REPORT SNO. 7653-2021

Monitoring of environmental contaminants in freshwater ecosystems 2020

Occurence and biomagnification

Photo: Morten Jartun

Norwegian Institute for Water Research

REPORT

Main Office
Gaustadalléen 21
NO-0349 Oslo, Norway
Phone (47) 22 18 51 00

NIVA Region South
Jon Lilletuns vei 3
NO-4879 Grimstad, Norway
Phone (47) 22 18 51 00

NIVA Region East
Sandvikaveien 59
NO-2312 Ottestad, Norway
Phone (47) 22 18 51 00

NIVA Region West
Thormøhlensgate 53 D
NO-5006 Bergen Norway
Phone (47) 22 18 51 00

NIVA Denmark
Njalsgade 76, 4th floor
DK 2300 Copenhagen S, Denmark
Phone (45) 39 17 97 33

Internet: www.niva.no

Title	Serial number	Date
Monitoring of environmental contaminants in freshwater ecosystems 2020 – Occurrence and biomagnification	7653-2021	01.10.2021
Author(s) Morten Jartun, Asle Økelsrud, Henriette Kildahl, Sigurd Øxnevad, Thomas Rundberget, Kine Bæk (NIVA), Ellen Katrin Enge, Anne Karine Halse, Linda Hanssen, Mikael Harju (NILU) and Ingar Johansen (IFE)	Topic group Environmental monitoring	Distribution Open
	Geographical area Innlandet, Norway	Pages 147

Client(s)	Client's reference
Miljødirektoratet	Eivind Farmen
Client's publication: M-2067|2021	Printed NIVA Project number 17197

Summary

This program, «Monitoring of environmental contaminants in freshwater ecosystems and single species in large Norwegian lakes", has covered sampling and determination of environmental contaminants by analyses of organisms in an aquatic, pelagic food web of Lake Mjøsa, and in the top predator in Lake Femunden. Samples of different trophic levels, from epipelagic zooplankton to the top predator brown trout, were collected during the late stages of the growth season in 2020. In this report, the status of contamination in the food web, trends and biomagnification potential of various environmental contaminants is discussed.

Four keywords	Fire emneord
1. Contaminants	1. Miljøgifter
2. Environmental monitoring	2. Miljøovervåking
3. Freshwater	3. Ferskvann
4. Biomagnification	4. Biomagnifisering

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

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

ISBN 978-82-577-7389-2
NIVA-report ISSN 1894-7948

© Norsk institutt for vannforskning/Norwegian Institute for Water Research and the Norwegian Environment Agency.
The publication can be cited freely if the source is stated.

Monitoring of environmental contaminants in freshwater ecosystems, 2020

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 environmental monitoring on samples of biota collected from Lakes Mjøsa and Femunden in 2020.

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. Brown trout was sampled from the pristine reference Lake Femunden.

Sampling of zooplankton, *Mysis*, and European smelt was carried out by Morten Jartun and Asle Økelsrud from NIVA. 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 and Henriette Kildahl.

Chemical analyses:

- Stable isotopes of nitrogen ($\delta^{15}N$) and carbon ($\delta^{13}C$): Institute for Energy Technology (IFE, Ingar Johansen)
- Mercury (Hg): Eurofins Environment Testing Norway AS
- Brominated flame retardants (BFR), cyclic volatile methylated siloxanes (cVMS), new brominated flame retardants (nBFR), alkyl- and bisphenols: Norwegian Institute for Air Research (NILU)
- PFAS and UV-chemicals: Norwegian Institute for Water Research (NIVA)

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

Oslo, 23.06.2021

Morten Jartun
Project manager
NIVA

Table of contents

Summary

«Monitoring of environmental contaminants in freshwater ecosystems and single species in large Norwegian lakes", has from 2017 to 2020 covered sampling and determination of environmental contaminants by analyses of organisms in an aquatic, pelagic food web of Lake Mjøsa, and in the top predator in Lake Femunden. Samples of different trophic levels, from epipelagic zooplankton to the top predator brown trout, were collected during the late stages of the growth season in 2020. In this report, the status of contamination in the food web, trends and biomagnification potential of various environmental contaminants is discussed, along supplementary information on ecological and morphometric predictors such as length, weight, conditional factor (CF), lipid content, age, sex, trophic level ($\delta^{15}N$) and carbon source ($\delta^{15}N$).

Main objectives of the program are:

- Study the occurrence of contaminants in various trophic levels
- Estimation of biomagnification potential of legacy and new contaminants in an aquatic food web

Data from this program can be used as input to international chemical regulations (e.g. REACH and Stockholm convention), and in reports according to the national requirements of the Water Framework Directive (Vannforskriften). 2020 was the eighth year of contamination monitoring of the two lakes following the same approach, although the time series are much longer for specific contaminants, such as brominated flame retardants (PBDEs) and mercury (Hg). The contaminants studied include mercury (Hg), cyclic volatile methylated siloxanes (cVMS), PBDEs, per- and polyfluorinated substances (PFAS), organic phosphorus flame retardants (oPFR), alkylphenols, bisphenols, new brominated flame retardants (nBFR), UV-chemicals and dechloranes. oPFR and dechloranes were not studied in 2020.

Statistical models on significant ecological and morphometric predictors for Hg variation in brown trout from Lakes Mjøsa and Femunden show that a major part of the variation is explained by trophic level ($\delta^{15}N$) and size in Lake Mjøsa, whereas trophic level, carbon source ($\delta^{13}C$) and size explained most of the variation in Lake Femunden. Based on the entire dataset for Lake Mjøsa from 2006-2020, in average the brown trout will reach the EU's and the Norwegian upper limit for placing on the market of 0.5 mg/kg w.w. in fish muscle at around 56 cm, which corresponds to ~ 2.1 kg. For Lake Femunden the trout based on data from 2013 to 2020 will reach the 0.5 mg/kg w.w. limit at around 52 cm, and ~ 1.25 kg.

The cyclic volatile methylated siloxane (cVMS) D5 show biomagnifying potential in Lake Mjøsa. Studying the data from 2013-2020 mean concentrations of D5 in brown trout from Lake Mjøsa have been stable. D5 concentrations in brown trout display a significant covariation with trophic level ($\delta^{15}N$) and lipid content. It is also observed that D5 concentrations in brown trout increases with a higher pelagic diet (i.e. a lower $\delta^{13}C$ value).

Levels of PBDEs peaked in early 2000 in biota from Lake Mjøsa after an industrial discharge of these compounds in the late 1990s. From 2000 to 2020 there is a decline of 90 % in the top predator concentrations, but still all fish samples have concentrations exceeding the EQS for ΣBDE_6.

PFAS is detected in both lakes, with long-chained carboxylic acids (C9 to C14) dominating the PFAS distribution in both lakes. In addition, PFOS was found in higher concentrations in Lake Mjøsa compared to Lake Femunden, with 7 out of 15 samples exceeding the EQS for PFOS. Ecological and morphometric predictors such as length, weight, age, $\delta^{15}N$ and $\delta^{13}C$ do not explain the variation of PFAS concentrations within the top predator brown trout, which means that length is not a good predictor for PFAS concentrations in brown trout. However, on a food chain level, PFOS is observed to biomagnify. Previously biomagnification potential has also been observed for long-chained PFCAs. PFAS-concentrations have stabilized the last four years after a decline from 2014-2017.

Alkylphenols, bisphenols, new brominated flame retardants (nBFR) and UV-chemicals are only sporadically detected in the sampled material.

Sammendrag

Tittel: Miljøgifter i ferskvann (Milfersk) – forekomst og biomagnifisering i 2020.
År: 2021
Forfatter(e): Morten Jartun, Asle Økelsrud, Henriette Kildahl, Sigurd Øxnevad, Thomas Rundberget, Kine Bæk (NIVA), Ellen Katrin Enge, Anne Karine Halse, Linda Hanssen, Mikael Harju (NILU) and Ingar Johansen (IFE).
Utgiver: Norsk institutt for vannforskning, ISBN 978-82-577- 7389-2

Gjennom «Overvåking av miljøgifter i ferskvann – Miljøgifter i næringsnett og enkeltarter i store norske innsjøer» har NIVA gjennomført prøvetaking og analyser av organismer i et akvatisk, pelagisk næringsnett i Mjøsa, og i toppredatoren ørret fra Femunden. Prøver fra forskjellige trofiske nivåer, fra epipelagisk dyreplankton til toppredatoren ørret, ble samlet i løpet av siste del av vekstsesongen 2020. I denne rapporten diskuteres forekomsten og biomagnifiseringspotensialet til ulike miljøgifter.

Hovedmålene for programmet er:

- å studere forekomsten av forurensninger i forskjellige trofiske nivåer
- å estimere potensialet for biomagnifisering av enkelte gamle og nye miljøgifter i et næringsnett i ferskvann

Data fra dette programmet kan brukes som bidrag og bakgrunnsmateriale til internasjonale kjemiske forskrifter (f.eks. REACH og Stockholmkonvensjonen), og de nasjonale kravene i vannrammedirektivet (vannforskriften). 2020 var det åttende året med overvåking av miljøgifter som inkluderte studier av ulike trofiske nivå og biomagnifisering i Mjøsa. Tidsseriene strekker seg enda lenger tilbake i tid for enkelte stoffgrupper som kvikksølv (Hg) og bromerte flammehemmere (polybromerte difenyletere, PBDE). De andre miljøgiftene i studien fra 2020 omfatter siloksaner (cVMS), per- og polyfluorinerte alkylstoffer (PFAS), alkylfenoler, bisfenoler, nye bromerte flammehemmere (nBFR) og UV-kjemikalier. I tidligere år er det også gjort bestemmelse av organiske fosforflammehemmere (oPFR) og dekloraner.

Statistiske modeller for signifikante økologiske og morfometriske prediktorer for miljøgiftvariasjonen i ørret fra Mjøsa og Femunden viser at en stor del av variasjonen av Hg forklares med trofisk nivå ($\delta^{15}N$) og fiskelengde i Mjøsa, mens trofisk nivå, karbonkilde ($\delta^{13}C$) og lengde forklarte det meste av variasjonen i Femunden. Ørret i Mjøsa oppnår anbefalt omsetningsgrense på 0,5 mg/kg våtvekt i muskel når den blir ca. 56 cm lang eller 2,1 kg. I Femunden vil ørreten oppnå denne konsentrasjonen ved ca. 52 cm, og 1,25 kg.

Siloksanforbindelsen (cVMS) D5 viser biomagnifiserende potensial i den pelagiske næringskjeden i Mjøsa. Når vi studerer dataene fra 2013-2020, ser vi en uforandret trend. D5-konsentrasjonene som vi måler i ørret fra Mjøsa har en signifikant samvariasjon med trofisk nivå ($\delta^{15}N$) og lipidinnhold. Vi ser også at konsentrasjonen av D5 i ørret øker med økende pelagisk diett (lavere $\delta^{13}C$).

Nivåene av PBDE toppet seg tidlig på 2000-tallet i biota fra Mjøsa etter industrielt utslipp av disse forbindelsene på slutten av 1990-tallet. Fra 2000 til 2020 er det en nedgang på 90 % av PBDE i fisk, men likevel har samtlige prøver av fiskemuskel fortsatt konsentrasjoner som overskrider EQS for ΣBDE_6.

PFAS påvises i begge innsjøene, med langkjedede karboksylsyrer (C9 til C14) som dominerer PFAS-fordelingen i begge innsjøene. I tillegg ble PFOS funnet i høyere konsentrasjoner i Mjøsa sammenlignet med Femunden, med 7 av 15 prøver som oversteg EQS (9,1 ng/g w.w.) for PFOS. Vi observerer en signifikant biomagnifisering av PFOS opp gjennom den pelagiske næringskjeden, og i tidligere år er dette også påvist for bl.a. langkjedede syrer (PFCA). Konsentrasjonen av PFAS har stabilisert seg de fire siste årene, etter en liten nedgang fra 2014-2017. Statistiske modeller viser at den PFAS-variasjonen vi observerer i ørret fra Mjøsa og Femunden ikke kan forklares med de økologiske og morfologiske data som foreligger (lengde, vekt, K-faktor, lipidinnhold, alder, kjønn, karbonkilde eller trofisk nivå). Det vil si at bl.a. lengde ikke er en god prediktor for PFOS-konsentrasjonen i ørret.

I 2020 var det kun sporadiske påvisninger over kvantifiseringsgrensen (LOQ) for gruppene av miljøgifter som alkylfenoler, bisfenoler, nye bromerte flammehemmere (nBFR) og UV-kjemikalier.

1 Introduction

1.1 Background

"Contaminants in freshwater ecosystems" (Miljøgifter i ferskvann – MILFERSK) is a monitoring program designed to monitor the occurrence and biomagnification of selected new and legacy contaminants in large freshwater ecosystems in Norway. The aquatic, pelagic food web in Lake Mjøsa is studied in detail succeeding the sampling strategy from "Contaminants in great Norwegian lakes" established in the period 2013-2016. Lake Mjøsa is the largest lake in Norway, with a total catchment area of approx. 17000 km^2. The lake acts as both drinking water source and recipient for wastewater discharges in addition to receiving anthropogenic input by the means of stormwater and agricultural runoff. Lake Mjøsa is thus especially interesting for studying impact of emerging contaminants. Lake Femunden, the third largest lake in Norway acts as a reference lake, as it resides in a pristine mountain and forest area with limited impact from human activities.

The Norwegian Institute for Water Research (NIVA) is carrying out the studies on the behalf of the Norwegian Environment Agency (Miljødirektoratet).

A wide range of environmental, emerging contaminants have been determined in samples of zooplankton, the planktonic opossum shrimp *Mysis relicta*, in addition to the fish species vendace (*Coregonus albula*), European smelt (*Osmerus eperlanus*), and brown trout (*Salmo trutta*) in Lake Mjøsa, and the top predator brown trout from Lake Femunden.

Main objectives for the monitoring program are:

- Report the concentrations of selected contaminants in multiple trophic levels within a pelagic food web
- 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, data from 2020 is presented and discussed. Detection frequencies and concentrations of **mercury** (Hg), **cyclic volatile methylated siloxanes** (cVMS), **brominated flame retardants** (including polybrominated diphenyl ethers (PBDEs) and new BFRs), **per- and polyfluorinated substances** (PFAS), **alkylphenols and bisphenols** and **UV-chemicals** in biota are presented alongside key parameters such as **stable isotopes** ($\delta^{15}N$, $\delta^{13}C$), **lipid** content, **length**, **weight, condition factor (CF)**, **age** and **sex**. In addition, we have presented detection frequencies and previous results of organic phosphorous flame retardants (oPFR) and dechloranes, both included in the monitoring program from 2017-2019, but not in 2020.

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. Muscle was the main target tissue for the determination of Hg, cVMS, BFRs, phenols and UV chemicals in fish, whereas liver was the selected tissue for PFAS. Biomagnification potential (Trophic magnification factors, TMF) was discussed, in addition to an overview of observed concentrations in fish against environmental quality standards (EQS).

Contamination is discussed based on concentrations in biota tissues 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 selected species have been studied for several years, such as for mercury (Hg) and PBDEs. For other contaminant groups, i.e. emerging contaminants, such as siloxanes, PFAS, organic phosphorus flame retardants (oPFR) and phenols, different target tissues have been studied to find the tissue with higher detection frequency. This means that the time series for some of the contaminants are longer and more detailed than for others.

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., 2017) with some additional lakes studied in specific years. In 2020 the main sampling program consisted of biota samples from five trophic levels in Lake Mjøsa and the top predator, brown trout, collected from the pristine Lake Femunden (Figure 1). Table 1 lists some of the main properties of the two lakes studied in 2020. The main sampling sites are indicated in Figure 2. 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
Potential anthropogenic impacts	5 urban areas, major roads, (old) industry, 3 major wastewater treatment plants (WWTPs), agriculture, LRTAP*	Minimal. Some cabins, minor roads and small settlements. LRTAP

*Long-range transboundary air pollution

1.2.1 Lake Mjøsa

Lake Mjøsa is the largest lake in Norway. It is a deep fjord lake (down to 450 meters below surface) carved out from the erosion of several glacial periods. Situated in the southeastern part of Norway,

see Figure 2, Lake Mjøsa spans between the city of Lillehammer in the north to Minnesund in the south, covering a surface area of 369 km^2 and a total catchment area of 17000 km^2. The potential environmental impact on Lake Mjøsa is caused by several local, anthropogenic sources of contamination such as stormwater runoff from major roads, industrial discharges, urban stormwater (five cities located at the lake shore), 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 Lake Mjøsa from the large catchment area. Theoretical mean residence time is 4.9 years.

1.2.2 Lake Femunden

Lake Femunden is the third largest lake in Norway. Contrary to Lake Mjøsa, it is situated in a forest and mountain catchment area. The area of the lake is 1 700 km^2. It is characterized as a low productive oligotrophic lake with no artificial regulation and with limited anthropogenic impacts from small settlements, cabins, hikers and some minor roads in addition to potential LRTAP. 62 % of the catchment area consist of bare mountain, whereas 26 % is forests, 12 % water bodies and only 0.2 % agriculture. To our knowledge, the main environmental impact must come from long-range transported air pollution. 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 climate in this area is dry (annual precipitation in southern end of the lake is 570 mm), but with large differences in temperature between seasons. Femunden as a lake is stretched, approx. 60 km long and 10 km wide (widest area). The lake is 90 m deep in the northern part and 150 m deep in the southern end. Riverine inputs peak in the snow melting season in May/June with a mean discharge of 12-16 L s^{-1} km^{-2}. Theoretical mean residence time is 7.6 years.

Figure 1. Lake Femunden resides in pristine areas dominated by mountains and forests (Photo: Morten Jartun).

Table 2. Sampling stations with coordinates in UTM33N. Sample sizes (in g for zooplankton and *Mysis*; individuals for fish) are given in brackets.

Lake	Parameters	N samples	Stations	UTM33 (EUREF89)		Depth
				N	E	m
Mjøsa	Zooplankton	3 (50 g)	South/east of Helgøya	6735833	283365	0-10
	Mysis	3 (100 g)	South/east of Helgøya	6735833	283365	70-110
	E. smelt	10 (100 ind.)	East of Helgøya	6738520	285438	30-50
	Vendace	10 (25 ind.)	North of Gjøvik	6749473	265847	10-50
	Brown trout	15	North of Gjøvik	6749473	265847	10-50
Femunden	Brown trout	10	Area of Elgå	6898700	338500	10-30

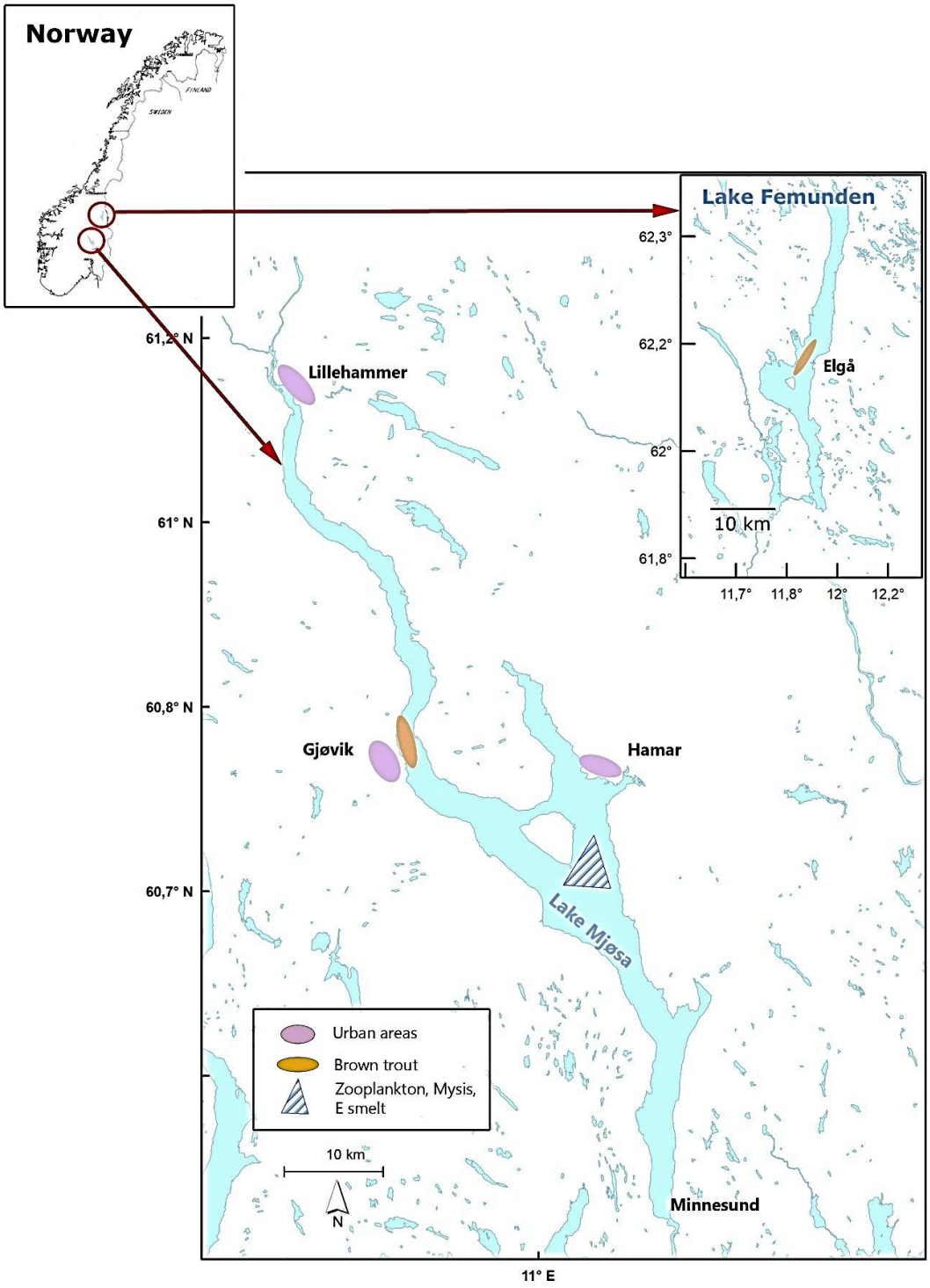

Figure 2. Map of Lakes Mjøsa and Femunden with the main sampling areas for zooplankton, *Mysis* and fish in Lake Mjøsa, and for fish in Lake Femunden.

1.2.3 Food webs of Lakes Mjøsa and Femunden

The (pelagic) food webs established within the two lakes are quite 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 popular for recreational fishing. These species interact in two relatively distinct food webs; the pelagic, open water food web and the food web in the littoral/profundal zone. In Lake Mjøsa the pelagic food web has been well defined and studied over several years (Spikkeland et al., 2016; Sandlund et al., 2017; Fjeld et al., 2017), and has contained the preferred sampling material in this monitoring program between 2017 – 2020. However, the pelagic food web is linked to the more indigenous species in the littoral zone as described in Figure 3.

On the lower trophic level there is a large variation of zooplankton populations, some being true primary consumers such as *Daphnia* and some are being omnivorous and potentially on a higher trophic level such as *Limnocalanus macrurus*. The crustacean *Mysis* is an important part of the pelagic food web, as it feeds on zooplankton, and is an important prey for European smelt (*Osmerus eperlanus*). European 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 addition, vendace (*Coregonus albula*) is a part of this food web as a central planktivore species. The biodiversity of Lake Mjøsa is high which causes the top-predator brown trout and European smelt to be at a higher trophic level in this lake compared to similar lakes in Norway.

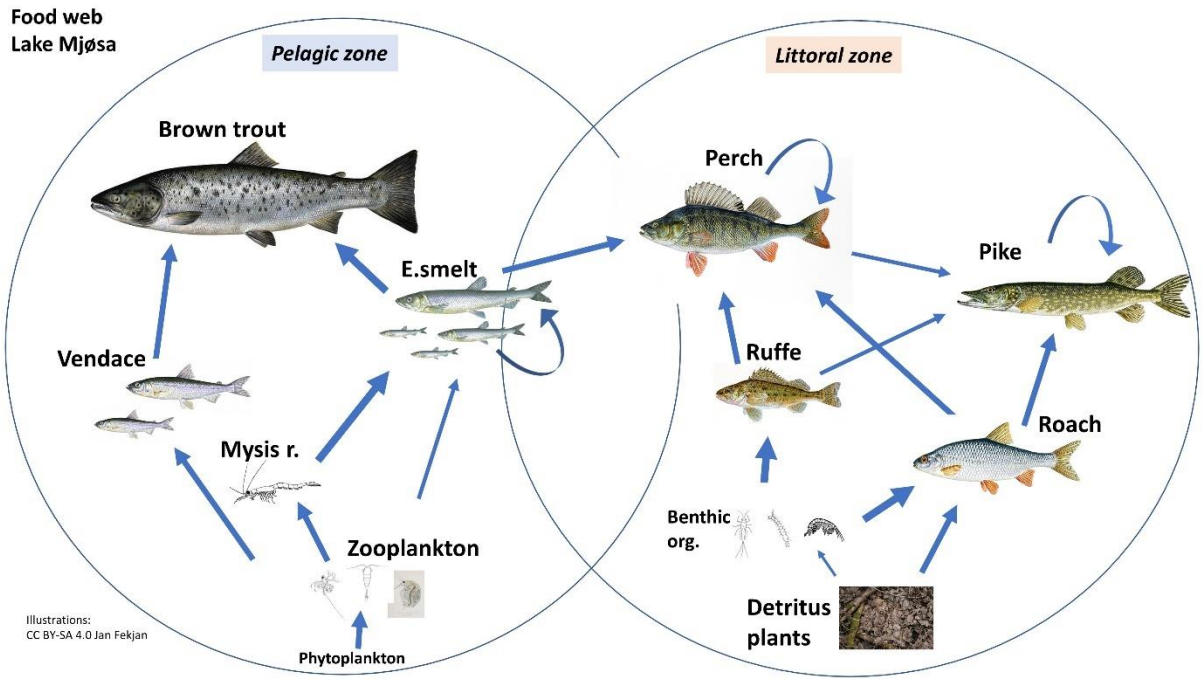

Figure 3. Illustration of the pelagic and littoral food web of Lake Mjøsa sampled in this study. Thickness of arrows indicate main prey, i.e. a thicker arrow means major food source.

Samples of brown trout from Lake Femunden were also studied. The ecosystem in Femunden consist of eight species of fish including brown trout, European whitefish (*Coregonus lavaretus*) and Arctic char (*Salvelinus alpinus*), Figure 4. European 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 organisms, such as insects. For brown trout in Lake Femunden to become large, they need to be opportunistic and undergo changes in diet with increasing prey size (Næsje et al., 1996). The size of European whitefish population will have a relatively large impact on the production of large brown trout in Lake Femunden.

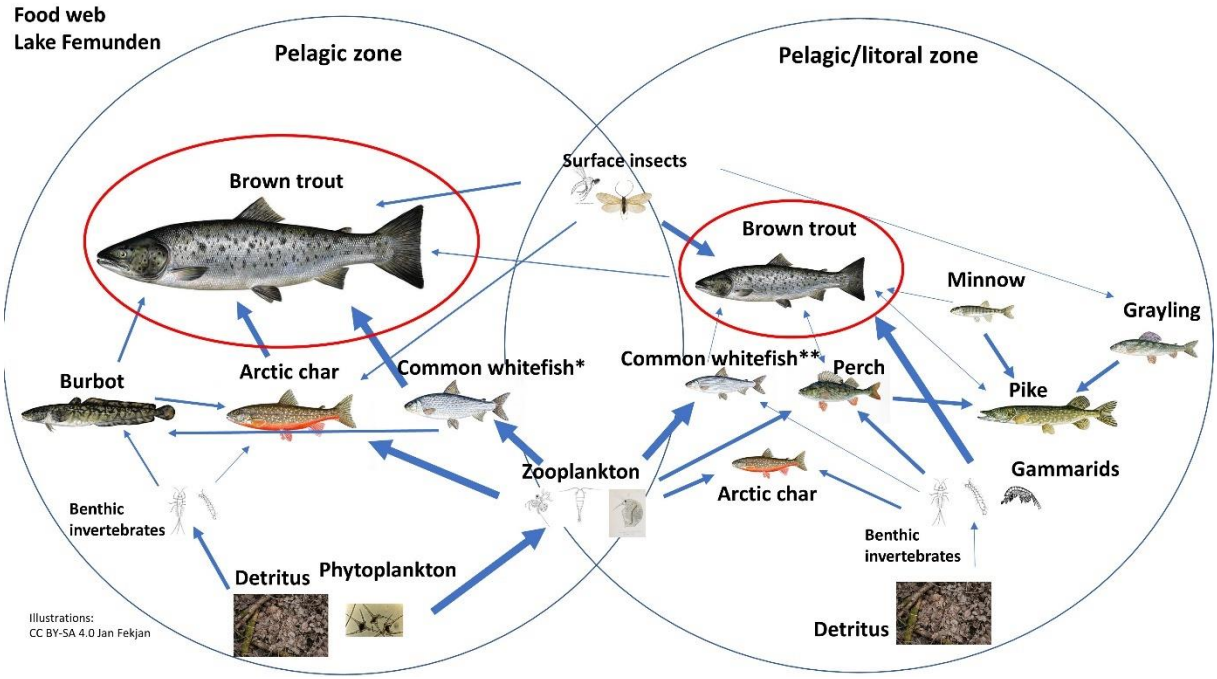

Figure 4. Illustration of the pelagic and littoral food webs of Lake Femunden, indicating the potential main prey of brown trout (only species sampled in this lake, marked with red circle). Thickness of arrows indicate main prey, i.e. a thicker arrow means major food source. *Pelagic population, in deep waters. **Littoral/benthic population, also in rivers.

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 (Driscoll et al., 2013; Donadt et al., 2021). Local sources such as the pulp 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 discharged to the aquatic environments mainly through wastewater (e.g. Lu et al., 2011; Huse and Aas-Aune, 2009). As the name of the contaminant group suggests, these siloxanes are volatile under normal conditions, making them susceptible to accumulation in indoor environments and air (Tran et al., 2019).

The European chemical agency (ECHA) categorizes D4 as persistent, bioaccumulative, and toxic (PBT) and very persistent very bioaccumulative (vPvB). D5 is categorized as vPvB (ECHA, 2015). Both D4 and D5 are on the REACH candidate list, and a restriction applies to wash-off cosmetic products in a concentration above 0.1 % of either substance after 31 January 2020. A proposal for a more general restriction of D4, D5 and D6 in consumer and professional products is currently pending. These siloxanes exhibit unusual physical-chemical properties in the environment being both hydrophobic and volatile. Biomagnifying properties have been demonstrated by e.g. Borgå et al. (2012a and b).

1.3.3 Brominated flame retardants (BFR); polybrominated diphenyl ethers (PBDEs)

Polybrominated diphenyl ethers (PBDE) are anthropogenic contaminants that have been 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 (Fjeld et al., 2017).

1.3.4 Per- and polyfluorinated alkyl substances (PFASs)

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, ski wax and textiles. Emissions worldwide are, and have been, substantial given the range of products for industrial and personal purposes. Several PFASs are very persistent, bioaccumulative and are reported very mobile in the environment (e.g. ECHA, 2019).

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). Both substances are listed in Stockholm Convention. Several PFASs have been included in the REACH candidate list, such as PFBS, PFHxS, PFOA, C9–C14 PFCAs and HFPO-DA). In 2020, the European Food Safety Authority (EFSA) announced a new safety threshold for tolerable weekly intake (TWI) of 4.4 ng/kg body weight for a group of main PFASs (PFOA, PFNA, PFHxS and PFOS), see EFSA Contam Panel (2020).

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

1.3.5 Alkylphenols and bisphenols

Alkylphenols (APs) are a class of endocrine disruptors (EDCs) and are the degradation products of the non-ionic surfactants alkylphenol polyethoxylates (APEs), used mainly as plasticizers in high density polyethylene (HDPE), polyethyleneterephthalate (PET) and polyvinylchloride (PVC) and in the manufacture of textiles, paper and agricultural chemical products (Sheikh et al., 2017; Salgueiro-González et al., 2015). Bisphenol-A (BPA) is considered an environmental and human EDC and is included on the REACH candidate list (ECHA, 2018a). Due to the potential impact on human health, the use of BPA in e.g. baby bottles and in thermal paper is prohibited according to EU-legislation and the use in food-packaging is restricted (EU regulation, 2018). 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.

1.3.6 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 Introduction to Environmental quality standards (EQS)

According to the Water Framework Directive, chemical status of a water body is assessed from compliance with environmental quality standards (EQS) for chemicals that are defined as priority substances and/or priority hazardous substances. Chemical status is recorded as 'good' or 'poor'. The EQS is determined based on PNEC (Predicted no-effect concentrations) values and standard toxicity tests. Depending on the amount and character of the data, the derivation of EQS is performed according to three approaches: i) the assessment factor (AF), ii) the species sensitivity distribution (SSD) and iii) the multispecies test (SCHEER, 2017). In Norway, EQS values are implemented through the Water Regulation (*vannforskriften*). In this monitoring study, only biota samples are included, however some of the contaminants are more susceptible to biomagnification (e.g. Hg, BDE-47) than others. Mercury (Hg) is a contaminant which tends to biomagnify (as me-Hg) 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-values for bioaccumulating compounds, such as e.g. Hg and PBDEs (ΣBDE_6), in biota are derived to protect predators (in this study pelagic brown trout from Lake Mjøsa and Femunden) from secondary poisoning.

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, in addition to the siloxane D5. Due to limited detections in muscle in previous years, phenolic compounds such as bisphenol A, TBBPA (tetrabromobisphenol A) and octyl- and

nonylphenol were determined in both muscle and bile for the 2020 samples. PFOS and PFOA are determined in liver, which is the preferred matrix for freshwater fish when comparing concentrations to EQS (Direktoratsgruppen vanndirektivet, 2018).

2 Methods

2.1 Sampling of fish and zooplankton

All biological materials in the project were collected and processed according to the stringent procedures of the Norwegian Environmental Specimen Bank for freshwater fish (Miljøprøvebanken, 2015). In this procedure several mandatory actions are implemented for the field personnel in order to avoid potential cross-contamination of the samples from equipment and ambient air. One example is that all personnel must avoid using personal care products, or only use approved products, 24 hrs 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.

2.1.1 Zooplankton and *Mysis*

Zooplankton and the planktonic opossum shrimp *Mysis* from Lake Mjøsa were sampled in August 2020 when the zooplankton population was fully developed. Sampling was performed using nets with 200 and 500 µm mesh for zooplankton and *Mysis*, respectively. Zooplankton were sampled in the epilimnetic zone (0 - 10 m) whereas *Mysis* were sampled at depths of 80-110 m during daylight as they tend to vertically migrate. Sampling area was located in the main basin of the lake east and south of Helgøya (see Figure 2). Sample equipment included a nylon mesh net equipped with a collecting cup and 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 the desired amount of 200 g material in total for the chemical analyses. Bulk samples of zooplankton were sieved in field into glass jars. Subsamples of zooplankton were extracted from the bulk mass to verify the species composition in a magnifier. Both zooplankton and *Mysis* were kept frozen (-20 °C) upon analyses.

2.1.2 Vendace, European smelt and brown trout

In normal years, the vendace population remain in deep, cold waters within Lake Mjøsa until the temperature in the main spawning river Gudbrandsdalslågen reaches the optimum temperature of approx. 7 °C in October. Then they start the journey upriver to spawn. In the previous year (2019) almost no vendace was caught in Lake Mjøsa or Gudbrandsdalslågen (Linløkken and Rukan, 2020). In 2020, the catch was better, but contained fish with a lower conditional factor (CF) than before 2019. Because of limited size of these individuals, composite samples were analyzed for vendace (2-3 individuals per sample).

European smelt (E.smelt) were caught using bottom nets in the same areas as brown trout, in the Gjøvik area. Both vendace and European smelt tend to migrate vertically in the water column within a 24-hour period to avoid predation from brown trout. 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. Brown trout were caught by local fishermen using bottom nets in an area north of Gjøvik (Figure 2). In Lake Femunden, brown trout were caught during the annual fishing for European whitefish and char (October) in the main lake basin outside Elgå.

2.1.3 Sample preparation

Sampling of zooplankton, *Mysis* and fish from Lake Mjøsa and Lake Femunden were carried out in August and September 2020. 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. 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). Otoliths were dissected from brown trout in both lakes for age analysis. For brown trout about 150 - 200 g of dorsal muscle filet was dissected out from each individual. Vendace and European smelt had an individual weight ranging from 4 – 37 g, and composite samples from an average of 2 - 5 individuals within a similar weight class had to be processed to provide enough sample for analysis (a total of 20 – 25 g). Liver samples were dissected of European smelt, vendace, and brown trout for PFAS-analysis. In 2020 we also sampled bile in brown trout from both lakes for the determination of phenolic compounds.

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 ($\delta^{15}N$) and C ($\delta^{13}C$)

Sample matrices for isotope analyses were whole body for zooplankton and *Mysis*, and muscle tissue for the fish samples. Approx. 0.5 g material was dissected and transferred to Eppendorf tubes upon analyses.

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). Samples were dried at 80 °C for 12 hours and homogenized to fine powder. Analyses were performed according to standard protocols without removing lipids and 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 helium flux inside 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

Sample matrices for Hg determination were whole body for zooplankton and *Mysis*, and muscle tissues for all fish samples.

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 used as 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-Atomic Absorption Spectrophotometry, HG-AAS), a so-called cold-vapor technique.

2.2.3 Cyclic volatile methyl siloxanes (cVMS)

Sample matrices for siloxane determination were whole body for zooplankton and *Mysis*, and muscle tissues for all fish samples.

The samples were analyzed by NILU according to methods published by Krogseth et al. (2017) and Warner et al. (2020). Field blanks for sampling of siloxanes were prepared using 2 – 3 g 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 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 determine potential contamination during sampling. 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.

Prior to extraction, the homogenized samples were added isotope labelled siloxanes. Samples were extracted using a mixture of hexane/acetonitrile (3:1) 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 acceptable 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). However, 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. Three blanks are prepared per sample batch for extraction, and LOD and LOQ is reported per batch. LOD and LOQ may therefore vary within matrices. Samples were blank corrected based on the average concentrations determined in laboratory blanks.

Siloxanes (D4, D5 and D6) were determined in a clean-room facility using GC-MS. The uncertainty was estimated to be in the range of ± 20 %.

2.2.4 Brominated flame retardants, including polybrominated diphenyl ethers (PBDEs) and new BFRs

Sample matrices for PBDE determination were whole body for zooplankton and *Mysis*, and muscle tissues for all fish samples.

PDBEs were determined by NILU, based on the methods by Bengtson Nash (2008) and described in Mariussen et al. (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 standard 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 (to remove potential interferences) down to 100 µL with addition of a recovery standard. BFR components were determined and quantified using GC/HRMS and/or GC-qTOF in electron impact modus (EI). 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.

Normally, several blinds are included in each sample batch. Low variation in blank levels are usually found for BFRs. Results are plotted in a control diagram upon quality control, used to determine LOD and LOQ for the specific analytical batch.

If the concentration of a PBDE was below 3 x blank average (i.e. below LOQ), the result was reported as "not detected", indicated with negative numbers in the raw data.

The uncertainty was estimated to be in the range of ± 35 - 50 %.

2.2.5 Alkylphenols and bisphenols

Sample matrices for alkyl- and bisphenol determination in 2020 were muscle and bile from brown trout in Lakes Mjøsa and Femunden. In 2019, bile was chosen as the preferred matrix to check for potential increased detection frequencies compared to muscle. However, concentrations of phenols in brown trout bile from 2019 was on the same level as in muscle for previous years. Bile might be a suitable matrix as the analytical method does not distinguish between original compounds and their metabolites. Jonsson et al. (2008) found the concentration of bile metabolites relatively persistent during starving condition (< 45 % decrease in 12 days). We therefore suggested that analysis of de-conjugated metabolites in fish bile could be used as a sensitive parameter to monitor alkylphenol and bisphenol exposure in fish. In samples from 2020, both muscle and bile from the same fish were the preferred target matrices.

Alkylphenols and bisphenols (octyl phenol, nonylphenol, bisphenol A, G, S, F, P, Z, TBBPA) were determined by NILU. Prior to extraction, the homogenized samples were added isotope labelled phenols, following both extraction and preconcentration. Extraction was carried out using distilled MTBE (methyl tert-butyl ether) ultrasonic bath and an orbital shaker in order to secure acceptable recovery. Clean-up was performed using an automated solid phase extraction (Freestyle SPE) unit 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.

The uncertainty was estimated to be in the range of ± 30 - 40 %.

2.2.6 Per- and polyfluorinated substances (PFASs)

Sample matrices for PFAS determination were whole body for zooplankton and *Mysis*, and liver tissue from fish. As of 2014 liver has been the preferred matrix for PFASs since a wider range of substances are detected in this blood rich organ. In 2013, the monitoring program "Contaminants in great Norwegian lakes" analyzed samples of both muscle and liver on the same individuals showing that the concentrations were significantly higher in liver (Fjeld et al., 2014). Similar analyses were performed in the project "PFAS in Tyrifjorden", where NIVA and the Norwegian geotechnical institute (NGI) studied

the PFASs fingerprint in samples of both liver and muscle in 7 different fish species (Slinde et al., 2019). Figure 5 shows higher detected concentrations and a higher number of detected target-PFASs in liver compared to fish muscle.

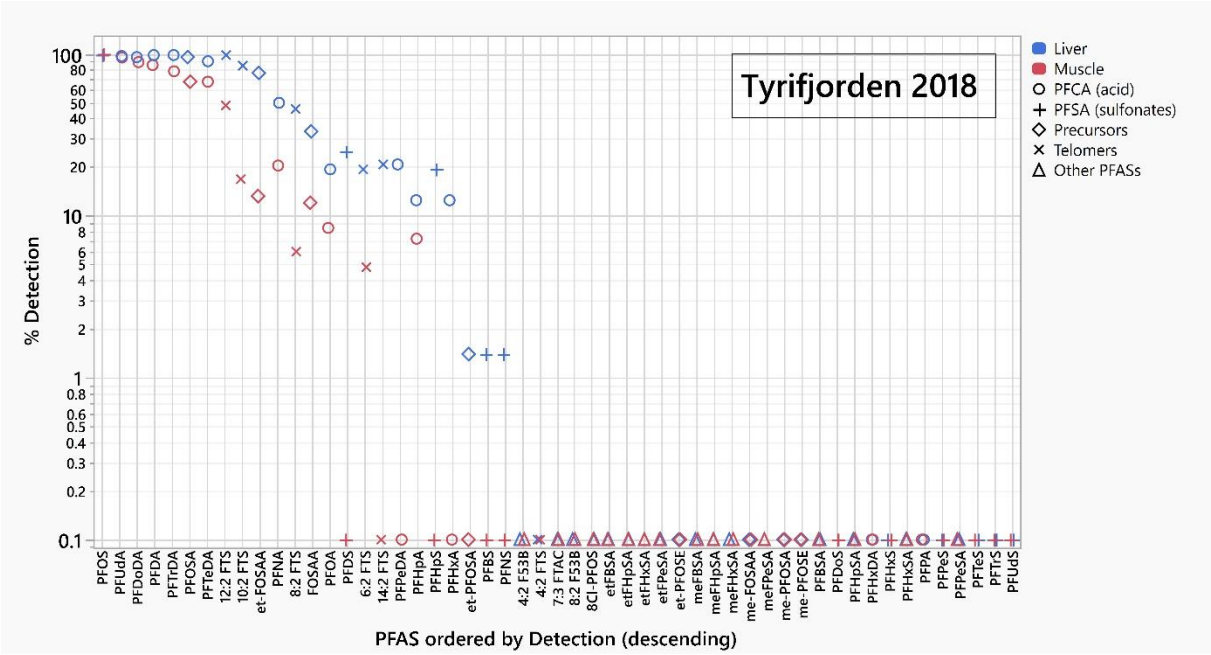

Figure 5. Overview of PFASs detections in liver (blue) and muscle (red) for target PFAS in samples of perch and trout from Lake Tyrifjorden (data from Slinde et al., 2019).

PFASs were determined by NIVA. Prior to extraction, a mixture of isotope labelled PFASs were added to the sample (~2 g), following the sequence of both extraction and preconcentration with acetonitrile. The analytical method is based on 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. PFASs were determined using a LC-qToF-MS. LOD and LOQ were calculated for each sample using 3x the signal to noise ratio (z/n) and 9x for LOD and LOQ, respectively.

2.2.7 UV-chemicals

Sample matrices for UV-chemicals were whole body for zooplankton and *Mysis* and muscle tissue in all samples of fish.

UV-chemicals (octocrylene (OC), benzophenone (BP3) and ethylhexylmethoxycinnamate (EHMC)) 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 (z/n) and 9 times z/n respectively.

2.3 Data treatment

Each sample group (e.g. vendace and brown trout from Lake Mjøsa) was analyzed in batches, with field blanks following each batch analyses. Some of the contaminants were found in relative high concentrations in the blind (blank) samples, such as for the phenolic compounds. For these specific compounds a high variation within both the blanks and the actual samples was observed. This was partially explained by the presence of unsaturated fatty acids causing difficult matrix effects, subsequently causing high LOQs. For D4 in brown trout from Lake Femunden, three blanks were analyzed, and a high variation was observed within these blanks. Subtraction of blank concentrations from the actual samples resulted in a large standard deviation and subsequent high, and variable LOQ for D4.

Statistical analyses, such as simple descriptive statistics (mean, median), linear regressions, and models, were performed using the JMP 15.0.0 software from SAS Institute Inc. Generally, a significance level of α=0.05 was used, and for some calculations data were $\log_e$(ln-)transformed.

For reported results below LOQ, half the value was chosen in statistical evaluations when approx. 50 % or more of the total N within each sample type were above LOQ for that specific compound. When a majority of results for a given compound and species are below LOQ, the value of information is reduced or limited, subsequently causing challenges when performing statistical analysis. For simple statistical calculations such as mean and range for the contaminant groups consisting of low detection frequency (<50%), half of the LOD/LOQ was used. If mean concentrations indicate a value below LOD/LOQ, the LOD/LOQ value was used in the table indicated by e.g. "*Mean: < 0.001"*.

2.4 Calculating trophic magnification factors

Correlations between contaminant concentrations and trophic position were performed on a lipid weight basis for siloxanes, Hg, BDEs and PFAS.

Trophic magnification factor (TMF) is the factor of increase in concentration of a contaminant per integer trophic level (TL) in the food web. 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 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 $\Delta^{15}N$:

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

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

3.1 Detection frequency for contaminants (2020)

Table 3 provides an overview of the entire data set from 2020, highlighting the detection frequency for each contaminant within the major groups of substances. Detection frequency is the percentage of samples for each matrix above LOQ. In their specific chapters, the total detection frequency for each contaminant within the overall monitoring program period (2017-2020) is discussed. LOQ often varies greatly also within matrices, see raw data tables in the Appendix.

Table 3. Detection frequency (%) for the contaminants in 2020 sorted in compound groups. Presented as percentage of detected results. Shading refers to 5 subclasses: white: 0-20 %, light pink: 21-40 %, pink: 41-60 %, light red: 61-80 % and red: 81-100 %. Data for mercury (Hg), cyclic volatile methylated siloxanes (cVMS), brominated flame retardants (PBDEs), per- and polyfluorinated alkyl substances (PFAS), alkyl- and bisphenols, new brominated flame retardants (nBFR) and UV-chemicals.

