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EU Water Framework-Directive Priority Contaminants in Norwegian Freshwater Fish

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Summary

Priority substances under EU water framework directive, and other substances of concern, were analyzed in fish liver sampled from 13 Norwegian lakes (see map under) in 2019. The concentration of different contaminants in liver tissue may differ from muscle tissue because they have various chemical properties. EU has established Environmental quality standard (EQS) for prioritized environmental contaminants and the EQSs are given in wet weight values. The EQSs are established to prevent the negative effects in the aquatic ecosystem (ensuring protection for the most sensitive species). An EQS has been defined as "the concentration of a particular pollutant or group of pollutants in water, sediment or biota that should not be exceeded in order to protect human health and the environment".

The levels of mercury and PCB7 in fish liver exceed EU Environmental Quality Standards (EQS) in all 13 lakes included in this monitoring program and PBDEs exceeded EQS in 9 of the 13 lakes. Heptachlor exceeded the EQS in 8 lakes, 4-tert-octylphenol exceeded EQS in 6 lakes and DL-PCBs exceeded EQS in one lake. The EQS for PFOS was exceeded in three lakes (Lake Eikereren, Lake Randsfjorden, Lake Tyrifjorden). The levels of PFOS in Lake Tyrifjorden (267 ng/g ww) and Lake Eikeren (31 ng/g ww) were substantially higher than in the other lakes. Conspicuously high levels of PFOs has previously been detected if fish from Lake Tyrifjorden, and the present study confirm that the levels of PFOS in fish from this lake are high. Possible emission sources to the Tyrifjord have previously been assessed in a previous Norwegian Environment Agency report (Slinde and Høysæter, 2017).

PFOS has specific affinity to liver tissue, and it is most likely that the concentration in muscle is lower than in liver. Furthermore, the EQSs are set lower than the European limit values (Minimum Residual Limit Levels (MRLs)) for foodstuffs and animal feed, to protect the entire ecosystem (ensuring protection for the most sensitive species). The results from the present survey, suggest that background levels of PBDEs, PCBs mercury, heptachlor and octylphenol in Norwegian lakes do not meet the environmental targets in Europe. However, these results are comparable with results from different European countries, which may indicate an environmental problem for these contaminants across Europe.

Sammendrag

EUs vannrammedirektivs prioriterte forurensninger ble analysert i fiskelever prøvetatt i 13 norske innsjøer (se kart under). Konsentrasjonen av de forskjellige stoffene i levervev kan avvike fra muskelvev fordi de har forskjellige kjemiske egenskaper. EU har etablert miljøkvalitetsstandarder (EQS) for prioriterte miljøkjemikalier og EQS er gitt i våtvektverdier. EQS er etablert for å forhindre negative effekter i vannlevende organismer (sikre beskyttelse for de mest følsomme artene). En EQS er blitt definert som "konsentrasjonen av en bestemt miljøgift eller en gruppe miljøgifter i vann, sediment eller biota som ikke bør overskrides for å beskytte menneskers helse og miljø".

Nivået av kvikksølv og PCB7 i fiskelever overstiger EUs miljøkvalitetsstandarder (EQS) i alle de 13 innsjøene og PBDE overskred EQS i 9 innsjøer analysert i dette overvåkningsprogrammet. Heptaklor overskred EQS i 8 innsjøer, 4-tertoktylfenol overskred EQS i 6 innsjøer og DL-PCB overskred EQS i en innsjø. EQS for PFOS ble overskredet i tre innsjøer (Eikereren, Randsfjorden, Tyrifjorden). Nivåene av PFOS i Tyrifjorden (267 ng/g ww) og Eikeren (31 ng/g ww) var betydelig høyere enn i de andre innsjøene. PFOS har spesifikk affinitet til levervev, og det er mest sannsynlig at konsentrasjonen i muskel er lavere enn i lever. Videre er EQS-er satt lavere enn de europeiske grenseverdiene (minimum restnivåer (MRLs)) for matvarer og dyrefôr, for å beskytte hele økosystemet (sikre beskyttelse for de mest følsomme artene). Resultatene fra denne undersøkelsen antyder at bakgrunnsnivåer av PBDE, PCB kvikksølv, heptachlor og oktylfenol i norske innsjøer ikke tilfredsstiller miljøkravene i Europa. Imidlertid er disse resultatene sammenlignbare med resultater fra forskjellige europeiske land, noe som kan indikere at disse stoffene representerer et miljøproblem i hele Europa. De høye nivåene av PFOS som ble målt i fisk fra Tyrifjorden og Eikeren sammenlignet med andre norske innsjøer indikerer lokale utslippskilder. Mulige utslippskilder til Tyrifjorden er tidligere er vurdert i en tidligere Miljødirektoratet rapport (Slinde og Høysæter, 2017).

MAP: The map shows the localization of the lakes from which fish livers were analyzed for priority environmental contaminants.

Contents

1. Introduction

On behalf of the Norwegian Environment Agency, the Laboratory of Environmental Toxicology, Norwegian University of Life Sciences (NMBU) is monitoring contaminants in fish from Norwegian lakes. The current monitoring program started in 2017, proceeding the sampling strategy from previous years. In this study, a wide range of environmental contaminants has been determined in fish from 13 Norwegian lakes (see map). Mainly the lakes selected would have relatively low impact from human activity, but there were also examples of lakes known to be affected by one or more contaminants. Further the lakes should be located throughout the country.

Main goals for the monitoring program are:

- To report the concentrations of selected contaminants in fish from Norwegian lakes.

- Evaluate the potential for harmful effects on fish with different size and food preferences, and comparing the levels in biota (fish) with the environmental quality standards (EQS) for biota.

Ideally, monitoring programs should be based on measurement on the same species. However, sampling of fish from different lakes and different parts of Norway is challenging because of the variation in fish species and size distribution between lakes. Therefore, in the present survey the analyses were conducted on four fish species (trout, perch, char and whitefish; table 1). However, the contributing laboratories from the Norwegian University of Life Sciences (NMBU), the Institute of Marine Research (IMR), the Institute for Energy Technology (IFE) and the Institute of Environmental Science and Health, Geesthacht, Germany (MINJIE), are all experienced and have completed the annual analytical program with high quality. In this report, the occurrence and levels of EU Water framework directive priority contaminants in Norwegian freshwater fish are reported. Individual and groups of contaminants analyzed include organochlorine pesticides (OCP), Polychlorinated Biphenyls (PCBs), brominated flame-retardants (BFR), per and polyfluorinated substances (PFAS), alkylphenols, siloxanes, heavy metals and a wide range of environmental chemicals of emerging concern (CECs).

Environmental quality standards (EQS)

EQS (Environmental quality standard) is the concentration of a pollutant or group of pollutants in water, sediments or biota, which should not be exceeded in order to protect human health and the environment (EU directive 2000/60/EC, Article 2). EQSs serve as a tool to distinguishing between a "good" and a "poor" environmental condition in a water body. The EQS values are determined based on risk assessments for human health and the environment, such as an aquatic ecosystem. For water, two different EQSs are established, the annual average (AA-EQS) and the maximum value (Max-EQS), representing chronic and acute exposure. To understand the environmental impact caused by contaminants over time, biota samples are preferred over abiotic samples. As an example, mercury (Hg) is a contaminant, which tends to biomagnify in food chains, and a low EQS biota-value for Hg may indicate high toxicity and a high bioaccumulation and biomagnifying factor (Direktoratsgruppen vanndirektivet, 2018). The EQS value for Hg in freshwater biota is considered low (0.02 µg/g w.w.) but should, based on risk assessments, protect the most sensitive species within the ecosystem from adverse effects. There are several objectives for protecting various organisms from exposure to contaminants, such as protecting top predators from secondary poisoning through the consumption of contaminated prey. Another objective is to prevent the risk of toxic effects in humans caused by consumption of contaminated fish. Persistent pollutants such as persistent organic pollutants (POPs) and heavy metals, which accumulate in biota and biomagnify in food chains, may be very low in water and high in biota.

2. Materials and Methods

Collection of fish

Fish were sampled by the Norwegian Institute for Nature Research (NINA) as part of an assignment for ecosystem monitoring. Frozen fish were brought to the Norwegian School of Veterinary Science at the Norwegian University of Life Sciences (NMBU), where pooled samples was prepared. Species and individual length, weight, lake, water code and capture date of each fish in the samples from 1 to 36 analysed in the project from 2019 is shown in Appendix 1. The samples were prepared from pooled livers.

In the present report, the monitoring program included fish caught during summer and autumn 2019 from 13 lakes. Pooled samples were prepared by pooling 15 specimens from each lake into three samples. In some lakes, the number of fish were smaller than needed. Consequently, only trout (*Salmo trutta*) was collected in 8, and only perch (*Perca fluvialis*) in 3 lakes. A combination of char (*Salvelinus alpinus*) and trout were collected in one lake, and a combination of perch and whitefish (Coregonus alpinus) in one lake.

A rough overview of the available fish was first presented to Miljødirektoratet for final choice of specimens for each sample. Individual data for fish used to prepare each sample is shown in appendix 1, including location, length, weight and species. The individual fish were assigned a number (1 to 36) to show how the pooled samples had been made. For each lake, all individual fish with the same number were pooled into one sample.

Analyses at the Institute for Energy Technology (IFE)

Isotope analyses

Pooled muscle samples were used for measurements of Isotopes, δ 13C and δ 15N. Approximately 1.5 mg sample was placed in a Sn- capsule for combustion with access to O_2 and Cr_2O_3 1700 °C in a Eurovector EA3028 element instrument. The reduction of NOx to N_2 took place in a Cu heater at 650 °C. H_2O was removed in a chemical Mg $(ClO_4)_2$ trap before separation of N_2 and CO_2 in a 2 m Poraplot Q GC column. N_2 and CO_2 were injected directly on-line to a Horizon Isotope Ratio Mass Spectrometer (IRMS) from Nu-Instruments for δ 15 N and δ 13 C determination.

Analyses at the Norwegian University of Life Sciences (NMBU)

Metal analyses

The following metals were analysed in liver samples at the Metal Laboratory at the Norwegian University of Life Sciences (NMBU): Li, Al, V, Cr, Fe, Co, Ni, Cu, Zn, As, Se, Mo, Ag, Cd, Hg and Pb. Hg was also analysed in muscle. The samples were weighed, with approximately 500 mg (liver) or 1000 mg (muscle) in ultra-pure teflon tubes. Then 5 mL HNO3 (Ultrapure. subboiled) was added, and HCl to prevent loss of Hg. Internal standards consisting of Sc. Ge. Rh. In and Bi were added. Then the samples were decomposed at 260 ^{o}C for at least 20 min in an UltraClave from Milestone. For each series, at least one certified reference material (CRM) was analysed, with at least 3 blanks. After decomposing, the samples were diluted to 50.0 mL using distilled water in centrifuge tubes from Sarstedt. Glass and filters are avoided to reduce contamination. The samples were then analysed on Agilent 8800 QQQ ICP-MS against standards for each element.

Analyses of organic chemicals at NMBU

The extraction of chemicals from the fish samples were performed using one method for fluorinated components, and another method for the rest of the components. Most of the analyzed chemicals were extracted, using nonpolar solvents in the laboratory's multimethod (MT 2.2). For the fluorinated components, a different method (M-MT.2.7) was applied.

Analyses of fluorinated chemicals

Perfluorinated sulfonates and derivatives (PFAS), and Perfluorinated carboxylic acids were extracted and quantified. The following perfluorinated sulfonates and derivatives were analyzed (CAS nr): PFBS (375-73-5), PFHxS (355-46-4), PFOS (1763-23-1), PFOSA (754-91-6), N-EtFOSA (4151-50-2), N-MeFOSA (31506-32-8) N-Et-FOSE (1691-99-2), N-MeFOSE (24448-09-7), N-Et-FOSEA (423-82-5), N-MeFOSEA (25268-77-3), The following perfluorinated carboxylic acids (6 – 14 C-atoms) were analyzed: PFHxA (307-24-4), PFHpA (375-85-9), PFOA (335-67-1), PFNA (375-95-1), PFDA (335-76-2), PFUnDA (2058-94-8), PFDoDA (307-55-1), PFTrDA (72629-94-8), PFTeDA (376-06-7). The two groups were analyzed using the same method (M-MT.2.7). Because of the possible adhesion to glass for these chemicals, all extraction equipment are made of plastic. A 0.5 g sample was weighed in a 15 mL centrifuge tube with internal standards (^{13}C) added. After adding 5 mL methanol, samples were homogenized using an Ultra-Turrax®, IKA homogenizer. The samples were then shaken, using an IKA Vibrax VXR®, 2000 rpm, 30 min, and centrifuged at 3000 rpm for 10 min. The upper phase was transferred to a new tube, and a new extraction with 3 mL methanol was performed. After evaporation to 2 mL on a TurboVap®, under a flow of N_2. 0.3 g Envi-Carb® was added. This compound is actively using carbon for lipid removal from the samples. The tubes were shaken, centrifuged and the upper phase transferred to a new tube. The precipitate was extracted again, and the sample reduced to 1 mL before analysis on a LC/MS/MS system. This consists of Agilent triple quad 6460 LC/MS/MS1100 series (Auto sampler, quaternary pump, degasser), and API 3000 LC/MS/MS system equipped with Supelco, Discovery C18 column, 15 cm x 2.1 mm, 5 µm with pre column; Supelco, superguard Discovey 18.2 cm x 2.1 mm, 5 µm, Mobil phases A: 2 mM ammonium acetate in methanol, B: 2 mM ammonium acetate in water.

Analyses of other organic chemicals

The laboratory's multimethod (M-MT.2.2.) was used for extraction. First around 3 gram fish sample (liver or whole fish) was weighed. Internal standards for PCBs, HCB, DDTs and phenols were added: PCB-29, -112 and -207 (Ultra Scientific. RI, USA). For brominated compounds: BDE-77, -119 and -181 and $^{13}C_{12}$-BDE-209 (Cambridge Isotope Laboratories. Inc., MA, USA). Cyclohexane (CHX), acetone and distilled water (20:15:10 mL) were added, before further homogenization with an Ultra-Turrax®, IKA homogenizers and an ultra sonicator. After centrifuging (3000 rpm, 10 min), the organic upper phase was transferred to a Zymark® evaporation unit, and the water phase extracted a second time with CHX and acetone (10:5 mL). After evaporation, the upper phase was volume adjusted to 5 mL. One mL of this extract was used for gravimetric lipid determination.

Analyses of HCB, PCB, DDTs, PBDE and HBCDD

The extracts were cleaned using ≥ 97.5% H_2SO_4 (Fluka Analytical®). Then the extracts were up-concentrated to 0.25 mL under a flow of N_2. The following OCs were analysed: HCB, PCB 7 (PCB-28, -52, -101, -118, -138, -153 and -180). DDTs (*p,p'*-DDE, *o,p'*-DDD, *p,p'*-DDD, *o,p'*-DDT and *p,p'*-DDT). Separation and detection of PCB, HCB and DDTs were done on a «high resolution gas chromatograph" (HRGC) (Agilent 6890 Series gas chromatography system; Agilent Technologies, PA, USA) equipped with an auto sampler (Agilent 7683 Series; Agilent Technologies), coupled to a MS detector (Agilent 5975C Agilent Technologies) run in a negative chemical ionization (NCI) condition with selected ion monitoring (SIM). The components were separated using a DB-5 MS column (J&W Scientific, Agilent Technologies) (60 m, 0.25 mm i.d., 0.25 µm film thickness). The temperature program was: 90 °C (2 min hold); 25 °C/min increase to 180 °C (2 min hold); 1.5 °C/min increase to 220 °C (2 min hold); and 3 °C/min increase to 275 °C (12 min hold) and 25 °C/min increase to 300 °C (4 min hold). Total run time was 71.6 min. Carrier gas helium, make up gas nitrogen. The following brominated diphenyl ethers (PBDE) were quantified: BDE-28, -47, -99, -100, -153, -154, -183, -196, -202, -206, -207 and -209, also in addition to HBCDD (α-HBCDD, ß-HBCDD, γ-HBCDD), BDE -28, -47, -99, -100, -153, -154, -183, and HBCDD (sum) were quantified on a HRGC–LRMS (Agilent 6890 Series; Agilent Technologies), with an auto sampler (Agilent 7683 Series; Agilent Technologies) connected to a MS detector (Agilent 5973 Network; Agilent Technologies). Separation and identification of the components were done using a DB-5 MS column (30 m, 0.25 mm i.d., 0.25 µm film thickness; J&W Scientific). The temperature program was: start 90 °C; 25 °C/min increase to 180 °C; 2.5 °C/min increase to 220 °C (hold 1 min); 20 °C/min increase to 320 °C (hold 5 min); total run time 31.60 min. Carrier gas helium, makeup gas nitrogen. For detection of BDE 196, -202, -206, -207 and -209, the extracts (10 µL) were injected on a GC–MS (Agilent 6890 Series/5973Network) configured with a programmed temperature evaporation (PTV) injector (Agilent Technologies). For separation and identification, a DB-5-MS column (10 m, 0.25 mm i.d., 0.10 µm film thickness; J&W Scientific. Agilent Technologies) was used. The temperature program was: start 80 °C (hold 2 min); 30 °C/min increase to 315 °C (hold 6 min); total run time 15.83 min. Carrier gas helium, makeup gas nitrogen. For PBDE and HBCDD detection, negative chemical ionizing (NCI) in selected ion monitoring (SIM) (with m/z 79/81, BDE-209 m/z 484/486 and $^{13}C_{12}$-BDE-209 at m/z 495/497) was used.

Analyses of phenols

The following phenols were analysed: 4-nonylphenol (84852-15-3) and 4-tert-oktylphenol (140-66-9). 2mL lipid extract was cleaned using gel permeation chromatography, Bio-Beads S-X3, 200-400 mesh (Bio-Rad Laboratories, Inc., CA. USA) with mobile phase 1:1 Chx/ethyl acetate on a «Freestyle Robotic System, Type Basic, 740 mm Working Area and GPC-module". After pentafluorobenzoyl chloride derivatization and evaporation to 0.5 mL, 1 mL 1M NaHCO3 and 0.5 mL 1 M NaOH were added and the samples were shaken. Then 1 mL CHX and 50 µL 10% pentafluorobenzoyl chloride were added, and the samples were shaken and kept hot (60 ºC for 30 min). After cooling, 4 mL 1 M NaOH was added and the samples kept cool overnight. Room temperature samples were extracted with 2 x 2 mL CHX and the volume reduced to 150µL under a gentle stream of N_2. Phenols were then quantified on a HRGC–LRMS (Agilent 6890 Series; Agilent Technologies), with an auto sampler (Agilent 7683 Series; Agilent Technologies) and coupled to a MS detector (Agilent 5973Network; Agilent Technologies). Component separation and identification were done using a DB-5 MS column (30 m, 0.25 mm i.d., 0.25 µm film thickness; J&W Scientific). Carrier gas was Helium and reagent gas Methane 5.5. The temperature program was: start 90 °C; 20 °C/min to 140 °C; 5 °C/min increase to 260 °C; 25 °C/min to 310 °C (hold 2 min); total run time 31.50 min.

Quality assurance

The laboratory is accredited by the Norwegian Accreditation for testing the analyzed chemicals in biological material according to the requirements of the NS-EN ISO/IEC 17025 (TEST 137). Every analytical series included three procedural blanks (solvents), one blind (non-spiked brown trout (*Salmo trutta*)), two spiked samples of brown trout for recoveries and the laboratory's own reference materials (LRMs) of blubber of harp seal (*Pagophilus groenlandicus*). The lowest levels of detection (LODs) for individual compounds were defined as three times the noise level. The quality control parameters were within the accepted ranges for the method. In addition to the laboratory's own blubber RLM, analytical quality was successfully approved by routinely analyzing relevant Certified Reference Materials (CRM). One of them was mackerel oil (CRM 350). Further, the laboratory participates in relevant inter calibration tests such as the 2011 MOE Inter laboratory study for the Northern Contaminants Program (NCP) III — phase 6 on lake trout (*Salvelinus namaycush*) and brown trout organized by the Ontario Ministry of the Environment. Laboratory Services Branch.

Analyses at Institute of Environmental Science and Health, Geesthacht, Germany (MINJIE)

Chemicals and materials

The analyses were performed at Institute of Environmental Science and Health, Geestacht, Germany. The native standards, including short-chain chlorinated paraffin (SCCPs, C10-13) and medium-chain chlorinated paraffins (MCCPs, C14-17), decamethylcyclopentasiloxane (D5), polycyclic aromatic hydrocarbon (naphthalene, anthracene, fluoranthene and benzo(a)pyrene), hexachlorobutadiene (HCBD), trichlorobenzene isomers (135-TCB, 124-TCB, 123-TCB), dicofol, diethylhexyl phthalate (DEHP), *tris*(*2*-chloroethyl) phosphate (TCEP), triclosan (TCS), pentachlorophenol (PCP), tributyltin, and triphenyltin isomers, were purchased from LGC Standards (Wesel, Germany) and Sigma Aldrich Germany, respectively. D5-$^{13}C_{10}$, DEP-d4, DnBP-d4, Naphthalene d8, Anthracene d10, Fluoranthene d10 and TCEP-d12 were supplied from Cambridge Isotope Laboratories, Inc. USA. The standards including tributyltin chloride (TBT, 90%), dibutyltin dichloride (DBT, 97%), monobutyltin trichloride (MBT, 97%), tetrabutyltin (TeBT, 96%) and triphenyltin were purchased from Acros Organics (New Jersey, USA). TeBT was used as an internal standard. Organic solvents e.g., acetone, *n*-hexane and dichloromethane (DCM) were for residual analysis. Neutral silica gel (0.1-0.2 mm, Macherey-Nagel, Düren, Germany) and anhydrous sodium sulfate (Merck purity 99%, Darmstadt, Germany) were baked at 450°C for 12 h. Silica gel was deactivated with 10% (w:w) of Millipore water. The organic solvents e.g., acetone, n-hexane and dichloromethane (DCM) were of residual analysis grade and redistilled using glass system. Laboratory glassware was baked at 250 °C for 12 h, and then rinsed with acetone and n-hexane.

Sample extraction and fractionation

The fish liver samples (0.5 – 2.0 g) were homogenized with 10 g anhydrous sodium sulfate and packed in 50 mL centrifuge glass vial, 10 ng of Naphthalene d8, Anthracene d10, Fluoranthene d10, benzo(a)pyrene d12, DEP-d4, DnBP-d4 and 20 ng of TCEP-d15 were added as internal standards. The samples were then extracted with 20 mL n-hexane/DCM (1:1v:v) by 30-min sonication for three times. After centrifugation, the clear extracts were combined and concentrated down to 2 mL. The samples were equally split into part A and B for analysis of different substances. Part A was purified using a GPC column with SX-3 Bio-Beads (40 g), eluted with a mixture of n-hexane/DCM (3:7) at 5 mL/min. The fraction 1 containing SCCP and MCCP was further cleaned on a column packed with 20 g of acidified silica gel and eluded with 150 mL n-hexane/DCM (1:1). The elute was concentrated to dryness with nitrogen. The sample volume was redefined with addition of 50 µL of isooctane, 10 ng ^{13}C labeled chloroparaffin (1.5.5.6.6,10-$C_{10}Cl_5$) and 20 ng Dechlorane 603 were spiked as internal standards (Ma et al., 2014). Fraction 2 was concentrated down to 150 µL and spiked with 20 ng of D5-$^{13}C_{10}$ as injection standards. Fraction 2 was used for the analysis of TCEP, DEHP, dicofol, TCS and PCP. Part B was cleaned on a neutral silica gel column (2.5 g, 10 % water deactivated) topped on 3 g anhydrous granulated sodium sulfate. The extract was purified by eluting with 20 mL hexane (fraction 1) and 20 mL acetone/DCM (1:$1_{V/V}$) (fraction 2), respectively. Fraction 1 was concentrated down to 150 µL and spiked with 20 ng D5-$^{13}C_{10}$ as injection standard. Fraction 1 was used for the determination of D4, D5, HCBD, 135-TCB, 124-TCB, 123-TCB, naphthalene, anthracene, fluoranthene, benzo(a)pyrene and HCB.

Extraction for tributyltins (TBT) and triphenyltin (TPhT)

About 1 g fish liver sample was used to measure organotin concentrations. After it was mixed with appropriate amount of internal standard TeBT, 10 mL of THF–HCl (11:1, v/v) solution was added and then extracted with 25 mL 0.01% (m/v) tropolone–hexane solution under vigorous shaking for 40 min. The supernatant was transferred to a flask and the residue was extracted again in the same way with another 10 mL of hexane for 10 min. The combined extract was concentrated to about 2–3 mL and subjected to Grignard propylation. The analytes were purified using a chromatography column packed with anhydrous Na_2SO_4 (2 g), silica gel (2 g) and Florisil (2 g) in turn from the top. The elution was conducted with 10 mL of hexane and concentrated down to 200 µL under a gentle stream of pure nitrogen.

Instrumental analysis of SCCP, MCCP, PAH, DEHP, TCEP, TCS, PCP.

Method 1 was applied for the determination of D4, D5, HCBD, 135-TCB, 124-TCB, 123-TCB, naphthalene, anthracene, fluoranthene, benzo(a)pyrene and HCB using GC-MS-EI. The samples were analyzed with an Agilent 6890N gas chromatography coupled to an Agilent 5975 mass spectrometer (GC-MS) (Agilent Technologies, Avondale, PA, USA), operating in electron impact and selective ion monitoring modes (SIM), and a HP-5MS capillary column (30 m × 250 μm i.d.; 0.25 μm film thickness, J&W Scientific) for chromatographic separation. The transfer line and the ion source temperature were maintained at 280 and 230 °C, respectively. The column temperature program was initiated at 60 ºC for 2.0 min, increased to 120 °C at a rate of 10 ºC/min held for 10 min. The oven temperature was further ramped at 2 °C/min to 240 °C and then ramped at 30°C/min to 300°C and kept for 10 min. The flow rate of the carrier gas helium was kept constant at 1.3 mL min^{-1}. The flow rate of the carrier gas helium was kept constant at 1.3 mL min^{-1}. The extracts (1.0 μL) were injected onto GC-MS in splitless mode with an inlet temperature of 280 °C. Quantitation was performed using the internal calibration method based on 5-point calibration curve for individual substances. The response factors were derived from the calibration curves (7-points) made for response ratio between targets compounds and internal standards.

