Chemical Contaminant Sampling and Analysis of Shellfish from Classified Harvesting Areas (2015)

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Contents

Glossary of Main Terms

Term or Acronym	General Meaning Of Term
EU	European Union
EC	European Commission
FSA	Food Standards Agency
WHO	World Health Organisation
PAHs	Polycyclic aromatic hydrocarbons
PAH 4 Sum	Sum of 4 PAHs (benzo[*a*]pyrene, benz[a]anthracene, benzo[b]fluoranthene, chrysene)
PCB	Polychlorinated biphenyl
Ortho-PCB	Ortho-substituted PCB (non planar)
Non-ortho-PCB	Non-ortho-substituted PCB (co-planar)
PCDD/F	Polychlorinated dibenzo-*p*-dioxin/ polychlorinated dibenzofuran (dioxins)
TEF	Toxic Equivalency Factor – toxicity expressed for each dioxin-like compound as a fraction of 2,3,7,8-TCDD (2,3,7,8-TCDD = 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
Sum of ICES 6	Sum of PCB28, PCB52, PCB101, PCB138, PCB153 and PCB180
fat weight	Values relevant to the assessed fat content of the sample
whole weight	Values based on the sample as received 'whole' or wet
WHO-TEQ 2005	World Health Organisation - TEQ based on values as set in 2005
LOD	Limit of Detection
LOQ	Limit of Quantification
Lower bound	assumes values at less than the limit of detection are zero (e.g.<0.01=0)
Upper bound	assumes values at less than the limit of detection are equal to the limit of detection (e.g. <0.07=0.07)
Trace Element	An element in a sample that has an average concentration of less than 100 parts per million (less than 100 mg/kg)
Heavy Metals	A loosely defined subset of elements that exhibit metallic properties (some are toxic, some are a nutritional requirement in small amounts), (This survey includes, Cr, Mn, Co, Ni, Cu, Zn, As, Se, Ag, Cd, Hg & Pb, (Chromium, manganese, cobalt, nickel, copper, zinc, arsenic, selenium, silver, cadmium, mercury and lead)
ng/kg	Nanogram per kilogram ($x10^{-9}$/ part per trillion)
µg/kg	Microgram per kilogram (x 10^{-6}/ part per billion)
mg/kg	Milligram per kilogram (x 10^{-3}/ part per million)
ICP-MS	Inductively coupled plasma-mass spectrometry
HRGC-HRMS	High resolution gas chromatography - high resolution mass spectrometry
HRGC-LRMS	High resolution gas chromatography – unit resolution mass spectrometry
LIMS	Laboratory Information Management System

Executive Summary

This study on chemical contaminants in shellfish from English and Welsh classified shellfish production areas, fulfils part of the requirements of EU member states to adopt appropriate monitoring measures and carry out compliance checks on shellfish produced for human consumption (EU Regulations (EC) No.1881/2006 and (EC) No. 854/2004). Marine shellfish bio-accumulate environmental contaminants because of their inability to metabolise these compounds during feeding. The study determines concentrations of regulated environmental contaminants in the edible flesh of a variety of species in order to determine current levels of occurrence and to allow estimation of consumer exposure.

The study analysed forty four composite samples of shellfish including mussels, Pacific oysters, cockles, native oysters, razor clams and surf clams for polycyclic aromatic hydrocarbons (PAHs) and heavy metals. Six of the samples including mussels, Pacific oysters and native oysters were also analysed for polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs, dioxins), polychlorinated biphenyls (PCBs). 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 observed levels of the currently regulated PAHs were benzo[a]pyrene at 11.59 µg/kg, and PAH 4 at 52.67 µg/kg compared to the maximum permitted level (MPL) of 5 µg/kg and 30 µg/kg respectively (Regulation (EC) No. 835/2011). Both of these concentrations were found in the only sample that exceeded MPL for benzo[a]pyrene & PAH4 (mussels from Mersey Bay, sample S15-020910). In the case of PCDD/Fs and PCBs in particular, contaminant concentrations were all below the regulatory maximum levels (Regulation (EU) No. 1259/2011). Concentrations of the regulated heavy metals, mercury, cadmium and lead were all below the set maximum limits (EC) No. 1881/2006 as amended). This is the first year data has been included in this monitoring programme from England and Wales but profiles from the current study are broadly similar to the previous year's data from Scotland and Northern Ireland.

1. Background to Study

Marine shellfish are an excellent source of protein, are high in essential minerals, and low in calories and fat. In many parts of the UK, 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 that washes through their habitat. This feeding mechanism leads to the bio-accumulation of pollutants of biogenic and anthropogenic origin such as polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), polychlorinated biphenyls (PCBs), heavy metals (trace elements) and polycyclic aromatic hydrocarbons (PAHs), 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 chlorinated PCDD/Fs and PCBs. These contaminants have been the subject of a number of 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.

In recognising the requirements of food safety the EU has, for a number of years, defined limits for the control of these contaminants in a range of foods including shellfish. (Commission Regulation (EC) No 1881/2006, Commission Regulation (EC) No 1259/2011, Commission Regulation (EU) No 835/2011). Some of the regulations specify new requirements on the controls expected by the competent authority (Food Standards Agency) with respect to classified shellfish production areas. EU member states are required to adopt appropriate monitoring measures and carry out compliance checks with regard to the occurrence of these contaminants in shellfish produced for human consumption.

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) (FSA 2003) carried out over the last two decades, fish (including shellfish) has consistently been one of the highest dioxin 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 filter feeding species appear unable to effect bio-transformation of 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 PAH compounds have been shown to be genotoxic and carcinogenic, the most studied of which (benzo[a]pyrene, or B[a]P) is regulated in a range of foods including shellfish, within the EU (Scientific Committee on Food, 2002, Commission Regulation (EC) No. 208/2005). However, more recent evaluation by EFSA's CONTAM panel, concluded that a set of 4 compounds, namely benzo[a]pyrene, chrysene, benz[a]anthracene and benzo[b]fluoranthene (collectively referred to as PAH4) were more suitable indicators of PAH contamination in food (EFSA, 2008). These four compounds were subsequently included in Commission Regulation (EC) No. 835/2011, an amendment to Regulation 1881/2006, which came into force from September 2012. In a study on bivalve molluscs including mussels, oysters and scallops, the FSA reported positive detection of most PAH compounds in samples taken in England and Wales (FSA 2005). However in comparison to a study carried out about a decade earlier, reported levels were significantly lower and no sample showed levels above the 5 µg/kg EU limit for B[a]P in shellfish.

Some trace elements and, in particular, heavy metals are established toxic contaminants. Some elements, such as copper, chromium, selenium and zinc, are essential to health but may be toxic at high levels of exposure. Metals and other elements may enter marine and aquatic environments and bio-accumulate in species at any point during growth and harvesting. 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.

As part of its monitoring requirements in support of EU regulations, Food Standards Scotland and the FSA in Northern Ireland have overseen the collection of shellfish each year, from classified shellfish production sites within relevant local authority areas. In comparison to previous years, the analysis conducted this year also included shellfish from England and Wales. Environmental Health Officers from England and Wales were required to obtain suitable shellfish samples from designated sampling points within classified shellfish production areas, as defined by the FSA. 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, in accordance with the provisions of Commission Regulations (EU) No. 333/2007, as amended, or 252/2012. The analysis was carried out at Fera in York.

FERA has generated environmental contaminant data on shellfish collected from new and existing shellfish sites since 2007. This report collates the results of the individual analyses for dioxins,

PAHs and heavy metals in samples of shellfish collected from English and Welsh sites in the first quarter of 2015.

2. Method

2.1 Sample Collection and Preparation

Forty four samples of shellfish, including species such as common mussels, Pacific oysters, common cockles, surf clams, native oysters and razor clams were collected during January to March 2015. The sampling period was timed to coincide with the period of optimal contaminant concentrations in the shellfish.

The English and Welsh production areas selected for monitoring in 2015 were potential high risk areas chosen by the FSA based on the outcome of a review conducted in 2014 detailing chemical contaminant levels in England and Wales. 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 database using a Laboratory Information Management System (LIMS). The samples were stored frozen prior to analysis. Sample preparation consisted of shelling followed by thorough homogenisation and aliquots taken for PAH and heavy metal analysis, prior to freeze-drying. Freeze-dried sample powders were re-homogenised and aliquots used for dioxin and PCB analysis.