Class	Compound	CAS-no.	Zoopl. N=3	Mysis N=3	E.smelt N=10	Vendace N=10	Brown trout, Mjøsa N=15	Brown trout, Femunden N=10	Total set N=51
Mercury	Hg	7439-97-6	67	100	100	100	100	100	98
UV	BP3	131-57-7	0	0	0	0	0	0	0
	EHMC-Z	5466-77-3	0	0	30	0	7	0	8
	EHMC-E	5466-77-3	0	0	30	20	7	0	12
	Sum-EHMC		0	0	30	0	7	0	8
	UV-320	3846-71-7	0	0	30	70	0	0	20
	UV-326	3896-11-5	0	100	20	0	0	0	10
	UV-329	3147-75-9	0	0	0	0	0	0	0
	UV-328	25973-55-1	0	67	30	100	27	30	43
	UV-327	3864-99-1	0	0	40	100	40	0	39
	OC	6197-30-4	100	100	50	30	0	0	27
	ODPABA	58817-05-3	0	0	0	10	13	0	6
PFAS	PFPA	2706-90-3	0	0	0	0	0	0	0
	PFHxA	307-24-4	0	0	0	0	0	0	0
	PFHpA	375-85-9	0	0	0	0	0	0	0
	PFOA	335-67-1	0	0	0	0	0	0	0
	PFNA	375-95-1	0	0	100	0	100	100	69
	PFDA	335-76-2	0	0	100	30	100	100	75
	PFUnDA	2058-94-8	0	0	100	90	100	100	86
	PFDoDA	307-55-1	0	0	100	80	100	100	84
	PFTrDA	72629-94-8	0	0	100	90	100	100	86
	PFTeDA	376-06-7	0	0	80	0	100	100	65
	PFPeDA	18024-09-4	0	0	0	0	40	100	31
	PFHxDA	67905-19-5	0	0	0	0	0	0	0
	PFBS	375-73-5	0	0	0	0	0	0	0
	PFPS	2706-91-4	0	0	0	0	0	0	0
	PFHxS	355-46-4	0	0	0	0	13	0	4
	PFHpS	375-92-8	0	0	0	0	0	0	0
	PFOS	1763-23-1	0	0	100	100	100	100	88

Class	Compound	CAS-no.	Zoopl. N=3	Mysis N=3	E.smelt N=10	Vendace N=10	Brown trout, Mjøsa N=15	Brown trout, Femunden N=10	Total set N=51
	8Cl-PFOS	N/A	0	0	0	0	0	0	0
	PFNS	474511-07-4	0	0	0	0	0	0	0
	PFDS	335-77-3	0	0	0	30	20	0	12
	PFDoS	7978-39-5	0	0	0	0	0	0	0
	PFOSA	754-91-6	0	0	60	0	**100**	**90**	59
	N-MeFOSA	31506-32-8	0	0	0	0	0	0	0
	N-EtFOSA	4151-50-2	0	0	0	0	0	0	0
	N-MeFOSE	24448-09-7	0	0	0	0	0	0	0
	N-EtFOSE	1691-99-2	0	0	0	0	0	0	0
	4:2 FTS	757124-72-4	0	0	0	0	0	0	0
	6:2 FTS	27619-97-2	0	0	0	0	0	0	0
	8:2 FTS	39108-34-4	0	0	0	0	0	0	0
	10:2 FTS	120226-60-0	0	0	0	0	0	0	0
	4:2 F53B	N/A	0	0	0	0	0	0	0
	6:2 F53B	73606-19-6	0	0	0	0	0	0	0
	N-MeFOSAA	2355-31-9	0	0	0	0	0	0	0
	N-EtFOSAA	2991-50-6	0	0	0	0	0	0	0
	F53	754925-54-7	0	0	0	0	0	0	0
	7:3 FTCA	812-70-4	0	0	0	0	0	0	0
	PFBSA	30334-69-1	0	0	20	0	**100**	**100**	53
	N-MeFBSA	68298-12-4	0	0	0	0	0	0	0
	N-EtFBSA	40630-67-9	0	0	0	0	0	0	0
cVMS	D4	556-67-2	**100**	**100**	**100**	**100**	**100**	**100**	**100**
	D5	541-02-6	**100**	**100**	**100**	**100**	**100**	**100**	**100**
	D6	540-97-6	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Phenols	4,4-bis-A	80-05-7	0	0	0	0	7	0	2
	2,4-bis-A	80-05-7	0	0	0	0	0	0	0
	bis-G	127-54-8	0	0	0	0	0	0	0
	4,4-bis-S	80-09-1	0	0	0	0	0	0	0
	2,4-bis-S	80-09-1	0	0	0	0	0	0	0
	4,4-bis-F	620-92-8	0	0	0	0	20	0	6
	2,4-bis-F	620-92-8	0	0	0	0	20	0	6
	2,2-bis-F	620-92-8	0	0	0	0	7	0	2
	bis-P	2167-51-3	0	0	0	0	0	0	0
	bis-Z	843-55-0	0	0	0	0	0	0	0
	TBBPA	79-94-7	0	0	0	0	0	0	0
	4-tert-octyl-phenol	140-66-9	0	0	0	0	0	0	0
	4-octyl-phenol	1806-26-4	0	0	0	0	0	0	0
	4-nonyl-phenol	84852-15-3	0	0	0	0	0	0	0
	TBA	607-99-8	0	0	30	**90**	**87**	80	65
BDEs	17	147217-75-2	0	0	50	0	67	30	35
	28	41318-75-6	0	33	**100**	**100**	**100**	60	**82**
	47	5436-43-1	**100**	**100**	**100**	**100**	**100**	**100**	**100**
	49	243982-82-3	33	**100**	**100**	**100**	**100**	**100**	**96**
	66	189084-61-5	33	0	40	70	**100**	**100**	73
	71	189084-62-6	0	0	30	0	13	20	14
	77	93703-48-1-	0	0	40	0	**87**	50	43
	85	182346-21-0	0	0	40	0	13	20	16

Class	Compound	CAS-no.	Zoopl. N=3	Mysis N=3	E.smelt N=10	Vendace N=10	Brown trout, Mjøsa N=15	Brown trout, Femunden N=10	Total set N=51
	99	60348-60-9	**100**	**100**	**100**	**100**	**100**	**100**	**100**
	100	189084-64-8	**100**	**100**	**100**	**100**	**100**	**100**	**100**
	119	189084-66-0	0	0	50	0	**100**	**90**	57
	126	366791-32-4	0	0	40	0	**93**	30	41
	138	182677-30-1	0	0	20	0	0	10	6
	153	68631-49-2	0	33	70	**100**	**100**	**100**	**84**
	154	207122-15-4	0	**100**	**100**	**100**	**100**	**100**	**94**
	156	N/A	0	0	0	0	7	0	2
	183	207122-16-5	0	0	50	10	60	40	37
	184	117948-63-7	0	0	30	0	73	70	41
	191	189084-68-2	0	0	10	0	0	10	4
	196	446255-38-5	0	0	20	0	7	10	8
	197	117964-21-3	0	0	30	0	13	20	14
	202	67797-09-5	0	0	40	10	40	20	25
	206	63387-28-0	0	0	30	10	13	30	18
	207	437701-79-6	0	0	40	10	13	30	20
	209	1163-19-5	0	0	40	10	7	30	18
nBFRs	ATE (TBP-AE)	3278-89-5	0	0	0	0	0	0	0
	a-TBECH	3322-93-8	0	0	10	0	13	0	6
	b-TBECH	3322-93-8	0	0	0	0	0	0	0
	g/d-TBECH	3322-93-8	0	0	0	0	0	0	0
	BATE	99717-56-3	0	0	0	0	0	0	0
	PBT	87-83-2	0	0	0	0	0	0	0
	PBEB	85-22-3	0	0	0	0	0	0	0
	PBBZ	608-90-2	0	0	0	0	0	0	0
	HBB	87-82-1	0	0	0	0	0	0	0
	DPTE	35109-60-5	0	0	0	0	0	0	0
	EHTBB	183658-27-7	0	0	10	0	0	0	2
	BTBPE	37853-59-1	0	0	10	0	0	10	4
	TBPH (BEH /TBP)	26040-51-7	0	0	10	0	0	10	4
	DBDPE	84852-53-9	0	0	10	0	0	0	2

3.2 Fish morphometry, lipid-levels and food web structure

In addition to the apparent 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 upon, reflected by the $\delta^{13}C$, may also have impact on the 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 preferred feeding habitat ($\delta^{13}C$) in sampled biota for 2020 (Table 4) and for 2013-2020 (0) in order to explore the relationships between these

predictors and measured contaminant concentrations in the biota. In addition, we have added correlations matrices to explore the relationship between these environmental and morphometric predictors for contaminant variations in fish (Figure 8 and Figure 9).

Table 4. 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 2020 in Lake Mjøsa. The mean ($\bar{x}$), standard deviation (SD), and number(n) of samples are shown.

2020			Length (cm)	Weigth (g)	$\delta^{15}N$ (‰)	$\delta^{13}C$ (‰)	Lipid (%)
Species		n	$\bar{x}$ ± SD	$\bar{x}$ ± SD	$\bar{x}$ ± SD	$\bar{x}$ ± SD	$\bar{x}$ ± SD
Mjøsa	Zooplankton epi.	3	-	-	6.8 ± 0.3	-29.2 ± 0.1	0.4 ± 0.1
	Mysis	3	-	-	9.9 ± 0.1	-30.7 ± 0.5	2.0 ± 1.1
	Vendace	5	16.1 ± 0.6	30.7 ± 1.9	12.3 ± 0.3	-28.5 ± 0.3	2.3 ± 0.4
	E. smelt	10	13.7 ± 3.4	18.1 ± 11.8	14.3 ± 0.5	-27.3 ± 0.7	1.1 ± 0.4
	Brown trout	15	68.0 ± 7.1	3557 ± 1728	16.0 ± 0.6	-27.2 ± 1.3	2.8 ± 2.2
Femunden	Brown trout	10	40.0 ± 3.9	619 ± 241	10.7 ± 0.4	-24.3 ± 1.3	1.1 ± 0.8

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 2013-2019 in Lake Mjøsa. The mean ($\bar{x}$), standard deviation (SD), and number(n) of samples are shown.

2013-2020			Length (cm)	Weigth (g)	$\delta^{15}N$ (‰)	$\delta^{13}C$ (‰)	Lipid (%)
Species		n	$\bar{x}$ ± SD	$\bar{x}$ ± SD	$\bar{x}$ ± SD	$\bar{x}$ ± SD	$\bar{x}$ ± SD
Mjøsa	Zooplankton epi.	18			6.9 ± 1.1	-28.6 ± 1.3	0.3 ± 0.2
	Zooplankton hypo.	6			12.2 ± 1.1	- 32.6 ± 1.1	4.7 ± 2.5
	Mysis	20			10.4 ± 0.9	-30.6 ± 1.3	2.8 ± 1.2
	Vendace	47	18.7 ± 2.2	52.9 ± 26.9	13.1 ± 0.9	-29.2 ± 1.1	2.9 ± 1.3
	E. smelt	88	15.3 ± 5.0	32.0 ± 30.5	14.8 ± 0.9	-27.9 ± 0.9	1.2 ± 0.6
	Brown trout	119	67.1 ± 9.5	3773 ± 1863	15.7 ± 0.5	-28.0 ± 1.2	2.9 ± 1.9
Femunden	Brown trout	100	41.5 ± 4.4	767 ± 229	9.8 ± 1.2	-23.0 ± 2.2	1.0 ± 0.7

Mean length of brown trout from Lake Mjøsa sampled from 2013 to 2020 was 67.1 cm and mean weight 4.3 kg, while for brown trout sampled from Lake Femunden the mean length and weight was 41.5 cm and 0.77 kg, respectively. Lake Mjøsa has a denser population of large trout than Lake Femunden (Kraabøl et al., 2009; Sandlund et al., 2012), which evidently affects the sample selection. As is evident from the scatterplot (Figure 6), 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 (Table 4 and 0). A likely explanation for this difference in mean lipid concentration, is that some of the zooplankton species in the lower part of the food chain in Lake Mjøsa, such as the lipid rich *Limnocalanus macrurus* (Dahlgren et al., 2012) and the planktonic crustacean *Mysis relicta*, is not present in Lake Femunden (https://artskart.artsdatabanken.no/). Mean %-lipid content in Vendace caught in 2019 was around half of what has been recorded in previous years (Table 4 and 0). This was likely explained by the batch consisting of fish caught during spawning migration, i.e. with lowered condition factor and depleted lipid-levels. It appears that the Vendace caught in 2020 are closer to previous years, with both a more pelagic signature ($\delta^{13}C$), as well as a higher lipid content than in 2019.

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 15.7 ‰ in brown trout in the sampled material

from 2013 to 2020 (0). This translates into~ 2.6 trophic levels given the 3.4 ‰ increase per trophic level. A typical pelagic food chain in Lake Mjøsa, leading up to brown trout as the top predator, consist of epipelagic zooplankton as primary consumers of phytoplankton, via either predatory cladocerans and/or *Mysis*, which are again eaten by smaller fish species such as Vendace and or E. smelt (Figure 7). This is a simplified food chain as there likely is a large degree of omnivory along the food chain. For example, some of the pelagic copepod species are opportunistic omnivores, such as the large-bodied copepod *L. macrurus*, which may also periodically display predacious behavior (Warren, 1985). The sample of hypolimnetic zooplankton in 2018, which consisted of mainly *L. macrurus* (~δ^{15}N of 13.15 ‰) suggested a high degree of predatory within the zooplankton samples this year (Jartun et al., 2019). There may also be some enrichment to the δ^{15}N of the potential food sources (i.e. increased baseline δ^{15}N) for hypolimnetic zooplankton, such as in decaying and settling phytoplankton and/or particulate organic matter (POM) from allochthonous origins mediated via microbial links (Grey et al., 2001), as well as the infusion of δ^{15}N -enriched pool of inorganic N available for uptake by primary producers during mixing periods (Vander Zanden and Rasmussen, 1999; Post, 2002).

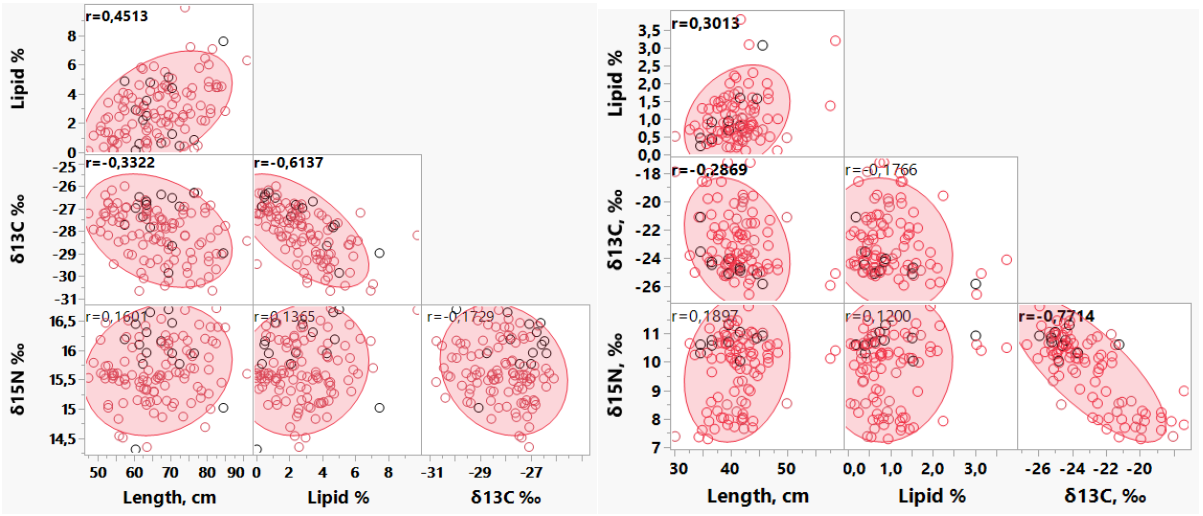

Figure 6. Correlation matrices between stable N- and C-isotopes (δ^{15}N, δ^{13}C), length and lipid content in brown trout from Lake Mjøsa (left) and Lake Femunden (right) sampled from 2013 to 2020 (trout from 2020 in black). 90 % confidence elipses are shown for each pair of correlations.

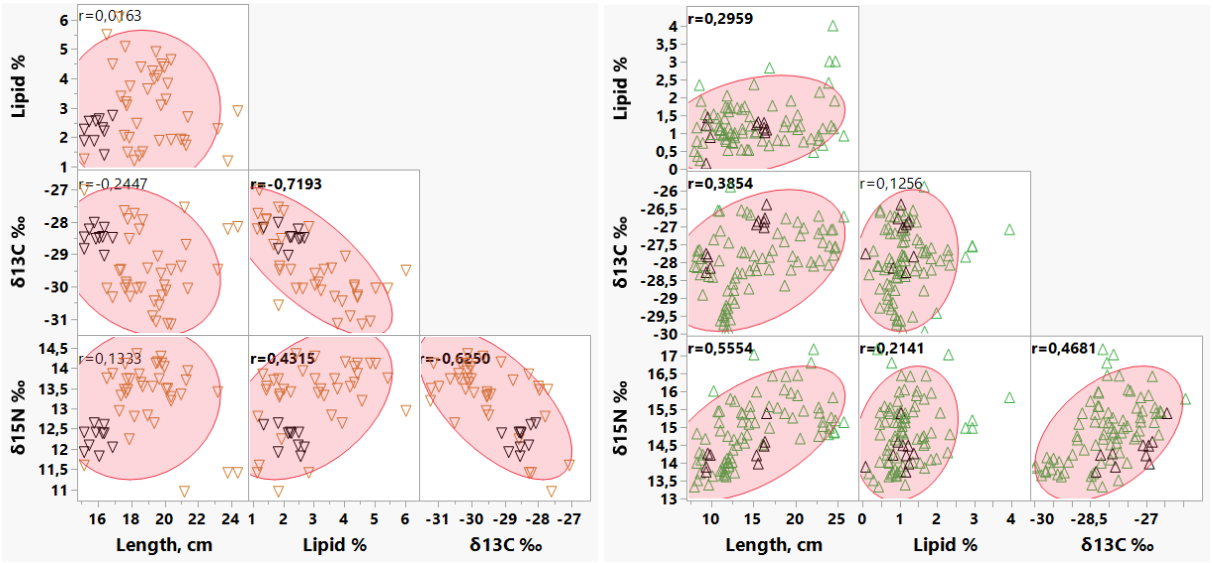

Figure 7. Correlation matrices between stable N- and C-isotopes ($\delta^{15}N$, $\delta^{13}C$), length and lipid content in vendace (left) and E. smelt (right) from Lake Mjøsa sampled from 2013 to 2020 (fish from 2020 in black). 90 % confidence elipses are shown for each pair of correlations.

True planktonic primary consumers of Lake Mjøsa, on the other hand, is expected to have a $\delta^{15}N$ ~6 ‰ (Fjeld et al., 2017), however, as observed by Fjeld et al. (2016), primary consumer epipelagic zooplankton in Mjøsa vary between $\delta^{15}N$ 4.63 and 8.43 ‰ (Figure 8). Annual variations may occur due to differences in nitrogen sources and accordingly baseline $\delta^{15}N$ (Vander Zanden and Rasmussen, 1999). Increasing C:N ratio, i.e. decreasing nitrogen content relative to carbon, in phytoplankton has also been found to increase the $\delta^{15}N$ in grazing primary consumer zooplankton *Daphnia magna* (Adams and Sterner, 2000). This also corresponds with a significant positive relationship between C:N ratios and $\delta^{15}N$ in epipelagic zooplankton ($\delta^{15}N$ ‰ = 3.14 + 0.93*C:N, R^2 = 0.45, p = 0.02), with significant variations in $\delta^{15}N$ ‰ among some years (Tukey-Kramer HSD, $p < 0.05$). Seasonal variations in $\delta^{15}N$ in phytoplankton was reported to vary less in phytoplankton, main food source to epipelagic zooplankton during summer (June-August), than POM in Lake Loch Ness, Scotland (Grey et al., 2001). A recent in-depth analysis of the zooplankton community structure in Lake Mjøsa (Duinmejer, 2020), however, show rather large seasonal $\delta^{15}N$ variations in the epipelagic daphnids *Daphnia galeata* and *Daphnia cristata.* Both species ranged in $\delta^{15}N$ signatures from ~ 6 ‰ in July and August to ~ 10 ‰ in September. Although there are seasonal as well as significant annual variations in $\delta^{15}N$ ‰ in the lower trophic levels (Tukey-Kramer HSD, $p < 0.05$), year to year variations decreases up the food-chain (Figure 9).

Mysis, an important food source for several species of fish, appears from its isotopic composition (Figure 8 and Figure 9, see also below regarding $\delta^{13}C$) to rely mainly on a diet of epipelagic planktonic primary consumers, i.e. Daphnia spp. and Bosmina spp. (Kjellberg et al., 1991), but also to some degree on deep water omnivorous plankton species (copepods). Difference in trophic level between sampled brown trout and E. smelt has been quite low some previous years which could be explained by the inclusion of some large, cannibalistic individuals up to 113 g in the sample batch of E. smelt. In 2019 the difference in mean was $\delta^{15}N$ was only 0.5 ‰. However, in 2020, all sampled E. smelt was rather small (mean 18.1 g) and the difference in mean $\delta^{15}N$ signatures for trout and E. smelt is increased to 1.7 ‰. Nevertheless, in 2020, as in previous years $\delta^{15}N$ for E. smelt increases with length, indicating a

shift in diet with increasing size (Figure 7, right). For the trout there is less variation in trophic level ($\delta^{15}N$ -values) within the sampled length range, 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 small sized 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 (15.7 ‰) compared to the trout from Lake Femunden (9.8 ‰).

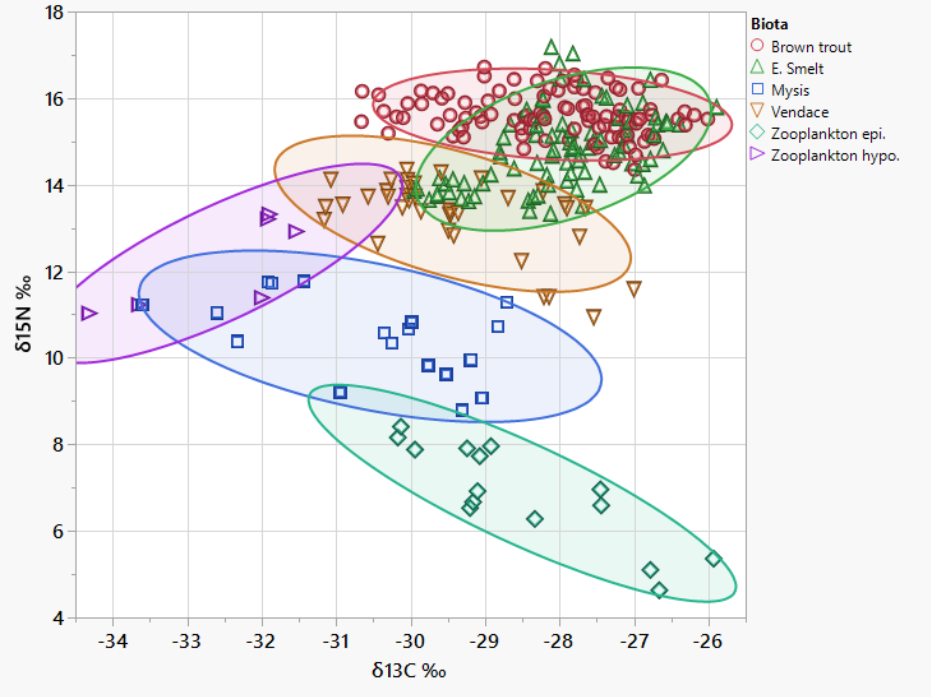

Figure 8. Relationships between measured $\delta^{15}N$ and $\delta^{13}C$ ‰ in biota sampled in Lake Mjøsa from 2013 to 2020. Zooplankton sampled from the upper strata (down to ~ 10 m) of the lake are defined as epilimnetic zooplankton (Zooplankton epi.), while zooplankton sampled from the deeper parts of the lake (50-80 m) are defined as hypolimnetic zooplankton (Zooplankton hypo.).

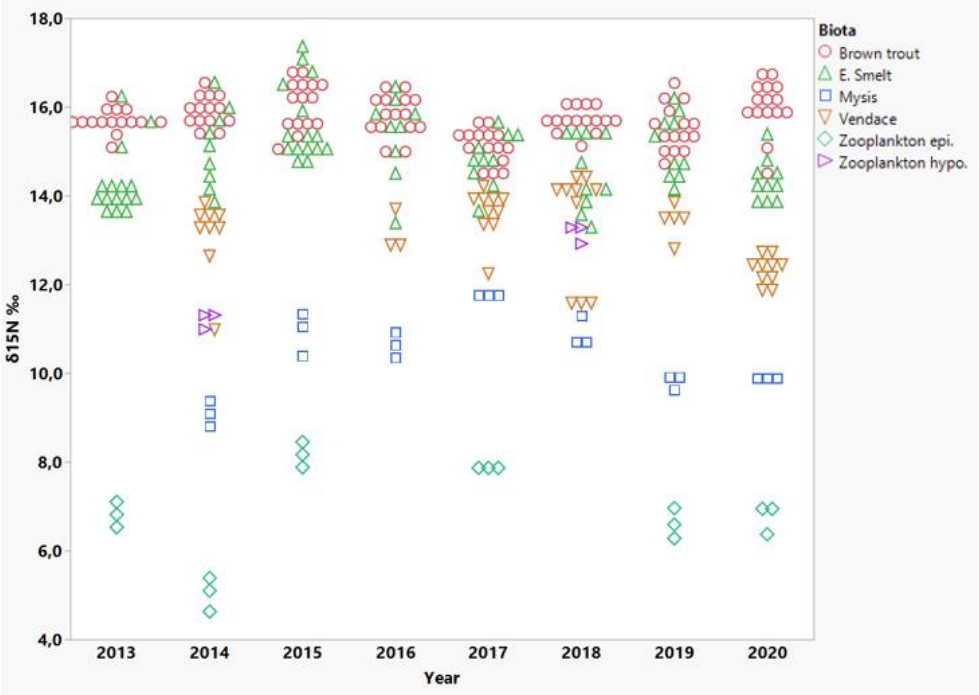

Figure 9. Year to year variations in measured $\delta^{15}N$ in sampled biota groups in Lake Mjøsa from 2013 to 2020. Zooplankton sampled from the upper strata (down to ~ 10 m) of the lake are defined as epilimnetic zooplankton (Zooplankton epi.), while zooplankton sampled from the deeper parts of the lake (50-80 m) are defined as hypolimnetic zooplankton (Zooplankton hypo.).

$\delta^{13}C$ 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 8). As Lake Mjøsa is a large lake, and pelagic food webs are predominantly dependent on the primary production in phytoplankton, and likely to a lesser degree on allochthonous material (Post, 2002), this is reflected in an overall pelagic signature in sampled biota. As zooplankton reflects the isotopic signature of their food, e.g. in phytoplankton, mechanisms governing isotopic ratios of ^{13}C to ^{12}C in dissolved inorganic carbon (DIC) affects $\delta^{13}C$ signature in phytoplankton. Indeed, observed fluctuations in the $\delta^{13}C$ of phytoplankton have been found to correspond with $\delta^{13}C$ in DIC (Grey et al., 2001). In general, increased productivity results in increased $\delta^{13}C$ in DIC (Herczeg, 1987; Hollander and McKenzie, 1991; Wang and Veizer, 2000), whereas respiration has been considered to be the reason for declining $\delta^{13}C$ (more depleted), particularly in hypolimnetic waters during stratification (Quay et al., 1986; Miyajima et al., 1997). Significant differences in mean $\delta^{13}C$ (from- 26.5 to - 30.8 ‰) among years in sampled epipelagic zooplankton in Lake Mjøsa (Tukey-Kramer HSD, $p < 0.05$), may therefore be explained by variations in DIC $\delta^{13}C$, available for assimilation by phytoplankton, related to variations in production rates, and/or upwelling of water from hypolimnion with depleted $\delta^{13}C$ as a result of respiration. Lake Mjøsa is a well-mixed lake, especially in the main basin south-east of the Helgøya island (where annual samples are made), with a relatively deep and weakly developed thermocline during the summer, and therefore prone to mixing with colder underlying water during periods of strong winds (Lyche-Solheim et al., 2018). Most likely, the $\delta^{13}C$ in epipelagic zooplankton may vary between periods of wind induced mixing of epilimnion with deeper water and periods with more stagnant water and a more pronounced and stable epilimnion. Given that the isotopic turnover, or half-life of the isotopic signature of

epipelagic zooplankton such as adult daphnids is ~15 days (Vander Zanden et al., 2015), a shift to either a more enriched or a more depleted $\delta^{13}C$ may follow after longer periods of strong winds or stagnation. In 2020 more than 90 % of each of the three samples of epipelagic zooplankton consisted of *D.cristata* and *D.galeata* with the latter dominating the sample. This is reflected in a rather low $\delta^{15}N$, i.e. trophic level. The $\delta^{13}C$ in the epipelagic zooplankton sample was more depleted (mean $\delta^{13}C$ = -29.2 ‰) than in 2019 (-27.4 ‰), suggesting more upwelling of water from hypolimnion of DIC with depleted $\delta^{13}C$ in 2020.

Allochthonous matter may incorporate a considerable part of the diet in some zooplankton species in Lake Mjøsa such as in the abundant copepod *Eudiaptomus gracilis*, as were reported in Loch Ness (Grey et al., 2001). During the winter months and early spring, before the growth season, copepods are more dependent on POM originating from allochthonous sources, which again should affect the isotopic signature in planktivorous fish during this period. However, epipelagic zooplankton such as daphnids are present in samples 0 - 50 meters, mainly in the period June-September (Lyche-Solheim et al., 2019), and are likely a significant food source at the base of the pelagic food chain during summer months. It is therefore expected that this would have contributed significantly to the $\delta^{13}C$ in the sampled fish in our study, in the smaller fish such as E. smelt and Vendace caught in the autumn. Isotopic turnover (half-life) in smaller fish (20 - 30 g) may be about 2 months (Weidel et al., 2011), i.e. a change in diet (isotopic signature in dietary items) will influence the signature of the predator after more than two months upon shift of the diet. In large fish such as the trout in this study, may have an isotopic half-life of over 1 year, or even longer in slow growing fish (Hesslein et al. 1993), although many estimates on larger fishes are poorly constrained (Weidel et al., 2011). This means that the isotopic signature in large trout reflects a diet integrated over a longer period and therefore to a lesser degree vary among years due to variations at lower trophic levels, as also discussed above regarding seasonal and annual variations in $\delta^{15}N$.

Data on trout from Lake Mjøsa indicate that size increases with a more pelagic diet, as shown by the negative correlation between length and $\delta^{13}C$ (Figure 6). This reflects an overall pelagic piscivore diet in large trout. The annual mean $\delta^{13}C$ values for E. smelt from 2013 to 2019, adjusted for year to year variations in length, appears to be increasingly influenced by more enriched carbon sources (Figure 10).

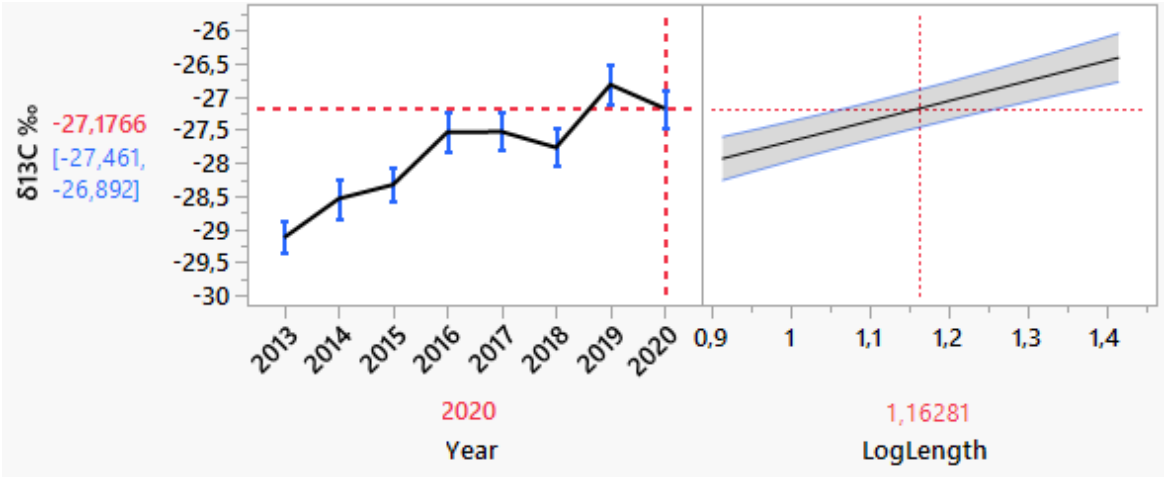

Figure 10. Length adjusted $\delta^{13}C$ ‰ (with 95 % confidence intervals) in E. smelt from Lake Mjøsa 2013-2020. Mean $\delta^{13}C$ ‰ for 2020 marked in red with min and max 95 % confidence limits in blue (beside the y-axis to the left) E. smelt are adjusted to the geometric average length (14.5 cm) in the dataset. The figure to the right shows the variation in $\delta^{13}C$ ‰ with length for the last year in the analysis, 2020. Note that the figure to the right has the same y-axis unit as the figure to the left.

This may be explained by either variation in the baseline $\delta^{13}C$ in phytoplankton, following changes in DIC $\delta^{13}C$, or possibly increased reliance on terrestrial and or littoral derived carbon sources. However, in order to establish a more reliable hypothesis, more research on both isotopic signatures in both phytoplankton and catchment derived allochthonous matter, as well as analysis of stomach sample and isotopic signatures of E. smelt food items, would be pertinent. The relatively strong 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 6, right). This may reflect variations in feeding strategies in the population, or also an ontogenetic niche shift from a predominantly 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.

3.3 Overview of main results

Figure 11 provide an overview of the combined impact from the contaminant groups studied in this monitoring survey of biota from Lakes Mjøsa and Femunden. Based on concentration means (ng/g w.w.), mercury (Hg) dominates in all sample types. Siloxanes seem to dominate over BDEs, other BFRs, and UV-chemicals. For PFAS, concentrations are slightly higher in liver compared to gonads in brown trout from both lakes.

Phenolic compounds, especially the bis-F analogues, were detected in high concentrations in brown trout bile from Lake Femunden. This is not previously observed in this sample type, and results must be used with caution, see also chapter 2.3.

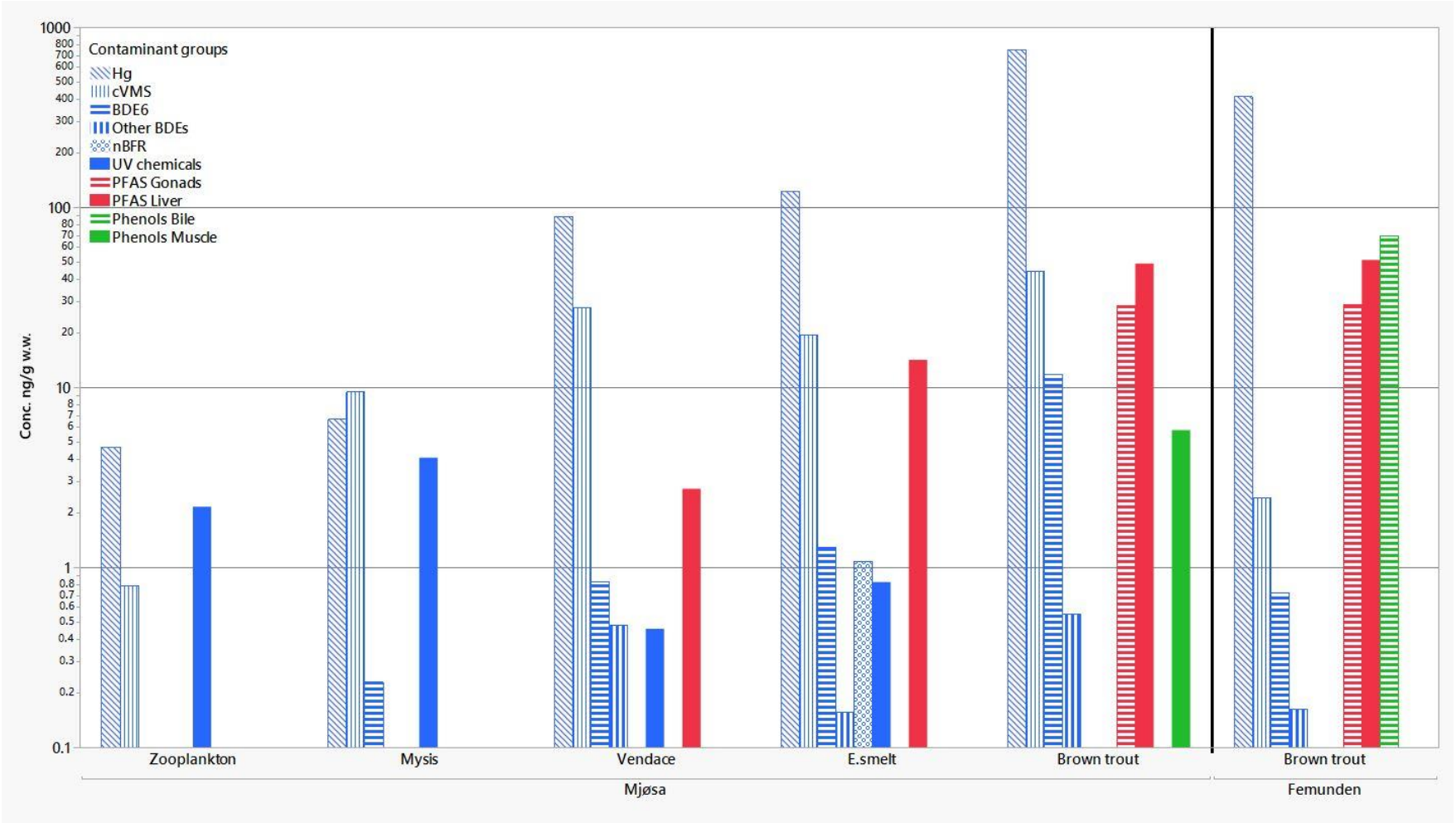

Figure 11. Overview of barplots with sum of all mean concentrations (ng/g w.w.) per contaminant group in all biota matrices collected in Lakes Mjøsa and Femunden in 2020. Blue color: wholebody (Zooplankton and Mysis) and muscle tissue (fish). Red color: PFAS in gonads and liver (fish). Green color: Phenols in bile and muscle (only brown trout).

3.4 Contaminant levels compared to EQS

Table 6 lists the contaminants with EQSs in the monitoring program for Lake Mjøsa and Lake Femunden and the concentrations detected in fish (biota) samples. EQS 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 more detail in their respective chapter. Notice that the concentrations are given as *µg/kg* in the EQS table (Direktoratsgruppen vanndirektivet, 2018) and in Table 6, which corresponds to *ng/g* used throughout the rest of the report. In this table we have included the compiled results from the entire monitoring period 2017-2020.

Comparing the concentrations of compounds found in the top predator brown trout in both lakes with their specified EQS, we see that the EQSs for PBDEs (ΣBDE_6=0.0085 µg/kg) and Hg (20 µg/kg) are exceeded for all samples. This is in compliance with previous years, see discussions in respective result chapters. For PFOS, 7 out of 15 samples of brown trout in Lake Mjøsa exceeds the EQS (9.1 µg/kg) in 2020, or 20 out of 60 samples totally for 2017-2020. Mean concentrations of PFOS in brown trout from Lake Mjøsa for 2020 and 2017-2020 are 9.1 and 7.8 µg/kg, respectively.

The rest of the brown trout samples have concentrations of the specific compounds listed in the Water framework directive (Direktoratsgruppen vanndirektivet, 2018) below their respective EQS.

Table 6. EQS in biota (Direktoratsgruppen vanndirektivet, 2018) compared to results from Lakes Mjøsa and Femunden for the contaminants that fall under the WFD in the years 2017-2020. Last column lists the number of samples (n) in total and above the EQS value. Results (Lake, concentration ranges and N) above EQS are all 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) in Lakes Mjøsa and Femunden 2017-2020			
Contaminant	**EQS_{biota}**	**Concentration range (min- max) for brown trout**		**n > EQS**
	µg/kg w.w.	*µg/kg w.w.*		*N out of total samples*
PBDEs (ΣBDE_6)*	0.0085	**Mjøsa**	**1.6 – 27**	**60/60**
		Femunden	**0.11 – 2.5**	**40/40**
PFOS	9.1	**Mjøsa**	**0.9 – 19.9**	**20/60**
		Femunden	0.4 – 5.2	0/40
PFOA	91.3	< LOQ (both lakes)		0/100
Nonylphenol**	3000	< LOQ (both lakes)		0/116
Octylphenol**	0.004	< LOQ (both lakes)		0/116
cVMS (D5)	15 000	Mjøsa	2.6 – 120	0/60
		Femunden	< LOQ – 2.9	0/40
Hg	20	**Mjøsa:**	**190 - 1500**	**60/60**
		Femunden:	**25 – 960**	**40/40**

* (ΣBDE_6): BDE-28, BDE-47, BDE-99, BDE-100, BDE-153, BDE-154.

** In 2019 phenols were determined in *bile* (Brown trout), and not fish muscle (suggested as preferred matrix for EQS evaluation). In 2020, both muscle and bile were analyzed in both lakes.

3.5 Mercury (Hg)

3.5.1 Detection frequency of Hg 2017-2020

Detection frequency for Hg in samples from 2020 are listed in the compilation in Table 3. In Table 7 below we have listed the total detection frequencies for Hg in biota from the entire monitoring program (2017-2020).

Table 7. Detection frequency (%) for Hg in biota from Lakes Mjøsa and Femunden. Data from 2017-2020 presented as percentage of analytical detections. Shading refers to 5 subclasses: white: 0-20 %, light pink: 21-40 %, pink: 41-60 %, light red: 61-80 % and **red: 81-100 %**.

	2017-2020					
	Mjøsa					Femunden
	Zooplankt.on	Mysis	Vendace	E.smelt	Brown trout	Brown trout
N	*12*	*12*	*35*	*40*	*60*	*40*
	Whole body	Whole body	Muscle	Muscle	Muscle	Muscle
Hg	50	**100**	**100**	**100**	**100**	**100**

3.5.2 Predictors for variations in 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), this is particularly the case for methylated Hg, MeHg. Several studies show that Hg increases with relative trophic level (TL) in fish (McIntyre and Beauchamp, 2007; Garcia and Carignan, 2005; Cabana and Rasmussen., 1994; Vander Zanden and Rasmussen, 1996). This means that in fish at the top of the food chain, MeHg comprise 90-95 % of the total Hg (Bloom, 1992; Bjerregaard, 2005). 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).

In Lake Mjøsa, the best predictors , among the tested, for variations in Hg in brown trout is length and trophic level, with significant positive relationships, i.e. Hg increases with length and trophic position in trout from 2013 to 2020 (Figure 12). Age as a predictor was added for Hg from 2019 onwards, as we hypothesized that variations in Hg among years at a certain length may be influenced by large variations in age. As expected, age was positively correlated with length ($r = 0.6$, $p < 0,05$) in our 2019 data, but not with Hg ($r= 0.32$, $p > 0.05$). In the 2020 data there was an even weaker positive correlation ($r = 0.06$, $p > 0.05$). However, the variation in age in our collected trout from Lake Mjøsa is rather low, ranging from 7 to 13 years, and together with a low number of individuals the basis for significant statistical relationships are insufficient. However, as we noted in last year's report the condition factor (weight by length) increases with age ($r = 0.51$, $p < 0.05$) in the 2019 data. This may be explained by

increased somatic growth dilution (SGD) in some large individuals. We have therefore explored condition factor (CF) as an additional explanatory factor for variations in Hg. As can be seen from the correlation matrices, there is no significant relationship in the 2013 - 2020 data (Figure 12). However, if we expand the data back to 2006, there is a significant negative relationship between CF and Hg, with decreasing Hg with increasing CF (Figure 13). The large variations in length at a similar age in our sampled trout, likely reflects that the sampled trout are from different subpopulations with distinct differences in growth (Rustadbakken et al.,2004; Rustadbakken and Westly, 2006; Nater et al., 2018) and thus variations in SGD.

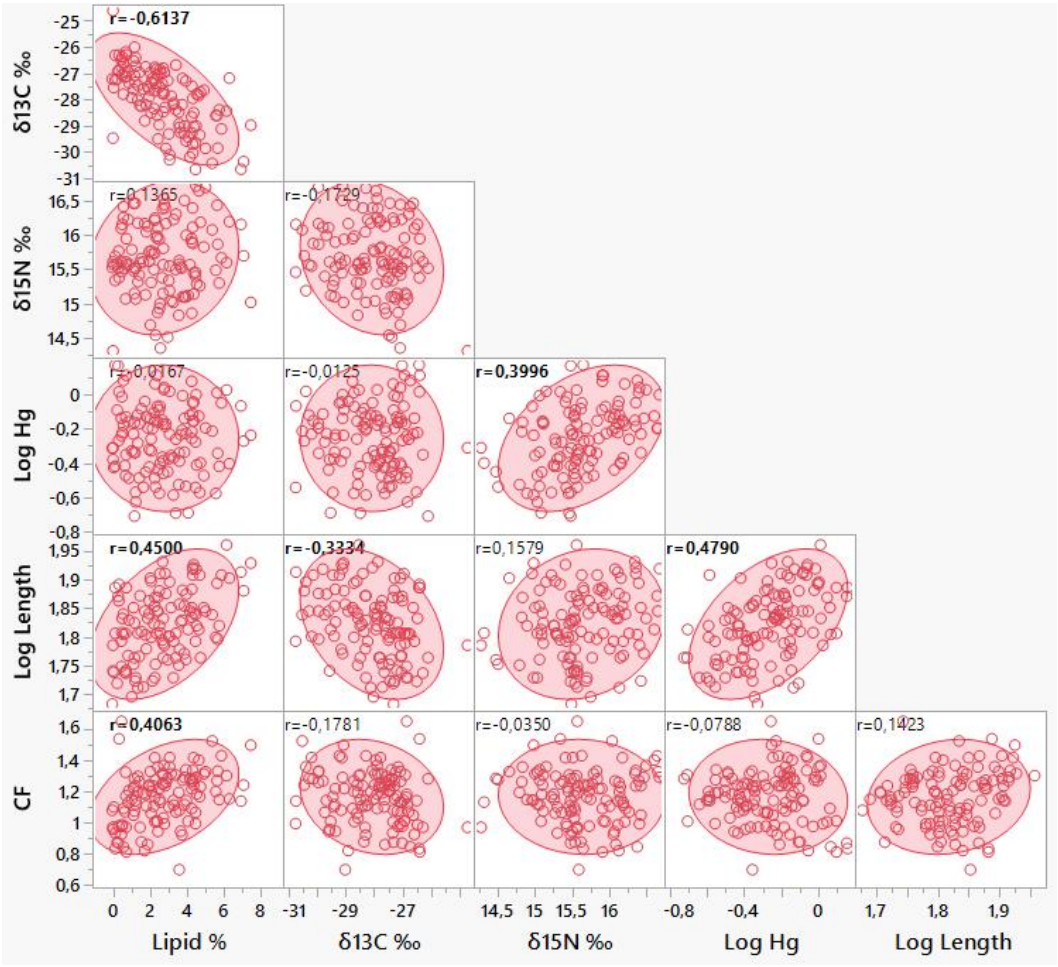

Figure 12. Correlation matrices between stable N- and C-isotopes ($\delta^{15}N$, $\delta^{13}C$), Log Length, lipid content and Log Hg in brown trout from Lake Mjøsa sampled from 2013 to 2020. 90 % confidence ellipses are shown for each pair of correlations, and correlations (Pearson's r). All correlations in bold are significant ($p < 0.05$).

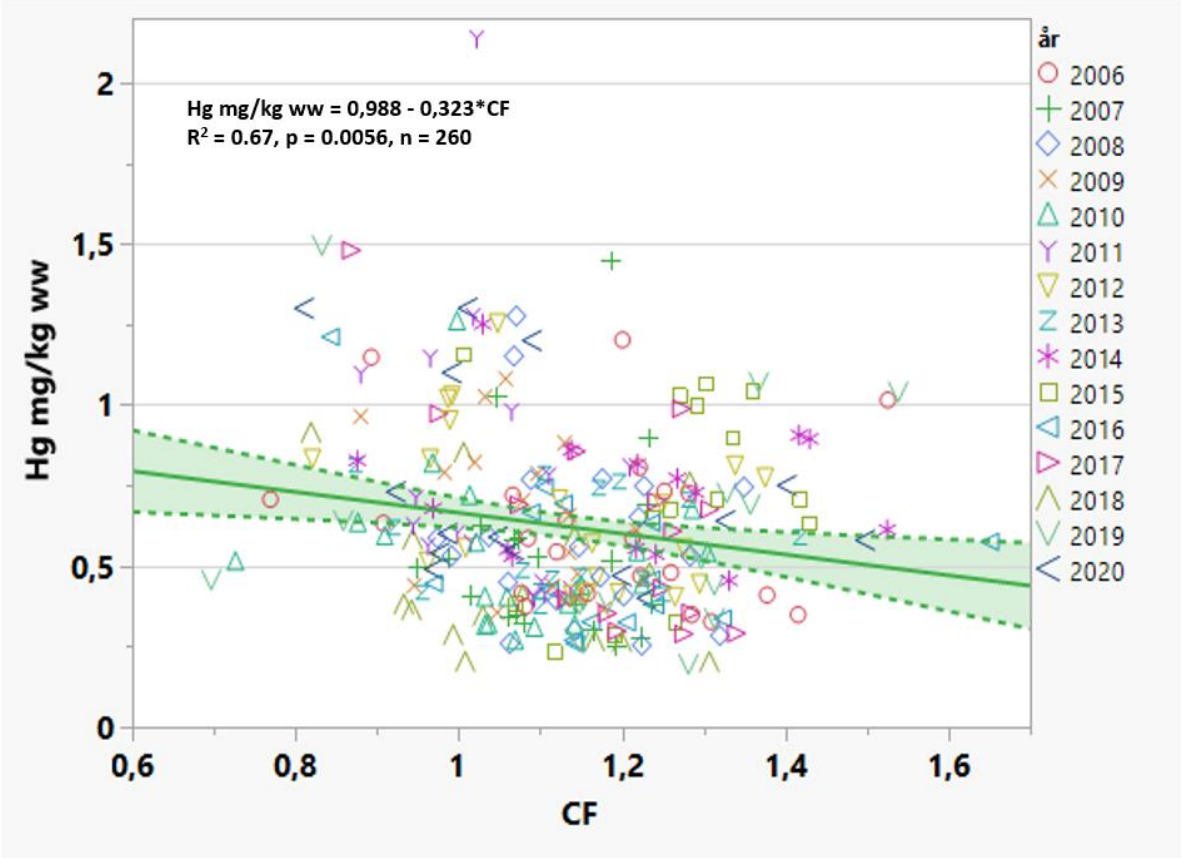

Figure 13. Regression analysis between condition factor (CF) and Hg (with 95 % confidence level) in brown trout from Lake Mjøsa sampled from 2006 to 2020.

In E.smelt the strongest predictors for variations in Hg are size (as length) and trophic level, among tested predictors, with significant increase in Hg with both predictors (Figure 14). Variations in $\delta^{13}C$ also influence upon variations in Hg, with increased Hg with a more enriched $\delta^{13}C$ signature. This suggests an increased accumulation of Hg with increased reliance on terrestrial and or littoral derived carbon sources, as suggested in chapter 3.2. However, to strenghten this as a hypothesis, more in-depth analysis of diet and isotopic signature of allocthonous derived POM would be needed. Hg transport into Lake Mjøsa is most likely driven from runoff within the total catchment area of 17 000 km^2, as Hg is an ubiquitous contaminant (e.g. Thrane et al., 2020). This could be a relevant pathway of increased Hg in allocthonous derived foodchains versus foodchains based on autocthonous production. However, signatures in $\delta^{13}C$ phytoplankton, and subsequently in epipelagic zooplankton, also varies substantially. There are also strong indications that accumulation of Hg is increased in pelagic versus littoral foodchains (Chetelat et al., 2011; Stewart et al., 2008; Økelsrud et al., 2016). Lake Mjøsa is a large and well mixed lake, and likely the transport and fate of Hg in the lake is complex with mixing across both vertical and horizontal axes. The significant correlation between $\delta^{15}N$ and $\delta^{13}C$, as well as both with length and Hg, may also indicate that large predatory E.smelt may integrate its diet across both pelagic and littoral foodchains, and that these individuals strongly influence on the adressed relationships.

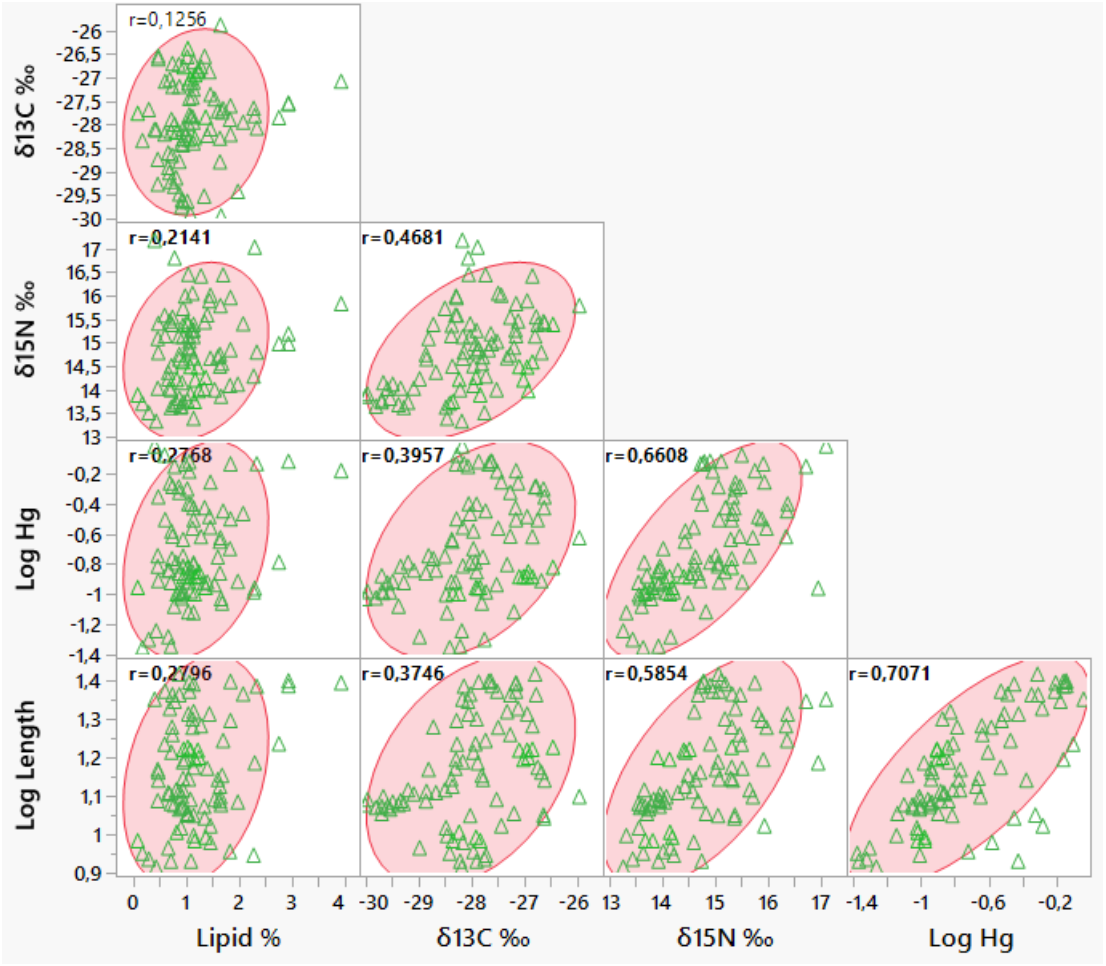

Figure 14. Correlation matrices between stable N- and C-isotopes ($\delta^{15}N$, $\delta^{13}C$), Log Length, lipid content and Log Hg in E. smelt from Lake Mjøsa sampled from 2013 to 2020. 90 % confidence ellipses are shown for each pair of correlations, and correlations (Pearson's r). All correlations in bold are significant ($p < 0.05$).