Method 2 was applied for the determination of TCEP, dicofol, DEHP, DEP, DiBP and DnBP using GC-MS-EI. The samples were analyzed with an Agilent 6890N gas chromatography coupled to an Agilent 5975 mass spectrometer (GC-MS) (Agilent Technologies, Avondale, PA, USA), operating in electron impact and selective ion monitoring modes (SIM), and a HP-5MS capillary column (30 m × 250 μm i.d.; 0.25 μm film thickness, J&W Scientific) for chromatographic separation. The transfer line and the ion source temperature were maintained at 280 and 230 °C, respectively. The column temperature program was initiated at 60 ºC for 2.0 min, increased to 120 °C at a rate of 10 ºC/min held for 10 min. The oven temperature was further ramped at 2 °C/min to 240 °C and then ramped at 30°C/min to 300°C and kept for 10 min. The flow rate of the carrier gas helium was kept constant at 1.3 mL min^{-1}. The extracts (1.0 μL) were injected onto GC-MS in splitless mode with an inlet temperature of 280 °C. Quantitation was performed using the internal calibration method based on 5-point calibration curve for individual substances. The response factors were derived from the calibration curves (7-points) made for response ratio between targets compounds and internal standards (Xie et al., 2007).

Method 3 was applied for the determination of PCP and TCS using GC-MS-EI. The samples were analyzed with an Agilent 6890N gas chromatography coupled to an Agilent 5975 mass spectrometer (GC-MS) (Agilent Technologies, Avondale, PA, USA), operating in electron impact and selective ion monitoring modes (SIM), and a HP-5MS capillary column (30 m × 250 μm i.d.; 0.25 μm film thickness, J&W Scientific) for chromatographic separation. The column temperature program was initiated at 60 ºC for 2.0 min, increased to 120 °C at a rate of 10 ºC/min held for 10 min. The oven temperature was further ramped at 2 °C/min to 240 °C and then ramped at 30°C/min to 300°C and kept for 10 min. The flow rate of the carrier gas helium was kept constant at 1.3 mL min^{-1}. The flow rate of the carrier gas helium was kept constant at 1.3 mL min^{-1}. Before the injection, a derivatization step was carried out following the method reported by xie et al, (2018). Briefly, 50 µL of BSTFA+1% TMS was added for derivatization and 5 ng octylphenol 13C6 (OP-$_{13}C^{6}$) was spiked as internal standard for quantitation. The reaction was carried out for 60 min at 60°C. The samples (1.0 μL) were injected onto GC-MS in splitless mode with an inlet temperature of 280 °C. Quantitation was performed using the internal calibration method based on 5-point calibration curve for individual substances. The response factors were derived from the calibration curves (7-points) made for response ratio between targets compounds and internal standards OP-13C6.

Method 4 was applied for the determination of SCCP, MCCP and LCCP using APCI-QTOF-MS, SCCP, MCCP and LCCP have been analyzed with the direct injection full scan method (scan range m/z 250 – 1000) using quadrupole time-of-flight high-resolution mass spectrometry (APCI-QTOF-MS) (QTOF Premier, Waters, Manchester, UK), which has developed by Bogdal et al, (2015) and Yuan et al, (2017). The observed resolution was 9.000 to 10.000 FWHM. All the chemicals and extracts were analyzed in cyclohexane to be consistent with the solvent of the chain length standards, 10 ng 13C labeled chloroparaffin (1.5.5.6.6.10-C10Cl5) and 20 ng Dechlorane 603 were spiked as internal standards.

Method 4 was applied for the determination of tributyltin (TBT), dibutyltin (DBT) and monobutyltin (MBT), triphenyltin (TPT), diphenyltin (DPT) and monophenyltin (MPT) using GC-FPD. The samples were analyzed with an Agilent 7890 gas chromatography coupled to a flame photometric detector equipped with Sn-filter (650 nm) (GC-FPD). Organotin compounds were based-line separated with a HP-5 fused-silica capillary column (30m× 0.32 mm×0.25 µm). The oven temperature program conditions were 80 °C held for 1 min, ramped at 5 °C/min to 190 °C then ramped at 10°C/min to 240°C held for 10min. The temperatures of the detector and the injector were kept at 250 °C. High pure nitrogen severed as carrier gas and kept at 2 mL/min, and the flow rate of hydrogen and air were 120 and 100 mL/min, respectively.

Quality assurance

In this report, the concentrations of the target compounds in fish liver samples are defined as the masses of the analysts divided by the masses of fish liver, and normally expressed as µg/kg. Quantification was performed by the internal standard method. Three procedural blanks were performed to check the interference and cross-contamination. The method detection limits (MDLs) were calculated by the means of three procedure blanks plus 3 times of the standard diversions. The recoveries of the sample preparation were determined by spiking target compounds to the matrixes. The analytical method adopted for TBT, DBT, MBT, TPT, DPT and MPT have been certified with international laboratory inter calibration. The recoveries for TBTs were achieved by analyzing certified reference materials. As the analytical methods adopted for other compounds have not been certified through laboratory inter calibration exercises, the measurement uncertainty were estimated roughly between 10 and 50 % (TA-2564/ 2009). The concentrations reported in this work were not subtracted from procedure blanks.

Analyses at Institute of Marine Research (IMR)

Diflubenzuron and teflubenzuron

The analytes were extracted with acetone. Solid phase extraction was used for sample clean up. The samples were analysed and quantified by LC-MS/MS as described in (Samuelsen et al. 2014). The method is accredited as a screening method in liver.

Dioxins, dl-PCBs

This method is an adaptation to modern clean-up equipment of the US-EPAs (Environmental Protection Agency) methods No. 1613 and 1668. Separation and quantification were performed by high resolution gas chromatography/high resolution mass spectrometry (HRGC/HRMS). The method determines all of the 29 compounds on the WHO list: 17 PCDD / PCDF congeners, four non-ortho substituted PCBs: PCB -77, -81, -126 and -169 and eight mono-ortho substituted PCBs: PCB-105, -114, -118, -123, -156, --157, 167 and 1-89. The method has been further described in Berntssen et al, (2010). The PCBs included in PCB-6, PCBs no. -28, -52, -101, -138, -153 and -180, were analysed by GC-MS/MS. The method is accredited for the analysis of fish liver.

Poly-aromatic hydrocarbons (PAH)

Samples were freeze-dried and mixed with hydromatrix (Agilent, Santa Clara Cal, USA) and internal standard (US EPA 16 PAH Cocktail (13C, 99 %), CIL ES-4087) were added, before the PAH are extracted using dichloromethane : cyclohexane (1:3) with use of Accelerated Solvent Extractor (ASE) at 100ºC and 1500 psi. Fat is partly removed on-line using silica gel. The extracts are evaporated on a TurboVap®, and purified further on SPE columns (Envichrom). The solvent is changed to isooctane and the samples concentrated to 50 µL before addition of recovery standard (3-Fluorchrysene, Chiron 1317,18-100-T). The samples were subsequently analysed by GCMSMS. A calibration curve is included in each series for quantification. The method determines 16 PAHs, and is accredited for most of these as specified in table

Quality assurance

The laboratory routines and the analytical methods at Institute of Marine Research (IMR) are accredited in accordance with the standard ISO 17025. The LOD is the lowest level at which the method is able to detect the substance, while the LOQ is the lowest level for a reliable quantitative measurement. For all methods, a quality control sample (QC) with a known composition and concentration of target analyte, is included in each series. The methods are regularly verified by participation in inter laboratory proficiency tests, and by analysing certified reference material (CRM), where such exist

3. Results

3.1.1 Fish species, tissue, weight, length and fat percentage and stabile isotopes

The fish species and the tissues analyzed are shown in table 1. Weight, length, and fat percentage of the analyzed tissue are also given in Table 1. The species analyzed were trout alone from eight lakes, and a combination of trout and char in one lake. Perch alone were caught in three lakes, and a mix of whitefish and perch from one lake. The mean fish weight differed between lakes from a min weight of 195 g in Lake Fjellgardsvatnet to a max weight of 1036 g in Lake Eikeren. Stable isotopes are shown in table 2

Table 1. Overview over tissues and species analyzed and mean weight, length and fat percentage for the fish in each lake.

Lake	Species	Tissue	Weight (g)	Lenght (cm)	Fat %
Bjørnsund	Perch/Whitefish	Liver	467.4	32.7	2.6
Eikeren	Trout	Liver	1036.3	45.0	4.4
Fjellgardsvatnet	Trout	Liver	195.0	25.8	3.9
Forolsjøen	Trout	Liver	460.7	30.8	3.5
Gjende	Trout	Liver	330.7	32.5	2.9
Grungstadsvatnet	Trout	Liver	459.0	34.2	3.6
Kapervatnet	Trout	Liver	404.3	32.5	2.0
Nystølsvatnet	Trout	Liver	315.2	30.5	3.5
Randsfjorden	Perch	Liver	354.6	29.8	4.2
Tangenfossen	Perch	Liver	422.0	29.0	6.1
Tinnsjå	Trout	Liver	328.5	31.1	4.0
Tyrifjorden	Perch	Liver	503.9	33.0	5.3
Ytre Fiskelausvatnet	Trout/char	Liver	414.2	31.2	3.2

Table 2. Mean, min and max values of stabile isotopes in fish liver.

Lake	Mean Weight	Min d15NAIR2			Min d13CVPDB		
	g	Min	Mean	Max	Min	Mean	Max
Bjørnsund	467.38	8.36	8.98	9.27	-21.91	-20.38	-19.20
Eikeren	1036.30	13.13	13.20	13.26	-27.19	-26.94	-26.77
Fjellgardsvatnet	194.99	7.46	7.91	8.68	-26.72	-26.45	-26.26
Forolsjøen	460.67	6.16	6.39	6.62	-21.33	-20.85	-20.37
Gjende	330.70	4.62	4.91	5.32	-26.10	-25.62	-25.11
Grungstadsvatnet	459.00	11.33	11.33	11.33	-24.01	-24.01	-24.01
Kapervatnet	404.25	6.00	6.00	6.00	-23.23	-23.23	-23.23
Nystølsvatnet	315.20	3.23	3.48	3.83	-22.45	-22.28	-22.12
Randsfjorden	354.61	11.51	11.89	12.14	-24.25	-23.40	-22.27
Tangenfossen	422.00	8.47	8.47	8.47	-25.03	-25.03	-25.03
Tinnsjå	328.46	7.15	7.34	7.46	-27.66	-26.95	-25.73
Tyrifjorden	503.87	11.58	11.83	12.18	-24.27	-23.40	-22.68
Ytre Fiskelausvatnet	414.25	7.38	7.98	8.78	-22.89	-22.06	-20.83

3.1.2 Organochlorine pesticides (OCP)

The wet weight (µg/kg ww) concentrations of hexachlorobenzene (HCB), pentachlorobenzene (PeCB), ∑hexachlorocyclohexane (∑HCH), heptachlor, ∑endosulfan and ∑dichlorodiphenyltrichloroethane (∑DDT) in fish from the different lakes are shown in table 3 and the lipid weight (lw) concentrations of the respective chemicals are shown in table 4. The lipid weight (lw) concentrations are also shown in figure 1. The lipid weight concentrations of fat-soluble compounds enable the estimation the body-burden, which is used to compare the total concentrations of Organochloride Pesticides (OCP) and other POPs between individuals and populations. The OCPs, which occurred at the highest concentrations (lw) in fish liver were heptachlor, DDTs and HCB. The highest levels of ∑DDTs were found in fish liver from Lake Eikeren (2371 µg/kg) followed by Lake Gjende (1103 µg/kg) and Lake Tyrifjorden (606 µg/kg). The lowest concentrations were found in Lake Ytre Fiskelausvatnet (10 µg/kg) and Lake Tangenfossen (13 µg/kg). The concentration (lw) of HCB were highest in fish liver from Lake Gjende (21 µg/kg) and Lake Eikeren (20 µg/kg) followed by Lake Nystølsvatnet (17 µg/kg). The lowest concentrations of HCB were detected in Lake Fjellgardsvatnet (5 µg/kg) and Lake Tangenfossen (7 µg/kg). Relative high levels of Heptachlor was detected in Lake Bjørnsund (24 µg/kg), Lake Kapervatnet (13 µg/kg) and Lake Gjende (7 µg/kg). Available data on levels of heptachlor in Norwegian biota is scarce. However, one study measured heptachlor levels in perch, roach and pike livers from Lake

Årungen (Sharma et al., 2010) and the wet weight levels in perch and roach livers were under the detection limit, whereas the levels in pike (0.60 ng/g; mean weight 1.6 kg) were comparable to the levels in Lake Bjørnsund (0.46 mg; weight 0.5 kg) and Lake Kapervatnet (0.24 ng/g; weight 0.4 kg).

EU has established European Quality Standards (EQS) for prioritized environmental contaminants and the EQSs are given in wet weight values. The EQSs are established to prevent the entire ecosystem (ensuring protection for the most sensitive species). The limit of detection (LOD) were lower than the EQS for the OCPs except for heptachlor for which LOD exceeded the EQS. The EU EQS (0.0067 µg/kg ww) for heptachlor were exceeded in fish liver from the lakes with levels above the LOD (LOD = 0.073 µg/kg ww).

Table 3: Mean wet weight (µg/kg ww) concentrations of HCB, PeCB, ∑HCH, ∑Endosulfan and ∑DDT. Under the detection limit=not detected (nd).

Lake	HCB ww	PeCB ww	∑HCH ww	∑Heptachlor ww	∑Endosulfan ww	∑DDT ww
Bjørnsund	0.27	0.01	0.02	0.46	0.01	1.33
Eikeren	0.87	0.03	0.06	0.19	0.10	103.75
Fjellgardsvatnet	0.20	0.01	0.04	ND	ND	0.78
Forolsjøen	0.39	0.01	0.04	0.06	ND	0.87
Gjende	0.61	0.02	0.05	0.21	0.08	33.07
Grungstadsvatnet	0.31	0.02	0.04	ND	ND	1.19
Kapervatnet	0.18	0.01	0.02	0.24	0.05	0.37
Nystølsvatnet	0.59	0.02	0.03	0.02	0.02	3.58
Randsfjorden	0.24	0.01	0.04	0.16	0.02	4.21
Tangenfossen	0.42	0.02	0.08	ND	ND	0.81
Tinnsjå	0.32	0.02	0.04	0.03	0.04	1.41
Tyrifjorden	0.39	0.02	0.06	0.17	0.07	30.01
Ytre Fiskelausvatnet	0.35	0.02	0.03	ND	0.01	0.32

Table 4: Mean lipid weight (µg/kg lw) concentrations of HCB, PeCB, ∑HCH, ∑Endosulfan and ∑DDT. Under the detection limit=not detected (nd).

Lake	HCB lw	PeCB lw	∑HCH lw	∑Heptachlor lw	∑Endosulfan lw	∑DDT lw
Bjørnsund	11	0.57	0.75	24	0.36	45
Eikeren	20	0.79	1.37	4	2.21	2371
Fjellgardsvatnet	5	0.36	1.04	ND	ND	21
Forolsjøen	11	0.41	1.14	2	ND	25
Gjende	21	0.58	1.72	7	2.84	1103
Grungstadsvatnet	9	0.54	1.01	ND	ND	33
Kapervatnet	9	0.50	0.87	13	2.52	19
Nystølsvatnet	17	0.66	0.91	1	0.65	103
Randsfjorden	6	0.33	0.87	4	0.46	97
Tangenfossen	7	0.40	1.31	ND	ND	13
Tinnsjå	8	0.40	1.02	1	0.88	36
Tyrifjorden	7	0.36	1.12	4	1.32	606
Ytre Fiskelausvatnet	11	0.54	0.83	ND	0.41	10

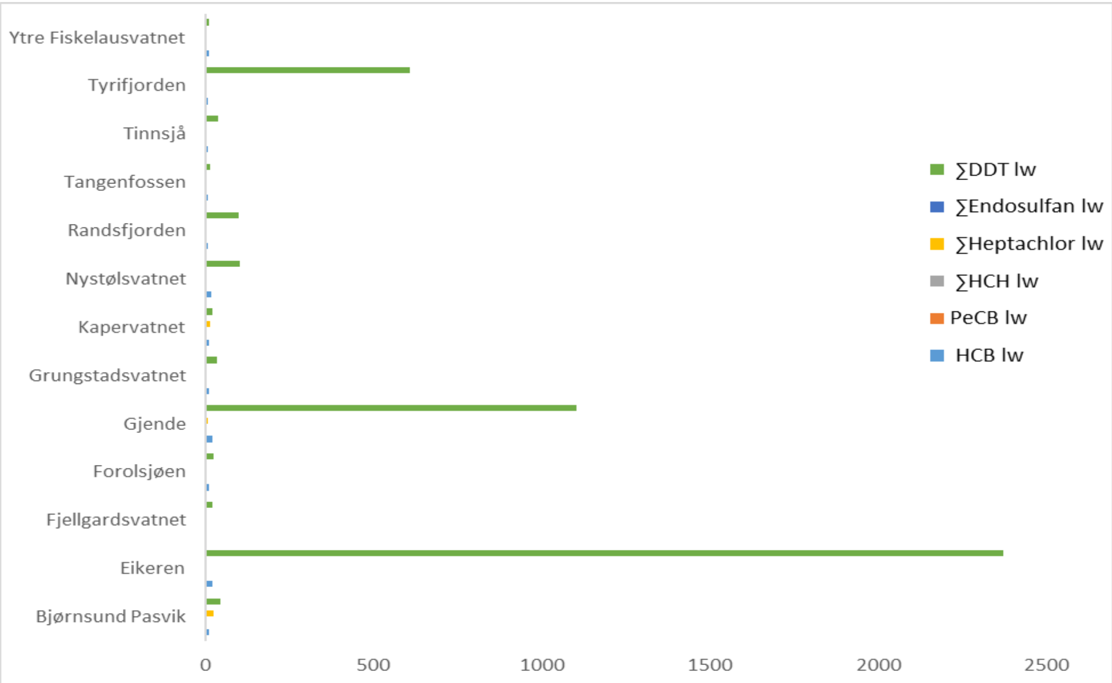

Figure 1: Mean lipid weight (µg/kg lw) concentrations of DDT, HCB, PeCB, HCH, Heptaklor and Endosulfan

3.1.3 PCBs and Brominated Flame Retardants (PBDEs and HBCDD)

The mean wet weight (ww) concentrations of Polychlorinated Biphenyls (PCBs). Polybrominated diphenyl ethers (PBDEs) and Hexabromocyclododecane (HBCD or HBCDD) in fish from the different lakes are given in table 5 and the lipid weight (lw) concentrations of the respective chemicals are given in table 6. The lipid weight concentrations are also shown in figure 2. The lipid weight concentrations of fat-soluble compounds are used to compare the levels of fat-soluble PCB and Brominated Flame Retardants between tissues, individuals and populations. The lipid weight concentrations of ∑PCB7 in fish liver were highest in Lake Eikeren (744 µg/kg) followed by Lake Gjende (697 µg/kg) and Lake Bjørnsund (228 µg/kg). The highest concentrations (lw) of ∑PBDEs were measured in Lake Eikeren (183 µg/kg), Lake Gjende (83 µg/kg) and Lake Tyrifjorden (17 µg/kg), whereas the highest concentrations of HBCDD were measured in Lake Eikeren (70 µg/kg), Lake Gjende (63 µg/kg).

The concentration of POPs in the study lakes are relatively low compared to other lakes in Norway, which have a location nearer to areas with industrial and human activity such as Lake Øyeren (liver), Lake Eikeren (liver) and Lake Mjøsa (muscle). The concentrations are also relatively low compared to the levels in European freshwater fish (Fliedner et al., 2016; Luigi et al., 2015).

Despite the relatively low concentration of POPs detected in the study lakes the wet weight concentrations of PBDEs exceeded the EQS in fish from all the lakes and the wet weight concentrations of PCBs exceeded the EQS in fish from 11 out of 14 lakes. Fish in Lake Altevann Bardu. Lake Stuorajávri and Lake Vaggatem had PCBs levels below the EQS for PCB7. The detection limits were lower than the EQS for all the PCBs PBDEs and HBCDDs.

Table 5: Mean wet weight (µg/kg ww) concentrations of the sum of PCBs (ΣPCB), thirteen PBDEs (ΣPBDE) and HBCDD in liver samples. Under the detection limit=not detected (nd).

Lake	∑PCB ww	∑PBDE ww	HBCD ww
Bjørnsund	5.65	0.07	0.02
Eikeren	32.32	7.93	3.08
Fjellgardsvatnet	3.27	0.51	ND
Forolsjøen	2.04	ND	ND
Gjende	20.84	2.51	1.94
Grungstadsvatnet	3.61	0.13	ND
Kapervatnet	2.58	ND	ND
Nystølsvatnet	3.86	0.16	0.02
Randsfjorden	5.61	0.47	0.14
Tangenfossen	2.69	ND	ND
Tinnsjå	6.78	0.19	0.08
Tyrifjorden	4.35	0.56	0.60
Ytre Fiskelausvatnet	2.46	ND	ND

Table 6: Mean lipid weight (µg/kg lw) concentrations of the sum of PCBs (ΣPCB), thirteen PBDEs and HBCDD in liver samples. Under the detection limit=not detected (nd).

Lake	∑PCB7 lw	∑PBDE lw	HBCD lw
Bjørnsund	228	1.97	0.91
Eikeren	744	183	70
Fjellgardsvatnet	87	13.35	ND
Forolsjøen	58	ND	ND
Gjende	697	83	63
Grungstadsvatnet	100	4	ND
Kapervatnet	132	ND	ND
Nystølsvatnet	111	5	0.67
Randsfjorden	137	10	3
Tangenfossen	44	ND	ND
Tinnsjå	165	4	2
Tyrifjorden	120	17	10
Ytre Fiskelausvatnet	76	ND	ND

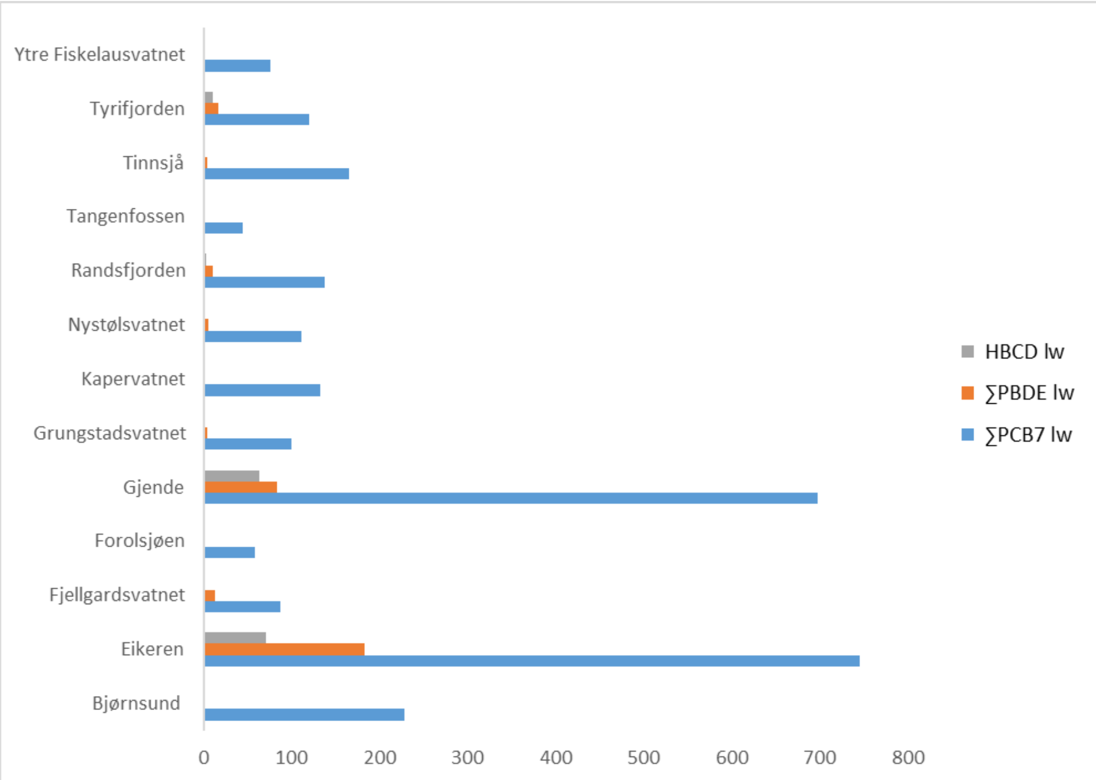

Figure 2: Mean lipid weight (µg/kg lw) concentrations of ΣPCBs. thirteen PBDEs and HBCDD in liver samples.

3.1.4 Dioxins and dioxin-like PCBs

The mean toxic equivalency (TEQ) values in pg/g wet weight (pg/g TEQ ww) of dioxin-like PCBs (dl-PCBs). Polychlorinated dibenzodioxins (PCDDs) and Polychlorinated dibenzofurans (PCDFs) and the sum of PCDDs and PCDFs and dl-PCBs are given in table 7 and figure 3. The mean TEQ in lipid weight are given in table 8 and figure 4. Toxic equivalency factor (TEF) expresses the individual toxicity of each dioxin. dibenzofurans and dl-PCB, which may vary by orders of magnitude. The toxic equivalency (TEQ) is a single figure resulting from the product of the concentration and individual TEF values of each dioxin. dibenzofurans and dl-PCB and express the additive toxicity of a mixture of dioxins and dioxin-like compounds (van den Berg et al. 2006). The highest wet weight additive dioxin toxicity (sum of PCDDs + PCDFs + dl-PCBs) was detected in fish from Lake Eikeren followed by Lake Grongstadsvatnet and Lake Gjende. Fish from Lake Eikeren and Lake Gjende had also the highest levels of the other POPs.

All the lakes had levels of dioxins below the EQS for biota.

Table 7: Mean wet weight TEQ (pg/g TEQ ww) levels of ∑dl-PCB, ∑PCDD+PCDF and ∑PCDD+PCDF+dl-PCB in fish from each lake. Under the detection limit=not detected (nd).

