REPORT SNO 7397-2019

Monitoring of environmental contaminants in freshwater ecosystems 2018 –

Occurrence and biomagnification

Photo: Morten Jartun: Sampling of fish from Lake Mjøsa outside Helgøya.

Norwegian Institute for Water Research

REPORT

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Summary

Denne rapporten omhandler forekomsten av en rekke gamle og nye miljøgifter i den pelagiske næringskjeden i Mjøsa og Femunden. Prøver av zooplankton, Mysis, lågåsild, krøkle og ørret fra Mjøsa, samt ørret fra Femunden, er samlet inn. Innholdet av kvikksølv (Hg), siloksaner (cVMS: D4, D5, D6), bromerte flammehemmere (PBDEer), alkylfenoler og bisfenoler, fosfororganiske flammehemmere (PFR), poly- og perfluorerte alkylstoffer (PFAS), nye flammehemmere (nBFR) og UV-stoffer er bestemt. Resultater er sammenlignet med eksisterende miljøkvalitetsstandarder (EQS) i henhold til vannforskriften. I tillegg er tidstrendene for de enkelte stoffgruppene vurdert.

This report studies the distribution and fate of contaminants such as mercury (Hg), cyclic volatile methylated siloxanes (cVMS: D4, D5, D6), brominated flame retardants (BFR, PBDEs), alkylphenols, organic phosphorous flame retardants (oPFR), poly- and perfluorated alkyl substances (PFAS), new brominated flame retardants (nBFR) and UV-chemicals. Samples of the pelagic food web of Lake Mjøsa (zooplankton, Mysis, vendace, European smelt and brown trout) and the top predator brown trout in Lake Femunden are studied. Results are compared to environmental quality standards (EQS) and the time trends for major contaminants are studied.

Four keywords	Fire emneord
1. Contaminants	1. Miljøgifter
2. Food web	2. Næringsnett
3. Freshwater	3. Ferskvann
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Monitoring of environmental contaminants in freshwater ecosystems, 2018

Occurrence and biomagnification

Preface

The Norwegian Institute for Water Research (NIVA) is on behalf of the Norwegian Environment Agency (Miljødirektoratet) carrying out a monitoring program of contaminants in freshwater ecosystems (MILFERSK 2017-2021). This report presents the main results of the monitoring study in 2018, discussing the major findings of contaminants in pelagic food webs in Lake Mjøsa and Lake Femunden.

Samples of zooplankton, the crustacean *Mysis relicta*, vendace (*Coregonus albula*), European (E.) smelt (*Osmerus eperlanus*) and brown trout (*Salmo trutta*) were collected from Lake Mjøsa. In Lake Femunden, only brown trout were sampled.

Sampling of zooplankton, Mysis, and E. smelt was carried out by Morten Jartun and Asle Økelsrud from NIVA with help from Trolling Adventures AS providing necessary equipment for safe collection of the material. Brown trout from Lake Mjøsa was caught by Harald Jøranli, vendace from Lake Mjøsa was caught by Mass Haugen, and brown trout from Lake Femunden was caught by Bjørn Arvid Foss. Sample processing and dissection of target matrices for chemical analyses were performed by Morten Jartun.

Chemical analyses:

- Stable isotopes of nitrogen and carbon carried out by IFE (Ingar Johansen)
- Hg by Eurofins Environment Testing Norway AS
- Brominated flame retardants (BFR), organic phosphorous flame retardants (oPFR), cyclic volatile methylated siloxanes (cVMS), new brominated flame retardants (nBFR) and alkylphenols by NILU
- PFAS and UV-chemicals by NIVA

Coordination of sampling equipment and chemical data was carried out by Katharina B. Løken (NIVA). Data analyses and reporting by Morten Jartun and Asle Økelsrud. Quality assurance was performed by Marianne Olsen and Sissel B. Ranneklev. Coordinator at the Norwegian Environment Agency (Miljødirektoratet) has been Eivind Farmen, and the project manager at NIVA has been Morten Jartun.

Oslo, 13 June 2019

Morten Jartun
Project manager
NIVA

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Summary

The monitoring program "Milfersk – Contaminants in freshwater ecosystems" studies the concentration levels, distribution pattern and time trends of selected contaminants in Lake Mjøsa and Lake Femunden. In Lake Mjøsa, the pelagic food web consisting of zooplankton, the planktonic opossum shrimp *Mysis*, vendace (*Coregonus albula*), European smelt (*Osmerus eperlanus*), and brown trout (*Salmo trutta*) was sampled. From Lake Femunden the top predator brown trout was sampled. Lake Mjøsa is the largest lake in Norway, representing several potential local sources of contamination such as from urban areas, major roads, wastewater treatment plants, industry and agricultural areas. Lake Femunden on the other hand is located in a catchment area consisting of mountains and forests with minor anthropogenic impact.

All collected samples were processed and analyzed for a long range of contaminants:

- Mercury (Hg)
- Cyclic volatile methylated siloxanes (cVMS)
- Brominated flame retardants (BFR, PBDEs) and new BFRs
- Organic phosphorous flame retardants (oPFR)
- Per- and polyfluorinated alkyl substances (PFAS)
- Alkylphenols and bisphenols
- UV-chemicals

Levels of contaminants in different trophic levels were determined, and the trophic magnification factor (TMF) for selected compounds were determined using stable nitrogen and carbon isotopes.

Main conclusions from the monitoring program in 2018 is that the concentrations of the well-known contaminants such as Hg and BFRs (PBDEs) in fish muscle are reducing considering the past 10-20 years. Annual mean Hg concentrations have been on the same level since 2014 (0.5 mg/kg = 500 ng/g), but a slight decrease in mean concentrations in brown trout was observed from 2017 to 2018. Mean concentration of ΣBDE_6 in brown trout from Lake Mjøsa was 8.5 ng/g w.w. in 2018. Still, the levels of Hg and ΣBDE_6 in brown trout from Lake Mjøsa are above the environmental quality standard (EQS) of 20 and 0.0085 ng/g w.w., respectively, by several orders. Looking at these contaminants, the concentration levels found in fish from Lake Mjøsa are higher than those found in Lake Femunden.

Trophic magnification of Hg, BDE-47, cVMS (D5 and D6) and PFOS were observed in the food web of Lake Mjøsa as calculated trophic magnification factors (TMF) were > 1 for all these compounds. This means that higher concentrations were found in top predators such as brown trout and cannibalistic E. smelt, residing on a higher trophic level than zooplankton, Mysis, vendace and small E. smelt. Of the 39 determined per- and polyfluorinated alkyl substances (PFASs), only 9 were detected above LOQ, including long-chained carboxylic acids (PFCAs) and PFOS. 8 out of 15 samples of brown trout in Lake Mjøsa exceeded the EQS value of 9.1 ng/g w.w. for PFOS, which is an increase in number of individuals from 2016 and 2017 to 2018. Annual mean concentrations for PFAS is decreasing for PFCAs and PFOS for all fish in Lake Mjøsa from 2013 to 2018. Only very few detections were observed in biota samples (fish muscle) for organic phosphorous flame retardants (oPFR), alkylphenols and bisphenols, new brominated flame retardants (nBFR) and UV-filters. Other matrices such as bile or liver should be considered as alternative sample media in future sampling campaigns.

Norsk sammendrag

Tittel: Miljøgifter i ferskvann - MILFERSK
År: 2018
Forfatter(e): Morten Jartun, Asle Økelsrud, Thomas Rundberget, Ellen Katrin Enge, Pawel Rostkowski, Nicholas Warner, Mikael Harju (NILU) and Ingar Johansen (IFE)
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Norsk institutt for vannforskning (NIVA) har på vegne av Miljødirektoratet studert innholdet av miljøgifter i det pelagiske næringsnettet i Mjøsa. I tillegg har vi sammenlignet med prøver av ørret fra Femunden. Mjøsa er Norges største innsjø, og har en moderat påvirkning fra lokale forurensningskilder som f.eks. tilførsler fra renseanlegg, urbane områder, veg, industri og landbruk. Femunden er i ubetydelig grad direkte berørt av menneskelig påvirkning, med et nedslagsfelt bestående av fjell- og skogsområder. Overvåkingsprogrammet er inne i sitt andre år, og varer fra 2017-2021, men er en videreføring av tidligere studier i store norske innsjøer. Denne rapporten omfatter en sammenstilling av forekomsten til en rekke miljøgifter på ulike trofiske nivåer i 2018, og vurderer potensialet for biomagnifisering til utvalgte miljøgifter, f.eks. kvikksølv (Hg), bromerte flammehemmere, siloksaner og PFAS.

Sommeren og høsten 2018 ble det samlet inn prøver av det pelagiske næringsnettet i Mjøsa, som er bygget opp av zooplankton, istidskrepsen *Mysis relicta*, lågåsild (*Coregonus albula*), krøkle (*Osmerus eperlanus*) og ørret (*Salmo trutta*). Zooplankton og Mysis ble samlet inn med planktonhåv med maskestørrelse 500 µm i områdene sør og øst for Helgøya. Lågåsild ble tatt på bunngarn på 30-50 meters dyp øst for Helgøya. Krøkle ble fanget inn ved hjelp av prøvefiske med trål, mens ørret ble fanget med garn i Gjøvikområdet av lokale fiskere. Ørret fra Femund ble fanget i garn av lokale fiskere.

For zooplankton og Mysis benyttes hele organismen, det vil si at en gitt prøvemengde homogeniseres før kjemisk opparbeiding og analyser. Fra fisk er det benyttet muskelprøver for bestemmelse av kvikksølv (Hg), siloksaner (cVMS: D4, D5 og D6), bromerte flammehemmere (BFR), fenoler, fosfororganiske flammehemmere (oPFR), UV-kjemikalier og for stabile isotoper. Prøvematriks for PFAS var lever. For å estimere organismenes trofiske posisjon i næringsnettet og deres hovedkarbonkilder ble innholdet av stabile nitrogen- ($\delta^{15}N$) og karbonisotoper ($\delta^{13}C$) bestemt i alle prøver. I 2018 var det utfordrende å framskaffe tilstrekkelige mengder primærkonsumenter (zooplankton) fra de øvre vannlagene, noe som resulterte i at de innsamlede zooplanktonartene i 2018 befant seg på et høyere trofisk nivå enn ønskelig. Vi har likevel tilstrekkelig grunnlag fra tidligere år til å estimere trofisk posisjon for zooplankton, og således regne ut TMF for de ulike miljøgiftene. Dette er forklart i større detalj i de enkelte resultatkapitlene.

I resultatkapitlene for de ulike miljøgiftene er det presentert data for innsamlingen i 2018, og det er gjort en beregning av trofisk magnifiseringsfaktor (TMF) for aktuelle miljøgifter som Hg, BDE-47 (bromert flammehemmer), siloksaner og PFOS. I tillegg har vi sammenstilt data fra tidligere år for å vurdere tidstrenden av årsgjennomsnittet til miljøgiftene Hg, bromerte flammehemmere, siloksaner og PFAS. For alkyl- og bisfenoler, fosfororganiske flammehemmere, nye bromerte flammehemmere og UV-kjemikalier er det så få deteksjoner i prøvematerialet at tidstrender ikke lar seg framskaffe ennå. Endring i prøvematriks for enkelte av disse stoffgruppene er vurdert før innsamlingen i 2019, f.eks. vurderes galle som mulig prøvematriks for fenoler og lever for oPFR.

For Hg ser vi en nedadgående trend fra 2006, men at konsentrasjonene ser ut til å ha stabilisert seg på ca. 0,5 mg/kg våtvekt i muskel siden 2014. Vi observerer også lavere konsentrasjoner av Hg i 2018 enn vi gjorde i 2017. Alle prøver av fisk fra både Mjøsa og Femunden har Hg-konsentrasjoner langt over miljøstandarden EQS på 0,020 mg/kg, gitt i Vannforskriften.

Innholdet av sykliske siloksaner, (cVMS: D4, D5 og D6), ble bestemt i alle prøver fra Mjøsa og Femunden. De høyeste konsentrasjonene ble påvist i ørret og krøkle fra Mjøsa. TMF er vist for både D5 og D6 i Mjøsa, mens det ikke ble påvist siloksaner i ørret fra Femunden. D5 dominerer i prøvene fra Mjøsa, og skyldes trolig lokale tilførsler, men ingen av prøvene av stor ørret overskrider nasjonal EQS for biota (QS_{biota}=15217 µg/kg). Resultatene viser at D5 biomagnifiserer i Mjøsas næringsnett med en trofisk magnifikasjonsfaktor (TMF) på 2,0. I trenddataene ser vi en liten økning i 2018-nivåene fra perioden 2013-2017.

Gjennomsnittlig sum av ΣBDE_6, (summen av BDE-28, BDE-47, BDE-99, BDE-100, BDE-153 og BDE-154, gitt i vannforskriften) var for stor ørret i Mjøsa på 8,5 ng/g våtvekt. Samtlige prøver av muskel fra ørret i Mjøsa og Femunden overskrider EQS-konsentrasjonen på 0,0085 ng/g våtvekt. Høye konsentrasjoner av bromerte flammehemmere ble observert i Mjøsa på begynnelsen av 2000-tallet, og var forårsaket av lokale industriutslipp på 1990-tallet og tidlige 2000-tallet. Nivåene i biota har etter dette gått kraftig ned, som vi ser av trenddata fra år 2000-2018. Likevel er konsentrasjonene av PBDEer fortsatt høye sammenlignet med både EQS-verdien og andre innsjøer

PFAS ble bestemt i prøver av fiskelever. PFAS ble detektert i over 50 % av prøvene for kun 8 ulike PFASer. For resten av PFAS-forbindelsene var alle prøver under deteksjonsgrensen. De langkjedede PFAS (C10-C15) dominerer prøvene i tillegg til PFOS. Gjennomsnittlig konsentrasjon av PFOS i ørretlever fra Mjøsa var 9,9 ng/g våtvekt. EQS for PFOS i biota er 9,1 ng/g, og 8 av 15 prøver av ørret fra Mjøsa overskrider denne grensen. I Femunden dominerer også de langkjedede PFASene, bl.a. PFTrDA (C13). Noe av forklaringen på dette kan være at ørret i Femunden har sitt hovedinntak av næring fra terrestriske kilder, f.eks. overflateinsekter, mens ørret i Mjøsa hovedsakelig spiser fisk i den pelagiske sonen. Sammenlignet med tidligere år, har årsgjennomsnittet for PFOS holdt seg relativt stabilt i ørret, men flere individer har konsentrasjoner over EQS i 2018 enn for 2017 og tidligere år i Mjøsa. I Femunden var det en observert nedgang i konsentrasjonen av de langkjedede PFASene fra 2017 til 2018, uten at det er noen holdbare forklaringer på dette så langt. Sammenlignet med andre sjøer med kjente lokale kilder til PFAS, som Vansjø og Tyrifjorden, er nivåene av PFAS i Mjøsa lave.

Konsentrasjonene av nesten alle fosfororganiske flammehemmere, alkyl- og bisfenoler, nye bromerte flammehemmere og UV-kjemikalier i analyseprogrammet var under deteksjonsgrensen (LOD), kun med enkelte få unntak like over LOD. Det er store usikkerheter for enkelte analyser blant annet pga. lav prøvemengde og utfordringer med matriks. Analysene regnes som semikvantitative. I framtidig innsamling av prøver vil vi forsøke bl.a. galle og lever for enkelte av disse stoffgruppene. Utfordringen med disse prøvetypene er at de finnes i langt lavere volum i de studerte artene.

1 Introduction

1.1 Background

The Norwegian Institute for Water Research (NIVA) is, on the behalf of the Norwegian Environment Agency (Miljødirektoratet) monitoring contaminants in aquatic, pelagic food webs in Lakes Mjøsa and Femunden. The current monitoring program "Contaminants in freshwater ecosystems" (Miljøgifter i ferskvann – MILFERSK) was initiated in 2017, succeeding the sampling strategy from "Contaminants in great lakes" established in the period from 2013-2016.

Within the project, a wide range of environmental contaminants have been determined in samples of zooplankton, the planktonic opossum shrimp *Mysis relicta*, vendace (*Coregonus albula*), E. smelt (*Osmerus eperlanus*), and brown trout (*Salmo trutta*) in Lake Mjøsa, and brown trout from Lake Femunden. Mjøsa and Femunden were selected in order to continue the data series from previous annual monitoring, where Mjøsa represents a large lake with several potential anthropogenic sources while Femunden represents a lake with minor anthropogenic impact.

Main objectives for the monitoring program are:

- Report the concentrations of selected contaminants in multiple trophic levels within a pelagic food web
- Estimate the bioaccumulation of contaminants in selected species
- Estimate the biomagnification factors for selected contaminants in the pelagic food web
- Evaluate the potential for harmful effects on different trophic levels in the food web
- Evaluate the historic trends and discuss potential sources for selected contaminants

In this report, levels of stable isotopes ($\delta^{15}N$, $\delta^{13}C$, and $\delta^{34}S$), mercury (Hg), cyclic volatile methylated siloxanes (cVMS), brominated flame retardants (BFR), organic phosphorous flame retardants (PFR), per- and polyfluorinated substances (PFAS), alkylphenols and bisphenols, and UV-chemicals in biota are presented. Several of these substances tend to accumulate in specific tissues (bioaccumulation) within the organisms, exhibiting higher concentrations relative to their surroundings such as the water or sediment. In addition to the direct ecological importance of studying these contaminants in biota, impact on potential human health is also an important consideration, e.g. by discussing the contaminant levels in respect to environmental quality standards (EQS).

Contamination is discussed based on current levels in the specific trophic levels and the time trends for the individual contaminant or contaminant group. The monitoring program for large lakes in Norway has been revised several times, but for some of the contaminants the concentrations in specific species have been studied for several years, such as for mercury (Hg) and brominated flame retardants (BFR). Still, the program has been changed regularly according to knowledge on upcoming contaminants, such as siloxanes, PFAS, organic phosphorous flame retardants (oPFR) and phenols. This means that the time series for some of the contaminants are longer and more detailed than for others. This is also to ensure early detections of possible new contaminants in a large aquatic ecosystem.

1.2 Studied lakes – a short description

Studies of the concentration of environmental contaminants in pelagic food webs have previously been carried out in large Norwegian lakes such as Mjøsa, Randsfjorden, Tyrifjorden, and Femunden (Fjeld et al., 2014; 2015; 2016; 2017) with some additional lakes studied in specific years. For the main sampling program in 2018 biota samples from five trophic levels were collected from Lake Mjøsa and the top predator, brown trout, collected from Lake Femunden. Table 1 lists some of the main properties of the two lakes studied in 2018. The main sampling sites are indicated in Figure 1. Table 2 lists the main sampling stations.

Table 1. Lake information. PE: population equivalents (number of persons connected to a wastewater treatment plant).

Info	Lake Mjøsa	Lake Femunden
Location (UTM33 EUREF89)	N: 6746114 E: 282000	N: 6898700 E: 338500
Volume (km^3)	65	6
Surface area (km^2)	369	203
Max depth (m)	453	153
Catchment area (km^2)	17 251	1 790
PE	206000	~200

Lake Mjøsa and Lake Femunden are both large, deep fjord lakes situated in the southeastern part of Norway, see Figure 1. They do, however, differ in the potential environmental impact from local, anthropogenic sources of contamination. Lake Mjøsa is located in the east-central part of Norway with several possible environmental impacts, such as runoff from major roads, industries, urban areas (five cities located at the lake), and discharge from waste water treatment plants (WWTP), including three large ones and several of minor sizes, with a total of 200 000 population equivalents (PE). Agricultural runoff and input from major rivers are other fluxes to the lake. In addition, several large and minor tributaries flow into Mjøsa from a large catchment area of 17 000 km^2. Lake Femunden on the other hand is situated in a forest and mountain catchment area with only minor anthropogenic impacts, mostly from backpacking hikers and some minor roads.

The (pelagic) food webs established within the lakes are also different. Lake Mjøsa is the largest lake in Norway, holding over 20 different fish species, such as brown trout (*Salmo trutta*), pike (*Esox Lucius*), perch (*Perca fluviatilis*) and burbot (*Lota lota*) to mention a few of the common species. The pelagic food web of Lake Mjøsa (Figure 2) has been well defined and studied for several years (e.g. Spikkeland et al., 2016; Sandlund et al., 2017; Fjeld et al., 2017). On the lower trophic level there is a large variation of zooplankton populations, some being true primary consumers such as copepods and some being omnivorous and potentially on a higher trophic level such as *Limnocalanus macrurus*. The crustacean

Mysis relicta is an important part of the pelagic food web, as it feeds on zooplankton, and is an important prey for E. smelt (*Osmerus eperlanus*). E. smelt is, together with brown trout (*Salmo trutta*), considered a top predator in Lake Mjøsa as they tend to be cannibalistic after reaching approx. 15 cm in size. In addition, vendace (*Coregonus albula*) is a part of this food web as a central planktivore species. The biodiversity of Lake Mjøsa is rich and it causes the top-predator brown trout and E. smelt to be at a higher trophic level in this lake compared to similar lakes in Norway.

Samples of brown trout from Lake Femunden were also studied. This is the third largest lake in Norway. Lake Femunden is a deep, cold and low productive oligotrophic lake with no artificial regulation. Its catchment area consists mostly of bare mountains and forests within a national park. The surrounding area is mostly rural except for small settlements and some tourist activities (e.g. hiking, fishing, hunting, skiing). To our knowledge, the main environmental impact must come from long-range transport. There is a small wastewater facility close to the lake (PE: ~200), but it has infiltration to the ground and no direct discharges to the lake. The ecosystem in Femunden consist of eight species of fish including brown trout, European whitefish (*Coregonus lavaretus*) and Arctic char (*Salvelinus alpinus*). E whitefish is the main prey for brown trout as they become piscivorous at the age of 3-9 years, or approximately 30 cm (Sandlund et al., 2012). Only a small proportion of the brown trout population in Lake Femunden is pelagic, the majority prey in the littoral zone on benthic or terrestrial (insects) organisms. To become a large brown trout in Lake Femunden it must be opportunistic and undergo changes in diet with increasing prey size. The size of European whitefish population will have a relatively large impact on the production of large brown trout in Lake Femunden.

Table 2. Sampling stations with coordinates in UTM33N.

Lake	Parameters	Stations	UTM33 (EUREF89)		Depth
			N	E	m
Mjøsa	Zooplankton Mysis	South/east of Helgøya	6735833	283365	Zoop.: 0-10/30-50 Mysis: 70-100
	E. smelt	East of Helgøya	6738520	285438	30-50
			6737040	280445	
	Brown trout Vendace	North of Gjøvik	6749473	265847	50
Femunden	Brown trout	Area of Elgå	6898700	338500	-

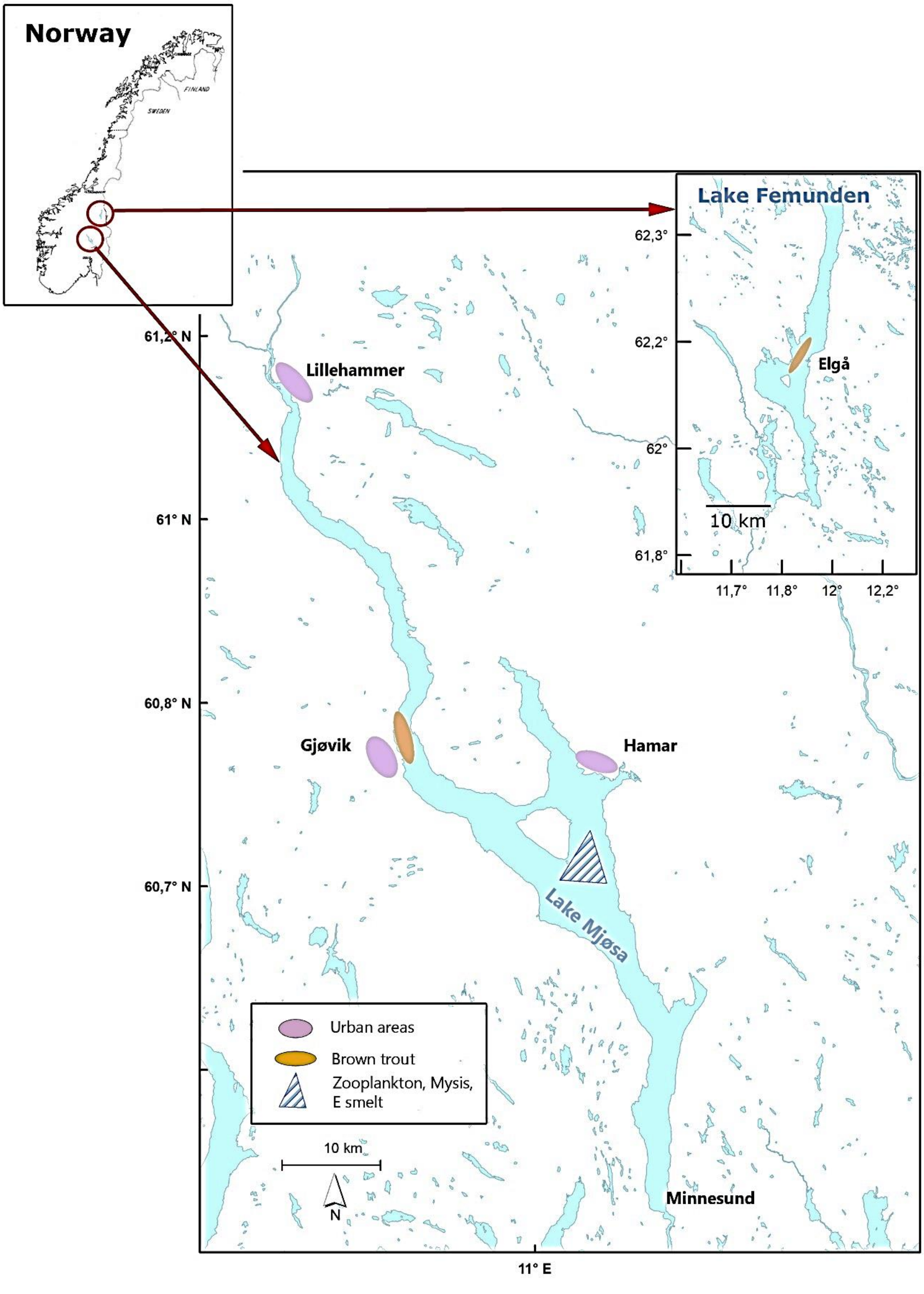


Figure 1. Map of Lakes Mjøsa and Femunden with the main sampling areas for zooplankton, Mysis and fish in Lake Mjøsa.

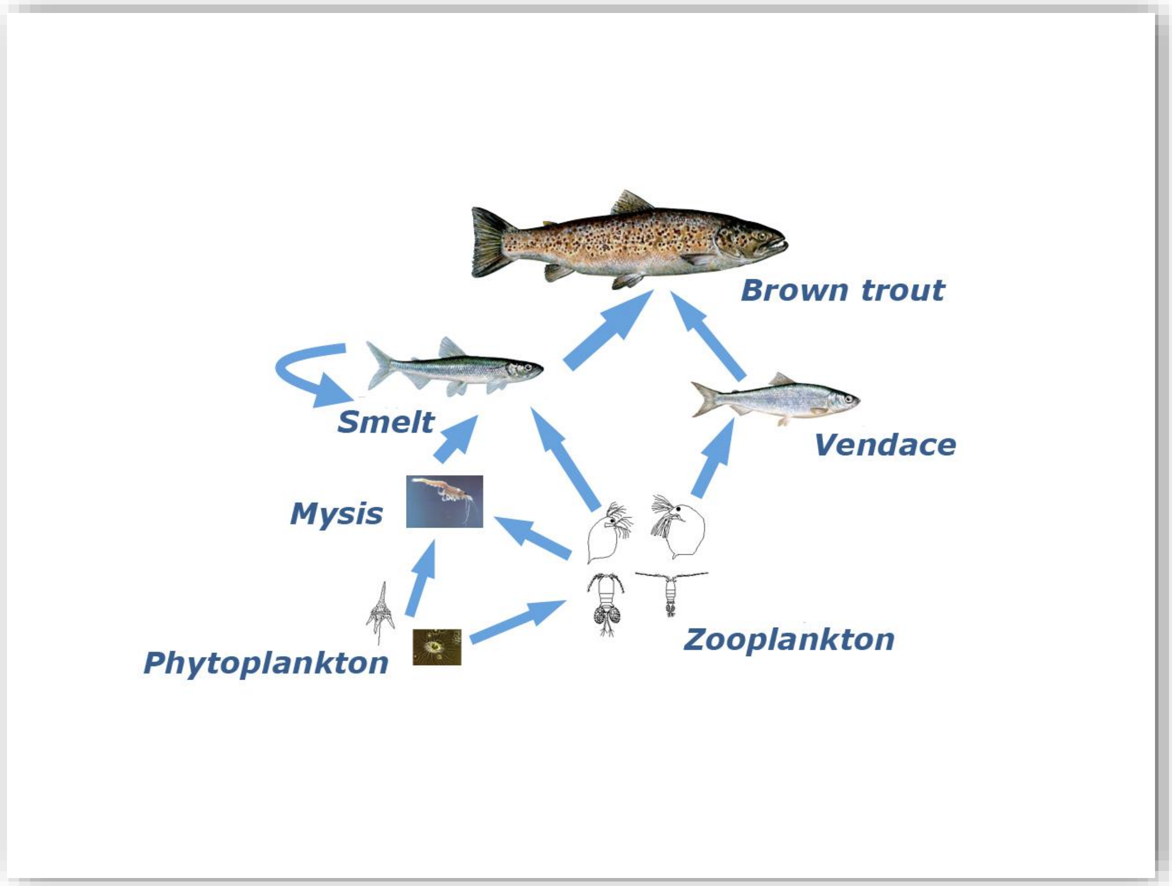


Figure 2. The pelagic food web of Lake Mjøsa.

1.3 Introduction to the contaminants

1.3.1 Mercury, Hg

Hg in fish is mostly present as the toxic compound Methyl-Hg, which is a neurotoxin also for humans. Historically, the two main sources of elemental Hg are point source discharges and atmospheric deposition. Local sources such as the woodworking industry have been known to cause severe contamination of Lake Mjøsa in the past (Underdal, 1970; Sandlund et al., 1981). Because of this, Hg has been monitored in Lake Mjøsa for several years. Strict restrictions on the use of Hg exists in Norway. There is a general ban on the use of Hg in products such as older thermometers and barometers, industrial catalysts and dental amalgam. Regulation of Hg applies to several activities such as the restrictions on manufacture, import, export, sale and use of chemicals and other products hazardous to health and the environment (Product regulation), the industrial directives and waste regulation.

1.3.2 Cyclic volatile methylated siloxanes (cVMS)

Cyclic volatile methyl siloxanes (cVMS), such as octamethylcyclotetrasiloxane (D4), decamethylcyclopentasiloxane (D5), and dodecamethylcyclohexasiloxane (D6), are used as ingredients in personal care products and are emitted to aquatic environments first through wastewater discharge. The European chemical agency (ECHA) categorize D4 as persistent, bioaccumulative, and toxic, whereas D5 is categorized as very persistent and very bioaccumulative (ECHA, 2015). Both D4 and D5 are on the REACH candidate list, and restrictions will apply to wash-off cosmetic products in a concentration above 0.1 % in 2020. cVMS are mostly used in personal care products and detergents (Huse and Aas-Aune, 2009). These siloxanes exhibit unusual physical-chemical properties in the environment being both hydrophobic and volatile. Once in the water phase, they slowly undergo hydrolysis with acid- and bases, and/or are being adsorbed to particles. Biomagnifying properties have been demonstrated by e.g. Borgå et al. (2012a and b).

1.3.3 Brominated flame retardants (BFR)

Polybrominated diphenyl ethers (PBDE) are anthropogenic contaminants used as flame retardants in a range of products such as textiles and EE-products. These compounds are generally very stable and hydrophobic, and some exhibit hormone disrupting and neurotoxic properties (Stockholm convention, 2013). In Norway there is a ban against all use, import and production of PBDEs. The Stockholm convention included in 2009 several PBDEs, such as BDE-47, BDE-99, BDE-153 and BDE-154, in its Annex A, and BDE-209 was listed in 2017. In 2000, fish with extreme concentrations of PBDEs were found in Lake Mjøsa (Fjeld et al., 2001), caused by a local industrial discharge. Levels of PBDEs are now coming down and are reduced to 1/5 of the initial concentrations 15-20 years ago.

1.3.4 Phosphorous flame retardants (PFR)

PFRs are often considered a substitute for BFRs after they were banned. Major uses include flame retardants such as chlorinated organophosphate esters tris-(chloroisopropyl) phosphate (TCPP), tris-(dichloroisopropyl) phosphate (TDCP) and tris-(chloroethyl) phosphate (TCEP), plasticizers such as tri-n-butylphosphate (TnBP), tri-isobutylphosphate (TiBP), triphenylphosphate (TPP), ethylhexyldiphenylphosphate (EHDPP) and tris-(butoxyethyl) phosphate (TBEP) (non-halogenated) and anti-foaming agents (Andresen, 2006; Van der Veen and de Boer, 2012; Wei et al., 2015). Levels of PFRs in environmental compartments have been reported in e.g. Evenset et al. (2009) and Regnery et al. (2011). Knowledge of the biological effects of PFRs are still limited.

1.3.5 Per- and polyfluorinated alkyl substances (PFAS)

Per- and polyfluoroalkyl substances are a large group of anthropogenic chemicals with exceptional physical-chemical properties. Exhibiting both hydrophilic and hydrophobic properties, these compounds are widely used in products mainly for their abilities to reduce surface tension in addition to both water and oil repellant properties. Products include fire-fighting foam (AFFF), food packaging, and textiles. Emissions worldwide are, and have been, substantial given the range of products for industrial and personal purposes. The same properties that make them so useful in consumer products are also resulting in environmental persistency, toxicity, and biomagnification once they enter nature.

Some of the substances are carcinogenic, have reproductive effects, and may alter the lipid metabolism in organisms. Two specific compounds, perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS), have so far driven the regulation of fluorinated substances because of their ubiquitous presence in environmental compartments, in addition to their bioaccumulative and toxic potential for aquatic and mammal species (e.g. Lau et al., 2007).

PFASs are often divided into subgroups such as the PFCAs (perfluoroalkyl carboxylic acids, e.g. PFOA), PFSAs (perfluoroalkane sulfonic acids, e.g. PFOS), perfluorooctane sulfonamide substances (preFOS, precursors, e.g. PFOSA, FOSAA), and fluorotelomer sulfonic acids (n:2 FTSA, linear chained compounds not fully fluorinated, e.g. 6:2 FTS).

1.3.6 Alkylphenols and bisphenols

Bisphenol-A (BPA) is considered an environmental endocrine disruptor (EDC), and with the potential impact on human health, some nations have banned the use of BPA in specific products such as food-packaging. However, the substitutes such as bisphenol-B, -S, and -F have been reported to exhibit similar biological effects (Chen et al., 2016). The analogues are not yet regulated. Alkylphenols (APs) are a class of EDCs and are the degradation products of the non-ionic surfactants alkylphenol polyethoxylates (APEs), used as plasticizers in high density polyethylene (HDPE), polyethyleneterephthalate (PET) and polyvinylchloride (PVC) and in the manufacture of textiles, paper and agricultural chemical products (Salgueiro-González et al., 2015).

1.3.7 UV-chemicals

Organic UV-filters such as octocrylene (CAS: 6197-30-4), benzophenone-3 (CAS: 131-57-7), and ethylhexylmethoxycinnamate (CAS: 5466-77-3) are aromatic compounds adsorbing UV-radiation and are thus used in sunscreen and other personal care products. Other uses include additives as stabilizers in e.g. clothes, plastics, and paints, e.g. benzotriazole UV-stabilizers (e.g. UV-327, UV-328, and UV-329). UV-filters are ubiquitous in the environment, posing a potential for endocrine disruption and developmental toxicity (Vidal-Linan et al., 2018). They are most likely to enter aquatic environments through wastewater effluents and sludge (Langford et al., 2015). In the EU, there are regulations limiting the concentrations of these compounds in care products to 4-10 % depending on substance (EC, 2009).

1.4 Environmental quality standards (EQS) – short introduction

EQS (Environmental quality standards) is a specific concentration distinguishing between a "good" and a "poor" environmental condition in a water body for a given contaminant, as described in the Water Framework Directive. The concentration limit is determined based on risk assessments for human health and the environment, such as an aquatic ecosystem. In Norway EQS values are implemented through the Water Regulation (*Vannforskriften*), and for monitoring surveys biota samples are preferred over abiotic samples to better understand the environmental impact caused by contaminants over time. As an example, mercury (Hg) is a contaminant which tends to biomagnify upwards in food chains, and a low EQS_{biota}-value for Hg indicate a high toxicity for this contaminant and a high bioaccumulation and biomagnifying factor (Direktoratsgruppen vanndirektivet, 2018). The EQS-value is set to protect the most sensitive species within the ecosystem from adverse effects.

In freshwater, brown trout is one of the species that meet most of the criteria for EQS classification such as:

- reflecting changes of contaminant concentrations in the environment,
- ability of biomagnification in the entire study area,
- representative for the study area,
- large population
- large enough individual size for target tissue sampling

Several legacy POPs (persistent organic pollutants), such as PBDEs binds to sulfhydryl groups in proteins. The same is relevant for mercury (Hg). Fish muscle is thus the preferred sample tissue for these contaminants. Due to the amount of samples bisphenol A, TBBPA (tetrabromobisphenol A), D5 (cyclic volatile methylated siloxane), octyl- and nonylphenol were determined in muscle. PFOS and PFOA are determined in liver.

1.4.1 EQS values and contaminants included in this study

Table 3 lists the contaminants with EQS values in the monitoring program for Lake Mjøsa and Lake Femunden and the concentrations detected in fish (biota) samples. QS_{biota} was considered for samples of brown trout muscle, except for PFOS and PFOA where the sample media was liver. The results for each contaminant are discussed in their respective chapter.

Table 3. EQS values from Norwegian water framework directive (WFD) (Direktoratsgruppen vanndirektivet, 2018) compared to results from Lakes Mjøsa and Femunden for the contaminants that fall under the WFD. Last column lists the number of samples (n) above the EQS value. Values exceeding QS_{biota} are marked in **red** and the difference between Lake Mjøsa (M) and Femunden (F) is shown. Concentrations in µg/kg w.w. (ng/g w.w.).

	Biota (brown trout)			
Contaminant	QS_{biota}	Detected concentration range min- max for Brown trout		n > QS_{biota}
	µg/kg w.w.	µg/kg w.w.		n
PBDEs (ΣBDE_6)*	0.0085	Mjøsa	3.5 - 16	15/15
		Femunden	0.13 – 2.60	10/10
PFOS	9.1	Mjøsa	0.9 – 19	8/15
		Femunden	0.39 – 2.6	0/10
PFOA	91.3	< 0.5		0/25
Nonylphenol	3000	< LOD (50)		0/25
Octylphenol	0.004	< LOD (40)		0/25
cVMS (D5)	15217	0.48 – 39.3		0/25
Hg	20	Mjøsa: 289 - 1480		15/15
		Femunden: 56 - 739		10/10

n.e.: non-existing
* (ΣBDE_6): BDE-28, BDE-47, BDE-99, BDE-100, BDE-153, BDE-154.

2 Methods

2.1 Sampling of fish and zooplankton

All biological materials in the project were collected and processed according to the strict procedures of the Norwegian Environmental Specimen Bank for freshwater fish (Miljøprøvebanken, 2015). In this procedure several actions are mandatory to implement for the field personnel in order to avoid potential cross-contamination of the samples. One example is that all personnel must avoid using personal care products, or only use approved products one day prior to sampling. During capture, later handling and sampling it is vital that the fish must not come into contact with potentially contaminating surfaces or substances.

Zooplankton and the planktonic opossum shrimp Mysis from Lake Mjøsa were sampled in September and October when the zooplankton population was fully developed. Due to difficulties obtaining satisfactory amount of zooplankton samples, collection of material was done partly from the circulating surface water (epilimnion, 0-10 m) and partly from hypolimnion (30-50 m) where the denser populations of zooplankton were found. Sampling of Mysis was carried out using net tows at a depth of 70 to 100 meters. Mysis tend to migrate vertically to avoid predation. Sampling area was located in the main basin of the lake east and south of Helgøya (see Figure 1). Sample equipment included a nylon mesh net (mesh size 500 microns) equipped with a collecting cup with a sieve (both in brass). Clogging of nets by diatoms (algae) that may form jelly-like aggregates on the net was partly lowering the efficiency of zooplankton sampling, challenging the sampling procedure to provide 200 g of material. Hypolimnic zooplankton proved to be omnivorous species, noticed post-sampling, reducing the quality of zooplankton samples as we aimed for the true primary consumers on a lower trophic level. After sampling, Mysis were transferred to the same type of test glasses and tubes as the fish samples and stored frozen until analysis at -20 °C. All tools supposed to be in direct contact with the samples were cleaned with methanol and acetone (HPLC grade). At all times during field work, approved disposable gloves (nitrile rubber) were used.

Vendace were caught using bottom nets in the same areas as brown trout, in the Gjøvik area. E. smelt was captured using large trawls in October. This method allowed us to catch E. smelt in the preferred size range for the brown trout to prey on. Both vendace and E. smelt tend to migrate vertically in the water column within a 24-hour period to avoid predation. During the night both species will prey on zooplankton and Mysis in the epilimnion, whereas they both undergo shoaling during daylight on depths of 30-50 m. In Lake Mjøsa, vendace and brown trout were caught by local fishermen using bottom nets in an area north of Gjøvik (Figure 1). In Lake Femunden, brown trout were caught during the annual fishing for European whitefish in the main basin outside Elgå.

Sampling of fish in Lake Mjøsa and Lake Femunden were carried out in August and September 2018. After collection, individual fish were wrapped in clean aluminum foil, packed in clean polyethylene bags and kept cold (≈ 4°C) or frozen (-20°C) until dissection of samples. The fish were stored in boxes lined with rinsed aluminum foil. Traditional fish boxes in expanded polystyrene (EPS) were avoided because of the risk of contamination by flame retardants.

Dissections of fish samples were performed out in the open air in a non-urban environment to prevent contamination of siloxanes (cVMS) from indoor sources. All surfaces that could come into contact with fish were covered by aluminum foil, rinsed with methanol and acetone (HPLC grade). Fish length and weight were recorded. All tools used for dissection were made of steel and cleaned according to the Environmental Specimen Bank procedures (dishwasher, rinsed in Milli-Q water, acetone, and methanol). For vendace and brown trout about 20 – 100 g of dorsal muscle filet was dissected out from each individual. E. smelt had an individual weight ranging from 4 – 86 g. Composite samples from an average of 4-5 individuals within a similar weight class had to be processed to provide enough sample for analysis (a total of 20 – 25 g). Six out of ten samples for E. smelt were pooled samples, the remaining four were large individuals (73 – 86 g). In addition, liver samples were dissected out of E. smelt, vendace, and brown trout for PFAS-analysis.

