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Perfluorinated alkylated substances, brominated flame retardants and chlorinated paraffins in the Norwegian Environment - Screening 2013

NILU Norsk institutt for luftforskning
Norwegian Institute for Air Research

SWECO

Norsk Polarinstitutt

Preface

This report presents findings from the 2013 screening study conducted by the Norwegian Climate and Pollution Agency (Klif) on selected pollutants of concern in background locations on the Norwegian mainland and Arctic. The aim of this study was to assess background concentrations of selected compounds and whether their current use poses a risk to the Norwegian environment including the Arctic. Selected compounds (i.e., brominated flame retardants, perfluorinated alkylated substances and chlorinated paraffins) have been chosen by Klif. Sampling has been designed by NILU and SWECO with exception of samples collected from the Arctic, which were preselected by Klif.

Within the project we assessed background concentrations of selected compounds and whether their current use poses a risk to the Norwegian environment including the Arctic.

The project was collaboration between NILU and SWECO and sampling was assisted by NINA, NPI and Akvaplan-niva.

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Halvard Kaasa
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Norwegian Polar Institute

Sveinn Are Hansen
Norwegian Institute for Nature Research

Mikael Harju, Athanasios Katsoyiannis, Anders R. Borgen, Ellen Katrin Enge, Nick Warner, Eldbjørg S. Heimstad
NILU - Norwegian Institute for Air Research

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Dorte Herzke
Senior Researcher, Project Coordinator

1. Content

2. Summary

The 2013 screening project, funded by the Norwegian Climate and Pollution Agency (Klif), focused on three brominated flame retardants (BFRs) and two intermediates; precursors and final degradation products of perfluoroalkyl substances (PFAS); and chlorinated paraffins (CPs). To be able to distinguish between pollution sources (i.e., long-range transport vs. local sources) and establish a contaminant baseline for future time- and spatial trends, samples collected at remote locations were analyzed. Studies of biomagnification of the contaminants in the terrestrial and marine food web was carried out with the use of field derived bioaccumulation factor (BAF), biota-sediment accumulation factor (BSAF) and trophic magnification factors (TMF). Biomagnification of the contaminants was assessed only if the majority of the samples contained detectable levels to ensure accurate assessment.

PFAS. Only 10 of the 17 preselected PFAS compounds were found above detection limits in the samples. Lowest PFAS levels were found in abiotic samples, while the highest levels were found in seal liver, plasma and eggs of marine birds and polar bear plasma. No considerable differences in sumPFAS levels between Norwegian mainland and the Arctic were found, except that perfluoroctane sulfonate (PFOS) contributed in higher proportions in samples from the mainland. Perfluorinated carboxylic acids (PFCAs) contributed mostly to terrestrial samples, whilst perfluorinated sulfonates dominated marine biota. The PFAS levels are in good agreement with background data reported in literature. However, environmental levels of the various PFAS compounds from scientific literature over the past years show large variability due to voluntary production stop by the industry and legislation and rapid environmental responses, making comparison of levels from this screening study difficult. The finding of PFCAs levels exceeding the levels of the sulfonates in terrestrial samples have barely been observed previously. This might indicate coincident decreasing PFOS- and increasing PFCA levels in the environment.

The PFOS substitutes 1H,1H,2H,2H—perfluorooctane sulfonate (6:2 FTS) and perfluorodecane sulphonate (PFDcS) were only detected occasionally and at levels close to quantification limits with most detects occurring in field mouse liver and soil. This may be attributed to their high surface activity, leading to adsorption to particles. Their low presence in the environment indicates either limited use of these chemicals or that they are not stable enough to reach remote locations. In contrast, the other group of not detected PFAS, the fluorotelomer alcohols (FTOHs) and fluorotelomer saturated/ unsaturated carboxylic acids (FT(U)CAs), are widely used chemicals, but they are either too volatile to be taken up by organisms or too chemically reactive to reach remote areas.

BFRs. Polybrominated diphenyl ether (PBDE) 47 and decabromodiphenyl ethane (DBDPE) were the most frequently detected BFR compounds within this study. An interesting and new finding from the screening was that DBDPE levels exceeded the levels of PBDE 47 in numerous samples, including the Arctic samples. This is likely due to the European and global ban in 2004 and 2009, respectively, of the lower brominated PBDEs and increased use of substitute chemicals, such as DBDPE. The highest levels of DBDPE on a lipid weight basis were found in plasma from polar bear, glaucous gull and ringed seal from Arctic and in harbor seal liver from the mainland. The compound 2,4,6-tribromophenol (TBP) was detected in a broad range of samples and at high concentrations, whereas pentabromophenol (PBP) was only sparsely detected. As TBP can be formed naturally in the marine environment, it is difficult to evaluate the potential environmental risk of this compound and to elucidate anthropogenic sources.

CPs. Short-chained and medium-chained chlorinated paraffins (SCCPs and MCCPs) were only investigated in Arctic biota. Detectable concentrations were found in a majority of samples. Levels of SCCPs were found to dominate compared to MCCPs in polar bear and seal plasma, kittiwake eggs, cod liver and polar cod. However, the opposite trend was observed for glaucous gull plasma and eider duck eggs where MCCPs were found at higher concentrations.

Biomagnification. PFOS, perfluorononanoic acid (PFNA) and long-chained PFCAs, PBDE 47, DBDPE and TBP showed trophic magnification factors (TMFs) > 1 in both marine ecosystems from the Norwegian mainland and the Arctic. This is also one of the first studies indicating that SCCP and MMCP biomagnify in Arctic food webs with TMF > 1. In the freshwater system, DBDPE and TBP exhibited biota-sediment accumulation factor (BSAF) > 10000. These data, together with literature supplementing data, add to the evidence that biomagnifications takes place in nature

between different trophic levels of food webs and from bottom to top of food webs. The partly natural sources of TBP make an estimation of biomagnifications and the role of man-made emissions difficult to assess.

The results from the screening study reveal the need for follow studies to verify the potential environmental risk of TBP and DBDPE, follow up on time trends of PFAS emissions and exposure as well as increasing the understanding of the fate of S/MCCP in the environment.

3. Sammendrag

Screening-prosjektet i 2013, finansiert av Klima-og forurensningsdirektoratet (Klif), fokuserte på tre bromerte flammehemmere (BFR) og to intermediater fra tilvirkningsprosesser, forløpere og nedbrytningsprodukter av perfluoralkylstoffer (PFAS), og klorerte parafiner (CPS). Det ble samlet inn prøver fra bakgrunnslokaliteter på fastlandet og Arktis for å kunne eliminere lokale forurensingskilder samt gi innsikt i bakgrunnsdata for de valgte komponentene som følge av langtransportert forurensing. Denne type bakgrunnsdata vil kunne være viktig grunnlag for fremtidige studier på tidstrender og geografiske forskjeller. Biomagnifikasjon av forbindelsene i terrestriske og marine næringskjeden ble vurdert ved bruk av bioakkumulering (BAF), biota-sediment akkumulering faktor (BSAF) og trofiske magnifiseringfaktorer (TMF). Vurderingen ble kun gjort for de stoffene som var påvist i 60 % eller mer av prøvene.

PFAS. Kun 10 av de 17 forhåndsvalgte PFAS forbindelsene ble funnet over deteksjonsgrensene i prøvene. Laveste PFAS nivå ble funnet i abiotiske prøver, mens de høyeste nivåene ble funnet i sel-lever, plasma og egg av marine fugler samt isbjørnplasma. Det ble ikke funnet noen betydelige ulikheter i sumPFAS nivåer mellom norsk fastland og Svalbard, bortsett fra at perfluoroktansulfonat (PFOS) bidro mer i prøver fra fastlandet. Perfluorerte karboksylsyrer (PFCAs) utgjorde mesteparten av PFAS i de terrestriske prøvene, mens perfluorerte sulfonater dominerte marin biota. Siden PFAS nivåene i miljøet over tid har vist stor variasjon på grunn av frivillig produksjonsstans fra industri og reguleringer med påfølgende rask respons i miljøet, er sammenligning med tidligere data utfordrende. PFAS-nivåene er i god overensstemmelse med bakgrunnsdata rapportert i litteraturen. Det at PFCA-nivåene overskrider nivåene av sulfonatene i de terrestriske prøvene er et interessant funn som kan tyde på sammenfallende minkende PFOS- og økende PFCA nivåer i miljøet.

PFOS-erstatningsstoffene 1H, 1H, 2H, 2H-Perfluoroktansulfonat (6:2 FTS) og perfluorodecane sulphonate (PFDcS) ble bare sporadisk detektert, med størst bidrag i jord og i mus, samt i nivåer nær kvantifiseringsgrensene. Dette kan potensielt forklares av den høye overflateaktiviteten til disse stoffene som favoriserer partikkeladsorpsjon. Den lave forekomsten i miljøet antyder enten begrenset bruk av disse kjemikaliene, eller at de ikke er stabile nok til å bli langtransportert. Fluorotelomer alkoholer (FTOHs) og fluorotelomer mettet/ umettete karboksylsyrer (FT(U)CAs) som har stor (industriell) anvendelse, ble ikke påvist i noen prøver, og er enten for flyktig eller for reaktiv til å nå avsidesliggende områder.

BFR. Polybromerte difenyleteren (PBDE) 47 og dekabromdifenyletan (DBDPE) var de hyppigst påviste BFR-forbindelser i denne studien. Overraskende funn var at DBDPE-nivåene overskred nivåene av PBDE 47 i mange av prøvene. Dette skyldes sannsynligvis det europeiske og globale forbudet i 2004 og 2009 av PentaBDE og økt bruk av erstatningskjemikalier som for eksempel DBDPE. 2,4,6-tribromfenol (TBP) ble funnet i relativt høye konsentrasjoner i et bredt spekter av prøver uten klare ulikheter mellom det terrestre og marine miljøet. Pentabromfenol (PBP) ble bare detektert i noen få prøver. Siden TBP kan dannes naturlig i miljøet, er det vanskelig å vurdere antropogene kilder og miljømessige risiko for denne forbindelsen, og det anbefales nye studier av terrestre prøver som kan bekrefte eller avkrefte funnene i denne studien.

CPs. Kortkjedete og mellomstore klorparafiner (SCCP og MCCP) ble kun undersøkt i arktisk biota og stoffene ble påvist i flertallet av prøvene. Nivåene av SCCP ble funnet å dominere i forhold til MCCP i isbjørn, selplasma, krykkjeegg, torskelever og polartorsk. Imidlertid ble det motsatte observert for polarmåkeplasma og ærfuglegg der MCCP dominerte.

Biomagnifisering. PFOS, perfluorert nonansyre (PFNA) og langkjedete PFCA, PBDE 47, DBDPE, TBP viste alle trofiske magnifiseringsfaktorer høyere enn 1, (TMFs)> 1, for både marine økosystemer fra det norske fastlandet og Arktis. Dette er også den første studien som indikerer at SCCP og MMCP biomagnifiserer i arktisk næringsnett med TMF> 1. Biota-sediment akkumuleringsfaktor (BSAF) > 10000 ble funnet for DBDPE og TBP i ferskvanns økosystemer. TMF- og BSAF-data sammen med litteraturdata, understøtter at biomagnifisering er tilstede i marint miljø mellom ulike trofiske nivåer og fra bunnen til toppen av næringsweb av PFOS, PFNA, PBDE 47, TBP, SCCP og MCCP. Det delvis

naturlige opphav til TBP gjør det vanskelig å estimere en eventuell biomagnifisering og rollen av antropogent utslipp til eksponering i det norske miljøet.

Resultatene fra screening studien viser behovet for oppfølgingsstudier for å vurdere potensiell miljørisiko av TBP og DBDPE, følge opp tidstrender av PFAS utslipp og eksponering, samt øke forståelsen av skjebnen til S / MCCP i miljøet.

4. Frame of the study

The aim of this study was to conduct a survey of selected brominated flame retardants and intermediates (BFRs), perfluorinated alkylated substances (PFAS) and chlorinated paraffins (CPs) in background locations of the Norwegian Arctic and the Norwegian mainland. The selected mainland sampling sites are locations that are assumed to be little affected by point sources of PFAS and BFR due to limited human activity. Water, sediment and biota from marine, freshwater and terrestrial locations were examined. PFAS, BFRs and additional CPs were investigated in samples collected in the Norwegian Arctic, Svalbard. The study was aiming to assess the potential risk of these contaminants to the Norwegian environment including the Arctic.

5. Background

Three different groups of environmental pollutants were focused on in the 2013 screening by Klif. Within the group of BFRs, five compounds representing a variety of physicochemical properties and industrial applications were selected. For PFAS, both precursor compounds and stable end products were selected. In Arctic biota samples, chlorinated paraffins were investigated as well. See *Table 1* for a complete list of compounds selected for this screening.

In order to distinguish between pollution sources (i.e., long-range transport vs. local sources) and establish a contaminant baseline for future time- and spatial trend analysis, only samples collected from remote locations were analyzed. In addition, it is also important to supply valuable general knowledge about background levels in the Norwegian environment.

Table 1. Chemical name and CAS numbering of the targeted pollutants.

Name	CAS number	Abbreviation
Ionic PFAS:		
Perfluoroctane sulphonate	1763-23-1	PFOS
Perfluorodecane sulphonate	67906-42-7	PFDS
Perfluorooctanoic acid	335-67-1	PFOA
Perfluorononanoic acid	375-95-1	PFNA
Perfluordecanoic acid	335-76-2	PFDcA
Perfluoroundecanoic acid	4234-23-5/ 2058-94-8	PFUnA
Perfluorododecanoic acid	307-55-1	PFDoA
Perfluorotridecanoic acid	72629-94-8	PFTrA
Perfluorotetradecanoic acid	376-06-7	PFTeA
1H,1H,2H,2H—perfluorooctane sulfonate	27619-97-2	6:2 FTS
Volatile and precursor PFAS:		
Perfluorohexyl ethanol	647-42-7	6:2 FTOH
Perfluorooctyl ethanol	678-39-7	8:2 FTOH
Perfluorodecanyl ethanol	678-39-7	10:2 FTOH
1H,1H,2H,2H—perfluorooctanoate	27854-30-4	6:2 FTCA
1H,1H,2H,2H—perfluorodecanoate	34598-33-9	8:2 FTCA
1H,1H,2H,2H—perfluoro Decenoic acid	70887-84-2	8:2 FTUCA

1H,1H,2H,2H—perfluoro Dodecenoic acid	70887-94-4	10:2 FTUCA
BFRs:		
Decabromodiphenylethane	84852-53-9	DBDPE
Pentabromophenol	608-71-9	PBP
2,4,6-tribromophenol	118-79-6	TBP
Bis(2-ethylhexyl)tetrabromophthalate	26040-51-7	BEHTBP
2,2',4,4'-tetrabromodiphenylether	5436-43-1	PBDE 47
CPs:		
Medium chained chloroparaffins (C14-17)	85535-85-9	MCCP
Short chained chloroparaffins (C10-13)	85535-84-8	SCCP

Knowledge of background levels for the selected compounds will be useful in assessing the impacts of future climatic changes on contaminant transport routes. As many of the target compounds are potential substitutes for already regulated chemicals, the collected data can provide information on whether they already pose a threat to the environment as well and to assess eventual future risks.