2.2 Contaminants measured – Specific Analytes

The following analytes were determined: Regulated contaminants are highlighted in **bold.**

Dioxins - all 17, 2378-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, **benz[a]anthracene**, **chrysene**, **benzo[b]fluoranthene**, benzo[j]fluoranthene, benzo[k)fluoranthene, **benzo[a]pyrene**, cyclopenta[c,d]pyrene, indeno[123cd]pyrene, dibenzo[ah]anthracene, benzo[ghi]perylene, dibenzo[al]pyrene, dibenzo[ae]pyrene, dibenzo[ai]pyrene, dibenzo[ah]pyrene and the substituted PAH, 5-methylchrysene.

Heavy Metals – Chromium (Cr), Manganese (Mn), Cobalt (Co), Nickel (Ni), Copper (Cu), Zinc (Zn), Arsenic (As), Selenium (Se), Silver (Ag), **Cadmium** (**Cd), Mercury (Hg), Lead (Pb)**

2.3 PCDD/F and PCB - Analytical Methodology

(FERA (UK NRL) SOPs FSG 453-460)

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 high resolution gas chromatography-high resolution mass spectrometry (HRGC-HRMS) for the seventeen, 2,3,7,8-Cl substituted PCDD/F congeners and non-ortho substituted PCBs. HRGC-unit resolution mass spectrometry (HRGC-LRMS) was used for the measurement of the ortho substituted PCBs.

All analyses were UKAS accredited to ISO 17025 standards, with the inclusion of reference material and method blanks which were evaluated prior to reporting. Further quality assurance measures included the successful participation in international inter-comparison exercises such as Dioxins in Food-2013 and Dioxins in Food-2014, on dioxins and dioxin-like PCBs. Quality control evaluation for the accompanying data follows the criteria specified for chlorinated dioxins and PCBs (Commission Regulation (EU) No 252/2012). In addition, as the National Reference Laboratory (NRL) for chemical contaminants, FERA participates in Proficiency Testing (PT) exercises and other inter-laboratory exercises as organised by the European Union Reference Laboratory (EU-RL), and achieves consistently good results.

2.4 Polycyclic Aromatic Hydrocarbons (PAH) - Analytical Methodology

(FERA (UK NRL) 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

DMF/cyclohexane partition followed by adsorption chromatography on activated silica. Purified extracts were sensitivity standardised and measured using high resolution gas chromatography-unit resolution mass spectrometry.

The analytical procedure for PAHs is UKAS accredited to the ISO 17025 standard and includes the assessment of method blanks and reference materials, (e.g. T0654, PAHs in palm oil) 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 EU Commission Regulations. FERA regularly participates in FAPAS PT exercises for PAHs in food. In addition, as NRL for chemical contaminants, FERA participates in PT exercises and other inter-laboratory exercises as organised by the EU-RL and achieves consistently good results.

2.5 Trace Elements - Analytical Methodology

(Fera (UK NRL) SOP FSG 461 and 457)

Aliquots of the homogenised sample were weighed into alloted 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 or rhodium in dilute nitric acid (1 %v/v). Measurements were made using an Agilent 7700x ICP-MS with collision cell.

In common with the other two sets of analyses, the analytical procedure is accredited to the ISO17025 standard. The criteria used to assess data included checks on instrument drift, spike recovery, replicate agreement, limits of detection and certified reference material values. Regular, successful participation in FAPAS inter-comparison exercises provides further confidence in the data. In addition, as NRL for chemical contaminants, Fera participates in PT exercises and other inter-laboratory exercises as organised by the EU-RL and achieves consistently good results.

3. Results

Analyte concentrations are presented in Tables 2.1 to 2.6. Concentration units reflect current convention as required by regulation, and data were rounded to two decimal places or as appropriate. The reporting limits (quoted as "<") for dioxins, PCBs and PAHs are estimated as a dynamic parameter and therefore represent the limits of determination that prevail during the course of the measurement. For PCDD/Fs, PCBs, metals and PAHs, the reporting limits are consistent with the requirements of EU regulations. Data on the reference materials that were analysed concurrently with the samples, were within established acceptable limits. Measurement uncertainty (MU) was calculated and applied to data following guidelines and principals set out in Measurement Uncertainty For Persistent Organic Pollutants By Isotope-Diluition Mass Spectrometry (Epp, et al 2014). MU and reference material data can be made available if required.

In addition to the concentration of individual congeners, 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 terms of the 2005 TEFs (van den Berg et al 2006). Additionally as per the requirements of Regulation 1259/2011, the sum of the ICES-6 PCBs is also provided. The regulations for shellfish are based on whole weight concentrations; however in keeping with previous reports to Food Standards Scotland and FSA in Northern Ireland, the results for PCDD/Fs and PCBs have also been reported on a fat weight basis.

PCDD/Fs and PCBs were detected in all samples at levels well within the regulatory limits (Table 2.1). The combined PCDD/F + PCB TEQ ranged from 0.17 pg TEQ/g to 2.56 pg TEQ/g. For most of the samples PCDD/Fs contributed approximately half to the total TEQ. The exception was a native oyster sample from The Solent (S15-000220) where PCDD/Fs contributed approximately 85% the total TEQ. This sample had the highest total TEQ value and although this was comfortably below MPL (6.5 pg TEQ/g) it was approximately five times higher than the other five samples collected.

The concentration of ICES-6 PCB ranged from 0.58 µg/kg to 5.58 µg/kg, with the highest levels found in Pacific Oysters (S15-000240). The summary of PCDD/F, PCB WHO-TEQ and ICES-6 results is given in Table 2.4.

PAHs were detected in all 44 samples analysed (Table 2.5). Higher molecular weight PAHs such as anthanthrene and the dibenzopyrenes were either not found above the LOQ or at relatively low

levels in all of the samples. BaP concentrations ranged from 0.27 µg/kg to 11.59 µg/kg and PAH4 concentrations ranged from 2.14 µg/kg to 52.67 µg/kg. The two highest concentrations for the regulated compounds both came from the only sample that exceeded MPL for benzo[a]pyrene (set at 5 µg/kg) and PAH4 (set at 30 µg/kg). This mussel sample was collected from the site Mersey Mussel North (S15-020910), which is closed for harvesting.

Heavy metals were detected in all samples.The four most abundant heavy metals were zinc (Zn), manganese (Mn) and copper (Cu), with Zn present at the highest concentration, most notably in oysters as expected. Concentrations of the regulated heavy metals mercury (Hg), cadmium (Cd) and lead (Pb) were all below the regulatory limit (Commission Regulation EC 1881/2006 as amended by 629/2008).

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Table 1: Overview of Samples

Local Authority	Production Area	Site name	Collection period	Sample type	GR or *NGR for sample	Fera LIMS no.
Allerdale DC	Silloth	Lees Scar	26/01/2015	Mussels	NY10055345	S15-020908
Barrow-in Furness BC	Morecombe Bay - Roosebeck	Foulney Island	13/01/2015	Mussels	SD24826340	S15-000389
Barrow-in Furness BC	Morecombe Bay - Barrow	Cocken Tunnel	13/01/2015	Mussels	SD185706	S15-000390
Canterbury CC	N Kent	Whitstable Bay	19/01/2015	Native Oysters	5122207, 00100200	S15-000677
Carmarthenshire CC	Burry Inlet	Burry North - Central aka Pwll	06/01/2015	Mussels	N5141089/WW412423	S15-000215
Chichester DC	Chichester Harbour	Thorney	04/02/2015	Native Oysters	SU77100360	S15-024035
Colchester BC	Mersea Flats	Coopers Beach	13/01/2015	Pacific Oysters	TM05141346	S15-000391
Conwy CBC	Conwy Morfa	Morfa	27/01/2015	Mussels	SH76107970	S15-023657
Cornwall PHA	Camel	Porthilly Cove	04/02/2015	Mussels	SW93427533	S15-024038
Cornwall PHA	South of Porth Navas Bar	South of Porth Navas Bar	02/02/2015	Mussels	SW75332672	S15-023881
Cornwall PHA	River Fowey	Wisemans	04/02/2015	Mussels	SX12595313	S15-024034
Cornwall PHA	Fal River	Turnaware Pontoon	04/02/2015	Mussels	SW84073879	S15-024037
Flintshire CC	River Dee	Mostyn/Talacre	11/02/2015	Cockles	SJ 13769 BNG 83109	S15-038452
Gwynedd CC	Menai Strait West	Llanfairisgaer	03/02/2015	Mussels	SH49906587	S15-038229
Gwynedd CC	Menai Strait East	Bangor Kim 6	03/02/2015	Mussels	SH57587302	S15-038230
Kings Lynn & West Norfolk BC	The Wash - Kings Lynn	Heacham, Holmside & Hunstanton	20/01/2015	Mussels	525695N, 002950E	S15-003448
London PHA	Thames estuary	Foulness Sands	06/01/2015	Cockles	TR12929919	S15-000217
London PHA	Roach	Middleway	20/01/2015	Mussels	TQ96449174	S15-003447