Vendace differs from both brown trout and E. smelt in dietary sources, as vendace is mainly a pelagic zooplankton specialist whereas both brown trout and E.smelt have diets varying from zooplankton, litoral benthos and fish. This is evidient from both an overall pelagic signature as well as being at a lower trophic level, compared to brown trout and E.smelt. Length is the only significant predictor for variation in Hg, with increased Hg with length. It should be noted that age, which is a potential predictor for Hg variations in fish, was not included in the above correlation analysis. As little variance is explained by trophic level, most likely age is a strong contributer to Hg accumulation in the sampled size-range of vendace. As can be seen by the strong correlation between lipid % and $\delta^{13}C$, fat increases with a more pelagic signature (diet), however lipid % is neither a strong predictor for Hg in vendace (Figure 15), nor in the other two sampled fish species (Figure 12 and Figure 14). This relates to the strong capacity of Hg (mono-methyl-Hg) to bind to sulfhydryl (SH) groups in cysteine residues of proteins and enzymes in muscle and therefore to a stronger degree accumulate in muscle rather than in fatty tissues (Pelletier, 1995; Bjerregaard 2005; Kuwabara et al., 2007), in contrast to several lipophilic organic pollutants (Bjerregaard, 2005).

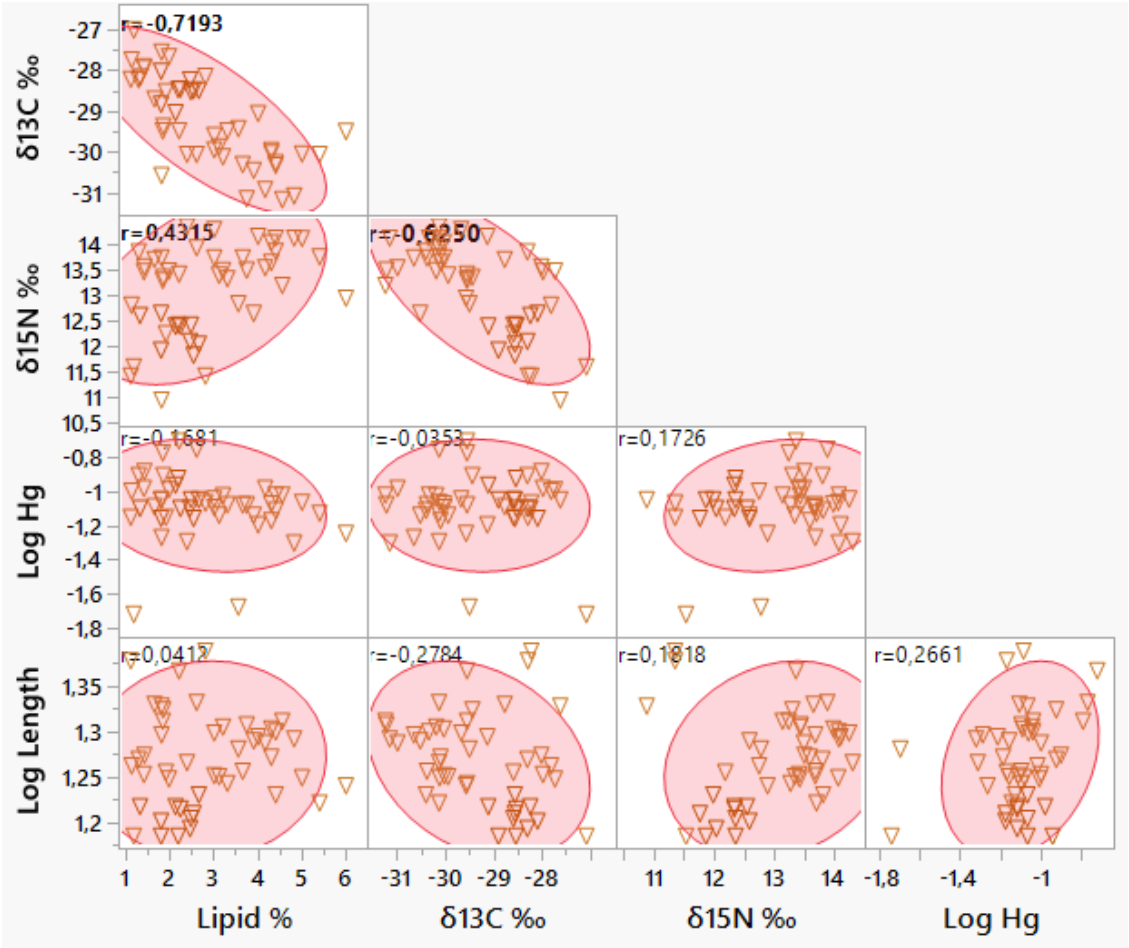

Figure 15. Correlation matrices between stable N- and C-isotopes ($\delta^{15}N$, $\delta^{13}C$), Log Length, lipid content and Log Hg in vendace from Lake Mjøsa sampled from 2013 to 2020. 90 % confidence ellipses are shown for each pair of correlations, and correlations (Pearson's r). All correlations in bold are significant ($p < 0.05$).

While $\delta^{13}C$ is not a strong predictor for Hg in Lake Mjøsa trout, the opposite is the situation for Lake Femunden trout. Whereas most trout in Lake Mjøsa are pelagic piscivore, the fish sampled from Lake Femunden have a larger spread in $\delta^{13}C$, which suggests more variation in feeding habitat, from littoral area to open waters. There is a strong correlation between $\delta^{15}N$ and $\delta^{13}C$ in Femunden trout, and the data clusters into two groups, indicating an ontogenetic shift from mainly littoral to mainly pelagic feeding (becoming predominately piscivores) which leads to an increase in trophic level (increased $\delta^{15}N$), as well a more pelagic signature (more depleted $\delta^{13}C$). This again increases the bioaccumulation through the increased pelagic diet (Chételat et al., 2011). As discussed previously this shift is not seen in the Lake Mjøsa trout while all sampled fish are likely pelagic piscivores. Although there is a significant positive correlation between Hg and length, the correlation is weaker than that for $\delta^{15}N$ and $\delta^{13}C$ with Hg. Suggesting that the change of feeding habitat and diet has a stronger effect on variation in Hg, than size in Lake Femunden. As with the sampled fish in Lake Mjøsa, % lipid is not a significant predictor for variation in Hg in brown trout in Lake Femunden (Figure 16), likely related to mechanisms discussed above.

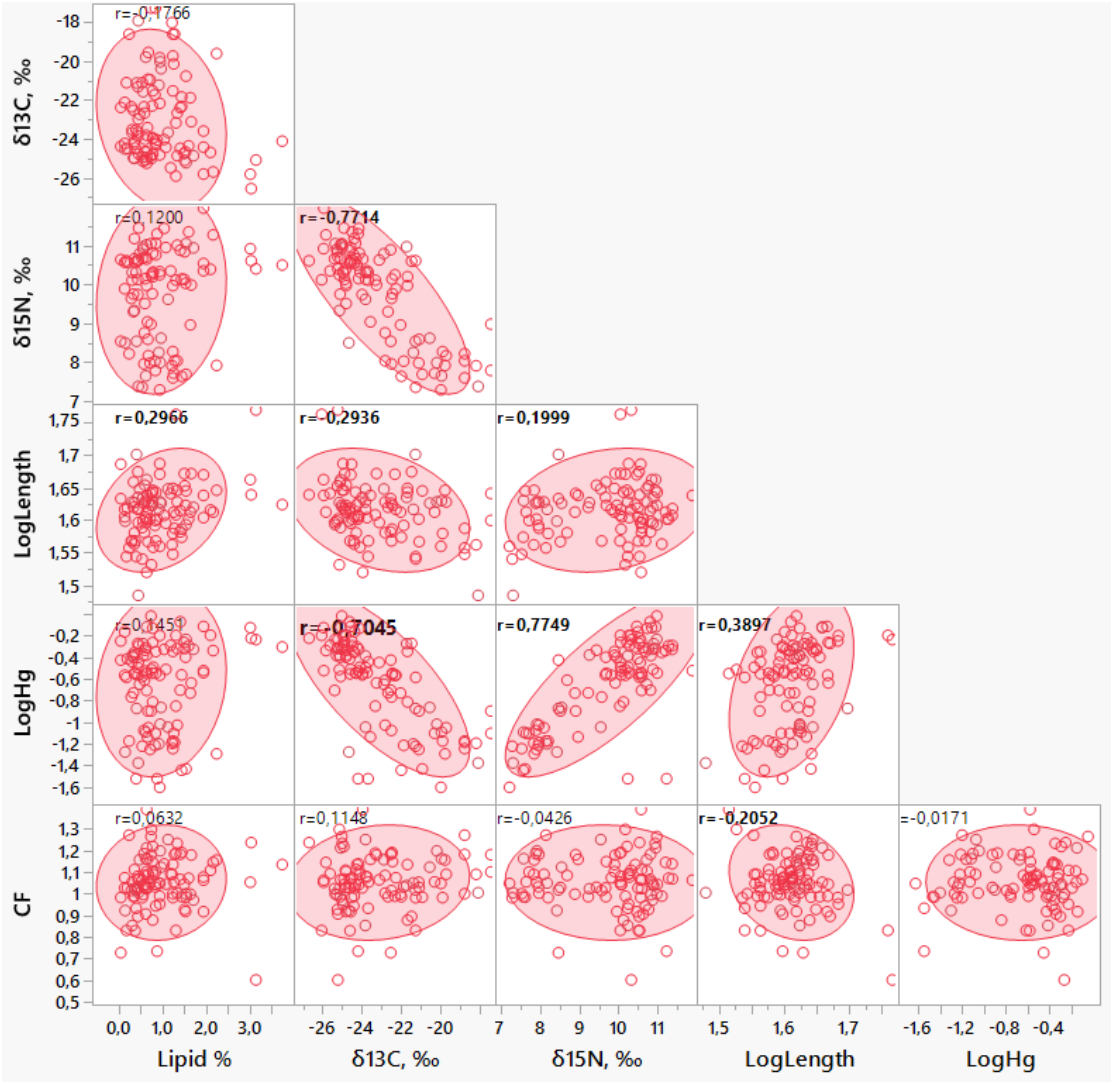

Figure 16. Correlation matrices between stable N- and C-isotopes ($\delta^{15}N$, $\delta^{13}C$), Log Length, lipid content and Log Hg in brown trout from Lake Femunden sampled from 2013 to 2020. 90 % confidence elipses are shown for each pair of correlations, and correlations (Pearson's r). All correlations in bold are significant ($p < 0.05$).

Statistical models (covariance analyses) on significant ecological and morphometric predictors for Hg variations in trout from Lake Mjøsa and Lake Femunden, equation 1 and 2 respectively, indicate that more of the variation may be explained by such factors in the Lake Femunden trout than in Lake Mjøsa trout (Table 8 and Table 9). In Lake Mjøsa trout differences in trophic level ($\delta^{15}N$) and size (length) explained 37 % of the Hg variation, while in Lake Femunden trophic level, carbon source ($\delta^{13}C$) and size explained 67 % of the variation in the Hg in the trout. This suggest that more of the Hg in the Lake Mjøsa trout is explained by non-ecological factors, i.e. more dependant on variations in bioavaialable Hg than in Lake Femunden trout. This is also a probable scenario, while there are likely both more legacy-Hg in both the catchment of Lake Mjøsa as well as in lake sediments, compared to in Lake Femunden. The lower model-intercept for Lake Femunden compared to for Lake Mjøsa, also suggest lower mercury levels at the bottom of the food chain compared to in Lake Mjøsa. However, for firm conclusions on this, sampling of prey items for the Lake Femunden trout would be pertinent.

Equation 1: $LogHg_{Lake\ Mjøsa\ trout} = a + b_1 (\delta^{15}N) + b_2$ (log length)

Equation 2: : $LogHg_{Lake\ Femunden\ trout} = a + b_1 (\delta^{15}N) + b_2$ (log length) $+ b_3 (\delta^{13}C)$

Table 8. Statistical model (ANCOVA) explaining total Hg concentrations (mg/kg ww) in brown trout in Lake Mjøsa from 2013-2020. The term estimate refer to the parameters given in equation 1 above.

Term		Response: log Hg		
		R^2 = 0.37	n = 120	
		d.f. = 2, 117	p < 0.0001	
		Estimate	tRatio	Prob > |t|
a	Intercept	-4.831	-8.36	<.0001
b_1	$\delta^{15}N$	0.129	4.49	<.0001
b_2	log length	1.400	5.68	<.0001

Table 9. Statistical model (ANCOVA) explaining total Hg concentrations (mg/kg w.w.) in brown trout in Lake Femunden from 2013-2020. The term estimate refer to the parameters given in equation 2 above.

Term		Response: log Hg		
		R^2 = 0.67	n = 100	
		d.f. = 3, 96	p < 0.0001	
		Estimate	tRatio	Prob > |t|
a	Intercept	-15.021	-7.63	<.0001
b_1	$\delta^{15}N$	0.447	6.37	<.0001
b_2	log length	4.417	3.55	0.0006
b_3	$\delta^{13}C$	-0.081	-2.00	0.0479

3.5.3 Mercury levels in 2020

Mean Hg concentrations in trout muscle from both Lake Mjøsa (0.75 mg/kg) and Lake Femunden (0.41 mg/kg) were higher in 2020 (Table 10) compared to 2019. The mean concentration in brown trout in Lake Mjøsa in 2020 was higher than the mean (0.61 mg/kg) for all sampled previous years (2006-2019). In Lake Femunden the mean concentration of Hg for 2020 was lower than the average for the years 2013-2019 (0.31 mg/kg w.w).

The mean Hg concentration in 2020 was above the average for previous years in Lake Mjøsa. The averages for strong predictors such as trophic level and length were also above that for previous years, with mean $\delta^{15}N$ (16.0 ‰) and mean length (68 cm) for 2019, compared to the mean $\delta^{15}N$ (15.2 ‰) and the mean length (62.7 cm) for the years 2006 to 2019. Length is proven to be a significant positive predictor for variations in Hg. As there are variations in size in sampled trout from year to year, adjustment to a common size in the data is pertinent in order to reflect the true variations in Hg concentrations among years. This is further discussed below. Variations in year to year

biomagnification of Hg is also discussed below. E. smelt in Lake Mjøsa naturally varies in Hg because of the inclusion of a few large cannibalistic individuals up to 26 cm (in the 2018 samples), that are also higher up in the food chain. For most years though sizes of individuals in the samples are relatively homogenous and mainly consist of individuals around 14 cm (± SD = x cm). 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. Hg concentrations in zooplankton are all below this EQS threshold (Figure 17).

Table 10. 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 2020.

2020	Sample	n	x̄	Min	Max	Length, cm (x̄)	Weight, g (x̄)
Mjøsa	Brown trout	15	0.75	0.40	1.30	67.5	3557
	E. smelt	10	0.12	0.10	0.15	13.7	18.1
	Vendace	5	0.08	0.10	0.12	16.1	30.7
	Mysis	3	0.01	0.01	0.01		
	Zooplankton	3	0.007	0.0001	0.01		
Femunden	Brown trout	10	0.41	0.03	0.96	39.9	619

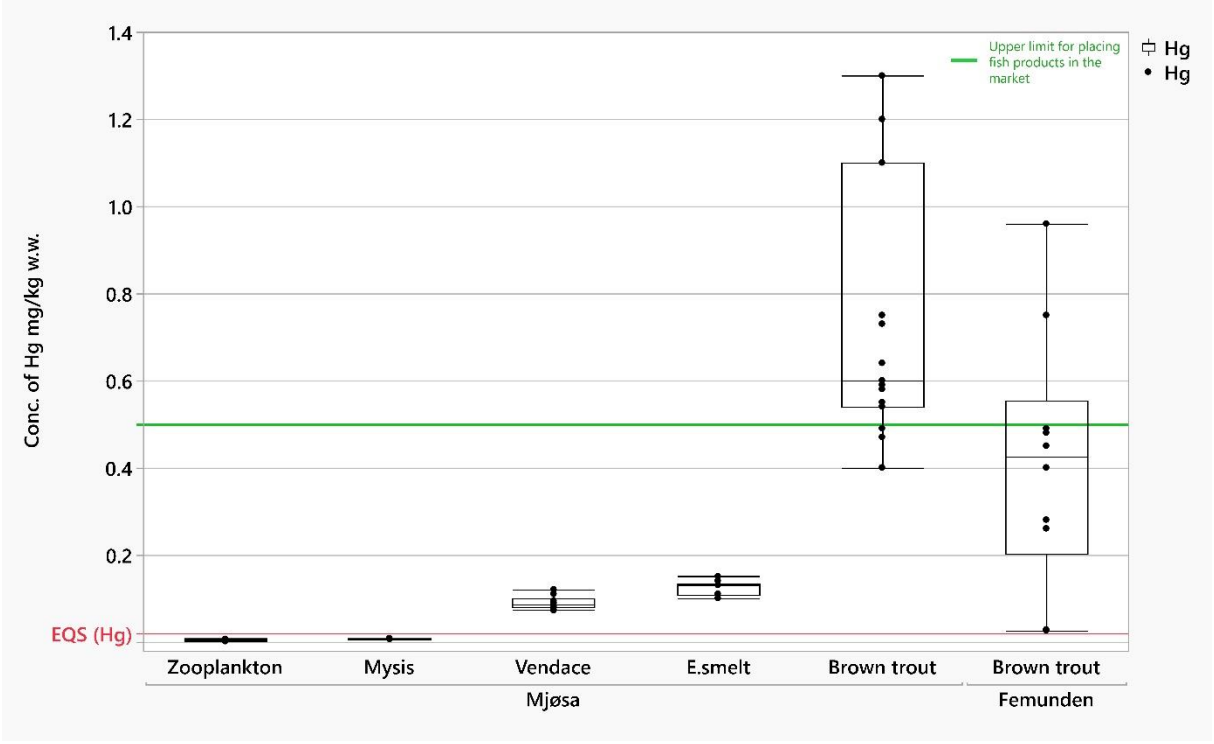

Figure 17. Hg concentrations (box: median with 25-75 % of data) in mg/kg w.w. in zooplankton, *Mysis*, and fish from Lake Mjøsa, and brown trout from Lake Femunden in 2020. Whiskers indicate min and max concentrations within the data. The concentrations for the EQS (red line) and upper limit for placing fish products in the market are shown.

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

Annual trophic magnification factors (TMFs) for mercury (Hg) were calculated, including all sampled biota (zooplankton, *Mysis* and fish), for each year from 2013 to 2020, Figure 18. In order to calculate a common TMF for a longer period (2013 – 2020) 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 $\delta^{15}N$ in the combined data from 2013 to 2020 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, $F_{(6,257)} = 5.13$, $p < 0.0001$) as did the annual intercepts ($F_{(6,298)} = 8.3$, $p < 0.0001$). 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 11). The shorter measured $\delta^{15}N$ range for some years is a result of the lack of true primary consumers. Annual fluctuations from 2013 to 2020 occur in sampled primary consumer $\delta^{15}N$ signatures (range: 4.63-8.43), likely as a result of variations in nitrogen sources influencing the isotopic signature in phytoplankton. Nevertheless, the calculated TMF for all years included is not influenced by these annual variations, and probably reflects the best estimate for TMF of Hg in the lake.

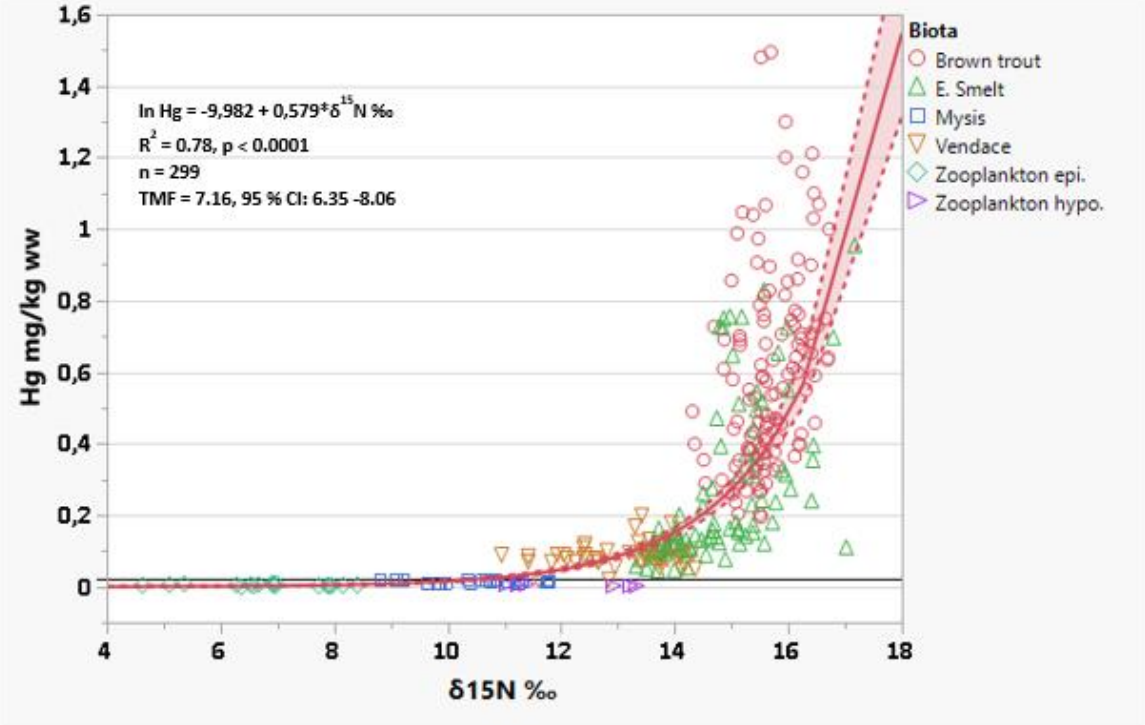

Figure 18. Exponential regression, with 95 % confidence level, of Hg concentrations in Lake Mjøsa biota from 2013 to 2020 as a function of measured $\delta^{15}N$. Prediction formula and estimated TMF with 95 % confidence level are shown above the regression curve. The horizontal line (bold) indicate the EQS for mercury at 0.02 mg/kg Hg.

Table 11. 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 2020 and number (n) of samples are shown.

Year (n)	2013 (33)	2014 (41)	2015 (36)	2016 (30)	2017 (41)	2018 (41)	2019 (36)	2020 (41)
Hg mg/kg, min-max	0.006-0.83	0.004-0.91	0.004-1.20	0.020-1.20	0.003-1.50	0.003-0.91	0.001-1.49	0.0001-1.30
$\delta^{15}N$, min-max	6.5-16.2	4.6-16.5	7.9-17.2	10.3-16.5	7.7-15.5	10.7-16.2	6.3-16.5	6.4- 16.7
~ TL	2.8	3.5	2.7	1.8	2.3	1.6	3.0	3.0
TMF	5.8	4.9	8.6	8.5	13.2	13.1	7.2	7.8

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; Olsen et al., 2019). We have added data from previous years to investigate the correlation between length and Hg in a larger dataset for Lake Mjøsa (Figure 19) and Lake Femunden (Figure 20). We also present the length adjusted (to geometric mean length) Hg concentrations for each of the years sampled in Lake Mjøsa (Figure 21). Based on the entire dataset for Lake Mjøsa from 2006 - 2020, in average the trout will reach the EU's and the Norwegian upper limit for placing fish products in the market of 0.5 mg/kg w.w. in fish muscle at around 57 cm, which corresponds to ~ 2.1 kg. For Lake Femunden the trout based on data from 2013 to 2020 will reach the 0.5 mg/kg w.w. limit at around 52 cm, and ~ 1.25 kg. While this is an estimate of the average length at

the upper limit for placing fish products in the market, there are certainly individual fish with both above and below 0.5 mg/kg w.w. at this length. In addition, there are greater uncertainties in the estimate for Lake Femunden due to the large span between lower and upper 95 % confidence limits (Figure 20).

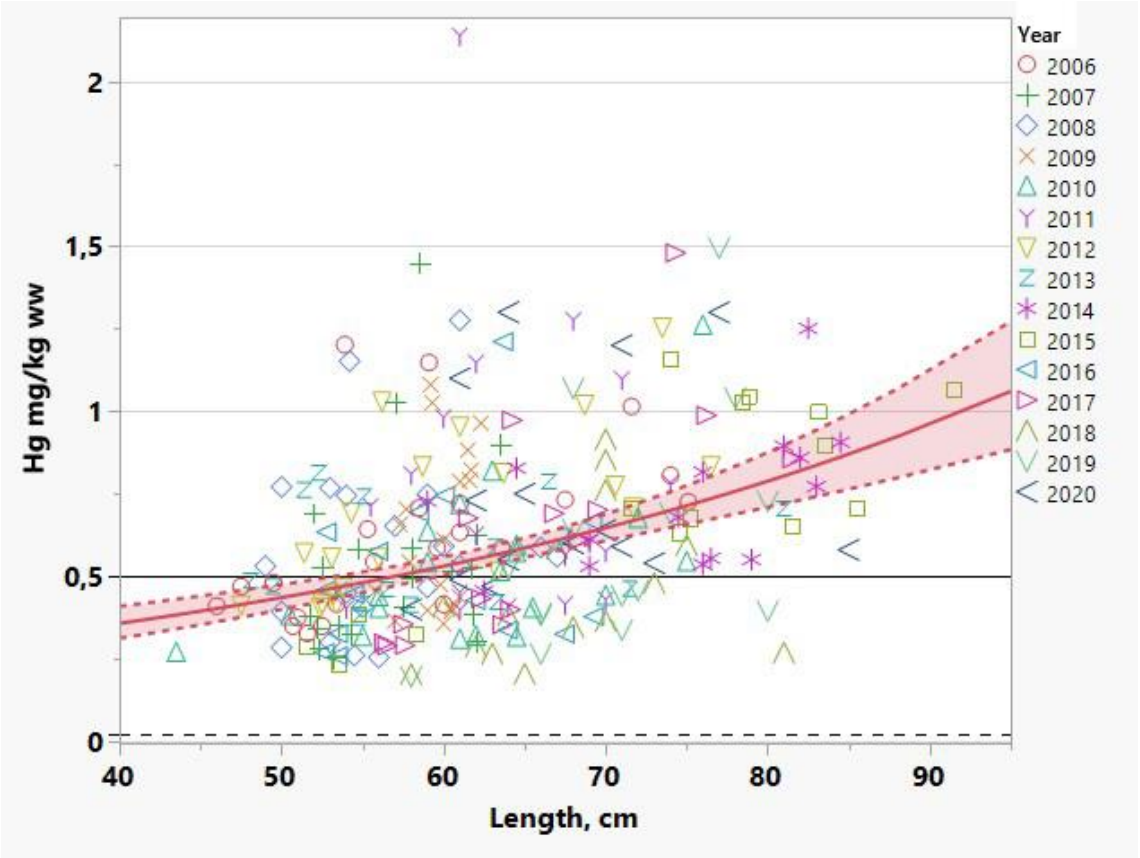

Figure 19. Regression analysis of length and Hg (with 95 % confidence level) in trout from Lake Mjøsa sampled from 2013 to 2020. Horizontal lines at 0.5 mg/kg Hg (solid line, upper limit for placing fish products in the market) and the EQS for mercury at 0.02 mg/kg Hg (dashed line).

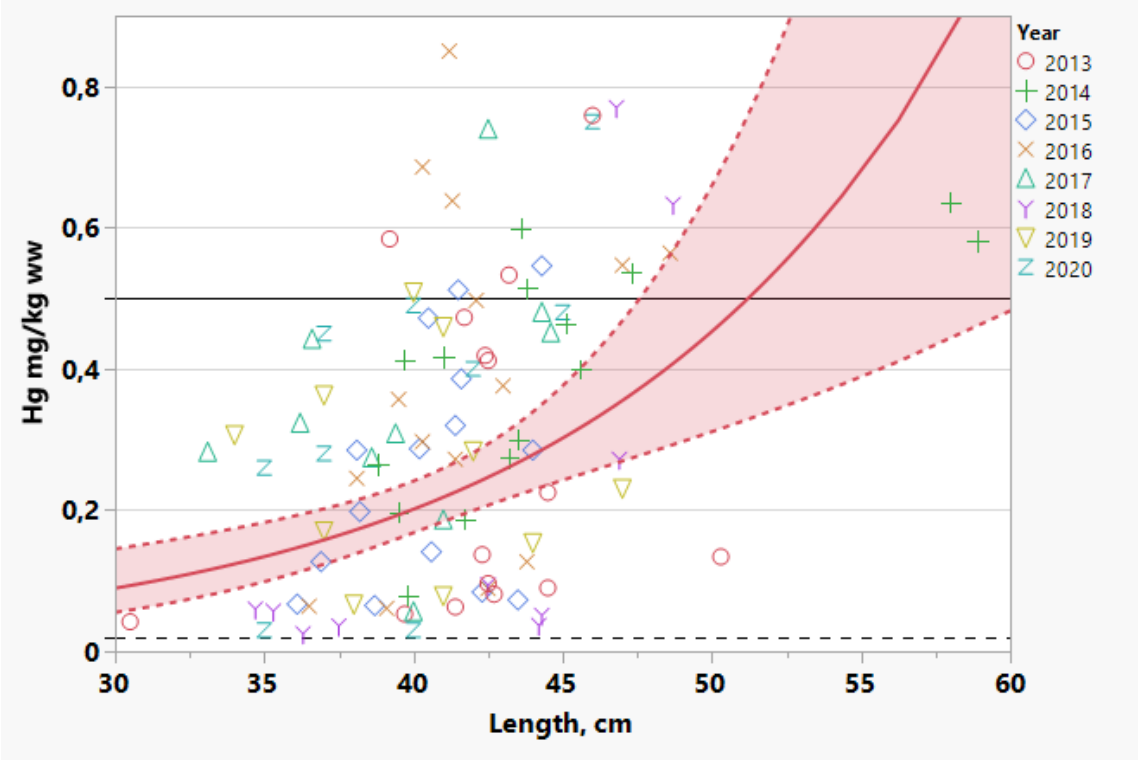

Figure 20. Regression analysis of length and Hg (with 95 % confidence bands) in trout from Lake Femunden sampled from 2013 to 2020. Horizontal lines at 0.5 mg/kg Hg (solid line, upper limit for placing fish products in the market) and the EQS for mercury at 0.02 mg/kg Hg (dashed line).

Length adjusted mean Hg in trout in Lake Mjøsa decreased in the years after 2012, and the length adjusted mean Hg concentrations in the seven years between 2006 and 2012, except for 2010, were all higher than the length adjusted mean Hg concentrations in the following seven years from 2013 to 2019 (Figure 21). In 2020, however length adjusted mean Hg increased to levels not reported since 2013. It's also worth remarking that if we look at a longer timeframe, mean length adjusted Hg in trout in Lake Mjøsa also varied in the years prior to 2006. In 1979-80 length adjusted Hg was 1.4 mg/kg (adjusted to 58 cm), which after it dropped down to around 0.5 mg/kg in 1982-84, and from 1998 to 2005 it was stable around 0.4 mg/kg, where it increased to about 0.6 mg/kg (Fjeld et al., 2016). The very high Hg concentrations in 1979/80 was attributed to discharges from the local pulp and paper industry (Fjeld et al., 2016). Fluctuations in Hg in trout that follow in the years after, are more difficult to find any apparent reasons for, while the emissions in Norway has dropped with 80 % since 1995 (https://miljostatus.miljodirektoratet.no/kvikksolv) and deposited long range transported transboundary elemental Hg (Hg^0) from 1990 to 2013 has decreased by 1-2 % per year in North-America and Europe (Zhang et al., 2019). Yearly emissions in the years 2013 - 2015 from the three largest local water treatment plants, situated in the north, west and east, ranged from 0.1 to 0.5 kg (Garmo et al., 2017). Likely these relatively low concentrations mirror the general ban on mercury in products in Norway from 2008. Results from studies on sediment profiles in Lake Mjøsa also reflect a decrease in Hg depositions from 1960s to around 2003, and furthermore that Hg from local sources have declined relatively more than long-range transported Hg in this period (Rognerud, 1985; Fjeld et al., 2004).

Both the reduction in local discharges and deposits from long-range transported Hg has led to consistent declines in measured Hg in fish in boreal and subarctic Fennoscandia (Braaten et al., 2018). However, local variations in catchment properties and mechanisms related to release and transport of Hg stored in catchments soils (legacy-Hg), may lead to both temporal and geographical variations in fluxes of Hg into lakes (Braaten et al., 2018), with variations in Hg uptake in the food web and subsequently concentrations in fish (Stewart et al., 2008; Braaten et al., 2018). In addition, legacy-Hg from lake sediments may be remobilized as a result of sediment resuspension through strong currents (Rognerud, 1985) and/or disturbance of sediments through urban development, within the lake or adjacent to the lake shoreline. Hence, variations in Hg in fish populations may fluctuate despite the decreased reductions in emissions. As mentioned above the means for the strong predictors length and trophic level were above average in 2020 compared to the means for the previous years (2006-2019), which could explain some of the increase in length adjusted Hg in 2020 compared to the period 2014-2019. However, in 2019 the means of these two predictors were higher than in 2020. This leaves a portion of the non-explained variation in the ANCOVA model (Table 8), to the factors discussed above, that are not related to morphometric and ecological variations.

In our previous reports (Jartun et al., 2019 and 2020) we suggested that the relatively low length adjusted Hg in brown trout in 2018 could be related to 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). As we did not have data on variations in growth (length by age) from earlier years this was only an assumption at that stage. Adding the factor CF (Figure 13), may accentuate the effect of SGD as a part of the variations observed. Annual fluctuations in biomass at lower trophic levels (zooplankton) may also indicate some degree of correlation between increased biomass and lowered Hg. As reported in our previous report (Jartun et al. 2020), biomass concentrations of zooplankton in Lake Mjøsa were high in 2018, i.e. comparable to concentrations recorded in the 1980s (Lyche-Solheim et al., 2019). The biomass concentrations of zooplankton in Lake Mjøsa were almost as high in 2019 as in 2018 (Lyche-Solheim et al., 2020), with also a correspondingly relatively low length adjusted Hg compared to previous years (up to 2018). In 2020 the biomass concentration of zooplankton was lower than in 2018 and 2019 (Thrane et al., 2021), which may account for some of the increase in the length adjusted Hg in trout in 2020 compared to the two years prior. Although the mechanisms contributing to Hg concentrations in fish at the top of the food chains in Lake Mjøsa are many and complex, this may still be a contributing factor to the observed annual fluctuations.

We also include the timeseries for Femunden as a comparison (Figure 22). As the results show the length adjusted Hg concentration for trout in Lake Femunden is lower than for Lake Mjøsa trout, due to the lower geometric average (41.4 cm) in the dataset. All annual averages at this length are below the upper limit for placing fish products in the market of 0.5 mg/kg w.w. As length is not the strongest predictor for variations in Hg in Lake Femunden, likely fluctuations may partly be explained by variations in other strong predictors trophic level and dietary carbon source (as shown in the ANCOVA model). For example, the two highest annual length adjusted Hg co-occurs with the two highest annual

mean $\delta^{15}N$ (2017: mean $\delta^{15}N$ = 10.2 ‰ and 2020: mean $\delta^{15}N$= 10.7 ‰), while the lowest annual length adjusted Hg cooccurs with lowest annual mean $\delta^{15}N$ (2018: mean $\delta^{15}N$ = 8.5 ‰).

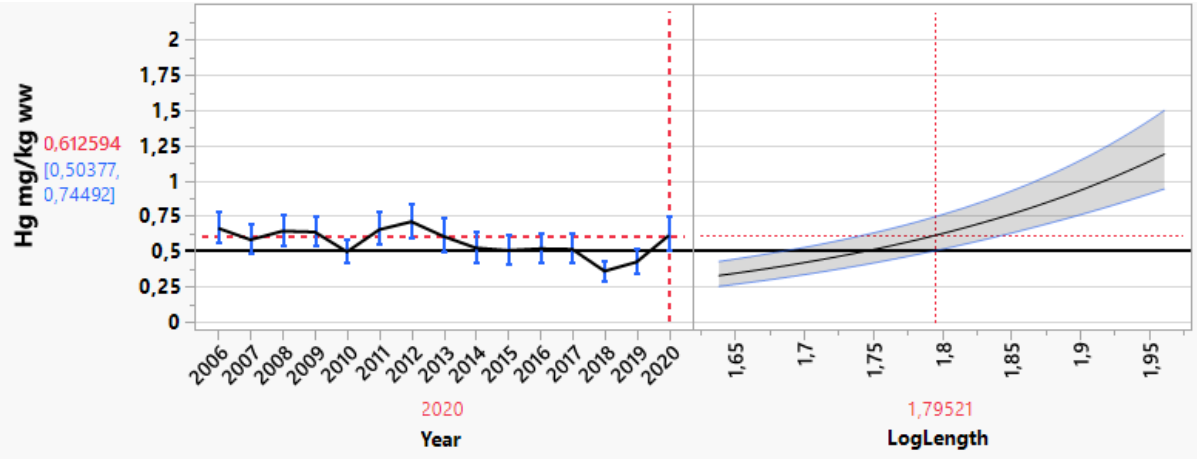

Figure 21. Length adjusted Hg (with 95 % confidence intervals) in trout from Lake Mjøsa 2006-2020. Trout are adjusted to the geometric average length (62.4 cm) in the dataset (~2.7 kg). Horizontal line at 0.5 mg/kg Hg (upper limit for placing fish products in the market) are added. Length adjusted mean Hg concentration (with 95 % confidence limits) for 2020 is marked with a red dashed line and numbers. Length adjusted Hg (with 95 % confidence intervals) for each individual year, together with mean metrics are added in Table 12 below.

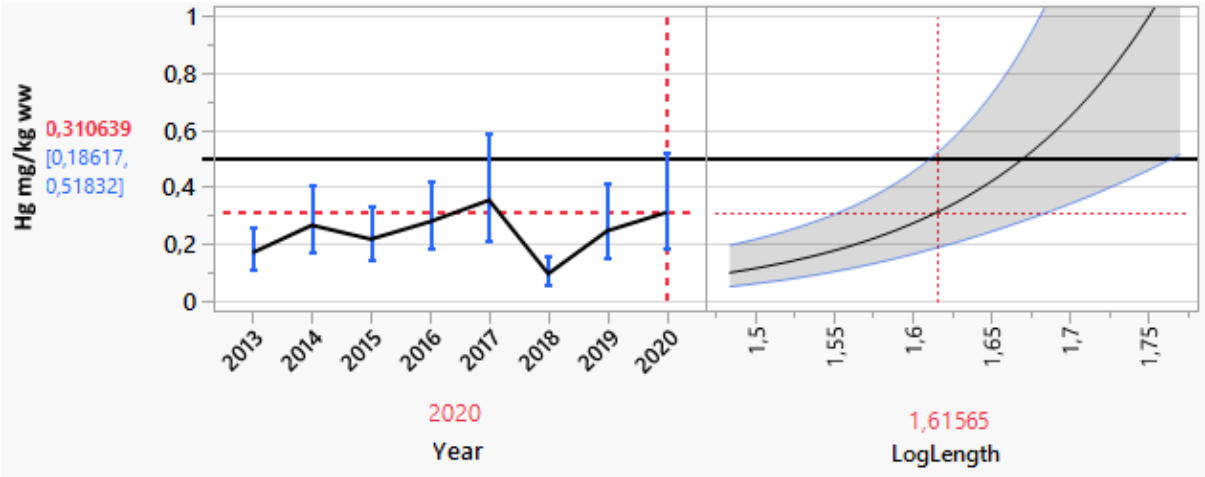

Figure 22. Length adjusted Hg (with 95 % confidence intervals) in trout from Lake Femunden (2013-2020). Trout are adjusted to the geometric average length (41.2 cm) in the dataset (0.75 kg). Horizontal line at 0.5 mg/kg Hg (upper limit for placing fish products in the market) are added. Length adjusted mean Hg concentration (with 95 % confidence limits) for 2020 is marked in red and with a red dashed line. Length adjusted Hg (with 95 % confidence intervals) for each individual year, together with mean metrics are added in Table 13 below.

Table 12. Length adjusted mean Hg (mg/kg w.w.) with 95 % confidence limits in brown trout from Lake Mjøsa from each individual year as shown in Figure 17. Corresponding Hg concentrations (mean (x̄), min, max) in mg/kg w.w. and values for mean length (cm) and weight (g) are included for fish from 2006-2020.

Year	n	Length adjusted mean Hg (mg/kg ww)	Lower 95 % CI	Upper 95 % CI	x̄	Min	Max	Length, cm (x̄)	Weight, g (x̄)
2006	22	0.66	0.56	0.78	0.61	0.33	1.20	58.1	2459
2007	20	0.58	0.49	0.69	0.55	0.25	1.45	56.8	2074
2008	20	0.64	0.54	0.76	0.59	0.25	1.28	56.1	2054
2009	20	0.63	0.54	0.75	0.63	0.36	1.08	59.7	2321
2010	20	0.49	0.42	0.59	0.52	0.27	1.26	62.1	2675
2011	18	0.65	0.55	0.78	0.77	0.40	2.14	64.2	2814
2012	20	0.71	0.60	0.84	0.68	0.41	1.26	59.6	2493
2013	15	0.61	0.50	0.74	0.57	0.38	0.81	59.6	2587
2014	15	0.52	0.43	0.64	0.73	0.45	1.25	74.6	5180
2015	15	0.51	0.41	0.62	0.72	0.24	1.16	73.0	5395
2016	15	0.52	0.43	0.63	0.52	0.26	1.21	59.3	2515
2017	15	0.51	0.42	0.62	0.63	0.29	1.48	65.3	3391
2018	15	0.36	0.30	0.44	0.46	0.20	0.92	67.7	3416
2019	15	0.42	0.35	0.52	0.60	0.20	1.50	70.6	4280
2020	15	0.61	0.50	0.74	0.75	0.40	1.30	67.5	3557

Table 13. Length adjusted mean Hg (mg/kg w.w.) with 95 % confidence limits in brown trout from Lake Femunden from each individual year as shown in Figure 22. Corresponding Hg concentrations (mean (x̄), min., max.) in mg/kg w.w. and values for mean length (cm) and weight (g) are included for fish from 2013-2020.

Year	n	Length adjusted mean Hg (mg/kg ww)	Lower 95 % CI	Upper 95 % CI	x̄	Min.	Max.	Length, cm (x̄)	Weight, g (x̄)
2013	15	0.17	0.11	0.26	0.27	0.04	0.76	42.2	830
2014	15	0.27	0.17	0.41	0.39	0.08	0.64	44.6	891
2015	15	0.22	0.14	0.33	0.26	0.06	0.55	40.5	760
2016	15	0.28	0.18	0.42	0.38	0.06	0.85	41.6	767
2017	10	0.35	0.21	0.59	0.35	0.06	0.74	39.6	712
2018	10	0.10	0.06	0.16	0.20	0.02	0.77	41.7	756
2019	10	0.25	0.15	0.41	0.26	0.07	0.51	40.1	712
2020	10	0.31	0.19	0.52	0.41	0.03	0.96	39.9	619

3.6 Cyclic volatile methylated siloxanes (cVMSs)

3.6.1 Detection frequency of cVMS 2017-2020.

Detection frequency for cVMS in samples from 2020 are listed in the compilation in Table 3. In Table 14 below we have listed the total detection frequencies for D4, D5 and D6 in biota from the entire monitoring program (2017-2020).

Table 14. Detection frequency (%) for cVMS in biota from Lakes Mjøsa and Femunden. Data from 2017-2020 presented as percentage of analytical detections. Shading refers to 5 subclasses: white: 0-20 %, light pink: 21-40 %, pink: 41-60 %, light red: 61-80 % and **red: 81-100 %**.

	2017-2020					
			Mjøsa			Femunden
	Zooplankton	Mysis	Vendace	E.smelt	Brown trout	Brown trout
N	*12*	*12*	*35*	*40*	*60*	*40*
	Whole body	Whole body	Muscle	Muscle	Muscle	Muscle
D4	50	42	51	25	37	25
D5	**100**	**100**	**91**	**100**	**100**	25
D6	75	75	77	**93**	**88**	50

3.6.2 Levels of cVMS in 2020

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

Detection frequencies for the individual cVMS (D4, D5 and D6) in biota from the total monitoring period from 2017-2020 are shown in Table 14. Results from 2020 are shown in Table 15, where detections > LOQ are indicated with orange cells. In 2020, D4, D5 and D6 were detected above LOQ in all samples except for D6 in a single sample of zooplankton, and D4 in brown trout from Femunden.

Highest concentrations of cVMS were found in the top predator brown trout from Lake Mjøsa with D5 being the dominant compound in all matrices (Table 15, Figure 23). On a wet weight basis, the mean D5 concentration in brown trout muscle tissue from Lake Mjøsa was 39 ± 34 ng/g w.w. (2000 ± 1900 ng/g lipid). In 2020, vendace holds higher concentrations than European smelt on a wet weight basis (23 and 17 ng/g, respectively) differing from previous years where wet weight concentrations in European smelt have been on the same level as in brown trout (Jartun et al., 2020). On a lipid basis, however, the concentrations in European smelt are higher than in brown trout from 2020 (2800 and 2000 ng/g lipid, respectively), mainly because of low lipid levels in European smelt (Table 4). Figure 23 provides an overview of cVMS-concentrations in 2020, where the median for the three species of fish

in Lake Mjøsa is on the same level. There are some individual high concentrations that increases the mean values for European smelt.

Siloxanes are used in a variety of products such as personal care products (PCP), detergents, paint and insulation, following that discharges from wastewater treatment plants (WWTP) might be a substantial source of siloxanes to freshwater recipients (Montemayor et al., 2013; Wang et al., 2009). The total amount of siloxanes imported to Norway in products was estimated to 475 tonnes in 2015 with D5 being the dominant chemical (Blytt and Stang, 2018). In a study of contaminants in sludge from Norwegian WWTPs, the total concentration of Σ(D4,D5,D6) has doubled between 2013 and 2018. All three cVMS have increased in sludge in this period: D4 (10x), D5 (1.5 x) and D6 (30x), indicating a shift from D5 to D6 being the dominant cVMS in sludge (Blytt and Stang, 2018). This may indicate that discharges from the WWTPs may be the major sources of cVMS in Lake Mjøsa. Atmospheric deposition of cVMS is discussed in Xu and Wania (2013) and Bohlin-Nizzetto et al. (2019), but we do not know to which extent atmospheric deposition may be a significant source for cVMS in Lakes Mjøsa and Femunden.

The EQS value for D5 in biota is 15000 ng/g w.w. (Direktoratsgruppen vanndirektivet, 2018). No samples in either lake exceeded this value. D5 is considered a very persistent and very bioaccumulative (vPvB) substance, meaning that they rise concerns regarding the long-term effects of such accumulation. This accumulation is most often difficult to reverse as a stop of direct emissions and discharges not necessarily will result in a reduction in substance concentration in biota. Safe values are thus difficult to establish, and quantitative risk assessments are not performed under REACH for these substances.

Mean concentrations of D5 in vendace, European smelt and brown trout from Lake Mjøsa (23, 17 and 39 ng/g w.w., respectively) are all lower than those found in cod liver in the Oslofjord (D5 conc. 1200 ng/g w.w., in Ruus et al., 2020). Fish muscle has so far been the preferred matrix for studying cVMS in Lake Mjøsa and Lake Femunden.

Table 15. Concentration range (min-max), mean ($\bar{x}$) and number (N) of detections 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 in 2020. Left part of the table is ng/g on wet weight (w.w.) basis and the right part is ng/g on lipid basis. Concentrations below LOQ (w.w.) have been replaced by half the limit when calculating $\bar{x}$ and ng/g lipid. "N>LOQ" is the number of samples above LOQ. Orange cells indicate that more than 50 % of the samples are above LOQ.

2020				Concentrations ng/g, wet weight, w.w.			Concentrations ng/g, lipid		
Lake	Matrix	N	Statistics	D4	D5	D6	D4	D5	D6
Mjøsa	Zoopl.	3	Range	0.30 - 0.50	0.30 - 0.40	0.10 - <0.60	68-110	54-110	27-<120
			Mean, $\bar{x}$	0.40	0.30	0.30	93	85	61
			N>LOQ	3/3	3/3	2/3	3/3	3/3	2/3
	Mysis	3	Range	1.1 – 1.4	6.5 – 8.2	0.70	36 – 150	260 – 710	24 - 73
			Mean, $\bar{x}$	1.2	7.5	0.70	83	450	44
			N>LOQ	3/3	3/3	3/3	3/3	3/3	3/3
	Vendace	10	Range	2.5 – 4.8	12 - 33	1.2 – 2.5	110 – 310	560 – 1500	44 - 110
			Mean, $\bar{x}$	3.2	23	1.9	150	1000	86
			N>LOQ	10/10	10/10	10/10	10/10	10/10	10/10
	E. smelt	10	Range	1.0 – 1.9	4.8 – 35	1.0 – 2.9	73 – 820	470 – 16000	79 - 1500
			Mean, $\bar{x}$	1.3	17	1.7	190	2800	280
			N>LOQ	10/10	10/10	10/10	10/10	10/10	10/10
	B. trout	15	Range	0.50 – 2.3	4.8 – 120	0.60 – 14	12 – 590	230 – 8100	32 - 1000
			Mean, $\bar{x}$	1.1	39	4.3	104	2000	260
			N>LOQ	15/15	15/15	15/15	15/15	15/15	15/15
Femunden	B. trout	10	Range	<5.9*	1.2 – 2.9	0.60 – 1.7	97 – 1800	45 – 500	21 - 250
			Mean, $\bar{x}$	3.5	1.6	0.89	570	230	130
			N>LOQ	0/10	10/10	10/10	0/10	10/10	10/10

*D4 in brown trout from Lake Femunden were all below LOQ, but above LOD for this specific analysis.

Figure 23 shows the concentrations of D4, D5 and D6 on lipid weight basis in all matrices in Lake Mjøsa and Lake Femunden in 2020. Limit of detection and quantification (LOD/Q) for the individual cVMS varied between sample matrices, but also within each matrix, indicated with red triangles.