For most of the investigated compounds, little is known regarding their ecotoxicological characteristics. PBDE 47 and PFOS are compounds in which previous knowledge regarding their environmental behaviour is known. These chemicals are listed under the Stockholm convention for persistent organic pollutants (POPs), fulfilling the requirements for persistency, bioaccumulation and toxicology. The long chained PFCAs, PFDoA, PFUnA, PFTrA and PFTeA have been included in the Candidate list of substances of very high concern by the ECHA due to their very persistent and very bioaccumulative characteristics (vPvB). For SCCPs the Annex E risk profile under the Stockholm Convention was not accepted by the POPs review committee, and instead they decided to postpone any decision for 3 years, and try and reach a decision in 2015. MCCPs have also been assessed for their risk and have been identified as harmful on a number of areas; the assessment for PBT characteristics is still ongoing.

5.1 Brominated flame retardants (BFRs)

Halogenated flame retardants are primarily based on chlorine and bromine. Typical halogenated flame retardants are halogenated paraffins, halogenated alicyclic and aromatic compounds and halogenated polymeric materials. Flame retardants are characterised in two different ways depending upon how they are manufactured. Reactive flame retardants are added during the polymerization process and become an integral part of the polymer, forming a copolymer, see *Table* 2. Additive flame retardants are incorporated into the polymer prior to, during, or more frequently after polymerization. They are used especially in thermoplastics. Additive flame retardants are monomer molecules that are not chemically bound to the polymer and may be released from the polymer and discharged to the environment (Danish Environmental Protection Agency 1999).

Historically the pentaBDE and octaBDE technical mixtures have been used as flame retardants containing polybrominated diphenyl ethers (PBDEs). In a most recent review of these chemicals, PBDEs are considered ubiquitous contaminants in the Arctic where increasing concentrations of tetra- to heptaBDEs have been observed over time in some environmental matrices. However, other matrices show a different trend where concentrations appear to be leveling off. Location of sample collection has also been observed to have an effect on observed concentrations, making assessment of the fate of these chemicals difficult within the Arctic (de Wit et al. 2010).

Spatial trends of PBDEs in Arctic seabirds and marine mammals indicate that Western Europe and east coast of North America as important source regions of these compounds via long range atmospheric transport and ocean currents. The tetra-hexaBDEs have been shown to biomagnify in Arctic food webs, while results for BDE-209 are more conflicting, showing either only low or no biomagnification potential. PBDE concentrations have been observed to be low in terrestrial organisms and higher in marine top predators (de Wit et al. 2010). Data on marine fish from Greenland and northern Norway (e.g. Atlantic cod, polar cod, halibut) show BDE-47 to be the main BDE congener, accounting for 90–95% of the ΣPBDE concentration with concentrations ranging between 3 to 480 ng/g lw (de Wit et al. 2010).

As a result of the regulation of the penta- and octaBDEs and more recently decaBDE, new non-PBDE BFRs have been introduced into the market. Firemaster 550 (containing BEHTBP) is a replacement product for PentaBDE (Venier and Hites, 2008) and was introduced to the market in 2003 (Stapleton et al., 2008). Saytex 8010 (Albemarle) and Firemaster 2100 (Chemtura), which are common trade names for decabromodiphenyl ethane (DBDPE) is a replacement for the DecaBDE and was introduced into the market in the mid-1980s (Umweltbundesamt, 2001).

DBDPE has only been studied in a few screening activities connected to Scandinavia and the Arctic region. DBDPE and DecaBDE were investigated in air from remote locations within Sweden to assess thier long-range transport capacity from point sources from the continental Europe. The concentration ranges of DBDPE and BDE-209 were similar, 0.077-7.9 and 0.093-1.8 pg m^{-3} air, respectively. The highest concentrations were detected when the air trajectories originated from the European continent (Egebäck et al. 2012).

More recently, 14 “new” BFRs have been under investigation as potentially relevant for further investigation and monitoring in the Norwegian environment (Harju et al. 2009). In 2010, a screening exercise for these ”new” brominated flame retardants (BFRs) in seven animal species from Svalbard was carried out: three seabird species (common eider *Somateria mollissima*, Brünnich’s Guillemot *Uria lomvia* and black-legged kittiwake *Rissa tridactyla*), one fish species (capelin *Mallotus villosus*), and three mammalian species (ringed seal *Pusa hispida*, arctic fox *Vulpes lagopus* and polar bear *Ursus maritimus*). The goal was to investigate the long-range transport, persistence, and bioaccumulation potential of these BFRs in Arctic biota. Results of this screening showed that two of the “new” BFRs; 2-ethylhexyl-2,3,4,5-tetrabromobenzoate (TBB) and bis(2-ethylhexyl) tetrabromophthalate (BEHTBP) undergo long range transport to higher latitudes. Results also indicate that TBB had potential to biomagnify in the marine food web, while BEHTBP did not. Three other BFRs was found at very low levels e.g. 1,2-bis(2,4,6-tribromophenoxy)ethane (BTBPE), decabromodiphenylethane (DBDPE) and 2,4,6-tribromophenol (2,4,6-TriBP) (mean 0.05-0.7 ng/g wet weight) (Sagerup et al. 2010).

The predominant industrial use of TBP is as an intermediate in the preparation of flame retardants such as brominated epoxy resins. TBP reacts with sodium hydroxide to form the sodium salt, which is used as a fungicide and wood preservative. It is produced at high volumes and has been estimated to have a high potential for bio-accumulation and long-range transport. It has been detected in a wide range of environmental samples (i.e., indoor/outdoor air, water, sediment, biota and humans) in Australia, Asia, Pacific Ocean, Great Lake System (US), and Europe and in the North and Baltic Seas (Harju et al., 2008, Schlabach et al. 2011, Møskeland, 2010). TBP is also naturally formed in marine organisms such as sponges and algae (Vetter and Janussen 2005;Sim et al. 2009). The compound TBP was the only “new” BFR found in previous studies investigating terrestrial animals (0.01 – 0.15 ng/g ww) (Polder et al. 2008). It has been also detected in Arctic animals such as ringed seal and common eider (0.05 and 0.09 ng/g ww) (Sagerup et al. 2010). TBP has been detected in edible crab (Cancer pagurus) from Drammensfjorden (3.0 –8.2 ng/g ww) and in higher concentrations in spider crab and lyre crab from Sannesundet (42.1 – 131 ng/g ww) (Møskeland, 2010). An excellent compilation of Norwegian screening data on BFRs can be found in previous reports (Arp 2013; Thomsen et al. 2001). Temporal trend investigations (1977-2003) for BFRs have also been conducted in, pooled serum samples from the Norwegian population. PBDEs levels were observed to increased from 1977 to 1988 and then stabilize from 1989 to 2003, while TBP showed no relations to trends, which might be due to short half-lives of TBP in humans (Thomsen et al. 2002; Thomsen et al. 2007).

Table 2. BFRs names, CAS numbers and type of usage in commercial products

Substance	CAS	Type of BFR	Area of application
Decabromodiphenylethane	84852-53-9	Additive	Styrene
2,4,6-Tribromophenol Pentabromophenol	118-79-6 608-71-9	Reactive intermediates	Epoxy resins, Phenolic resins, Polyester resins, Polyolefins
Bis(2-ethylhexyl) tetrabromophthalate	26040-51-7	Additive	PVC, Neoprene

In the Klif report "Current state of knowledge and monitoring requirements- Emerging "new" brominated flame retardants in flame retardant products and the environment ". (TA-2462/2008), physicochemical characteristics for the target BFR are mentioned. Similar physicochemical characteristics can be found in Wania et al. 2002 for the PBDEs. The air-water partitioning coefficient (K_{AW}) and the octanol-air partitioning coefficient (K_{OA}) can be used to locate the BFR chemicals in the chemical partitioning space defined by these two equilibrium partitioning coefficients. K_{AW} and K_{OA} were predicted with the SPARC On-line Calculator, which is a chemical property prediction software, which is available for public use, free of charge, and can be accessed at http://sparc.chem.uga.edu (Hilal et al., 2000).

CAS	Name	log K_{OA}	log K_{AW}
118-79-6	2,4,6-Tribromophenol	6.6	-2.30
26040-51-7	Bis(2-ethylhexyl) tetrabromophthalate	17.7	-5.95
84852-53-9	Decabromodiphenylethane (DBDPE)	18.8	-6.29
5436-43-1	PBDE 47	10.3	

Predicted properites indicate that TBP is more volatile as well as more water soluble than PBDE 47, DBDPE and BEHTBP, explaining in part the ubiquitous findings of this compound in marine samples.

5.2 Chlorinated paraffins (CPs)

CPs has been produced since the 1930s and the world production of chloroparaffins was 300,000 tonnes in 2009. Chloroparaffins are used in coolants and lubricants in metal manufacturing industry and as plasticizers and flame retardant additives in plastic, sealants, rubber and leather (KEMI, 2013, WHO 1996). The non-flammability of CPs, particularly at high chlorine contents, relies on their ability to release hydrochloric acid at elevated temperatures, thereby inhibiting the radical reactions in flames (WHO, 1996).

CPs have been studied in the environment but data from Scandinavia and the Arctic is limited (Bayen et al. 2006). In air collected at Bear Island (Norway), concentrations were 1.8 to 10.6 ng/m^3 (Borgen et al. 2003) while SCCPs have been detected in river water in a range of 15.7 to 59.6 ng/L in the St. Lawrence River, Canada (Moore et al., 2003) and < 0.1 to 1.7 µg/L in England and Wales (Nicholls et al., 2001). SCCP have been detected in surface sediments in Arctic lakes in Canada 1.6 to 257 ng/g (Tomy et al., 1997), and SCCPs and MCCPs have been found in sediments from landfills in Norway at levels of up to 19,400 and 11,400 ng/g ww with peak levels associated with waste deposition from mechanical and shipping industries (Borgen et al., 2003). CPs have been detected in biota samples collected in Norway, SCCPs ranged from 14 to 130 ng/g wet weight (ww) in mussels and were also detected in moss samples (3–100 ng/g ww), revealing the potential transportation of SCCPs in the atmosphere (Borgen et al., 2003). Levels of MCCPs ranged from 276 to 563 ng/g ww in carp and 0.257 to 4.39 µg/g ww in trout from Lake Ontario. In Beluga whales collected between 1987 and 1991, SCCPs ranged from 1.78 to 80.0 µg/g ww in blubber and 0.545 to 20.9 µg/g ww in liver samples (Bennie et al. 2000). In fish livers collected from samples in the North and Baltic Seas, SCCPs and MCCPs ranged from 19 to 286 and <10 to 260 ng/g ww (Geiss et al. 2010; Reth et al. 2005).

5.3 Perflorinated alkylated substances (PFASs)

For the PFASs the most important representatives found in environmental samples worldwide were selected. Per- and polyfluorinated alkylated substances (PFASs) have been widely used in many industrial and commercial applications. The chemical and thermal stability of a perfluoroalkyl moiety, which is caused by the very strong C-F bond, in addition to its hydrophobic and lipophobic nature, lead to highly useful and enduring properties in surfactants and polymers. Polymer applications include textile stain and water repellents, grease-proof, food-contact paper and other food contact materials used for cooking. Surfactant applications that take advantage of the unparalleled aqueous surface tension-lowering properties include processing aids for fluoropolymer manufacture, coatings, and aqueous film-forming foams (AFFFs) used to extinguish fires involving highly flammable liquids. Numerous additional applications have been described, including floor polish, ski waxes, and water proof coatings of textile fibers.

Because they are so persistent and hardly degrade in the environment, and because of their widespread use, PFASs have been detected in the environment, wildlife, and humans. Scientific questions focus on how these substances are transported in the environment, and to what extent and how humans and wildlife are exposed (Butt et al. 2010;Jahnke et al. 2007;Kannan et al. 2005;Stock et al. 2007;Taniyasu et al. 2003;Trier et al. 2011).
Within the Screening project both stable ionic PFAS as well as precursor PFAS were investigated in order to acquire insight into the distribution of a broad spectrum of PFASs, to be able to determine if eventually secondary sources could be important for the detection of stable PFAS.

6. Materials and methods

6.1 Chemicals

A detailed list of the chemicals analyzed can be found in *Table 1. Chemical name and CAS numbering of the targeted pollutants.*

6.2 Sampling

Sampling was carried out in a number of locations illustrated in *Figure 1*, covering terrestrial, aquatic and marine locations in remote regions on the Norwegian mainland in addition to Svalbard (Norwegian Arctic). The sampling on the Norwegian mainland was carried out by applying internationally accepted methods following a detailed description for each sample matrix (see Attachment). The samples from the Norwegian Arctic were collected by the Norwegian Polar Institute with the exception of the seal plasma samples which were collected by Akvaplan-niva. Overall 94 samples were collected in the Norwegian mainland and 77 samples from the Norwegian Arctic.