Local Authority	Production Area	Site name	Collection period	Sample type	GR or *NGR for sample	Fera LIMS no.
London PHA	Thames estuary	West of Southend Pier	13/03/2015	Pacific Oysters	TQ88148489	S15-040412
Maldon DC	River Crouch	Outer Crouch	20/01/2015	Native Oysters	Not listed on sample sheet	S15-003450
Maldon DC	Blackwater West	Ramsey Marsh	10/02/2015	Native Oysters	TL 93510601	S15-038371
Maldon DC	Blackwater (East)	Batchelor Spit	11/02/2015	Native Oysters	Not listed on sample sheet	S15-038451
Mersey PHA	Liverpool Bay	Harrison Drive East	11/02/2015	Cockles	532642N, 030374W	S15-038454
Mersey PHA	Hoylake Cockles	Hoylake-Cockles listed on sample sheet	11/02/2015	Cockles	532436N 0310 44W	S15-038455
Mersey PHA	Mersey Mussel North	Mersey Mussel North	26/01/2015	Mussels	N5325218 W00301365	S15-020910
North Norfolk DC	Blakeney	Wells-The Pool	20/01/2015	Mussels	TF91814545	S15-003453
Northumberland CC	Holy Island	Rosslinks R9	03/02/2015	Pacific Oysters	NU12333958	S15-023930
Plymouth PHA	Yealm	Fox Cove	07/01/2015	Oysters (unverified type)	SX54404952	S15-000240
Poole DC	Poole Harbour North	Rockley	03/02/2015	Mussels	SY97349058	S15-023926
Portsmouth PHA	Portsmouth Harbour	Porchester	19/01/2015	Native Oysters	504965N, 010629W	S15-000678
Portsmouth PHA	Langstone Harbour	Langstone	20/01/2015	Native Oysters	5048796N, 1 1 889W	S15-003452
South Hams DC	Dart	Waddeton	21/01/2015	Pacific Oysters	SX87415599	S15-009219
South Hams DC	Start Bay	Slapton Sands 2	29/01/2015	Surf clams	SX82634290	S15-023843
Southampton PHA	Solent	Browndown	05/01/2015	Native Oysters	504669N, 011117W	S15-000122
Southampton PHA	Solent	Off Fawley outfall Ashlett Creek	06/01/2015	Native Oysters	504974N, 1 1908W	S15-000220
Suffolk Coastal DC	Deben	Stonner Point	12/01/2015	Mussels	TM28834500	S15-000370
Suffolk Coastal DC	Butley	Butley Creek	13/01/2015	Pacific Oysters	TM39704870	S15-000395
Swale BC	Thames, North Kent, Swale	Swale Outer	09/02/2015	Mussels	TR06136863	S15-038351
Swansea PHA	Swansea Bay	Queens Dock	05/01/2015	Mussels	SS67659210	S15-000119
Teinbridge DC	River Teign	Gasworks Bank	12/01/2015	Mussels	SX92107237	S15-000392

Local Authority	Production Area	Site name	Collection period	Sample type	GR or *NGR for sample	Fera LIMS no.
Teinbridge DC	River Exe	Beacon	12/01/2015	Mussels	SX99698050	S15-000393
Torbay DC	Fishcombe Cove Brixham	Fishcombe Cove	06/01/2015	Mussels	SX91125735	S15-000222
Torridge DC	Taw Torridge	Spratt Ridge East	02/02/2015	Mussels	SS46573142	S15-023879
Weymouth PHA	Portland	Fleet Oyster Farm	04/02/2015	Pacific Oysters	SY66477627	S15-024040

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/Cefas.

Table 2.1: PCDD/Fs (dioxins) concentrations - Whole weight

Note: results maked with an “i” are indicative

Fera LIMS Sample No.	S15-003448	S15-020910	S15-000240	S15-000220	S15-038351	S15-000119
Sample type	Mussels	Mussels	Oysters (unverified type)	Native Oysters	Mussels	Mussels
Whole weight						
pg/g						
2,3,7,8-TCDD	0.02	0.07	0.01	0.77	0.02	0.02
1,2,3,7,8-PeCDD	0.02	0.07	0.08	1.17	0.05	0.07
1,2,3,4,7,8-HxCDD	<0.01	0.04	0.02	0.13	0.03	0.05
1,2,3,6,7,8-HxCDD	0.03	0.11	0.06	0.17	0.07	0.10
1,2,3,7,8,9-HxCDD	0.01	0.05	0.04	0.15	0.03	0.07
1,2,3,4,6,7,8-HpCDD	0.11	0.54	0.10	0.16	0.28	1.26
OCDD	0.42	2.57	0.18	0.24	0.84	10.53
2,3,7,8-TCDF	0.20	1.42i	1.00	0.92	0.50	0.92
1,2,3,7,8-PeCDF	0.04	0.23i	0.10	0.16	0.11i	0.08i
2,3,4,7,8-PeCDF	0.08	0.47	0.23	0.37	0.19	0.24
1,2,3,4,7,8-HxCDF	0.03	0.21	<0.01	<0.01	0.02	0.02
1,2,3,6,7,8-HxCDF	0.01	0.06	0.02	<0.01	0.01	0.02
1,2,3,7,8,9-HxCDF	<0.01	0.04	<0.01	<0.01	<0.01	<0.01
2,3,4,6,7,8-HxCDF	0.02	0.10i	0.05	0.03i	0.03	0.04
1,2,3,4,6,7,8-HpCDF	0.04	0.16	0.01	0.01	0.04i	0.18
1,2,3,4,7,8,9-HpCDF	<0.01	0.04	<0.01	<0.01	<0.01	0.01
OCDF	0.08	0.31	0.01	<0.02	0.07	0.69
WHO-TEQ 2005 (pg/g) lower*	**0.10**	**0.50**	**0.28**	**2.20**	**0.20**	**0.30**
WHO-TEQ 2005 (pg/g) upper	**0.10**	**0.50**	**0.28**	**2.20**	**0.20**	**0.31**

*See Glossary for explanation of lower and upper terms

Table 2.1: PCDD/Fs (dioxins) concentrations - Lipid weight

Fera LIMS Sample No.	S15-003448	S15-020910	S15-000240	S15-000220	S15-038351	S15-000119
Sample Type	Mussels	Mussels	Oysters (unverified type)	Native Oysters	Mussels	Mussels
Lipid weight						
pg/g						
2,3,7,8-TCDD	2.16	10.35	1.42	74.19	2.57	2.95
1,2,3,7,8-PeCDD	2.48	11.63	7.65	111.91	5.41	8.38
1,2,3,4,7,8-HxCDD	1.02	6.79	2.06	12.48	3.02	5.86
1,2,3,6,7,8-HxCDD	2.92	18.11	6.07	16.65	8.32	12.47
1,2,3,7,8,9-HxCDD	1.53	7.88	3.40	14.78	3.44	8.47
1,2,3,4,6,7,8-HpCDD	12.92	85.44	9.32	15.64	31.59	154.28
OCDD	47.56	407.19	17.24	22.99	94.73	1288.01
2,3,7,8-TCDF	22.54	225.15i	96.41	88.22	56.66	112.76
1,2,3,7,8-PeCDF	5.11	35.92i	9.70	15.20	12.33i	9.66i
2,3,4,7,8-PeCDF	9.30	74.73	22.20	35.86	21.34	29.86
1,2,3,4,7,8-HxCDF	3.05	33.01	<0.09	<0.13	2.77	2.32
1,2,3,6,7,8-HxCDF	1.61	8.83	2.29	0.18	1.62	2.06
1,2,3,7,8,9-HxCDF	<0.38	6.41	0.15	<0.22	0.73	0.19i
2,3,4,6,7,8-HxCDF	2.35	16.28i	5.05	3.01i	3.89i	5.27
1,2,3,4,6,7,8-HpCDF	5.08	25.72	1.13	1.10	5.01i	22.38
1,2,3,4,7,8,9-HpCDF	0.64	6.54	0.10	<0.57	0.48	1.60
OCDF	9.19	48.78	1.05	<2.15	7.44	84.48
WHO-TEQ 2005 (pg/g) lower	**11.29**	**79.04**	**27.67**	**211.02**	**23.20**	**37.71**
WHO-TEQ 2005 (pg/g) upper	**11.33**	**79.04**	**27.68**	**211.06**	**23.20**	**37.71**