Lake	∑dl-PCB ww	∑PCDD+PCDF ww	∑PCDD+PCDF+dl-PCB ww
Bjørnsund	0.29	0.07	0.36
Eikeren	5.33	1.58	6.91
Fjellgardsvatnet	0.08	0.02	0.10
Forolsjøen	0.04	0.02	0.06
Gjende	3.12	0.28	3.40
Grungstadsvatnet	0.38	3.23	3.61
Kapervatnet	0.50	0.07	0.57
Nystølsvatnet	0.31	0.26	0.57
Randsfjorden	0.43	0.13	0.57
Tangenfossen	0.04	0.96	1.00
Tinnsjå	0.63	0.14	0.77
Tyrifjorden	0.70	0.21	1.01
Ytre Fiskelausvatnet	0.12	0.01	0.13

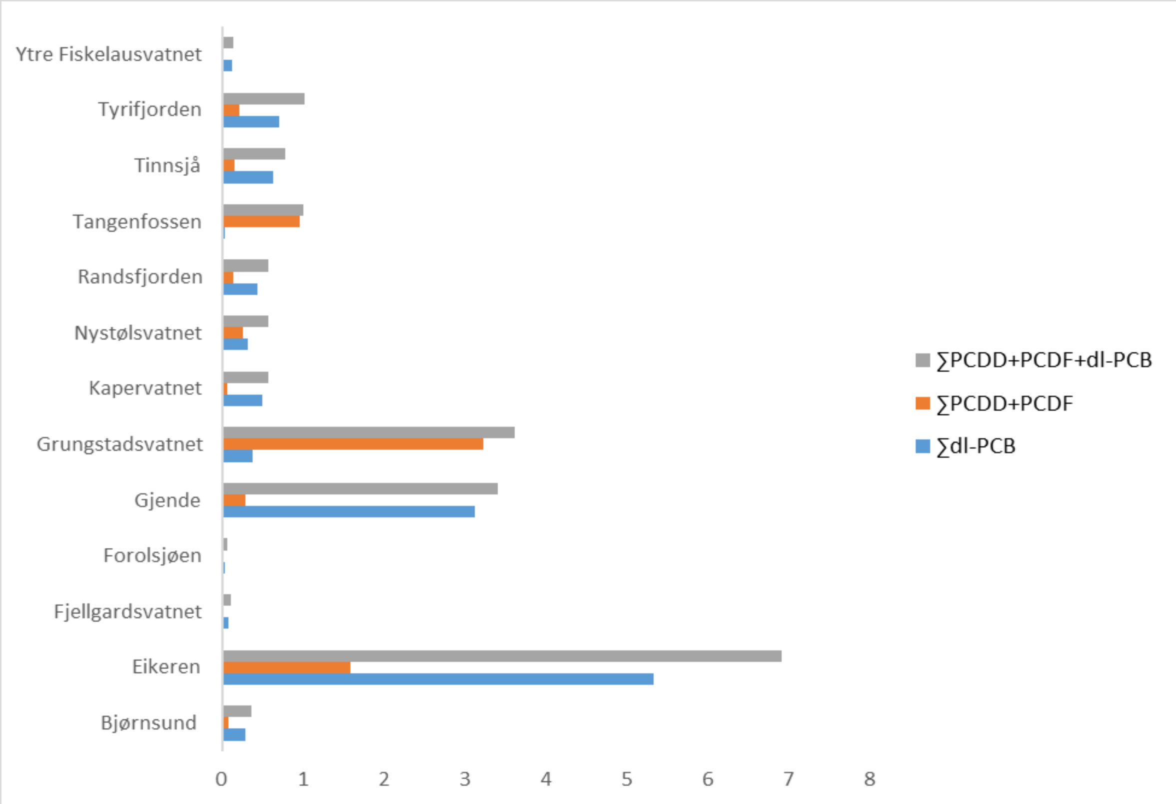

Figure 3: Mean wet weight TEQ (pg/g TEQ ww) values of ∑dl-PCB, ∑PCDD+PCDF and ∑PCDD+PCDF+dl-PCB in fish from each lake.

Table 8: Mean lipid weight TEQ (pg/g TEQ lw) values of ∑dl-PCB, ∑PCDD+PCDF and ∑PCDD+PCDF+dl-PCB in fish from each lake. Under the detection limit=not detected (nd).

Lake	∑dl-PCB lw	∑PCDD+PCDF lw	∑PCDD+PCDF+dl-PCB lw
Bjørnsund	10.74	3.45	14.19
Eikeren	122.69	36.64	159.33
Fjellgardsvatnet	2.18	0.51	2.69
Forolsjøen	1.05	0.68	1.73
Gjende	103.80	10.66	114.46
Grungstadsvatnet	10.55	89.28	99.83
Kapervatnet	25.63	3.52	29.15
Nystølsvatnet	8.75	7.51	16.26
Randsfjorden	9.31	3.13	12.44
Tangenfossen	0.63	15.81	16.44
Tinnsjå	15.99	3.27	19.27
Tyrifjorden	18.08	5.21	24.41
Ytre Fiskelausvatnet	3.59	0.23	3.85

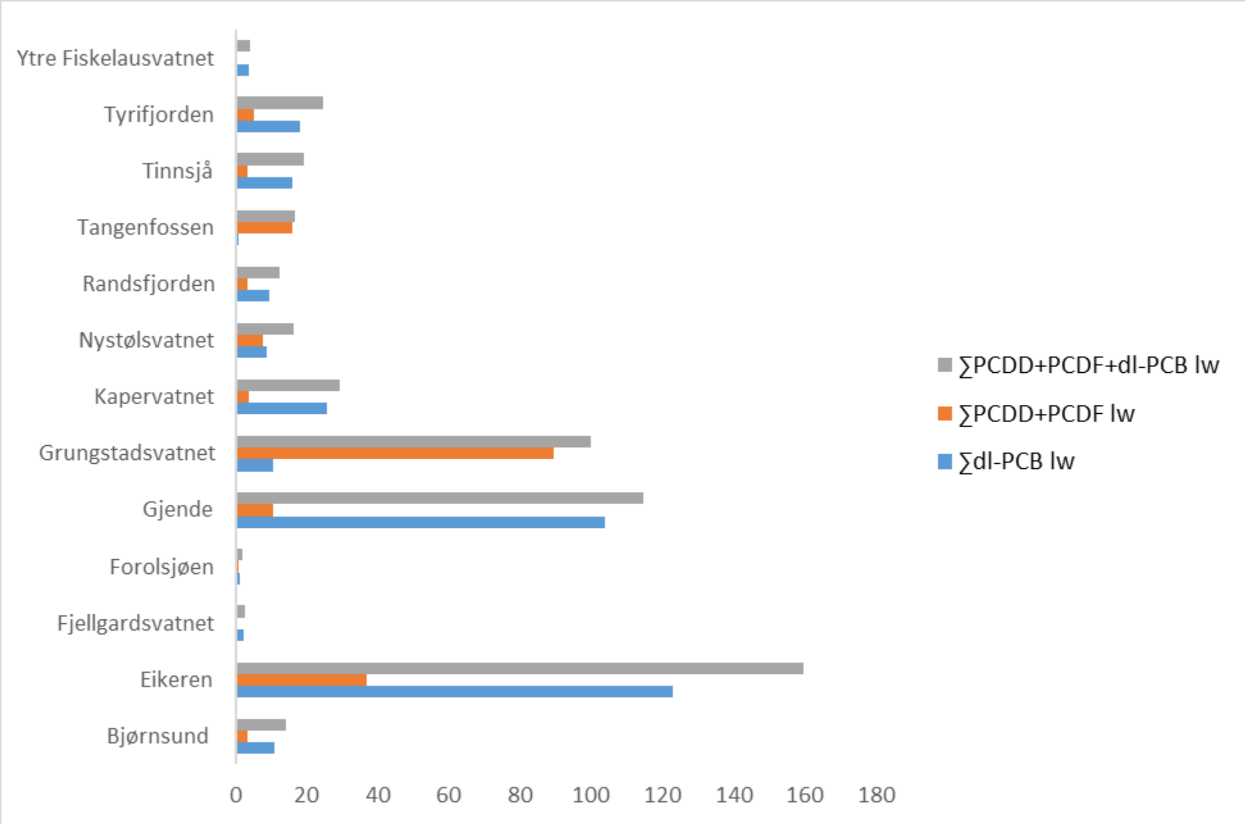

Figure 4: Mean lipid weight TEQ (pg/g TEQ lw) values of Σdl-PCB, ΣPCDD+PCDF and ΣPCDD+PCDF+dl-PCB in fish from each lake.

3.1.5 Polyaromantic Hydrocarbons (PAH)

The mean wet weight concentrations of the polyaromatic hydrocarbons Naphthalene, Anthracene, Fluoranthene and Benzo[a]pyrene in fish from each lake are given in table 9 and figure 5. Among the four PAHs measured naphthalene showed the highest levels in fish liver from the lakes. The highest level of naphthalene was detected in Lake Gjende. The levels of benzo[a]pyrene were under the detection limit in all the lakes.

The detection limit for benzo[a]pyrene was 0.65 µg/kg. which are lower than the EQS (5 µg/kg ww). indicating that the levels of benzo[a]pyrene did not exceed the EQS in any of the lakes.

Table 9: Mean wet weight concentrations (µg/kg ww) of Naphthalene and Fluoranthene. Under the detection limit=not detected (nd).

Lake	Naphthalene	Anthracene	Fluoranthene	Benzo[a]pyrene	Benz(a)anthracen
Bjørnsund	1.07	0.02	0.50	ND	ND
Eikeren	0.95	0.28	0.64	ND	ND
Fjellgardsvatnet	1.03	0.03	0.53	ND	ND
Forolsjøen	1.09	0.02	0.26	ND	ND
Gjende	3.61	0.08	0.45	ND	ND
Grungstadsvatnet	0.63	0.02	0.15	ND	ND
Kapervatnet	2.60	0.02	0.39	ND	ND
Nystølsvatnet	1.05	0.02	0.34	ND	ND
Randsfjorden	1.20	0.01	0.22	ND	ND
Tangenfossen	0.94	0.03	0.51	ND	ND
Tinnsjå	3.08	0.08	0.27	ND	ND
Tyrifjorden	1.08	0.01	0.20	ND	ND
Ytre Fiskelausvatnet	1.48	0.02	0.92	ND	ND

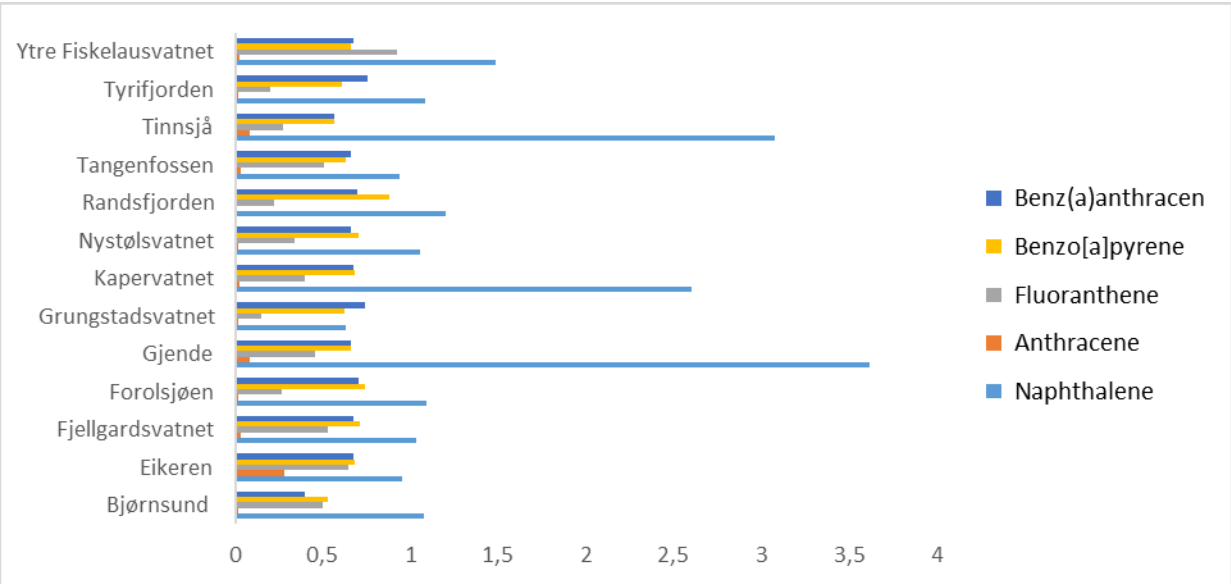

Figure 5: Mean wet weight concentrations (µg/kg ww) of Naphthalene, Anthracene, Fluoranthene and Benzo[a]pyrene.

3.1.6 Per- and polyfluorinated Compounds (PFAS)

The mean wet weight (ww) concentrations of 11 different PFAS in fish from each lake are given in tables 10 and 11 and in figures 6 and 7. The mean ww concentrations of the sum of the 11 PFAS are given table 12 and figure 8. The highest concentrations of PFOS were detected In Lake Tyrifjorden (267 µg/kg ww) followed by Lake Eikeren (21 µg/kg ww) and Lake Randsfjorden (12 µg/kg ww). The sum of PFAS (∑PFAS) were highest in Lake Tyrifjorden (497 µg/kg ww) followed by Lake Eikeren (142 µg/kg ww) and Lake Foroll (83 µg/kg ww). The long chained PFASs, PFDoDA, PFUnDA, PFTrDA were the individual PFASs detected at highest levels in most of the lakes. The same trend was found in a previous study on PFAS levels in Lake Femunden, Lake Mjøsa and Lake Randsfjorden (Miljødirektoratet. 2017).

EU has established EQS for PFOS (9.1 µg/kg ww) but not for PFOA. However, Norway has established an EQS for PFOA. In this survey, it was found that fish from Lake Tyrifjorden (267 µg/kg ww,) Lake Eikeren (21 µg/kg ww) and Lake Randsfjorden (12 µg/kg ww) had PFOS levels which exceeded the EQS. The levels I Lake Tyrifjorden were substantial higher than those in the other lakes. The PFOA levels in fish did not exceed the Norwegian EQS (91.3 µg/kg ww) in any of the lakes.

Table 10: Mean wet weight concentrations of (µg/kg ww) 6 individual PFASs in fish from each lake.

Row Labels	PFOS	PFDA	PFTeDA	PFDoDA	PFUnDA	PFTrDA
Bjørnsund	3.05	2.25	0.22	1.31	5.10	2.13
Eikeren	31	9.61	4.27	22.93	33.44	35.17
Fjellgardsvatnet	4.38	0.66	0.24	1.31	2.13	2.08
Forolsjøen	5.21	10.01	2.16	7.52	30.82	16.03
Gjende	1.91	2.95	3.37	7.01	8.45	13.58
Grungstadsvatnet	2.40	0.50	0.29	1.13	1.49	1.73
Kapervatnet	5.42	1.37	0.31	0.68	2.95	1.40
Nystølsvatnet	2.10	1.11	0.58	1.55	2.73	3.39
Randsfjorden	12	3.32	1.14	5.04	8.14	7.07
Tangenfossen	0.95	0.51	0.09	0.38	1.36	0.75
Tinnsjå	5.00	2.39	1.20	5.63	7.96	9.60
Tyrifjorden	267	36.89	22.89	74.97	48.38	40.85
Ytre Fiskelausvatnet	1.90	0.84	0.08	0.51	1.84	0.85

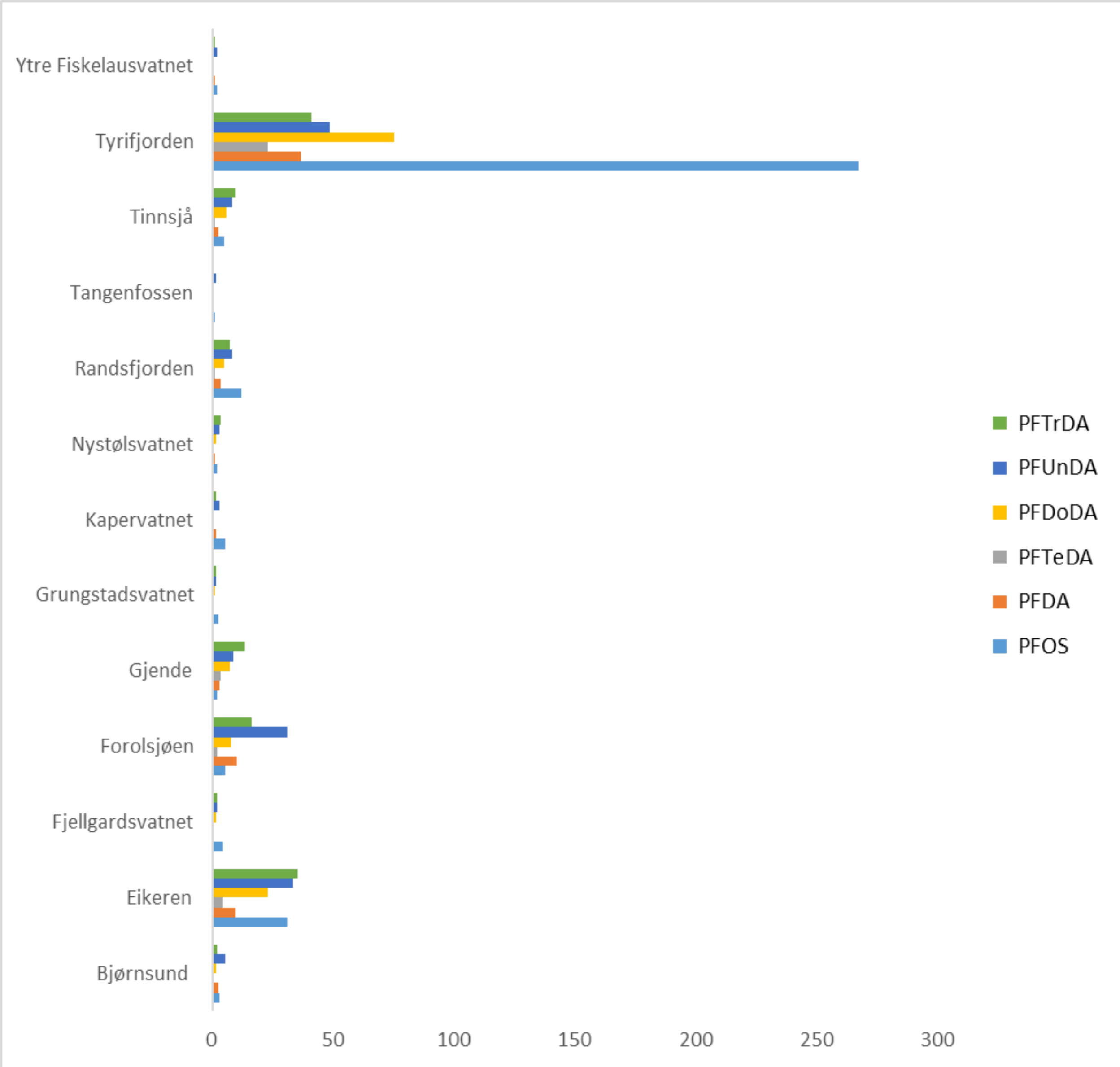

Figure 6: Mean wet weight concentrations (µg/kg ww) of 6 individual PFAS in fish from each lake

Table 11: Mean wet weight concentrations (µg/kg ww) of 5 individual PFASs in fish from each lake. Under the detection limit= not detected (nd).

Row Labels	PFOA	PFOSA	PFNA	PFBS	PFHpA
Bjørnsund	ND	0.19	2.12	ND	ND
Eikeren	ND	3.17	2.04	ND	ND
Fjellgardsvatnet	ND	0.49	0.59	ND	0.09
Forolsjøen	1.62	2.97	16.19	ND	0.35
Gjende	ND	0.61	0.89	ND	ND
Grungstadsvatnet	ND	0.56	0.31	ND	ND
Kapervatnet	ND	0.32	0.45	ND	ND
Nystølsvatnet	ND	0.44	0.44	ND	ND
Randsfjorden	ND	0.22	1.45	ND	ND
Tangenfossen	ND	ND	0.68	ND	ND
Tinnsjå	ND	0.53	0.56	ND	ND
Tyrifjorden	ND	1.08	3.22	1.57	ND
Ytre Fiskelausvatnet	0.99	0.15	2.90	ND	0.11

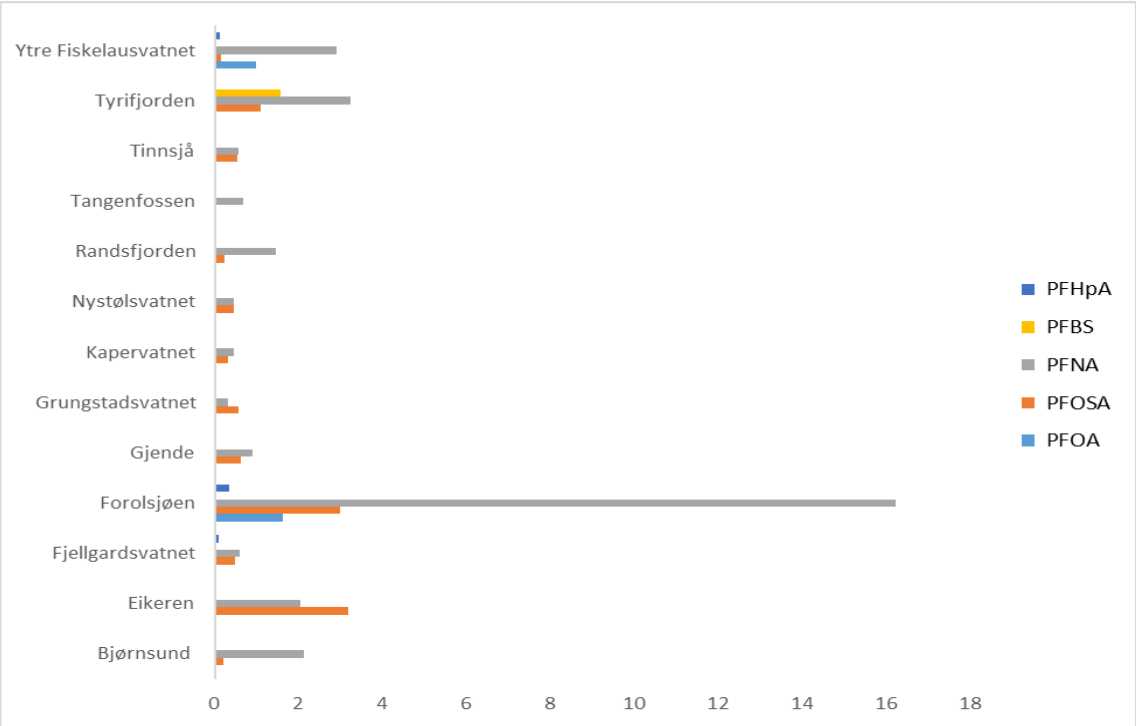

Figure 7: Mean wet weight concentrations (µg/kg ww) of 5 individual PFASs in fish from each lake.

Table 12: Mean wet weight concentrations (µg/kg ww) of the sum of 11 PFASs in fish from each lake.

Lake	∑PFAS
Bjørnsund	16
Eikeren	142
Fjellgardsvatnet	12
Forolsjøen	93
Gjende	39
Grungstadsvatnet	8
Kapervatnet	13
Nystølsvatnet	12
Randsfjorden	38
Tangenfossen	5
Tinnsjå	33
Tyrifjorden	497
Ytre Fiskelausvatnet	10

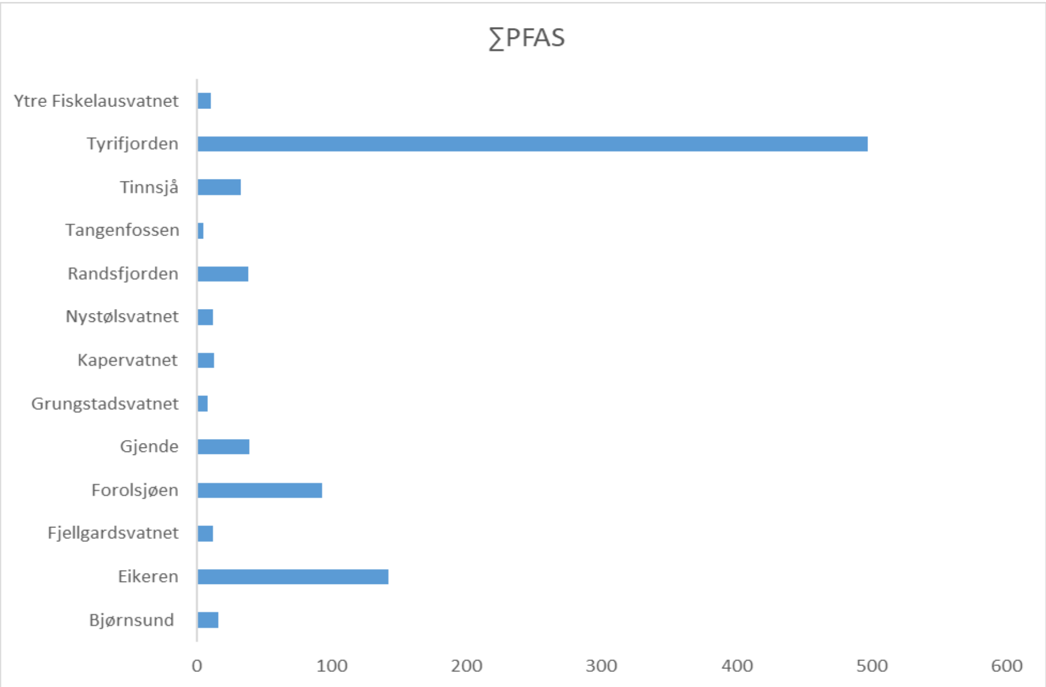

Figure 8: Mean wet weight (µg/kg ww) concentrations of the sum of 11 PFASs in fish from each lake.

3.1.7 Phenols

The mean wet weight concentrations of the phenols, 4-tert-octylphenol and p-nonylphenol in fish from each lake are given in table 13 and figure 9.

The highest level of p-nonylphenol was detected in Lake Bjørnsund (35 µg/kg ww) followed by Lake Kapervatnet (5.60 µg/kg ww) and Lake Tangenfossen (3.53 µg/kg ww).

The highest level of 4-tert-oktylfenol was detected in Lake Tyrifjorden (5.03 µg/kg ww) followed by Lake Kapervatnet (1.89 µg/kg ww) and Lake Randsfjorden (0.86 µg/kg ww).

The EQS for 4-tert-oktylfenol (0.22 µg/kg ww) was exceeded in fish livers from all the lakes except for those with levels under the detection limit, whereas the levels of p-nonylfenol were below the EQS in all lakes. The detection limit for 4-tert- octylphenol was higher than the EQS for this chemical.

Table 13: Mean wet weight concentrations (µg/kg ww) of 4-tert-octylphenol and p-nonylphenol in fish from each lake. Under the detection limit= not detected (nd).