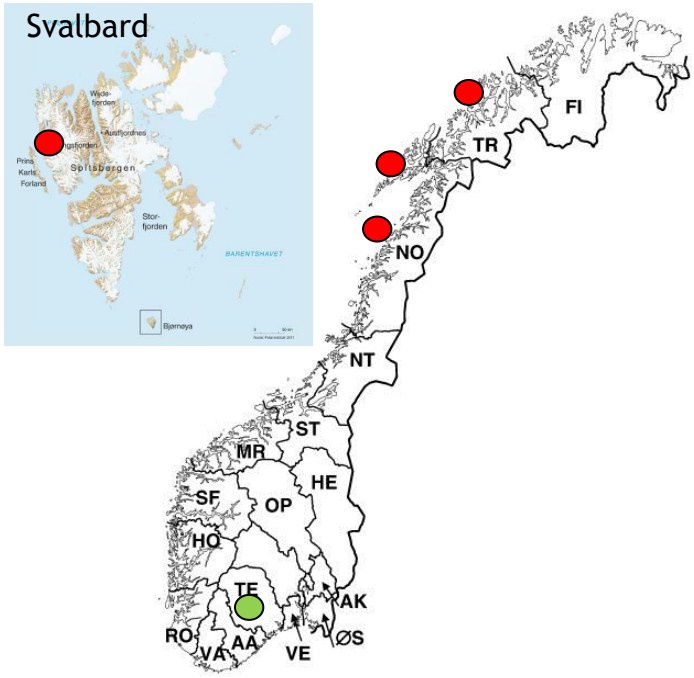

Figure 1. Map showing sampling locations in the Screening 2012/13 on the Norwegian mainland and Svalbard (green: terrestrial, red: marine)

6.2.1 Sampling strategy

Terrestrial and freshwater environment
The sampling plan was based on providing a comprehensive picture as possible from the same locality / region to allow direct comparison of analytical results. Dalsvatn, a small lake in Telemark, was selected due to low human activities, high biodiversity and primary biomass production (*Figure 2*). As representative for the terrestrial environment, soil, mice (*Apodemus* and *Soricidae*) and moose (*Alces Alces*) were sampled in that region. Moose was hunted by local hunters accompanied by a veterinarian and mice were caught in traps. For freshwater representatives we collected sediments, water, European perch (*Perca fluviatilis*) and brown trout (*Salmo trutta*). Due to the lateness in the season no sampling of terrestrial bird eggs was possible.

The terrestrial food chain is much shorter than the marine one and with the selected samples we aimed at providing an adequate picture, supported by published data from other species as representatives of the terrestrial and aquatic ecosystems (Ahrens et al. 2011, Letcher et al. 2010).
Marine samples from the Norwegian mainland were collected along the coast of Troms and Nordland County (*Figure 3*). Seabird eggs from Common eiders (*Somateria mollissima*) and herring gull (*Larus argentatus*) were collected at the remote islands Grinnøya and Sørøya, representing low and high trophic level. Water, sediment, blue mussel (*Mytilus edulis*) and Atlantic cod (*Gadus morhua*) samples were collected in Lofoten and liver from Harbor seal (*Phoca vitulina*) was sampled in Vestvågøy.

In the Norwegian Arctic, samples were collected in the Svalbard region. Species representing the different parts of the Arctic marine food chain were sampled, including polar cod (*Boreogadus saida*), Atlantic cod, Common eider, kittiwake (*Rissa tridactyla*), glaucous gull (*Larus hyperboreus*), ringed seal (*Phoca hispida*) and polar bear (*Ursus maritimus*).

As both PFAS and BFRs can be found in blood rich/lipid rich organs and in order to enable comparability with the samples collected in the Norwegian Arctic and literature data in general, liver was the main organ sampled in the present study. Seabird samples included mostly eggs. From Arctic marine mammals, plasma was collected. For all sample types, individual samples were analyzed in order to facilitate the assessment of variations within one species. The sampled tissue varied more in the Arctic samples due to limitations during sampling campaigns etc. However, the overall campaign was designed to provide similar sample types from all locations to facilitate an optimal comparison of data.

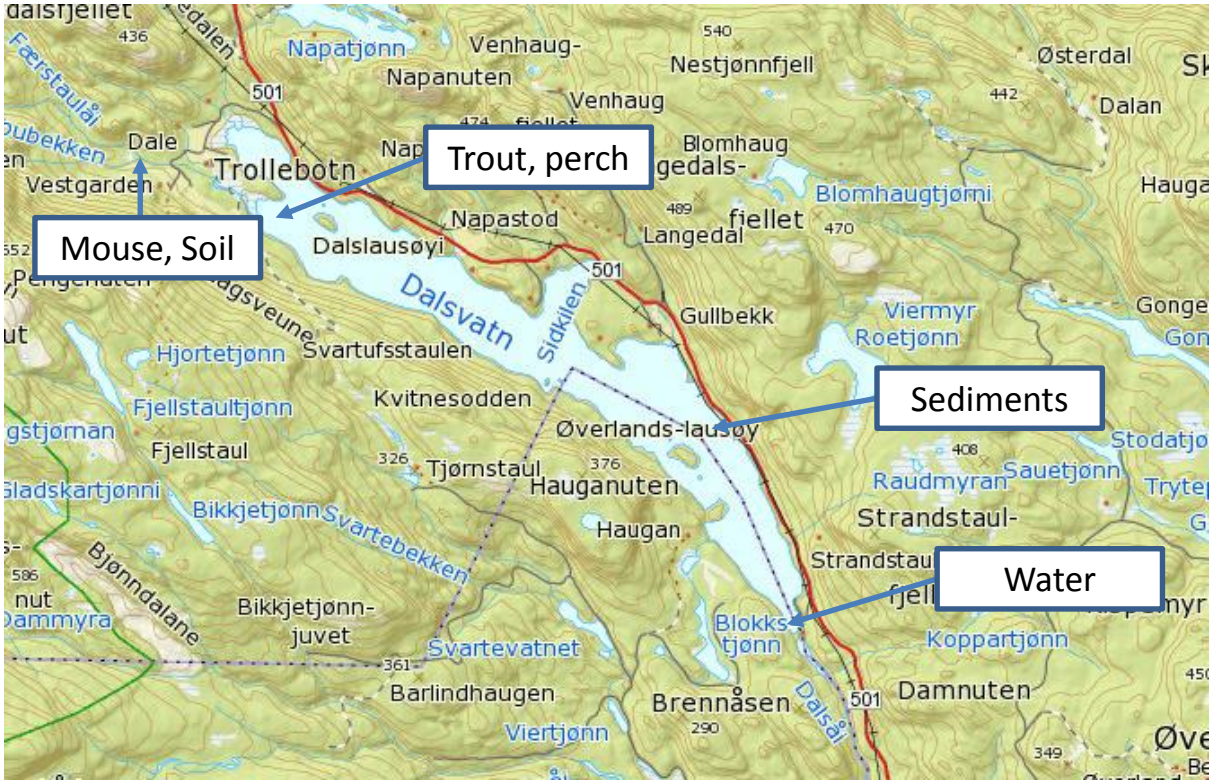

Figure 2. Sampling location in the fall 2012, Dalsvatn, Telemark (Sweco Norge AS). Moose was sampled in the same region of Dalsvatn.

Marine environment, Northern Norway

Samples of water, sediments, Atlantic cod, mussels and harbor seals were all collected in Lofoten while eggs from Common eider and Herring gull were collected in Troms and Finnmark, respectively. The selected samples were chosen to reflect a significant part of the marine food chain to make an assessment of biomagnification possible. *Table 3* shows the samples for terrestrial, aquatic and marine sampling.

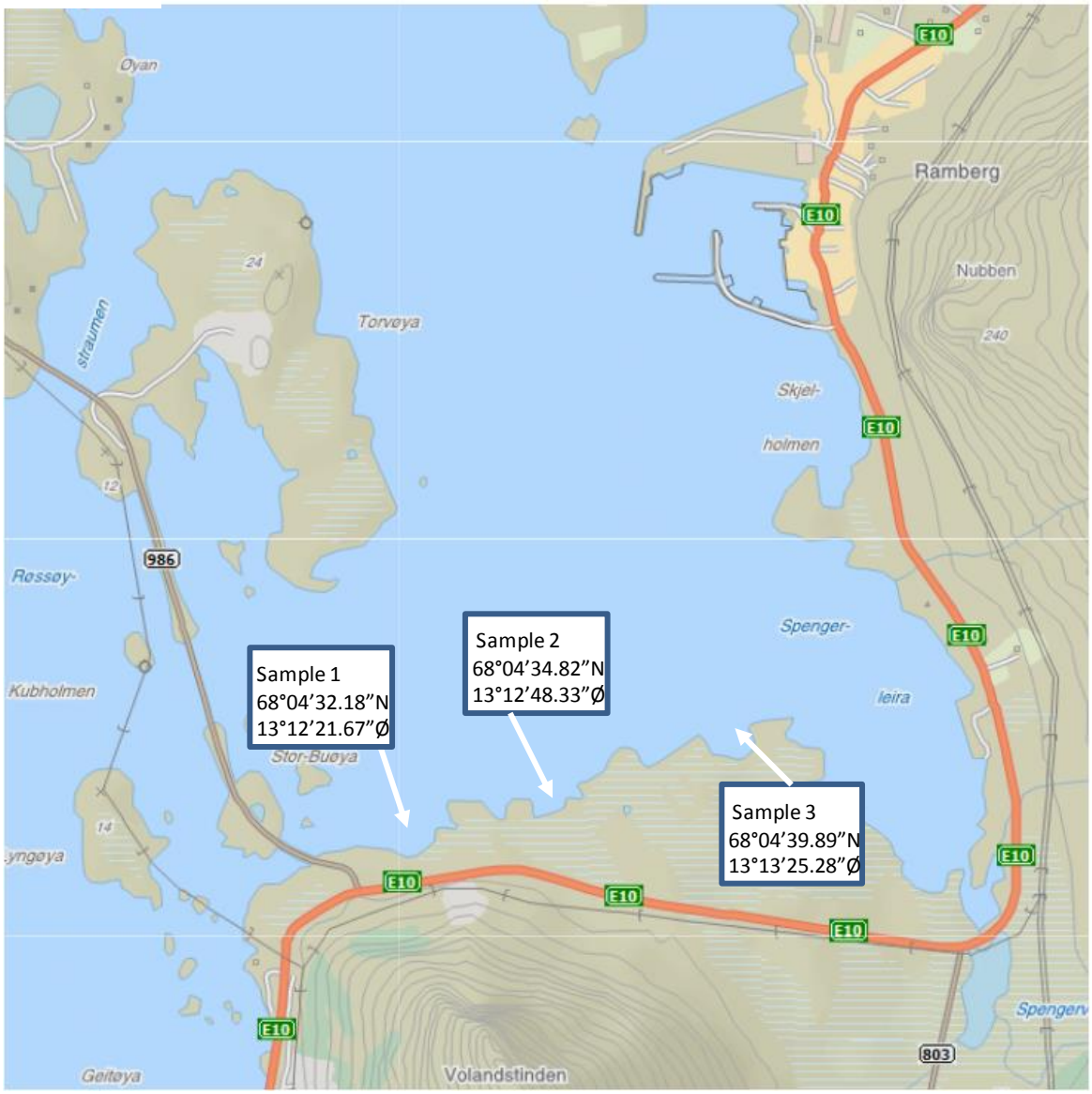

Figure 3. Sampling location SW of Ramberg, Lofoten (Sweco Norge AS) for sediment (Sample 1-3, above), water, blue mussel and Atlantic cod. Map from Finn kart, (http://kart.finn.no/, accessed 10.04.2013).

Table 3. Overview of the collected samples, terrestrial, freshwater and marine (Norway mainland)

Sample type	No. Sample	Sample amount	Location	Date	Sampling details
Terrestrial					
Soil	1	2 kg	Dalsvatn along Færstaulåi	Sep-2012	Pooled sample from 3 locations
Mouse (*Apodemus & Soricidae*)	10	0.001 kg	Dalsvatn along Færstaulåi	Sep-2012	individual liver samples
Moose (*Alces alces*)	9	1 kg	Areas around Dalsvatn (8 Seljord, 1 Kviteseid)	Sep-Oct 2012	individual liver samples
Freshwater					
Water	3 + 3	2 L	Outlet Dalsvatn	Oct-2012	3 locations (water and particles)
Sediments	3	2 kg	Dalsvatn	Oct-2012	3 pooled samples on 3 locations
Trout (*Salmo trutta*)	10	0.05 kg	8 Dalsvatn & 2 Færstaul elvi	Sep-Oct 2012	individual liver samples
Perch (*Perca fluviatilis*)	3		Dalsvatn	Sep-Oct 2012	individual liver samples
Marine					
Water	3 + 3	2 L	Lofoten, Flakstad principality	Oct 2012	3 locations (water and particles)
Sediments	3	2 kg	Lofoten, Flakstad principality	Oct 2012	3 locations
Atlantic Cod (*Gadus morhua*)	10	0.1 kg	Lofoten, Flakstad principality	Oct 2012	individual liver samples
Common Eider (*Somateria Mollissima*)	10	0.1 kg	Grinnøya, Troms	June 2012	individual egg samples
Herring gull (*Larus argentatus*)	10	0.1 kg	Sørøya, Finnmark	June 2012	individual egg samples
Mussels (*Mytilus edulis*)	3	5 st ind	Lofoten, Flakstad principality	Oct 2012	Pooled samples
Harbor Seal (*Phoca vitulina*)	10	0.1 kg	Lofoten -Terrøya, 5 Fjellmoa, 3 Beinøya, Anda	Oct 2012	Individual liver samples

Arctic marine environment

Arctic samples were provided by the Norwegian Polar Institute and were sent in frozen state (-20°C) to the analyzing lab. Detailed information on the species, sampling procedure, areas and quality assurance of the Arctic samples can be found in *Table 4* and Sagerup et al., 2010.

