Distribution of PFAS in liver and muscle of herring, perch, cod, eelpout, arctic char, and pike from limnic and marine environments in Sweden

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Summary

Generally, concentrations of PFASs were significantly higher in liver compared to muscle for most compounds and species, with a few exceptions.

For the majority of the liver:muscle ratios calculated, no significant differences were found between species. These compounds include the carboxylates: PFOA, PFUnDA, PFDoDA, PFTrDA, PFTeDA and PFPeDA, and the sulfonic acids: BPFOS and PFOS. The ratios for PFNA, PFDA, LPFOS, LFOSA, and FOSA differed significantly between species. Thus, for these compounds it seems to be important to calculate species specific ratios.

Even though no significant difference in PFOS liver:muscle ratio was found between species, it might not be appropriate to use a mean ratio for all the species, since only some of the species did show a linear relationship between the liver and muscle. For herring and perch (both marine and limnic), there were strong linear relationships between liver and muscle, therefore these can be grouped. The derived EQS

for liver needs to assure the same level of protection as the original EQS. Thereby, the lower limit of the 95% CI for the liver: muscle ratio is used in the calculation of a liver EQS. The existing EQS of 9.1 µg/kg wet weight in edible parts of fish to liver concentrations multiplied with 17.0 (mean ratio liver:muscle =18.4, 95% CI 17.0, 20.4) gives a value of 155 µg/kg wet weight for liver in perch and herring.
For the other species more samples are needed in order to be able to recalculate the existing EQS in edible parts of fish to liver concentrations.

Introduction

Perfluoroalkyl substances (PFASs) are organofluorine compounds, where all hydrogens have been replaced by fluorine on a carbon chain. There are a number of different PFASs, but the two most well-known are perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS).
PFASs have been used industrially and commercially since the beginning of the 1950s. They are found in a wide range of products, e.g. grease proof packaging such as food boxes, fire-fighting foams, outdoor clothing, Teflon and many cleaning and personal care products.
Exponentially increasing concentrations of PFOS in wildlife were reported during the 1990s (Holmström et al. 2005). In biota, PFASs tend to accumulate in protein rich tissues such as blood, liver, and eggs. Hence in fish, concentrations are often measured in liver.

Target level

There is an EQS (Environmental Quality Standard) for PFOS. It is based on QS (Quality Standard) set for human health and it is considered to give the highest protection. The EQS_{biota} for concentrations of PFOS is set at 9.1 µg/kg wet weight (Directive 2013/39/EU).

Aim

Since PFOS often is measured in liver, while the EQS is set to protect human health via consumption of fishery products and thus is more relevant for the evaluation of measured concentrations in edible parts (e.g., muscle or muscle+skin), it is important to investigate the possibility to calculate conversion factors between liver and muscle.

Hence, the aims of this study were to (1) compare concentrations of PFASs in liver and muscle (2) calculate conversion factors between liver and muscle (3) establish an alternative EQS for liver that offer at least the same level of protection as the EQSbiota in accordance with Article 3.3 (Directive 2013/39/EU).

Material and methods

Limnic environment

For this project, 17 lakes out of the 32 lakes in the Swedish national monitoring for contaminants in biota were chosen (figure 1, table 1) where PFAS was analysed in both liver and muscle of perch, arctic char, and pike. In nine of the lakes (the time series lakes), two pooled samples containing 12 individuals in each pool were used, while for the other eight lakes one pooled sample with 12 individuals was used. These eight lakes were chosen because elevated concentrations of PFAS, compared to the other reference lakes, have been observed there (Nyberg et al. 2013).

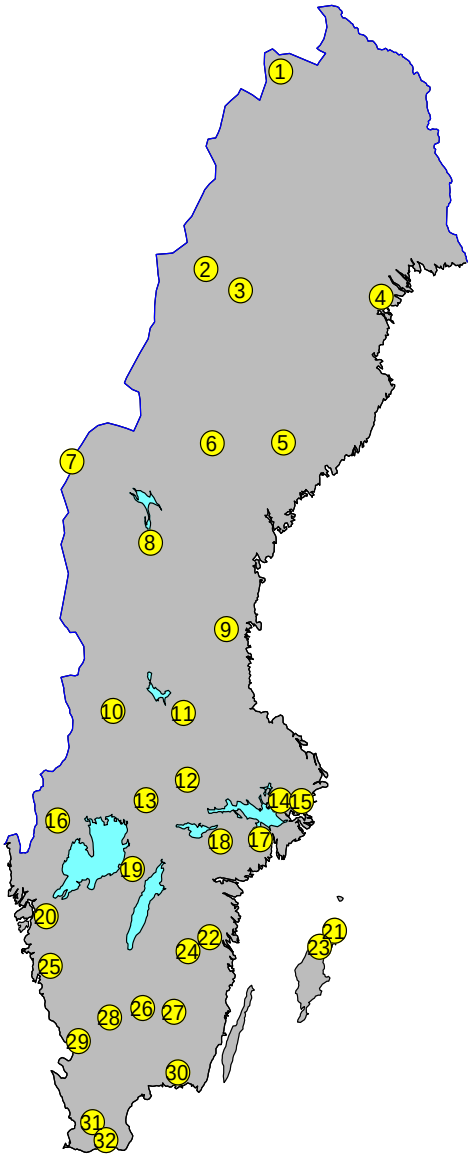

Figure 1. Sampling sites within the Swedish National Monitoring Program for Contaminants in Freshwater Biota. See table 1 for information about the different lakes.

Table 1. Sampling sites and species within the Swedish National Monitoring Program for Contaminants in Freshwater Biota. Column four shows which lakes that were analysed for PFAS in liver and muscle and how many samples that were analysed at each lake. The first column refers to the sampling site numbers in figure 1.

N in map	Sampling site	Species	PFAS samples (pooled)
1	Abiskojaure	Arctic char	2
2	Tjulträsk	Arctic char	2
3	Storvindeln	Pike	2
4	Brännträsket	Perch	1
5	Remmarsjön	Perch	
6	Degervattnet	Perch	
7	Stor-Björsjön	Arctic char	
8	Stor-Backsjön	Perch	
9	Stensjön	Perch	2
10	Gipsjön	Perch	

11	Spjutsjön	Perch	
12	Övre Skärsjön	Perch	1
13	Limmingsjön	Perch	1
14	Fysingen	Perch	1
15	Tärnan	Perch	
16	Bysjön	Perch	1
17	Stora Envättern	Perch	
18	Älgsjön	Perch	
19	Svartsjön	Perch	2
20	Fräcksjön	Perch	1
21	Bästeträsk	Perch	
22	Allgjuttern	Perch	
23	Horsan	Perch	2
24	Skärgölen	Perch	2
25	Lilla Öresjön	Perch	
26	Fiolen	Perch	
27	Hjärtsjön	Perch	1
28	Bolmen	Pike	2
29	Stora Skärsjön	Perch	1
30	Sännen	Perch	
31	Krankesjön	Perch	2
32	Krageholmsjön	Perch	

Marine environment

PFAS was analysed in liver and muscle in fish collected during a measuring campaign in 2011 in possibly polluted areas. In a report by Danielsson et al. (2014) liver concentrations on PFAS was presented, but here also muscle concentrations are related to the liver concentrations. In this project, fish (eelpout, herring, cod, and perch) was sampled from 10 different areas along the coastline of Sweden (figure 2, table 2). For more information about the different sites, see Danielsson et al. (2014). At each site 24 individuals of each species were sampled and two pooled samples with 12 specimens in each pool were later analysed for PFAS in liver and muscle respectively for each species.

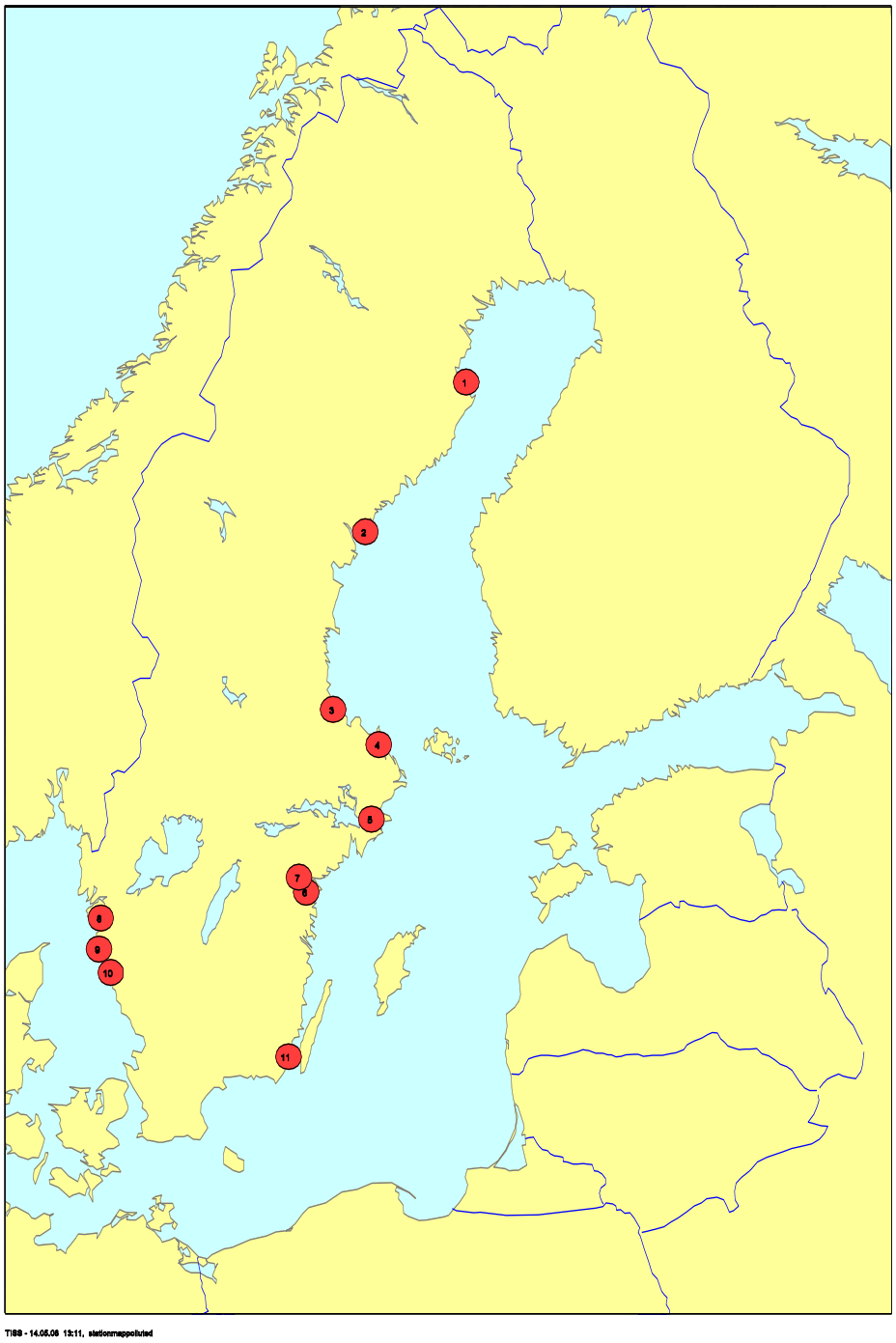

Figure 2. Sampling sites for the marine fish species.

Table 2. Sampling sites and species from the marine stations. Column four shows which areas that were analysed for PFAS in liver and muscle and how many samples that were analysed at each area. The first column refers to the sampling site numbers in figure 2.

N in map	Sampling site	Species	PFAS samples (pooled)
1	Skelleftebukten	Perch, Herring	2
2	Örnsköldsviksfjärden	Perch, Herring	2
3	Yttre Fjärden	Perch, Herring,	2
4	Östhammarsfjärden	Perch	2
5	Lilla Värtan	Perch, Herring,	2
6	Inre Slätbaken	Perch	2
7	Bråviken, s Esterön*	Perch	
7	Bråviken, n Esterön*	Perch	
7	Bråviken, n Svindra*	Perch	
8	Askeröfjorden, Halsefjorden	Eelpout, Cod	2
9	Rivö fjorden	Eelpout, Cod	2
10	Kungsbackafjorden	Eelpout, Cod	2
11	Torsås	Perch, Herring	2

* Fish from these sites were only analysed in muscle in Danielsson et al. (2014) while liver concentrations from an earlier study from other specimens from the same sites were used in that report, therefore no ratios between liver/muscle will be calculated for Bråviken.

For each fish specimen, total body weight, body length, total length (body length plus the tail fin), sex, age, gonad weight, liver weight and sample weight were recorded. To avoid surface contamination and to obtain a sample consisting of only muscle tissue, the epidermis and subcutaneous fatty tissue were carefully removed before the muscle tissue was excised. Muscle samples were taken from the middle dorsal muscle layer. The sampling and sample preparations were all performed according to the manual for collection, preparation and storage of fish (SMNH 2012).

Analytical methods

The analyses were conducted at the Department of Applied Environmental Science, Stockholm University. Abbreviations of PFASs are according to Buck et al. (2011). The target analytes in this study were PFBS, PFHxS, PFOS, PFDS, FOSA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA, and PFPeDA. A sample aliquot of approximately 1.0 g homogenized tissue in a polypropylene (PP)-centrifuge tube was spiked with 1.0 ng each of a suite of mass-labelled internal standards (^{18}O- or ^{13}C-labelled perfluoroalkyl sulfonates and carboxylic acids). The samples were extracted twice with 5 mL of acetonitrile in an ultrasonic bath. Following centrifugation, the supernatant extract was removed and the combined acetonitrile phases were concentrated to 1 mL under a stream of nitrogen. The concentrated extract underwent dispersive clean-up on graphitised carbon and acetic acid. A volume of 0.5 mL of the cleaned-up extract was added to 0.5 mL of aqueous ammonium acetate. Precipitation occurred and the extract was centrifuged before the clear supernatant was transferred to an autoinjector vial for instrumental analysis and the volume standards M8PFOA and M8PFOS were added.

Aliquots of the final extracts were injected automatically on an ultra performance liquid chromatography (UPLC) system (Acquity, Waters) coupled to a tandem mass spectrometer (MS-MS; Xevo TQS, Waters). Compound separation was achieved on a BEH C18 UPLC column (1.7 µm particles, 50 × 2.1 mm, Waters) with a binary gradient of ammonium acetate buffered acetonitrile and water. The mass spectrometer was operated in negative electrospray ionisation mode. Quantification was performed in selected reaction monitoring chromatograms using the internal standard method.

