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Monitoring of environmental contaminants in freshwater food webs (MILFERSK) 2022

Photo: Morten Jartun

Norwegian Institute for Water Research

REPORT

Main Office	NIVA Region South	NIVA Region East	NIVA Region West	NIVA Denmark
Økernveien 94 NO-0579 Oslo. Norway Phone (47) 22 18 51 00	Jon Lilletuns vei 3 NO-4879 Grimstad. Norway Phone (47) 22 18 51 00	Sandvikaveien 59 NO-2312 Ottestad. Norway Phone (47) 22 18 51 00	Thormøhlensgate 53 D NO-5006 Bergen Norway Phone (47) 22 18 51 00	Njalsgade 76. 4th floor DK 2300 Copenhagen S. Denmark Phone (45) 39 17 97 33

Internet: www.niva.no

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Morten Jartun, Asle Økelsrud, Kine Bæk, Thomas Rundberget, Sigurd Øxnevad, Anders Ruus, Merete Grung (NIVA), Ellen Katrin Enge, Linda Hanssen, Mikael Harju (NILU), Ingar Johansen (IFE)	Environmental contaminants - freshwater	Open
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Summary

Samples of a benthic food chain in Lake Mjøsa have been collected, and the concentrations of emerging contaminants such as Siloxanes, PFAS, UV-compounds, Quaternary Ammonium Compounds, Musks, Benzothiazoles and Chlorinated paraffins in addition to legacy contaminants such as Mercury, other Metals and PBDEs have been determined. For comparison, samples of the top predator brown trout have been collected and analysed from Lake Femunden, a rural counterpart to the more urban Lake Mjøsa.

Four keywords	Fire emneord
1. Contaminants	1. Miljøgifter
2. Freshwater ecosystems	2. Ferskvann
3. Bioaccumulation	3. Bioakkumulering
4. Timetrends	4. Tidstrender

This report is quality assured in accordance with NIVA's quality system and approved by:

Morten Jartun	*Anders Ruus*	*Marianne Olsen*
Project Manager/Main Author	Quality Assurance	Research director

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Environmental contaminants in freshwater food webs, 2022

MILFERSK 2022

Preface

This report presents data from freshwater ecosystems in Lakes Mjøsa and Femunden (MILFERSK) in Innlandet, Norway. Studies of environmental contaminants in food webs of great Norwegian lakes date back several years, and the current monitoring program runs from 2021-2025 and will cover new insight in the environmental risk posed by local contaminant sources on both the pelagic and benthic food webs of Lake Mjøsa.

This year's sampling campaign was carried out by NIVA, with help from local sport anglers in Lake Mjøsa (Heidi Jøranli) and Lake Femunden (Øystein Trondsen). Chemical analyses were performed by NIVA, the Norwegian Institute for Air Research (NILU) and the Institute for Energy Technology (IFE).

This report represents an extended summary of the data provided through the MILFERSK 2022 campaign. Scientific quality assurance (QA/QC) have been performed throughout the different parts of the project by Kine Bæk, Anders Ruus and Merete Grung. Final approval of the report was given by research director Marianne Olsen.

Oslo. 22.06.2023

Morten Jartun
Project manager

Table of contents

Summary

In 2022, under the program "Monitoring of environmental contaminants in freshwater food webs (MILFERSK)" samples of sediment and biota were collected from Lake Mjøsa and Lake Femunden. Biological samples from Lake Mjøsa included representatives of a benthic food chain from the area outside the city of Hamar in addition to large brown trout from an area close to the city of Gjøvik. The benthic food chain contained samples of chironomid larvae, fish species *ruffe*, the stomach content (semi-digested) of the fish ruffe, in addition to the predator fish species perch and pike. From Lake Femunden, brown trout were caught from the central part of the lake.

From most of the sample types, a total of 185 single compounds/isomers were determined in the analytical program. The major compound groups included:

- Per- and polyfluorinated alkyl substances (PFAS)
- UV-compounds
- Brominated flame retardants (PBDEs)
- Siloxanes
- Benzothiazoles
- Musk compounds
- Chlorinated paraffins (CP)
- Quaternary ammonium compounds (QAC)
- Metals (incl. Hg)
- Metabolites of organic phosphorous flame retardants
- Phthalate metabolites

In 2022, the dominating contaminant groups in sediment were QAC, siloxanes and UV-compounds. We observe that the same contaminant groups dominate the lower trophic levels of the food chain, i.e. in Chironomid larvae and ruffe. Overall, in biota, the highest total concentrations of contaminants were unexpectedly found in the stomach content of ruffe, with siloxanes and QACs being the dominating contaminant groups in this sample type. In lower trophic levels, such as chironomids, ruffe and the stomach content of ruffe, siloxanes, QACs and partly CP dominate. PFAS is the dominating contaminant in perch and pike from Lake Mjøsa and in brown trout from Lake Femunden, whereas siloxanes and PBDEs are the dominating contaminant groups in brown trout from Lake Mjøsa, suggesting an urban impact of these two contaminant groups.

For contaminants with a minimum detection frequency of about 0.6 (60 %) throughout the food chain, a potential trophic magnification factor (TMF) has been calculated, with additional data from the same sample types in 2021 to strengthen the statistical model. A calculated TMF value > 1 indicates biomagnifying properties of the particular contaminant. TMF > 1 was observed in the benthic food chain for contaminants such as PFOS, PFUnDA, PFDoDA, PFTrDA, siloxane D5, mercury (Hg), PBDEs (BDE_6 represented by the most frequent congener BDE-47). Higher concentrations in lower trophic levels compared to predators, indicating metabolism or excretion, were found for contaminants such as QAC-compounds DADMAC-17, DADMAC-18 and ATAC-22 in addition to UV-compounds EHMC-Z and UV-327.

Lake Mjøsa experienced a large discharge of brominated flame retardants from local industry towards the end of 1990's resulting in rocketing concentrations of PBDEs in top predators in the years after.

Between 2000 and 2023 there is a significant decrease in BDE_6-concentrations in brown trout, although the concentrations still are way above the environmental quality standards (EQS biota) set by the Water Framework Directive. A downwards trend in brown trout concentrations in Lake Mjøsa has also been observed for PFOS and PFTrDA. These regressions are however weak, but significant.

Sammendrag

Tittel: Overvåking av miljøgifter i ferskvannsnæringsnett (MILFERSK) 2021 - 2025
År: 2023
Forfatter(e): Morten Jartun, Asle Økelsrud, Kine Bæk, Thomas Rundberget, Sigurd Øxnevad, Anders Ruus, Merete Grung (NIVA), Ellen Katrin Enge, Linda Hanssen, Mikael Harju (NILU), Ingar Johansen (IFE)
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Overvåkingsprogrammet «Overvåking av miljøgifter i ferskvannsnæringsnett (MILFERSK)» er inne i sitt andre rapporteringsår, og i 2022 ble det samlet inn prøver av sediment og biota fra Mjøsa og Femunden. Biologiske prøver fra Mjøsa inkluderer representanter fra en bentisk næringskjede fra området utenfor Hamar i tillegg til stor Mjøsørret fra et område nær Gjøvik. Den bentiske næringskjeden består av prøver av fjærmygglarver, fiskearten hork, mageinnholdet (halvfordøyd) funnet i hork, i tillegg til rovfiskartene abbor og gjedde. Fra innsjøen Femunden ble det fanget ørret fra den sentrale delen av innsjøen.

Fra de fleste prøvetypene ble innholdet av totalt 185 enkeltforbindelser/isomerer av miljøgifter bestemt i analyseprogrammet. Hovedgruppene av miljøgifter inkluderer:

- Per- og polyfluorerte alkylstoffer (PFAS)
- UV-forbindelser
- Bromerte flammehemmere (PBDE)
- Siloksaner
- Benzotiazoler
- Muskforbindelser
- Klorparafiner (CP)
- Kvaternære ammoniumforbindelser (QAC)
- Metaller (inkl. Hg)
- oPFR-metabolitter
- Ftalatmetabolitter

I 2022 var de dominerende forurensningsgruppene i sedimentet QAC, siloksaner og UV-forbindelser. Vi observerer at de samme forurensningsgruppene dominerer de lavere trofiske nivåene i næringskjeden, det vil si i fjærmygglarver og hork. Totalt sett i biota, ble de høyeste totale konsentrasjonene av forurensninger overraskende nok funnet i mageinnholdet til hork, med siloksaner og QAC som de dominerende forurensningsgruppene i denne prøvetypen. I lavere trofiske nivåer, som fjærmygglarver, hork og mageinnholdet av hork, dominerer siloksaner, QAC og delvis klorparafiner. PFAS er den dominerende miljøgiften i abbor og gjedde fra Mjøsa og i ørret fra Femunden, mens siloksaner og PBDE er de dominerende forurensningsgruppene i ørret fra Mjøsa, noe som tyder på en urban påvirkning for disse stoffgruppene.

For miljøgifter med en deteksjonsfrekvens på minst ca. 0,6 (60 %) gjennom hele næringskjeden, er det beregnet en trofisk magnifiseringsfaktor (TMF), med tilleggsdata fra de samme prøvetypene i 2021 for å styrke de statistiske modellene. En beregnet TMF-verdi > 1 indikerer biomagnifiserende egenskaper til den aktuelle komponenten. TMF > 1 ble observert i den bentiske næringskjeden for miljøgifter som

PFOS, PFUnDA, PFDoDA, PFTrDA, siloksanen D5, kvikksølv (Hg), PBDE-er (BDE_6 representert ved den hyppigste kongeneren BDE-47). Høyere konsentrasjoner i lavere trofiske nivåer sammenlignet med predatorer, noe som indikerer metabolisme eller utskillelse, ble funnet for miljøgiftene DADMAC-17, DADMAC-18 og ATAC-22 (QAC) i tillegg til UV-forbindelsene EHMC-Z og UV-327.

Mot slutten av 90-tallet fikk Mjøsa et stort utslipp av bromerte flammehemmere fra lokal industri, noe som resulterte i skyhøye konsentrasjoner av PBDEer i fisk fra Mjøsa i de kommende årene. Fra 2000 og 2023 er det en signifikant nedgang i BDE_6-konsentrasjoner i ørret, selv om konsentrasjonene fortsatt er langt over miljøkvalitetsstandardene (EQS) fastsatt av vanndirektivet. Det er også observert en nedadgående trend i konsentrasjoner av ørret i Mjøsa for PFOS og PFTrDA. Disse regresjonene er imidlertid svake, men signifikante.

A revision on the original report is made due to an analytical error on the siloxane compound L4.

1 Introduction

"Environmental contaminants in freshwater food webs (MILFERSK)" is a program designed to provide an early warning knowledge of potential harmful contaminants in Norwegian nature. This means that we need to monitor the presence and potential sources of contaminants in a lake with a high anthropogenic impact such as Lake Mjøsa, the largest lake in Norway. Our sampling program consists of key species from a benthic food chain caught in a geographically limited area outside the cities of Hamar and Gjøvik (Figure 1). For comparison, samples of the top predator brown trout (*Salmo trutta*) are also collected from a rural, large lake (Femunden) with close to no anthropogenic local sources of contaminants, see Figure 2. In 2022, the program focused on a specific area of Lake Mjøsa with potentially high urban impact. Sample types range from larvae of the group *Chironomidae* to the selected fish species **ruffe** (*Gymnocephalus cernua*), **perch** (*Perca fluviatilis*) and **pike** (*Esox Lucius*), all representing a typical benthic food chain in Lake Mjøsa. Biota samples in 2022 also include **brown trout** (*Salmo trutta*) from Lakes Mjøsa and Femunden, and the stomach content of ruffe in Lake Mjøsa. Sediment samples were also analyzed for the content of specific contaminant groups.

1.1 Locations

Figure 1 indicate the sampling locations for the benthic food chain and top predator brown trout in Lake Mjøsa. Chironomids were found only in limited amount in 2022 due to a long period of extremely low water level, lasting until the end of June, leaving our preferred catchment dry. Large specimen of perch and pike was also quite difficult to catch in this area this year, making it necessary to increase the preferred sampling area, shown in green. Detailed information is given in Table 1.

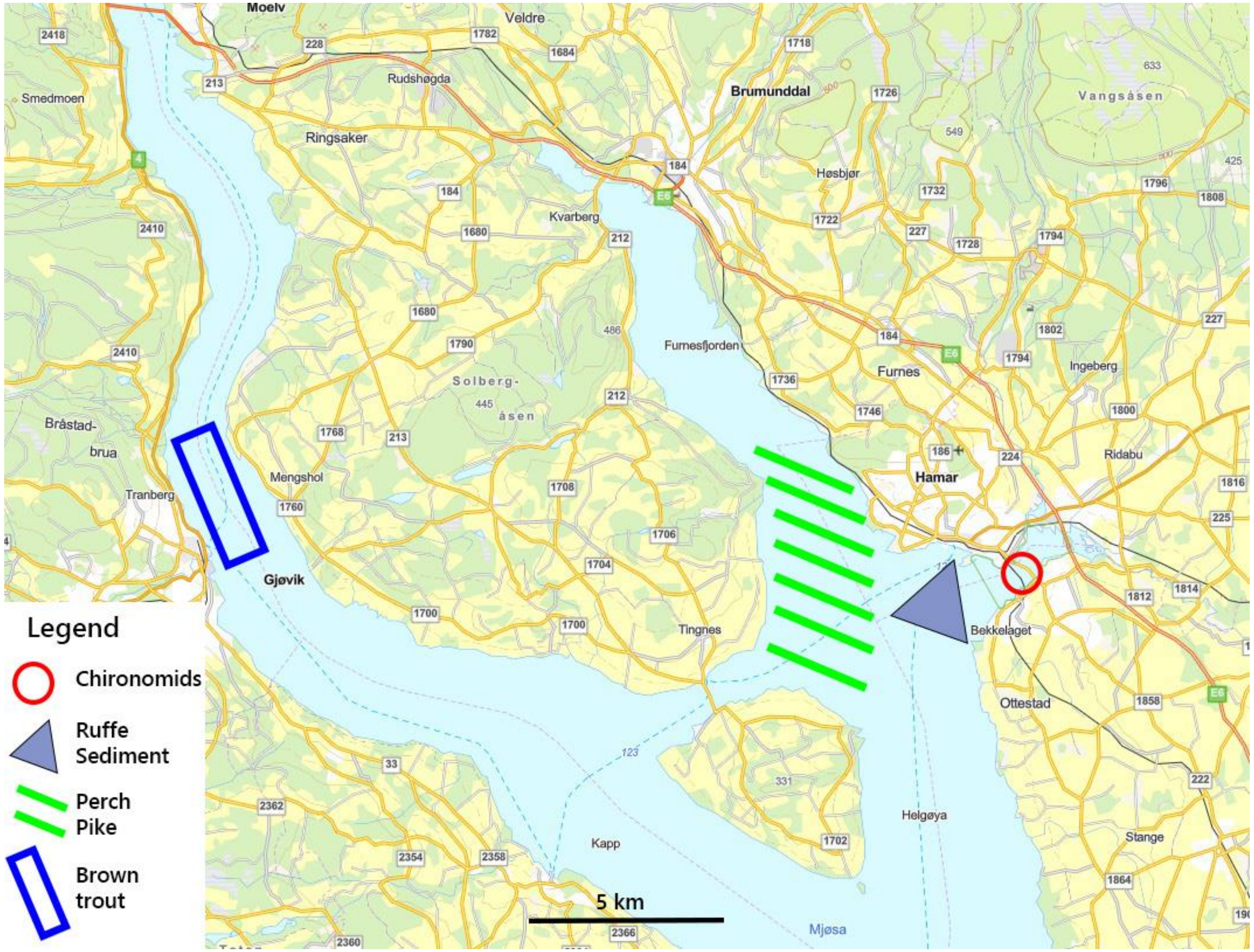


Figure 1. Sampling stations for the benthic food chain (sediment, Chironomids, ruffe, perch, pike) and brown trout in Lake Mjøsa, 2022.

Table 1. Key information on sampling locations and sample types.

Main category	Species/sample	Matrix	Locality	Station code	Depth	Coordinates UTM 33	No. for analysis
Abiotic samples	Sediment Surface water	Whole sediment Surface water	Pooled sample in transect, Mjøsa	S1	Sediment: 2 m Water: 0.3 m	N: 6744423 E: 285298	3
				S2	Sediment: 3 m Water: 0.3 m	N: 6745020 E: 285721	
				S3	Sediment: 5 m Water: 0.3 m	N: 6745472 E: 286262	
Biological samples	Chironomidae (larvae stage)	Whole body	Hamar – HIAS, Mjøsa	FM-H	1-3 m	N: 6744576 E: 286465	1
	Ruffe (*Gymnocephalus cernua*) Stomach content	Whole body	Hamar – HIAS, Mjøsa	HM-H	2-7 m	N: 6744393 E: 286107	6 pooled sample of 15 individuals 1 (stomach)
	Perch (*Perca fluviatilis*)	Muscle and liver	Hamarfjorden/Furnesfjorden, Mjøsa	AM-M/L	0-10 m	N: 6746826 E: 282362	6 pooled samples of 15 individuals
	Pike (*Esox Lucius*)	Muscle and liver	Hamarfjorden/Furnesfjorden, Mjøsa	GM-M/L	0-10 m	N: 6746826 E: 282362	6 pooled samples of 9 individuals
	Brown trout (*Salmo trutta*)	Muscle and liver	Gjøvik, Mjøsa	ØM-M/L	1-20 m	N: 6749999 E: 265299	15
	Brown trout (*Salmo trutta*) – **Pooled samples**	Muscle and liver	Gjøvik, Mjøsa	ØB-M/L	1-20 m	N: 6749999 E: 265299	3 pooled samples á 5 individuals
	Brown trout (*Salmo trutta*)	Muscle and liver	Femunden	ØF-M/L	1-20 m	N: 6890748 E: 332137	3 pooled samples of 15 individuals

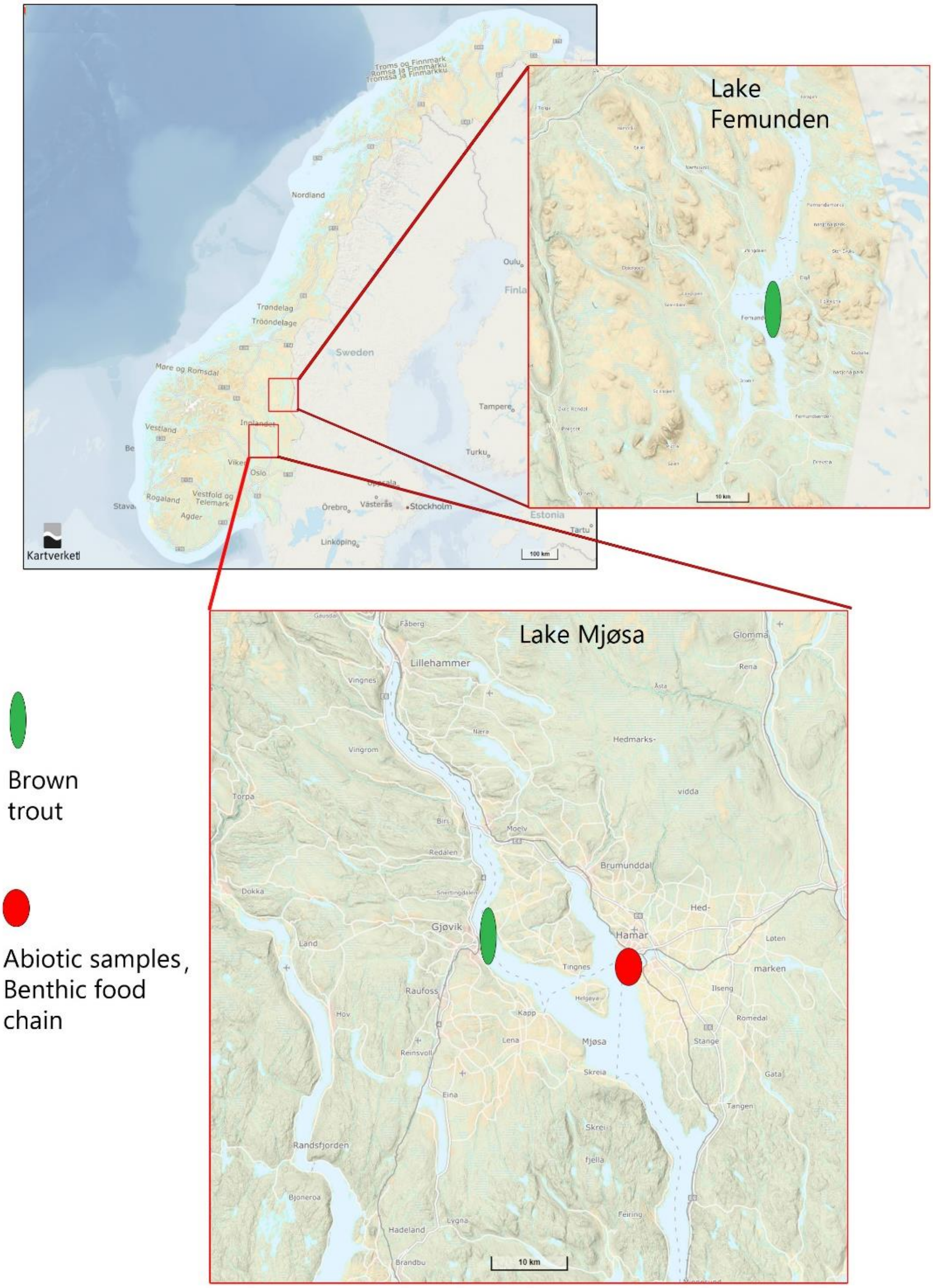


Figure 2. Map of both lakes in the study, Lake Mjøsa and Lake Femunden.

1.2 Sample types and matrixes

As the monitoring program in 2013-2021 focused on the pelagic food chain in Mjøsa[1], the sampling program in 2022 included species from a presumed benthic food chain, including sediment samples, the larvae stages of *Chironomidae,* the bottom dwelling fish species ruffe (*Gymnocephalus cernua*) and the predator species perch (*Perca fluviatilis*) and pike (*Esox Lucius*), see Figure 3. In addition, large pelagic specimen of brown trout (*Salmo trutta*) from Lakes Mjøsa and Femunden were caught.

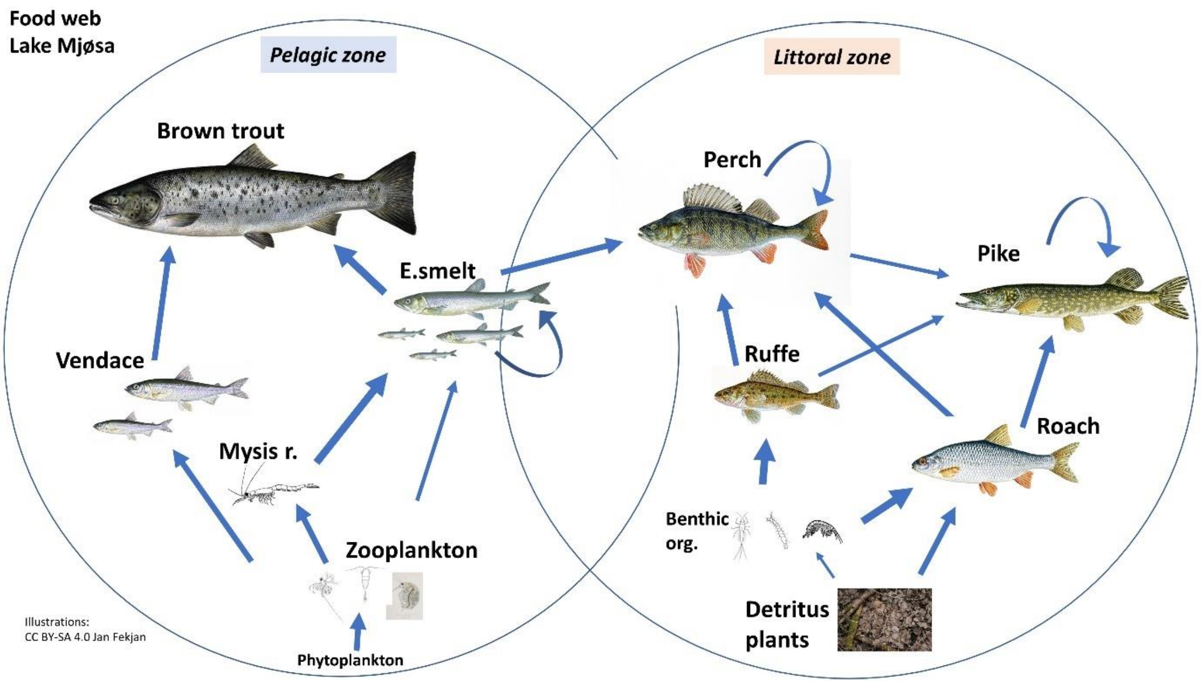


Figure 3. Examples of interconnected food chains (pelagic and benthic) studied in MILFERSK 2022.

1.3 Samples and analytical program

Table 2 shows an overview of the analytical program with main compound groups, sample types and number of analyses, divided between the NILU and NIVA laboratories in 2022.

[1] Jartun et al., 2021. Monitoring of environmental contaminants in freshwater ecosystems 2020 – Occurrence and biomagnification, NIVA-report 7653-2021.

Table 2. Analytical program for the 2022 sampling program

	Parameters	Sediment	Chironomids[1,2]	Ruffe	Perch[2]	Pike[2]	Brown trout. Mjøsa[2]	Brown trout. Femunden[2]	Brown trout (BT) pooled samples. Mjøsa[2]	N analyses
NILU	Mercury (Hg)	3	2	6	6	6	15	3	3	44
	Metals	3	2							5
	Rare earth metals	3	2							5
	Siloxanes	3	2	6	6	6	15	3	3	44
	PBDEs	3	2	6	6	6	15	3	3	44
	Chlorinated paraffins (CP)	3	2	6	6	6	15	3	3	44
	Musk	3	2	6	6	6				23
	Metabolites of 1) oPFR and 2) phtalates					6	15	3		24
	LCCP					6	15	3		24
NIVA	PFAS	3								3
	REDUCED PFAS (biota). excl. Short-chained PFCAs		2	6	6	6	15	3	3	41
	UV-compounds	3	2	6	6	6	15	3	3	44
	Benzothiazoles	3								3
	Quaternary Ammonium Compounds (QAC)	3	2	6	6	6				23
IFE	Isotopes ($\delta^{13}C$. $\delta^{15}N$)		4	15	15	9	15	15	3	76

[1] Only one sample of Chironomids, because of low population density in 2022. In addition: one sample of stomach content of ruffe.
[2] Chironomids, ruffe, and ruffe stomach: whole body samples. For fish: samples of muscle and liver.

2 Main findings

2.1 Stable isotopes

Stable isotopes of carbon and nitrogen are useful indicators of food origin and trophic levels, $\delta^{13}C$ provides an indication of carbon source in the diet or a food web. $\delta^{15}N$ increases in organisms with higher trophic level because of a greater retention of the heavier isotope (^{15}N) and provides a continuous descriptor of trophic position, see Figure 4 and Figure 5. The results of stable isotopes in individual biota samples are given in the Appendix (Table 21). Note that there are more determinations of stable isotopes (individual fish samples) than chemical analyses in this study, to establish the properties and trophic levels of the benthic food chain in Lake Mjøsa (see metadata in Appendix, Table 21).

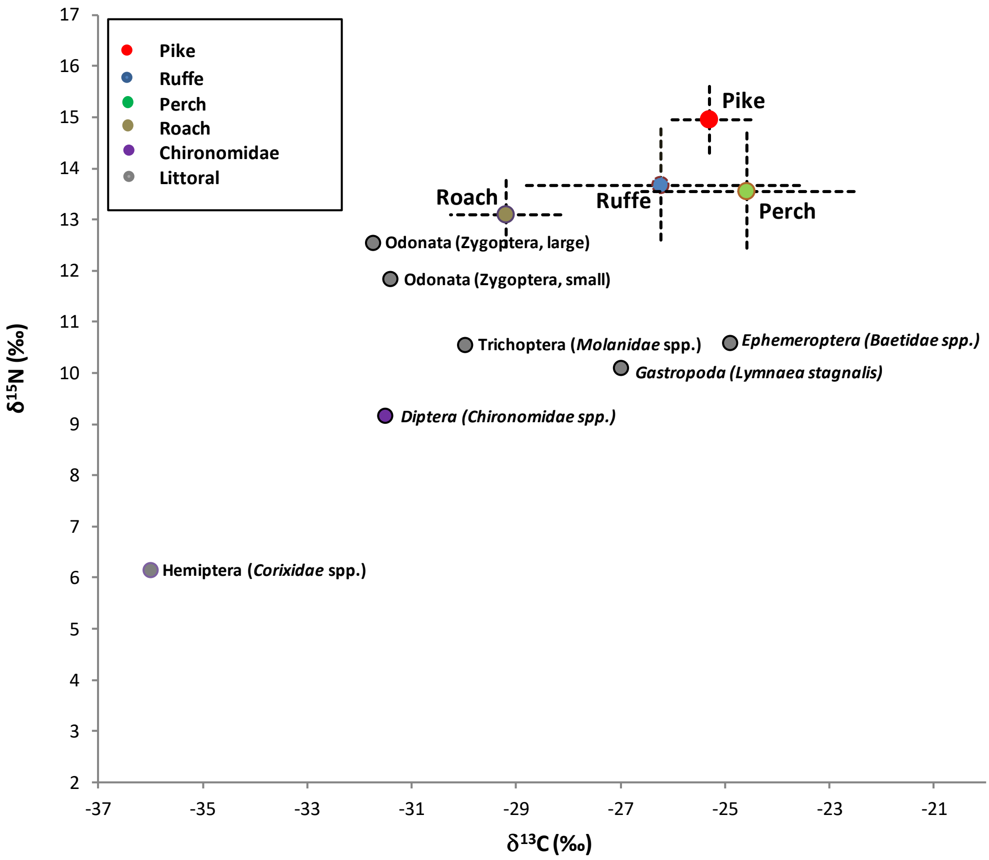


Figure 4. Isotope signatures from the benthic food chain caught in Lake Mjøsa 2022 (colored markers) compared to signatures from additional invertebrates found in the same area (grey markers, not included in chemical analyses in this study).

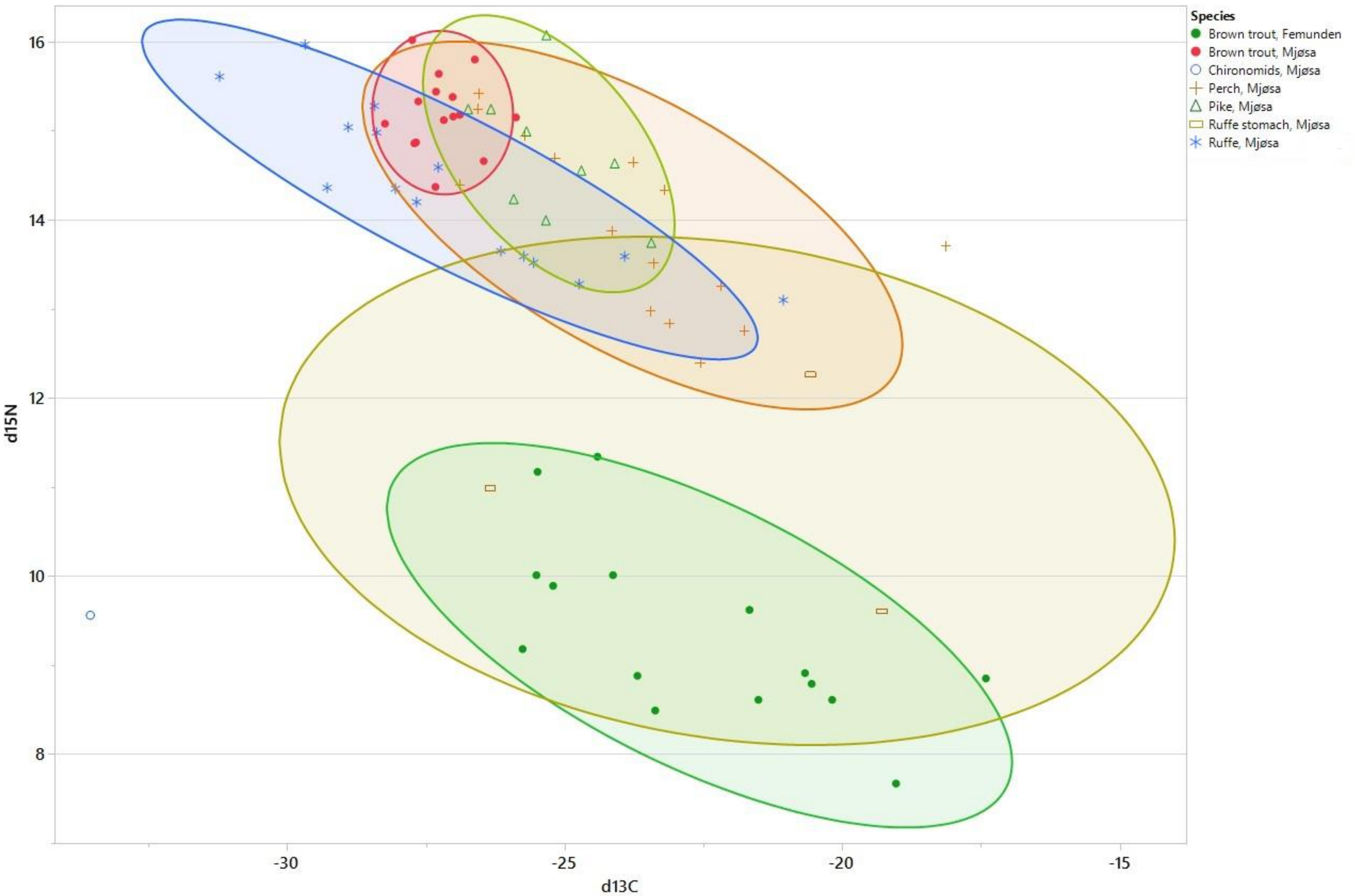


Figure 5. $\delta^{15}N$ plotted against $\delta^{13}C$ in individual samples of fish and Chironomids in 2022 from Lake Mjøsa. Brown trout was the only species from Lake Femunden. 90% confidence areas are indicated.