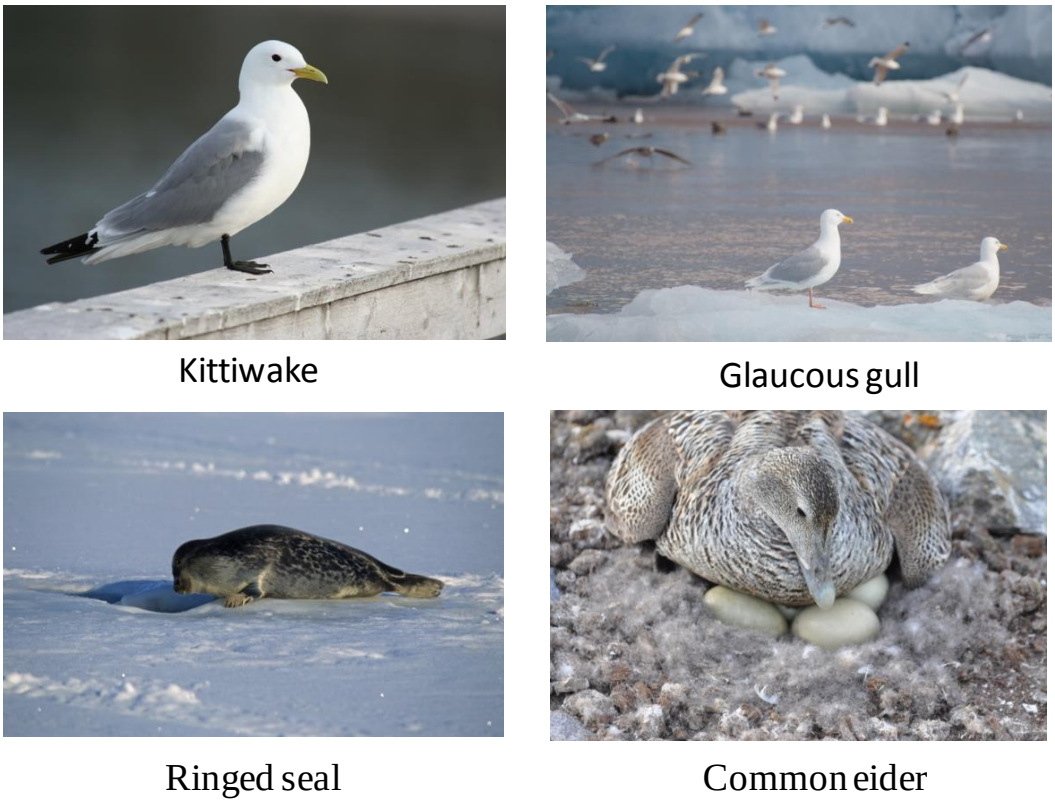

Figure 4. Examples of Artic species sampled within the Screening 2013 (Pictures by: © Anja Johansen Haugerud; Geir Wing Gabrielsen, Bjørn Frantzen; Kim Holmén; Kjetil Sagerup Norsk Polarinstitutt

Table 4. Arctic samples sampled at Svalbard

Sample type	No. Sample	Location	Date	Sampling strategy
Polar bear (*Ursus maritimus*)	20	Svalbard	2012	Individual plasma samples
Kittiwake (*Rissa Tridactyla*)	12	Kongsfjord, Svalbard	2012	Individual egg samples
Common Eider (*Somateria mollissima*)	12	Kongsfjord, Svalbard	2012	Individual egg samples
Glaucous gull (*Larus hyperboreus*)	12	Kongsfjord, Svalbard	2012	Individual plasma samples
Ringed seal (*Phoca hispida*)	10	Kongsfjord, Svalbard	2010	Individual plasma samples
Atlantic Cod (*Gadus morhua*)	10	Svalbard	2012	Individual liver samples
Polar cod (Boreogadus saida)	1	Svalbard	2012	Pooled whole fish sample

6.2.2 Sediment and soil sampling

Sediments were sampled using a core sampler (Plastic tube, 1.5m x 40mm). Samples were taken at 1m water depth and only the top 1-2 cm sediments were analyzed. Three replicate samples per sampling station were taken and pooled to give a mixed sample. Sample material was kept cool and frozen as soon as possible after collection and sent to the laboratory.

Figure 5. Sampling of marine sediments, Lofoten, SWECO

6.2.3 Water sampling

Water was sampled with a water sampler and kept cool (in a cooler) and transported to the laboratory. Three freshwater samples were taken at the surface of the outlet river Dalsål. Water samples were taken at the same time point as the sediment samples. Marine water was sampled in Lofoten, Flagstad principality, Ramberg at three different locations near the coast at rising tides.

6.2.4 Sampling of biota from the Norwegian mainland

By sampling, sample preparation and processing of the sample will be endeavored to follow the guidelines of JAMP Guidelines for Monitoring Contaminants in Biota, Ref. No: 1999-2. The guidelines provide a detailed method description for trapping technique and treatment of samples.

Fish and mussels

The fish (Brown Trout and Perch) were captured in Dalsvatn (Telemark) alive using nets and the liver was sampled as soon after capture as possible, so that the sample should be as fresh as possible. The cod liver and mussels from Lofoten (Northern Norway) were collected by local fishermen approx. 15 km NV of Ramberg, Flakstad municipality. All the liver and mussel samples were kept cool (in a cooler), frozen and transported to the laboratory.

Harbor Seal

Seal samples from Lofoten were collected by local hunters / fishermen and the seal livers was dissected and a sample was frozen and sent to the laboratory.

Mouse and Moose

A total of 15 mice (*Apodemus* & *Soricidae*) were captured along the Færstaulåi, Dalsvatn. More than 100 mouse traps where put out with 10 meter intervals along the Færstaulåi in 2 + 2 + 3 days.

Moose (*Alces alces*) liver was obtained by teams of local hunters in the hunting season of October 2012 in the area around Dalsvatn. These hunters were equipped with sampling equipment and a manual. Age of Moose was determined using tooth analysis. Gender, injuries, abnormalities, antler size, was also recorded. Mice and Liver samples of Moose was frozen and sent to the laboratory.

Seabird eggs

Eider eggs were collected by NINA. Eggs from herring gulls were collected with the help of a local fisherman from Sørøya. Eider eggs were collected at Grinnøya in Troms while Herring gull eggs were collected from Sørøya in Finnmark (both locations from Northern Norway). The entire eggs were frozen and sent to the laboratory where they were opened prior sample preparation.

Details for sampling of the Arctic samples were carried out in a similar manner as described in Sagerup et al. (2010) Klif report TA2630-2010.

Figure 6. Sampling of blood samples, picture by Anja Johansen Haugerud Norsk Polarinstitutt

6.2.5 Quality assurance

Norwegian Standard: SWECO and NILU are certified to both ISO 9001 and 14001. In addition, the "Guidelines for field work in connection with environmental monitoring" was followed. SWECO is accredited to this standard (ISO 9420). This is a more general standard for quality management and logging of data. Sampling of marine sediments followed the standard ISO 9422 and EN ISO 5667 covering sediment sampling in rivers, streams, lakes, estuarine and harbor areas and Jampa Guidelines for Monitoring Contaminants in Biota.
In addition, special precautions were taken when sampling to prevent contamination of samples during field work. Sample collection manuals, were followed that have been tested and adapted to special conditions so as to avoid materials which may contain PFAS and BFRs during sampling, handling and storage. Sampling materials as bags, containers, knives, scalpels, gloves etc were supplied by NILU, in all cases pre-cleaned or disposable. In addition, emphasis was placed on the use of disposable gloves, disposable knives and as little processing of the samples as practical and general cleanliness. Most samples were prepared in the same laboratory for the same compound group which minimized sample handling, shipment, repeated freezing and thawing, etc. to ensure minimum variation in sample quality in all steps and at the same time improves comparability of results (See Appendix for applied manuals).

6.3 Sample preparation and analysis

6.3.1 Sample preparation

Due to the differing physicochemical properties of the pollutants of interest, several sample preparations methods were applied. Lipophilic compounds as PBDE 47, BEHTBP and DBDPE were analyzed together with the chlorinated paraffin's and phenolic compounds were analyzed together. Volatile PFAS and ionic PFAS required a dedicated sample preparation each as well. Together four different sample preparation methods were applied.

Lipophilic compounds and phenols. All biological samples, for the analysis of BFRs PBDE 47, BEHTBP and DBDPE and chloroparaffins, were prepared in a similar manner. Briefly, 3-4 grams of sample or 1-2 mL of plasma were mixed and homogenized with a 20 fold amount of dry Na_2SO_4. The homogenized sample was then split into two equal portions: One portion for the sample preparation and analysis of BFRs and chloroparaffins and one portion for the sample preparation and analysis of bromophenols.

Extraction and clean up of lipophilic compounds. The homogenate was extracted using a mixture of ethylacetate/Cyclohexane (1/1 v/v). The organic extract was evaporated and treated 2-4 times with 3-4 mL of concentrated sulphuric acid to remove the lipids and the organic extract was additionally cleaned-up by adsorption chromatography using activated silica and extracted with diethyl ether/hexane (1:9 v/v).

Extraction and cleanup of phenolic compounds. The sample was extracted using a mixture of MTBE/cyclohexane and the extract was concentrated. After addition of hexane, sodium hydroxide solution was added; the aqueous phase was collected, acidified and back-extracted with MTBE/cyclohexane. Prior to analyses the extracts were concentrated and transferred to 1.5mL analysis vials.

Water
Only PFAS compounds were analyzed in sea- and fresh water samples due to limited access of suitable sampling devices. European char and blue mussels were used as supplements instead representing fresh and marine water for the other compounds. Briefly, 1L of water was filtered and one half was extracted using solid phase extraction (SPE) cartridges for analyses of ionic PFAS. The other half was l/l extracted with ethylacetate. Particles were analysed using the same methodology as used for sediments and soils.

Soil and Sediments
Samples of soil and sediments were treated in a similar manner for the analysis of BFRs, Bromophenols and chloroparaffins. Soil and sediments were first dried in an oven at 30 °C, soxhlet extracted for 12h using diethylether/ hexan and subsequently split for bromophenol and BFR/chloroparaffins sample preparation, respectively. BFR/chloroparaffins sample fractions was cleanup using a column packed with activated silica and extracted with diethyl ether/hexane (1:9 v/v), samples was concentrated, added recovery standard and analyzed. The bromophenols fractions were cleaned up using the Base/acid method as for the biota samples (see above).

Samples for PFAS analysis were prepared separately. 1 - 2 g of dry soil or sediment was treated with NaOH, acidified and extracted with methanol and cleaned-up using the Powley method for ionic PFAS. For volatile PFAS, ethylacetat was used as extracting solvent.

6.3.2 Analysis

BFRs and chloroparaffins were analyzed using GC/HRMS while bromophenols and PFAS compounds were analyzed using LC/MS/MS.

6.3.3 Quality control and analytical uncertainty

All chemical analyses followed international requirements for quality assurance and control (QA/QC), e.g., recommendations of the Arctic Monitoring and Assessment Programme (AMAP) and the requirements in the European quality norm EN 17049. The QA/QC of the sample preparation and analysis was assured through the use of mass labeled internal standards for the BFRs (^{13}C DBDPE), bromophenols (^{13}C PBP) and PFAS (^{13}C PFC mixture) while a surrogate standard (^{13}C POPs mixture) was used for the SCCP and MCCP. Quality of sample preparation and analysis was achieved through the use of certified reference materials and the use of laboratory blanks. For each batch of 10 samples, either one fish SRM or a NIST fortified Human serum 1958 and one blank sample was prepared. Only analytes with concentrations above the detection limit are presented in tables and figures.

6.3.4 Stable isotopes and other supporting information

Stable isotopes were analysed by Institutt for Energiteknikk, Kjeller, Norway. TOC and particle size in soils and sediments were analysed by ALS Scandinavia, Oslo, Norway. All additional supporting data were determined by SWECO. All data are listed in the Appendix.

6.3.5 Biomagnification

The trophic position (TP) was calculated for each species relative to the species representing the lowest position. In case of the marine foodchain from the Norwegian mainland blue mussel was used and defined as inhabiting TP 2. In the Arctic marine food chain capelin was used defined as inhabiting TP 3.7 according to Haukås et al., 2005. Following equations were used:

$TP_{mainland} = 2 + (\square^{\square\square}\square\square_{consumer}\square\square\square^{\square\square}\square\square_{blue\ mussel}\square\square\square\square\square$

$TP_{Arctic} = 3.7 + (\square^{\square\square}\square_{consumer}\square\square\square^{\square\square}\square\square_{polar\ cod}\square\square\square\square\square$

We made the assumption that isotopic enrichment was constant among trophic positions and of the order 3.4 ‰ according to Hallanger et al, 2010. $\square^{\square\square}\square\square_{consumer}$ is relating to the organism in question.

For birds the trophic enrichment of $\square^{\square\square}\square\square$changes, with an isotopic enrichment factor of 2.4‰ causing a modification of the equation for TP calculations to:

$TP_{bird\ mainland} = 2 + (\square^{\square\square}\square\square_{bird}\square\square\square^{\square\square}\square\square_{blue\ mussel}+2.4\square\square\square\square\square$

$TP_{bird\ Arctic} = 2 + (\square^{\square\square}\square\square_{bird}\square\square\square^{\square\square}\square\square_{polar\ cod}+2.4\square\square\square\square\square$

For further data assessment of biomaginication all BFR and CP data were lipid normalized. PFASs are not lipophilic and were not lipid normalized. Subsequently a logarithmical transformation was carried out. TMFs were calculated as the antilogarithm of the slope (b) of the linear regression between log concentration (lw) and the samples TP in the case of BFR and CP, and between log concentration (ww) and the samples TP in the case of PFAS.
Log [compound] = a + *b*TP

$TMF = 10^{b}$

The here estimated TMFs have to be treated with caution since the recommended tissue type (muscle) could not be used. Instead plasma, liver and egg samples were available which are characterized by a much shorter turnover rate and those only reflect the short term exposure rather than the long term one.

BMFs were taken from literature and the calculation is described in the respective references.

For compounds measured in both water and organisms the bioaccumulation factor (BAF) was calculated by the ratio of steadystate chemical concentrations in an aquatic water-respiring organism and the water in which the organism is exposed to:

$BAF = [compound_{biota}]/ [compound_{water}]$

For compounds detected in both sediment/ soil and organisms the Biota-sediment accumulation factor BSAF was calculated by the ratio of steadystate chemical concentrations in an organism and the sediments/soil which the organism is exposed to:

$BSAF= [compound_{biota}]/ [compound_{sediment/soil}]$

Since the sediment concentration is related the content of organic carbon, only lipophile chemicals are relevant for the application of the BSAF. Since PFAS are not lipophilic compounds or and thereby not correlated to the carbon content in soils and sediments, the BSAF is not a suitable tool for assessment of bioaccumulation. However, the BAF can be used to assess the bioaccumulation of a compound in water-respiring organisms and the water in which the organism is exposed to.