Statistical treatment

Before any statistical analyses were conducted, PFAS concentrations below the limit of quantification (LOQ) were estimated by dividing the reported value for LOQ with the square root of two. These values were later used when comparing concentrations between liver and muscle, but only for those compounds where most concentrations were above LOQ, the others were excluded, as described below.
All concentrations for PFHxA, PFHpA, and PFBS were below LOQ in both liver and muscle and were therefore not included in any of the analyses. In addition, PFOA, PFHxS, and PFDS were below LOQ in liver and muscle in the limnic samples and PFTeDA and PFPeDA in fish from the marine environment were below LOQ in all muscle samples and in the majority of the liver samples, hence they were not included in the analyses.

Correlations between liver and muscle concentrations of most compounds were tested for perch limnic, perch marine, herring, and eelpout using Pearson's product moment correlation. The sample sizes of arctic char, pike, and cod were too small (only four samples per species) hence, requirements for Pearson's product moment correlation was not met. Instead the Spearman rank correlation was used.

Liver:muscle ratios were calculated for each sample. However, if a sample was below LOQ, either in both liver and muscle or only in muscle, the whole sample was excluded, since that otherwise would affect the ratios.

Differences in PFAS concentrations between liver and muscle were tested using a paired t-test. Differences in ratios between species were tested with the non-parametric Kruskal Wallis rank sum test.

Results

Liver and muscle concentrations of most compounds in eelpout, herring and perch (limnic and marine) were correlated ($p<0.05$), while almost no correlations were found in cod, arctic char and pike (Appendix table 1). One reason for not finding any correlations for the latter species could be due to a low number of sampling sites (see table 3). The correlation coefficient (r) for PFOS was between 0.87 to 1.0 for eelpout, herring and perch (limnic and marine) showing that they all fitted well to a straight line (figure 4-7). In perch limnic, one sample (Lake Fysingen) had much higher concentrations and also a bit deviating relationship between concentrations in liver and muscle compared to the rest (see figure 4). Due to its differing concentration this sample could have a multiplier effect on the slope of the regression line and possibly an unjustified effect on the r-value and the mean ratios of concentrations between liver and muscle. However, testing with and without Lake Fysingen did not affect the correlation between liver and muscle concentration, and neither did it affect the mean ratios (concentrations in liver:muscle) for the different compounds for perch limnic compared to the other species, therefore Lake Fysingen is included in all analyses.
In figure 8, liver and muscle concentrations of PFOS for all species are shown.

Table 3. Number of samples and sampling sites used for each species.

Species	Number of samples	Number of sampling sites
Eelpout	6	3
Herring	10	5
Perch marine	14	7
Cod	4	2
Perch limnic	17	13
Arctic char	4	2
Pike	4	2

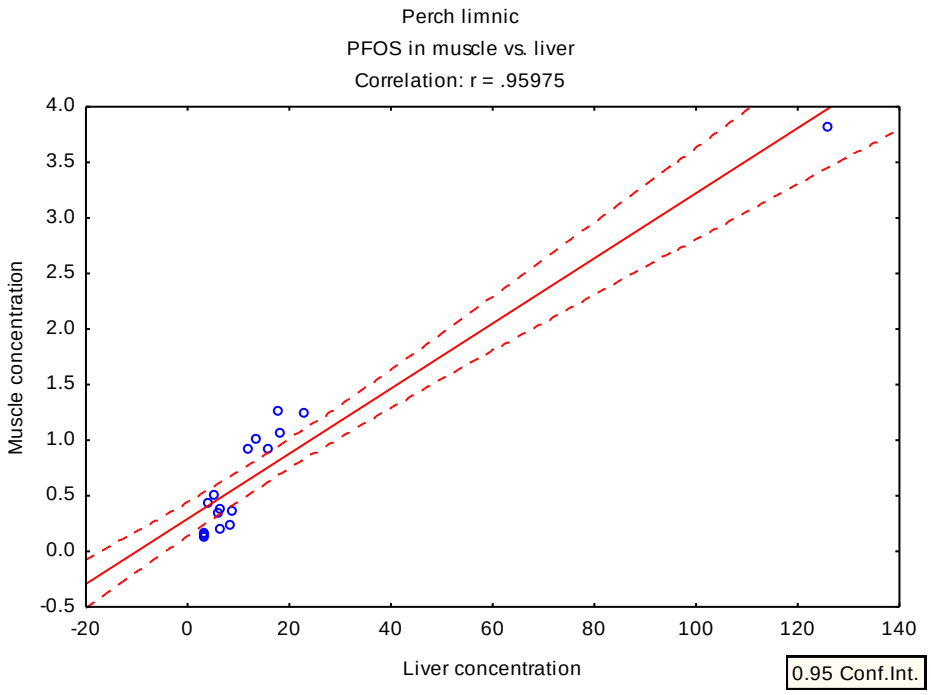

Figure 4. Correlation of PFOS (ng/g ww) in liver versus muscle for perch limnic. The dotted line shows the 95% confidence interval.

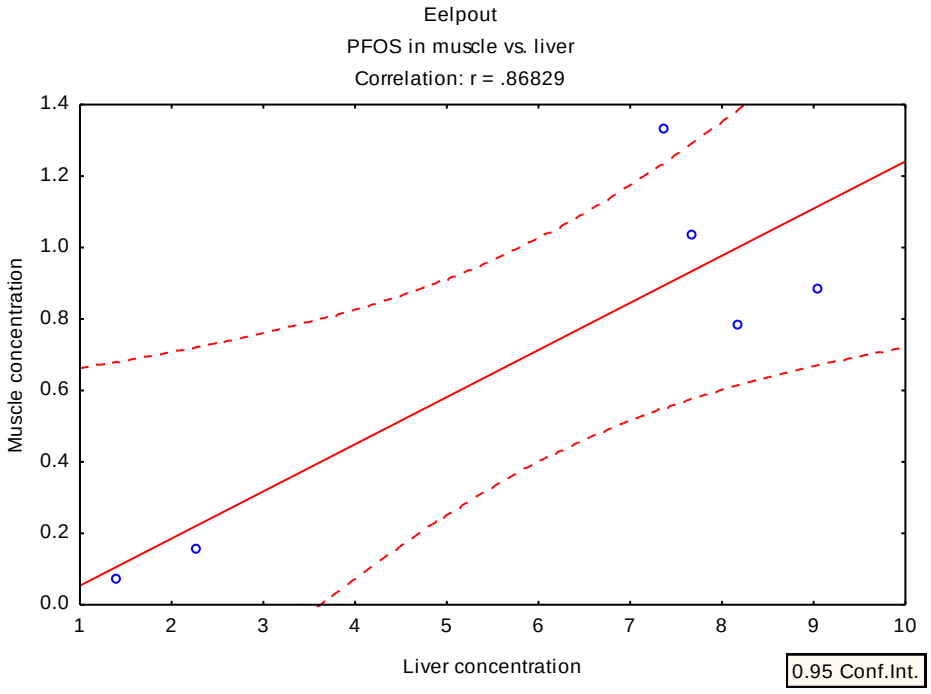

Figure 5. Correlation of PFOS (ng/g ww) in liver versus muscle for eelpout. The dotted line shows the 95% confidence interval.

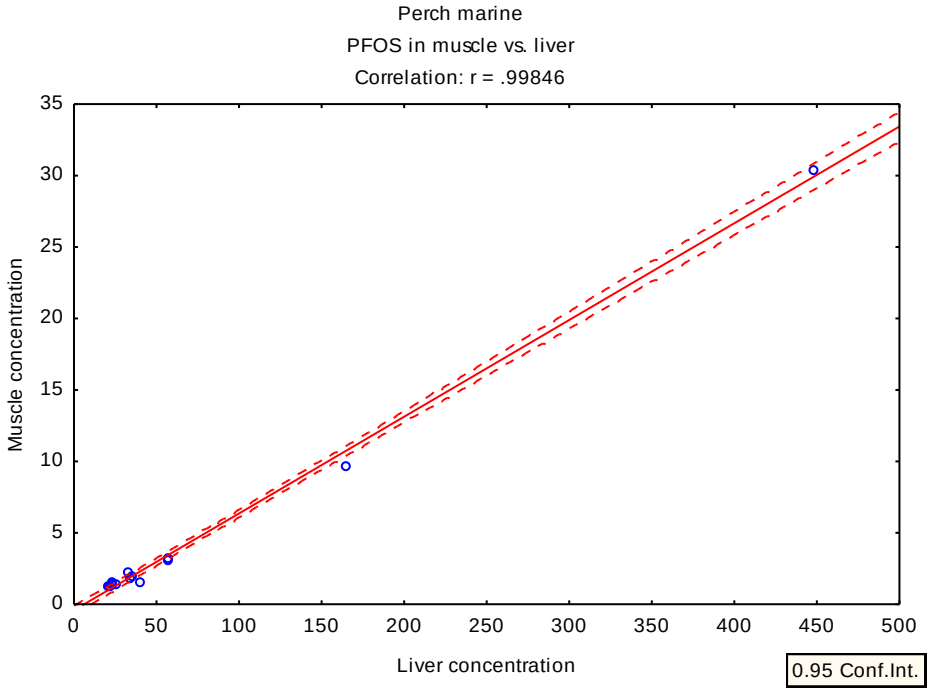

Figure 6. Correlation of PFOS (ng/g ww) in liver versus muscle for perch marine. The dotted line shows the 95% confidence interval.

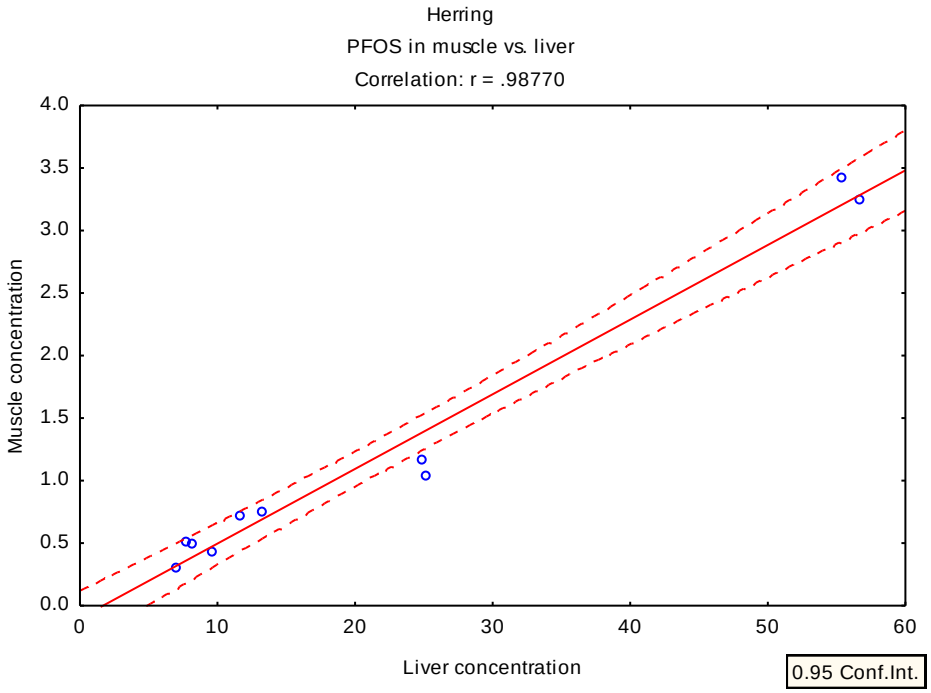

Figure 7. Correlation of PFOS (ng/g ww) in liver versus muscle for herring. The dotted line shows the 95% confidence interval.

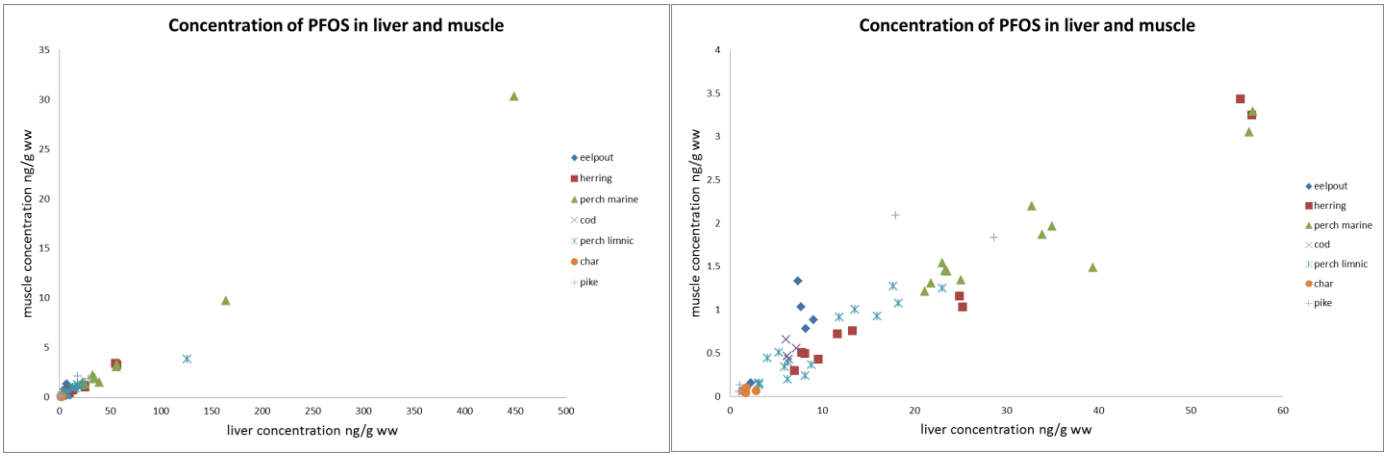

Figure 8. Liver to muscle PFOS concentrations in eelpout, herring, perch (marine and limnic), arctic char, and pike. In the left figure are all concentrations included, while the right figure shows the relationship when the extreme values (conc > 50 ng/g ww) seen in the left figure have been excluded. Note the different axis of the two figures.

Generally, concentrations of PFASs were higher in liver compared to muscle (Appendix table 2, 3). Concentrations of PFAS differed significantly between liver and muscle for most of the species, with a few exceptions in arctic char and pike (Appendix figure 1-16, appendix table 4).