Table 2.2: Non-*ortho* PCB concentrations

FERA LIMS Sample No.	S15-003448	S15-020910	S15-000240	S15-000220	S15-038351	S15-000119
Sample type	Mussels	Mussels	Oysters (unverified type)	Native Oysters	Mussels	Mussels
Whole Weight						
pg/g						
PCB77	2.99	25.93	13.99	25.93	51.22	27.03
PCB81	0.17	2.26	0.49	2.26	1.46	1.35
PCB126	0.52	3.06	2.94	3.06	2.64	3.08
PCB169	0.13	0.58	0.29	0.58	0.41	0.24
WHO-TEQ 2005 (pg/g) lower	**0.06**	**0.33**	**0.30**	**0.33**	**0.28**	**0.32**
WHO-TEQ 2005 (pg/g) upper	**0.06**	**0.33**	**0.30**	**0.33**	**0.28**	**0.32**
Lipid Weight						
pg/g						
PCB77	340.34	2488.87	1352.22	2488.87	8126.28	3307.17
PCB81	19.91	216.90	47.59	216.90	231.78	164.62
PCB126	59.42	294.13	284.18	294.13	419.10	377.02
PCB169	14.28	56.11	27.72	56.11	64.30	29.22
WHO-TEQ 2005 (pg/g) lower	**6.41**	**31.41**	**29.40**	**31.41**	**44.72**	**38.96**
WHO-TEQ 2005 (pg/g) upper	**6.41**	**31.41**	**29.40**	**31.41**	**44.72**	**38.96**

Table 2.3: *Ortho* PCB concentrations – Whole weight

FERA LIMS Sample No.	S15-003448	S15-020910	S15-000240	S15-000220	S15-038351	S15-000119
Sample type	Mussels	Mussels	Oysters (unverified type)	Native Oysters	Mussels	Mussels
Whole weight						
µg/kg						
PCB18	<0.01	0.03	<0.01	0.13	0.01	0.02
PCB28	0.02	0.17	0.03i	0.36	0.07	0.10
PCB31	0.02	0.13	0.02	0.26	0.05	0.06
PCB47	0.01	0.17	0.07	0.14	0.07	0.06
PCB49	0.02	0.38	0.12	0.30	0.13	0.07
PCB51	<0.01	0.01	<0.01	0.02	<0.01	<0.01
PCB52	0.03	0.51	0.20	0.40	0.16	0.17
PCB99	0.04	0.63	0.69	0.48	0.33	0.44
PCB101	0.10	1.25	1.00	0.87	0.55	0.80
PCB105	0.02	0.20	0.26	0.17	0.12	0.23
PCB114	<0.01	0.01	0.01	<0.01	<0.01	<0.01
PCB118	0.06	0.83	1.09	0.66	0.39	0.73
PCB123	<0.01	0.02	0.01	0.02	0.02	0.01
PCB128	0.02	0.20	0.15	0.13	0.14	0.26
PCB138	0.18	1.57	1.24	1.08	1.03	1.71
PCB153	0.23	1.94	1.61	1.48	1.26	1.78
PCB156	<0.01	0.06	0.04	0.03	0.04	0.06
PCB157	<0.01	0.03	0.03	0.02	0.02	0.03
PCB167	<0.01	0.05	0.06	0.04	0.04	0.06
PCB180	0.02	0.14	0.07	0.05	0.08	0.08
PCB189	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SUM of ICES 6(µg/kg) lower	**0.58**	**5.58**	**4.15**	**4.24**	**3.15**	**4.64**
SUM of ICES 6(µg/kg) upper	**0.58**	**5.58**	**4.15**	**4.24**	**3.15**	**4.64**
WHO-TEQ 2005 (pg/g) lower	**<0.01**	**0.04**	**0.05**	**0.03**	**0.02**	**0.03**
WHO-TEQ 2005 (pg/g) upper	**<0.01**	**0.04**	**0.05**	**0.03**	**0.02**	**0.03**

Table 2.3: *Ortho* PCB concentrations – Lipid weight

FERA LIMS Sample No.	S15-003448	S15-020910	S15-000240	S15-000220	S15-038351	S15-000119
Sample type	Mussels	Mussels	Oysters (unverified type)	Native Oysters	Mussels	Mussels
Lipid weight						
µg/kg						
PCB18	0.94	5.06	0.59	12.35	1.38	2.23
PCB28	2.11	27.30	3.04i	34.41	7.39	11.80
PCB31	1.85	20.72	1.50	25.14	5.21	7.44
PCB47	1.18	27.52	6.59	13.89	8.28	7.59
PCB49	1.89	60.35	11.82	28.88	14.28	8.98
PCB51	0.14	1.87	0.94	1.61	0.37	0.21
PCB52	3.23	80.92	19.72	38.06	17.92	20.37
PCB99	4.66	100.60	66.22	45.69	37.28	53.75
PCB101	10.95	197.94	97.06	83.04	62.21	97.78
PCB105	2.15	31.85	24.82	16.20	12.97	28.08
PCB114	0.12	1.74	1.06	0.72	0.63	1.11
PCB118	6.72	131.21	104.95	63.70	43.90	89.65
PCB123	0.23	2.92	1.37	1.55	1.72	1.80
PCB128	2.61	31.93	14.41	12.01	15.76	32.13
PCB138	20.11	249.42	119.83	103.88	115.81	208.72
PCB153	26.27	308.56	156.10	142.21	141.93	217.84
PCB156	0.82	10.02	4.28	3.03	4.70	7.35
PCB157	0.46	4.39	2.74	1.81	2.16	3.18
PCB167	0.70	8.27	5.50	4.09	4.04	7.50
PCB180	2.42	22.59	7.04	5.24	9.13	10.27
PCB189	<0.18	1.19	0.04i	0.22	0.45	0.57
SUM of ICES 6(µg/kg) lower	**65.09**	**886.73**	**402.79**	**406.84**	**354.39**	**566.78**
SUM of ICES 6(µg/kg) upper	**65.09**	**886.73**	**402.79**	**406.84**	**354.39**	**566.78**
WHO-TEQ 2005 (pg/g) lower	**0.34**	**5.75**	**4.34**	**2.74**	**2.12**	**4.18**
WHO-TEQ 2005 (pg/g) upper	**0.34**	**5.75**	**4.34**	**2.74**	**2.12**	**4.18**

Table 2.4: Summary of PCDD/F and PCB WHO-TEQ, and ICES-6 concentrations

FERA LIMS Sample No.	S15-003448	S15-020910	S15-000240	S15-000220	S15-038351	S15-000119
Sample Details:	Mussels	Mussels	Oysters (unverified type)	Native Oysters	Mussels	Mussels
Fat content (% whole)	**0.9**	**0.6**	**1.0**	**1.0**	**0.9**	**0.8**
WHO TEQ 2005 pg/g whole						
Dioxin	0.10	0.50	0.28	2.20	0.20	0.31
non ortho-PCB	0.06	0.33	0.30	0.33	0.28	0.32
ortho-PCB	<0.01	0.04	0.05	0.03	0.02	0.03
Sum of WHO TEQs (upper)	**0.17**	**0.87**	**0.63**	**2.56**	**0.50**	**0.66**
WHO TEQ 2005 pg/g Fat						
Dioxin	11.33	79.04	27.68	211.06	23.20	37.71
non ortho-PCB	6.41	31.41	29.40	31.41	44.72	38.96
ortho-PCB	0.34	5.75	4.34	2.74	2.12	4.18
Sum of WHO TEQs (upper)	**18.08**	**116.20**	**61.42**	**245.21**	**70.04**	**80.85**
SUM of ICES 6 µg/kg whole (upper)	**0.58**	**5.58**	**4.15**	**4.24**	**3.15**	**4.64**
SUM of ICES 6 µg/kg fat (upper)	**65.09**	**886.73**	**402.79**	**406.84**	**354.39**	**566.78**