7. Results

7.1 Norway mainland; terrestrial and fresh water environment

7.1.1 Brominated flame retardants

The brominated flame retardants, PBDE 47 and DBDPE were detected in the majority of samples from the terrestrial/fresh water environment. The highest levels were found in trout liver. Perch as a leaner fish generally had lower levels of contaminants (see summary *Table 4b)*. PBDE 47 and DBDPE were also found in field mice and shrew liver with DBDPE being found at greater abundance compared to BPDE 47 (*Table 4a* and *Figure 7*). DBDPE was also the dominant BFR compared to the other BFRs investigated, where BEHTBP and PBP were only detected in a few samples. In moose liver no PBDE 47 but DBDPE was detected.

In the following we use boxplot figures to illustrate the variation of the data per sample type. The upper and lower boundaries of the box are representing the 25th and 75th percentile, the horizontal line in the box marks the median, plotted with error bars and outlying points. Lines without statistics are below three valid data points (<detection limits).

Species	**Moose**	**Field Mouse**	**Shrew**	**Soil**
Organ (No. samples)	Liver (n=9)	Liver (n=8)	Liver (n=2)	(pooled)
Lipid %	4.6	N.A.[a]	N.A.[a]	-
PBDE 47	N.D.	100% 0.24 (0.51)	100% 0.08 (0.02)	N.D.
BEHTBP	N.D.	N.D.	N.D.	100% 1.04 (-)
DBDPE	100% 0.40 (0.09)	100% 11.9 (5.7)	100% 25.5 (9.1)	N.D.
TBP	89% 80.7 (44.6)	88% 53.6 (43.4)	100% 27.1 (6.9)	N.D.
PBP	N.D.	N.D.	N.D.	N.D.

Table 4a. The percentage of **terrestrial** samples above detection limit, mean and standard deviation (in bracket) at ng/g wet weight and sediment and soil concentration at ng/g dry weight (Telemark, Norway mainland).
[a] = to little material to determine lipid %; N.D. = below method detection limit; N.A. = Not Analysed

Of the two bromophenols screened for, only TBP was detected in the terrestrial/freshwater environment. No significant differences were found in the levels of TBP among the aquatic and terrestrial animals and tribromophenol was not detected in neither soil or sediments (*Table 4 a,b*). TBP was found in high concentrations in all biota samples, but due to the potential natural sources of this compound as well as possible matrix effects in the analytical method, future studies are encouraged to follow up on the present findings in terrestrial samples.

Species	Perch	Brown Trout	Sediment	Water
Organ (No.	Liver (n=3)	Liver (n=10)	(n=3)	(n=3)
Lipid %	2.4	2.7	-	-
PBDE 47	100% 0.12 (0.02)	100% 0.37 (0.42)	N.D.	N.A.
BEHTBP	N.D.	30% 0.04 (0.01)	100% 0.11 (0.03)	N.A.
DBDPE	100% 2.47 (0.30)	100% 11.1 (8.57)	100% 2.08 (0.76)	N.A.
TBP	67% 42.4 (16.1)	40% 66.2 (39.6)	N.D.	N.A.
PBP	N.D.	N.D.	N.D.	N.A.

Table 4b. The percentage of **fresh water** samples above detection limit, mean and standard deviation (in bracket) at ng/g wet weight and sediment and soil concentration at ng/g dry weight (Telemark, Norway mainland).
[a] = to little material to determine lipid %; N.D. = below method detection limit; N.A. = Not Analysed

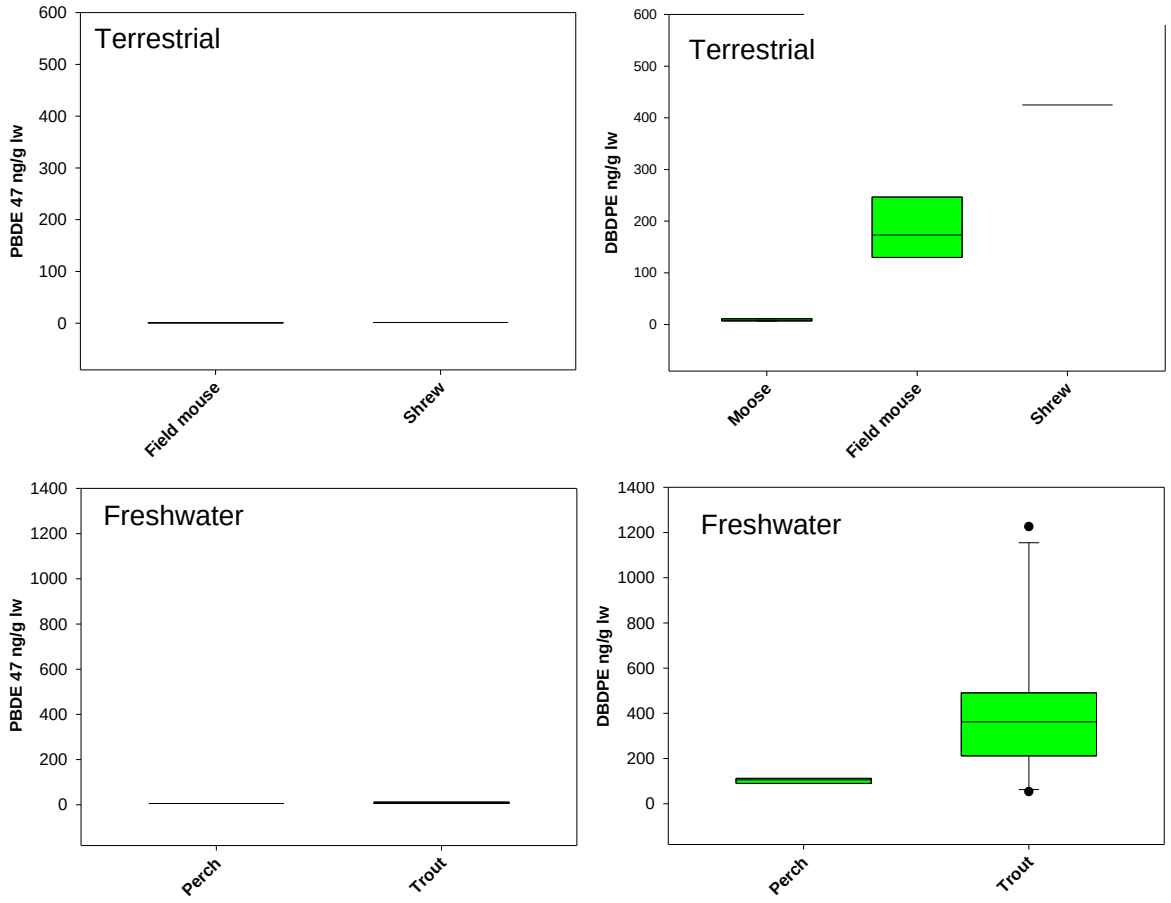

Figure 7. Box plot of PBDE 47 (left) and DBDPE (right) in the freshwater (top) and terrestrial (bottom) environment in Telemark, Norway. Data plotted using lipid weight concentration assuming a 6% lipid content of field mouse and shrew livers. The upper and lower boundaries of the box are representing the 25th and 75th percentile, the horizontal line in the box marks the median, plotted with error bars and outlying points. Lines without statistics are below three valid datapoints (< detection limits)

7.1.2 PFAS

Of the 17 PFAS compounds that were screened for, only 10 were found above detection limits (*Table 5 a and b)*. None of the volatile fluorotelomer alcohols (FTOH), 6:2 FTS or fluorotelomer carboxylic acids (FT(U)CAs) were detected in the samples. PFOS and PFNA through PFTeA were detected in almost all fresh water samples and terrestrial samples except in sediments and low levels in soil. Trout had the highest wet weight concentration of PFOS (4.6 ng/g ww) and PFTrA (16.3 ng/g ww) while the terrestrial animals (moose, mouse and shrew) had relatively low levels. PFTrA had the highest concentrations of the analysed PFAS for most of the samples (*Table 5a and b)*. Even if the terrestrial animals have different feeding patterns (herbivore, omnivore and insectivore) no specific differences could be found.

Species	**Moose**	**Field Mouse**	**Shrew**	**Soil**
Organ (No. samples)	Liver (n=9)	Liver (n=8)	Liver (n=2)	(pooled)
6:2 FTS	N.D.	75% 0.07 (0.04)	N.D.	N.D.
PFOS	100% 0.43 (0.20)	100% 0.87 (0.34)	100% 1.21 (1.58)	100% 0.22 (-)
PFDS	N.D.	N.D.	N.D.	100% 0.06 (-)
PFOA	N.D.	N.D.	N.D.	100% 0.25 (-)
PFNA	100% 0.28 (0.23)	50% 0.62 (0.42)	N.D.	100% 0.12 (-)
PFDcA	100% 0.29 (0.11)	100% 0.45 (0.18)	100% 0.46 (0.05)	N.D.
PFUnA	100% 0.25 (0.12)	100% 0.89 (0.25)	100% 0.86 (0.21)	N.D.
PFDoA	89% 0.08 (0.02)	88% 0.33 (0.08)	100% 0.25 (0.23)	N.D.
PFTrA	33% 0.09 (0.01)	100% 2.34 (1.49)	50% 0.82 (-)	N.D.
PFTeA	N.D.	63% 1.22 (0.61)	N.D.	N.D.
ΣPFAS	1.42	6.72	3.6	0.65

Table 5a. The percentage of **terrestrial** samples above detection limit, mean and standard deviation (in bracket) at ng/g wet weight and soil concentration at ng/g dry weight (Telemark, Norway mainland). [a] = to little material to determine lipid %; N.D. = below method detection limit; N.A. = Not Analysed

Species	Perch	Brown Trout	Sediment	Water
Organ	Liver (n=3)	Liver (n=10)	(n=3)	(n=3)
6:2 FTS	N.A.	N.D.	N.D.	N.D.
PFOS	N.A.	70% 4.57 (1.89)	N.D.	N.D.
PFDS	N.A.	N.D.	N.D.	N.D.
PFOA	N.A.	30% 0.09 (0.01)	N.D.	100% 0.56 (0.19)
	N.A.	90% 0.46 (0.32)	N.D.	100% 0.3
PFDcA	N.A.	50% 1.45 (0.18)	N.D.	33% 0.2
PFUnA	N.A.	70% 8.14 (4.59)	33% 0.16 (-)	N.D.
PFDoA	N.A.	40% 5.07 (1.33)	N.D.	N.D.
PFTrA	N.A.	30% 16.3 (14.3)	N.D.	N.D.
PFTeA	N.A.	20% 0.77 (0.72)	N.D.	N.D.
ΣPFAS		36.85	0.16	1.06

Table 5b. The percentage of **aquatic** samples above detection limit, mean and standard deviation (in bracket) at ng/g wet weight and sediment at ng/g dry weight and water at ng/L (Telemark, Norway mainland).
[a] = to little material to determine lipid %;
N.D. = below method detection limit;
N.A. = Not Analysed

Figure 8 illustrates the relative distribution of the detected PFAS in the freshwater and the terrestrial samples. As can be clearly seen, water, sediment and soil contain only a limited number of PFAS. However, the number of detected PFAS increases in biota samples mainly due to the presence of long chained PFCAs. Interestingly, PFOS is not the dominating PFAS in trout and mice liver samples, but rather the PFTrA which is a very particle-bound compound. No PFAS were detected in the particle phase of the water samples.

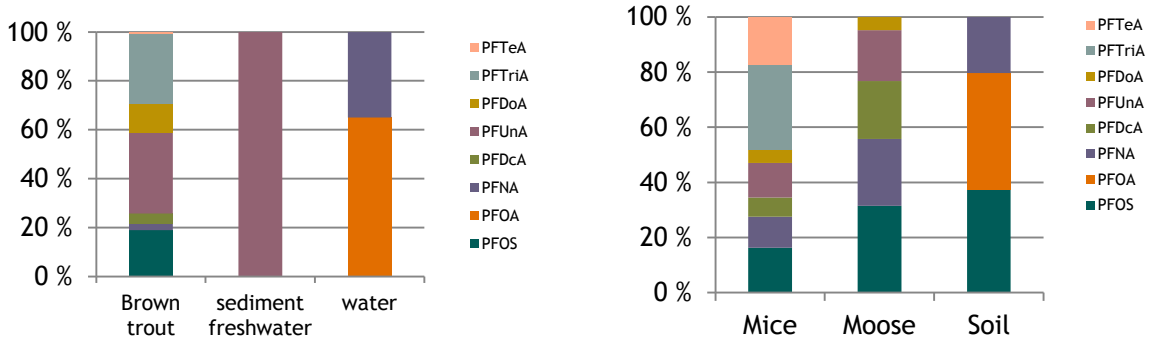

Figure 8. Relative distribution of detected PFAS in freshwater (left panel) and terrestrial (right panel) environment

When comparing PFAS levels in the soil/sediment samples collected (*Figure 9*), soil clearly contains a larger variety of PFAS at higher concentrations (ΣPFAS 0.65 ng/g dw in soil compared to 0.16 ng/g dw in freshwater and marine sediment). PFOS and PFOA were detected at similar amounts (0.2 and 0.3 ng/g dw respectively). Soil represents much more complex constituents of both biotic and abiotic origin compared to mainly sandy sediments, causing a different PFAS adsorption behavior (Figure 9). Additional information regarding total organic carbon (TOC) can be found in Appendix II.

