB 169	ng/kg	0.06	5
PCB 105	µg/kg	0.03	2.7
PCB 114	µg/kg	<0.01	0.09
PCB 118	µg/kg	0.08	7.22
PCB 123	µg/kg	<0.01	<0.07
PCB 156	µg/kg	<0.01	0.40
PCB 157	µg/kg	<0.01	0.14
PCB 167	µg/kg	<0.01	0.24
PCB 189	µg/kg	<0.01	<0.04
PCB 28	µg/kg	0.02	1.59
PCB 52	µg/kg	0.03	2.67
PCB 101	µg/kg	0.08	7.31
PCB 138	µg/kg	0.15	13.06
PCB 153	µg/kg	0.16	14.36
PCB 180	µg/kg	<0.01	0.38
PCB 18	µg/kg	<0.01	<0.30
PCB 31	µg/kg	0.01	1.19
PCB 47	µg/kg	0.02	1.61
PCB 49	µg/kg	0.02	2.09
PCB 51	µg/kg	<0.01	0.14
PCB 99	µg/kg	0.05	4.46
PCB 128	µg/kg	0.02	1.55

NOTE: *where shown i = indicative*

Table 5: PAH concentrations (µg/kg Whole weight)

FERA LIMS No.	S23-001566	S23-017181	S23-019598	S23-017182
Description	Razors, North Berwick Razors, North Berwick Razors	Common Mussels, Camas a Chuilinn: Loch Linnhe, Camas a Chuilinn: Loch Linnhe	Pacific Oysters, North Bay Oysters - Hoy, North Bay Oysters - Hoy	Common Mussels, Mid Yell Voe East, Bunya Sand
acenaphthylene	0.56	<0.12	0.14	<0.13
acenaphthene	<0.69	<0.77	<0.7	<0.87
fluorene	1.31	<0.80	1.35	<1.02
phenanthrene	1.98	<1.29	<1.61	<1.40
anthracene	0.31	0.04	<0.11	<0.03
fluoranthene	4.38	1.30	<1.51	<1.07
benzo[c]fluorene	0.27	0.06	0.08	<0.02
pyrene	3.62	<1.97	<1.76	<1.59
benzo[ghi]fluoranthene	1.87	0.59	0.78	0.13
benzo[a]anthracene	2.1	0.39	0.49	0.09
benzo[b]naphtho[2,1-d]thiophene	0.48	0.22	0.17	<0.04
cyclopenta[cd]pyrene	0.03	0.02	<0.01	<0.05
chrysene	1.93	0.76	0.49	0.2
5-methylchrysene	<0.09	0.02	0.03	0.04
benzo[b]fluoranthene	2.29	1.01	1.51	0.36
benzo[j]fluoranthene	1.06	0.41	0.3	0.13
benzo[k]fluoranthene	1.12	0.33	0.7	0.13
benzo[e]pyrene	2.88	1.44	1.31	0.4
benzo[a]pyrene	1.2	0.32	<0.16	<0.20
indeno[1,2,3-cd]pyrene	0.74	0.34	0.31	<0.19
dibenz[a,h]anthracene	<0.18	<0.10	<0.11	0.11
benzo[ghi]perylene	0.94	0.49	0.32	0.26
anthanthrene	<0.10	<0.10	<0.10	<0.10
dibenzo[a,l]pyrene	<0.37	<0.35	<0.38	<0.35
dibenzo[a,e]pyrene	<0.29	<0.28	<0.3	<0.29
dibenzo[a,i]pyrene	<0.10	<0.10	<0.10	<0.10
dibenzo[a,h]pyrene	<0.10	<0.10	<0.01	<0.10
coronene	0.34	0.20	<0.10	0.13
PAH 4 Sum LB	7.52	2.48	2.49	0.65
PAH 4 Sum UB	7.52	2.48	2.65	0.85