2.2 Detection frequency of individual compounds

A total of 185 single compounds/isomers were determined in 9 different sample types in this study. Figure 6 gives the detection frequency of the various individual compounds from each of the main contaminant groups in the different samples. Detection frequency is calculated as a fraction of the total positive detection of all compounds in the different species/matrices in this study, indicated by a number from 0 – 1 and a colored scale from blue (0 detections) to red (100 % detection for the given sample type). Grey cells (-1): not analyzed.

Figure 6 is divided into three tables:

A: UV-compounds, siloxanes, phthalate metabolites, oPFR-metabolites, PBDEs and musk.
B: Quaternary ammonium compounds (QAC), metals and Hg.
C: PFAS, chlorinated paraffins (CP) and benzothiazoles.

Generally, UV compound octocrylene (OC) is detected in all biota from Mjøsa, but not in sediment nor brown trout from Femunden. Detections of PFAS are dominated by PFOS, PFOSA, PFBSA and long-chained PFCAs. For CP, LCCP was detected in all analyzed samples (pike and brown trout). Some QAC compounds were detected in sediment and chironomids, but to a lesser degree in fish on a higher trophic level. The only musk compound detected above LOQ was galaxolide, found in ruffe and pike. oPFR-metabolites HDEHP, HDBP and DPP was found in brown trout liver in both Lakes Mjøsa and Femunden.

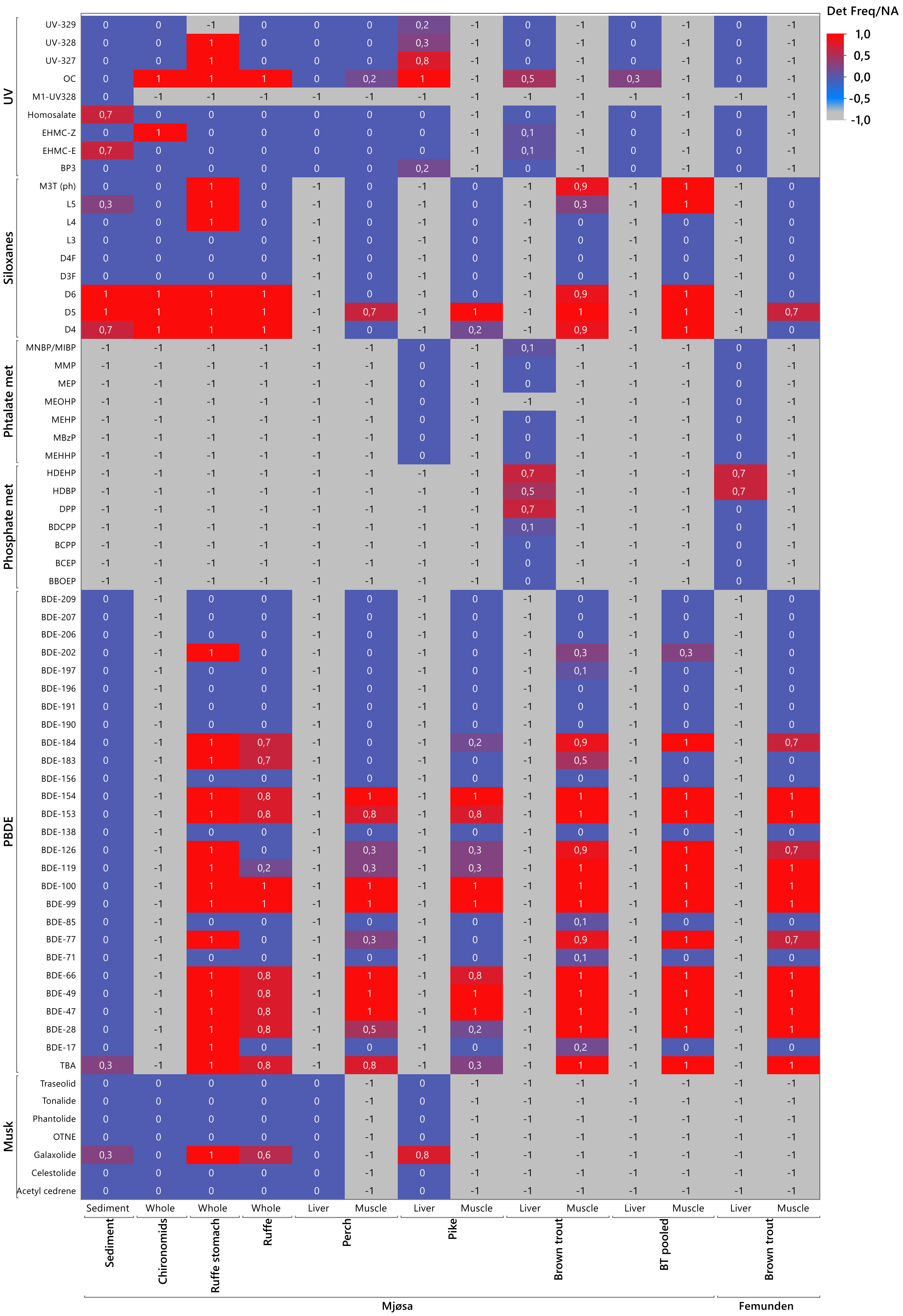


Figure 6. A. Detection frequencies of UV-compounds, siloxanes, metabolites, PBDEs and musk.

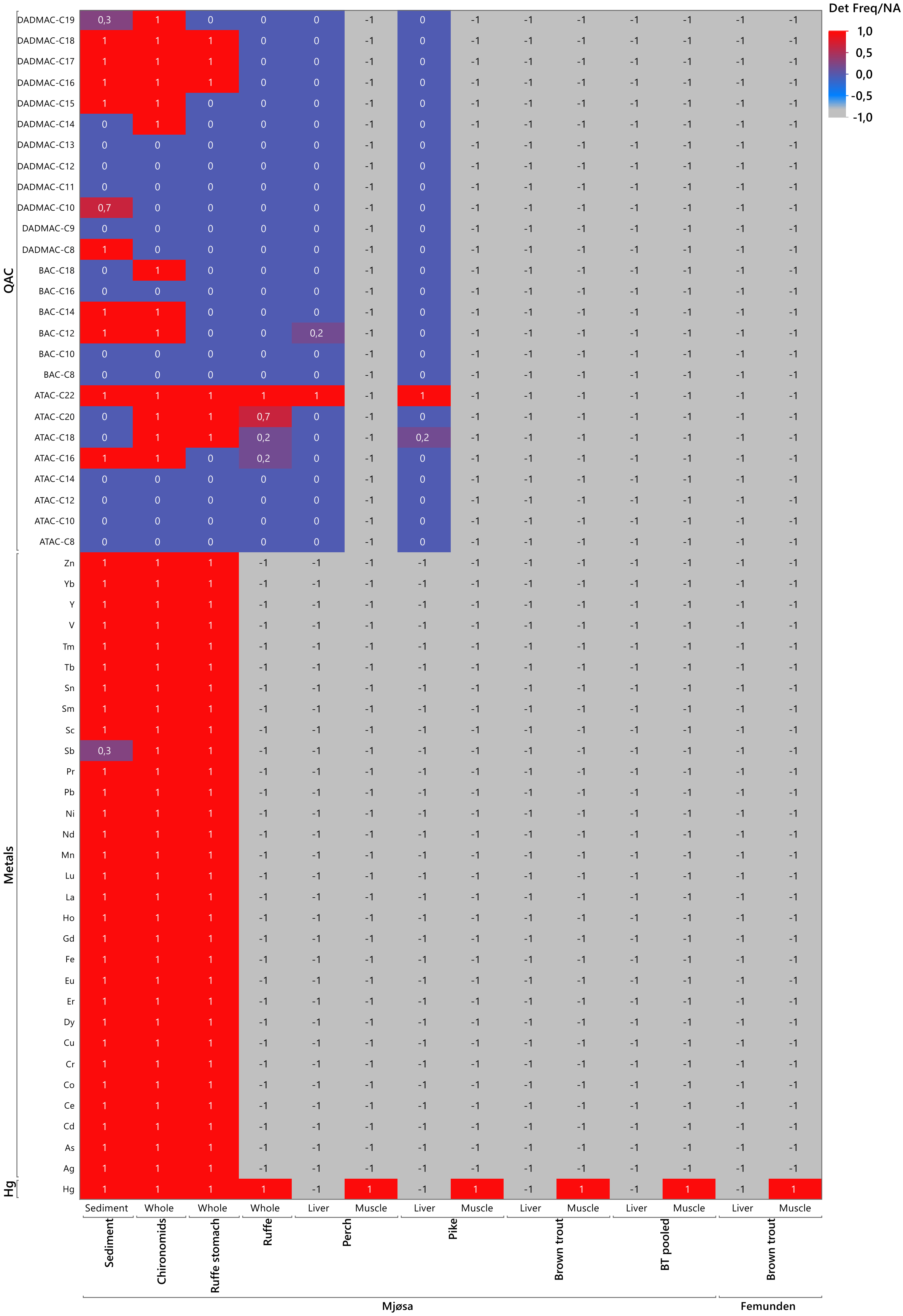


Figure 6. B. Detection frequencies of QAC, Metals and Hg.

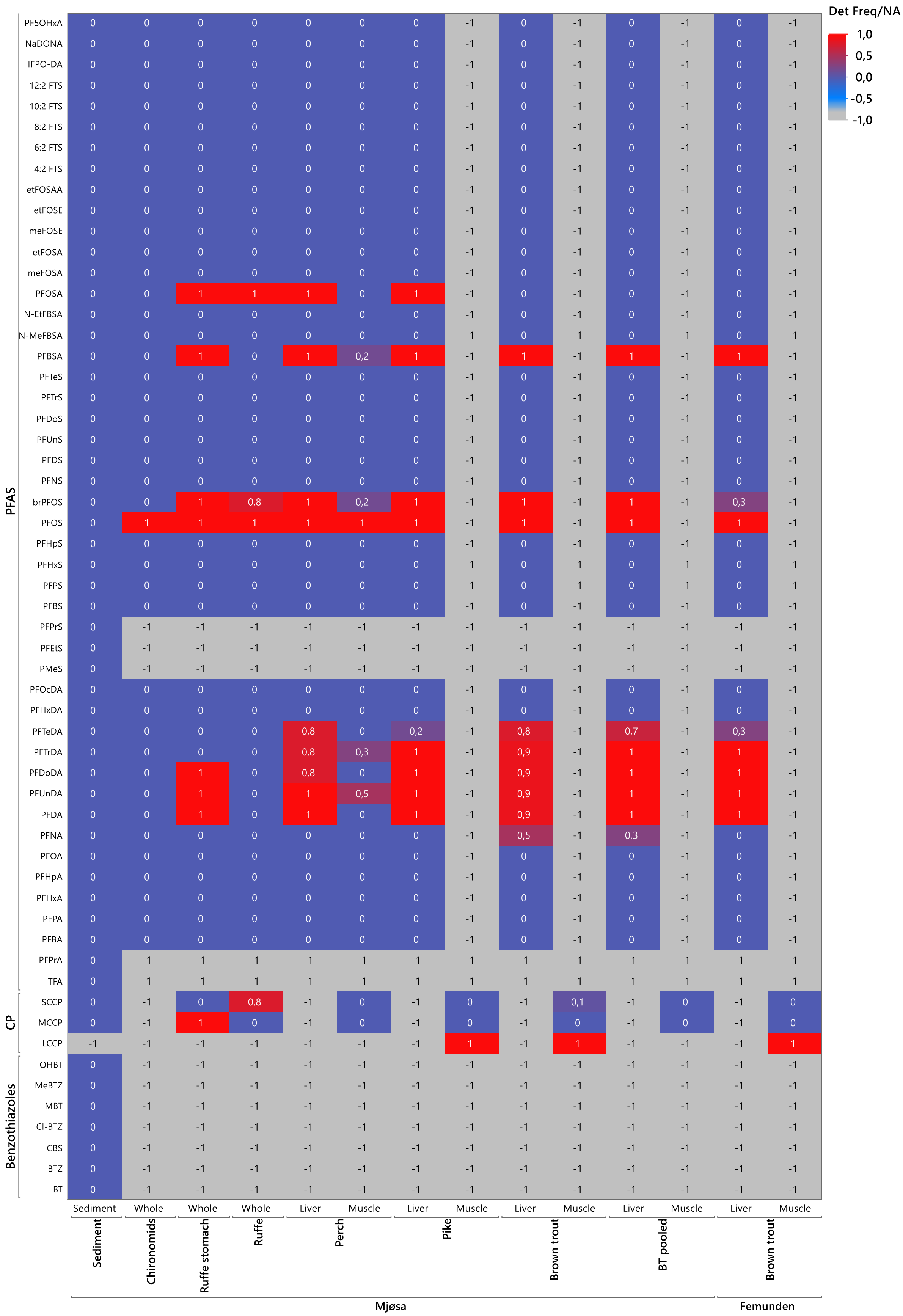


Figure 6. C. Detection frequencies of PFAS, chlorinated paraffins (CP) and Benzothiazoles.

2.3 Overview of main results

Major overview of the results is presented in Figure 7 (concentrations in analysed samples) and Figure 8 (percentage of contaminant groups). In these two figures, metals have been removed from the calculation because they dominate the total content by several orders of magnitude compared to the other contaminant groups. Concentrations of the compounds/compound groups are shown for all matrices, and their contribution (in %) to the sum concentration of all these compounds/compound groups.

Focusing on biota, in Figure 7 and Figure 8, QAC and siloxanes are the dominating contaminants within the lower trophic levels (chironomids, stomach content and ruffe). For the top predator representatives of the benthic food chain, PFAS is dominating in perch, whereas chlorinated paraffins are the dominating compound group in pike in addition to PFAS. In the pelagic top predator brown trout in Lake Mjøsa, PBDEs and siloxanes are dominating, as these two compound groups also tend to biomagnify in the pelagic food chain. In brown trout from rural Lake Femunden, long-chained PFAS (e.g. PFUnDa and PFTrDA) are dominating.

Cyclic D5 is the dominating contaminant in the siloxane group, found in stomach content of ruffe and in the top predator brown trout in Lake Mjøsa, with concentrations 100 times above what is found in brown trout from Lake Femunden. We also observe unexpected concentrations of the linear siloxane L4 (comparable to D5 and higher than D4 and D6) in some matrices such as stomach content and brown trout. L4 has not been detected in considerable frequency in freshwater fish[2]. Note that the quantification is uncertain because of the lack of internal standards for L4 in this study.

Chlorinated paraffins is a contaminant group of some concern, as they are extensively used in common products, e.g., as plastic additives. This makes field and lab blanks sensitive to contamination, which is scarcely avoided. In this study, SCCP, MCCP and LCCP is detected independently in different sample types. Results suggest that SCCP and MCCP were detected in lower trophic levels. LCCP was only included in analysis of the top predators pike and brown trout, but was detected in rather high frequency. It is important to note that all CPs fall under uncertainty category 3 in this study, in terms of precision and accuracy for the quantification.

In sediment (Figure 9), non-biomagnifying compound groups UV-filters and quaternary ammonium compounds (QAC) are dominating together with siloxanes. Metals have been removed from this figure, see 2.11.

Graphs indicating concentration ranges and congener patterns for individual contaminant groups are given in subchapters.

[2] Wang et al., 2021. Tissue-specific distribution and bioaccumulation of cyclic and linear siloxanes in South Korean crucian carp (*Carassius carassius*). Env Poll 288.

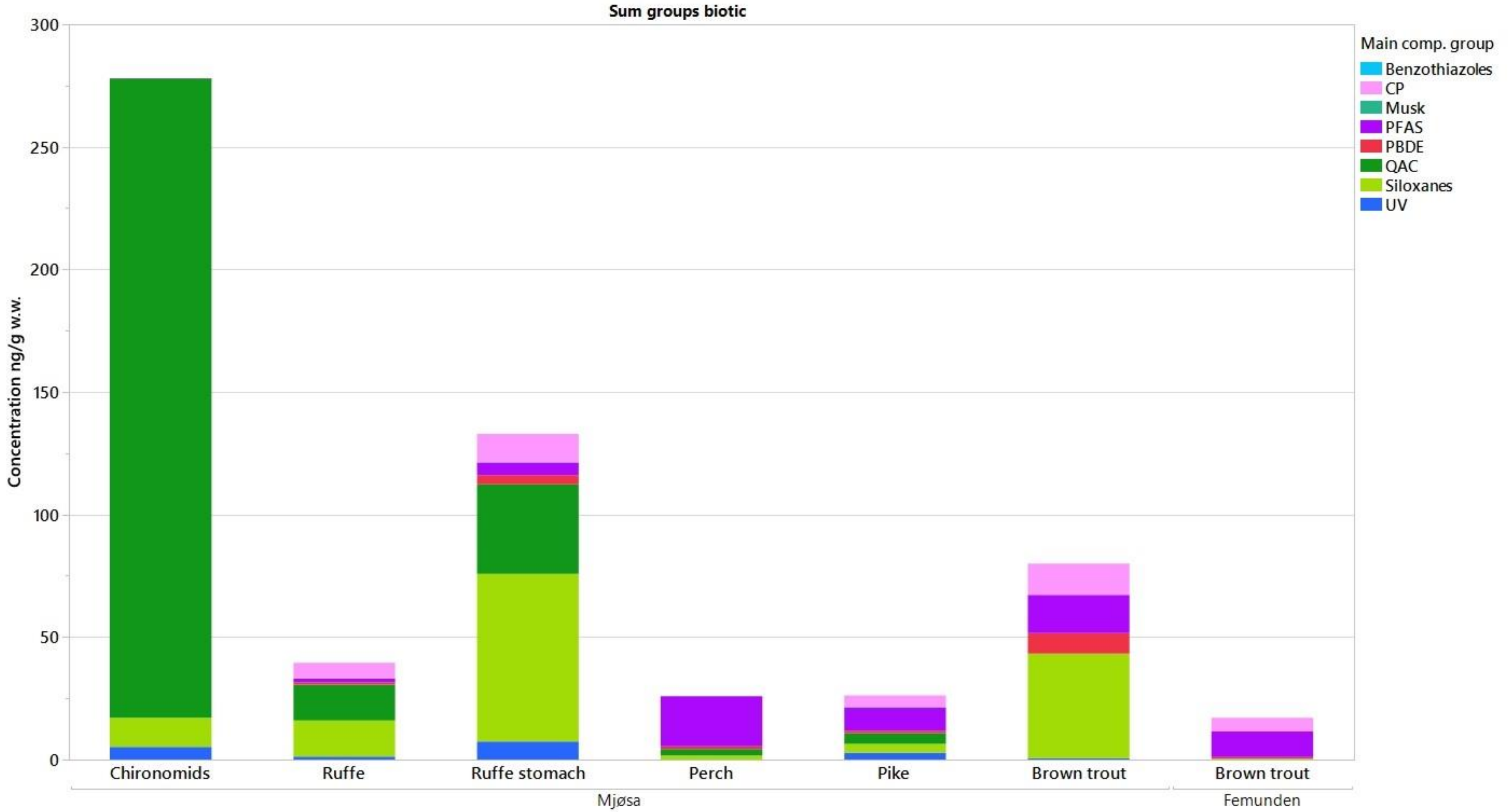


Figure 7. Mean concentration per sample of main contaminant groups in all biotic matrices. Concentrations are in ng/g w.w. for all sample types. Non-detected concentrations are assigned a value of zero (0). See Table 2 for analytical program. Metals have been removed from this overview, see chapter 2.10 and 2.11.

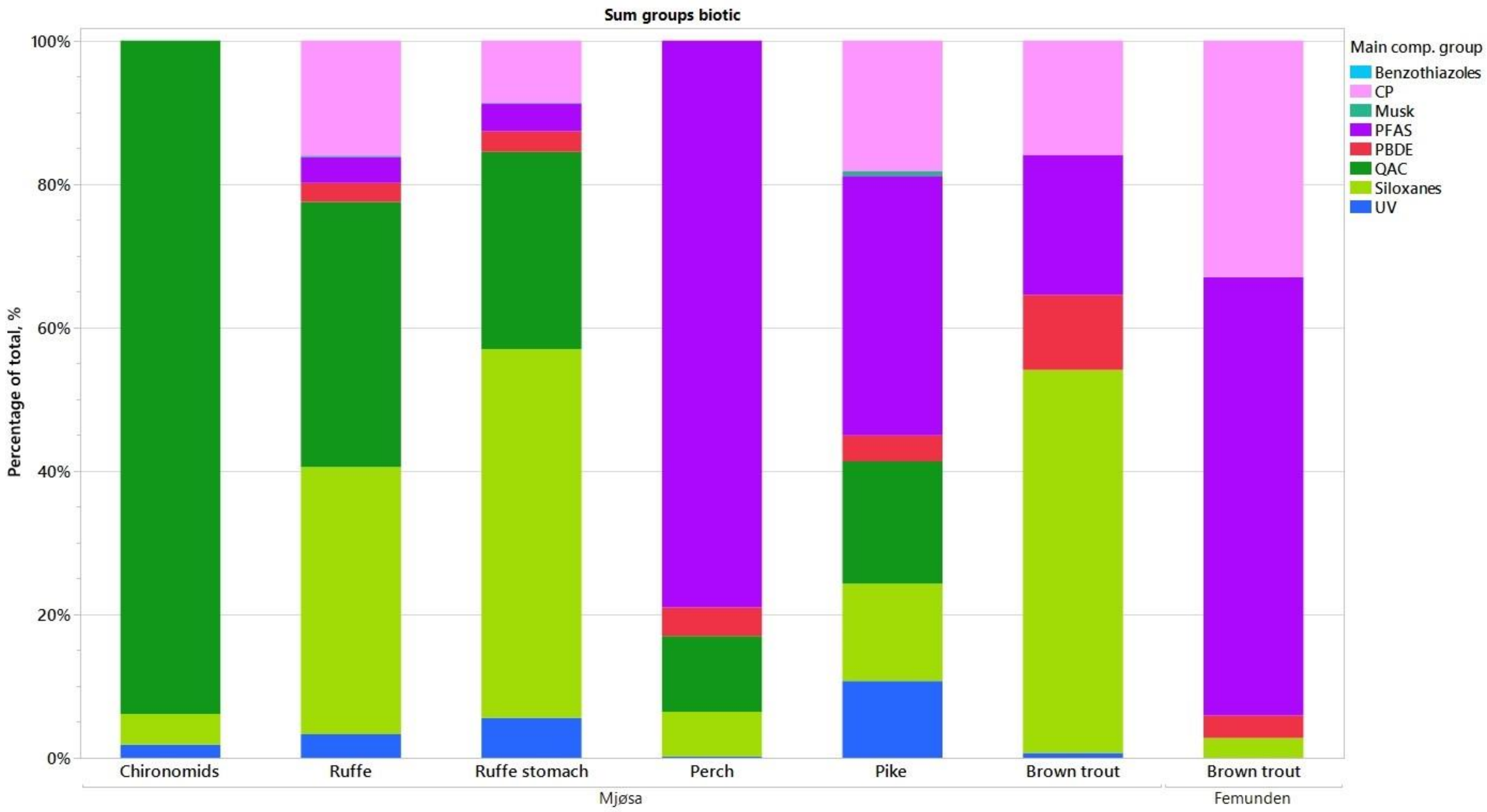
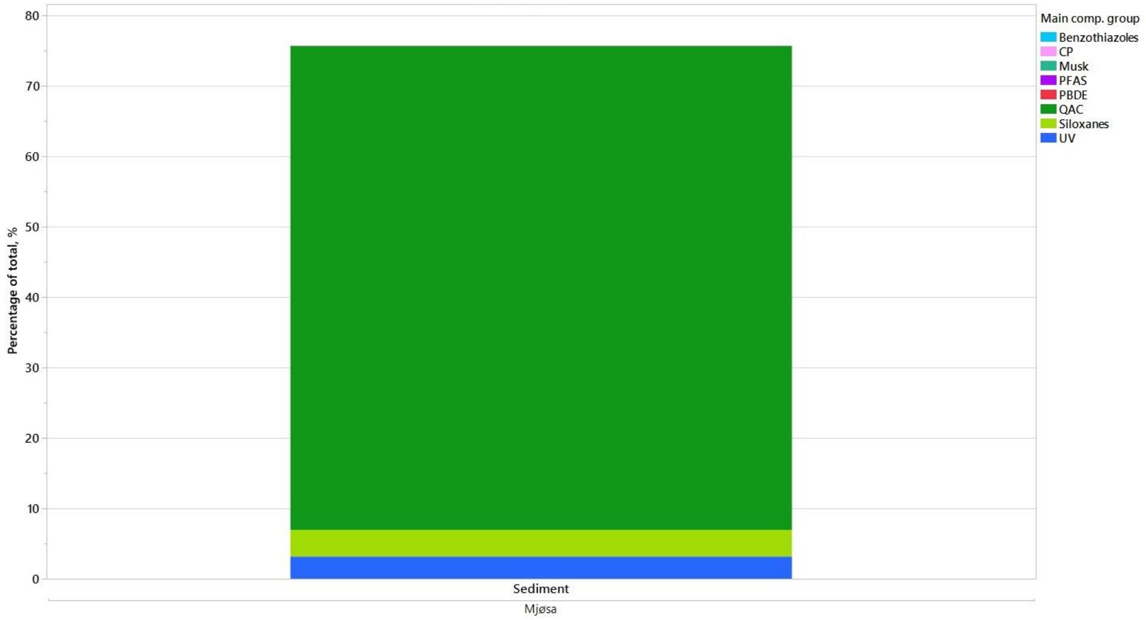


Figure 8. Percentage contribution of main contaminant groups to the sum in all biotic matrices, including whole body samples of chironomids (non-biting midges, larvae), homogenized samples of the stomach content in ruffe, whole body of ruffe, as well as muscle and liver in perch, pike and brown trout from Lake Mjøsa, and muscle + liver in brown trout from Lake Femunden. Non-detected concentrations are assigned a value of zero (0). See Table 2 for analytical program. Metals have been removed from this overview, see chapter 2.10 and 2.11.



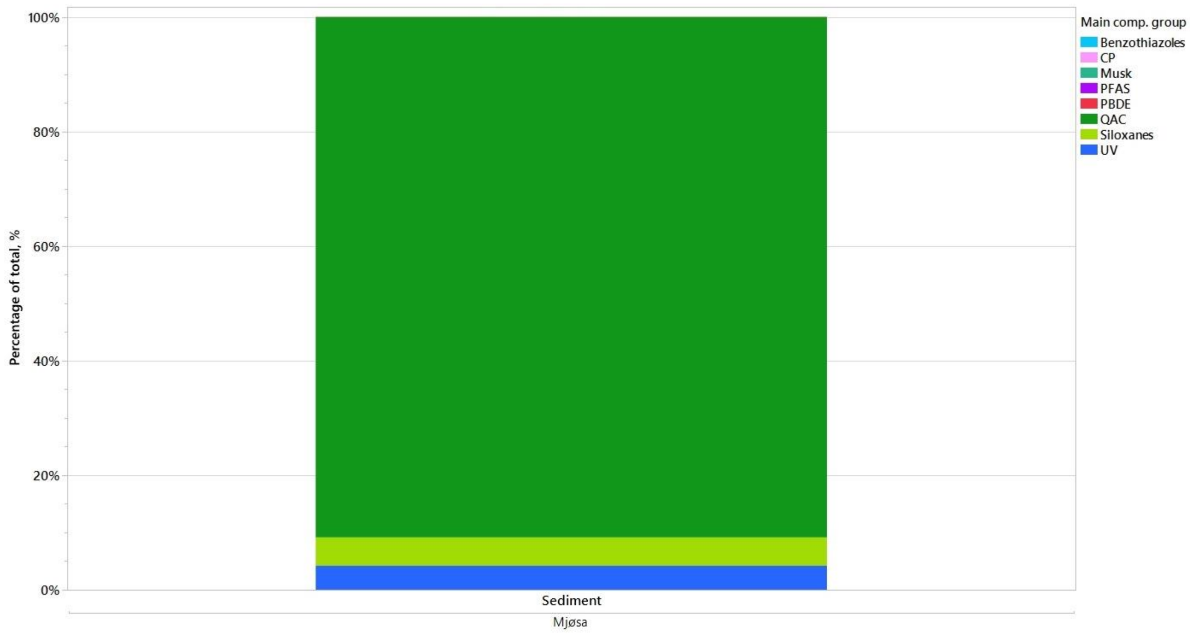
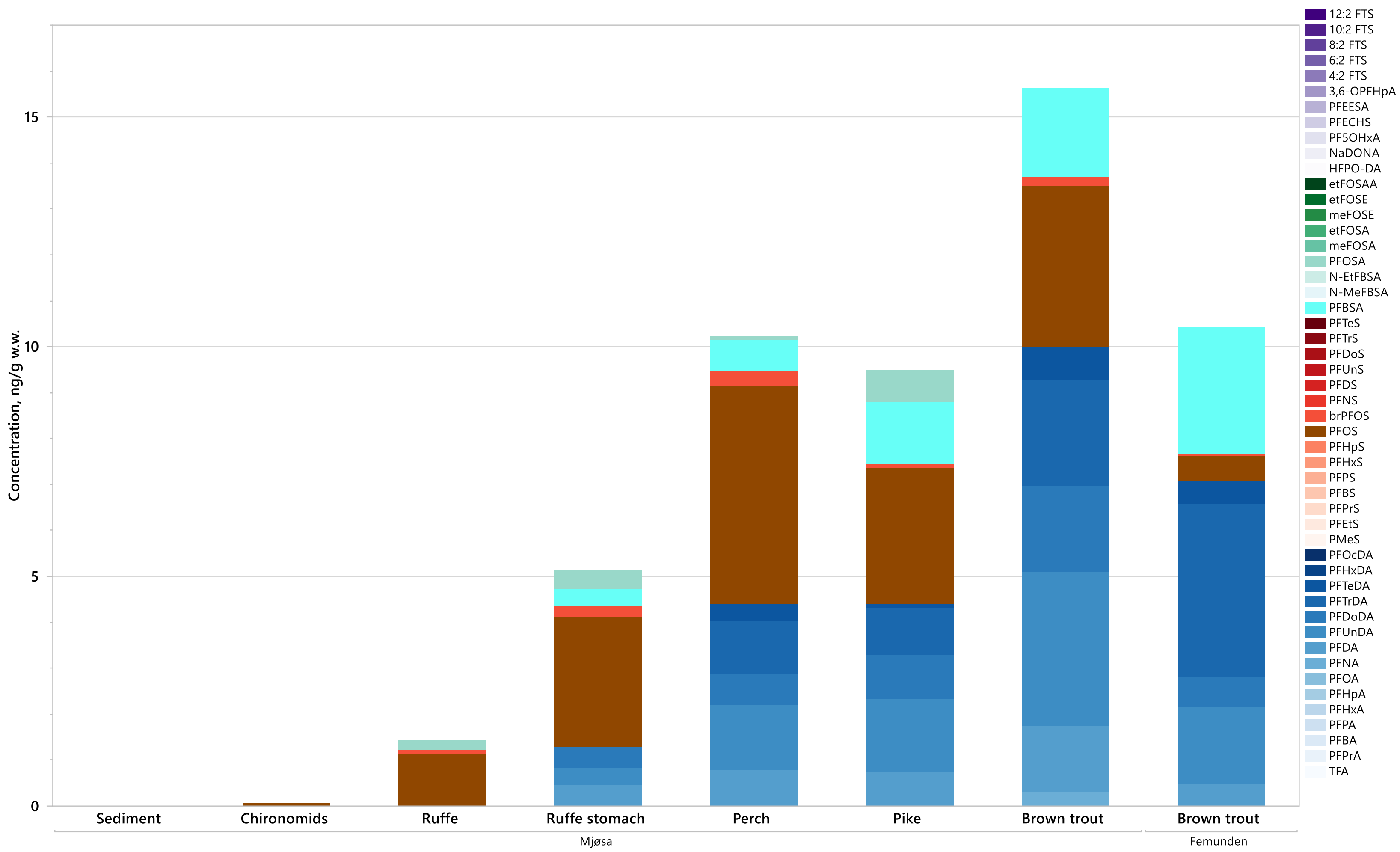


Figure 9. Mean concentration per sample of main contaminant groups in sediment samples outside Hamar city. Concentrations (**top**) are in ng/g d.w. **Bottom** figure shows the percentage of main contaminant groups. Non-detected concentrations are assigned a value of zero (0). Metals have been removed from this overview, see chapter 2.10 and 2.11.