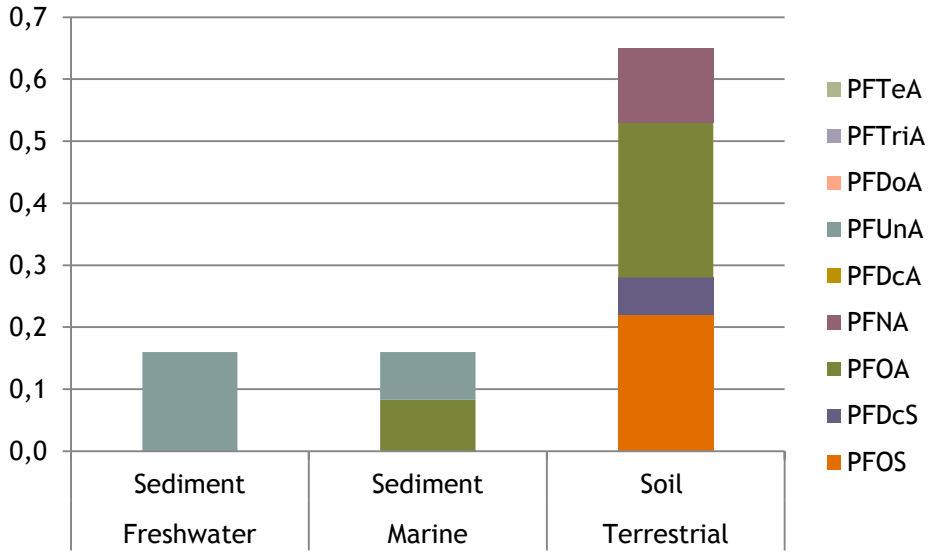

Figure 9. Comparison of PFAS levels in sediment and soil samples from the Norwegian mainland (ng/g dw).

7.1.3 Biomagnification

Samples from background locations are often characterized by low concentrations or not detectable levels. Biomagnification assessments can only be carried out with detectable concentrations in all parts of the food chain or the surrounding environment (sediment, water). In our assessments only a percentage of detection of a pollutant of 60 % and higher was used for further data treatment. As a limiting factor no complete food chain but rather representatives of a food web were sampled within the frame of the project, enabling only an estimation of the biomagnification. Stable isotopes were determined as supporting parameters on all biological samples within this study. Relative trophic positions can be estimated by using □□□ data. To compensate for missing food chain representatives, literature data will be used when available. However, since the main focus of the study was on background samples, not all compounds were found in quantifiable amounts neither in all samples nor in all species, hampering the biomagnification assessments.

The terrestrial food chain is in general very short, preventing major bioaccumulation of pollutants. In addition, the sampling of terrestrial top predators was out of the scope of the here reported project. Moose and mice contain a lower □□□ signature compared to freshwater fish, with moose having a diet with a lower □□□ signature than the mice mainly due to the intake of insects and larvae by the mice (*Figure 10*). In the fish samples from the freshwater system, □□□ levels do not vary a lot when comparing Perch and Brown trout samples, indicating feeding on a similar trophic level (Overlapping box areas in *Figure 10*). The difference in variation of □□□ levels is also influenced by the differences in sample numbers (n = 3 for perch and n = 10 for brown trout) giving only limited opportunity for statistical data treatment.

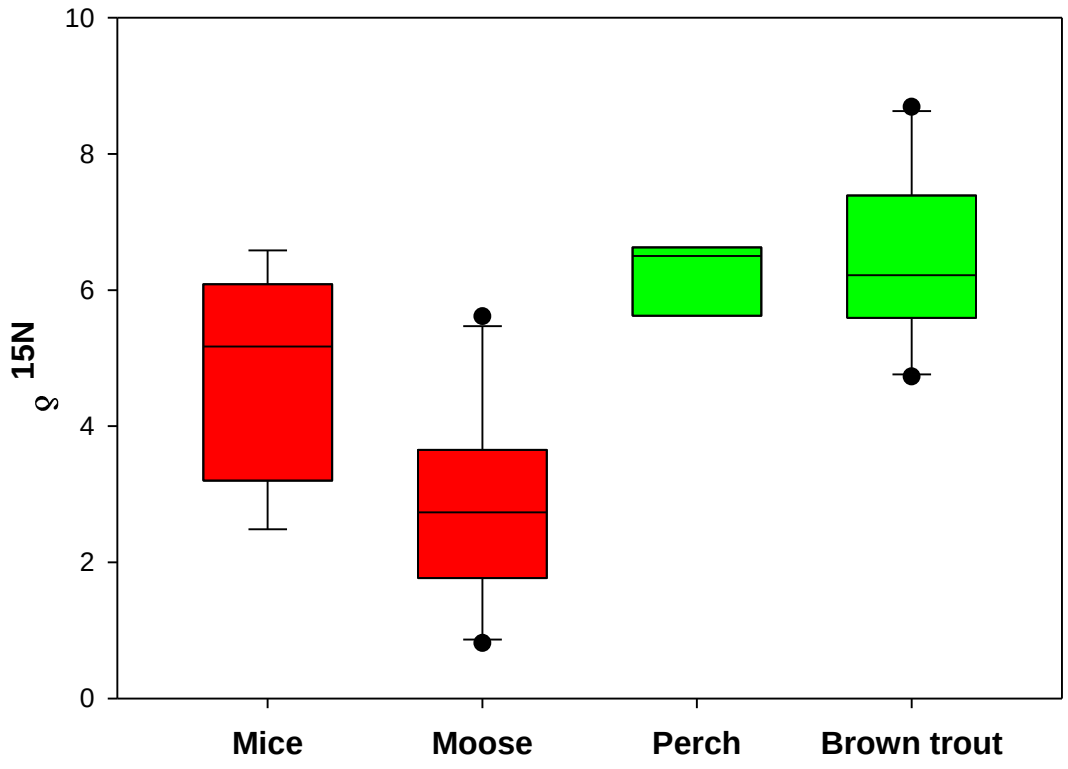

Figure 10. Stable nitrogen isotope levels in moose, mice, perch and brown trout

BFRs. In the terrestrial samples PBDE 47 was found below detection limits in soil and moose liver while an average concentration of 0.24 ng/g ww was found in mice liver (100 % detection rate). Similar observations were made for the other BFRs analysed. Mariussen et al (2008), reported PBDE 47 concentrations in mice, moose and lynx in Norway at 1.7, 0.3 and 1.0 ng/g lw respectively; indicating bioaccumulation potential.

Herbivore food webs from different locations can be easier compared than aquatic systems since the diet is not differing so much between locations allowing us to use literature data to supplement data. So did Müller et al. report a □□□□average of 3.7 in caribou from a remote terrestrial location in North Canada (Müller et al., 2011). This is similar to our findings within moose liver, indicating a comparable trophic level and feeding behavior (Figure 10).

Using the BSAF equation stated above, BSAF can be calculated for the lipophilic compounds DBDPE for both fish species investigated, due to high detectable levels in both sediment and fish. The highest BSAF can be observed for brown trout and DBDPE with 53000 pointing to a bioaccumulation potential. The total organic content (TOC) in the lake sediment of lake Dalsvatn was with levels varying between 5.4 and 8.8 relatively high pointing to a high content of organic material in the sediment of the lake (see Appendix II).

PFAS. Since PFAS were detected in brown trout and water from Dalsvatn the bioaccumulation factor (BAF) can be calculated. The BAF reflects the uptake of pollutants via the surrounding water into the fish and can be calculated by dividing the concentration in fish with the respective one in water (see equation above). Levels above detection limit were found for PFNA both in lake water and in the liver yielding a BAF of 1507, indicating no bioaccumulative capabilities. A compound expressing a BAF of 5000 and higher is regarded as bioaccumulating according to the Canadian Environmental Protection Act, 1999.

Supplementing further information regarding the accumulation behavior of PFAS in aquatic organisms, Martin et al., found BMFs to vary from 0.4 and 3.4 between lake trout and prey organisms in Canada. BMFs are derived from the concentration ratio of the compound of interest in biota and respective diet. BMFs above 1 indicate trophic biomagnification. In the study by Martin et al., 2004, PFOA had the lowest and PFUnA the highest BMF (Martin, 2004). The BMF for PFNA varied in Martin's study between 0.13 and 5.1 for trout and different prey items and the TMF was defined as 1, supporting our findings of no bioaccumulation of PFNA in fresh water ecosystems.

For comparison, in the case of PFOS a TMF of 5.9 was calculated in a freshwater foodchain based on invertebrate species *Mysis*, two forage fish species (rainbow smelt and ale wife) and a top predator fish species, lake trout by Martin et al. as well. Despite a longer food chain, TMFs for PFOS were found to be similar between aquatic ecosystems and in terrestrial foodchains (TMF of 5.9 versus 6.7).

In our study, PFAS were measured in the terrestrial sample set in soil, mice and moose allowing the calculation of the BSAF for PFOS and PFNA (detected in soil and biota). However, since PFAS are not lipophilic the calculation was carried out using wet weight data for the biota samples. We observed BSAF of 0.4 and 0.2 for PFOS and 0.6 and 0.2 for PFNA in mice and moose respectively pointing to a very low bioaccumulation. However, due to the non-lipophilic character of PFAS, BSAF data for PFAS must be treated carefully.

For comparison of terrestrial samples Müller et al., 2011, described BMF and TMFs from caribou - lichen for PFAS. Highest BMFs were found for PFDcA and PFUnA with 75 and 46 respectively. TMFs of the food chain wolf – caribou – lichen varied between 2.4 and 7.1 for all PFAS with PFDcA and PFOS showing the highest TMFs of 7.1 and 6.7 respectively.

In summary, BMFs and TMFs above 1 indicate trophic biomagnification for PFOS and all PFCAs from PFNA and longer chain length in both the terrestrial and the freshwater ecosystems. Contrasting, a BAF of 1500 for PFNA for brown trout and a BSAF below 1 for PFOS and PFNA are not indicating bioaccumulation in the investigated Norwegian terrestrial ecosystem.

7.2 Norway mainland; marine environment

7.2.1 Brominated flame retardants

The marine environment gives a similar compound pattern of BFRs as the terrestrial/freshwater environment (*Table 6)*. PBDE 47 and DBDPE were above detection limits in all biota samples, while BEHTBP was only detected in a fraction of the samples. No PBDE 47 and BEHTBP were detected in sediments and only low levels of DBDPE (0.24 ng/g wet dry wt) were found. A TOC of 0.4 – 0.8 was determined in the marine sediment, pointing to a very low organic content. The highest levels of PBDE 47 were found in herring gull eggs (average 142.5 ng/g lw) and in Atlantic cod (13.0 ng/g lw). The pattern was different for DBDPE where the highest levels were found in harbor seal liver (average 430 ng/g lw) and cod liver (6.8 ng/g lw) (see *Figure 11*).

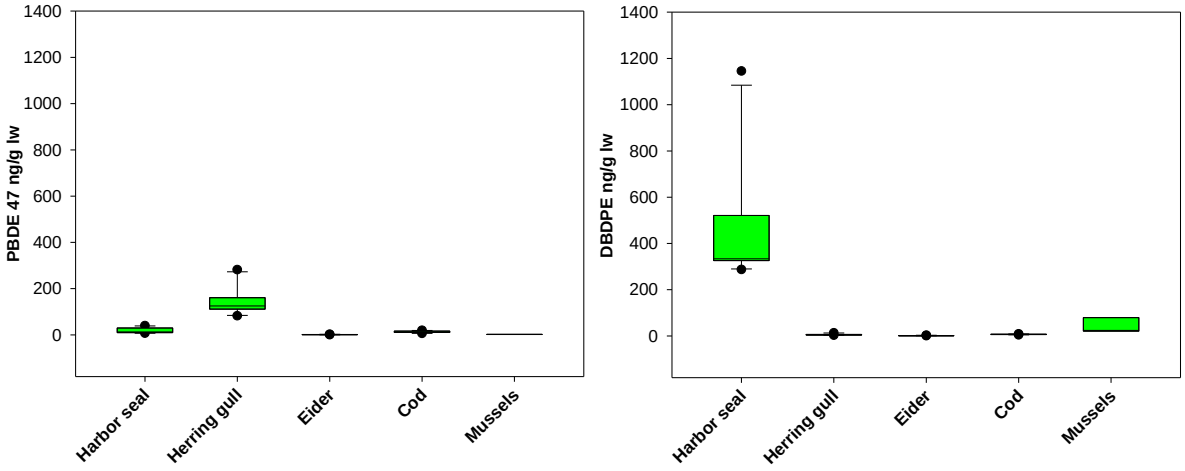

Figure 11. Box plot of PBDE 47 (left) and DBDPE (right) in the marine environments of Norway mainland. For comparison concentrations based on ng/g lipid weight is plotted. The boundary of the box is the 25th and 75th percentile, line marks the median, plot with error bars and outlying points. Lines without statistics are below three valid data points (>detection limits).

The 2,4,6- tribromophenol (TBP) was detected at relatively high levels in most of the marine samples. Trace levels of PBDE 47 (which historically is the predominant flame retardant in the marine environment) was only found in the mussel samples but not the sediment whereas both sediment and mussels contained DBDPE (*Table 6*).

Table 6. The percentage of samples above detection limit (DL), BFR mean and standard deviation (in bracket) at ng/g wet weight and sediment concentration at ng/g dry weight and ng/L in water in the marine environment (Lofoten, Troms and Finnmark, Northern Norway mainland).

Species	Harbor Seal	Herring gull	Common eider	Atlantic cod	Mussels	Sediment	Water
Organ	Liver (n=10)	Egg (n=10)	Egg (n=10)	Liver (n=10)	Pooled (n=3)	- (n=3)	- (n=3)
Lipid %	2.9	8.1	14.7	62.9	0.9	-	
PBDE 47	100% 0.53 (0.31)	100% 11.4 (4.8)	100% 0.29 (0.09)	100% 8.17 (2.35)	100% 0.02 (0.01)	N.D.	N.A.
BEHTBP	10% 0.10 (-)	20% 1.99 (2.65)	100% 0.04 (0.02)	30% 0.14 (0.02)	N.D.	N.D.	N.A.
DBDPE	100% 12.9 (6.8)	100% 0.44 (0.20)	100% 0.33 (0.11)	100% 4.29 (0.70)	100% 0.29 (0.10)	100% 0.24 (0.21)	N.A.
2,4,6-TriBP	100% 164 (84)	80% 62.5 (64.8)	90% 66.2 (74.2)	60% 68.8 (35.8)	100% 2.53 (0.22)	100% 2.47 (0.51)	N.A.
PBP	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.A.