FERA LIMS No.	S23-017281	S23-017282	S23-020507	S23-021174	S23-019599
Description	Common Mussels, Papa Little Voe, Millburn	Common Mussels, Uyea Sound, Cow Head	Common Mussels, Weisdale Voe Upper, Olligarth	Common Mussels, Vaila Sound: Riskaness, Riskaness	Razors, Heads of Ayr, Heads of Ayre Razors
acenaphthylene	<0.13	<0.12	<0.15	<0.13	0.57
acenaphthene	<0.85	<0.77	<0.87	<0.87	<0.69
fluorene	<1.0	<0.8	<1.02	<1.02	1.44
phenanthrene	<1.38	<1.29	<1.41	<1.41	<1.59
anthracene	0.05	<0.02	0.03	<0.03	0.26
fluoranthene	<1.06	<1.19	<1.08	<1.08	3.55
benzo[c]fluorene	0.02	0.01	<0.02	<0.01	0.19
pyrene	<1.57	<1.97	<1.60	<1.60	3.95
benzo[ghi]fluoranthene	0.19	<0.17	0.19	<0.12	1.97
benzo[a]anthracene	<0.10	0.08	0.09	0.02	1.53
benzo[b]naphtho[2,1-d]thiophene	<0.08	<0.04	0.06	<0.04	0.53
cyclopenta[cd]pyrene	<0.05	<0.01	<0.05	<0.05	0.03
chrysene	0.20	0.17	0.23	<0.09	2.05
5-methylchrysene	0.06	<0.01	<0.02	<0.02	<0.07
benzo[b]fluoranthene	0.41	0.36	0.52	0.13	2.17
benzo[j]fluoranthene	0.15	0.12	0.17	0.03	0.96
benzo[k]fluoranthene	0.15	0.12	0.19	<0.03	1.01
benzo[e]pyrene	0.4	0.43	0.65	0.11	2.98
benzo[a]pyrene	<0.20	<0.22	<0.21	<0.21	0.68
indeno[1,2,3-cd]pyrene	<0.19	<0.19	<0.26	<0.08	0.64
dibenzo[ah]anthracene	<0.10	<0.10	<0.11	<0.11	<0.14
benzo[ghi]perylene	0.25	0.25	0.35	0.06	0.72
anthanthrene	<0.10	<0.10	<0.10	<0.10	<0.10
dibenzo[a,l]pyrene	<0.34	<0.35	<0.35	<0.35	<0.37
dibenzo[a,e]pyrene	<0.29	<0.28	<0.29	<0.29	<0.29
dibenzo[a,i]pyrene	<0.1	<0.1	<0.10	<0.10	<0.10
dibenzo[a,h]pyrene	<0.1	<0.1	<0.10	<0.10	<0.10
coronene	0.1	0.12	0.19	<0.10	0.21
PAH 4 Sum LB	0.61	0.61	0.84	0.15	6.43
PAH 4 Sum UB	0.91	0.83	1.05	0.45	6.43

Table 6: Trace Element Concentrations (mg/kg whole weight)

FERA LIMS No.	S23-001448	S23-001759	S23-001760	S23-002400	S23-017504
Description	Pacific Oysters, Oitir Mhor Bay, Oitir Mhor	Common Cockles, Loch Craignish Cockles, Ardfern	Pacific Oysters, Loch Linnhe, Loch Linnhe	Pacific Oysters, Lynn of Lorn: Sgeir Liath, Sgeir Liath	Common Cockles, Kerrera East, Ardantrive
Chromium	0.06	0.15	0.05	0.05	0.35
Manganese	2.75	2.85	4.65	2.68	1.56
Cobalt	0.02	0.148	0.021	0.023	0.127
Nickel	<0.07	1.36	<0.07	<0.07	1.95
Copper	5.33	0.37	5.03	4.77	0.27
Zinc	100	5.17	77	142	5.17
Arsenic	1.37	0.83	1.05	2.03	1.02
i-As	0.03	ND	0.04	ND	ND
Selenium	0.19	0.14	0.16	0.25	0.15
Silver	0.463	<0.003	0.384	0.26	0.006
Cadmium	0.125	0.029	0.112	0.127	0.023
Mercury	0.01	0.007	0.007	0.013	0.009
Lead	0.054	0.032	0.029	0.062	0.094