Table 2.5: PAH concentrations (µg/kg whole weight)

FERA LIMS No.	S15-020908	S15-000389	S15-000390	S15-000677	S15-000215
Description	Mussels	Mussels	Mussels	Pacific Oysters,	Mussels
µg/kg whole weight					
acenaphthylene	0.59	1.27	1.28	1.85	0.75
acenaphthene	0.61	<0.4	<0.4	<0.26	<0.31
fluorene	2.53	0.51	<0.45	0.60	<0.37
phenanthrene	11.22	2.63	3.12	3.41	1.40
anthracene	1.17	0.52	0.59	1.05	0.22
fluoranthene	8.41	5.07i	6.05i	9.90	2.83
benzo[c]fluorene	0.78	0.34	0.33	0.43	0.12
pyrene	7.38i	5.50i	5.36i	8.94i	2.45i
benzo[ghi]fluoranthene	2.36	1.71	2.43	2.74	0.65
benz (a) anthracene	**4.24**	**2.59**	**2.04**	**2.54**	**0.83**
benzo[b]naphtho[2,1-d]thiophene	1.08	0.52	0.42	0.57	0.34
cyclopenta[c,d]pyrene	0.07	0.05	0.06	0.06	<0.01
chrysene	**4.13**	**2.36**	**1.91**	**2.79**	**1.03**
5-methylchrysene	0.09	<0.06	<0.02	<0.06	<0.01
benzo[b]fluoranthene	**5.41**	**5.09**	**3.50**	**7.10**	**1.58**
benzo[j]fluoranthene	2.48	2.27	1.63	1.87	0.59
benzo[k]fluoranthene	2.34	2.22	1.44	3.23	0.62
benzo[e]pyrene	6.82	5.60	5.50	7.32	1.84
benzo[a]pyrene	**3.19**	**2.68**	**1.70**	**2.49**	**0.66**
indeno[1,2,3-cd]pyrene	2.39	2.71	1.72	1.45	0.68
dibenz[ah]anthracene	0.61	0.56	0.34	0.42	0.15
benzo-[g,h,i]perylene	3.60	3.59	2.55	2.09	0.93
anthanthrene	0.25	0.13	<0.1	<0.1	<0.1
dibenzo[a,l]pyrene	<0.1	0.19	<0.1	<0.1	<0.1
dibenzo[a,e]pyrene	0.41	0.33	0.21	<0.16	<0.12
dibenzo[a,i]pyrene	0.45	0.39	0.13	0.13	<0.1
dibenzo[a,h]pyrene	<0.1	<0.1	<0.1	<0.1	<0.1
coronene	0.33	0.38	0.26	0.13	<0.1
PAH 4 Sum Lower µg/kg	**16.97**	**12.72**	**9.15**	**14.92**	**4.10**
PAH 4 Sum Upper µg/kg	**16.97**	**12.72**	**9.15**	**14.92**	**4.10**

FERA LIMS No.	S15-024035	S15-000391	S15-023657	S15-024038	S15-023881
Description	Native Oysters	Pacific Oysters	Mussels	Mussels	Mussels
µg/kg whole weight					
acenaphthylene	0.47	1.12	0.43	<0.34	1.12
acenaphthene	<0.35	0.43	<0.34	<0.35	<0.29
fluorene	<0.41	0.95	0.63	<0.41	0.61
phenanthrene	1.81	6.45	3.74	1.29	2.48
anthracene	0.37	0.67	0.40	0.15	0.68
fluoranthene	5.14i	12.03i	6.31	1.70	8.82
benzo[c]fluorene	0.37	0.52	0.30	0.08	0.62
pyrene	4.57i	9.06i	4.72i	1.62	8.04i
benzo[ghi]fluoranthene	1.24	2.55	1.79	0.51	3.49
benz (a) anthracene	**1.73**	**2.03**	**1.00**	**0.47**	**3.24**
benzo[b]naphtho[2,1-d]thiophene	0.47	0.60	0.29	<0.01	0.90
cyclopenta[c,d]pyrene	0.04	0.15	0.09	<0.01	0.19
chrysene	**1.64**	**2.67**	**1.17**	**0.63**	**3.22**
5-methylchrysene	<0.02	<0.01	<0.02	<0.01	<0.02
benzo[b]fluoranthene	**2.94**	**4.03**	**1.71**	**0.77**	**5.79**
benzo[j]fluoranthene	0.76	0.93	0.78	0.29	2.37
benzo[k]fluoranthene	3.15	1.68	0.70	0.27	2.38
benzo[e]pyrene	2.65	3.73	3.01	1.59	10.31
benzo[a]pyrene	**1.20**	**0.87**	**0.67**	**0.27**	**2.03**
indeno[1,2,3-cd]pyrene	0.84	0.68	0.65	0.29	1.81
dibenz[ah]anthracene	0.31	0.16	0.11	0.04	0.31
benzo-[g,h,i]perylene	1.14	1.01	0.94	0.49	2.57
anthanthrene	<0.1	<0.1	<0.1	<0.1	0.12
dibenzo[a,l]pyrene	<0.1	<0.1	<0.1	<0.1	<0.1
dibenzo[a,e]pyrene	<0.14	<0.1	<0.1	<0.11	0.33
dibenzo[a,i]pyrene	<0.1	<0.1	<0.1	<0.1	<0.1
dibenzo[a,h]pyrene	<0.1	<0.1	<0.1	<0.1	<0.1
coronene	<0.1	<0.1	<0.1	<0.1	0.52
PAH 4 Sum Lower µg/kg	**7.51**	**9.60**	**4.55**	**2.14**	**14.28**
PAH 4 Sum Upper µg/kg	**7.51**	**9.60**	**4.55**	**2.14**	**14.28**

FERA LIMS No.	S15-024034	S15-024037	S15-038452	S15-038229	S15-038230
Description	Mussels	Mussels	Cockles	Mussels	Mussels
µg/kg whole weight					
acenaphthylene	0.62	1.50	0.28	0.42	0.28
acenaphthene	<0.35	<0.35	<0.3	<0.29	<0.29
fluorene	<0.41	<0.41	0.58	0.53	0.40
phenanthrene	1.23	1.87	3.03	2.62	2.09
anthracene	0.25	0.63	0.46	0.27	0.25
fluoranthene	3.81i	6.64i	5.11	4.58	3.50
benzo[c]fluorene	0.33	0.54	0.36	0.29	0.21
pyrene	4.79i	7.39i	5.23i	3.21i	2.79i
benzo[ghi]fluoranthene	1.57	2.45	1.10	1.30	1.00
benz (a) anthracene	**1.53**	**2.48**	**1.93**	**1.09**	**1.35**
benzo[b]naphtho[2,1-d]thiophene	0.35	0.69	0.48	0.46	0.33
cyclopenta[c,d]pyrene	0.04	0.09	<0.06	0.11	0.08
chrysene	**1.51**	**2.54**	**2.15**	**1.41**	**1.56**
5-methylchrysene	<0.03	<0.04	<0.13	0.01	<0.01
benzo[b]fluoranthene	**2.28**	**4.53**	**2.93**	**1.78**	**2.30**
benzo[j]fluoranthene	0.94	1.75	1.44	0.76	1.05
benzo[k]fluoranthene	0.98	1.93	1.50	0.62	1.01
benzo[e]pyrene	3.77	6.87	3.69	3.10	3.03
benzo[a]pyrene	**0.86**	**1.69**	**2.54**	**0.71**	**1.22**
indeno[1,2,3-cd]pyrene	0.75	1.38	2.26	0.79	1.40
dibenz[ah]anthracene	0.12	0.26	0.43	0.14	0.24
benzo-[g,h,i]perylene	1.30	2.02	2.35	1.12	1.72
anthanthrene	<0.1	<0.1	0.13	<0.1	0.11
dibenzo[a,l]pyrene	<0.1	<0.1	<0.1	<0.1	<0.1
dibenzo[a,e]pyrene	<0.17	<0.27	0.61	<0.13	0.37
dibenzo[a,i]pyrene	<0.1	<0.1	0.18	<0.1	<0.1
dibenzo[a,h]pyrene	<0.1	<0.1	<0.1	<0.1	<0.1
coronene	<0.1	<0.1	0.74	0.38	0.59
PAH 4 Sum Lower µg/kg	**6.18**	**11.24**	**9.55**	**4.99**	**6.43**
PAH 4 Sum Upper µg/kg	**6.18**	**11.24**	**9.55**	**4.99**	**6.43**