Lake	4-tert-octylphenol	p-nonylphenol
Bjørnsund	0.70	35
Eikeren	ND	ND
Fjellgardsvatnet	ND	ND
Forolsjøen	ND	ND
Gjende	0.20	ND
Grungstadsvatnet	ND	ND
Kapervatnet	1.89	5.60
Nystølsvatnet	ND	ND
Randsfjorden	0.86	ND
Tangenfossen	ND	3.53
Tinnsjå	0.22	ND
Tyrifjorden	5.03	ND
Ytre Fiskelausvatnet	ND	2.24

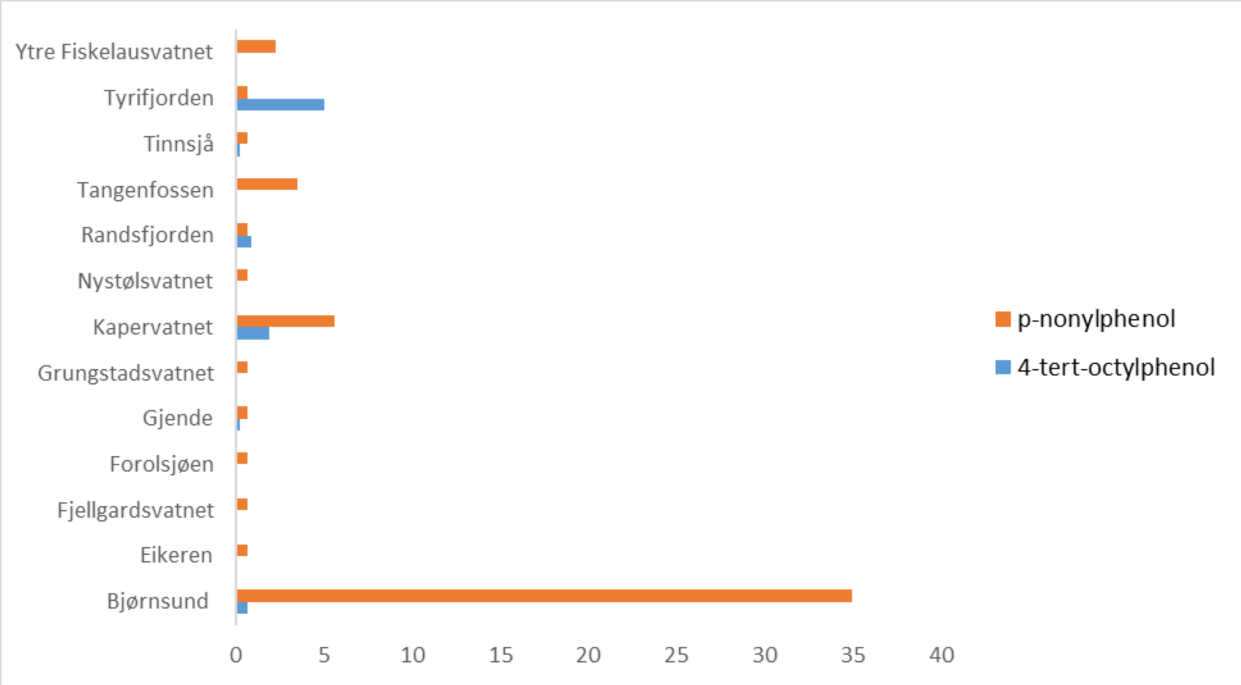

Figure 9: Mean wet weight concentrations (µg/kg) of 4-tert-octylphenol and p-nonylphenol in fish from each lake.

3.1.8 Organotin Compounds

The mean wet weight concentrations of the organotins. Dibutyltin (DBT), Tributyltin (TBT), Monobutyltin (MBT), Triphenyltin (TPT), Diphenyltin (DPT) and Monophenyltin (MPT) in fish from each lake are given in table 14 and figure 10.

The highest level of dibutyltin was detected in Lake Tyrifjorden (3.21 µg/kg ww) followed by Lake Randsfjorden (1.89 µg/kg ww) and Lake Foroll (1.69 µg/kg ww). The highest levels of tributyltin were detected in Lake Tyrifjorden (2.72 µg/kg ww) followed by Lake Randsfjorden (0.88 µg/kg ww) and Ytre Fiskelausvatnet (0.41 µg/kg ww).

The levels of tributyltin did not exceed the EQS for this contaminant in any of the lakes.

Table 14: Mean wet weight concentrations (µg/kg ww) of the organotins, DBT, TBT, MBT, TPT, DPT and MPT in fish from each lake.

Lake	TBT	DBT	MBT	TPT	DPT	MPT
Bjørnsund	0.09	0.23	0.11	0.12	0.03	0.12
Eikeren	0.34	1.17	0.24	14.00	2.41	0.27
Fjellgardsvatnet	0.09	1.08	0.11	0.01	0.01	0.19
Forolsjøen	0.13	1.69	0.27	0.03	0.01	0.16
Gjende	0.14	0.26	0.12	0.16	0.02	0.09
Grungstadsvatnet	0.23	0.35	0.08	0.09	0.03	0.11
Kapervatnet	0.22	0.34	0.07	0.01	0.03	0.17
Nystølsvatnet	0.10	0.30	0.08	0.03	0.01	0.16
Randsfjorden	0.88	1.89	0.37	2.47	0.54	0.14
Tangenfossen	0.06	0.34	0.39	0.12	0.03	0.08
Tinnsjå	0.24	1.27	0.56	0.28	0.12	0.10
Tyrifjorden	2.72	3.21	0.71	3.60	1.09	0.71
Ytre Fiskelausvatnet	0.41	0.43	0.10	0.08	0.03	0.21

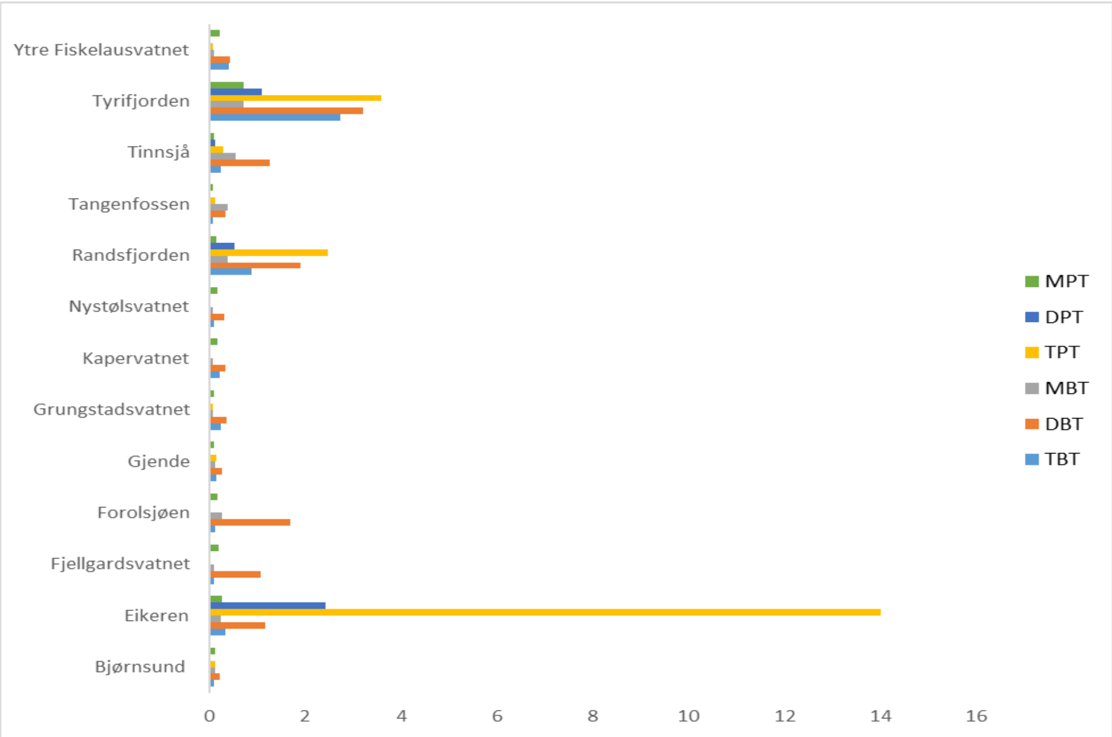

Figure 10: Mean wet weight concentrations (µg/kg) of organotins in fish from each lake.

3.1.9 Siloxane, Triclosan, Dicofol and Short-Chain (SCCPs) and Medium-Chain (MCCPs) Chlorinated Paraffins

The mean wet weight concentrations of siloxane, triclosan, dicofol and short-chain (SCCPs) and medium-chain (MCCPs) chlorinated paraffins in fish from each lake are given in table 15 and figure 11.

The highest level of siloxane (D5) was detected in Lake Eikeren (10.58 µg/kg ww) followed by Lake Tyrifjorden (6.65 µg/kg ww) and Lake Ytre Fiskelausvatnet (5.81 µg/kg ww).

The levels of D5 were lower than EQS in fish from all the lakes.

The highest level of triclosan was detected in Lake Kapervatnet (3.55 µg/kg ww) followed by Lake Fjellgardsvatnet (3.03 µg/kg ww) and Lake Forolsjøen (2.29 µg/kg ww).

The levels of Triclosan did not exceed the EQSs.

The highest level of dicofol was detected in Lake Gjende (2.13 µg/kg ww) followed by Lake Nystølsvatnet (0.97 µg/kg ww) and Lake Eikeren (0.93 µg/kg ww).

The levels of Dicofol did not exceed the EQSs.

The levels of SCCPs and MCCPs ranged from 0.73 to 8.35 µg/kg and from 1.11 to 9.88 µg/kg for SCCPs and MCCPs, respectively, which are much lower than the EQS for SCCPs (6000 µg/kg) and MCCPs (170 µg/kg), indicating that these chemicals did not exceed the EQS for biota. The highest levels of both groups of chlorinated paraffins were detected in Lake Eikeren, followed by Lake Bjørnsund.

The levels of SCCP and MCCP in the samples from the present study were lower than the corresponding levels in freshwater fish in the same program from 2017. Analyses of SCCP and MCCP from large Norwegian lakes (Fjeld et al. 2014), show that the detected levels of these contaminants in freshwater fish are within the same range as the present study. In the marine environment, the levels in cod liver appear to be clearly higher than in freshwater fish (Green et al. 2018)

Table 15: Mean wet weight concentrations (µg/kg) of D5, TCS, dicofol, SCCPs and MCCPs. Under the detection limit=not detected (nd).

Lake	Siloxane (D5)	Triclosan (TCS)	Dicofol	SCCPs	MCCPs
Bjørnsund	4.76	1.16	0.75	5.66	7.97
Eikeren	10.58	0.18	0.93	8.35	9.88
Fjellgardsvatnet	4.69	3.03	ND	1.72	4.21
Forolsjøen	3.34	2.29	ND	0.73	1.11
Gjende	3.56	1.27	2.13	2.00	6.68
Grungstadsvatnet	3.45	0.54	ND	1.93	3.57
Kapervatnet	3.08	3.55	ND	3.35	6.47
Nystølsvatnet	4.92	0.57	0.97	2.00	4.98
Randsfjorden	3.30	ND	0.62	0.71	1.86
Tangenfossen	4.16	0.12	ND	1.03	2.33
Tinnsjå	4.11	ND	0.35	1.98	4.37
Tyrifjorden	6.65	0.37	ND	0.98	2.01
Ytre Fiskelausvatnet	5.81	ND	0.29	1.47	2.73

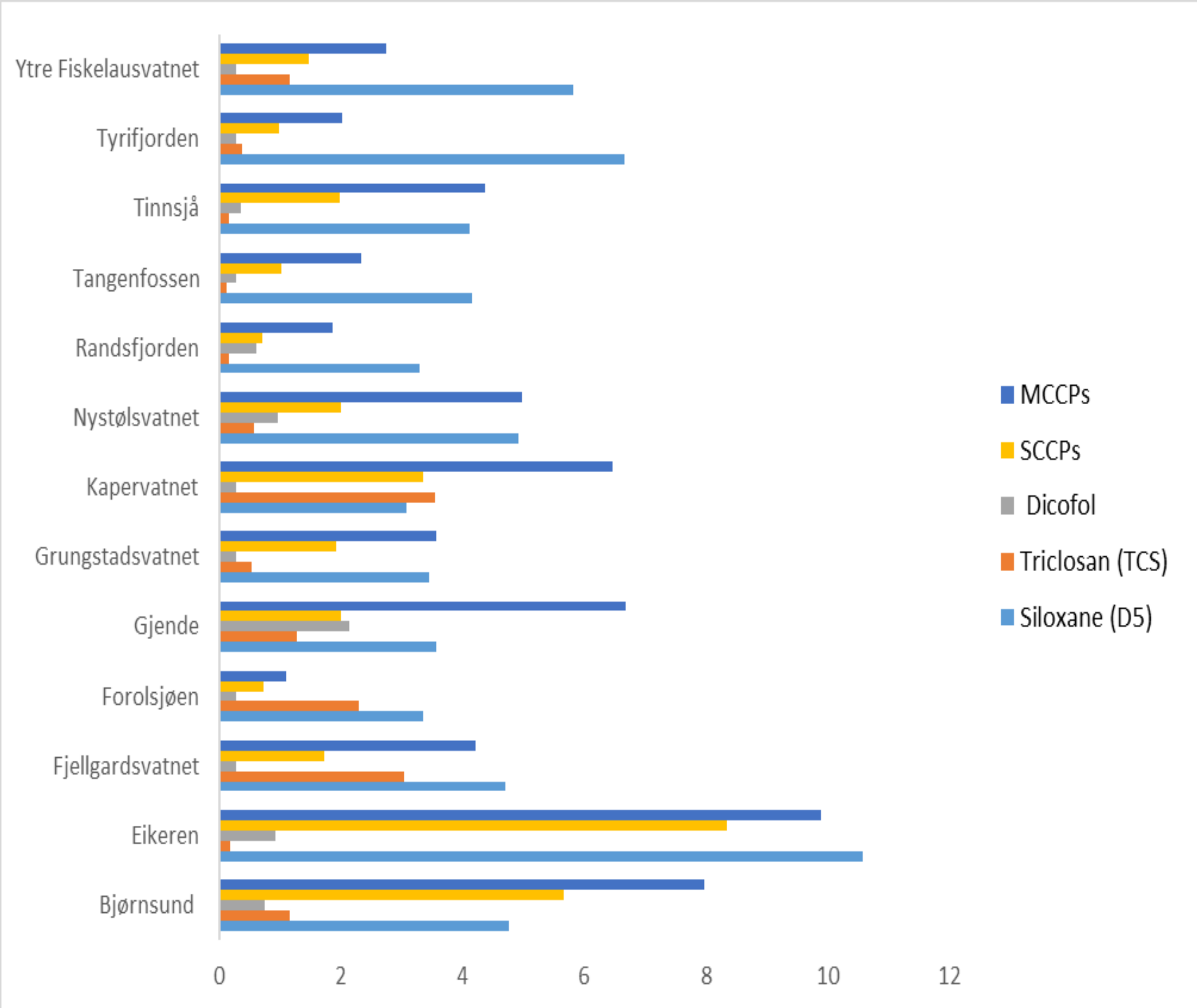

Figure 11: Mean wet weight concentrations (µg/kg) of D5, TCS, Dicofol, SCCPs and MCCPs

3.1.10 Hexachlorobutadien (HCBD), Trichlorobenzene (TCBs), Pentachlorophenol (PCP) and TCEP (tris(2-kloretyl)fosfat)

The mean wet weight concentrations of Hexachlorobutadien (HCBD), Trichlorobenzene (TCBs). Pentachlorophenol (PCP) and TCEP (tris(2-kloretyl)fosfat) in fish from each lake are given in table 16 and figure 12.

The highest level of HCBD was detected in Lake Ytre Fiskelausvatnet (0.07 µg/kg ww) followed by Lake Bjørnsund (0.05 µg/kg ww) and Lake Nystølsvatnet (0.05 µg/kg ww).

PCP was under the detection in all lakes except for Lake Gjende (0.04 µg/kg ww).

The highest levels of TCBs was detected in Lake Randsfjorden (0.6 µg/kg ww) and Lake Tinnsjå (0.6 µg/kg ww).

The highest level of TCEP was detected in Lake Eikeres (3.4 µg/kg ww) followed by Lake Ytre Fiskelausvatnet (1.7 µg/kg ww) and Lake Randsfjorden (1.5 µg/kg ww).

The levels of HBCD, TCBs, PCP and TCEP in fish were lower than the EQSs for these contaminants in all the lakes.

Table 16: Mean wet weight concentration (µg/kg) of HBCD, TCBs, PCP and TCEP in fish from each lake.

Lake	HCBD	TCBs	PCP	TCEP
Bjørnsund	0.05	0.05	ND	0.79
Eikeren	0.04	0.05	ND	3.40
Fjellgardsvatnet	0.03	0.03	ND	0.42
Forolsjøen	0.04	0.05	ND	0.59
Gjende	0.03	0.05	0.04	0.65
Grungstadsvatnet	0.02	0.03	ND	0.18
Kapervatnet	0.03	0.03	ND	0.12
Nystølsvatnet	0.05	0.03	ND	0.91
Randsfjorden	0.04	0.06	ND	1.46
Tangenfossen	0.03	0.04	ND	0.19
Tinnsjå	0.04	0.06	ND	0.67
Tyrifjorden	0.03	0.04	ND	0.35
Ytre Fiskelausvatnet	0.07	0.04	ND	1.67

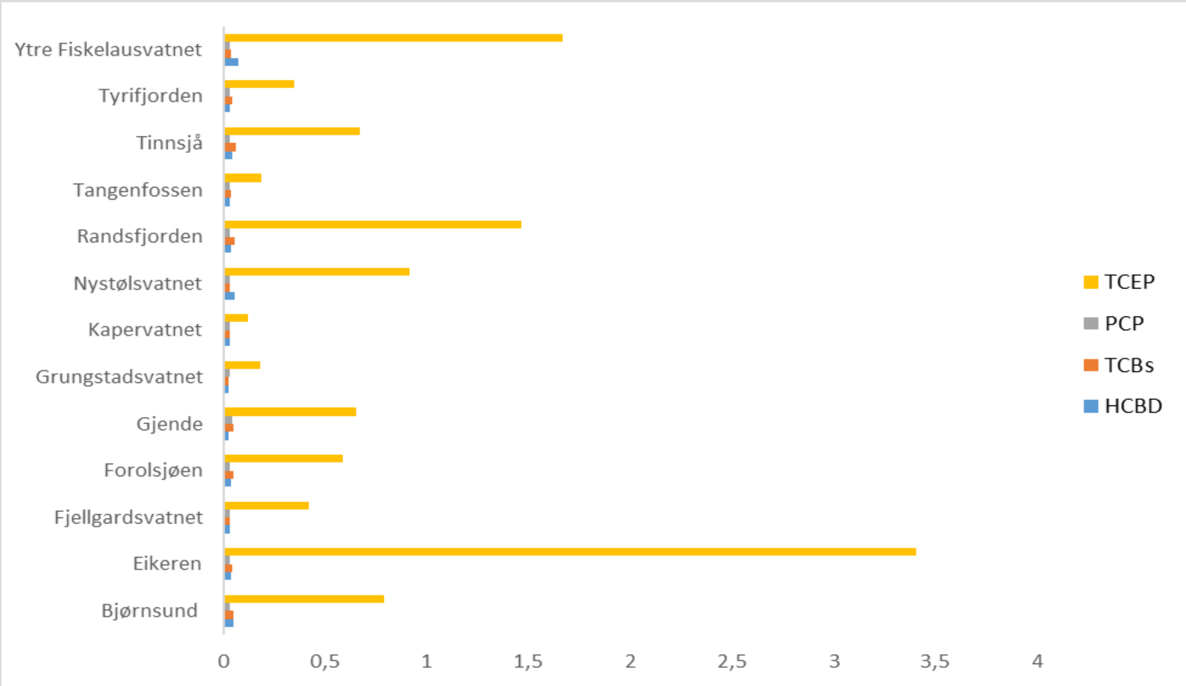

Figure 12: Mean wet weight concentration (µg/kg) of HBCD, TCBs, PCP and TCEP in fish from each lake.

3.1.11 Bis (2-etylheksyl) phthalate (DEHP)

The mean wet weight concentrations of Bis (2-etylheksyl) phthalate (DEHP) in fish from each lake are given in table 17 and figure 13 and the lipid weight concentrations of DEHP are given in table 17.

The levels of DEHP were under the detection limit for all the lakes exept for Gjende (31 µg/kg ww).

The levels of DEHP in fish were lower than the EQSs for these contaminants in all the lakes.

Table 17: Mean wet weight (ww) and lipid weight (lw) concentrations (µg/kg) of DEHP in fish from each lake.

Lake	DEHP
Bjørnsund	ND
Eikeren	ND
Fjellgardsvatnet	ND
Forolsjøen	ND
Gjende	31.45
Grungstadsvatnet	ND
Kapervatnet	ND
Nystølsvatnet	ND
Randsfjorden	ND
Tangenfossen	ND
Tinnsjå	ND
Tyrifjorden	ND
Ytre Fiskelausvatnet	ND

3.1.12 **Metals**

The mean wet weight concentrations of Aluminum (Al) Magnesium (Mg), Iron (Fe), Copper (Cu), Zinc (Zn) and Selenium (Se) in fish from each lake are given in table 18 and figure 13. The mean wet weight concentrations of Silver (Ag), Chromium (Cr) Molybdenum (Mo), Cobalt (Co), Lithium (Li), Nickel (Ni) and Vanadium (V) are given in table 19 and figure 14 and the mean wet weight concentrations of Lead (Pb) Arsenic (As), Cadmium (Cd), Mercury (Hg) in liver and Hg in muscle are given in table 20 and figure 15.

The levels of Hg in muscle were highest in Lake Eikeren (760 µg/kg ww) followed by Lake Randsfjorden (320µg/kg ww) and Lake Tyrifjorden (310 µg/kg ww).

The levels of Cd in liver was highest in Lake Fjellgardsvatnet (1833 µg/kg ww) followed by Lake Nystølsvatnet (887 µg/kg ww) and Lake Kapervatnet (840 µg/kg ww).

The levels of Hg in fish muscle exceeded the EQS in all the lakes.

EU has not established an EQS for Cd in biota. However, the high levels of Cd detected Lake Fjellgardsvatnet, Lake Nystølsvatnet and Lake Kapervatnet, suggest that these lakes are polluted from local sources.

Table 18: Mean wet weight concentration (µg/kg) of Mg, Fe, Cu, Zn and Se in fish from each lake

Lake	Al	Mg	Fe	Cu	Zn	Se
Bjørnsund	2525	175000	135250	7925	32250	1008
Eikeren	530	153333	90000	9000	47333	2367
Fjellgardsvatnet	3100	186667	163333	170000	50333	15500
Forolsjøen	5105	175000	115000	40500	45500	4950
Gjende	45067	200000	236667	193333	45667	9467
Grungstadsvatnet	830	240000	68000	52000	50000	3600
Kapervatnet	4900	140000	310000	1000000	41000	110000
Nystølsvatnet	8267	190000	186667	51333	47000	16333
Randsfjorden	4067	170000	173333	3700	27000	1027
Tangenfossen	790	140000	34000	1400	17000	790
Tinnsjå	4973	223333	120000	34667	53000	3600
Tyrifjorden	9367	216667	122000	4467	29667	963
Ytre Fiskelausvatnet	9340	201667	232167	52717	32833	3150

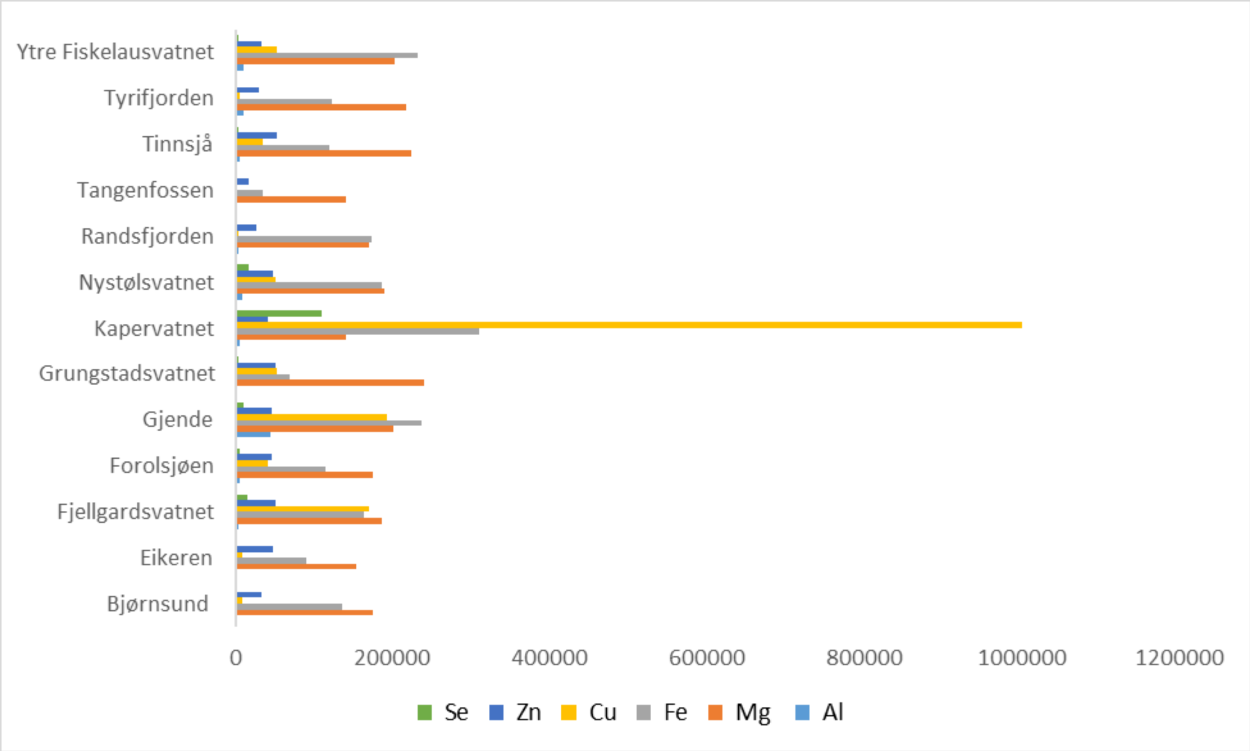

Figure 13: Mean wet weight concentration (µg/kg) of Mg, Fe, Cu, Zn and Se in fish from each lake.