FERA LIMS No.	S23-017631	S23-018125	S23-027831	S23-020440	S23-001979
Description	Common Cockles, Eriska Shoal, Eriska Shoal Cockles	Common Mussels, Seil Sound East, East of Balvicar	Common Cockles, Seilebost, Seilebost	Common Cockles, South Ford, South Ford	Native Oysters, Loch Ryan, Leffnoll Point
Chromium	0.1	0.14	0.17	0.19	0.28
Manganese	3.46	3.72	0.83	0.82	5.53
Cobalt	0.181	0.039	0.081	0.054	0.051
Nickel	2.14	0.12	1.65	1.17	0.17
Copper	0.35	0.85	0.35	0.35	14.4
Zinc	5.63	9.8	4.93	4.01	155
Arsenic	1.11	1.76	1.03	1.09	1.22
i-As	ND	ND	0.08	ND	0.07
Selenium	0.19	0.4	0.19	0.12	0.32
Silver	0.008	0.005	0.026	0.006	1.14
Cadmium	0.03	0.049	0.042	0.031	0.227
Mercury	0.008	0.01	<0.007	<0.007	0.012
Lead	0.057	0.088	0.028	0.032	0.095

FERA LIMS No.	S23-001566	S23-001106	S23-017181	S23-019598	S23-017182
Description	Razors, North Berwick Razors, North Berwick Razors	Surf Clams, Forth Estuary Surf Clams, Shell Bay	Common Mussels, Camas a Chuilinn: Loch Linnhe, Camas a Chuilinn: Loch Linnhe	Pacific Oysters, North Bay Oysters - Hoy, North Bay Oysters - Hoy	Common Mussels, Mid Yell Voe East, Bunya Sand
Chromium	0.15	0.3	0.07	0.06	0.11
Manganese	1.64	14.1	2.26	1.08	0.62
Cobalt	0.066	0.152	0.028	0.02	0.021
Nickel	0.07	0.27	0.08	<0.07	0.11
Copper	1.44	1.1	0.67	3.97	0.62
Zinc	17.2	8.9	10.9	133	8.68
Arsenic	1.57	1.6	1.48	1.68	1.05
i- As	0.04	0.21	0.03	0.06	0.03
Selenium	0.36	0.29	0.37	0.25	0.24
Silver	0.159	0.097	0.018	0.171	0.007
Cadmium	0.029	0.057	0.061	0.165	0.11
Mercury	0.016	0.01	0.014	0.031	<0.007
Lead	0.087	0.273	1.08	0.134	0.097

FERA LIMS No.	S23-017281	S23-017282	S23-020507	S23-021174	S23-019599
Description	Common Mussels, Papa Little Voe, Millburn	Common Mussels, Uyea Sound, Cow Head	Common Mussels, Weisdale Voe Upper, Olligarth	Common Mussels, Vaila Sound: Riskaness, Riskaness	Razors, Heads of Ayr, Heads of Ayre Razors
Chromium	0.07	0.09	0.09	0.05	0.34
Manganese	0.88	0.48	1.12	0.37	2.19
Cobalt	0.017	0.019	0.02	0.009	0.111
Nickel	0.07	0.09	0.09	<0.07	0.19
Copper	0.61	0.61	0.66	0.3	1.21
Zinc	12.7	15.1	10.4	7.62	16.4
Arsenic	1.14	1.16	1.19	0.68	1.49
i- As	0.03	ND	ND	ND	0.04
Selenium	0.22	0.24	0.27	0.16	0.36
Silver	<0.003	0.005	0.003	0.003	0.627
Cadmium	0.099	0.153	0.104	0.073	0.029
Mercury	<0.007	<0.007	<0.007	<0.007	0.016
Lead	0.09	0.12	0.06	0.051	0.08