2.4 PFAS


Concentration, ng/g w.w.
0
5
10
15
Sediment
Chironomids
Ruffe
Ruffe stomach
Perch
Pike
Brown trout
Brown trout
Mjøsa
Femunden
12:2 FTS
10:2 FTS
8:2 FTS
6:2 FTS
4:2 FTS
3,6-OPFHpA
PFEESA
PFECHS
PF5OHxA
NaDONA
HFPO-DA
etFOSAA
etFOSE
meFOSE
etFOSA
meFOSA
PFOSA
N-EtFBSA
N-MeFBSA
PFBSA
PFTeS
PFTrS
PFDoS
PFUnS
PFDS
PFNS
brPFOS
PFOS
PFHpS
PFHxS
PFPS
PFBS
PFPrS
PFEtS
PMeS
PFOcDA
PFHxDA
PFTeDA
PFTrDA
PFDoDA
PFUnDA
PFDA
PFNA
PFOA
PFHpA
PFHxA
PFPA
PFBA
PFPrA
TFA

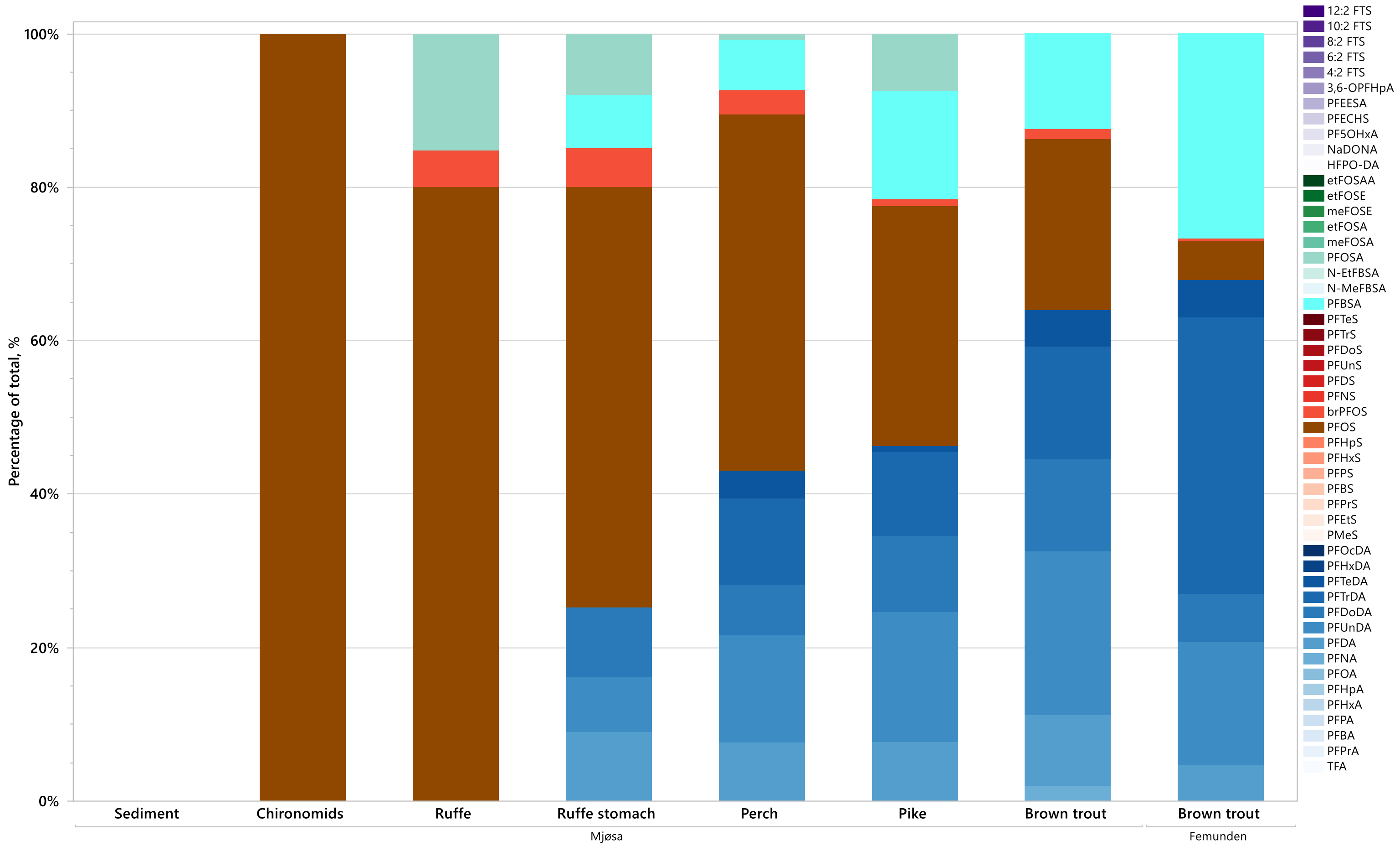
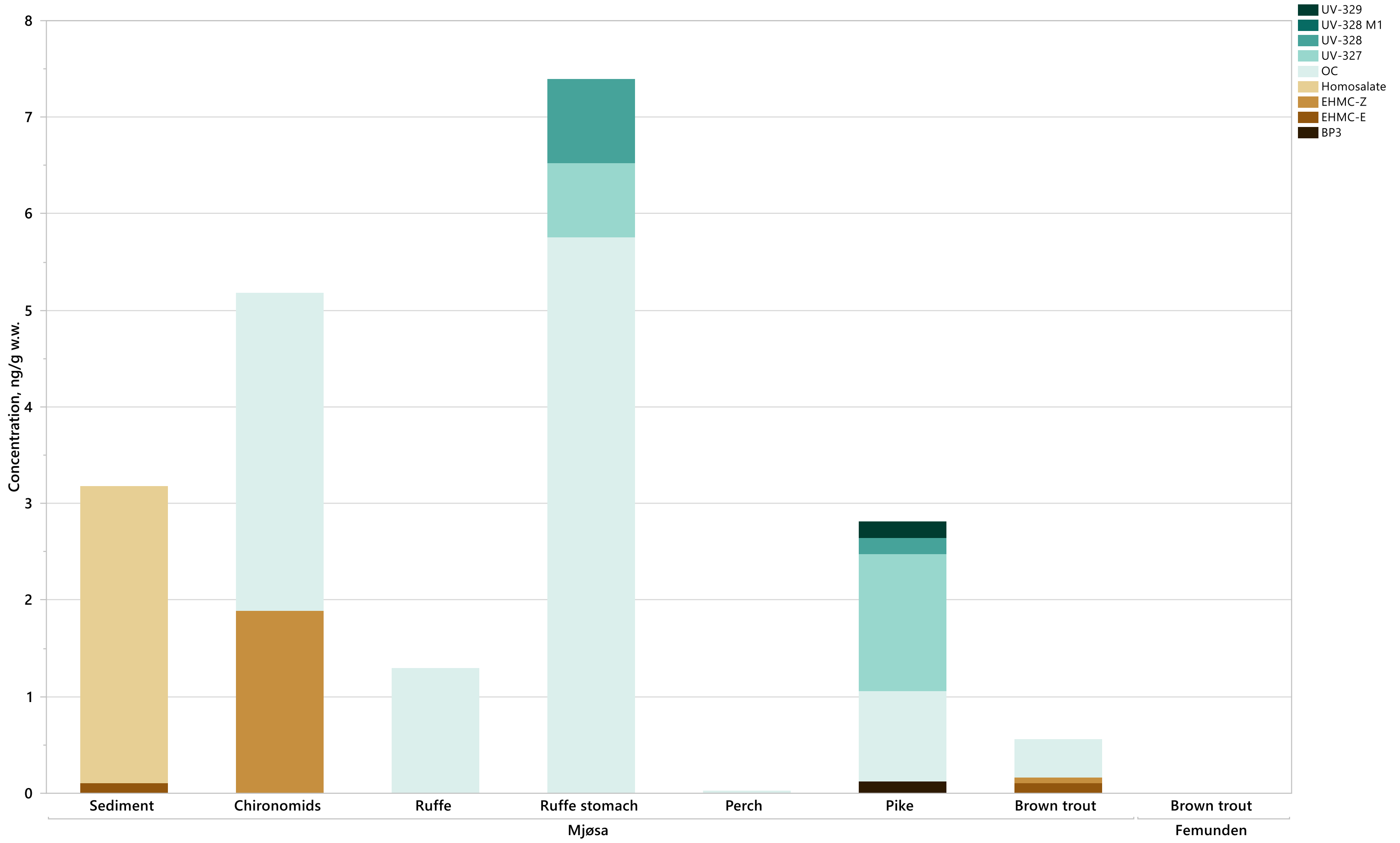


Figure 11. (Top) Concentrations (ng/g ww in biota, ng/g dw in sediment) of individual PFAS compounds for all matrices. (Bottom) PFAS compounds as percentage contribution to the sum of PFAS. Non detects are assigned a value of zero.

2.5 UV compounds



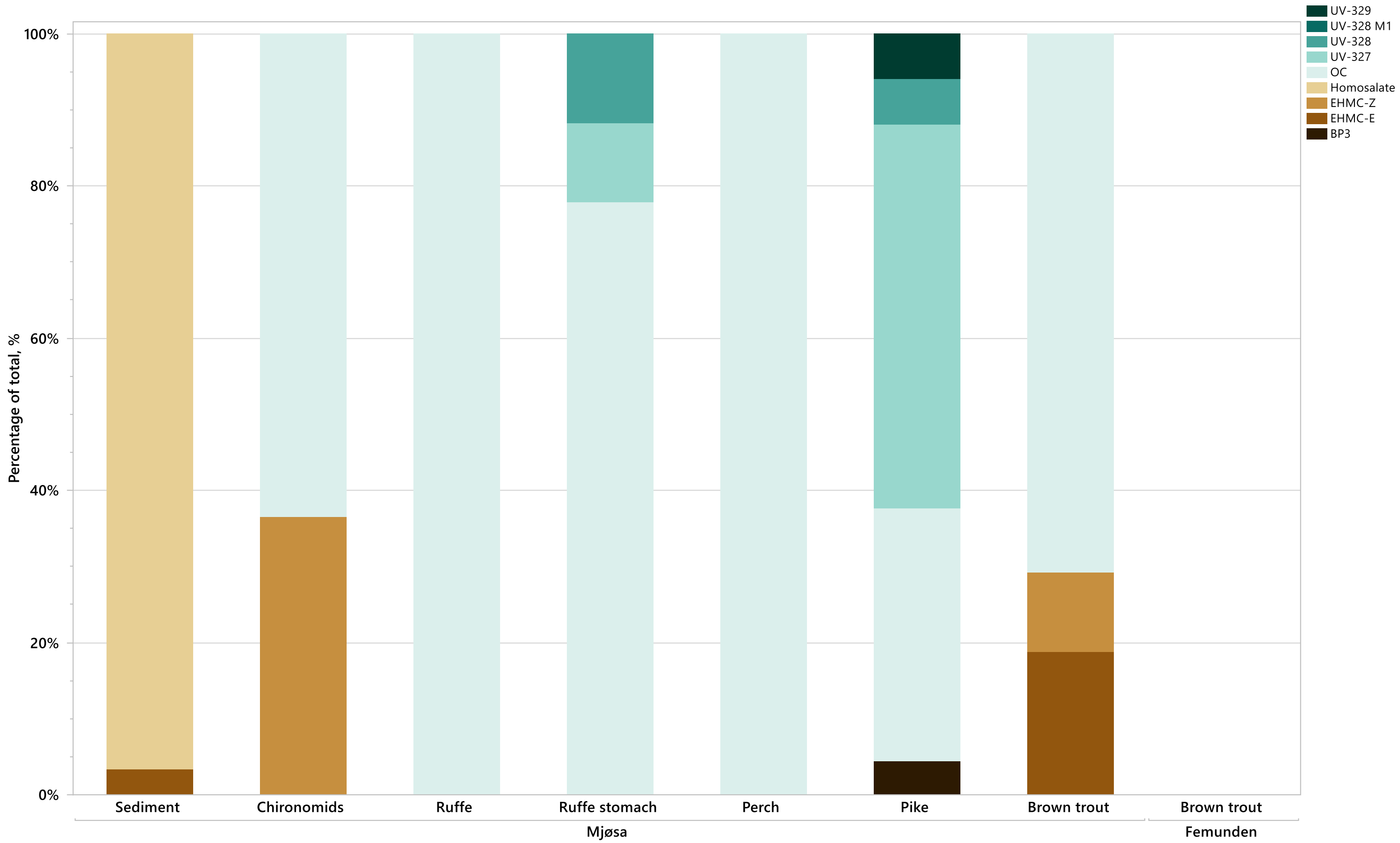
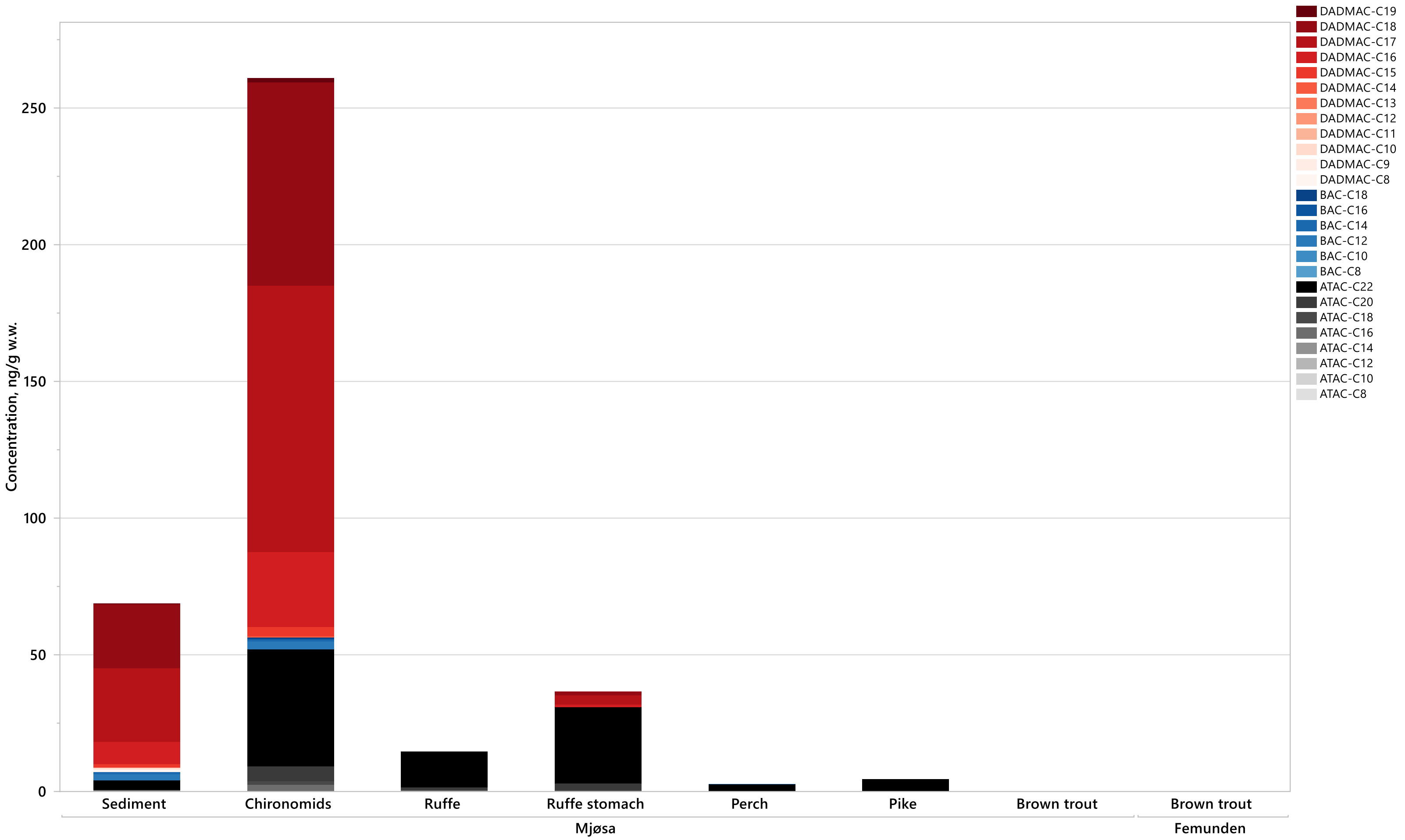


Figure 12. (Top) Concentrations (ng/g ww in biota, ng/g dw in sediment) of individual UV compounds for all matrices. (Bottom) UV compounds as percentage contribution to the sum of UV. Non detects are assigned a value of zero.

2.6 Quaternary ammonium compounds (QAC)



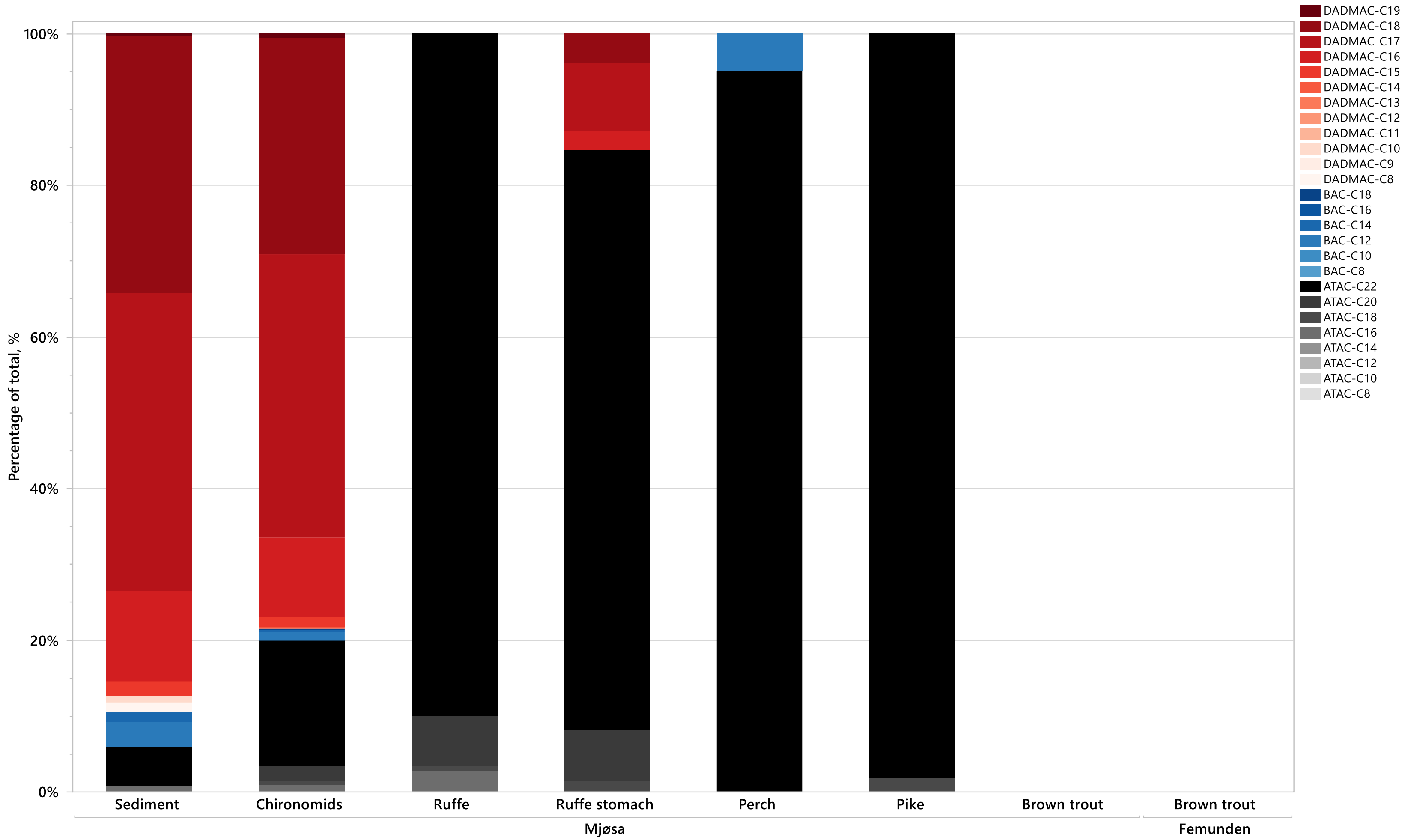
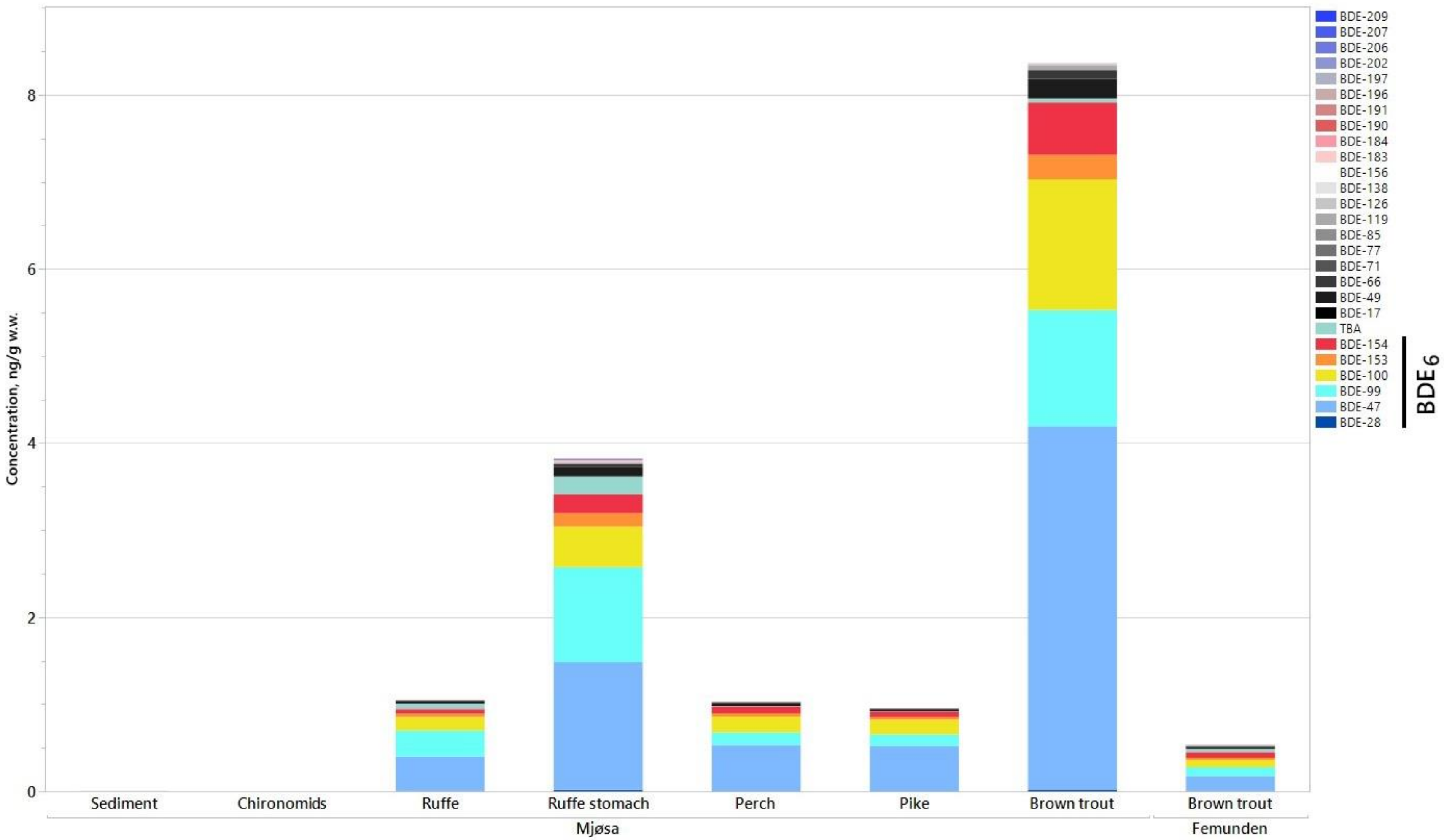


Figure 13. (Top) Concentrations (ng/g ww in biota, ng/g dw in sediment) of individual QAC compounds for all matrices. (Bottom) QAC compounds as percentage contribution to the sum of QAC. Non detects are assigned a value of zero.

2.7 PBDEs



Concentration, ng/g w.w.
0
2
4
6
8
Sediment
Chironomids
Ruffe
Ruffe stomach
Perch
Pike
Brown trout
Brown trout
Mjøsa
Femunden
BDE-209
BDE-207
BDE-206
BDE-202
BDE-197
BDE-196
BDE-191
BDE-190
BDE-184
BDE-183
BDE-156
BDE-138
BDE-126
BDE-119
BDE-85
BDE-77
BDE-71
BDE-66
BDE-49
BDE-17
TBA
BDE-154
BDE-153
BDE-100
BDE-99
BDE-47
BDE-28
BDE 6

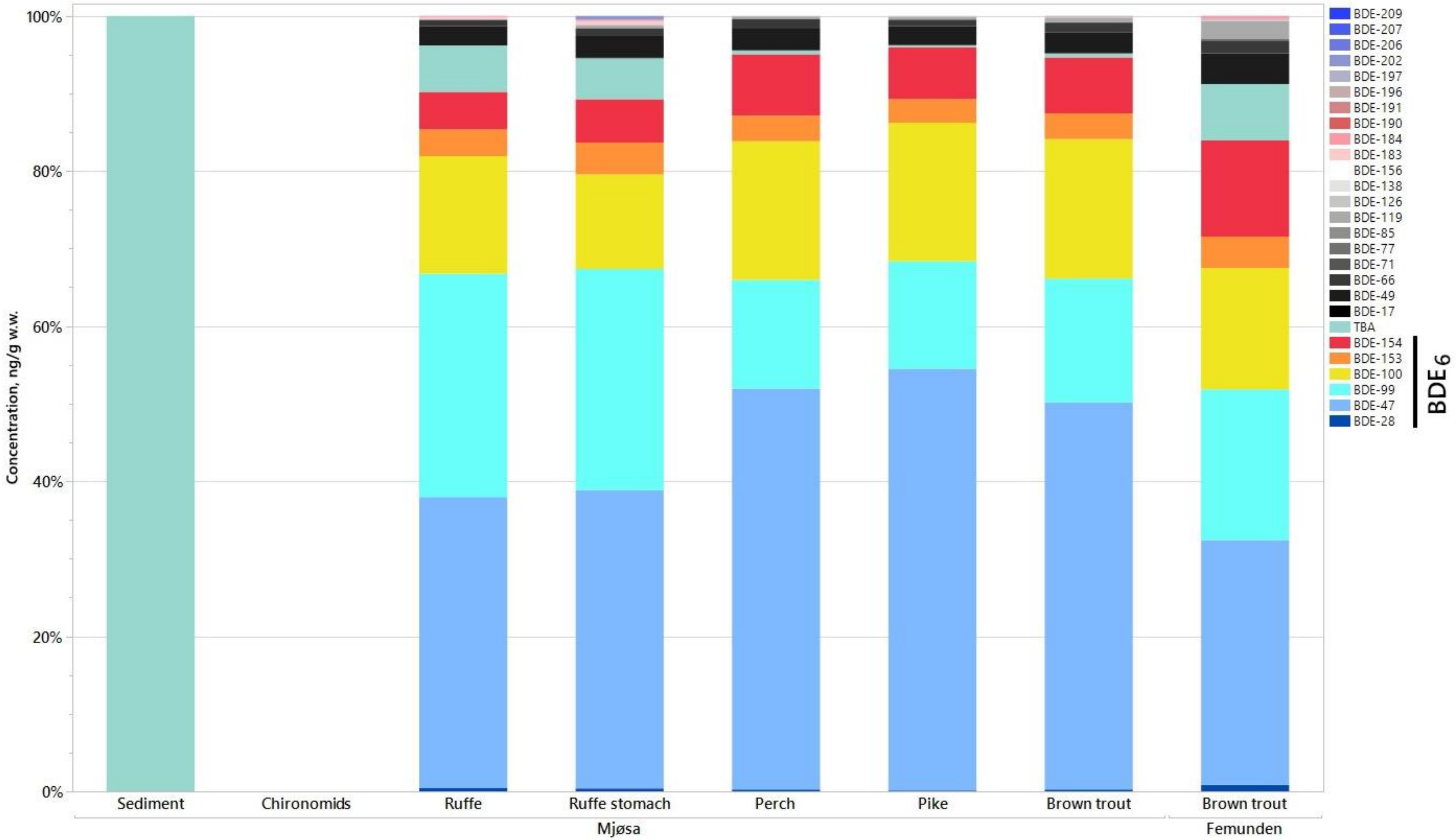
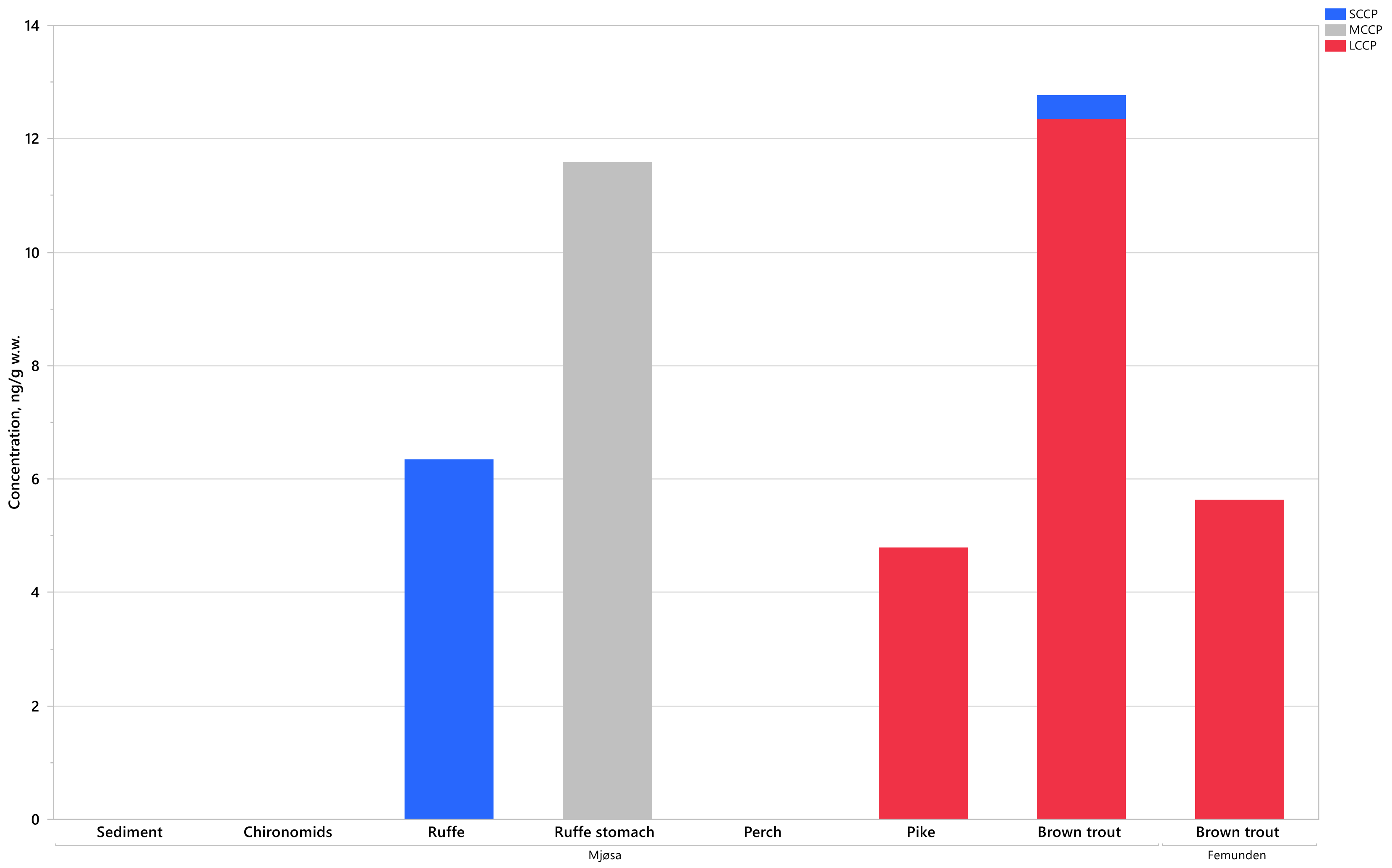


Figure 14. (Top) Concentrations (ng/g ww in biota, ng/g dw in sediment) of individual PBDEs for all matrices. (Bottom) PBDEs as percentage contribution to the sum of PBDEs. Non detects are assigned a value of zero.