FERA LIMS No.	S15-003448	S15-000217	S15-003447	S15-040412	S15-003450
Description	Mussels	Cockles	Mussels	Pacific Oysters	Native Oysters
µg/kg whole weight					
acenaphthylene	0.50	0.45	0.87	3.55i	0.43
acenaphthene	<0.35	0.43	<0.3	<0.39	<0.34
fluorene	0.84	<0.36	0.59	0.53	0.47
phenanthrene	5.72	3.74	3.16	2.23	2.04
anthracene	0.51	0.48	0.78	1.49	0.36
fluoranthene	5.99	6.78i	13.64	6.19i	7.44
benzo[c]fluorene	0.29	0.38	0.67	0.38	0.33
pyrene	4.98i	6.23i	12.88i	8.52i	5.47i
benzo[ghi]fluoranthene	1.32	1.30	3.46	3.10	2.26
benz (a) anthracene	**1.34**	**2.58**	**2.51**	**2.55**	**2.07**
benzo[b]naphtho[2,1-d]thiophene	0.44	0.62	0.85	0.69	0.57
cyclopenta[c,d]pyrene	0.05	0.04	0.12	0.03	0.05
chrysene	**1.58**	**2.91**	**2.85**	**2.97**	**2.02**
5-methylchrysene	<0.03	0.13	<0.15	<0.02	<0.05
benzo[b]fluoranthene	**1.87**	**3.60**	**4.91**	**6.77**	**5.78**
benzo[j]fluoranthene	0.84	1.83	2.03	1.40	2.42
benzo[k]fluoranthene	0.81	2.04	2.12	3.23	7.52
benzo[e]pyrene	2.85	3.47	7.23	10.39	4.61
benzo[a]pyrene	**1.10**	**3.10**	**1.70**	**2.73**	**2.02**
indeno[1,2,3-cd]pyrene	0.99	2.66	1.29	1.15	1.92
dibenz[ah]anthracene	0.20	0.55	0.25	0.42	0.45
benzo-[g,h,i]perylene	1.79	2.93	2.35	2.00	1.94
anthanthrene	<0.1	<0.1	<0.1	<0.1	<0.1
dibenzo[a,l]pyrene	0.11	0.15	<0.1	<0.1	0.10
dibenzo[a,e]pyrene	0.17	0.33	0.12	<0.1	<0.1
dibenzo[a,i]pyrene	0.16	0.37	0.11	<0.1	<0.1
dibenzo[a,h]pyrene	<0.1	<0.1	<0.1	<0.1	<0.1
coronene	0.21	0.34	0.16	0.31	0.12
PAH 4 Sum Lower µg/kg	**5.89**	**12.19**	**11.97**	**15.02**	**11.89**
PAH 4 Sum Upper µg/kg	**5.89**	**12.19**	**11.97**	**15.02**	**11.89**

FERA LIMS No.	S15-038371	S15-038451	S15-038454	S15-038455	S15-020910
Description	Pacific Oysters	Native Oysters	Cockles	Cockles	Mussels
µg/kg whole weight					
acenaphthylene	0.87	0.81	0.53	0.30	5.35
acenaphthene	0.31	<0.29	<0.3	<0.29	0.74
fluorene	0.92	0.58	0.50	0.57	1.22
phenanthrene	5.34	2.51	2.07	2.85	5.07
anthracene	0.75	0.41	0.47	0.46	2.16
fluoranthene	10.83	5.13	5.30	5.69	19.00
benzo[c]fluorene	0.55	0.22	0.37	0.40	2.16
pyrene	8.06i	2.92i	6.30i	6.22i	29.08i
benzo[ghi]fluoranthene	1.78	1.43	1.63	1.48	10.66
benz (a) anthracene	**2.24**	**1.22**	**2.22**	**2.08**	**10.59**
benzo[b]naphtho[2,1-d]thiophene	0.60	0.37	0.58	0.53	2.76
cyclopenta[c,d]pyrene	0.06	0.03	0.08	0.07	0.41
chrysene	**2.63**	**1.26**	**2.37**	**2.35**	**9.39**
5-methylchrysene	<0.09	<0.08	<0.22	<0.04	<0.13
benzo[b]fluoranthene	**3.10**	**4.18**	**4.14**	**3.64**	**21.10**
benzo[j]fluoranthene	0.75	1.56	2.12	1.83	8.99
benzo[k]fluoranthene	1.34	3.38	2.29	1.91	8.91
benzo[e]pyrene	3.84	3.72	5.26	4.59	32.46
benzo[a]pyrene	**1.19**	**1.12**	**3.40**	**2.84**	**11.59**
indeno[1,2,3-cd]pyrene	0.69	1.33	2.52	2.61	6.44
dibenz[ah]anthracene	0.18	0.29	0.51	0.50	1.46
benzo-[g,h,i]perylene	0.94	1.33	2.68	2.73	8.81
anthanthrene	<0.1	<0.1	0.19	0.23	0.63
dibenzo[a,l]pyrene	<0.1	<0.1	<0.1	<0.1	0.11
dibenzo[a,e]pyrene	<0.19	<0.15	0.54	0.63	1.17
dibenzo[a,i]pyrene	<0.1	<0.1	0.12	0.17	0.24
dibenzo[a,h]pyrene	<0.1	<0.1	<0.1	<0.1	<0.1
coronene	0.18	0.26	0.72	0.83	1.42
PAH 4 Sum Lower µg/kg	**9.16**	**7.78**	**12.13**	**10.91**	**52.67**
PAH 4 Sum Upper µg/kg	**9.16**	**7.78**	**12.13**	**10.91**	**52.67**

FERA LIMS No.	S15-003453	S15-023930	S15-000240	S15-023926	S15-000678
Description	Mussels	Pacific Oysters	Oysters (unverified type)	Mussels	Native Oysters
µg/kg whole weight					
acenaphthylene	0.71	0.74	1.45	1.48	0.45
acenaphthene	0.55	0.36	<0.31	0.41	<0.34
fluorene	1.79	0.89	<0.37	0.68	0.53
phenanthrene	9.24	4.81	1.47	3.41	2.27
anthracene	0.87	0.44	0.60	0.58	0.68
fluoranthene	11.66	10.06i	7.06i	6.47i	10.35
benzo[c]fluorene	0.42	0.51	0.34	0.34	0.66
pyrene	7.45i	6.03i	6.55i	5.72i	9.49i
benzo[ghi]fluoranthene	2.22	2.74	2.75	1.84	2.49
benz (a) anthracene	**1.46**	**1.91**	**2.96**	**1.48**	**3.55**
benzo[b]naphtho[2,1-d]thiophene	0.51	0.60	0.62	0.40	1.33
cyclopenta[c,d]pyrene	0.07	0.10	0.08	0.13	0.14
chrysene	**1.87**	**2.72**	**2.60**	**1.50**	**3.34**
5-methylchrysene	<0.02	<0.02	<0.04	<0.01	<0.12
benzo[b]fluoranthene	**2.11**	**5.47**	**7.78**	**2.55**	**4.91**
benzo[j]fluoranthene	0.87	1.25	1.91	0.92	1.74
benzo[k]fluoranthene	0.88	2.21	3.66	0.99	5.01
benzo[e]pyrene	3.94	4.86	6.77	3.71	4.49
benzo[a]pyrene	**1.08**	**0.79**	**1.99**	**0.86**	**2.23**
indeno[1,2,3-cd]pyrene	0.99	0.92	1.19	0.81	1.36
dibenz[ah]anthracene	0.20	0.19	0.30	0.14	0.48
benzo-[g,h,i]perylene	1.93	1.33	1.64	1.33	1.74
anthanthrene	<0.1	<0.1	<0.1	<0.1	<0.1
dibenzo[a,l]pyrene	<0.1	<0.1	<0.1	<0.1	<0.1
dibenzo[a,e]pyrene	0.17	<0.13	<0.1	<0.18	<0.1
dibenzo[a,i]pyrene	0.21	<0.1	<0.1	<0.1	0.11
dibenzo[a,h]pyrene	<0.1	<0.1	<0.1	<0.1	<0.1
coronene	0.25	<0.1	<0.1	<0.1	0.10
PAH 4 Sum Lower µg/kg	**6.52**	**10.89**	**15.33**	**6.39**	**14.03**
PAH 4 Sum Upper µg/kg	**6.52**	**10.89**	**15.33**	**6.39**	**14.03**