When comparing liver:muscle ratios between species (Appendix figure 17-24), there were no differences in the ratios for PFUnDA, PFDoDA, PFTrDA, PFTeDA, PFPeDA, and PFOS, hence mean liver:muscle ratios for all species for each compound were calculated (table 8). While for those compounds where liver:muscle ratios differed between species, species specific ratios is used (table 8). For PFNA, the liver:muscle ratio was significantly lower in perch limnic compared to herring (p=0.006), and in eelpout compared to perch marine (p=0.003) and herring (p=0.000) (Appendix figure 18). For PFDA, the liver:muscle ratio was significantly lower in eelpout compared to perch limnic (p=0.01), herring (p=0.000), and perch marine (p=0.01) (Appendix figure 19). The liver:muscle ratio for FOSA were significantly higher in herring compared to eelpout (p=0.0005), perch marine (p=0.000), pike (p=0.01), and cod (p=0.01) also perch marine had significantly higher liver:muscle ratio compared to pike (p=0.02 FOSA respectively) (Appendix figure 24). For PFTeDA and PFPeDA no difference in liver:muscle ratio was seen between species, however, only two species could be tested (perch limnic and pike for PFPeDA and perch limnic and perch marine for PFTeDA) because the others were below LOQ (no graphs are presented).

Table 8. Mean liver:muscle ratios for the different compounds with 95% confidence intervals within parentheses. The column with all species is presented when there was no statistical difference between any of the species involved in the analyses for each respective compound. One column for perch, where marine and limnic samples have been merged, are also shown because there was no statistical difference between the two.

	All species	Herring	Perch marine	Perch limnic	Perch all	Eelpout	Pike	Arctic char	Cod
PFOA		13.4 (11, 16)	13.7 (6.9, 21)			6.13 (3.5, 8.7)			8.88 (2.8, 15)
PFNA		15.5 (13, 18)	12.3 (11, 14)	9.06 (7-2, 11)	10.7 (9.4, 12)	5.62(3.8, 7.4)	8.58 (6.6, 11)	14.3 (-6.1, 35)	9.78 (3.1, 16)
PFDA		19.4 (13, 26)	13.7 (12, 15)	14.3 (12, 17)	14.1 (13, 16)	5.69(4.2, 7.1)	14.3 (5.5, 23)	10.1 (5.4, 15)	13.3 (11, 16)
PFUNDA	10.1 (9.0, 11)	14.3 (11, 18)	9.83 (8.8, 11)	10.5 (8.8, 12)	10.2 (9.2, 11)	4.21(2.9, 5.5)	8.73 (3.5, 14)	8.44 (2.8, 14)	10.1 (5.3, 15)
PFDODA	10.2 (8.6, 12)	12.9 (6.7, 19)	8.84 (7.4, 10)	12.1 (9.5, 15)	10.6 (9.0, 12)	3.51 (1.9, 5.1)	10.1 (6.6, 14)		15.3 (-2.9, 33)
PFTRDA	7.8 (6.7, 9.0)	8.98 (6.3, 12)	8.73 (6.11, 11)	7.99 (5.7, 10)	8.34 (6.7, 10)	3.77 (2.7, 4.8)	4.81 (1.4, 8.2)		10.3 (5.3, 15)
PFTEDA	7.4 (4.6, 10)		8.24 (-1.2, 18)	6.95 (5.0, 8.9)	7.40 (4.6, 10)				
PFPEDA	7.4 (4.5, 10)			7.87 (3.7, 12)			6.24 (-1.7, 14)		
PFOS	17.9 (16, 20)	19.0 (17, 21)	17.5 (16, 19)	18.8 (15, 22)	18.2 (16, 20)	11.1 (6.0, 16)	13.4 (3.8, 23)	33.6 (10, 57)	12.5 (8.8, 16)
FOSA		49.5 (20, 79)	7.43 (5.0, 9.9)			3.85 (2.0, 5.7)	2.47 (0.40, 4.5)		6.35 (2.3, 10)

Summary

Generally, concentrations of PFASs were significantly higher in liver compared to muscle for most compounds and species, with a few exceptions.

For the majority of the liver:muscle ratios calculated, no significant differences were found between species. These compounds include the carboxylates: PFOA, PFUnDA, PFDoDA, PFTrDA, PFTeDA and PFPeDA, and the sulfonic acid PFOS. The liver:muscle ratio for PFOS was approximately 18 while the carboxylate compounds were in the range 7-10.
The ratios for PFNA, PFDA, and FOSA differed significantly between species. For PFNA, the ratios ranged between 6 for eelpout to 15 for herring. PFDA ranged from 6 for eelpout to 19 for herring. FOSA ranged from approximately 2 for pike to 49 for herring. Thus, for these compounds it seems to be important to calculate species specific ratios.

Even though no significant difference in PFOS liver:muscle ratio was found between species, it might not be appropriate to use a mean ratio for all the species, since only some of the species did show a linear relationship between the liver and muscle (see figure 4-7). For herring and perch (both marine and limnic), there were strong linear relationships between liver and muscle (r-value ranging between 0.96-1.0) and the ratios liver:muscle were at similar levels and did not differ significantly between the groups. Therefore a mean liver:muscle ratio (mean ratio=18.4, (95% confidence interval 17.0, 20.4)) of these species can be used (calculated from table 8) in order to derive an alternative EQS for maximum PFOS concentration in herring or perch liver.

The derived EQS for liver needs to assure the same level of protection as the original EQS. Thereby, the lower limit of the 95% CI for the liver: muscle ratio is used in the calculation of a liver EQS. The existing EQS of 9.1 µg/kg wet weight in edible parts of fish to liver concentrations multiplied with 17.0 (mean ratio liver:muscle =18.4, 95% CI 17.0, 20.4) gives a value of 155 µg/kg wet weight for liver in perch and herring. For eelpout, with a slightly lower r-value (0.87) a value of 6.0 (mean ratio liver:muscle = 11.1, CI 6.0, 16) (table 8) can instead be used to recalculate the existing EQS, thus 9.1 multiplied with 6.0 gives a value of 55 µg/kg wet weight for liver in eelpout.

For arctic char, pike and cod, more samples are needed in order to be able to recalculate the existing EQS in edible parts of fish to liver concentrations.

When comparing PFOS concentrations in relation to the EQS in muscle and the derived EQS in liver, only perch from Lilla Värtan exceed the existing EQS set in muscle and also the derived liver EQS.

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Appendix

Table 1. Correlations between liver and muscle. Pearson's product moment correlation was used for perch (limnic and marine), eelpout, and herring. R-value is the correlation coefficient, and shows how well the points fit to a straight line. Spearman rank correlation was used for arctic char, pike, and cod. R-value shows the correlation coefficient. ns=non significant.

Species	Compounds	r-value	p
Perch limnic			
	PFNA	0.69	<0.05
	PFDA	0.87	<0.05
	PFUNDA	0.90	<0.05
	PFDODA	0.96	<0.05
	PFTRDA	0.87	<0.05
	PFTEDA	0.59	<0.05
	PFPEDA	0.093	ns
	LPFOS	0.97	<0.05
	BPFOS	0.62	<0.05
	PFOS	0.96	<0.05
Arctic char			
	PFNA	0.42	ns
	PFDA	0.37	ns
	PFUNDA	-0.21	ns
	PFTEDA	0.48	ns
	LPFOS	0.062	ns
	PFOS	0.6	ns.
Pike			
	PFNA	1.0	<0.05
	PFDA	0.55	ns
	PFUNDA	0.77	ns
	PFDODA	-0.38	ns
	PFTRDA	0.73	ns
	PFTEDA	0.77	ns
	PFPEDA	-0.17	ns
	LPFOS	0.91	ns
	BPFOS	-0.92	ns
	PFOS	0.8	ns
	LFOSA	0.86	ns
Eelpout			
	PFOA	0.83	<0.05
	PFNA	0.83	<0.05
	PFDA	0.86	<0.05
	PFUNDA	0.74	ns
	PFDODA	0.40	ns
	PFTRDA	0.95	<0.05
	LPFOS	0.88	<0.05
	BPFOS	0.68	ns
	PFOS	0.87	<0.05
	LFOSA	0.75	<0.05
	FOSA	0.71	<0.05
Herring			
	PFOA	0.97	<0.05
	PFNA	0.78	<0.05
	PFDA	0.85	<0.05
	PFUNDA	0.68	<0.05
	PFDODA	0.93	<0.05
	PFTRDA	0.70	<0.05
	LPFOS	0.99	<0.05
	BPFOS	0.89	<0.05
	PFOS	0.99	<0.05
	LFOSA	0.92	<0.05
	FOSA	0.87	<0.05
Perch marine			
	PFOA	0.64	<0.05
	PFNA	0.90	<0.05
	PFDA	0.99	<0.05
	PFUNDA	0.94	<0.05

	PFDODA	0.97	<0.05
	PFTRDA	0.92	<0.05
	PFTEDA	0.92	<0.05
	LPFOS	1.0	<0.05
	BPFOS	1.0	<0.05
	PFOS	1.0	<0.05
	LFOSA	0.97	<0.05
	FOSA	0.98	<0.05
Cod			
	PFOA	-0.1	ns
	PFNA	0.56	ns
	PFDA	0.95	ns
	PFUNDA	0.51	ns
	PFDODA	0.31	ns
	PFTRDA	0.58	ns
	LPFOS	0.12	ns
	BPFOS	-0.2	ns
	PFOS	0.006	ns
	LFOSA	0.13	ns
	BFOSA	0.67	ns
	FOSA	0.2	ns

Table 2. Concentrations of different PFAS (ng/g wet weight) in liver (L) and muscle (M) in perch, arctic char and pike from different lakes in Sweden. A minus sign in front of some of the figures represents values below the reported LOQ.

Species	Site	PFNA_L	PFNA_M	PFDA_L	PFDA_M	PFUnDA_L	PFUnDA_M	PFDoDA_L	PFDoDA_M	PFTrDA_L	PFTrDA_M	PFTeDA_L	PFTeDA_M	PFPeDA_L	PFPeDA_M	lin-PFOS_L	lin-PFOS_M	br-PFOS_L	br-PFOS_M	PFOS_L	PFOS_M	lin-FOSA_L	lin-FOSA_M
Perca fluviatilis	Brännträsket	0.45	0.04	2.1	0.14	4.1	0.39	1.5	0.16	3.3	0.66	0.43	-.05	0.14	-.03	5.5	0.36	0.78	0.03	6.3	0.40	0.04	-.03
Perca fluviatilis	Bysjön	0.33	0.04	3.7	0.33	6.1	0.71	3.1	0.35	8.2	1.4	1.3	0.20	0.60	0.04	10	0.83	1.6	0.09	11	0.92	0.18	0.04
Perca fluviatilis	Fräcksjön	0.41	0.04	3.4	0.22	6.3	0.64	3.6	0.44	9.9	1.2	1.3	0.18	0.56	-.03	16	0.95	2.4	0.12	18	1.1	0.05	-.03
Perca fluviatilis	Fysingen	0.59	0.07	4.7	0.25	2.3	0.23	1.0	-.1	1.7	0.24	0.27	0.07	0.10	-.03	117	3.6	8.2	0.19	126	3.8	0.04	-.03
Perca fluviatilis	Hjärtsjön	0.44	0.08	8.7	0.46	16	1.3	10	0.88	14	1.8	3.1	0.39	0.75	0.09	16	1.1	1.6	0.17	18	1.3	0.07	-.03
Perca fluviatilis	Horsan	0.76	0.10	1.8	0.18	2.2	0.20	0.68	0.07	1.4	0.17	0.37	-.02	0.24	0.02	5.7	0.15	0.57	0.04	6.2	0.20	-.03	-.03
Perca fluviatilis	Horsan	0.90	0.07	1.2	0.20	2.8	0.21	1.5	0.06	3.2	0.15	0.72	-.02	0.35	-.03	2.8	0.14	0.34	0.01	3.1	0.15	-.03	-.03
Perca fluviatilis	Limmingsjön	0.73	0.04	2.3	0.19	5.6	0.55	2.9	0.30	4.5	0.63	1.0	0.08	0.44	-.03	15	0.88	1.0	0.05	16	0.93	0.07	-.03
Perca fluviatilis	Övre Skärsjön	0.43	0.05	1.9	0.12	8.2	0.48	3.9	0.40	11	0.89	2.7	-.05	1.37	-.03	5.1	0.28	0.80	0.06	5.9	0.34	0.09	-.03
Perca fluviatilis	Krankesjön	0.33	0.04	1.5	0.16	1.0	0.21	0.58	-.1	0.63	0.07	0.19	-.05	0.07	-.03	13	0.93	1.0	0.08	14	1.0	0.04	-.03
Perca fluviatilis	Stora Skärsjön	0.74	0.08	5.9	0.40	8.8	0.84	4.3	0.39	5.9	0.98	1.0	0.16	0.30	-.03	20	1.1	2.6	0.11	23	1.3	0.12	-.03
Perca fluviatilis	Skärgölen	0.30	0.04	2.7	0.13	5.6	0.39	3.6	0.20	4.8	0.62	1.0	0.12	0.35	-.03	6.3	0.32	2.5	0.04	8.8	0.36	-.03	-.03
Perca fluviatilis	Skärgölen	0.24	-.02	2.6	0.09	5.2	0.38	2.8	0.17	4.2	0.36	0.56	0.12	0.25	-.03	5.4	0.21	2.7	0.03	8.1	0.24	-.03	-.03
Perca fluviatilis	Stensjön	0.33	0.08	2.7	0.28	8.2	0.82	4.9	0.39	7.7	1.4	0.99	0.33	0.44	0.06	4.2	0.36	1.1	0.15	5.3	0.51	0.03	-.03
Perca fluviatilis	Stensjön	0.37	0.05	2.5	0.23	6.1	0.89	4.1	0.42	6.1	1.3	1.2	0.21	0.39	0.04	3.7	0.40	0.38	0.05	4.0	0.44	-.03	-.03
Perca fluviatilis	Svartsjön	0.18	0.02	1.3	0.11	2.3	0.35	0.77	0.09	1.7	0.43	0.20	0.06	0.09	0.05	2.3	0.10	0.83	0.06	3.2	0.16	0.04	-.03
Perca fluviatilis	Svartsjön	0.17	-.02	1.2	0.10	2.7	0.38	0.76	0.07	1.0	0.28	0.21	0.02	0.14	0.07	2.3	0.12	0.82	0.01	3.2	0.13	0.07	-.03
Salvelinus alpinus	Tjulträsk	0.80	0.02	0.66	0.05	0.77	-.05	0.54	-.05	1.1	-.05	0.33	-.02	0.10	-.02	1.5	0.04	0.12	-.01	1.7	0.04	0.32	-.03
Salvelinus alpinus	Tjulträsk	0.80	0.12	0.62	0.07	0.78	0.07	0.49	-.05	1.2	0.26	0.45	0.04	0.12	0.04	1.3	0.06	0.07	-.01	1.3	0.06	0.32	-.03
Salvelinus alpinus	Abiskojaure	1.1	0.10	1.1	0.09	1.0	0.12	0.43	-.05	0.49	-.05	0.11	-.02	-.05	-.02	2.7	0.06	0.10	-.01	2.8	0.06	0.04	-.03
Salvelinus alpinus	Abiskojaure	0.97	0.15	0.74	0.12	0.72	0.12	0.22	-.05	0.20	-.05	-.05	-.02	-.05	-.02	1.7	0.09	0.04	-.01	1.7	0.09	0.03	-.03
Esox lucius	Storvindeln	0.35	0.03	0.82	0.05	1.6	0.16	1.1	-.05	1.7	0.22	0.47	-.02	0.23	-.02	0.82	0.04	0.11	-.01	0.93	0.12	0.18	0.10
Esox lucius	Storvindeln	0.49	0.06	1.0	0.10	1.4	0.28	1.0	0.12	1.4	0.44	0.60	-.02	0.23	0.03	0.95	0.12	0.11	-.01	1.1	0.20	0.22	0.16
Esox lucius	Bolmen	0.39	0.04	1.5	0.17	3.5	0.47	1.7	0.16	2.1	0.52	0.51	0.05	0.17	0.07	17	2.1	0.58	0.02	18	2.1	0.83	0.38
Esox lucius	Bolmen	0.68	0.10	2.6	0.13	5.3	0.42	2.3	0.20	2.6	0.66	0.83	-.02	0.29	0.04	28	1.8	0.67	0.04	29	1.8	1.38	0.34

Table 3. Concentrations of PFAS (ng/g wet weight) in liver (L) and muscle (M) in eelpout, herring, perch, and cod from different marine sites in Sweden. A minus sign in front of some of the figures represents values below the reported LOQ.