N.D. = below method detection limit; N.A. = Not Analysed

7.2.2 PFAS

PFAS were not analyzed in mussels and only trace amounts of the perfluorinated carboxylic acids were detected in the sediments. PFAS were detected for all congeners in all biota marine samples (*Table 7)* except PFTeA, FTOH, 6:2 FTS and FT(U)CA. The most significant PFAS detected in the marine samples was PFOS with the highest concentrations found in harbor seal liver (66.3 ng/g ww) and herring gull egg (48.2 ng/g ww). The perfluorinated carboxylic acids were also higher in seal and herring gull with PFNA and PFTrA typically having highest levels.

Table 7. The percentage of samples above detection limit (DL), PFAS mean and standard deviation (in bracket) at ng/g wet weight and sediment concentration at ng/g dry weight and ng/L in water in the marine environment (Lofoten, Troms and Finnmark, Northern Norway mainland).

Species	**Harbor Seal**	**Herring gull**	**Eider**	**Cod**	**Mussels**	**Sediment**	**Water**
Organ	**Liver (n=10)**	**Egg (n=10)**	**Egg (n=10)**	**Liver (n=10)**	**Pooled (n=3)**	**- (n=3)**	**- (n=3)**
6:2 FTS	40% 0.03 (0.04)	N.D.	N.D.	N.D.	N.A.	N.D.	N.D.
PFOS	100% 66.3 (26.3)	100% 48.2 (24.3)	100% 10.1 (3.5)	100% 0.59 (0.35)	N.A.	N.D.	N.D.
PFDS	20% 0.11 (0.03)	20% 0.30 (0.01)	50% 0.21 (0.10)	N.D.	N.A.	N.D.	N.D.
PFOA	100% 0.80 (0.80)	80% 0.18 (0.11)	100% 1.62 (1.29)	30% 0.09 (0.01)	N.A.	100% 0.08 (0.03)	100 % 0.2
PFNA	100% 4.43 (3.08)	90% 1.55 (0.64)	100% 3.61 (2.44)	80% 0.14 (0.06)	N.A.	100% 0.09 (0.01)	N.D.
PFDcA	100% 3.28 (1.82)	100% 2.27 (1.36)	100% 0.59 (0.20)	90% 0.13 (0.05)	N.A.	33% 0.09 (0.01)	N.D.
PFUnA	80% 6.88 (3.40)	100% 8.78 (4.37)	100% 1.23 (0.57)	100% 0.43 (0.19)	N.A.	100% 0.08 (0.07)	N.D.
PFDoA	20% 0.83 (0.06)	90% 1.85 (0.93)	100% 0.36 (0.19)	100% 0.11 (0.05)	N.A.	N.D.	N.D.
PFTrA	40% 2.86 (2.96)	100% 8.32 (6.33)	100% 0.98 (0.81	100% 0.40 (0.20)	N.A.	N.D.	N.D.
PFTeA	N.D.	70% 0.54 (0.49)	60% 0.11 (0.03)	N.D.	N.A.	N.D.	N.D.
ΣPFAS	85.5	72.1	18.3	1.89		0.34	0.2

N.D. = below method detection limit; N.A. = Not Analysed

As illustrated in *Figure 12*, increasing contribution of PFOS can be observed when moving from abiotic samples like water and sediment to cod, marine bird eggs and seal. In the abiotic parts of the ecosystem (water and sediment), only PFCAs can be found while PFOS is the dominating compound in the biological samples.

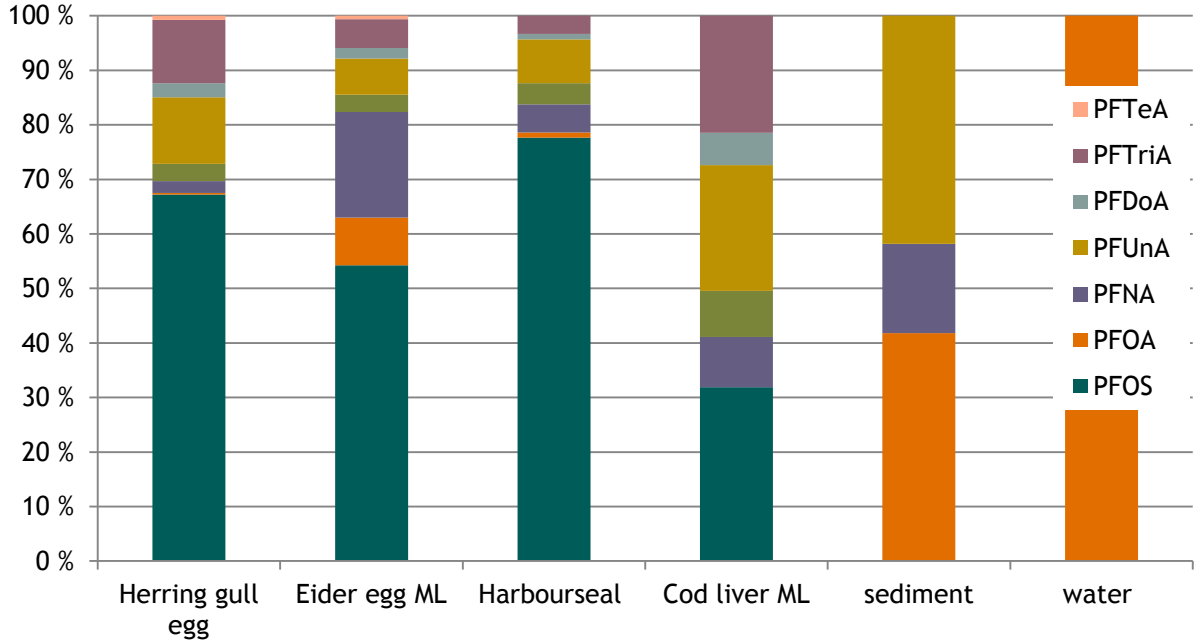

Figure 12. Relative distribution of detected PFAS in the marine environment of the Norwegian mainland

The average SumPFAS levels were highest in the harbor seal samples (85.4 ng/g ww) followed by herring gull eggs (71.8 ng/g ww), eider eggs (18.6 ng/g ww) and cod liver (1.8 ng/g ww) (*Figure 13*). SumPFAS in Herring gull eggs and seal liver were significantly different form SumPFAS in cod liver ($p < 0.05$) but SumPFAS in eider duck eggs was not. Interestingly, PFNA is the dominating PFCA congener in the eider eggs while PFUnA and PFTrA dominate in the herring gull eggs. This may be potentially caused by metabolic differences, although diet preferences must also be considered as eider ducks are benthic feeding while herring gulls and seals are feeding opportunistically and pelagic respectively.

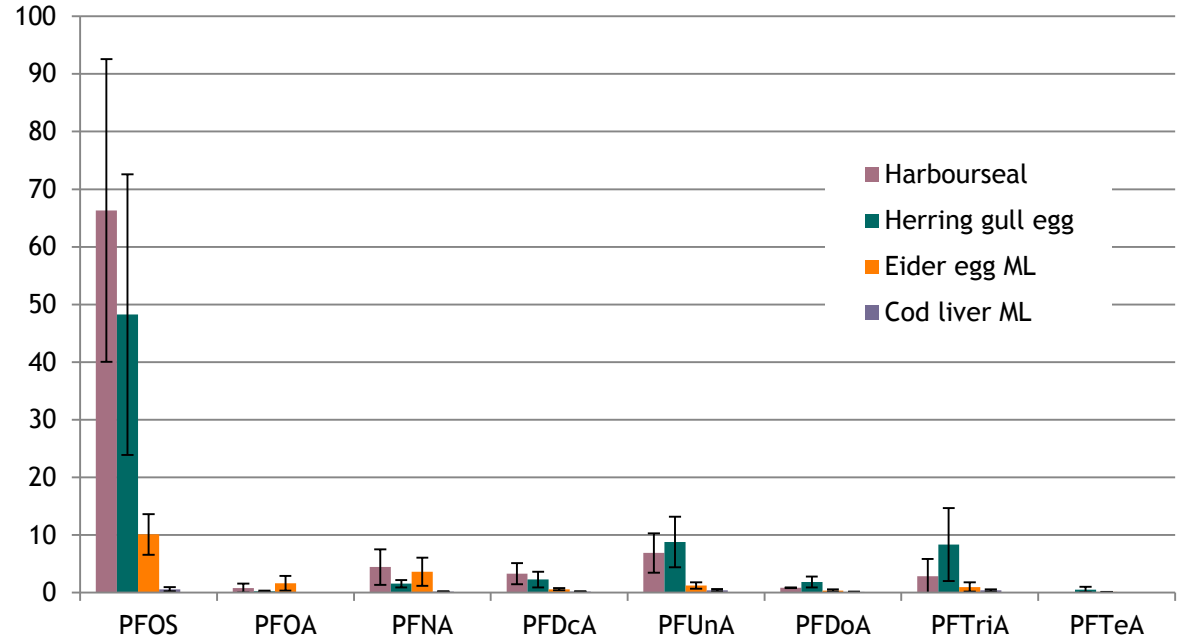

Figure 11. PFAS in tissue of marine samples from the Norwegian mainland (ng/g ww).

7.2.3 Biomagnification

Samples from background locations are often characterized by low concentrations or not detectable levels. Biomagnification assessments can only be carried out with detectable concentrations in all parts of the food chain or the surrounding environment (sediment, water). In our assessments only a percentage of detection of a pollutant of 60 % and higher was used for further data treatment. As a limiting factor no complete food chain but rather representatives of a food web were sampled within the frame of the project, enabling only an estimation of the biomagnification. Stable isotopes were determined as supporting parameters within this study on all biological samples. Although trophic positions cannot be accurately calculated with knowledge of isotope signature from the base of the food web, relative trophic positions can be estimated by using $\delta^{15}N$ data (*Figure 15*). However, since the main focus of the study was on background samples, not all compounds were found in quantifiable amounts neither in all samples nor in all species, hampering the biomagnification assessments.

An ANOVA test comparing the $\delta^{15}N$ data of different marine species uncovered a highl significant difference between all species. When comparing $\delta^{15}N$ data of pelagic and benthic feeders a strong significant difference could be found as well ($p = 4*10^{-8}$).

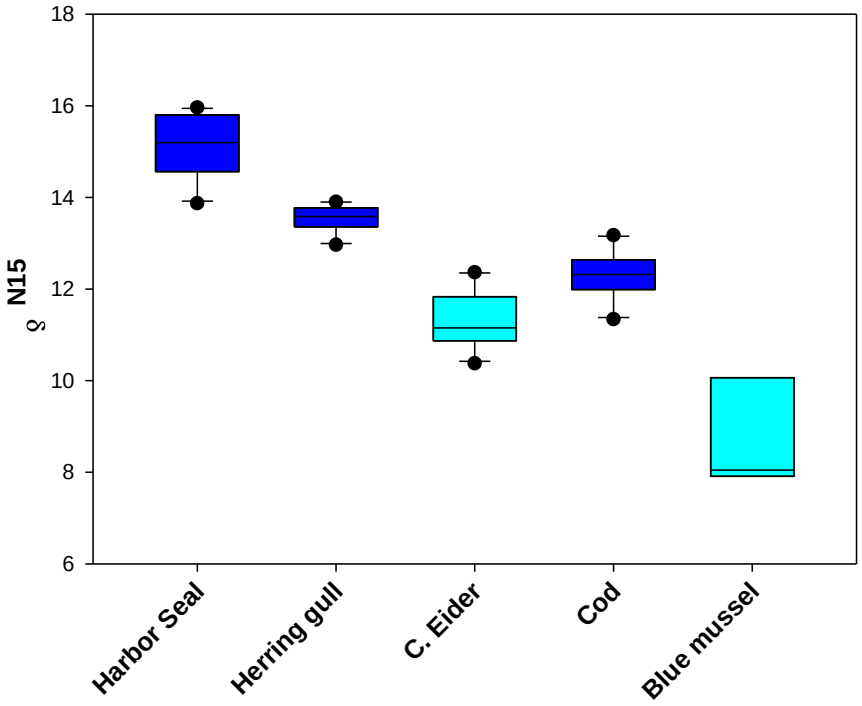

Figure 12. □□□ data in the Norwegain marine mainland samples, dark blue: pelagic/opportunistic feeders and light blue: benthic feeders

As the boxplot illustrates do pelagic feeders like harbor seal, herring gull and cod show slightly higher □□□□levels than the benthic feeder's Common eider and blue mussel indicating feeding on lower trophic levels. The differences are not significant except for the blue mussel.

BFR. When relating the □□□□levels with the found log-transformed concentrations of the respective compounds of interest, mostly PBDE 47 exhibits a linear relationship (*Figure 15*). When considering all samples together, relative TMFs can be estimated on the basis of relative trophic positions and log-transformed concentrations. The calculation of relative TMFs results in values of 9.8 and 14.5 for PBDE 47 and DBDPE, respectively, and 21 for the TBP, indicating biomagnifiaction (correlation coefficient r^2 = 0.31; 0.23 and 0.52 respectively). Blue mussels were excluded from the calculation since they are exposed to contaminants through other routes as well. Due to the potential natural sources of this compound as well as possible matrix effects in the analytical method, future studies are encouraged to follow up on the present findings. R^2 for the linear correlation between log concentration and trophic position varies between 0.23 for DBDPE, 0.32 for PBDE 47 and 0.51 for TBP.