All samples were stored in glass beakers sealed with an aluminum foil under the lid. Glass and the aluminum foil were cleansed by heating up to 500°C. The samples were stored in sub-zero temperatures (-20°C) until analysis.

2.2 Analytical methods

2.2.1 Stable isotopes of N *($\delta^{15}N$)*, C *($\delta^{13}C$)*, and S *($\delta^{34}S$)*

The ratio between the stable nitrogen isotopes ^{14}N and ^{15}N ($\delta^{15}N$), the carbon isotopes ^{12}C and ^{13}C ($\delta^{13}C$), and the sulfur isotopes ^{32}S and ^{34}S were determined by IFE (Institute for Energy Technology), based on Vander Zanden and Rasmussen (2001). Analyses were performed according to standard protocols without removing lipids nor carbonates prior to analysis. Important steps of the method include combustion in an element analyzer, reduction of NO_x in a Cu-oven, separation of N_2 and CO_2 on a GC-column followed by determination of ^{15}N, ^{13}C, and ^{34}S on an Isotope Ratio Mass Spectrometer (IRMS).

2.2.2 Mercury, Hg

Mercury, Hg, was determined in all samples by Eurofins, according to NS-EN ISO 12846 (Norsk standard, 2012). For zooplankton and Mysis, whole body samples were analyzed, whereas muscle was the sample matrix for all fish. After homogenization, 1 g of sample is weighed in a test tube, followed by extraction with nitric acid (HNO_3). Blinds and control samples are treated the same way. Quantification was performed by a M-7500 Mercury analyzer (HydridGenerating-AtomicAbsorptionSpectrophotometry, HG-AAS). This is a cold-vapor technique.

2.2.3 Cyclic volatile methyl siloxanes (cVMS)

The samples were analyzed by NILU according to methods published by Krogseth et al. (2017). Field blanks for sampling of siloxanes were prepared using 2 – 3 grams of XAD-2 sorbent packed into a polypropylene/cellulose filter bag. Before use in the field, XAD-2 sorbent was cleaned by ultra-sonication in hexane for 30 minutes. Hexane was removed and replaced with dichloromethane and XAD-2 sorbent was sonicated again for 30 minutes. After sonification, XAD-2 sorbent was dried overnight in a clean cabinet equipped with a HEPA (high efficiency particulate air) and carbon filter to prevent contamination of the XAD-2 sorbent from indoor air. XAD-2 sorbent was then packed into the previously described filter bags and placed in polypropylene tubes and sent to field personnel for sampling purposes.

Several prepared field blanks prepared were kept at NILU's laboratories and analyzed to determine reference concentrations present in the field blanks prior to exposure within the field. Comparison of concentrations between reference levels and field blank levels was done to assess if contamination during sampling had occurred. Extraction of all sample material was done in a clean cabinet equipped with both HEPA- and carbon filters to prevent contamination from indoor air and dust. All laboratory personnel involved in sample extraction avoid use of personal care products such as lotion or deodorant.

Samples were extracted using a mixture of 3:1 hexane:acetonitrile with ultrasonification for 15 min. Samples were subsequently shaken for 1 hour followed by centrifugation at 2500 rpm. A small aliquot of hexane supernatant was transferred to a GC vial followed by addition of tris(trimethylsiloxy)silane as a recovery standard.

Samples were analyzed by GC-MS equipped with DB-5MS column using large volume injection (5 µL). Instrumental conditions have been described by Krogseth et al. (2017). Method detection limits (MDLs) have been shown to be ideal for the analysis of siloxanes in environmental samples as they account for the variation introduced to the analytical signal from the extracted matrix (Warner et al. 2013). Due to the different matrices investigated in this study, it was not possible logistically to determine MDL for all matrices. Therefore, limit of quantification (LOQ) was described as the average plus 10 × standard deviation of the procedural blank signal. This LOQ was used as a conservative detection limit for reporting concentrations. Limits of detection (LOD) described as 3 × standard deviation of the procedural blank signal was also reported for comparison with LOQ.

Siloxanes (D4, D5 and D6) were determined in a clean-room facility using GC-MS.

2.2.4 Brominated flame retardants (BFR)

BFRs were determined by NILU, based on the methods by Bengtson Nash (2008). In brief, 2-5 g of biological material is weighed and homogenized with about 50 g of dry sodium sulphate to fine grained powder. This fine-grained powder was transferred to an elution column with several isotope labelled BFR components and eluted with cyclohexane/acetone (1:1). The extract was concentrated and cleaned using a silica column, conc. H_2SO_4 was added followed by another clean-up on silica column down to 100 µL with addition of a recovery standard. BFR components were determined and quantified in 2 separate GC/HRMS-analyses. Proper identification and quantification were confirmed based on correct retention time, correct isotope ratio, a signal/noise ratio > 3:1, and a correct recovery of internal standard, in addition to accepted blind for the method.

2.2.5 Alkylphenols and bisphenols

Alkylphenols and bisphenols (octylphenol, nonylfenol, bisphenol A, S, F, AF, AP, B, E, FL, M and Z, TBBPA) were determined by NILU. Prior to extraction, isotope labelled phenols were added to the samples, following both extraction and preconcentration. Extraction was carried out using distilled methanol, ethyl acetate, and MTBE (methyl tert-butyl ether) securing good recovery, and preconcentration under nitrogen followed by clean-up with SPE-column to remove lipids and other interferences. All samples were analyzed using Thermo LC-QExactive Plus OrbiTrap. Limits of detection (LOD) and quantification (LOQ) were calculated for each sample using an accepted standard method which included an average of blank concentrations plus 3- and 10-times standard deviation for the blanks for LOD and LOQ respectively. Methods are also described in Ruus et al. (2016).

2.2.6 Phosphorous flame retardants (PFR)

PFRs were determined by NILU. Prior to extraction, a mixture of isotope labelled PFR-standards were added to the sample for quantification. All samples, including biota, water, and sediment, were extracted using acetonitrile. The extracts were reduced under a stream of nitrogen followed by a clean-up using silica column to ensure good recovery. PFR-compounds were quantified using a Thermo TSQ Vantage UPLC/MS-MS, methods described in Evenset et al. (2018).

2.2.7 Per- and polyfluorinated substances (PFAS)

PFAS were determined by NIVA. Prior to extraction, a mixture of isotope labelled PFAS were added to the sample (~2 g), following the sequence of both extraction and preconcentration with acetonitrile. The analytical method is based on e.g. Verrault (2007) with some adaptions. Samples were extracted using acetonitrile and buffers for pH-control. Extracts were cleaned using solid phase extraction (SPE) and active carbon. PFAS were determined using a LC-qToF-MS.

2.2.8 UV-chemicals

UV-chemicals (octocrylen, benzophenone and ethylhexylmethoxycinnamate) were determined by NIVA. The analytical methods are based on published works by e.g. Langford et al. (2015). A mixture of isotope labelled internal standards were added to homogenized biota samples, following both the extraction and preconcentration steps. Samples were extracted with organic solvents (isopropanol and cyclohexane), and the extracts were reduced to approximately 1 ml under a stream of nitrogen (35 °C) before further clean-up via Gel Permeation Chromatography (GPC). UV-chemicals were quantified using GC-MSD (Agilent) or APGC-Vion (Waters). LOD and LOQ were calculated for each sample using an accepted standard method of 3 x signal/noise ratio (s/n) and 9 times s/n respectively.

2.3 Calculating trophic magnification factors

Trophic magnification factor (TMF) is the factor of increase in concentration of a contaminant per integer trophic level (TL) in the food web (see chapter 3.1). The trophic level is traditionally estimated from stable N-isotope ratios ($\delta^{15}N$) using empirical data from analyses of $^{15}N/^{14}N$ in organisms.

Calculating TL from $\delta^{15}N$-ratios preferably involves a baseline adjustment, which means that the $\delta^{15}N$-ratio for primary consumers (pc) are subtracted from the $\delta^{15}N$ in consumers (c) of a higher trophic level:

$$TL=[(\delta^{15}N_C - \delta^{15}N_{pc})/\Delta^{15}N] + 2$$

Where TL is the trophic level of consumers, $\delta^{15}N_c$ *and* $\delta^{15}N_{pc}$ are the N-isotope ratio for consumers and primary consumers, respectively. $\Delta^{15}N$ is the enrichment factor of 3.4 ‰ per trophic level (Vander Zanden et al., 1997; Vander Zanden and Rasmussen, 1999).

When the natural logarithm of the of the concentration is plotted against the trophic level of the organisms, the relationship between the concentration of a contaminant (C_{LW}) and trophic level might be expressed with the following function:

$$ln\ C_{LW} = a + b \cdot TL$$

This is the natural exponential function, in which *b* is the gradient (slope) to the regression between the *ln*-transformed concentration (lipid weight) of a contaminant (C_{LW}) and the trophic level (TL) of this contaminant. If a baseline adjustment for primary consumers is not possible, a relative trophic level (TL_{rel}) for the different organisms may be calculated by dividing $\delta^{15}N_c$ with the N-enrichment factor $\Delta^{15}N$:

$$TL_{rel} = \frac{\delta 15Nc}{\Delta 15\mathrm{N}}$$

where TL_{rel} is the relative trophic level, $\delta^{15}N_c$ is the measured ratio between stable N-isotopes and $\Delta^{15}N$ is the empirical N-enrichment factor of 3,4 ‰ (Vander Zanden et al., 1997; Vander Zanden and Rasmussen, 1999; Post, 2002). In this respect, a baseline adjustment for each lake and year to account for the difference in $\delta^{15}N$ between consumers and primary consumers will not be necessary. TL_{rel} may then be used to calculate the trophic distance between different organisms within a lake but will not be accurate for determining their absolute level or to compare trophic levels between lakes with a different $\delta^{15}N$.

When

$$ln\ C_{LW} = a + b \cdot TL_{rel}$$

TMF is now defined as:

$$TMF = e^b$$

A trophic magnification is determined when the regression coefficient *b* is significantly > 0. The corresponding trophic magnification factor (TMF), defined as e^b, will then consequently be > 1.

3 Results

Table 4 provides an overview of the entire data set, highlighting the detection frequency for each contaminant within the major groups of substances. Detection frequency is the percentage of samples in which a contaminant was detected relative to the total number of analyzed samples. All results are dependent on detection limits for each compound.

Table 4. Detection frequency (%) for the contaminants sorted in compound groups. Presented as percentage of detected results. Shading refers to 5 subclasses: white: 0-20 %, light pink: 20-40 %, pink: 40-60 %, light red: 60-80 % and red: 80-100 %. Data for mercury (Hg), cyclic volatile methylated siloxanes (cVMS), brominated flame retardants (BFR), organic phosphorous flame retardants (oPFR), per- and polyfluorinated alkyl substances (PFAS), alkyl- and bisphenols, new brominated flame retardants (nBFR) and UV-filters.

		Detection frequency							
Contaminant class	Compound	Zooplankton (n=3)	Mysis (n=3)	E. Smelt (n=10)	Vendace (n=10)	Brown trout, L.Mjøsa (n=15)	Brown trout, L.Femunden (n=10)	Total dataset (n=51)	CAS-no.
Hg	Hg	0	100	100	100	100	100	94	7439-97-6
cVMS	D4	100	66	0	80	0	0	25	556-67-2
	D5	100	100	100	70	100	0	75	541-02-6
	D6	100	100	100	30	53	0	53	540-97-6
BFR (PBDEs)	BDE-17	100	100	90	80	60	30	67	147217-75-2
	BDE-28	100	100	100	100	100	100	100	41318-75-6
	BDE-47	100	100	100	100	100	100	100	5436-43-1
	BDE-49	0	100	100	100	100	100	96	243982-82-3
	BDE-66	0	0	50	70	100	60	67	189084-61-5
	BDE-71	0	0	0	10	7	10	6	189084-62-6
	BDE-77	0	0	10	80	73	40	49	93703-48-1-
	BDE-85	0	0	30	10	7	0	10	182346-21-0
	BDE-99	100	100	100	100	100	100	100	60348-60-9
	BDE-100	100	100	100	100	100	100	100	189084-64-8
	BDE-119	0	0	10	80	100	70	63	189084-66-0
	BDE-126	0	0	40	60	47	20	39	366791-32-4
	BDE-138	0	0	0	10	0	0	2	182677-30-1
	BDE-153	0	100	100	100	100	100	96	68631-49-2
	BDE-154	100	100	100	100	100	100	100	207122-15-4
	BDE-156	0	0	0	10	0	0	2	N/A
	BDE-183	0	0	40	70	53	90	57	207122-16-5
	BDE-184	0	0	0	70	87	90	59	117948-63-7

Detection frequency									
Contaminant class	Compound	Zooplankton (n=3)	Mysis (n=3)	E. Smelt (n=10)	Vendace (n=10)	Brown trout, L.Mjøsa (n=15)	Brown trout, L.Femunden (n=10)	Total dataset (n=51)	CAS-no.
	BDE-191	0	0	0	10	0	0	2	189084-68-2
	BDE-196	0	0	0	10	7	0	4	446255-38-5
	BDE-197	0	0	0	10	20	20	12	117964-21-3
	BDE-202	0	0	20	10	47	20	24	67797-09-5
	BDE-206	0	50	20	20	13	0	14	63387-28-0
	BDE-207	0	0	30	20	13	0	14	437701-79-6
	BDE-209	50	100	40	40	47	10	39	1163-19-5
oPFRs	TEP	0	0	0	0	0	0	0	78-40-0
	TCEP	0	0	0	0	0	0	0	115-96-8
	TPrP	0	0	0	0	0	0	0	513-08-6
	TCPP	50	100	20	50	73	90	67	13674-84-5
	TiBP	0	33	0	0	0	0	2	126-71-6
	BdPhP	0	0	0	0	0	0	0	2752-95-6
	TPP	100	33	20	70	20	0	31	115-86-6
	DBPhP	0	0	0	0	0	0	0	2528-36-1
	TnBP	0	66	0	0	27	0	13	126-73-8
	TDCPP	50	0	0	0	0	0	2	13674-87-8
	TBEP	0	0	0	0	0	0	0	78-51-3
	TCP	100	0	0	0	0	0	4	1330-78-5
	EHDP	0	33	0	0	0	0	2	1241-94-7
	TXP	0	0	20	0	7	0	4	25155-23-1
	TEHP	100	0	0	0	7	0	7	78-42-2
PFAS	PFPA	0	0	0	0	0	0	0	2706-90-3
	PFHxA	0	0	0	0	0	0	0	307-24-4
	PFHpA	0	0	0	0	0	0	0	375-85-9
	PFOA	0	0	0	0	0	0	0	335-67-1
	PFNA	0	0	70	30	60	30	43	375-95-1
	PFDA	0	0	80	10	100	90	65	335-76-2
	PFUnDA	0	0	90	50	100	100	76	2058-94-8
	PFDoDA	0	0	90	60	100	100	78	307-55-1
	PFTrDA	0	0	70	30	100	100	69	72629-94-8
	PFTeDA	0	0	50	10	100	90	59	376-06-7
	PFPeDA	0	0	50	0	93	80	53	18024-09-4
	PFHxDA	0	0	0	0	0	0	0	67905-19-5
	PFBS	0	0	0	0	0	0	0	375-73-5
	PFPS	0	0	0	0	0	0	0	2706-91-4
	PFHxS	0	0	0	0	0	0	0	355-46-4
	PFHpS	0	0	0	0	27	0	8	375-92-8
	PFOS	0	66	100	100	100	100	92	1763-23-1

Contaminant class	Compound	Zooplankton (n=3)	Mysis (n=3)	E. Smelt (n=10)	Vendace (n=10)	Brown trout, L.Mjøsa (n=15)	Brown trout, L.Femunden (n=10)	Total dataset (n=51)	CAS-no.
		Detection frequency							
	8Cl-PFOS	0	0	0	0	0	0	0	N/A
	PFNS	0	0	0	0	0	0	0	474511-07-4
	PFDS	0	0	0	50	20	0	16	335-77-3
	PFDoS	0	0	0	0	0	0	0	7978-39-5
	PFOSA	0	0	50	0	100	20	43	754-91-6
	N-MeFOSA	0	0	0	0	0	0	0	31506-32-8
	N-EtFOSA	0	0	0	0	0	0	0	4151-50-2
	N-MeFOSE	0	0	0	0	0	0	0	24448-09-7
	N-EtFOSE	0	0	0	0	0	0	0	1691-99-2
	4:2 FTS	0	0	0	0	0	0	0	757124-72-4
	6:2 FTS	0	0	0	0	7	0	2	27619-97-2
	8:2 FTS	0	0	0	0	0	0	0	39108-34-4
	10:2 FTS	0	0	0	0	0	0	0	120226-60-0
	4:2 F53B	0	0	0	0	0	0	0	N/A
	6:2 F53B	0	0	0	0	0	0	0	73606-19-6
	N-MeFOSAA	0	0	0	0	0	0	0	2355-31-9
	N-EtFOSAA	0	0	0	0	0	0	0	2991-50-6
	F53	0	0	0	0	0	0	0	754925-54-7
	7:3 FTCA	0	0	0	0	0	0	0	812-70-4
	PFBSA	0	0	0	0	0	0	0	30334-69-1
	N-MeFBSA	0	0	0	0	0	0	0	68298-12-4
	N-EtFBSA	0	0	0	0	0	0	0	40630-67-9
Alkylphenols bisphenols	4,4-Bis-A	0	0	0	0	27	10	10	80-05-7
	2,4-Bis-A	0	0	0	0	0	0	0	80-05-7
	Bis-G	0	0	0	0	0	0	0	127-54-8
	4,4-Bis-S	0	0	0	0	0	0	0	80-09-1
	2,4-Bis-S	0	0	0	0	0	0	0	80-09-1
	4,4-Bis-F	0	50	0	0	0	20	6	620-92-8
	2,4-Bis-F	0	50	0	0	0	0	2	620-92-8
	2,2-Bis-F	0	50	0	0	0	0	4	620-92-8
	Bis-P	0	0	0	0	0	0	0	2167-51-3
	Bis-Z	0	0	0	0	0	0	0	843-55-0
	TBBPA	0	0	0	0	0	0	0	79-94-7
	4-tert-octylphenol	0	0	0	0	0	0	0	140-66-9
	4-octylphenol	0	0	0	0	0	0	0	1806-26-4
	Nonylphenol	0	0	0	0	0	0	0	84852-15-3
nBFR	TBA	100	50	90	80	93	100	90	607-99-8
	ATE (TBP-AE)	0	0	0	0	0	0	0	3278-89-5

Detection frequency									
Contaminant class	Compound	Zooplankton (n=3)	Mysis (n=3)	E. Smelt (n=10)	Vendace (n=10)	Brown trout, L.Mjøsa (n=15)	Brown trout, L.Femunden (n=10)	Total dataset (n=51)	CAS-no.
	a-TBECH	0	0	0	0	0	0	0	3322-93-8
	b-TBECH	0	0	0	0	0	0	0	3322-93-8
	g/d-TBECH	0	0	0	0	0	0	0	3322-93-8
	BATE	0	0	0	30	0	40	14	99717-56-3
	PBT	0	0	0	0	0	0	0	87-83-2
nBFR	PBEB	0	0	0	0	0	0	0	85-22-3
	PBBZ	100	100	100	100	100	100	100	608-90-2
	HBB	0	0	0	0	27	50	18	87-82-1
	DPTE	0	0	0	0	0	10	2	35109-60-5
	EHTBB	50	0	0	0	0	0	2	183658-27-7
	BTBPE	0	100	100	100	100	90	94	37853-59-1
	TBPH (BEH /TBP)	0	0	40	0	0	0	8	26040-51-7
	DBDPE	100	50	30	10	27	60	35	84852-53-9
UV-filters	BP3	100	0	70	0	0	10	19	131-57-7
	EHMC-Z	0	0	0	10	0	50	13	5466-77-3
	EHMC-E	0	0	0	10	0	0	2	5466-77-3
	OC	100	0	10	10	0	0	6	6197-30-4

3.1 Fish size, trophic levels, lipid and stable isotopes

Besides the obvious magnitude of input of contaminants to the ecosystem, contaminant concentrations in aquatic biota are to large degree driven by variations in individual size, age, trophic level in the food web (reflected in the $\delta^{15}N$ and calculated TL), as well as lipid content (Bjerregaard, 2005). Although often co-occurring, accumulation related to variation in individual size and age are inherently different than mechanisms related to biomagnification. Biomagnification is the increase of a contaminant up the food chain due to transfer of contaminants from one trophic level to the next, also referred to as trophic transfer. In addition, habitat use, i.e. where in the ecosystem an organism feed and which carbon sources they rely on, reflected by the $\delta^{13}C$, may also impact on organism contaminant concentrations (Power et al., 2002). We have added data related to individual size (in fish only), lipid content, trophic level ($\delta^{15}N$) and habitat use ($\delta^{13}C$) in sampled biota for 2018 (Table 5) and for 2013-2018 and (Table 6) in order to explore the relationships between these predictors and measured contaminant concentrations in the biota.

Mean length in brown trout from Lake Mjøsa sampled from 2013 to 2018 was 66.4 and mean weight 3.7 kg, while for brown trout sampled from Lake Femunden the mean length and weight was 41.9 and 0.79 kg, respectively. This probably reflects that Lake Mjøsa has a denser population of large trout than Lake Femunden (Kraabøl et al., 2009; Sandlund et al., 2012). As is evident from the scatterplot (Figure

3 and Figure 4), lipid concentration increases with length in trout in Lake Mjøsa. The mean lipid concentration is also higher in Lake Mjøsa compared to trout from Lake Femunden.

Values for $\delta^{15}N$ will tend to increase upwards in the food web with an average of 3.4 ‰ for each trophic level (Minagawa and Wada, 1984; Vander Zanden and Rasmussen, 1999). In Lake Mjøsa, the mean $\delta^{15}N$-values range from 6.9 in epipelagic zooplankton to 15.6 ‰ in brown trout in the sampled material from 2013 to 2018. This translates into~ 2.6 trophic levels given the 3.4 ‰ increase per trophic level. As can be seen from Table 6 there is a relatively large difference in mean $\delta^{15}N$, thus trophic level, in sampled epiplimnetic (6.9 ‰) and hypolimnetic zooplankton (12.2 ‰). Samples of hypolimnetic zooplankton in 2018 consisted mainly of the large-bodied omnivorous copepod *Limnocalanus macrurus* (> 99 %), with a mean $\delta^{15}N$ of 13.15 ‰ (Table 5). This species may also periodically display predacious behavior (Warren, 1985). True planktonic primary consumers of Lake Mjøsa is expected to have a $\delta^{15}N$ ~6‰ (Fjeld et al., 2017), although annual variations may occur due to variations in nitrogen sources and accordingly baseline $\delta^{15}N$ (Vander Zanden and Rasmussen, 1999).

Difference in trophic level between brown trout and E. smelt in Lake Mjøsa was quite low (0.9 ‰), which may be explained by the inclusion of some large, cannibalistic individuals up to 113 g in the sample batch of E. smelt. $\delta^{15}N$ for E. smelt increases with length, also indicating that large E. smelt become cannibals (Figure 4, right). For the trout there is less variation in trophic level ($\delta^{15}N$-values) within the sampled lengthrange, reflecting lesser variation in diet in the sampled trout (i.e. all are piscivores). In Lake Mjøsa there are plenty of pelagic prey fish, including smaller sized species (e.g. E. smelt and vendace), meaning that a greater portion of trout can become piscivore at an early age compared to lakes with less smallsized pelagic prey fish, such as in Lake Femunden (Museth et al., 2018). In addition, Lake Mjøsa is more productive and has a more complex ecosystem structure than Lake Femunden, and thus longer food chains, which is reflected in a higher measured mean $\delta^{15}N$ for the Lake Mjøsa trout (15.6 ‰) compared to the trout from Lake Femunden (9.7 ‰).

$\delta^{13}C$ values varies with different carbon sources, typically with around -27 ‰ for terrestrial, -20 ‰ for littoral, - 28 ‰ for pelagial and -30 ‰ for profundal carbon sources (Figure 4). However, measured $\delta^{13}C$ values may often be a result of a mix of carbon sources. Trout in Lake Mjøsa may e.g. integrate across littoral and pelagic food chains and habitats for feeding, which have been reported in other lakes ecosystems for piscivorous trout (Vander Zanden and Vadeboncoeur, 2002; Økelsrud et al. 2017). The largest trouts at the highest trophic levels in our data from Lake Mjøsa also have intermediate $\delta^{13}C$ values (~ 29 ‰), which may indicate that they have a more varied piscivorous diet, including both pelagic and littoral carbon sources, than smaller trout (Figure 5). The relatively strong and significant correlation between ($\delta^{15}N$) and carbon source ($\delta^{13}C$) in Lake Femunden trout ($r = 0.77$, $p<0.05$), suggest that trophic level increases with a more pelagic diet (Figure 3, right). This may reflect variations in feeding strategies in the population, or also an ontogenetic niche (and diet) shift from more littoral to more pelagic feeding at a certain size (Klemetsen et al., 2003). Since trout in Lake Mjøsa to a greater degree rely on more pelagic food sources than trout in Lake Femunden (Sandlund et al., 1992; Museth et al., 2018), the trout in Lake Mjøsa, tend to display lower, more negative, $\delta^{13}C$-values.

Table 5. Length (cm), weight (g), lipid content (%), and stable N- and C- isotopes ($\delta^{15}N$, $\delta^{13}C$) for samples of fish (muscle), Mysis and zooplankton from 2018 in Lake Mjøsa. The mean (x̄), and number(n) of samples are shown.

2018			Length, cm	Weigth, g	$\delta^{15}N$, ‰	$\delta^{13}C$, ‰	Lipid, %
Species		n	x̄	x̄	x̄	x̄	x̄
Mjøsa	Zooplankton hypo.	3			13.2	-31.8	6.2
	Mysis	3			10.9	-29.2	3.3
	Vendace	10	20.1	70.2	13.3	-29.4	3.1
	E. smelt	10	15.9	38.6	14.4	-28.9	0.8
	Brown trout	15	67.7	3416	15.6	-28.9	3.4
Femunden	Brown trout	10	41.7	756	8.5	-21.6	1.4

Table 6. Length (cm), weight (g), lipid content (%), and stable N and C isotopes ($\delta^{15}N$, $\delta^{13}C$) for samples of fish (muscle), Mysis and zooplankton from 2013-2018 in Lake Mjøsa. The mean (x̄), and number(n) of samples are shown.

2013-2018			Length, cm	Weigth, g	$\delta^{15}N$, ‰	$\delta^{13}C$, ‰	Lipid, %
Species		n	x̄	x̄	x̄	x̄	x̄
Mjøsa	Zooplankton epi.				6.9	-28.7	0.3
	Zooplankton hypo.				12.2	-32.5	4.6
	Mysis	14			10.6	-30.7	3.3
	Vendace	32	19.6	62.7	13.3	-29.7	3.4
	E. smelt	68	16.2	35.6	14.7	-28.2	1.2
	Brown trout	89	66.4	3724	15.6	-28.2	2.9
Femunden	Brown trout	80	41.9	792.6	9.7	-22.9	1.0

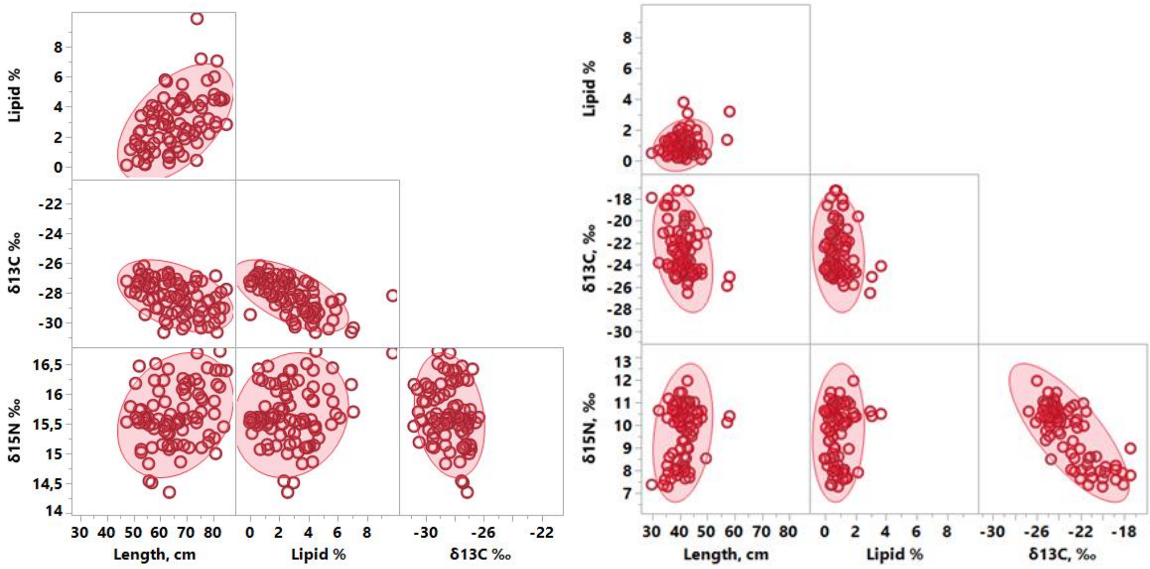


Figure 3. Correlation matrices between stable N- and C-isotopes ($\delta^{15}N$, $\delta^{13}C$), length and lipid content in brown trout from Lake Mjøsa (left) and Lake Femunden (right) sampled from 2013 to 2018. 90 % confidence elipses are shown for each pair of correlations.

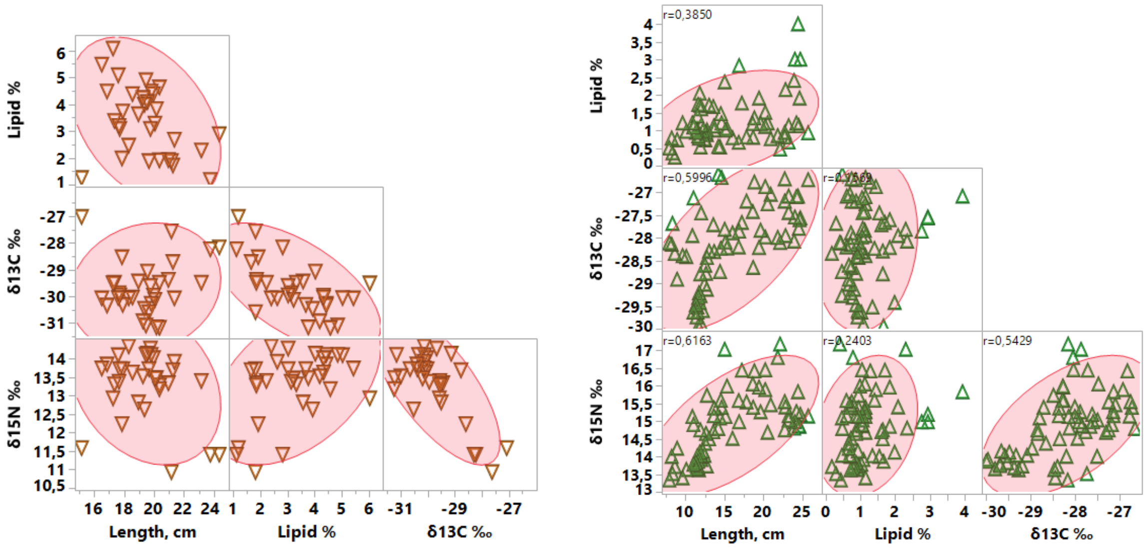


Figure 4. Correlation matrices between stable N- and C-isotopes ($\delta^{15}N$, $\delta^{13}C$), length and lipid content in vendace (left) and E. smelt (right) from Lake Mjøsa sampled from 2013 to 2018. 90 % confidence elipses are shown for each pair of correlations.

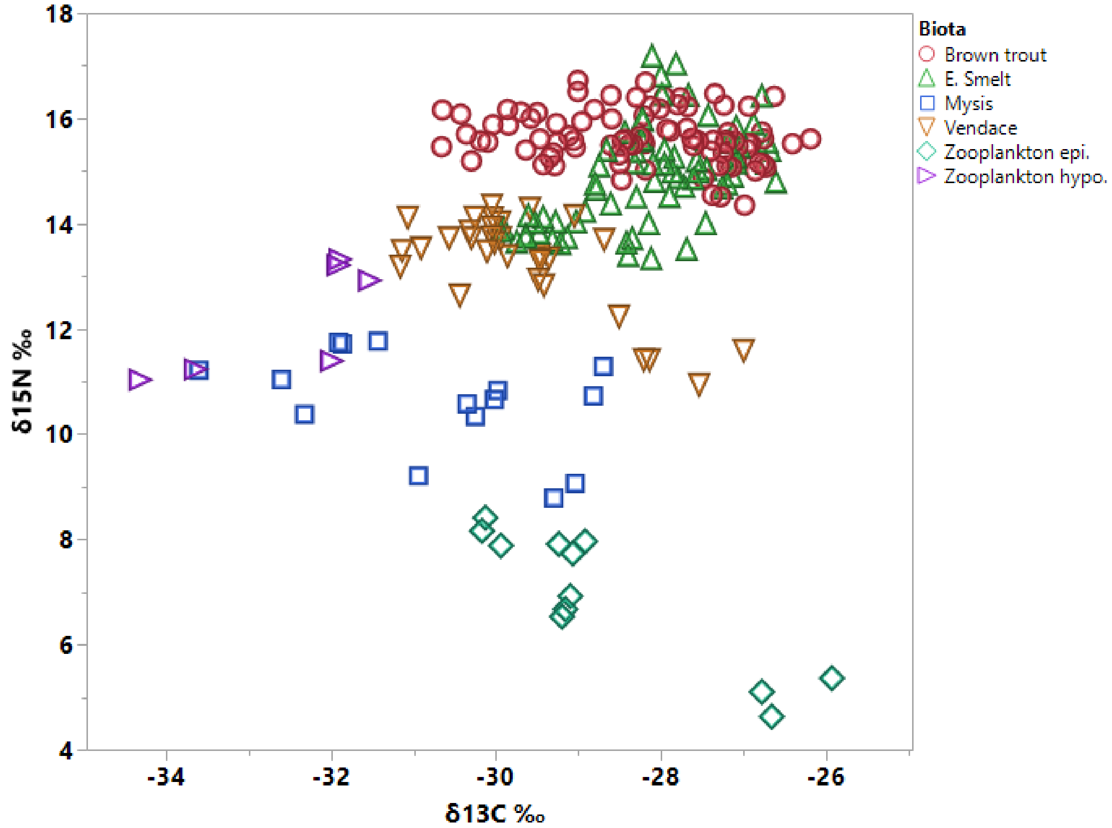


Figure 5. Relationships between measured $\delta^{15}N$ and $\delta^{13}C$ ‰ in biota sampled in Lake Mjøsa from 2013 to 2018. Zooplankton sampled from the upper strata (down to ~ 10 m) of the lake are defined as epilimnetic zooplankton (Zooplankton epi.), while zooplankton sampled from the deeper parts of the lake (50-80 m) are defined as hypolimnetic zooplankton (Zooplankton hypo.).

3.2 Mercury (Hg)

Mercury (Hg) is known to increase in fish by increasing size (Cidzdziel et al., 2002) and age (Stafford et al., 2004; Trudel and Rasmussen, 2006). Hg also has a high potential for biomagnification (i.e. mercury increase with trophic level). Several studies show that Hg increase with relative trophic level (TL) in fish (McIntyre and Beauchamp, 2007; Garcia and Carignan, 2005; Cabana and Rasmussen., 1994; Vander Zanden and Rasmussen, 1996). There are also variations in Hg accumulation between littoral and pelagic food webs, with reported increased bioaccumulation of Hg in pelagic food webs (Chételat et al., 2011) and higher Hg concentrations in pelagic fish compared to littoral fish at similar trophic levels (Power et al., 2002; Gorski et al., 2003; Stewart et al., 2008). Hg also in general increases in biota with depth (Eagles-Smith et al., 2008; Stafford et al., 2004).

We added a principal component analysis (PCA) in order to visualize, some of the beforementioned, predictors for variations of Hg in fish in Lake Mjøsa (Figure 6). The first two components explained 56.9 % (component 1) and 26.7 % (component 2) of the variability in the dataset. As can be seen from the proximity between the arrows in the PCA, Hg and measured $\delta^{15}N$ in fish is closely correlated, as well as length and weight, more closely correlated to each other but also with a close correlation to Hg (component 1). This reflects that Hg in the sampled fish increases with increasing trophic level, length and weight. Naturally this PCA is strongly influenced by the sampled trout with the highest concentrations/values for all measured variables. Interestingly lipid content and $\delta^{13}C$ had opposite signs of eigenvectors, meaning that lipid content increases with a more negative, i.e. more pelagic/profundal $\delta^{13}C$ signature (component 2). Lipid content, however, is not a strong predictor for Hg variations in the fish.

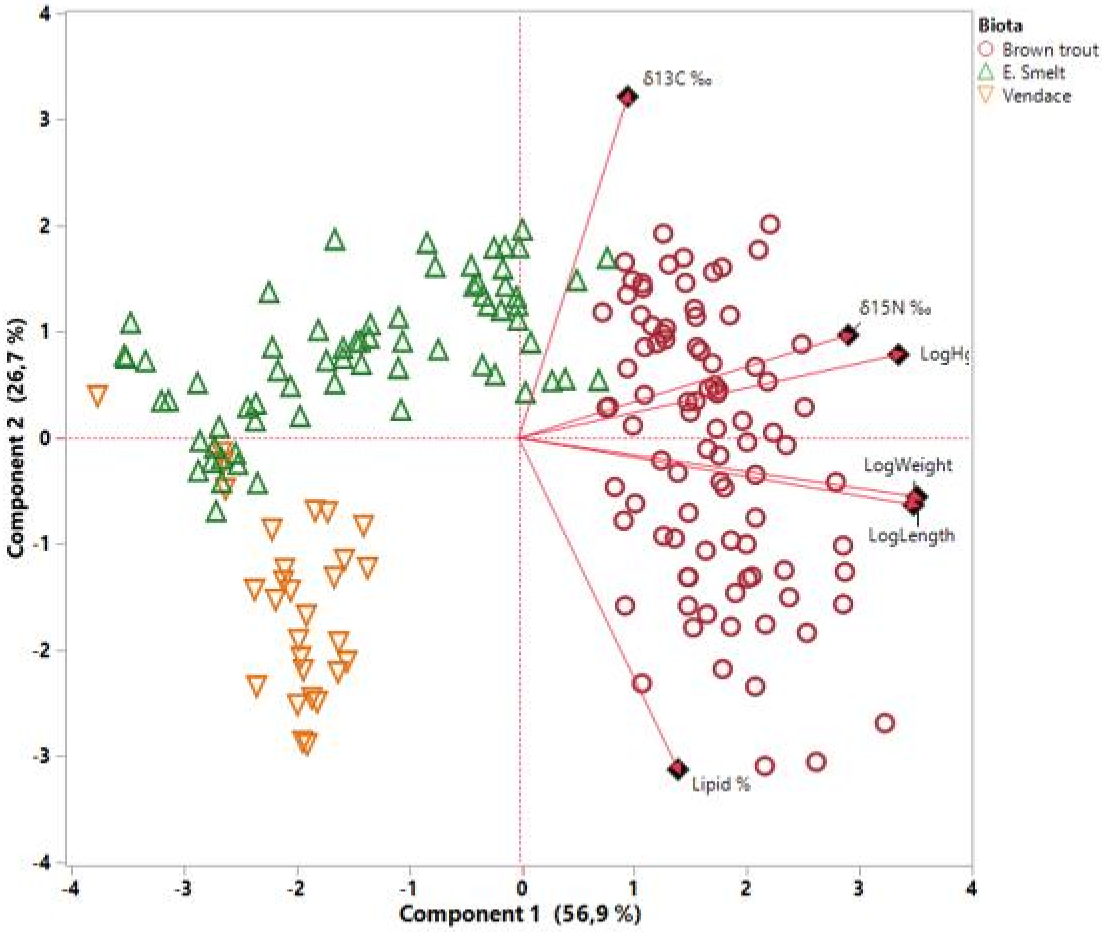


Figure 6. The PCA biplot of the biota data depict the scores of each individual fish (points) and loading of each variable (arrows), where the length of each arrow approximates the variance of the variables, whereas the angles between them demonstrate their correlations. Data on length, weight and Hg concentrations in fish were log-transformed in order to improve normality, stabilize variance and remove influence from sttistical outliers. All data from 2013 to 2018 are added.

3.2.1 Mercury levels in 2018

Mean Hg in trout muscle from both Lake Mjøsa (0.46 mg/kg) and Lake Femunden (0.20 mg/kg) was lower in 2018 (Table 7) than all previous years sampled (in Lake Mjøsa from 2006 and in Lake Femunden from 2013). We cannot find any obvious reason for this in the predictors added, as both size (Table 5), trophic level and carbon sources (Table 6) are close to average for previous years. As seen in Figure 8 and Figure 9, a few trout from 2018 in each of the two lakes with below average Hg concentrations will strongly influence on the mean estimate for 2018. This means that too much emphasis on the potential causality behind this somewhat unexpected result must be placed with caution. However, some potential hypotheses are discussed in the end of this chapter.

E. smelt in Lake Mjøsa naturally varies in Hg because of the inclusion of a few large cannibalistic individuals, that are also higher up in the food chain. Hg concentrations in vendace are low, and reflects a diet mainly consisting of zooplankton. Mysis which is an important dietary source for pelagic fish in Lake Mjøsa is at level with the EQS for mercury at 0.02 mg/kg Hg.

Table 7. Hg concentrations (mean, min, max) in mg/kg w.w. in zooplankton, Mysis, and fish from Lake Mjøsa, and brown trout from Lake Femunden. Values for mean length (cm) and weight (g) are included for fish. Data are from 2018.

2018	Sample	n	x̄	Min	Max	Length, cm (x̄)	Weight, g (x̄)
Mjøsa	Brown trout	15	0.46	0.20	0.92	67.7	3416
	E. smelt	10	0.20	0.04	0.51	15.9	38.6
	Vendace	10	0.07	0.02	0.10	20.1	70.2
	Mysis	3	0.02	0.01	0.02		
	Zooplankton	3	0.00	0.00	0.00		
Femunden	Brown trout	10	0.20	0.02	0.77	41.7	756

3.2.2 Biomagnification of Hg, Hg accumulation by size and time trends in Hg concentrations

Annual trophic magnification factors (TMFs) for mercury (Hg) was calculated, including all sampled biota (zooplankton, Mysis and fish), for each year from 2013 to 2018. In order to calculate a common TMF for a longer period (2013 – 2018) we checked for differences in annual trophic magnification slopes (TMS, i.e. slope (b) of the relationship between ln-transformed Hg concentrations and the measured biota $\delta^{15}N$), by formulating an ANCOVA, allowing for interactions between year and TMS. We also checked the model for any significant differences in intercepts between years. Measured δ15N in the combined data from 2013 to 2018 ranged from 4.63 to 17.17 ‰, thus above the recommended minimum $\delta^{15}N$ range (at least three trophic levels) in biota for proper TMF calculations (Borgå et al., 2011).