Table 19: Mean wet weight concentration (µg/kg) of Al, Ag, Mo, V, Ni and Co in fish from each lake.

Lake	Ag	Cr	Co	Li	Mo	Ni	V
Bjørnsund	21	28	243	ND	101	265	63
Eikeren	387	ND	18	ND	140	ND	10
Fjellgardsvatnet	5467	ND	100	ND	173	24	23
Forolsjøen	845	25	185	ND	145	74	16
Gjende	710	102	108	ND	170	54	270
Grungstadsvatnet	780	36	19	ND	98	ND	26
Kapervatnet	8400	ND	350	ND	230	59	70
Nystølsvatnet	2533	ND	54	ND	170	ND	59
Randsfjorden	6	ND	383	9	143	ND	23
Tangenfossen	13	ND	95	ND	80	ND	16
Tinnsjå	1073	ND	32	ND	157	ND	12
Tyrifjorden	11	ND	337	13	127	42	54

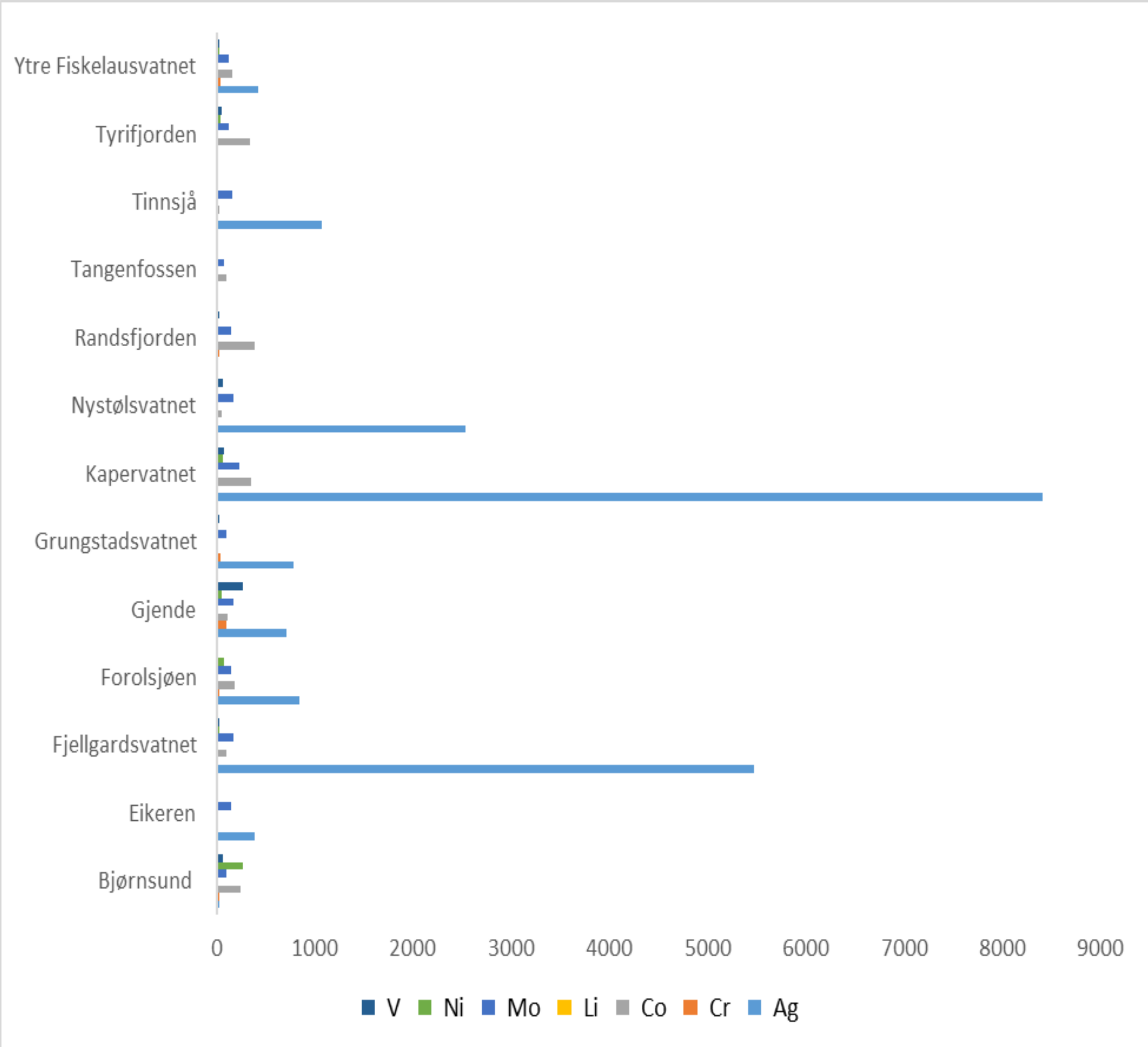

Figure 14: Mean wet weight concentration (µg/kg) of Al, Ag, Mo, V, Ni and Co in fish from each lake.

Table 20: Mean wet weight concentration (µg/kg) of As, Cd, Pb, Hg in liver and Hg muscle in fish from each lake.

Lake	As	Cd	Pb	Hg liver	Hg muscle
Bjørnsund	130	430	13	68	144
Eikeren	113	253	3	1533	760
Fjellgardsvatnet	35	1833	167	120	123
Forolsjøen	40	86	8	42	37
Gjende	13	323	11	103	113
Grungstadsvatnet	160	88	3	220	150
Kapervatnet	45	840	28	250	64
Nystølsvatnet	8	887	183	120	88
Randsfjorden	257	743	18	183	320
Tangenfossen	44	84	4	60	87
Tinnsjå	18	610	14	217	170
Tyrifjorden	150	703	14	246	310
Ytre Fiskelausvatnet	58	107	8	70	58

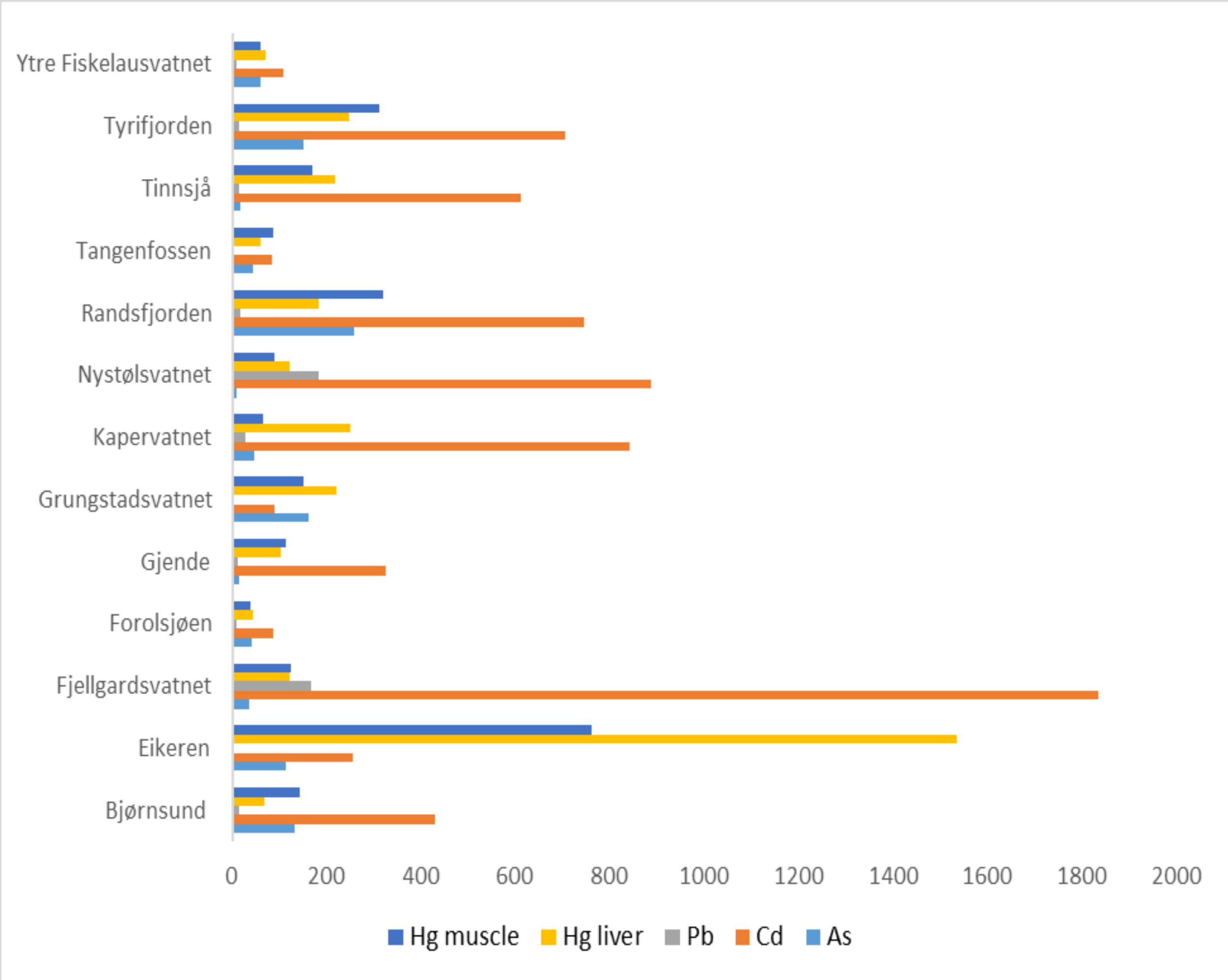

Figure 15: Mean wet weight concentration (µg/kg) of As, Cd, Pb, Hg in liver and Hg in muscle in fish from each lake.

4. Levels of environmental contaminants in fish compared to environmental quality standards (EQS)

Table 21- 32: Levels of individual chemicals and groups of pollutants given in µg / kg wet weight and environmental quality standards (EQS) for these chemicals given in µg / kg wet weight (except for dioxins and dioxin-like PCBs which are given on pg/gTEQ). **All the contaminants were analyzed in the fish liver except for Hg, which was analyzed in fish muscle and liver.** Red numbers indicate exceedance of EQS.

Table 20: Lake Bjørnsund water code: 246-97067 L

Chemical(s) Species: Perch/Whitefish Tissue: Liver **Fish weight (mean): 467 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.02
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	5.66
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	7.97
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	ND
Decmethylcyclosiloxane (D5)	541-02-6	15217	4.76
Endosulfan	115-29-7	370	0.01
Hexachlorobutadien (HBCD)	87-68-3	55	0.05
HCB	A 118-74-1	10	0.27
Naphthalene	91-20-3	2400	1.07
Pentachlorophenol (PCP)	87-86-5	180	ND
Benzo[a]pyrene	50-32-8	5	ND
Tributyltin (TBT)	36643-28-4	150	0.09
Trichlorobenzene (TCBs)	12002-48-1	490	0.05
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.79
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	0.09
PCB7	1336-36-3	0.6	5.65
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.36
PBDE	A 32534-81-9	0.0085	0.07
HBCDD	134237-51-7	167	0.02
PFOA	3825-261	91.3	ND
PFOS	1763-21-1	9.1	3.05
p-nonylphenol	A 84852-15-3	3000	34.98
4-tert- octylphenol	140-66-9	0.004	0.70
Hg (muscle)	A 7439-97-6	20	144
Triclosan	3380-34-5	15217	1.16
Dicofol	115-32-2	33	0.75
Heptachlor	1024-57-3	0.0067	0.46

Table 22: Lake Eikeren, water code: 012-542-2 L

Chemical(s) Species: Trout Tissue: Liver **Fish weight (mean): 1036 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.28
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	8.35
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	9.88
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	ND
Decmethylcyclosiloxane (D5)	541-02-6	15217	10.58
Endosulfan	115-29-7	370	0.10
Hexachlorobutadien (HBCD)	87-68-3	55	0.04
HCB	A 118-74-1	10	0.87
Naphthalene	91-20-3	2400	0.95
Pentachlorophenol (PCP)	87-86-5	180	ND
Benzo[a]pyrene	50-32-8	5	ND
Tributyltin (TBT)	36643-28-4	150	0.34
Trichlorobenzene (TCBs)	12002-48-1	490	0.05
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	3.40
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	0.34
PCB7	1336-36-3	0.6	32.32
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	6.91
PBDE	A 32534-81-9	0.0085	7.93
HBCDD	134237-51-7	167	3.08
PFOA	3825-261	91.3	ND
PFOS	1763-21-1	9.1	31.00
p-nonylphenol	A 84852-15-3	3000	ND
4-tert- octylphenol	140-66-9	0.004	ND
Hg (muscle)	A 7439-97-6	20	760
Triclosan	3380-34-5	15217	0.18
Dicofol	115-32-2	33	0.93
Heptachlor	1024-57-3	0.0067	0.19

Table 23: Lake Fjellgardsvatnet, water code: 038-3034 L

Chemical(s) Species: Trout Tissue: Liver **Fish weight (mean):** 195 **g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.03
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	1.72
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	4.21
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	ND
Decmethylcyclosiloxane (D5)	541-02-6	15217	4.69
Endosulfan	115-29-7	370	ND
Hexachlorobutadien (HBCD)	87-68-3	55	0.03
HCB	A 118-74-1	10	0.20
Naphthalene	91-20-3	2400	1.03
Pentachlorophenol (PCP)	87-86-5	180	ND
Benzo[a]pyrene	50-32-8	5	ND
Tributyltin (TBT)	36643-28-4	150	0.09
Trichlorobenzene (TCBs)	12002-48-1	490	0.03
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.42
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	0.09
PCB7	1336-36-3	0.6	3.27
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.10
PBDE	A 32534-81-9	0.0085	0.51
HBCDD	134237-51-7	167	ND
PFOA	3825-261	91.3	ND
PFOS	1763-21-1	9.1	4.38
p-nonylphenol	A 84852-15-3	3000	ND
4-tert- octylphenol	140-66-9	0.004	ND
Hg (muscle)	A 7439-97-6	20	123
Triclosan	3380-34-5	15217	3.03
Dicofol	115-32-2	33	ND
Heptachlor	1024-57-3	0.0067	ND

Table 24: Lake Forolsjøen, water code: 122-876 L

Chemical(s) Species: Trout Tissue: Liver **Fish weight (mean): 461 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.02
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	0.73
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	1.11
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	ND
Decmethylcyclosiloxane (D5)	541-02-6	15217	3.34
Endosulfan	115-29-7	370	ND
Hexachlorobutadien (HBCD)	87-68-3	55	0.04
HCB	A 118-74-1	10	0.39
Naphthalene	91-20-3	2400	1.09
Pentachlorophenol (PCP)	87-86-5	180	ND
Benzo[a]pyrene	50-32-8	5	ND
Tributyltin (TBT)	36643-28-4	150	0.13
Trichlorobenzene (TCBs)	12002-48-1	490	0.05
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.59
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	0.13
PCB7	1336-36-3	0.6	2.04
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.06
PBDE	A 32534-81-9	0.0085	ND
HBCDD	134237-51-7	167	ND
PFOA	3825-261	91.3	1.62
PFOS	1763-21-1	9.1	5.21
p-nonylphenol	A 84852-15-3	3000	ND
4-tert- octylphenol	140-66-9	0.004	ND
Hg (muscle)	A 7439-97-6	20	37
Triclosan	3380-34-5	15217	2.29
Dicofol	115-32-2	33	ND
Heptachlor	1024-57-3	0.0067	0.06

Table 25: Lake Gjende, water code: 002-147L

Chemical(s) Species: Trout Tissue: Liver **Fish weight (mean): 331 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.08
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	2.00
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	6.68
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	31.45
Decmethylcyclosiloxane (D5)	541-02-6	15217	3.56
Endosulfan	115-29-7	370	0.08
Hexachlorobutadien (HBCD)	87-68-3	55	0.03
HCB	A 118-74-1	10	0.61
Naphthalene	91-20-3	2400	3.61
Pentachlorophenol (PCP)	87-86-5	180	0.04
Benzo[a]pyrene	50-32-8	5	ND
Tributyltin (TBT)	36643-28-4	150	0.14
Trichlorobenzene (TCBs)	12002-48-1	490	0.05
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.65
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	0.14
PCB7	1336-36-3	0.6	20.84
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	3.40
PBDE	A 32534-81-9	0.0085	2.51
HBCDD	134237-51-7	167	1.94
PFOA	3825-261	91.3	ND
PFOS	1763-21-1	9.1	1.91
p-nonylphenol	A 84852-15-3	3000	ND
4-tert- octylphenol	140-66-9	0.004	0.20
Hg (muscle)	A 7439-97-6	20	113
Triclosan	3380-34-5	15217	1.27
Dicofol	115-32-2	33	2.13
Heptachlor	1024-57-3	0.0067	0.21

Table 26: Lake Grungstadsvatnet, water code: 139-704 L

Chemical(s) Species: Trout Tissue: Liver **Fish weight (mean): 459 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.02
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	1.93
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	3.57
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	ND
Decmethylcyclosiloxane (D5)	541-02-6	15217	3.45
Endosulfan	115-29-7	370	ND
Hexachlorobutadien (HBCD)	87-68-3	55	0.02
HCB	A 118-74-1	10	0.31
Naphthalene	91-20-3	2400	0.63
Pentachlorophenol (PCP)	87-86-5	180	ND
Benzo[a]pyrene	50-32-8	5	ND
Tributyltin (TBT)	36643-28-4	150	0.23
Trichlorobenzene (TCBs)	12002-48-1	490	0.03
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.18
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	0.23
PCB7	1336-36-3	0.6	3.61
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	3.61
PBDE	A 32534-81-9	0.0085	0.13
HBCDD	134237-51-7	167	ND
PFOA	3825-261	91.3	ND
PFOS	1763-21-1	9.1	2.40
p-nonylphenol	A 84852-15-3	3000	ND
4-tert- octylphenol	140-66-9	0.004	ND
Hg (muscle)	A 7439-97-6	20	150
Triclosan	3380-34-5	15217	0.54
Dicofol	115-32-2	33	ND
Heptachlor	1024-57-3	0.0067	ND

Table 27: Lake Kapervatnet, water code: 194-2380

Chemical(s) Species: Trout Tissue: Liver **Fish weight (mean): 404 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.02
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	3.35
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	6.47
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	ND
Decmethylcyclosiloxane (D5)	541-02-6	15217	3.08
Endosulfan	115-29-7	370	0.05
Hexachlorobutadien (HBCD)	87-68-3	55	0.03
HCB	A 118-74-1	10	0.18
Naphthalene	91-20-3	2400	2.60
Pentachlorophenol (PCP)	87-86-5	180	ND
Benzo[a]pyrene	50-32-8	5	ND
Tributyltin (TBT)	36643-28-4	150	0.22
Trichlorobenzene (TCBs)	12002-48-1	490	0.03
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.12
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	0.22
PCB7	1336-36-3	0.6	2.58
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.57
PBDE	A 32534-81-9	0.0085	ND
HBCDD	134237-51-7	167	ND
PFOA	3825-261	91.3	ND
PFOS	1763-21-1	9.1	5.42
p-nonylphenol	A 84852-15-3	3000	5.60
4-tert- octylphenol	140-66-9	0.004	1.89
Hg (muscle)	A 7439-97-6	20	64
Triclosan	3380-34-5	15217	3.55
Dicofol	115-32-2	33	ND
Heptachlor	1024-57-3	0.0067	0.24

Table 28: Lake Nystølsvatnet, water code: 083-1651

Chemical(s) Species: Trout Tissue: Liver **Fish weight (mean): 315 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.02
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	2.00
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	4.98
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	ND
Decmethylcyclosiloxane (D5)	541-02-6	15217	4.92
Endosulfan	115-29-7	370	0.02
Hexachlorobutadien (HBCD)	87-68-3	55	0.05
HCB	A 118-74-1	10	0.59
Naphthalene	91-20-3	2400	1.05
Pentachlorophenol (PCP)	87-86-5	180	ND
Benzo[a]pyrene	50-32-8	5	ND
Tributyltin (TBT)	36643-28-4	150	0.10
Trichlorobenzene (TCBs)	12002-48-1	490	0.03
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.91
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	0.10
PCB7	1336-36-3	0.6	3.86
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.57
PBDE	A 32534-81-9	0.0085	0.16
HBCDD	134237-51-7	167	0.02
PFOA	3825-261	91.3	ND
PFOS	1763-21-1	9.1	2.10
p-nonylphenol	A 84852-15-3	3000	ND
4-tert- octylphenol	140-66-9	0.004	ND
Hg (muscle)	A 7439-97-6	20	88
Triclosan	3380-34-5	15217	0.57
Dicofol	115-32-2	33	0.97
Heptachlor	1024-57-3	0.0067	0.02

Table 29: Lake Randsfjorden, water code: 012-523 L

Chemical(s) Speciest: Perch Tissue: Liver **Fish weight (mean): 355 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.01
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	0.71
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	1.86
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	ND
Decmethylcyclosiloxane (D5)	541-02-6	15217	3.30
Endosulfan	115-29-7	370	0.02
Hexachlorobutadien (HBCD)	87-68-3	55	0.04
HCB	A 118-74-1	10	0.24
Naphthalene	91-20-3	2400	1.20
Pentachlorophenol (PCP)	87-86-5	180	ND
Benzo[a]pyrene	50-32-8	5	ND
Tributyltin (TBT)	36643-28-4	150	0.88
Trichlorobenzene (TCBs)	12002-48-1	490	0.06
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	1.46
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	0.88
PCB7	1336-36-3	0.6	5.61
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.57
PBDE	A 32534-81-9	0.0085	0.47
HBCDD	134237-51-7	167	0.14
PFOA	3825-261	91.3	ND
PFOS	1763-21-1	9.1	11.92
p-nonylphenol	A 84852-15-3	3000	ND
4-tert- octylphenol	140-66-9	0.004	0.86
Hg (muscle)	A 7439-97-6	20	320
Triclosan	3380-34-5	15217	ND
Dicofol	115-32-2	33	0.62
Heptachlor	1024-57-3	0.0067	0.16

Table 30: Lake Tangenfossen, water code: 246-65299 L

Chemical(s) Species: Perch Tissue: Liver **Fish weight (mean): 422 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.03
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	1.03
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	2.33
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	ND
Decmethylcyclosiloxane (D5)	541-02-6	15217	4.16
Endosulfan	115-29-7	370	ND
Hexachlorobutadien (HBCD)	87-68-3	55	0.03
HCB	A 118-74-1	10	0.42
Naphthalene	91-20-3	2400	0.94
Pentachlorophenol (PCP)	87-86-5	180	ND
Benzo[a]pyrene	50-32-8	5	ND
Tributyltin (TBT)	36643-28-4	150	0.06
Trichlorobenzene (TCBs)	12002-48-1	490	0.04
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.19
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	0.06
PCB7	1336-36-3	0.6	2.69
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	1.00
PBDE	A 32534-81-9	0.0085	ND
HBCDD	134237-51-7	167	ND
PFOA	3825-261	91.3	ND
PFOS	1763-21-1	9.1	0.95
p-nonylphenol	A 84852-15-3	3000	3.53
4-tert- octylphenol	140-66-9	0.004	ND
Hg (muscle)	A 7439-97-6	20	87
Triclosan	3380-34-5	15217	0.12
Dicofol	115-32-2	33	ND
Heptachlor	1024-57-3	0.0067	ND

Table 31: Lake Tinnsjå, water code: 016-2 L

Chemical(s) Species: Trout Tissue: Liver **Fish weight (mean): 329 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.08
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	1.98
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	4.37
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	ND
Decmethylcyclosiloxane (D5)	541-02-6	15217	4.11
Endosulfan	115-29-7	370	0.04
Hexachlorobutadien (HBCD)	87-68-3	55	0.04
HCB	A 118-74-1	10	0.32
Naphthalene	91-20-3	2400	3.08
Pentachlorophenol (PCP)	87-86-5	180	ND
Benzo[a]pyrene	50-32-8	5	ND
Tributyltin (TBT)	36643-28-4	150	0.24
Trichlorobenzene (TCBs)	12002-48-1	490	0.06
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.67
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	0.24
PCB7	1336-36-3	0.6	6.78
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.77
PBDE	A 32534-81-9	0.0085	0.19
HBCDD	134237-51-7	167	0.08
PFOA	3825-261	91.3	ND
PFOS	1763-21-1	9.1	5.00
p-nonylphenol	A 84852-15-3	3000	ND
4-tert- octylphenol	140-66-9	0.004	0.22
Hg (muscle)	A 7439-97-6	20	170
Triclosan	3380-34-5	15217	ND
Dicofol	115-32-2	33	0.35
Heptachlor	1024-57-3	0.0067	0.03

Table 32: Lake Tyrifjorden, water code: 012-522-2 L

Chemical(s) Species: Perch Tissue: Liver **Fish weight (mean): 504 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.01
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	0.98
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	2.01
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	ND
Decmethylcyclosiloxane (D5)	541-02-6	15217	6.65
Endosulfan	115-29-7	370	0.07
Hexachlorobutadien (HBCD)	87-68-3	55	0.03
HCB	A 118-74-1	10	0.39
Naphthalene	91-20-3	2400	1.08
Pentachlorophenol (PCP)	87-86-5	180	ND
Benzo[a]pyrene	50-32-8	5	ND
Tributyltin (TBT)	36643-28-4	150	2.72
Trichlorobenzene (TCBs)	12002-48-1	490	0.04
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.35
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	2.72
PCB7	1336-36-3	0.6	4.35
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	1.01
PBDE	A 32534-81-9	0.0085	0.56
HBCDD	134237-51-7	167	0.60
PFOA	3825-261	91.3	ND
PFOS	1763-21-1	9.1	267
p-nonylphenol	A 84852-15-3	3000	ND
4-tert- octylphenol	140-66-9	0.004	5.03
Hg (muscle)	A 7439-97-6	20	310
Triclosan	3380-34-5	15217	0.37
Dicofol	115-32-2	33	ND
Heptachlor	1024-57-3	0.0067	0.17

Table 33: Lake Ytre Fiskelausvatnet, water code: 196-2417 L

Chemical(s) Species: Trout Tissue: Liver **Fish weight (mean): 414 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.02
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	1.47
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	2.73
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	ND
Decmethylcyclosiloxane (D5)	541-02-6	15217	5.81
Endosulfan	115-29-7	370	0.01
Hexachlorobutadien (HBCD)	87-68-3	55	0.07
HCB	A 118-74-1	10	0.35
Naphthalene	91-20-3	2400	1.48
Pentachlorophenol (PCP)	87-86-5	180	ND
Benzo[a]pyrene	50-32-8	5	ND
Tributyltin (TBT)	36643-28-4	150	0.41
Trichlorobenzene (TCBs)	12002-48-1	490	0.04
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	1.67
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	0.41
PCB7	1336-36-3	0.6	2.46
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.13
PBDE	A 32534-81-9	0.0085	ND
HBCDD	134237-51-7	167	ND
PFOA	3825-261	91.3	0.99
PFOS	1763-21-1	9.1	1.90
p-nonylphenol	A 84852-15-3	3000	2.24
4-tert- octylphenol	140-66-9	0.004	ND
Hg (muscle)	A 7439-97-6	20	58
Triclosan	3380-34-5	15217	ND
Dicofol	115-32-2	33	0.29
Heptachlor	1024-57-3	0.0067	ND

5. Discussion

The levels of environmental pollutants measured in fish liver from 13 Norwegian lakes sampled in 2019, were compared with environmental quality standards (EQS) set by EU (table 21-34). The wet weight concentrations of PCB7 in fish liver exceed EQS in all lakes and PBDEs exceeded EQS in 9 of the 13 lakes. Fish in Lake Forolsjøen. Lake Kapervatnet, Lake Tangenfossen and Lake Ytre Fiskelausvatnet had levels of PCBs below the EQS for PBDEs. In a time trend study from Swedish lakes, the levels of PCB 153 around 2015 were around 10 ng/g lipid w in arctic char, 20-40 ng/g in perch, and 100-200 ng/g in pike (Faxneld et al 2019). This is higher than the corresponding levels in many of the lakes from the present study. Fish from some lakes, such as Gjende and Eikeren, had relatively high levels of PCBs. For Eikeren this could be a result of large fish size, while Gjende had a more medium size. For both these lakes, it can be seen that also DDE and PBDEs are relatively high in these lakes. It seems unlikely that local sources from all three contaminant groups are present at these two lakes. A more reasonable explanation is that lipid soluble contaminants are up-concentrated in an efficient way in the lakes. In a German study published in 2018. PBDEs exceeded the EQS in all fish (Fliedner et al., 2018). The German fish contained levels, which were about four times higher than the mean levels in Norwegian fish. In the same study, they analyzed fish from River Danube in the vicinity of industrial activity, which may explain the higher levels than in this Norwegian survey. Studies from Germany (Fliedner et al. 2016), Italy (Squadrone et al., 2013) and Spain (Bordajandi et al., 2003; Vives et al., 2005) show that the levels of PCB also exceed EU's EQS in these countries. The German study, published in 2018, and therefore most comparable with the present study, measured levels, which exceeded environmental quality standard for PCB7 in all fish.