Species	Site	PFOA_L	PFOA_M	PFNA_L	PFNA_M	PFDA_L	PFDA_M	PFUNDA_L	PFUNDA_M	PFDODA_L	PFDODA_M	PFTRDA_L	PFTRDA_M	PFTEDA_L	PFTEDA_M	LPFOS_L	LPFOS_M	BPFOS_L	BPFOS_M	PFOS_L	PFOS_M	LFOSA_L	LFOSA_M	BFOSA_L	BFOSA_M	FOSA_L	FOSA_M
Zoarces viviparus	Kungsbackafjorden	0.37	0.044	0.49	0.13	1.2	0.25	1.1	0.35	0.46	0.31	0.71	0.18	0.10	0.12	6.4	1.1	0.98	0.21	7.4	1.3	0.59	0.088	0.04	-.01	0.63	0.088
Zoarces viviparus	Kungsbackafjorden	0.49	0.050	0.48	0.08	0.62	0.18	0.92	0.27	0.32	0.12	0.41	0.13	-.10	-.05	6.3	0.89	1.4	0.15	7.7	1.0	0.20	0.068	-.01	-.01	0.20	0.068
Zoarces viviparus	Göteborgs hamninlopp	0.14	0.029	0.30	0.04	0.76	0.11	1.3	0.21	0.63	0.12	0.78	0.16	-.10	-.05	6.8	0.67	1.4	0.12	8.2	0.79	0.50	0.17	-.01	-.01	0.50	0.17
Zoarces viviparus	Göteborgs hamninlopp	0.15	0.038	0.31	0.04	0.87	0.13	1.5	0.29	0.67	0.13	0.86	0.17	-.10	-.05	7.7	0.75	1.4	0.14	9.0	0.89	0.50	0.19	0.01	-.01	0.51	0.19
Zoarces viviparus	Askeröfjorden	0.15	0.027	0.16	0.04	0.31	0.053	0.36	0.13	0.17	0.054	0.19	0.06	-.10	-.05	0.99	0.07	0.41	-.05	1.4	0.074	0.16	0.039	0.02	-.01	0.17	0.039
Zoarces viviparus	Askeröfjorden	0.17	0.041	0.20	0.04	0.42	0.062	0.53	0.12	0.19	0.060	0.18	0.07	-.10	-.05	1.8	0.16	0.51	-.05	2.3	0.16	0.14	0.047	-.01	-.01	0.14	0.047
Clupea harengus	Skellefteå	0.28	0.036	1.5	0.11	1.1	0.069	1.4	0.10	0.48	-.05	0.90	0.07	-.10	-.05	7.4	0.50	0.64	-.05	8.1	0.50	0.24	-.01	0.15	-.01	0.38	-.01
Clupea harengus	Skellefteå	0.33	0.036	1.2	0.09	0.92	0.057	1.5	0.11	0.42	-.05	0.87	0.10	-.10	-.05	8.7	0.43	0.89	-.05	9.5	0.43	0.43	-.01	0.12	-.01	0.55	-.01
Clupea harengus	Öviksfjärden	0.43	0.027	0.79	-.03	0.42	0.021	0.74	0.03	0.21	-.05	0.57	0.03	-.10	-.05	6.1	0.30	0.89	-.05	7.0	0.30	0.36	-.01	0.15	-.01	0.51	-.01
Clupea harengus	Öviksfjärden	0.36	-.02	0.79	-.03	0.42	0.021	0.75	0.09	0.22	-.05	0.50	0.08	-.10	-.05	7.0	0.51	0.80	-.05	7.8	0.51	0.45	-.01	0.26	-.01	-.01	-.01
Clupea harengus	Yttre Fjärden, Gävlebukten	0.66	0.038	2.4	0.10	2.2	0.059	2.3	0.11	1.0	0.071	1.2	0.14	0.13	-.05	24	1.1	1.2	0.085	25	1.2	1.0	0.013	0.19	-.01	1.2	0.013
Clupea harengus	Yttre Fjärden, Gävlebukten	0.54	0.045	1.8	0.11	1.7	0.086	2.0	0.13	1.1	0.060	0.88	0.11	-.10	-.05	24	0.98	1.6	0.061	25	1.0	1.0	0.019	0.13	-.01	1.1	0.019
Clupea harengus	Lilla Värtan, Uppland	1.1	0.076	1.0	0.07	2.5	0.12	1.3	0.08	1.6	0.15	1.0	0.20	0.33	0.07	54	3.1	2.4	0.15	57	3.3	3.1	0.10	0.52	0.02	3.6	0.12
Clupea harengus	Lilla Värtan, Uppland	1.1	0.091	0.87	0.09	2.4	0.14	1.1	0.12	1.7	0.18	0.90	0.18	0.54	0.07	52	3.3	3.5	0.14	55	3.4	5.8	0.10	0.76	-.01	6.6	0.11
Clupea harengus	Torsås	2.3	0.13	2.1	0.15	0.67	0.058	0.83	0.08	0.21	-.05	0.62	0.08	-.10	-.05	11	0.64	1.1	0.086	12	0.72	0.90	0.034	0.21	-.01	1.1	0.034
Clupea harengus	Torsås	2.2	0.15	2.2	0.12	0.89	0.056	0.89	0.08	0.22	-.05	0.52	0.06	-.10	-.05	12	0.67	1.7	0.094	13	0.76	0.64	0.031	0.13	0.01	0.78	0.042
Perca fluviatilis	Skellefteå	0.44	0.041	3.4	0.21	3.6	0.25	3.7	0.36	1.3	0.25	1.1	0.26	0.16	0.051	34	1.3	4.9	0.16	39	1.5	0.084	0.010	0.04	-.01	0.12	0.010
Perca fluviatilis	Skellefteå	0.21	-.02	2.2	0.21	2.6	0.21	4.3	0.37	1.19	0.16	1.8	0.31	0.13	0.057	19	1.4	3.7	0.19	23	1.5	0.049	0.016	-.01	-.01	0.049	0.016
Perca fluviatilis	Öviksfjärden	0.24	0.021	1.1	0.12	1.1	0.054	1.6	0.17	0.43	0.052	1.0	0.05	0.21	-.05	16	0.97	4.8	0.24	21	1.2	0.04	0.014	0.01	-.01	0.052	0.014
Perca fluviatilis	Öviksfjärden	0.34	0.038	1.1	0.10	0.88	0.067	1.4	0.11	0.50	-.05	0.26	0.10	-.10	-.05	16	1.0	5.9	0.31	22	1.3	0.033	0.019	0.01	-.01	0.047	0.019
Perca fluviatilis	Yttre Fjärden, Gävlebukten	0.19	-.02	2.2	0.21	2.4	0.26	2.4	0.35	1.1	0.25	1.6	0.20	0.35	0.11	28	2.0	4.6	0.22	33	2.2	0.10	0.023	0.02	-.01	0.12	0.023
Perca fluviatilis	Yttre Fjärden, Gävlebukten	0.42	0.029	2.1	0.15	2.6	0.21	2.8	0.32	1.3	0.14	1.8	0.17	0.14	0.087	29	1.7	4.6	0.20	34	1.9	0.10	0.020	0.02	-.01	0.12	0.020
Perca fluviatilis	Östhammarsfjärden	0.20	0.021	1.3	0.12	1.6	0.12	2.1	0.22	0.79	0.073	1.2	0.12	0.66	-.05	20	1.3	3.3	0.17	24	1.5	0.044	-.01	-.01	-.01	0.044	-.01
Perca fluviatilis	Östhammarsfjärden	0.071	-.02	0.74	0.08	1.3	0.092	1.5	0.18	0.49	0.070	1.2	0.12	0.50	-.05	22	1.2	3.1	0.11	25	1.3	0.022	-.01	-.01	-.01	-.01	-.01
Perca fluviatilis	Lilla Värtan, Uppland	0.16	-.02	1.2	0.08	13	0.98	7.5	0.67	8.1	0.84	4.4	0.66	6.9	0.39	401	29	47	1.8	449	30	1.4	0.17	0.18	-.01	1.6	0.17
Perca fluviatilis	Lilla Värtan, Uppland	0.12	-.02	0.78	0.06	9.6	0.62	5.7	0.44	4.5	0.41	1.8	0.33	2.9	0.13	139	8.8	25	0.95	164	9.7	0.99	0.087	0.14	0.01	1.13	0.097
Perca fluviatilis	Inre Slätbaken	0.17	0.027	1.8	0.13	4.7	0.28	3.6	0.34	1.27	0.12	0.94	0.13	1.1	-.05	50	2.8	6.3	0.22	56	3.1	0.19	-.01	0.02	-.01	0.21	-.01
Perca fluviatilis	Inre Slätbaken	0.16	0.025	1.7	0.15	4.1	0.25	3.0	0.38	1.1	0.11	0.84	0.08	0.89	-.05	51	3.1	5.8	0.23	57	3.3	0.13	0.013	0.02	-.01	0.15	0.013
Perca fluviatilis	Torsås	0.80	0.037	3.6	0.35	2.7	0.21	2.7	0.34	0.70	0.068	1.4	0.11	1.4	-.05	30	1.7	5.2	0.24	35	2.0	0.13	0.023	0.02	-.01	0.15	0.023
Perca fluviatilis	Torsås	1.1	0.031	4.2	0.25	1.9	0.18	2.2	0.25	0.67	0.057	0.95	0.13	0.73	-.05	20	1.3	3.6	0.18	23	1.5	0.17	0.020	0.03	-.01	0.19	0.020
Gadus morhua	Kungsbackafjorden	0.42	0.034	1.1	0.08	1.6	0.12	2.4	0.18	1.9	0.059	1.4	0.12	0.68	-.05	5.7	0.47	1.5	0.088	7.2	0.56	1.53	0.17	0.093	-.01	1.6	0.17
Gadus morhua	Kungsbackafjorden	0.36	0.031	1.3	0.10	1.6	0.11	1.5	0.15	0.47	0.053	0.59	0.10	0.33	-.05	5.1	0.37	1.3	0.061	6.3	0.43	0.90	0.15	-.01	-.01	0.96	0.15
Gadus morhua	Göteborgs hamninlopp	0.18	0.023	0.52	0.09	0.94	0.069	1.0	0.10	0.46	-.05	0.82	0.06	0.40	-.05	4.9	0.38	1.3	0.083	6.2	0.47	1.6	0.24	0.10	0.029	1.7	0.27
Gadus morhua	Göteborgs hamninlopp	0.19	0.048	0.48	0.07	1.0	0.090	1.2	0.19	0.46	0.065	0.82	0.08	0.66	-.05	4.8	0.52	1.2	0.14	6.1	0.65	1.2	0.40	0.098	0.021	1.3	0.42

Table 4. Differences in liver and muscle concentration for the different compounds using a paired t-test. A few compounds are not included due to that all or the majority of the values were below LOQ. Column three and four shows the mean liver and muscle concentrations respectively with standard deviation within parentheses. Column five shows the concentration difference between liver and muscle. P-values are presented in column six where ns=non significant.