The ANCOVA model testing interactions between year and trophic magnification slope (TMS) indicated that the TMS differed significantly among years (test for different slopes, $F_{(5,207)} = 7.19$, $p<0.0001$) as did the annual intercepts ($F_{(5,207)} = 4.3$, $p=0.0010$). The trophic magnification factor (TMF) is a measure of average increase of a contaminant (e.g. Hg) per trophic level, thus a decrease in the $\delta^{15}N$ range in measured biota, will naturally increase the calculated TMF, given that contaminant concentrations in biota at the minimum and maximum of the measured range are equal, or close to equal. The measured Hg range among years differed less than the range of measured $\delta^{15}N$, which in part explains the great variations in TMF among years (Table 8). The shorter measured $\delta^{15}N$ range for some years is a result of the lack of true primary consumers.

Table 8. Minimum (min) and maximum (max) concentrations of Hg mg/kg, min and max values of stable N isotopes ($\delta^{15}N$, ‰), approximate numbers of trophic levels (TL), and calculated TMFs for sampled biota in Lake Mjøsa for each individual year from 2013 to 2018 and number(n) of samples are shown. n = number of samples

Year (n)	2013 (33)	2014 (41)	2015 (36)	2016 (30)	2017 (41)	2018 (41)
Hg mg/kg, min-max	0.006-0.83	0.004-0.91	0.004-1.2	0.020-1.2	0.003-1.5	0.003-0.91
$\delta^{15}N$, min-max	6.5-16	4.6-17	7.9-17	10-16	7.7-16	11-16
~ TL	2.8	3.5	2.7	1.8	2.3	1.8
TMF	5.8	4.9	8.6	8.5	13	13

Although TMS and intercepts differed among years, a common TMF for all the data from each year combined is presented below, with a forced common intercept and slope for all the years combined. This resulted in a TMF of 7.06 for all years combined, meaning that the Hg in average increase ~7 fold per trophic level (Figure 7). This is most likely a more realistic measure of the biomagnification potential for Hg in Lake Mjøsa than the one calculated for 2017 and 2018. If this is converted into Log_{10} Hg this corresponds to a TMS of ~0.24, which is relatively high compared to average TMS for temperate freshwater sites worldwide (average = 0.16; Lavoie et al., 2013). We did not calculate a TMF for Lake Femunden as only fish is included in the data, and the measured $\delta^{15}N$ range (7.29-11.96) does not include the recommended minimum three trophic levels in biota for proper TMF calculations (Borgå et al., 2011). Previous calculations of TMF for Lake Femunden suggest that the TMF is much lower than for Lake Mjøsa (Fjeld et al. 2017).

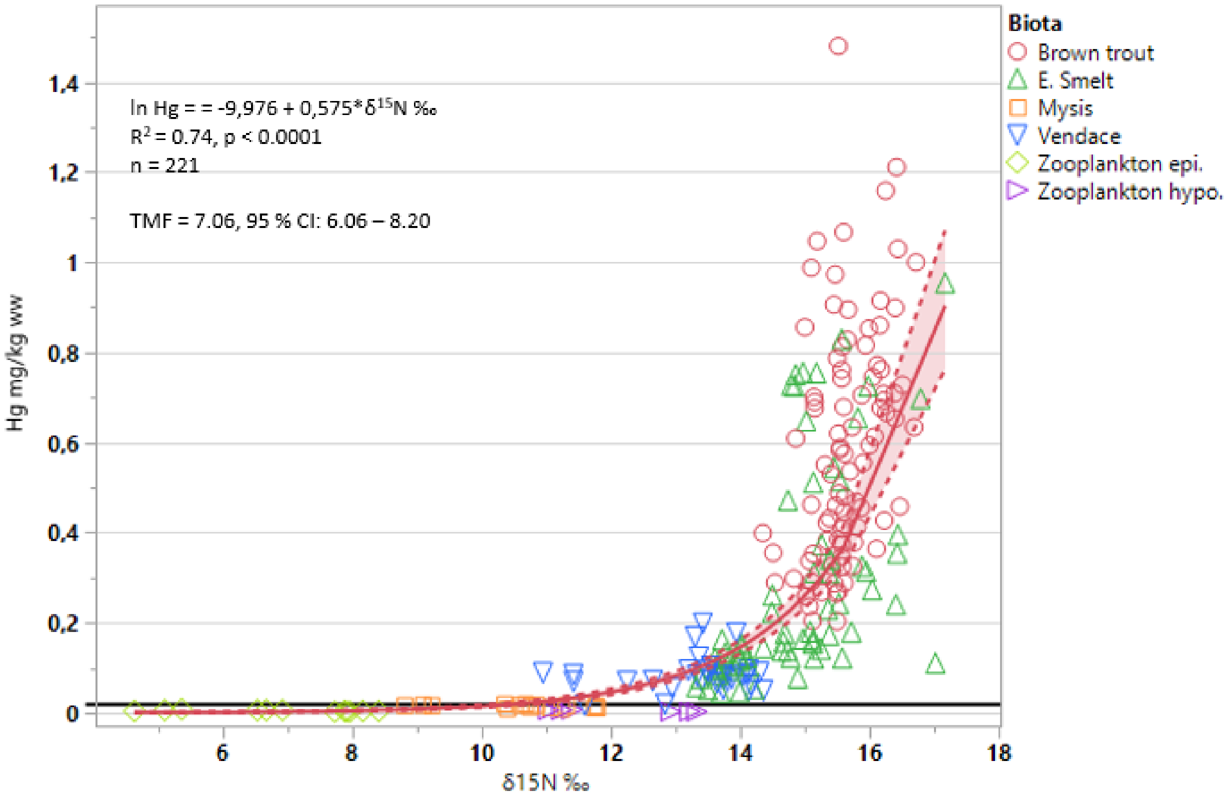


Figure 7. Exponential regression, with 95 % confidence level, of Hg concentrations in Lake Mjøsa biota from 2013 to 2018 as a function of measured $\delta^{15}N$. Prediction formula and estimated TMF with 95 % confidence level are shown above the regression curve. The horizontal line (bold) indicate the EQS for mercury at 0.02 mg/kg Hg.

Length is a well-known predictor for Hg concentrations in fish, in general with increasing Hg with length (Økelsrud et al. 2016; Olk et al. 2016). We have added data from previous years to investigate the correlation between length and Hg in a larger dataset for Lake Mjøsa (Figure 8) and Lake Femunden (Figure 9). We also present the length adjusted (to geometric mean length) Hg concentrations for each of the years sampled in Lake Mjøsa (Figure 10). Based on the entire dataset for Lake Mjøsa from 2013-2018, in average the trout will reach the EU's and the Norwegian recommended upper consumption limit of 0.5 mg/kg w.w. in fish muscle at around 57 cm, which corresponds to ~ 2.2 kg. For Lake Femunden the trout based on data from 2013 to 2018 will reach the 0.5 mg/kg w.w. limit at around 51 cm, and ~ 1.2 kg. However as seen in Figure 9, there are uncertainties in this estimate due to the large span between lower and upper 95 % confidence limits.

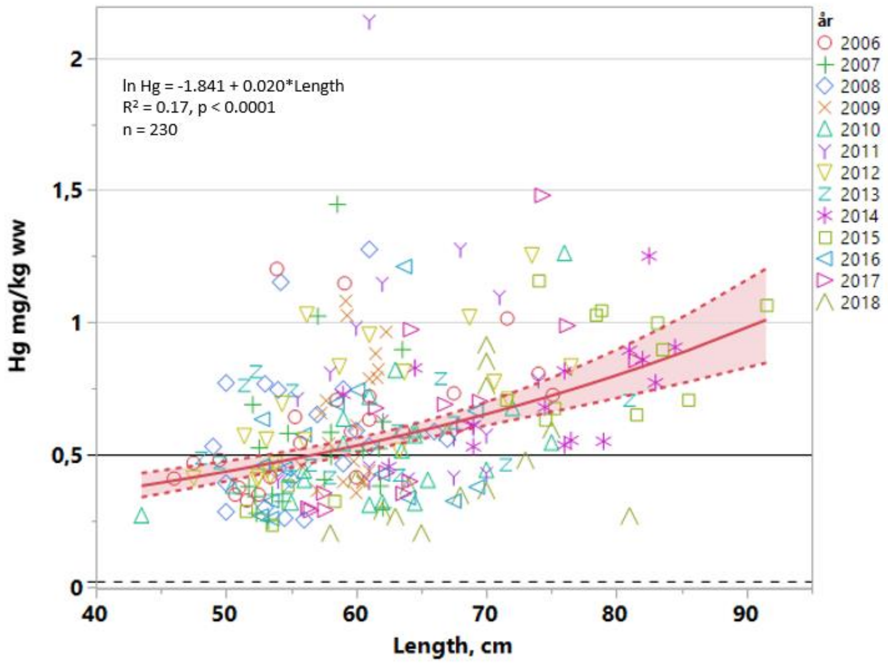


Figure 8. Regression analysis of length and Hg (with 95 % confidence level) in trout from Lake Mjøsa sampled from 2013 to 2018. Horizontal lines at 0,5 mg/kg Hg (solid line, upper consumption limit) and the EQS for mercury at 0.02 mg/kg Hg (dashed line).

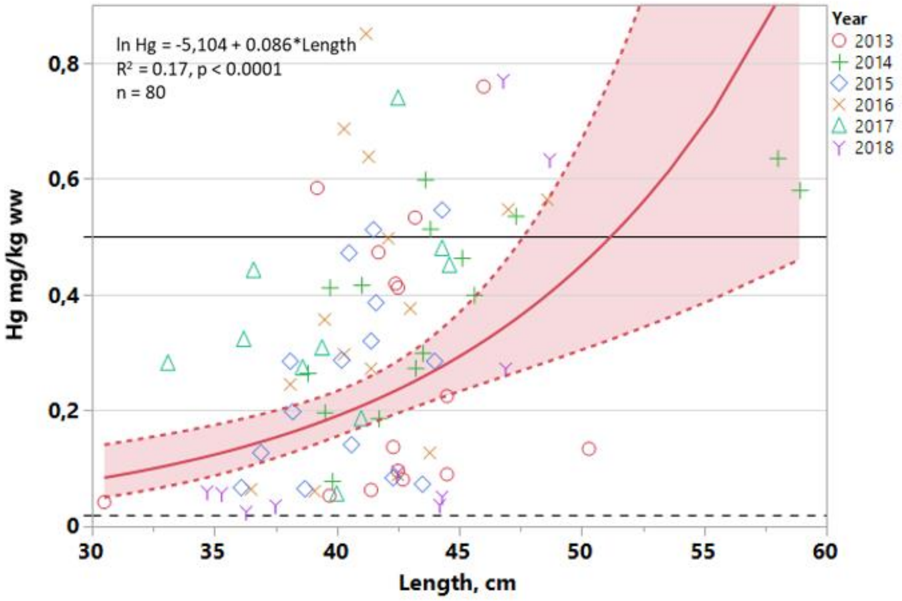


Figure 9. Regression analysis of length and Hg (with 95 % confidence bands) in trout from Lake Femunden sampled from 2013 to 2018. Horizontal lines at 0.5 mg/kg Hg (solid line, upper consumption limit) and the EQS for mercury at 0.02 mg/kg Hg (dashed line).

Length adjusted mean Hg in trout in Lake Mjøsa has decreased in the years after 2013, with a marked drop in length adjusted Hg concentrations in fish from 2018 compared to previous years. Length adjusted Hg in Lake Mjøsa trout in 2018 was 0.35 mg/kg, considerably lower than previous years (Figure 10). One possible explanation may be that Hg is diluted in biota either by increased primary production, through algal bloom dilution, ABD (Pickhardt et al., 2002, 2005) which may dilute Hg up the food chain (Allen et al., 2005), and/or increased growth, also known as somatic growth dilution, SGD (Verta, 1990; Ward et al., 2010; Lepak et al., 2012). Biomass concentrations of zooplankton in Lake Mjøsa were high in 2018, i.e. comparable to concentrations recorded in the 1980s (Solheim et al., 2019). It is possible that the increased biomass of zooplankton in 2018 has increased the dilution of Hg (Karimi et al., 2007), and that this dilution effect is transferred up the food chain. Whether growth in trout differ between years in Lake Mjøsa, and potential SGD in trout, is unknown. In addition, year to year variations in trout Hg concentrations may be explained by variations in sampled material; trout captured in different years may belong to different sub-populations, with different growth rates, i.e. that one year's catch may include a higher fraction of faster growing trout than another year's catch. Including analyses of age, may help to elucidate whether variations in Hg in trout, both within and between years, can be explained by variations in growth.

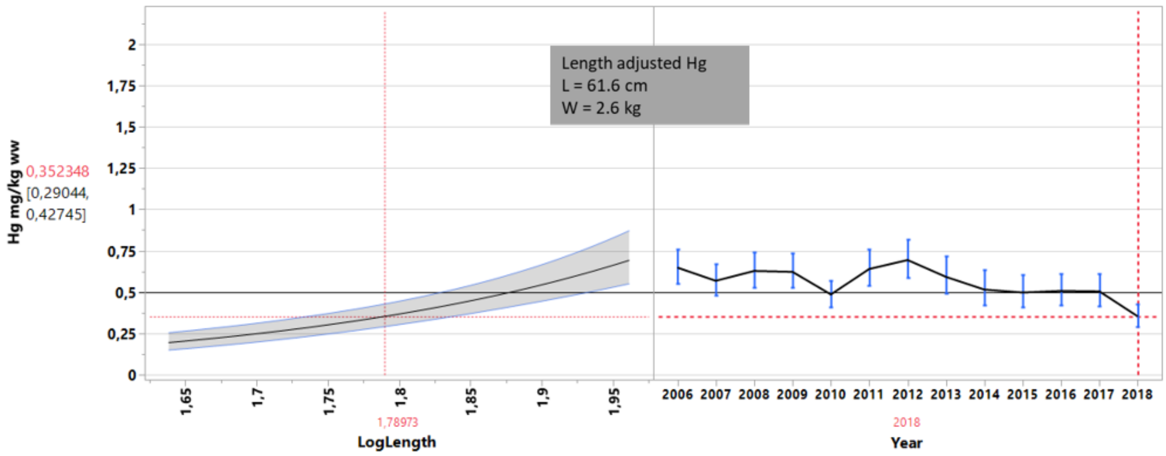


Figure 10. Length adjusted Hg (with 95 % confidence intervals) in trout from Lake Mjøsa 2006-2018. Trout are adjusted to the geometric average length (61,6 cm) in the dataset (~2,6 kg). Horizontal line at 0,5 mg/kg Hg (upper consumption limit) are added. Length adjusted mean Hg concentration (with 95 % confidence limits) for 2018 is marked with a red dashed line.

3.3 Cyclic volatile methylated siloxanes (cVMS)

3.3.1 Levels of cVMS in 2018

Concentrations of cyclic volatile methylated siloxanes (cVMS) were determined in zooplankton, Mysis, and in fish muscle of vendace, E. smelt and brown trout from Lake Mjøsa, and in brown trout from Lake Femunden.

Detection frequency for the individual cVMS in the specific sample matrices is shown in Table 4, indicating that D4 was detected in the lower trophic levels for zooplankton, Mysis and vendace at 100 %, 66 % and 80 % of the total N samples, respectively. D4 was not detected in the two upper trophic levels of E. smelt and brown trout in either lake.

LODs were higher in brown trout (Lake Mjøsa) than for the other samples but there are no specific explanations for this other than the possible interference from other compounds and general analytical uncertainty. D5 was detected in all samples of zooplankton, Mysis, E. smelt and brown trout and in 70 % of the samples of vendace in Lake Mjøsa. D5 was not detected in brown trout from Lake Femunden. D6 was detected in all samples of zooplankton, Mysis and E. smelt, but only in 30 and 53 % of the samples for vendace and brown trout in Lake Mjøsa, respectively. D6 was not detected in brown trout from Lake Femunden.

Highest concentrations of cVMS were generally found in the top predator brown trout in Lake Mjøsa. D5 is the dominant compound (Table 9, Figure 11). The EQS value for D5 in biota is 15217 ng/g w.w. (Direktoratsgruppen, 2018). No samples in either lakes exceeded this value.

Table 9. Mean (x̄), minimum and maximum concentrations for siloxanes (cVMS: D4, D5 and D6) in samples of zooplankton, Mysis, vendace, E. smelt and brown trout from Lake Mjøsa and brown trout from Lake Femunden 2018. Upper part of table is on the wet weight basis and the lower part on lipid basis. Concentrations below LOQ (w.w.) have been replaced by half the limit. Detections (D) indicates the number of samples above LOQ. For matrices where all data are below LOQ, cells have been shaded in orange.

			Concentration ng/g w.w.											
			D4				D5				D6			
Lake	Matrix	N	Min	Max	x̄	D	Min	Max	x̄	D	Min	Max	x̄	D
Mjøsa	Zoopl.	3	1.2	1.5	1.3	3	21	28	23	3	1.6	2.3	2.0	3
	Mysis	3	0.40	1.4	0.93	3	8.6	13	11	3	1.0	1.5	1.3	3
	Vendace	10	0.40	2.1	1.2	8	0.65	69	29	7	0.7	5.3	2.1	3
	E. smelt	10	0.40	0.40	0.40	0	6.5	76	25	10	0.9	5.2	2.1	10
	B. trout	15	1.3	3.7	1.6	0	16	107	42	10	1.6	7.5	3.5	8
Femunden	B. trout	10	0.40	0.40	0.40	0	1.2	1.2	1.2	0	0.50	0.85	0.64	0

Continued…

			Concentration ng/g lipid											
			D4				D5				D6			
Lake	Matrix	N	Min	Max	x̄		Min	Max	x̄		Min	Max	x̄	
Mjøsa	Zoopl.	2*	44	141	93	-	815	2370	1592	-	68	217	143	-
	Mysis	2*	34	39	37	-	364	407	385	-	42	45	43	-
	Vendace	10	14	89	43	-	47	2226	875	-	24	171	70	-
	E. smelt	10	17	61	39	-	508	8215	2491	-	70	559	210	-
	B. trout	15	27	500	77	-	520	6192	1626	-	33	1115	179	-
Femunden	B. trout	10	17	67	33	-	50	192	96	-	22	142	55	-

*Not enough material for lipid determination in one sample of zooplankton and Mysis.

Limit of detection and quantification (LOD/Q) for the individual cVMS varied between sample matrices, but also within each matrix, indicated with red triangles in Figure 11. LODs for brown trout in Lake Mjøsa were particularly high (3.6 – 7.3 ng/g w.w.). LOD / Q is based on the average of a series of blank samples taken over a long period of time for the actual method + 3 x standard deviation. The analytical method might be matrix dependent. Values over LOD / LOQ are assumed to be calculated with a high degree of safety, with a certain measurement uncertainty. In addition to this, LOD / LOQ can also be affected by the instrument's sensitivity and recovery.

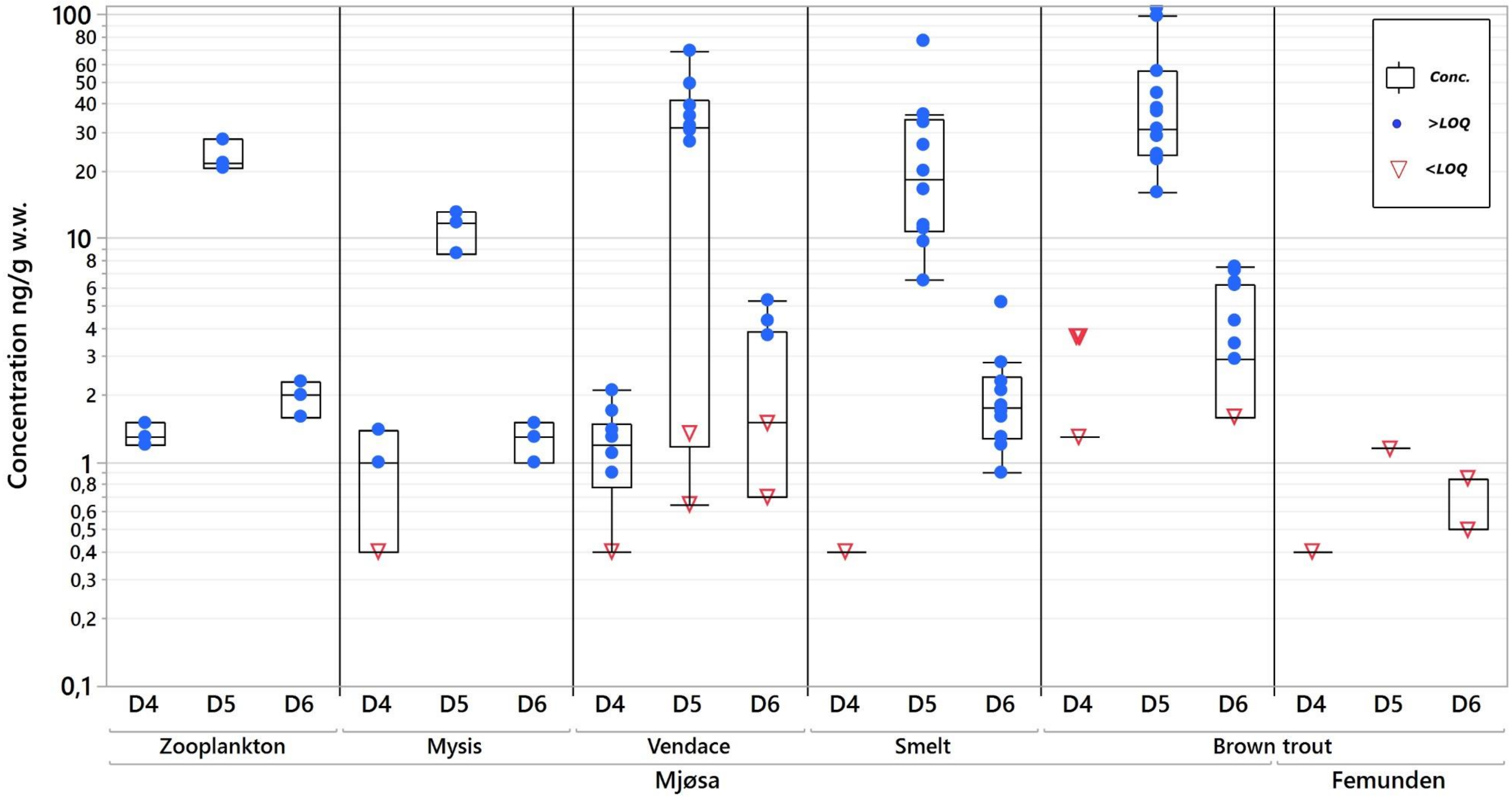


Figure 11. Box-plot of cVMS-concentrations in zooplankton, Mysis, vendace, E. smelt and brown trout from Lake Mjøsa and brown trout from Lake Femunden 2018. Concentrations are given in ng/g wet weight. Boxes show the median and 50 % of the total data. Concentrations below LOQ have been replaced by half the limit and visualized by red triangles, whereas concentrations above LOQ are visualized by blue dots.

D5 was detected in highest concentrations in E. smelt with 8200 ng/g lipid (76 ng/g w.w.). Brown trout and vendace had lower levels of 6200 and 2200 ng/g lipid (107 and 69 ng/g w.w.), respectively. Lowest mean concentrations of D5 were found in Mysis from Lake Mjøsa and brown trout from Lake Femunden with 380 ng/g lipid (11 ng/g w.w.) and 94 ng/g lipid (1.2 ng/g w.w.), respectively.

E. smelt in Lake Mjøsa exhibited the same level of D5 concentrations as the top predator brown trout. Due to some large, cannibalistic individuals in the sample material E. smelt and brown trout are almost at the same trophic level and thus high concentrations of cVMS might also be expected in E. smelt. High concentrations were also detected in samples of zooplankton (1600 ng/g lipid). As discussed in chapter 3.1, large specimens of omnivorous copepods dominated the zooplankton samples. The species of zooplankton captured in 2018 may periodically display predacious behavior and thus find themselves on a higher trophic level, and subsequently exhibit higher concentrations of cVMS, than true planktivory consumers would have been expected to.

Mean concentrations of D4 and D6 in the samples from Lake Mjøsa were respectively 37-93 ng/g lipid (0.4-1.6 ng/g w.w.) and 43-210 ng/g lipid (1.3-3.5 ng/g w.w.) with the lowest concentrations found in Mysis. For Lake Femunden D4, D5 or D6 were all below LOQ in all samples of brown trout.

Higher concentrations of cVMS in Lake Mjøsa compared to Femunden is to be expected based on previous studies (Jartun et al., 2018; Fjeld et al., 2014, 2015, 2016; Borgå et al., 2012, 2013). These compounds are usually found in industrial and consumer applications such as personal care products (Montemayor et al., 2013; Wang et al., 2009), and might be expected to accumulate in waterbodies influenced by higher anthropogenic activities such as discharges from public waste water treatment plants (WWTPs) and urban areas, such as those around Lake Mjøsa. Lake Femunden on the other hand is situated in a nature reserve with minimum anthropogenic impact. Local sources of cVMS to this lake is expected to be absent. Atmospheric deposition of cVMS is discussed in e.g. Xu and Wania (2013) and Bohlin-Nizzetto et al. (2018), but we do not know to which extent atmospheric deposition may be applicable for Lakes Mjøsa and Femunden.

cVMS levels and potential bioaccumulation behavior have been studied by Krogseth et al. (2017) in a subarctic lake, detecting concentrations of D5 in the range of 9.9 – 131 ng/g w.w. This food web included a benthic link, differing from Lake Mjøsa in which a pure pelagic food web was studied. Krogseth et al. (2017) found no trophic magnification for D5, with lower cVMS concentrations in the higher trophic levels such as brown trout and Arctic char (*Salvelinus alpinus*). Concentrations of cVMS in freshwater fish from Lake Mjøsa are higher than comparable studies in Sweden (Kierkegaard et al., 2013) and North America (McGoldrick et al., 2014). Studies from the Baltic sea found a ratio between D4, D5 and D6 in fish to be 1:20:4, respectively (Kierkegaard et al., 2013). Studies from Mjøsa, including the 2018 data in this report, support these findings (Jartun et al., 2018; Fjeld et al., 2017).

3.3.2 Annual variation of cVMS in Lake Mjøsa and Lake Femunden

Although some of the cVMS data collected between 2010 and 2018 in biota from Lake Mjøsa and Lake Femunden are below the LOQ, comparable concentrations for D5 and D6 in brown trout from Lake Mjøsa are shown in Figure 12. Annual variation of cVMS-concentrations between Lake Femunden and Lake Mjøsa is given in Figure 13. D5 is the dominant compound throughout the entire period with some detections of D6 each year. Concentrations of D4 has been almost exclusively below LOQ.

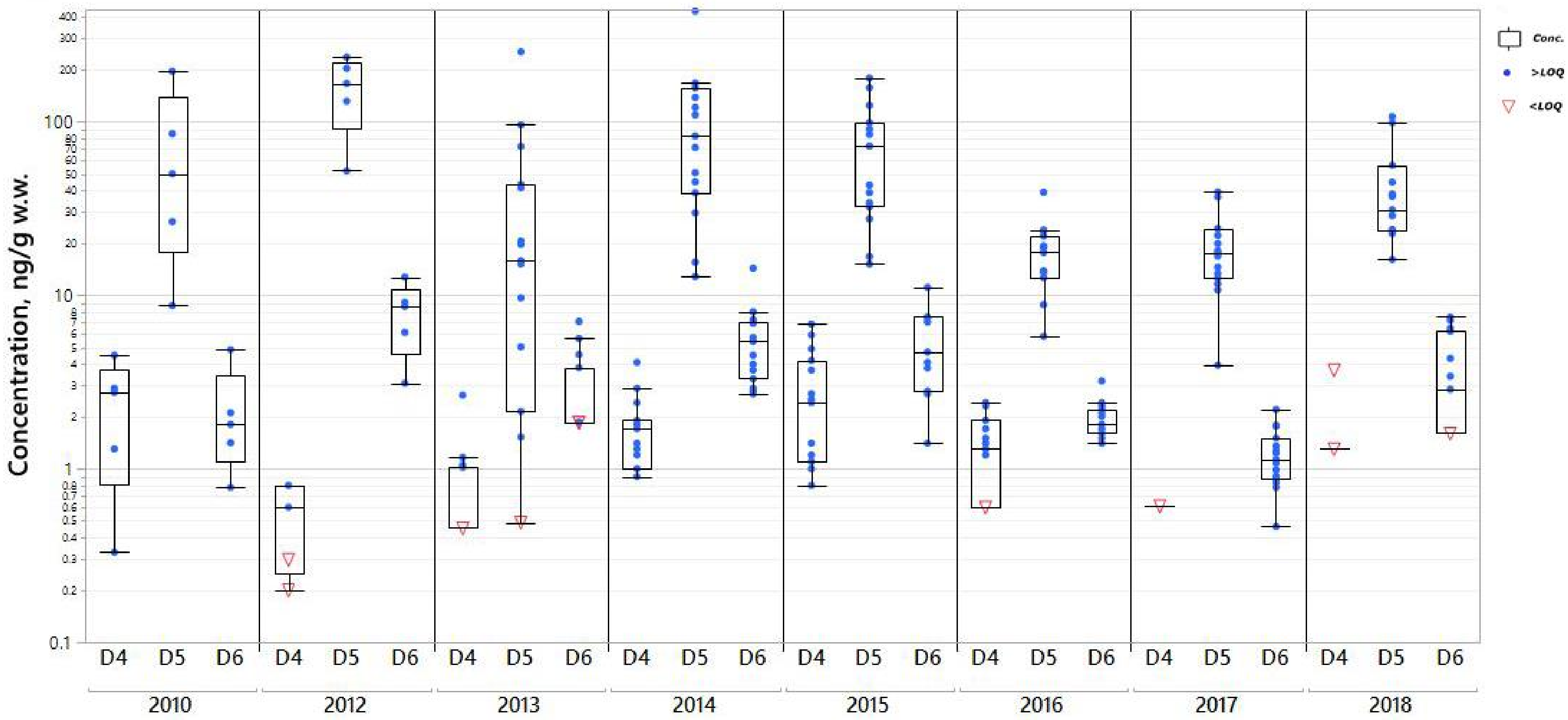


Figure 12. Box-plot indicating the concentrations of cVMS D4, D5 and D6 in samples of brown trout from Lake Mjøsa from 2010 to 2018 (total N=115). Note the logarithmic scale on the y-axis.

An analysis of variance (ANOVA) tested the interactions between year and ln-transformed concentrations of D5 in brown trout from Lake Mjøsa within the years 2010 to 2018. Firstly, the distribution of data was analyzed, and the ln-transformed concentration exhibited a normal distribution pattern using a Goodness-of-fit test (Shapiro-Wilk W test). The ANOVA assumes that although different samples can come from populations with different means, they have the same variance. Multiple calculations, such as the Bartlett's test, were performed to verify that the variances within the data were equal. Although the sample sizes for some years are small, the tests verified equal variances.

The Anova tested the ln-transformed concentrations of lipid normalized D5 in samples of brown trout muscle from Lake Mjøsa against years from 2010 and 2018. Statistically significant differences in D5-concentrations were found between the years 2012 – 2017 (p<0.0001), 2012-2013 (p=0.0020), 2012 – 2016 (p=0.0068), 2010 – 2017 (p=0.0094), 2012 – 2018 (p=0.0107), 2015 – 2017 (p=0.0181) and 2014 – 2017 (p=0.0267). This means that there were no statistically significant differences between the D5-concentrations in 2017 and 2018.

Interpretation on the inter-annual variability of cVMS data should be done with caution. Variation may arise from e.g. the substitution of data < LOD/LOQ, especially for D4 and D6 for which a large part of the data is below LOD/Q (Table 4) and where these LOD/Q-values differ within the sampled matrixes.

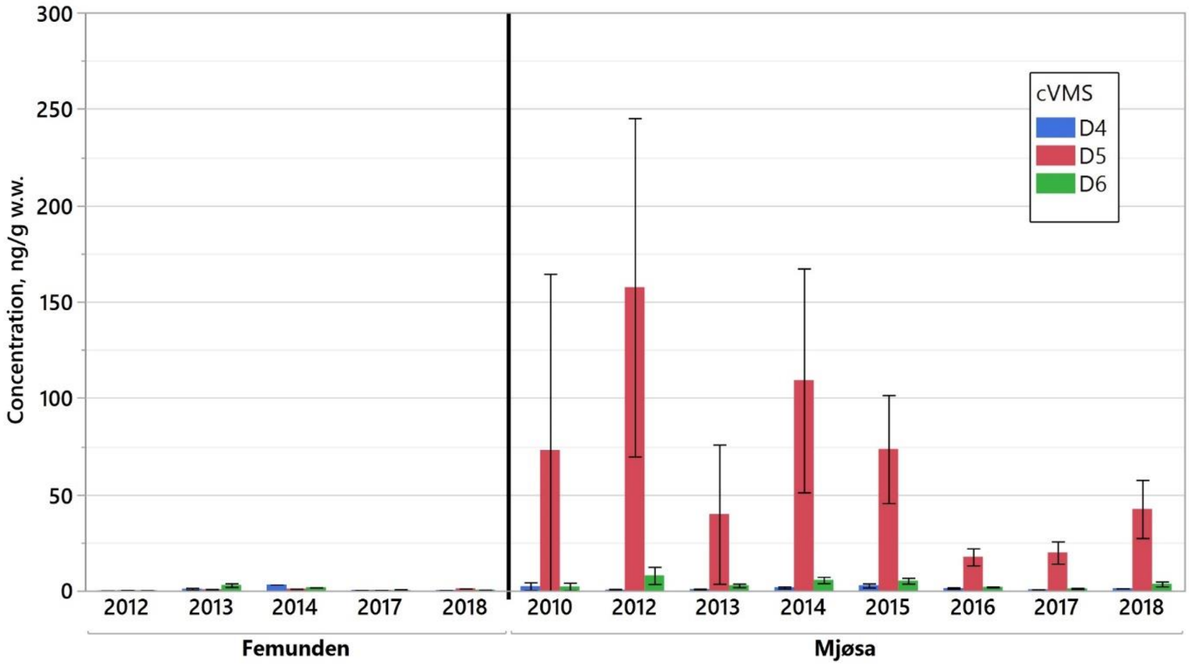


Figure 13. Annual mean concentrations (ng/g, w.w.) of cVMS D4, D5 and D6 with 95% confidence intervals in samples of brown trout in Lake Mjøsa and Lake Femunden 2010-2018. Concentrations below LOQ have been replaced by half the limit. Error bars indicate one standard deviation from the median.

Generally, a downwards trend of D5 concentrations in brown trout muscle from Lake Mjøsa was found from 2010 – 2018 as shown in Figure 13. However, a slight increase in mean concentrations of D5 was implied for the years 2016-2018. Continued monitoring in the coming years will reveal whether this increase will continue significantly. The increase has not been applied to a specific contributing source, but discharges from wastewater treatment plants are considered major sources for cVMS to the aquatic environment (Sparham et al., 2008) depending on the treatment method (Wang et al., 2015). In addition, much focus has been on the coming regulation of D4 and D5 in consumer products from 2020, maybe resulting in more consumers choosing products without these compounds.

3.3.3 Trophic magnification of D5 and D6 in Lake Mjøsa

Trophic magnification of D5 and D6 in the pelagic food web of Lake Mjøsa has previously been demonstrated by e.g. Borgå et al. (2012b), Borgå et al. (2013a) and Fjeld et al. (2014,2015,2016). Calculations of trophic level (TL) are partly dependent on the $\delta^{15}N$ in zooplankton samples. It is shown that $\delta^{15}N$ for zooplankton varies significantly between years (e.g. Fjeld et al., 2017), without any plausible explanation. We see that for some years large omnivorous species tend to dominate the sampled material, which alters the $\delta^{15}N$ and subsequently the calculation of TL. For 2018, the major part of zooplankton collected was on a higher TL.

Lack of true primary consumers for some years initiated an alternate calculation of relative trophic level (TL_{rel}) instead by dividing the $\delta^{15}N$ with the empirical N-enrichment factor (Δ15N=3.4 ‰), as explained previously. Annual variation of TL in higher trophic levels, such as for brown trout, is then avoided. Estimated TMF will not change by using TL_{re}.

When calculating the TMF for D5, all data from 2010-2018 have been analyzed. For some sampling years the sampling material is scarce for some trophic levels in the food web, e.g. challenging sampling of zooplankton. Figure 14 shows the regression of ln-transformed D5 concentrations vs. TL_{rel} in brown trout from Lake Mjøsa for the years 2010-2018.

A detailed approach to find the best model to describe the potential biomagnification of D5 through the pelagic food web of Mjøsa from 2010-2016 is described by Fjeld et al. (2017). When including the data for 2018, a TMF for D5 was found to be 2.13. A significant positive correlation (r^2 = $p < 0.0001$) was found between lipid normalized D5 concentrations and trophic levels in organisms.

For the analysis of D6 against TL_{rel} there are larger uncertainties to the interpretations as a larger proportion of the analytical results were below LOQ. The model for all years between 2010 and 2018 is shown in Figure 15, which gave a TMF for D6 in Lake Mjøsa of 1.29.

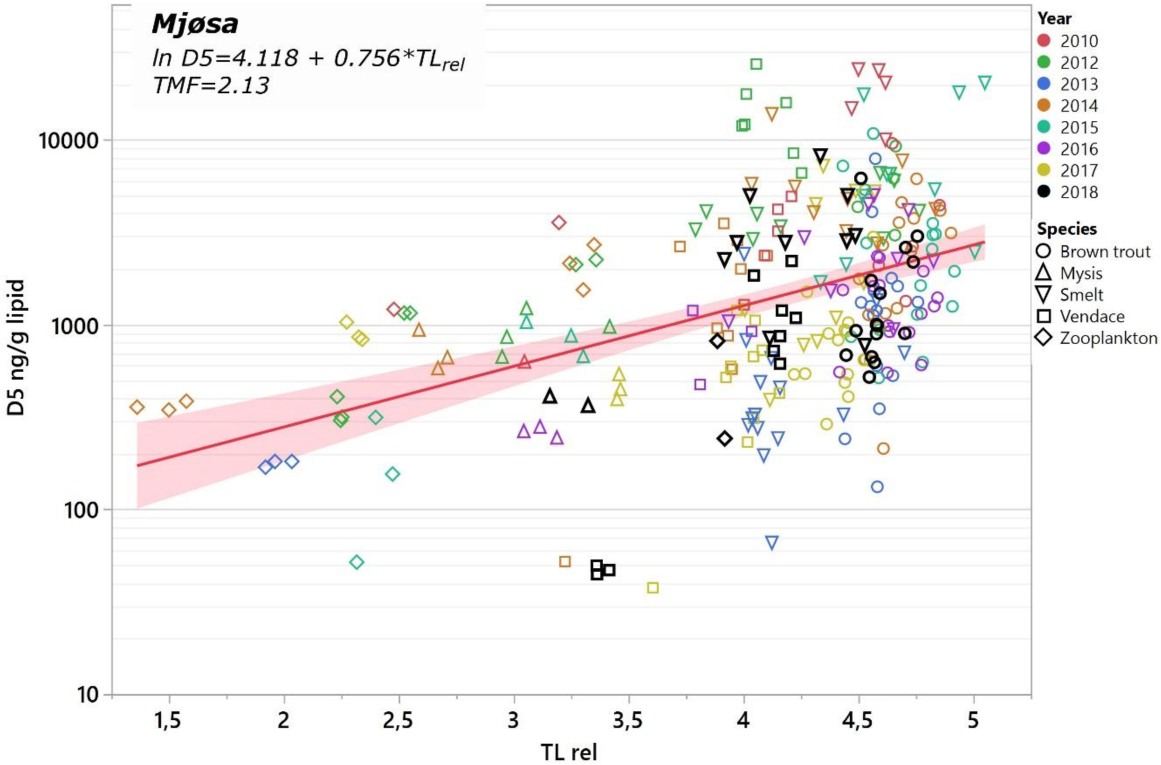


Figure 14. Relations between D5 (lipid normalized) and relative trophic level (TL_{re}) in zooplankton, Mysis and fish muscle from Lake Mjøsa between 2010-2018. Regressions of ln-D5 on TL_{rel} with 95 % confidence levels are shown. Results from 2018 are shown in black. Concentrations below LOQ have been replaced by half the limit.

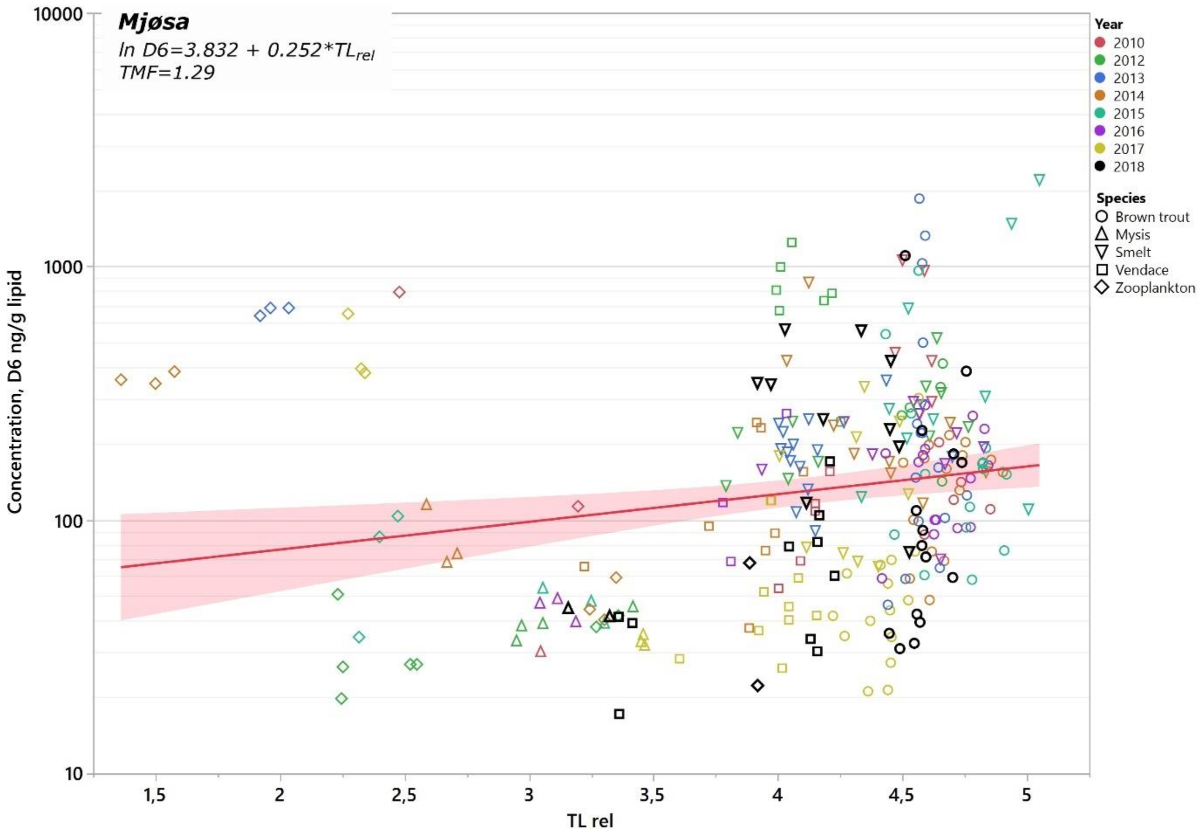


Figure 15. Relations between D6 (lipid normalized) and relative trophic level (TL_{re}) in zooplankton, Mysis and fish muscle from Lake Mjøsa between 2010-2018. Regressions of ln-D5 on TL_{rel} with 95 % confidence levels are shown. Results from 2018 are shown in black. Concentrations below LOQ have been replaced by half the limit.