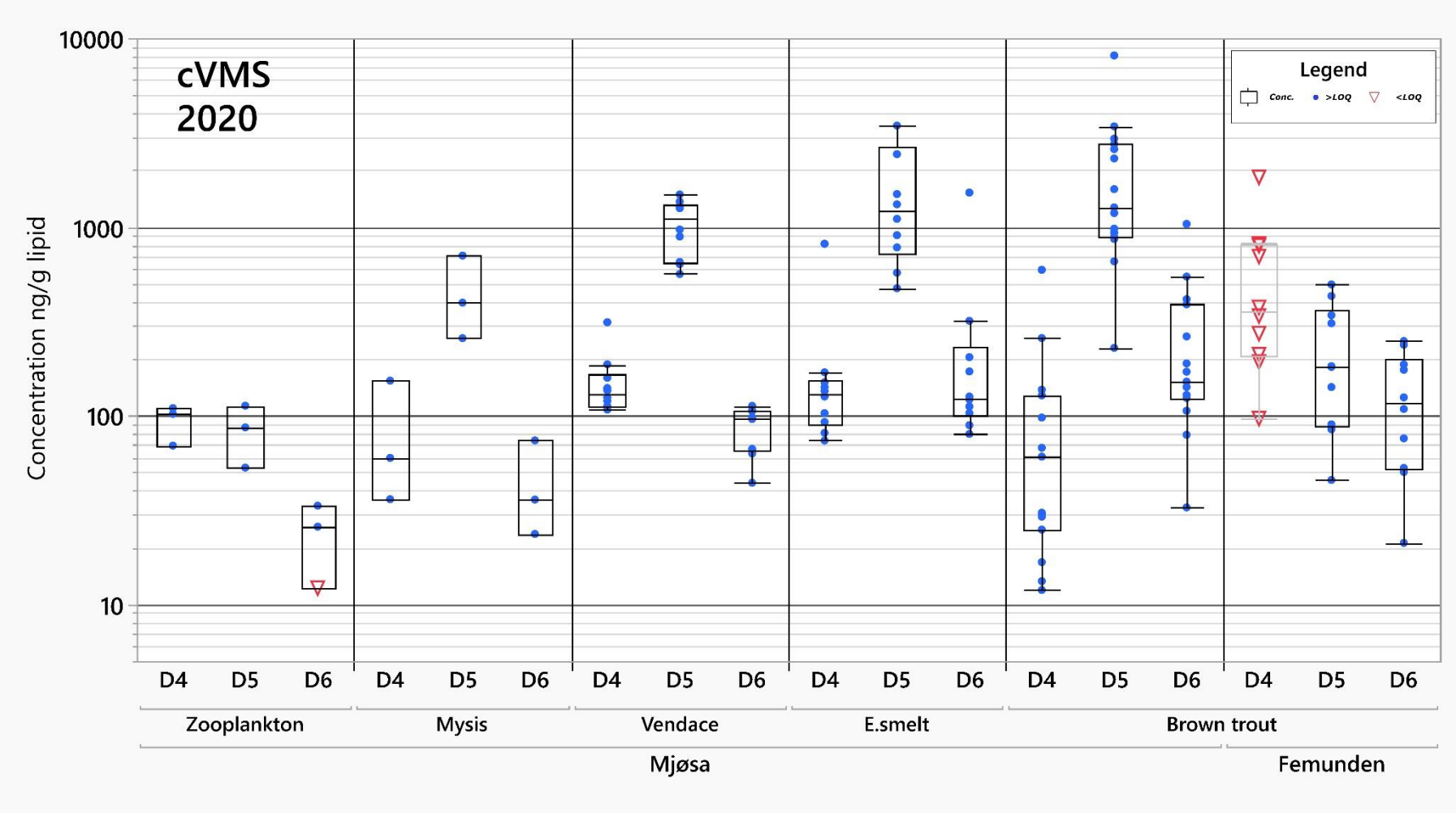

Figure 23. Boxplot of cVMS-concentrations in zooplankton, *Mysis*, vendace, E. smelt and brown trout from Lake Mjøsa and brown trout from Lake Femunden 2020. Concentrations in ng/g lipid. Boxes show the median and 50 % of the total data. Concentrations below LOQ have been replaced by half the limit and visualized by red triangles and grey boxes, whereas concentrations above LOQ are visualized by blue dots. Note that LOQ for D4 in brown trout from Lake Femunden vary greatly within the matrix, caused by high blank values.

3.6.3 Annual variation of cVMS in Lake Mjøsa and Lake Femunden 2010-2020

Although some of the cVMS data collected between 2010 and 2020 in biota from Lake Mjøsa and Lake Femunden are below the LOQ, comparable concentrations of D4, D5 and D6 in brown trout from Lake Mjøsa are shown in Figure 24. Annual variation of cVMS-concentrations between Lake Femunden and Lake Mjøsa is given in Figure 25. D5 is the dominant compound throughout the entire period with sporadic detections of D4 and D6 each year.

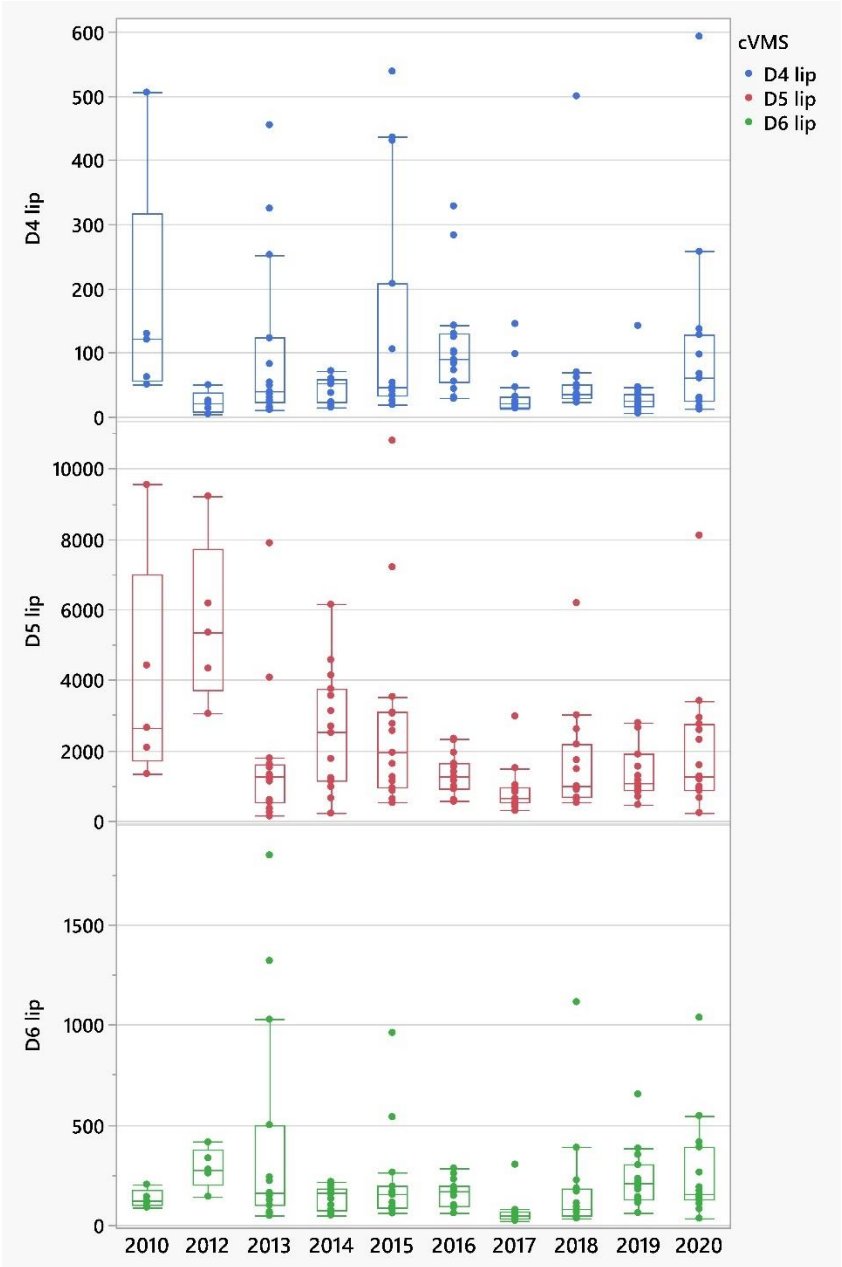

Figure 24. Boxplot indicating the concentrations in ng/g lipid of cVMS D4, D5 and D6 in samples of brown trout from Lake Mjøsa between 2010 - 2020 (total N=130). Boxes show the median and 50 % of the total data. Note the logarithmic scale on the y-axis, and that LOQ may vary within each matrix.

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 3) and where these LOD/Q-values differ within the sampled matrixes.

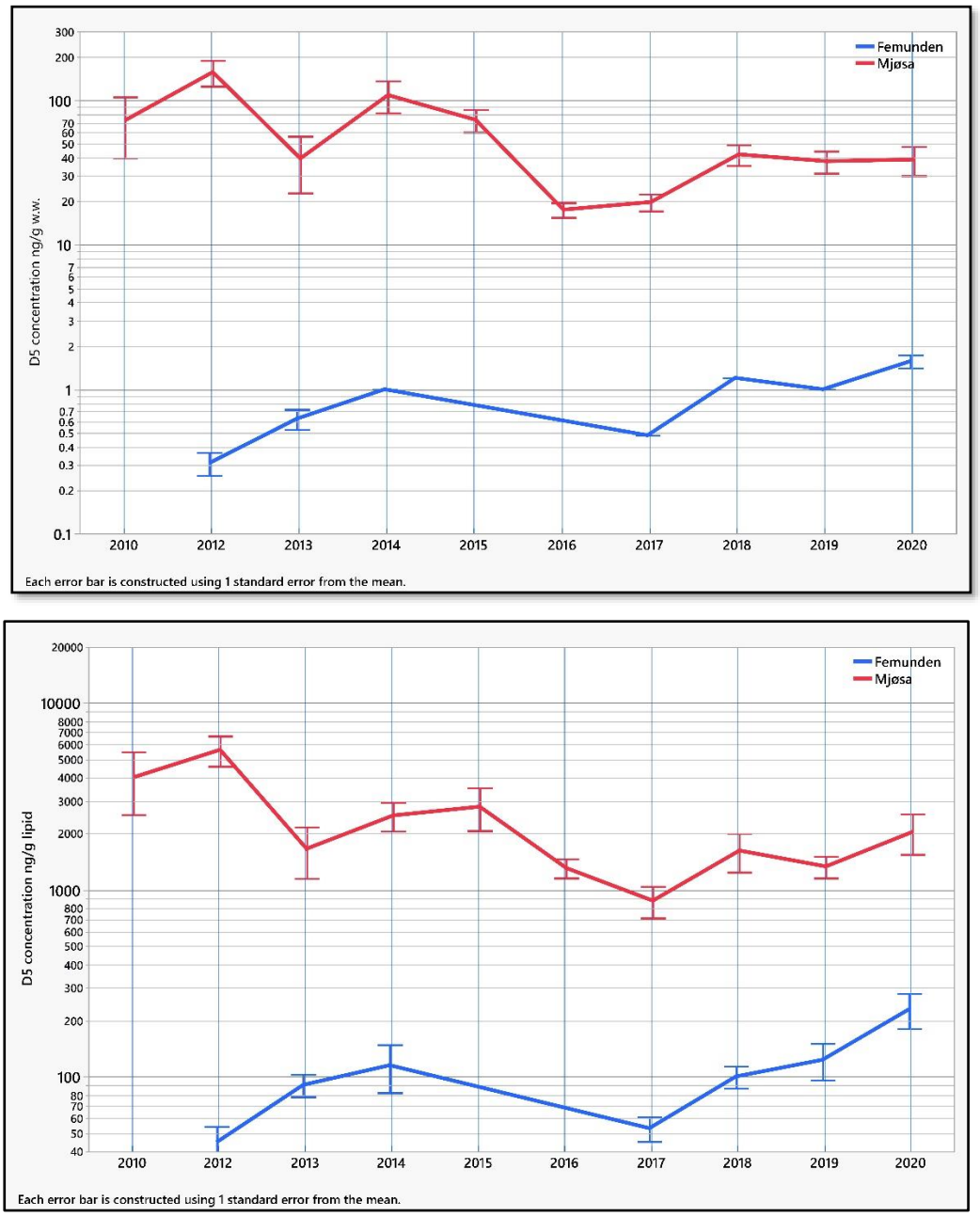

Figure 25. Time series for D5 concentrations on wet weight (top) and lipid weight (bottom) in samples of brown trout (muscle) from Lake Mjøsa (red) and Lake Femunden (blue) 2010-2020. Annual mean concentrations shown with a line with one standard error of the calculated mean.

3.6.4 Covariance analyses for D5

Statistical models (covariance analyses) on significant ecological and morphometric predictors for D5 variations in brown trout from Lake Mjøsa and Lake Femunden, equation 1 and 2 respectively, indicate that more of the variation may be explained by such factors in Lake Mjøsa trout than in Lake Femunden (Table 16 and Table 17). In Lake Mjøsa trout differences in trophic level ($\delta^{15}N$) and carbon source ($\delta^{13}C$) and lipid levels (% lipd) explained 49 % of the D5 variation. Model outcome suggest that D5 increases with trophic level and lipid level and decreases with increasing $\delta^{13}C$ (i.e. D5 increase with a more pelagic signature). In Lake Femunden, carbon source ($\delta^{13}C$) and condition factor (CF) explained 33 % of the variation of the D5 conctrations in the brown trout and that the concentration of D5 decrease with increasing $\delta^{13}C$, i.e. in fish with a more littoral signature and decrease with increasing CF, i.e. increase in more lean fish. The latter suggest a dilution of D5 that is related to fish growth, as discussed in the chapter on Hg, where somatic growth dilution (SGD) is suggested as an effect on lowered contaminant concentrations. The model outcomes indicate that more of the D5 in the brown trout from Lake Mjøsa is explained by ecological and morphometric factors, i.e. less dependant on variations in bioavaialable D5 than in Lake Femunden trout. A likely explantion for the differences in dependancy on ecological and morphometric factors in the models for the two lakes, are likely as much related to substantial differences in D5 concentrations and range, as they reflect the true differences between them. More data would be pertinent for a valid model for Lake Femunden.

Equation 1: $LogD5_{Lake\ Mjøsa\ trout} = a + b_1(\delta^{15}N) + b_2(\delta^{13}C) + b_3(\%\ Lipid)$

Equation 2: : $LogD5_{Lake\ Femunden\ trout} = a + b_1(\delta^{13}C) + b_2(CF)$

Table 16. Statistical model (ANCOVA) explaining total D5 concentrations (ng/g ww) in brown trout in Lake Mjøsa from 2014-2020. The term estimate refer to the parameters given in equation 1 above.

Term		Response: log D5		
		$R^2 = 0.49$	n = 105	
		d.f. = 3, 101	$p < 0.0001$	
		Estimate	tRatio	Prob > |t|
a	Intercept	- 9.408	-3.71	0.0003
b_1	$\delta^{15}N$	0.350	2.87	0.0050
B_2	$\delta^{13}C$	- 0.243	-3.24	0.0016
b_2	Lipid %	0.189	4.04	0.0001

Table 17. Statistical model (ANCOVA) explaining total D5 concentrations (ng/g w.w.) in brown trout in Lake Femunden from 2018-**2020**. The term estimate refer to the parameters given in equation 2 above. Model outcome uncertain due to issues on normality of distribution and non-significant intercept (α = 0.05).

Term		Response: log D5		
		R^2 = 0.33	n = 30	
		d.f. = 2, 27	p < 0.0040	
		Estimate	tRatio	Prob > |t|
a	Intercept	0.024	-7.63	0.9603
b_1	$\delta^{13}C$	- 0.043	-2.52	0.0180
B_2	CF	- 0.815	-2.80	0.0094

3.6.5 Trophic magnification of D5 in Lake Mjøsa

cVMS levels and their 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 where we are studying a pure pelagic food web. 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 2020 data in this report, support these findings (Jartun et al., 2019 and 2020; Fjeld et al., 2017).

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. (2017). 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 (Fjeld et al., 2017). We see that for some years (e.g. Jartun et al., 2018) large omnivorous zooplankton species tend to dominate the sampled material, which alters the $\delta^{15}N$ and subsequently the calculation of TL. In 2020, true primary consumers on a lower trophic level, such as *D. cristata* dominated the zooplankton samples. Calculation of the trophic magnification factor (TMF) is explained in chapter 2.4. Annual variation of TL in higher trophic levels, such as for brown trout, is then avoided. Estimated TMF will not change by using TL_{rel}.

When calculating the TMF for D5, all data from 2010-2020 in Lake Mjøsa have been analyzed. For some sampling years the sampling material is scarce for some trophic levels in the food web, such as the explained challenging sampling of zooplankton. Figure 26**Error! Reference source not found.** shows t he linear regression of ln-transformed D5 concentrations vs. TL_{rel} in zooplankton, *Mysis*, vendace, European smelt and brown trout from Lake Mjøsa for the years 2010-2020. There is a significant positive regression (r^2=0.22, p<0.0001) between TL_{rel} and ln D5 (ng/g lip) resulting in a calculated TMF of 2.1 (95 % CI: 1.75 – 2.43).

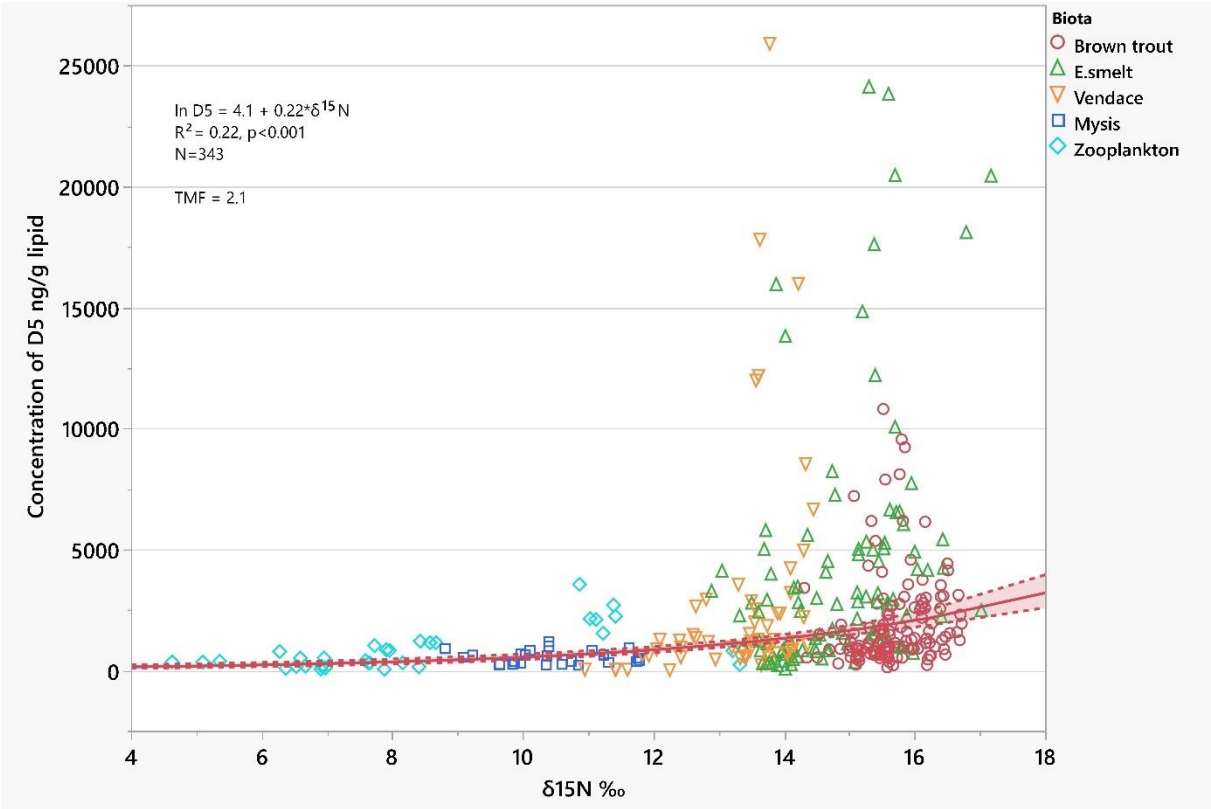

Figure 26. Exponential regression, with 95 % confidence level, of D5 concentrations in Lake Mjøsa biota from 2010 to 2020 as a function of measured $\delta^{15}N$. Prediction formula and estimated TMF are shown.

Trophic magnification of D5 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. (2020). Some other 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 an urban fjord (Ruus et al., 2020) or in a marine food web of the Oslofjord, rather a trophic dilution up the food web (Powell et al., 2018).

3.7 Polybrominated diphenyl ethers (PBDEs)

3.7.1 Detection frequency of PBDEs 2017-2020

Detection frequency for PBDEs in samples from 2020 are listed in the compilation in Table 3. In Table 18 below we have listed the total detection frequencies for all BDEs in biota from the entire monitoring program (2017-2020).

Table 18. Detection frequency (%) for PBDEs in biota from Lakes Mjøsa and Femunden. Data from 2017-2020 presented as percentage of analytical detections. Shading refers to 5 subclasses: white: 0-20 %, light pink: 21-40 %, pink: 41-60 %, light red: 61-80 % and **red: 81-100 %**.

	2017-2020					
	Mjøsa					Femunden
	Zoopl.	Mysis	Vendace	E.smelt	Brown trout	Brown trout
N	*11*	*11*	*35*	*40*	*60*	*40*
	Whole body	Whole body	Muscle	Muscle	Muscle	Muscle
BDE-17	18	18	43	60	77	30
BDE-28	18	55	**100**	**100**	**100**	**83**
BDE-47	73	**100**	**100**	**100**	**100**	**100**
BDE-49	18	**100**	**100**	**100**	**100**	**100**
BDE-66	9	27	**83**	55	**100**	75
BDE-71	0	0	3	8	8	8
BDE-77	0	0	51	13	63	23
BDE-85	0	0	3	18	22	13
BDE-99	**82**	**100**	**100**	**100**	**100**	**100**
BDE-100	45	**100**	**100**	**100**	**100**	**100**
BDE-119	0	0	60	38	**92**	78
BDE-126	0	0	17	20	50	23
BDE-138	0	0	3	5	0	3
BDE-153	0	55	**100**	**90**	**100**	**93**
BDE-154	18	**100**	**100**	**100**	**100**	**100**
BDE-156	0	0	3	0	2	0
BDE-183	0	0	51	28	53	58
BDE-184	0	0	46	10	80	80
BDE-191	0	0	3	3	0	3
BDE-196	0	0	3	5	3	3
BDE-197	0	0	6	8	15	15
BDE-202	0	0	9	18	40	13
BDE-206	9	9	14	20	12	15
BDE-207	9	0	11	23	10	15
BDE-209	27	27	26	35	35	23

3.7.2 Concentrations of PBDEs in 2020

PBDEs were determined in samples of zooplankton, *Mysis* and fish muscle (vendace, European smelt and brown trout) from Lake Mjøsa and in muscle of brown trout from Lake Femunden. Detection frequency for the individual BDEs is shown in Table 3. Results are mainly focused on the most common BDEs, specified by the Water Framework Directive ΣBDE_6: BDE-28, BDE-47, BDE-99, BDE-100, BDE-153 and BDE-154 (Direktoratsgruppen, 2018). All these compounds are commonly found in natural compartments as reviewed by Eljarrat and Barceló (2018). Detection frequencies for BDEs (ΣBDE_6) were 80-100 % in the *Mysis* and fish samples, and no detections in the zooplankton samples at the lower trophic level.

Concentrations of ΣBDE_6 and individual BDEs 28, 47, 99, 100, 153 and 154 in 2020 are presented for both wet weight concentrations and lipid normalized concentrations in Table 19 and Figure 27. Highest concentrations were found in brown trout from Lake Mjøsa with a mean concentration of ΣBDE_6 12 ng/g w.w. (870 ng/g lipid). Mean concentrations of ΣBDE_6 in European smelt and vendace were 1.3 and 0.84 ng/g w.w., respectively (310 and 38 ng/g lipid, respectively). Corresponding concentrations in *Mysis* and zooplankton in Lake Mjøsa were 0.23 and 0.024 ng/g w.w., respectively. Brown trout in Lake Femunden had mean ΣBDE_6 concentrations of 0.73 ng/g w.w. (89 ng/g lipid).

A full overview of all the BDEs in the analytical program is given in Figure 28 together with the ΣBDE_6 concentrations. ΣBDE_6 constitutes 75-97 % of total PBDEs in most samples. BDEs 47, 99, 100, 153 and 154 are dominating the results, as is also shown in previous years in Lake Mjøsa and Femunden (Jartun et al., 2020; Fjeld et al., 2017). Concentrations in brown trout from Lake Femunden are significantly lower than in brown trout from Lake Mjøsa, caused mainly by a 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.

EQS for ΣBDE_6 in biota is 0.0085 ng/g w.w. All biota samples exceeded this value. The European food safety authority (EFSA) presented a risk assessment on PBDEs in 2011. There are 209 theoretical congeners of PBDEs, but sufficient toxicity data only for four (BDE-47, -99, -153 and -209), with the highest dietary exposure to BDE-47 and -209 (EFSA CONTAM, 2011). PBDEs may cause DNA damage (Gao et al., 2009), and effects on neurodevelopment has also been identified as a critical effect (Eriksson et al., 2001). Based on uncertainties and limited data for some food groups, a tolerable weekly intake (TWI) could not be established. However, studies of exposure and subsequent concentrations in human tissue have found that with current dietary exposure there's a potential health concern for BDE-99, but not for the other three BDEs studied (EFSA CONTAM, 2011). This study is a general study covering several European countries. In early 2000 an industrial discharge of PBDEs into Lake Mjøsa caused substantial contamination of organisms living in the lake (Mariussen et al., 2008). Elevated concentrations of PBDEs were subsequently found in samples of serum in local consumers of fish from Lake Mjøsa compared to a reference group, and that approx. 98 % of the measured PBDE concentration in serum derived from fish consumption (Thomsen et al., 2008). Since

early 2000, the levels of PBDEs in fish from Lake Mjøsa has declined (see Figure 29) but there are no specific studies on potential effects on fish or humans caused by these substances.

The fully brominated congener BDE-209 was detected in 9 out of 46 samples, 7 of these detections were in brown trout and European smelt from Lake Mjøsa. 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 debrominated to lower brominated congeners, especially BDE-154 (Kierkegaard et al., 1999; Stapleton et al., 2006; Noyes et al., 2013).

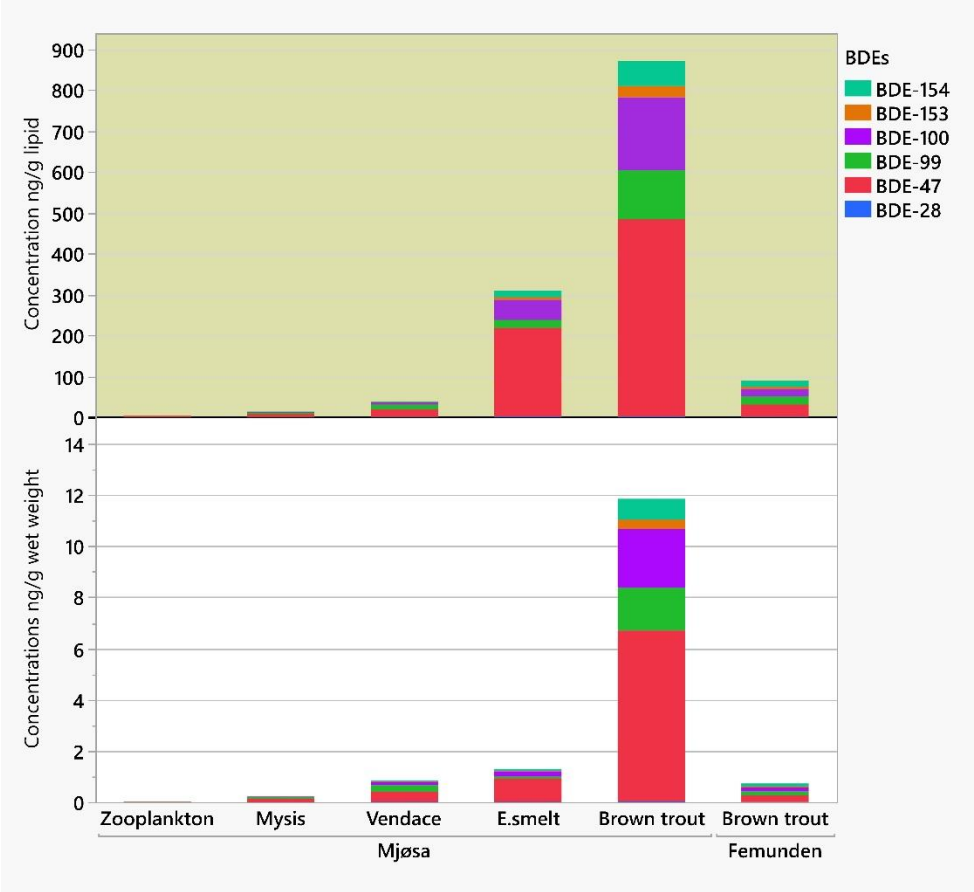

Figure 27. Concentrations of ΣBDE_6 (top: lipid weight; bottom: wet weight) included in the 2020 study in samples of zooplankton, *Mysis*, vendace, E. smelt and brown trout in Lake Mjøsa and brown trout in Lake Femunden. Concentrations are given in ng/g and results below LOQ have been replaced by half the limit.

Table 19. Mean, minimum (min) and maximum (max) 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 2020. Concentrations (ng/g w.n.) below LOQ have been replaced by half the limit when calculating $\bar{x}$ and ng/g lipid. Results above LOQ are shaded in orange. Upper table shows conc. in wet weight (w.w.), lower table on lipid weight (lipid).

2020				Concentration of PBDEs and ΣBDE$_6$ in ng/g wet weight (w.w.)						
Lake	**Matrix**	**N**	**Statistics**	**BDE-28**	**BDE-47**	**BDE-99**	**BDE-100**	**BDE-153**	**BDE-154**	**ΣBDE$_6$**
Mjøsa	Zoopl.	3	*Range*	<0.002	0.011 – 0.013	0.004	0.002	<0.006	<0.004	0.024 – 0.025
			Mean, $\bar{x}$	<0.002	0.012	0.004	0.002	0.003	0.002	0.024
			N>LOQ	0/3	3/3	3/3	3/3	0/3	0/3	
	Mysis	3	*Range*	<0.002 – 0.003	0.10 – 0.15	0.050 – 0.073	0.024 – 0.032	<0.0060 – 0.0060	0.010 – 0.013	0.19 – 0.27
			Mean, $\bar{x}$	0.002	0.13	0.062	0.027	0.0040	0.011	0.23
			N>LOQ	1/3	3/3	3/3	3/3	1/3	3/3	
	Vendace	10	*Range*	0.003 – 0.006	0.32 – 0.49	0.19 – 0.32	0.089 – 0.14	0.017 – 0.033	0.026 – 0.047	0.66 – 1.0
			Mean, $\bar{x}$	0.005	0.40	0.25	0.12	0.025	0.038	0.84
			N>LOQ	10/10	10/10	10/10	10/10	10/10	10/10	
	E. smelt	10	*Range*	0.0020 – 0.028	0.025 – 3.7	0.0050 – 0.37	0.0050 – 0.79	<0.0060 – 0.11	0.0050 – 0.26	0.048 – 5.2
			Mean, $\bar{x}$	0.0090	0.91	0.079	0.20	0.028	0.069	1.3
			N>LOQ	10/10	10/10	10/10	10/10	7/10	10/10	
	B. trout	15	*Range*	0.006 – 0.056	1.5 – 14	0.33 – 4.4	0.67 – 5.8	0.097 – 0.87	0.18 – 1.9	2.7 - 27
			Mean, $\bar{x}$	0.027	6.7	1.7	2.3	0.36	0.82	12
			N>LOQ	15/15	15/15	15/15	15/15	15/15	15/15	
Femunden	B. trout	10	*Range*	<0.004 – 0.010	0.069 – 0.55	0.081 – 0.42	0.042 – 0.38	0.012 – 0.092	0.031 – 0.28	0.30 – 1.7
			Mean, $\bar{x}$	0.005	0.25	0.16	0.15	0.042	0.12	0.73
			N>LOQ	6/10	10/10	10/10	10/10	9/10	10/10	

2020				Concentration of PBDEs and ΣBDE$_6$ in ng/g lipid						
Lake	**Matrix**	**N**	**Statistics**	**BDE-28**	**BDE-47**	**BDE-99**	**BDE-100**	**BDE-153**	**BDE-154**	**ΣBDE$_6$**
Mjøsa	Zoopl.	3	*Range*	0.20 – 0.32	2.3 – 4.0	0.83 – 1.2	0.42 – 0.54	0.61 – 0.97	0.41 – 0.65	4.8 – 7.7
			Mean, $\bar{x}$	0.25	3.0	0.99	0.47	0.75	0.50	6.0
	Mysis	3	*Range*	0.050 – 0.11	4.8 – 11	2.4 – 5.4	1.0 – 2.6	0.15 – 0.33	0.43 – 1.0	9.0 – 20
			Mean, $\bar{x}$	0.082	7.3	3.6	1.6	0.23	0.66	14
	Vendace	10	*Range*	0.11 – 0.35	12 – 26	7.1 – 17	3.3 – 7.3	0.60 – 1.7	0.96 – 2.5	23 - 55
			Mean, $\bar{x}$	0.25	18	12	5.2	1.2	1.8	38
	E. smelt	10	*Range*	0.19 – 14	2.0 – 1500	0.76 – 140	0.45 – 340	0.25 – 46	0.42 – 110	4.0 – 2100
			Mean, $\bar{x}$	2.1	220	20	49	6.7	16	310
	B. trout	15	*Range*	0.36 – 4.8	65 – 1600	11 – 510	19 – 670	2.5 – 100	6.7 – 230	100 - 3100
			Mean, $\bar{x}$	1.9	480	120	180	27	61	870
Femunden	B. trout	10	*Range*	0.16 – 2.1	9.1 – 58	1.6 – 45	5.5 – 41	1.1 – 12	2.2 – 34	27 - 190
			Mean, $\bar{x}$	0.63	30	20	19	5.3	15	89

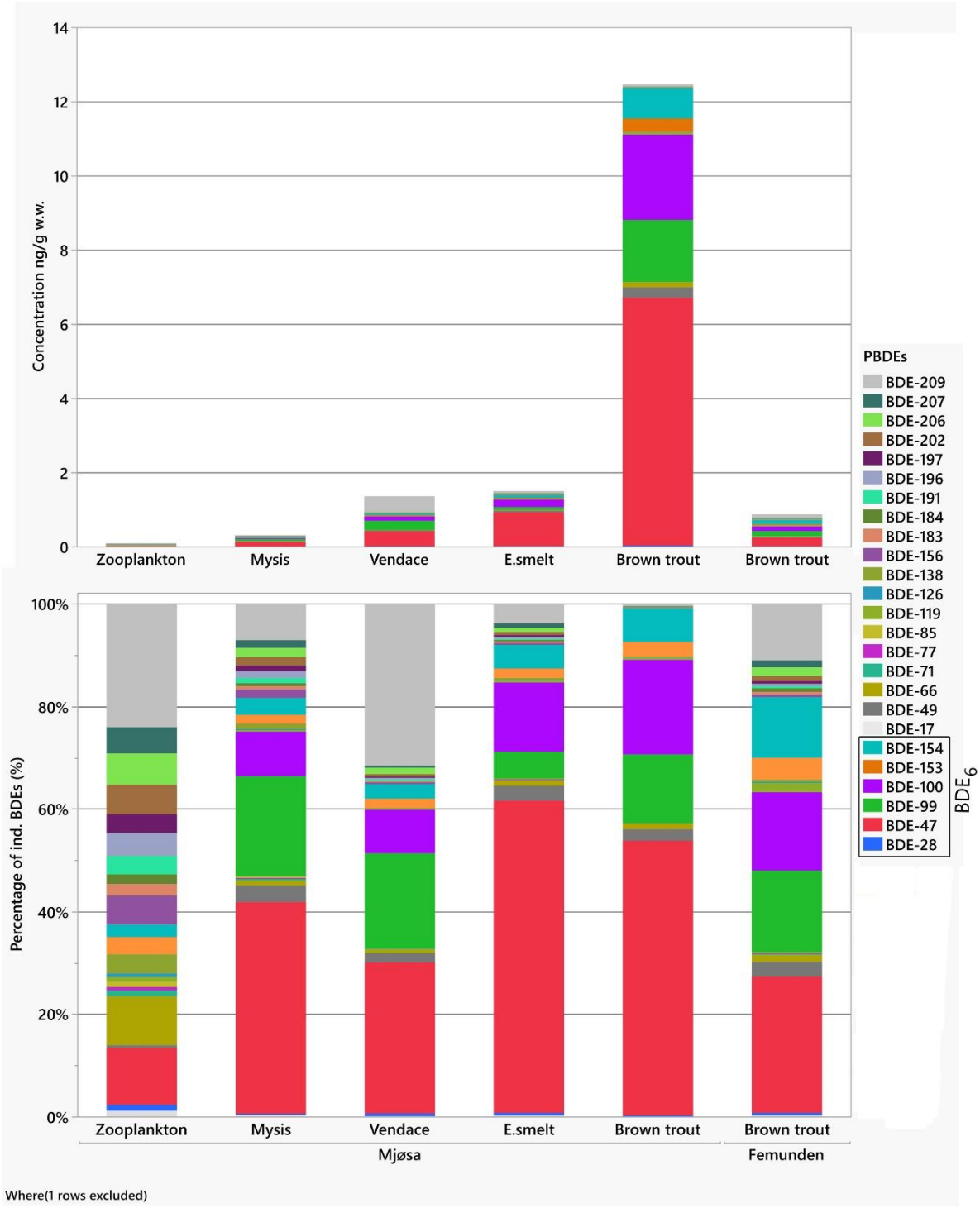

Figure 28. Stacked graphs of all BDEs (top: concentrations in ng/g w.w.; bottom: percentage of individual BDEs) in samples of zooplankton, *Mysis*, vendace, E.smelt and brown trout from Lake Mjøsa in 2020, and brown trout from Lake Femunden. One sample of brown trout in Lake Femunden was removed from the calculations because of high uncertainty and low recovery of BDEs 206, 207 and 209 in this specific sample.

3.7.3 Time trends for PBDEs

PBDEs have been studied in Lake Mjøsa in several fish species such as vendace, European 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 newer data with the oldest concentrations. But for brown trout and vendace, consistent data for PBDEs in muscle is available from around year 2000.

Mean concentrations of BDE_6 in samples of brown trout from Lake Mjøsa between 2000-2020 are shown in Figure 29. Concentrations have decreased since the extreme values in the early 2000, an approximate decrease of 95 %, at which point large discharges from an industry company close to Lillehammer affected the entire lake. Highest reported concentrations of ΣBDE_6 was 5400 ng/g lipid in brown trout in the year 2000 (Mariussen et al., 2008; Fjeld et al., 2016). Discharges to Lake Mjøsa was stopped in 2003. In 2019 the concentration was 560 ng/g lipid in brown trout (Table 19, Figure 27), however the mean BDE_6 lipid concentrations are calculated differently when looking at a single year (Figure 27) compared to the entire time series (Figure 29). We only have mean concentrations for the congeners in BDE_6 from 2000-2012, and no individual fish data. When calculating the mean concentration in the entire **time series** from year 2000, we have to use the mean for each BDE-congener and the **mean lipid content** before calculating ΣBDE_6 lipid. For fish caught in 2013-2020 we use individual fish data (Figure 30).

Levels of ΣBDE_6 in brown trout from Lake Mjøsa seem to have stabilized the latest years around concentrations of 8 ng/g w.w. (approx. 350-500 ng/g lipid).

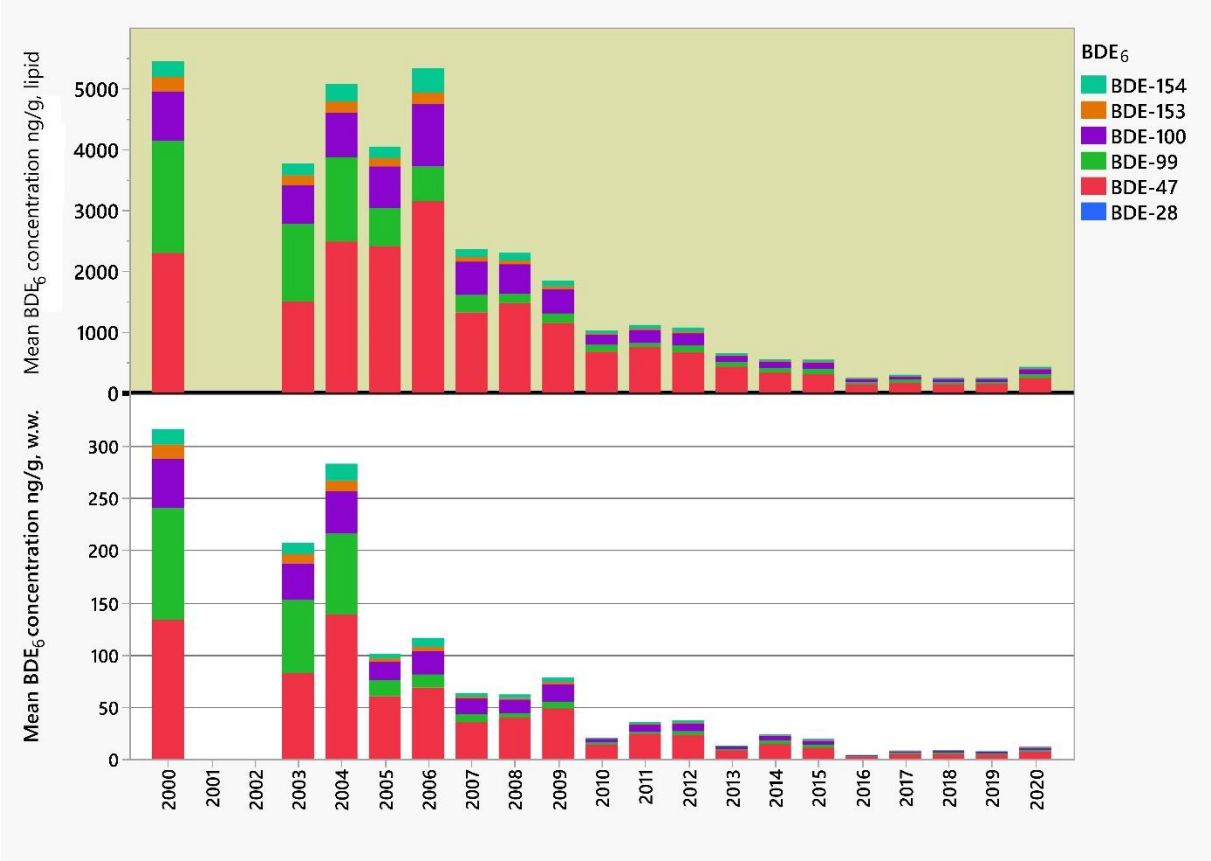

Figure 29. Mean concentrations of BDE_6 in samples of brown trout from Lake Mjøsa between 2000-2020. Concentrations are given in ng/g lipid weight (top, yellow) and ng/g wet weight (bottom). Concentrations below LOQ have been replaced by half the limit.

In Figure 30 the ΣBDE_6 levels in brown trout from Lake Mjøsa on lipid weight basis from 2013-2020 are given. In this figure we have calculated ΣBDE_6 using individual data for both BDE congeners and lipid content. The congener fingerprint seems similar in 2017 – 2020 and diverging lipid content may explain the small differences. The decrease in ΣBDE_6 concentrations from 2013 to 2020 was not statistically significant (p=0.13).

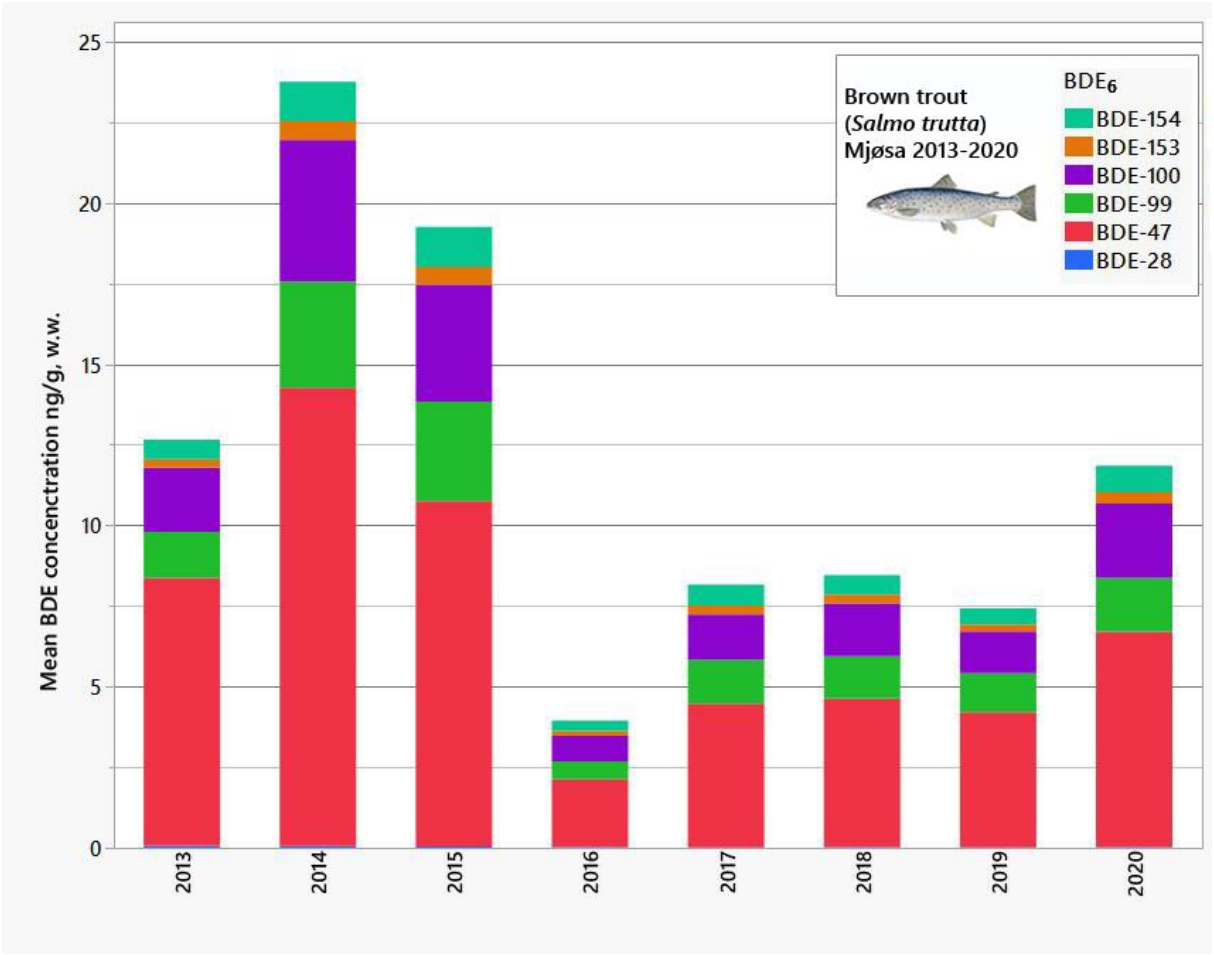

Figure 30. Mean concentrations for ΣBDE_6 in samples of brown trout (muscle) from Lake Mjøsa, 2013-2020. Concentrations are given in ng/g wet weight. Concentrations below LOQ have been replaced by half the limit.

The differences in mean concentrations (ng/g, w.w.) between brown trout in Lake Mjøsa and in Lake Femunden are illustrated in Figure 31. Individual concentrations for ΣBDE_6 (w.w.) are shown with dots, and the mean concentration is smoothed over the years from 2013-2020. 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.

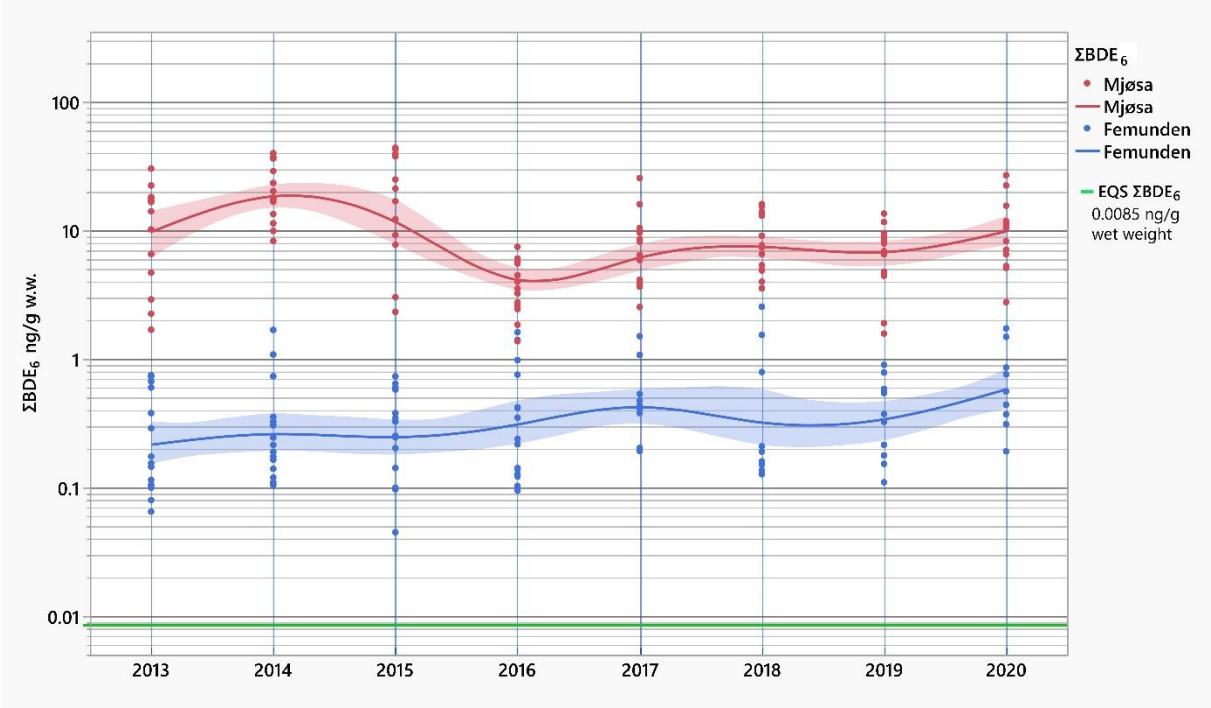

Figure 31. Mean concentrations for ΣBDE_6 in samples of brown trout from Lakes Mjøsa and Femunden, 2013-2020. Concentrations are given in ng/g w.w. A fitted line indicates the mean value smoothed over the years with a 95 % confidence interval shading. Concentrations below LOQ have been replaced by half the limit.

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

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}, calculated from $\delta^{15}N$) have been studied 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, with concentrations typically normalized to lipid content before regression analysis (Borgå et al., 2012a). Trophic magnification factors (TMF) are calculated and reported on the basis of lipid equivalent concentrations. Fjeld et al. (2017) and Jartun et al. (2019, 2020) have shown good correlation with relative trophic level (TL_{rel}) for D5 and D6 concentrations indicating biomagnification for these compounds. Same patterns are shown for Hg and BDE-47 and PFOS.