2.8 Chlorinated paraffins (CP)



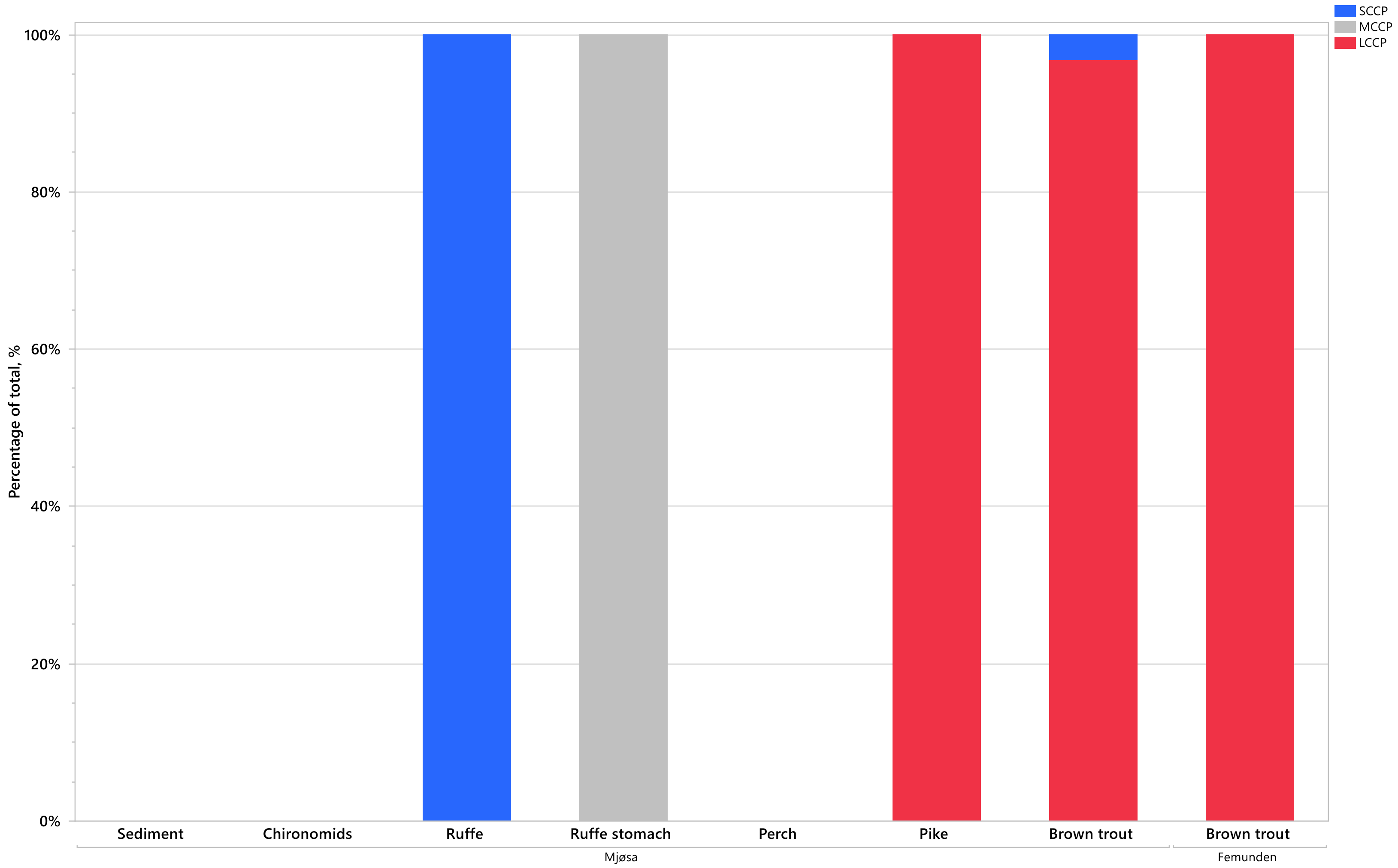
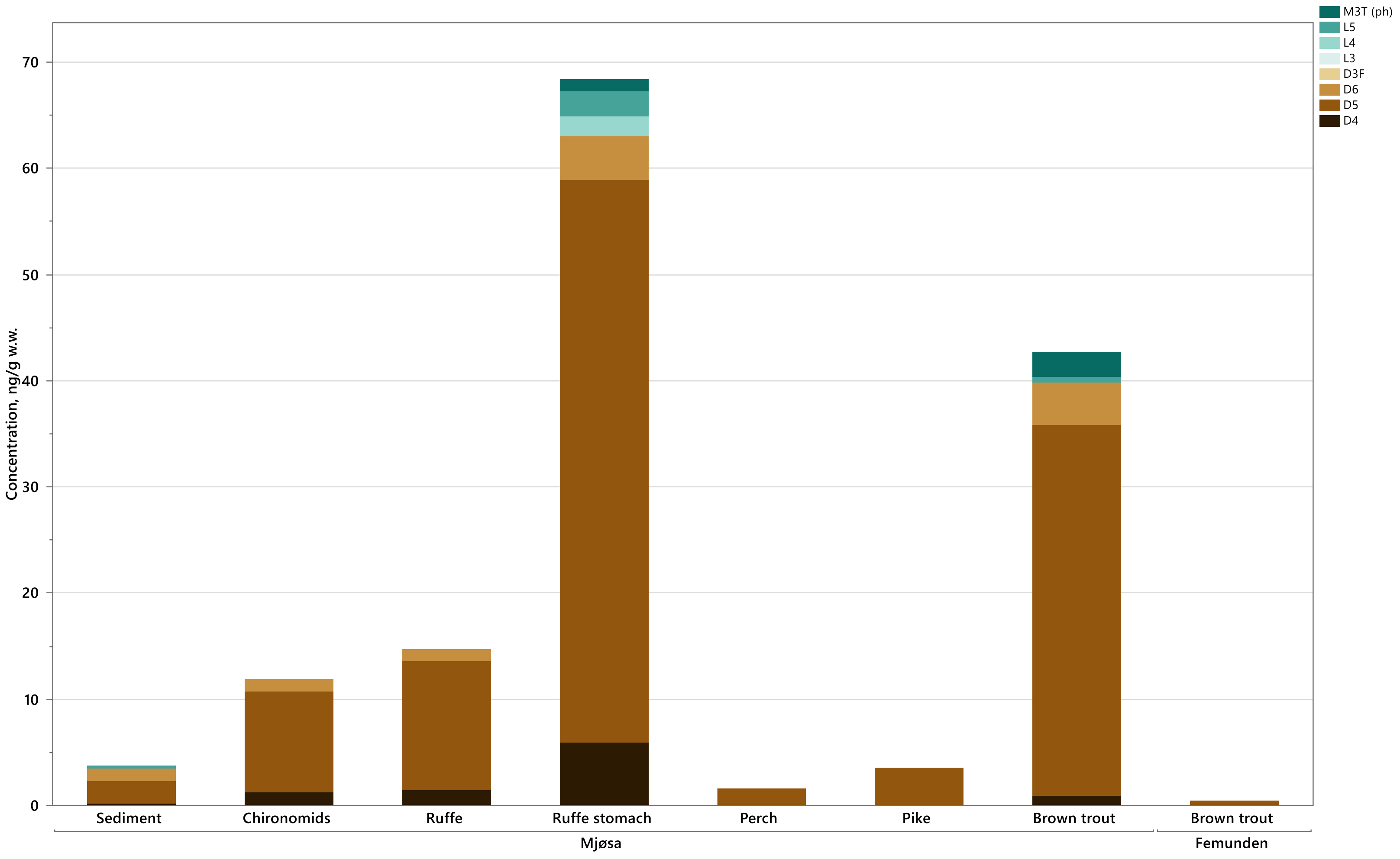


Figure 15. (Top) Concentrations (ng/g ww in biota, ng/g dw in sediment) of individual CPs for all matrices. (Bottom) CP as percentage contribution to the sum of CPs. Non detects are assigned a value of zero.

2.9 Siloxanes



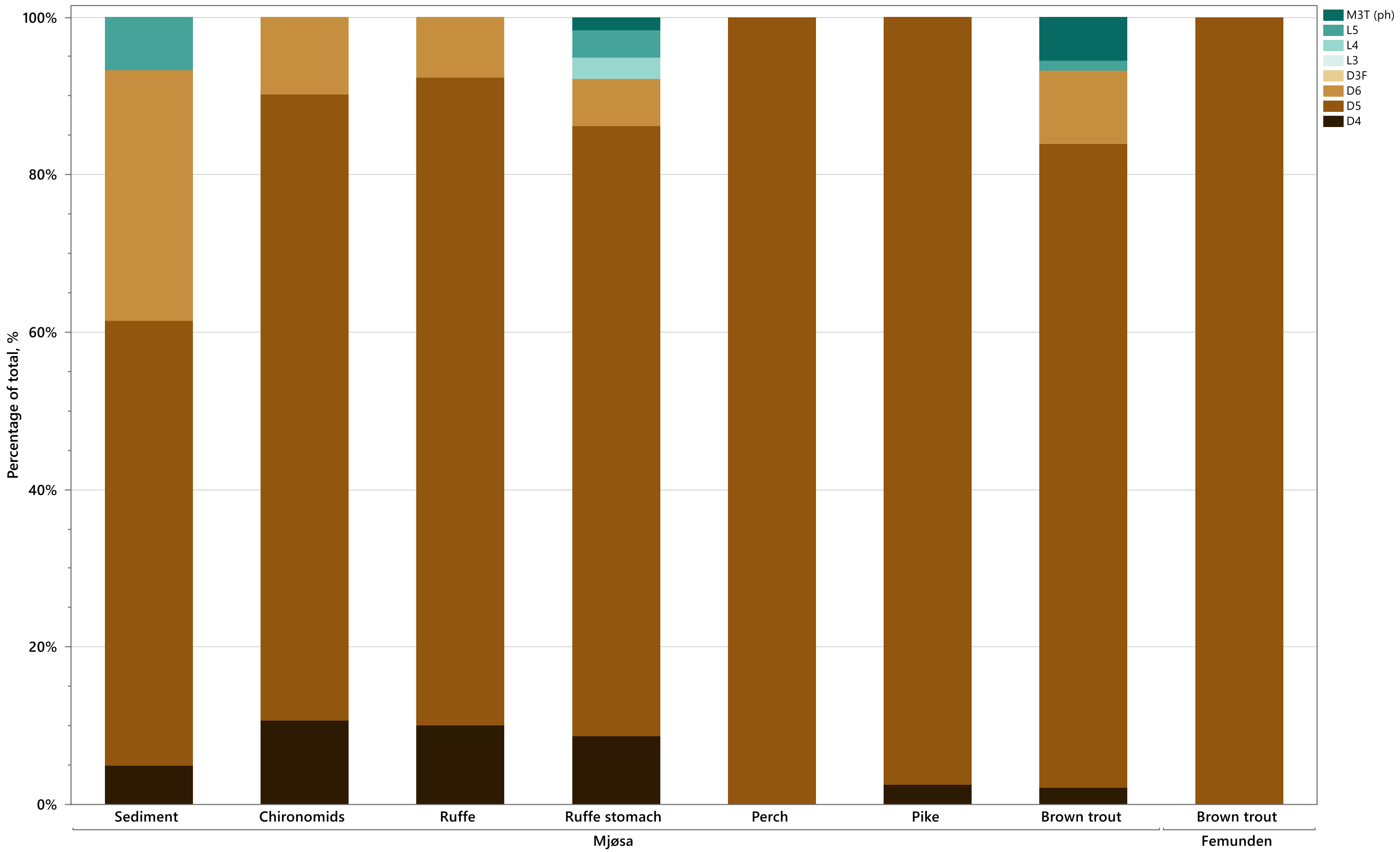


Figure 16. (Top) Concentrations (ng/g ww in biota, ng/g dw in sediment) of individual siloxanes for all matrices. (Bottom) Siloxanes as percentage contribution to the sum of siloxanes. Non detects are assigned a value of zero.

2.10 Mercury (Hg)

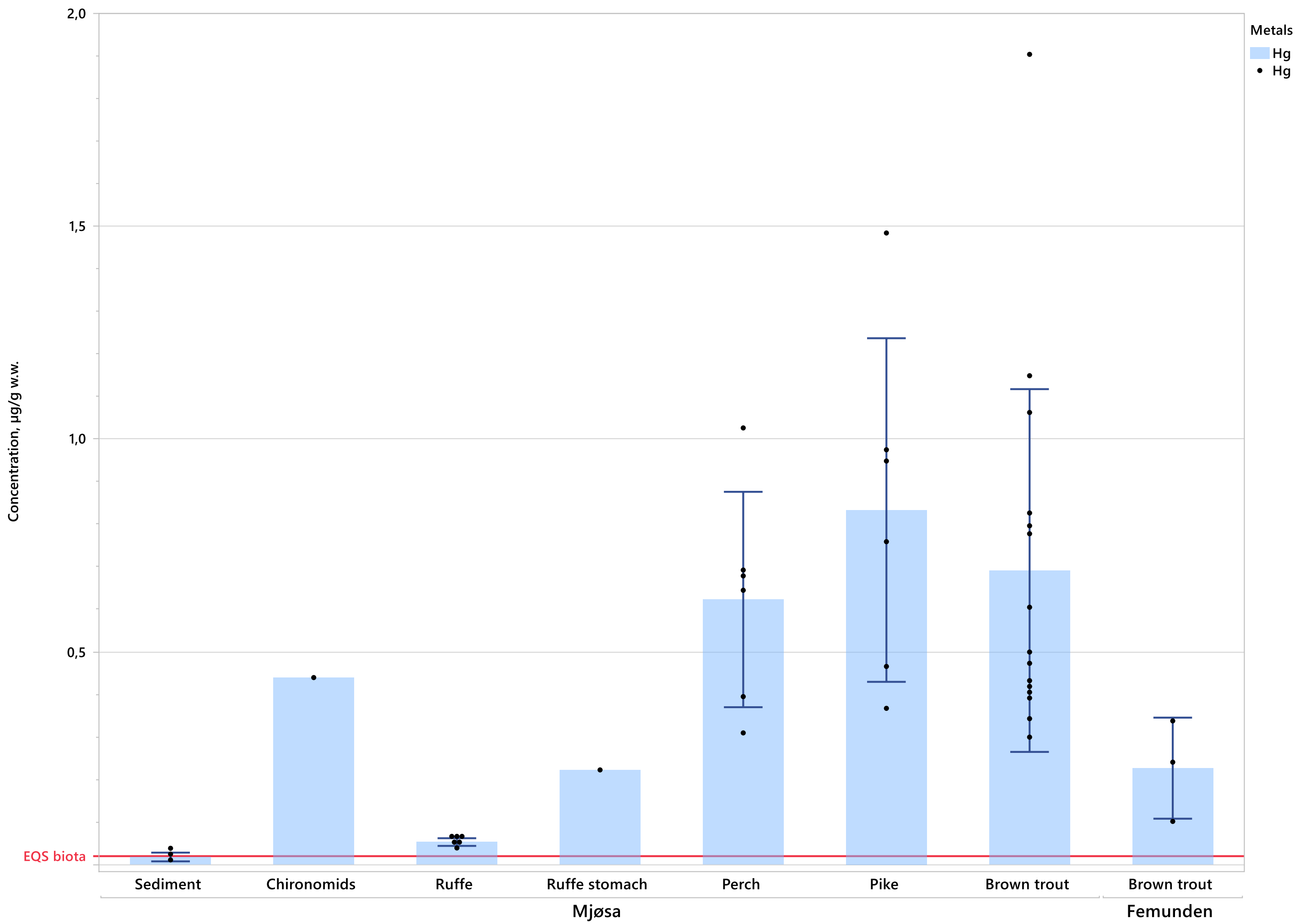
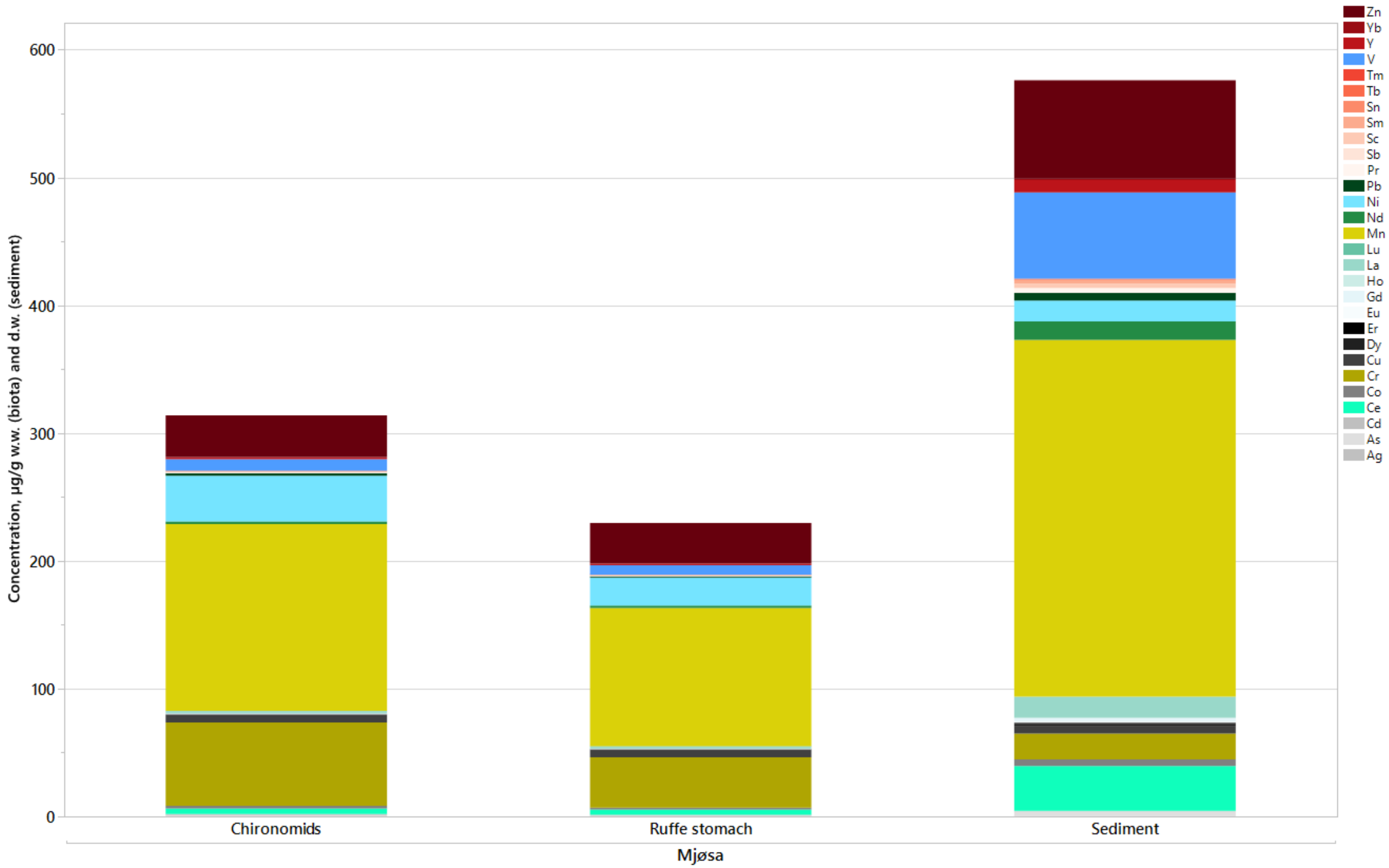


Figure 17. Concentrations (dots) and mean (bars) in µg/g w.w. for Hg in all matrices, compared to the EQS (0.02 µg/g) in biota.

2.11 Metals


600
500
400
300
200
100
0
Concentration, µg/g w.w. (biota) and d.w. (sediment)
Chironomids
Ruffe stomach
Sediment
Mjøsa
Zn
Yb
Y
V
Tm
Tb
Sn
Sm
Sc
Sb
Pr
Pb
Ni
Nd
Mn
Lu
La
Ho
Gd
Eu
Er
Dy
Cu
Cr
Co
Ce
Cd
As
Ag

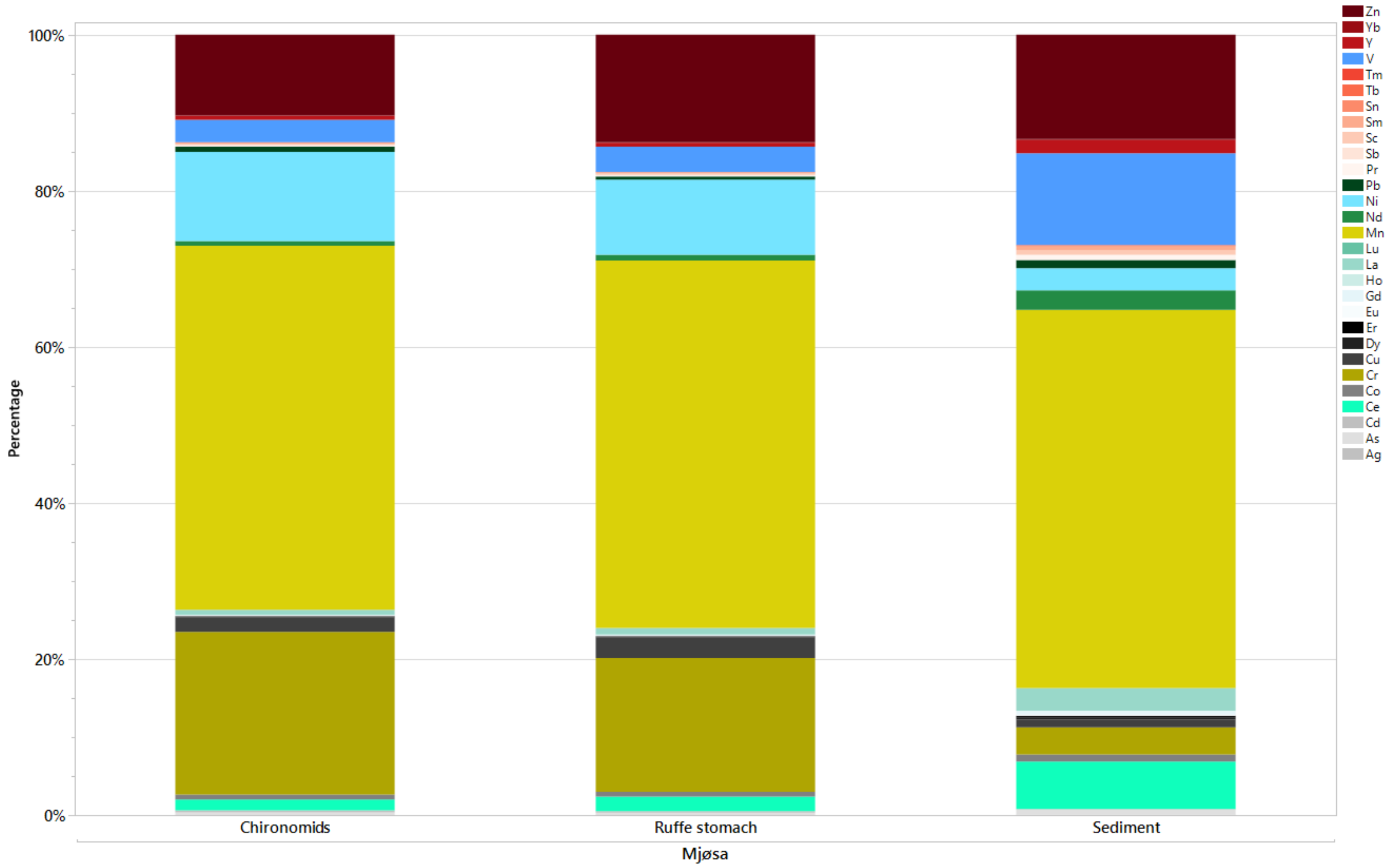


Figure 18. (Top) Concentrations (µg/g ww in biota, µg/g dw in sediment) of individual metals (except Fe) for all matrices. (Bottom) Metals as percentage contribution to the sum of metals. Non detects are assigned a value of zero.

2.12 Biomagnification – contaminant flow through the benthic food chain

2.12.1 Examples of contaminants with TMF > 1

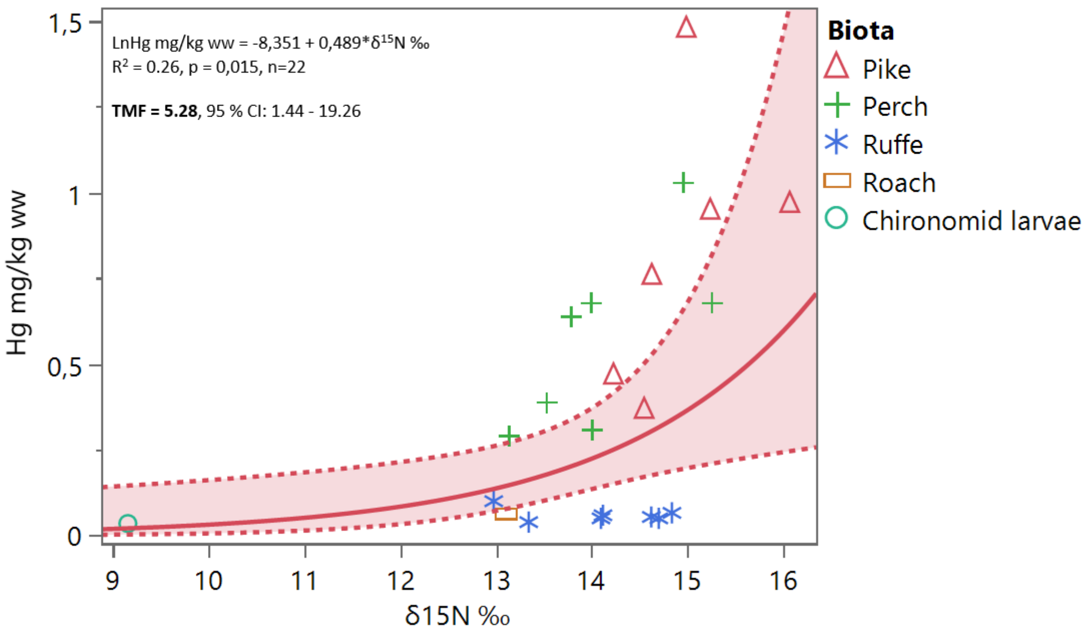


Figure 19. Biomagnification of Hg in the benthic food chain in Lake Mjøsa (data from 2021 and 2022).

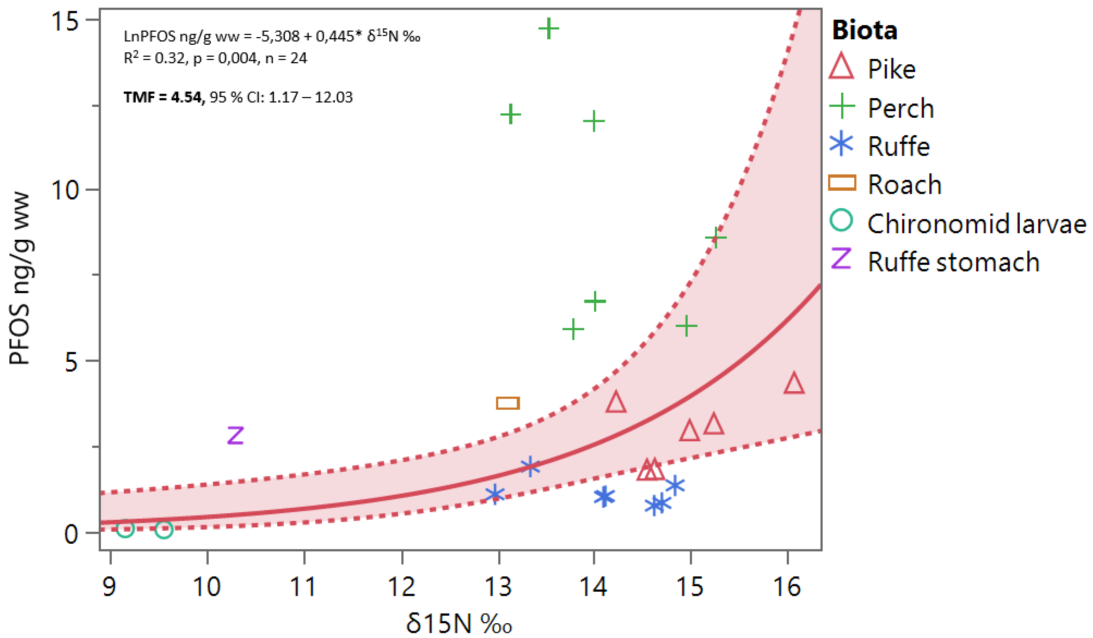


Figure 20. Biomagnification of PFOS in the benthic food chain of Lake Mjøsa (data from 2021 and 2022).

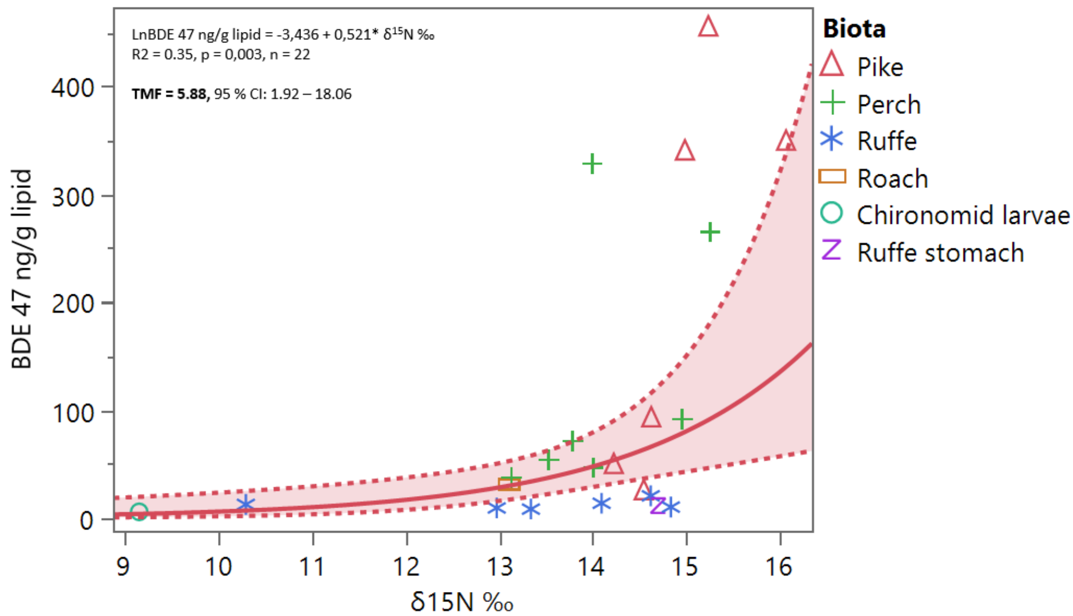


Figure 21. Biomagnification of BDE-47 in the benthic food chain of Lake Mjøsa (data from 2021 and 2022).

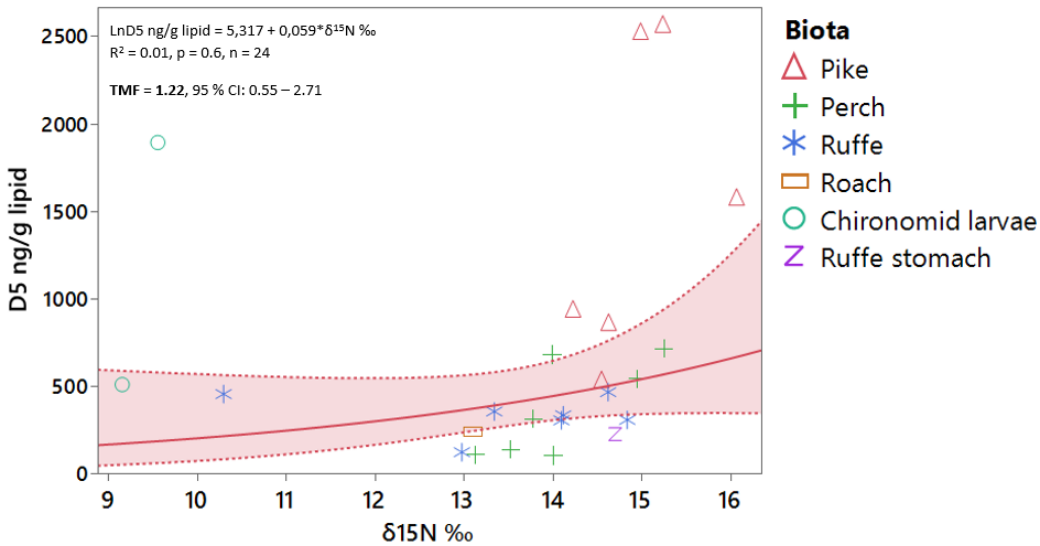


Figure 22. Biomagnification of siloxane D5 in the benthic food chain of Lake Mjøsa (data from 2021 and 2022).