Trophic magnification of cVMS up the pelagic food web of Lake Mjøsa have been reported by Borgå et al. (2012, 2013) in Fjeld et al. (2014,2015,2016,2017) and in Jartun et al. (2018). Some studies support the trophic magnification of cyclic siloxanes in aquatic food webs, although the methods and models studied vary in sensitivity as for Lake Erie (McGoldrick et al., 2014). Differences in exposure and lipid partitioning between cVMS and legacy POPs such as specific PCBs may contribute to the results. Trophic magnification of D5 was also shown in a study from China with BDE-99 as a reference contaminant (Jia et al., 2015). However, no evidence was found to support biomagnification of any cVMS in a marine food web of the Oslofjord, rather a trophic dilution up the food web (Powell et al., 2018).

3.4 Brominated flame retardants (BFR)

3.4.1 Concentrations of PBDEs in 2018

PBDEs were determined in samples of zooplankton, Mysis and fish muscle (vendace, E. smelt and brown trout) from Lake Mjøsa and in brown trout from Lake Femunden. Detection frequency for the individual BDEs is shown in Table 4, indicating detection up to 100 % in most matrices for tri-brominated congeners BDE-17 and BDE-28, tetra-brominated congener BDE-47, penta-brominated congeners BDE-99 and BDE-100, and hexa-brominated congeners BDE-153 and BDE-154. All of these compounds are commonly found in nature as reviewed by Eljarrat and Barceló (2018).

LOQ for the individual compounds vary a lot from compound to compound, from individual sample to the next and within species. LOQ for the most common BDEs (Water Framework Directive ΣBDE_6: BDE-28, BDE-47, BDE-99, BDE-100, BDE-153 and BDE-154) were in the range 0.001 – 0.04 ng/g w.w. The fully brominated compound BDE-209 had LOQ ranging from 0.03 – 0.13 ng/g w.w.

Concentrations of ΣBDE_6 and individual BDEs 28, 47, 99, 100, 153 and 154 are presented in Table 10 and Table 11. Highest concentrations were found in brown trout from Lake Mjøsa with a mean concentration of ΣBDE_6 8.5 ng/g w.w. (348 ng/g lipid). Mean concentrations of ΣBDE_6 in E. smelt and vendace were 1.3 and 1.7 ng/g w.w., respectively (168 and 53 ng/g lipid, respectively). Corresponding concentrations in Mysis and zooplankton in Lake Mjøsa were 0.41 and 0.47 ng/g w.w., respectively. Brown trout in Lake Femunden had mean ΣBDE_6 concentrations of 0.60 ng/g w.w. (45 ng/g lipid).

EQS for ΣBDE_6 in biota is 0.0085 ng/g w.w. All biota samples exceeded this value.

The fully brominated congener BDE-209 was detected in 19 of 51 samples, evenly distributed between the five sample matrices. A result of this is a limited estimate of the mean concentrations by substituting LOQ values with half the limit for BDE-209. Studies have shown that deca-BDE (209) is absorbed through the dietary intake, but it is rapidly dibrominated to lower brominated congeners, especially BDE-154 (Kierkegaard et al., 1999; Stapleton et al., 2006; Noyes et al., 2013).

A full overview of all the BDEs in the analytical program is given in Figure 16. BDEs 47, 99, 100, 153 and 154 are dominating the results, as is also shown for previous years in Lake Mjøsa and Femunden (Jartun et al., 2018; Fjeld et al., 2017). Concentrations in brown trout from Lake Femunden are significantly lower than in brown trout from Lake Mjøsa, caused mainly by large, local discharges to Lake Mjøsa in the early 2000s. Still, for Lake Femunden, with limited local sources, the levels are all higher than the EQS-concentration of 0.0085 ng/g w.w.

Table 10. Mean, minimum (min) and maximum (max) wet weight (w.w.) concentrations of the six BDEs referenced in the Water Framework Directive; BDEs 28, 47, 99, 100, 153 and 154 (Direktoratsgruppen, 2018) in samples of zooplankton, Mysis, vendace, E. smelt and brown trout from Lake Mjøsa and in brown trout from Lake Femunden in 2018. Concentrations (ng/g w.w.) below LOQ have been replaced by half the limit. Results below LOQ are shaded in orange.

ng/g w.w.			BDE-28 w.w.			BDE-47 w.w.			BDE-99 w.w.			BDE-100 w.w.		
Lake	Species	N	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Mjøsa	Brown trout	15	0.028	0.008	0.050	4.6	1.9	8.4	1.3	0.48	2.9	1.6	0.69	3.2
	E. smelt	10	0.008	0.004	0.017	0.94	0.21	2.0	0.056	0.040	0.090	0.19	0.040	0.41
	Vendace	10	0.010	0.004	0.016	0.84	0.069	1.7	0.48	0.040	1.1	0.27	0.013	0.55
	Mysis	2*	0.004	0.004	0.004	0.23	0.20	0.26	0.10	0.090	0.12	0.050	0.045	0.056
	Zooplankton	2*	0.026	0.011	0.041	0.21	0.092	0.34	0.11	0.046	0.17	0.074	0.031	0.12
Femunden	Brown trout	10	0.004	0.002	0.009	0.19	0.052	0.76	0.15	0.030	0.69	0.13	0.021	0.57

ng/g w.w.			BDE-153 w.w.			BDE-154 w.w.			ΣBDE6 w.w.		
Lake	Species	N	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Mjøsa	Brown trout	15	0.27	0.12	0.53	0.60	0.27	1.2	8.5	3.5	16
	E. smelt	10	0.036	0.010	0.067	0.088	0.016	0.17	1.3	0.32	2.7
	Vendace	10	0.054	0.005	0.11	0.097	0.007	0.20	1.7	0.14	3.6
	Mysis	2*	0.008	0.008	0.008	0.018	0.017	0.020	0.41	0.36	0.46
	Zooplankton	2*	0.005	0.005	0.005	0.039	0.015	0.064	0.47	0.20	0.73
Femunden	Brown trout	10	0.034	0.005	0.16	0.087	0.015	0.36	0.60	0.13	2.6

*not enough material for analysis of one sample of zooplankton and Mysis.

Table 11. Mean, minimum (min) and maximum (max) lipid normalized (lipid, lip) concentrations of the six BDEs referenced in the Water Framework Directive; BDEs 28, 47, 99, 100, 153 and 154 (Direktoratsgruppen, 2018) in samples of zooplankton, Mysis, vendace, E. smelt and brown trout from Lake Mjøsa and in brown trout from Lake Femunden in 2018. Concentrations (ng/g lipid) below LOQ have been replaced by half the limit.

ng/g lipid			BDE-28 lip			BDE-47 lip			BDE-99 lip			BDE-100 lip		
Lake	**Species**	**N**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**
Mjøsa	**Brown trout**	15	1.0	0.46	2.9	187	55	803	55	10	250	69	19	325
	E. smelt	10	1.1	0.55	2.2	117	28	197	8.6	4.0	20	24	5.2	46
	Vendace	10	0.34	0.16	0.51	25	4.8	46	14	2.3	27	8.1	1.0	15
	Mysis	2	0.13	0.12	0.14	7.0	6.9	7.1	3.2	3.1	3.2	1.5	1.5	1.5
	Zooplankton	2	0.67	0.13	1.2	5.4	1.0	9.9	2.7	0.51	4.9	1.9	0.34	3.4
Femunden	**Brown trout**	10	0.30	0.11	0.71	15	3.5	47	11	2.2	39	9.4	1.4	34

ng/g lipid			BDE-153 lip			BDE-154 lip			ΣBDE6 lip		
Lake	**Species**	**N**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**
Mjøsa	**Brown trout**	15	11	3.0	51	25	7.7	105	348	100	1540
	E. smelt	10	4.7	1.4	8.8	11	2.1	20	168	42	284
	Vendace	10	1.7	0.41	3.5	3.0	0.58	6.1	53	9.8	99
	Mysis	2	0.25	0.22	0.28	0.57	0.56	0.58	13	13	13
	Zooplankton	2	0.10	0.056	0.15	1.0	0.16	1.9	12	2.2	21
Femunden	**Brown trout**	10	2.5	0.36	9.0	6.6	1.0	25	45	8.6	154

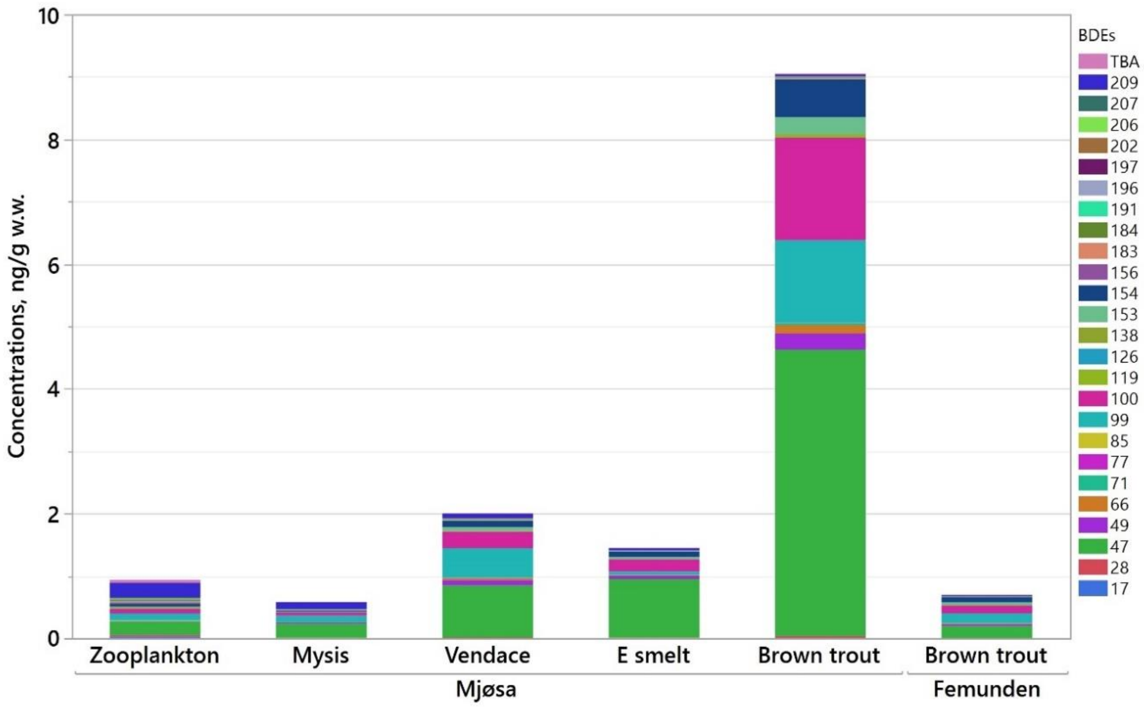


Figure 16. Stacked graph of all BDEs and tribromoanisole (TBA) included in the 2018 study in samples of zooplankton, Mysis, vendace, E. smelt and brown trout in Lake Mjøsa and brown trout in Lake Femunden. Concentrations are given in ng/g w.w. and results below LOQ have been replaced by half the limit.

3.4.2 Time trends for PBDEs

PBDEs have been studied in Lake Mjøsa in several fish species such as vendace, E. smelt and brown trout since the early 1990s. The number of samples, and the choice of matrices throughout the years have changed, which limits the value of comparing new data with the oldest concentrations. But for brown trout, consistent data for PBDEs in muscle is available from around year 2000.

Mean concentrations of BDE_6 in samples of fish (vendace, E. smelt and brown trout) from Lake Mjøsa between 2000-2018 are shown in Figure 17. For all three species the concentrations have gone down since the extreme values in the early 2000s. At this time, large local discharges from an industry company close to Lillehammer ran directly to the lake. Highest reported concentrations of ΣBDE_6 was 5400 ng/g lipid in brown trout in 2000. In 2018 the concentration was 348 ng/g lipid (Figure 17), an approximate decrease of 95 % since 2000. Other studies have shown concentrations in salmonids of 2440 ng/g lipid in Lake Michigan, considered at the time as “among the highest reported levels globally for salmonids in open waters” (Manchester-Neesvig et al., 2001).

Levels of ΣBDE_6 in vendace, E. smelt and brown trout seem to have stabilized the latest years around concentrations of 1.5, 1.5 and 8 ng/g w.w., respectively (50, 150 and 350 ng/g lipid, respectively). Figure 17 also indicates that the relative contribution of BDE-99 to ΣBDE_6 decreases over time, which is allegedly an ageing effect after the major discharges of PBDEs in the early 2000s. Penta-BDE-99 might undergo debromination down to the tetra-BDE-47 (Benedict et al., 2007). E. smelt seem to have consistently low concentrations of BDE-99, which may mean that this species is able to debrominate this congener more effectively than vendace and brown trout.

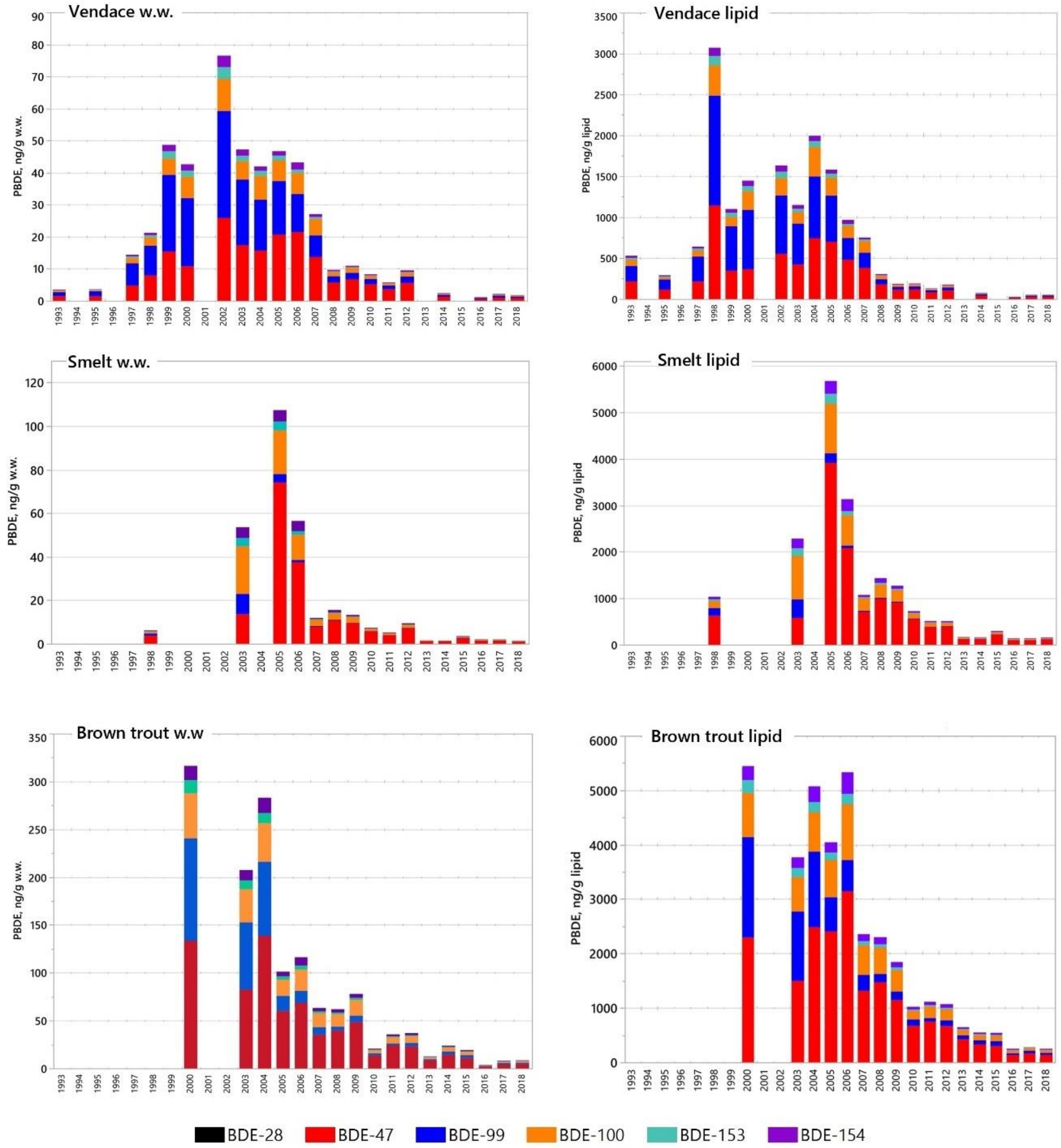
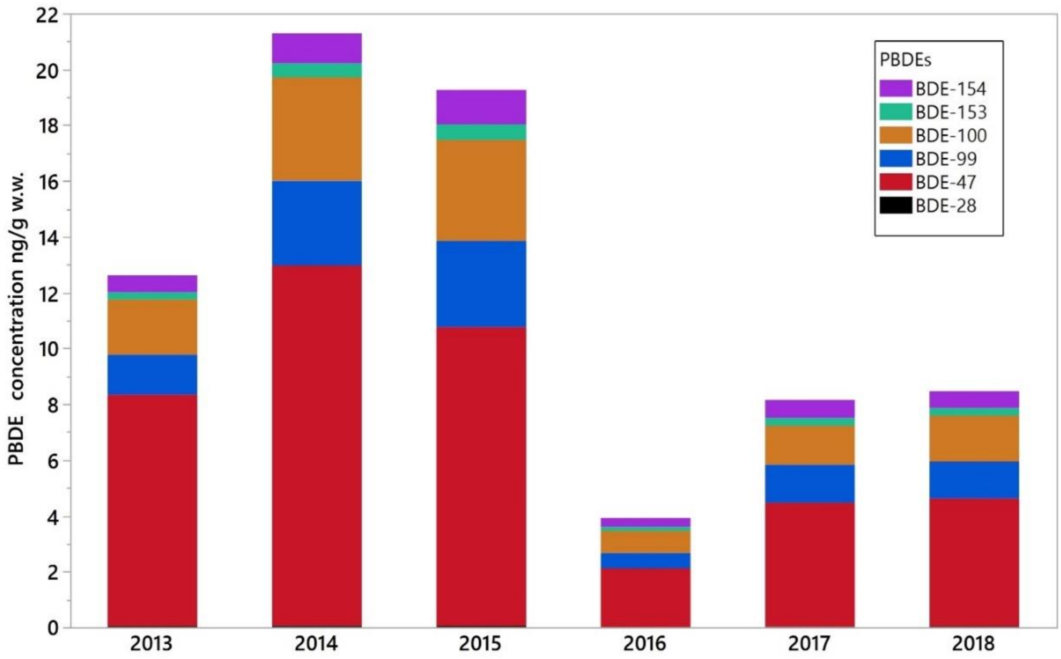


Figure 17. Mean concentrations of BDE_6 in samples of fish from Lake Mjøsa between 2000-2018. Top row: vendace, middle row: E. smelt, bottom row: brown trout. Concentrations are given in ng/g w.w. (left) and ng/g lipid (right). Concentrations below LOQ have been replaced by half the limit.

In Figure 18 we take a closer look at ΣBDE$_6$ levels in brown trout on wet weight (top) and lipid weight (bottom) from 2013-2018. The congener distribution pattern seems similar in 2017 and 2018, but as we see minimal change in mean concentrations from 2017 to 2018 on wet weight basis, we see a slight decrease on a lipid normalization. Mean lipid content was 2.75 and 3.40 in brown trout from 2017 and 2018, respectively, which may explain this difference.



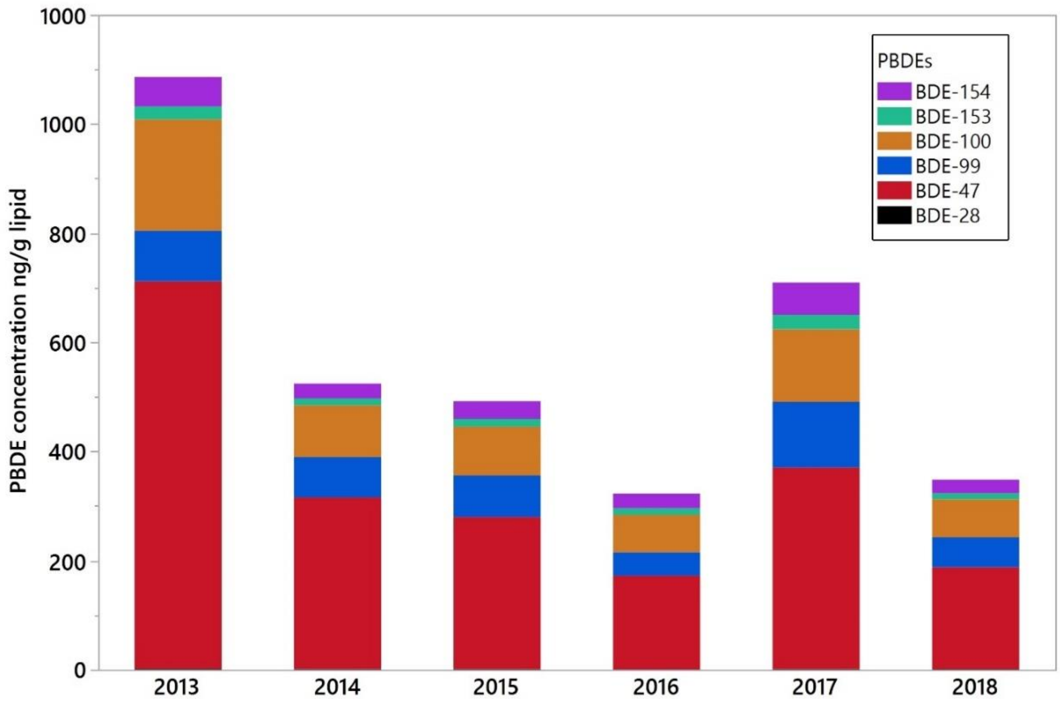


Figure 18. Mean concentrations for ΣBDE$_6$ in samples of brown trout from Lake Mjøsa, 2013-2018. Concentrations are given in ng/g w.w. (top) and in ng/g lipid (bottom), respectively. Concentrations below LOQ have been replaced by half the limit.

The differences in mean concentrations (ng/g, w.w.) between brown trout in Lake Mjøsa and in Lake Femunden are illustrated in Figure 19. We have included the EQS-value of 0.0085 ng/g w.w. in this figure, showing that all samples of brown trout in this period exceed the EQS value.

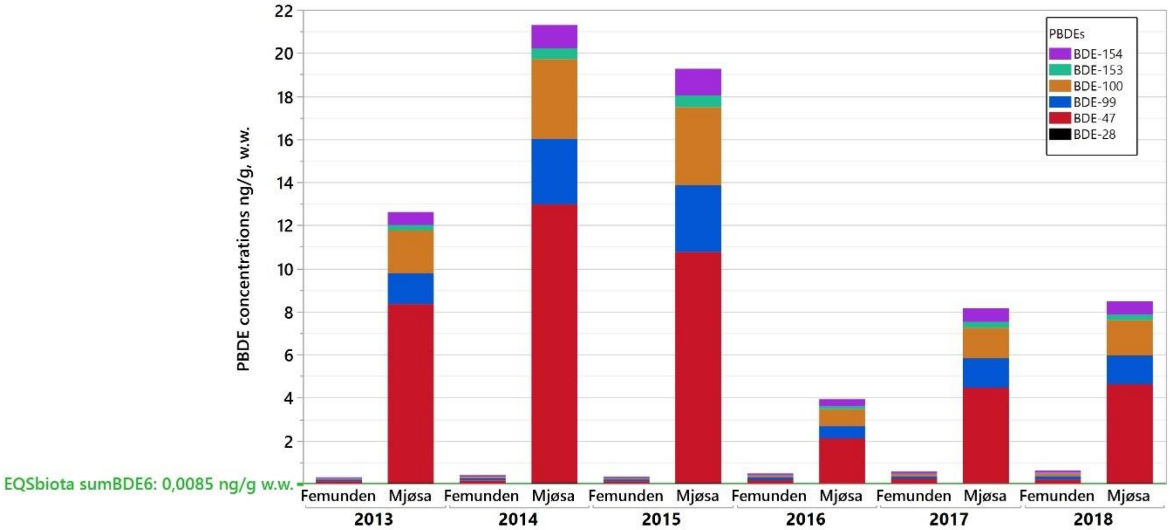


Figure 19. Mean concentrations for BDE_6 in samples of brown trout from Lakes Mjøsa and Femunden, 2013-2018. Concentrations are given in ng/g w.w. Concentrations below LOQ have been replaced by half the limit.

3.5 Correlation and trophic magnification of Hg, D5, D6 and BDE-47

Contaminants with similar physical-chemical properties such as volatile siloxanes, mercury, and some brominated flame retardants (e.g. BDE-47) can express comparable accumulation pattern in food webs. Lipophilicity and bioaccumulative tendency are important properties for these compounds. Previously in Lake Mjøsa, the correlation between D5 and D6, PCB-153, BDE-47, Hg, and relative trophic level (TL_{rel}, based on $\delta^{15}N$) have been calculated based on ln-transformed lipid-normalized concentrations in samples from the pelagic food web. Lipid content and lipophilic contaminant concentrations are often correlated across organisms, results are typically normalized to lipid content before the regression analysis, such that the TMF values are calculated and reported on the basis of lipid equivalent concentrations. Fjeld et al. (2017) and Jartun et al. (2018) have shown good correlation with relative trophic level (TL_{rel}) for D5 and D6 with trophic magnification factors (TMFs) of about 3 and 2 in Lake Mjøsa, respectively. Data from 2018 are in compliance with previous years, indicating a biomagnification of BDE-47 and Hg in addition to D5 and D6.

Figure 20 displays the concentration data for Hg, D5, D6 and BDE-47 against TL_{rel} as well as the correlation between the individual contaminants from 2018. All compounds have a significant correlation with TL_{rel} ($p<0.0001$) except for D6 with p=0,066. Caution is to be made regarding these results solely for 2018 because of the lack of true primary consumers in the zooplankton samples for this year. The zooplankton will thus be on a higher trophic level than would have been expected with higher contents of primary consumers. To illustrate this, we have included a scatterplot for the bivariate fit of all contaminants against a TL_{rel} where zooplankton values for TL_{rel} in 2018 have been replaced by mean values from previous years (2013-2017) ($TL_{rel\ mean\ primary\ consumers}$ = 2.3), see Figure 21. TMF calculated from a larger dataset (2013/2014-2018) is discussed for each contaminant in its respective chapter. TMF for 2018-data with manipulated TL_{rel} levels for zooplankton was 6.95, 9.9, 2.5 and 1.8 for BDE-47, Hg, D5 and D6, respectively.

BDE-47 and Hg correlate well internally across the dataset for 2018 with $r^2=0.77$. TMF values of 6.95 and 9.9 for these two compounds confirm their biomagnifying properties in Lake Mjøsa, as is reported by Fjeld et al. (2016, 2017) and Jartun et al. (2018). D5 shows moderate correlation with BDE-47 and Hg (r=0.57 and 0.30, respectively), and a strong correlation with D6 in the data from 2018. These correlation coefficients are somewhat weaker than showed e.g. in Fjeld et al. (2017).

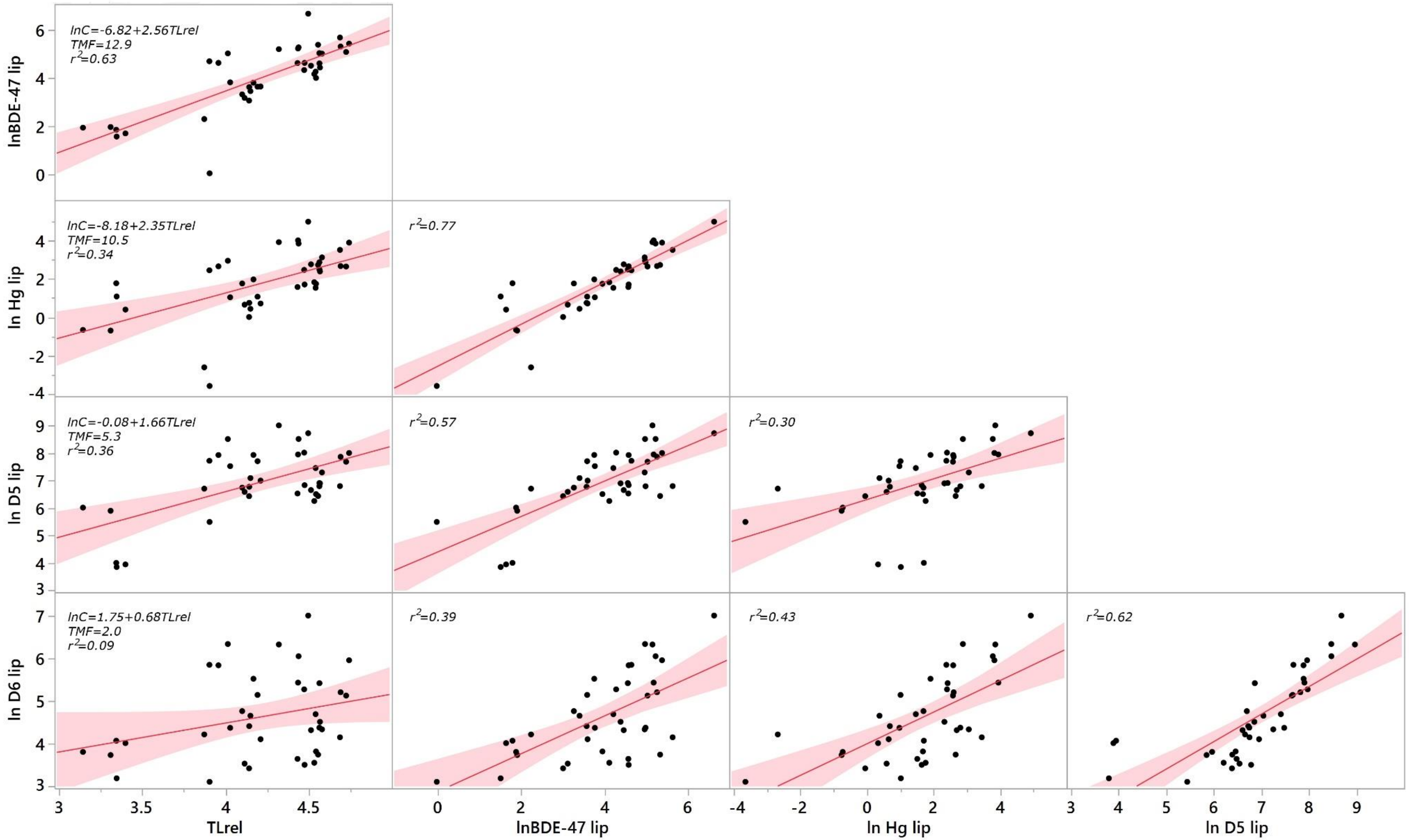


Figure 20. Scatter plots and regression lines between D5, D6, BDE-47, Hg, and relative trophic level (TL_{rel}) in fish (muscle), Mysis, and zooplankton from Lake Mjøsa, sampled in 2018. Concentrations are log_e(ln)-transformed on a lipid weight basis, ng/g lip. Conc. below LOQ are replaced by half the limit. r^2: correlation coefficient, TMF: trophic magnification factor.

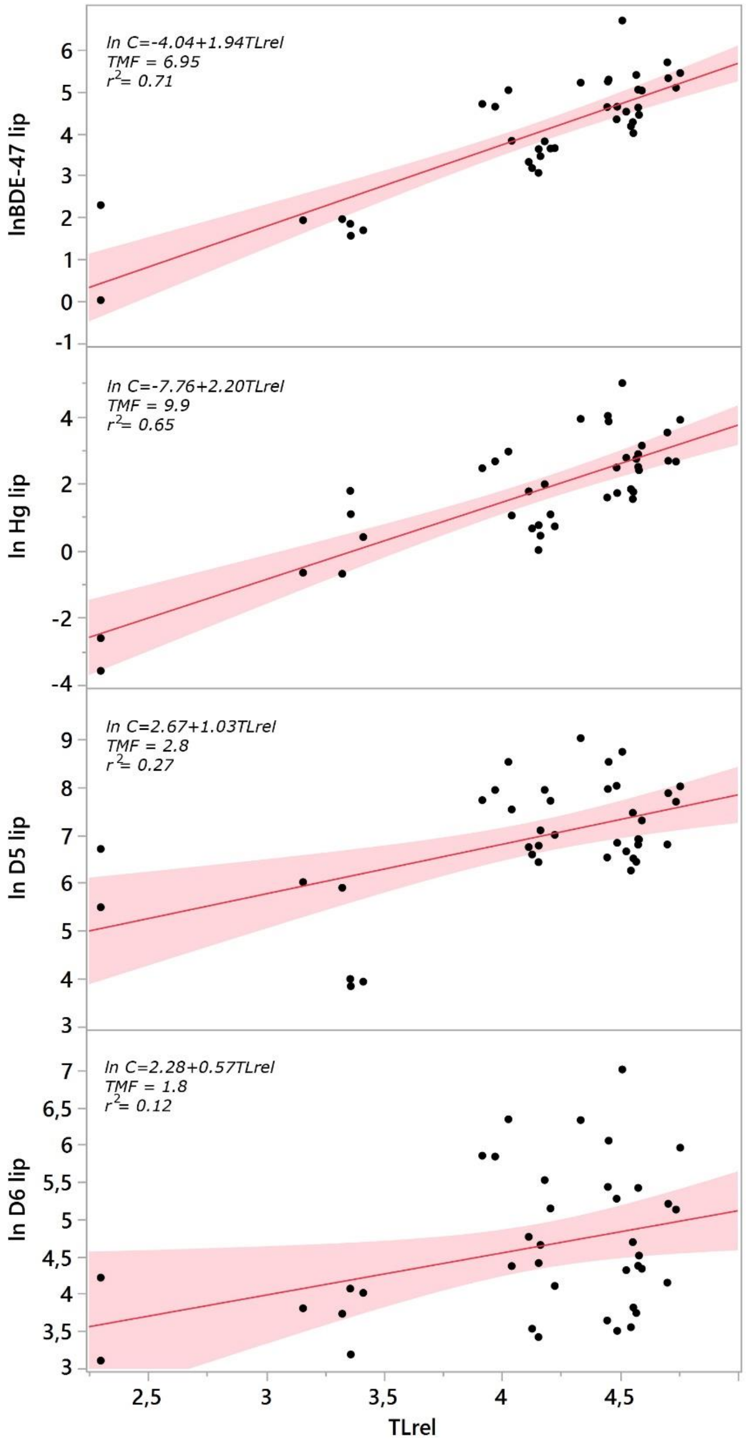


Figure 21. Scatter plots and regression lines between D5, D6, BDE-47, Hg, and relative trophic level (TL_{rel}) in fish (muscle), Mysis, and zooplankton from Lake Mjøsa, sampled in 2018. Concentrations are log_e(ln)-transformed on a lipid weight basis, ng/g lip. Conc. below LOQ are replaced by half the limit. In this figure TL_{rel} for zooplankton is manipulated to reflect the mean from the years 2014-2018. r^2: correlation coefficient, TMF: trophic magnification factor.

3.6 Alkylphenols and bisphenols

Alkylphenols (AP) and bisphenols were determined in zooplankton, Mysis and fish muscle from Lake Mjøsa and in brown trout from Lake Femunden. Almost all samples were below LOQ, as is shown in Table 4 and in Figure 22, except some minor detections of bis-A and bis-F in Mysis. Figure 22 provides an overview of all compounds with detection limits given for each sample matrix.

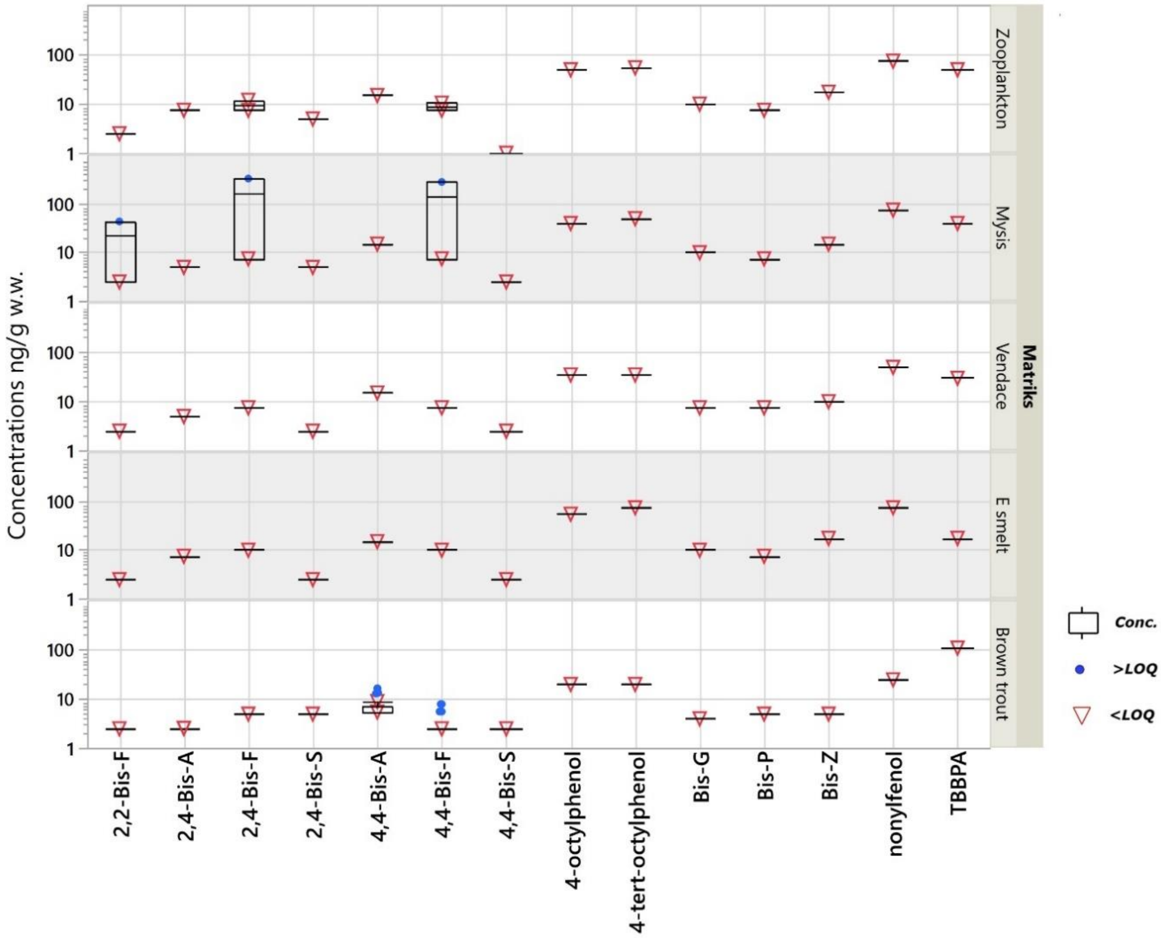


Figure 22. Box-plot of alkylphenols and bisphenols in biota from Lake Mjøsa sampled in 2018. Concentrations are given in ng/g w.w. Concentrations below LOQ have been replaced by half the limit and visualized with red triangle symbols, whereas concentrations above LOQ are visualized by blue dots.

The only detections of phenols in this study was of 4,4-Bisphenol-A and 4,4-Bisphenol-F in a few samples of brown trout from Lake Mjøsa, however only just above the LOQ. In Figure 22 we see some detections for Mysis, but the uncertainties here are large, partly because of small sample amounts and challenges with the sample matrix. LOQ for the individual compounds vary greatly for phenols, and the analytical methods are considered semi-quantitative. These results are consistent with the results obtained in the study from 2017 (Jartun et al., 2018). Fish muscle was chosen as matrix due to sufficient amounts of material. Fish bile has been reported to contain higher concentrations of alkylphenols (Jonsson et al., 2008; Wu et al., 2016), and should be a more suitable matrix given enough sample is retrieved.

Liver is present in more convenient amounts in the fish from Mjøsa than bile, but chemical analysis of alkylphenols in fish liver may not be an optimal approach to describe AP exposure data because tissue distribution studies reveal that only a small fraction of Aps is retained in liver or other organs compared to bile. Based on previous studies, it is likely that analysis of fish bile would be a more sensitive indicator of potential AP contamination (Sundt et al., 2009).

3.7 Organic phosphorous flame retardants (oPFR)

Organic phosphorous flame retardants were determined in zooplankton, Mysis and fish muscle from Lake Mjøsa and in brown trout from Lake Femunden. Almost all samples were below LOQ, as is shown in Table 4 and in Figure 23, except some minor detections of tris-chloropropyl phosphate (TCPP) and triphenoxyphosphine oxide (TPP). Detections in zooplankton and Mysis are considered with caution due to the combined effect of analytical challenges for these compounds and low sample amounts. Figure 23 provides an overview of all compounds with detection limits given for each sample matrix.