Species	Compound	Liver conc	Muscle conc	Diff	p
Perch limnic	PFNA	0.45 (0.22)	0.051 (0.025)	0.40	0.000
	PFDA	3.03 (1.19)	0.21 (0.11)	2.82	0.000
	PFUnDA	5.52 (3.6)	0.52 (0.3)	3.33	0.000
	PFDoDA	2.97 (2.43	0.26 (0.21)	2.7	0.000
	PFTrDA	5.28 (3.91)	0.74 (0.53)	4.54	0.000
	PFTeDA	0.97 (0.83)	0.12 (0.11)	0.85	0.000
	PFPeDA	0.38 (0.32)	0.034 (0.021)	0.35	0.000
	LPFOS	14.8 (27.1)	0.70 (0.84)	14.1	0.040
	BPFOS	1.72 (1.84)	0.076 (0.054)	1.64	0.001
	PFOS	16.5 (28.9)	0.78 (0.88)	28	0.030
Pike	PFNA	0.48 (0.15)	0.058 (0.027)	0.42	0.006
	PFDA	1.48 (0.78)	0.11 (0.054)	1.37	0.040
	PFUnDA	2.92 (1.81)	0.33 (0.14)	2.59	ns
	PFDoDA	1.52 (0.62)	0.31 (0.3)	1.21	ns
	PFTrDA	1.97 (0.52)	0.46 (0.18)	1.51	0.005
	PFTeDA	0.60 (0.16)	0.35 (0.23)	0.25	0.040
	PFPeDA	0.23 (0.052)	0.074 (0.063)	0.16	0.040
	LPFOS	11.8 (13.3)	1.01 (1.07)	10.8	ns
	BPFOS	0.37 (0.3)	0.054 (0.028)	0.31	ns
	PFOS	12.1 (13.6)	1.06 (1.04)	11.1	ns
	LFOSA	0.65 (0.57)	0.24 (0.14)	0.41	ns
Arctic char	PFNA	0.91 (0.13)	0.098 (0.053)	0.81	0.000
	PFDA	0.77 (0.21)	0.081 (0.029)	0.69	0.006
	PFUnDA	0.82 (0.14)	0.21 (0.22)	0.61	0.020
	PFTeDA	0.35 (0.18)	0.18 (0.15)	0.17	ns
	LPFOS	1.79 (0.62)	0.061 (0.023)	1.73	0.011
	PFOS	1.87 (0.63)	0.068 (0.023)	1.80	0.011
Eelpout	PFOA	0.25 (0.15)	0.038 (0.009)	0.21	0.016
	PFNA	0.32 (0.14)	0.062 (0.038)	0.26	0.002
	PFDA	0.70 (0.32)	0.13 (0.07)	0.56	0.003
	PFUnDA	0.95 (0.44)	0.23 (0.09)	0.72	0.005
	PFDoDA	0.41 (0.22)	0.13 (0.09)	0.27	0.019
	PFTrDA	0.52 (0.30)	0.13 (0.052)	0.39	0.001
	LPFOS	4.98 (2.85)	0.61 (0.41)	4.37	0.008
	BPFOS	1.0 (0.44)	0.11 (0.07)	0.89	0.003
	PFOS	5.99 (3.28)	0.71 (0.5)	5.27	0.006
	LFOSA	0.35 (0.20)	0.10 (0.064)	0.25	0.013
	FOSA	0.36 (0.21)	0.10 (0.06)	0.26	0.014
Perch marine	PFOA	0.33 (0.28)	0.024 (0.01)	0.3	0.001
	PFNA	1.95 (1.1)	0.16 (0.08)	1.79	0.000
	PFDA	3.72 (3.5)	0.27 (0.25)	3.45	0.002
	PFUnDA	3.18 (1.72)	0.32 (0.14)	2.86	0.000
	PFDoDA	1.67 (2.1)	0.19 (0.21)	1.48	0.012
	PFTrDA	1.44 (0.95)	0.20 (0.16)	1.24	0.000
	PFTeDA	1.15 (1.82)	0.08 (0.1)	1.07	0.037
	LPFOS	62.6 (102)	4.07 (7.3)	58.5	0.039
	BPFOS	9.14 (12.3)	0.37 (0.46)	8.77	0.016
	PFOS	71.7 (115)	4.44 (7.8)	67.3	0.035
	LFOSA	0.25 (0.41)	0.031 (0.04)	0.22	0.047
	FOSA	0.29 (0.47)	0.032 (0.04)	0.25	0.042
Herring	PFOA	0.93 (0.76)	0.065 (0.05)	0.86	0.004
	PFNA	1.47 (0.63)	0.094 (0.03)	1.38	0.000
	PFDA	1.32 (0.80)	0.068 (0.037)	1.25	0.000
	PFUnDA	1.28 (0.54)	0.093 (0.028)	1.18	0.000
	PFDoDA	0.71 (0.57)	0.067 (0.053)	0.64	0.004
	PFTrDA	0.80 (0.24)	0.10 (0.054)	0.7	0.000
	LPFOS	20.5 (18.3)	1.15 (1.11)	19.3	0.006
	BPFOS	1.48 (0.89)	0.076 (0.043)	1.4	0.000

	PFOS	21.9 (19.1)	1.21 (1.16)	20.7	0.005
	LFOSA	1.40 (1.75)	0.034 (0.039)	1.36	0.033
	FOSA	1.66 (1.95)	0.036 (0.043)	1.62	0.025
Cod	PFOA	0.29 (0.12)	0.034 (0.01)	0.25	0.025
	PFNA	0.86 (0.42)	0.087 (0.014)	0.77	0.033
	PFDA	1.29 (0.37)	0.096 (0.021)	1.19	0.006
	PFUnDA	1.54 (0.63)	0.15 (0.04)	1.39	0.020
	PFDoDA	0.82 (0.71)	0.053 (0.013)	0.77	ns
	PFTrDA	0.91 (0.36)	0.09 (0.023)	0.82	0.017
	LPFOS	5.13 (0.40)	0.43 (0.07)	4.69	0.000
	BPFOS	1.31 (0.12)	0.092 (0.032)	1.21	0.000
	PFOS	6.43 (0.51)	0.53 (0.10)	5.91	0.000
	LFOSA	1.32 (0.32)	0.24 (0.11)	1.08	0.007
	BFOSA	0.087 (0.022)	0.016 (0.011)	0.07	0.004
	FOSA	1.41 (0.34)	0.25 (0.13)	1.15	0.006

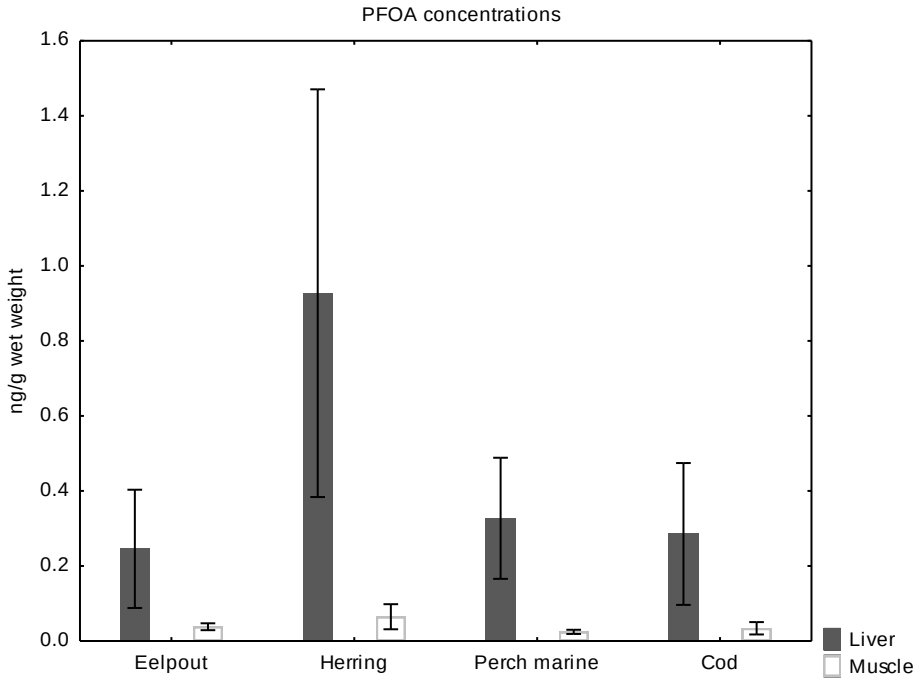

Figure 1. Mean PFOA (ng/g ww) concentrations (bars indicate 95% CI) in liver and muscle in eelpout, herring, perch and cod from the marine environment. All species had significantly higher concentration in liver compared to muscle.

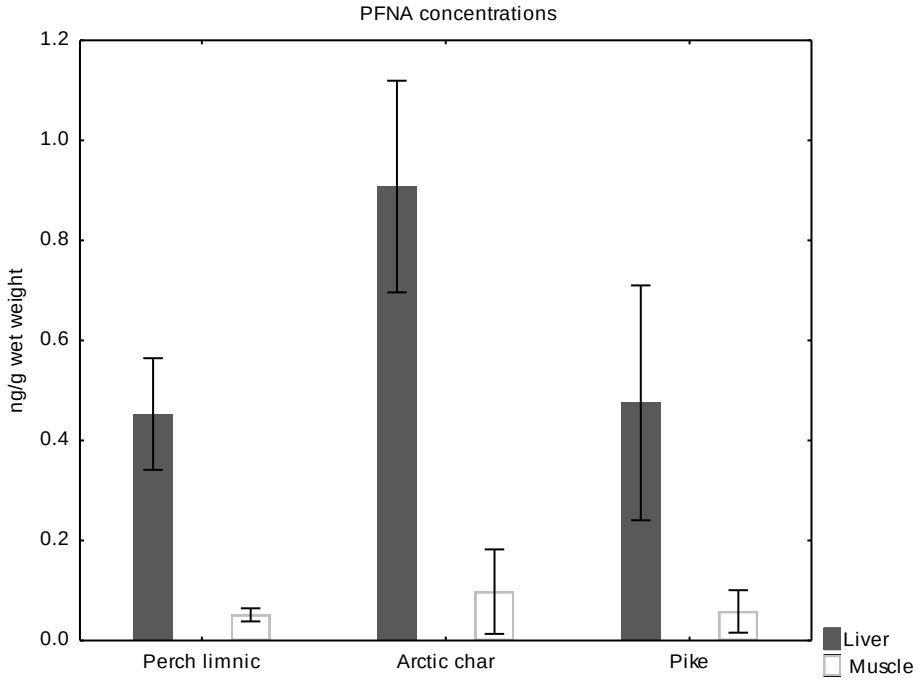

Figure 2. Mean PFNA (ng/g ww) concentrations (bars indicate 95% CI) in liver and muscle in perch, arctic char, and pike from the limnic environment. All species had significantly higher concentration in liver compared to muscle.

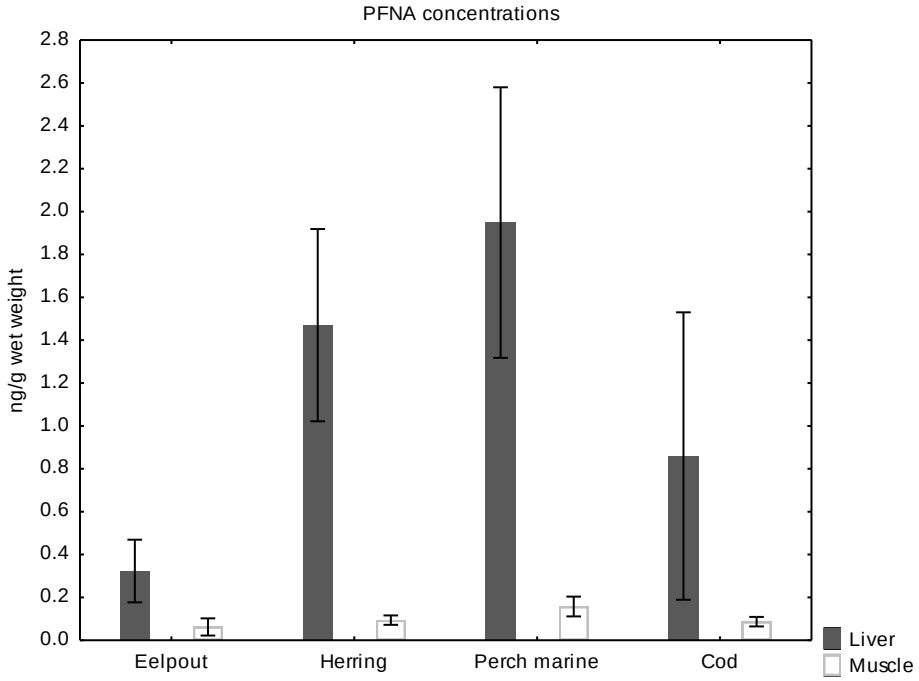

Figure 3. Mean PFNA (ng/g ww) concentrations (bars indicate 95% CI) in liver and muscle in eelpout, herring, perch and cod from the marine environment. All species had significantly higher concentration in liver compared to muscle.

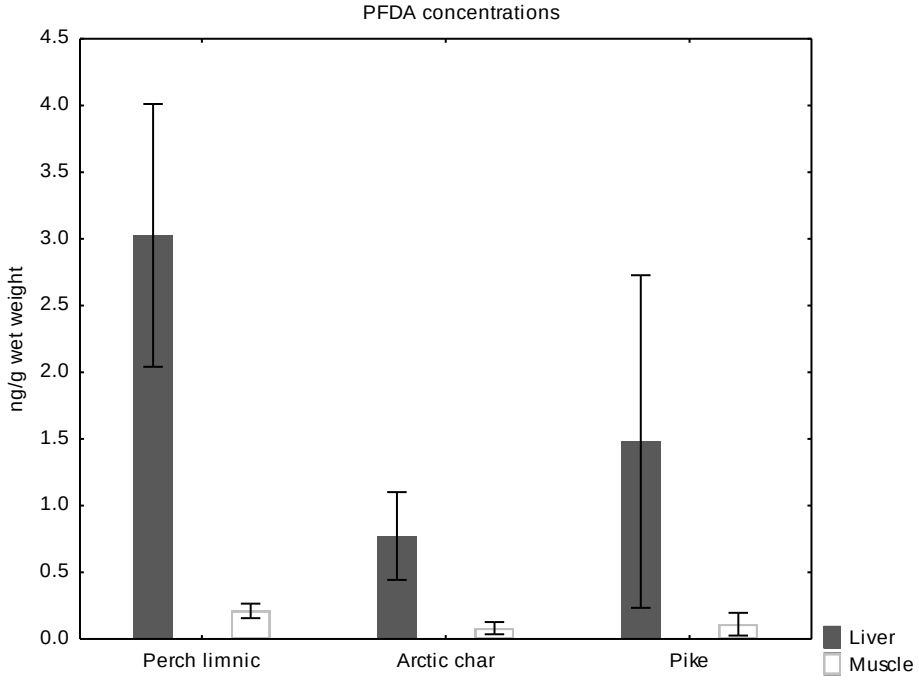

Figure 4. Mean PFDA (ng/g ww) concentrations (bars indicate 95% CI) in liver and muscle in perch, arctic char, and pike from the limnic environment. All species had significantly higher concentration in liver compared to muscle.