2.12.2 Examples of contaminants with no biomagnification

Some of the contaminant groups in this study exhibit higher concentrations in sediment and the lower trophic levels, which means no trophic magnification. These compounds are still interesting, because they seem to bioaccumulate from sediment to Chironomids and ruffe, but are not detected to a large degree in predators. One of these contaminants, the QAC ATAC-22 are detected to some degree throughout the benthic food chain, but as Figure 23 indicates, higher concentrations are observed in lower trophic levels. Similar observations are made for individual UV-compounds (see 4.1.2).

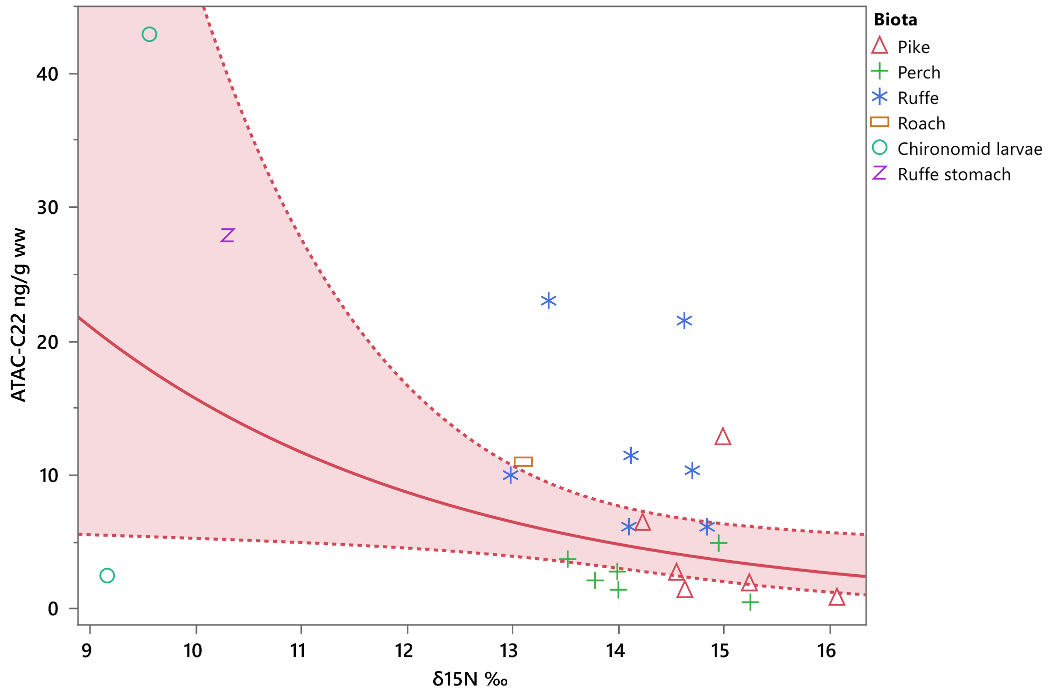


Figure 23. Contaminant flow of the QAC ATAC-22 through the benthic food chain in Lake Mjøsa (data from 2021 and 2022).

2.13 Time trends for contaminants

Several of the contaminants included in this report have been studied in the pelagic food chain for years, constituting a valuable historical time trend for contaminant levels in the top predator brown trout. In this chapter we provide some examples of time trends for major contaminant groups in brown trout from Lakes Mjøsa and Femunden.

For PBDEs (sum of BDE_6: BDE-28, -47, -99, -100, -153 and -154) there is a significant decrease in muscle concentration in brown trout in Lake Mjøsa from the peak in the early 2000s to 2023, and the regression is strong. As for PFAS, and the sum of detected PFASs (PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA, PFPeDA, PFOS and PFOSA), the decreasing trend in liver concentrations in brown trout in Lake Mjøsa is significant, but the regression is weak.

2.13.1 Sum PFAS

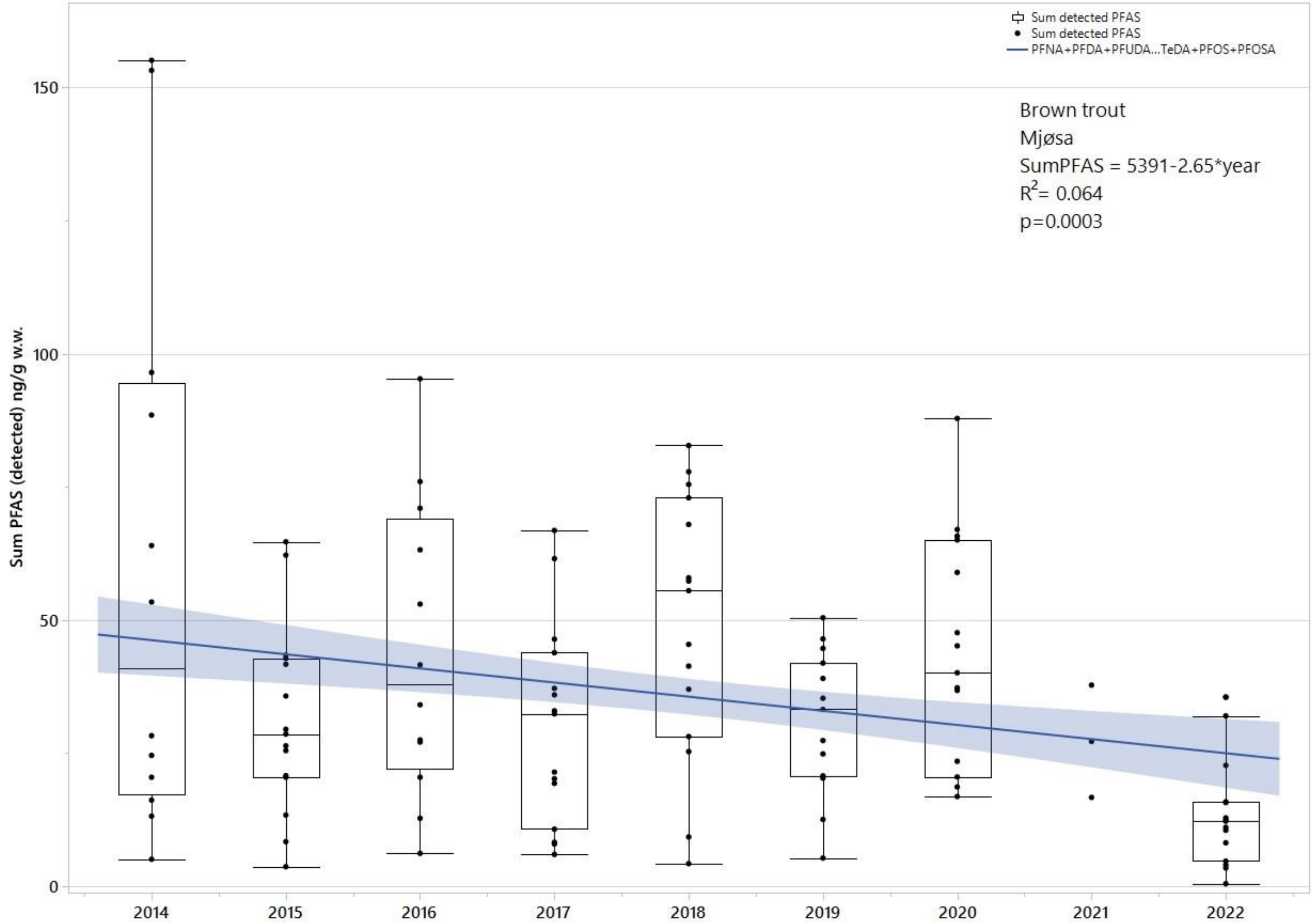


Figure 24. Time trend for PFAS (sum of detected PFASs: PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA, PFPeDA, PFOS and PFOSA) in brown trout from Lake Mjøsa (ng/g w.w.) from 2014 – 2022. In 2021 three pooled samples á five individuals were analysed. Boxes indicates median, 25 and 75 percentiles. Bars indicate max and min of sumPFAS in individual samples indicated with points. Line indicates the regression with 90 % CI.

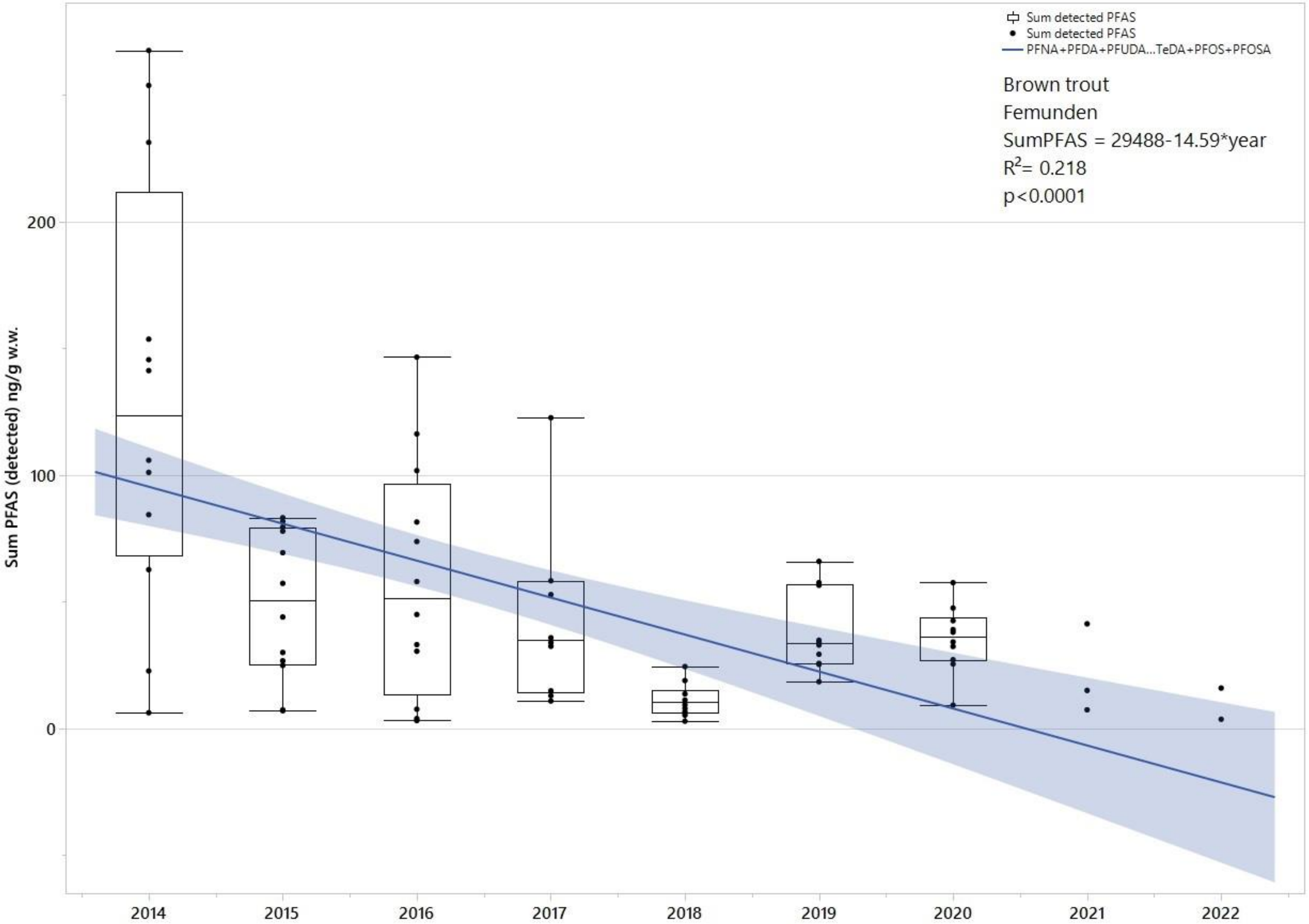


Figure 25. Time trend for PFAS (sum of detected PFASs: PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA, PFPeDA, PFOS and PFOSA) in brown trout from Lake Femunden (ng/g w.w.) from 2014 – 2022. In 2021 three pooled samples á five individuals were analysed. Boxes indicates median, 25 and 75 percentiles. Bars indicate max and min of sumPFAS in individual samples indicated with points. Line indicates the regression with 90 % CI.

2.13.2 PFOS

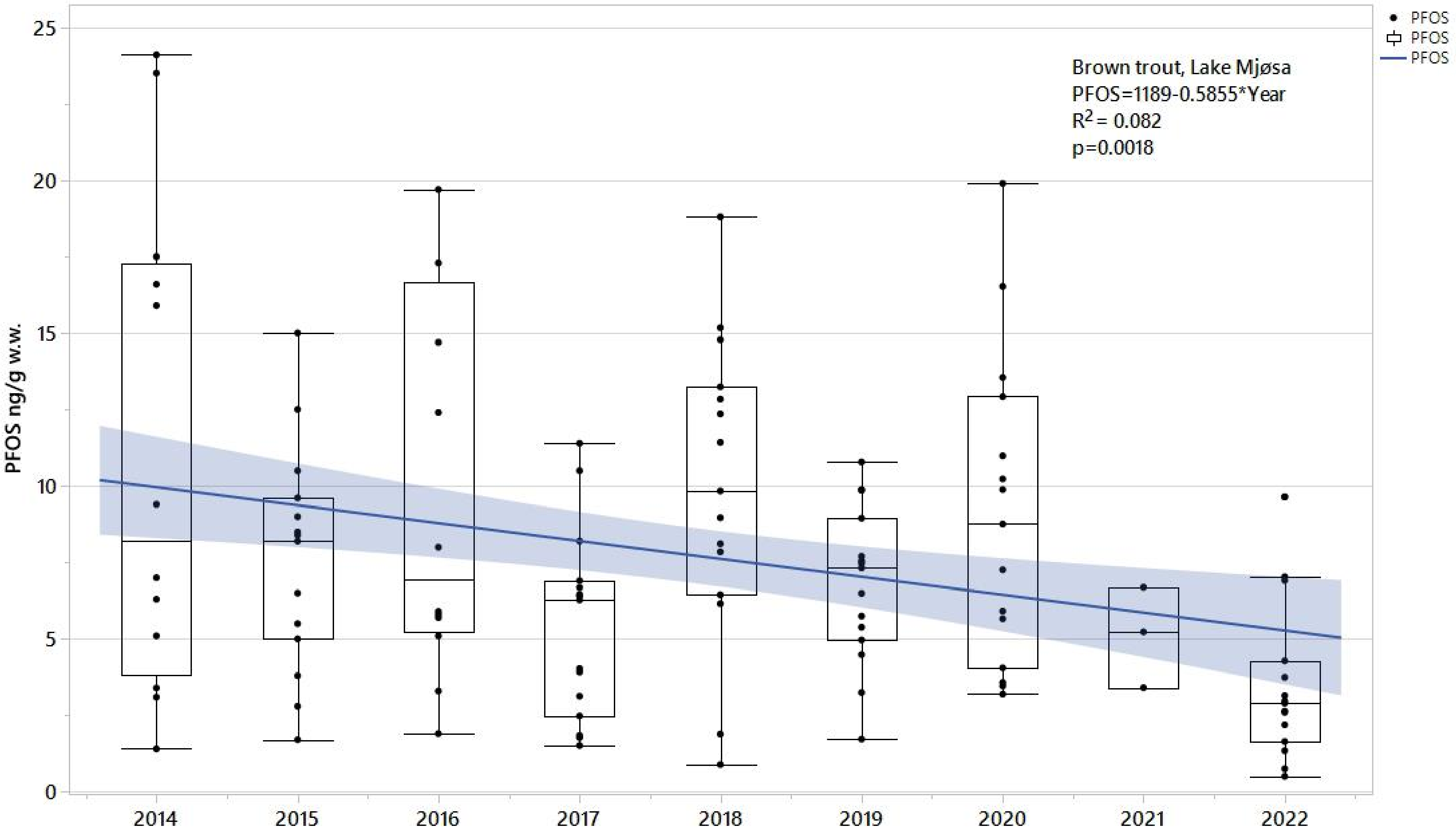


Figure 26. Linear regression of PFOS (ng/g, w.w.) in brown trout from **Lake Mjøsa** 2014-2023, indicating a significant but weak decreasing trend. Non-detects have been assigned a value of 0 (zero).

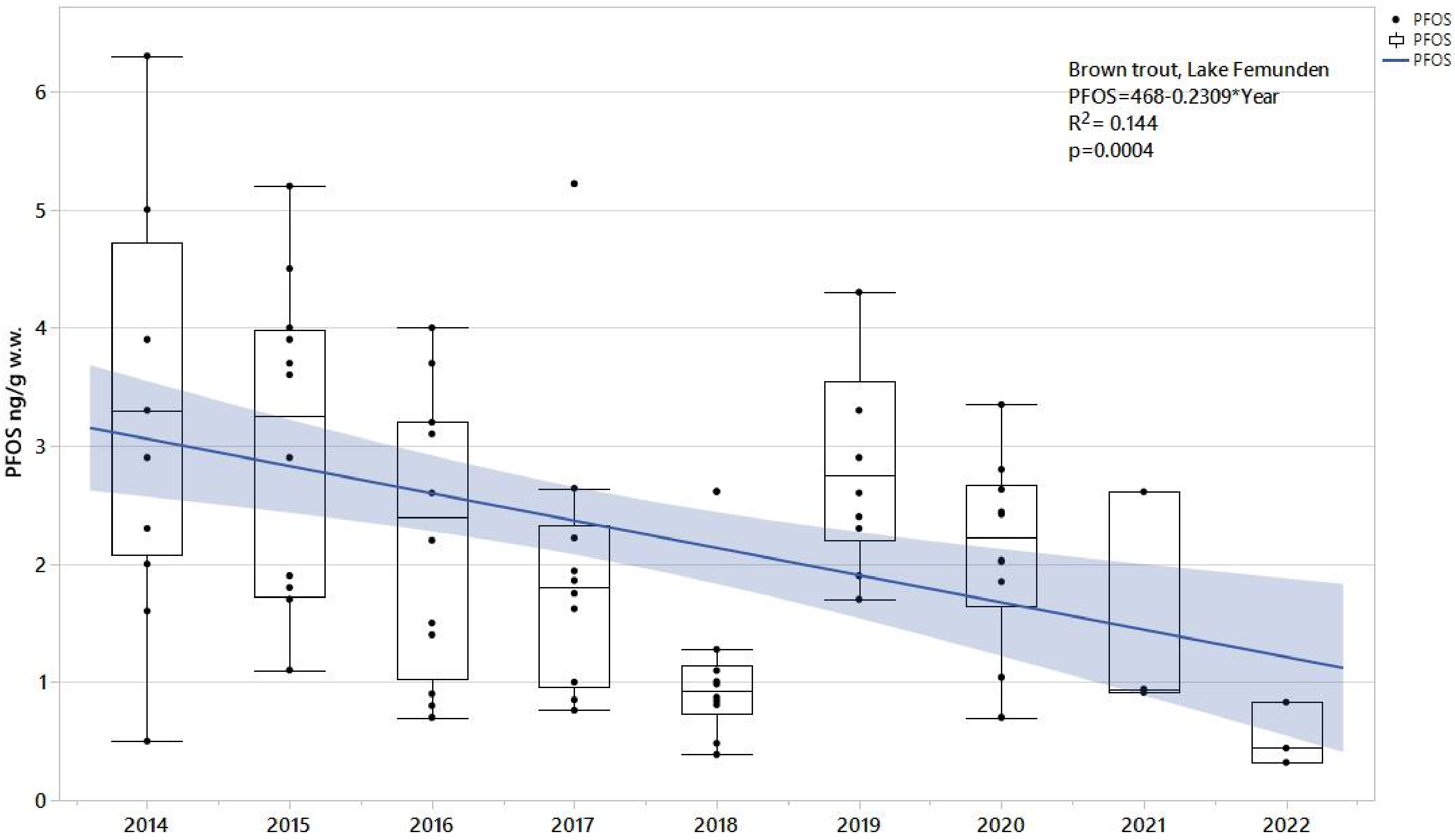


Figure 27. Linear regression of PFOS (ng/g, w.w.) in brown trout from **Lake Femunden** 2014-2023, indicating a significant but weak decreasing trend. Non-detects have been assigned a value of 0 (zero).

2.13.3 PFTrDA

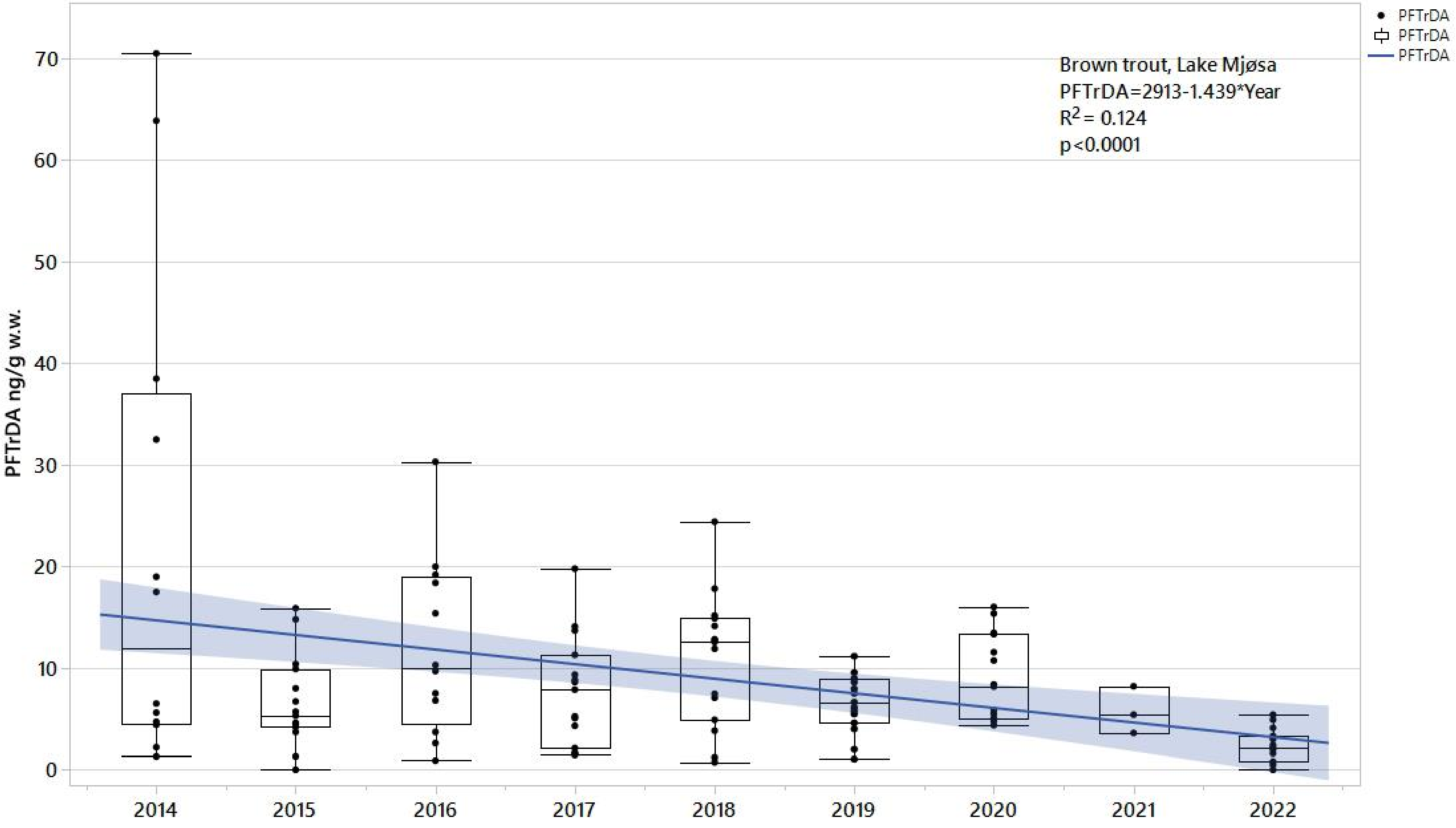


Figure 28. Linear regression of PFTrDA (ng/g, w.w.) in brown trout from **Lake Mjøsa** 2014-2023, indicating a significant but weak decreasing trend. Non-detects have been assigned a value of 0 (zero).

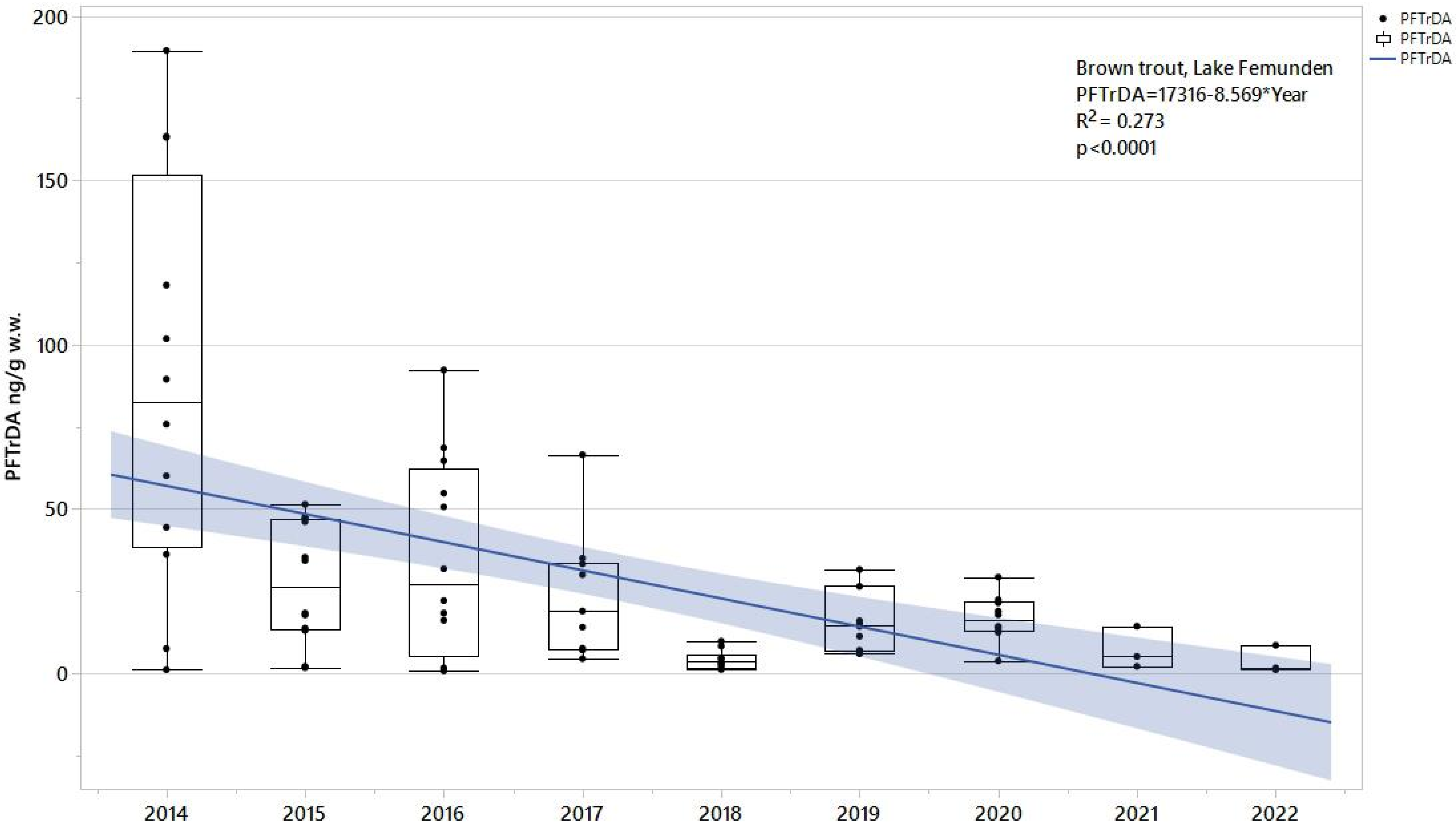


Figure 29. Linear regression of PFTrDA (ng/g, w.w.) in brown trout from **Lake Femunden** 2014-2023, indicating a significant but weak decreasing trend. Non-detects have been assigned a value of 0 (zero).

2.13.4 PBDEs

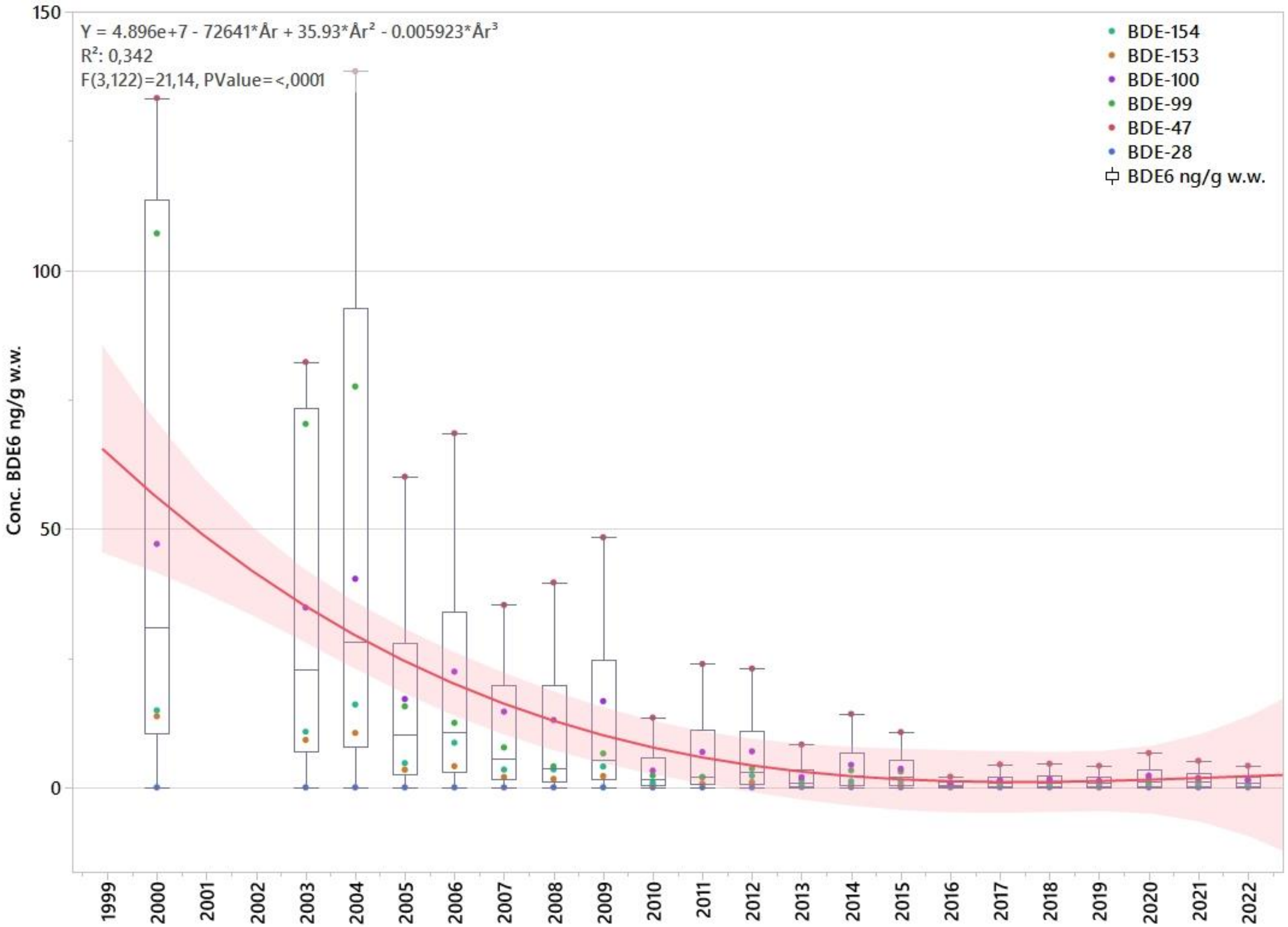


Figure 30. Time trend for PBDEs (ΣBDE_6: 28, 47, 99, 100, 153 and 154) in ng/g w.w. in brown trout from Lake Mjøsa from 2000 – 2022. The model describes a significant cubic regression with 90 % CI. Non detects have been assigned a value of 0 (zero).