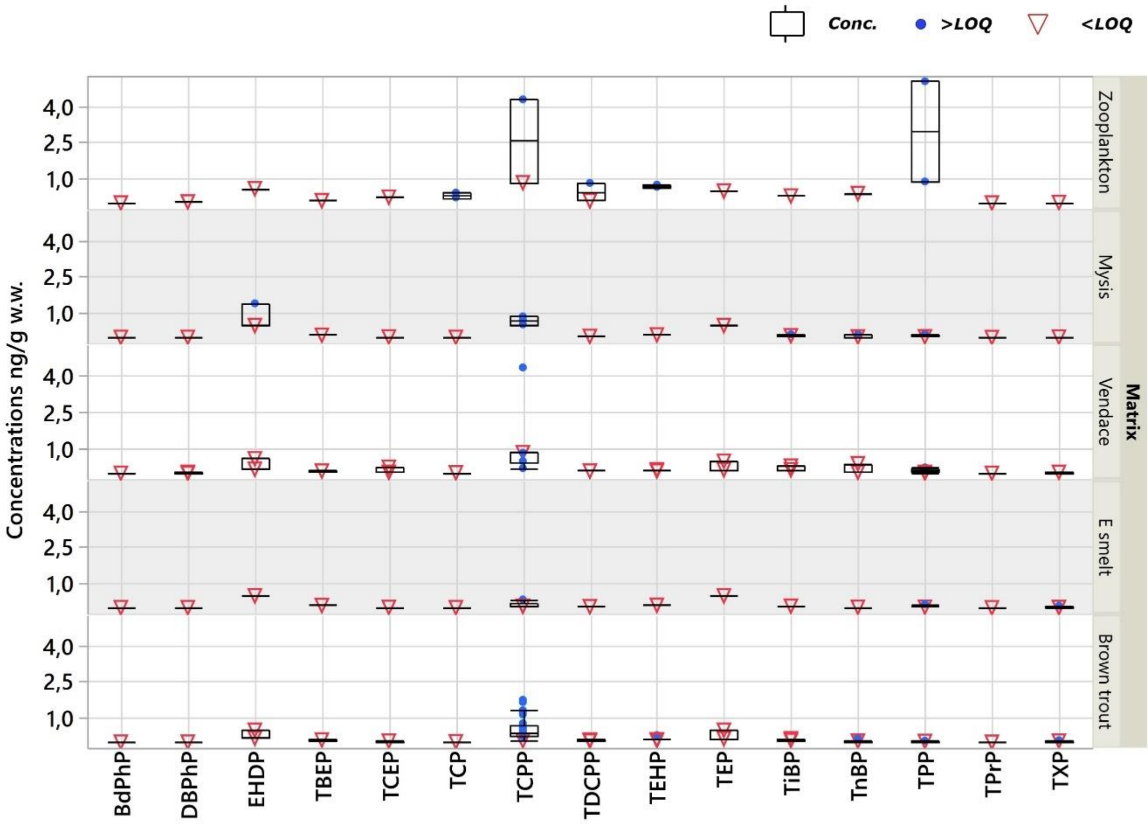


Figure 23. Box-plot of oPFR concentrations in biota from Lake Mjøsa sampled in 2018. Concentrations are given in ng/g w.w. Concentrations below LOQ are replaced by half the limit visualized by a red triangle. Concentrations above LOQ are visualized by blue dots.

The only detections of oPFR in this study was of TCPP in samples from Lake Mjøsa. LOQ for the individual compounds vary, and the analytical methods are considered semi-quantitative. TPP was also detected in zooplankton, but with a large uncertainty attached to the results. oPFRs are compounds to look out for, as they to a certain degree have been replacing legacy BFRs in the market. Despite increasing use of these compounds worldwide, knowledge about their trophic transfer is limited, however Zhao et al. (2018) were able to detect 9 out of 14 oPFRs but could not determine a trophic magnification in a food web in China.

Muscle might not be the optimal matrix to describe oPFR exposure to fish but is present in sufficient amount in the studied material. Results from 2017 and 2018 indicate that oPFRs do not accumulate in fish muscle, and that other matrices should be considered for future monitoring. Metabolites of oPFR might be detected in liver or bile and may be a better way to understand the distribution pattern and fate of oPFRs in the food web (Wang et al., 2017).

3.8 Per- and polyfluorinated substances (PFAS)

3.8.1 Levels of PFAS in 2018

Per- and polyfluorinated alkyl substances (PFAS) were determined in samples of zooplankton, Mysis and fish liver (vendace, E. smelt and brown trout) from Lake Mjøsa, and in brown trout liver from Lake Femunden. PFASs tend to accumulate in blood rich organs, so liver was the preferred sample matrix for fish. Detection frequency for PFASs are shown in Table 4. The long-chained carboxylic acids (PFCAs) with C > 9 are detected in almost all fish samples. No PFASs were detected in any samples of zooplankton nor Mysis, except for PFOS that was detected in two samples of Mysis. Other than the long-chained PFCAs, only the sulfonic acids (PFSAs) perfluoroheptasulfonate (PFHpS), perfluoroctanesulfonate (PFOS) and perfluorodecasulfonate (PFDS), and the precursor perfluorooctanesulfonamide (PFOSA) were detected. The major results for detectable PFASs are given in Table 12.

Table 12. Concentrations of selected PFAS (ng/g w.w.) presented as mean, minimum and maximum in zooplankton, Mysis, vendace, E. smelt and brown trout from Lake Mjøsa and in brown trout from Lake Femunden. Concentrations below LOQ have been replaced by half the limit. Results below LOD are marked in orange.

			PFDA			PFUnDA			PFDoDA		
	Matrix	N	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Mjøsa	Zooplankton	3	0.25	0.25	0.25	0.20	0.20	0.20	0.20	0.20	0.20
	Mysis	3	0.25	0.25	0.25	0.20	0.20	0.20	0.20	0.20	0.20
	Vendace	10	0.32	0.25	0.98	0.48	0.20	1.4	0.55	0.20	1.3
	E. smelt	10	2.1	0.25	4.8	5.5	0.20	13	3.7	0.20	7.9
	Brown trout	15	4.4	0.68	7.5	12	0.73	22	7.6	0.58	12
Femunden	Brown trout	10	0.79	0.25	1.4	2.3	0.72	4.3	1.5	0.48	2.8

			PFTrDA			PFTeDA			PFPeDA		
		N	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Mjøsa	Zooplankton	3	0.20	0.20	0.20	0.20	0.20	0.20	0.25	0.25	0.25
	Mysis	3	0.20	0.20	0.20	0.20	0.20	0.20	0.25	0.25	0.25
	Vendace	10	0.39	0.20	1.4	0.23	0.20	0.49	0.25	0.25	0.25
	E. smelt	10	3.8	0.20	9.2	1.3	0.20	3.4	0.54	0.25	1.2
	Brown trout	15	11	0.73	24	3.2	0.49	5.4	1.4	0.25	2.6
Femunden	Brown trout	10	4.2	1.2	9.7	0.99	0.20	2.1	1.3	0.25	3.3

			PFOS			PFOSA		
		N	Mean	Min	Max	Mean	Min	Max
Mjøsa	Zooplankton	3	0.03	0.03	0.03	0.05	0.05	0.05
	Mysis	3	0.07	0.03	0.09	0.05	0.05	0.05
	Vendace	10	1.8	0.31	5.8	0.05	0.05	0.05
	E. smelt	10	3.6	0.47	8.3	0.31	0.05	0.78
	Brown trout	15	9.9	0.90	19	0.88	0.15	1.5
Femunden	Brown trout	10	1.0	0.39	2.6	0.10	0.05	0.46

An overview of the minimum, maximum and mean concentrations (ng/g w.w., liver) of the eight most frequently detected PFAS are shown in Table 12. For these substances 43 – 78 % of all samples combined had concentrations above LOQ. Box-plots indicating the results and detection limits for all PFAS analyzed in this study are shown for each of the four sub-groups of PFASs (PFCA, PFSA, preFOS and other PFASs) in Figure 24, Figure 25, Figure 26 and Figure 27, respectively. These figures show that in Lake Mjøsa, the concentrations of the detected PFAS seem to increase up the food web, as almost all samples for zooplankton and Mysis were below LOQ.

Long-chained carboxylic acids (PFCAs) dominate the results, and PFTrDA (C-13) has the highest concentrations in liver of brown trout in Lake Mjøsa (mean concentration of 11 ng/g w.w., ranging from 0.73 – 24 ng/g w.w.). In 2018, concentrations were higher in Lake Mjøsa than in Lake Femunden (mean concentrations of 11 and 4.2, respectively). PFTrDA concentrations are significantly different in samples of brown trout from the two lakes (p=0.0064). In previous studies (Fjeld et al., 2017; Jartun et al., 2018) concentrations of PFTrDA have been higher in Lake Femunden, with suggested explanation in the differences in diet between brown trout in Lake Femunden and Lake Mjøsa. Large brown trout in Mjøsa are almost solely pelagic, whereas the brown trout in Lake Femunden are more closely linked to the terrestrial food web, e.g. insects. Studies have shown that the respiratory elimination of ionic and thus more water soluble PFAS, such as the carboxylic acids, are less efficient in terrestrial organisms (e.g. insects) than in aquatic organisms (Kelly et al., 2009). We can't find a confirming explanation as to why the trend of higher PFTrDA concentrations in Lake Femunden compared to Mjøsa now has reversed from 2013-2017 to 2018. Looking at d13C and d34S data from 2017 and 2018, there are some differences between the lakes; d13C in Lake Femunden of -27.3 and -29.0 in 2017 and 2018, respectively and -23.1 and -21.6 in Lake Mjøsa. These data indicate a more negative value from 2017 to 2018 in Lake Femunden, but a more positive value for Lake Mjøsa. As for d34S, there is a difference between Lake Femunden (mean 6.7‰) and Lake Mjøsa (mean 2.9‰), but the difference is equal in 2017 and 2018. Variations might be caused by uncertainties of about 30 % in the analytical methods for PFAS.

To assess the actual contamination of PFOS and PFOA in biota, concentrations in fish from Lake Mjøsa and Lake Femunden (ng/g w.w., liver) were compared to the EQS values for the two substances given in Table 3. EQS_{biota} values are 9.1 and 91.3 ng/g w.w. for PFOS and PFOA, respectively. PFOA was not detected in any fish sample from either lake. PFOA is reported to be efficiently excreted via the renal route (kidneys, urine) with whole-body half-life of ~12 days (Consoer et al., 2014). PFOS was found above EQS of 9.1 ng/g w.w. in 8 out of 15 samples of brown trout in Lake Mjøsa, with concentrations ranging from 0.90 – 19 ng/g w.w. Mean concentration of PFOS in brown trout from Lake Mjøsa in 2018 was 9.9 ng/g w.w., whereas mean concentrations for the same species in Lake Femunden was 1.0 ng/g w.w.

Levels of PFAS in brown trout from Lake Mjøsa have generally been lower than other lakes more closely related to known, local sources of PFAS such as Lake Vansjø close to a fire-fighting training facility (Fjeld et al., 2015) and Lake Tyrifjorden with historical discharges of a range of PFAS from paper industry upstream in the catchment area (Slinde et al., 2017). In Tyrifjorden, concentrations of PFOS in perch liver were 322-1110 ng/g w.w., up to 500 times the concentrations found in brown trout from Lake Mjøsa in our study.

3.8.2 Concentrations of PFCAs in 2018

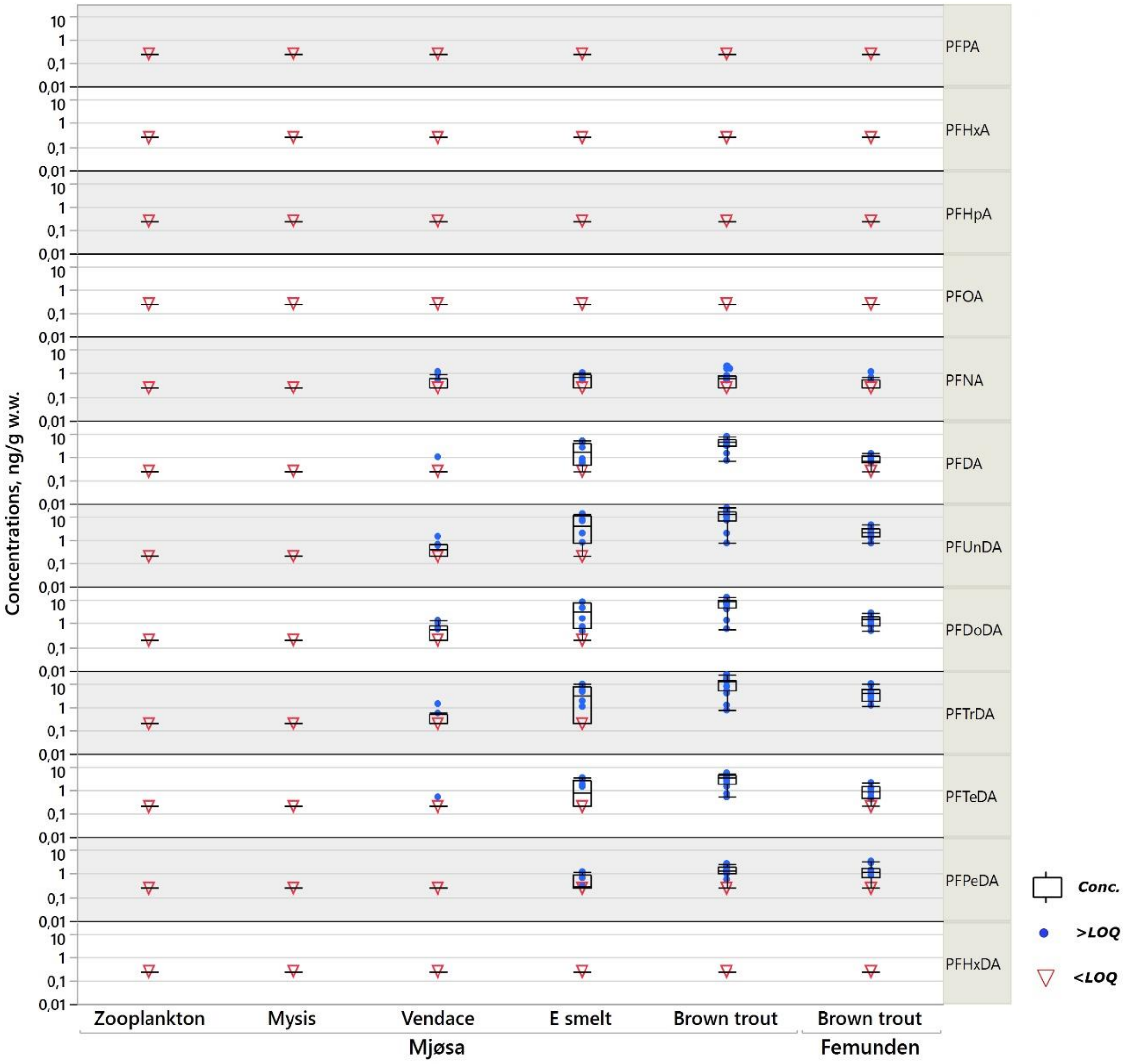


Figure 24. Box-plot of perfluorinated carboxylic acids (PFCA) concentrations in biota from Lake Mjøsa and Femunden sampled in 2018. Concentrations are given in ng/g w.w. Concentrations below LOQ are replaced by half the limit visualized by a red triangle. Concentrations above LOQ are visualized by blue dots.

3.8.3 Concentrations of PFSAs in 2018

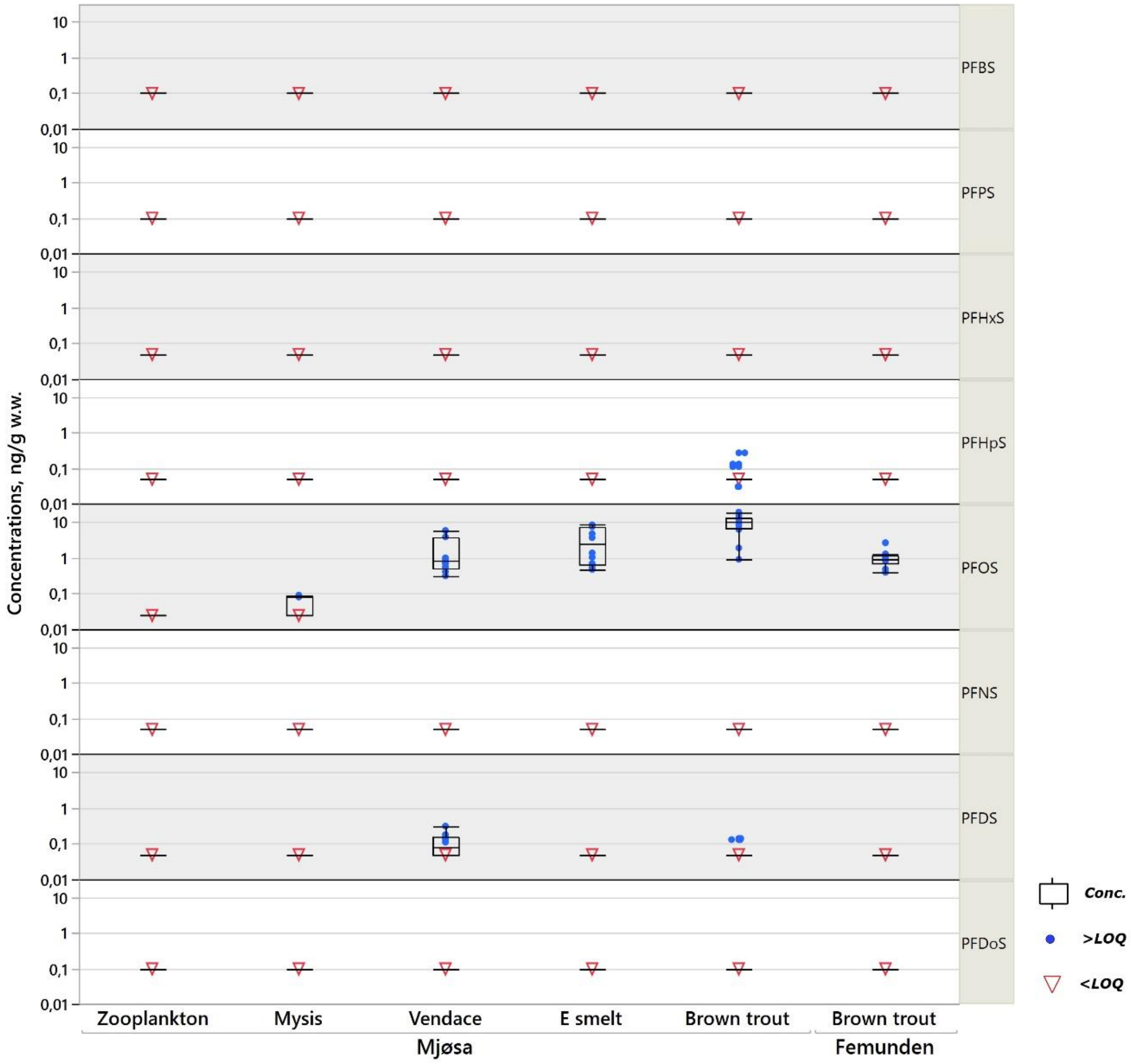


Figure 25. Box-plot of perfluorinated sulfonic acids (PFSA) concentrations in biota from Lake Mjøsa and Femunden sampled in 2018. Concentrations are given in ng/g w.w. Concentrations below LOQ are replaced by half the limit visualized by a red triangle. Concentrations above LOQ are visualized by blue dots.

3.8.4 Concentrations of preFOS (precursors) in 2018

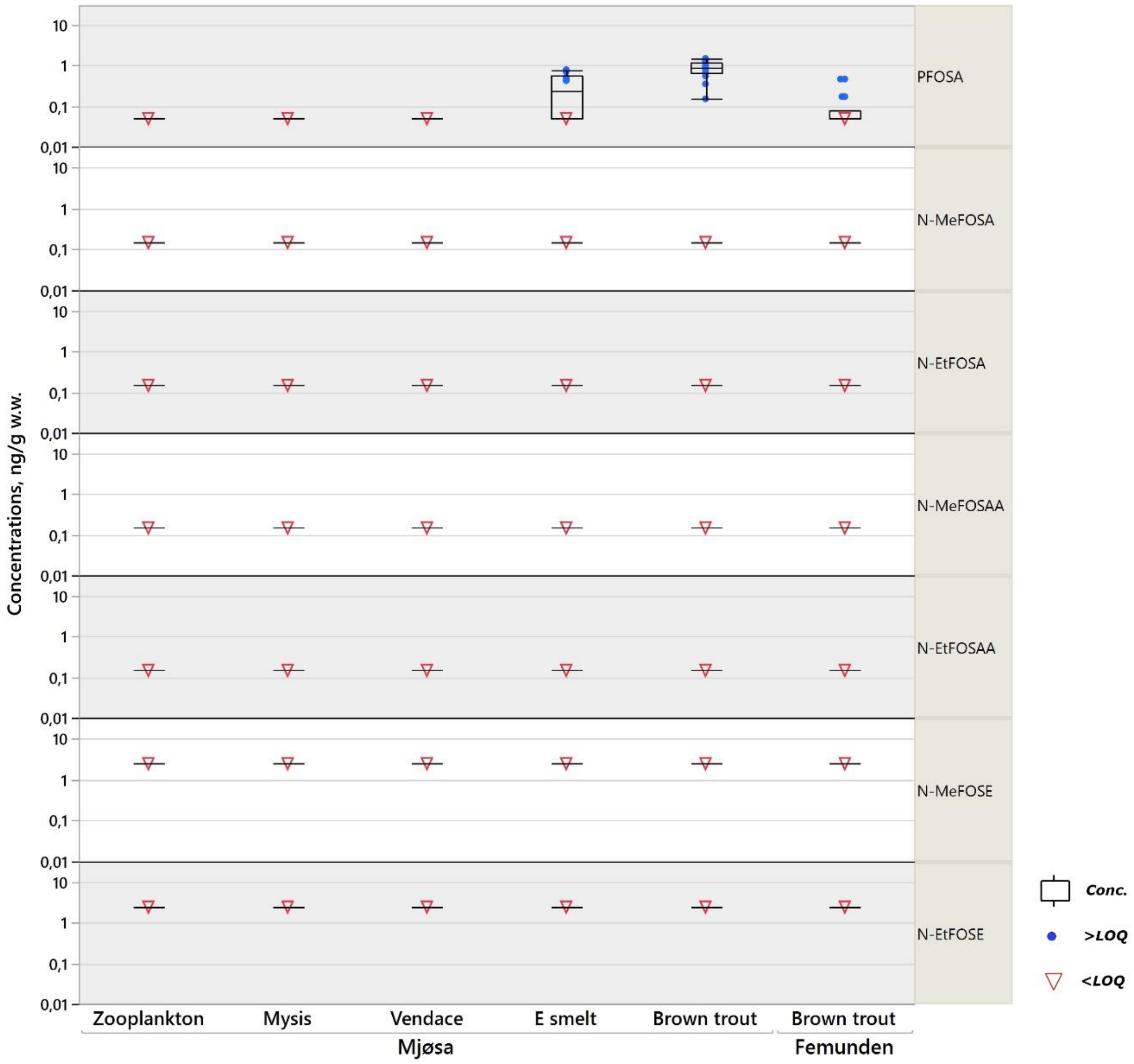


Figure 26. Box-plot of precursors to PFOS (preFOS)- concentrations in biota from Lake Mjøsa and Femunden sampled in 2018. Concentrations are given in ng/g w.w. Concentrations below LOQ are replaced by half the limit visualized by a red triangle. Concentrations above LOQ are visualized by blue dots.

3.8.5 Concentrations of other PFASs in 2018

Figure 27. Box-plot of other PFAS concentrations in biota from Lake Mjøsa and Femunden sampled in 2018. Concentrations are given in ng/g w.w. Concentrations below LOQ are replaced by half the limit visualized by a red triangle. Concentrations above LOQ are visualized by blue dots.

3.8.6 PFAS – trends from 2014-2018 for Lake Mjøsa and Femunden

Studies of PFAS in Lake Mjøsa have been carried out since 2006 (Fjeld et al., 2013), but for several years the matrix was muscle with large parts of the data below LOQ, or at least in low concentrations. To compare the results from 2017 and 2018 with previous data from liver samples, time trends here include concentrations from 2014.

Trends for all sample types (zooplankton, Mysis, vendace, E. smelt and brown trout) in Lake Mjøsa from 2014 to 2018 are shown in Figure 28. Looking at brown trout only, there seem to be a downwards trend from 2014 to 2018 for PFOS and PFTrDA, but the trend is not significant (p=0.42 and 0.07, respectively). The other substances do not reveal a clear trend. The total detectable PFAS concentration (Σ(PFDA, PFUDA, PFDoDA, PFTrDA, PFTeDA and PFOS)) seem to have a downwards trend for vendace, E. smelt and brown trout in Lake Mjøsa, but continuous monitoring in coming years will reveal whether this trend is significant or not.

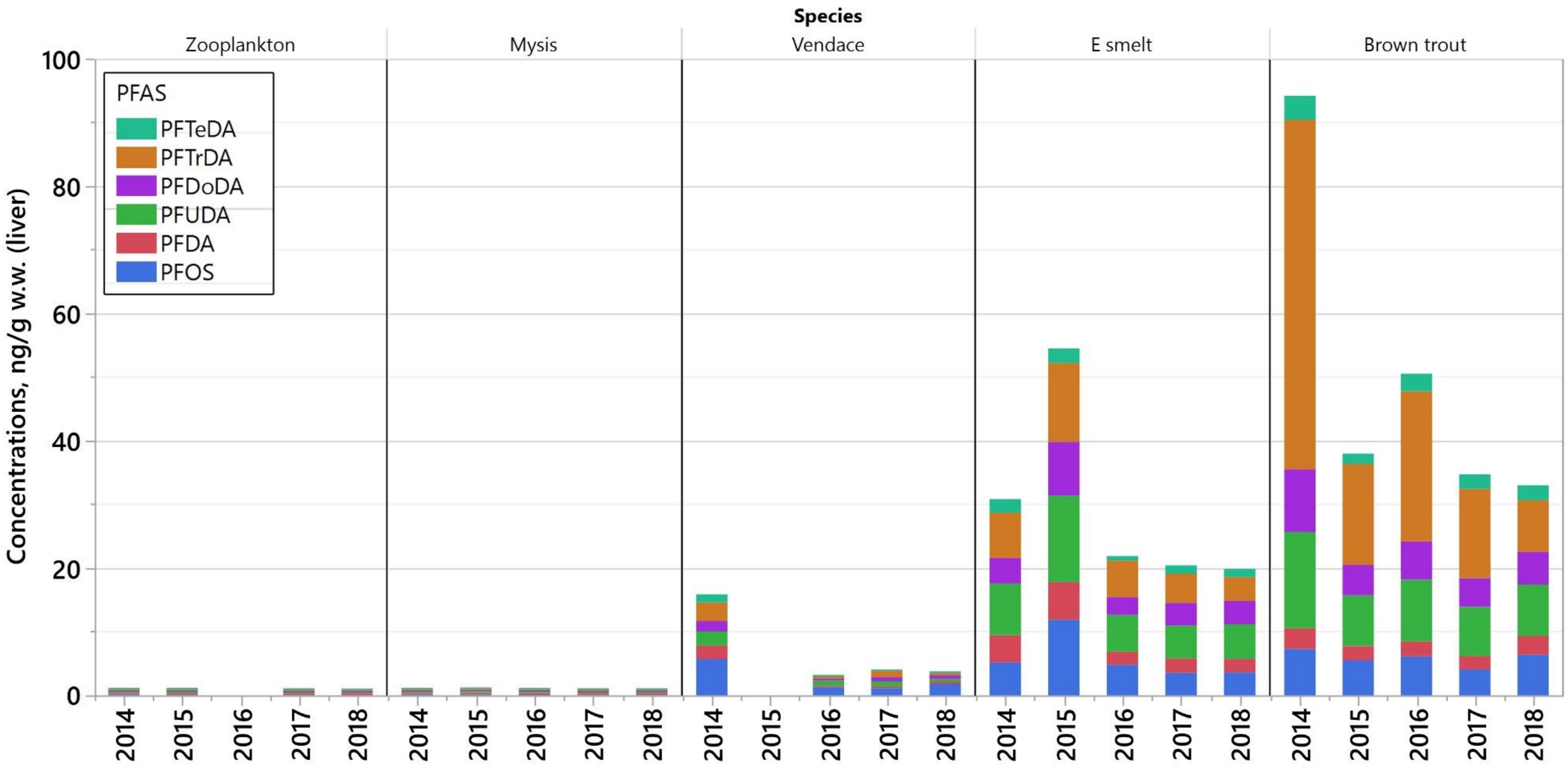


Figure 28. Mean concentrations (ng/g w.w.) of selected PFASs in samples of liver from zooplankton, Mysis, vendace, E. smelt, and brown trout in Lake Mjøsa 2014-2018. Concentrations below LOQ have been replaced by half the limit.

Comparison of the time trends for detectable PFASs in Lake Mjøsa and Lake Femunden is given in Figure 29. In Lake Femunden PFTrDA has dominated the liver samples since 2014, but we do see a downward trend for this substance, as we also do for PFUDA and PFDoDA. This is also evident when looking at the Σ(PFAS; PFDA, PFUDA, PFDoDA, PFTrDA, PFTeDA and PFOS), and this downward trend from 2014 to 2018 is statistically significant (p=0,0082). Σ of detectable PFASs in 2018 are for the first time lower in Lake Femunden than for Lake Mjøsa, but there are currently no supported explanations for this trend.

Knowledge of the most important local sources for PFASs around Lake Mjøsa is limited, and should be followed in more detail, e.g. the difference between PFAS contamination pattern between Lake Mjøsa and Lake Femunden. We have no indication as to where the rather high concentrations of PFOS in biota from Lake Mjøsa may originate.

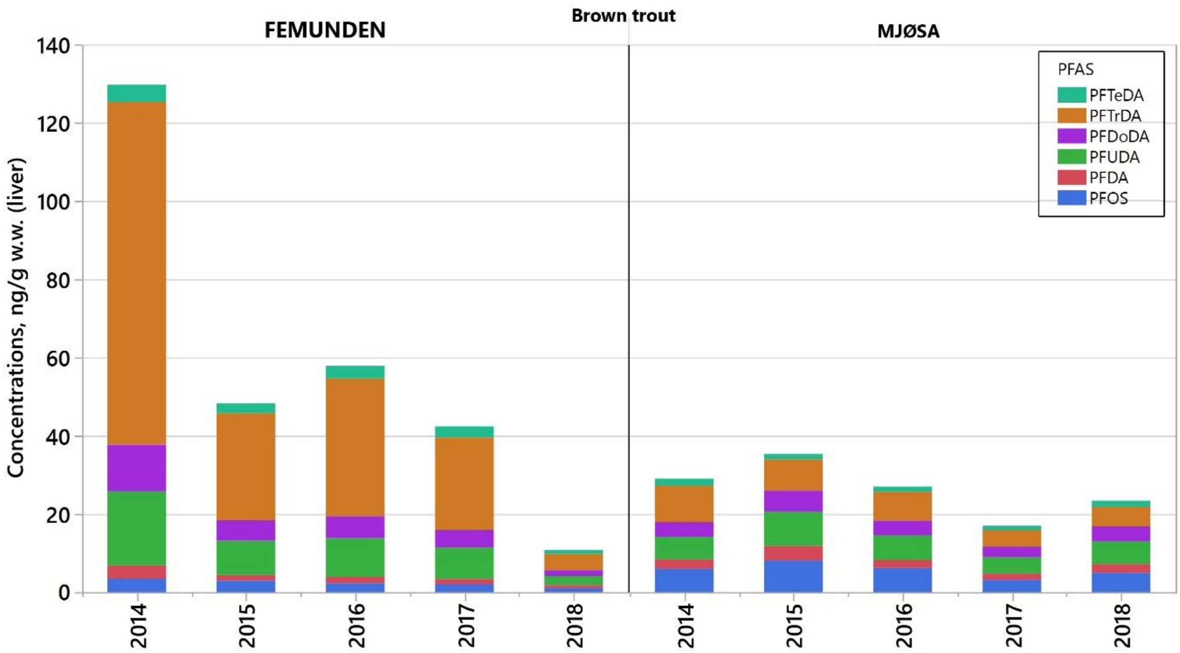


Figure 29. Mean concentrations (ng/g w.w.) of selected PFASs in samples of liver from brown trout in Lakes Femunden and Mjøsa 2014-2018. Concentrations below LOQ have been replaced by half the limit.

3.8.7 Trophic magnification of PFOS

As discussed for Hg, cVMS and PBDEs, the lack of true primary consumers (zooplankton) in the samples for 2018 limits the value of evaluating trophic transfer for any given contaminant for this year only. We have instead looked at the total data set from 2014 – 2018 for all sample types in Lake Mjøsa to calculate a TMF for PFOS. In Figure 30, concentrations of PFOS (ng/g w.w.) in zooplankton, Mysis, vendace, E. smelt and brown trout (fish liver) in Lake Mjøsa 2014-2018 are plotted against $\delta^{15}N$. The regression line was used to calculate a TMF of 6.9 up the aquatic food web for PFOS with $r^2=0.60$ and $p<0.0001$.

The EQS value for PFOS in biota of 9.1 ng/g w.w. is also inserted in Figure 30.

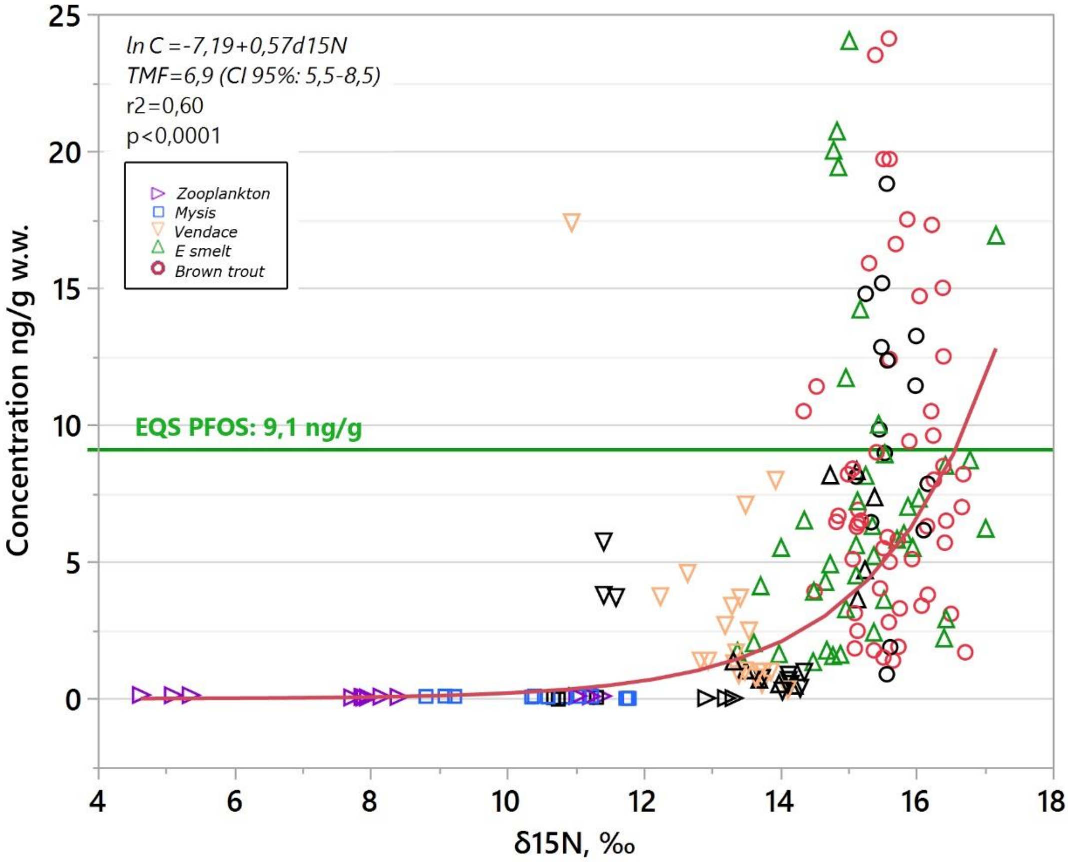


Figure 30. Concentrations of PFOS (ng/g w.w.) in zooplankton, Mysis, vendace, E. smelt and brown trout (fish liver) in Lake Mjøsa 2014-2018 plotted against $\delta^{15}N$. Regression line is inserted, and details from the model included calculation of trophic magnification factor (TMF) shown. The EQS value for PFOS in freshwater biota is shown with a green line. Concentrations from 2018 are shown with black color. Concentrations below LOQ have been replaced by half the limit.

3.9 UV-filters

Synthetic ultraviolet light filtering (UV-filter) compounds are contaminants of emerging concern and have regulatory limitations for their concentrations in cosmetic products (EC, 2009). In the main analytical program for Lake Mjøsa and Femunden, three UV-filters have been determined in zooplankton, Mysis and fish muscle by NIVA; octocrylene (OC, CAS: 6197-30-4), benzophenone-3 (BP-3, CAS: 131-57-7), and ethylhexylmethoxycinnamate (EHMC, CAS: 5466-77-3).

Table 4 indicate the detection frequency of UV-filters in our study. BP3 was detected in zooplankton and E.smelt but with high degree of uncertainties due to sample amount and matrix effects. Octocrylene was only detected in zooplankton and in two samples of E.smelt and vendace slightly above LOQ. A box-plot of the detections and LOQs for UV-filters is given in Figure 31. EHMC-isomers were only detected in brown trout from Lake Femunden with a high degree of uncertainty.

EHMC is a very lipophilic compound known to accumulate in the aquatic food chain (Christen et al., 2011). EHMC-E and EHMC-Z are *trans* and *cis* isomers of 2-ethylhexyl-4-methoxycinnamate (EHMC) with somewhat different properties. The Z (*cis*) isomer has a lower absorption coefficient than E (*trans*), and often co-exist in a ratio of *trans*:*cis* 99:1 (Pangnakorn et al., 2007; Sharma et al., 2016). The Z (*cis*) isomer may cause more damaging effect than the *trans* isomer. When these chemicals are exposed to sunlight, the *trans*-isomer is transformed to the *cis*-isomer. Although levels of these contaminants are currently low in Lake Mjøsa, future monitoring should include further studies of these chemicals in the aquatic environment.

UV-filters benzophenone-3 (BP3), ethylhexylmethoxycinnamate (EHMC), octocrylene (OC), and 2-(2Hbenzotriazol-2-yl)-4,6-bis(2-phenyl-2-propanyl)phenol (UV-234) have been studied in Norwegian environment by Thomas et al. (2014). These compounds were detected in treated wastewater and leachate, indicating that effluents from wastewater treatment plants (WWTPs) might be relevant sources to the aquatic environment. BP3, EHMC, OC, 2-(5-chloro-2H-benzotriazol-2-yl)- 4,6-bis(2-methyl-2-propanyl)phenol (UV- 327) and 2-(2H-benzotriazol-2-yl)-4-(2,4,4-trimethyl-2-pentanyl)phenol (UV-329) were detected in sludge. UV-filter chemicals such as EHMC and OC have also been reported in fish samples from Spain (Gago-Ferrero et al., 2015), but no indication of biomagnification was found in this study mainly because of a limited food web with few trophic levels.

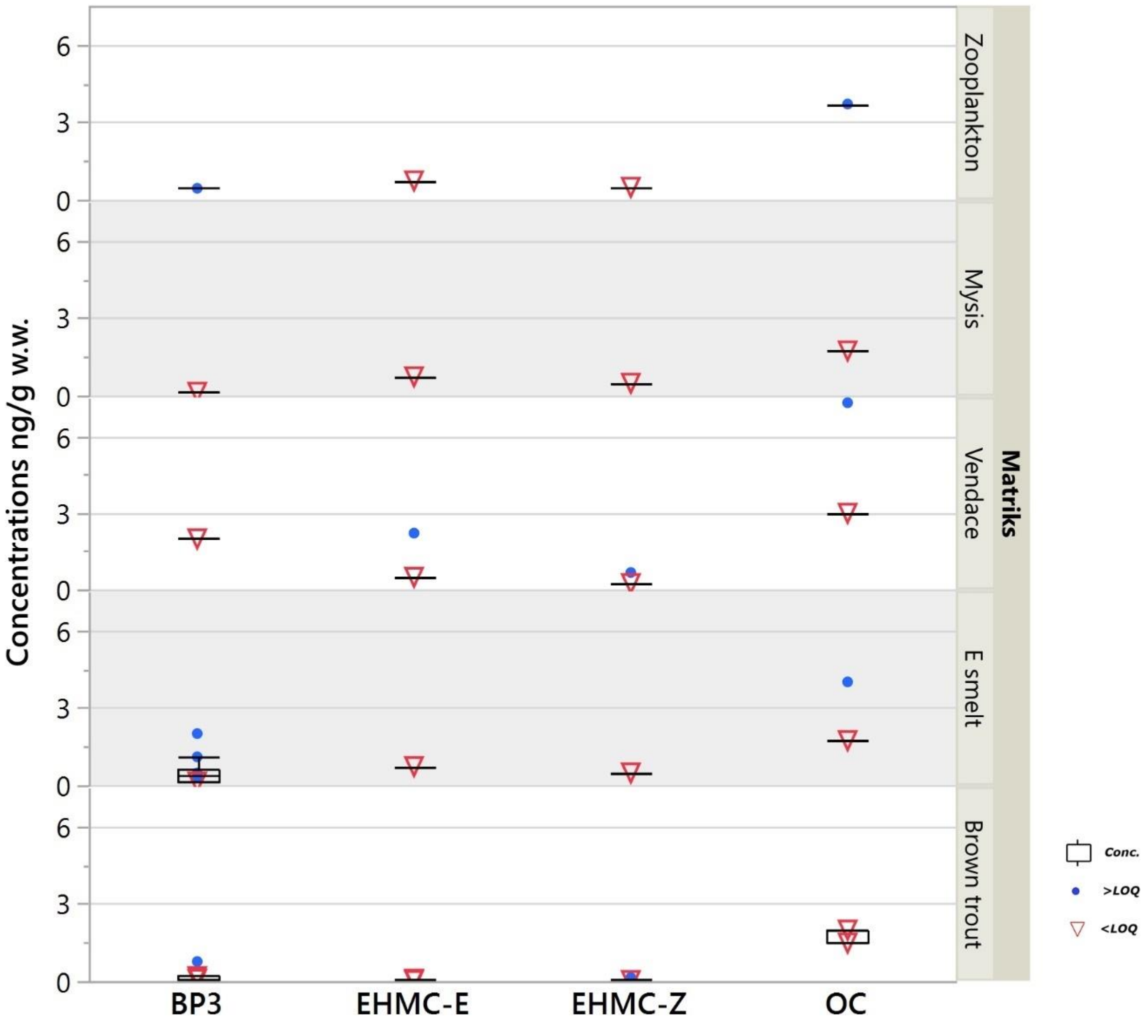


Figure 31. Box-plot of UV-filter concentrations in biota from Lake Mjøsa and Femunden sampled in 2018. Concentrations are given in ng/g w.w. Concentrations below LOQ are replaced by half the limit visualized by a red triangle. Concentrations above LOQ are visualized by blue dots.

3.10 New brominated flame retardants - nBFR

A graph listing the detections and LOQs of new brominated flame retardants in zooplankton, Mysis and fish muscle from Lake Mjøsa and Lake Femunden is shown in Figure 32 . Only 1,2-Bis(2,4,6-tribromophenoxy)ethane (BTBPE), Decabromodiphenylethane (DBDPE) and pentabromobenzene (PBBZ) were detected in the samples, as shown in Table 4.

Detections for zooplankton should be addressed carefully because of large uncertainties partly because of small sample amounts and matrix effects. Results for the n-BFR is considered semi-quantitative, which is also reflected in the fluctuating LOQs within each sample matrix, see Figure 32.