EU has established EQS for the organochlorine pesticides, endosulfan, HCB and heptachlor. The EU EQSs for heptachlor (0.0067 µg/kg ww) were exceeded in fish liver from 9 lakes. Furthermore, the limit of detection for heptachlor was higher than the EQS indicating that the levels in the other lakes could also be higher than the EQS. Relatively high levels of Heptachlor were detected in Lake Bjørnsund (24 µg/kg). This lake is in Finnmark near the Russian border not far from Nickel. However, it cannot be determined whether the increased levels of heptachlor originate from Russia. Heptachlor was one of the original POPs listed in the Stockholm Convention (chm.pops.int). Primarily it was used to kill soil insects and termites, heptachlor has also been used more widely to kill cotton insects, grasshoppers, other crop pests, and malaria-carrying mosquitoes. Therefore, high levels of this insecticide is unexpected at Lake Bjørnesjøen, since the industrial production at Nickel is unlikely to include heptachlor. Available data on levels of Heptachlor in Norwegian biota is scarce. However one study measured heptachlor levels in perch, roach and pike livers from Lake Årungen (Sharma et al., 2010) and the wet weight levels in perch and roach livers were under the detection limit, whereas the levels in pike (0.60 ng/g; mean weight 1.6 kg) were comparable to the levels in white fish from Lake Bjørnsund (0.46 ng/g ; weight 0.5 kg) and Lake Kapervatnet (0.24 ng/g; weight 0.4 kg). However, because the concentration of persistent pollutants like heptachlor in fish, depend on age, weight and species, it may be imprecise to assess exposure levels in the two lakes by comparing between pike with mean weight 1.5 kg from one lake with Roach with mean weight 0.5 kg from the other lake. When comparing the levels in roach from Lake Årungen (not detected)) with the levels in white fish from Lake Bjørnsund (0.46 ng/g) and Lake Kapervatnet (0.24 ng/g), it is apparent that the heptachlor contamination in these lakes are substantial higher than in Lake Årungen.

The EQS for mercury were exceeded in all lakes. The same trend was found in a study analyzing mercury levels in fish from all over Europe every year from 2007 to 2013 (Nguetseng et al., 2015). Except for one lake, the Hg levels exceeded the EQS in all lakes and the highest level measured was 251 µg/kg (wet weight), which is over 12 times the EQS (Nguetseng et al., 2015). However, three of the Norwegian lakes had higher values in muscle than the highest level measured in the European survey and the highest level measured was 760 µg/kg ww (Lake Eikeren). The mean concentration of Hg (mean 190 µg/kg ww) measured in the muscle in this survey was not far from highest concentration measured in the European study from 2015 (Nguetseng et al., 2015). The European study measured Hg in a different fish species (bream; *Abramis brama*) than in the present study (perch, trout, char, whitefish), which may explain the higher Hg in the Norwegian lakes. A Swedish study summarized the mercury levels in perch from freshwater lakes from throughout Scandinavia (Norway, Sweden and Finland), with the aim to compile and evaluate available data for geographical and temporal trends. The study concluded that the levels of Hg are high in Scandinavia and that the Hg levels appear to have increased the last years (Danielsson et al., 2011). The mean concentration of Hg (328 µg/kg ww) in Norwegian lakes measured in fish sampled in 2017 was comparable with the concentration in fish sampled in 2018 but higher than in fish from 2019 (187 µg/kg ww).

EU has not established an EQS for Cd in biota. However, high levels of Cd were detected in fish from Lake Fjellgardsvatenet (1833 µg/kg ww) followed by Lake Nystølsvatnet (887 µg/kg ww), Lake Kapervatnet (840 µg/kg ww) and Lake Tyrifjorden (703 µg/kg ww). The Cd levels in these lakes, which are 5 – 25 times higher than the mean of the other lakes, may indicate local sources of Cd. The mean concentration of Cd measured (537 µg/kg ww) in fish sampled in 2017 was comparable with the concentration measured (541 µg/kg ww) in fish sampled 2018 and 2019 (538 µg/kg ww), whereas the highest concentration (1833 µg/kg ww; Lake Fjellgardsvatnet) measured in 2019 were lower than in 2017 (3066 µg/kg ww; Lake Lundevannet); Miljødirektoratet rapport, 2018) and in 2018 (3500 µg/kg ww; Lake Lyseren).

The mean concentrations of Cd in fish liver from Italian rivers (Squadrone et al., 2013), and from highland lakes in the Czech Republic (Vičarová et al., 2016) were 40 µg/kg ww and 258 µg/kg ww, respectively, which are lower than in the present survey (541 µg/kg ww). The European Union have recommended Minimum Residual Limit Levels (MRLs) for heavy metal residues in fish meat for human consumption. For cadmium, lead, and mercury the MRLs are 0.05, 0.30, and 0.50 mg/kg fish and fish products, respectively. These MRLs are included in the European Commission Regulation (EC) No. 629/2008. Even though the Cd levels in the liver of Norwegian freshwater fish exceeded the MRL (50 µg/kg ww) for human consume, it may not pose any health risk for consumers because fish liver from freshwater fish is not commonly consumed. However, the concentration of Hg in fish muscle from Lake Storbørja (2867 µg/kg ww) exceeded the MRL (500 µg/kg ww), suggesting that eating fish from this lake may pose a health risk for the consumers.

The EQS for 4-tert-octylphenol was exceeded in fish livers from six lakes, while the seven other lakes had levels under the detection limit. The levels of p-nonylphenol were below the EQS in all lakes. The scientific data on levels of octylphenol in fish are scarce. However, an Environmental Risk Evaluation on 4-tert-Octylphenol reported levels between 0.2 µg/kg and 5.5 µg/kg ww in German freshwater fish collected between 1992 and 1997, which are comparable (ND – 5 µg/kg) with the levels in the Norwegian lakes (UKEA. 2006).

For the perfluorinated compounds (PFAS), EU has established EQS only for PFOS. However, Norway have established an EQS for PFOA. This study showed that fish from Lake Tyrifjorden (267 µg/kg ww,) Lake Eikeren (21 µg/kg ww) and Lake Randsfjorden (12 µg/kg ww) had PFOS levels which exceeded the EQS. However, fish from none of the lakes had PFOA levels which exceeded the EQS. The highest PFOS level (267 µg/kg ww) in the Norwegian lakes was between the mean levels measured in two fish species in Germany (123 µg/kg ww and 295 µg/kg ww (Becker et a. 2010)). The German fish were sampled from a highly industrialized area, while the Norwegian Lake Tyrifjorden is polluted with PFOS from a known point source. The fish from the other Norwegian lakes had levels, which were substantial lower than the German fish. Since PFOS was banned in 2009 (listed on Stockholm Convention), a temporal decrease in PFOS may in part explain the higher levels in the German fish sampled before 2010 compared to the Norwegian sampled in 2018 (Fliedner et al., 2016). Compared to the levels in Swedish screening data of PFAS in perch (Åkerblom et al. 2017), the levels in Norwegian freshwater fish seems to be clearly higher.

The levels of dioxin exceeded the dioxin EQS for biota in Lake Eikeren, while none of the other lakes exceeded the EQS. In a German survey, EQS for dioxin was exceeded in fish from about 40% of the sampling locations, suggesting that the dioxin contamination is lower in Norwegian freshwaters compared to German waters (Fliedner et al., 2016).

The fact that the levels of PCBs and mercury exceed EU EQS in all 13 lakes and PBDEs, and octylphenol and PFOS exceeded EQSs in several of the study lakes suggests that concentrations of these substances in Norwegian lakes do not meet the environmental requirements in Europe. However, these results are comparable with results from different European countries, which may indicate an environmental problem across Europe. In order to protect the entire ecosystem (ensuring protection for the most sensitive species), the EU's EQSs are set lower than the European limit values (Minimum Residual Limit Levels (MRLs)) for foodstuffs and animal feed. Even though the Cd levels in the liver of Norwegian freshwater fish exceeded the MRL (50 µg/kg ww) for human consume, it may not pose any health risk for consumers because fish liver from freshwater fish is not commonly consumed. However, the concentration of Hg in fish muscle from Lake Eikeren (760 µg/kg ww) exceeded the MRL (500 µg/kg ww), suggesting that eating fish from this lake may pose a health risk for the consumers.

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7. Attachments, fish data and analytical results

Appendix 1. Species and individual length, weight, lake, water code and capture date of each fish the samples from 1 to 36 analysed in the project from 2019.

Sample	Species	Length (cm)	Weight (g)	Lake	Water code	Capture date
1	Trout	25	140	Gjende	002-147-L	24.09.2019
1	Trout	26	165	Gjende	002-147-L	24.09.2019
1	Trout	26	172	Gjende	002-147-L	24.09.2019
1	Trout	26	173	Gjende	002-147-L	24.09.2019

1	Trout	26	175	Gjende	002-147-L	24.09.2019
1	Trout	26	176	Gjende	002-147-L	24.09.2019
1	Trout	27	190	Gjende	002-147-L	24.09.2019
1	Trout	28	191	Gjende	002-147-L	24.09.2019
1	Trout	28	193	Gjende	002-147-L	24.09.2019
1	Trout	27	195	Gjende	002-147-L	24.09.2019
1	Trout	28	195	Gjende	002-147-L	24.09.2019
1	Trout	28	202	Gjende	002-147-L	24.09.2019
1	Trout	31	258	Gjende	002-147-L	24.09.2019
2	Trout	30	292	Gjende	002-147-L	24.09.2019
2	Trout	31	296	Gjende	002-147-L	24.09.2019
2	Trout	32	350	Gjende	002-147-L	24.09.2019
2	Trout	35	354	Gjende	002-147-L	24.09.2019
2	Trout	36	396	Gjende	002-147-L	24.09.2019
2	Trout	36	420	Gjende	002-147-L	24.09.2019
2	Trout	36	423	Gjende	002-147-L	24.09.2019
3	Trout	38	427	Gjende	002-147-L	24.09.2019
3	Trout	36	428	Gjende	002-147-L	24.09.2019
3	Trout	35	442	Gjende	002-147-L	24.09.2019
3	Trout	38	479	Gjende	002-147-L	24.09.2019
4	Trout	29	224	Tinnsjå	016-2-L	26.08.2019
4	Trout	29	226	Tinnsjå	016-2-L	26.08.2019
4	Trout	29	228	Tinnsjå	016-2-L	26.08.2019
4	Trout	27	233	Tinnsjå	016-2-L	26.08.2019
4	Trout	28	237	Tinnsjå	016-2-L	26.08.2019
4	Trout	29	243	Tinnsjå	016-2-L	26.08.2019
4	Trout	29	244	Tinnsjå	016-2-L	26.08.2019
4	Trout	28	249	Tinnsjå	016-2-L	26.08.2019
4	Trout	29	260	Tinnsjå	016-2-L	26.08.2019
5	Trout	29	272	Tinnsjå	016-2-l	26.08.2019
5	Trout	29	294	Tinnsjå	016-2-l	26.08.2019
5	Trout	31	303	Tinnsjå	016-2-l	26.08.2019
5	Trout	30	314	Tinnsjå	016-2-l	26.08.2019
5	Trout	31	328	Tinnsjå	016-2-l	26.08.2019
5	Trout	33	368	Tinnsjå	016-2-l	26.08.2019
6	Trout	32	385	Tinnsjå	016-2-L	26.08.2019
6	Trout	34	430	Tinnsjå	016-2-L	26.08.2019
6	Trout	34	429	Tinnsjå	016-2-L	26.08.2019
6	Trout	37	492	Tinnsjå	016-2-L	26.08.2019
7	Perch	28	311	Randsfjorden	012-523-L	14.aug.19
7	Perch	29	307	Randsfjorden	012-523-L	14.aug.19
7	Perch	26	260	Randsfjorden	012-523-L	14.aug.19
7	Perch	29	341	Randsfjorden	012-523-L	14.aug.19
7	Perch	29	310	Randsfjorden	012-523-L	14.aug.19

7	Perch	26	255	Randsfjorden	012-523-L	14.aug.19
7	Perch	28	272	Randsfjorden	012-523-L	14.aug.19
7	Perch	27	305	Randsfjorden	012-523-L	14.aug.19
7	Perch	28	296	Randsfjorden	012-523-L	14.aug.19
7	Perch	26	255	Randsfjorden	012-523-L	14.aug.19
8	Perch	30	379	Randsfjorden	012-523-L	14.aug.19
8	Perch	29	312	Randsfjorden	012-523-L	14.aug.19
8	Perch	30	352	Randsfjorden	012-523-L	14.aug.19
8	Perch	29	331	Randsfjorden	012-523-L	14.aug.19
8	Perch	29	314	Randsfjorden	012-523-L	14.aug.19
8	Perch	29	350	Randsfjorden	012-523-L	14.aug.19
8	Perch	29	359	Randsfjorden	012-523-L	14.aug.19
9	Perch	33	495	Randsfjorden	012-523-L	14.aug.19
9	Perch	33	480	Randsfjorden	012-523-L	14.aug.19
9	Perch	33	446	Randsfjorden	012-523-L	14.aug.19
9	Perch	31	350	Randsfjorden	012-523-L	14.aug.19
9	Perch	32	380	Randsfjorden	012-523-L	14.aug.19
10	Perch	25	214	Tyrifjorden	012-522-2-L	19.aug.19
10	Perch	27	216	Tyrifjorden	012-522-2-L	19.aug.19
10	Perch	26	218	Tyrifjorden	012-522-2-L	19.aug.19
10	Perch	27	243	Tyrifjorden	012-522-2-L	19.aug.19
10	Perch	26	236	Tyrifjorden	012-522-2-L	19.aug.19
10	Perch	25	244	Tyrifjorden	012-522-2-L	19.aug.19
10	Perch	26	249	Tyrifjorden	012-522-2-L	19.aug.19
10	Perch	24	208	Tyrifjorden	012-522-2-L	19.aug.19
10	Perch	28	256	Tyrifjorden	012-522-2-L	19.aug.19
10	Perch	27	261	Tyrifjorden	012-522-2-L	19.aug.19
10	Perch	28	253	Tyrifjorden	012-522-2-L	19.aug.19
10	Perch	29	286	Tyrifjorden	012-522-2-L	19.aug.19
11	Perch	29	296	Tyrifjorden	012-522-2-L	19.aug.19
11	Perch	28	302	Tyrifjorden	012-522-2-L	19.aug.19
11	Perch	31	313	Tyrifjorden	012-522-2-L	19.aug.19
11	Perch	29	307	Tyrifjorden	012-522-2-L	19.aug.19
11	Perch	32	318	Tyrifjorden	012-522-2-L	19.aug.19
11	Perch	30	325	Tyrifjorden	012-522-2-L	19.aug.19
11	Perch	30	332	Tyrifjorden	012-522-2-L	19.aug.19
11	Perch	33	357	Tyrifjorden	012-522-2-L	19.aug.19
11	Perch	30	342	Tyrifjorden	012-522-2-L	19.aug.19
11	Perch	30	355	Tyrifjorden	012-522-2-L	19.aug.19
11	Perch	32	408	Tyrifjorden	012-522-2-L	19.aug.19
12	Perch	42	928	Tyrifjorden	012-522-2-L	19.aug.19
12	Perch	42	950	Tyrifjorden	012-522-2-L	19.aug.19
13	Trout	27	257	Forolsjøen	122-876-L	16.aug.19
13	Trout	27	274	Forolsjøen	122-876-L	16.aug.19

13	Trout	25	191	Forolsjøen	122-876-L	16.aug.19
13	Trout	28	260	Forolsjøen	122-876-L	16.aug.19
13	Trout	26	207	Forolsjøen	122-876-L	16.aug.19
13	Trout	27	277	Forolsjøen	122-876-L	16.aug.19
14	Trout	29	320	Forolsjøen	122-876-L	16.aug.19
14	Trout	41	1034	Forolsjøen	122-876-L	16.aug.19
15	Trout	29	283	Kapervann	194-2380-L	08.aug.19
15	Trout	27	217	Kapervann	194-2380-L	08.aug.19
15	Trout	30	303	Kapervann	194-2380-L	08.aug.19
15	Trout	44	814	Kapervann	194-2380-L	08.aug.19
16	Trout	24	159	Ytre FiskeLusvatnet	196-2417-L	08.aug.19
16	Trout	26	240	YFiskeLaus	196-2417-L	08.aug.19
16	Trout	28	268	YFiskeLaus	196-2417-L	08.aug.19
16	Trout	28	295	YFiskeLaus	196-2417-L	08.aug.19
16	Trout	27	298	YFiskeLaus	196-2417-L	08.aug.19
16	Trout	29	336	YFiskeLaus	196-2417-L	08.aug.19
16	Trout	32	415	YFiskeLaus	196-2417-L	08.aug.19
17	Trout	33	435	YFiskeLaus	196-2417-L	08.aug.19
17	Trout	34	441	YFiskeLaus	196-2417-L	08.aug.19
17	Trout	35	456	YFiskeLaus	196-2417-L	08.aug.19
17	Trout	34	461	YFiskeLaus	196-2417-L	08.aug.19
18	Trout	33	471	YFiskeLaus	196-2417-L	08.aug.19
18	Trout	35	500	YFiskeLaus	196-2417-L	08.aug.19
18	Trout	34	517	YFiskeLaus	196-2417-L	08.aug.19
18	Trout	38	747	YFiskeLaus	196-2417-L	08.aug.19
19	Char	24	183	YFiskeLaus	196-2417-L	08.aug.19
19	Char	26	203	YFiskeLaus	196-2417-L	08.aug.19
19	Char	27	222	YFiskeLaus	196-2417-L	08.aug.19
19	Char	26	243	YFiskeLaus	196-2417-L	08.aug.19
19	Char	27	267	YFiskeLaus	196-2417-L	08.aug.19
19	Char	28	280	YFiskeLaus	196-2417-L	08.aug.19
20	Char	28	310	YFiskeLaus	196-2417-L	08.aug.19
20	Char	30	320	YFiskeLaus	196-2417-L	08.aug.19
20	Char	30	359	YFiskeLaus	196-2417-L	08.aug.19
20	Char	31	341	YFiskeLaus	196-2417-L	08.aug.19
20	Char	32	431	YFiskeLaus	196-2417-L	08.aug.19
21	Char	31	440	YFiskeLaus	196-2417-L	08.aug.19
21	Char	34	590	YFiskeLaus	196-2417-L	08.aug.19
21	Char	36	680	YFiskeLaus	196-2417-L	08.aug.19
21	Char	36	714	YFiskeLaus	196-2417-L	08.aug.19
22	Trout	24	175	Nystølsvatnet	083-1651-L	14.aug.19
22	Trout	27	211	Nystølsvatnet	083-1651-L	14.aug.19
22	Trout	26	214	Nystølsvatnet	083-1651-L	14.aug.19
22	Trout	26	227	Nystølsvatnet	083-1651-L	14.aug.19

22	Trout	27	230	Nystølsvatnet	083-1651-L	14.aug.19
22	Trout	28	240	Nystølsvatnet	083-1651-L	14.aug.19
22	Trout	28	275	Nystølsvatnet	083-1651-L	14.aug.19
22	Trout	29	281	Nystølsvatnet	083-1651-L	14.aug.19
23	Trout	31	302	Nystølsvatnet	083-1651-L	14.aug.19
23	Trout	33	353	Nystølsvatnet	083-1651-L	14.aug.19
23	Trout	30	305	Nystølsvatnet	083-1651-L	14.aug.19
23	Trout	31	323	Nystølsvatnet	083-1651-L	14.aug.19
23	Trout	29	285	Nystølsvatnet	083-1651-L	14.aug.19
23	Trout	34	377	Nystølsvatnet	083-1651-L	14.aug.19
24	Trout	32	368	Nystølsvatnet	083-1651-L	14.aug.19
24	Trout	32	402	Nystølsvatnet	083-1651-L	14.aug.19
24	Trout	34	391	Nystølsvatnet	083-1651-L	14.aug.19
24	Trout	33	336	Nystølsvatnet	083-1651-L	14.aug.19
24	Trout	35	452	Nystølsvatnet	083-1651-L	14.aug.19
25	Trout	32	355	Grungstadsvatnet	139-704-L	22.aug.19
25	Trout	31	341	Grungstadsvatnet	139-704-L	22.aug.19
25	Trout	32	352	Grungstadsvatnet	139-704-L	22.aug.19
25	Trout	35	490	Grungstadsvatnet	139-704-L	22.aug.19
25	Trout	41	757	Grungstadsvatnet	139-704-L	22.aug.19
26	Trout	23	135	Fjellgardsvatnet	038-3034-L	04.sep.19
26	Trout	24	146	Fjellgardsvatnet	038-3034-L	04.sep.19
26	Trout	22	117	Fjellgardsvatnet	038-3034-L	04.sep.19
26	Trout	26	154	Fjellgardsvatnet	038-3034-L	04.sep.19
26	Trout	23	153	Fjellgardsvatnet	038-3034-L	04.sep.19
26	Trout	24	156	Fjellgardsvatnet	038-3034-L	04.sep.19
26	Trout	24	161	Fjellgardsvatnet	038-3034-L	04.sep.19
26	Trout	25	161	Fjellgardsvatnet	038-3034-L	04.sep.19
26	Trout	26	161	Fjellgardsvatnet	038-3034-L	04.sep.19
26	Trout	25	170	Fjellgardsvatnet	038-3034-L	04.sep.19
26	Trout	24	164	Fjellgardsvatnet	038-3034-L	04.sep.19
26	Trout	25	159	Fjellgardsvatnet	038-3034-L	04.sep.19
27	Trout	25	181	Fjellgardsvatnet	038-3034-L	04.sep.19
27	Trout	24	170	Fjellgardsvatnet	038-3034-L	04.sep.19
27	Trout	25	186	Fjellgardsvatnet	038-3034-L	04.sep.19
27	Trout	26	188	Fjellgardsvatnet	038-3034-L	04.sep.19
27	Trout	26	185	Fjellgardsvatnet	038-3034-L	04.sep.19
27	Trout	27	197	Fjellgardsvatnet	038-3034-L	04.sep.19
27	Trout	27	199	Fjellgardsvatnet	038-3034-L	04.sep.19
27	Trout	26	179	Fjellgardsvatnet	038-3034-L	04.sep.19
27	Trout	26	189	Fjellgardsvatnet	038-3034-L	04.sep.19
28	Trout	27	230	Fjellgardsvatnet	038-3034-L	04.sep.19
28	Trout	27	212	Fjellgardsvatnet	038-3034-L	04.sep.19
28	Trout	25	206	Fjellgardsvatnet	038-3034-L	04.sep.19

28	Trout	26	195	Fjellgardsvatnet	038-3034-L	04.sep.19
28	Trout	27	215	Fjellgardsvatnet	038-3034-L	04.sep.19
28	Trout	27	278	Fjellgardsvatnet	038-3034-L	04.sep.19
28	Trout	28	294	Fjellgardsvatnet	038-3034-L	04.sep.19
28	Trout	31	337	Fjellgardsvatnet	038-3034-L	04.sep.19
29	Perch	28	378	Tangenfossen	246-65299-L	02.nov.18
29	Perch	30	466	Tangenfossen	246-65299-L	02.nov.18
30	Trout	37	535	Eikeren	012-542-2-L	19.11.2019
30	Trout	37	451	Eikeren	012-542-2-L	19.11.2019
30	Trout	36	626	Eikeren	012-542-2-L	19.11.2019
30	Trout	38	565	Eikeren	012-542-2-L	19.11.2019
30	Trout	43	770	Eikeren	012-542-2-L	19.11.2019
31	Trout	43	949	Eikeren	012-542-2-L	19.11.2019
31	Trout	43	952	Eikeren	012-542-2-L	19.11.2019
31	Trout	44	850	Eikeren	012-542-2-L	19.11.2019
31	Trout	45	970	Eikeren	012-542-2-L	19.11.2019
31	Trout	47	1004	Eikeren	012-542-2-L	19.11.2019
32	Trout	48	1234	Eikeren	012-542-2-L	19.11.2019
32	Trout	57	1915	Eikeren	012-542-2-L	19.11.2019
33	Whitefish	35	400	Bjørnsund Pasvik	246-97067	15.nov.19
33	Whitefish	37	505	Bjørnsund Pasvik	246-97067	15.nov.19
34	Perch	29	390	Bjørnsund Pasvik	246-97067	15.nov.19
34	Perch	30	400	Bjørnsund Pasvik	246-97067	15.nov.19
34	Perch	32	440	Bjørnsund Pasvik	246-97067	15.nov.19
34	Perch	33	530	Bjørnsund Pasvik	246-97067	15.nov.19
34	Perch	34	540	Bjørnsund Pasvik	246-97067	15.nov.19
35	Perch	31	470	Bjørnsund Pasvik	246-97067	15.nov.19
35	Perch	30	370	Bjørnsund Pasvik	246-97067	15.nov.19
35	Perch	29	340	Bjørnsund Pasvik	246-97067	15.nov.19
35	Perch	31	386	Bjørnsund Pasvik	246-97067	15.nov.19
35	Perch	30	350	Bjørnsund Pasvik	246-97067	15.nov.19
35	Perch	25	217	Bjørnsund Pasvik	246-97067	15.nov.19
36	Perch	35	714	Bjørnsund Pasvik	246-97067	15.nov.19
36	Perch	33	532	Bjørnsund Pasvik	246-97067	15.nov.19
36	Perch	34	670	Bjørnsund Pasvik	246-97067	15.nov.19
36	Perch	33	490	Bjørnsund Pasvik	246-97067	15.nov.19

Appendix 2 Results of analyses (ng/g wet w for organic compounds, mg/kg for metals).