PFOS preferably interacts with serum proteins in blood rich tissue such as blood and liver (Jones et al., 2003), whereas Hg (me-Hg), siloxanes and PBDEs are highly lipophilic (McIntyre and Beauchamp, 2007; Borgå et al., 2013b; Eljarrat and Barceló, 2018). Trophic magnification factors (TMFs) describes the compound flux through multiple organisms on multiple trophic levels along a defined food chain or web (Franklin, 2015). The TMF thus increases with efficient and rapid uptake of a given compound by a consumer (or predator) organism through their diet and subsequent slow elimination rate of the compound (Goss et al., 2013). Ideally, calculations of TMFs (see chapter 2.4) should be performed on a whole-organism normalization or an organ specific basis (e.g. liver, muscle) normalized to respective lipid or protein concentrations. In our study we have not corrected the organ specific concentrations to whole-body, and thus introduced an uncertainty when interpreting the biomagnification potential. This is, however, not unusual when studying different organisms in a food web (Kelly et al., 2009) ranging from small copepods (zooplankton) to large predators such as brown trout. For Hg, cVMS and PBDEs concentrations have been evaluated on a lipid normalization, however for PFOS we do not have data on protein concentrations, and therefore the TMF calculation for PFOS was performed on a wet weight basis.

Figure 32 displays the $\log_e$-normalized concentration data for D5, Hg, BDE-47 and PFOS against TL_{rel} as well as the correlation between the individual contaminants in 2020. For PFOS, wet weight concentrations were used. All compounds have a significant positive correlation with TL_{rel} ($p<0.0001$). In this figure, data from 2013-2020 are included, limiting the influence of deviations in the trophic level of zooplankton in specific years (such as in 2018). TMF calculated from a larger dataset (2013/2014-2020) is discussed for each contaminant in its respective chapter. TMFs for D5, Hg, PFOS and BDE-47 in the total dataset from 2013-2020 were 2.1, 6.7, 6.0 and 3.6, respectively.

PFOS seem to have a strong positive correlation with Hg, and a moderate correlation with BDE-47 across the dataset for 2013-2020 ($r^2=0.60$ and $r^2=0.51$, respectively). TMF values confirm the biomagnifying properties for all these four contaminants in Lake Mjøsa, as is also previously reported

by Fjeld et al. (2016, 2017) and Jartun et al. (2020). D5 has a weak correlation with BDE-47 and Hg (r^2=0.30 and r^2=0.16, respectively).

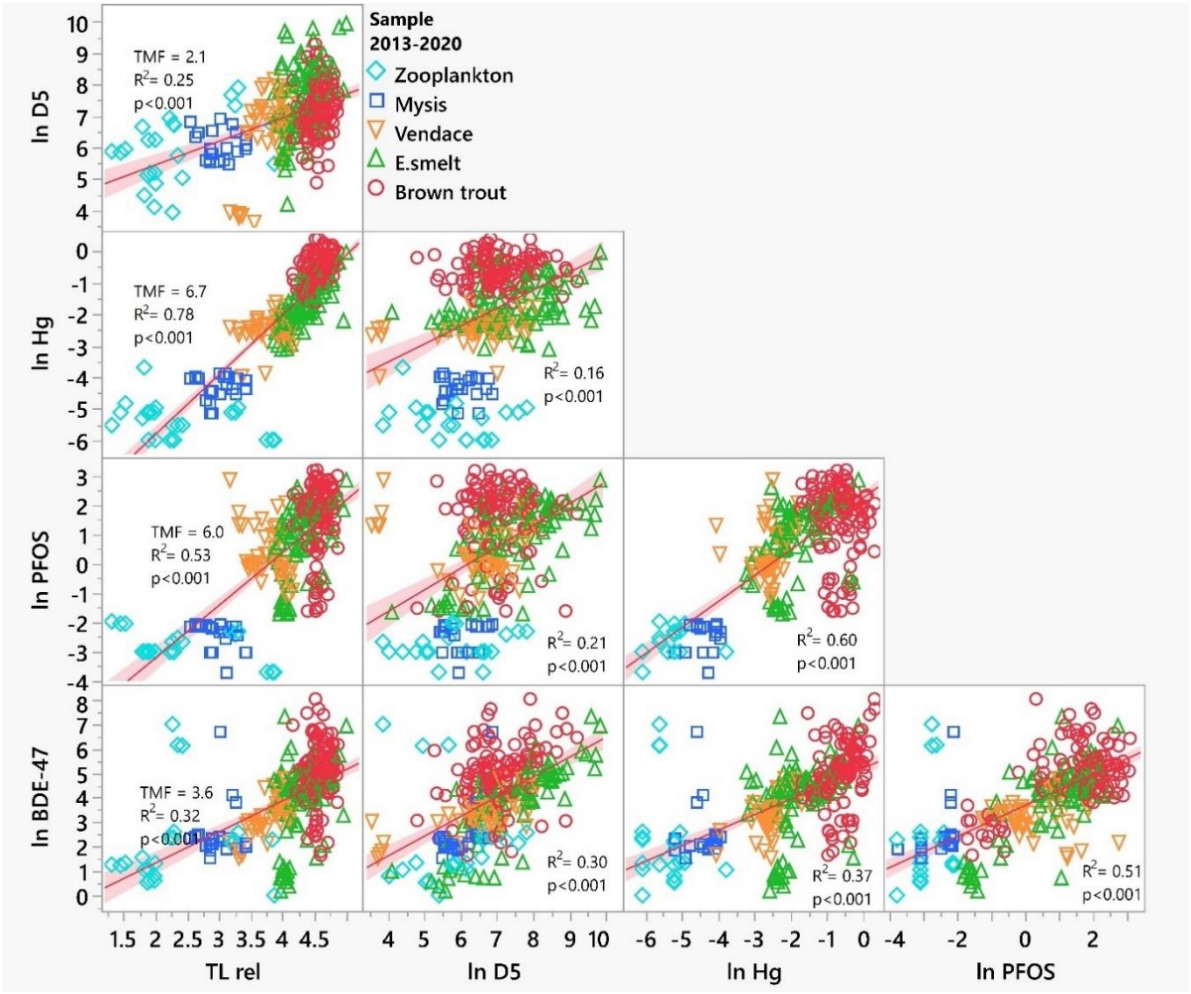

Figure 32. Scatter plots and regression lines between Hg, D5, PFOS, BDE-47 and relative trophic level (TL_{rel}) in fish (Hg, D5 and BDE-47: muscle; PFOS: liver), *Mysis*, and zooplankton from Lake Mjøsa, sampled in 2013-2020. Concentrations are log_e(ln)-transformed on a lipid weight basis, ng/g lip, except for PFOS (wet weight). Conc. below LOQ are replaced by half the limit. R^2: correlation coefficient, TMF: trophic magnification factor.

3.9 Alkylphenols and bisphenols

3.9.1 Detection frequency of alkylphenols and bisphenols 2017-2020

Detection frequency for phenolic compounds in samples from 2020 are listed in the compilation in Table 3. In Table 20 below we have listed the total detection frequencies for all phenols in biota from the entire monitoring program (2017-2020). There are only sporadic detections of single compounds, such as the bisphenol-F compounds and 4,4-bisphenol-A. There is no significant difference between concentrations above LOQ in muscle and bile. Number of samples analyzed have varied, see Table 21.

Table 20. Detection frequency (%) for alkyl- and bisphenols in biota from Lakes Mjøsa and Femunden. Data from 2017-2020 presented as percentage of analytical detections. Shading refers to 5 subclasses: white: 0-20 %, light pink: 21-40 %, pink: 41-60 %, light red: 61-80 % and **red: 81-100 %**.

	2017-2020							
	Mjøsa						Femunden	
	Zoopl.	Mysis	Vendace	E.smelt	Brown Trout	Brown trout	Brown trout	Brown trout
	Whole body	Whole body	Muscle	Muscle	Muscle	Bile	Muscle	Bile
4,4-bis-A	0	0	0	10	13	20	6	17
2,4-bis-A	0	0	0	0	0	0	0	0
bis-G	0	0	0	0	0	0	0	0
4,4-bis-S	0	0	0	0	0	0	0	0
2,4-bis-S	0	0	0	0	0	0	0	0
4,4-bis-F	0	13	4	13	11	0	15	50
2,4-bis-F	0	20	7	15	10	8	0	58
2,2-bis-F	0	20	0	0	3	20	0	42
bis-P	0	0	0	0	4	0	0	0
bis-Z	0	0	0	0	0	0	0	0
TBBPA	0	0	0	0	0	0	0	0
4-tert-octylphenol	0	0	0	0	0	4	0	0
4-octylphenol	0	0	0	0	0	0	0	0
4-nonylphenol	0	0	0	0	0	0	0	0

Table 21. Number of samples analyzed for alkyl- and bisphenols in samples of zooplankton, *Mysis* (whole body), vendace, E.smelt (muscle) and brown trout (muscle and bile) in Lake Mjøsa and brown trout (muscle and bile) in Lake Femunden between 2017-2020.

	2017-2020							
	Mjøsa						Femunden	
Alkyl- and bisphenols	Zoopl.	Mysis	Vendace	E.smelt	Brown trout (muscle)	Brown trout (bile)	Brown trout (muscle)	Brown trout (bile)
4,4-bis-A	8	8	25	30	45	25	33	12
2,4-bis-A	5	5	15	20	30	25	23	12
bis-G	5	5	15	20	30	25	23	12
4,4-bis-S	8	8	25	30	45	25	33	12
2,4-bis-S	5	5	15	20	30	25	23	12
4,4-bis-F	8	8	25	30	45	25	33	12
2,4-bis-F	5	5	15	20	30	25	23	12
2,2-bis-F	5	5	15	20	30	25	23	12
bis-P	8	8	25	30	45	25	33	12
bis-Z	8	8	25	30	45	25	33	12
TBBPA	8	8	25	30	45	25	33	12
4-tert-octylphenol	8	8	25	30	45	25	33	12
4-octylphenol	5	5	15	20	30	25	23	12
4-nonylphenol	8	8	25	30	45	22	33	12

Sample matrices for alkyl- and bisphenols were whole body for zooplankton and *Mysis*, fish muscle for European smelt and vendace. For brown trout in Lake Mjøsa bile was chosen as the preferred matrix. For brown trout in Lake Femunden we analyzed fish muscle in 4 out of 10 samples, and bile in 6 out of 10 samples. Almost all samples were below LOQ, as is shown in the overview of detection frequency in Table 3, except some minor detections of bisphenol-A and bisphenol-F compounds.

In 2017 and 2018 fish muscle was the preferred target matrix for phenols in this study. However, bile has been reported to contain higher concentrations of alkylphenols than other tissues within the same individual (Jonsson et al., 2008; Wu et al., 2016). In 2019, bile was introduced as alternative tissue in brown trout, and in 2020 we decided to test for phenols in muscle and bile from brown trout in both lakes only.

Although generally low concentrations were found (only some above LOQ), the highest concentrations were found in bile of brown trout from Lake Femunden (2,4-bis-F and 4,4-bis-F: mean concentrations 38 and 27 ng/g w.w., respectively (Table 22). The high concentrations of bis-F analogues found in brown trout from Lake Femunden should be discussed with caution. Blind (blank) samples for these substances were very high compared to the rest of the phenolic compounds, most likely because of the presence of unsaturated fatty acids in the sample.

Some detections of phenols slightly >LOQ were found in brown trout bile in both lakes, but there are no significant indications within the dataset from 2020 that bile was a more efficient matrix for the detection of alkyl- and bisphenols in freshwater biota than muscle, the preferred sample matrix in 2017 and 2018 (Jartun et al., 2019 and 2020). Nonylphenol and octylphenol are listed in the Norwegian EQS overview of priority hazardous substances (3000 and 0.004 ng/g w.w., respectively). All samples were below EQS for these two compounds.

The few detections of phenolic compounds in 2020 are comparable to the results from previous years 2017-2019 (Jartun et al., 2020). Bisphenol A was detected in a few samples of brown trout in both lakes, but only slightly above LOQ.

Higher concentrations of especially 4-tert-octylphenol have been observed in freshwater fish in other lakes in Norway (Lyche et al., 2020). There is, however, a significant difference in analytical method leading to these findings. In the present study of brown trout from Lake Mjøsa and Lake Femunden we are determining a long range of bisphenols in the same sample, with a much smaller sample volume, resulting in a relatively high LOD compared to Lyche et al. (2020) that only determine nonyl- and octylphenol. Concentrations of nonyl- and octylphenol have also been reported in cod liver and blue mussels along the Norwegian coast with median values of 5-36.9 ng/g w.w. for nonylphenol in cod liver (Green et al., 2019). Ruus et al. (2020) reported very few detections of phenolic compounds in biota, but concentrations above EQS for bisphenol-A in stormwater runoff around a Norwegian urban fjord.

Table 22. Concentration range (min-max), mean ($\bar{x}$) and number (N) of detections for alkylphenols and bisphenols in samples of zooplankton, *Mysis*, vendace, E. smelt and brown trout from Lake Mjøsa and brown trout from Lake Femunden in 2020. Concentrations are given in ng/g on wet weight (w.w.) basis. Concentrations below LOQ (w.w.) have been replaced by half the limit when calculating $\bar{x}$. "N>LOQ" is the number of samples above LOQ.

Lake	Matrix	N	Statistics	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	4-tert-octylphenol	4-octyl-phenol	4-nonyl-phenol
Mjøsa	Brown trout *Muscle*	15	Range	<11 – 21	<1.3	<2.1	<20.3	<0.50	<5.2 – 12	<9.6 – 21	<0.50 - 0.70	<1.6	<3.7	<4.5	<1.3	<5.1	<7.0
			Mean, $\bar{x}$	<11	<1.3	<2.1	<20.3	<0.50	<5.2	<9.6	<0.5	<1.5	<3	<3	<6	<3.5	<5
			N>LOQ	1	0	0	0	0	3	3	1	0	0	0	0	0	0
	Brown trout *Bile*	11	Range	<11	<2.2	<2.1	<20	<0.50	<5.2	<9.6	<0.75	<2.1	<4.0	<4.9	<2.9	<5.1	<7.0
			Mean, $\bar{x}$	<11	<2.2	<2.1	<20	<0.50	<5.2	<9.6	<0.75	<2.1	<4.0	<4.9	<2.9	<5.1	<7.0
			N>LOQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Femunden	B. trout *Muscle*	10	Range	<11	<1.3	<2.3	<20	<0.60	<5.2	<11	<0.60	<1.8	<4.0	<4.9	<3.2	<5.6	<7.0
			Mean, $\bar{x}$	<11	<1.3	<2	<20	<0.60	<5.2	<11	<0.60	<1.8	<4.0	<4.9	<3.2	<5.6	<7.0
			N>LOQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B.trout *Bile*	5	Range	<11 – 14	<1.4	<4.5	<22	<0.60	11 – 42	11 – 52	<1.1 – 4.9	<5.5	<4.0	<10	<12	<10	<13
			Mean, $\bar{x}$	<11	<1.4	<4.5	<22	<0.60	27	38	1.7	<5.5	<4.0	<10	<12	<10	<13
			N>LOQ	1	0	0	0	0	5	5	4	0	0	0	0	0	0

3.10 Organic phosphorus flame retardants (oPFR)

3.10.1 Detection frequency of oPFR 2017-2019

oPFR were not determined in this monitoring program in 2020. However, in Table 23 we show the combined detection frequency for these contaminants for 2017-2019. Total results for oPFR in this period are listed in Table 24.

Table 23. Detection frequency (%) for oPFR in biota from Lakes Mjøsa and Femunden (N: no. of samples). Data from 2017-2019 presented as percentage of analytical detections. Shading refers to 5 subclasses: white: 0-20 %, light pink: 21-40 %, pink: 41-60 %, light red: 61-80 % and **red: 81-100 %**.

	2017-2019					
	Mjøsa					Femunden
	Zoopl.	Mysis	Vendace	E.smelt	Brown trout	Brown trout
N	*5*	*6*	*25*	*25*	*45*	*30*
	Whole body	Whole body	Muscle	Muscle	Muscle	Muscle
TEP*	0	0	0	0	0	0
TCEP	0	0	0	0	0	0
TPrP	0	0	0	0	0	0
TCPP	80	**100**	40	52	29	53
TiBP	0	17	0	0	0	0
BdPhP	0	0	0	0	0	0
TPP	**100**	67	**88**	76	18	0
DBPhP	0	0	0	0	0	0
TnBP	60	50	4	8	13	7
TDCPP	20	0	0	4	0	0
TBEP	0	0	4	4	2	13
TCP	40	0	36	16	0	0
EHDP	0	17	20	0	0	3
TXP	0	0	0	4	2	0
TEHP	**100**	50	0	8	2	0

**TEP only 2, 3, 20, 15, 30 and 20 samples in total, respectively*

Organic phosphorus flame retardants were determined in whole body of zooplankton and *Mysis* and in fish muscle from Lake Mjøsa and brown trout from Lake Femunden. Tris-chloropropyl phosphate (TCPP) and triphenyl phosphate (TPP) were found in most samples of zooplankton, *Mysis* and the fish at lower trophic levels in Lake Mjøsa. TCPP was also detected in 50 % of the samples of brown trout in Lake Femunden, but only 30 % in the brown trout from Lake Mjøsa. Tri-n-butylphosphate (TnBP) and tris(2-ethylhexyl)phosphate (TEHP) were detected in almost all samples of zooplankton and *Mysis*. As for the rest of the oPFRs in the analytical program, there were only sporadic detections.

Table 24 shows the main results of oPFRs found in zooplankton, *Mysis*, vendace, European smelt and brown trout from Lake Mjøsa and brown trout from Lake Femunden in 2019. Highest concentrations of TCPP were found in vendace from Lake Mjøsa (0.32 – 1.1 ng/g w.w., mean 0.64 ng/g w.w.), and for TPP in samples of zooplankton (0.50-0.67 ng/g w.w., mean 0.58 ng/g w.w.). No oPFRs were detected in samples of the top predator brown trout from Lake Mjøsa, and only TCPP was detected in 6 out of 10 samples of brown trout from Lake Femunden. Similar results i.e. mostly concentrations below LOQ were found in a study of predator fish (Lake trout) in Canadian great lakes where only two oPFRs (TCEP and tris(2-butoxyethyl) phosphate (TBOEP)) were frequently detected in concentrations below 10 ng/g w.w. (McGoldrick et al., 2014). Another study by Zhao et al. (2018) were able to detect 9 out of 14 oPFRs but could not determine a trophic magnification of oPFRs in a food web in China.

The presence of a few specific oPFRs only in the lower trophic levels in Lake Mjøsa suggest that these compounds are readily metabolized in the top predators, and that future studies of oPFRs should be focused on potential degradation products. Some of the oPFRs are readily metabolized to diester equivalents, e.g. triphenyl phosphate (TPP, also determined TPHP in some literature) metabolizes to diphenyl phosphate (DPP/DPHP), and TCPP (also determined TClPP) degrades to *bis*(1-chloro-2-propyl) phosphate (BCPP/BClPP) (Butt et al., 2014; Wang et al., 2017).

Ruus et al. (2020) found detectable levels of oPFRs in samples of effluent water and sludge from a Norwegian wastewater treatment plant (WWTP) close to the Oslofjord. TCPP and triethyl phosphate (TEP) were the dominate oPFRs in effluent water whereas TCPP and tris(2-butoxyethyl) phosphate (TBEP) had the highest concentrations in sludge. This indicates that discharges from WWTPs might be a relevant source for these compounds to the environment.

Table 24. Concentration range (min-max), mean (x̄) and number (N) of detections for organic phosphorus flame retardants (oPFRs) in samples of zooplankton, *Mysis*, vendace, E. smelt and brown trout from Lake Mjøsa and brown trout from Lake Femunden in 2017-2019. Concentrations are given in ng/g on wet weight (w.w.) basis. Concentrations below LOQ (w.w.) have been replaced by half the limit when calculating x̄. "N>LOQ" is the number of samples above LOQ. Sample groups with more than 50 % of the samples above LOQ are marked in orange.

Lake	Matrix	N	Statistics	TEP	TCEP	TPrP	TCPP	TiBP	BdPhP	TPP	DBPhP	TnBP	TDCPP	TBEP	TCP	EHDP	TXP	TEHP
Mjøsa	Zoopl.	5	Range	<1	<0.4	<0.01	<1.7 – 4.3	<0.15	<0.01	0.50-5.0	<0.01	<0.8-0.12	<0.2-0.8	<0.1	<0.05-0.4	<0.1	<0.05	0.66-1.5
			Mean, x̄	<1	<0.4	<0.01	0.59	<0.15	<0.01	0.58	<0.01	0.11	<0.2	<0.1	<0.05	<0.1	<0.05	1.2
			N>LOQ	0	0	0	4	0	0	5	0	3	1	0	2	0	0	5
	Mysis	6	Range	<1	<0.4	<0.01	0.21 - 0.51	<0.15-0.12	<0.01	0.15-0.41	<0.01	<0.1-0.13	<0.2	<0.1	<0.05	<0.1-1.4	<0.05	<0.2-4.1
			Mean, x̄	<1	<0.4	<0.01	0.53	<0.15	<0.01	0.29	<0.01	<0.1	<0.2	<0.1	<0.05	<0.1	<0.05	3.6
			N>LOQ	0	0	0	6	1	0	4	0	3	0	0	0	1	0	3
	Vendace	25	Range	<1	<0.6	<0.05	<0.30 - 4.3	<0.20	<0.05	<0.03-0.69	<0.05	<0.1-0.17	<0.2	<0.1-0.11	<0.1-4.4	<0.2-0.77	<0.1	<0.1
			Mean, x̄	<1	<0.6	<0.05	0.64	<0.20	<0.05	0.22	<0.05	<0.1	<0.2	<0.1	0.9	0.31	<0.1	<0.1
			N>LOQ	0	0	0	10	0	0	22	0	1	0	1	9	5	0	0
	E. smelt	25	Range	<1	<0.4	<0.01	0.19 - 0.42	<0.15	<0.01	<0.03-5.6	<0.01	<0.1-0.27	<0.2-0.31	<0.1-0.72	<0.05-0.09	<0.1	<0.05	<0.2-2.6
			Mean, x̄	<1	<0.4	<0.01	0.31	<0.15	<0.01	0.60	<0.01	<0.1	<0.2	<0.1	<0.05	<0.1	<0.05	<0.3
			N>LOQ	0	0	0	13	0	0	19	0	2	1	1	4	0	1	2
	B. trout	45	Range	<0.050	<0.10	<0.010	<0.05 - 1.74	<0.15	<0.01	<0.03-0.08	<0.01	<0.010 – 0.20	<0.20	<0.1	<0.05	<0.1	<0.05 -0.07	<0.2 – 0.28
			Mean, x̄	<0.050	<0.10	<0.010	<0.3	<0.15	<0.01	<0.03	<0.01	<0.01	<0.20	<0.1	<0.05	<0.1	<0.05	<0.2
			N>LOQ	0	0	0	13	0	0	8	0	0	0	1	0	0	1	1
Femunden	B. trout	30	Range	<0.30	<0.60	<0.05	<0.10 - 0.49	<0.20	<0.05	<0.05	<0.05	<0.01 -0.1	<0.2	<0.05-1.9	<0.1	<0.1-0.52	<0.1	<0.1
			Mean, x̄	<0.30	<0.60	<0.05	0.13	<0.20	<0.05	<0.05	<0.05	<0.01	<0.2	<0.05	<0.1	<0.1	<0.1	<0.1
			N>LOQ	0	0	0	16	0	0	0	0	2	0	4	0	1	0	0

3.11 Per- and polyfluorinated substances (PFAS)

PFASs have been determined in samples of zooplankton and *Mysis* (whole body), vendace, European smelt and brown trout (liver) from Lake Mjøsa and brown trout (liver) from Lake Femunden in 2017-2020. Table 25 lists the detections and total number of samples of target PFAS within the monitoring program divided in subclasses of 0-20, 21-40, 41-60, 61-80 and 81-100 % analytical detections above LOD/LOQ for each sample type.

Only a limited number of PFAS compounds are determined, dominated by long-chained perfluoroalkyl acids (PFCA, C_9-C_{15}), PFOS, and the precursors PFOSA and PFBSA. PFAS is not detected in zooplankton, and Table 25 indicates higher detection frequencies for these compounds as we move up the trophic levels to brown trout as the top predator in Lake Mjøsa.

3.11.1 Detection frequency of PFAS 2017-2020

Detection frequency for PFAS in samples from 2020 are listed in the compilation in Table 3. In Table 25 below we have listed the total detection frequencies for all PFAS in biota from the entire monitoring program (2017-2020).

Table 25. Detection frequency (%) for PFAS in biota from Lakes Mjøsa and Femunden. Data from 2017-2020 presented as percentage of analytical detections. Shading refers to 5 subclasses: white: 0-20 %, light pink: 21-40 %, pink: 41-60 %, light red: 61-80 % and **red: 81-100 %**.

	2017-2020					
			Mjøsa			Femunden
	Zoopl.	Mysis	Vendace	E.smelt	Brown trout	Brown trout
N	*12*	*12*	*35*	*40*	*60*	*40*
	Whole body	Whole body	Liver	Liver	Liver	Liver
PFPA	0	0	0	0	0	0
PFHxA	0	0	0	0	0	0
PFHpA	0	0	0	0	0	0
PFOA	0	0	0	23	0	0
PFNA	0	0	20	**93**	65	65
PFDA	0	0	31	**95**	**100**	**98**
PFUnDA	0	0	**83**	**98**	**100**	**100**
PFDoDA	0	0	**83**	**98**	**98**	**100**
PFTrDA	0	0	77	**93**	**100**	**100**
PFTeDA	0	0	17	**83**	**98**	**98**
PFPeDA	0	0	0	25	70	**93**
PFHxDA	0	0	0	0	0	0
PFBS	0	0	0	5	0	0
PFPS	0	0	0	0	0	0
PFHxS	0	0	0	0	3	0
PFHpS	0	0	0	5	7	0
PFOS	0	42	**100**	**100**	**100**	**100**
8Cl-PFOS	0	0	0	0	0	0

	2017-2020					
			Mjøsa			Femunden
	Zoopl.	Mysis	Vendace	E.smelt	Brown trout	Brown trout
N	*12*	*12*	*35*	*40*	*60*	*40*
	Whole body	Whole body	Liver	Liver	Liver	Liver
PFNS	0	0	0	3	0	0
PFDS	0	0	23	0	10	0
PFDoS	0	0	0	0	0	0
PFOSA	0	0	11	78	**100**	75
N-MeFOSA	0	0	0	0	0	0
N-EtFOSA	0	0	0	0	0	0
N-MeFOSE	0	0	0	0	0	0
N-EtFOSE	0	0	0	0	0	0
4:2 FTS	0	0	0	0	0	0
6:2 FTS	0	0	0	0	2	0
8:2 FTS	0	0	0	0	0	0
10:2 FTS	0	0	0	0	0	0
4:2 F53B	0	0	0	0	0	0
6:2 F53B	0	0	0	0	0	0
N-MeFOSAA	0	0	0	0	0	0
N-EtFOSAA	0	0	0	0	0	0
F53	0	0	0	0	0	0
7:3 FTCA	0	0	0	0	0	0
PFBSA	0	0	0	25	50	50
N-MeFBSA	0	0	0	0	0	0
N-EtFBSA	0	0	0	0	0	0

3.11.2 Levels of PFAS in 2020

Per- and polyfluorinated alkyl substances (PFAS) were determined in samples of whole-body zooplankton and *Mysis*, and in fish liver (vendace, European 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 has been the preferred sample matrix for fish in the monitoring program since 2013, as discussed in chapter 2.2.6.

Detection frequencies for PFASs in 2020 are shown in Table 3. 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 and *Mysis*. Other than the long-chained PFCAs, only the perfluoroctanesulfonate (PFOS) and the precursors perfluorooctanesulfonamide (PFOSA) and perfluoro-1-butansulfonamide (PFBSA) were detected. The major results for PFASs above LOQ are given in Table 26.

Table 26. Concentrations of dominating 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 in 2020. Concentrations below LOQ have been replaced by half the limit. Results **above** LOD are marked in orange.

Lake	Matrix	N	Stats.	PFDA	PFUnDA	PFDoDA	PFTrDA	PFTeDA	PFOS	PFOSA	PFBSA
Mjøsa	Zoopl.	3	Range	<0.40	<0.40	<0.40	<0.40	<0.40	<0.10	<0.20	<0.30
			Mean, x̄	<0.40	<0.40	<0.40	<0.40	<0.40	<0.10	<0.20	<0.30
			N>LOQ	0	0	0	0	0	0	0	0
	Mysis	3	Range	<0.40	<0.40	<0.40	<0.40	<0.40	<0.1	<0.20	<0.30
			Mean, x̄	<0.40	<0.40	<0.40	<0.40	<0.40	<0.1	<0.20	<0.30
			N>LOQ	0	0	0	0	0	0	0	0
	Vendace	10	Range	<0.40 - 0.46	<0.40 - 1.0	<0.40 - 0.99	<0.40 -0.95	<0.40	0.55-1-29	<0.20	<0.30
			Mean, x̄	<0.40	0.60	0.50	0.57	<0.40	0.92	<0.20	<0.30
			N>LOQ	3	9	8	9	0	10	0	0
	E. smelt	10	Range	0.84 -2.2	1.8 - 4.6	1.3 - 3.1	1.6 - 4.3	<0.40 - 1.1	1.6 - 3.3	<0.20 - 0.57	<0.30 - 0.42
			Mean, x̄	1.5	3.3	2.2	2.9	0.61	2.6	0.40	0.40
			N>LOQ	10	10	10	10	8	10	6	2
	B. trout	15	Range	1.5 - 8.8	3.5 -23	2.2 – 12	4.4 - 16	0.83 - 3.6	3.2 – 20	0.66 - 2.6	2.0 - 9.0
			Mean, x̄	4.4	11	5.9	8.9	1.8	9.1	1.5	4.9
			N>LOQ	15	15	15	15	15	15	15	15
Fem.	B. trout	10	Range	0.55 -2.0	1.7 – 10	1.2 - 6.5	3.8 - 29	0.67 - 4.8	1.0 - 3.4	<0.20 - 0.77	5.2 – 22
			Mean, x̄	1.4	6.5	4.4	17	2.9	2.1	0.50	14
			N>LOQ	10	10	10	10	10	10	9	10

Generally, the individual PFAS with concentrations above LOQ are mostly found in fish, and not in the lower trophic levels (zooplankton and *Mysis*). Highest concentration of the carboxylic acids (PFCA) was found in samples of brown trout from Lake Femunden (PFTrDA, range 3.8-29 ng/g w.w., mean 17 ng/g w.w.). In Lake Mjøsa, the highest concentration of PFAS was found in brown trout (PFUnDA; mean 11 ng/g, w.w.). Shorter chained PFCAs, i.e. $5 \leq C \geq 8$, was not found above LOQ in any of the samples in either lake.

Dominating PFAS in both lakes are long-chained perfluorinated carboxylic acids (PFCAs): PFNA (C-9), PFDA (C-10), PFUnDA (C-11), PFDoDA (C-12), PFTrDA (C-13), PFTeDA (C-14), perfluoroctanesulfonate (PFOS) and the precursor substances perfluorooctanesulfonamide (PFOSA) and perfluoro-1-butansulfonamide (PFBSA). All other PFAS were below LOQ, except for sporadic low detections of PFHxS and PFDS in brown trout from Lake Mjøsa. The percentage of detected PFAS in all samples from 2020 are shown in Figure 33.

Long-chained PFCAs are representing 70-80 % of the detected PFAS in fish liver samples from Lake Mjøsa and Lake Femunden. The three fish species from Lake Mjøsa have the same pattern with PFCA (C9-C14: 70-80 %) and PFOS (15-20 %) as main constituents, whereas in Lake Femunden the PFOS

fraction is only 7 %. Precursor substances detected (PFOSA and PFBSA) constitute a larger percentage in the top predator (brown trout) in Lake Femunden compared to Lake Mjøsa.

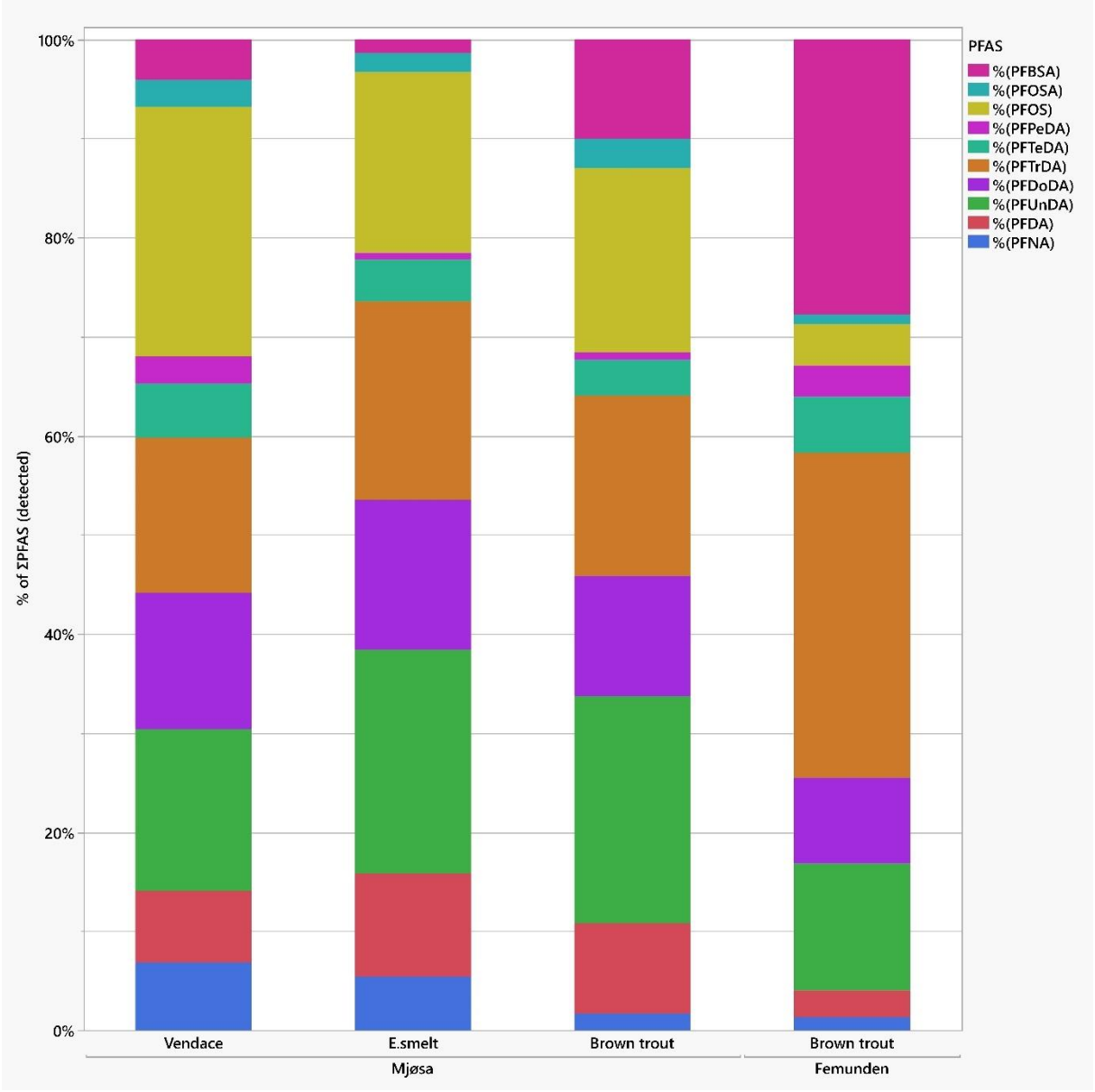

Figure 33. Percentage distribution of dominant and detected PFAS in samples of fish liver in Lake Mjøsa and Lake Femunden in 2020.

In boxplots of the PFCA concentrations in all matrices from 2020 are shown, indicating similar levels in brown trout from Lake Mjøsa and Lake Femunden. PFTrDA is significantly higher in brown trout from Lake Femunden compared to brown trout in Lake Mjøsa (mean concentrations 17 and 8.9 ng/g w.w., respectively, p=0.0012).

Concentrations of PFOS and PFOSA in 2020 are shown in Figure 34. Highest mean PFOS concentrations were found in brown trout from Lake Mjøsa (mean 9.1 ng/g w.w.), leveled with the EQS. In 2020 7 samples of brown trout from Lake Mjøsa exceeded the EQS concentration for PFOS (9.1 ng/g w.w.).

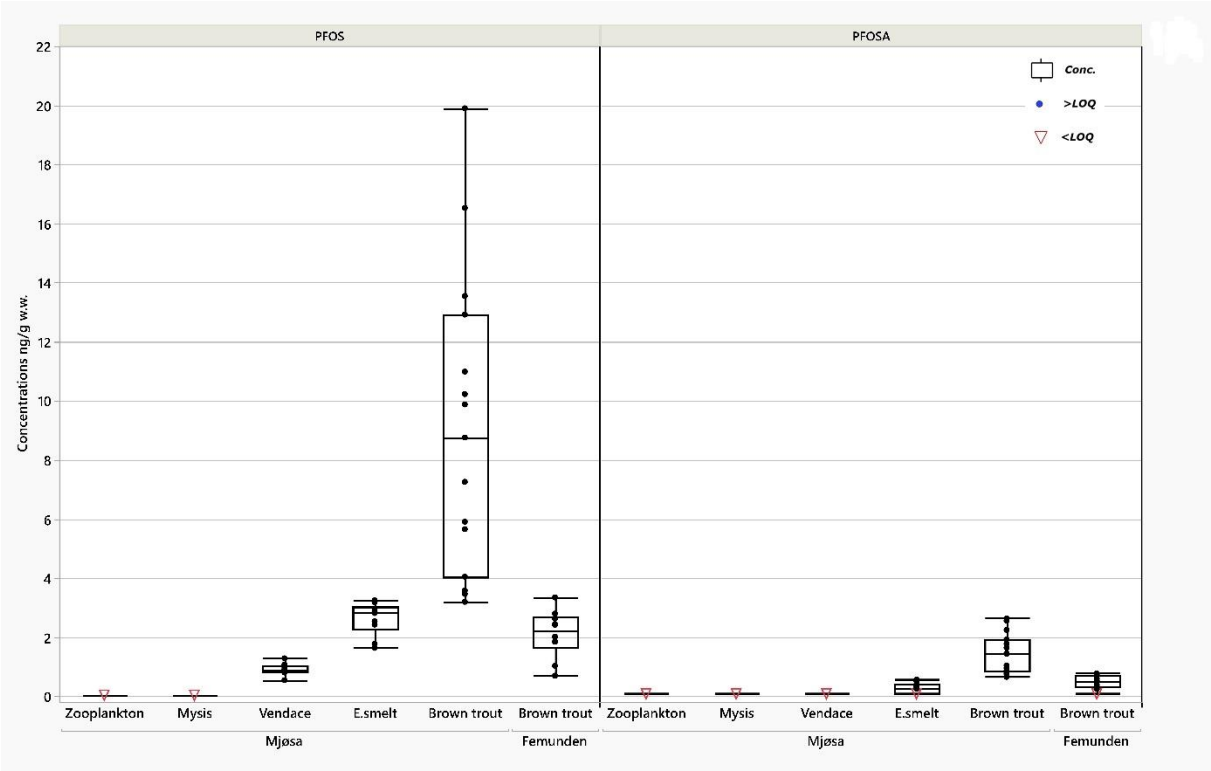

Figure 34. Boxplot of PFOS and PFOSA showing the concentrations (ng/g w.w.) in samples of zooplankton, *Mysis* (whole body), and fish liver in Lake Mjøsa and Lake Femunden in 2020. Concentrations <LOQ have been replaced by half the limit and indicated with a triangle.

In previous studies (Fjeld et al., 2017; Jartun et al., 2019) 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. This is observed through $\delta^{13}C$ where more negative values indicate a more pelagic diet. As described in chapter 3.2, $\delta^{13}C$ values in brown trout from Lake Mjøsa are lower than for brown trout in Lake Femunden, and there is a strong correlation between $\delta^{15}N$ and $\delta^{13}C$ indicating that trophic level increases with a more pelagic diet, occurring at a certain size.

$\delta^{13}C$ is poorly correlated with length for brown trout in Lake Femunden, as seen in Figure 6, however Figure 35 shows a significant correlation between the $\log_e$-transformed concentrations (ng/g w.w.) of long-chained PFCAs (R^2= 0.49, 0.64, 0.66 and 0.62 for PFUDA, PFDoDA, PFTrDA and PFTeDA, respectively) in brown trout from Lake Femunden between 2014-2020. The figure shows a large range

of $\delta^{13}C$ values (-26 - -17 ‰). Higher concentrations of PFCAs are observed at the more negative $\delta^{13}C$ values indicating that brown trout with a higher pelagic diet in Lake Femunden accumulate more PFCAs than the individuals with a benthic signal. However, the pelagic signal in brown trout diet from Lake Femunden is weaker than in brown trout from Lake Mjøsa, indicating a more diverse diet. The correlation between PFTrDA and $\delta^{13}C$ in brown trout from Lake Mjøsa is not significant, as seen in Figure 36.

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).

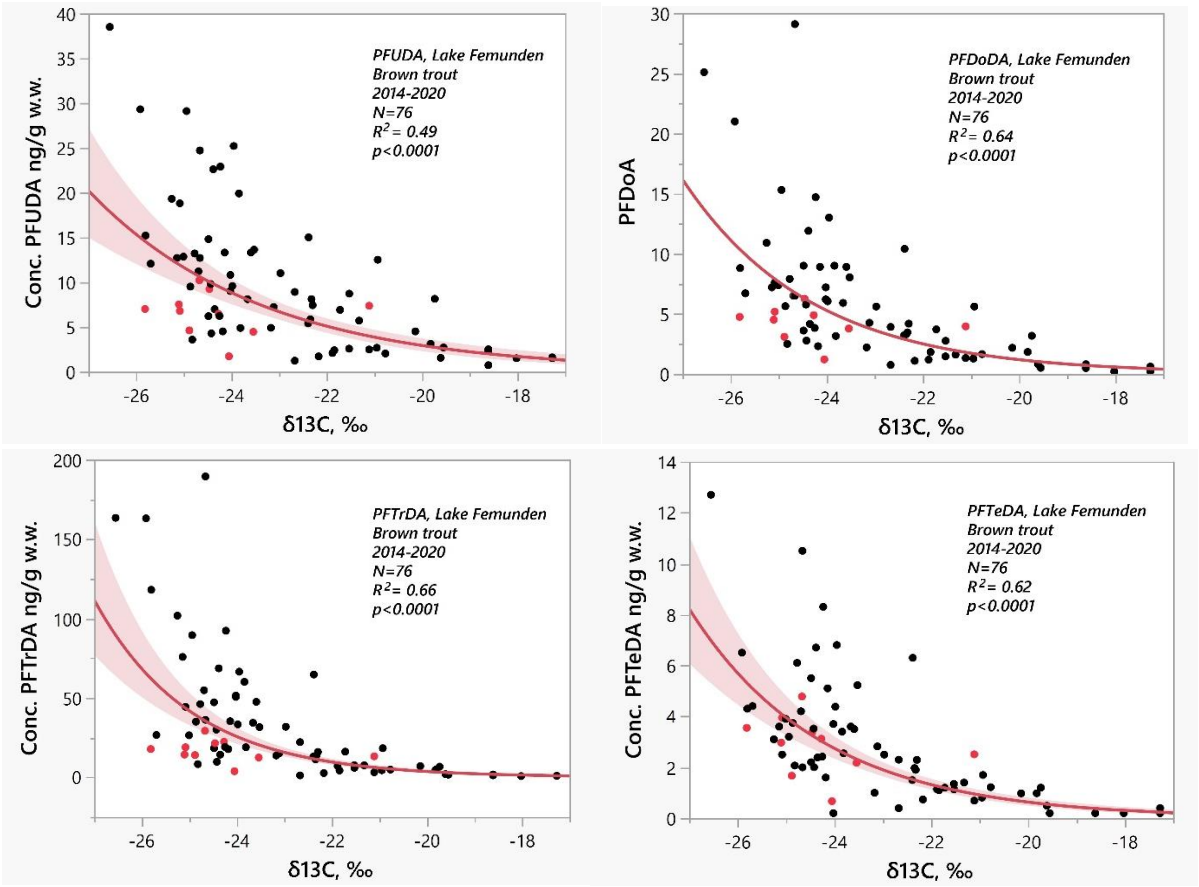

Figure 35. Regression between $\log_e$-transformed concentrations of long-chained PFCAs (PFUDA, PFDoDA, PFTrDA and PFTeDA; ng/g w.w.) and $\delta^{13}C$ in brown trout from Lake Femunden. Data from 2014-2020, N=76 with 95 % confidence limit. Data from 2020 are shown with red dots.

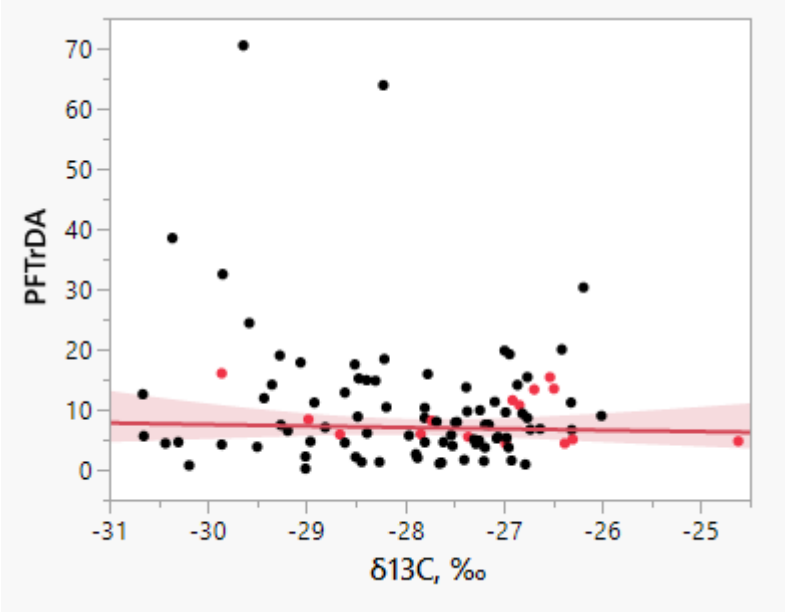

Figure 36. Regression of log_e-transformed concentrations of PFTrDA and $\delta^{13}C$ in brown trout from Lake Mjøsa. N=99, data from 2014-2020 with a 95 % confidence limit. Regression is not significant.

Statistical models (covariance analyses) on measured ecological and morphometric predictors for PFOS variations in brown trout from Lake Mjøsa and Lake Femunden indicate that none of the variation may be explained by factors such as length, weight, conditional factor, lipid, trophic level ($\delta^{15}N$) or carbon source ($\delta^{13}C$) in either lake, see example for the regression analysis PFOS by length for brown trout in Figure 37. None of the PFAS variation seen in top predator brown trout in Lake Mjøsa can be explained by these ecological and morphometric predictors. One single exception is PFOSA which reflects a positive significant relationship with $\delta^{15}N$ ($r = 0.33$, $p < 0.05$).

Model outcome suggest no significant covariance for any predictors. However, a significant correlation between PFOS and ($\delta^{15}N$) is observed on the food chain level, studying the biomagnifying properties of PFOS in Lake Mjøsa (Figure 38).

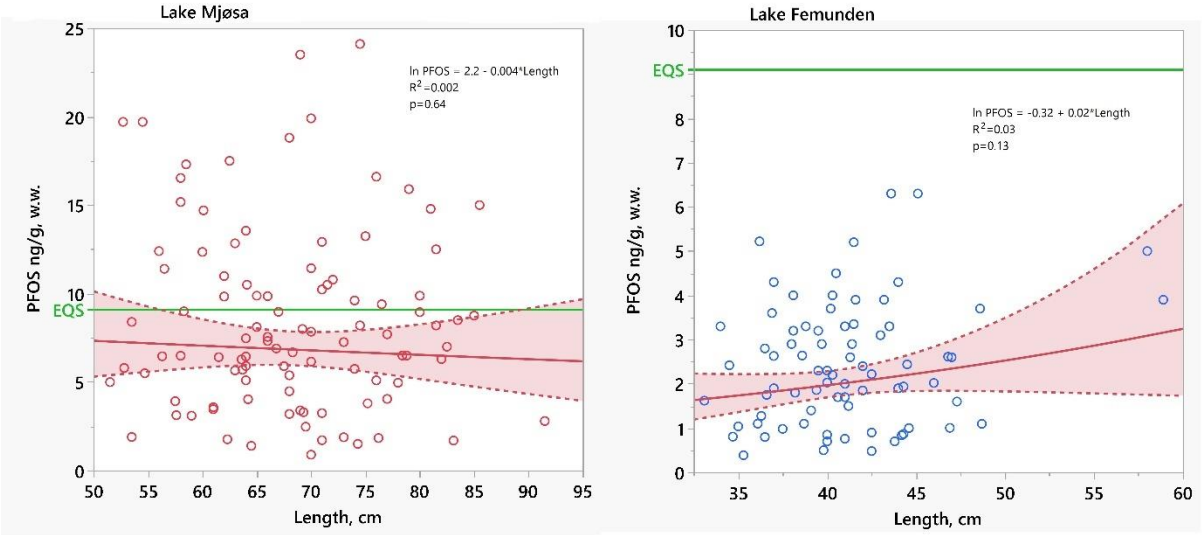

Figure 37. Regression analysis of length and PFOS (with 95 % confidence level) in brown trout from Lake Mjøsa (left) and Lake Femunden (right) sampled from 2014 to 2020. Horizontal line at 9.1 ng/g PFOS (solid, green line) indicates the EQS (9.1 ng/g PFOS).

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 6. 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 7 out of 15 samples of brown trout in Lake Mjøsa, with concentrations ranging from 3.2 – 20 ng/g w.w. Mean concentration of PFOS in brown trout from Lake Mjøsa in 2020 was 9.1 ng/g w.w., whereas mean concentrations for the same species in Lake Femunden was 2.1 ng/g w.w. Mean concentrations of PFOS in brown trout from the two lakes are higher than those observed in 2019 (6.8 and 2.9 ng/g w.w., respectively).

EFSA (European Food Safety Authority) presented in September 2020 a new safety threshold for a group of selected PFAS of 4.4 ng per kg. body weight per week (EFSA Contam Panel, 2020). Based on the old limits (2018) for tolerable weekly intake (TWI) for single PFASs, e.g. 13 ng PFOS per kg. body weight, the Norwegian Food Safety Authority has advised against consumption of fish from Lakes Vansjø, Leirin and Tyrifjorden based on the levels of PFAS found in freshwater fish (Matportalen, 2020). Concentrations of PFAS found in these lakes are higher than in Lake Mjøsa, and they all represent areas with specific local point sources for PFAS. There are no guidelines or advice against the consumption of fish from Lake Mjøsa specifically regarding the PFAS concentrations, but there are general advices based on historical data for Hg and PBDEs.

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., 2019). 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.