After regulation of some PBDEs as major contaminants in products such as textiles, alternative compounds (nBFR) have been introduced to the market to replace some of the older BFRs. The list of nBFR is expanding, but our analyses include 2,3-dibromopropyl-2,3,4-tribromophenyl-ether (DPTE) found in the Barents Sea and DBDPE which is found in the Arctic (de Wit et al., 2010; Harju et al., 2013). Little is so far known about the concentrations and environmental fate and impact these substances may have. In a recent study from the Arctic, nBFRs with low molecular weights such as hexabromobenzene (HBB), pentabromoethylbenzene (PBEB) and pentabromotoluene (PBT) were detected in amphipods (Carlsson et al., 2018). Several of the nBFRs may undergo long-range transport.

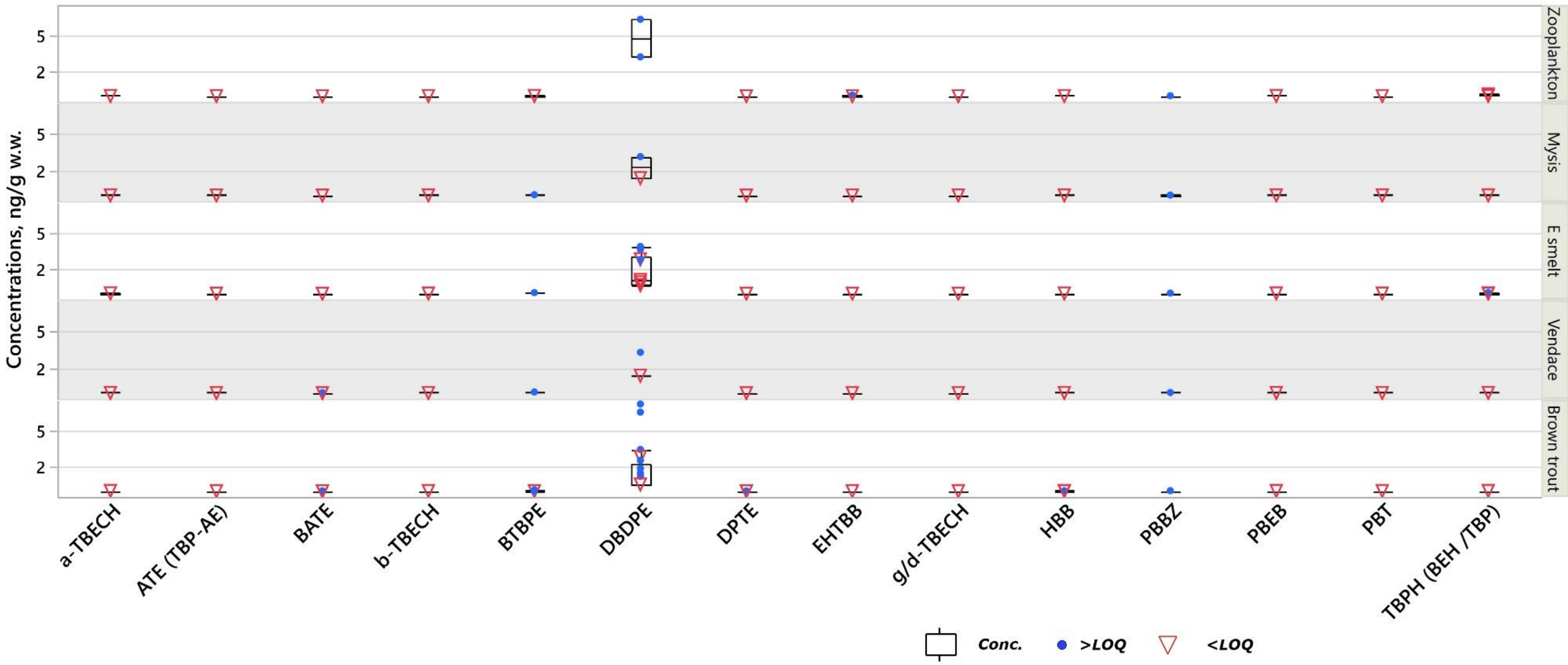


Figure 32. Box-plot of new brominated flame retardants compound concentrations in biota from Lake Mjøsa and Femunden sampled in 2018. Concentrations are given in ng/g w.w. Concentrations below LOQ are replaced by half the limit visualized by a red triangle. Concentrations above LOQ are visualized by blue dots.

4 Conclusions

This monitoring program studies the occurrence and environmental fate of contaminants in Norwegian freshwater ecosystems. Both long-term changes for some legacy contaminants and new additions of emerging contaminants are considered. This report has highlighted the major results from the sampling campaign of five species of different trophic levels (zooplankton, Mysis, vendace, E. smelt and brown trout) in Lake Mjøsa, and the top predator brown trout in Lake Femunden. Establishing a reference level and basis for considering the distribution and fate of selected compounds in the food web of major freshwater ecosystems is maybe the most important contribution of this monitoring program. Using the same species and approaches over several years provide relevant data for considering time trends for these contaminants in biota.

Contaminant concentrations on the basis of wet weight are related to environmental quality standards (EQS), and as far as possible compared to similar studies nationally and internationally. The main conclusions from the results in 2018 include:

- A slight downwards trend of mercury (Hg) concentrations in brown trout is observed, but levels are still above EQS of 20 µg/kg (= 20 ng/g = 0.020 mg/kg) w.w. Hg is biomagnifying in the food web.

- cVMS compounds D5 and D6 show trophic magnification in Lake Mjøsa with TMF of 2.5 and 1.8, respectively, based on data from 2013-2018. D5 is the more dominant cVMS, but no concentrations exceed EQS of 15217 ng/g w.w. for D5 in the sample material. A slight downward trend for D5 is observed since 2010/2012, but there is a small concentration increase in 2018 compared to 2016 and 2017, although small.

- For PBDE (ΣBDE_6) there is a downwards trend since the early 2000s, but a slight upward trend since 2016 for all fish species in the study.

- Of the 39 determined PFASs, only 9 were detected above LOQ, including long-chained carboxylic acids (PFCAs) and PFOS. 8 out of 15 samples of brown trout in Lake Mjøsa exceeded the EQS value of 9.1 ng/g w.w. for PFOS, which is an observed increase from 2016 and 2017. The time series for PFAS is on a downwards trend for the PFCAs and PFOS for all fish in Lake Mjøsa compared to levels in 2013/2014 but seem to have stabilized the last three years.

- Only very few detections were observed in biota samples (fish muscle) for organic phosphorous flame retardants (oPFR), alkylphenols and bisphenols, new brominated flame retardants (nBFR) and UV-filters. Other matrices such as bile or liver should be considered as alternative sample media.

The monitoring program addresses contaminants of high concern, and even though some contaminants are observed below the limit of quantification it is important to keep follow these compounds to provide an early warning if they were to enter Norwegian freshwater ecosystems. Well known contaminants such as Hg, PBDEs and PFOS are determined in concentrations well above the EQS. Even though several of these compounds are regulated in products and downwards trends are indicated for e.g. BDEs and Hg, the distribution and fate of these well-known contaminants should be studied in the same detail also in the years to come.

5 References

Allen, E.W., Prepas, E.E., Gabos, S., Strachan, W.M.J., Zhang, W., 2005. Methyl mercury concentrations in macroinvertebrates and fish from burned and undisturbed lakes on the Boreal Plain. Canadian Journal of Fisheries and Aquatic Sciences 62, 1963– 77.

Andresen, J.A., 2006. Emission, fate and behaviour of phosphororganic flame retardants and plasticisers in the aquatic environment. Dr. thesis, Universität Duisburg-Essen, Campus Essen, Institut für Umweltanalytik und Angewandte Geochemie.

Benedict, R.T., Stapleton, H.M., Letcher, R.J. and Mitchelmore, C.L., 2007. Debromination of polybrominated diphenyl ether-99 (BDE-99) in carp (*Cyprinus carpio*) microflora and microsomes. Chemosphere 69, 987-993.

Bengtson Nash, S.M., Poulsen, A.H., Kawaguchi, S., Vetter, W. and Schlabach, M., 2008. Persistent organohalogen contaminant burdens in Antarctic krill (*Euphausia superba*) from the eastern Antarctic sector: A baseline study. Science of the Total Environment 407, 304-314.

Bjerregaard, P., 2005. Økotoksikologi (*Ecotoxicology*), 1 utgave. København: Gyldendal. ISBN 87-02-03902-8

Bohlin-Nizzetto, P., Aas, W. and Warner, N.A., 2018. Monitoring of environmental contaminants in air and precipitation, annual report 2017. Norwegian Environment Agency, Report M-1062/2017. 140 pp.

Borgå, K., Kidd, K.A., Muir, D.C.G., Berglund, O., Conder, J.M., Gobas, F.A.P.C., Kucklick, J., Malm, O., and Powell, D.E., 2012a. Trophic magnification factors: Considerations of ecology, ecosystems, and study design. Integr. Environ. Assess. Manage., 8, 64–84.

Borgå, K., Fjeld, E., Kierkegaard, A., and McLachlan, M.S., 2012b. Food Web Accumulation of Cyclic Siloxanes in Lake Mjøsa, Norway. Environ Sci Technol 46, 6347–6354.

Borgå, K., Fjeld, E., Kierkegaard A., Løvik, J.E., Rognerud; S., Høgfeldt, A., Bæk, K., and McLachlan, M.S., 2013a. Siloxanes in freshwater food webs – a study of three lakes in Norway. Miljødirektoratet rapport M-81/2013. 36 pp.

Borgå, K., Fjeld, E., Kierkegaard, A., and McLachlan, M.S., 2013b. Consistency in trophic magnification factors of cyclic methyl siloxanes in pelagic freshwater food webs leading to brown trout. Environ Sci Technol 47(24), 14394–14402.

Borgå, K., Kidd, K.A., Muir, D.C., Berglund, O., Conder, J.M., Gobas, F.A., Kucklick, J., Malm,O., Powell, D.E., 2011. Trophic magnification factors: considerations of ecology, eco-systems, and study design. Integr. Environ. Assess. Manag. 8, 64–84. http://dx.doi.org/10.1002/ieam.244.

Cabana, G., Tremblay, A., Kalff, J., Rasmussen, J.B., 1994. Pelagic food chain structure in Ontario lakes: a determinant of mercury levels in lake trout (Salvelinus namaycush). Canadian Journal of Fisheries and Aquatic Sciences 51, 381-389.

Carlsson, P., Vrana, B., Sobotka, J., Borgå, K., Bohlin Nizzetto, P. and Varpe, Ø., 2018. Investigation of new brominated and organophosphorous flame retardants in Svalbard benthic marine food web; FlammePlank. NIVA-rapport 7261-2018, 29 p.

Chen, D., Kannan, K., Tan, H., Zheng, Z, Feng, Y.L., Wu, Y., and Widelka, M., 2016. Bisphenol analogues other than BPA: environmental occurrence, human exposure, and toxicity – a review. Environ. Sci. Technol., 50, 5438-5453.

Chételat, J., Amyot, M., Garcia, E., 2011. Habitat-specific bioaccumulation of methylmercury in invertebrates of small mid-latitude lakes in North America. Environmental Pollution 159, 10–17.

Christen, V., Zucchi, S., and Fent, K., 2011. Effects of the UV-filter 2-ethyl-hexyl-4-trimethoxycinnamate (EHMC) on expression of genes involved in hormonal pathways in fathead minnows (*Pimephales promelas*) and link to vitellogenin induction and histology. Aquatic Toxicology 102 (3-4), 167-176.

Cidzdziel, J.V., Hinners, T.A., Pollard, J.E., Heithmar, E.M., Cross, C.L., 2002. Mercury concentrations in fish from Lake Mead, USA, related to fish size, condition, trophic level, location and consumption risk. Archives of Environmental Contamination and Toxicology 43, 309–317.

Consoer, D.M., Hoffmann, A.D., Fitzsimmons, P.N., Kosian, P.A. and Nichols, J.W., 2014. Toxicokinetics of perfluorooctanoate (PFOA) in rainbow trout (*Oncorhynchus mykiss*). Aquatic toxicology 156, 65-73.

De Wit, C.A., Herzke, D. and Vorkamp, K., 2010. Brominated flame retardants in the Arctic environment – trends and new candidates. Science of the Total Environment 408, 2885-2918.

Direktoratsgruppen vanndirektivet, 2018. Veileder 02:2018. Klassifisering av miljøtilstand i vann.

Eagles-Smith, C.A., Suchanek, T.H., Colwell, A.E., Anderson, N.L., 2008. Mercury trophic transfer in a eutrophic lake: The importance of habitat-specific foraging. Ecological Applications 18, A196–A212.

EC, 2009. Regulation (EC) No 1223/2009 of the European Parliament and of the Council of 30.nov 2009 on Cosmetic Products.

ECHA, 2015. Annex XV restriction report, Proposal for a restriction. https://echa.europa.eu/documents/10162/9a53a4d9-a641-4b7b-ad58-8fec6cf26229. [Accessed May 2018].

Eljarrat, E. and Barceló, D., 2018. How do measured PBDE and HBCD levels in river fish compare to the European environmental quality standards? Environmental research 160, 203-211.

Evenset, A., Leknes, H., Christensen, G.N., Warner, N., Remberger, M. and Gabrielsen, G.W., 2009. Screening of New Contaminants in Samples from Norwegian Arctic. NIVA Report 4351-1, SPFO-Report 1049/2009. TA-2510/2009. ISBN:978-82- 449-0065-2.

Fjeld, E., Knutzen, J., Brevik, E.M., Schlabach, M., Skotvold, T., Borgen, A.R. and Wiborg, M.L., 2001. Halogenerte organiske miljøgifter og kvikksølv i norsk ferskvannsfisk 1995-1999. SFT rapport TA-1813/2001. 48 pp.

Fjeld, E., Bæk, K., Rognerud, S., Rundberget, J.T., Schalbach, M. and Warner, N.A., 2014. Miljøgifter i store norske innsjøer, 2013. Miljødirektoratet M-157/2014, 46 pp.

Fjeld, E., Bæk, K., Rognerud, S., Rundberget, J.T., Schalbach, M. and Warner, N.A., 2015. Miljøgifter i store norske innsjøer, 2014. Miljødirektoratet M-349/2015, 101 pp.

Fjeld, E., Bæk, K., Rognerud, S., Rundberget, J.T., Schalbach, M. and Warner, N.A., 2016. Miljøgifter I store norske innsjøer, 2015. Miljødirektoratet M-548/2016, 97 pp.

Fjeld, E., Bæk, K., Rundberget, J.T., Schlabach, M. and Warner, N.A., 2017. Miljøgifter i store norske innsjøer, 2016. Miljødirektoratet M-807/2017, 88 pp.

Gago-Ferrero, P., Díaz-Cruz, M.S. and Barceló, D., 2015. UV filters bioaccumulation in fish from Iberian river basins. Science of the Total Environment 518-519, 518-525.

Garcia, E., Carignan, R., 2005. Mercury concentrations in fish from forest harvesting and fire impacted Canadian boreal lakes compared using stable isotopes of nitrogen. Environmental Toxicology and Chemistry 24, 685-693

Gorski, P.R., Cleckner, L.B., Hurley, J.P., Sierzen, M.E., Armstrong, D.E., 2003. Factors affecting enhanced mercury bioaccumulation in inland lakes of Isle Royale National Park, USA. Science of the Total Environment 304, 327–348.

Harju, M., Herzke, D. and Kaasa, H., 2013. Perfluorinated alkylated substances (PFAS), brominated flame retardants (BFR) and chlorinated paraffins (CP) in the Norwegian environment – Screening 2013. Miljødirektoratet M 40-2013, 105 p.

Huse, A. og Aas-Aune, S. 2009. Kartlegging av siloksaner. Kartlegging av bruk i Norge i 2008. COWI. Klif. Rapport TA-2557/2009. 46 s.

Jartun, M., Fjeld, E., Bæk, K., Løken, K.B., Rundberget, T., Grung, M., Schlabach, M., Warner, N.A., Johansen, I., Lyche, J.L., Berg, V. and Nøstbakken, O.J., 2018. Monitoring of environmental contaminants in freshwater ecosystems. Miljødirektoratet M-1106, 136 p.

Jia, H., Zhang, Z., Wang, C. and Hong, W.J., 2015. Trophic transfer of methyl siloxanes in the marine food web from coastal area of northern China. Environmental Science and Technology 49(5), 2833-2840.

Jonsson, G., Cavcic, A., Stokke, T.U., Beyer, J., Sundt, R.C. and Brede, C., 2008. Solid-phase analytical derivatization of alkylphenols in fish bile for gas chromatography-mass spectrometry analysis. Journal of Chromatography A 1183 (1-2), 6-14.

Kelly, B.C., Ikonomou, M.G., Blair, J.D., Surridge, B., Hoover, D., Grace, R. and Gobas, F.A.P.C., 2009. Perfluoralkyl contaminants in an arctic marine food web: Trophic magnification and wildlife exposure. Environmental Science and Technology 43, 4037-4043.

Kierkegaard, A., Balk, L., Tjärnlund, u., de Wit, D.A. and Jansson, B., 1999. Dietary uptake and biological effects of decabromodihenyl ether in rainbow trout (*Oncorhynchus mykiss*). Environmental Science and Technology 33(10), 1612-1617.

Kierkegaard, A., Bignert, A. and McLachlan, M.S., 2013. Bioaccumulation of decamethylcyclopentasiloxane in perch in Swedish lakes. Chemosphere, 93: 789–793.

Klemetsen, A., Amundsen, P.A., Dempson, J.B., Jonsson, B., Jonsson, N., O'Connell, M.F., Mortensen, E., 2003. Atlantic salmon (Salmo salar L.), brown trout (Salmo trutta L.) and Arctic charr (Salvelinus alpinus L.): a review of aspects of their life histories. Ecology of Freshwater Fish 12, 1–59.

Krogseth, I.S., Undeman, E., Evenset, A., Christensen, G.N., Whelan, M.J., Breivik, K. and Warner, N.A., 2017. Elucidating the Behavior of Cyclic Volatile Methylsiloxanes in a Subarctic Freshwater Food Web: A Modeled and Measured Approach. Environmental Science & Technology 51 (21), 12489-12497.

Kraabøl, M., Museth, J. Johnsen, S.I. 2009. Fangsthistorikk og bestandsvurderinger av mjøsørret med hovedvekt på kultiveringen av hunderørret (Catch history and stock assessments of Lake Mjøsa trout with main emphasis on the cultivation of Hunder trout). NINA Rapport 485: 43 pp.

Langford, K., Reid, M.J., Fjeld, E., Øxnevad, S. and Thomas, K.V., 2015. Environmental occurrence and risk of organic UV filters and stabilizers in multiple matrices in Norway. Environment International 80, 1-7.

Lau, C., Anitole, K., Hodes, C., Lai, D., Pfahles-Hutchens, A. and Seed, J., 2007. Perfluoroalkyl acids: a review of monitoring and toxicological findings. Toxicol. Sci. 99, 366-394.

Lepak, J.M., Kinzli, K.D., Fetherman, E.R., Pate, W.M., Hansen, A.G., Gardunio, E.I., Cathcart, C.N., Stacy, W.L., Underwood, Z.E., Brandt, M.M., Myrick, C.A., Johnson, B.M., 2012. Manipulation of growth to reduce mercury concentrations in sport fish on a whole system scale. Canadian Journal of Fisheries and Aquatic Sciences 69, 122–35.

Manchester-Neesvig, J.B., Valters, K. and Sonzogni, W.C., 2001. Comparison of polybrominated diphenyl ethers (PBDEs) and polychlorinated bipenyls (PCBs) in Lake Michigan salmonids. Environmental Science and Technology 35, 1072-1077.

McGoldrick, J., Chan, C., and Drouillard, K.G., Keir, M.J, Clark, M.G. and Backus, S.M., 2014. Concentrations and trophic magnification of cyclic siloxanes in aquatic biota from the Western Basin of Lake Erie, Canada. Environmental pollution 186, 41–148.

McIntyre, J.K., Beauchamp, D.A., 2007. Age and trophic position dominate bioaccumulation of mercury and organochlorines in the food web of Lake Washington. Science of the Total Environment 372, 571-84.

Miljøprøvebanken, 2015. Procedure 001: Collection and sampling of freshwater fish, ver.1.1. Can be downloaded from: https://mpbank.files.wordpress.com/2018/04/mpb-eng-procedure-1-freshwater-fish.pdf

Minagawa, M. and Wada, E., 1984. Stepwise enrichment of 15N along food chains: Further evidence and the relation between d15N and animal age. Geochim. Cosmochim. Acta 48: 1135– 1140.

Montemayor, B.P., Price, B.B. and van Egmond, R.A., 2013. Accounting for intended use application in characterizing the contributions of cyclopentasiloxane (D5) to aquatic loadings following personal care product use: antiperspirants, skin care products and hair care products. Chemosphere 93, 735-740.

Museth, J., Dervo, B., Brabrand, Å., Heggenes, J., Karlsson, S. & Kraabøl, M. 2018. Storørret i Norge. Definisjon, status, påvirkningsfaktorer og kunnskapsbehov (Large trout in Norway. Definition, status, influencing factors and knowledge needs). NINA Rapport 1498.

Norsk Standard, 2012. Water quality - Determination of mercury - Method using atomic absorption spectrometry (AAS) with and without enrichment (ISO 12846:2012), 24 p.

Noyes, P.D., Lema, S.C., Macaulay, L.J., Douglas, N.K. and Stapleton, H.M., 2013. Low level exposure to the flame retardant BDE-209 reduces thyroid hormone levels and disrupts thyroid signalling in fathead minnows. Environmental Science and Technology 47(17), 10012-10021.

Olk R, Karlsson T, Lydersen E, Økelsrud A. Seasonal variations in the use of profundal habitat among freshwater fishes in Lake Norsjø, southern Norway, and subsequent effects on fish mercury concentrations. Environments 2016, 3, 29; doi:10.3390/environments3040029

Pangnakorn, P., Nonthabenjawan, R., Ekgasit, S., Thammacharoen, C. and Pattanaargson Wanichwecharungruang, S., 2007. Monitoring 2-Ethylhexyl-4-Methoxycinnamate Photoisomerization on Skin Using Attenuated Total Reflection Fourier Transform Infrared Spectroscopy. Applied spectroscopy 61, 193-198.

Pickhardt, P.C., Folt, C.L., Chen, C.Y., Klaue, B., Blum, J.D., 2002. Algal blooms reduce the uptake of toxic methylmercury in freshwater food webs. Proceedings of the National Academy of Sciences of the United States of America 99, 4419–23.

Pickhardt, P.C., Folt, C.L., Chen, C.Y., Klaue, B., Blum, J.D., 2005. Impacts of zooplankton composition and algal enrichment on the accumulation of mercury in an experimental freshwater food web. Science of the Total Environment 339, 89–101

Post, D.M., 2002. Using stable isotopes to estimate trophic position: models, methods, and assumptions. Ecology 83, 703-718.

Powell, D.E., Schøyen, M., Øxnevad, S., Gerhards, R., Böhmer, T., Koerner, M., Durham, J. and Huff, D.W., 2018. Bioaccumulation and trophic transfer of cyclic volatile methylsiloxanes (cVMS) in the aquatic marine food webs of the Oslofjord, Norway. Science of the Total Environment 622-623, 127-139.

Power, M., Klein, G.M., Guiguer, K., Kwan, M.K.H., 2002. Mercury accumulation in the fish community of a sub-Arctic lake in relation to trophic position and carbon sources. Journal of Applied Ecology 39, 819–30.

Regnery, J., Püttmann, W., Merz, C. and Berthold, G., 2011. Occurrence and distribution of organophosphous flame retardants and plastizers in anthropogenically affected groundwater. J. Environ. Monit. 13, 347-354.

Ruus, A., Bæk, K., Petersen, K., Allan, I., Beylich, B., Schlabach, M., Warner, N. and Helberg, M., 2016. Environmental contaminants in an Urban Fjord. M-601, 84 p.

Salgueiro-González, N., Turnes-Carou, I., Besada, V., Muniategui-Lorenzo, S., López-Mahía, P. and Prada-Rodríguez, D., 2015. Occurrence, distribution and bioaccumulation of endocrine disrupting compounds in water, sediment and biota samples from a European river basin. Science of the Total Environment 529, 121-130.

Sandlund, O.D., Nashoug, O., Norheim, G., Høye, R. and Kjellberg, G., 1981. Kvikksølv i fisk og evertebrater i Mjøsa og noen sjøer i Mjøsområdet, 1979-80. DVF- Mjøsundersøkelsen. Rapport nr. 4. 54 pp. + appendices.

Sandlund, 0.T., Næsje, T.F. & Lindem, T. 1992. Ekkoloddregistreringer av pelagisk fiskebestand i Mjøsa 1990-91 (Sonar records of pelagic fish stock in Mjøsa 1990-91). NINA Oppdragsmelding 138: 1-15.

Sandlund, O.T., Museth, J., Næsje, T.F., Qvenild, T., Saksgård, R. & Ugedal, O. 2012. Storauren i Femund og Isteren. Utvikling i bestandene over de siste 30 år (Brown trout in Femund and Isteren. Developments in stocks over the past 30 years). - NINA Rapport 853.

Sandlund, O.D., Grøndahl, F.A., Kjellberg, G. and Næsje, T.F., 2017. Variabel livshistorie hos krøkle (Osmerus eperlanus) i Mjøsa og Randsfjorden. VANN 01-2017, 81-92.

Sharma, A., Řiháčková, K., Literák, J. and Cupr, P., 2016. DNA damage of ethylhexyl methoxycinnamate: Cis-EHMC can cause more significant effect in comparison with trans-EHMC. Toxicology Letters 258, S209.

Slinde, G.A. and Høisæter, Å., 2017. Kildesporing av PFAS til Tyrifjorden. Miljødirektoratet M-863, 270 pp.

Solheim, A.L., Thrane, J.E., Løvik, J.E., Skjelbred, B., Eriksen, T.E., Røst Kile, M. 2018. Tiltaksorientert overvåking i vannområde Mjøsa. Årsrapport for 2017. (Monitoring of Lake Mjøsa. Annual report for 2017). NIVA rapport 7273-2018. ISBN978-82-577-7008-2

Sparham, C., Van Egmond, R., O'Connor, S., Hastie, C., Whelan, M., Kanda, R. and Franklin, O., 2008. Determination of decamethylcyclopentasiloxane in river water and final effluent by headspace gas chromatography/mass spectrometry. Journal of Chromatography A 1212 (1-2), 124-129.

Spikkeland, I., Kinsten, B., Kjellberg, G., Nilssen, J.P. and Väinölä, R., 2016. The aquatic glacial relict fauna of Norway – an update of distribution and conservation status. Fauna norvegica, Vol.36, 51-65.

Stafford, C.P., Hansen, B., Stanford, J.A., 2004. Mercury in fishes and their diet items from Flathead Lake, Montana. Transactions of the American Fisheries Society 133, 349–357.

Stapleton, H.M., Brazil, B., Holbrook, R.D., Mitchelmore, C.L., Benedict, R., Konstantinov, A. and Potter, D., 2006. In vivo and in vitro debromination of decabromodiphenyl ether (BDE-209) by juvenile rainbow trout and common carp. Environmental Science and Technology 40(15), 4653-4658.

Stewart, A.R., Saiki, M.K., Kuwabara, J.S., Alpers, C.N., Marvin-Dipasquale, M., Krabbenhoft, D.P., 2008. Influence of plankton mercury dynamics and trophic pathways on mercury concentrations of top predator fish of a mining-impacted reservoir. Canadian Journal of Fisheries and Aquatic Sciences 65, 2351–66

Stockholm Convention, 2013. The new POPs under the Stockholm Convention. Châtelaine. http://chm.pops.int/TheConvention/ThePOPs/TheNewPOPs/tabid/2511/Default.aspx [Accessed May 2018].

Sundt, R.C., Baussant, T. and Beyer, J., 2009. Uptake and tissue distribution of C4-C7 alkylphenols in Atlantic cod (Gadus morhua): Relevance for biomonitoring of produced water discharges from oil production. Marine Pollution Bulletin 58, 72–79.

Thomas, K.V., Schlabach, M., Langford, K., Fjeld, E., Øxnevad, S., Rundberget, T., Bæk, K., Rostkowski, P., and Harju, M., 2014. Screening programme 2013: New bisphenols, organic peroxides, fluorinated siloxanes, organic UV-filters and selected PBT substances. Miljødirektoratet M-176/2014, 101 pp.

Trudel, M., Rasmussen, J.B., 2006. Bioenergetics and mercury dynamics in fish: a modelling perspective. Canadian Journal of Fisheries and Aquatic Sciences 63, 1890–1902.

Underdal, B. 1970. Undersøkelse av kvikksølvinnholdet i fisk fra Mjøsområdet. «Survey of Hg-content in fish from the Mjøsa area." Norges veterinærhøgskole, Institutt for næringsmiddelhygiene. Rapport. 18 pp.

Van der Veen, I. and de Boer, J., 2012. Phosphorus flame retardants: properties, production, environmental occurrence, toxicity and analysis. Chemosphere 88 (10), 1119-1153.

Vander Zanden, M.J., Rasmussen, J.B., 1996. A trophic position model of pelagic food webs: impact on contaminant bioaccumulation in lake trout. Ecological Monographs 66, 451-477.

Vander Zanden, M.J., Cabana, G. and Rasmussen, J.B., 1997. Comparing the trophic position of littoral fish estimated using stable nitrogen isotopes (d15N) and dietary data. Can. J. Fish. Aquat. Sci., 54, 1142-1158.

Vander Zanden, M.J., Rasmussen, J.B., 1999. Primary consumer δ13C and δ15N and the trophic position of aquatic consumers. Ecology 80(4), 1395–1404

Vander Zanden, M.J. and Rasmussen, J.B., 2001. Variation in d15N and d13C trophic fractionation: implication for aquatic food web studies. Limnology and Oceanography 46, 2061–2066.

Vander Zanden, M.J., Vadeboncoeur, Y., 2002. Fishes as integrators of benthic and pelagic food webs in lakes. Ecology 83, 2152–61.

Verta, M., 1990. Changes in fish mercury concentrations in an intensively fished lake. Canadian Journal of Fisheries and Aquatic Sciences 47, 1888–97.

Verreault, J., Berger, U. and Gabrielsen, G.W., 2007. Trends of Perfluorinated Alkyl Substances in Herring Gull Eggs from Two Coastal Colonies in Northern Norway: 1983-2003. Environmental Science and Technology 41, 6671-6677.

Vidal-Linan, L., Villaverde-de-Saa, E., Rodil, R., Quintana, J.B. and Beiras, R., 2018. Bioaccumulation of UV filters in *Mytilus galloprovincialis* mussel. Chemosphere 190, 267-271.

Wang, R., Moody, R.P, Koniecki, D. and Zhu, J., 2009. Low molecular weight cyclic volatile methylsiloxanes in cosmetic products sold in Canada: implication for dermal exposure. Environment International 35 (6), 900-904.

Wang, D., Aggarwal, M., Tait, T., Brimble, S., Pacepavicius, G., Kinsman, G., Theocharides, M., Smyth, S.A. and Alaee, M., 2015. Fate of anthropogenic cyclic volatile methylsiloxanes in a wastewater treatment plant. Water Research 72, 209-217.

Wang, G., Chen, H., Du, Z., Li, J., Wang, Z. and Gao, S., 2017. In vivo metabolism of organophosphate flame retardants and distribution of their main metabolites in adult zebrafish. Science of the total environment 590-591, 50-59.

Ward, D.M., Nislow, K.H., Folt, C.L., 2010. Bioaccumulation syndrome: identifying factors that make some stream food webs prone to elevated mercury bioaccumulation. Annals of the New York Academy of Sciences 1195, 62–83.

Warner, N.A., Kozerski, G., Durham, J., Koerner, M., Gerhards, R., Campbell, R. and McNett, D.A., 2013. Positive vs. false detection: A comparison of analytical methods and performance for analysis of cyclic volatile methylsiloxanes (cVMS) in environmental samples from remote regions. Chemosphere 93, 749-756.

Warren, G.J. 1985. Predaceous feeding habits of Limnocalanus macrurus. J. Plankton Res. 7, 537–552.

Wei, G-L., Li, D-Q., Zhuo, M-N., Liao, Y-S., Xie, Z-Y., Guo, T-L., Li, J-J., Zhang, S-Y. and Liang, Z-Q., 2015. Organophosphorus flame retardants and plasticizers: sources, occurrence, toxicity and human exposure. Environmental Pollution, 196, 29-46.

Wu, M., Pan, C., Yang, M., Xu, B., Lei, X., Ma, J., Cai, I. and Chen, J., 2016. Chemicl analysis of fish bile extracts for monitoring endocrine disrupting chemical exposure in water: bisphenol A, alkylphenols and norethindrone. Environmental toxicology and chemistry, Vol. 35 (1), 182-190.

Xu, S. and Wania, F., 2013. Chemical fate, latitudinal distribution and long-range transport of cyclic volatile methylsiloxanes in the global environment: a modeling assessment. Chemosphere 93, 835-843.

Xu, S., Kozerski, G. and Mackay, D., 2014. Critical review and interpretation of environmental data for volatile methylsiloxanes: partition properties. Environ. Sci. Technol., 48, 11748−11759.

Zhao, H., Zhao, F., Liu, J., Zhang, S., Mu, D., An, L, Wan, Y. and Hu, J., 2018. Trophic transfer of organophosphorous flame retardants in a lake food web. Environmental Pollution 242 (B), 1887-1893.

Økelsrud A, Lydersen E, Fjeld E. Biomagnification of mercury and selenium in two lakes in southern Norway. Science of the Total Environment 2016; 566: 596-607. http://dx.doi.org/10.1016/j.scitotenv.2016.05.109

Økelsrud, A., Lydersen, E., Fjeld, E., Moreno, C., 2017. Mercury and selenium in free-ranging brown trout (Salmo trutta) in the River Skienselva watercourse, Southern Norway. Science of Total Environment 586 (2017) 188–196 http://dx.doi.org/10.1016/j.scitotenv.2017.01.199

6 Appendices

a. Raw data for 2018

ID	Matrix	Lake	Length	Weight	4,4-Bis-A	2,4-Bis-A	Bis-G	4,4-Bis-S	2,4-Bis-S	4,4-Bis-F	2,4-Bis-F	2,2-Bis-F	Bis-P	Bis-Z	TBBPA
			cm	g	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle
ZM-1	Zooplankton	Mjøsa			<30	<15	<20	<2	<10	<15	<15	<5	<15	<35	<100
ZM-2	Zooplankton	Mjøsa			<30	<15	<20	<2	<10	<21	<24	<5	<15	<35	<100
ZM-3	Zooplankton	Mjøsa													
MM-1	Mysis	Mjøsa			<30	<10	<20	<5	<10	279	327	43	<15	<30	<80
MM-2	Mysis	Mjøsa			<30	<10	<20	<5	<10	<15	<15	5	<15	<30	<80
MM-3	Mysis	Mjøsa													
KM-M-1	E. smelt	Mjøsa	8.5	4.1	<35	<15	<20	<5	<5	<20	<20	<5	<15	<35	<35
KM-M-2	E. smelt	Mjøsa	8.6	3.9	<35	<15	<20	<5	<5	<20	<20	<5	<15	<35	<35
KM-M-3	E. smelt	Mjøsa	8.2	4.1	<35	<15	<20	<5	<5	<20	<20	<5	<15	<35	<35
KM-M-4	E. smelt	Mjøsa	8.9	4.3	<35	<15	<20	<5	<5	<20	<20	<5	<15	<35	<35
KM-M-5	E. smelt	Mjøsa	9.2	4.5	<35	<15	<20	<5	<5	<20	<20	<5	<15	<35	<35
KM-M-6	E. smelt	Mjøsa	26	86	<35	<15	<20	<5	<5	<20	<20	<5	<15	<35	<35
KM-M-7	E. smelt	Mjøsa	23	73	<35	<15	<20	<5	<5	<20	<20	<5	<15	<35	<35
KM-M-8	E. smelt	Mjøsa	19.9	50.5	<35	<15	<20	<5	<5	<20	<20	<5	<15	<35	<35
KM-M-9	E. smelt	Mjøsa	23.5	78	<35	<15	<20	<5	<5	<20	<20	<5	<15	<35	<35
KM-M-10	E. smelt	Mjøsa	23.1	78	<35	<15	<20	<5	<5	<20	<20	<5	<15	<35	<35
LM-M-1	Vendace	Mjøsa	24.5	177	<30	<10	<15	<5	<5	<15	<15	<5	<15	<20	<60
LM-M-2	Vendace	Mjøsa	23.9	112	<30	<10	<15	<5	<5	<15	<15	<5	<15	<20	<60
LM-M-3	Vendace	Mjøsa	19.9	65	<445	<209	<279	<5	<5	<341	<506	<566	<113	<932	N.d.
LM-M-4	Vendace	Mjøsa	19.6	58	<30	<10	<15	<5	<5	<15	<15	<5	<15	<20	<60
LM-M-5	Vendace	Mjøsa	19.7	56	<30	<10	<15	<5	<5	<15	<15	<5	<15	<20	<60
LM-M-6	Vendace	Mjøsa	15.3	22	<30	<10	<15	<5	<5	<15	<15	<5	<15	<20	<60
LM-M-7	Vendace	Mjøsa	20.1	54	<30	<10	<15	<5	<5	<15	<15	<5	<15	<20	<60
LM-M-8	Vendace	Mjøsa	18.45	48	<30	<10	<15	<5	<5	<15	<15	<5	<15	<20	<60
LM-M-9	Vendace	Mjøsa	19.95	55	<30	<10	<15	<5	<5	<15	<15	<5	<15	<20	<60
LM-M-10	Vendace	Mjøsa	19.8	54.5	<30	<10	<15	<5	<5	<15	<15	<5	<15	<20	<60
ØM-M-1	Brown trout	Mjøsa	68	3237	<11	<5	<8	<5	<10	<5	<10	<5	<10	<10	<220
ØM-M-2	Brown trout	Mjøsa	70	2809	<11	<5	<8	<5	<10	<5	<10	<5	<10	<10	<220
ØM-M-3	Brown trout	Mjøsa	70	3231	<11	<5	<8	<5	<10	<5	<10	<5	<10	<10	<220
ØM-M-4	Brown trout	Mjøsa	60	2329	<11	<5	<8	<5	<10	<5	<10	<5	<10	<10	<220
ØM-M-5	Brown trout	Mjøsa	64	2445	<11	<5	<8	<5	<10	<5	<10	<5	<10	<10	<220
ØM-M-6	Brown trout	Mjøsa	75	4817	<11	<5	<8	<5	<10	<5	<10	<5	<10	<10	<220

ID	Matrix	Lake	4-tert-octylphenol	4-octylphenol	nonylfenol	D4	D5	D6	TEP	TCEP	TPrP	TCPP	TiBP	BdPhP
			ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle
ZM-1	Zooplankton	Mjøsa	<110	<100	<150	1.3	21.752	2	< 1.0	< 0.5	< 0.02	4.277	< 0.6	< 0.02
ZM-2	Zooplankton	Mjøsa	<110	<100	<150	1.5	27.704	2.3	< 1.0	< 0.5	< 0.02	< 1.7	< 0.6	< 0.02
ZM-3	Zooplankton	Mjøsa				1.2	20.740	1.6						
MM-1	Mysis	Mjøsa	<100	<80	<150	1	11.835	1.3	< 1.0	< 0.05	< 0.01	0.863	0.120	< 0.02
MM-2	Mysis	Mjøsa	<100	<80	<150	1.4	13.073	1.5	< 1.0	< 0.05	< 0.01	0.528	< 0.15	< 0.02
MM-3	Mysis	Mjøsa				< LOQ (0.8)	8.602	1	< 1.0	< 0.05	< 0.01	0.715	< 0.15	< 0.02
KM-M-1	E. smelt	Mjøsa	<150	<110	<150	< LOQ (0.8)	6.520	0.9						
KM-M-2	E. smelt	Mjøsa	<150	<110	<150	< LOQ (0.8)	9.747	1.2						
KM-M-3	E. smelt	Mjøsa	<150	<110	<150	< LOQ (0.8)	11.050	1.7						
KM-M-4	E. smelt	Mjøsa	<150	<110	<150	< LOQ (0.8)	11.502	1.3						
KM-M-5	E. smelt	Mjøsa	<150	<110	<150	< LOQ (0.8)	20.104	1.8						
KM-M-6	E. smelt	Mjøsa	<150	<110	<150	< LOQ (0.8)	26.152	2.100	< 1.0	< 0.05	< 0.01	< 0.14	< 0.15	< 0.02
KM-M-7	E. smelt	Mjøsa	<150	<110	<150	< LOQ (0.8)	76.413	5.200	< 1.0	< 0.05	< 0.01	< 0.14	< 0.15	< 0.02
KM-M-8	E. smelt	Mjøsa	<150	<110	<150	< LOQ (0.8)	35.869	2.300	< 1.0	< 0.05	< 0.01	0.334	< 0.15	< 0.02
KM-M-9	E. smelt	Mjøsa	<150	<110	<150	< LOQ (0.8)	33.050	2.800	< 1.0	< 0.05	< 0.01	< 0.14	< 0.15	< 0.02
KM-M-10	E. smelt	Mjøsa	<150	<110	<150	< LOQ (0.8)	16.563	1.600	< 1.0	< 0.05	< 0.01	< 0.14	< 0.15	< 0.02
LM-M-1	Vendace	Mjøsa	<70	<70	<100	< LOQ (0.8)	< LOQ (2.7)	< LOD (1.4)	< 0.30	< 0.10	< 0.01	0.487	< 0.30	< 0.01
LM-M-2	Vendace	Mjøsa	<70	<70	<100	0.9	< LOD (1.3)	< LOD (1.4)	< 0.30	< 0.10	< 0.01	0.834	< 0.30	< 0.01
LM-M-3	Vendace	Mjøsa	<390	<358	<2023	2.1	68.958	5.300	< 1.0	< 0.5	< 0.02	4.319	< 0.6	< 0.02
LM-M-4	Vendace	Mjøsa	<70	<70	<100	1.1	30.453	< LOQ (3.0)	< 1.0	< 0.5	< 0.02	< 1.7	< 0.6	< 0.02
LM-M-5	Vendace	Mjøsa	<70	<70	<100	1.4	49.236	4.300	< 1.0	< 0.5	< 0.02	< 1.7	< 0.6	< 0.02
LM-M-6	Vendace	Mjøsa	<70	<70	<100	< LOQ (0.8)	< LOD (1.3)	< LOD (1.4)	< 1.0	< 0.5	< 0.02	< 1.7	< 0.6	< 0.02
LM-M-7	Vendace	Mjøsa	<70	<70	<100	1.3	31.933	< LOQ (3.0)	< 1.0	< 0.5	< 0.02	< 1.7	< 0.6	< 0.02
LM-M-8	Vendace	Mjøsa	<70	<70	<100	0.9	27.129	< LOQ (3.0)	< 1.0	< 0.5	< 0.02	< 1.7	< 0.6	< 0.02
LM-M-9	Vendace	Mjøsa	<70	<70	<100	1.4	39.297	3.700	< 0.30	< 0.10	< 0.01	0.198	< 0.30	< 0.01
LM-M-10	Vendace	Mjøsa	<70	<70	<100	1.7	35.280	< LOQ (3.0)	< 0.30	< 0.10	< 0.01	0.179	< 0.30	< 0.01
ØM-M-1	Brown trout	Mjøsa	<40	<40	<50	< LOD (2.6)	28.629	6.444	< 0.30	< 0.10	< 0.01	< 0.14	< 0.30	< 0.01
ØM-M-2	Brown trout	Mjøsa	<40	<40	<50	< LOD (2.6)	55.919	7.179	< 0.30	< 0.10	< 0.01	0.340	< 0.30	< 0.01
ØM-M-3	Brown trout	Mjøsa	<40	<40	<50	< LOD (2.6)	56.048	4.328	< 0.30	< 0.10	< 0.01	1.136	< 0.30	< 0.01
ØM-M-4	Brown trout	Mjøsa	<40	<40	<50	< LOD (2.6)	36.966	3.391	< 0.30	< 0.10	< 0.01	0.492	< 0.30	< 0.01
ØM-M-5	Brown trout	Mjøsa	<40	<40	<50	< LOD (2.6)	16.068	2.866	< 0.30	< 0.10	< 0.01	< 0.14	< 0.30	< 0.01
ØM-M-6	Brown trout	Mjøsa	<40	<40	<50	< LOQ (7.3)	106.965	7.463	< 1.0	< 0.05	< 0.01	1.650	< 0.15	< 0.02