2.13.5 Siloxanes

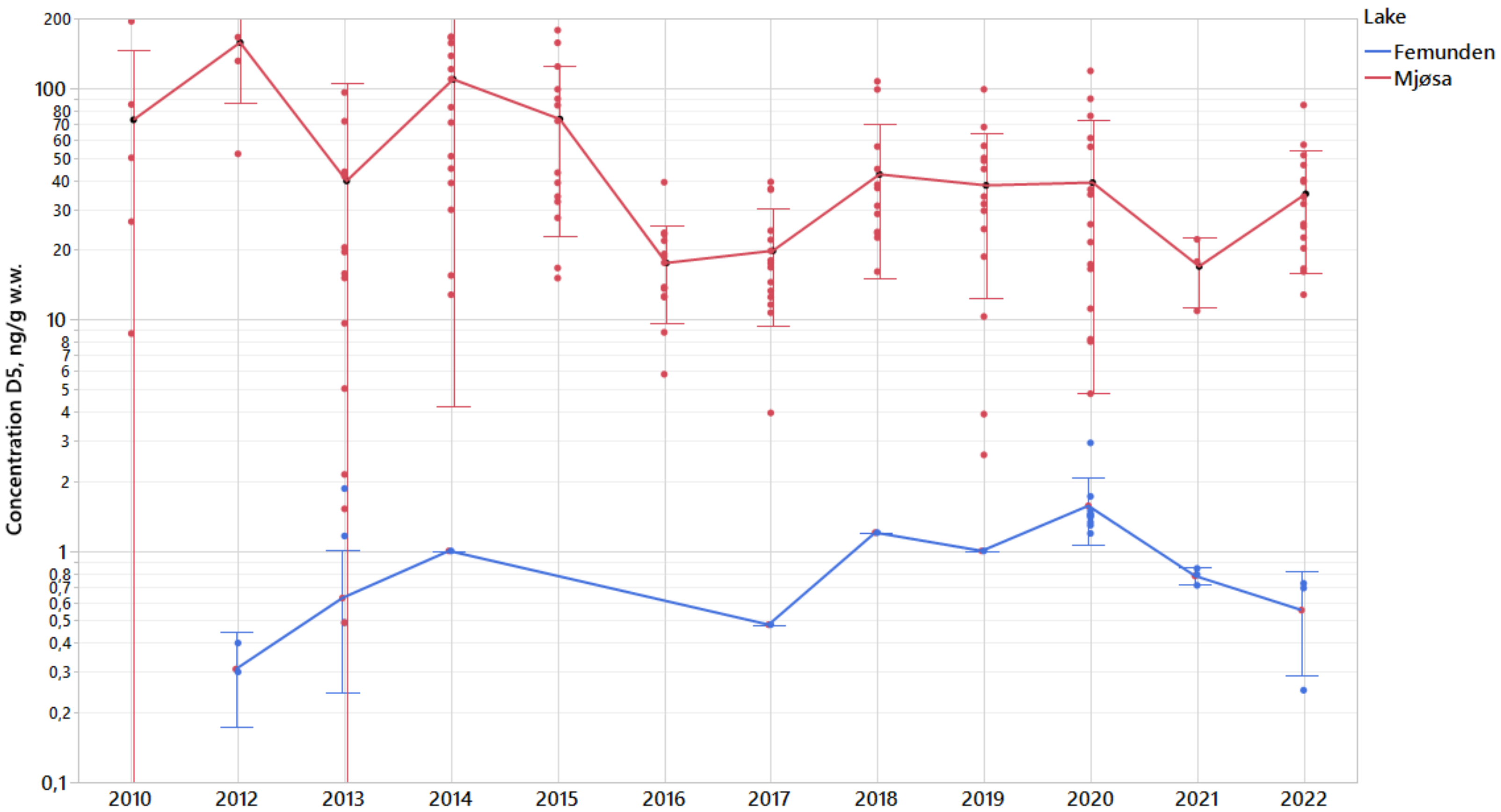


Figure 31. Time trend for mean D5 (siloxane) concentrations in brown trout from Lake Mjøsa and Lake Femunden (ng/g w.w.) from 2010 – 2022. In 2021 three pooled samples were analysed from both lakes. Note the logarithmic scale and the ≈100 factor difference in concentrations between Lake Mjøsa and Lake Femunden.

2.13.6 Mercury (Hg)

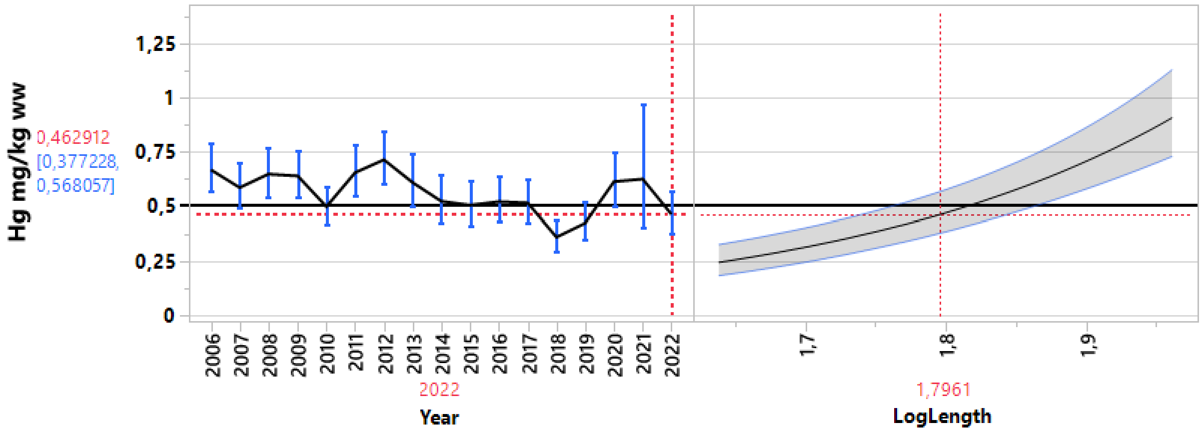


Figure 32. Length adjusted Hg (with 95 % confidence intervals) in trout from Lake Mjøsa 2006-2022. Brown trout are adjusted to the geometric average length (62.5 cm) in the dataset (~2.6 kg). Horizontal line at 0.5 mg/kg Hg (upper limit for placing fish products in the market) is shown. Length adjusted mean Hg concentration (with 95 % confidence limits) for 2022 is marked with a red dashed line and numbers. Note that the 2021 length adjusted Hg consist of three datapoints, each of which is a pooled sample of five individuals. Estimate for all other years are based on 15 to 22 individual datapoints.

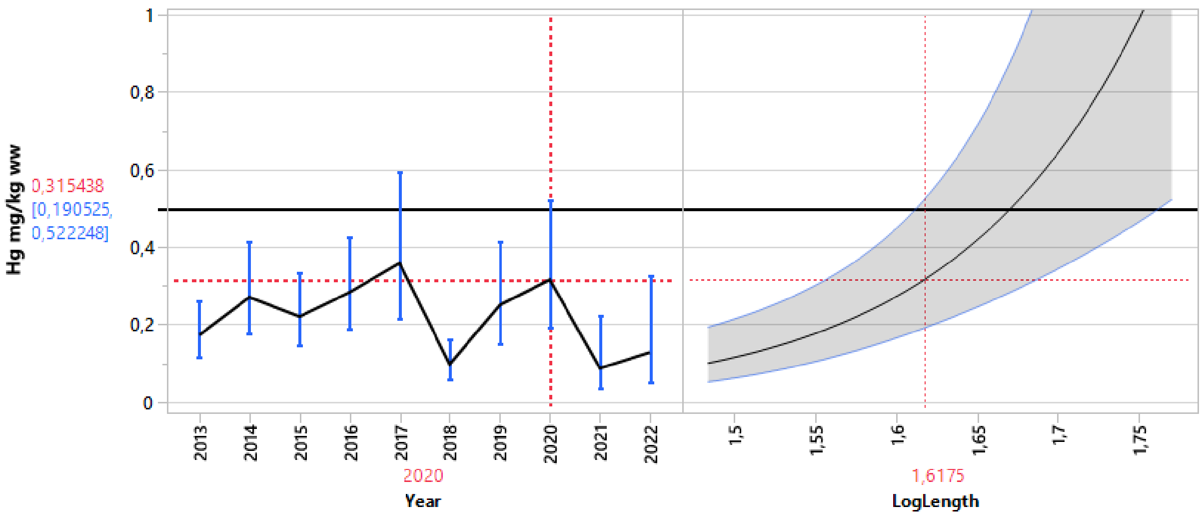


Figure 33. Length adjusted Hg (with 95 % confidence intervals) in trout from Lake Femunden 2013-2022. Brown trout are adjusted to the geometric average length (41.4 cm) in the dataset (~0.73 kg). Horizontal line at 0.5 mg/kg Hg (upper for placing fish products in the market) is shown. Length adjusted mean Hg concentration (with 95 % confidence limits) for 2022 is marked with a red dashed line and numbers. Note that the 2021 length adjusted Hg, consist of three datapoints, each of which is a pooled sample of five individuals. Estimate for all other years are based on 10 to 15 individual datapoints.

2.14 Comparison to EQS

Concentrations (medians) are compared to environmental quality standards (EQS).

Table 3. Concentrations of contaminants (mg/kg dry wt) with Norwegian environmental quality standards (Direktoratsgruppen vanndirektivet 2018) in samples of sediment from Lake Mjøsa (mean, n=3). Red numbers indicate concentrations exceeding the quality standard (annual average. AA-EQS).

EU priority substances	EQS (mg/kg dw)	Sediment conc. Lake Mjøsa (mg/kg dw)
Lead (Pb)	66	6.1
Brominated diphenyl ethers *	0.31	<0.0005
PFOS	0.0023	<0.0001
River basin specific compounds		
Decamethylcyclopentasiloxane (D5)	0.044	0.0024
Medium chained chloroparafins (MCCPs)	4.6	<0.01
Copper (Cu)	84	9.1
PFOA	0.071	<0.0005
Zinc (Zn)	139	77
Arsenic (As)	18	3.7
Chromium (Cr)	620	20
* Sum of BDE-28, -47, -99, -100, -153 and -154.		

Table 4. Concentrations of contaminants (µg/kg wet wt.) with Norwegian environmental quality standards (Direktoratsgruppen vanndirektivet 2018) in samples of brown trout (muscle and liver) from Lakes Mjøsa and Femunden. Red numbers indicate concentrations exceeding the quality standard.

	Biota (Brown trout) in Lake Mjøsa and Lake Femunden 2022			
Contaminant	EQS_{biota}	Concentration range (min-max) for Brown trout		$n>EQS_{biota}$
	µg/kg w.w.	µg/kg w.w.		n
Priority substances				
Hg	20	Mjøsa	300 – 1900	15/15
		Femunden	100 – 340	3/3
PBDEs (ΣBDE_6)*	0.0085	Mjøsa	1.7 – 16	3/3
		Femunden	0.24 – 0.63	3/3
PFOS (in liver)	9.1	Mjøsa	0.8 – 10	1/15
		Femunden	0.32 – 0.83	0
SCCPs	6000	Mjøsa	< 4	0
River basin-specific pollutants				
MCCPs	170	Mjøsa	< 16	0
D5	15000	Mjøsa	12 – 84	0
		Femunden	<0.5 – 0.70	0
PFOA (in liver)	91	Mjøsa	<0.5	0
		Femunden	<0.5	0

2.15 Metabolites

In 2022, selected metabolites of organic phosphorous flame retardants (oPFR) and phthalates were determined in liver samples of brown trout from Lake Mjøsa and Femunden, and pike from Lake Mjøsa, see Table 5. Results are shown in Appendix, chapter 4.2.10.

Table 5. List of oPFR- and phthalate metabolites

	Name	Short name
oPFR-metabolites	Bis(2-chloroethyl) phosphate	BCEP
	Bis(2-chloropropyl) phosphate	BCPP
	Diphenyl phosphate	DPP
	Bis (1,3-dichloro-2-propyl) phosphate	BDCPP
	Di n-butyl phosphate	HDBP
	Bis(2-butoxyhexyl) phosphate	BBOEP
	Di(2-ethylhexyl) phosphate	HDEHP

	Name	Short name
Phthalate metabolites	Monomethyl phthalate	MMP
	Monoethyl phthalate	MEP
	Monobutyl phthalate	MNBP/MIBP
	Mono(2-ethyl-5-oxohexyl) phthalate	MEOHP
	Monobenzyl phthalate	MBzP
	Mono(2-ethyl-5-hydroxyhexyl) phthalate	MEHHP
	Mono(2-ethylhexyl) phthalate	MEHP

Analytical methods for metabolites are semi-quantitative, as analytical standards are scarce for these compounds. Metabolites fall into the uncertainty category 3, see chapter 3.2.13. Liver is a challenging tissue with matrix challenges, but methods and standards will improve.

In this study, only a few oPFR-metabolites were detected above LOQ, such as DPP, HDBP and HDEHP, which are metabolites of the flame retardants, triphenyl phosphate (TPP), tributyl phosphate (TBP) and tris(2-ethylhexyl) phosphate (TEHP), respectively. These original mother compounds are widely used as plasticizers, flame retardants and solvents, and has previously been found in samples of the lower trophic levels in Lake Mjøsa, but not in top predators[3].

As for phthalate metabolites, no detections were made except for one sample of brown trout in Lake Mjøsa, with 49 ng/g w.w. of the metabolite MNBP/MIBP, originating from dibutyl phthalate (DBP/DnBP) previously found in samples of wastewater effluent and sludge ending up in Lake Mjøsa[4].

Other metabolites were not detected in this survey. For graphic presentation, see electronic appendix.

Recommendation is to continue the search for metabolites, as we observe that several of the main contaminant groups, such as QACs, CPs and UV-compounds accumulate from sediment to the

[3] Jartun et al., 2020. Monitoring of environmental contaminants in freshwater ecosystems 2019 – Occurrence and biomagnification. NIVA-report 7545-2020.
[4] Jartun et al., 2022. Environmental contaminants in freshwater food webs, 2021. NIVA-report 7794-2022.

sediment dwelling organisms but is not detectable in predator fish. As oPFR- and phthalate metabolites now have been tested, methods will improve over time, and subsequently LODs and uncertainty will decrease. As for other contaminant groups, metabolites of chlorinated paraffins (CP) should be something to look out for. Challenges with CP determination arise from their ubiquitous usage in everyday products, including major components of a modern laboratory.

3 Appendix - Material and Methods

3.1 Sampling methods

Sampling procedures follows the strict regulations for the Norwegian Environmental Specimen Bank, including avoiding commercial personal care products 24 hours upon sampling. All containers are pre-burned and rinsed with RO-water upon sampling. Field blanks (homogenized eggs) issued from the laboratory were included in the analyses, reflecting reference air contamination at the time of dissection of fish.

3.1.1 Sediment

Sediment was collected at three stations in a transect outside the city of Hamar (Figure 1**)** by means of a van Veen grab (0.15 m^2) from NIVAs own boat. Four grabs of the top layer (0-2 cm in grab samples with undisturbed surface) were prepared[5] for each station. Upon analysis, the samples from these three stations were pooled into one composite sample.

3.1.2 Chironomidae larvae

Larvae of the family *Chironomidae* were collected in the outer parts of the Åkersvika delta, see Figure 1. Using a van Veen grab (0.15 m^2), sediment was collected in bulk into a large container. The samples were subsequently sifted through a 2 mm nylon mesh, and the larvae of the *Chironomidae* family (red larvae, length approx. 1 cm. Ø 1mm) were collected manually using tweezers, to a total mass of approx. 50 g. Larvae were allowed approx. 24 hrs in clean water to empty their gastrointestinal system before homogenization and analysis.

3.1.3 Ruffe, stomach content, perch and pike

Ruffe and perch of the benthic food chain were collected using a series of bottom nets (12 – 45 mm mesh) in the area specified in Figure 1. 15 specimens of each species were pooled into 6 samples for analysis (whole body for ruffe; muscle and liver for perch). Stable isotopes of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) and were performed on individual muscle samples (n=15). The stomach content of about 50 individual ruffe was dissected into 1 sample for chemical analysis. Pike was caught by local anglers in the same area, using handheld equipment from boat.

3.1.4 Brown trout

Brown trout (*Salmo trutta*) were collected in an area outside Gjøvik (Lake Mjøsa) and in Lake Femunden (Figure 2) using series of bottom nets during the period July 1st – October 1st. 15 individuals were sampled from both lakes, and stable isotopes were determined in all individuals. In Lake Femunden, 15 individuals were pooled into 3 samples for chemical analysis.

[5] According to the Norwegian Environment Agency guidelines for risk assessment of contaminated sediment (M-409/2015)

3.2 QA/QC – chemical analyses

In Table 6 (separate tables for each main contaminant group) there is a short method description, including LOQ and an assessment and categorization of the uncertainty for every individual compound analyzed. The uncertainty is divided in three groups from 1-3.

Group 1 includes the compounds with the highest certainty. For the compounds in this group the method is vel establish, not only at NIVA/NILU, but also internationally. That means the quality of this analysis have been proven with intercalibration studies and quality parameters are good. Most of these analyses is accredited according to ISO 17025.

Group 2 includes the compounds with medium certainty. The internal control parameters in the lab are good. the method is fit for purpose, but the quality cannot, or have not been proven within intercalibration studies. These group also includes parameters that has been tested in intercalibration studies, but the results within the studies show that the uncertainty of this analysis still is high (typically more than 50%).

Group 3 includes the compounds with the highest uncertainty. This could be due to not satisfying recovery data, method not fit for purpose, high variability in blanks, or others. There will be comments on all these parameters.

3.2.1 Method information.

Uncertainty categories:

1. Results from analysis of control samples (spikes and blanks etc) are accurate and precise. The laboratory has participated in and has passed ring-tests and proficiency tests for this analysis. Results are considered to be very reliable.

2. Results from analysis of control samples (spikes and blanks etc) are accurate and precise. The laboratory has not participated in proficiency tests for this analysis, or ring-tests included too few participants to be reliable. Results are considered to be reliable.

3. Results from analysis of control samples (spikes and blanks etc) are variable and the analytical precision is not acceptable (results are highly scattered, and not to be considered in group 1 or 2). Results of these analyses are considered to be least reliable.

3.2.2 Tables of blanks, LOQ and uncertainty

Table 6. Tables for blanks, LOQ and uncertainty of the different contaminant groups.

3.2.3 UV-Compounds, method information.

Parameter group	Name parameter	CAS Number	Blank subtraction and determination of LOQ	LOQ range ng/g or ng/L	Method	Uncertainty category
UV compounds	Benzophenone-3	131-57-7	Three blanks per batch. Blank-subtraction and LOQ based on average signal of blanks + 3*std. Octocylene usually has the highest levels in blanks.	0.2-0.4	Internal Standard (IS) added. Samples then extracted twice, followed by clean-up via GPC and/or PSA. GC-MS/MS detection	2
	Ethylhexylmethoxycinnamate (EHMZ-Z)	5466-77-3		0.05-0.3		2
	Ethylhexylmethoxycinnamate (EHMZ-E)	5466-77-3		0.05-0.3		2
	Octocrylene	6197-30-4		0.5-2		2
	UV-327	3864-99-1		0.1-1		2
	UV-328	25973-55-1		0.1-1		2
	UV-329	3147-75-9		0.2-5		3
	Homosalate	118-56-9		1-5		2
	3-(2H-benzotriazol-2-yl)-5-(1,1-dimethylethyl)-4-hydroxy-benzenepropanoic acid I (M1-UV328)	84268-36-0	One blank pr batch. LOQ based on 10 x signal-to-noise as measured in each sample	0.5-1	IS added. Solid samples then extracted twice, and water samples pre-concentrated on SPE. LC-MS/MS detection	2

Comments to UV compounds:
Tests of the extraction and analysis recovery of UV-329 based on spiking experiments give results outside the range of 60-140%. The measured results of the analysis of complex samples (such as liver) could be overestimates as a consequence. A new internal standard will be tried out to improve the recovery. The pattern of the blank has changed a bit from earlier years, but it seems not to have changed the results.

3.2.4 PFAS. Method information.

Parameter group	Name parameter	CAS Number	Blank subtraction and determination of LOQ	LOQ range, ng/g	Method	Uncertainty category
PFAS	*PFCA*					
	TFA	76-05-1	One blank per batch. LOQ as validated and externally controlled in proficiency testing.	5	Internal standard is added and solid samples are extracted twice. Water samples are concentrated by freeze drying. LC-MS/MS detection	2
	PFPrA	422-64-0		0.5		2
	PFBA	375-22-4		0.5	Internal standard is added and solid samples are extracted twice. Water samples are concentrated on an SPE column. LC-QTOF-MS detection	2
	PFPA	422-64-0		0.5		2
	PFHxA	307-24-4		0.5		1
	PFHpA	335-67-1		0.5		2
	PFOA	375-95-1		0.5		1
	PFNA	335-76-2		0.5		1
	PFDcA	2058-94-8		0.4		1
	PFUnA	307-55-1		0.4		1
	PFDoA	72629-94-8		0.4		1
	PFTriA	376-06-7		0.4		1
	PFTeA	67905-19-5		0.4		1
	PFHxDA	16517-11-6		0.4		2
	PFOcDA	16517-11-6		0.4		2
	PFSA					
	PMeS	1493-13-6	One blank per batch. LOQ as validated and externally controlled in proficiency testing.	0.1	Same method as for TFA	2
	PFEtS	354-88-1		0.1		2
	PFPrS	423-41-6		0.1		2
	PFBS	375-73-5		0.2	Internal standard is added and solid samples are extracted twice. Water samples are concentrated on an SPE column. LC-QTOF-MS detection	1
	PFPS	2706-91-4		0.2		2
	PFHxS	355-46-4		0.1		1
	PFHpS	375-92-8		0.1		1
	PFOS	2795-39-3		0.05		1
	brPFOS	1763-23-1		0.05		2
	PFNS	17202-41-4		0.1		2
	PFDcS	67906-42-7		0.2		1
	PFUnS	441296-91-9		0.2		2
	PFDoS	79780-39-5		0.2		2
	PFTrS	749786-16-1		0.3		2

Parameter group	Name parameter	CAS Number	Blank subtraction and determination of LOQ	LOQ range, ng/g	Method	Uncertainty category
	PFTeS	n/a		0.3		3
	nPFAS					
	PFBSA	30334-69-1	One blank per batch. LOQ as validated and externally controlled in proficiency testing.	0.3	Internal standard is added and solid samples are extracted twice. Water samples are concentrated on an SPE column. LC-QTOF-MS detection	2
	N-MeFBSA	68298-12-4		0.3		2
	N-EtFBSA	40630-67-9		0.3		2
	PFOSA	754-91-6		0.1		1
	meFOSA	31506-32-8		0.3		2
	etFOSA	4151-50-2		0.3		2
	meFOSE	24448-09-7		1.0		2
	etFOSE	1691-99-2		1.0		2
	etFOSAA	2991-50-6		0.3		2
	newPFAS					
	4:2 FTS	757124-72-4	One blank per batch. LOQ as validated and externally controlled in proficiency testing.	0.3	Internal standard is added and solid samples are extracted twice. Water samples are concentrated on an SPE column. LC-QTOF-MS detection	2
	6:2 FTS	27619-97-2		0.3		2
	8:2 FTS	481071-78-7		0.3		2
	10:2 FTS	120226-60-0		0.3		2
	12:2 FTS	149246-64-0		0.3		3
	NaDONA	958445-44-8		0.3		2
	PFECHS	67584-42-3		0.3		2
	HFPO-DA (Gen-X)	13252-13-6		0.3		3

Comments to PFAS:
PFTeS, 12:2 FTS and HFPO-DA (Gen-X): Reference standard materials were unavailable for these compounds. Uncertainty category is therefore reported as 3. However, knowledge from similar compounds provides confidence and we judge the results to be reliable.
brPFOS: The reference standard for branched PFOS is provided as a technical mixture. It is therefore difficult to get reliable results on spiked samples. It is possible that additional branched PFOS have not been reported, but the results here present the most significant.

3.2.5 Quaternary ammonium compounds, QAC. Method information.

Parameter group	Name parameter	CAS Number	Blank subtraction and determination of LOQ	LOQ range, ng/g or ng/L	Method	Uncertainty category
Quaternary ammonium compounds	DADMAC-C8	3026-69-5	Three blanks per batch. Blank-subtraction and LOQ based on average signal of blanks + 3*std.	5	Internal Standard (IS) added. Samples are then extracted twice before clean-up via SPE. LC-MS/MS detection	2
	DADMAC-C10	2390-68-3		50		2
	DADMAC-C12	3282-73-3		5		2
	DADMAC-C14	68105-02-2		1		2
	DADMAC-C16	70755-47-4		5		2
	DADMAC-C18	3700-67-2		5		2
	BAC-C8	959-55-7		5		2
	BAC-C10	965-32-2		5		2
	BAC-C12	139-07-1		25		2
	BAC-C14	139-08-2		25		2
	BAC-C16	122-18-9		25		2
	BAC-C18	122-19-0		25		2
	ATAC-C8	2083-68-3		5		2
	ATAC-C10	2082-84-0		5		2
	ATAC-C12	1119-94-4		5		2
	ATAC-C14	1119-97-7		50		2
	ATAC-C16	57-09-0		50		2
	ATAC-C18	1120-02-1		50		2
	ATAC-C20	15809-05-9		25		2
	ATAC-C22	17301-53-0		5		2

Comments to QACs: The method has been significant improved since earlier years and the blank, and then also the LOQs has been reduced. The results are now considered have higher certainty than earlier years.

3.2.6 Benzothiazoles. Method information.

Parameter group	Name parameter	CAS Number	Blank subtraction and determination of LOQ	LOQ range, ng/g or ng/L	Method	Uncertainty category
Benzothiazoles	Mercaptobenzothiazole (meBZT	149-30-4	One blank per batch. LOQ based on 10 x signal-to-noise as measured in each sample	1.0	Internal Standard (IS) added. Solid samples are then extracted twice, while water samples are pre-concentrated on SPE. LC-MS/MS detection	2
	Benzotriazole BZT	95-14-7		0.5		2
	Benzothiazole (BT)	95-16-9		10.0		2
	2(3H)-Benzothiazolone (HBT)	934-34-9		1		2
	metyl-1H-benzotriazole	29385-43-1		0.5		2
	N-cyclohexylbenzothiazole-2-sulfenamide	95-33-0		1.0		2
	Cl-benzotriazole	94-97-3		0.5		2
	6 PPD quinone	No CAS		0.5		2

3.2.7 Metals. Method information.

Parameter group	Compound	Cas no	Blank	LOD range (mg/kg)	LOQ range (mg/kg)	Method	Uncertainty category
Metals Biota	Sc	7440-20-2	Method blanks following sample series. LOD/LOQ based on calculation of 3 and 10 stddev respectively	0.0001-0.0002	0.0005-0.001	In-house accredited method. Microwave assisted decomposition with HNO3. Analysed by ICP-MS (Agilent 7700x).	2
	V	7440-62-2		0.001-0.002	0.005-0.01		1
	Cr	7440-47-3		0.0001-0.0005	0.001-0.002		1
	Mn	7439-96-5		0.0001-0.0002	0.0005-0.001		1
	Fe	7439-89-6		0.002-0.01	0.02-0.1		1
	Co	7440-48-4		0.0001-0.0002	0.0005-0.001		1
	Ni	7440-02-0		0.0002-0.0005	0.001-0.002		1
	Cu	7440-50-8		0.0005-0.001	0.002-0.005		1
	Zn	7440-66-6		0.002-0.005	0.01-0.05		1
	As	7440-38-2		0.0001-0.0002	0.0005-0.001		1
	Y	7440-65-5		0.00005-0.0001	0.0002-0.0005		2*
	Ag	7440-22-4		0.0001-0.0002	0.0005-0.001		1*
	Cd	7440-43-9		0.0001-0.0002	0.0004-0.001		1
	Sn	7440-31-5		0.0005-0.001	0.002-0.005		2*
	Sb	7440-36-0		0.0001-0.0001	0.0005-0.001		1
	La	7439-91-0		0.00003-0.0001	0.0002-0.0005		2
	Ce	7440-00-8		0.00003-0.00010	0.0002-0.0005		2*
	Pr	7440-10-0		0.00001-0.0001	0.0002-0.0005		2
	Nd	7440-00-8		0.00004-0.0001	0.0002-0.0005		2*
	Sm	7440-19-9		0.00001-0.0001	0.0002-0.0005		2*
	Eu	7440-53-1		0.00005-0.0001	0.0002-0.0005		2*
	Gd	7440-53-2		0.00005-0.0001	0.0002-0.0005		2*
	Tb	7440-27-9		0.00001-0.0001	0.0002-0.0005		2*
	Dy	7429-91-6		0.00001-0.0001	0.0002-0.0005		2*
	Ho	7440-60-0		0.00001-0.0001	0.0002-0.0005		2*
	Er	7440-52-0		0.00001-0.0001	0.0002-0.0005		2*

Parameter group	Compound	Cas no	Blank	LOD range (mg/kg)	LOQ range (mg/kg)	Method	Uncertainty category
	Tm	7440-28-0		0.00001-0.0001	0.0002-0.0005		2*
	Yb	7440-64-0		0.00001-0.0001	0.0002-0.0005		2*
	Lu	7439-94-3		0.00001-0.0001	0.0002-0.0005		2*
	Pb	7439-92-1		0.0001-0.0003	0.0005-0.001		1
	Hg	7440-02-0		0.0002-0.0004	0.0007-0.001	In-house accredited method. Microwave assisted decomposition with HNO_3. digestate stabilized with HCl. Analysed by ICP-MS (Agilent 7700x).	1

*Not accredited

3.2.8 Metals cont. Method information.

Parameter group	Compound	Cas no	Blank	LOD range (mg/kg)	LOQ range (mg/kg)	Method	Uncertainty category
Metals Sediment	Sc	7440-20-2	Method blanks following sample series. LOD/LOQ based on calculation of 3 and 10 stddev respectively	0.001-0.002	0.005-0.01	In-house accredited method. Microwave assisted decomposition with HNO3. Analysed by ICP-HRMS (ELEMENTZ).	2
	V	7440-62-2		0.01-0.02	0.05-0.1		1
	Cr	7440-47-3		0.001-0.002	0.005-0.01		1
	Mn	7439-96-5		0.001-0.002	0.005-0.01		1
	Fe	7439-89-6		0.02-0.1	0.2-0.5		1
	Co	7440-48-4		0.001-0.002	0.005-0.01		1
	Ni	7440-02-0		0.002-0.005	0.01-0.02		1
	Cu	7440-50-8		0.005-0.01	0.02-0.05		1
	Zn	7440-66-6		0.02-0.05	0.1-0.2		1
	As	7440-38-2		0.001-0.002	0.005-0.01		1
	Y	7440-65-5		0.0005-0.001	0.002-0.005		2*
	Ag	7440-22-4		0.001-0.002	0.005-0.01		1*
	Cd	7440-43-9		0.001-0.002	0.005-0.01		1
	Sn	7440-31-5		0.005-0.01	0.02-0.05		2*
	Sb	7440-36-0		0.001-0.002	0.005-0.01		1
	La	7439-91-0		0.0002-0.001	0.002-0.003		2
	Ce	7440-00-8		0.0003-0.001	0.002-0.003		2*
	Pr	7440-10-0		0.0001-0.001	0.002-0.003		2
	Nd	7440-00-8		0.0004-0.001	0.002-0.003		2*
	Sm	7440-19-9		0.0001-0.001	0.002-0.003		2*
	Eu	7440-53-1		0.000-0.001	0.002-0.003		2*
	Gd	7440-53-2		0.0005-0.001	0.002-0.003		2*
	Tb	7440-27-9		0.0001-0.001	0.002-0.003		2*
	Dy	7429-91-6		0.0001-0.001	0.002-0.003		2*
	Ho	7440-60-0		0.0001-0.001	0.002-0.003		2*
	Er	7440-52-0		0.0001-0.001	0.002-0.003		2*

Parameter group	Compound	Cas no	Blank	LOD range (mg/kg)	LOQ range (mg/kg)	Method	Uncertainty category
	Tm	7440-28-0		0.0001-0.001	0.002-0.003		2*
	Yb	7440-64-0		0.0001-0.001	0.002-0.003		2*
	Lu	7439-94-3		0.0001-0.001	0.002-0.003		2*
	Pb	7439-92-1		0.001-0.002	0.005-0.01		1
	Hg	7440-02-0		0.0006-0.001	0.001-0.002	In-house accredited method. Filtration of water. Microwave assisted decomposition of particles on filter with HNO3. Digestate stabilized with HCl. Analysed by ICP-MS (Agilent 7700x).	1