3.11.3 Trophic magnification of PFOS

Biomagnification of PFOS was slightly discussed in chapter 3.8 with the correlation of other dominant contaminants (Hg, D5 and BDE-47). Substantial data for all PFAS in samples of the food web in Lake Mjøsa from 2014 – 2020 are available, and Figure 38 shows the exponential regression for PFOS as a function of $\delta^{15}N$. There is a significant positive regression ($p<0.0001$) between ln (PFOS) and $\delta^{15}N$ indicating that PFOS biomagnify in Lake Mjøsa. Measured $\delta^{15}N$ in the combined data from 2013 to 2020 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). Accordingly, calculated trophic magnification factor for PFOS in Lake Mjøsa is 6.9.

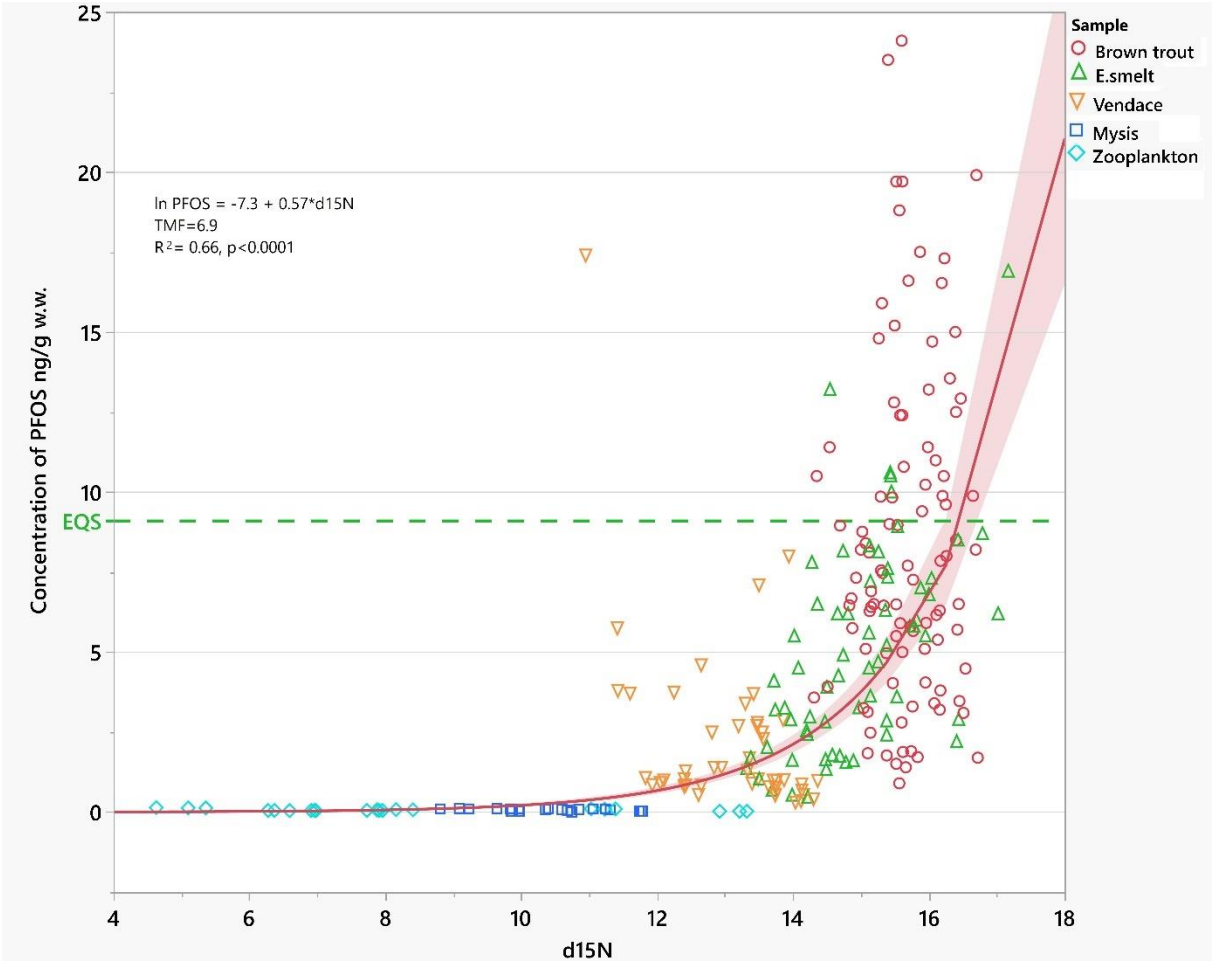

Figure 38. Exponential regression, with 95 % confidence level, of PFOS concentrations in Lake Mjøsa biota from 2014 to 2020 as a function of measured $\delta^{15}N$. Prediction formula and estimated TMF with 95 % confidence level are shown above the regression curve. The horizontal line (green) indicate the EQS for PFOS in biota at 9.1 ng/g.

3.11.4 PFAS – trends from 2014-2020

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 low detection frequency for most PFAS compounds, or at least in low concentrations. As of 2014 the target tissue for PFAS determination in fish has been liver, resulting in higher detection frequency and higher concentrations, in addition to more reliable comparison to other (monitoring) studies.

Time trends for the dominating PFASs in brown trout liver from Lake Mjøsa and Lake Femunden between 2014 to 2020 are shown in Figure 39. Looking at brown trout, variation in concentrations and detectable PFAS pattern are both low for the two lakes within this period. We have no plausible explanation for the distinct dip in concentrations in Lake Mjøsa in 2018.

The PFAS fingerprint of detected compounds is consistent for each lake between 2014 – 2020, with PFOS being a more dominant compound in Lake Mjøsa compared to the more pristine Lake Femunden. PFOS seem to dominate in fish inhabiting rivers and lakes with substantial impact from firefighting training facilities, such as airports (Hale et al., 2017; Hansen et al., 2016; Økelsrud et al., 2020), but also from paper industry (Langberg et al., 2020). The strong domination of long chained PFCAs in Lake Femunden has no apparent local sources. The discrepancy in PFAS fingerprints between these two lakes is a strong indication that the sources for PFCAs to these lakes are different. Long-range atmospheric transport and subsequent degradation of more volatile precursors, such as fluorotelomer alcohols (FTOH), to PFCAs may explain some of the concentrations of PFCAs such as PFUnDA and PFTrDA in both lakes. There is a significantly higher concentration of PFOS in Lake Mjøsa compared to Lake Femunden ($p<0.0001$), which may be a result of more urban runoff and effluents from WWTP (e.g. Ruus et al., 2020) to Lake Mjøsa compared to the rural Lake Femunden. However, levels of PFOS in fish liver in Lake Mjøsa are lower than in other great Norwegian lakes with identified local sources, such as Tyrifjorden (Slinde et al., 2019; Langberg et al., 2020) and Vansjø (Fjeld et al., 2017), and in the same concentration range as freshwater systems with more diffuse and unknown sources, such as Nitelva (Økelsrud et al., 2020). PFOS was the dominating PFAS in fire-fighting foam until banned in 2007. There are no large-scale fire training areas within the catchment of Lake Mjøsa, but some minor and local areas used by municipalities and local fire crews (Norwegian Civil Defence) with potential runoff to the lake.

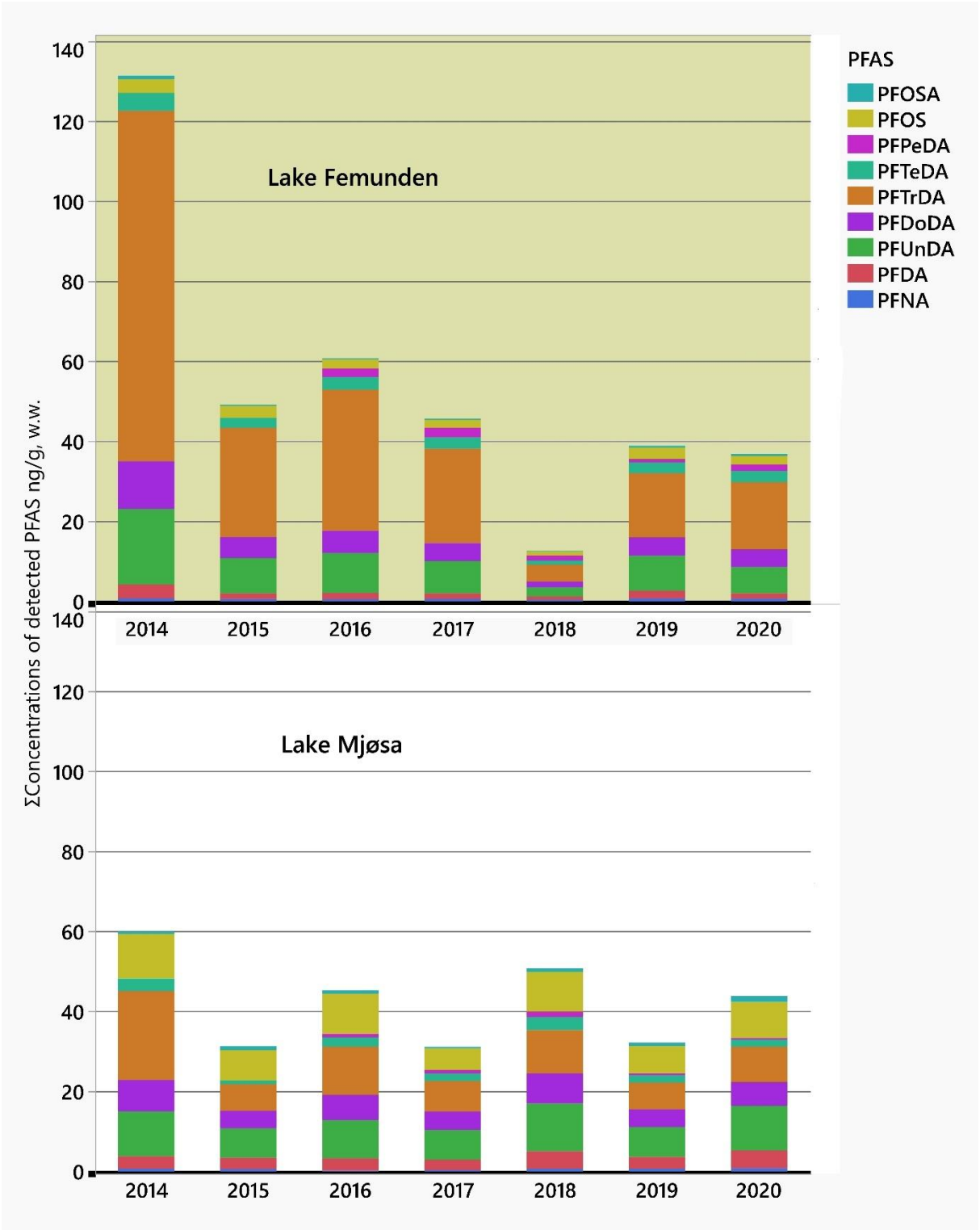

Figure 39. Time trend for dominating PFAS in brown trout from Lake Femunden (top) and Lake Mjøsa (bottom) indicated by Σ of mean concentrations (ng/g w.w.). Concentrations below LOQ have been replaced by half the limit.

3.11.5 PFAS in brown trout gonads

In previous years, liver has been the main target tissue for PFAS determination in freshwater fish included in this monitoring program (Fjeld et al., 2017; Jartun et al., 2020). In 2020, gonads from brown trout in Lake Mjøsa and Femunden were sampled in addition to liver from the same individuals. Table 27 lists the concentrations of detected PFASs in brown trout from the two lakes. The concentrations in gonads are slightly lower than those found in liver from the same fish (Figure 40), but the detection frequency is the same for the two sample materials. Concentrations are significantly higher for PFOS in gonads from brown trout in Lake Mjøsa compared to Lake Femunden. Long chained PFCAs are in the same concentration range in the two lakes.

Figure 41 and Figure 42 show the individual impact factor (%) of PFAS compounds relative to the detected compounds, and the total number of PFAS compounds included in the analytical program, respectively. The results indicate that the PFAS fingerprints in gonads and liver from the same fish are comparable, and that there is no variation between the PFAS content in male and female gonads, i.e. testes and eggs, respectively.

Table 27. Concentrations of dominating PFAS (ng/g w.w.) presented as mean, minimum and maximum in samples of gonads from brown trout from Lakes Mjøsa and Femunden in 2020. Concentrations below LOQ have been replaced by half the limit.

	Lake Mjøsa			Lake Femunden		
	Brown trout			Brown trout		
	N	15		10		
	Range	Mean, x̄	N>LOQ	Range	Mean, x̄	N>LOQ
PFNA	0.17 – 1.7	0.56	15	0.18 – 0.90	0.48	10
PFDA	0.79 – 7.8	2.6	15	0.36 – 1.6	0.89	10
PFUnDA	2.0 – 22	7.2	15	1.6 – 8.1	4.3	10
PFDoDA	1.3 – 10	4.2	14	1.2 – 5.3	3.1	10
PFTrDA	1.7 – 10	5.6	15	4.1 – 19	11	10
PFTeDA	0.43 – 3.3	1.4	15	1.1 – 3.7	2.2	10
PFPeDA	<0.40 – 1.2	0.36	5	0.17 – 5.1	1.7	10
PFOS	1.2 – 19	5.4	15	0.92 – 3.9	1.9	10
PFOSA	<0.20 – 0.55	0.27	10	<0.20	<0.20	0
PFBSA	0.22 – 4.9	1.3	15	1.0 – 6.4	3.3	10

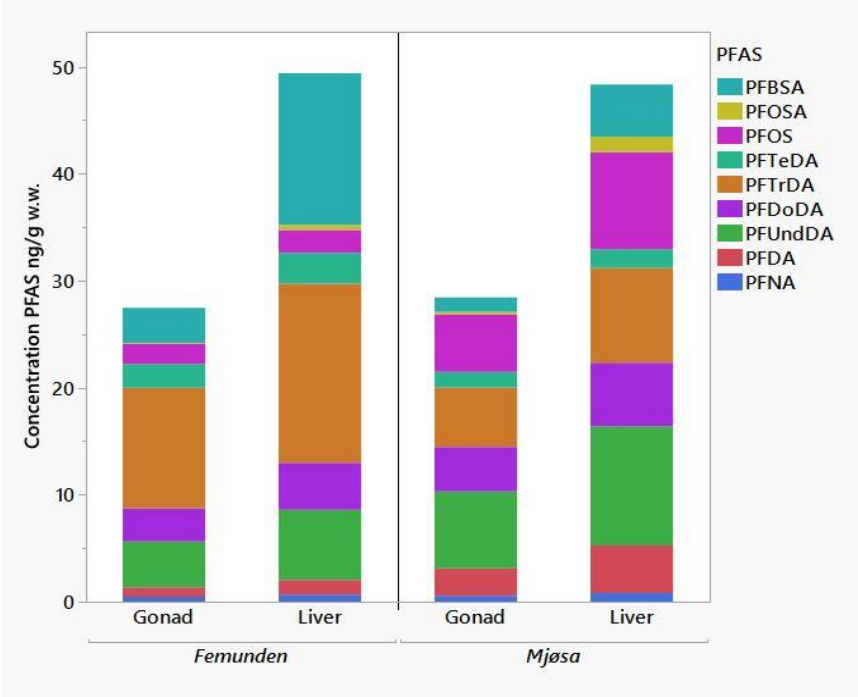

Figure 40. Individual PFAS above LOD in samples of gonads and liver from individual brown trout in Lakes Femunden and Mjøsa in 2020. Concentrations in ng/g w.w.

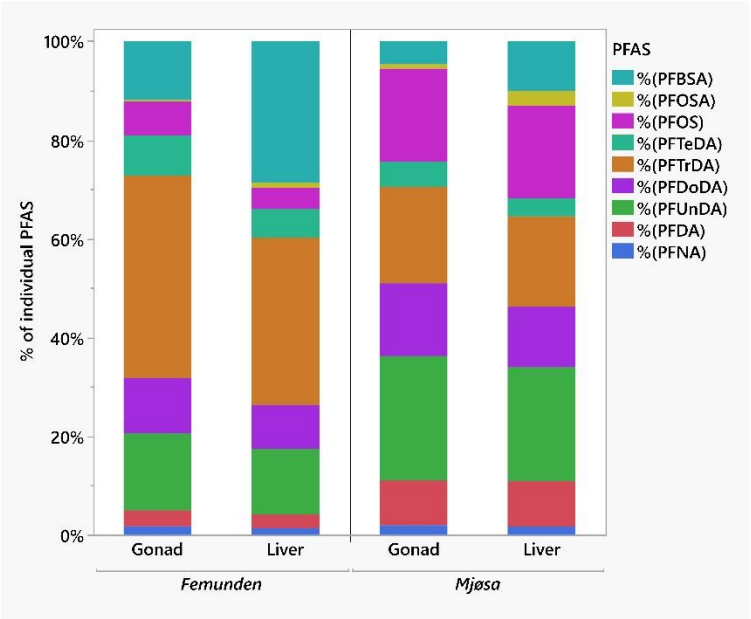

Figure 41. Percentage of dominating PFAS (PFDA – PFBSA) in samples of gonads and liver in brown trout individuals from Lakes Femunden and Mjøsa (2020).

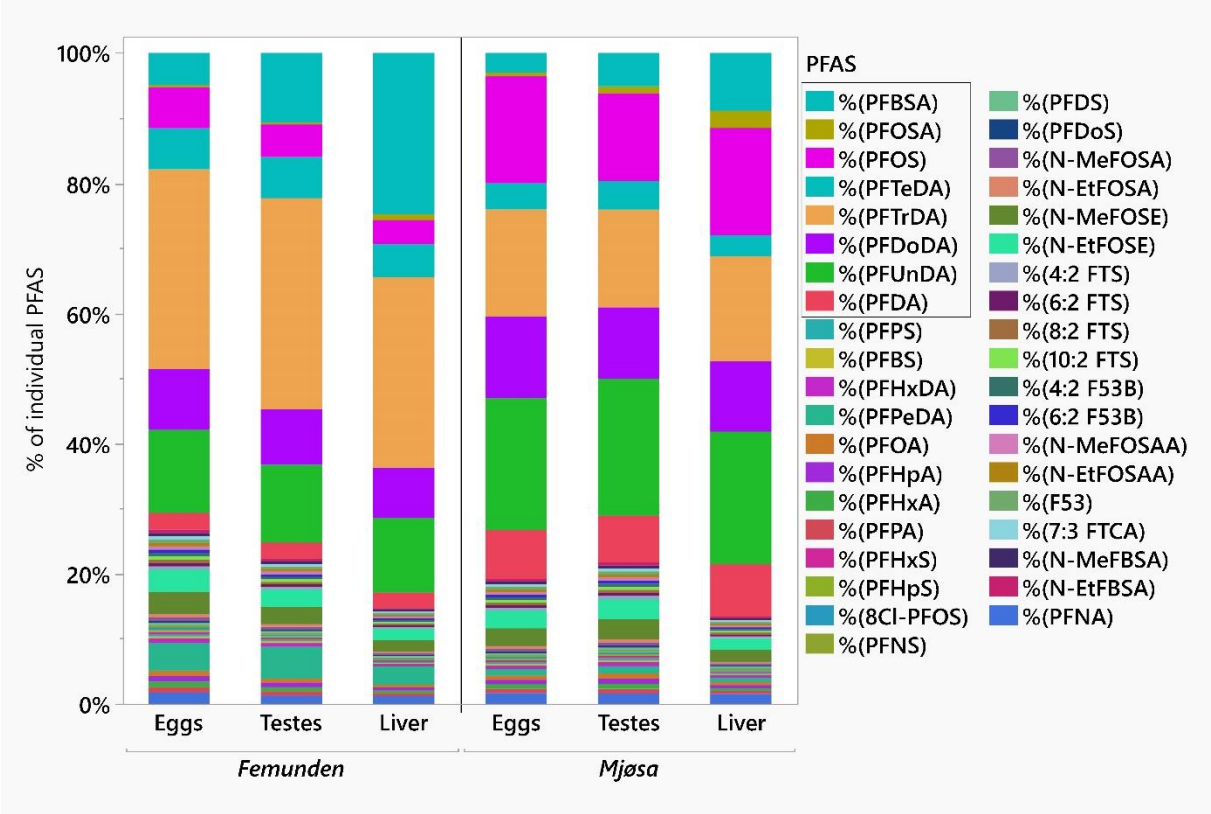

Figure 42. Percentage of all PFAS included in the analytical program, sorted with the most dominant compounds on top (PFDA – PFBSA). Samples of gonads are sorted according to sex (Eggs/Female, Testes/Male) and liver from brown trout individuals in Lakes Femunden and Mjøsa in 2020.

3.12 UV-chemicals

3.12.1 Detection frequency of UV-chemicals 2017-2020

Detection frequency for UV chemicals in samples from 2020 are listed in the compilation in Table 3. In Table 28 below we have listed the total detection frequencies for all UV chemicals in biota from the entire monitoring program (2017-2020).

Table 28. Detection frequency (%) for UV-chemicals in biota from Lakes Mjøsa and Femunden. Data from 2017-2020 presented as percentage of analytical detections. Shading refers to 5 subclasses: white: 0-20 %, light pink: 21-40 %, pink: 41-60 %, light red: 61-80 % and **red: 81-100 %**.

	2017-2020					
	Mjøsa					Femunden
	Zooplankton	Mysis	Vendace	E.smelt	Brown trout	Brown trout
	Whole body	Whole body	Muscle	Muscle	Muscle*	Muscle
BP3	30	0	0	20	0	3
EHMC-Z	0	0	4	20	2	17
EHMC-E	0	0	9	13	2	0
UV-320	0	0	70	30	0	0
UV-326	0	**100**	0	20	0	0
UV-329	0	0	0	0	0	0
UV-328	0	33	65	15	13	15
UV-327	0	0	50	20	20	0
OC	60	40	11	15	0	0
ODPABA	0	0	10	0	13	0

**In 2019 liver was analyzed for 7 of the brown trout samples in Lake Mjøsa*

Table 29. Number of samples analyzed for UV-chemicals in samples of zooplankton, *Mysis* (whole body), vendace, E.smelt (muscle) and brown trout (muscle, liver) in Lake Mjøsa and brown trout (muscle) in Lake Femunden between 2017-2020.

	2017-2020					
	Mjøsa					Femunden
	Zooplankton	Mysis	Vendace	E.smelt	Brown trout	Brown trout
BP3	10	10	35	40	60	40
EHMC-Z	7	7	25	30	45	30
EHMC-E	10	10	35	40	60	40
UV-320	3	3	10	10	15	10
UV-326	3	3	10	10	15	10
UV-329	6	6	20	20	30	20
UV-328	6	6	20	20	30	20
UV-327	6	6	20	20	30	20
OC	10	10	35	40	60	40
ODPABA	3	3	10	10	15	10

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-chemicals have been determined in zooplankton, *Mysis* and fish muscle and liver by NIVA; octocrylene (OC, CAS: 6197-30-4), benzophenone-3 (BP-3, CAS: 131-57-7), and ethylhexylmethoxycinnamate (EHMC, CAS: 5466-77-3).

Table 3 indicate the detection frequencies of UV-chemicals in our study. BP3 was not detected in any samples, and OC was detected in zooplankton (Figure 43) and sporadically in fish samples. EHMC-isomers were only sporadically detected.

In 2019 we analyzed liver in half of the brown trout samples from Lake Mjøsa to find out if the detection frequency was higher in liver compared to muscle. We could not detect any UV-chemicals in neither muscle nor liver for the brown trout samples (Jartun et al., 2020). In 2020, muscle was the preferred target tissue, such as in 2017 and 2018.

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 continue the search for 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-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 that study mainly because of a limited food web with few trophic levels.

Figure 43. Zooplankton species, mainly *Daphnia cristata*, in a hanging droplet from Lake Mjøsa. UV-chemicals are mostly found in species from the lower trophic levels, such as zooplankton and *Mysis relicta. Photo: Morten Jartun.*

Table 30. Concentrations of UV-chemicals (ng/g w.w.) presented as range (min-max), mean, in samples of zooplankton, *Mysis* (whole body), vendace, E. smelt (muscle) and brown trout (muscle and liver) from Lake Mjøsa and in brown trout (muscle) from Lake Femunden in 2020. Results where more than 50 % of the samples were **above** LOQ are marked in orange.

Lake	Matrix	N	Stats.	BP3	EHMC-Z	EHMC-E	ΣEHMC	UV-320	UV-326	UV-327	UV-328	UV-239	OC	ODPABA
Mjøsa	Zoopl.	3	Range	<0.30	<0.030	<0.15	<0.18	<0.030	<0.050	<0.030	<0.060	<0.30	2.1 - 2.2	<0.030
			Mean, x̄	<0.30	<0.030	<0.15	<0.18	<0.030	<0.050	<0.030	<0.060	<0.30	2.2	<0.030
			N>LOQ	0	0	0	0	0	0	0	0	0	3	0
	Mysis	3	Range	<0.30	<0.030	<0.15	<0.18	<0.030	0.19 - 0.23	<0.030	<0.060 - 0.070	<0.30	<1.2 - 1.2	<0.030
			Mean, x̄	<0.30	<0.030	<0.15	<0.18	<0.030	0.21	<0.030	<0.060	<0.30	<1.2	<0.030
			N>LOQ	0	0	0	0	0	3	0	2	0	1	0
	Vendace	10	Range	<0.05-<0.08	<0.030	<0.050 - 0.060	<0.080 - <0.090	<0.020 - 0.020	<0.30	0.020 - 0.040	0.090 - 0.15	<0.10	<0.60 - 1.3	<0.010 - 0.010
			Mean, x̄	<0.060	<0.030	<0.050	<0.080	<0.020	<0.30	0.030	0.12	<0.10	<0.60	<0.010
			N>LOQ	0	0	2	0	7	0	10	10	0	3	1
	E. smelt	10	Range	<0.30	<0.030 - 0.090	<0.15 - 0.33	<0.18 - 0.45	<0-030 - 0.050	<0.050 - 0.060	<0.030 - 0.10	<0.060 - 0.16	<0.30	<0.60 - 1.5	<0.30
			Mean, x̄	<0.30	0.03	<0.15	<0.12	<0.030	<0.050	<0.030	<0.060	<0.30	0.63	<0.30
			N>LOQ	0	3	3	3	3	2	4	3	0	5	0
	B. trout Muscle	15	Range	<0.30	<0.020 - 0.030	<0.080 - 0.090	<0.10 - 0.12	<0.030	<0.050	<0.020 - 0.070	<0.060 - 0.010	<0.30	<0.50	<0.010 - 0.010
			Mean, x̄	<0.30	<0.020	<0.080	<0.10	<0.030	<0.050	0.030	0.050	<0.30	<0.50	<0.010
			N>LOQ	0	1	1	1	0	0	6	4	0	0	2
Fem.	B. trout	10	Range	<0.050	<0.030	<0.050	<0.080	<0.020	<0.30	<0.020	<0.020 - 0.25	<0.10	<0.060	<0.010
			Mean, x̄	<0.050	<0.030	<0.050	<0.080	<0.020	<0.30	<0.020	0.050	<0.10	<0.060	<0.010
			N>LOQ	0	0	0	0	0	0	0	3	0	0	0

3.13 New brominated flame retardants - nBFR

3.13.1 Detection frequency of nBFR 2017-2020

Detection frequency for nBFR in samples from 2020 are listed in the compilation in Table 3. In Table 31 below we have listed the total detection frequencies for all nBFR in biota from the entire monitoring program (2017-2020).

Table 31. Detection frequency (%) and number of total samples for nBFR in biota from Lakes Mjøsa and Femunden. Data from 2017-2020 presented as percentage of analytical detections. Shading refers to 5 subclasses: white: 0-20 %, light pink: 21-40 %, pink: 41-60 %, light red: 61-80 % and **red: 81-100 %**.

	2017-2020					
	Mjøsa					Femunden
	Zoopl.	Mysis	Vendace	E.smelt	Brown trout	Brown trout
N	*11*	*11*	*35*	*40*	*60*	*40*
	Whole body	Whole body	Muscle	Muscle	Muscle	Muscle
TBA	27	45	**91**	68	**92**	**95**
ATE (TBP-AE)	0	0	11	10	8	0
a-TBECH	0	0	14	8	10	0
b-TBECH	0	0	14	8	12	0
g/d-TBECH	0	0	14	5	12	0
BATE	0	0	23	13	17	10
PBT	0	0	14	5	10	0
PBEB	0	0	14	5	10	0
PBBZ	25	25	40	33	33	33
HBB	9	0	34	10	30	18
DPTE	0	0	14	10	15	3
EHTBB	9	0	14	10	2	0
BTBPE	0	18	57	33	28	25
TBPH (BEH /TBP)	0	0	0	15	0	3
DBDPE	27	18	9	23	15	30

Table 32 and Table 33 list the results, detections and LOQs of new brominated flame retardants in zooplankton, *Mysis* and fish muscle from Lake Mjøsa and Lake Femunden from 2020. Only TBA was detected above LOQ in samples of vendace and brown trout (both lakes).

Detections for zooplankton should be addressed carefully because of large uncertainties due to small sample amounts and matrix effects. Results for the nBFR is considered semi-quantitative, which is also reflected in the fluctuating LOQs within each sample matrix, see Table 32 and Table 33.

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.

Table 32. (..part 1) Concentrations of new brominated flame retardants (nBFR) (ng/g w.w.) presented as range (min-max), mean, in samples of zooplankton, *Mysis* (whole body), vendace, E. smelt and brown trout (muscle) from Lake Mjøsa and in brown trout (muscle) from Lake Femunden in 2020. Results where more than 50 % of the samples were **above** LOQ are marked in orange.

Lake	Matrix	N	Stats.	TBA	ATE(TBP-AE)	a-TBEC	b-TBECH	g/d-TBECH	BATE	PBT	PBEB	PBBZ	HBB	DPTE
Mjøsa	Zoopl.	3	Range	<0.0040	<0.0070	<0.050	<0.040	<0.020	<0.0070	<0.020	<0.0080	<0.12	<0.050	<0.0060
			Mean, x̄	<0.0040	<0.0070	<0.050	<0.040	<0.020	<0.0070	<0.020	<0.0080	<0.12	<0.050	<0.0060
			N>LOQ	0	0	0	0	0	0	0	0	0	0	0
	Mysis	3	Range	<0.0040	<0.0070	<0.050	<0.040	<0.020	<0.0070	<0.020	<0.0080	<0.12	<0.050	<0.0060
			Mean, x̄	<0.0040	<0.0070	<0.050	<0.040	<0.020	<0.0070	<0.020	<0.0080	<0.12	<0.050	<0.0060
			N>LOQ	0	0	0	0	0	0	0	0	0	0	0
	Vendace	10	Range	<0.0040 – 0.019	<0.0070	<0.050	<0.040	<0.020	<0.0070	<0.020	<0.0080	<0.12	<0.050	<0.0060
			Mean, x̄	0.014	<0.0070	<0.050	<0.040	<0.020	<0.0070	<0.020	<0.0080	<0.12	<0.050	<0.0060
			N>LOQ	9	0	0	0	0	0	0	0	0	0	0
	E. smelt	10	Range	<0.0040 – 0.013	<0.0060	<0.050 - 0.10	<0.040	<0.020	<0.0070	<0.010	<0.0070 - <0.0080	<0.11 - <0.12	<0.040 - <0.050	<0.0060
			Mean, x̄	0.0040	<0.0060	<0.050	<0.040	<0.020	<0.0070	<0.010	<0.0080	<0.12	<0.050	<0.0060
			N>LOQ	3	0	0	0	0	0	0	0	0	0	0
	B. trout	15	Range	<0.0040 – 0.033	<0.0070	<0.050 - 0.12	<0.040	<0.020	<0.0070	<0.020	<0.0080	<0.12	<0.050	<0.0060
			Mean, x̄	0.018	<0.0070	<0.050	<0.040	<0.020	<0.0070	<0.020	<0.0080	<0.12	<0.050	<0.0060
			N>LOQ	13	0	2	0	0	0	0	0	0	0	0
Fem.	B. trout	10	Range	<0.0060 – 0.021	<0.0070	<0.050	<0.040	<0.020	<0.0070	<0.020	<0.0080	<0.12	<0.050	<0.0060
			Mean, x̄	0.011	<0.0070	<0.050	<0.040	<0.020	<0.0070	<0.020	<0.0080	<0.12	<0.050	<0.0060
			N>LOQ	8	0	0	0	0	0	0	0	0	0	0

Table 33. (..part 2) Concentrations of new brominated flame retardants (nBFR) (ng/g w.w.) presented as range (min-max), mean, in samples of zooplankton, *Mysis* (whole body), vendace, E. smelt and brown trout (muscle) from Lake Mjøsa and in brown trout (muscle) from Lake Femunden. Results where more than 50 % of the samples were **above** LOQ are marked in orange.

Lake	Matrix	N	Stats.	EHTBB	BTBPE	TBPH (BEH/TBP)	DBDPE
Mjøsa	Zoopl.	3	Range	<0.0090	<0.010	<0.040	<6.9
			Mean, x̄	<0.0090	<0.010	<0.040	<6.9
			N>LOQ	0	0	0	0
	Mysis	3	Range	<0.0090	<0.010	<0.040	<6.9
			Mean, x̄	<0.0090	<0.010	<0.040	<6.9
			N>LOQ	0	0	0	0
	Vendace	10	Range	<0.0090	<0.010	<0.040	<6.9
			Mean, x̄	<0.0090	<0.010	<0.040	<6.9
			N>LOQ	0	0	0	0
	E. smelt	10	Range	<0.0080 - 0.040	<0.010 - 0.020	<0.030 - 1.7	<6.2 - 8.9
			Mean, x̄	<0.0090	<0.010	<0.040	<6.9
			N>LOQ	1	1	1	1
	B. trout	15	Range	<0.0090	<0.010	<0.040	<6.9
			Mean, x̄	<0.0090	<0.010	<0.040	<6.9
			N>LOQ	0	0	0	0
Fem.	B. trout	10	Range	<0.0088	<0.010 - 0.020	<0.040 - 0.040	<6.9
			Mean, x̄	<0.090	<0.010	<0.040	<6.9
			N>LOQ	0	1	1	0

3.14 Dechloranes

3.14.1 Detection frequency of dechloranes 2017-2020

Dechloranes were not determined in this monitoring program in 2018 and 2020. However, in Table 34 we show the combined detection frequency for these contaminants for 2017 and 2019. The total number of analyses for dechloranes in Table 35.

Table 34. Detection frequency (%) and number of total samples for dechloranes in biota from Lakes Mjøsa and Femunden. Data from 2017-2020 presented as percentage of analytical detections. Shading refers to 5 subclasses: white: 0-20 %, light pink: 21-40 %, pink: 41-60 %, light red: 61-80 % and **red: 81-100 %**.

	2017-2020					
			Mjøsa			Femunden
	Zoopl.	Mysis	Vendace	E.smelt	Brown trout	Brown trout
	Whole body	Whole body	Muscle	Muscle	Muscle	Muscle
Dibromoaldrin	0	0	0	0	0	0
Dechlorane 602	50	50	**100**	**95**	**100**	**90**
Dechlorane 603	0	0	0	0	0	0
Dechlorane 604	0	0	0	0	0	0
Dechlorane 601	0	0	0	0	0	0
Dechlorane plus syn	50	50	67	55	40	40
Dechlorane plus anti	50	67	67	55	44	40
1,3-DPMA	0	0	0	0	0	0
1,5-DPMA	0	0	0	0	0	0

Table 35. Number of samples analyzed for dechloranes in samples of zooplankton, *Mysis* (whole body), vendace, E.smelt and brown trout (muscle, Mjøsa) and brown trout (muscle) in Femunden between 2017-2020.

	2017-2020					
			Mjøsa			Femunden
	Zoopl.	Mysis	Vendace	E.smelt	Brown trout	Brown trout
Dibromoaldrin	6	6	15	20	25	20
Dechlorane 602	6	6	15	20	25	20
Dechlorane 603	6	6	15	20	25	20
Dechlorane 604	6	6	15	20	25	20
Dechlorane 601	6	6	15	20	25	20
Dechlorane plus syn	6	6	15	20	25	20
Dechlorane plus anti	6	6	15	20	25	20
1,3-DPMA	3	3	5	10	15	10
1,5-DPMA	3	3	5	10	15	10

Dechlorane 602 were detected in almost all samples of fish lever from both Lake Mjøsa and Lake Femunden in 2017 and 2019. Mean concentration for vendace, European smelt and brown trout in Lake Mjøsa were 0.010, 0.005 and 0.019 ng/g w.w., respectively. Mean dechlorane 602 concentration in brown trout from Lake Femunden was 0.0090 ng/g w.w. Dechlorane plus *anti* and plus *syn* were detected sporadically in a few samples of *Mysis*, European smelt and brown trout from Lake Mjøsa, but 95 % of samples were <LOQ for the dechloranes besides 602. Detections ranged from 0.02-0.09 ng/g w.w. for dechlorane plus *anti* and *syn*, sum of dechlorane plus (sum *syn* and *anti*) ranged from 0.05-0.10 ng/g w.w.

Dechlorane plus, including its *anti* and *syn* isomers has been identified as a Substance of Very High Concern (SVHC) and incorporated in the EU Candidate List based on its very persistent and very bioaccumulative properties (ECHA, 2018b). Dechlorane plus was nominated to the Stockholm Convention on persistent organic pollutants by Norway in 2019, and in parallel Norway has submitted an Annex XV restriction proposal under REACH.. Thus far, dechlorane plus with its isomers has not been detected in a large number of samples of freshwater fish in Norway, but they have been reported in benthic food chains in the Arctic (Carlsson et al., 2018).

Table 36 provides an overview of the results, i.e. a summary of the LOQ for these compounds.

Table 36. Concentrations of dechloranes (ng/g w.w.) from 2017 and 2019 presented as range (min-max), mean, in samples of zooplankton, *Mysis* (whole body), vendace, E. smelt and brown trout (muscle) from Lake Mjøsa and in brown trout (muscle) from Lake Femunden. Results where more than 50 % of the samples were **above** LOQ are marked in orange.

Lake	Matrix	N	Stats.	Dechlorane 601	Dechlorane 602	Dechlorane 603	Dechlorane 604	Dechlorane plus syn	Dechlorane plus anti	1,3-DPMA*	1,5-DPMA*
Mjøsa	Zoopl.	6	Range	<0.015	<0.0030 – 0.001	<0.003	<0.094	<0.041 – 0.036	<0.054 – 0.059	<0.031	<0.064
			Mean, x̄	<0.015	<0.0030	<0.003	<0.094	<0.041	<0.054	<0.031	<0.064
			N>LOQ	0	3	0	0	3	3	0	0
	Mysis	6	Range	<0.015	<0.003 – 0.002	<0.003	<0.094	<0.041 – 0.030	<0.054- 0.086	<0.031	<0.064
			Mean, x̄	<0.015	<0.003	<0.003	<0.094	<0.041	<0.054	<0.031	<0.064
			N>LOQ	0	3	0	0	3	4	0	0
	Vendace	15	Range	<0.025-<0.03	0.008-0.012	<0.0048- <0.0056	<0.097- <0.11	<0.041 – 0.011	<0.054 – 0.019	<0.031	<0.064
			Mean, x̄	<0.025	0.008	<0.0049	<0.1	<0.041	<0.054	<0.031	<0.064
			N>LOQ	0	15	0	0	10	10	0	0
	E. smelt	20	Range	<0.01-<0.05	<0.009- 0.0076	<0.002- <0.01	<0.06-<0.17	<0.027-0.05	<0.036- 0.078	<0.021	<0.043
			Mean, x̄	<0.01	0.005	<0.002	<0.06	<0.027	<0.036	<0.021	<0.043
			N>LOQ	0	19	0	0	11	11	0	0
	B. trout	25	Range	<0.0060- <0.0076	0.007-0.046	<0.0013	<0.038	<0.016- 0.027	<0.022- 0.038	<0.013	<0.026
			Mean, x̄	<0.0060	0.019	<0.0013	<0.038	<0.016	<0.022	<0.013	<0.026
			N>LOQ	0	30	0	0	10	11	0	0
Fem.	B. trout	20	Range	<0.011-<0.13	<0.019-0.020	<0.0021- <0.0057	<0.038- <0.50	<0.016- <0.045	<0.022- <0.067	<0.013-<0.099	<0.026-<0.2
			Mean, x̄	<0.013	0.007	<0.0029	<0.050	<0.016	<0.022	<0.013	<0.026
			N>LOQ	0	18	0	0	0	0	0	0

*Only in 2019.

4 Conclusions

The main conclusions from the results in 2020 include:

- Statistical models on significant ecological and morphometric predictors for mercury (Hg) variation in brown trout from Lakes Mjøsa and Femunden show that a major part of the variation is explained by trophic level ($\delta^{15}N$) and fish size in Lake Mjøsa, whereas trophic level, carbon source ($\delta^{13}C$) and fish size explained most of the variation in Lake Femunden. Based on the entire dataset for Lake Mjøsa from 2006-2020, 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 56 cm, which corresponds to ~ 2.1 kg. For Lake Femunden the trout based on data from 2013 to 2020 will reach the 0.5 mg/kg w.w. limit at around 52 cm, and ~ 1.25 kg.

- Cyclic volatile methylated siloxanes (cVMS; D5 and D6), Hg, BDE-47 and PFOS, are biomagnifying in the food web of Lake Mjøsa with the highest concentrations found in the top predators brown trout and European smelt.

- There is a slight decline in D5 concentration in brown trout in the time frame of 2010 to 2020, with statistically significant ($p<0.01$) difference between 2012/2014 data and the concentrations in 2020. However, the concentrations have stabilized within this monitoring program between 2017-2020. There have been no samples exceeding the EQS of 15000 ng/g w.w. for D5, however with this substance being characterized as very persistent and very bioaccumulative (vPvB), attention should be paid to the concentrations and indication of biomagnification of D5 regarding the uncertainties of the long-term effect of these findings.

- For PBDEs (ΣBDE_6) there is a downwards trend since the early 2000s, but still all fish samples from both Lake Mjøsa and Lake Femunden are above the EQS concentration for ΣBDE_6 of 0.0085 ng/g w.w.

- Long-chained carboxylic acids (PFCAs), PFOS and the precursors PFOSA and PFBSA are the dominating PFAS in freshwater fish from both lakes. 7 out of 15 samples of brown trout in Lake Mjøsa exceeded the EQS value of 9.1 ng/g w.w. for PFOS. 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 four years.

- Ecological and morphometric predictors such as length, conditional factor (CF), lipid, trophic level ($\delta^{15}N$) or carbon source ($\delta^{13}C$) do not explain any of the variation in PFAS concentrations within the top predator level (brown trout) in Lake Mjøsa. This means that fish size is not correlated with e.g. PFOS or the long-chained PFCAs found in liver.

- Only very few detections were observed in biota samples (fish muscle, liver or bile) for alkylphenols and bisphenols, new brominated flame retardants (nBFR) and UV-chemicals. Change of target tissue from muscle to bile in 2019 and 2020 (brown trout) did not seem to increase number of detections in the sample material.

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 searching for these compounds to provide an early warning if they were to enter Norwegian freshwater ecosystems. Lake Mjøsa is a well described freshwater system with several potential impacts from anthropogenic activities, such as urban areas, road runoff, old and new industries within a large catchment area. Including both well-known and emerging contaminants in a regular monitoring program for biota provides information on potential discharges to the lake.

5 References

Adams, T. S., Sterner, R. W. 2000. The effect of dietary nitrogen content on trophic level 15N enrichment. Limnol. Oceanogr. 45: 601–607.

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.

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

Bloom, N.S., 1992. On the chemical form of mercury in edible fish and marine invertebrate tissue. Canadian Journal of Fisheries and Aquatic Sciences 49, 1010-1017.

Blytt, L.D. and Stang, P., 2018. Organiske miljøgifter i norsk avløpsslam – Resultater fra undersøkelsen i 2017/18. Norsk Vann rapport 242|2018.

Bohlin-Nizzetto, P., Aas, W. and Nikiforov, V., 2019. Monitoring of environmental contaminants in air and precipitation, annual report 2018. Norwegian Environment Agency, Report M-1419|2019. 124 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.

Braaten, H.F.V., de Wit, H., Larssen, T., Poste, A., 2018. Mercury in fish from Norwegian lakes: The complex influence of aqueous organic carbon. Science of the Total Environment ISSN 0048-9697. Vol 627 s341-348 doi: 10.1016/j.scitotenv.2018.01.252

Butt, C.M., Congleton, J., Hoffmann, K., Fang, M. and Stapleton, H.M., 2014. Metabolites of organophosphate flame retardants and 2-ethylhexyl tetrabromobenzoate in urine from paired mothers and toddlers. Environmental science & technology 48, 10432-10438.

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 organophosphorus 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. and 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.

Dahlgren, K., Rydland Olsen, B., Troedsson, C. and Båmstedt, U., 2012. Seasonal variation in was ester concentration and gut content in a Baltic Sea copepod (*Limnocalanus macurus*), Journal of Plankton Research, Vol. 34 (4), 286-297.

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.

Donadt, C., Cooke, C.A., Graydon, J.A. and Poesch, M.S., 2021. Mercury bioaccumulation in stream fish from an agriculturally-dominated watershed. Chemosphere 262, https://doi.org/10.1016/j.chemosphere.2020.128059

Driscoll, C.T., Mason, R.P, Chan, H.M., Jacob, D.J. and Pirrone, N., 2013. Mercury as a global pollutant: sources, pathways, and effects. Environmental Science & Technology 47, 4967-4983.

Duinmeijer, C., 2020. In-depth analysis of zooplankton community structure in lake Mjøsa. Carbon $\delta^{13}C$ and nitrogen $\delta^{15}N$ stable isotopic analysis on present key species in lake Mjøsa. The Faculty of Mathematics and Natural Sciences - University of Oslo. Unpublished thesis.

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.

ECHA, 2018a. Inclusion of substances of very high concern in the candidate list for eventual inclusion in Annex XIV.

ECHA, 2018b. Dechlorane plus. https://echa.europa.eu/candidate-list-table/-/dislist/details/0b0236e181f392bf

ECHA, 2019. Support document for identification of perfluorobutane sulfonic acid and its salts. SVHC draft support document. https://www.echa.europa.eu/documents/10162/891ab33d-d263-cc4b-0f2d-d84cfb7f424a

EFSA CONTAM Panel (EFSA Panel on Contaminants in the Food Chain), Schrenk, D., Bignami, M., Bodin, L., Chipman, J.K., del Mazo, J., Grasl-Kraupp, B., Hogstrand, C., Hoogenboom, L.R., Leblanc, J-C., Nebbia, C.S., Nielsen, E., Ntzani, E., Petersen, A., Sand, S., Vleminckx, C., Wallace, H., Barreg□ard, L., Ceccatelli, S., Cravedi, J-P., Halldorsson, T.I., Haug, L.S., Johansson, N., Knutsen, H.K., Rose, M., Roudot, A-C., VanLoveren, H., Vollmer, G., Mackay, K., Riolo, F. and Schwerdtle, T., 2020. Scientifc Opinion on the risk to human health related to the presence of perfluoroalkyl substances in food. EFSA Journal 2020;18(9):6223, 391.

EFSA CONTAM, 2011. Scientific opinion on polybrominated diphenyl ethers (PBDEs) in food. EFS Journal 2011;9(5):2156.

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.

Eriksson, P., Jakobsson, E. and Fredriksson, A., 2001. Brominated flame retardants: a novel class of developmental neurotoxicants in our environment? Environmental Health Perspectives, 109, 903-908

EU regulation, 2018. Commission regulation 2018/213 on the use of bisphenol A in varnishes and coatings intended to come into contact with food and amending Regulation (EU) No 10/2011 as regards the use of that substance in plastic food contact materials.

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., Schlabach, M., Rognerud, S., Kjellberg, G., 2004. Environmental pollutants in sediments and fish from Lake Mjøsa and the Drammens River and Drammensfjord, follow-up studies in 2004. SFT report TA-2051/2004. 27 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.

Franklin, J., 2015. How reliable are field-derived biomagnification factors and trophic magnification factors as indicators of bioaccumulation potential? Conclusions from a case study on per- and polyfluoroalkyl substances. Integrated environmental assessment and management vol.12 (1), 6-20.

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.

Gao, P., He, P., Wang, A., Xia, T., Xu, B., Xu, Z., Niu, Q., Guo, L. and Chen, X., 2009. Influence of PCB153 on oxidative DNA damage and DNA repair-related gene expression induced by PBDE-47 in human neuroblastoma cells in vitro. Toxicological Sciences, 107, 165-170.

Garcia, E. and 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

Garmo, Ø., Fjeld, E., Grung, M., 2017. Overvåking av utvalgte miljøgifter i Mjøsa 2016 (Monitoring of environmental contaminants in Lake Mjøsa 2016). NIVA report 7141-2017.

Gorski, P.R., Cleckner, L.B., Hurley, J.P., Sierzen, M.E. and 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.

Goss, K.U., Brown, T.N. and Endo, S., 2013. Elimination half-life as a metric for the bioaccumulation potential of chemicals in aquatic and terrestrial food chains. Environmental toxicology and chemistry 32: 1663-1671.

Green, N.W., Schøyen, M., Hjerman, D.Ø., Øxnevad, S., Ruus, A., Beylich, B., Lund, E., Tveiten, L., Jenssen, M.T.S., Håvardstun, J., Ribeiro, A.L., Doyer, I., Runderget, J.T. and Bæk, K., 2019. Contaminants in coastal waters of Norway 2018, NIVA report no. 7412-2019, 235 p.

Grey, J., Jones, R.I. and Sleep, D., 2001. Seasonal changes in the importance of the source of organic matter to the diet of zooplankton in Loch Ness, as indicated by stable isotope analysis. Limnology and Oceanography 46, 505–513.

Hale, S.E., Arp, H.P.H., Slinde, G.A., Wade, E.J., Bjørseth, K., Breedveld, G.D., Straith, B.F., Moe, K.G., Jartun, M. and Høisæter, Å., 2017. Sorbent amendment as a remediation strategy to reduce PFAS mobility and leaching in a contaminated sandy soil from a Norwegian firefighting training facility. Chemosphere 171, 9–18.

Hansen, S., Vestergren, R., Herzke, D., Melhus, M., Evenset, A., Hanssen, L., Brustad, M. and Sandanger, T.M., 2016. Exposure to per- and polyfluoroalkyl substances through the consumption of fish from lakes affected by aqueous film-forming foam emissions — A combined epidemiological and exposure modeling approach. The SAMINOR 2 Clinical Study. Environ. Int. 94, 272–282.

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.

Herczeg, A. L. 1987. A stable carbon isotope study of dissolved inorganic carbon cycling in a softwater lake. Biogeochemistry 4: 231–263.

Hesslein, R.H., Hallard, K.A., and Ramlal, P. 1993. Replacement of sulfur, carbon, and nitrogen in tissue of growing broad whitefish (Coregonus nasus) in response to a change in diet traced by d34S, d13C, and d15N. Can. J. Fish. Aquat. Sci. 50: 2071–2076. doi:10.1139/f93-230.

Hollander, D. J., Mckenzie J. A. 1991. CO2 control on carbon-isotope fractionation during aqueous photosynthesis: A paleo-pCO2 barometer. Geology 19: 929–932.

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 2017. Miljødirektoratet M-1106, 136 p.

Jartun, M., Økelsrud, A., Rundberget, T., Enge, E.K., Rostkowski, P., Warner, N., Harju, M. og Johansen, I., 2019. Monitoring of environmental contaminants in freshwater ecosystems 2018 – Occurrence and biomagnification. NIVA-report 7397-2019.