ID	Matrix	Lake	TPP	DBPhP	TnBP	TDCPP	TBEP	TCP	EHDP	TXP	TEHP	TBA	BDE-17	BDE-28
			ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle
ZM-1	Zooplankton	Mjøsa	5.031	< 0.1	< 0.8	0.821	< 0.2	0.218	< 1.2	< 0.06	0.656	0.0179	0.0133	0.0113
ZM-2	Zooplankton	Mjøsa	0.884	< 0.1	< 0.8	< 0.2	< 0.2	0.423	< 1.2	< 0.06	0.754	0.0756	0.0375	0.0412
ZM-3	Zooplankton	Mjøsa												
MM-1	Mysis	Mjøsa	< 0.07	< 0.02	0.130	< 0.10	< 0.20	< 0.02	< 1.0	< 0.04	< 0.22	0.0054	0.0035	0.0041
MM-2	Mysis	Mjøsa	< 0.07	< 0.02	< 0.06	< 0.10	< 0.20	< 0.02	< 1.0	< 0.04	< 0.22	< 0.0051	0.0029	0.0042
MM-3	Mysis	Mjøsa	0.152	< 0.02	0.102	< 0.10	< 0.20	< 0.02	1.402	< 0.04	< 0.22			
KM-M-1	E. smelt	Mjøsa										< 0.0101	< 0.0033	0.0064
KM-M-2	E. smelt	Mjøsa										0.0041	0.0019	0.0039
KM-M-3	E. smelt	Mjøsa										0.0048	0.0021	0.0063
KM-M-4	E. smelt	Mjøsa										0.0041	0.0013	0.0051
KM-M-5	E. smelt	Mjøsa										0.0050	0.0020	0.0045
KM-M-6	E. smelt	Mjøsa	< 0.07	< 0.02	< 0.06	< 0.10	< 0.20	< 0.02	< 1.0	< 0.04	< 0.22	0.0077	0.0021	0.0106
KM-M-7	E. smelt	Mjøsa	< 0.07	< 0.02	< 0.06	< 0.10	< 0.20	< 0.02	< 1.0	< 0.04	< 0.22	0.0068	0.0019	0.0107
KM-M-8	E. smelt	Mjøsa	< 0.07	< 0.02	< 0.06	< 0.10	< 0.20	< 0.02	< 1.0	< 0.04	< 0.22	0.0073	0.0018	0.0065
KM-M-9	E. smelt	Mjøsa	< 0.07	< 0.02	< 0.06	< 0.10	< 0.20	< 0.02	< 1.0	0.067	< 0.22	0.0077	0.0021	0.0091
KM-M-10	E. smelt	Mjøsa	0.140	< 0.02	< 0.06	< 0.10	< 0.20	< 0.02	< 1.0	< 0.04	< 0.22	0.0132	0.0034	0.0168
LM-M-1	Vendace	Mjøsa	< 0.03	< 0.01	< 0.10	< 0.20	< 0.15	< 0.05	< 0.35	< 0.10	< 0.20	0.0058	0.0018	0.0047
LM-M-2	Vendace	Mjøsa	< 0.03	< 0.01	< 0.10	< 0.20	< 0.15	< 0.05	< 0.35	< 0.10	< 0.20	< 0.0051	0.0021	0.0039
LM-M-3	Vendace	Mjøsa	0.234	< 0.1	< 0.8	< 0.2	< 0.2	<0.03	< 1.2	< 0.06	<0.3	0.0093	0.0043	0.0124
LM-M-4	Vendace	Mjøsa	0.234	< 0.1	< 0.8	< 0.2	< 0.2	<0.03	< 1.2	< 0.06	<0.3	0.0117	0.0033	0.0124
LM-M-5	Vendace	Mjøsa	0.162	< 0.1	< 0.8	< 0.2	< 0.2	<0.03	< 1.2	< 0.06	<0.3	0.0073	0.0026	0.0126
LM-M-6	Vendace	Mjøsa	< 0.1	< 0.1	< 0.8	< 0.2	< 0.2	<0.03	< 1.2	< 0.06	<0.3	< 0.0051	< 0.0017	0.0041
LM-M-7	Vendace	Mjøsa	0.171	< 0.1	< 0.8	< 0.2	< 0.2	<0.03	< 1.2	< 0.06	<0.3	0.0053	0.0024	0.0125
LM-M-8	Vendace	Mjøsa	0.154	< 0.1	< 0.8	< 0.2	< 0.2	<0.03	< 1.2	< 0.06	<0.3	0.0060	0.0051	0.0122
LM-M-9	Vendace	Mjøsa	0.187	< 0.01	< 0.10	< 0.20	< 0.15	< 0.05	< 0.35	< 0.10	< 0.20	0.0104	0.0033	0.0161
LM-M-10	Vendace	Mjøsa	0.117	< 0.01	< 0.10	< 0.20	< 0.15	< 0.05	< 0.35	< 0.10	< 0.20	0.0053	< 0.0017	0.0096
ØM-M-1	Brown trout	Mjøsa	< 0.03	< 0.01	< 0.10	< 0.20	< 0.15	< 0.05	< 0.35	< 0.10	< 0.20	0.0043	0.0016	0.0178
ØM-M-2	Brown trout	Mjøsa	0.044	< 0.01	< 0.10	< 0.20	< 0.15	< 0.05	< 0.35	< 0.10	< 0.20	0.0025	0.0013	0.0172
ØM-M-3	Brown trout	Mjøsa	0.039	< 0.01	0.114	< 0.20	< 0.15	< 0.05	< 0.35	< 0.10	< 0.20	0.0026	0.0019	0.0244
ØM-M-4	Brown trout	Mjøsa	0.054	< 0.01	< 0.10	< 0.20	< 0.15	< 0.05	< 0.35	< 0.10	< 0.20	0.0062	0.0017	0.0196
ØM-M-5	Brown trout	Mjøsa	< 0.03	< 0.01	< 0.10	< 0.20	< 0.15	< 0.05	< 0.35	< 0.10	< 0.15	< 0.0020	0.0007	0.0077
ØM-M-6	Brown trout	Mjøsa	< 0.07	< 0.02	0.198	< 0.10	< 0.20	< 0.02	< 1.0	< 0.04	< 0.22	0.0109	0.0104	0.0402

ID	Matrix	Lake	BDE-47	BDE-49	BDE-66	BDE-71	BDE-77	BDE-85	BDE-99	BDE-100	BDE-119	BDE-126	BDE-138	BDE-153
			ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle
ZM-1	Zooplankton	Mjøsa	0.0923	< 0.0026	< 0.0093	< 0.0025	< 0.0017	< 0.0036	0.046	0.031	< 0.0029	< 0.0024	< 0.0113	< 0.0098
ZM-2	Zooplankton	Mjøsa	0.3360	< 0.0141	< 0.0149	< 0.0135	< 0.0092	< 0.0222	0.167	0.117	< 0.0182	< 0.0150	< 0.0529	< 0.0459
ZM-3	Zooplankton	Mjøsa												
MM-1	Mysis	Mjøsa	0.2000	0.0135	< 0.0093	< 0.0014	< 0.0009	< 0.0018	0.090	0.045	< 0.0015	< 0.0013	< 0.0030	0.0081
MM-2	Mysis	Mjøsa	0.2550	0.0203	< 0.0093	< 0.0016	< 0.0011	< 0.0029	0.116	0.056	< 0.0025	< 0.0020	< 0.0030	0.0078
MM-3	Mysis	Mjøsa												
KM-M-1	E. smelt	Mjøsa	0.2130	0.0176	< 0.0187	< 0.0015	< 0.0011	< 0.0023	0.040	0.040	0.00269	< 0.0016	< 0.0061	0.0104
KM-M-2	E. smelt	Mjøsa	0.3610	0.0287	< 0.0057	< 0.0005	< 0.0003	< 0.0019	0.043	0.083	< 0.0015	< 0.0013	< 0.0018	0.0152
KM-M-3	E. smelt	Mjøsa	0.5400	0.0391	< 0.0075	< 0.0008	< 0.0006	< 0.0034	0.043	0.120	< 0.0027	< 0.0024	< 0.0024	0.0217
KM-M-4	E. smelt	Mjøsa	0.3520	0.0274	< 0.0062	< 0.0006	< 0.0004	< 0.0015	0.047	0.070	< 0.0012	< 0.0010	< 0.0020	0.0137
KM-M-5	E. smelt	Mjøsa	0.3250	0.0235	< 0.0075	< 0.0006	< 0.0004	< 0.0015	0.045	0.064	< 0.0012	< 0.0010	< 0.0024	0.0149
KM-M-6	E. smelt	Mjøsa	1.7300	0.0806	0.0169	< 0.0006	< 0.0005	0.00214	0.079	0.403	< 0.0015	0.0014	< 0.0015	0.0669
KM-M-7	E. smelt	Mjøsa	1.7000	0.0799	0.0182	< 0.0005	< 0.0004	0.00195	0.056	0.235	< 0.0015	0.0013	< 0.0015	0.0628
KM-M-8	E. smelt	Mjøsa	0.9010	0.0498	0.0094	< 0.0004	< 0.0003	< 0.0011	0.047	0.204	< 0.0009	< 0.0007	< 0.0015	0.0398
KM-M-9	E. smelt	Mjøsa	1.3000	0.0655	0.0150	< 0.0006	0.0005	< 0.0014	0.071	0.307	< 0.0011	0.0009	< 0.0015	0.0581
KM-M-10	E. smelt	Mjøsa	1.9600	0.1140	0.0212	< 0.0004	< 0.0003	0.00184	0.090	0.412	< 0.0012	0.0013	< 0.0015	0.0609
LM-M-1	Vendace	Mjøsa	0.1380	0.0142	< 0.0093	< 0.0008	0.0009	< 0.0011	0.067	0.044	0.00215	< 0.0008	< 0.0030	0.0118
LM-M-2	Vendace	Mjøsa	0.0759	0.0067	< 0.0093	< 0.0008	< 0.0006	< 0.0011	0.050	0.020	< 0.0010	< 0.0008	< 0.0030	0.0060
LM-M-3	Vendace	Mjøsa	1.1800	0.1050	0.0407	< 0.0008	0.0034	< 0.0013	0.699	0.426	0.0185	0.0018	< 0.0030	0.0826
LM-M-4	Vendace	Mjøsa	1.0500	0.0838	0.0365	< 0.0008	0.0038	< 0.0011	0.579	0.285	0.0132	< 0.0008	< 0.0030	0.0565
LM-M-5	Vendace	Mjøsa	1.3000	0.1510	0.0466	0.0014	0.0028	< 0.0011	0.688	0.410	0.0159	0.0016	< 0.0030	0.0764
LM-M-6	Vendace	Mjøsa	0.0689	0.0055	< 0.0093	< 0.0008	< 0.0006	< 0.0011	0.040	0.013	< 0.0010	< 0.0008	< 0.0030	0.0053
LM-M-7	Vendace	Mjøsa	1.0500	0.0959	0.0378	< 0.0008	0.0028	< 0.0011	0.574	0.321	0.0134	0.0014	< 0.0030	0.0620
LM-M-8	Vendace	Mjøsa	0.9530	0.1100	0.0405	< 0.0008	0.0055	0.00623	0.502	0.294	0.0163	0.0068	0.0109	0.0658
LM-M-9	Vendace	Mjøsa	1.6900	0.1480	0.0593	< 0.0018	0.0055	< 0.0011	1.060	0.547	0.0233	0.0029	< 0.0030	0.1100
LM-M-10	Vendace	Mjøsa	0.8700	0.0895	0.0327	< 0.0008	0.0028	< 0.0011	0.523	0.295	0.0129	0.0014	< 0.0030	0.0660
ØM-M-1	Brown trout	Mjøsa	2.8900	0.1580	0.0711	< 0.0003	0.0031	< 0.0007	0.672	0.869	0.0213	0.0012	< 0.0012	0.1480
ØM-M-2	Brown trout	Mjøsa	4.2800	0.1580	0.0927	< 0.0005	0.0027	< 0.0008	0.889	1.430	0.0282	0.0014	< 0.0012	0.2430
ØM-M-3	Brown trout	Mjøsa	4.1700	0.2460	0.1080	< 0.0008	0.0046	< 0.0010	1.430	1.330	0.0315	0.0017	< 0.0012	0.2360
ØM-M-4	Brown trout	Mjøsa	3.1700	0.1820	0.0767	< 0.0007	0.0031	< 0.0013	0.733	0.934	0.0195	0.0012	< 0.0012	0.1570
ØM-M-5	Brown trout	Mjøsa	2.0900	0.0820	0.0548	< 0.0004	0.0011	< 0.0006	0.651	0.844	0.0292	0.0010	< 0.0012	0.1320
ØM-M-6	Brown trout	Mjøsa	8.3600	0.4730	0.2050	< 0.0009	0.0087	< 0.0014	2.480	3.150	0.0813	0.0022	< 0.0012	0.4660

ID	Matrix	Lake	BDE-154	BDE-156	BDE-183	BDE-184	BDE-191	BDE-196	BDE-197	BDE-202	BDE-206	BDE-207	BDE-209	ATE (TBP-AE)
			ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle
ZM-1	Zooplankton	Mjøsa	0.0145	< 0.0168	< 0.0038	< 0.0031	< 0.0058	< 0.0080	< 0.0065	< 0.0099	< 0.0102	< 0.0064	0.437	< 0.0154
ZM-2	Zooplankton	Mjøsa	0.0639	< 0.0788	< 0.0171	< 0.0137	< 0.0262	< 0.0352	< 0.0288	< 0.0434	< 0.0574	< 0.0523	< 0.0697	< 0.0154
ZM-3	Zooplankton	Mjøsa												
MM-1	Mysis	Mjøsa	0.0168	< 0.0044	< 0.0023	< 0.0014	< 0.0027	< 0.0045	< 0.0036	< 0.0052	0.0112	< 0.00524	0.111	< 0.0154
MM-2	Mysis	Mjøsa	0.0201	< 0.0044	< 0.0023	< 0.0014	< 0.0027	< 0.0045	< 0.0036	< 0.0052	< 0.0102	< 0.00524	0.117	< 0.0154
MM-3	Mysis	Mjøsa												
KM-M-1	E. smelt	Mjøsa	0.0164	< 0.0089	< 0.0045	< 0.0028	< 0.0055	< 0.0091	< 0.0073	< 0.0105	< 0.0204	< 0.0105	< 0.1340	< 0.0310
KM-M-2	E. smelt	Mjøsa	0.0366	< 0.0027	0.0015	< 0.0008	< 0.0017	< 0.0027	< 0.0022	< 0.0032	< 0.0062	0.00322	0.0422	< 0.0094
KM-M-3	E. smelt	Mjøsa	0.0506	< 0.0036	< 0.0018	< 0.0011	< 0.0022	< 0.0036	< 0.0029	< 0.0042	< 0.0082	< 0.0042	< 0.0536	< 0.0124
KM-M-4	E. smelt	Mjøsa	0.0294	< 0.0030	0.0017	< 0.00092	< 0.0018	< 0.0030	< 0.0024	< 0.0035	< 0.0068	< 0.0035	0.0466	< 0.0103
KM-M-5	E. smelt	Mjøsa	0.0292	< 0.0036	< 0.0018	< 0.0011	< 0.0022	< 0.0036	< 0.0029	< 0.0042	0.00858	0.00509	0.0616	< 0.0124
KM-M-6	E. smelt	Mjøsa	0.1700	< 0.0022	0.0012	< 0.0007	< 0.0014	< 0.0023	< 0.0018	0.00297	< 0.0051	< 0.0026	< 0.0335	< 0.0077
KM-M-7	E. smelt	Mjøsa	0.1570	< 0.0022	< 0.0011	< 0.0007	< 0.0014	< 0.0023	< 0.0018	< 0.0026	< 0.0051	< 0.0026	< 0.0335	< 0.0077
KM-M-8	E. smelt	Mjøsa	0.1010	< 0.0022	< 0.0011	< 0.0007	< 0.0014	< 0.0022	< 0.0018	< 0.0026	< 0.0050	< 0.0026	< 0.0327	< 0.0076
KM-M-9	E. smelt	Mjøsa	0.1310	< 0.0022	< 0.0011	< 0.0007	< 0.0014	< 0.0023	< 0.0018	< 0.0026	< 0.0051	< 0.0026	< 0.0335	< 0.0077
KM-M-10	E. smelt	Mjøsa	0.1570	< 0.0022	0.0014	< 0.0007	< 0.0014	< 0.0023	< 0.0018	0.00268	0.00589	0.00313	0.0443	< 0.0077
LM-M-1	Vendace	Mjøsa	0.0181	< 0.0044	< 0.0023	< 0.0014	< 0.0027	< 0.0045	< 0.0036	< 0.0052	0.0212	0.0187	0.228	< 0.0155
LM-M-2	Vendace	Mjøsa	0.0084	< 0.0044	0.0024	< 0.0014	< 0.0027	< 0.0045	< 0.0036	< 0.0052	< 0.0102	< 0.0052	< 0.0670	< 0.0155
LM-M-3	Vendace	Mjøsa	0.1530	< 0.0044	0.0054	0.0020	< 0.0027	< 0.0045	< 0.0036	< 0.0052	< 0.0102	< 0.0052	< 0.0670	< 0.0155
LM-M-4	Vendace	Mjøsa	0.1010	< 0.0044	< 0.0023	0.0034	< 0.0027	< 0.0045	< 0.0036	< 0.0052	< 0.0102	< 0.0052	0.123	< 0.0155
LM-M-5	Vendace	Mjøsa	0.1510	< 0.0044	0.0049	0.0035	< 0.0027	< 0.0045	< 0.0036	< 0.0052	< 0.0102	< 0.0052	0.122	< 0.0155
LM-M-6	Vendace	Mjøsa	0.0074	< 0.0044	< 0.0023	< 0.0014	< 0.0027	< 0.0045	< 0.0036	< 0.0052	< 0.0102	< 0.0052	< 0.0670	< 0.0155
LM-M-7	Vendace	Mjøsa	0.1100	< 0.0044	0.0051	0.0027	< 0.0027	< 0.0045	< 0.0036	< 0.0052	< 0.0102	< 0.0052	< 0.0670	< 0.0155
LM-M-8	Vendace	Mjøsa	0.1060	0.0082	0.0166	0.0146	0.0116	0.0159	0.0157	0.0421	0.0323	0.0362	< 0.0670	< 0.0155
LM-M-9	Vendace	Mjøsa	0.2030	< 0.0044	0.0085	0.0069	< 0.0027	< 0.0045	< 0.0036	< 0.0052	< 0.0102	< 0.0052	0.0903	< 0.0155
LM-M-10	Vendace	Mjøsa	0.1160	< 0.0044	0.0048	0.0041	< 0.0027	< 0.0045	< 0.0036	< 0.0052	< 0.0102	< 0.0052	< 0.0670	< 0.0155
ØM-M-1	Brown trout	Mjøsa	0.3360	< 0.0018	0.0036	0.0031	< 0.0011	< 0.0018	< 0.0014	0.0046	< 0.0041	< 0.0021	0.0356	< 0.0062
ØM-M-2	Brown trout	Mjøsa	0.5330	< 0.0018	0.0144	0.0045	< 0.0011	< 0.0018	0.00276	0.00802	< 0.0041	< 0.0021	< 0.0268	< 0.0062
ØM-M-3	Brown trout	Mjøsa	0.5010	< 0.0018	0.0078	0.0091	< 0.0011	< 0.0018	0.00345	0.0098	0.00485	0.00269	0.0533	< 0.0062
ØM-M-4	Brown trout	Mjøsa	0.3680	< 0.0018	0.0041	0.0038	< 0.0011	< 0.0018	< 0.0014	0.0061	0.0056	0.00272	0.0526	< 0.0062
ØM-M-5	Brown trout	Mjøsa	0.2730	< 0.0018	0.0023	0.0044	< 0.0011	< 0.0018	< 0.0014	0.00651	< 0.0041	< 0.0021	0.0321	< 0.0062
ØM-M-6	Brown trout	Mjøsa	0.9720	< 0.0018	0.0081	0.0137	< 0.0013	0.00461	0.00758	0.0142	< 0.0041	< 0.0021	0.0378	< 0.0062

ID	Matrix	Lake	a-TBECH	b-TBECH	g/d-TBECH	BATE	PBT	PBEB	PBBZ	HBB	DPTE	EHTBB	BTBPE	TBPH (BEH /TBP)
			ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle
ZM-1	Zooplankton	Mjøsa	< 0.0379	< 0.0267	< 0.0118	< 0.0050	< 0.0254	< 0.0343	0.0104	< 0.0286	< 0.00474	0.0645	< 0.0435	< 0.3120
ZM-2	Zooplankton	Mjøsa	< 0.0379	< 0.0267	< 0.0118	< 0.0050	< 0.0254	< 0.0343	0.00979	< 0.0286	< 0.00474	< 0.0138	< 0.0137	< 0.0386
ZM-3	Zooplankton	Mjøsa												
MM-1	Mysis	Mjøsa	< 0.0379	< 0.0267	< 0.0118	< 0.0050	< 0.0254	< 0.0343	0.0066	< 0.0286	< 0.00474	< 0.0138	0.0286	< 0.0386
MM-2	Mysis	Mjøsa	< 0.0379	< 0.0267	< 0.0118	< 0.0050	< 0.0254	< 0.0343	0.00819	< 0.0286	< 0.00474	< 0.0138	0.037	< 0.0386
MM-3	Mysis	Mjøsa												
KM-M-1	E. smelt	Mjøsa	< 0.0758	< 0.0534	< 0.0235	< 0.0100	< 0.0509	< 0.0686	0.0258	< 0.0573	< 0.0095	< 0.0275	0.065	< 0.0772
KM-M-2	E. smelt	Mjøsa	< 0.0230	< 0.0162	< 0.0071	< 0.0030	< 0.0154	< 0.0208	0.00732	< 0.0174	< 0.0029	< 0.0083	0.0264	< 0.0234
KM-M-3	E. smelt	Mjøsa	< 0.0303	< 0.0214	< 0.0094	< 0.0040	< 0.0203	< 0.0275	0.00689	< 0.0229	< 0.0038	< 0.0110	0.0281	< 0.0309
KM-M-4	E. smelt	Mjøsa	< 0.0253	< 0.0178	< 0.0078	< 0.0033	< 0.0170	< 0.0229	0.00765	< 0.0191	< 0.0032	< 0.0092	0.0279	0.0773
KM-M-5	E. smelt	Mjøsa	< 0.0303	< 0.0214	< 0.0094	< 0.0040	< 0.0203	< 0.0275	0.0096	< 0.0229	< 0.0038	< 0.0110	0.0266	0.0337
KM-M-6	E. smelt	Mjøsa	< 0.0190	< 0.0134	< 0.0059	< 0.0025	< 0.0127	< 0.0172	0.00455	< 0.0143	< 0.0024	< 0.0069	0.0181	0.0223
KM-M-7	E. smelt	Mjøsa	< 0.0190	< 0.0134	< 0.0059	< 0.0025	< 0.0127	< 0.0172	0.00534	< 0.0143	< 0.0024	< 0.0069	0.0186	0.0344
KM-M-8	E. smelt	Mjøsa	< 0.0185	< 0.0130	< 0.0057	< 0.0025	< 0.0124	< 0.0167	0.00496	< 0.0140	< 0.0024	< 0.0067	0.0167	< 0.0188
KM-M-9	E. smelt	Mjøsa	< 0.0190	< 0.0134	< 0.0059	< 0.0025	< 0.0127	< 0.0172	0.0054	< 0.0143	< 0.0024	< 0.0069	0.0185	< 0.0193
KM-M-10	E. smelt	Mjøsa	< 0.0190	< 0.0134	< 0.0059	< 0.0025	< 0.0127	< 0.0172	0.00505	< 0.0143	< 0.0024	< 0.0069	0.0212	< 0.0193
LM-M-1	Vendace	Mjøsa	< 0.0379	< 0.0267	< 0.0118	< 0.0050	< 0.0254	< 0.0343	0.0241	< 0.0286	< 0.00474	< 0.0138	0.0609	< 0.0386
LM-M-2	Vendace	Mjøsa	< 0.0379	< 0.0267	< 0.0118	0.00506	< 0.0254	< 0.0343	0.0165	< 0.0286	< 0.00474	< 0.0138	0.0495	< 0.0386
LM-M-3	Vendace	Mjøsa	< 0.0379	< 0.0267	< 0.0118	< 0.0050	< 0.0254	< 0.0343	0.0146	< 0.0286	< 0.00474	< 0.0138	0.0547	< 0.0386
LM-M-4	Vendace	Mjøsa	< 0.0379	< 0.0267	< 0.0118	0.00541	< 0.0254	< 0.0343	0.017	< 0.0286	< 0.00474	< 0.0138	0.0589	< 0.0386
LM-M-5	Vendace	Mjøsa	< 0.0379	< 0.0267	< 0.0118	< 0.0050	< 0.0254	< 0.0343	0.0155	< 0.0286	< 0.00474	< 0.0138	0.0495	< 0.0386
LM-M-6	Vendace	Mjøsa	< 0.0379	< 0.0267	< 0.0118	< 0.0050	< 0.0254	< 0.0343	0.0171	< 0.0286	< 0.00474	< 0.0138	0.0574	< 0.0386
LM-M-7	Vendace	Mjøsa	< 0.0379	< 0.0267	< 0.0118	< 0.0050	< 0.0254	< 0.0343	0.0137	< 0.0286	< 0.00474	< 0.0138	0.0571	< 0.0386
LM-M-8	Vendace	Mjøsa	< 0.0379	< 0.0267	< 0.0118	< 0.0050	< 0.0254	< 0.0343	0.0149	< 0.0286	< 0.00474	< 0.0138	0.0529	< 0.0386
LM-M-9	Vendace	Mjøsa	< 0.0379	< 0.0267	< 0.0118	0.009	< 0.0254	< 0.0343	0.0193	< 0.0286	< 0.00474	< 0.0138	0.0596	< 0.0386
LM-M-10	Vendace	Mjøsa	< 0.0379	< 0.0267	< 0.0118	< 0.0050	< 0.0254	< 0.0343	0.0166	< 0.0286	< 0.00474	< 0.0138	0.0549	< 0.0386
ØM-M-1	Brown trout	Mjøsa	< 0.0152	< 0.0107	< 0.0047	< 0.0020	< 0.0102	< 0.0137	0.00228	< 0.0115	< 0.0019	< 0.0055	0.0163	< 0.0154
ØM-M-2	Brown trout	Mjøsa	< 0.0152	< 0.0107	< 0.0047	< 0.0020	< 0.0102	< 0.0137	0.00276	< 0.0115	< 0.0019	< 0.0055	0.0152	< 0.0154
ØM-M-3	Brown trout	Mjøsa	< 0.0152	< 0.0107	< 0.0047	< 0.0020	< 0.0102	< 0.0137	0.00352	< 0.0115	< 0.0019	< 0.0055	0.0198	< 0.0154
ØM-M-4	Brown trout	Mjøsa	< 0.0152	< 0.0107	< 0.0047	< 0.0020	< 0.0102	< 0.0137	0.00309	< 0.0115	< 0.0019	< 0.0055	0.0174	< 0.0154
ØM-M-5	Brown trout	Mjøsa	< 0.0152	< 0.0107	< 0.0047	< 0.0020	< 0.0102	< 0.0137	0.0025	< 0.0115	< 0.0019	< 0.0055	0.0127	< 0.0154
ØM-M-6	Brown trout	Mjøsa	< 0.0152	< 0.0107	< 0.0047	< 0.0020	< 0.0102	< 0.0137	0.00452	0.013	< 0.0019	< 0.0064	0.0184	< 0.0239

ID	Matrix	Lake	DBDPE	Lipid	BP3	EHMC-Z	EHMC-E	OC	Hg	d13C	d15N	d32S	W% C	PFPA	PFHxA	PFHpA
			ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	µg/g muscle	‰	‰	‰		ng/g liver	ng/g liver	ng/g liver
ZM-1	Zooplankton	Mjøsa	6.33	9					<0.005	-31.8977	13.3226	2.3232	53.1785	<0.5	<0.5	<0.5
ZM-2	Zooplankton	Mjøsa	3.22	3.4					<0.005	-31.9228	13.2136	2.2538	52.9969	<0.5	<0.5	<0.5
ZM-3	Zooplankton	Mjøsa			0.4433	<1	<1.5	3.7351	<0.005	-31.5432	12.9226	2.3493	50.9741	<0.5	<0.5	<0.5
MM-1	Mysis	Mjøsa	3.15	2.9					0.015	-28.8292	10.7362	2.8719	50.5433	<0.5	<0.5	<0.5
MM-2	Mysis	Mjøsa	< 2.86	3.6					0.018	-28.7115	11.3012	2.8050	48.9634	<0.5	<0.5	<0.5
MM-3	Mysis	Mjøsa			<0.3	<1	<1.5	<3.5	0.021	-30.0349	10.6716	2.6957	52.4608	<0.5	<0.5	<0.5
KM-M-1	E. smelt	Mjøsa	< 5.71	0.77	2.0322	<1	<1.5	4.0067	0.045	-28.1508	13.9886	2.6789	51.1283	<0.5	<0.5	<0.5
KM-M-2	E. smelt	Mjøsa	3.63	0.35	0.3735	<1	<1.5	<3.5	0.05	-27.6906	13.5039	2.6638	50.7550	<0.5	<0.5	<0.5
KM-M-3	E. smelt	Mjøsa	< 2.29	0.49	0.4042	<1	<1.5	<3.5	0.057	-28.1172	13.3189	2.6058	50.2941	<0.5	<0.5	<0.5
KM-M-4	E. smelt	Mjøsa	< 1.90	0.23	0.3079	<1	<1.5	<3.5	0.044	-28.3538	13.6956	2.2615	48.5058	<0.5	<0.5	<0.5
KM-M-5	E. smelt	Mjøsa	3.88	0.72	1.1372	<1	<1.5	<3.5	0.052	-28.9242	14.2181	2.2450	51.7757	<0.5	<0.5	<0.5
KM-M-6	E. smelt	Mjøsa	< 1.43	0.92	<0.3	<1	<1.5	<3.5	0.51	26.7306	15.1291	2.8649	50.0211	<0.5	<0.5	<0.5
KM-M-7	E. smelt	Mjøsa	< 1.43	0.93	0.4704	<1	<1.5	<3.5	0.47	-27.2023	14.7375	2.9430	50.3410	<0.5	<0.5	<0.5
KM-M-8	E. smelt	Mjøsa	< 1.39	1.18	0.4353	<1	<1.5	<3.5	0.14	-27.8424	15.2549	2.7213	45.4467	<0.5	<0.5	<0.5
KM-M-9	E. smelt	Mjøsa	< 1.43	0.66	<0.3	<1	<1.5	<3.5	0.31	-27.0945	15.1406	3.5010	49.6754	<0.5	<0.5	<0.5
KM-M-10	E. smelt	Mjøsa	2.8	2.14	<0.3	<1	<1.5	<3.5	0.34	-27.9570	15.3942	2.6561	51.1972	<0.5	<0.5	<0.5
LM-M-1	Vendace	Mjøsa	< 2.86	2.9	<4	<0.5	<1	<6	0.086	-28.1385	11.4242	2.1790	50.9719	<0.5	<0.5	<0.5
LM-M-2	Vendace	Mjøsa	< 2.86	1.2	<4	<0.5	<1	<6	0.071	-28.2078	11.4162	1.9539	51.7182	<0.5	<0.5	<0.5
LM-M-3	Vendace	Mjøsa	< 2.86	3.1	<4	<0.5	<1	7.3241	0.091	-29.5887	14.3024	2.4313	50.3946	<0.5	<0.5	<0.5
LM-M-4	Vendace	Mjøsa	< 2.86	4.92	<4	<0.5	<1	<6	0.05	-31.0653	14.1294	2.3790	54.4376	<0.5	<0.5	<0.5
LM-M-5	Vendace	Mjøsa	< 2.86	4.1	<4	<0.5	<1	<6	0.064	-29.0465	14.1572	2.4708	50.6191	<0.5	<0.5	<0.5
LM-M-6	Vendace	Mjøsa	< 2.86	1.27	<4	<0.5	<1	<6	0.019	-27.0024	11.6036	2.4465	51.2112	<0.5	<0.5	<0.5
LM-M-7	Vendace	Mjøsa	< 2.86	4.4	<4	0.66	2.2	<6	0.085	-29.9489	14.0377	2.4213	50.7273	<0.5	<0.5	<0.5
LM-M-8	Vendace	Mjøsa	< 2.86	2.48	<4	<0.5	<1	<6	0.051	-30.0496	14.3645	2.6261	52.7076	<0.5	<0.5	<0.5
LM-M-9	Vendace	Mjøsa	< 2.86	4.5	<4	<0.5	<1	<6	0.096	-30.2616	14.1321	2.5379	51.4681	<0.5	<0.5	<0.5
LM-M-10	Vendace	Mjøsa	3.3	1.9	<4	<0.5	<1	<6	0.054	-30.5729	13.7434	2.5872	52.7176	<0.5	<0.5	<0.5
ØM-M-1	Brown trout	Mjøsa	1.43	2.86	<0.2	<0.1	<0.1	<3	0.346	-28.4693	15.5663	2.7606	56.0473	<0.5	<0.5	<0.5
ØM-M-2	Brown trout	Mjøsa	< 1.14	1.86	<0.2	<0.1	<0.1	<3	0.915	-28.8088	16.1719	2.8638	53.0238	<0.5	<0.5	<0.5
ØM-M-3	Brown trout	Mjøsa	2.53	2.57	<0.2	<0.1	<0.1	<3	0.364	-29.5034	16.1111	2.4493	55.0950	<0.5	<0.5	<0.5
ØM-M-4	Brown trout	Mjøsa	3.43	3.73	<0.2	<0.1	<0.1	<3	0.409	-29.0632	15.5777	2.8743	54.7531	<0.5	<0.5	<0.5
ØM-M-5	Brown trout	Mjøsa	1.17	0.26	<0.2	<0.1	<0.1	<3	0.382	-27.2469	15.3368	3.2709	49.4025	<0.5	<0.5	<0.5
ØM-M-6	Brown trout	Mjøsa	< 1.14	4.1	<0.2	<0.1	<0.1	<3	0.594	-29.5772	15.9984	3.2376	55.0190	<0.5	<0.5	<0.5

ID	Matrix	Lake	PFOA	PFNA	PFDA	PFUnDA	PFDoDA	PFTrDA	PFTeDA	PFPeDA	PFHxDA	PFBS	PFPS	PFHxS	PFHpS	PFOS	8Cl-PFOS	PFNS
			ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver
ZM-1	Zooplankton	Mjøsa	<0.5	<0.5	<0.5	<0.4	<0.4	<0.4	<0.4	<0.5	<0.5	<0.2	<0.2	<0.1	<0.1	<0.05	<0.2	<0.1
ZM-2	Zooplankton	Mjøsa	<0.5	<0.5	<0.5	<0.4	<0.4	<0.4	<0.4	<0.5	<0.5	<0.2	<0.2	<0.1	<0.1	<0.05	<0.2	<0.1
ZM-3	Zooplankton	Mjøsa	<0.5	<0.5	<0.5	<0.4	<0.4	<0.4	<0.4	<0.5	<0.5	<0.2	<0.2	<0.1	<0.1	<0.05	<0.2	<0.1
MM-1	Mysis	Mjøsa	<0.5	<0.5	<0.5	<0.4	<0.4	<0.4	<0.4	<0.5	<0.5	<0.2	<0.2	<0.1	<0.1	<0.05	<0.2	<0.1
MM-2	Mysis	Mjøsa	<0.5	<0.5	<0.5	<0.4	<0.4	<0.4	<0.4	<0.5	<0.5	<0.2	<0.2	<0.1	<0.1	0.0862	<0.2	<0.1
MM-3	Mysis	Mjøsa	<0.5	<0.5	<0.5	<0.4	<0.4	<0.4	<0.4	<0.5	<0.5	<0.2	<0.2	<0.1	<0.1	0.0762	<0.2	<0.1
KM-M-1	E. smelt	Mjøsa	<0.5	<0.5	0.8086	<0.4	<0.4	<0.4	<0.4	<0.5	<0.5	<0.2	<0.2	<0.1	<0.1	0.5276	<0.2	<0.1
KM-M-2	E. smelt	Mjøsa	<0.5	<0.5	0.6164	1.8053	1.4972	1.0375	<0.4	<0.5	<0.5	<0.2	<0.2	<0.1	<0.1	1.0305	<0.2	<0.1
KM-M-3	E. smelt	Mjøsa	<0.5	0.6491	0.5078	1.9112	1.5649	1.8107	<0.4	<0.5	<0.5	<0.2	<0.2	<0.1	<0.1	1.3562	<0.2	<0.1
KM-M-4	E. smelt	Mjøsa	<0.5	0.5099	<0.5	0.7721	0.7075	<0.4	<0.4	<0.5	<0.5	<0.2	<0.2	<0.1	<0.1	0.6911	<0.2	<0.1
KM-M-5	E. smelt	Mjøsa	<0.5	<0.5	<0.5	0.7724	0.4571	<0.4	<0.4	<0.5	<0.5	<0.2	<0.2	<0.1	<0.1	0.4732	<0.2	<0.1
KM-M-6	E. smelt	Mjøsa	<0.5	1.0159	4.8439	11.4767	7.8698	9.2111	3.3706	1.1767	<0.5	<0.2	<0.2	<0.1	<0.1	8.3072	<0.2	<0.1
KM-M-7	E. smelt	Mjøsa	<0.5	0.9385	4.6018	12.7060	7.8117	7.6762	2.7371	0.9062	<0.5	<0.2	<0.2	<0.1	<0.1	8.1489	<0.2	<0.1
KM-M-8	E. smelt	Mjøsa	<0.5	0.8946	2.4808	7.2041	4.4972	4.4452	1.3589	0.3224	<0.5	<0.2	<0.2	<0.1	<0.1	4.6869	<0.2	<0.1
KM-M-9	E. smelt	Mjøsa	<0.5	0.7601	2.4872	6.2824	4.3695	5.1881	1.7108	0.6517	<0.5	<0.2	<0.2	<0.1	<0.1	3.6211	<0.2	<0.1
KM-M-10	E. smelt	Mjøsa	<0.5	1.0482	3.9765	11.5557	7.5842	7.5199	2.5686	1.0397	<0.5	<0.2	<0.2	<0.1	<0.1	7.3435	<0.2	<0.1
LM-M-1	Vendace	Mjøsa	<0.5	1.1772	<0.5	0.6486	0.5282	0.5550	<0.4	<0.5	<0.5	<0.2	<0.2	<0.1	<0.1	3.8006	<0.2	<0.1
LM-M-2	Vendace	Mjøsa	<0.5	0.8928	0.9765	1.3861	1.3160	1.3696	0.4922	<0.5	<0.5	<0.2	<0.2	<0.1	<0.1	5.7542	<0.2	<0.1
LM-M-3	Vendace	Mjøsa	<0.5	<0.5	<0.5	<0.4	<0.4	<0.4	<0.4	<0.5	<0.5	<0.2	<0.2	<0.1	<0.1	0.4052	<0.2	<0.1
LM-M-4	Vendace	Mjøsa	<0.5	<0.5	<0.5	0.5615	<0.4	<0.4	<0.4	<0.5	<0.5	<0.2	<0.2	<0.1	<0.1	0.8847	<0.2	<0.1
LM-M-5	Vendace	Mjøsa	<0.5	<0.5	<0.5	<0.4	<0.4	<0.4	<0.4	<0.5	<0.5	<0.2	<0.2	<0.1	<0.1	0.5482	<0.2	<0.1
LM-M-6	Vendace	Mjøsa	<0.5	0.5290	<0.5	<0.4	0.9991	<0.4	<0.4	<0.5	<0.5	<0.2	<0.2	<0.1	<0.1	3.7187	<0.2	<0.1
LM-M-7	Vendace	Mjøsa	<0.5	<0.5	<0.5	<0.4	0.6858	<0.4	<0.4	<0.5	<0.5	<0.2	<0.2	<0.1	<0.1	0.3079	<0.2	<0.1
LM-M-8	Vendace	Mjøsa	<0.5	<0.5	<0.5	0.5709	0.6285	0.5338	<0.4	<0.5	<0.5	<0.2	<0.2	<0.1	<0.1	0.9921	<0.2	<0.1
LM-M-9	Vendace	Mjøsa	<0.5	<0.5	<0.5	0.6521	0.5533	<0.4	<0.4	<0.5	<0.5	<0.2	<0.2	<0.1	<0.1	0.6901	<0.2	<0.1
LM-M-10	Vendace	Mjøsa	<0.5	<0.5	<0.5	<0.4	<0.4	<0.4	<0.4	<0.5	<0.5	<0.2	<0.2	<0.1	<0.1	0.7634	<0.2	<0.1
ØM-M-1	Brown trout	Mjøsa	<0.5	0.7552	7.4927	22.1910	12.1025	15.1763	5.3720	2.5582	<0.5	<0.2	<0.2	<0.1	<0.1	18.8033	<0.2	<0.1
ØM-M-2	Brown trout	Mjøsa	<0.5	<0.5	3.1599	9.0193	6.1558	7.0650	2.4057	1.1967	<0.5	<0.2	<0.2	<0.1	<0.1	7.8480	<0.2	<0.1
ØM-M-3	Brown trout	Mjøsa	<0.5	<0.5	2.8647	6.2869	3.9472	3.8253	1.3738	0.9577	<0.5	<0.2	<0.2	<0.1	<0.1	6.1568	<0.2	<0.1
ØM-M-4	Brown trout	Mjøsa	<0.5	0.6567	6.0104	16.2842	9.6017	17.8303	4.2909	1.4366	<0.5	<0.2	<0.2	<0.1	<0.1	12.3532	<0.2	<0.1
ØM-M-5	Brown trout	Mjøsa	<0.5	<0.5	3.1055	6.6486	4.6787	4.8897	1.8182	1.0200	<0.5	<0.2	<0.2	<0.1	<0.1	6.4476	<0.2	<0.1
ØM-M-6	Brown trout	Mjøsa	<0.5	<0.5	5.3036	15.2288	9.6300	24.3902	4.3990	2.0820	<0.5	<0.2	<0.2	<0.1	<0.1	13.2423	<0.2	<0.1