Lever	Innsjø	Art	Fett %	HCB	Pentaklorbenzen*	α-HCH	β-HCH	γ-HCH	*p,p'*-DDE	*o,p'*-DDD	*p,p'*-DDD	*o,p'*-DDT	*p,p'*-DDT
Det.lim				0,004	0,004	0,007	0,010	0,007	0,022	0,013	0,044	0,041	0,008
rec				84	79	105	102	107	100	124	117	107	137

1	Gjende	Ørret	**2,98**	0,553	0,015	0,027	n.d.	0,017	5,14	n.d.	n.d.	n.d.	0,300
2	Gjende	Ørret	**2,60**	0,462	0,015	0,025	n.d.	0,022	19,4	0,064	0,682	n.d.	0,067
3	Gjende	Ørret	**3,13**	0,811	0,021	0,028	n.d.	0,030	71,0	0,169	1,923	0,239	0,185
4	Tinnsjå	Ørret	**2,75**	0,236	0,012	0,014	n.d.	0,021	1,06	n.d.	n.d.	n.d.	0,019
5	Tinnsjå	Ørret	**5,10**	0,412	0,023	0,023	n.d.	0,019	1,74	n.d.	n.d.	n.d.	0,151
6	Tinnsjå	Ørret	**4,10**	0,311	0,014	0,017	n.d.	0,023	1,13	n.d.	0,113	n.d.	0,025
7	Randsfjorden	Abbor	**3,48**	0,198	0,010	0,015	n.d.	0,022	2,08	0,126	0,635	n.d.	0,114
8	Randsfjorden	Abbor	**4,20**	0,226	0,013	0,016	n.d.	0,016	3,10	0,089	0,507	n.d.	0,210
9	Randsfjorden	Abbor	**5,06**	0,300	0,019	0,014	n.d.	0,026	4,33	0,127	0,878	n.d.	0,446
10	Tyrifjorden	Abbor	**3,84**	0,267	0,012	0,020	n.d.	0,028	8,86	0,226	1,393	n.d.	0,238
11	Tyrifjorden	Abbor	**3,05**	0,201	0,012	0,012	n.d.	0,021	28,3	0,133	1,353	n.d.	0,411
12	Tyrifjorden	Abbor	**8,92**	0,716	0,034	0,044	n.d.	0,049	42,8	0,419	4,055	n.d.	1,857
13	Foroll	Ørret	**3,98**	0,479	0,017	0,021	n.d.	0,024	0,698	0,000	0,121	n.d.	0,029
14	Foroll	Ørret	**3,09**	0,299	0,013	0,015	n.d.	0,020	0,424	0,055	0,384	n.d.	0,028
15	Kapervatnet	Ørret	**1,96**	0,184	0,010	0,005	n.d.	0,012	0,375	n.d.	n.d.	n.d.	n.d.
16	Ytre Fiskelaus-	Ørret	**2,79**	0,203	0,011	0,011	n.d.	0,009	0,127	n.d.	n.d.	n.d.	n.d.
17	Ytre Fiskelaus-	Ørret	**3,24**	0,251	0,012	0,017	n.d.	0,015	0,209	n.d.	n.d.	n.d.	n.d.
18	Ytre Fiskelaus-	Ørret	**3,12**	0,294	0,011	0,018	n.d.	0,011	0,276	n.d.	n.d.	n.d.	n.d.
19	Ytre Fiskelaus-	Røye	**3,67**	0,511	0,022	0,017	n.d.	0,010	0,571	n.d.	n.d.	n.d.	0,046
20	Ytre Fiskelaus-	Røye	**3,15**	0,445	0,024	0,019	n.d.	0,005	0,353	n.d.	n.d.	n.d.	0,047
21	Ytre Fiskelaus-	Røye	**3,40**	0,391	0,026	0,019	n.d.	0,012	0,295	n.d.	n.d.	n.d.	n.d.
22	Nystøls-	Ørret	**3,83**	0,658	0,027	0,017	n.d.	0,029	3,235	n.d.	n.d.	n.d.	0,024
23	Nystøls-	Ørret	**3,23**	0,530	0,021	0,010	n.d.	0,013	3,501	n.d.	n.d.	n.d.	n.d.
24	Nystøls-	Ørret	**3,47**	0,578	0,023	0,013	n.d.	0,015	3,978	n.d.	n.d.	n.d.	n.d.
25	Grongstads-	Ørret	**3,61**	0,313	0,019	0,012	n.d.	0,024	1,145	n.d.	n.d.	n.d.	0,049
26	Fjellgards-	Ørret	**3,11**	0,172	0,010	0,010	n.d.	0,017	0,813	n.d.	n.d.	n.d.	n.d.
27	Fjellgards-	Ørret	**4,13**	0,194	0,014	0,014	n.d.	0,022	0,498	n.d.	n.d.	n.d.	0,038
28	Fjellgards-	Ørret	**4,43**	0,219	0,019	0,016	n.d.	0,046	0,973	n.d.	n.d.	n.d.	0,027
29	Tangenfossen	abbor	**6,10**	0,417	0,025	0,055	0,015	0,025	0,509	0,077	0,23	n.d.	n.d.
30	Eikeren	Ørret	**3,96**	0,785	0,030	0,017	n.d.	0,035	73,41	0,137	4,36	0,354	7,90
31	Eikeren	Ørret	**4,49**	1,076	0,042	0,020	n.d.	0,042	130	0,159	6,80	0,579	12,8
32	Eikeren	Ørret	**4,71**	0,758	0,031	0,019	n.d.	0,046	63,60	0,179	6,06	0,229	4,60
33	Bjørnsund	Sik	**1,20**	0,150	0,007	n.d.	n.d.	n.d.	0,240	n.d.	n.d.	n.d.	n.d.
34	Bjørnsund	abbor	**2,59**	0,275	0,016	0,024	n.d.	0,011	0,973	n.d.	0,296	n.d.	n.d.
35	Bjørnsund	abbor	**3,18**	0,285	0,016	0,019	n.d.	n.d.	0,910	n.d.	n.d.	n.d.	0,032
36	Bjørnsund	abbor	**3,55**	0,352	0,019	0,024	n.d.	0,015	2,113	0,056	0,578	n.d.	0,141

	Innsjø	Art	PCB-28	PCB-52	PCB-101	PCB-118	PCB-138	PCB-153	PCB-180	Heptaklor*	cis-	trans-
Lever											Heptaklor	Heptacl epoxyd*
Det.lim										0,092	0,048	0,048
rec										219	144	104
1	Gjende	Ørret	n.d	n.d	0,64	0,33	1	1,5	0,46	n.d.	0,163	n.d.

2	Gjende	Ørret	n.d	0,32	1,6	1,05	3,6	4,9	1,9	n.d.	0,160	n.d.
3	Gjende	Ørret	n.d	0,63	4,9	3,80	12	17	6,9	n.d.	0,303	n.d.
4	Tinnsjå	Ørret	n.d	n.d	0,55	0,35	1,2	2,1	1,1	n.d.	n.d.	n.d.
5	Tinnsjå	Ørret	n.d	n.d	1	0,95	2,9	5,1	3,7	n.d.	0,094	n.d.
6	Tinnsjå	Ørret	n.d	n.d	n.d	0,00	0,5	0,9	n.d	n.d.	n.d.	n.d.
7	Randsfjorden	Abbor	n.d	n.d	0,65	0,71	1,9	3,3	1,2	n.d.	0,152	n.d.
8	Randsfjorden	Abbor	n.d	n.d	0	0,25	0,6	0,86	0,32	n.d.	0,186	n.d.
9	Randsfjorden	Abbor	n.d	n.d	0,56	0,77	1,7	2,6	1,4	n.d.	0,147	n.d.
10	Tyrifjorden	Abbor	n.d	n.d	n.d	0,00	0,48	0,7	0,38	n.d.	0,184	n.d.
11	Tyrifjorden	Abbor	n.d	n.d	0,93	1,25	2,1	3,2	1,3	n.d.	0,160	n.d.
12	Tyrifjorden	Abbor	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.d.	n.d.	n.d.
13	Foroll	Ørret	n.d	n.d	0,46	0,20	0,48	0,97	0,19	n.d.	0,072	n.d.
14	Foroll	Ørret	n.d	n.d	0,46	n.d	0,47	0,85	n.d	n.d.	0,052	n.d.
15	Kapervatnet	Ørret	n.d	n.d	0,42	n.d	0,66	1,1	0,4	n.d.	0,244	n.d.
16	Ytre Fiskelaus-	Ørret	n.d	n.d	0,47	n.d	0,5	0,93	n.d	n.d.	n.d.	n.d.
17	Ytre Fiskelaus-	Ørret	n.d	n.d	0,49	n.d	0,73	1,3	0,35	n.d.	n.d.	n.d.
18	Ytre Fiskelaus-	Ørret	n.d	n.d	0,46	0,22	0,59	0,99	0,26	n.d.	n.d.	n.d.
19	Ytre Fiskelaus-	Røye	n.d	n.d	0,48	0,31	0,84	1,3	0,3	n.d.	n.d.	n.d.
20	Ytre Fiskelaus-	Røye	n.d	n.d	0,39	0,22	0,62	0,99	0,22	n.d.	n.d.	n.d.
21	Ytre Fiskelaus-	Røye	n.d	n.d	0,35	0,18	0,47	0,81	n.d	n.d.	n.d.	n.d.
22	Nystøls-	Ørret	n.d	n.d	0,47	0,23	0,73	1,2	0,48	n.d.	n.d.	n.d.
23	Nystøls-	Ørret	n.d	n.d	0,51	0,32	1	1,7	0,86	n.d.	n.d.	n.d.
24	Nystøls-	Ørret	n.d	n.d	0,53	0,28	0,92	1,6	0,74	n.d.	0,057	n.d.
25	Grongstads-	Ørret	n.d	n.d	0,63	0,30	0,91	1,4	0,37	n.d.	n.d.	n.d.
26	Fjellgards-	Ørret	n.d	n.d	0,48	0,30	0,97	1,4	0,65	n.d.	n.d.	n.d.
27	Fjellgards-	Ørret	n.d	n.d	0,4	0,26	0,59	0,99	0,32	n.d.	n.d.	n.d.
28	Fjellgards-	Ørret	n.d	n.d	0,47	0,41	0,87	1,3	0,42	n.d.	n.d.	n.d.
29	Tangenfossen	abbor	n.d	n.d	0,5	0,33	0,62	1	0,24	n.d.	n.d.	n.d.
30	Eikeren	Ørret	n.d	0,55	2	2,87	8,4	12	5,6	n.d.	0,197	n.d.
31	Eikeren	Ørret	n.d	0,73	2,9	4,33	12	17	8,1	n.d.	0,185	n.d.
32	Eikeren	Ørret	n.d	0,41	1,4	1,89	5,3	8	3,5	n.d.	0,197	n.d.
33	Bjørnsund	Sik	n.d	n.d	0,64	0,45	0,78	1,2	0,25	0,643	n.d.	n.d.
34	Bjørnsund	abbor	n.d	0,31	0,99	1,43	2	2,5	0,48	0,655	0,183	n.d.
35	Bjørnsund	abbor	n.d	n.d	0,43	0,54	0,79	1	0,22	0,358	n.d.	n.d.
36	Bjørnsund	abbor	n.d	0,3	1,1	1,84	2,2	2,6	0,55	n.d.	n.d.	n.d.

Liver	Innsjø	Art	Endosulfan I*	Endosulfan II*	Endosulfan sulfat*	PBDE 28	PBDE 47	PBDE 99	PBDE 100	PBDE 153	PBDE 154	Sum HBCDD
Det.lim			0,012	0,012	0,010							0,022
rec			163	146	117							100
1	Gjende	Ørret	0,025	n.d.	0,070	< .015	0,17	0,11	< .061	< .061	< .061	0,114

2	Gjende	Ørret	0,020	n.d.	0,028	< .021	0,64	0,44	0,22	< .085	0,11	0,702
3	Gjende	Ørret	0,063	n.d.	0,047	0,038	2,5	1,8	0,87	0,26	0,4	5,00
4	Tinnsjå	Ørret	n.d.	n.d.	0,015	< .024	< .2	< .097	< .097	< .097	< .097	0,042
5	Tinnsjå	Ørret	0,013	n.d.	0,046	< .056	< .45	0,3	< .22	< .22	< .22	0,159
6	Tinnsjå	Ørret	n.d.	n.d.	0,038	< .017	0,18	0,086	< .069	< .069	< .069	0,040
7	Randsfjorden	Abbor	n.d.	n.d.	0,016	< .022	< .18	< .088	< .088	< .088	< .088	0,042
8	Randsfjorden	Abbor	n.d.	n.d.	0,012	< .023	0,3	< .092	0,12	< .092	< .092	0,113
9	Randsfjorden	Abbor	0,014	n.d.	0,019	< .024	0,52	0,17	0,2	< .094	0,11	0,276
10	Tyrifjorden	Abbor	n.d.	n.d.	0,067	< .024	0,35	0,17	0,11	< .094	< .094	0,222
11	Tyrifjorden	Abbor	n.d.	n.d.	0,033	< .024	0,49	0,28	0,18	< .095	0,1	0,317
12	Tyrifjorden	Abbor	0,031	n.d.	0,071	n.a	n.a	n.a	n.a	n.a	n.a	1,26
13	Foroll	Ørret	n.d.	n.d.	n.d.	< .019	< .15	< .076	< .076	< .076	< .076	n.d.
14	Foroll	Ørret	n.d.	n.d.	n.d.	< .019	< .16	< .077	< .077	< .077	< .077	n.d.
15	Kapervatnet	Ørret	n.d.	n.d.	0,049	< .021	< .17	< .082	< .082	< .082	< .082	n.d.
16	Ytre Fiskelaus-	Ørret	n.d.	n.d.	n.d.	< .021	< .17	< .083	< .083	< .083	< .083	n.d.
17	Ytre Fiskelaus-	Ørret	n.d.	n.d.	n.d.	< .022	< .18	< .087	< .087	< .087	< .087	n.d.
18	Ytre Fiskelaus-	Ørret	n.d.	n.d.	n.d.	< .019	< .15	< .076	< .076	< .076	< .076	n.d.
19	Ytre Fiskelaus-	Røye	n.d.	n.d.	0,020	< .019	< .16	< .077	< .077	< .077	< .077	n.d.
20	Ytre Fiskelaus-	Røye	0,015	n.d.	0,012	< .02	< .17	< .081	< .081	< .081	< .081	n.d.
21	Ytre Fiskelaus-	Røye	0,018	n.d.	0,017	< .019	< .15	< .074	< .074	< .074	< .074	n.d.
22	Nystøls-	Ørret	n.d.	n.d.	0,024	< .022	< .18	0,13	< .089	< .089	< .089	n.d.
23	Nystøls-	Ørret	n.d.	n.d.	0,023	< .02	< .16	0,21	< .078	< .078	< .078	0,047
24	Nystøls-	Ørret	n.d.	n.d.	0,021	< .021	< .17	0,14	< .083	< .083	< .083	n.d.
25	Grongstads-	Ørret	n.d.	n.d.	n.d.	< .023	< .18	0,13	< .09	< .09	< .09	n.d.
26	Fjellgards-	Ørret	n.d.	n.d.	n.d.	< .021	< .17	0,22	0,1	0,097	0,13	n.d.
27	Fjellgards-	Ørret	n.d.	n.d.	n.d.	< .017	< .14	0,13	< .069	< .069	< .069	n.d.
28	Fjellgards-	Ørret	n.d.	n.d.	n.d.	< .019	0,21	0,37	0,11	0,079	0,086	n.d.
29	Tangenfossen	abbor	n.d.	n.d.	n.d.	< .021	< .17	< .083	< .083	< .083	< .083	n.d.
30	Eikeren	Ørret	0,039	n.d.	0,063	0,035	3,8	0,55	1,5	0,43	1,3	2,56
31	Eikeren	Ørret	0,042	n.d.	0,054	0,056	5,8	0,85	2,2	0,64	1,8	4,19
32	Eikeren	Ørret	0,018	n.d.	0,074	0,028	2,6	0,28	0,98	0,26	0,81	2,48
33	Bjørnsund	Sik	n.d.	n.d.	n.d.	< .025	< .2	< .1	< .1	< .1	< .1	n.d.
34	Bjørnsund	abbor	n.d.	n.d.	0,025	< .021	< .17	< .082	< .082	< .082	< .082	0,025
35	Bjørnsund	abbor	n.d.	n.d.	0,015	< .018	< .14	< .071	< .071	< .071	< .071	n.d.
36	Bjørnsund	abbor	n.d.	n.d.	n.d.	< .018	0,17	0,11	< .07	< .07	< .07	0,054

Liver	Innsjø	Art	Endosulfan I*	Endosulfan II*	Endosulfan sulfat*	PBDE 28	PBDE 47	PBDE 99	PBDE 100	PBDE 153	PBDE 154	Sum HBCDD
Det.lim			0,012	0,012	0,010							0,022

rec			163	146	117							100
1	Gjende	Ørret	0,025	n.d.	0,070	< .015	0,17	0,11	< .061	< .061	< .061	0,114
2	Gjende	Ørret	0,020	n.d.	0,028	< .021	0,64	0,44	0,22	< .085	0,11	0,702
3	Gjende	Ørret	0,063	n.d.	0,047	0,038	2,5	1,8	0,87	0,26	0,4	5,00
4	Tinnsjå	Ørret	n.d.	n.d.	0,015	< .024	< .2	< .097	< .097	< .097	< .097	0,042
5	Tinnsjå	Ørret	0,013	n.d.	0,046	< .056	< .45	0,3	< .22	< .22	< .22	0,159
6	Tinnsjå	Ørret	n.d.	n.d.	0,038	< .017	0,18	0,086	< .069	< .069	< .069	0,040
7	Randsfjorden	Abbor	n.d.	n.d.	0,016	< .022	< .18	< .088	< .088	< .088	< .088	0,042
8	Randsfjorden	Abbor	n.d.	n.d.	0,012	< .023	0,3	< .092	0,12	< .092	< .092	0,113
9	Randsfjorden	Abbor	0,014	n.d.	0,019	< .024	0,52	0,17	0,2	< .094	0,11	0,276
10	Tyrifjorden	Abbor	n.d.	n.d.	0,067	< .024	0,35	0,17	0,11	< .094	< .094	0,222
11	Tyrifjorden	Abbor	n.d.	n.d.	0,033	< .024	0,49	0,28	0,18	< .095	0,1	0,317
12	Tyrifjorden	Abbor	0,031	n.d.	0,071	n.a	n.a	n.a	n.a	n.a	n.a	1,26
13	Foroll	Ørret	n.d.	n.d.	n.d.	< .019	< .15	< .076	< .076	< .076	< .076	n.d.
14	Foroll	Ørret	n.d.	n.d.	n.d.	< .019	< .16	< .077	< .077	< .077	< .077	n.d.
15	Kapervatnet	Ørret	n.d.	n.d.	0,049	< .021	< .17	< .082	< .082	< .082	< .082	n.d.
16	Ytre Fiskelaus-	Ørret	n.d.	n.d.	n.d.	< .021	< .17	< .083	< .083	< .083	< .083	n.d.
17	Ytre Fiskelaus-	Ørret	n.d.	n.d.	n.d.	< .022	< .18	< .087	< .087	< .087	< .087	n.d.
18	Ytre Fiskelaus-	Ørret	n.d.	n.d.	n.d.	< .019	< .15	< .076	< .076	< .076	< .076	n.d.
19	Ytre Fiskelaus-	Røye	n.d.	n.d.	0,020	< .019	< .16	< .077	< .077	< .077	< .077	n.d.
20	Ytre Fiskelaus-	Røye	0,015	n.d.	0,012	< .02	< .17	< .081	< .081	< .081	< .081	n.d.
21	Ytre Fiskelaus-	Røye	0,018	n.d.	0,017	< .019	< .15	< .074	< .074	< .074	< .074	n.d.
22	Nystøls-	Ørret	n.d.	n.d.	0,024	< .022	< .18	0,13	< .089	< .089	< .089	n.d.
23	Nystøls-	Ørret	n.d.	n.d.	0,023	< .02	< .16	0,21	< .078	< .078	< .078	0,047
24	Nystøls-	Ørret	n.d.	n.d.	0,021	< .021	< .17	0,14	< .083	< .083	< .083	n.d.
25	Grongstads-	Ørret	n.d.	n.d.	n.d.	< .023	< .18	0,13	< .09	< .09	< .09	n.d.
26	Fjellgards-	Ørret	n.d.	n.d.	n.d.	< .021	< .17	0,22	0,1	0,097	0,13	n.d.
27	Fjellgards-	Ørret	n.d.	n.d.	n.d.	< .017	< .14	0,13	< .069	< .069	< .069	n.d.
28	Fjellgards-	Ørret	n.d.	n.d.	n.d.	< .019	0,21	0,37	0,11	0,079	0,086	n.d.
29	Tangenfossen	abbor	n.d.	n.d.	n.d.	< .021	< .17	< .083	< .083	< .083	< .083	n.d.
30	Eikeren	Ørret	0,039	n.d.	0,063	0,035	3,8	0,55	1,5	0,43	1,3	2,56
31	Eikeren	Ørret	0,042	n.d.	0,054	0,056	5,8	0,85	2,2	0,64	1,8	4,19
32	Eikeren	Ørret	0,018	n.d.	0,074	0,028	2,6	0,28	0,98	0,26	0,81	2,48
33	Bjørnsund	Sik	n.d.	n.d.	n.d.	< .025	< .2	< .1	< .1	< .1	< .1	n.d.
34	Bjørnsund	abbor	n.d.	n.d.	0,025	< .021	< .17	< .082	< .082	< .082	< .082	0,025
35	Bjørnsund	abbor	n.d.	n.d.	0,015	< .018	< .14	< .071	< .071	< .071	< .071	n.d.
36	Bjørnsund	abbor	n.d.	n.d.	n.d.	< .018	0,17	0,11	< .07	< .07	< .07	0,054

Liver	Innsjø	Art	Oktylfenol (4-tert-oktylfenol)*	Nonylfenol (p-nonylfenol	PFBA*	PFHxA*	PFHpA*	PFOA*	PFNA*	PFDA*	PFUnDA*	PFDoDA*

				teknisk blanding)*								
Det.lim			0,07	1,50	0,966	0,417	0,164	0,256	0,169	0,122	0,067	0,043
rec			107	91	85	106	108	106	107	101	103	103
1	Gjende	Ørret	0,552	n.d.	n.d.	n.d.	n.d.	n.d.	1,64	4,49	12,64	11,07
2	Gjende	Ørret	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0,49	2,40	6,82	5,23
3	Gjende	Ørret	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0,53	1,96	5,90	4,73
4	Tinnsjå	Ørret	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0,67	1,39	4,37	3,49
5	Tinnsjå	Ørret	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0,40	2,38	8,03	6,47
6	Tinnsjå	Ørret	0,607	n.d.	n.d.	n.d.	n.d.	n.d.	0,62	3,41	11,49	6,91
7	Randsfjorden	Abbor	0,770	n.d.	n.d.	n.d.	n.d.	n.d.	1,80	3,71	8,99	5,16
8	Randsfjorden	Abbor	0,945	n.d.	n.d.	n.d.	n.d.	n.d.	1,43	3,44	7,96	4,84
9	Randsfjorden	Abbor	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1,13	2,82	7,48	5,10
10	Tyrifjorden	Abbor	7,23	n.d.	n.d.	n.d.	n.d.	n.d.	3,36	33,02	36,23	54,09
11	Tyrifjorden	Abbor	3,65	n.d.	n.d.	n.d.	n.d.	n.d.	2,09	36,45	55,04	85,87
12	Tyrifjorden	Abbor	4,21	n.d.	n.d.	n.d.	n.d.	n.d.	4,20	41,20	53,89	84,93
13	Foroll	Ørret	n.d.	n.d.	n.d.	n.d.	0,36	1,8	12,23	6,84	22,54	5,43
14	Foroll	Ørret	n.d.	n.d.	n.d.	n.d.	0,34	1,4	20,15	13,17	39,10	9,62
15	Kapervatnet	Ørret	1,89	5,60	n.d.	n.d.	n.d.	n.d.	0,45	1,37	2,95	0,68
16	Ytre Fiskelaus-	Ørret	n.d.	9,95	n.d.	n.d.	n.d.	0,9	3,91	1,18	2,75	0,73
17	Ytre Fiskelaus-	Ørret	n.d.	n.d.	n.d.	n.d.	0,40	3,3	5,85	1,30	3,00	0,93
18	Ytre Fiskelaus-	Ørret	n.d.	n.d.	n.d.	n.d.	n.d.	0,4	1,72	0,77	1,91	0,62
19	Ytre Fiskelaus-	Røye	n.d.	n.d.	n.d.	n.d.	0,24	1,1	3,37	1,01	2,01	0,51
20	Ytre Fiskelaus-	Røye	n.d.	n.d.	n.d.	n.d.	n.d.	0,3	1,73	0,59	1,05	0,21
21	Ytre Fiskelaus-	Røye	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0,81	0,18	0,34	0,08
22	Nystøls-	Ørret	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0,50	1,85	4,47	2,61
23	Nystøls-	Ørret	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0,37	0,75	1,94	0,96
24	Nystøls-	Ørret	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0,46	0,72	1,78	1,09
25	Grongstads-	Ørret	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0,31	0,50	1,49	1,13
26	Fjellgards-	Ørret	n.d.	n.d.	n.d.	n.d.	0,25	n.d.	0,89	0,72	2,49	1,57
27	Fjellgards-	Ørret	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0,38	0,47	1,34	0,82
28	Fjellgards-	Ørret	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0,48	0,78	2,55	1,55
29	Tangenfossen	abbor	n.d.	3,53	n.d.	n.d.	n.d.	n.d.	0,68	0,51	1,36	0,38
30	Eikeren	Ørret	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1,26	6,11	19,07	12,43
31	Eikeren	Ørret	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	2,42	13,33	48,44	34,36
32	Eikeren	Ørret	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	2,43	9,38	32,82	21,99
33	Bjørnsund	Sik	2,70	73,0	n.d.	n.d.	n.d.	n.d.	0,66	0,71	1,50	0,34
34	Bjørnsund	abbor	n.d.	19,4	n.d.	n.d.	n.d.	n.d.	3,22	3,46	7,35	1,82
35	Bjørnsund	abbor	n.d.	33,8	n.d.	n.d.	n.d.	n.d.	1,99	2,34	5,71	1,57
36	Bjørnsund	abbor	n.d.	13,8	n.d.	n.d.	n.d.	n.d.	2,62	2,48	5,84	1,50