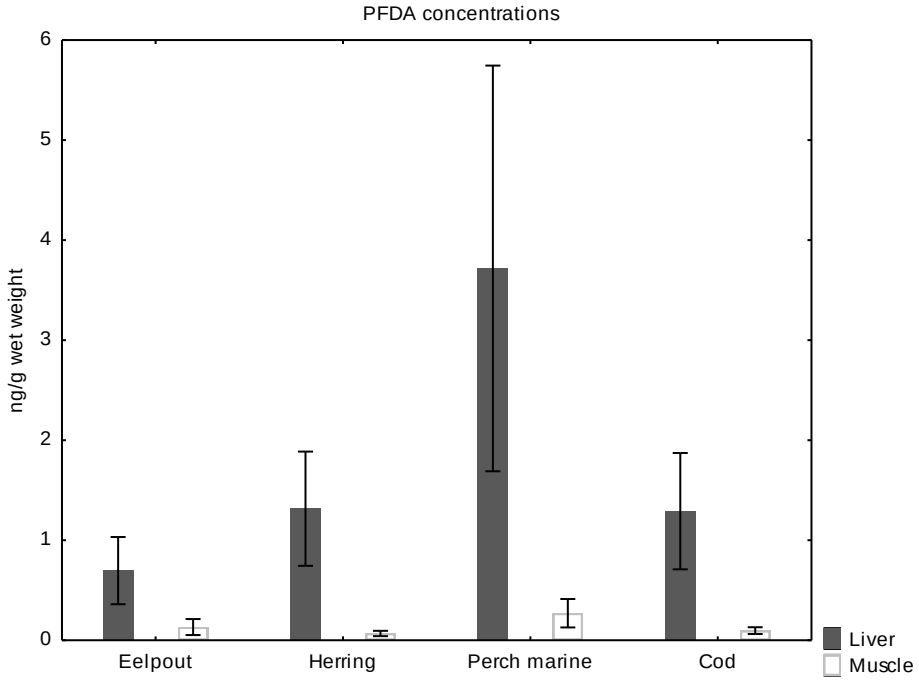

Figure 5. Mean PFDA (ng/g ww) concentrations (bars indicate 95% CI) in liver and muscle in eelpout, herring, perch and cod from the marine environment. All species had significantly higher concentration in liver compared to muscle.

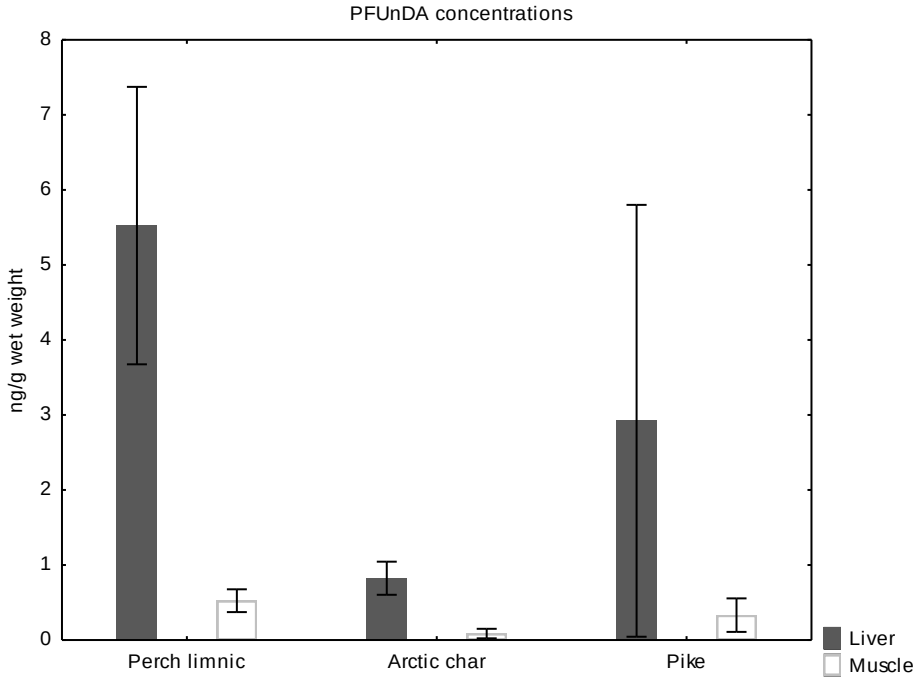

Figure 6. Mean PFUnDA (ng/g ww) concentrations (bars indicate 95% CI) in liver and muscle in perch, arctic char, and pike from the limnic environment. Perch and arctic char had significantly higher concentration in liver compared to muscle.

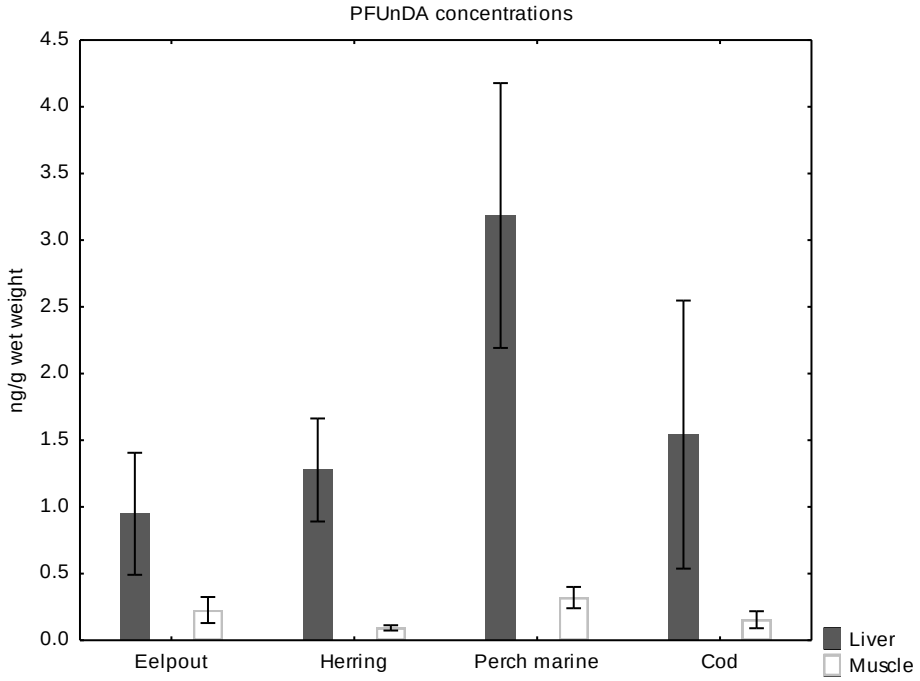

Figure 7. Mean PFUnDA (ng/g ww) concentrations (bars indicate 95% CI) in liver and muscle in eelpout, herring, perch and cod from the marine environment. All species had significantly higher concentration in liver compared to muscle.

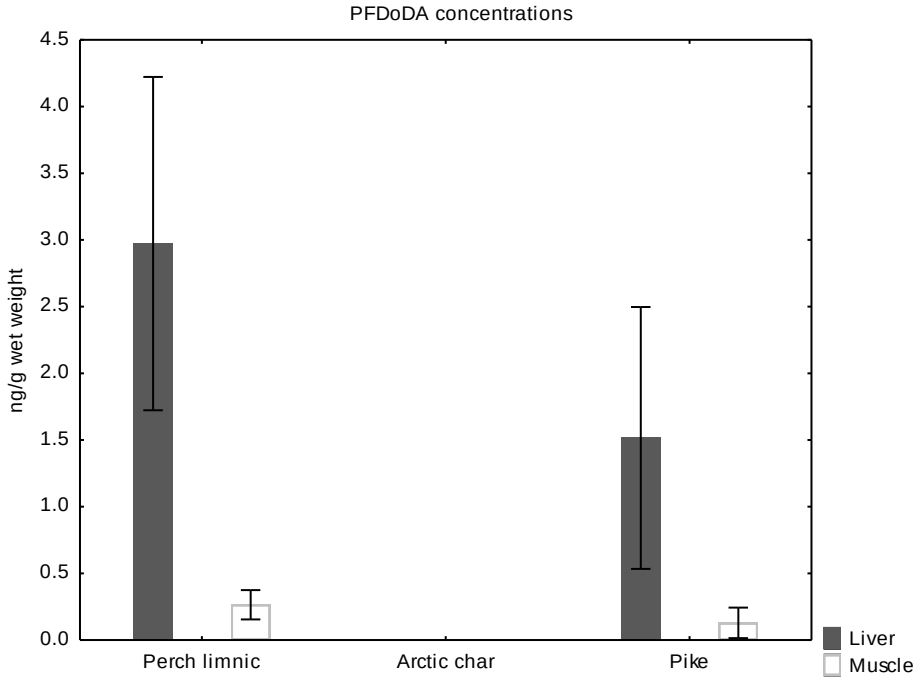

Figure 8. Mean PFDoDA (ng/g ww) concentrations (bars indicate 95% CI) in liver and muscle in perch and pike from the limnic environment. No bars are presented for arctic char because all muscle values were below LOQ. Perch had significantly higher concentration in liver compared to muscle.

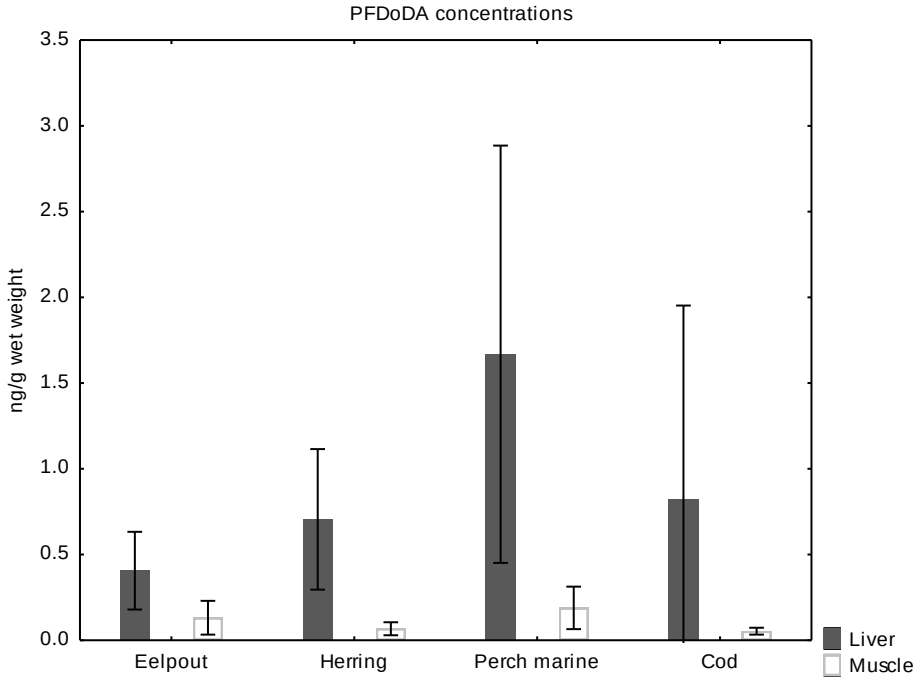

Figure 9. Mean PFDoDA (ng/g ww) concentrations (bars indicate 95% CI) in liver and muscle in eelpout, herring, perch and cod from the marine environment. Eelpout, herring, and perch had significantly higher concentration in liver compared to muscle.

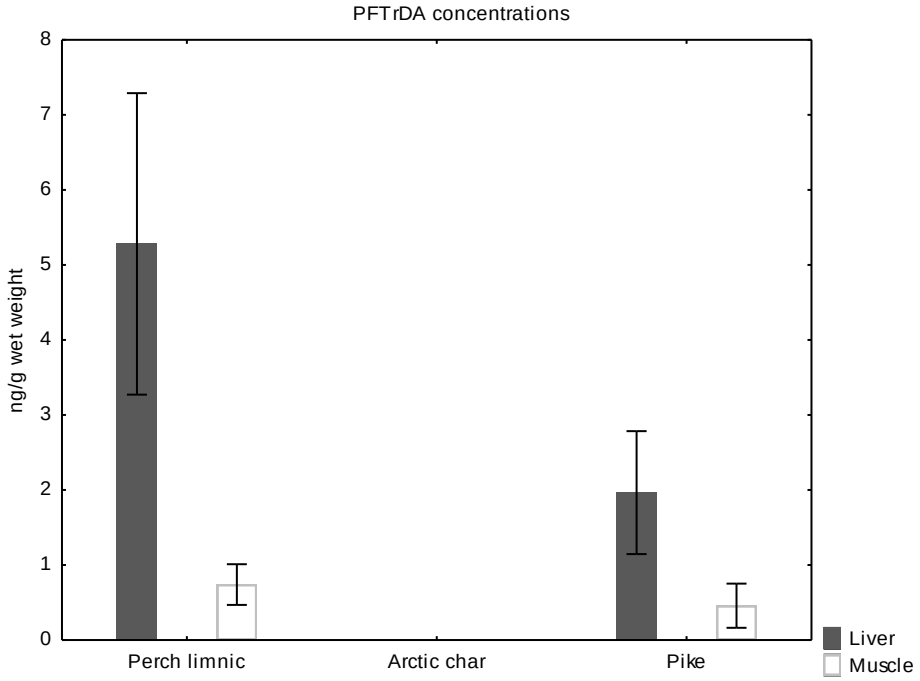

Figure 10. Mean PFTrDA (ng/g ww) concentrations (bars indicate 95% CI) in liver and muscle in perch, arctic char, and pike from the limnic environment. No bars are presented for arctic char because the majority of the muscle values were below LOQ. Perch and pike had significantly higher concentration in liver compared to muscle.

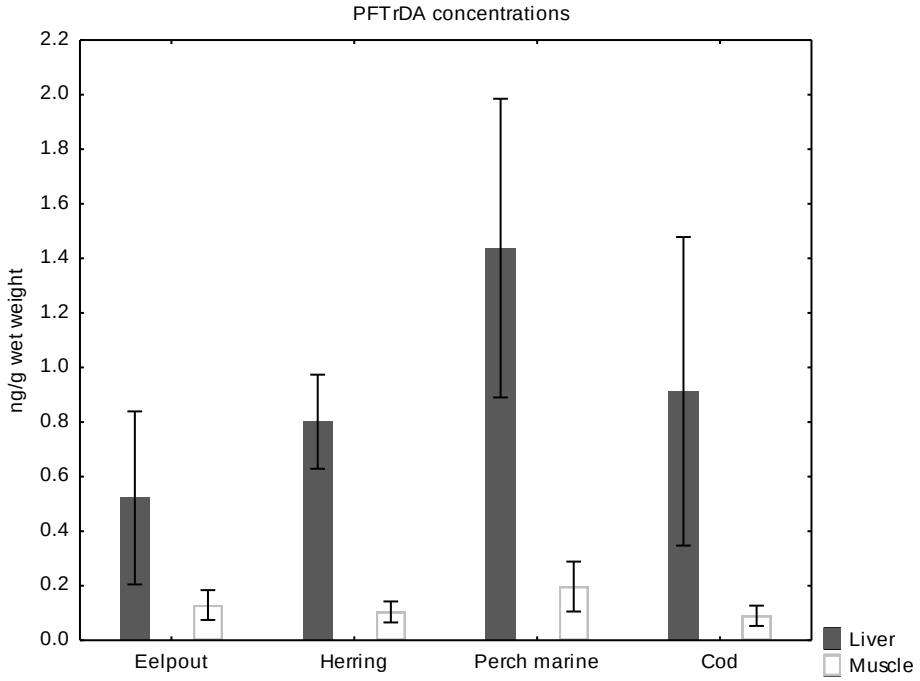

Figure 11. Mean PFTrDA (ng/g ww) concentrations (bars indicate 95% CI) in liver and muscle in eelpout, herring, perch and cod from the marine environment. All species had significantly higher concentration in liver compared to muscle.