Note: ND – Not determined for this sample

Table 7: PFAS Concentrations (µg/kg whole weight)

FERA LIMS No.		S23-001448	S23-001759	S23-001760	S23-002400	S23-017504
Description	MPL Regulation (EU) 2022/2388	Pacific Oysters, Oitir Mhor Bay, Oitir Mhor	Common Cockles, Loch Craignish Cockles, Ardfern	Pacific Oysters, Loch Linnhe, Loch Linnhe	Pacific Oysters, Lynn of Lorn: Sgeir Liath, Sgeir Liath	Common Cockles, Kerrera East, Ardantrive
PFNA	**1.0**	0.024	0.012	0.016	0.017	0.011
PFHxS LB	**1.5**	0.0	0.0	0.0	0.0	0.0
PFHxS UB		0.1	0.1	0.1	0.1	0.15
PFOS LB	**3.0**	0.039	0.0	0.0	0.024	0.026
PFOS UB		0.089	0.07	0.07	0.074	0.076
PFDA		0.006	0.006	0.006	0.006	<0.05
PFBS		<0.05	<0.05	<0.05	<0.05	<0.20
PFDoA		<0.02	<0.02	<0.02	<0.02	<0.05
PFHpA		<0.05	<0.05	<0.05	<0.05	0.198
PFHxA		<0.05	<0.05	<0.05	<0.05	0.252 *i*
PFPeA		<0.02	<0.02	<0.02	<0.02	<0.50
PFBA		<0.10	0.162	<0.10	<0.10	<0.50
PFOA	**0.70**	<0.05	<0.05	<0.05	<0.05	0.154 *i*
SUM EU 4 PFAS LB	**5.0**	0.062	0.012	0.016	0.04	0.186 *i*
SUM EU 4 PFAS UB	**5.0**	0.262	0.232	0.236	0.24	0.39

FERA LIMS No.		S23-017631	S23-018125	S23-027831	S23-020440	S23-001979
Description	MPL Regulation (EU) 2022/2388	Common Cockles, Eriska Shoal, Eriska Shoal Cockles	Common Mussels, Seil Sound East, East of Balvicar	Common Cockles, Seilebost, Seilebost	Common Cockles, South Ford, South Ford	Native Oysters, Loch Ryan, Leffnoll Point
PFNA	**1.0**	0.011	0.011	0.012	0.013	0.017
PFHxS LB	**1.5**	0.0	0.0	0.0	0.0	0.0
PFHxS UB		0.15	0.15	0.15	0.15	0.1
PFOS LB	**3.0**	0.038	0.076 *i*	0.036	0.023	0.038
PFOS UB		0.088	0.126 *i*	0.086	0.072	0.088
PFDA		<0.05	<0.05	<0.05	<0.05	0.009
PFBS		<0.20	<0.20	<0.20	<0.20	<0.05
PFDoA		<0.05	<0.05	<0.05	<0.05	<0.02

FERA LIMS No.		S23-017631	S23-018125	S23-027831	S23-020440	S23-001979
Description	MPL Regulation (EU) 2022/2388	Common Cockles, Eriska Shoal, Eriska Shoal Cockles	Common Mussels, Seil Sound East, East of Balvicar	Common Cockles, Seilebost, Seilebost	Common Cockles, South Ford, South Ford	Native Oysters, Loch Ryan, Leffnoll Point
PFHpA		0.436 *i*	0.643 *i*	0.612	0.274 *i*	<0.05
PFHxA		0.464	0.43	0.575	0.344 *ir*	<0.05
PFPeA		<0.50	2.948 *r*	<0.50	<0.50	<0.02
PFBA		<0.50	<0.50	<0.50	<0.50	<0.10
PFOA	**0.70**	0.052	0.1 *i*	0.074	0.032 *i*	<0.05
SUM EU 4 PFAS LB	**5.0**	0.1	0.188 *i*	0.122	0.049 *i*	0.054
SUM EU 4 PFAS UB	**5.0**	0.3	0.388	0.322	0.264	0.254