Jartun, M., Økelsrud, A., Rundberget, T., Bæk, K., Enge, E.K., Halse, A.K., Götsch, A, Harju, M. and Johansen, I., 2020. Monitoring of environmental contaminants in freshwater ecosystems 2019 – Occurrence and biomagnification. NIVA-report 7545-2020.

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.

Jones, P.D., Hu, W., Coen, W.D., Newsted, J.L. and Giesy, J.P., 2003. Binding of perfluorinated fatty acids to serum proteins. Environmental toxicology and chemistry, Vol.22 (11), 2639-2649.

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.

Kjellberg, G., Hessen, D.O., Nilssen, J.P. 1991. Life history, growth and production of Mysis relicta in the large fiord-type Lake Mjøsa, Norway. Freshwater Biology (1991) 26, 165-173.

Klemetsen, A., Amundsen, P.A., Dempson, J.B., Jonsson, B., Jonsson, N., O'Connell, M.F. and 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.

Kuwabara, J.S., Arai, Y., Topping, B.R., Pickering I J., George, G., 2007. Mercury speciation in piscivorous fish from mining-impacted reservoirs. *Environmental Science & Technology* **2007** *41* (8), 2745-2749 DOI: 10.1021/es0628856

Langberg, H.A., Breedveld, G.D., Slinde, G.A., Grønning, H.M., Høisæter, Å., Jartun, M., Rundberget, T., Jenssen, B.M., Hale, S.E., 2020. Fluorinated Precursor Compounds in Sediments as a Source of Perfluorinated Alkyl Acids (PFAA) to Biota. Environ. Sci. Technol. 54, 13077–13089

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. and 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.

Linløkken, A.N. and Rukan, K., 2020. Har lågåsilda i Mjøsa forsvunnet – sporløst? VANN 01-2020, 87-93.

Lu, Y., Yuan, T., Wang, W. and Kannan, K., 2011. Concentrations and assessment of exposure to siloxanes and synthetic musks in personal care products from China. Environmental pollution 159, 3522-3528.

Lyche, J.L., Nøstbakken, O.J. and Berg, V., 2020. EU Water Framework-Directive Priority Contaminants in Norwegian Freshwater Fish. NMBU, Miljødirektoratet M-1789|2020.

Lyche Solheim, A., Thrane, J-E., Løvik, J., Skjelbred, B., Persson, J., Eriksen, T.E. and Røst Kile, M., 2018. Tiltaksorientert overvåkning av vannområde Mjøsa. Årsrapport for 2017. NIVA-rapport Lnr. 7144-2017.

Lyche Solheim, A., Thrane, J-E., Skjelbred, Økelsrud, A., Håll, J.P. and Røst Kile, M., 2019. Tiltaksorientert overvåkning av vannområde Mjøsa. Årsrapport for 2018. NIVA-rapport Lnr. 7373-2019.

Lyche Solheim, A., Thrane, J-E., Skjelbred, Økelsrud, A., Håll, J.P. and Røst Kile, M., 2020. Tiltaksorientert overvåkning av vannområde Mjøsa. Årsrapport for 2019. NIVA-rapport Lnr. 7491-2020.

Mariussen, E., Fjeld, E., Breivik, K., Steinnes, E., Borgen, A., Kjellberg, G. and Schlabach, M., 2008. Elevated levels of polybrominated diphenyl ethers (PBDEs) in fish from Lake Mjøsa, Norway. Science of the total environment 390, 132-141.

Matportalen, 2020. https://www.matportalen.no/matvaregrupper/tema/fisk_og_skalldyr/advarer_mot_aa_spise_selvfanget_fisk_fra_vansjo_i_mossevassdraget

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. and 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.

Miyajima, T., Yamada Y., Wada, E., Nakajima, T., Koitabashi, T., Hanba, Y. T. and Yoshii, K. 1997. Distribution of greenhouse gases, nitrite, and 13C of dissolved inorganic carbon in Lake Biwa: Implications for hypolimnetic metabolism. Biogeochemistry 36: 205–221.

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.

Nater C., Rustadbakken, A., Ergon T., Langangen Ø., Moe, S.J., Vindenes, Y., Vøllestad, L.A. and Aass, P., 2018. Individual heterogeneity and early life conditions shape growth in a freshwater top predator. Ecology 99 (5): 1011-1017. https://doi.org/10.1002/ecy.2178

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.

Næsje, T.F., Forseth, T., Saksgård, R. Hårsaker K. and Sandlund, O.T., 1996. Production and management of piscivorous brown trout in Lake Femund. Annual report 1995. - NINA 436: 1-37.

Olk, R., Karlsson, T., Lydersen, E., Økelsrud, A., 2016. 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

Olsen, M., Fjeld, E. and Lydersen, E., 2019. The influence of a submerged meadow on uptake and trophic transfer of legacy mercury from contaminated sediment in the food web in a brackish Norwegian fjord. Science of he total environment, vol 654, 209-217

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.

Pelletier E., 1995. Environmental organometallic chemistry of mercury, tin, and lead: present status and perspectives. In: Tessier A, Turner DR (Eds). Metal Speciation and Bioavailability in Aquatic Systems. IUPAC, John Wiley and Sons Ltd, 1995:103– 48. ISBN13:9780471958307.

Pickhardt, P.C., Folt, C.L., Chen, C.Y., Klaue, B. and 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. and 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. and 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.

Quay, P. D., Emerson, S. R., Quay, B. M. and Devol, A. H. 1986. The carbon cycle for Lake Washington—a stable isotope study. Limnol. Oceanogr. 31: 596–611

Rognerud, S., 1985. Kvikksølv i Mjøsa's sedimenter. Arealfordeling og vertikalprofiler av antropogent kvikksølv (Mercury in the sediments of Lake Mjøsa. Areal distribution and vertical profiles of antropogenic mercury). NIVA-report 1710.

Rustadbakken, A., Qvenild, T. and Narud, A., 2004. Storørreten i Brumunda. En framstilling av merke-/gjenfangstdata samt vekstanalyser av fisk fra perioden 1973 til 2000. (Piscivorous brown trout from River Brumunda. Tagging/recapturing and growth analysis of fish in the period 1973-2000). Naturkompetanse AS/Fylkesmannen i Hedmark.

Rustadbakken, A., Westly, T., 2006. Storørreten i Lenaelva. (Piscivorous brown trout in River Lenaelva). Naturkompetanse AS.

Ruus, A., Bæk, K., Rundberget, T., Allan, I., Beylich, B., Vogelsang, C., Schlabach, M., Götsch, A., Borgå, K., and Helberg, M., 2020. Environmental contaminants in an urban fjord, 2019. NIVA-rapport 7555-2020.

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. and 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. and 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.

SCHEER (Scientific Committee on Health, Environmental and Emerging Risks), 2017. Scientific advice on environmental quality standards (EQS). doi:10.2875/018826

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.

Sheikh, I.A., Tayubi, I.A., Ahmad, E., Ganaie, M.A., Bajouh, O.S., AlBasri, S.F., Abdulkarim, I.M.J. and Beg, M.A., 2017. Computational insights into the molecular interactions of environmental xenoestrogens 4-tert-octylphenol, 4-nonylphenol, bisphenol A (BPA), andBPA metabolite, 4-methyl-2, 4-bis (4-hydroxyphenyl) pent-1-ene (MBP)with human sex hormone-binding globulin. Ecotoxicology and environmental safety 135, 284-291.

Slinde, G.A., Grønning, H.M., Hale, S., Langberg, H.A., Jartun, M. og Rundberget, J.T., 2019. Environmental monitoring of PFAS in biotic and abiotic media, Miljødirektoratet M-1318|2019.

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. and 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].

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.

Thomsen, C., Knutsen, H.K., Liane, V.H., Frøshaug, M., Kvalem, H.E., Haugen, M., Meltzer, H.M., Alexander, J. and Becher, G., 2008. Consumption of fish from a contaminated lake strongly affects the concentrations of polybrominated diphenyl ethers and hexabromocyclododecane in serum. Molecular nutrition & food research 52(2), 228-237.

Thrane, J.E., Økelsrud, A., Skjelbred, B., Ranneklev, S.B., Håll, J. and Røst Kile, M., 2018. Tiltaksorientert overvåking i vannområde Mjøsa. Årsrapport for 2020. (Monitoring of Lake Mjøsa. Annual report for 2020). NIVA rapport 7622-2021. ISBN 978-82-577-7358-8

Thrane, J.-E., Persson, J., Kile, M. R., Grung, M., Bækkelie, K.A., Myrvold, K.M., Garmo, Ø. A., Calidonio, J.L.G, de Wit, H. and Moe, T. F., 2020. Overvåking av referanseelver 2019. Basisovervåking i henhold til vannforskriften. NIVA-rapport 7485-2020.

Tran, T.M., Hoang, A.Q., Le, S.T., Minh, T.B. and Kannan, K., 2019. A review of contamination status, emission sources, and human exposure to volatile methyl siloxanes (VMSs) in indoor environments. Science of the total environment 691, 584-594.

Trudel, M. and 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.

Vander Zanden, M.J. and 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. and Rasmussen, J.B., 1999. Primary consumer $\delta^{13}C$ and $\delta^{15}N$ 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., Clayton, M.K., Moody, E.K., Solomon, C.T. and Weidel, B.C. 2015. Stable Isotope Turnover and Half-Life in Animal Tissues: A Literature Synthesis. PLoSONE 10(1):e0116182. doi:10.1371/ journal.pone.0116182

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

Verrault, 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, X. and Veizer, J. 2000. Respiration-photosynthesis balance of terrestrial aquatic ecosystems, Ottawa area, Canada. Geochim. Cosmochim. Acta 64: 3775–3786.

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, 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. and 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.

Warner, N. A., Nikiforov, V., Krogseth, I.S., Bjørneby, S.M., Kierkegaard, A. and Bohlin-Nizzetto, P., 2020. "Reducing sampling artifacts in active air sampling methodology for remote monitoring and atmospheric fate assessment of cyclic volatile methylsiloxanes." Chemosphere 255: 126967.

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

Weidel, B.C., Carpenter, S.R., Kitchell, J.F. and Vander Zanden M.J., 2011. Rates and components of carbon turnover in fish muscle: insights from bioenergetics models and a whole-lake (13)C addition. Canadian Journal of Fisheries and Aquatic Sciences, 68:387–399.

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.

Zhang, Y., D.J. Jacob, H.M. Horowitz, L. Chen, H.M. Amos, D.P. Krabbenhoft, F. Slemr, V.L. St Louis, et al. 2016. Observed decrease in atmospheric mercury explained by global decline in anthropogenic emissions. Proceedings of the National Academy of Sciences of the United States of America 113: 526–531.

Økelsrud, A., Lydersen E. and Fjeld, E., 2016. 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., Jartun, M., Øxnevad, S., Lund, E., Jenssen, M. and Bæk, K., 2020. Kartlegging av miljøgifter i fisk i vannforekomsten Nedre Nitelva. NIVA-report 7566-2020.

6 Appendices

6.1 List of all compounds in the Milfersk program.

Compound class	Compound	Name	CAS-no.
Mercury	Hg	Mercury	7439-97-6
cVMS	D4	2,2,4,4,6,6,8,8-Octamethyl-1,3,5,7,2,4,6,8-tetroxatetrasilocane	556-67-2
	D5	2,2,4,4,6,6,8,8,10,10-Decamethyl-1,3,5,7,9,2,4,6,8,10-pentoxapentasilecane	541-02-6
	D6	Dodecamethylcyclohexasiloxane	540-97-6
PBDEs	17	2,2',4-Tribromodiphenyl ether	147217-75-2
	28	2,4,4'-Tribromodiphenyl ether	41318-75-6
	47	2,2',4,4'-Tetrabromodiphenyl ether	5436-43-1
	49	2,2',4,5'-Tetrabromodiphenyl ether	243982-82-3
	66	2,3',4,4'-Tetrabromodiphenyl ether	189084-61-5
	71	2,3',4',6-Tetrabromodiphenyl ether	189084-62-6
	77	3,3',4,4'-Tetrabromodiphenyl ether	93703-48-1-
	85	2,2',3,4,4'-Pentabromodiphenyl ether	182346-21-0
	99	2,2',4,4',5-Pentabromodiphenyl ether	60348-60-9
	100	2,2',4,4',6-Pentabromodiphenyl ether	189084-64-8
	119	2,3',4,4',6-Pentabromodiphenyl ether	189084-66-0
	126	3,3',4,4',5-Pentabromodiphenyl ether	366791-32-4
	138	2,2',3,4,4',5'-Hexabromodiphenyl ether	182677-30-1
	153	2,2',4,4',5,5'-Hexabromodiphenyl ether	68631-49-2
	154	2,2',4,4',5,6'-Hexabromodiphenyl ether	207122-15-4
	156	2,3,3',4,4',5-Hexabromodiphenyl ether	N/A
	183	2,2',3,4,4',5',6-Heptabromodiphenyl ether	207122-16-5
	184	2,2',3,4,4',6,6'-Heptabromodiphenyl ether	117948-63-7
	191	2,3,3',4,4',5',6-Heptabromodiphenyl ether	189084-68-2
	196	2,2',3,3',4,4',5',6-Octabromodiphenyl ether	446255-38-5
	197	2,2',3,3',4,4',6,6'-Octabromodiphenyl ether	117964-21-3
	202	2,2',3,3',5,5',6,6'-Octabromodiphenyl ether	67797-09-5
	206	2,2',3,3',4,4',5,5',6-Nonabromodiphenyl ether	63387-28-0
	207	2,2',3,3',4,4',5,6,6'-Nonabromodiphenyl ether	437701-79-6
	209	Decabromodiphenyl ether	1163-19-5
nBFR	TBA	Tribromoanisole	607-99-8
	ATE (TBP-AE)	Allyl-2,4,6-tribromophenyl ether	3278-89-5
	a-TBECH	Tetrabromoethylcyclohexane	3322-93-8
	b-TBECH	Tetrabromoethylcyclohexane	3322-93-8
	g/d-TBECH	Tetrabromoethylcyclohexane	3322-93-8
	BATE	2-bromoallyl 2,3,6-tribromophenylether	99717-56-3

Compound class	Compound	Name	CAS-no.
nBFR	PBT	Pentabromotoluene	87-83-2
	PBEB	Pentabromoethylbenzene	85-22-3
	PBBZ		608-90-2
	HBB	Hexabromobenzene	87-82-1
	DPTE	2,3-dibromopropyl-2,4,6-tribromophenyl ether	35109-60-5
	EHTBB	2-ethyl-hexyl tetrabromobenzoate	183658-27-7
	BTBPE	1,1'-[1,2-Ethanediylbis(oxy)]bis(2,4,6-tribromobenzene)	37853-59-1
	TBPH (BEH /TBP)	bis(2-ethylhexyl) tetrabromophthalate	26040-51-7
	DBDPE	Decabromodiphenyl ethane	84852-53-9
oPFR Not in 2020	*TEP*	*Tetraethyl diphosphate*	*78-40-0*
	TCEP	*Tris(2-chloroethyl) phosphate*	*115-96-8*
	TPrP	*Tripropyl phosphate*	*513-08-6*
	TCPP	*Tris(1-chloropropyl) phosphate*	*13674-84-5*
	TiBP	*Triisobutyl phosphate*	*126-71-6*
	BdPhP	*Butyl diphenyl phosphate*	*2752-95-6*
	TPP	*Triphenyl phosphate*	*115-86-6*
	DBPhP	*Dibutyl phenyl phosphate*	*2528-36-1*
	TnBP	*Tri-n-butyl phosphate*	*126-73-8*
	TDCPP	*Tris(1,3-dichloro-2-propyl)phosphate*	*13674-87-8*
	TBEP	*Tris(2-butoxyethyl) phosphate*	*78-51-3*
	TCP	*Tricresyl phosphate*	*1330-78-5*
	EHDP	*2-Ethylhexyl diphenyl phosphate*	*1241-94-7*
	TXP		*25155-23-1*
	TEHP	*Tris(2-ethylhexyl) phosphate*	*78-42-2*
Phenols	4,4-bis-A	4,4'-(Propanediyl)diphenol	80-05-7
	2,4-bis-A	2,4'-(Propanediyl)diphenol	80-05-7
	bis-G	4,4’-(1-Methylethylidene)bis[2-(1-methylethyl)phenol]	127-54-8
	4,4-bis-S	4,4'-Sulfonyldiphenol	80-09-1
	2,4-bis-S	2,4'-Sulfonyldiphenol	80-09-1
	4,4-bis-F	4,4'-Methylenediphenol	620-92-8
	2,4-bis-F	2,4'-Methylenediphenol	620-92-8
	2,2-bis-F	2,2'-Methylenediphenol	620-92-8
	bis-P	4,4’-(1,4-Phenylenediisopropylidene)bisphenol	2167-51-3
	bis-Z	4,4'-(1,1-Cyclohexanediyl)diphenol	843-55-0
	TBBPA	Tetrabromobisphenol A	79-94-7
	4-tert-octylphenol	4-tert-octylphenol	140-66-9
	4-octylphenol	4-octylphenol	1806-26-4
	4-nonylphenol	4-Nonylphenol	84852-15-3
PFAS	PFPA	Perfluoropentanoic acid	2706-90-3
	PFHxA	Perfluorohexanoic acid	307-24-4

Compound class	Compound	Name	CAS-no.
PFAS	PFHpA	Perfluoroheptanoic acid	375-85-9
	PFOA	Perfluorooctanoic acid	335-67-1
	PFNA	Perfluorononanoic acid	375-95-1
	PFDA	Perfluorodecanoic acid	335-76-2
	PFUnDA	Perfluoroundecanoic acid	2058-94-8
	PFDoDA	Perfluorododecanoic acid	307-55-1
	PFTrDA	Perfluorotridecanoic acid	72629-94-8
	PFTeDA	Perfluorotetradecanoic acid	376-06-7
	PFPeDA	Perfluoropentadecanoic acid	18024-09-4
	PFHxDA	Perfluorohexadecanoic acid	67905-19-5
	PFBS	Perfluorobutanesulfonic acid	375-73-5
	PFPS	Perfluoropentane-1-sulfonic acid	2706-91-4
	PFHxS	Perfluorohexanesulfonic acid	355-46-4
	PFHpS	Perfluoroheptanesulfonic acid	375-92-8
	PFOS	Perfluorooctanesulfonic acid	1763-23-1
	8Cl-PFOS	8-chloroperfluoro-1-octanesulfonate	N/A
	PFNS	Perfluorononanesulfonic acid	474511-07-4
	PFDS	Perfluorodecane sulfonic acid	335-77-3
	PFDoS	Perfluoro-1-dodecansulfonate	7978-39-5
	PFOSA	Perfluorooctanesulfonamide	754-91-6
	N-MeFOSA	N-methylperfluoro-1-octanesulfonamide	31506-32-8
	N-EtFOSA	N-Ethylperfluoroctansulfonamid	4151-50-2
	N-MeFOSE	2-(N-methylperfluoro-1-octanesulfonamido)-ethanol	24448-09-7
	N-EtFOSE	2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol	1691-99-2
	4:2 FTS	1H,2H-perfluorohexane sulfonate (4:2) (Fluortelomer sulfonic acid)	757124-72-4
	6:2 FTS	1H,2H-perfluorooctane sulfonate (6:2) (Fluortelomer sulfonic acid)	27619-97-2
	8:2 FTS	1H,2H-perfluorodecane sulfonate (8:2) (Fluortelomer sulfonic acid)	39108-34-4
	10:2 FTS	1H,2H-perfluorododecane sulfonate (10:2) (Fluortelomer sulfonic acid)	120226-60-0
	4:2 F53B	Chlorinated polyfluorinated ether sulfonate	N/A
	6:2 F53B	Potassium 2-(6-chloro-1,1,2,2,3,3,4,4,5,5,6,6-dodecafluorohexyloxy)-1,1,2,2-tetrafluoroethane sulfonate	73606-19-6
	N-MeFOSAA	2-(N-methylperfluoro-1-octanesulfonamido)acetic acid	2355-31-9
	N-EtFOSAA	2-(N-ethylperfluoro-1-octanesulfonamido)acetic acid	2991-50-6
	F53	Potassium 1,1,2,2-tetrafluoro-2-(perfluorohexyloxy)ethane sulfonate	754925-54-7
	7:3 FTCA	7:3 Fluorotelomer carboxylic acid	812-70-4
	PFBSA	Perfluoro-1-butansulfonamide	30334-69-1
	N-MeFBSA	N-Methyl perfluorobutanesulfonamide	68298-12-4
	N-EtFBSA	N-ethyl perfluorobutanesulfonamide	40630-67-9
UV-chemicals	BP3	Benzophenone 3	131-57-7

Compound class	Compound	Name	CAS-no.
UV-chemicals	EHMC-Z	2-ethylhexyl-4-methoxycinnamate ester	5466-77-3
	EHMC-E	2-ethylhexyl-4-methoxycinnamate ester	5466-77-3
	Sum-EHMC		
	OC	Octocrylene	6197-30-4
	UV-320	2-benzotriazol-2-yl-4,6-di-tert-butylphenol	3846-71-7
	UV-326	2-(2'-Hydroxy-3'-tert-butyl-5'-methylphenyl)-5-chlorobenzortriazole	3896-11-5
	UV-327	2,4-di-tert-butyl-6-(5-chlorobenzotriazol-2-yl)phenol	3864-99-1
	UV-328	2-(2H-benzotriazol-2-yl)-4,6-di-tert-pentylphenol	25973-55-1
	UV-329	2-(2'-hydroxy-5'-tert-octyllphenyl)benzotriazole	3147-75-9
	ODPABA	Ocytldimethyl p-aminobenzoic acid	58817-05-3
Dechloranes Not in 2020	*Dibromoaldrin*	*Dibromoaldrin*	*20389-65-5*
	Dechlorane 602		*31107-44-5*
	Dechlorane 603		*13560-92-4*
	Dechlorane 604		*34571-16-9*
	Dechlorane 601		*13560-90-2*
	Dechlorane plus syn	*Bis(hexachlorocyclopentadieno)cyclooctane*	*135821-03-3*
	Dechlorane plus anti	*Bis(hexachlorocyclopentadieno)cyclooctane*	*135821-74-8*
	1,3-DPMA	*1,3-Dechlorane Plus monoadduct*	*N/A*
	1,5-DPMA	*1,5-Dechlorane Plus monoadduct*	*13821-04-4*

6.2 Raw data, all compounds.

Table A1. Raw data of environmental contaminants in zooplankton, Mysis, E.smelt, vendace and brown trout, 2020.

MILFERSK 2020								ISOTOPES		Hg		UV-chem				
ID	**Sample**	**Lake**	**Sex**	**Age**	**Length**	**Weight**	**Lipid**	**$d^{13}C_{VPDB}$**	**$d^{15}N_{AIR}$**	**Hg**		**BP3**	**EHMC-Z**	**EHMC-E**	**Sum-EHMC**	**UV-320**
				year	cm	g	%	‰	‰	µg/g	*Matrix*	ng/g	ng/g	ng/g	ng/g	ng/g
ZM-1	Zooplankton	Mjøsa					0.45	-29.29	6.37	<0,005	*Whole body*	<0.3	<0.03	<0.15	<0.18	<0.03
ZM-2	Zooplankton	Mjøsa					0.31	-29.07	6.98	0.007	*Whole body*	<0.3	<0.03	<0.15	<0.18	<0.03
ZM-3	Zooplankton	Mjøsa					0.49	-29.28	6.91	0.006	*Whole body*	<0.3	<0.03	<0.15	<0.18	<0.03
MM-1	Mysis	Mjøsa					0.92	-30.27	9.96	0.006	*Whole body*	<0.3	<0.03	<0.15	<0.18	<0.03
MM-2	Mysis	Mjøsa					2.06	-31.29	9.86	0.006	*Whole body*	<0.3	<0.03	<0.15	<0.18	<0.03
MM-3	Mysis	Mjøsa					3.05	-30.64	9.84	0.008	*Whole body*	<0.3	<0.03	<0.15	<0.18	<0.03
KM-M-1	E.smelt	Mjøsa			9.6	4.1	0.14	-27.77	13.88	0.11	*Muscle*	<0.3	0.09	0.33	0.42	0.04
KM-M-2	E.smelt	Mjøsa			9.8	4.5	1.43	-27.85	14.25	0.11	*Muscle*	<0.3	0.05	0.18	0.23	0.05
KM-M-3	E.smelt	Mjøsa			10.1	5.1	0.88	-28.17	14.21	0.1	*Muscle*	<0.3	0.08	0.36	0.45	0.03
KM-M-4	E.smelt	Mjøsa			9.6	4.6	1.22	-28.29	13.74	0.1	*Muscle*	<0.3	<0.03	<0.15	<0.18	<0.03
KM-M-5	E.smelt	Mjøsa			16.5	27.3	1.28	-26.88	14.47	0.13	*Muscle*	<0.3	<0.03	<0.15	<0.18	<0.03
KM-M-6	E.smelt	Mjøsa			15.8	26.3	1.30	-26.86	13.97	0.14	*Muscle*	<0.3	<0.03	<0.15	<0.18	<0.03
KM-M-7	E.smelt	Mjøsa			16.8	32.0	1.09	-26.39	15.38	0.15	*Muscle*	<0.3	<0.03	<0.15	<0.18	<0.03
KM-M-8	E.smelt	Mjøsa			16.5	26.0	1.14	-27.03	14.48	0.13	*Muscle*	<0.3	<0.03	<0.15	<0.18	<0.03
KM-M-9	E.smelt	Mjøsa			16.6	27.0	1.01	-26.78	14.58	0.13	*Muscle*	<0.3	<0.03	<0.15	<0.18	<0.03
KM-M-10	E.smelt	Mjøsa			15.6	24.2	1.23	-26.95	14.20	0.13	Muscle	<0.3	<0.03	<0.15	<0.18	<0.03
LM-M-1	Vendace	Mjøsa			15.6	27.7	2.55	-28.22	12.10	0.08	*Muscle*	<0.08	<0.03	<0.05	<0.08	0.02
LM-M-2	Vendace	Mjøsa			16.4	30.6	2.33	-28.45	12.40	0.079	*Muscle*	<0.05	<0.03	<0.05	<0.08	0.02
LM-M-3	Vendace	Mjøsa			16.5	32.6	1.41	-28.16	12.61	0.082	*Muscle*	<0.08	<0.03	0.06	<0.088	<0.015
LM-M-4	Vendace	Mjøsa			15.9	30.7	1.89	-28.01	12.65	0.072	*Muscle*	<0.08	<0.03	0.06	<0.094	0.02
LM-M-5	Vendace	Mjøsa			16.0	31.8	2.57	-28.51	12.42	0.094	*Muscle*	<0.05	<0.03	<0.05	<0.08	0.02
LM-M-6	Vendace	Mjøsa			15.3	29.0	2.28	-28.46	12.42	0.12	*Muscle*	<0.05	<0.03	<0.05	<0.08	<0.015
LM-M-7	Vendace	Mjøsa			16.5	31.9	2.22	-29.03	12.40	0.11	*Muscle*	<0.05	<0.03	<0.05	<0.08	0.02
LM-M-8	Vendace	Mjøsa			15.3	28.1	1.89	-28.82	11.93	0.09	*Muscle*	<0.05	<0.03	<0.05	<0.08	0.02
LM-M-9	Vendace	Mjøsa			17.0	33.2	2.75	-28.48	12.05	0.088	*Muscle*	<0.05	<0.03	<0.05	<0.08	<0.015
LM-M-10	Vendace	Mjøsa			16.2	31	2.63	-28.48	11.83	0.074	Muscle	<0.05	<0.03	<0.05	<0.08	0.02
ØM-M-1	Brown trout	Mjøsa	M	9	85	9200	7.59	-28.98	15.02	0.58	*Muscle*	<0.3	<0.02	<0.08	<0.1	<0.03
ØM-M-2	Brown trout	Mjøsa	M	7	73	3800	0.45	-26.91	15.77	0.54	*Muscle*	<0.3	<0.02	<0.08	<0.1	<0.03
ØM-M-3	Brown trout	Mjøsa	F	8	71	3900	4.39	-28.66	15.95	1.2	*Muscle*	<0.3	<0.02	<0.08	<0.1	<0.03
ØM-M-4	Brown trout	Mjøsa	F	7	71	3750	1.25	-26.53	16.47	0.59	*Muscle*	<0.3	<0.02	<0.08	<0.1	<0.03
ØM-M-5	Brown trout	Mjøsa	F	8	64	2650	2.50	-26.84	15.96	1.3	*Muscle*	<0.3	<0.02	<0.08	<0.1	<0.03

MILFERSK 2020								ISOTOPES		Hg		UV-chem				
ID	**Sample**	**Lake**	**Sex**	**Age**	**Length**	**Weight**	**Lipid**	**$d^{13}C_{VPDB}$**	**$d^{15}N_{AIR}$**	**Hg**		**BP3**	**EHMC-Z**	**EHMC-E**	**Sum-EHMC**	**UV-320**
				year	cm	g	%	‰	‰	µg/g	*Matrix*	ng/g	ng/g	ng/g	ng/g	ng/g
ØM-M-6	Brown trout	Mjøsa	M	8	70	4550	5.14	-29.86	16.70	0.64	*Muscle*	<0.3	<0.02	<0.08	<0.1	<0.03
ØM-M-7	Brown trout	Mjøsa	F	7	65	3850	4.78	-27.84	16.65	0.75	*Muscle*	<0.3	<0.02	<0.08	<0.1	<0.03
ØM-M-8	Brown trout	Mjøsa	F	7	68	3100	0.64	-26.38	16.16	0.6	*Muscle*	<0.3	0.03	0.09	0.12	<0.03
ØM-M-9	Brown trout	Mjøsa	F	9	77	3700	0.86	-26.30	15.95	1.3	*Muscle*	<0.3	<0.02	<0.08	<0.1	<0.03
ØM-M-10	Brown trout	Mjøsa	M	7	63	3000	2.21	-27.36	15.77	0.47	*Muscle*	<0.3	<0.02	<0.08	<0.1	<0.03
ØM-M-11	Brown trout	Mjøsa	M	8	62	2200	0.59	-26.49	16.10	0.73	*Muscle*	<0.3	<0.02	<0.08	<0.1	<0.03
ØM-M-12	Brown trout	Mjøsa	M	7	64	2800	3.54	-26.69	16.31	0.55	*Muscle*	<0.3	<0.02	<0.08	<0.1	<0.03
ØM-M-13	Brown trout	Mjøsa	F	13	61	2200	0.14	-24.62	14.31	0.49	*Muscle*	<0.3	<0.02	<0.08	<0.1	<0.03
ØM-M-14	Brown trout	Mjøsa	F	7	58	2400	4.87	-27.73	16.19	0.4	*Muscle*	<0.3	<0.02	<0.08	<0.1	<0.03
ØM-M-15	Brown trout	Mjøsa	F	8	61	2250	2.91	-26.98	16.45	1.1	*Muscle*	<0.3	<0.02	<0.08	<0.1	<0.03
ØF-M-1	Brown trout	Femunden	F		46	1025	3.07	-25.81	10.92	0.75	*Muscle*	<0.05	<0.03	<0.05	<0.08	<0.015
ØF-M-2	Brown trout	Femunden	M		34.5	356	0.24	-21.11	10.61	0.26	*Muscle*	<0.05	<0.03	<0.05	<0.08	<0.015
ØF-M-3	Brown trout	Femunden	F		37	478	0.91	-24.27	10.76	0.45	*Muscle*	<0.05	<0.03	<0.05	<0.08	<0.015
ØF-M-4	Brown trout	Femunden	M		36.5	420	0.44	-24.46	10.58	0.28	*Muscle*	<0.05	<0.03	<0.05	<0.08	<0.015
ØF-M-5	Brown trout	Femunden	M		40	470	0.94	-24.05	11.30	0.026	*Muscle*	<0.05	<0.03	<0.05	<0.08	<0.015
ØF-M-6	Brown trout	Femunden	M		41.5	680	1.59	-24.67	10.03	0.4	*Muscle*	<0.05	<0.03	<0.05	<0.08	<0.015
ØF-M-7	Brown trout	Femunden	M		40	580	0.68	-25.08	10.70	0.49	*Muscle*	<0.05	<0.03	<0.05	<0.08	<0.015
ØF-M-8	Brown trout	Femunden	M		44.5	845	1.57	-25.10	10.84	0.48	*Muscle*	<0.05	<0.03	<0.05	<0.08	<0.015
ØF-M-9	Brown trout	Femunden	M		35	400	0.46	-23.54	10.31	0.028	*Muscle*	<0.05	<0.03	<0.05	<0.08	<0.015
ØF-M-10	Brown trout	Femunden	F		42	937	0.80	-24.88	11.05	0.96	*Muscle*	<0.05	<0.03	<0.05	<0.08	<0.015

MILFERSK 2020			UV-chemicals							PFAS								
ID	**Sample**	**Lake**	**UV-326**	**UV-329**	**UV-328**	**UV-327**	**OC**	**ODPABA**		PFPA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnDA	PFDoDA	PFTrDA
			ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	*Matrix PFAS*	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
ZM-1	Zooplankton	Mjøsa	<0.05	<0.3	<0.06	<0.03	2.22	<0.03	*Whole body*	<0.5	<0.5	<0.5	<0.5	<0.4	<0.4	<0.4	<0.4	<0.4
ZM-2	Zooplankton	Mjøsa	<0.05	<0.3	<0.06	<0.03	2.18	<0.03	*Whole body*	<0.5	<0.5	<0.5	<0.5	<0.4	<0.4	<0.4	<0.4	<0.4
ZM-3	Zooplankton	Mjøsa	<0.05	-0.03	<0.06	<0.03	2.07	<0.03	*Whole body*	<0.5	<0.5	<0.5	<0.5	<0.4	<0.4	<0.4	<0.4	<0.4
MM-1	Mysis	Mjøsa	0.21	<0.3	<0.06	<0.03	4.40	<0.03	*Whole body*	<0.5	<0.5	<0.5	<0.5	<0.4	<0.4	<0.4	<0.4	<0.4
MM-2	Mysis	Mjøsa	0.24	<0.3	0.07	<0.03	3.40	<0.03	*Whole body*	<0.5	<0.5	<0.5	<0.5	<0.4	<0.4	<0.4	<0.4	<0.4
MM-3	Mysis	Mjøsa	0.19	<0.3	0.07	<0.03	3.62	<0.03	*Whole body*	<0.5	<0.5	<0.5	<0.5	<0.4	<0.4	<0.4	<0.4	<0.4
KM-M-1	E.smelt	Mjøsa	0.06	<0.3	0.07	0.08	1.55	<0.03	*Liver*	<0.5	<0.5	<0.5	<0.5	1.42	2.18	4.62	3.08	4.31
KM-M-2	E.smelt	Mjøsa	<0.05	<0.3	0.17	0.10	1.04	<0.03	*Liver*	<0.5	<0.5	<0.5	<0.5	1.17	1.70	3.84	2.67	3.57
KM-M-3	E.smelt	Mjøsa	0.06	<0.3	0.10	0.07	1.19	<0.03	*Liver*	<0.5	<0.5	<0.5	<0.5	0.73	1.47	3.54	2.41	3.22
KM-M-4	E.smelt	Mjøsa	<0.05	<0.3	<0.06	<0.03	<0.5	<0.03	*Liver*	<0.5	<0.5	<0.5	<0.5	1.12	1.94	4.46	2.85	4.27
KM-M-5	E.smelt	Mjøsa	<0.05	<0.3	<0.06	<0.03	<0.5	<0.03	*Liver*	<0.5	<0.5	<0.5	<0.5	0.51	1.47	3.27	2.04	2.85
KM-M-6	E.smelt	Mjøsa	<0.05	<0.3	<0.06	<0.03	<0.5	<0.03	*Liver*	<0.5	<0.5	<0.5	<0.5	0.89	1.70	3.13	2.30	2.50
KM-M-7	E.smelt	Mjøsa	<0.05	<0.3	<0.06	0.03	0.63	<0.03	*Liver*	<0.5	<0.5	<0.5	<0.5	0.57	1.50	3.10	1.93	2.52
KM-M-8	E.smelt	Mjøsa	<0.05	<0.3	<0.06	<0.03	<0.5	<0.03	*Liver*	<0.5	<0.5	<0.5	<0.5	0.42	0.84	1.79	1.27	1.60
KM-M-9	E.smelt	Mjøsa	<0.05	<0.3	<0.06	<0.03	<0.5	<0.03	*Liver*	<0.5	<0.5	<0.5	<0.5	0.36	0.88	2.09	1.42	1.78
KM-M-10	E.smelt	Mjøsa	<0.05	<0.3	<0.06	<0.03	0.74	<0.03	Liver	<0.5	<0.5	<0.5	<0.5	0.61	1.37	2.79	1.86	2.34
LM-M-1	Vendace	Mjøsa	<0.3	<0.1	0.13	0.04	0.78	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	<0.5	<0.4	0.53	0.47	0.46
LM-M-2	Vendace	Mjøsa	<0.3	<0.1	0.11	0.03	<0.6	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	<0.5	0.42	1.03	0.99	0.95
LM-M-3	Vendace	Mjøsa	<0.3	<0.1	0.10	0.03	1.28	0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	<0.5	<0.4	<0.4	<0.4	<0.4
LM-M-4	Vendace	Mjøsa	<0.3	<0.1	0.15	0.04	<0.6	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	<0.5	0.37	0.60	0.47	0.50
LM-M-5	Vendace	Mjøsa	<0.3	<0.1	0.13	0.03	0.64	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	<0.5	<0.4	0.69	0.63	0.78
LM-M-6	Vendace	Mjøsa	<0.3	<0.1	0.12	0.02	<0.6	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	<0.5	<0.4	0.45	<0.4	0.45
LM-M-7	Vendace	Mjøsa	<0.3	<0.1	0.12	0.03	<0.6	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	<0.5	<0.4	0.50	0.45	0.52
LM-M-8	Vendace	Mjøsa	<0.3	<0.1	0.14	0.03	<0.6	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	<0.5	<0.4	0.58	0.49	0.70
LM-M-9	Vendace	Mjøsa	<0.3	<0.1	0.09	0.02	<0.6	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	<0.5	<0.4	0.61	0.48	0.51
LM-M-10	Vendace	Mjøsa	<0.3	<0.1	0.11	0.03	<0.6	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	<0.5	0.46	0.79	0.66	0.67
ØM-M-1	Brown trout	Mjøsa	<0.05	<0.3	0.10	0.06	<0.5	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	1.04	4.50	12.54	7.03	8.38
ØM-M-2	Brown trout	Mjøsa	<0.05	<0.3	0.07	<0.02	<0.5	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	0.77	3.44	8.44	5.62	11.56

MILFERSK 2020			UV-chemicals							PFAS								
ID	**Sample**	**Lake**	**UV-326**	**UV-329**	**UV-328**	**UV-327**	**OC**	**ODPABA**		PFPA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnDA	PFDoDA	PFTrDA
			ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	*Matrix PFAS*	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
ØM-M-3	Brown trout	Mjøsa	<0.05	<0.3	<0.06	0.05	<0.5	0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	1.24	6.48	13.47	6.77	5.88
ØM-M-4	Brown trout	Mjøsa	<0.05	<0.3	0.10	<0.02	<0.5	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	1.00	5.90	17.40	9.32	15.38
ØM-M-5	Brown trout	Mjøsa	<0.05	<0.3	0.09	0.07	<0.5	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	0.45	3.13	8.47	4.78	10.74
ØM-M-6	Brown trout	Mjøsa	<0.05	<0.3	<0.06	0.03	<0.5	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	1.50	8.79	23.05	12.40	16.03
ØM-M-7	Brown trout	Mjøsa	<0.05	<0.3	<0.06	0.07	<0.5	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	0.87	4.40	9.21	3.98	5.93
ØM-M-8	Brown trout	Mjøsa	<0.05	<0.3	<0.06	<0.02	<0.5	0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	0.38	1.46	3.54	2.24	4.39
ØM-M-9	Brown trout	Mjøsa	<0.05	<0.3	<0.06	<0.02	<0.5	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	0.52	2.12	4.21	2.79	5.06
ØM-M-10	Brown trout	Mjøsa	<0.05	<0.3	<0.06	<0.02	<0.5	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	0.39	1.83	4.81	2.90	5.49
ØM-M-11	Brown trout	Mjøsa	<0.05	<0.3	<0.06	<0.02	<0.5	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	0.99	5.45	16.23	7.65	13.47
ØM-M-12	Brown trout	Mjøsa	<0.05	<0.3	<0.06	<0.02	<0.5	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	0.92	7.14	16.97	9.12	13.34
ØM-M-13	Brown trout	Mjøsa	<0.05	<0.3	<0.06	<0.02	<0.5	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	0.43	2.18	4.91	3.00	4.76
ØM-M-14	Brown trout	Mjøsa	<0.05	<0.3	<0.06	0.03	<0.5	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	1.52	8.18	19.84	8.31	8.17
ØM-M-15	Brown trout	Mjøsa	<0.05	<0.3	<0.06	<0.02	<0.5	<0.01	Liver	<0.5	<0.5	<0.5	<0.5	0.25	1.60	4.33	2.73	4.36
ØF-M-1	Brown trout	Femunden	<0.3	<0.1	<0.02	<0.02	<0.6	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	0.59	1.47	7.00	4.74	17.77
ØF-M-2	Brown trout	Femunden	<0.3	<0.1	<0.02	<0.02	<0.6	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	0.75	1.76	7.36	3.95	13.17
ØF-M-3	Brown trout	Femunden	<0.3	<0.1	<0.02	<0.02	<0.6	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	1.05	1.32	6.46	4.88	22.37
ØF-M-4	Brown trout	Femunden	<0.3	<0.1	0.04	<0.02	<0.6	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	1.57	2.02	9.23	6.25	21.46
ØF-M-5	Brown trout	Femunden	<0.3	<0.1	<0.02	<0.02	<0.6	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	0.22	0.55	1.72	1.20	3.78
ØF-M-6	Brown trout	Femunden	<0.3	<0.1	<0.02	<0.02	<0.6	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	0.96	1.95	10.21	6.53	29.26
ØF-M-7	Brown trout	Femunden	<0.3	<0.1	0.18	<0.02	<0.6	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	0.36	1.22	6.78	5.17	18.88
ØF-M-8	Brown trout	Femunden	<0.3	<0.1	<0.02	<0.02	<0.6	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	0.31	1.61	7.51	4.50	14.25
ØF-M-9	Brown trout	Femunden	<0.3	<0.1	<0.02	<0.02	<0.6	<0.01	*Liver*	<0.5	<0.5	<0.5	<0.5	0.25	0.77	4.45	3.77	12.44
ØF-M-10	Brown trout	Femunden	<0.3	<0.1	0.25	<0.02	<0.6	<0.01	Liver	<0.5	<0.5	<0.5	<0.5	0.67	1.10	4.61	3.08	13.96

MILFERSK 2020			PFAS													
ID	**Sample**	**Lake**	PFTeDA	PFPeDA	PFHxDA	PFBS	PFPS	PFHxS	PFHpS	PFOS	8Cl-PFOS	PFNS	PFDS	PFDoS	PFOSA	N-MeFOSA
			ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
ZM-1	Zooplankton	Mjøsa	<0.4	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3
ZM-2	Zooplankton	Mjøsa	<0.4	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3
ZM-3	Zooplankton	Mjøsa	<0.4	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3
MM-1	Mysis	Mjøsa	<0.4	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3
MM-2	Mysis	Mjøsa	<0.4	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3
MM-3	Mysis	Mjøsa	<0.4	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3
KM-M-1	E.smelt	Mjøsa	1.08	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	3.25	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3
KM-M-2	E.smelt	Mjøsa	0.68	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	2.97	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3
KM-M-3	E.smelt	Mjøsa	<0.4	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	2.43	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3
KM-M-4	E.smelt	Mjøsa	0.93	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	3.19	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3
KM-M-5	E.smelt	Mjøsa	0.70	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	2.82	<0.2	<0.2	<0.2	<0.2	0.57	<0.3
KM-M-6	E.smelt	Mjøsa	0.73	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	2.88	<0.2	<0.2	<0.2	<0.2	0.40	<0.3
KM-M-7	E.smelt	Mjøsa	0.60	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	2.85	<0.2	<0.2	<0.2	<0.2	0.52	<0.3
KM-M-8	E.smelt	Mjøsa	<0.4	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	1.64	<0.2	<0.2	<0.2	<0.2	0.27	<0.3
KM-M-9	E.smelt	Mjøsa	0.43	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	1.78	<0.2	<0.2	<0.2	<0.2	0.36	<0.3
KM-M-10	E.smelt	Mjøsa	0.53	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	2.54	<0.2	<0.2	<0.2	<0.2	0.26	<0.3
LM-M-1	Vendace	Mjøsa	<0.4	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	1.00	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3
LM-M-2	Vendace	Mjøsa	<0.4	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	0.81	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3
LM-M-3	Vendace	Mjøsa	<0.4	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	0.55	<0.2	<0.2	0.18	<0.2	<0.2	<0.3
LM-M-4	Vendace	Mjøsa	<0.4	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	0.84	<0.2	<0.2	0.18	<0.2	<0.2	<0.3
LM-M-5	Vendace	Mjøsa	<0.4	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	1.29	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3
LM-M-6	Vendace	Mjøsa	<0.4	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	0.84	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3
LM-M-7	Vendace	Mjøsa	<0.4	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	1.04	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3
LM-M-8	Vendace	Mjøsa	<0.4	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	0.86	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3
LM-M-9	Vendace	Mjøsa	<0.4	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	0.92	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3
LM-M-10	Vendace	Mjøsa	<0.4	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	1.08	<0.2	<0.2	0.19	<0.2	<0.2	<0.3
ØM-M-1	Brown trout	Mjøsa	2.26	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	8.76	<0.2	<0.2	<0.2	<0.2	0.66	<0.3
ØM-M-2	Brown trout	Mjøsa	2.07	0.40	<0.4	<0.2	<0.2	<0.2	<0.2	7.26	<0.2	<0.2	<0.2	<0.2	0.96	<0.3
ØM-M-3	Brown trout	Mjøsa	1.92	0.40	<0.4	<0.2	<0.2	<0.2	<0.2	10.23	<0.2	<0.2	0.17	<0.2	1.65	<0.3
ØM-M-4	Brown trout	Mjøsa	2.97	0.47	<0.4	<0.2	<0.2	<0.2	<0.2	12.92	<0.2	<0.2	<0.2	<0.2	0.87	<0.3
ØM-M-5	Brown trout	Mjøsa	1.53	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	5.91	<0.2	<0.2	<0.2	<0.2	1.78	<0.3
ØM-M-6	Brown trout	Mjøsa	3.63	1.27	<0.4	<0.2	<0.2	0.20	<0.2	19.90	<0.2	<0.2	0.37	<0.2	2.56	<0.3

MILFERSK 2020			PFAS													
ID	**Sample**	**Lake**	PFTeDA	PFPeDA	PFHxDA	PFBS	PFPS	PFHxS	PFHpS	PFOS	8Cl-PFOS	PFNS	PFDS	PFDoS	PFOSA	N-MeFOSA
			ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
ØM-M-7	Brown trout	Mjøsa	0.78	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	9.88	<0.2	<0.2	<0.2	<0.2	2.25	<0.3
ØM-M-8	Brown trout	Mjøsa	0.85	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	3.20	<0.2	<0.2	<0.2	<0.2	0.82	<0.3
ØM-M-9	Brown trout	Mjøsa	1.06	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	4.05	<0.2	<0.2	<0.2	<0.2	0.76	<0.3
ØM-M-10	Brown trout	Mjøsa	0.98	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	5.66	<0.2	<0.2	<0.2	<0.2	1.44	<0.3
ØM-M-11	Brown trout	Mjøsa	2.24	0.39	<0.4	<0.2	<0.2	<0.2	<0.2	10.99	<0.2	<0.2	<0.2	<0.2	1.93	<0.3
ØM-M-12	Brown trout	Mjøsa	2.55	0.88	<0.4	<0.2	<0.2	0.17	<0.2	13.55	<0.2	<0.2	0.28	<0.2	1.46	<0.3
ØM-M-13	Brown trout	Mjøsa	0.83	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	3.58	<0.2	<0.2	<0.2	<0.2	0.87	<0.3
ØM-M-14	Brown trout	Mjøsa	1.82	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	16.53	<0.2	<0.2	<0.2	<0.2	2.64	<0.3
ØM-M-15	Brown trout	Mjøsa	0.89	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	3.47	<0.2	<0.2	<0.2	<0.2	1.05	<0.3
ØF-M-1	Brown trout	Femunden	3.55	1.66	<0.4	<0.2	<0.2	<0.2	<0.2	2.02	<0.2	<0.2	<0.2	<0.2	0.78	<0.3
ØF-M-2	Brown trout	Femunden	2.51	1.16	<0.4	<0.2	<0.2	<0.2	<0.2	2.42	<0.2	<0.2	<0.2	<0.2	0.35	<0.3
ØF-M-3	Brown trout	Femunden	3.12	1.87	<0.4	<0.2	<0.2	<0.2	<0.2	2.63	<0.2	<0.2	<0.2	<0.2	0.61	<0.3
ØF-M-4	Brown trout	Femunden	3.37	1.62	<0.4	<0.2	<0.2	<0.2	<0.2	2.80	<0.2	<0.2	<0.2	<0.2	0.75	<0.3
ØF-M-5	Brown trout	Femunden	0.67	0.42	<0.4	<0.2	<0.2	<0.2	<0.2	0.70	<0.2	<0.2	<0.2	<0.2	0.25	<0.3
ØF-M-6	Brown trout	Femunden	4.78	2.51	<0.4	<0.2	<0.2	<0.2	<0.2	3.35	<0.2	<0.2	<0.2	<0.2	0.41	<0.3
ØF-M-7	Brown trout	Femunden	3.95	2.37	<0.4	<0.2	<0.2	<0.2	<0.2	2.03	<0.2	<0.2	<0.2	<0.2	0.54	<0.3
ØF-M-8	Brown trout	Femunden	2.97	1.20	<0.4	<0.2	<0.2	<0.2	<0.2	2.44	<0.2	<0.2	<0.2	<0.2	0.49	<0.3
ØF-M-9	Brown trout	Femunden	2.18	1.71	<0.4	<0.2	<0.2	<0.2	<0.2	1.04	<0.2	<0.2	<0.2	<0.2	0.69	<0.3
ØF-M-10	Brown trout	Femunden	1.67	1.61	<0.4	<0.2	<0.2	<0.2	<0.2	1.85	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3

MILFERSK 2020			PFAS									
ID	**Sample**	**Lake**	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
			ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
ZM-1	Zooplankton	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ZM-2	Zooplankton	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ZM-3	Zooplankton	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
MM-1	Mysis	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
MM-2	Mysis	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
MM-3	Mysis	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
KM-M-1	E.smelt	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
KM-M-2	E.smelt	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
KM-M-3	E.smelt	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
KM-M-4	E.smelt	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
KM-M-5	E.smelt	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
KM-M-6	E.smelt	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
KM-M-7	E.smelt	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
KM-M-8	E.smelt	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
KM-M-9	E.smelt	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
KM-M-10	E.smelt	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
LM-M-1	Vendace	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
LM-M-2	Vendace	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
LM-M-3	Vendace	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
LM-M-4	Vendace	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
LM-M-5	Vendace	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
LM-M-6	Vendace	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
LM-M-7	Vendace	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
LM-M-8	Vendace	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
LM-M-9	Vendace	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
LM-M-10	Vendace	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-1	Brown trout	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-2	Brown trout	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-3	Brown trout	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-4	Brown trout	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-5	Brown trout	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-6	Brown trout	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3