ID	Matrix	Lake	PFDS	PFDoS	PFOSA	N-MeFOSA	N-EtFOSA	N-MeFOSE	N-EtFOSE	4:2 FTS	6:2 FTS	8:2 FTS	10:2 FTS	4:2 F53B	6:2 F53B	N-MeFOSAA	N-EtFOSAA
			ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver
ZM-1	Zooplankton	Mjøsa	<0.1	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ZM-2	Zooplankton	Mjøsa	<0.1	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ZM-3	Zooplankton	Mjøsa	<0.1	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
MM-1	Mysis	Mjøsa	<0.1	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
MM-2	Mysis	Mjøsa	<0.1	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
MM-3	Mysis	Mjøsa	<0.1	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
KM-M-1	E. smelt	Mjøsa	<0.1	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
KM-M-2	E. smelt	Mjøsa	<0.1	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
KM-M-3	E. smelt	Mjøsa	<0.1	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
KM-M-4	E. smelt	Mjøsa	<0.1	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
KM-M-5	E. smelt	Mjøsa	<0.1	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
KM-M-6	E. smelt	Mjøsa	<0.1	<0.2	0.7038	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
KM-M-7	E. smelt	Mjøsa	<0.1	<0.2	0.7848	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
KM-M-8	E. smelt	Mjøsa	<0.1	<0.2	0.5112	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
KM-M-9	E. smelt	Mjøsa	<0.1	<0.2	0.4224	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
KM-M-10	E. smelt	Mjøsa	<0.1	<0.2	0.4635	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
LM-M-1	Vendace	Mjøsa	0.1327	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
LM-M-2	Vendace	Mjøsa	<0.1	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
LM-M-3	Vendace	Mjøsa	0.1490	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
LM-M-4	Vendace	Mjøsa	<0.1	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
LM-M-5	Vendace	Mjøsa	<0.1	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
LM-M-6	Vendace	Mjøsa	<0.1	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
LM-M-7	Vendace	Mjøsa	0.3082	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
LM-M-8	Vendace	Mjøsa	<0.1	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
LM-M-9	Vendace	Mjøsa	0.1066	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
LM-M-10	Vendace	Mjøsa	0.1827	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-1	Brown trout	Mjøsa	<0.1	<0.2	0.8775	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-2	Brown trout	Mjøsa	<0.1	<0.2	1.3663	<0.3	<0.3	<5	<5	<0.3	0.58	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-3	Brown trout	Mjøsa	<0.1	<0.2	0.8622	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-4	Brown trout	Mjøsa	<0.1	<0.2	0.9349	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-5	Brown trout	Mjøsa	<0.1	<0.2	0.5495	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-6	Brown trout	Mjøsa	<0.1	<0.2	0.7683	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3

ID	Matrix	Lake	F53	7:3 FTCA	PFBSA	N-MeFBSA	N-EtFBSA
			ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver
ZM-1	Zooplankton	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
ZM-2	Zooplankton	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
ZM-3	Zooplankton	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
MM-1	Mysis	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
MM-2	Mysis	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
MM-3	Mysis	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
KM-M-1	E. smelt	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
KM-M-2	E. smelt	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
KM-M-3	E. smelt	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
KM-M-4	E. smelt	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
KM-M-5	E. smelt	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
KM-M-6	E. smelt	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
KM-M-7	E. smelt	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
KM-M-8	E. smelt	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
KM-M-9	E. smelt	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
KM-M-10	E. smelt	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
LM-M-1	Vendace	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
LM-M-2	Vendace	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
LM-M-3	Vendace	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
LM-M-4	Vendace	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
LM-M-5	Vendace	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
LM-M-6	Vendace	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
LM-M-7	Vendace	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
LM-M-8	Vendace	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
LM-M-9	Vendace	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
LM-M-10	Vendace	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
ØM-M-1	Brown trout	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
ØM-M-2	Brown trout	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
ØM-M-3	Brown trout	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
ØM-M-4	Brown trout	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
ØM-M-5	Brown trout	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
ØM-M-6	Brown trout	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2

ID	Matrix	Lake	Length	Weight	4,4-Bis-A	2,4-Bis-A	Bis-G	4,4-Bis-S	2,4-Bis-S	4,4-Bis-F	2,4-Bis-F	2,2-Bis-F	Bis-P	Bis-Z	TBBPA
			cm	g	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle
ØM-M-7	Brown trout	Mjøsa	65	2768	<11	<5	<8	<5	<10	<5	<10	<5	<10	<10	<220
ØM-M-8	Brown trout	Mjøsa	67	2838	12.8	<5	<8	<5	<10	<5	<10	<5	<10	<10	<220
ØM-M-9	Brown trout	Mjøsa	62	2367	13.2	<5	<8	<5	<10	<5	<10	<5	<10	<10	<220
ØM-M-10	Brown trout	Mjøsa	70	3450	<11	<5	<8	<5	<10	<5	<10	<5	<10	<10	<220
ØM-M-11	Brown trout	Mjøsa	81	6200	13	<5	<8	<5	<10	<5	<10	<5	<10	<10	<220
ØM-M-12	Brown trout	Mjøsa	73	4800	<11	<5	<8	<5	<10	<5	<10	<5	<10	<10	<220
ØM-M-13	Brown trout	Mjøsa	58	2550	12.9	<5	<8	<5	<10	<5	<10	<5	<10	<10	<220
ØM-M-14	Brown trout	Mjøsa	70	4400	<11	<5	<8	<5	<10	<5	<10	<5	<10	<10	<220
ØM-M-15	Brown trout	Mjøsa	63	3000	<18	<5	<8	<5	<10	<5	<10	<5	<10	<10	<220
ØF-M-1	Brown trout	Femunden	42.5	770	<11	<5	<8	<5	<10	<5	<10	<5	<10	<10	<220
ØF-M-2	Brown trout	Femunden	35.3	440	16.3	<5	<8	<5	<10	<5	<10	<5	<10	<10	<220
ØF-M-3	Brown trout	Femunden	46.8	940	<11	<5	<8	<5	<10	<5	<10	<5	<10	<10	<220
ØF-M-4	Brown trout	Femunden	36.3	501	<11	<5	<8	<5	<10	<5	<10	<5	<10	<10	<220
ØF-M-5	Brown trout	Femunden	44.3	1005	<11	<5	<8	<5	<10	5.5	<10	<5	<10	<10	<220
ØF-M-6	Brown trout	Femunden	48.7	1100	<11	<5	<8	<5	<10	<5	<10	<5	<10	<10	<220
ØF-M-7	Brown trout	Femunden	34.7	410	<11	<5	<8	<5	<10	<5	<10	<5	<10	<10	<220
ØF-M-8	Brown trout	Femunden	37.5	520	<11	<5	<8	<5	<10	<5	<10	<5	<10	<10	<220
ØF-M-9	Brown trout	Femunden	44.2	850	<11	<5	<8	<5	<10	7.8	<10	<5	<10	<10	<220
ØF-M-10	Brown trout	Femunden	46.9	1020	<11	<5	<8	<5	<10	<5	<10	<5	<10	<10	<220

ID	Matrix	Lake	4-tert-octylphenol	4-octylphenol	nonylfenol	D4	D5	D6	TEP	TCEP	TPrP	TCPP	TiBP	BdPhP
			ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle
ØM-M-7	Brown trout	Mjøsa	<40	<40	<50	< LOD (2.6)	28.672	< LOQ (3.2)	< 1.0	< 0.05	< 0.01	0.266	< 0.15	< 0.02
ØM-M-8	Brown trout	Mjøsa	<40	<40	<50	< LOD (2.6)	23.703	< LOQ (3.2)	< 1.0	< 0.05	< 0.01	1.250	< 0.15	< 0.02
ØM-M-9	Brown trout	Mjøsa	<40	<40	<50	< LOD (2.6)	23.895	< LOQ (3.2)	< 1.0	< 0.05	< 0.01	< 0.14	< 0.15	< 0.02
ØM-M-10	Brown trout	Mjøsa	<40	<40	<50	< LOD (2.6)	22.648	< LOQ (3.2)	< 1.0	< 0.05	< 0.01	< 0.14	< 0.15	< 0.02
ØM-M-11	Brown trout	Mjøsa	<40	<40	<50	< LOD (2.6)	44.713	< LOQ (3.2)	< 1.0	< 0.05	< 0.01	0.772	< 0.15	< 0.02
ØM-M-12	Brown trout	Mjøsa	<40	<40	<50	< LOD (2.6)	30.991	< LOQ (3.2)	< 1.0	< 0.05	< 0.01	1.738	< 0.15	< 0.02
ØM-M-13	Brown trout	Mjøsa	<40	<40	<50	< LOD (2.6)	23.599	< LOQ (3.2)	< 1.0	< 0.05	< 0.01	0.227	< 0.15	< 0.02
ØM-M-14	Brown trout	Mjøsa	<40	<40	<50	< LOD (2.6)	38.323	3.406	< 1.0	< 0.05	< 0.01	0.314	< 0.15	< 0.02
ØM-M-15	Brown trout	Mjøsa	<40	<40	<50	< LOQ (7.3)	98.674	6.203	< 1.0	< 0.05	< 0.01	1.309	< 0.15	< 0.02
ØF-M-1	Brown trout	Femunden	<40	<40	<50	< LOD (0.8)	< LOD (2.3)	< LOD (1.0)	< 0.30	< 0.10	< 0.01	0.376	< 0.30	< 0.01
ØF-M-2	Brown trout	Femunden	<40	<40	<50	< LOD (0.8)	< LOD (2.3)	< LOD (1.0)	< 0.30	< 0.10	< 0.01	0.461	< 0.30	< 0.01
ØF-M-3	Brown trout	Femunden	<40	<40	<50	< LOD (0.8)	< LOD (2.3)	< LOQ (1.7)	< 0.30	< 0.10	< 0.01	0.484	< 0.30	< 0.01
ØF-M-4	Brown trout	Femunden	<40	<40	<50	< LOD (0.8)	< LOD (2.3)	< LOQ (1.7)	< 0.30	< 0.10	< 0.01	0.487	< 0.30	< 0.01
ØF-M-5	Brown trout	Femunden	<40	<40	<50	< LOD (0.8)	< LOD (2.3)	< LOD (1.0)	< 0.30	< 0.10	< 0.01	0.371	< 0.30	< 0.01
ØF-M-6	Brown trout	Femunden	<40	<40	<50	< LOD (0.8)	< LOD (2.3)	< LOD (1.0)	< 0.30	< 0.10	< 0.01	0.570	< 0.30	< 0.01
ØF-M-7	Brown trout	Femunden	<40	<40	<50	< LOD (0.8)	< LOD (2.3)	< LOQ (1.7)	< 0.30	< 0.10	< 0.01	0.328	< 0.30	< 0.01
ØF-M-8	Brown trout	Femunden	<40	<40	<50	< LOD (0.8)	< LOD (2.3)	< LOQ (1.7)	< 0.30	< 0.10	< 0.01	0.234	< 0.30	< 0.01
ØF-M-9	Brown trout	Femunden	<40	<40	<50	< LOD (0.8)	< LOD (2.3)	< LOD (1.0)	< 0.30	< 0.10	< 0.01	0.440	< 0.30	< 0.01
ØF-M-10	Brown trout	Femunden	<40	<40	<50	< LOD (0.8)	< LOD (2.3)	< LOD (1.0)	< 0.30	< 0.10	< 0.01	< 0.14	< 0.30	< 0.01

ID	Matrix	Lake	TPP	DBPhP	TnBP	TDCPP	TBEP	TCP	EHDP	TXP	TEHP	TBA	BDE-17	BDE-28
			ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle
ØM-M-7	Brown trout	Mjøsa	< 0.07	< 0.02	< 0.06	< 0.10	< 0.20	< 0.02	< 1.0	< 0.04	< 0.22	0.0068	0.0059	0.0264
ØM-M-8	Brown trout	Mjøsa	< 0.07	< 0.02	0.198	< 0.10	< 0.20	< 0.02	< 1.0	0.071	0.283	0.0310	0.0111	0.0503
ØM-M-9	Brown trout	Mjøsa	< 0.07	< 0.02	< 0.06	< 0.10	< 0.20	< 0.02	< 1.0	< 0.04	< 0.22	0.0148	< 0.0007	0.0213
ØM-M-10	Brown trout	Mjøsa	< 0.07	< 0.02	< 0.06	< 0.10	< 0.20	< 0.02	< 1.0	< 0.04	< 0.22	0.0467	0.0222	0.0475
ØM-M-11	Brown trout	Mjøsa	< 0.07	< 0.02	< 0.06	< 0.10	< 0.20	< 0.02	< 1.0	< 0.04	< 0.22	0.0678	< 0.0065	0.0437
ØM-M-12	Brown trout	Mjøsa	< 0.07	< 0.02	< 0.06	< 0.10	< 0.20	< 0.02	< 1.0	< 0.04	< 0.22	0.0141	< 0.0014	0.0232
ØM-M-13	Brown trout	Mjøsa	< 0.07	< 0.02	< 0.06	< 0.10	< 0.20	< 0.02	< 1.0	< 0.04	< 0.22	0.0154	< 0.0012	0.0175
ØM-M-14	Brown trout	Mjøsa	< 0.07	< 0.02	< 0.06	< 0.10	< 0.20	< 0.02	< 1.0	< 0.04	< 0.22	0.0184	< 0.0018	0.0378
ØM-M-15	Brown trout	Mjøsa	< 0.07	< 0.02	0.153	< 0.10	< 0.20	< 0.02	< 1.0	< 0.04	< 0.22	0.0187	< 0.0012	0.0285
ØF-M-1	Brown trout	Femunden	< 0.03	< 0.01	< 0.10	< 0.20	< 0.15	< 0.05	< 0.35	< 0.10	< 0.20	0.0033	< 0.0007	0.0032
ØF-M-2	Brown trout	Femunden	< 0.03	< 0.01	< 0.10	< 0.20	< 0.15	< 0.05	< 0.35	< 0.10	< 0.20	0.0048	< 0.0007	0.0021
ØF-M-3	Brown trout	Femunden	< 0.03	< 0.01	< 0.10	< 0.20	< 0.15	< 0.05	< 0.35	< 0.10	< 0.20	0.0089	< 0.0007	0.0093
ØF-M-4	Brown trout	Femunden	< 0.03	< 0.01	< 0.10	< 0.20	< 0.15	< 0.05	< 0.35	< 0.10	< 0.20	0.0038	< 0.0007	0.0022
ØF-M-5	Brown trout	Femunden	< 0.03	< 0.01	< 0.10	< 0.20	< 0.15	< 0.05	< 0.35	< 0.10	< 0.20	0.0123	< 0.0007	0.0025
ØF-M-6	Brown trout	Femunden	< 0.03	< 0.01	< 0.10	< 0.20	< 0.15	< 0.05	< 0.35	< 0.10	< 0.20	0.0066	0.0011	0.0071
ØF-M-7	Brown trout	Femunden	< 0.03	< 0.01	< 0.10	< 0.20	< 0.15	< 0.05	< 0.35	< 0.10	< 0.20	0.0032	0.0008	0.0020
ØF-M-8	Brown trout	Femunden	< 0.03	< 0.01	< 0.10	< 0.20	< 0.15	< 0.05	< 0.35	< 0.10	< 0.20	0.0054	< 0.0007	0.0021
ØF-M-9	Brown trout	Femunden	< 0.03	< 0.01	< 0.10	< 0.20	< 0.15	< 0.05	< 0.35	< 0.10	< 0.20	0.0063	< 0.0007	0.0021
ØF-M-10	Brown trout	Femunden	< 0.03	< 0.01	< 0.10	< 0.20	< 0.15	< 0.05	< 0.35	< 0.10	< 0.20	0.0064	0.0011	0.0048

ID	Matrix	Lake	BDE-47	BDE-49	BDE-66	BDE-71	BDE-77	BDE-85	BDE-99	BDE-100	BDE-119	BDE-126	BDE-138	BDE-153
			ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle
ØM-M-7	Brown trout	Mjøsa	4.3000	0.2550	0.1070	< 0.0015	0.0048	0.00194	1.150	1.260	0.0313	0.0013	< 0.0012	0.2200
ØM-M-8	Brown trout	Mjøsa	8.3500	0.5370	0.2740	0.5140	0.0107	< 0.0047	2.870	3.090	0.11	< 0.0032	< 0.0091	0.5300
ØM-M-9	Brown trout	Mjøsa	2.9800	0.1600	0.0542	< 0.0008	0.0033	< 0.0008	0.482	0.899	0.0298	< 0.0006	< 0.0016	0.1400
ØM-M-10	Brown trout	Mjøsa	7.5100	0.3370	0.2200	< 0.0095	< 0.0064	< 0.0125	1.780	3.070	0.0884	< 0.0085	< 0.0441	0.4700
ØM-M-11	Brown trout	Mjøsa	4.9800	0.2920	0.1520	< 0.0101	< 0.0068	< 0.0086	1.220	1.830	0.0841	< 0.0058	< 0.0268	0.3140
ØM-M-12	Brown trout	Mjøsa	3.1800	0.2220	0.1190	< 0.0036	< 0.0024	< 0.0048	1.350	1.260	0.0511	< 0.0032	< 0.0082	0.2200
ØM-M-13	Brown trout	Mjøsa	1.9400	0.1240	0.0514	< 0.0020	< 0.0014	< 0.0036	0.503	0.691	0.0291	< 0.0025	< 0.0093	0.1190
ØM-M-14	Brown trout	Mjøsa	6.6600	0.3750	0.2240	< 0.0032	0.0100	< 0.0047	2.370	2.650	0.0949	< 0.0032	< 0.0077	0.4350
ØM-M-15	Brown trout	Mjøsa	4.0700	0.2750	0.1270	< 0.0026	0.0077	< 0.0022	1.270	1.360	0.0529	< 0.0015	< 0.0057	0.2280
ØF-M-1	Brown trout	Femunden	0.0774	0.0103	0.0041	< 0.0003	0.0009	< 0.0005	0.041	0.035	0.0043	< 0.0003	< 0.0012	0.0093
ØF-M-2	Brown trout	Femunden	0.0630	0.0073	< 0.0037	< 0.0003	< 0.0002	< 0.0005	0.040	0.030	0.00172	< 0.0003	< 0.0012	0.0073
ØF-M-3	Brown trout	Femunden	0.7630	0.0957	0.0542	< 0.0004	0.0038	< 0.0006	0.691	0.572	0.0696	0.0015	< 0.0012	0.1580
ØF-M-4	Brown trout	Femunden	0.0536	0.0065	< 0.0037	< 0.0003	< 0.0002	< 0.0005	0.034	0.023	0.00274	< 0.0003	< 0.0012	0.0063
ØF-M-5	Brown trout	Femunden	0.0861	0.0110	0.0048	< 0.0003	< 0.0002	< 0.0009	0.053	0.032	< 0.0007	< 0.0006	< 0.0012	0.0089
ØF-M-6	Brown trout	Femunden	0.4740	0.0681	0.0371	< 0.0003	0.0032	< 0.0007	0.387	0.336	0.0469	0.0010	< 0.0012	0.0904
ØF-M-7	Brown trout	Femunden	0.0517	0.0057	< 0.0037	< 0.0003	< 0.0002	< 0.0005	0.030	0.023	< 0.0004	< 0.0003	< 0.0012	0.0052
ØF-M-8	Brown trout	Femunden	0.0523	0.0075	< 0.0037	< 0.0003	< 0.0002	< 0.0008	0.032	0.021	< 0.0007	< 0.0005	< 0.0012	0.0054
ØF-M-9	Brown trout	Femunden	0.0606	0.0082	0.0041	< 0.0003	< 0.0002	< 0.0005	0.039	0.025	0.00182	< 0.0003	< 0.0012	0.0069
ØF-M-10	Brown trout	Femunden	0.2520	0.0374	0.0200	0.0361	0.0026	< 0.0009	0.196	0.163	0.0279	< 0.0006	< 0.0012	0.0461

ID	Matrix	Lake	BDE-154	BDE-156	BDE-183	BDE-184	BDE-191	BDE-196	BDE-197	BDE-202	BDE-206	BDE-207	BDE-209	ATE (TBP-AE)
			ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle
ØM-M-7	Brown trout	Mjøsa	0.4650	< 0.0018	0.0061	0.0051	< 0.0011	< 0.0018	< 0.0014	0.00638	< 0.0041	< 0.0021	0.0348	< 0.0062
ØM-M-8	Brown trout	Mjøsa	1.1500	< 0.0136	< 0.0048	0.0248	< 0.0074	< 0.0095	< 0.0078	< 0.0117	< 0.0115	< 0.0105	< 0.0268	< 0.0062
ØM-M-9	Brown trout	Mjøsa	0.3530	< 0.0025	0.0063	0.0050	< 0.0038	< 0.0027	< 0.0022	< 0.0034	< 0.0041	< 0.0021	0.0299	< 0.0310
ØM-M-10	Brown trout	Mjøsa	1.1500	< 0.0657	< 0.0172	< 0.0138	< 0.0264	< 0.0233	< 0.0190	< 0.0287	< 0.0506	< 0.0461	< 0.0688	< 0.0062
ØM-M-11	Brown trout	Mjøsa	0.7180	< 0.0398	< 0.0132	0.0283	< 0.0203	< 0.0284	< 0.0232	< 0.0350	< 0.0369	< 0.0337	< 0.0399	< 0.0062
ØM-M-12	Brown trout	Mjøsa	0.5190	< 0.0122	< 0.0059	0.0141	< 0.0091	< 0.0072	< 0.0059	< 0.0089	< 0.0083	< 0.0076	< 0.0268	< 0.0062
ØM-M-13	Brown trout	Mjøsa	0.2770	< 0.0139	< 0.0033	< 0.0027	< 0.00512	< 0.0042	< 0.0034	< 0.0051	< 0.0069	< 0.0063	< 0.0268	< 0.0062
ØM-M-14	Brown trout	Mjøsa	0.9010	< 0.0115	< 0.0043	0.0195	< 0.0066	< 0.0071	< 0.0058	< 0.0088	< 0.0093	< 0.0085	< 0.0268	< 0.0062
ØM-M-15	Brown trout	Mjøsa	0.5190	< 0.0084	< 0.0036	0.0137	< 0.0056	< 0.0049	< 0.0040	< 0.0060	< 0.0054	< 0.0049	< 0.0268	< 0.0062
ØF-M-1	Brown trout	Femunden	0.0244	< 0.0018	0.0022	0.0013	< 0.0011	< 0.0018	< 0.0014	< 0.0021	< 0.0041	< 0.0021	< 0.0268	< 0.0310
ØF-M-2	Brown trout	Femunden	0.0177	< 0.0018	0.0024	0.0007	< 0.0011	< 0.0018	< 0.0014	< 0.0021	< 0.0041	< 0.0021	< 0.0268	< 0.0310
ØF-M-3	Brown trout	Femunden	0.3600	< 0.0018	0.0105	0.0155	< 0.0011	< 0.0018	0.00518	0.00503	< 0.0041	< 0.0021	0.036	< 0.0062
ØF-M-4	Brown trout	Femunden	0.0172	< 0.0018	0.0023	0.0010	< 0.0011	< 0.0018	< 0.0014	< 0.0021	< 0.0041	< 0.0021	< 0.0268	< 0.0062
ØF-M-5	Brown trout	Femunden	0.0278	< 0.0018	< 0.0009	< 0.0006	< 0.0013	< 0.0026	< 0.0021	< 0.0031	< 0.0053	< 0.0046	< 0.0268	< 0.0062
ØF-M-6	Brown trout	Femunden	0.2460	< 0.0018	0.0052	0.0108	< 0.0011	< 0.0018	0.0028	0.00412	< 0.0041	< 0.0021	< 0.0268	< 0.0062
ØF-M-7	Brown trout	Femunden	0.0148	< 0.0018	0.0025	0.0009	< 0.0011	< 0.0018	< 0.0014	< 0.0021	< 0.0041	< 0.0021	< 0.0268	< 0.0062
ØF-M-8	Brown trout	Femunden	0.0150	< 0.0018	0.0020	0.0008	< 0.0011	< 0.0018	< 0.0014	< 0.0021	< 0.0041	< 0.0021	< 0.0268	< 0.0062
ØF-M-9	Brown trout	Femunden	0.0167	< 0.0018	0.0020	0.0010	< 0.0011	< 0.0018	< 0.0014	< 0.0021	< 0.0041	< 0.0021	< 0.0268	< 0.0062
ØF-M-10	Brown trout	Femunden	0.1300	< 0.0018	0.0027	0.0061	< 0.0011	< 0.0018	< 0.0014	< 0.0021	< 0.0041	< 0.0021	< 0.0268	< 0.0062

ID	Matrix	Lake	a-TBECH	b-TBECH	g/d-TBECH	BATE	PBT	PBEB	PBBZ	HBB	DPTE	EHTBB	BTBPE	TBPH (BEH /TBP)
			ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle
ØM-M-7	Brown trout	Mjøsa	< 0.0152	< 0.0107	< 0.0047	< 0.0020	< 0.0102	< 0.0137	0.00417	0.0123	< 0.0019	< 0.0055	0.0178	< 0.0154
ØM-M-8	Brown trout	Mjøsa	< 0.0152	< 0.0107	< 0.0047	< 0.0020	< 0.0102	< 0.0137	0.00483	0.0119	< 0.0019	< 0.0055	0.0224	< 0.0154
ØM-M-9	Brown trout	Mjøsa	< 0.0758	< 0.0534	< 0.0235	< 0.0100	< 0.0509	< 0.0686	0.0211	< 0.0573	< 0.0095	< 0.0275	0.0981	< 0.0772
ØM-M-10	Brown trout	Mjøsa	< 0.0152	< 0.0107	< 0.0047	< 0.0020	< 0.0102	< 0.0137	0.00378	< 0.0115	< 0.0019	< 0.0055	0.0171	< 0.0154
ØM-M-11	Brown trout	Mjøsa	< 0.0152	< 0.0107	< 0.0047	< 0.0020	< 0.0102	< 0.0137	0.0044	0.012	< 0.0019	< 0.0055	0.0206	< 0.0154
ØM-M-12	Brown trout	Mjøsa	< 0.0152	< 0.0107	< 0.0047	< 0.0020	< 0.0102	< 0.0137	0.0042	< 0.0115	< 0.0019	< 0.0055	0.0185	< 0.0154
ØM-M-13	Brown trout	Mjøsa	< 0.0152	< 0.0107	< 0.0047	< 0.0020	< 0.0102	< 0.0137	0.0046	< 0.0115	< 0.0019	< 0.0055	0.0189	< 0.0154
ØM-M-14	Brown trout	Mjøsa	< 0.0152	< 0.0107	< 0.0047	< 0.0020	< 0.0102	< 0.0137	0.00418	< 0.0115	< 0.0019	< 0.0055	0.0218	< 0.0154
ØM-M-15	Brown trout	Mjøsa	< 0.0152	< 0.0107	< 0.0047	< 0.0020	< 0.0102	< 0.0137	0.00411	< 0.0115	< 0.0019	< 0.0055	0.0233	< 0.0154
ØF-M-1	Brown trout	Femunden	< 0.0758	< 0.0534	< 0.0235	< 0.0100	< 0.0509	< 0.0686	0.0246	< 0.0573	< 0.0095	< 0.0275	< 0.0274	< 0.0772
ØF-M-2	Brown trout	Femunden	< 0.0758	< 0.0534	< 0.0235	< 0.0100	< 0.0509	< 0.0686	0.0208	< 0.0573	< 0.0095	< 0.0275	0.053	< 0.0772
ØF-M-3	Brown trout	Femunden	< 0.0152	< 0.0107	< 0.0047	< 0.0020	< 0.0102	< 0.0137	0.00611	< 0.0115	< 0.0019	< 0.0055	0.012	< 0.0154
ØF-M-4	Brown trout	Femunden	< 0.0152	< 0.0107	< 0.0047	< 0.0020	< 0.0102	< 0.0137	0.00376	< 0.0115	< 0.0019	< 0.0055	0.0137	< 0.0154
ØF-M-5	Brown trout	Femunden	< 0.0152	< 0.0107	< 0.0047	< 0.0020	< 0.0102	< 0.0137	0.00776	0.0137	< 0.0019	< 0.0055	0.0243	< 0.0154
ØF-M-6	Brown trout	Femunden	< 0.0152	< 0.0107	< 0.0047	< 0.0020	< 0.0102	< 0.0137	0.00651	< 0.0115	< 0.0019	< 0.0055	0.026	< 0.0154
ØF-M-7	Brown trout	Femunden	< 0.0152	< 0.0107	< 0.0047	0.00427	< 0.0102	< 0.0137	0.0116	0.0168	0.00222	< 0.0055	0.0257	< 0.0154
ØF-M-8	Brown trout	Femunden	< 0.0152	< 0.0107	< 0.0047	0.00311	< 0.0102	< 0.0137	0.00815	0.0133	< 0.0019	< 0.0055	0.0263	< 0.0154
ØF-M-9	Brown trout	Femunden	< 0.0152	< 0.0107	< 0.0047	0.00313	< 0.0102	< 0.0137	0.00825	0.0169	< 0.0019	< 0.0055	0.0249	< 0.0154
ØF-M-10	Brown trout	Femunden	< 0.0152	< 0.0107	< 0.0047	0.00507	< 0.0102	< 0.0137	0.0095	0.0136	< 0.0019	< 0.0055	0.0246	< 0.0154

ID	Matrix	Lake	DBDPE	Lipid	BP3	EHMC-Z	EHMC-E	OC	Hg	d13C	d15N	d32S	W% C	PFPA	PFHxA	PFHpA
			ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	ng/g muscle	µg/g muscle	‰	‰	‰		ng/g liver	ng/g liver	ng/g liver
ØM-M-7	Brown trout	Mjøsa	< 1.14	4.2	<0.2	<0.1	<0.1	<3	0.204	-29.4305	15.1188	3.0185	55.7969	<0.5	<0.5	<0.5
ØM-M-8	Brown trout	Mjøsa	< 1.14	3.8	<0.2	<0.1	<0.1	<3	0.584	-29.2631	15.5386	2.9429	55.2978	<0.5	<0.5	<0.5
ØM-M-9	Brown trout	Mjøsa	< 5.71	4.6	<0.2	<0.1	<0.1	<3	0.287	-30.6648	15.4612	2.3716	59.5833	<0.5	<0.5	<0.5
ØM-M-10	Brown trout	Mjøsa	< 1.14	2.53	<0.2	<0.1	<0.1	<3	0.853	-28.6010	15.9861	3.4213	53.5255	<0.5	<0.5	<0.5
ØM-M-11	Brown trout	Mjøsa	< 1.14	4.83	<0.2	<0.1	<0.1	<3	0.268	-29.3467	15.2636	3.0425	56.7164	<0.5	<0.5	<0.5
ØM-M-12	Brown trout	Mjøsa	< 1.14	2.1	<0.2	<0.1	<0.1	<3	0.479	-27.6325	15.6192	2.7714	50.9688	<0.5	<0.5	<0.5
ØM-M-13	Brown trout	Mjøsa	< 1.14	3.53	<0.2	<0.1	<0.1	<3	0.203	-28.3920	15.4966	2.7329	53.1784	<0.5	<0.5	<0.5
ØM-M-14	Brown trout	Mjøsa	< 1.14	4.3	<0.2	<0.1	<0.1	<4	0.761	-30.1894	15.5652	2.2441	58.9115	<0.5	<0.5	<0.5
ØM-M-15	Brown trout	Mjøsa	< 1.14	5.7	<0.2	<0.1	<0.1	<3	0.265	-28.6054	15.4883	3.2402	54.2217	<0.5	<0.5	<0.5
ØF-M-1	Brown trout	Femunden	7.19	1.4	<0.4	<0.07	<0.2	<4	0.094	-22.6667	8.0443	6.6833	48.9963	<0.5	<0.5	<0.5
ØF-M-2	Brown trout	Femunden	< 5.71	1.3	0.7554	<0.07	<0.2	<4	0.057	-18.6130	7.6001	6.9028	48.1496	<0.5	<0.5	<0.5
ØF-M-3	Brown trout	Femunden	< 1.14	2	<0.4	<0.07	<0.2	<4	0.77	-24.4216	10.5421	6.7385	49.8157	<0.5	<0.5	<0.5
ØF-M-4	Brown trout	Femunden	< 1.14	1	<0.4	<0.07	<0.2	<4	0.025	-19.8176	7.2927	6.7547	46.9638	<0.5	<0.5	<0.5
ØF-M-5	Brown trout	Femunden	1.87	2.3	<0.4	<0.07	<0.2	<4	0.051	-19.6060	7.9224	6.7933	46.3717	<0.5	<0.5	<0.5
ØF-M-6	Brown trout	Femunden	< 1.14	1	<0.4	0.1385	<0.2	<4	0.633	-24.8239	10.3332	6.4721	50.0808	<0.5	<0.5	<0.5
ØF-M-7	Brown trout	Femunden	1.47	0.6	<0.4	0.1428	<0.2	<4	0.06	-21.1102	7.3591	7.0525	48.4890	<0.5	<0.5	<0.5
ØF-M-8	Brown trout	Femunden	1.21	1.5	<0.4	0.1265	<0.2	<4	0.036	-21.8391	7.6445	6.6966	48.9262	<0.5	<0.5	<0.5
ØF-M-9	Brown trout	Femunden	6.52	1.6	<0.4	0.1369	<0.2	<4	0.037	-20.7748	7.6914	6.7195	46.8715	<0.5	<0.5	<0.5
ØF-M-10	Brown trout	Femunden	1.16	1	<0.4	0.1348	<0.2	<4	0.272	-22.1711	10.2504	6.5082	49.7866	<0.5	<0.5	<0.5

ID	Matrix	Lake	PFOA	PFNA	PFDA	PFUnDA	PFDoDA	PFTrDA	PFTeDA	PFPeDA	PFHxDA	PFBS	PFPS	PFHxS	PFHpS	PFOS	8Cl-PFOS	PFNS
			ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver
ØM-M-7	Brown trout	Mjøsa	<0.5	<0.5	3.4715	10.3406	7.2679	11.9021	3.6033	1.2349	<0.5	<0.2	<0.2	<0.1	<0.1	8.1119	<0.2	<0.1
ØM-M-8	Brown trout	Mjøsa	<0.5	0.5966	4.2436	10.2870	6.8023	7.4566	2.3541	1.1049	<0.5	<0.2	<0.2	<0.1	<0.1	8.9693	<0.2	<0.1
ØM-M-9	Brown trout	Mjøsa	<0.5	0.5116	4.8164	14.5125	9.6475	12.5575	4.2410	1.3867	<0.5	<0.2	<0.2	<0.1	<0.1	9.8331	<0.2	<0.1
ØM-M-10	Brown trout	Mjøsa	<0.5	0.6637	5.1714	12.9708	8.2766	12.7321	2.9589	1.4808	<0.5	<0.2	<0.2	<0.1	<0.1	11.4315	<0.2	<0.1
ØM-M-11	Brown trout	Mjøsa	<0.5	1.5379	7.5177	20.9854	12.3443	14.1483	5.0462	2.3239	<0.5	<0.2	<0.2	<0.1	0.2684	14.7844	<0.2	<0.1
ØM-M-12	Brown trout	Mjøsa	<0.5	0.5898	1.3782	1.9007	1.3046	1.2017	0.6841	0.5660	<0.5	<0.2	<0.2	<0.1	0.0304	1.8843	<0.2	<0.1
ØM-M-13	Brown trout	Mjøsa	<0.5	1.9722	6.3061	19.1014	11.9028	14.8929	5.2276	1.9365	<0.5	<0.2	<0.2	<0.1	0.1275	15.1735	<0.2	<0.1
ØM-M-14	Brown trout	Mjøsa	<0.5	<0.5	0.6848	0.7280	0.5826	0.7325	0.4868	<0.5	<0.5	<0.2	<0.2	<0.1	<0.1	0.8978	<0.2	<0.1
ØM-M-15	Brown trout	Mjøsa	<0.5	0.7974	4.3730	12.7358	8.9848	12.8365	4.3723	1.5033	<0.5	<0.2	<0.2	<0.1	0.1060	12.8395	<0.2	<0.1
ØF-M-1	Brown trout	Femunden	<0.5	0.5280	0.6463	1.2253	0.7421	1.1571	0.3977	<0.5	<0.5	<0.2	<0.2	<0.1	<0.1	0.4820	<0.2	<0.1
ØF-M-2	Brown trout	Femunden	<0.5	<0.5	<0.5	0.7220	0.4774	1.1720	<0.4	<0.5	<0.5	<0.2	<0.2	<0.1	<0.1	0.3874	<0.2	<0.1
ØF-M-3	Brown trout	Femunden	<0.5	1.1492	1.3567	4.2757	2.7680	9.7075	2.0050	2.7449	<0.5	<0.2	<0.2	<0.1	<0.1	2.6124	<0.2	<0.1
ØF-M-4	Brown trout	Femunden	<0.5	0.6683	1.0071	3.1039	1.8187	4.6624	0.9816	1.2104	<0.5	<0.2	<0.2	<0.1	<0.1	1.2759	<0.2	<0.1
ØF-M-5	Brown trout	Femunden	<0.5	<0.5	0.7528	1.5424	0.8157	1.9354	0.4895	0.8360	<0.5	<0.2	<0.2	<0.1	<0.1	0.8699	<0.2	<0.1
ØF-M-6	Brown trout	Femunden	<0.5	<0.5	1.1453	3.5772	2.4925	8.2493	2.0712	3.2553	<0.5	<0.2	<0.2	<0.1	<0.1	1.0967	<0.2	<0.1
ØF-M-7	Brown trout	Femunden	<0.5	<0.5	0.8597	2.4789	1.3167	3.1045	0.6932	0.7982	<0.5	<0.2	<0.2	<0.1	<0.1	0.8071	<0.2	<0.1
ØF-M-8	Brown trout	Femunden	<0.5	<0.5	0.6256	2.3966	1.8142	4.2660	1.1002	1.1752	<0.5	<0.2	<0.2	<0.1	<0.1	0.9829	<0.2	<0.1
ØF-M-9	Brown trout	Femunden	<0.5	<0.5	0.5582	2.0261	1.6431	4.8243	1.2204	1.3970	<0.5	<0.2	<0.2	<0.1	<0.1	0.8401	<0.2	<0.1
ØF-M-10	Brown trout	Femunden	<0.5	<0.5	0.6359	1.7070	1.0865	2.6376	0.7375	1.3468	<0.5	<0.2	<0.2	<0.1	<0.1	1.0056	<0.2	<0.1

ID	Matrix	Lake	PFDS	PFDoS	PFOSA	N-MeFOSA	N-EtFOSA	N-MeFOSE	N-EtFOSE	4:2 FTS	6:2 FTS	8:2 FTS	10:2 FTS	4:2 F53B	6:2 F53B	N-MeFOSAA	N-EtFOSAA
			ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver
ØM-M-7	Brown trout	Mjøsa	<0.1	<0.2	0.7470	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-8	Brown trout	Mjøsa	<0.1	<0.2	0.6545	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-9	Brown trout	Mjøsa	<0.1	<0.2	1.2119	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-10	Brown trout	Mjøsa	<0.1	<0.2	1.3180	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-11	Brown trout	Mjøsa	0.1431	<0.2	1.4804	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-12	Brown trout	Mjøsa	<0.1	<0.2	0.3453	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-13	Brown trout	Mjøsa	0.1316	<0.2	0.8884	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-14	Brown trout	Mjøsa	<0.1	<0.2	0.1519	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-15	Brown trout	Mjøsa	0.1261	<0.2	0.9962	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØF-M-1	Brown trout	Femunden	<0.1	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØF-M-2	Brown trout	Femunden	<0.1	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØF-M-3	Brown trout	Femunden	<0.1	<0.2	0.4559	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØF-M-4	Brown trout	Femunden	<0.1	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØF-M-5	Brown trout	Femunden	<0.1	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØF-M-6	Brown trout	Femunden	<0.1	<0.2	0.1745	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØF-M-7	Brown trout	Femunden	<0.1	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØF-M-8	Brown trout	Femunden	<0.1	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØF-M-9	Brown trout	Femunden	<0.1	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØF-M-10	Brown trout	Femunden	<0.1	<0.2	<0.1	<0.3	<0.3	<5	<5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3

ID	Matrix	Lake	F53	7:3 FTCA	PFBSA	N-MeFBSA	N-EtFBSA
			ng/g liver	ng/g liver	ng/g liver	ng/g liver	ng/g liver
ØM-M-7	Brown trout	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
ØM-M-8	Brown trout	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
ØM-M-9	Brown trout	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
ØM-M-10	Brown trout	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
ØM-M-11	Brown trout	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
ØM-M-12	Brown trout	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
ØM-M-13	Brown trout	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
ØM-M-14	Brown trout	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
ØM-M-15	Brown trout	Mjøsa	<0.3	<0.5	<0.2	<0.2	<0.2
ØF-M-1	Brown trout	Femunden	<0.3	<0.5	<0.2	<0.2	<0.2
ØF-M-2	Brown trout	Femunden	<0.3	<0.5	<0.2	<0.2	<0.2
ØF-M-3	Brown trout	Femunden	<0.3	<0.5	<0.2	<0.2	<0.2
ØF-M-4	Brown trout	Femunden	<0.3	<0.5	<0.2	<0.2	<0.2
ØF-M-5	Brown trout	Femunden	<0.3	<0.5	<0.2	<0.2	<0.2
ØF-M-6	Brown trout	Femunden	<0.3	<0.5	<0.2	<0.2	<0.2
ØF-M-7	Brown trout	Femunden	<0.3	<0.5	<0.2	<0.2	<0.2
ØF-M-8	Brown trout	Femunden	<0.3	<0.5	<0.2	<0.2	<0.2
ØF-M-9	Brown trout	Femunden	<0.3	<0.5	<0.2	<0.2	<0.2
ØF-M-10	Brown trout	Femunden	<0.3	<0.5	<0.2	<0.2	<0.2

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