FERA LIMS No.		S23-001566	S23-001106	S23-017181	S23-019598	S23-017182
Description	MPL Regulation (EU) 2022/2388	Razors, North Berwick Razors, North Berwick Razors	Surf Clams, Forth Estuary Surf Clams, Shell Bay	Common Mussels, Camas a Chuilinn: Loch Linnhe, Camas a Chuilinn: Loch Linnhe	Pacific Oysters, North Bay Oysters - Hoy, North Bay Oysters - Hoy	Common Mussels, Mid Yell Voe East, Bunya Sand
PFNA	**1.0**	0.041	0.162 *i*	0.03	<0.01	0.018
PFHxS LB	**1.5**	0.0	0.0	0.0	0.0	0.0
PFHxS UB		0.1	0.041	0.1	0.15	0.1
PFOS LB	**3.0**	0.078	0.024	0.061	0.028	0.032
PFOS UB		0.128	0.024	0.111	0.074	0.082
PFDA		0.028	<0.025	0.022	<0.05	0.008
PFBS		<0.05	<0.022	<0.05	<0.20	<0.05
PFDoA		<0.02	<0.005	<0.02	<0.05	<0.02
PFHpA		<0.05	0.162 *i*	<0.05	1.356 *i*	<0.05
PFHxA		<0.05	0.122 *i*	<0.05	0.651 *i*	<0.05
PFPeA		<0.02	<0.025	<0.02	<0.50	<0.02
PFBA		<0.10	0.352	<0.10	<0.50	<0.10
PFOA	**0.70**	<0.05	0.03 *i*	<0.05	0.029 *i*	<0.05
SUM EU 4 PFAS LB	**5.0**	0.12	0.215 *i*	0.092	0.043 *i*	0.051
SUM EU 4 PFAS UB	**5.0**	0.32	0.258	0.292	0.263	0.251

FERA LIMS No.		S23-017281	S23-017282	S23-020507	S23-021174	S23-019599
Description	MPL Regulation (EU) 2022/2388	Common Mussels, Papa Little Voe, Millburn	Common Mussels, Uyea Sound, Cow Head	Common Mussels, Weisdale Voe Upper, Olligarth	Common Mussels, Vaila Sound: Riskaness , Riskaness	Razors, Heads of Ayr, Heads of Ayre Razors
PFNA	**1.0**	0.022	0.02	0.017	0.016	0.038 *i*
PFHxS LB	**1.5**	0.0	0.0	0.0	0.0	0.0
PFHxS UB		0.1	0.1	0.15	0.15	0.15
PFOS LB	**3.0**	0.034	0.032	0.043	0.042 *i*	0.064 *i*
PFOS UB		0.084	0.082	0.093	0.092	0.114 *i*
PFDA		0.01	0.008	<0.05	<0.05	0.058
PFBS		<0.05	<0.05	<0.20	<0.20	<0.20
PFDoA		<0.02	<0.02	<0.05	<0.05	<0.05
PFHpA		<0.05	<0.05	1.084 *i*	0.763 *i*	0.073 *i*
PFHxA		<0.05	<0.05	0.733 *i*	1.099 *i*	<0.10
PFPeA		<0.02	<0.02	8.13 *r*	1.89 *ir*	<0.50
PFBA		<0.10	<0.10	<0.50	0.557	<0.50
PFOA	**0.70**	<0.05	<0.05	0.08 *i*	0.096	0.025 *i*
SUM EU 4 PFAS LB	**5.0**	0.056	0.051	0.139 *i*	0.146 *i*	0.126 *i*
SUM EU 4 PFAS UB	**5.0**	0.256	0.251	0.339	0.35	0.326

Note: i : indicative
r: ion ration outside range

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