*Not accredited

3.2.9 PBDEs. Method information.

Parameter group	Name parameter	Cas no	Blank	LOD range ng/g ng/g (ng/L)	LOQ range ng/g (ng/L)	Method	Uncertainty category	Stable isotope labeled (SIL) analogue
PBDE	TBA	607-99-8	Method blanks following sample series. LOD/LOQ based on calculation of 3 and 10 stddev respectively	0.003-0.02	0.006-0.04	In-house method. Internal standard addition, extraction, GPC and/or H2SO4 cleanup followed by adsorption chromatography. GC/HRMS (autspec)	2	N
	BDE-17	147217-75-2		0.003-0.02	0.01-0.05		2	N
	BDE-28	41318-75-6		0.003-0.02	0.01-0.05		1	Y
	BDE-47	5436-43-1		0.03-0.2	0.07-0.6		2	N
	BDE-49	123982-82-3		0.002-0.02	0.006-0.05		2	N
	BDE-66	189084-61-5		0.006-0.07	0.02-0.2		2	N
	BDE-71	189084-62-6		0.001-0.01	0.003-0.02		2	N
	BDE-77	93703-48-1		0.002-0.01	0.006-0.02		2	N
	BDE-85	446254-52-0		0.003-0.01	0.01-0.02		2	N
	BDE-99	60348-60-9		0.006-0.1	0.01-0.2		1	Y
	BDE-100	189084-64- 8		0.003-0.03	0.007-0.08		2	N
	BDE-119	189084-66-0		0.002-0.01	0.006-0.03		2	N
	BDE-126	366791-32-4		0.001-0.01	0.003-0.02		2	N
	BDE-138	182677-30-1		0.005-0.02	0.01-0.05		2	N
	BDE-153	68631-49-2		0.004-0.03	0.01-0.09		1	Y
	BDE-154	207122-15-4		0.004-0.02	0.01-0.05		2	N
	BDE-156	405237-85-6		0.007-0.03	0.02-0.07		2	N
	BDE-183	207122-16-5		0.004-0.02	0.01-0.05		1	Y
	BDE-184	117948-63-7		0.003-0.02	0.01-0.04		2	N
	BDE-191	446255-30-7		0.003-0.02	0.01-0.06		2	N
	BDE-196	32536-52-0		0.005-0.04	0.01-0.1		2	N
	BDE-197	117964-21-3		0.004-0.04	0.01-0.1		2	Y
	BDE-202	67797-09-5		0.006-0.04	0.02-0.1		2	N
	BDE-206	63387-28-0		0.04-0.1	0.1-0.3		2	Y
	BDE-207	437701-79-6		0.02-0.1	0.07-0.2		2	N
	BDE-209	1163-19-5		0.5-2	1.4-7		2	Y

3.2.10 Chlorinated paraffins. Method information.

Parameter group	Name parameter	Cas no	Blank	LOD range ng/g (ng/L)	LOQ range ng/g (ng/L)	Method	Uncertainty category	Stable isotope labeled (SIL) analogue
CP	SCCP	85535-84-8	Method blanks following sample series. S, M and LCCP are corrected for blanks prior to deconvolution. Results are corrected for blanks. Blanks are subtracted on congener group level prior to deconvolution. LOD/LOQ based on calculation of 3 and 10 stddev respectively	3-50	10-170	In-house method. Internal standard addition, extraction, H2SO4 cleanup followed by adsorption chromatography. In some cases with high levels of sulfur and/or PCB an additional cleanup with florsil is needed. GC-qToF 7200 in ECNI	3	13C-hexachlorodecane
	MCCP	85535-85-9		1-70	3-230		3	
	LCCP	63449-39-8		0.5-2	1.7-10	In-house method. Internal standard addition, extraction, GPC and/or H2SO4 cleanup followed by adsorption chromatography. Agilent LC-qToF 6546	3	

3.2.11 Siloxanes. Method information.

Parameter group	Name parameter	Cas nr	Blank	LOQ range ng/g or ng/L	Method	Uncertainty category	Stable isotope labeled (SIL) analogue
Siloxanes, biota/sediment	D4 - octamethylcyclotetrasiloxane	556-67-2	Three blanks per batch. Blank subtraction for each batch based on the blank average. LOQ calculated from 10 x stdev. From blanks	0.255-0.6383	To 1-2 g of sample, ^{13}C D4, D5 and D6 were added as internal standard, followed by addition of acetonitrile and hexane. Ultrasonic bath and shaking before centrifugation. No further cleanup. Recovery standard added to a sub sample before analysis on GC/MSD. As described in previous MILFERSK/Urban fjord reports. No standard was available for L9-L10, and we used a crude product to estimate the retention time and transitions.	2	Y
	D5 - decamethylcyclopentasiloxane	541-02-6		0.174-0.910		2	y
	D6 - dodecamethylcyclohexasiloxane	540-97-6		0.316-1.20		2	y
	M3T (Ph)			0.035-0.791		2	N
	L3 - octamethyltrisiloxane	107-51-7		0.167-0.513		2	N
	L4 - decamethyltetrasiloxane	141-62-8		0.764-2.50		2	N
	L5 - dodecamethylpentasiloxane	141-63-9		2.23-10.02		2	N
	D3F - tris-(trifluoropropyl)trimethylcyclotrisiloxane	2374-14-3		2-50		2	N
	D4F - tetrakis-(trifluoropropyl)tetramethylcyclotetrasiloxane	429-67-4		3-30		2	N

3.2.12 Musks. Method information.

Parameter group	Name parameter	Cas nr	Blank	LOQ range ng/g or ng/L	Method	Uncertainty category	Stable isotope labeled (SIL) analogue
Musk, biota	Traseolide	68857-95-4	Three blanks pr batch. All extraction was done in clean room or clean cabinet. LOQ based on calculation of background in the instrument analysis.	0.132-1.24	1 g sample was mixed with Na2SO4, added d11-Tonalide as internal standard, and extracted with acetone/hexane (1:3). After up-concentration the extract was cleaned up with EZ-POP. The extracts were analysed on a GC/MSD with EI ionization. 5 µL of the extract were injected on a DB5 column with 5 m pre column.	3	N
	Phantolide	15323-35-0		0.029-0.28		3	N
	Otne	54464-57-2		0.132-1.24		3	N
	Acetyl cedrene	32388-55-9		0.132-1.24		3	N
	Galaxolide	1222-05-5		0.068-0.64		3	N
	AHMT/Tonalide	21145-77-7		0.132-1.24		3	Y
	Celestolide	13171-00-1		0.021-0.18		3	N

3.2.13 oPFR- and phthalate metabolites. Method information.

Compound group	Compound name	Short name	Cas no	Blank	Method	LOD range ng/g	LOQ range ng/g	Uncertainty category	Stable isotope labelled (SIL) analogue?
oPFR-metabolites	Bis(2-chloroethyl) phosphate	BCEP	3040-56-0	Method blanks following sample series. LOD/LOQ based on calculation of 3 and 10 stdev respectively (or instrument detection limit if this is higher)	In-house method. Extraction, deconjugation, Internal standard addition, clean-up using SPE. LC/HRMS (orbitrap)	5-15	20-40	3	Y
	Bis(2-chloropropyl) phosphate	BCPP	789440-10-4			1-3	5-7	3	N
	Diphenyl phosphate	DPP	838-85-7			3-5	10-15	3	N
	Bis (1,3-dichloro-2-propyl) phosphate	BDCPP	72236-72-7			1-3	5-7	3	Y
	Di n-butyl phosphate	HDBP	107-66-4			1000-2000	3000-4000	3	Y
	Bis(2-butoxyhexyl) phosphate	BBOEP	14260-97-0			15-25	30-60	3	Y
	Di(2-ethylhexyl) phosphate	HDEHP	298-07-7			4-8	10-20	3	N
Phthalate metabolites	Monomethyl phthalate	MMP	4376-18-5	Method blanks following sample series. LOD/LOQ based on calculation of 3 and 10 stdev respectively (or instrument detection limit if this is higher)	In-house method. Internal standard addition, extraction, clean-up using SPE. LC/HRMS (orbitrap)	5-20	10-30	3	N
	Monoethyl phthalate	MEP	2306-33-4			30-40	70-100	3	Y
	Monobutyl phthalate	MNBP/MIBP	30833-53-5			30-50	80-120	3	Y
	Mono(2-ethyl-5-oxohexyl) phthalate	MEOHP	131-70-4			0.5-2	2-4	3	N
	Monobenzyl phthalate	MBzP	2528-16-7			0.5-2	2-4	3	Y
	Mono(2-ethyl-5-hydroxyhexyl) phthalate	MEHHP	40321-99-1			0.5-2	2-4	3	N
	Mono(2-ethylhexyl) phthalate	MEHP	4376-20-9			5-20	20-30	3	Y

3.3 List of contaminants and support parameters

Table 7. Analytes and support parameters included in the programme.

Substances	Abbreviation	CAS
Metals		
Mercury	Hg	7440-02-0
Chromium	Cr	7440-47-3
Nickel	Ni	7440-02-0
Copper	Cu	7440-50-8
Zinc	Zn	7440-66-6
Arsenic	As	7440-38-2
Silver	Ag	7440-22-4
Cadmium	Cd	7440-43-9
Lead	Pb	7439-92-1
Antimony	Sb	7440-36-0
Tin	Sn	7440-31-5
Iron	Fe	7439-89-6
Rare earth metals	Sc, Y, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu	
Siloxanes		
2,2,4,4,6,6,8,8-Octamethyl-1,3,5,7,2,4,6,8-tetroxatetrasilocane	D4	556-67-2
2,2,4,4,6,6,8,8,10,10-Decamethyl-1,3,5,7,9,2,4,6,8,10-pentoxapentasilecane	D5	541-02-6
Dodecamethylcyclohexasiloxane	D6	540-97-6
tris(trimethylsiloxy)phenylsilane	M3T(Ph)	2116-84-9
Octamethyltrisiloxane (L3)	L3	107-51-7
Decamethyltetrasiloxane (L4)	L4	141-62-8
Dodecamethylpentasiloxane (L5)	L5	141-63-9
2,4,6-Trimethyl-2,4,6-tris(3,3,3-trifluoropropyl)cyclotrisiloxane (D3F)	D3F	2374-14-3
2,4,6,8-tetramethyl-2,4,6,8-tetrakis(3,3,3-trifluoropropyl)cyclotetrasiloxane (D4F)	D4F	429-67-4

Substances	Abbreviation	CAS
PBDEs Polybrominated diphenyl ethers		
2,2',4-Tribromodiphenyl ether	BDE-17	147217-75-2
2,4,4'-Tribromodiphenyl ether	BDE-28	41318-75-6
2,2',4,4'-Tetrabromodiphenyl ether	BDE-47	5436-43-1
2,2',4,5'-Tetrabromodiphenyl ether	BDE-49	123982-82-3
2,3',4,4'-Tetrabromodiphenyl ether	BDE-66	189084-61-5
2,3',4',6-Tetrabromodiphenyl ether	BDE-71	189084-62-6
3,3',4,4'-Tetrabromodiphenyl ether	BDE-77	93703-48-1
2,2',3,4,4'-Pentabromodiphenyl ether	BDE-85	182346-21-0
2,2',4,4',5-Pentabromodiphenyl ether	BDE-99	60348-60-9
2,2',4,4',6-Pentabromodiphenyl ether	BDE-100	189084-64- 8
2,3',4,4',6-Pentabromodiphenyl ether	BDE-119	189084-66-0
3,3',4,4',5-Pentabromodiphenyl ether	BDE-126	366791-32-4
2,2',3,4,4',5'-Hexabromodiphenyl ether	BDE-138	182677-30-1
2,2',4,4',5,5'-Hexabromodiphenyl ether	BDE-153	68631-49-2
2,2',4,4',5,6'-Hexabromodiphenyl ether	BDE-154	207122-15-4
2,3,3',4,4',5-Hexabromodiphenyl ether	BDE-156	405237-85-6
2,2',3,4,4',5',6-Heptabromodiphenyl ether	BDE-183	207122-16-5
2,2',3,4,4',6,6'-Heptabromodiphenyl ether	BDE-184	117948-63-7
2,3,3',4,4',5',6-Heptabromodiphenyl ether	BDE-191	446255-30-7
2,2',3,3',4,4',5',6-Octabromodiphenyl ether	BDE-196	32536-52-0
2,2',3,3',4,4',6,6'-Octabromodiphenyl ether	BDE-197	117964-21-3
2,2',3,3',5,5',6,6'-Octabromodiphenyl ether	BDE-202	67797-09-5
2,2',3,3',4,4',5,5',6-Nonabromodiphenyl ether	BDE-206	63387-28-0
2,2',3,3',4,4',5,6,6'-Nonabromodiphenyl ether	BDE-207	437701-79-6
Decabromodiphenyl ether	BDE-209	1163-19-5
Per- and polyfluoroalkyl substances (PFAS)		
PFCA		

Substances	Abbreviation	CAS
(Perfluorinated carboxylate acids)		
Tri fluoro acetic acid	TFA	76-05-1
Perfluoro propanoic acid	PFPrA	422-64-0
Perfluorinated butanoic acid	PFBA	375-22-4
Perfluorinated pentanoic acid	PFPA	2706-90-3
Perfluorinated hexanoic acid	PFHxA	307-24-4
Perfluorinated heptanoic acid	PFHpA	335-85-9
Perfluorinated octanoic acid	PFOA	335-67-1
Perfluorinated nonanoic acid	PFNA	375-95-1
Perfluorinated decanoic acid	PFDA	335-76-2
Perfluorinated undecanoic acid	PFUnDA	2058-94-8
Perfluorinated dodecanoic acid	PFDoDA	307-55-1
Perfluorinated tridecanoic acid	PFTrDA	72629-94-8
Perfluorinated tetradecanoic acid	PFTeDA	376-06-7
Perfluorinated hexadecanoic acid	PFHxDA	67905-19-5
Perfluorinated octadecanoic acid	PFOcDA	16517-11-6
PFSA (Perfluoroalkane sulfonic acids)		
Perfluoro methane sulfonic acid	PMeS	1493-13-6
Perfluoro ethan sulfonic acid	PFEtS	354-88-1
perfluoropropan sulfonic acid	PFPrS	423-41-6
Perfluorinated butane sulfonic acid	PFBS	375-73-5
Perfluorinated pentane sulfonic acid	PFPS	2706-91-4
Perfluorinated hexane sulfonic acid	PFHxS	355-46-4
Perfluorinated heptane sulfonic acid	PFHpS	375-92-8
Perfluorinated octane sulfonic acid (linear)	PFOS	1763-23-1
Perfluorinated octane sulfonic acid (branched)	brPFOS	2795-39-3
Perfluorinated nonane sulfonic acid	PFNS	474511-07-4
Perfluorinated decane sulfonic acid	PFDS	335-77-3

Substances	Abbreviation	CAS
Perfluoroundecane sulfonic acid	PFUnDS	749786-16-1
Perfluorododecane sulfonic acid	PFDoDS	79780-39-5
Perfluorotridecane sulfonic acid	PFTrDS	791563-89-8
Perfluorotetradecane sulfonic acid	PFTeDS	1379460-39-5
nPFAS (polyfluorinated neutral compounds)		
Perfluorobutylsulphonamide	PFBSA	30334-69-1
n-(methyl)nonafluorobutanesulfonamide	N-MeFBSA	68298-12-4
N-ethyl-perfluorobutane-1-sulfonamide	N-EtFBSA	40630-67-9
Perfluorooctane sulfonamide	PFOSA	754-91-6
N-Methyl perfluorooctane sulphonamide	meFOSA	31506-32-8
N-Ethyl perfluorooctane sulfonamide	etFOSA	4151-50-2
N-Methyl perfluorooctane sulfonamidoethanol	meFOSE	24448-09-7
N-Ethyl perfluorooctane sulfonamidoethanol	etFOSE	1691-99-2
N-Ethyl perfluorooctane sulfonamidoacetic acid	etFOSAA	2991-50-6
newPFAS		
4:2 Fluorotelomer sulfonic acid	4:2 FTS	757124-72-4
6:2 Fluorotelomer sulfonic acid	6:2 FTS	27619-97-2
8:2 Fluorotelomer sulfonic acid	8:2 FTS	39108-34- 4
10:2 Fluorotelomer sulfonic acid	10:2 FTS	120226-60-0
12:2 Fluorotelomer sulfonic acid	12:2 FTS	149246-64-0
Sodium dodecafluoro-3H- 4,8-dioxanonanoate	NaDONA	958445-44-8
Cyclohexanesulfonic acid	PFECHS	67584-42-3
2,3,3,3-Tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)propanoic acid (Gen-X)	HFPO-DA (Gen-X)	13252-13-6
Perfluoro-3,6-dioxaheptanoic acid	3,6-OPFHpA (Gen-X, NFDHA)	N/A
Perfluoro-5-oxahexanoic acid	PF5OHxA (Gen-X, PFMBA)	N/A
UV chemicals		
Benzophenone-3	BP3	131-57-7

Substances	Abbreviation	CAS
Ethylhexylmethoxycinnamate	EHMC	5466-77-3
Octocrylene	OC	6197-30-4
UV-327	UV-327	3864-99-1
UV-328	UV-328	25973-55-1
UV-329	UV-329	3147-75-9
Homosalate		118-56-9
3-(2H-benzotriazol-2-yl)-5-(1,1-dimethylethyl)-4-hydroxy-benzenepropanoic acid l	M1-UV328	84268-36-0
Quaternary ammonium compounds		
Dimethyldioctylammonium (DADMAC-C8)		3026-69-5
Didecyldimethylammonium (DADMAC-C10)		2390-68-3
Didodecyldimethylammonium (DADMAC-C12)		3282-73-3
Dimethylditetradecylammonium (DADMAC-C14)		68105-02-2
Dihexadecyldimethylammonium (DADMAC-C16)		70755-47-4
Dimethyldioctadecylammonium (DADMAC-C18)		3700-67-2
Benzyldimethyloctylammonium (BAC-C8)		959-55-7
Benzyldimethyldecylammonium (BAC-C10)		965-32-2
Benzyldimethyldodecylammonium (BAC-C12)		139-07-1
Benzyldimethyltetradecylammonium (BAC-C14)		139-08-2
Benzyldimethylhexadecylammonium (BAC-C16)		122-18-9
Benzyldimethyloctadecylammonium (BAC-C18)		122-19-0
Trimethyloctylammonium (ATAC-C8)		2083-68-3
Decyltrimethylammonium (ATAC-C10)		2082-84-0
Dodecyltrimethylammonium (ATAC-C12)		1119-94-4
Tetradecyltrimethylammonium (ATAC-C14)		1119-97-7
Hexadecyltrimethylammonium (ATAC-C16)		57-09-0
Trimethyloctadecylammonium (ATAC-C18)		1120-02-1
ATAC-C20		15809-05-9
ATAC-C22		17301-53-0
Musks		

Substances	Abbreviation	CAS
Traseolide		68140-48-7
Phantolide		15323-35-0
OTNE		54464-57-2
Acetyl cedrene		32388-55-9
Galaxolide		1222-05-5
AHMT		1506-02-1
Celestolide		13171–00–1
Tonalide		21145–77–7
Benzothiazoles		
Mercaptobenzothiazole	MBT	149-30-4
Benzotriazole	BTZ	95-14-7
Benzothiazole	BT	95-16-9
2(3H)-Benzothiazolone	OHBT	934-34-9
metyl-1H-benzotriazole	MeBZT	29385-43-1
N-cyclohexylbenzothiazole-2-sulfenamide	CBS	95-33-0
Cl-benzotriazole	Cl-BTZ	21050-95-3
Chlorinated paraffins		
Short-chain chlorinated paraffins (C10-C13)	SCCP	85535-84-8
Medium-chain chlorinated paraffins (C14-C17)	MCCP	85535-85-9
Long-chain chlorinated paraffins (C18-C30)	LCCP	63449-39-8
oPFR- and phthalate metabolites		
Bis(2-chloroethyl) phosphate	BCEP	3040-56-0
Bis(2-chloropropyl) phosphate	BCPP	789440-10-4
Diphenyl phosphate	DPP	838-85-7
Bis (1,3-dichloro-2-propyl) phosphate	BDCPP	72236-72-7
Di n-butyl phosphate	HDBP	107-66-4
Bis(2-butoxyhexyl) phosphate	BBOEP	14260-97-0
Di(2-ethylhexyl) phosphate	HDEHP	298-07-7
Monomethyl phthalate	MMP	4376-18-5

Substances	Abbreviation	CAS
Monoethyl phthalate	MEP	2306-33-4
Monobutyl phthalate	MNBP/MIBP	30833-53-5
Mono(2-ethyl-5-oxohexyl) phthalate	MEOHP	131-70-4
Monobenzyl phthalate	MBzP	2528-16-7
Mono(2-ethyl-5-hydroxyhexyl) phthalate	MEHHP	40321-99-1
Mono(2-ethylhexyl) phthalate	MEHP	4376-20-9
Support parameters		
Stable isotopes $\delta^{15}N$, $\delta^{13}C$		
Lipid content (biota)		
Age determination (fish)		
Length/weight (fish)		
TOC (sediment) and pH		
Grain size distribution (sediment)		

4 Appendix – Results: figures and tables

4.1 Contaminant flow through the benthic food chain

Concentrations of individual contaminants with detections across the sample types of the benthic food chain have been measured against the content of stable nitrogen isotope $\delta^{15}N$. Biomagnification occurs when TMF>1, indicated in the figures. Here we present some examples of contaminants not mentioned in chapter 2.12. The following species are included in the calculation:

- Chironomids (2021, 2022)
- Ruffe (2021, 2022)
- Ruffe stomach (2022)
- Roach (2021)
- Perch (2021, 2022)
- Pike (2022)

4.1.1 Examples of contaminants with TMF > 1

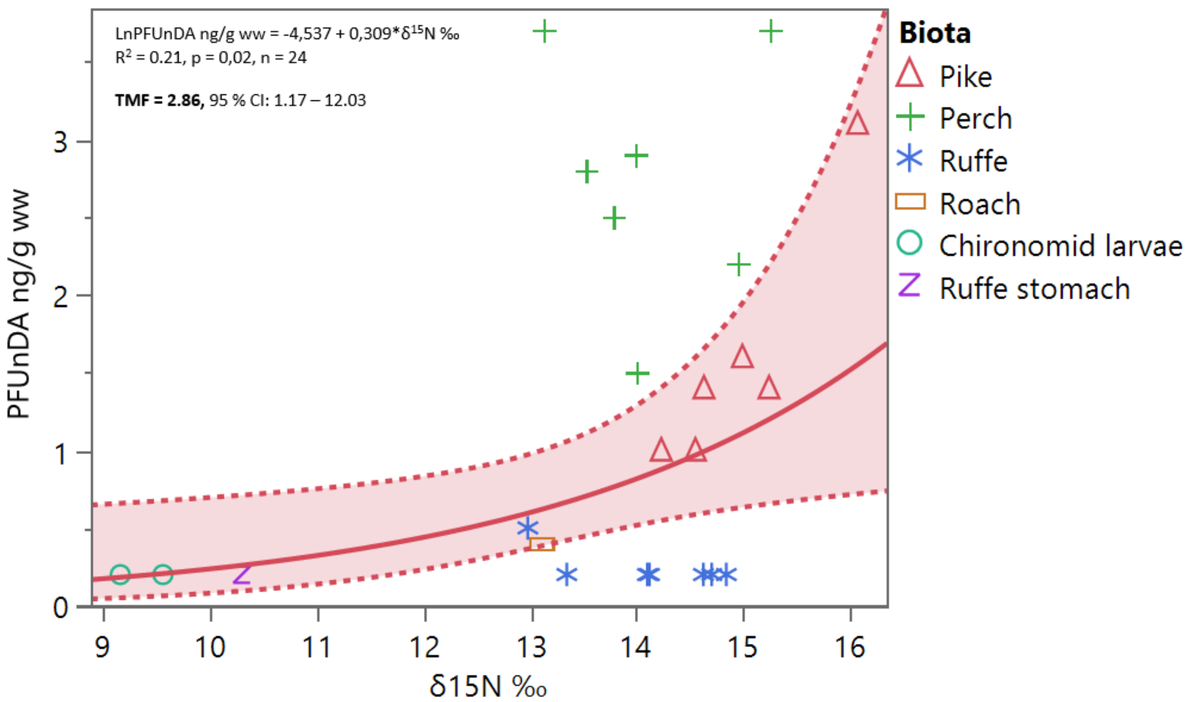


Figure 34. Biomagnification of the PFAS PFUnDA (a C11-chained carboxylic acid) in Lake Mjøsa, data from 2021 and 2022.

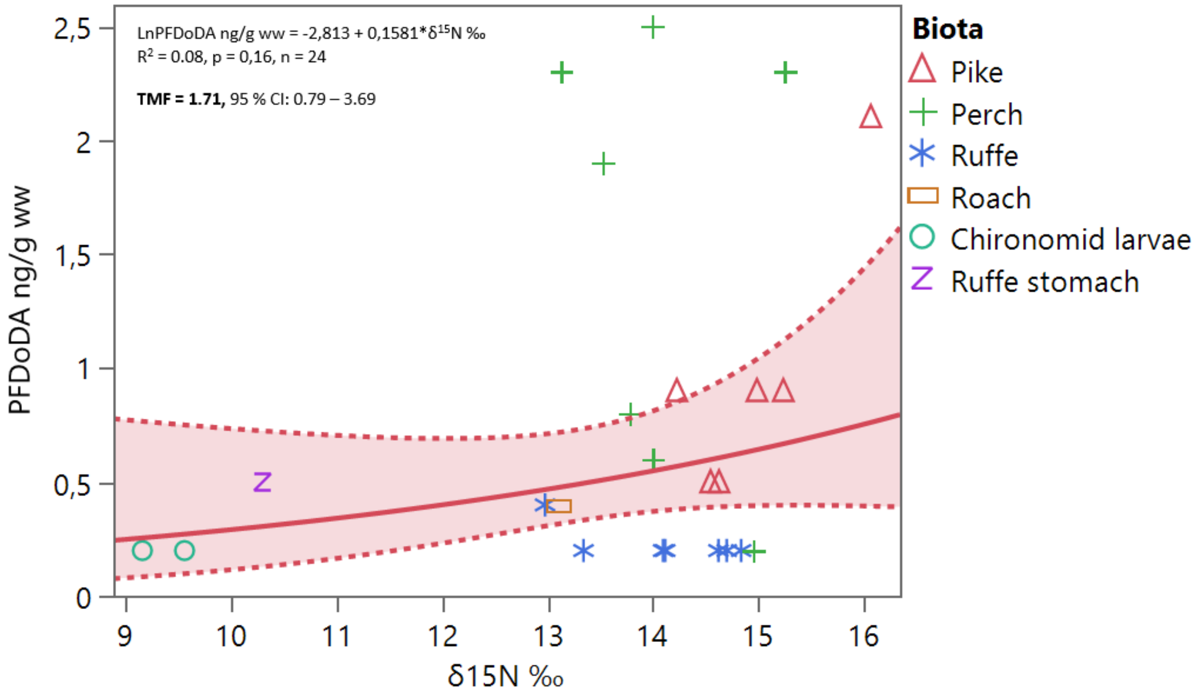


Figure 35. Biomagnification of the PFAS PFDoDA (a C12-chained carboxylic acid) in Lake Mjøsa, data from 2021 and 2022.

4.1.2 Contaminants with TMF < 1

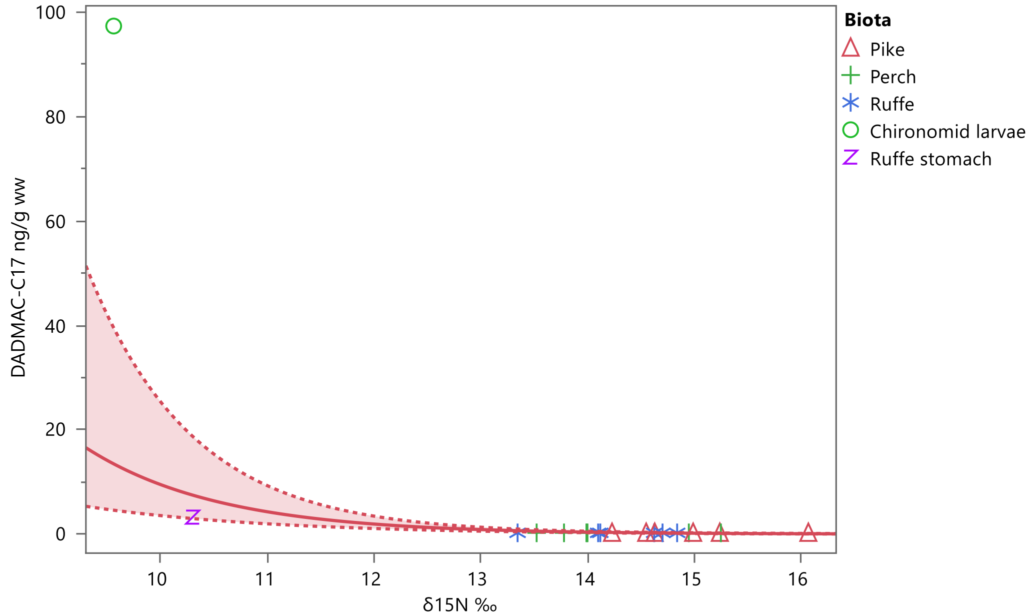


Figure 36. QAC-component DADMAC-17 occurring in higher concentrations in lower trophic levels, data from 2022.

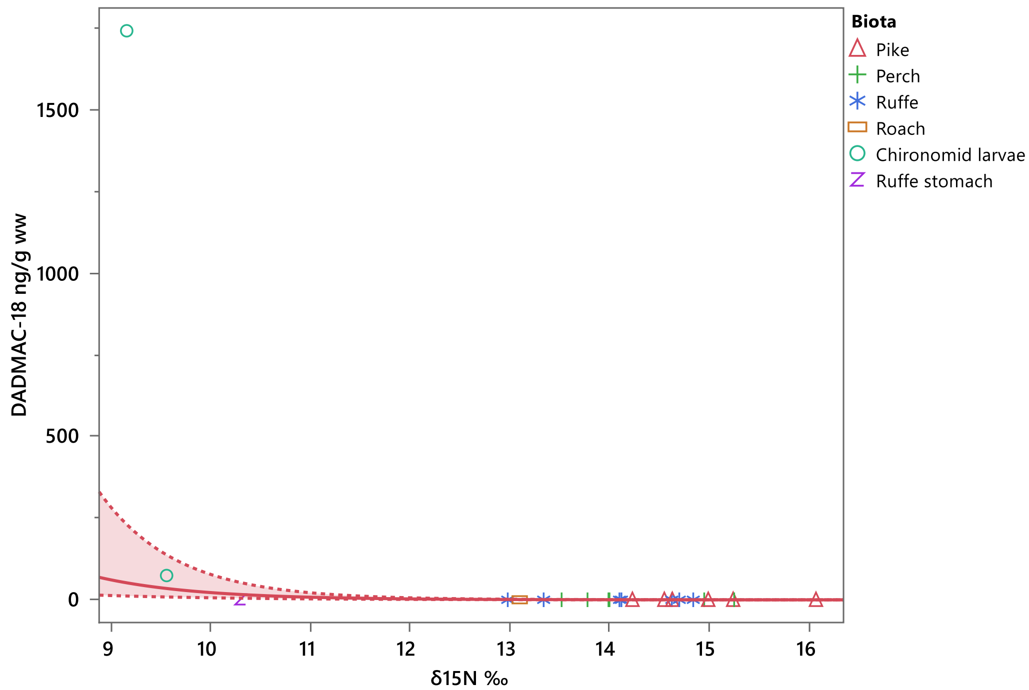


Figure 37. QAC-component DADMAC-18 occurring in higher concentrations in lower trophic levels, data from 2021 and 2022.

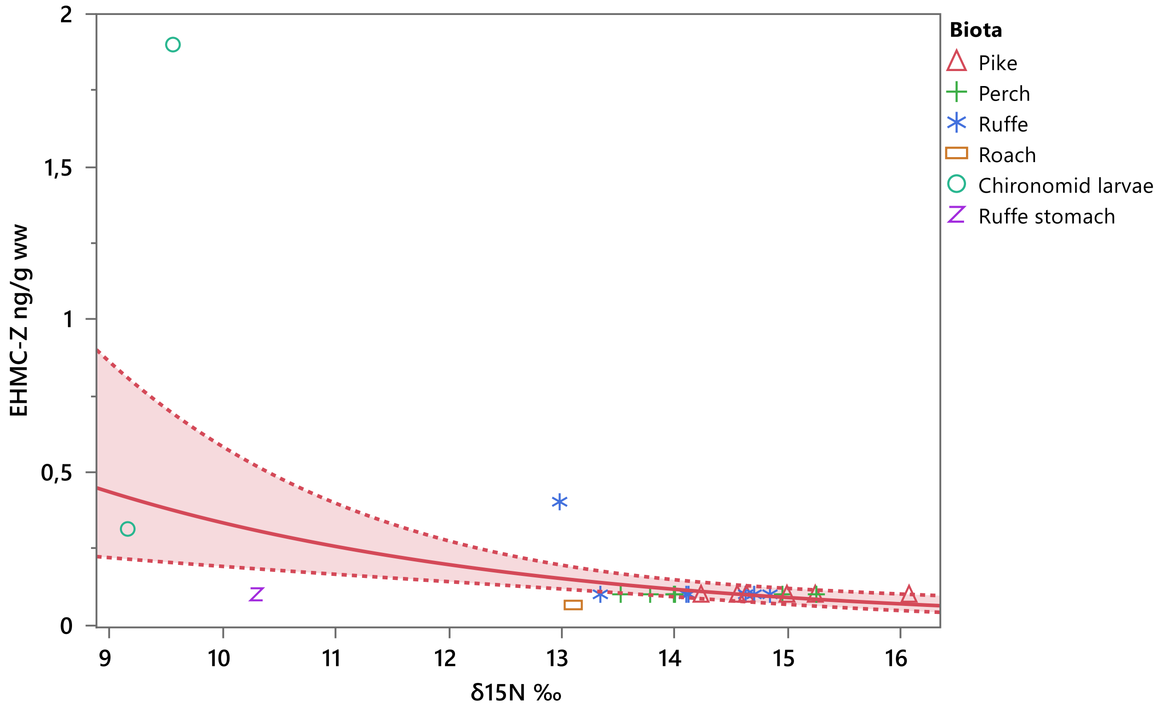


Figure 38. UV-component EHMC-Z occurring in higher concentrations in lower trophic levels, data from 2021 and 2022.