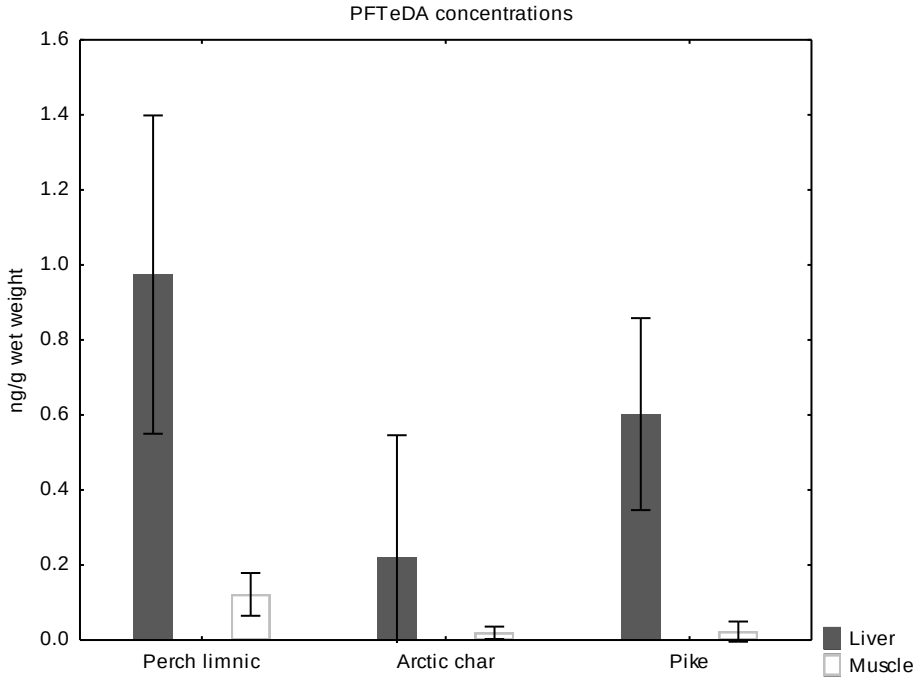

Figure 12. Mean PFTeDA (ng/g ww) concentrations (bars indicate 95% CI) in liver and muscle in perch, arctic char, and pike from the limnic environment. Perch and pike had significantly higher concentration in liver compared to muscle.

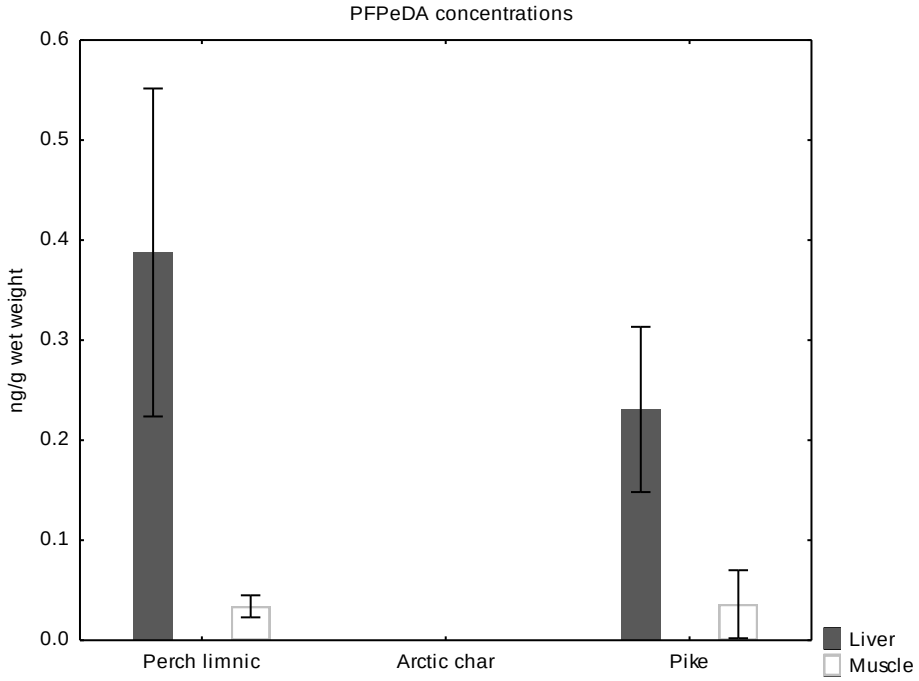

Figure 13. Mean PFPeDA (ng/g ww) concentrations (bars indicate 95% CI) in liver and muscle in perch and pike from the limnic environment. No bars are presented.for arctic char because the majority of the values in both liver and muscle were below LOQ. Perch and pike had significantly higher concentration in liver compared to muscle.

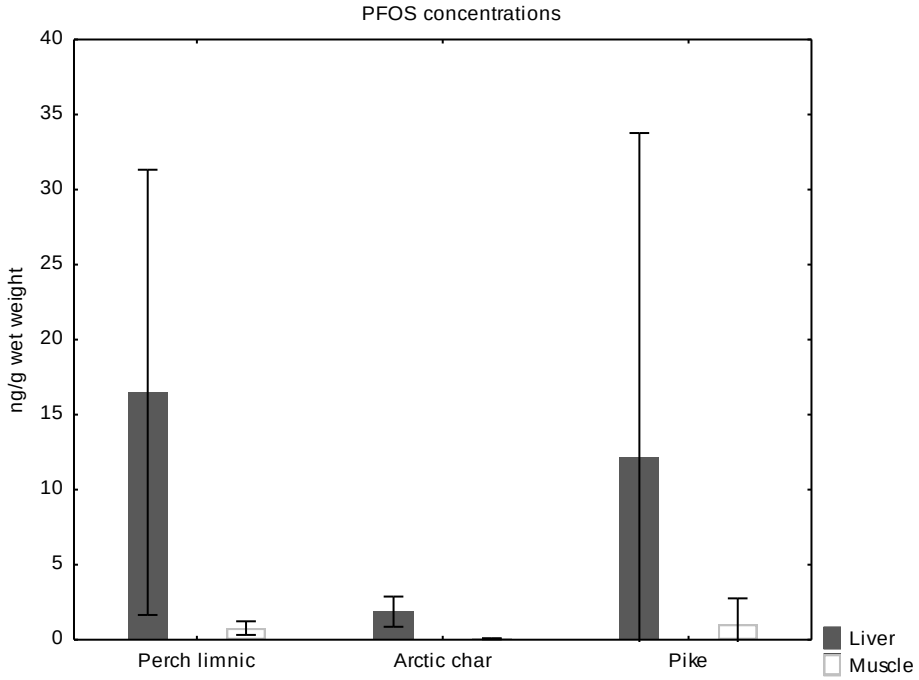

Figure 14. Mean PFOS (ng/g ww) concentrations (bars indicate 95% CI) in liver and muscle in perch, arctic char, and pike from the limnic environment. Perch and arctic char had significantly higher concentration in liver compared to muscle.

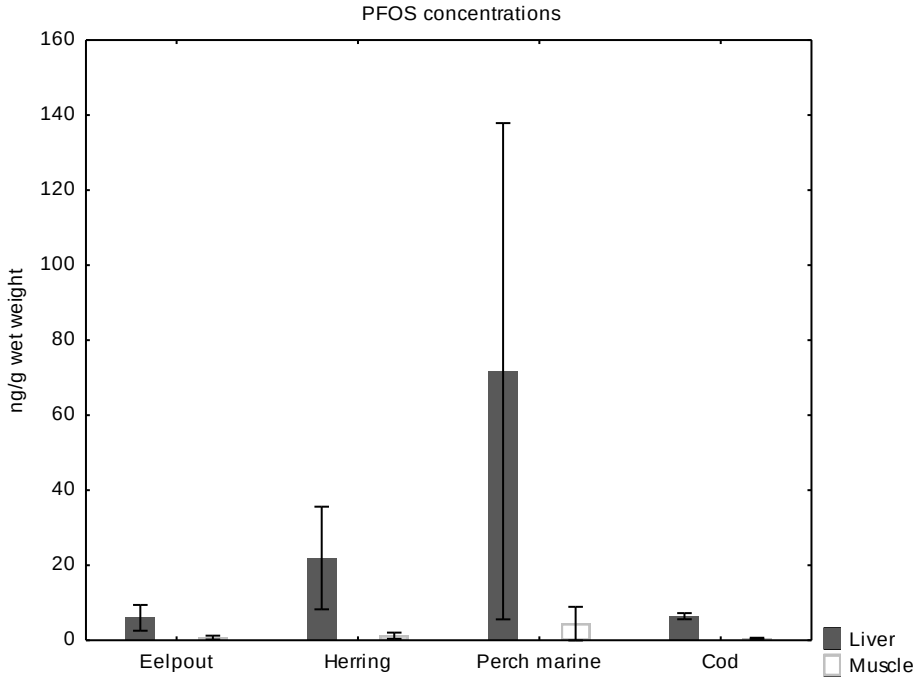

Figure 15. Mean PFOS (ng/g ww) concentrations (bars indicate 95% CI) in liver and muscle in eelpout, herring, perch and cod from the marine environment. All species had significantly higher concentration in liver compared to muscle.

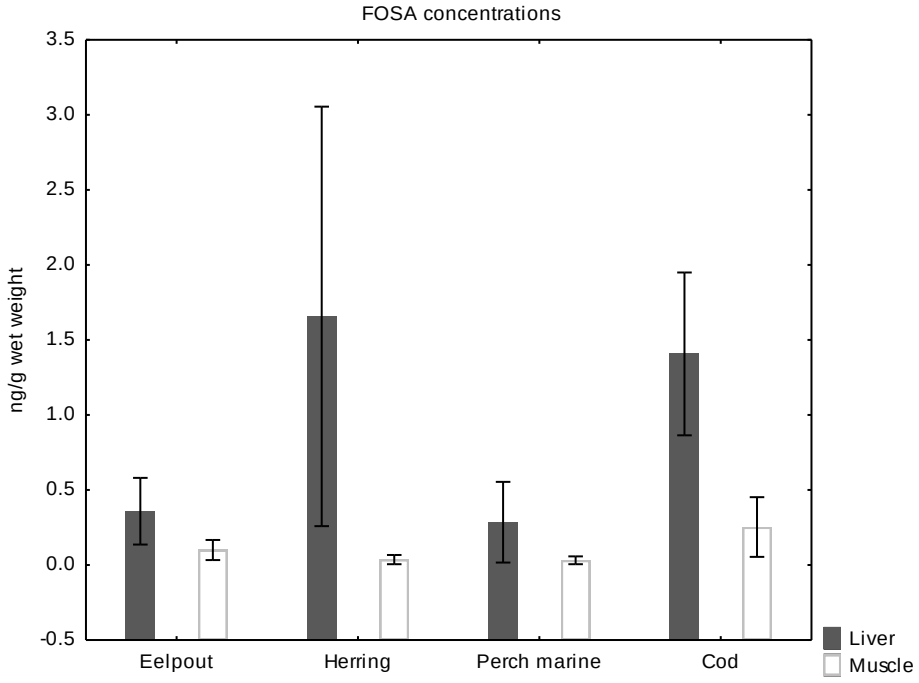

Figure 16. Mean FOSA (ng/g ww) concentrations (bars indicate 95% CI) in liver and muscle in eelpout, herring, perch and cod from the marine environment. All species had significantly higher concentration in liver compared to muscle.

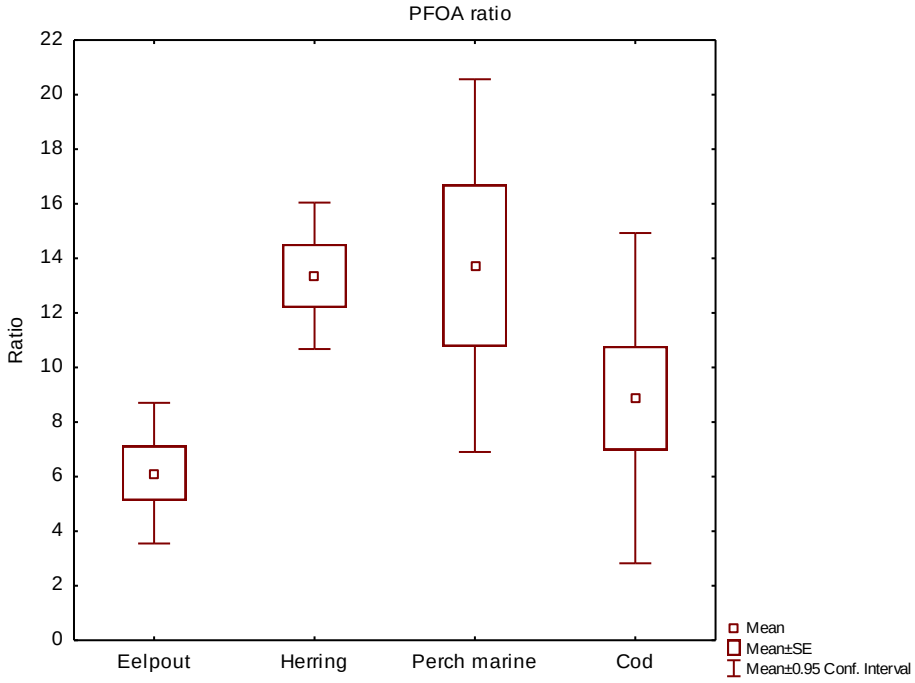

Figure 17. Liver:muscle ratio for PFOA. Eelpout was significantly lower compared to herring and perch marine.