FERA LIMS No.	S15-003452	S15-009219	S15-023843	S15-000122	S15-000220
Description	Native Oysters	Pacific Oysters	Surf Clams	Native Oysters	Native Oysters
µg/kg whole weight					
acenaphthylene	0.38	0.41	3.17	<0.38	0.39
acenaphthene	<0.34	<0.34	<0.35	<0.31	<0.31
fluorene	0.46	<0.41	<0.41	<0.36	0.61
phenanthrene	2.20	1.65	2.08	0.88	2.59
anthracene	0.53	0.37	0.53	0.40	0.83
fluoranthene	7.22	6.92	5.29i	4.96i	5.64i
benzo[c]fluorene	0.48	0.36	0.35	0.21	0.18
pyrene	5.99i	6.94i	4.34i	3.55i	2.47i
benzo[ghi]fluoranthene	1.74	2.90	1.35	1.78	2.91
benz (a) anthracene	**2.54**	**2.70**	**4.15**	**2.35**	**5.98**
benzo[b]naphtho[2,1-d]thiophene	1.06	0.56	0.76	1.42	5.98
cyclopenta[c,d]pyrene	0.12	0.08	0.07	0.03	0.10
chrysene	**2.77**	**2.14**	**3.96**	**2.81**	**7.05**
5-methylchrysene	<0.23	<0.04	<0.05	<0.09	<0.09
benzo[b]fluoranthene	**3.36**	**6.24**	**4.10**	**3.44**	**4.71**
benzo[j]fluoranthene	1.08	1.53	1.89	0.86	1.01
benzo[k]fluoranthene	3.91	2.79	2.83	3.14	4.82
benzo[e]pyrene	3.53	6.31	5.46	3.76	5.72
benzo[a]pyrene	**1.59**	**1.39**	**3.57**	**1.51**	**2.37**
indeno[1,2,3-cd]pyrene	1.00	0.86	2.46	0.87	1.27
dibenz[ah]anthracene	0.35	0.20	0.42	0.37	0.60
benzo-[g,h,i]perylene	1.45	1.23	2.79	1.54	2.63
anthanthrene	<0.1	<0.1	0.13	<0.1	0.10
dibenzo[a,l]pyrene	<0.1	<0.1	<0.1	<0.1	<0.1
dibenzo[a,e]pyrene	<0.1	<0.1	0.52	<0.1	0.11
dibenzo[a,i]pyrene	<0.1	<0.1	0.11	<0.1	<0.1
dibenzo[a,h]pyrene	<0.1	<0.1	<0.1	<0.1	<0.1
coronene	<0.1	<0.1	0.14	<0.1	0.16
PAH 4 Sum Lower µg/kg	**10.26**	**12.47**	**15.78**	**10.11**	**20.11**
PAH 4 Sum Upper µg/kg	**10.26**	**12.47**	**15.78**	**10.11**	**20.11**

FERA LIMS No.	S15-000370	S15-000395	S15-038351	S15-000119	S15-000392
Description	Mussels	Pacific Oysters	Mussels	Mussels	Mussels
µg/kg whole weight					
acenaphthylene	0.59	1.04	1.98	2.34	0.57
acenaphthene	<0.39	<0.4	<0.3	0.34	<0.4
fluorene	<0.45	0.71	0.66	0.64	<0.45
phenanthrene	2.79	4.33	3.21	4.52	2.95
anthracene	0.35	0.51	0.97	1.21	0.70
fluoranthene	4.19	8.86i	8.01	10.04i	6.74i
benzo[c]fluorene	0.20	0.35	0.49	0.44	0.47
pyrene	3.61i	6.33i	7.73i	13.28i	5.64i
benzo[ghi]fluoranthene	1.09	2.10	2.77	5.02	1.78
benz (a) anthracene	**1.05**	**1.54**	**2.51**	**4.71**	**4.33**
benzo[b]naphtho[2,1-d]thiophene	0.30	0.46	0.67	1.55	0.84
cyclopenta[c,d]pyrene	0.04	0.06	0.07	0.25	0.11
chrysene	**1.11**	**1.78**	**2.58**	**4.82**	**3.62**
5-methylchrysene	<0.04	<0.01	<0.02	<0.1	<0.02
benzo[b]fluoranthene	**1.63**	**3.75**	**5.20**	**11.86**	**5.80**
benzo[j]fluoranthene	0.71	0.90	1.93	5.58	3.05
benzo[k]fluoranthene	0.65	1.38	2.03	6.95	3.29
benzo[e]pyrene	2.17	3.97	8.97	7.05	5.72
benzo[a]pyrene	**0.62**	**0.73**	**2.37**	**4.81**	**4.95**
indeno[1,2,3-cd]pyrene	0.68	0.57	1.64	4.93	3.56
dibenz[ah]anthracene	0.11	0.13	0.34	1.03	0.98
benzo-[g,h,i]perylene	1.21	0.97	3.28	7.13	3.81
anthanthrene	<0.1	<0.1	0.13	0.32	0.73
dibenzo[a,l]pyrene	<0.1	<0.1	<0.1	0.25	0.62
dibenzo[a,e]pyrene	<0.11	<0.1	0.38	0.41	0.56
dibenzo[a,i]pyrene	<0.1	<0.1	<0.1	0.39	0.86
dibenzo[a,h]pyrene	<0.1	<0.1	<0.1	<0.1	<0.1
coronene	0.12	<0.1	0.58	0.35	0.32
PAH 4 Sum Lower µg/kg	**4.41**	**7.80**	**12.66**	**26.20**	**18.70**
PAH 4 Sum Upper µg/kg	**4.41**	**7.80**	**12.66**	**26.20**	**18.70**

FERA LIMS No.	S15-000393	S15-000222	S15-023879	S15-024040
Description	Mussels	Mussels	Mussels	Pacific Oysters
µg/kg whole weight				
acenaphthylene	1.24	0.63	0.56	<0.34
acenaphthene	<0.4	<0.31	<0.35	<0.35
fluorene	<0.45	<0.37	<0.41	<0.41
phenanthrene	2.38	1.32	0.63	1.32
anthracene	0.51	0.19	0.14	0.11
fluoranthene	6.57i	2.19	1.51	3.12
benzo[c]fluorene	0.29	0.11	0.05	0.14
pyrene	4.74i	1.72i	1.32	2.31i
benzo[ghi]fluoranthene	2.62	0.90	0.45	0.82
benz (a) anthracene	**2.51**	**0.70**	**0.65**	**0.68**
benzo[b]naphtho[2,1-d]thiophene	0.64	0.19	0.22	0.18
cyclopenta[c,d]pyrene	0.09	0.04	<0.01	0.05
chrysene	**2.40**	**0.84**	**0.83**	**0.89**
5-methylchrysene	<0.01	<0.01	<0.02	<0.03
benzo[b]fluoranthene	**4.65**	**1.70**	**0.97**	**1.81**
benzo[j]fluoranthene	1.83	0.65	0.36	0.42
benzo[k]fluoranthene	1.83	0.68	0.39	0.82
benzo[e]pyrene	6.16	2.09	1.45	1.54
benzo[a]pyrene	**1.42**	**0.48**	**0.36**	**0.37**
indeno[1,2,3-cd]pyrene	1.35	0.94	0.44	0.30
dibenz[ah]anthracene	0.24	0.12	0.07	0.06
benzo-[g,h,i]perylene	2.34	1.36	0.70	0.38
anthanthrene	<0.1	<0.1	<0.1	<0.1
dibenzo[a,l]pyrene	<0.1	<0.1	<0.1	<0.1
dibenzo[a,e]pyrene	0.11	0.12	<0.14	<0.1
dibenzo[a,i]pyrene	<0.1	<0.1	<0.1	<0.1
dibenzo[a,h]pyrene	<0.1	<0.1	<0.1	<0.1
coronene	0.16	0.21	<0.1	<0.1
PAH 4 Sum Lower µg/kg	**10.98**	**3.72**	**2.81**	**3.75**
PAH 4 Sum Upper µg/kg	**10.98**	**3.72**	**2.81**	**3.75**