Liver	Innsjø	Art	PFTrDA*	PFTeDA*	PFBS*	PFHxS*	PFOS*	PFOSA*	Benz(a)-anthracen	Diflubenzuron	Teflubenzuron	Naphthalene
Det.lim			0,049	0,054	0,964	0,385	0,328	0,071		3,0	3,0	1,51
rec			103	78	113	117	106	128				
1	Gjende	Ørret	20,22	5,67	n.d.	n.d.	3,17	0,98	< .58	n.d	n.d	2,72
2	Gjende	Ørret	10,27	2,36	n.d.	n.d.	1,50	0,60	< .74	n.d	n.d	3,52
3	Gjende	Ørret	10,26	2,10	n.d.	n.d.	1,07	0,25	< .65	n.d	n.d	4,60
4	Tinnsjå	Ørret	7,57	1,40	n.d.	n.d.	2,86	0,69	< .54	n.d	n.d	3,64
5	Tinnsjå	Ørret	12,74	1,16	n.d.	n.d.	4,41	0,38	< .55	n.d	n.d	4,61
6	Tinnsjå	Ørret	8,50	1,06	n.d.	n.d.	7,75	0,52	< .59	n.d	n.d	0,98
7	Randsfjorden	Abbor	5,90	0,94	n.d.	n.d.	15,95	0,45	< .7	n.d	n.d	1,30
8	Randsfjorden	Abbor	7,08	1,22	n.d.	n.d.	10,78	0,12	< .72	n.d	n.d	0,95
9	Randsfjorden	Abbor	8,24	1,27	n.d.	n.d.	9,02	0,09	< .67	n.d	n.d	1,34
10	Tyrifjorden	Abbor	33,66	22,15	1,43	n.d.	281,25	1,21	< .7	n.d	n.d	1,09
11	Tyrifjorden	Abbor	49,84	24,68	0,54	n.d.	196,95	0,98	< .81	n.d	n.d	0,89
12	Tyrifjorden	Abbor	39,06	21,85	2,73	n.d.	322,63	1,04	< .74	n.d	n.d	1,26
13	Foroll	Ørret	13,35	1,85	n.d.	n.d.	4,03	2,56	< .73	n.d	n.d	1,00
14	Foroll	Ørret	18,71	2,48	n.d.	n.d.	6,38	3,38	< .68	n.d	n.d	1,17
15	Kapervatnet	Ørret	1,40	0,31	n.d.	n.d.	5,42	0,32	< .67	n.d	n.d	2,60
16	Ytre Fiskelaus-	Ørret	1,19	0,08	n.d.	n.d.	1,58	0,21	< .72	n.d	n.d	0,65
17	Ytre Fiskelaus-	Ørret	1,59	0,09	n.d.	n.d.	1,68	0,25	< .73	n.d	n.d	2,52
18	Ytre Fiskelaus-	Ørret	1,04	0,09	n.d.	n.d.	1,51	0,15	< .72	n.d	n.d	1,11
19	Ytre Fiskelaus-	Røye	0,83	0,10	n.d.	n.d.	3,85	0,08	< .64	n.d	n.d	0,70
20	Ytre Fiskelaus-	Røye	0,33	0,054	n.d.	n.d.	1,78	0,08	< .48	n.d	n.d	2,23
21	Ytre Fiskelaus-	Røye	0,10	n.d.	n.d.	n.d.	0,99	n.d.	< .75	n.d	n.d	1,69
22	Nystøls-	Ørret	5,66	0,94	n.d.	n.d.	2,99	0,50	< .75	n.d	n.d	1,74
23	Nystøls-	Ørret	2,15	0,35	n.d.	n.d.	1,77	0,50	< .6	n.d	n.d	0,89
24	Nystøls-	Ørret	2,36	0,46	n.d.	n.d.	1,53	0,33	< .62	n.d	n.d	0,53
25	Grongstads-	Ørret	1,73	0,29	n.d.	n.d.	2,40	0,56	< .74	n.d	n.d	0,63
26	Fjellgards-	Ørret	2,28	0,36	n.d.	n.d.	5,27	0,52	< .71	n.d	n.d	0,87
27	Fjellgards-	Ørret	1,29	0,13	n.d.	n.d.	2,87	0,36	< .67	n.d	n.d	0,98
28	Fjellgards-	Ørret	2,68	0,23	n.d.	n.d.	4,99	0,58	< .63	n.d	n.d	1,23
29	Tangenfossen	abbor	0,75	0,09	n.d.	n.d.	0,95	n.d.	< .66	n.d	n.d	0,94
30	Eikeren	Ørret	23,67	3,11	n.d.	n.d.	19,52	2,50	< .69	n.d	n.d	0,93
31	Eikeren	Ørret	44,61	4,69	n.d.	n.d.	42,71	3,59	< .7	n.d	n.d	0,92
32	Eikeren	Ørret	37,23	5,01	n.d.	n.d.	30,77	3,42	< .63	n.d	n.d	1,00
33	Bjørnsund	Sik	0,52	0,06	n.d.	n.d.	2,64	0,34	< .55	n.d	n.d	1,91
34	Bjørnsund	abbor	2,58	0,22	n.d.	n.d.	3,71	n.d.	< .63	n.d	n.d	0,71
35	Bjørnsund	abbor	2,65	0,26	n.d.	n.d.	3,54	0,09		n.d	n.d	0,78
36	Bjørnsund	abbor	2,75	0,33	n.d.	n.d.	2,30	0,14		n.d	n.d	0,89

			Anthracene	Fluoranthene	Benzo[a]-pyrene	(D5)	HCBD	Trichloro-benzenes	Penta-chlorophenol	Triclosan	Dicofol	TCEP
Det.lim			0,05	0,96		3,07	0,07		0,03	0,16	0,27	0,12
rec												
1	Gjende	Ørret	0,02	0,91	< .58	2,7	0,02	0,03	<0.03	3,19	<0.27	1,17
2	Gjende	Ørret	0,21	0,24	< .74	3,9	0,03	0,09	0,03	0,33	3,92	<0.12
3	Gjende	Ørret	0,01	0,21	< .65	4,1	0,03	0,03	0,07	0,28	2,22	0,65
4	Tinnsjå	Ørret	0,01	0,32	< .54	6,4	0,04	0,04	<0.03	<0.16	0,53	0,85
5	Tinnsjå	Ørret	0,23	0,28	< .55	3,7	0,05	0,10	<0.03	<0.16	0,25	0,53
6	Tinnsjå	Ørret	0,01	0,22	< .59	2,2	0,04	0,04	<0.03	<0.16	<0.27	0,64
7	Randsfjorden	Abbor	0,01	0,20	< .7	3,1	0,04	0,05	<0.03	<0.16	<0.27	0,57
8	Randsfjorden	Abbor	0,01	0,23	< .72	3,7	0,03	0,04	<0.03	<0.16	1,32	3,70
9	Randsfjorden	Abbor	0,01	0,23	1,2	3,2	0,04	0,08	<0.03	<0.16	<0.27	<0.12
10	Tyrifjorden	Abbor	0,01	0,31		4,5	0,04	0,05	<0.03	<0.16	<0.27	<0.12
11	Tyrifjorden	Abbor	0,01	0,21	< .7	8,9	0,00	0,03	<0.03	0,43	<0.27	0,80
12	Tyrifjorden	Abbor	0,02	0,08	< .81	6,6	0,05	0,04	<0.03	0,53	<0.27	<0.12
13	Foroll	Ørret	0,03	0,29	< .74	3,7	0,03	0,06	<0.03	1,02	<0.27	<0.12
14	Foroll	Ørret	0,01	0,24	< .73	3,0	0,05	0,03	<0.03	3,56	<0.27	1,05
15	Kapervatnet	Ørret	0,02	0,39	< .68	3,1	0,03	0,03	<0.03	3,55	<0.27	<0.12
16	Ytre Fiskelaus-	Ørret	0,02	0,47	< .67	2,0	0,03	0,04	<0.03	1,00	<0.27	<0.12
17	Ytre Fiskelaus-	Ørret	0,01	0,25	< .72	2,9	0,02	0,02	<0.03	4,10	<0.27	<0.12
18	Ytre Fiskelaus-	Ørret	0,01	0,29	< .73	5,5	0,07	0,03	<0.03	0,19	<0.27	<0.12
19	Ytre Fiskelaus-	Røye	0,02	0,20	< .72	4,2	0,04	0,04	<0.03	<0.16	0,36	2,81
20	Ytre Fiskelaus-	Røye	0,06	4,09	< .64	10,0	0,14	0,06	<0.03	0,53	<0.27	0,93
21	Ytre Fiskelaus-	Røye	0,01	0,25	< .48	10,3	0,13	0,04	0,03	1,00	<0.27	5,91
22	Nystøls-	Ørret	0,02	0,49	< .75	6,6	0,12	0,03	<0.03	<0.16	<0.27	2,50
23	Nystøls-	Ørret	0,02	0,32	< .75	4,5	0,03	0,03	<0.03	0,70	1,68	<0.12
24	Nystøls-	Ørret	0,01	0,21	< .6	3,6	0,02	0,02	<0.03	0,85	0,95	<0.12
25	Grongstads-	Ørret	0,02	0,15	< .62	3,5	0,02	0,03	<0.03	0,54	<0.27	0,18
26	Fjellgards-	Ørret	0,02	0,97	< .74	5,9	0,03	0,04	<0.03	2,73	<0.27	<0.12
27	Fjellgards-	Ørret	0,04	0,33	< .71	4,4	0,03	0,04	<0.03	4,49	<0.27	1,01
28	Fjellgards-	Ørret	0,02	0,29	< .67	3,7	0,02	0,03	<0.03	1,87	<0.27	<0.12
29	Tangenfossen	abbor	0,03	0,51	< .63	4,2	0,03	0,04	<0.03	0,12	<0.27	0,19
30	Eikeren	Ørret	0,01	0,21	< .66	12,4	0,03	0,03	<0.03	0,21	1,19	1,53
31	Eikeren	Ørret	0,01	0,23	< .69	10,6	0,04	0,02	<0.03	<0.16	1,35	7,05
32	Eikeren	Ørret	0,82	1,49	< .7	8,7	0,04	0,08	<0.03	<0.16	0,26	1,62
33	Bjørnsund	Sik	0,03	0,79		7,9	0,09	0,08	<0.03	0,82	0,67	<0.12
34	Bjørnsund	abbor	0,02	0,50	< .63	3,0	0,04	0,04	<0.03	1,31	0,62	<0.12
35	Bjørnsund	abbor	0,01	0,29	< .55	3,7	0,02	0,06	<0.03	1,81	1,42	2,80
36	Bjørnsund	abbor	0,01	0,42	< .63	4,4	0,03	0,02	<0.03	0,70	<0.27	<0.12

			DEHP	SCCPs -(C10-13)	MCCPs (C14-17)	TBT	DBT	MBT	TPT	DPT	MPT

Det.lim			22	1,3	2,1	0,15	0,61	0,24	0,01	0,09	0,30
rec											
1	Gjende	Ørret	48	1,11	11,99	0,08	0,34	0,13	0,24	0,02	0,12
2	Gjende	Ørret	<22	1,35	3,04	0,15	0,31	0,16	0,04	0,01	0,09
3	Gjende	Ørret	24	3,53	5,02	0,18	0,13	0,07	0,19	0,02	0,05
4	Tinnsjå	Ørret	<22	2,80	4,52	0,07	1,69	0,58	0,25	0,06	0,10
5	Tinnsjå	Ørret	<22	1,33	4,79	0,22	0,52	0,22	0,12	0,06	0,08
6	Tinnsjå	Ørret	<22	1,80	3,80	0,42	1,60	0,87	0,47	0,24	0,13
7	Randsfjorden	Abbor	<22	0,71	1,75	1,03	3,21	0,63	4,39	0,93	0,16
8	Randsfjorden	Abbor	<22	0,69	1,76	0,61	1,58	0,21	1,47	0,32	0,15
9	Randsfjorden	Abbor	<22	0,74	2,05	0,99	0,88	0,29	1,56	0,36	0,12
10	Tyrifjorden	Abbor	<22	0,75	1,54	3,29	2,46	0,67	2,22	0,69	1,62
11	Tyrifjorden	Abbor	<22	0,61	1,73	2,39	2,09	0,56	1,93	0,52	0,21
12	Tyrifjorden	Abbor	<22	1,57	2,77	2,48	5,09	0,90	6,64	2,07	0,28
13	Foroll	Ørret	<22	0,47	1,13	0,07	2,55	0,25	0,03	0,01	0,04
14	Foroll	Ørret	<22	0,98	1,09	0,19	0,82	0,29	0,02	0,02	0,29
15	Kapervatnet	Ørret	<22	3,35	6,47	0,22	0,34	0,07	0,01	0,03	0,17
16	Ytre Fiskelaus-	Ørret	<22	1,85	2,49	0,11	0,48	0,16	0,03	0,03	0,61
17	Ytre Fiskelaus-	Ørret	<22	1,38	1,54	0,12	0,64	0,10	0,05	0,03	0,11
18	Ytre Fiskelaus-	Ørret	<22	1,47	2,51	0,11	0,37	0,05	0,06	0,02	0,10
19	Ytre Fiskelaus-	Røye	<22	1,36	4,33	1,71	0,30	0,07	0,18	0,03	0,22
20	Ytre Fiskelaus-	Røye	<22	1,39	2,52	0,28	0,48	0,16	0,10	0,02	0,07
21	Ytre Fiskelaus-	Røye	<22	1,39	3,02	0,15	0,31	0,07	0,09	0,02	0,16
22	Nystøls-	Ørret	<22	2,19	6,22	0,09	0,36	0,10	0,02	0,01	0,06
23	Nystøls-	Ørret	<22	1,43	2,12	0,04	0,29	0,08	0,05	0,01	0,28
24	Nystøls-	Ørret	<22	2,38	6,60	0,17	0,26	0,04	0,03	0,01	0,14
25	Grongstads-	Ørret	<22	1,93	3,57	0,23	0,35	0,08	0,09	0,03	0,11
26	Fjellgards-	Ørret	<22	1,54	5,73	0,04	1,27	0,11	0,01	0,02	0,11
27	Fjellgards-	Ørret	<22	1,75	3,75	0,09	0,62	0,11	0,01	0,01	0,40
28	Fjellgards-	Ørret	<22	1,86	3,16	0,14	1,35	0,10	0,02	0,01	0,06
29	Tangenfossen	abbor	<22	1,03	2,33	0,06	0,34	0,39	0,12	0,03	0,08
30	Eikeren	Ørret	<22	7,03	5,42	0,34	1,22	0,14	6,50	1,57	0,20
31	Eikeren	Ørret	<22	12,82	18,65	0,27	1,22	0,16	17,99	2,71	0,21
32	Eikeren	Ørret	<22	5,19	5,58	0,40	1,09	0,43	17,51	2,96	0,38
33	Bjørnsund	Sik	<22	16,46	21,27	0,07	0,11	0,05	0,11	0,01	0,25
34	Bjørnsund	abbor	<22	2,39	4,13	0,15	0,58	0,18	0,16	0,04	0,12
35	Bjørnsund	abbor	<22	1,97	2,80	0,04	0,12	0,10	0,11	0,03	0,05
36	Bjørnsund	abbor	<22	1,81	3,69	0,09	0,10	0,13	0,12	0,05	0,07

			Li	Mg	Al	V	Cr	Fe	Co	Ni	Cu	Zn
Det.lim												
rec												
1	Gjende	Ørret	0,02	270	120	0,38	0,20	280	0,21	0,12	170	66
2	Gjende	Ørret	<0,005	160	14	0,26	0,06	230	0,071	0,026	240	38
3	Gjende	Ørret	<LOD	170	1,2	0,17	0,05	200	0,043	0,015	170	33
4	Tinnsjå	Ørret	0,009	200	13	0,016	<0,02	130	0,036	0,014	30	59
5	Tinnsjå	Ørret	<0,005	230	0,7	0,009	<0,02	110	0,022	<0,01	47	54
6	Tinnsjå	Ørret	<0,005	240	1,2	0,011	<0,02	120	0,038	<0,01	27	46
7	Randsfjorden	Abbor	0,01	180	4,2	0,019	0,03	150	0,43	<0,01	3,2	28
8	Randsfjorden	Abbor	0,01	180	5,6	0,037	<0,02	230	0,44	0,015	3,9	29
9	Randsfjorden	Abbor	0,008	150	2,4	0,013	<0,02	140	0,28	<LOD	4	24
10	Tyrifjorden	Abbor	0,02	240	15	0,10	<0,02	180	0,37	0,042	3,3	31
11	Tyrifjorden	Abbor	0,01	200	6,4	0,043	<0,02	150	0,34	<0,01	2,7	29
12	Tyrifjorden	Abbor	0,01	210	6,7	0,019	<0,02	36	0,3	<LOD	7,4	29
13	Foroll	Ørret	<0,005	200	0,6	0,010	<0,02	110	0,21	0,057	37	46
14	Foroll	Ørret	0,006	150	9,6	0,021	0,03	120	0,16	0,091	44	45
15	Kapervatnet	Ørret	<LOD	140	4,9	0,070	<LOD	310	0,35	0,059	1000	41
16	Ytre Fiskelaus-	Ørret	<0,005	200	5,7	0,013	<0,02	90	0,11	0,022	64	34
17	Ytre Fiskelaus-	Ørret	<0,005	200	3,4	0,008	<0,02	100	0,13	0,042	87	40
18	Ytre Fiskelaus-	Ørret	<LOD	200	0,5	0,004	<0,02	73	0,053	<0,01	49	33
19	Ytre Fiskelaus-	Røye	<0,005	200	4,2	0,017	<0,02	370	0,18	0,032	9,1	29
20	Ytre Fiskelaus-	Røye	<0,005	190	4,2	0,017	<0,02	390	0,19	0,012	7,2	29
21	Ytre Fiskelaus-	Røye	0,020	220	38	0,10	0,12	370	0,25	0,027	100	32
22	Nystøls-	Ørret	<0,005	180	4,7	0,025	<0,02	170	0,061	<LOD	43	48
23	Nystøls-	Ørret	0,009	200	11	0,069	<0,02	180	0,043	0,015	35	53
24	Nystøls-	Ørret	<0,005	190	9,1	0,082	<0,02	210	0,057	<0,01	76	40
25	Grongstads-	Ørret	<LOD	240	0,8	0,026	0,04	68	0,019	0,012	52	50
26	Fjellgards-	Ørret	<LOD	180	2,6	0,013	<0,02	170	0,079	0,026	240	57
27	Fjellgards-	Ørret	<LOD	180	2,8	0,018	<0,02	160	0,11	0,028	110	48
28	Fjellgards-	Ørret	<LOD	200	3,9	0,037	<0,02	160	0,11	0,019	160	46
29	Tangenfossen	abbor	<LOD	140	0,8	0,016	<0,02	34	0,095	<0,01	1,4	17
30	Eikeren	Ørret	<LOD	180	0,6	0,012	<0,02	71	0,018	<LOD	8,8	51
31	Eikeren	Ørret	<LOD	140	0,5	0,010	<0,02	110	0,017	<0,01	14	51
32	Eikeren	Ørret	<LOD	140	0,5	0,008	<0,02	89	0,018	<LOD	4,2	40
33	Bjørnsund	Sik	<LOD	200	1,2	0,061	<0,02	120	0,26	0,52	24	56
34	Bjørnsund	abbor	<0,005	170	3,3	0,064	<0,02	180	0,30	0,26	3,6	26
35	Bjørnsund	abbor	<0,005	180	2,8	0,073	0,03	150	0,22	0,14	1,9	24
36	Bjørnsund	abbor	<0,005	150	2,8	0,054	0,04	91	0,19	0,14	2,2	23

			As	Se	Mo	Ag	Cd	Hg	Hg muskel	Pb	d15NAIR	d13CVPDB

Det.lim												
rec												
1	Gjende	Ørret	0,026	11	0,19	0,65	0,23	0,050	0,048	0,022	4,62	-25,11
2	Gjende	Ørret	0,007	9	0,17	0,85	0,38	0,14	0,15	0,0058	4,78	-25,64
3	Gjende	Ørret	0,005	8,4	0,15	0,63	0,36	0,12	0,14	0,0065	5,32	-26,10
4	Tinnsjå	Ørret	0,024	2,9	0,15	0,86	0,68	0,21	0,16	0,018	7,41	-27,45
5	Tinnsjå	Ørret	0,014	5,4	0,17	1,4	0,59	0,25	0,17	0,0092	7,15	-27,66
6	Tinnsjå	Ørret	0,015	2,5	0,15	0,96	0,56	0,19	0,18	0,016	7,46	-25,73
7	Randsfjorden	Abbor	0,28	1,1	0,17	0,0051	0,77	0,20	0,29	0,028	12,02	-24,25
8	Randsfjorden	Abbor	0,3	1,1	0,15	0,0069	1,0	0,15	0,27	0,012	12,14	-22,27
9	Randsfjorden	Abbor	0,19	0,88	0,11	0,0067	0,46	0,20	0,40	0,013	11,51	-23,68
10	Tyrifjorden	Abbor	0,13	0,89	0,12	0,0058	0,87	0,097	0,23	0,022	11,58	-23,24
11	Tyrifjorden	Abbor	0,17	0,9	0,13	0,0059	0,76	0,11	0,27	0,012	12,18	-24,27
12	Tyrifjorden	Abbor	0,15	1,1	0,13	0,02	0,48	0,53	0,43	0,0066	11,73	-22,68
13	Foroll	Ørret	0,042	4,3	0,14	0,72	0,091	0,045	0,038	0,0056	6,16	-20,37
14	Foroll	Ørret	0,037	5,6	0,15	0,97	0,080	0,039	0,036	0,011	6,62	-21,33
15	Kapervatnet	Ørret	0,045	110	0,23	8,4	0,84	0,25	0,064	0,028	6,00	-23,23
16	Ytre Fiskelaus-	Ørret	0,042	3,4	0,12	0,57	0,047	0,039	0,032	0,013	7,51	-22,06
17	Ytre Fiskelaus-	Ørret	0,066	6,4	0,15	0,74	0,044	0,063	0,028	0,005	7,60	-20,83
18	Ytre Fiskelaus-	Ørret	0,038	5,1	0,11	0,64	0,041	0,050	0,060	0,0032	8,54	-22,21
19	Ytre Fiskelaus-	Røye	0,046	1,3	0,12	0,036	0,13	0,098	0,075	0,0066	7,38	-22,76
20	Ytre Fiskelaus-	Røye	0,056	1,2	0,093	0,048	0,16	0,082	0,092	0,0056	8,78	-22,89
21	Ytre Fiskelaus-	Røye	0,10	1,5	0,12	0,5	0,22	0,088	0,061	0,012	8,04	-21,63
22	Nystøls-	Ørret	0,008	15	0,16	2	0,68	0,10	0,067	0,18	3,38	-22,12
23	Nystøls-	Ørret	0,009	13	0,16	2,1	1,0	0,12	0,10	0,19	3,83	-22,45
24	Nystøls-	Ørret	0,007	21	0,19	3,5	0,98	0,14	0,098	0,18	3,23	-22,26
25	Grongstads-	Ørret	0,16	3,6	0,098	0,78	0,088	0,22	0,15	0,0027	11,33	-24,01
26	Fjellgards-	Ørret	0,045	22	0,20	7,2	1,8	0,13	0,14	0,16	7,60	-26,38
27	Fjellgards-	Ørret	0,021	8,5	0,16	4,4	2,0	0,10	0,078	0,17	7,46	-26,72
28	Fjellgards-	Ørret	0,040	16	0,16	4,8	1,7	0,13	0,15	0,17	8,68	-26,26
29	Tangenfossen	abbor	0,044	0,79	0,080	0,013	0,084	0,060	0,087	0,0036	8,47	-25,03
30	Eikeren	Ørret	0,12	2,3	0,14	0,41	0,28	1,5	0,84	0,0036	13,13	-26,77
31	Eikeren	Ørret	0,13	2,9	0,13	0,42	0,27	1,6	0,70	0,0028	13,26	-26,86
32	Eikeren	Ørret	0,088	1,9	0,15	0,33	0,21	1,5	0,74	0,0027	13,22	-27,19
33	Bjørnsund	Sik	0,29	0,73	0,08	0,078	0,098	0,064	0,044	0,018	8,36	-20,46
34	Bjørnsund	abbor	0,11	1,2	0,12	0,0011	0,76	0,065	0,15	0,019	9,12	-19,20
35	Bjørnsund	abbor	0,067	0,9	0,11	0,00072	0,42	0,063	0,17	0,0038	9,27	-21,91
36	Bjørnsund	abbor	0,054	1,2	0,094	0,0028	0,44	0,081	0,21	0,0094	9,18	-19,97