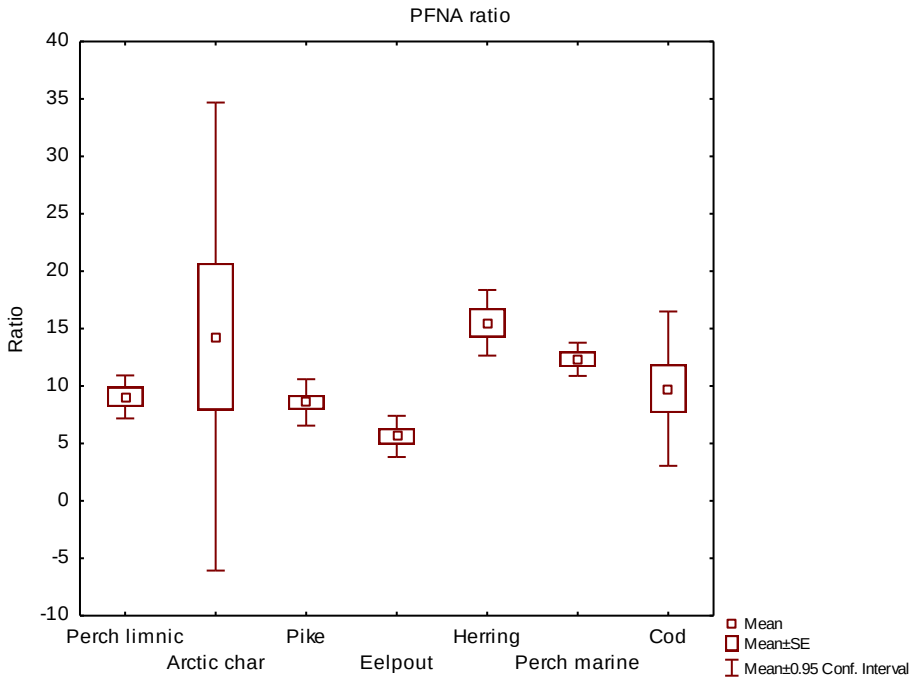

Figure 18. Liver:muscle ratio for PFNA. Perch limnic was significantly lower compared to herring and eelpout was significantly lower compared to perch marine and herring.

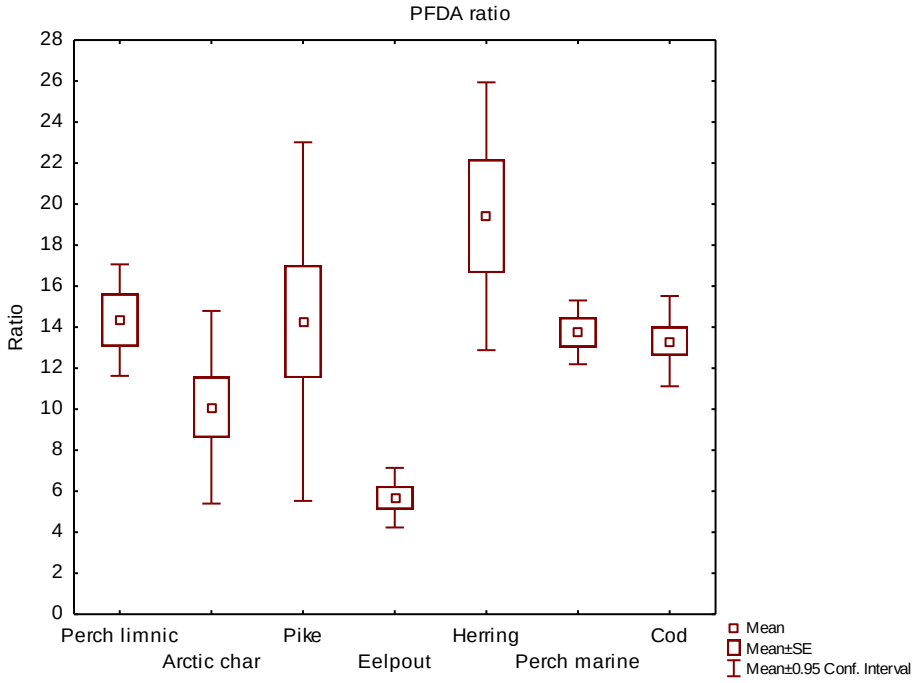

Figure 19. Liver:muscle ratio for PFDA. Eelpout was significantly lower than perch limnic, perch marine, and herring.

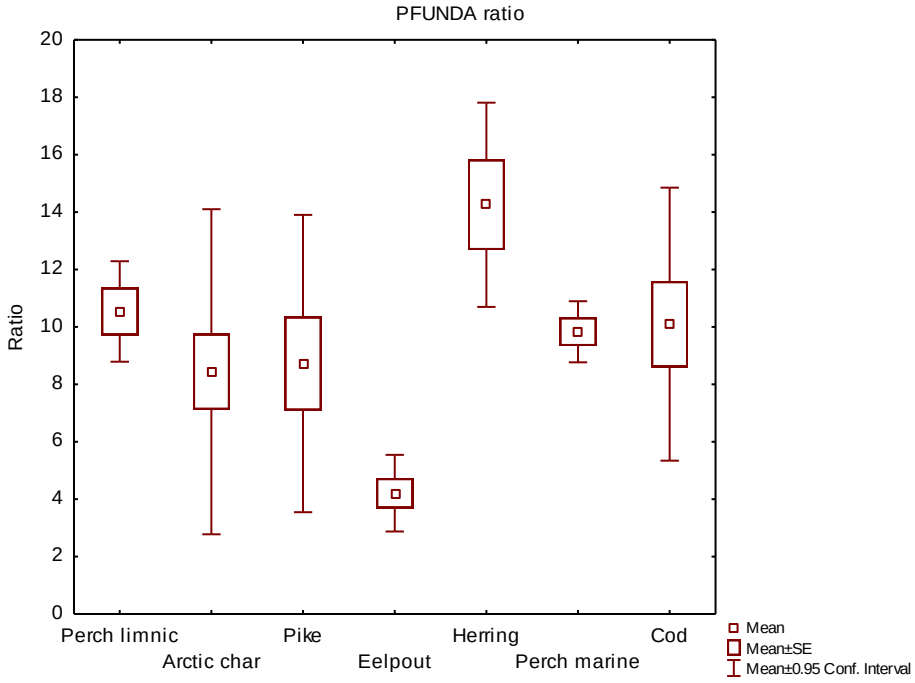

Figure 20. Liver:muscle ratio for PFUnDA. No significant difference between the species.

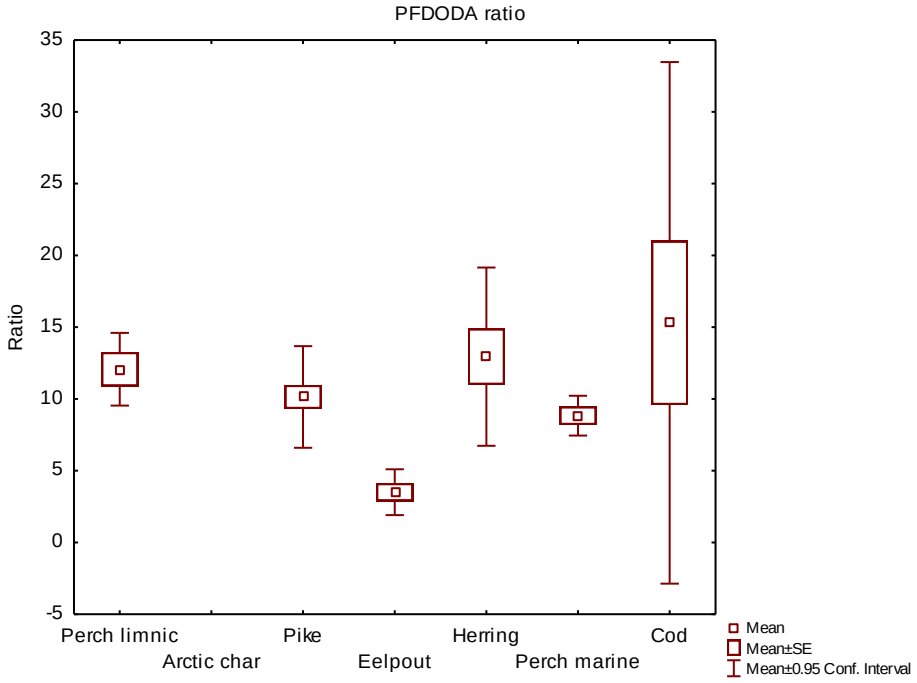

Figure 21. Liver:muscle ratio for PFDoDA. No significant difference between the species.

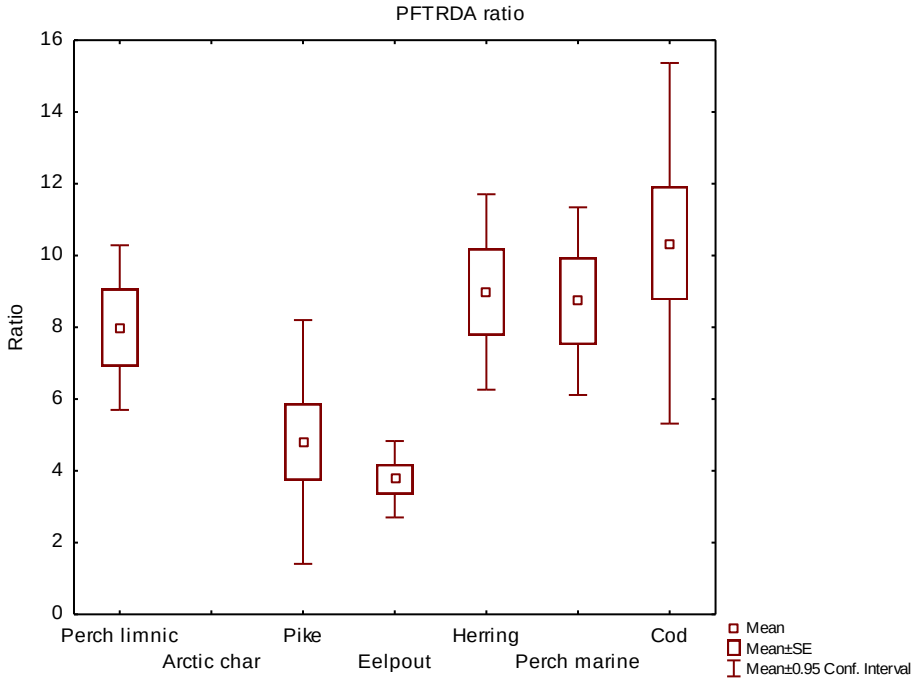

Figure 22. Liver:muscle ratio for PFTrDA. No significant difference between the species.

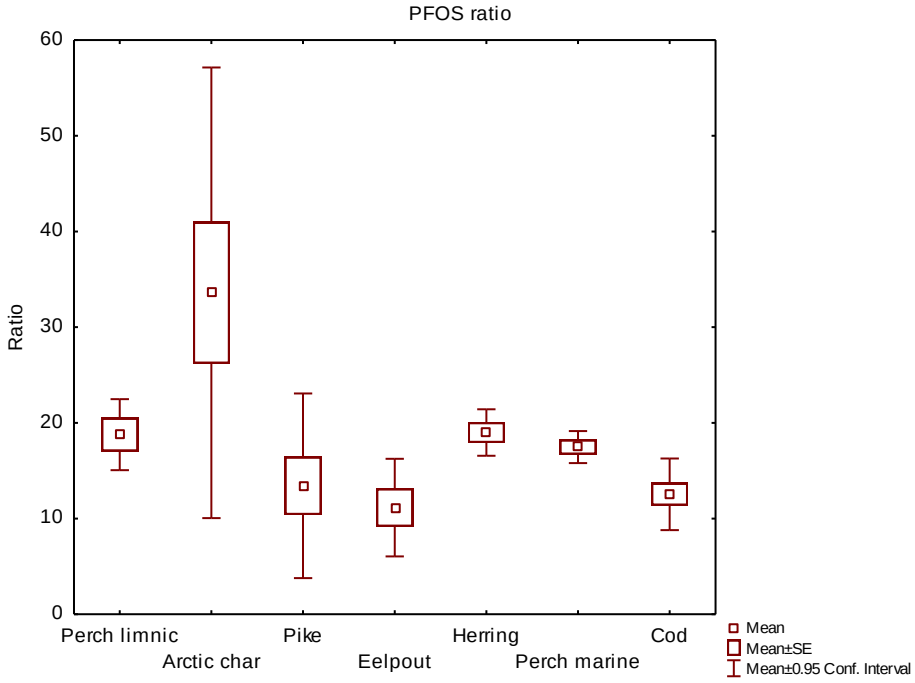

Figure23. Liver:muscle ratio for PFOS. No significant difference between the species.

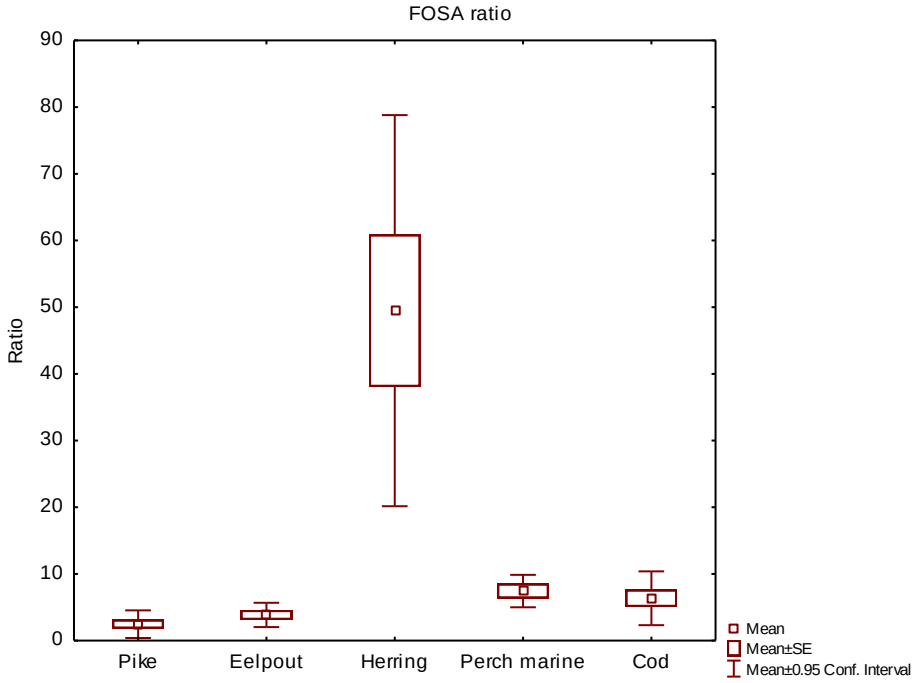

Figure 24. Liver:muscle ratio for FOSA. Herring was significantly higher compared to pike, eelpout, perch marine, and cod and perch marine was significantly higher compared to pike.