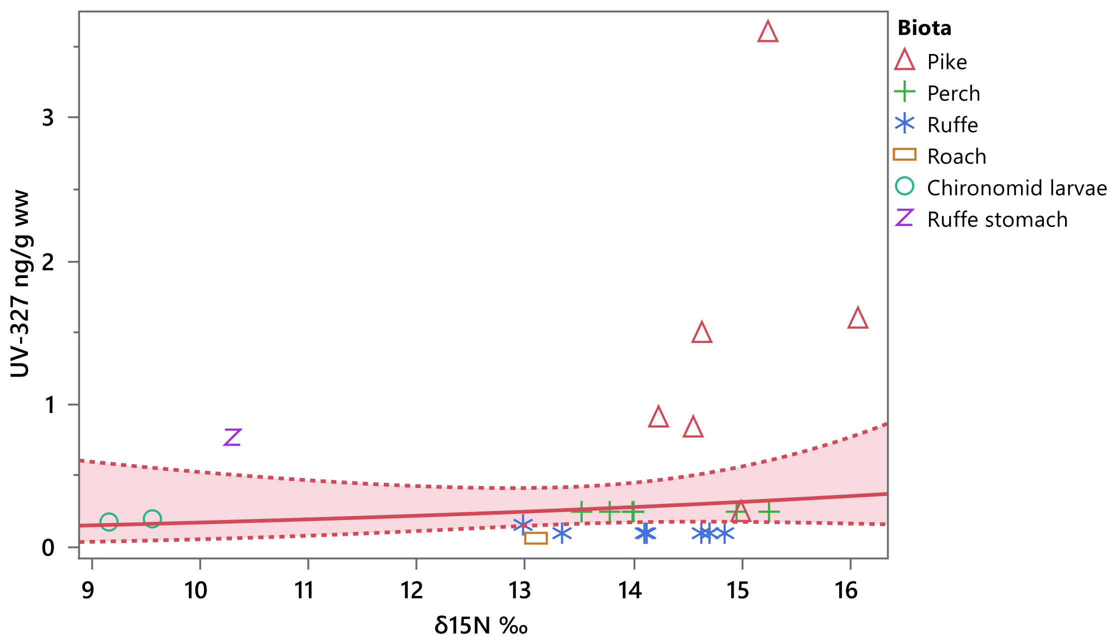


Figure 39. UV-component UV-327 occurring on average in equal concentrations in the benthic food chain, but visually higher in the predator pike (red triangle Δ). Data from 2021 and 2022.

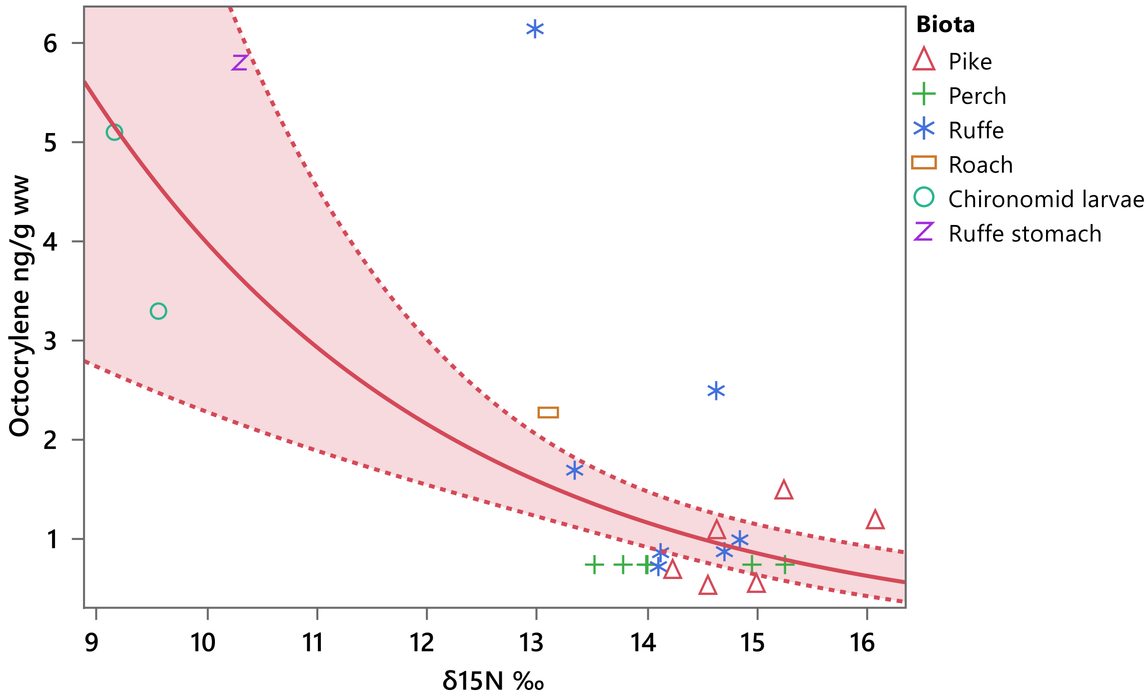


Figure 40. UV-compound octocrylene occurring in higher concentrations in lower trophic levels. Data from 2021 and 2022.

4.2 Tables for data results – contaminant groups

Table 8 to Table 20 provide the main results for each contaminant group, with:

- N, number of analyses
- Units (e.g. ng/g w.w.)
- Results with **mean** and **range** (min – max)

4.2.1 PFAS - PFCAs

Table 8. Tabulated results for PFCAs

PFCA	Sediment Mjøsa n=3	Chironomids n=1	Ruffe stomach Mjøsa n=1	Ruffe Mjøsa n=6	Perch Muscle n=6	Perch Liver n=6	Pike liver Mjøsa n=6	Brown trout Liver Mjøsa n=15	Brown trout Liver Femunden n=3
	ng/g d.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.
TFA	<0.5								
PFPrA	<0.5								
PFBA	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PFPA	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PFHxA	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PFHpA	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PFOA	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PFNA	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4 (<0.4 – **1.0**)	<0.4
PFDA	<0.4	<0.4	**0.5**	<0.4	<0.4	**1.55** (**1.1 – 2.1**)	**0.7** (**0.6 – 1.3**)	**1.4** (<0.4 – **4.3**)	**0.5** (**0.3 – 0.7**)
PFUnDA	<0.4	<0.4	**0.4**	<0.4	<0.4 (<0.4 – 0.6)	**2.6** (**1.5 – 3.7**)	**1.6** (**1.0 – 3.1**)	**3.3** (<0.4 – **9.5**)	**1.7** (**0.8 – 3.1**)
PFDoDA	<0.4	<0.4	**0.5**	<0.4	<0.4	**1.3** (<0.4 – **2.5**)	**0.9** (**0.5 – 2.1**)	**1.9** (<0.4 – **4.8**)	**0.6** (**0.3 – 1.2**)
PFTrDA	<0.4	<0.4	<0.4	<0.4	<0.4 (<0.4 – **0.6**)	**2.1** (<0.4 – **3.7**)	**1.0** (**0.7 – 1.8**)	**2.3** (<0.4 – **5.4**)	**3.8** (**1.1 – 8.5**)
PFTeDA	<0.4	<0.4	<0.4	<0.4	<0.4	**0.7** (<0.4 – **1.3**)	<0.4 (<0.4 – **0.5**)	**0.7** (<0.4 – **1.5**)	**0.5** (<0.4 – **1.5**)
PFHxDA	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
PFOcDA	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4

4.2.2 PFAS – PFSAs

Table 9. Tabulated results for PFSAs

PFSA	Sediment Mjøsa n=3	Chironomids n=1	Ruffe stomach Mjøsa n=1	Ruffe Mjøsa n=6	Perch Muscle n=6	Perch Liver n=6	Pike liver Mjøsa n=6	Brown trout Liver Mjøsa n=15	Brown trout Liver Femunden n=3
	ng/g d.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.
PMeS	<0.1								
PFEtS	<0.1								
PFPrS	<0.1								
PFBS	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
PFPS	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
PFHxS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
PFHpS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
PFOS	<0.05	0.06	2.8	1.2 (0.76 – 1.9)	0.48 (0.18 – 1.0)	9.0 (6.0 – 15)	3.0 (1.8 – 4.3)	3.5 (0.51 – 9.6)	0.53 (0.32 – 0.83)
brPFOS	<0.05	<0.05	0.26	0.068 (<0.05 – 0.10)	<0.05 (<0.05 – 0.08)	0.63 (0.43 – 0.85)	0.087 (0.05 – 0.13)	0.20 (0.06 – 0.51)	<0.05 (<0.05 – 0.09)
PFNS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
PFDS	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
PFUnS	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
PFDoS	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
PFTrS	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
PFTeS	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3

4.2.3 PFAS – nPFASs and newPFASs

Table 10. Tabulated results for nPFAS and newPFAS

nPFAS	Sediment Mjøsa n=3	Chironomids n=1	Ruffe stomach Mjøsa n=1	Ruffe Mjøsa n=6	Perch Muscle n=6	Perch Liver n=6	Pike liver Mjøsa n=6	Brown trout Liver Mjøsa n=15	Brown trout Liver Femunden n=3
	ng/g d.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.
PFBSA	<0.3	<0.3	**0.4**	<0.3	<0.3 (<0.3 – **0.3**)	**1.3** (**0.9** – **1.6**)	**1.3** (**0.4** – **3.0**)	**1.9** (**0.6** – **3.7**)	**2.8** (**1.2** – **4.5**)
N-MeFBSA	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
N-EtFBSA	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
PFOSA	<0.1	<0.1	**0.4**	**0.22** (**0.2** – **0.3**)	<0.1	**0.17** (**0.1** – **0.2**)	**0.7** (**0.4** – **1.4**)	<0.1	<0.1
meFOSA	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
etFOSA	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
meFOSE	<1.0	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
etFOSE	<1.0	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
etFOSAA	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3

newPFAS	Sediment Mjøsa n=3	Chironomids n=1	Ruffe stomach Mjøsa n=1	Ruffe Mjøsa n=6	Perch Muscle n=6	Perch Liver n=6	Pike liver Mjøsa. n=6	Brown trout Liver Mjøsa n=15	Brown trout Liver Femunden n=3
	ng/g d.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.
4:2 FTS	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
6:2 FTS	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
8:2 FTS	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
10:2 FTS	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
12:2 FTS	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
NaDONA	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
PFECHS	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
PFEESA	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
HFPO-DA	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
3.6-OPFHpA	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
PF5OHxA	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3

4.2.4 QAC

Table 11. Tabulated results for QACs

QAC	Sediment Mjøsa n=3	Chironomids n=1	Ruffe stomach n=1	Ruffe Mjøsa n=6	Perch liver Mjøsa n=6	Pike liver Mjøsa n=6
	ng/g d.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.
ATAC-C8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
ATAC-C10	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
ATAC-C12	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
ATAC-C14	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
ATAC-C16	**0.52** (**0.5** – **0.6**)	**2.40**	<0.5	<0.5 (<0.5 – **2.45**)	<0.5	<0.5
ATAC-C18	<0.5	**1.42**	**0.54**	<0.5 (<0.5 – **0.62**)	<0.5	<0.5 (<0.5 – **0.5**)
ATAC-C20	<0.5	**5.30**	**2.44**	**0.95** (<0.5 – **2.22**)	<0.5	<0.5
ATAC-C22	**3.6** (**1.5** – **6.9**)	**42.92**	**27.91**	**13.12** (**6.14** – **23.03**)	**2.59** (**0.87** – **12.86**)	**4.39** (**0.87** – **12.86**)
DADMAC-C8	**0.9** (**0.7** – **1.2**)	<0.5	<0.5	<0.5	<0.5	<0.5
DADMAC-C10	**0.57** (<0.5 – **1.1**)	<0.5	<0.5	<0.5	<0.5	<0.5
DADMAC-C12	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
DADMAC-C14	<0.5	**0.53**	<0.5	<0.5	<0.5	<0.5
DADMAC-C16	**8.2** (**5.0** – **11.2**)	**27.39**	**0.95**	<0.5	<0.5	<0.5
DADMAC-C18	**23.3** (**14.0** – **34.1**)	**74.45**	**1.40**	<0.5	<0.5	<0.5
DADMAC-C9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
DADMAC-C11	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
DADMAC-C13	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
DADMAC-C15	**1.3** (**0.9** – **1.7**)	**3.37**	<0.5	<0.5	<0.5	<0.5
DADMAC-C17	**27.0** (**17.4** – **36.1**)	**97.37**	**3.26**	<0.5	<0.5	<0.5
DADMAC-C19	<0.5 (<0.5 – **0.6**)	**1.51**	<0.5	<0.5	<0.5	<0.5
BAC-C8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
BAC-C10	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
BAC-C12	**2.3** (**1.8** – **2.8**)	**2.91**	<0.5	<0.5	<0.5	<0.5
BAC-C14	**0.8** (**0.7** – **1.0**)	**0.82**	<0.5	<0.5	<0.5	<0.5
BAC-C16	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
BAC-C18	<0.5	**0.52**	<0.5	<0.5	<0.5	<0.5

4.2.5 UV-compounds

Table 12. Tabulated results for UV compounds

UV compounds	Sediment Mjøsa n=3	Chironomids n=1	Ruffe stomach Mjøsa n=1	Ruffe Mjøsa n=6	Perch muscle Mjøsa n=6	Perch liver Mjøsa n=6	Pike liver Mjøsa n=6	Brown trout Liver Mjøsa n=15	Brown trout Liver Femunden n=3
	ng/g d.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.	ng/g w.w.
Homosalate	**3.07** (<1.5 – **5.0**)	<2.0	<2.0	<1.0	<0.5	<2.0	<1.5	<1.5	<1.5
BP3	<0.25	<1.5	<1.5	<0.2	<0.1	<1.5	<0.3 (<0.3 – **0.74**)	<0.3	<0.3
EHMC-Z	<0.2	1.9	<0.2	<0.2	<0.1	<0.2	<0.2	<0.2 (<0.2 – **0.87**)	<0.2
EHMC-E	**0.11** (<0.07 – **0.21**)	<0.3	<0.2	<0.2	<0.1	<0.5	<0.2	<0.2 (<0.2 – **1.1**)	<0.2
UV-329	<0.2	<1.0	n.a.	<0.5	<0.5	<2.0	**0.17** (<0.1 – **1.0**)	<0.1	<0.1
UV-328	<0.3	<0.4	**0.87**	<0.2	<0.1	<0.5	<0.4 (<0.4 – 0.56)	<0.2	<0.2
UV-327	<0.3	<0.4	**0.77**	<0.2	<0.1	<0.5	1.4 (<0.5 – 3.6)	<0.4	<0.4
OC	<0.9	**3.3**	**5.8**	**1.30** (**0.73 – 1.7**)	<0.2 (<0.2 – **0.31**)	<1.5	**0.9** (**0.54 – 1.5**)	**0.40** (<0.4 – **1.4**)	<0.4
M1-UV328									

4.2.6 Mercury (Hg)

Table 13. Tabulated results for mercury (Hg)

Metals	Sediment Mjøsa n=3	Chironomids n=1	Ruffe stomach Mjøsa n=1	Ruffe Mjøsa n=6	Perch Muscle n=6	Pike muscle Mjøsa n=6	Brown trout muscle Mjøsa n=15	Brown trout muscle Femunden n=3
Hg	0.018 (0.011 – 0.030)	0.44	0.22	0.053 (0.039 – 0.066)	0.62 (0.31 – 1.03)	0.83 (0.37 – 1.5)	0.69 (0.30 – 1.9)	0.23 (0.10 – 0.34)

4.2.7 Metals

Table 14. Tabulated results for metals.

Metals	Sediment N=3	Chironomids N=1	Ruffe. stomach N=1
	µg/g d.w.	µg/g w.w.	µg/g w.w.
Ag	0.369 (0.20 - 0.58)	0.086	0.072
As	3.72 (3.12 – 4.2)	1.02	0.64
Cd	0.39 (0.27 - 0.53)	0.863	0.527
Ce	35 (27 – 51)	4.30	4.23
Co	5.2 (3.7 – 7.2)	2.02	1.37
Cr	20 (9.5 – 30)	65.4	39.4
Cu	5.7 (3.8 – 9.0)	5.86	6.04
Dy	1.8 (1.2 – 2.7)	0.279	0.211
Er	1.1 (0.79 – 1.7)	0.178	0.135
Eu	0.68 (0.48 – 0.91)	0.103	0.080
Fe	12700 (10000 – 15400)	2880	1864
Gd	2.7 (2.2 – 3.7)	0.377	0.343
Ho	0.38 (0.27 – 0.54)	0.056	0.043
La	17 (13 – 24)	2.03	1.96
Lu	0.13 (0.080 – 0.20)	0.023	0.015
Mn	280 (180 – 460)	146	108
Nd	15 (11 – 21)	1.87	1.72
Ni	16 (10 – 23)	35.9	22.1
Pb	6.1 (4.3 – 8.5)	2.09	0.96
Pr	3.8 (3.0 – 5.5)	0.480	0.450
Sb	0.0034 (<0.0005 – 0.01)	0.082	0.027
Sc	3.5 (1.8 – 5.0)	0.455	0.355
Sm	2.7 (2.1 – 3.8)	0.361	0.329
Sn	0.52 (0.40 – 0.63)	0.330	0.108
Tb	0.44 (0.35 – 0.61)	0.066	0.053
Tm	0.14 (0.094 – 0.21)	0.022	0.016
V	68 (36 – 100)	8.99	7.43
Y	9.7 (6.5 – 14)	1.62	1.16
Yb	0.95 (0.64 – 1.4)	0.151	0.107
Zn	77 (64 – 99)	32.5	31.7

4.2.8 Benzothiazoles

Table 15. Tabulated results for benzothiazoles

Benzothiazoles	Sediment Mjøsa n=3
MBT	<1.0
BTZ	<0.5
BT	<10.0
OHBT	<1.0
MeBTZ	<0.5
CBS	<1.0

4.2.9 Musk

Table 16. Tabulated results for Musks

Musk	Sediment Mjøsa n=3	Chironomids n=1	Ruffe stomach n=3	Ruffe Mjøsa n=6	Perch liver Mjøsa n=6	Pike liver Mjøsa n=6
Galaxoide	<0.05 (<0.05 – **0.067**)	<0.05	**0.098**	**0.067** (<0.05 – **0.20**)	<0.05	**0.17** (<0.13 -**0.30**)
Tonalide	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05 (<0.05 - <0.14)
Traseolid	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Phantolide	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Celestolide	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
OTNE	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Acetyl credene	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10

4.2.10 oPFR- and phthalate metabolites

Table 17. Tabulated results for oPFR- and phthalate metabolites

Metabolites	Pike muscle Mjøsa n=6	Brown trout liver Mjøsa n=15	Brown trout liver Femunden n=3
	ng/g w.w.	ng/g w.w	ng/g w.w
BCEP		<10	<10
BCPP		<2.0	<2.0
DPP		**18** (<4.0 – **45**)	<4.0
BDCPP		<2.0 (<2.0 – **3.0**)	<2.0
HDBP		**2200** (<1400 – **6700**)	**1750** (<1400 – **1900**)
BBOEP		<17	<17
HDEP		**13** (<6.1 – **41**)	**7.5** (<6.2 – **14**)
MMP	<11	<10.7	<11
MEP	<34	<34	<34
MNBP/MIBP	<43	<43 (<43 – **49**)	<43
MEOHP	<0.6	<0.6	<0.6
MBzP	<0.6	<0.6	<0.6
MEHHP	<0.6	<0.6	<0.6
MEHP	<11	<11	<11

4.2.11 PBDEs

Table 18. Tabulated results for PBDEs

PBDE	Sediment Mjøsa n=3	Ruffe stomach Mjøsa n=1	Ruffe Mjøsa n=6	Perch Muscle n=6	Pike muscle Mjøsa n=6	Brown trout muscle Mjøsa n=15	Brown trout muscle Femunden n=3
TBA	<0.011 .011 – **0.015**)	**0.20**	**0.063** (<0.014 – **0.11**)	**0.005** (<0.004 – **0.008**)	<0.004 (<0.004 – **0.01**)	**0.044** (**0.020** – **0.071**)	**0.039** (**0.026** – **0.050**)
BDE-17	<0.013	**0.005**	<0.004	<0.004	<0.004	<0.004 (<0.004 – **0.008**)	<0.004
BDE-28	<0.013	**0.015**	**0.004** (<0.004 – **0.007**)	**0.002** (<0.004 – **0.007**)	<0.004 (<0.004 – **0.007**)	**0.021** (**0.006** – **0.044**)	**0.005** (**0.004** – **0.005**)
BDE-47	<0.53	**1.5**	**0.393** (<0.026 – **0.739**)	**0.531** (**0.104** – **1.33**)	**0.519** (**0.077** – **1.230**)	**4.2** (**1.0** – **8.2**)	**0.17** (**0.093** – **0.23**)
BDE-49	<0.10	**0.10**	**0.026** (<0.08 – **0.036**)	**0.029** (**0.010** – **0.063**)	**0.023** (**0.005** – **0.070**)	**0.22** (**0.10** – **0.52**)	**0.021** (**0.012** – **0.028**)
BDE-66	<0.014	**0.039**	**0.009** (<0.007 – **0.015**)	**0.013** (**0.002** – **0.031**)	**0.008** (<0.002 – **0.015**)	**0.098** (**0.020** – **0.23**)	**0.009** (**0.006** – **0.012**)
BDE-71	<0.004	<0.002	<0.002	<0.002	<0.002	**0.012** (<0.002 – **0.19**)	<0.002
BDE-77	<0.003	**0.002**	<0.001	**0.001** (<0.001 – **0.002**)	<0.001	**0.002** (<0.001 – **0.006**)	<0.001 (<0.001 – **0.001**)
BDE-85	<0.005	<0.003	<0.006	<0.003	<0.003	<0.002 (<0.002 – **0.009**)	<0.003
BDE-99	<0.019	**1.1**	**0.30** (**0.21** – **0.34**)	**0.14** (**0.046** – **0.31**)	**0.13** (**0.029** – **0.34**)	**1.3** (**0.23** – **3.4**)	**0.10** (**0.048** – **0.15**)
BDE-100	<0.006	**0.466**	**0.16** (**0.10** – **0.23**)	**0.18** (**0.18** – **0.47**)	**0.17** (**0.022** – **0.40**)	**1.5** (**0.68** – **3.6**)	**0.084** (**0.046** – **0.12**)
BDE-119	<0.004	**0.014**	<0.004 (<0.003 – **0.005**)	**0.003** (<0.002 – **0.010**)	**0.003** (<0.002 – **0.011**)	**0.042** (**0.012** – **0.091**)	**0.012** (**0.006** – **0.018**)
BDE-126	<0.004	**0.002**	<0.004	**0.001** (<0.001 – **0.003**)	**0.0011** (<0.001 – **0.004**)	**0.009** (<0.001 – **0.021**)	<0.002 (<0.002 – **0.002**)
BDE-138	<0.019	<0.005	<0.008	<0.005	<0.005	<0.005	<0.005
BDE-153	<0.016	**0.16**	**0.036** (<0.021 – **0.056**)	**0.034** (<0.006 – **0.081**)	**0.029** (<0.006 – **0.071**)	**0.280** (**0.050** – **0.68**)	**0.022** (**0.013** – **0.029**)
BDE-154	<0.011	**0.21**	**0.050** (<0.015 – **0.061**)	**0.081** (**0.018** – **0.20**)	**0.064** (**0.010** – **0.15**)	**0.60** (**0.11** – **1.3**)	**0.066** (**0.037** – **0.097**)
BDE-156	<0.029	<0.007	<0.012	<0.007	<0.007	<0.007	<0.007
BDE-183	<0.09	**0.017**	**0.0036** (<0.002 – **0.006**)	<0.002	<0.002	**0.004** (<0.002 – **0.013**)	<0.002
BDE-184	<0.005	**0.007**	**0.0011** (<0.001 – **0.002**)	<0.002	<0.002	**0.007** (<0.001 – **0.020**)	**0.002** (<0.002 – **0.004**)
BDE-190	<0.04	<0.008	<0.005	<0.005	<0.005	<0.003	<0.004
BDE-191	<0.011	<0.006	<0.0075	<0.004	<0.004	<0.004	<0.003
BDE-196	<0.021	<0.005	<0.011	<0.005	<0.005	<0.005	<0.005
BDE-197	<0.017	<0.004	<0.0091	<0.004	<0.004	<0.004 (<0.004 – **0.007**)	<0.004
BDE-202	<0.021	**0.019**	<0.014	<0.006	<0.006	**0.005** (<0.006 – **0.023**)	<0.006
BDE-206	<0.085	<0.012	<0.025	<0.012	<0.012	<0.012	<0.012
BDE-207	<0.050	<0.009	<0.021	<0.009	<0.009	<0.009	<0.011
BDE-209	<0.594	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15

4.2.12 CP

Table 19. Tabulated results for CPs

CP	Sediment Mjøsa n=3	Chironomids n=1	Ruffe stomach Mjøsa n=1	Ruffe Mjøsa n=6	Perch Muscle n=6	Pike muscle Mjøsa n=6	Brown trout muscle Mjøsa n=15	Brown trout muscle Femunden n=3
SCCP	<28	ND	<4.16	**6.3** (<4.9 – **9.4**)	<4.1	<4.71	<3.4 (<3.4 – **6.2**)	<5.3
MCCP	<29	ND	**11.6**	<19	<8.2	<6.9	<16	<4.2
LCCP						**4.8** (**1.8 – 5.4**)	**12** (**5.5 – 20**)	**5.6** (**5.0 – 6.5**)

4.2.13 Siloxanes

Table 20. Tabulated results for siloxanes

Siloxanes	Sediment Mjøsa n=3	Chironomids n=1	Ruffe stomach Mjøsa n=1	Ruffe Mjøsa n=6	Perch muscle Mjøsa n=6	Pike muscle Mjøsa n=6	Brown trout muscle Mjøsa n=15	Brown trout muscle Femunden n=3
D4	**0.18** (<0.24 – **0.38**)	**1.3**	**5.9**	**1.5** (**0.92 – 2.3**)	<0.51	<0.51 (<0.51 – **0.54**)	**0.91** (<0.48 – **1.5**)	<0.51
D5	**2.1** (**1.6 – 3.1**)	**9.46**	**53.0**	**12** (**9.1 – 17**)	**1.6** (<0.51 – **3.1**)	**3.5** (**1.8 – 6.9**)	**35** (**13 – 85**)	<0.51 (<0.51 – **0.72**)
D6	**1.2** (**0.64 – 1.8**)	**1.17**	**4.1**	**1.1** (**0.87 – 1.4**)	<3.1	<3.1	**4.0** (<2.5 – **9.3**)	<3.1
M3T(ph)	<0.29 (<0.25 - <0.33)	<1.58	**1.1**	<1.1 (<0.52 - <1.5)	<0.52 (<0.43 - <0.75)	<0.43 (<0.32 – <0.53)	**2.4** (<0.79 – **5.3**)	<0.45 (<0.30 - <0.62)
L3	<0.10 (<0.096 - <0.10)	<0.094	<0.216	<0.24 (<0.091 - <<0.345)	<0.19 (0.093 – 0.37)	<0.17 (0.095 – 0.29)	<0.13 (<0.09 - <0.19)	<0.26 (<0.11 - <0.35)
L4	<3.6 (<2.4 - <5.4)	<1.1	**1.9**	<1.5 (<1.0 - <3.1)	<2.2 (<1.1 – <4.8)	<2.1 (<1.5 - <3,7)	<1.4 (<0.6 – <2.8)	<2.2 (<1.1 - <3.9)
L5	<0.72 (<0.72 – **0.76**)	<1.77	**2.4**	<1.17 (<0.64 - <1.65)	<0.82 (<0.692 - <1.3)	<0.69 (<0.50 - <0.83)	**0.53** (<0.99 – 2.0)	<0.62 (<0.56 - <0.68)
D3F	<20 (<3.1 - <43)	<330	<291	<297 (<68 - 540)	<18 (<11 - <27)	<20 (<10 - <28)	<124 (<29 - <550)	<41 (<29 - <62)
D4F	<9.6 (<1.6 - <20)	<195	<179	<160 (<98 - <310)	<11 (7.6 – 16)	<12 (<6.2 - <17)	<71 (<16 - <320)	<24 (<17 - <36)

4.3 Metadata for biota samples

Table 21. Metadata – biota samples 2022

Lake	Norw. Name Species (En.) *Latin name*	ID	Length cm	Weight g	Subsample	d13C	d15N
Mjøsa	Hork Ruffe *Gymnocephalus cernuus*	H1	11.5	14	1	-25.56	13.52
		H2	12.5	16	1	-28.39	14.98
		H3	12.5	17	1	-31.22	15.61
		H4	12	16	2	-28.05	14.35
		H5	12.5	16	2	-23.92	13.59
		H6	13	18	2	-29.28	14.36
		H7	12	15	3	-27.67	14.20
		H8	12	14	3	-28.90	15.04
		H9	11.5	14	3	-28.43	15.28
		H10	9.5	11	4	-21.06	13.10
		H11	9.5	11	4	-25.74	13.59
		H12	9.5	10	5	-27.28	14.59
		H13	9	10	5	-26.15	13.65
		H14	9	10	6	-29.68	15.97
		H15	9.5	10	6	-24.74	13.28
	Abbor Perch *Perca fluviatilis*	A1	38	720	1	-25.72	14.95
		A2	35.5	610	2	-26.57	15.25
		A3	33	480	3	-26.56	15.42
		A4	34.5	520	4	-25.18	14.70
		A5	26	170	6	-22.19	13.26
		A6	26.5	200	5	-22.56	12.40
		A7	32.5	370	5	-23.77	14.65
		A8	25	150	4	-24.16	13.88
		A9	28.5	270	3	-23.12	12.84
		A10	29.5	260	4	-21.77	12.76
		A11	28	240	5	-23.41	13.52
		A12	28.5	210	3	-18.14	13.71
		A13	31	370	6	-23.21	14.34
		A14	27	220	6	-26.90	14.40
		A15	29	280	6	-23.46	12.98
	Gjedde Pike *Esox lucius*	G1	108	8800	1	-25.33	16.07
		G2	76	3000	2	-24.70	14.55
		G3	75	2500	3	-26.33	15.24
		G4	106	6800	4	-25.69	14.99
		G5	86	4300	5	-24.10	14.63
		G6	73	2600	6	-25.92	14.23
		G7	75	2600		-23.44	13.74
		G8	68	2100		-25.34	13.99

Lake	Norw. Name Species (En.) *Latin name*	ID	Length cm	Weight g	Subsample	d^{13}C	d^{15}N
		G9	68	1900		-26.74	15.24
Mjøsa	Ørret Brown trout *Salmo trutta*	ØM1	70	4135	1	-27.64	15.33
		ØM2	77	6400	2	-26.46	14.66
		ØM3	75	5300	3	-25.88	15.15
		ØM4	75	5000	4	-27.27	15.64
		ØM5	74	4600	5	-27.75	16.02
		ØM6	69	3700	6	-27.71	14.86
		ØM7	71	3900	7	-27.02	15.38
		ØM8	69	3700	8	-27.01	15.16
		ØM9	65	3300	9	-27.68	14.87
		ØM10	68	3400	10	-26.89	15.18
		ØM11	72	3300	11	-26.62	15.80
		ØM12	67	3300	12	-27.18	15.12
		ØM13	82	6600	13	-28.24	15.08
		ØM14	87	8600	14	-27.33	14.37
		ØM15	69	3900	15	-27.32	15.44
	Ørret blandp. BT pooled	ØM_B1				-27.67	15.11
		ØM_B2				-27.00	15.15
		ØM_B3				-27.56	15.30
Femunden	Ørret Brown trout *Salmo trutta*	ØF1	56	1878	1	-25.51	10.01
		ØF2	55	1478	1	-17.41	8.85
		ØF3	52.5	1461	1	-24.41	11.34
		ØF4	51	1551	1	-25.21	9.89
		ØF5	48	1154	1	-21.67	9.62
		ØF6	49.5	1287	2	-25.49	11.17
		ØF7	42.5	891	2	-25.76	9.18
		ØF8	46.5	1020	2	-20.67	8.91
		ØF9	45	927	2	-24.13	10.01
		ØF10	45	993	2	-20.55	8.79
		ØF11	43	860	3	-20.18	8.61
		ØF12	44	1031	3	-23.69	8.88
		ØF13	44.5	984	3	-21.51	8.61
		ØF14	43	950	3	-19.03	7.67
		ØF15	39	660	3	-23.37	8.49
Mjøsa	Fjærmygglarver Chironomids	FM-H-2				-19.29	9.56
	Hork Mageinnhold Ruffe stomach	HOM1				-26.35	9.61
		HOM2				-33.55	10.99
		FM-H-3				-20.58	12.27