MILFERSK 2020			PFAS									
ID	**Sample**	**Lake**	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
			ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
ØM-M-7	Brown trout	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-8	Brown trout	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-9	Brown trout	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-10	Brown trout	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-11	Brown trout	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-12	Brown trout	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-13	Brown trout	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-14	Brown trout	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØM-M-15	Brown trout	Mjøsa	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØF-M-1	Brown trout	Femunden	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØF-M-2	Brown trout	Femunden	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØF-M-3	Brown trout	Femunden	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØF-M-4	Brown trout	Femunden	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØF-M-5	Brown trout	Femunden	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØF-M-6	Brown trout	Femunden	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØF-M-7	Brown trout	Femunden	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØF-M-8	Brown trout	Femunden	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØF-M-9	Brown trout	Femunden	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
ØF-M-10	Brown trout	Femunden	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3

MILFERSK 2020			PFAS						Siloxanes			PBDEs				
ID	**Sample**	**Lake**	N-EtFOSAA	F53	7:3 FTCA	PFBSA	N-MeFBSA	N-EtFBSA	**D4**	**D5**	**D6**	**TBA**	**17**	**28**	**47**	**49**
			ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
ZM-1	Zooplankton	Mjøsa	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.46	0.39	0.15	<0.004	<0.002	<0.002	0.013	0.001
ZM-2	Zooplankton	Mjøsa	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.34	0.35	0.08	<0.004	<0.002	<0.002	0.012	<0.001
ZM-3	Zooplankton	Mjøsa	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.34	0.26	0.06	<0.004	<0.002	<0.002	0.011	<0.001
MM-1	Mysis	Mjøsa	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	1.41	6.49	0.68	<0.004	<0.002	<0.002	0.098	0.006
MM-2	Mysis	Mjøsa	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	1.23	8.18	0.74	<0.004	<0.002	<0.002	0.134	0.007
MM-3	Mysis	Mjøsa	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	1.10	7.85	0.72	<0.004	<0.002	0.003	0.147	0.009
KM-M-1	E.smelt	Mjøsa	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	1.14	22.34	2.13	0.007	0.009	0.020	2.070	0.100
KM-M-2	E.smelt	Mjøsa	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	1.16	34.78	2.92	0.005	0.008	0.014	1.230	0.061
KM-M-3	E.smelt	Mjøsa	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	1.19	30.34	2.80	0.013	0.012	0.028	3.660	0.184
KM-M-4	E.smelt	Mjøsa	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	1.13	13.47	1.54	<0.004	0.005	0.004	0.025	0.004
KM-M-5	E.smelt	Mjøsa	<0.3	<0.3	<0.3	0.42	<0.3	<0.3	1.32	11.58	1.14	<0.004	0.003	0.010	0.959	0.043
KM-M-6	E.smelt	Mjøsa	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.96	10.13	1.04	<0.004	<0.002	0.003	0.180	0.007
KM-M-7	E.smelt	Mjøsa	<0.3	<0.3	<0.3	0.38	<0.3	<0.3	1.85	16.28	1.87	<0.004	<0.002	0.003	0.366	0.013
KM-M-8	E.smelt	Mjøsa	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	1.44	15.04	1.39	<0.004	<0.002	0.002	0.202	0.010
KM-M-9	E.smelt	Mjøsa	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	1.43	4.78	1.13	<0.004	<0.002	0.004	0.176	0.009
KM-M-10	E.smelt	Mjøsa	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	1.85	7.04	1.27	<0.004	<0.002	0.004	0.256	0.010
LM-M-1	Vendace	Mjøsa	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	4.77	32.89	2.51	0.015	<0.002	0.006	0.420	0.024
LM-M-2	Vendace	Mjøsa	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	2.51	29.91	2.49	0.018	<0.002	0.006	0.408	0.024
LM-M-3	Vendace	Mjøsa	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	4.41	20.97	1.59	0.011	<0.002	0.005	0.371	0.024
LM-M-4	Vendace	Mjøsa	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	3.00	25.76	2.00	0.013	<0.002	0.005	0.356	0.027
LM-M-5	Vendace	Mjøsa	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	3.08	14.48	1.62	0.015	<0.002	0.005	0.404	0.033
LM-M-6	Vendace	Mjøsa	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	2.56	22.10	2.23	<0.004	<0.002	0.006	0.404	0.030
LM-M-7	Vendace	Mjøsa	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	3.11	27.93	2.13	0.017	<0.002	0.006	0.422	0.025
LM-M-8	Vendace	Mjøsa	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	2.57	12.00	1.26	0.019	<0.002	0.006	0.409	0.027
LM-M-9	Vendace	Mjøsa	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	3.43	24.48	1.80	0.017	<0.002	0.003	0.324	0.020
LM-M-10	Vendace	Mjøsa	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	2.96	17.17	1.16	0.017	<0.003	0.006	0.485	0.034
ØM-M-1	Brown trout	Mjøsa	<0.3	<0.3	<0.3	4.20	<0.3	<0.3	2.29	89.95	6.01	0.031	0.008	0.042	5.980	0.446
ØM-M-2	Brown trout	Mjøsa	<0.3	<0.3	<0.3	4.67	<0.3	<0.3	1.16	36.50	4.67	0.008	0.005	0.021	4.110	0.196
ØM-M-3	Brown trout	Mjøsa	<0.3	<0.3	<0.3	5.36	<0.3	<0.3	1.28	55.79	6.23	0.033	0.005	0.050	13.200	0.443
ØM-M-4	Brown trout	Mjøsa	<0.3	<0.3	<0.3	3.76	<0.3	<0.3	0.85	8.22	1.61	0.009	<0.002	0.024	6.140	0.229
ØM-M-5	Brown trout	Mjøsa	<0.3	<0.3	<0.3	3.54	<0.3	<0.3	1.69	21.60	3.80	0.028	0.004	0.056	13.500	0.379
ØM-M-6	Brown trout	Mjøsa	<0.3	<0.3	<0.3	8.97	<0.3	<0.3	1.28	118.65	13.52	0.025	0.003	0.036	9.330	0.361

MILFERSK 2020			PFAS						Siloxanes			PBDEs				
ID	**Sample**	**Lake**	N-EtFOSAA	F53	7:3 FTCA	PFBSA	N-MeFBSA	N-EtFBSA	**D4**	**D5**	**D6**	**TBA**	**17**	**28**	**47**	**49**
			ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
ØM-M-7	Brown trout	Mjøsa	<0.3	<0.3	<0.3	6.81	<0.3	<0.3	0.80	75.84	7.24	0.031	0.003	0.028	6.550	0.285
ØM-M-8	Brown trout	Mjøsa	<0.3	<0.3	<0.3	4.14	<0.3	<0.3	0.82	16.55	2.49	0.006	0.003	0.022	4.750	0.228
ØM-M-9	Brown trout	Mjøsa	<0.3	<0.3	<0.3	3.66	<0.3	<0.3	0.84	8.03	1.47	<0.004	0.003	0.033	13.900	0.514
ØM-M-10	Brown trout	Mjøsa	<0.3	<0.3	<0.3	4.93	<0.3	<0.3	1.34	60.83	4.18	0.018	<0.002	0.017	2.870	0.241
ØM-M-11	Brown trout	Mjøsa	<0.3	<0.3	<0.3	7.12	<0.3	<0.3	0.81	17.33	3.22	0.009	<0.003	0.010	3.610	0.101
ØM-M-12	Brown trout	Mjøsa	<0.3	<0.3	<0.3	5.83	<0.3	<0.3	0.47	34.69	4.39	0.028	0.004	0.024	6.130	0.167
ØM-M-13	Brown trout	Mjøsa	<0.3	<0.3	<0.3	2.03	<0.3	<0.3	0.83	4.78	0.58	<0.006	<0.003	0.006	1.480	0.049
ØM-M-14	Brown trout	Mjøsa	<0.3	<0.3	<0.3	6.00	<0.3	<0.3	0.58	11.14	1.59	0.027	<0.002	0.018	3.190	0.149
ØM-M-15	Brown trout	Mjøsa	<0.3	<0.3	<0.3	2.24	<0.3	<0.3	0.89	25.80	3.09	0.020	0.003	0.022	5.400	0.422
ØF-M-1	Brown trout	Femunden	<0.3	<0.3	<0.3	18.23	<0.3	<0.3	2.98	1.40	0.65	0.021	<0.003	0.005	0.280	0.030
ØF-M-2	Brown trout	Femunden	<0.3	<0.3	<0.3	5.22	<0.3	<0.3	4.43	1.19	0.57	<0.006	<0.003	<0.003	0.069	0.010
ØF-M-3	Brown trout	Femunden	<0.3	<0.3	<0.3	13.40	<0.3	<0.3	3.09	1.29	0.69	0.008	<0.003	<0.003	0.118	0.014
ØF-M-4	Brown trout	Femunden	<0.3	<0.3	<0.3	21.77	<0.3	<0.3	3.60	1.50	0.77	<0.006	<0.003	<0.003	0.100	0.013
ØF-M-5	Brown trout	Femunden	<0.3	<0.3	<0.3	10.43	<0.3	<0.3	3.54	1.72	1.02	0.016	<0.003	0.008	0.553	0.059
ØF-M-6	Brown trout	Femunden	<0.3	<0.3	<0.3	8.84	<0.3	<0.3	3.37	1.43	0.80	0.016	<0.003	<0.003	0.141	0.018
ØF-M-7	Brown trout	Femunden	<0.3	<0.3	<0.3	17.05	<0.3	<0.3	4.77	2.93	1.69	0.012	<0.003	0.005	0.241	0.032
ØF-M-8	Brown trout	Femunden	<0.3	<0.3	<0.3	13.75	<0.3	<0.3	3.04	1.33	0.83	0.004	0.004	0.008	0.382	0.019
ØF-M-9	Brown trout	Femunden	<0.3	<0.3	<0.3	27.16	<0.3	<0.3	3.68	1.42	0.86	0.018	0.005	0.010	0.192	0.027
ØF-M-10	Brown trout	Femunden	<0.3	<0.3	<0.3	5.83	<0.3	<0.3	2.19	1.45	1.00	0.010	0.002	0.006	0.435	0.048

MILFERSK 2020			PBDEs																
ID	**Sample**	**Lake**	**66**	**71**	**77**	**85**	**99**	**100**	**119**	**126**	**138**	**153**	**154**	**156**	**183**	**184**	**191**	**196**	**197**
			ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
ZM-1	Zooplankton	Mjøsa	<0.006	<0.002	<0.001	<0.002	0.004	0.002	<0.002	<0.001	<0.007	<0.006	<0.004	<0.010	<0.004	<0.003	<0.006	<0.008	<0.007
ZM-2	Zooplankton	Mjøsa	<0.006	<0.002	<0.001	<0.002	0.004	0.002	<0.002	<0.001	<0.007	<0.006	<0.004	<0.010	<0.004	<0.003	<0.006	<0.008	<0.007
ZM-3	Zooplankton	Mjøsa	0.017	<0.002	<0.001	<0.002	0.004	0.002	<0.002	<0.001	<0.007	<0.006	<0.004	<0.010	<0.004	<0.003	<0.006	<0.008	<0.007
MM-1	Mysis	Mjøsa	<0.006	<0.002	<0.001	<0.002	0.050	0.024	<0.002	<0.001	<0.007	<0.006	0.010	<0.010	<0.004	<0.003	<0.006	<0.008	<0.007
MM-2	Mysis	Mjøsa	<0.006	<0.002	<0.001	<0.002	0.064	0.026	<0.002	<0.001	<0.007	<0.006	0.011	<0.010	<0.004	<0.003	<0.006	<0.008	<0.007
MM-3	Mysis	Mjøsa	<0.006	<0.002	<0.001	<0.002	0.073	0.032	<0.002	<0.001	<0.007	0.006	0.013	<0.010	<0.004	<0.003	<0.006	<0.008	<0.007
KM-M-1	E.smelt	Mjøsa	0.039	0.005	0.006	0.006	0.191	0.479	0.021	0.005	0.008	0.064	0.148	<0.010	0.012	0.009	0.008	0.011	0.013
KM-M-2	E.smelt	Mjøsa	0.023	0.004	0.006	0.004	0.103	0.256	0.013	0.005	0.007	0.042	0.090	<0.010	0.011	0.009	<0.006	0.009	0.009
KM-M-3	E.smelt	Mjøsa	0.062	<0.002	<0.002	<0.002	0.365	0.792	0.029	<0.002	<0.005	0.109	0.262	<0.008	0.006	<0.003	<0.005	<0.007	<0.005
KM-M-4	E.smelt	Mjøsa	<0.006	<0.002	0.002	0.002	0.005	0.005	0.002	0.002	<0.007	<0.006	0.005	<0.010	0.004	<0.003	<0.006	<0.008	<0.007
KM-M-5	E.smelt	Mjøsa	0.018	0.003	0.003	0.003	0.069	0.203	0.010	0.003	<0.007	0.027	0.065	<0.010	0.006	0.005	<0.006	<0.008	0.007
KM-M-6	E.smelt	Mjøsa	<0.006	<0.002	<0.001	<0.002	0.010	0.042	<0.002	<0.001	<0.007	0.006	0.017	<0.010	<0.004	<0.003	<0.006	<0.008	<0.007
KM-M-7	E.smelt	Mjøsa	<0.006	<0.002	<0.001	<0.002	0.014	0.091	<0.002	<0.001	<0.007	0.014	0.039	<0.010	<0.004	<0.003	<0.006	<0.008	<0.007
KM-M-8	E.smelt	Mjøsa	<0.006	<0.002	<0.001	<0.002	0.012	0.047	<0.002	<0.001	<0.007	<0.006	0.020	<0.010	<0.004	<0.003	<0.006	<0.008	<0.007
KM-M-9	E.smelt	Mjøsa	<0.006	<0.002	<0.001	<0.002	0.011	0.037	<0.002	<0.001	<0.007	<0.006	0.015	<0.010	<0.004	<0.003	<0.006	<0.008	<0.007
KM-M-10	E.smelt	Mjøsa	<0.006	<0.002	<0.001	<0.002	0.014	0.058	<0.002	<0.001	<0.007	0.013	0.029	<0.010	<0.004	<0.003	<0.006	<0.009	<0.007
LM-M-1	Vendace	Mjøsa	0.010	<0.002	<0.001	<0.002	0.262	0.112	<0.002	<0.001	<0.007	0.029	0.043	<0.010	<0.004	<0.003	<0.006	<0.008	<0.007
LM-M-2	Vendace	Mjøsa	<0.006	<0.002	<0.001	<0.002	0.234	0.120	<0.002	<0.001	<0.007	0.028	0.043	<0.010	<0.004	<0.003	<0.006	<0.008	<0.007
LM-M-3	Vendace	Mjøsa	0.011	<0.002	<0.001	<0.002	0.239	0.103	<0.002	<0.001	<0.007	0.022	0.035	<0.010	<0.004	<0.003	<0.006	<0.008	<0.007
LM-M-4	Vendace	Mjøsa	<0.006	<0.002	<0.001	<0.002	0.231	0.100	<0.002	<0.001	<0.007	0.022	0.033	<0.010	<0.004	<0.003	<0.006	<0.008	<0.007
LM-M-5	Vendace	Mjøsa	0.012	<0.002	<0.001	<0.002	0.243	0.116	<0.002	<0.001	<0.007	0.024	0.044	<0.010	<0.004	<0.003	<0.006	<0.008	<0.007
LM-M-6	Vendace	Mjøsa	0.013	<0.002	<0.001	<0.002	0.249	0.126	<0.002	<0.001	<0.007	0.025	0.040	<0.010	<0.004	<0.003	<0.006	<0.008	<0.007
LM-M-7	Vendace	Mjøsa	0.010	<0.002	<0.001	<0.002	0.273	0.139	<0.002	<0.001	<0.007	0.031	0.047	<0.010	<0.004	<0.003	<0.006	<0.008	<0.007
LM-M-8	Vendace	Mjøsa	<0.006	<0.002	<0.001	<0.002	0.287	0.109	<0.002	<0.001	<0.007	0.033	0.029	<0.010	0.007	<0.003	<0.006	<0.008	<0.007
LM-M-9	Vendace	Mjøsa	0.010	<0.002	<0.001	<0.002	0.196	0.089	<0.002	<0.001	<0.007	0.017	0.026	<0.010	<0.004	<0.003	<0.006	<0.008	<0.007
LM-M-10	Vendace	Mjøsa	0.016	<0.002	<0.001	<0.002	0.316	0.132	<0.002	<0.001	<0.007	0.024	0.045	<0.010	<0.004	<0.003	<0.006	<0.008	<0.007
ØM-M-1	Brown trout	Mjøsa	0.168	0.005	0.010	0.004	2.380	1.940	0.062	0.009	<0.007	0.359	0.737	<0.010	0.014	0.015	<0.006	0.009	0.012
ØM-M-2	Brown trout	Mjøsa	0.088	0.003	0.005	<0.002	0.827	1.380	0.044	0.005	<0.007	0.220	0.526	<0.010	0.008	0.008	<0.006	<0.008	0.007
ØM-M-3	Brown trout	Mjøsa	0.270	<0.002	0.006	0.002	2.680	4.340	0.113	0.010	<0.007	0.677	1.470	0.011	0.011	0.011	<0.006	<0.008	<0.007
ØM-M-4	Brown trout	Mjøsa	0.128	<0.002	0.003	<0.002	1.310	1.910	0.058	0.004	<0.007	0.319	0.747	<0.010	0.005	0.006	<0.006	<0.008	<0.007
ØM-M-5	Brown trout	Mjøsa	0.277	<0.002	0.005	<0.002	2.670	4.250	0.111	0.009	<0.007	0.705	1.480	<0.010	0.027	0.006	<0.006	<0.008	<0.007
ØM-M-6	Brown trout	Mjøsa	0.166	<0.002	0.004	<0.002	1.760	3.010	0.089	0.007	<0.007	0.391	1.040	<0.010	0.026	0.008	<0.006	<0.008	<0.007

MILFERSK 2020			PBDEs																
ID	**Sample**	**Lake**	**66**	**71**	**77**	**85**	**99**	**100**	**119**	**126**	**138**	**153**	**154**	**156**	**183**	**184**	**191**	**196**	**197**
			ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
ØM-M-7	Brown trout	Mjøsa	0.123	<0.002	0.003	<0.002	1.140	2.080	0.061	0.005	<0.007	0.288	0.797	<0.010	0.005	0.005	<0.006	<0.008	<0.007
ØM-M-8	Brown trout	Mjøsa	0.101	<0.002	0.003	<0.002	1.230	1.450	0.045	0.006	<0.007	0.250	0.564	<0.010	0.006	0.006	<0.006	<0.008	<0.007
ØM-M-9	Brown trout	Mjøsa	0.310	<0.002	0.003	<0.002	4.350	5.800	0.135	0.011	<0.007	0.865	1.940	<0.010	<0.004	0.015	<0.006	<0.008	<0.007
ØM-M-10	Brown trout	Mjøsa	0.047	<0.002	0.002	<0.002	1.030	0.896	0.021	0.002	<0.007	0.147	0.319	<0.010	<0.004	<0.003	<0.006	<0.008	<0.007
ØM-M-11	Brown trout	Mjøsa	0.070	<0.002	<0.002	<0.003	0.773	1.450	0.033	0.005	<0.008	0.200	0.494	<0.011	<0.004	<0.003	<0.005	<0.009	<0.007
ØM-M-12	Brown trout	Mjøsa	0.093	<0.002	0.002	<0.002	1.220	2.220	0.059	0.006	<0.005	0.280	0.724	<0.008	<0.004	0.004	<0.005	<0.007	<0.005
ØM-M-13	Brown trout	Mjøsa	0.028	<0.002	<0.002	<0.002	0.328	0.668	0.018	<0.002	<0.005	0.097	0.183	<0.008	<0.004	<0.003	<0.005	<0.007	<0.005
ØM-M-14	Brown trout	Mjøsa	0.058	<0.002	0.002	<0.002	0.527	0.916	0.026	0.003	<0.007	0.120	0.328	<0.010	<0.004	<0.003	<0.006	<0.008	<0.007
ØM-M-15	Brown trout	Mjøsa	0.172	<0.002	0.005	<0.002	2.880	2.190	0.074	0.006	<0.007	0.465	0.884	<0.010	0.008	0.013	<0.006	<0.008	<0.007
ØF-M-1	Brown trout	Femunden	0.016	<0.002	0.002	<0.002	0.196	0.177	0.024	<0.002	<0.005	0.048	0.146	<0.008	0.005	0.007	<0.005	<0.007	<0.005
ØF-M-2	Brown trout	Femunden	0.004	<0.002	<0.002	<0.002	0.040	0.042	0.006	<0.002	<0.005	0.012	0.031	<0.008	<0.004	<0.003	<0.005	<0.007	<0.005
ØF-M-3	Brown trout	Femunden	0.007	<0.002	<0.002	<0.002	0.081	0.080	0.010	<0.002	<0.005	0.025	0.067	<0.008	<0.004	0.004	<0.005	<0.007	<0.005
ØF-M-4	Brown trout	Femunden	0.005	<0.002	<0.002	<0.003	0.067	0.058	0.008	<0.002	<0.005	0.017	0.059	<0.008	<0.004	<0.003	<0.005	<0.007	<0.005
ØF-M-5	Brown trout	Femunden	0.029	<0.002	0.005	<0.002	0.421	0.384	0.050	<0.002	<0.006	0.092	0.282	<0.009	<0.004	0.013	<0.005	<0.007	<0.005
ØF-M-6	Brown trout	Femunden	0.008	<0.003	<0.002	<0.002	0.101	0.088	0.011	<0.002	<0.005	0.026	0.078	<0.008	<0.004	<0.003	<0.005	<0.007	<0.005
ØF-M-7	Brown trout	Femunden	0.015	<0.002	<0.001	<0.006	0.170	0.163	<0.005	<0.004	<0.007	0.050	0.143	<0.010	<0.004	0.008	<0.006	<0.008	<0.007
ØF-M-8	Brown trout	Femunden	0.010	0.003	0.004	0.003	0.025	0.086	0.007	0.004	<0.007	0.018	0.035	<0.010	0.009	0.007	<0.006	<0.008	0.008
ØF-M-9	Brown trout	Femunden	0.014	0.006	0.006	0.005	0.130	0.112	0.018	0.005	0.009	0.036	0.082	<0.010	0.014	0.014	0.008	0.011	0.014
ØF-M-10	Brown trout	Femunden	0.022	<0.002	0.002	<0.002	0.349	0.324	0.042	0.004	<0.007	0.096	0.270	<0.010	0.008	0.012	<0.006	<0.012	<0.010

MILFERSK 2020			PBDEs				nBFRs													
ID	**Sample**	**Lake**	**202**	**206**	**207**	**209**	**ATE (TBP-AE)**	**a-TBECH**	**b-TBECH**	**g/d-TBECH**	**BATE**	**PBT**	**PBEB**	**PBBZ**	**HBB**	**DPTE**	**EHTBB**	**BTBPE**	**TBPH (BEH /TBP)**	**DBDPE**
			ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
ZM-1	Zooplankton	Mjøsa	<0.010	<0.011	<0.009	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
ZM-2	Zooplankton	Mjøsa	<0.010	<0.011	<0.009	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
ZM-3	Zooplankton	Mjøsa	<0.010	<0.011	<0.009	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
MM-1	Mysis	Mjøsa	<0.010	<0.011	<0.009	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
MM-2	Mysis	Mjøsa	<0.010	<0.011	<0.009	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
MM-3	Mysis	Mjøsa	<0.010	<0.011	<0.009	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
KM-M-1	E.smelt	Mjøsa	0.021	0.030	0.025	0.066	<0.006	<0.047	<0.035	<0.020	<0.007	<0.014	<0.007	<0.11	<0.044	<0.006	<0.008	<0.02	<0.04	<6.9
KM-M-2	E.smelt	Mjøsa	0.020	0.029	0.026	0.051	<0.006	<0.047	<0.035	<0.020	<0.007	<0.014	<0.007	<0.11	<0.044	<0.006	<0.008	<0.02	<0.04	<6.9
KM-M-3	E.smelt	Mjøsa	<0.008	<0.022	<0.014	0.183	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	0.042	0.016	1.680	<6.9
KM-M-4	E.smelt	Mjøsa	0.011	0.015	0.015	0.046	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
KM-M-5	E.smelt	Mjøsa	0.013	<0.011	0.013	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
KM-M-6	E.smelt	Mjøsa	<0.010	<0.011	<0.009	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
KM-M-7	E.smelt	Mjøsa	<0.010	<0.015	<0.013	<0.142	<0.007	0.099	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	8.870
KM-M-8	E.smelt	Mjøsa	<0.010	<0.015	<0.013	<0.087	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
KM-M-9	E.smelt	Mjøsa	<0.010	<0.011	<0.009	<0.061	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
KM-M-10	E.smelt	Mjøsa	<0.010	<0.011	<0.009	<0.058	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
LM-M-1	Vendace	Mjøsa	<0.010	<0.011	<0.009	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
LM-M-2	Vendace	Mjøsa	<0.010	<0.011	<0.009	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
LM-M-3	Vendace	Mjøsa	<0.010	<0.011	<0.009	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
LM-M-4	Vendace	Mjøsa	<0.010	<0.011	<0.009	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
LM-M-5	Vendace	Mjøsa	<0.010	0.124	0.013	4.090	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
LM-M-6	Vendace	Mjøsa	<0.010	<0.011	<0.009	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
LM-M-7	Vendace	Mjøsa	<0.010	<0.011	<0.009	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
LM-M-8	Vendace	Mjøsa	0.020	<0.011	<0.009	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
LM-M-9	Vendace	Mjøsa	<0.010	<0.011	<0.009	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
LM-M-10	Vendace	Mjøsa	<0.010	<0.011	<0.009	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
ØM-M-1	Brown trout	Mjøsa	0.026	0.029	0.025	0.233	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
ØM-M-2	Brown trout	Mjøsa	0.019	0.013	0.011	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
ØM-M-3	Brown trout	Mjøsa	0.017	<0.011	<0.009	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
ØM-M-4	Brown trout	Mjøsa	<0.010	<0.011	<0.009	<0.043	<0.007	0.120	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
ØM-M-5	Brown trout	Mjøsa	0.011	<0.011	<0.009	<0.043	<0.007	0.097	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
ØM-M-6	Brown trout	Mjøsa	0.012	<0.011	<0.009	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9

MILFERSK 2020			PBDEs				nBFRs													
ID	**Sample**	**Lake**	**202**	**206**	**207**	**209**	**ATE (TBP-AE)**	**a-TBECH**	**b-TBECH**	**g/d-TBECH**	**BATE**	**PBT**	**PBEB**	**PBBZ**	**HBB**	**DPTE**	**EHTBB**	**BTBPE**	**TBPH (BEH /TBP)**	**DBDPE**
			ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
ØM-M-7	Brown trout	Mjøsa	0.011	<0.011	<0.009	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
ØM-M-8	Brown trout	Mjøsa	<0.010	<0.011	<0.009	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
ØM-M-9	Brown trout	Mjøsa	<0.010	<0.011	<0.009	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
ØM-M-10	Brown trout	Mjøsa	<0.010	<0.011	<0.009	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
ØM-M-11	Brown trout	Mjøsa	<0.009	<0.022	<0.014	<0.183	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
ØM-M-12	Brown trout	Mjøsa	<0.008	<0.022	<0.014	<0.183	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
ØM-M-13	Brown trout	Mjøsa	<0.008	<0.022	<0.014	<0.183	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
ØM-M-14	Brown trout	Mjøsa	<0.010	<0.011	<0.009	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
ØM-M-15	Brown trout	Mjøsa	<0.010	<0.011	<0.009	<0.043	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
ØF-M-1	Brown trout	Femunden	<0.008	<0.022	<0.014	<0.183	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
ØF-M-2	Brown trout	Femunden	<0.008	<0.022	<0.014	<0.183	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
ØF-M-3	Brown trout	Femunden	<0.008	<0.022	<0.014	<0.183	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
ØF-M-4	Brown trout	Femunden	<0.008	<0.022	<0.014	<0.183	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
ØF-M-5	Brown trout	Femunden	<0.008	<0.022	<0.014	<0.183	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	0.020	0.037	<6.9
ØF-M-6	Brown trout	Femunden	<0.008	<0.022	<0.014	<0.183	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
ØF-M-7	Brown trout	Femunden	<0.010	<0.011	<0.009	<0.056	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.031	<0.02	<0.04	<6.9
ØF-M-8	Brown trout	Femunden	0.019	0.020	0.023	0.084	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
ØF-M-9	Brown trout	Femunden	0.027	0.039	0.038	0.204	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9
ØF-M-10	Brown trout	Femunden	<0.015	0.963	0.697	23	<0.007	<0.05	<0.038	<0.021	<0.007	<0.015	<0.008	<0.12	<0.048	<0.006	<0.009	<0.02	<0.04	<6.9

Table A2. Phenolic compounds in muscle and bile of brown trout from Lake Mjøsa and Lake Femunden, 2020.

MILFERSK 2020			Phenols														
ID	**Sample**	**Lake**	**Matrix phenols**	**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**	**4-tert-octylphenol**	**4-octylphenol**	**4-nonylphenol**
				ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
ØM-M-1	Brown trout	Mjøsa	*Muscle*	-10.6	-1.8	-2.1	-20.3	-0.5	-5.2	-9.6	-0.5	-1.6	-3.7	-4.5	-3.4	-5.1	-7.0
ØM-M-2	Brown trout	Mjøsa	*Muscle*	-11.6	-2.2	-2.6	-22.4	-0.7	-5.7	-10.5	-0.7	-1.8	-4.0	-6.7	-5.1	-5.6	-7.7
ØM-M-3	Brown trout	Mjøsa	*Muscle*	-10.6	-1.9	-2.3	-20.3	-0.5	12.1	20.9	0.7	-1.6	-3.7	-5.1	-4.6	-5.1	-7.0
ØM-M-4	Brown trout	Mjøsa	*Muscle*	-10.6	-2.2	-2.6	-20.3	-0.6	-5.2	-9.6	-0.8	-1.6	-3.7	-6.6	-5.7	-5.1	-7.0
ØM-M-5	Brown trout	Mjøsa	*Muscle*	-10.6	-2.2	-2.5	-20.3	-0.6	-5.2	-9.6	-0.6	-1.6	-3.7	-5.5	-4.1	-5.1	-7.0
ØM-M-6	Brown trout	Mjøsa	*Muscle*	-11.6	-2.1	-2.5	-22.4	-0.7	-5.7	-10.5	-0.7	-1.8	-4.0	-6.1	-4.9	-5.6	-7.7
ØM-M-7	Brown trout	Mjøsa	*Muscle*	21.6	-2.2	-2.6	-20.3	-0.7	6.1	10.4	-0.7	-1.7	-3.8	-6.5	-4.9	-5.1	-7.0
ØM-M-8	Brown trout	Mjøsa	*Muscle*	-11.6	-2.3	-2.7	-22.4	-0.6	-5.7	-10.5	-0.8	-1.8	-4.1	-6.1	-8.1	-6.6	-7.7
ØM-M-9	Brown trout	Mjøsa	*Muscle*	-11.6	-1.7	-2.3	-22.4	-0.6	-5.7	-10.5	-0.6	-1.8	-4.0	-4.9	-3.6	-5.6	-7.7
ØM-M-10	Brown trout	Mjøsa	*Muscle*	-11.6	-2.3	-2.7	-22.4	-0.7	-5.7	-10.5	-0.8	-1.8	-4.0	-6.1	-4.4	-5.6	-7.7
ØM-M-11	Brown trout	Mjøsa	*Muscle*	-11.6	-1.9	-2.3	-22.4	-0.6	-5.7	-10.5	-0.7	-1.8	-4.0	-5.5	-3.8	-5.6	-7.7
ØM-M-12	Brown trout	Mjøsa	*Muscle*	-11.6	-2.1	-2.4	-22.4	-0.6	-5.7	-10.5	-0.7	-1.8	-4.0	-5.7	-4.4	-5.6	-7.7
ØM-M-13	Brown trout	Mjøsa	*Muscle*	-10.6	-1.3	-2.1	-20.3	-0.5	-5.2	-9.6	-0.5	-1.6	-3.7	-4.5	-2.8	-5.1	-7.0
ØM-M-14	Brown trout	Mjøsa	*Muscle*	-10.6	-1.3	-2.1	-20.3	-0.5	5.4	9.6	-0.5	-1.6	-3.7	-4.5	-1.3	-5.1	-7.0
ØM-M-15	Brown trout	Mjøsa	*Muscle*	-10.6	-1.3	-2.1	-20.3	-0.5	-5.2	-9.6	-0.5	-1.6	-3.7	-4.5	-2.4	-5.1	-7.0
ØF-M-1	Brown trout	Femunden	*Muscle*	-11.6	-1.5	-4.1	-22.4	-0.6	-5.7	-10.5	-0.6	-2.6	-6.2	-5.5	-5.2	-5.6	-9.0
ØF-M-2	Brown trout	Femunden	*Muscle*	-11.6	-1.4	-3.6	-22.4	-0.6	-5.7	-10.5	-0.6	-2.3	-4.8	-5.3	-5.1	-5.6	-7.7
ØF-M-3	Brown trout	Femunden	*Muscle*	-10.6	-1.3	-2.8	-20.3	-0.5	-5.2	-9.6	-0.5	-1.8	-3.8	-4.5	-3.8	-5.1	-7.0
ØF-M-4	Brown trout	Femunden	*Muscle*	-11.6	-1.4	-3.1	-22.4	-0.6	-5.7	-10.5	-0.6	-2.1	-4.3	-4.9	-4.0	-5.6	-7.7
ØF-M-5	Brown trout	Femunden	*Muscle*	-10.6	-1.3	-3.0	-20.3	-0.5	-5.2	-9.6	-0.5	-2.1	-4.7	-4.6	-5.0	-5.5	-7.0
ØF-M-6	Brown trout	Femunden	*Muscle*	-11.6	-1.4	-2.9	-22.4	-0.6	-5.7	-10.5	-0.6	-2.0	-5.0	-4.9	-4.0	-5.6	-7.7
ØF-M-7	Brown trout	Femunden	*Muscle*	-11.6	-1.4	-2.8	-22.4	-0.6	-5.7	-10.5	-0.6	-1.8	-4.3	-4.9	-4.4	-5.6	-7.7
ØF-M-8	Brown trout	Femunden	*Muscle*	-11.6	-1.4	-2.9	-22.4	-0.6	-5.7	-10.5	-0.6	-2.0	-5.5	-4.9	-3.9	-5.6	-7.7
ØF-M-9	Brown trout	Femunden	*Muscle*	-11.6	-1.4	-2.4	-22.4	-0.6	-5.7	-10.5	-0.6	-1.8	-4.0	-4.9	-3.9	-5.6	-7.7
ØF-M-10	Brown trout	Femunden	*Muscle*	-11.6	-1.4	-2.3	-22.4	-0.6	-5.7	-10.5	-0.6	-1.8	-4.0	-4.9	-3.2	-5.6	-7.7
ØM-M-1	Brown trout	Mjøsa	*Bile*	-11.6	-3.0	-2.9	-22.4	-0.6	-5.7	-10.5	-0.6	-3.6	-4.0	-4.9	-2.9	-5.6	-7.7
ØM-M-2	Brown trout	Mjøsa	*Bile*	-11.6	-2.2	-2.3	-22.4	-0.6	-5.7	-10.5	-0.6	-11.9	-4.0	-5.6	-2.9	-5.6	-7.7
ØM-M-3	Brown trout	Mjøsa	*Bile*	-10.6	-4.4	-4.2	-20.3	-0.5	-5.2	-9.6	-0.8	-2.1	-4.9	-6.3	-3.9	-5.1	-89.6
ØM-M-4	Brown trout	Mjøsa	*Bile*	-11.6	-6.6	-6.3	-22.4	-0.6	-6.3	-10.5	-1.7	-29.5	-7.9	-11.2	-5.5	-5.6	-10.0
ØM-M-5	Brown trout	Mjøsa	*Bile*	-11.6	-3.6	-3.4	-22.4	-0.6	-5.7	-10.5	-0.8	-8.1	-4.0	-5.7	-5.2	-5.6	-7.7
ØM-M-6	Brown trout	Mjøsa	*Bile*	-13.6	-13.6	-13.1	-22.4	-0.6	-14.7	-19.4	-3.1	-33.5	-16.8	-14.2	-11.4	-8.0	

MILFERSK 2020			Phenols														
ID	**Sample**	**Lake**	**Matrix phenols**	**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**	**4-tert-octylphenol**	**4-octylphenol**	**4-nonylphenol**
				ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
ØM-M-7	Brown trout	Mjøsa															
ØM-M-8	Brown trout	Mjøsa	*Bile*	-11.6	-6.6	-6.4	-22.4	-0.6	-5.8	-10.5	-1.3	-5.6	-29.8	-8.4	-6.6	-6.2	-9.9
ØM-M-9	Brown trout	Mjøsa	*Bile*	-10.6	-2.2	-2.1	-20.3	-0.5	-5.2	-9.6	-0.5	-16.4	-9.0	-6.1	-5.5	-5.1	-7.0
ØM-M-10	Brown trout	Mjøsa	*Bile*	-10.6	-6.7	-6.4	-20.3	-0.5	-8.3	-11.0	-1.3	-8.1	-48.7	-9.0	-14.2	-5.1	
ØM-M-11	Brown trout	Mjøsa	*Bile*	-11.6	-3.8	-3.7	-22.4	-0.6	-5.7	-10.5	-0.7	-20.3	-13.7	-8.6	-9.6	-5.6	-7.7
ØM-M-12	Brown trout	Mjøsa	*Bile*	-11.6	-4.9	-4.7	-22.4	-0.6	-10.4	-16.6	-1.6	-33.1	-21.1	-11.7	-8.9	-6.2	
ØM-M-13	Brown trout	Mjøsa															
ØM-M-14	Brown trout	Mjøsa															
ØM-M-15	Brown trout	Mjøsa															
ØF-M-1	Brown trout	Femunden	*Bile*	-11.6	-1.4	-5.2	-22.4	-0.6	19.3	29.7	1.1	-12.0	-4.0	-10.4	-12.2	-10.1	-13.2
ØF-M-2	Brown trout	Femunden															
ØF-M-3	Brown trout	Femunden															
ØF-M-4	Brown trout	Femunden															
ØF-M-5	Brown trout	Femunden	*Bile*	-11.6	-1.4	-4.5	-22.4	-0.6	41.7	47.6	4.9	-6.9	-4.0	-10.8	-16.5	-13.8	-13.5
ØF-M-6	Brown trout	Femunden	*Bile*	-10.6	-5.4	-21.3	-20.3	-0.5	33.3	49.2	2.0	-20.0	-12.9	-19.8	-34.2	-28.5	-
ØF-M-7	Brown trout	Femunden	*Bile*	13.9	-2.7	-10.7	-22.4	-0.6	11.3	11.3	-1.2	-5.5	-4.3	-29.7	-30.2	-25.1	-25.5
ØF-M-8	Brown trout	Femunden	*Bile*	-11.6	-2.9	-11.5	-22.4	-0.6	29.9	52.0	1.7	-9.6	-4.9	-19.6	-27.4	-22.8	-
ØF-M-9	Brown trout	Femunden															
ØF-M-10	Brown trout	Femunden															

Table A3. Rawdata, PFAS compounds in gonads (M:testes, F:eggs) from brown trout in Lake Mjøsa and Lake Femunden, 2020.

MILFERSK 2020				PFAS												
ID	**Sample**	**Lake**	**Sex**	PFPA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnDA	PFDoDA	PFTrDA	PFTeDA	PFPeDA	PFHxDA	PFBS	PFPS
				ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
ØM-G-1	Testes	Mjøsa	M	<0.5	<0.5	<0.5	<0.5	0.40	1.60	2.73	2.34	4.42	1.06	<0.4	<0.4	<0.2	<0.2
ØM-G-2	Testes	Mjøsa	M	<0.5	<0.5	<0.5	<0.5	0.74	2.18	5.22	3.80	5.83	1.36	0.42	<0.4	<0.2	<0.2
ØM-G-3	Eggs	Mjøsa	F	<0.5	<0.5	<0.5	<0.5	0.90	4.69	12.33	7.81	9.79	2.40	0.54	<0.4	<0.2	<0.2
ØM-G-4	Eggs	Mjøsa	F	<0.5	<0.5	<0.5	<0.5	0.75	2.82	6.37	4.96	8.76	1.86	<0.4	<0.4	<0.2	<0.2
ØM-G-5	Eggs	Mjøsa	F	<0.5	<0.5	<0.5	<0.5	0.41	1.79	6.09	3.89	6.31	1.36	<0.4	<0.4	<0.2	<0.2
ØM-G-6	Testes	Mjøsa	M	<0.5	<0.5	<0.5	<0.5	0.54	2.86	15.62	4.78	5.33	1.88	0.53	<0.4	<0.2	<0.2
ØM-G-7	Eggs	Mjøsa	F	<0.5	<0.5	<0.5	<0.5	0.72	3.87	9.94	5.59	7.17	1.30	<0.4	<0.4	<0.2	<0.2
ØM-G-8	Eggs	Mjøsa	F	<0.5	<0.5	<0.5	<0.5	0.31	1.06	2.73	1.51	4.35	0.85	<0.4	<0.4	<0.2	<0.2
ØM-G-9	Eggs	Mjøsa	F	<0.5	<0.5	<0.5	<0.5	0.23	0.80	1.99	1.91	1.94	0.58	<0.4	<0.4	<0.2	<0.2
ØM-G-10	Testes	Mjøsa	M	<0.5	<0.5	<0.5	<0.5	0.43	1.90	4.58	2.64	3.84	1.29	<0.4	<0.4	<0.2	<0.2
ØM-G-11	Testes	Mjøsa	M	<0.5	<0.5	<0.5	<0.5	0.32	1.75	4.25	2.47	3.57	0.98	<0.4	<0.4	<0.2	<0.2
ØM-G-12	Testes	Mjøsa	M	<0.5	<0.5	<0.5	<0.5	0.50	3.52	8.02	5.12	5.95	1.87	0.62	<0.4	<0.2	<0.2
ØM-G-13	Eggs	Mjøsa	F	<0.5	<0.5	<0.5	<0.5	0.21	0.79	2.00	1.26	1.74	0.43	<0.4	<0.4	<0.2	<0.2
ØM-G-14	Eggs	Mjøsa	F	<0.5	<0.5	<0.5	<0.5	1.70	7.79	21.63	10.39	10.29	3.33	1.23	<0.4	<0.2	<0.2
ØM-G-15	Eggs	Mjøsa	F	<0.5	<0.5	<0.5	<0.5	0.17	1.20	4.01	4.25	4.10	1.15	<0.4	<0.4	<0.2	<0.2
ØF-G-1	Eggs	Femunden	F	<0.5	<0.5	<0.5	<0.5	0.35	0.81	3.89	2.65	8.50	2.19	1.59	<0.4	<0.2	<0.2
ØF-G-2	Testes	Femunden	M	<0.5	<0.5	<0.5	<0.5	0.53	1.01	4.70	2.85	11.38	2.61	1.26	<0.4	<0.2	<0.2
ØF-G-3	Eggs	Femunden	F	<0.5	<0.5	<0.5	<0.5	0.90	0.73	3.01	2.43	6.74	1.11	0.87	<0.4	<0.2	<0.2
ØF-G-4	Testes	Femunden	M	<0.5	<0.5	<0.5	<0.5	0.68	0.67	3.55	3.68	15.53	2.36	5.12	<0.4	<0.2	<0.2
ØF-G-5	Testes	Femunden	M	<0.5	<0.5	<0.5	<0.5	0.18	0.36	1.56	1.24	4.10	1.14	0.86	<0.4	<0.2	<0.2
ØF-G-6	Testes	Femunden	M	<0.5	<0.5	<0.5	<0.5	0.67	1.39	6.75	4.77	18.74	3.68	1.93	<0.4	<0.2	<0.2
ØF-G-7	Testes	Femunden	M	<0.5	<0.5	<0.5	<0.5	0.23	0.63	3.22	2.60	11.16	2.41	1.58	<0.4	<0.2	<0.2
ØF-G-8	Testes	Femunden	M	<0.5	<0.5	<0.5	<0.5	0.32	1.64	8.13	5.27	17.35	3.16	2.01	<0.4	<0.2	<0.2
ØF-G-9	Testes	Femunden	M	<0.5	<0.5	<0.5	<0.5	0.68	0.89	3.63	2.27	7.37	1.43	0.17	<0.4	<0.2	<0.2
ØF-G-10	Eggs	Femunden	F	<0.5	<0.5	<0.5	<0.5	0.24	0.73	4.33	3.08	11.79	2.24	1.26	<0.4	<0.2	<0.2

MILFERSK 2020				PFAS															
ID	**Sample**	**Lake**	**Sex**	PFHxS	PFHpS	PFOS	8Cl-PFOS	PFNS	PFDS	PFDoS	PFOSA	N-MeFOSA	N-EtFOSA	N-MeFOSE	N-EtFOSE	4:2 FTS	6:2 FTS	8:2 FTS	10:2 FTS
				ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
ØM-G-1	Testes	Mjøsa	M	<0.2	<0.2	2.30	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3
ØM-G-2	Testes	Mjøsa	M	<0.2	<0.2	3.68	<0.2	<0.2	<0.2	<0.2	0.23	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3
ØM-G-3	Eggs	Mjøsa	F	0.16	<0.2	10.03	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3
ØM-G-4	Eggs	Mjøsa	F	<0.2	<0.2	2.78	<0.2	<0.2	<0.2	<0.2	0.30	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3
ØM-G-5	Eggs	Mjøsa	F	<0.2	<0.2	4.16	<0.2	<0.2	<0.2	<0.2	0.38	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3
ØM-G-6	Testes	Mjøsa	M	<0.2	<0.2	5.37	<0.2	<0.2	0.17	<0.2	0.46	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3
ØM-G-7	Eggs	Mjøsa	F	<0.2	<0.2	8.54	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3
ØM-G-8	Eggs	Mjøsa	F	<0.2	<0.2	2.06	<0.2	<0.2	<0.2	<0.2	0.32	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3
ØM-G-9	Eggs	Mjøsa	F	<0.2	<0.2	2.21	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3
ØM-G-10	Testes	Mjøsa	M	<0.2	<0.2	5.01	<0.2	<0.2	<0.2	<0.2	0.40	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3
ØM-G-11	Testes	Mjøsa	M	<0.2	<0.2	3.82	<0.2	<0.2	<0.2	<0.2	0.37	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3
ØM-G-12	Testes	Mjøsa	M	<0.2	<0.2	5.71	<0.2	<0.2	<0.2	<0.2	0.55	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3
ØM-G-13	Eggs	Mjøsa	F	<0.2	<0.2	1.23	<0.2	<0.2	<0.2	<0.2	0.22	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3
ØM-G-14	Eggs	Mjøsa	F	<0.2	<0.2	19.48	<0.2	<0.2	<0.2	<0.2	0.27	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3
ØM-G-15	Eggs	Mjøsa	F	<0.2	<0.2	3.89	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3
ØF-G-1	Eggs	Femunden	F	<0.2	<0.2	2.27	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3
ØF-G-2	Testes	Femunden	M	<0.2	<0.2	1.45	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3
ØF-G-3	Eggs	Femunden	F	<0.2	<0.2	1.96	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3
ØF-G-4	Testes	Femunden	M	<0.2	<0.2	3.93	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3
ØF-G-5	Testes	Femunden	M	<0.2	<0.2	0.98	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3
ØF-G-6	Testes	Femunden	M	<0.2	<0.2	2.20	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3
ØF-G-7	Testes	Femunden	M	<0.2	<0.2	0.92	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3
ØF-G-8	Testes	Femunden	M	<0.2	<0.2	2.40	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3
ØF-G-9	Testes	Femunden	M	<0.2	<0.2	1.33	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3
ØF-G-10	Eggs	Femunden	F	<0.2	<0.2	1.29	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3	<0.3	<2	<2	<0.3	<0.3	<0.3	<0.3

MILFERSK 2020				PFAS								
ID	**Sample**	**Lake**	**Sex**	4:2 F53B	6:2 F53B	N-MeFOSAA	N-EtFOSAA	F53	7:3 FTCA	PFBSA	N-MeFBSA	N-EtFBSA
				ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
ØM-G-1	Testes	Mjøsa	M	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.22	<0.3	<0.3
ØM-G-2	Testes	Mjøsa	M	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.68	<0.3	<0.3
ØM-G-3	Eggs	Mjøsa	F	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.30	<0.3	<0.3
ØM-G-4	Eggs	Mjøsa	F	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	1.25	<0.3	<0.3
ØM-G-5	Eggs	Mjøsa	F	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.76	<0.3	<0.3
ØM-G-6	Testes	Mjøsa	M	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	2.34	<0.3	<0.3
ØM-G-7	Eggs	Mjøsa	F	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.35	<0.3	<0.3
ØM-G-8	Eggs	Mjøsa	F	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	1.26	<0.3	<0.3
ØM-G-9	Eggs	Mjøsa	F	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.36	<0.3	<0.3
ØM-G-10	Testes	Mjøsa	M	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	1.18	<0.3	<0.3
ØM-G-11	Testes	Mjøsa	M	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	3.40	<0.3	<0.3
ØM-G-12	Testes	Mjøsa	M	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	2.03	<0.3	<0.3
ØM-G-13	Eggs	Mjøsa	F	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.41	<0.3	<0.3
ØM-G-14	Eggs	Mjøsa	F	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	4.94	<0.3	<0.3
ØM-G-15	Eggs	Mjøsa	F	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.39	<0.3	<0.3
ØF-G-1	Eggs	Femunden	F	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	1.01	<0.3	<0.3
ØF-G-2	Testes	Femunden	M	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	2.13	<0.3	<0.3
ØF-G-3	Eggs	Femunden	F	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	1.17	<0.3	<0.3
ØF-G-4	Testes	Femunden	M	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	6.42	<0.3	<0.3
ØF-G-5	Testes	Femunden	M	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	2.51	<0.3	<0.3
ØF-G-6	Testes	Femunden	M	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	3.81	<0.3	<0.3
ØF-G-7	Testes	Femunden	M	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	4.13	<0.3	<0.3
ØF-G-8	Testes	Femunden	M	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	5.98	<0.3	<0.3
ØF-G-9	Testes	Femunden	M	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	3.40	<0.3	<0.3
ØF-G-10	Eggs	Femunden	F	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	2.17	<0.3	<0.3

NIVA: Norway´s leading centre of competence in aquatic environmentes

The Norwegian Institute for Water Research (NIVA) is Norway's leading institute for fundamental and applied research on marine and freshwaters. Our research comprises a wide array of environmental, climatic and resource-related fields. NIVA's world-class expertise is multidisciplinary with a broad scientific scope. We combine research, monitoring, evaluation, problem-solving and advisory services at international, national and local levels.

Norwegian Institute for Water Research

Økernveien 94 • NO-0579 Oslo, Norway
Telephone: +47 22 18 51 00
www.niva.no • post@niva.no