Table 2.6: Heavy metal concentrations (mg/kg whole weight)

Fera LIMS Sample No.	S15-020908	S15-000389	S15-000390	S15-000677	S15-000215	S15-024035	S15-000391	S15-023657	S15-024038	S15-023881
Sample type	Mussels	Mussels	Mussels	Pacific Oysters	Mussels	Native Oysters	Pacific Oysters	Mussels	Mussels	Mussels
Cr	0.44	0.57	0.52	0.22	0.22	~0.06	0.28	0.27	0.22	0.39
Mn	10.5	10.2	9.97	4.57	4.5	1.25	7.2	3.65	1.93	2.47
Co	0.109	0.149	0.124	0.066	0.069	0.036	0.106	0.089	0.093	0.099
Ni	0.36	0.47	0.35	0.2	0.18	~0.05	0.2	0.19	0.15	0.22
Cu	0.98	1.05	1.1	80.9	0.65	25.7	136	1.28	0.9	1.89
Zn	11.2	13.3	13	344	7.95	247	480	13.6	27.4	19.4
As	1.33	2.37	2.44	1.2	1.08	0.98	2.36	1.88	1.82	2.33
Se	0.487	0.637	0.621	0.489	0.271	0.236	0.584	0.391	0.372	0.473
Ag	~0.007	0.01	~0.008	4.93	~0.003	0.502	6.92	0.01	<0.003	~0.004
Cd	0.12	0.187	0.183	0.348	0.143	0.13	0.446	0.096	0.089	0.093
Hg	0.028	0.081	0.078	0.031	0.009	0.03	0.034	0.024	0.015	0.037
Pb	0.539	0.817	1.05	0.163	0.295	0.056	0.192	0.454	0.382	0.824

' ~ ' indicates the measured value was above LoD but below LoQ

Fera LIMS Sample No.	S15-024034	S15-024037	S15-038452	S15-038229	S15-038230	S15-003448	S15-000217	S15-003447	S15-040412	S15-003450
Sample type	Mussels	Mussels	Cockles	Mussels	Mussels	Mussels	Cockles	Mussels	Pacific Oysters	Native Oysters
Cr	0.18	0.17	0.58	3.02	0.76	0.42	2.45	0.33	0.1	0.11
Mn	1.57	1.68	16.6	8.81	7.17	5.44	14.5	5.13	2.57	2.84
Co	0.072	0.062	0.305	0.136	0.189	0.131	1.19	0.191	0.043	0.056
Ni	0.14	0.14	4.51	0.36	0.47	0.23	7	0.4	0.11	0.2
Cu	1.14	1.63	0.78	1.12	0.99	1.02	0.98	1.19	42.7	84
Zn	11.7	12.8	10.8	14	13.8	13.2	10.3	9.83	292	264
As	1.95	1.72	1.32	2.48	3.18	2.03	2.04	2.28	0.74	1.66
Se	0.325	0.32	0.289	0.454	0.391	0.431	0.503	0.369	0.324	0.774
Ag	<0.003	0.371	~0.005	~0.004	~0.009	~0.007	0.094	0.015	3.88	2.7
Cd	0.089	0.063	0.041	0.113	0.108	0.107	0.058	0.135	0.279	0.343
Hg	0.029	0.024	0.029	0.05	0.063	0.018	0.026	0.017	0.025	0.023
Pb	0.63	0.55	0.537	0.665	1.06	0.45	0.646	0.235	0.149	0.061

' ~ ' indicates the measured value was above LoD but below LoQ

Fera LIMS Sample No.	S15-038371	S15-038451	S15-038454	S15-038455	S15-020910	S15-003453	S15-023930	S15-000240	S15-023926	S15-000678
Sample type	Pacific Oysters	Native Oysters	Cockles	Cockles	Mussels	Mussels	Pacific Oysters	Oysters (unverified type)	Mussels	Native Oysters
Cr	0.1	0.11	0.51	0.51	0.65	0.4	~0.08	~0.09	0.27	0.22
Mn	3.84	2.43	9.48	18.1	10.5	6.62	6.84	4.84	1.99	2.08
Co	0.041	0.043	0.33	0.268	0.172	0.142	0.04	0.029	0.239	0.065
Ni	0.12	~0.07	3.38	3.45	0.36	0.3	~0.07	~0.07	0.34	0.33
Cu	19	53.8	0.57	0.68	1.43	1.51	12	11.3	1.07	64.5
Zn	124	305	11	9.58	24.2	13.7	267	94.4	14.4	358
As	1.3	1.24	1.05	1.75	2.18	2.39	3.35	1.22	1.63	2.21
Se	0.328	0.945	0.272	0.292	0.57	0.547	0.442	0.196	0.359	0.444
Ag	1.51	4.66	~0.005	~0.004	~0.008	~0.008	0.858	0.146	~0.005	0.387
Cd	0.132	0.386	0.042	0.044	0.321	0.092	0.285	0.066	0.106	0.202
Hg	0.029	0.03	0.024	0.04	0.069	0.019	0.055	0.029	0.034	0.03
Pb	0.076	0.047	0.406	0.435	1.16	0.429	0.159	0.175	0.285	0.138

' ~ ' indicates the measured value was above LoD but below LoQ

Fera LIMS Sample No.	S15-003452	S15-009219	S15-023843	S15-000122	S15-000220	S15-000370	S15-000395	S15-038351	S15-000119	S15-000392
Sample type	Native Oysters	Pacific Oysters	Surf Clams	Native Oysters	Native Oysters	Mussels	Pacific Oysters	Mussels	Mussels	Mussels
Cr	0.52	~0.09	0.71	0.14	0.19	0.43	0.17	0.36	0.14	0.48
Mn	4.12	4.1	8.18	2.05	2.7	4.01	5.53	2.82	3.83	3.4
Co	0.089	0.019	0.206	0.073	0.076	0.243	0.063	0.181	0.11	0.125
Ni	0.14	0.33	0.28	0.1	0.1	0.43	0.14	0.36	0.18	0.29
Cu	43.5	13	2.09	82.2	94.3	0.84	44.9	0.91	0.9	0.88
Zn	203	92.8	11.7	579	580	11.6	228	10.9	27.1	13
As	1.93	1.01	2.27	1.42	1.76	1.82	1.88	1.39	0.95	2.78
Se	0.606	0.213	0.606	0.872	0.76	0.338	0.62	0.327	0.332	0.415
Ag	0.72	0.158	0.158	3.8	2.27	~0.005	1.85	0.015	~0.003	~0.004
Cd	0.228	0.096	0.067	0.37	0.361	0.169	0.327	0.153	0.403	0.137
Hg	0.042	0.009	0.038	0.026	0.025	0.019	0.019	0.035	0.008	0.027
Pb	0.168	0.122	0.458	0.07	0.105	0.341	0.188	0.261	1.43	1.2

' ~ ' indicates the measured value was above LoD but below LoQ

Fera LIMS Sample No.	S15-000393	S15-000222	S15-023879	S15-024040
Sample type	Mussels	Mussels	Mussels	Pacific Oysters
Cr	0.42	0.31	0.22	~0.06
Mn	3.62	1.7	1.78	1.43
Co	0.116	0.06	0.082	0.017
Ni	0.26	0.2	0.16	~0.07
Cu	1.56	1	0.44	7.29
Zn	15	9.51	8.18	93.9
As	2.93	1.85	1.52	1.24
Se	0.596	0.882	0.299	0.156
Ag	~0.009	~0.006	0.01	0.195
Cd	0.137	0.052	0.132	0.064
Hg	0.027	0.024	0.018	0.012
Pb	0.499	0.5	0.261	0.059

' ~ ' indicates the measured value was above LoD but below LoQ

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