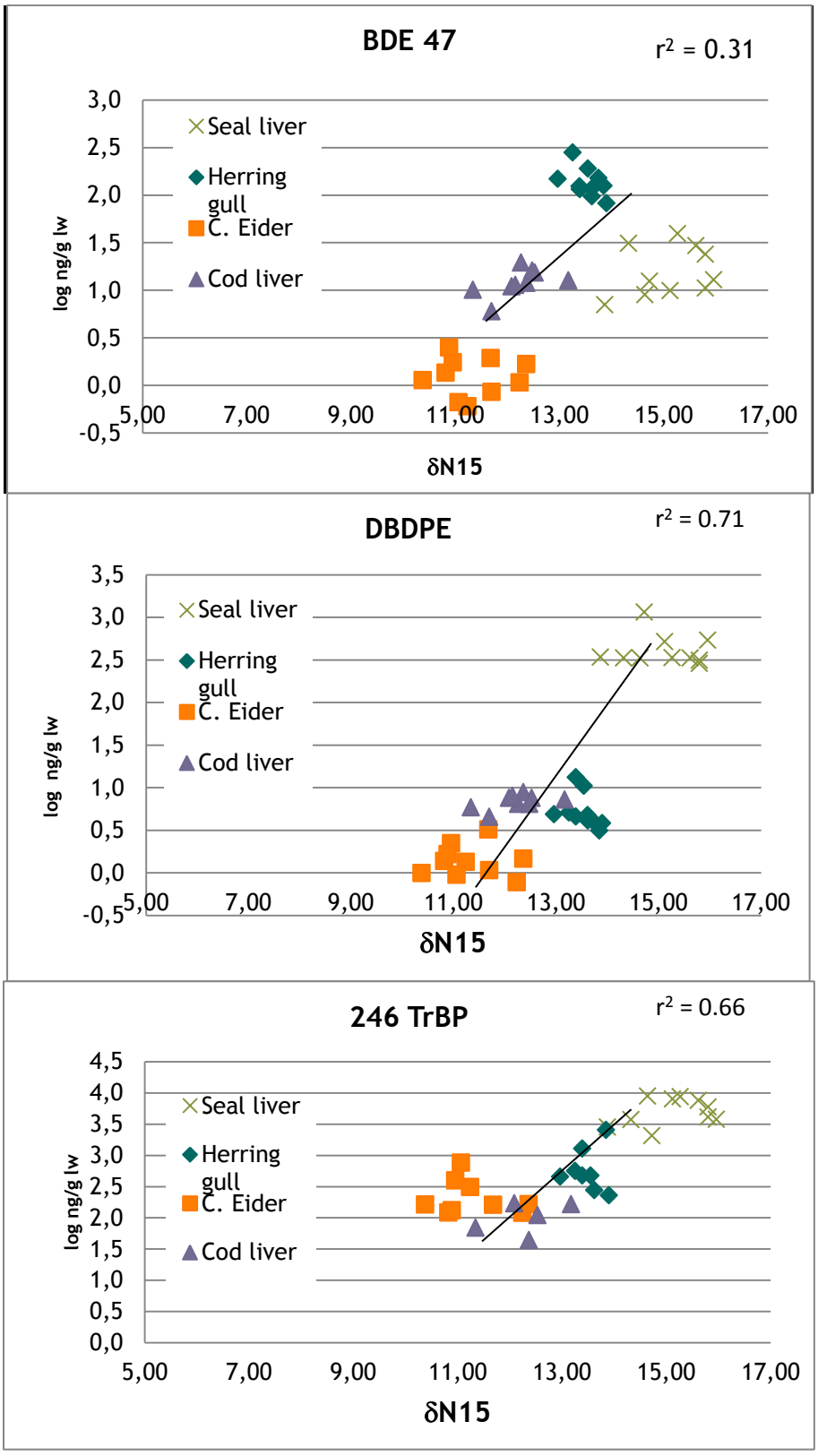

Figure 13. □□□□levels and log-transformed concentrations (ng/g lw) of the compounds PBDE 47(top), DBDPE (middle) and TBP (bottom).

PFAS. Comparisons of log concentration resulted in positive relationships between □□□ and subsequently trophic position and logarithmic PFAS concentrations indicating a bioaccumulation of PFAS (Figure 16). Since no primary feeder could be sampled within the sampling campaign only relative trophic levels can be calculated by applying the above mentioned equations and using blue mussel as the lowest representatives for the food chain.
The relationship between trophic position (TP) and log concentrations of PFOS and PFNA up to PFTrA, where characterized by high correlation coefficients r^2 of 0.65 and higher (*Figure 16*). PFOA did not show a linear relationship to the TP.

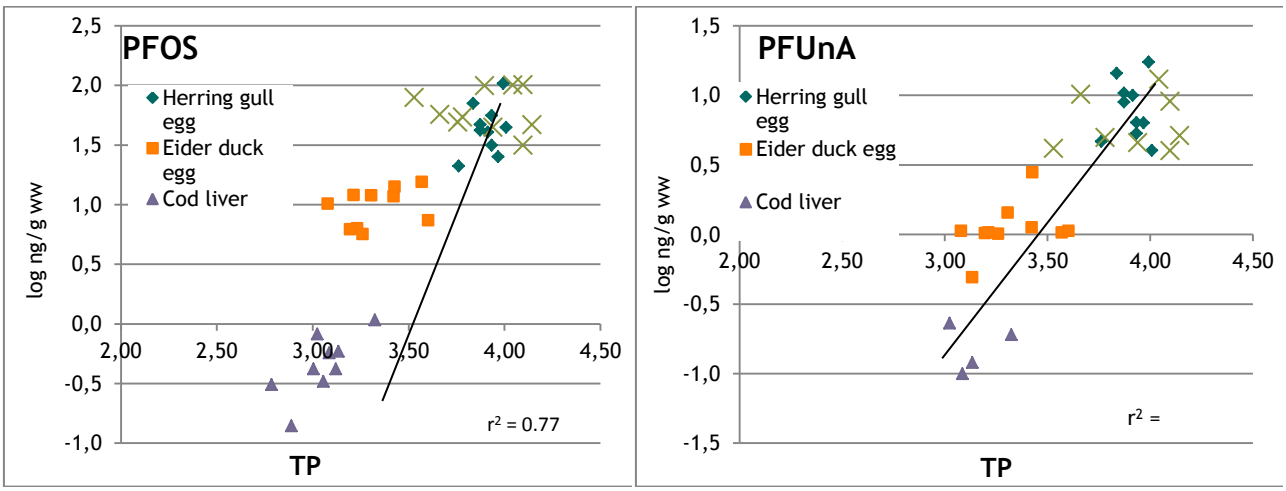

Figure 14. Relationship between log PFOS (left panel) and log PFUnA (right panel) in ng/g ww to Trophic position (TP) (x-axis)

When considering all samples together, TMFs can be estimated on the basis of relative trophic positions and log-transformed concentrations. The calculation of TMFs results in values ranging between 0.4 and 76 with PFOS and PFUnA representing the highest estimated TMFs (76 and 19) and PFOA the lowest (0.4). R^2 for the linear correlation between log concentration and trophic position varies between 0.77 for PFOS, 0.08 for PFOA and 0.79 for PFDoA. The here found TMF estimates are in agreement with findings by Kelly et al., who reported a similar pattern but with lower TMFs values for all PFAS besides PFOA (Kelly, 2009). ECHA reports similar findings when considering the bioaccumulation of PFCAs and rating the PFCAs PFDoA and with longer chain length as very bioaccumulative (ECHA, 2012).

Supplementing to the TMF data, PFOA could be detected in both sea water and the organisms sampled in this campaign leading to BAF of 1070, 8100 and 4000 for herring gull, common eider and harbour seal. Consequently the requirement of a BAF > 5000 as a bioaccumulation endpoint is only fulfilled for PFOA in harbor seal.

Since PFAS are not lipophilic compounds and thereby not correlated to the carbon content in soils and sediments, the BSAF is not a suitable tool for assessment of bioaccumulation. However, the BAF can be used to assess the bioaccumulation of a compound in water-respiring organisms and the water in which the organism is exposed to.

7.3 Norway Arctic; marine environment

7.3.1 Brominated flame retardants

With regard to samples collected at Svalbard, plasma was taken from polar bear, ringed seal and glaucous gull, while eggs were collected from kittiwake and eider ducks. Liver was collected from Atlantic cod and whole fish of Polar cod. The BFRs (PBDE 47, BEHTBP and DBDPE) were all detected in Arctic samples. PBDE 47 concentrations were low in polar bear and ringed seal plasma (average 0.10 and 0.08 ng/g ww; 11 and 11.4 ng/g lw) but higher in the glaucous gull plasma (2.3 ng/mL plasma, 15.9 ng/g lw) and kittiwake egg (2.7 ng/g ww; 33.7 ng/g lw) and cod liver (1.4 ng/g ww, 2.8 ng/g lw) (see *Figure 17*). DBDPE was detected at higher concentrations compared to PBDE 47 in all samples. Polar bear, ringed seal and glaucous gull plasma have on average 7 ng/mL, 5.4 ng/mL and 6.4 ng/mL plasma (775 ng/g lw, 765 ng/g lw and 460 ng/g lw) and common eider and kittiwake eggs contained approximately 1 ng/g ww (0.12 ng/g lw and 0.05 ng/g lw). Cod liver contained similar concentration levels between the new BFR and PBDE47, see *Figure 19*.

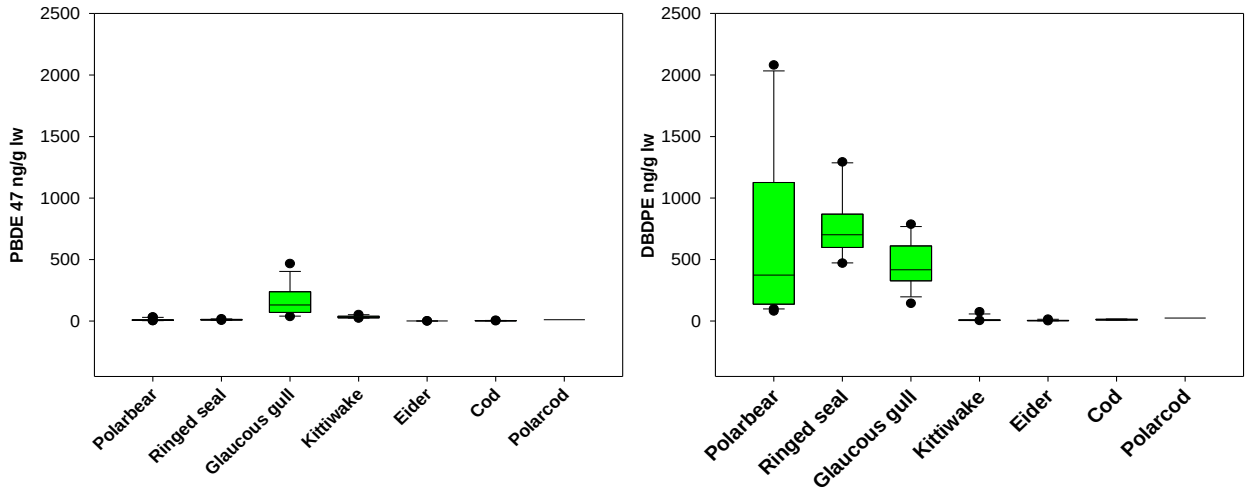

Figure 15. Box plot of PBDE47 (left) and DBDPE (right) in the marine Arctic environment of Svalbard. For comparison ng/g lipid weight is plotted. The boundary of the box is the 25th and 75th percentile, line marks the median, plot with error bars and outlying points. Lines without statistics are below three valid datapoints (>detection limits).

The bromophenol TBP was found in high concentration in most of the Arctic samples except for Polar cod. Atlantic cod liver had the highest average concentration of 115 ng/g ww while the plasma samples for polar bear, ringed seal and glaucous gull had an average plasma concentration of 25-30 ng/mL (2855 ng/g lw, 4454 ng/g lw and 2200 ng/g lw). Similar concentrations were measured in kittiwake and eider eggs (*Table 8*).

Table 8. The percentage of samples above detection limit (DL), mean and standard deviation (in bracket) at ng/mL plasma and ng/g wet weight of other samples in the Arctic environment (Svalbard)

Species	Polar bear	Ringed seal	Glaucous gull	Kittiwake	Common eider	Atlantic cod	Polar cod
Organ	Plasma (n=20)	Plasma (n=10)	Plasma (n=12)	Egg (n=12)	Egg (n=12)	Liver (n=3)	Pooled (n=10)
Lipid %	0.9*	0.7*	14.4*	8.1	17.4	50.5	1.7
PBDE 47	100% 0.10 (0.08)	100% 0.08 (0.02)	100% 2.28 (1.70)	100% 2.68 (0.78)	100% 0.12 (0.06)	100% 1.41 (0.42)	100% 0.19 (-)
BEHTBP	95% 0.15 (0.16)	10% 0.04 (-)	17% 0.026 (0.001)	100% 0.10 (0.09)	58% 0.06 (0.07)	10% 0.07 (-)	N.D.
DBDPE	100% 6.98 (9.11)	100% 5.36 (1.94)	100% 6.43 (2.62)	100% 1.01 (1.55)	100% 0.82 (0.62)	90% 5.57 (1.38)	100% 0.42 (-)
2,4,6-TriBP	100% 25.7 (14.7)	100% 31.2 (32.3)	100% 30.8 (9.0)	83% 52.6 (18.8)	58% 37.8 (17.6)	70% 115 (61)	N.D.
PBP	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
SCCP	95% 3.99 (2.91)	100% 4.96 (2.70)	75% 3.95 (1.99)	67% 7.83 (8.26)	83% 3.23 (1.77)	100% 10.3 (10.7)	100% 2.28 (-)
MCCP	95% 2.20 (1.84)	90% 2.91 (2.39)	67% 8.87 (9.88)	100% 4.91 (4.88)	100% 4.24 (4.07)	10% 0.94 (-)	100% 1.51 (-)

N.D. = below method detection limit; * from literature data

7.3.2 Chlorinated paraffins

The chlorinated paraffins were analyzed only in the Arctic samples (summary in *Table 8*). SCCP and MCCP were detected in all Arctic species. The concentrations in polar bear, ringed seal and glaucous gull plasma had an average ΣCP concentrations raging from 5-13 ng/mL in plasma (900 ng/g lw polar bear, 1130 ng/g lw ringed seal, 90 ng/g lw glaucous gull) and 7-14 ng/g ww (158 ng/g lw kittiwake, 44 ng/g lw eider duck) in seabird eggs. The SCCPs show higher concentrations (average of 10 ng/g ww, 20.6 ng/g lw, 100% detected) in Atlantic cod liver than MCCPs (detected in only one sample). Such a trend is not seen in polar cod where the concentrations were fairly similar among all chain lengths with an average around 2 ng/g ww (134 ng/g lw SCCP and 89 ng/g lw MCCP) (see *Figure 18*).

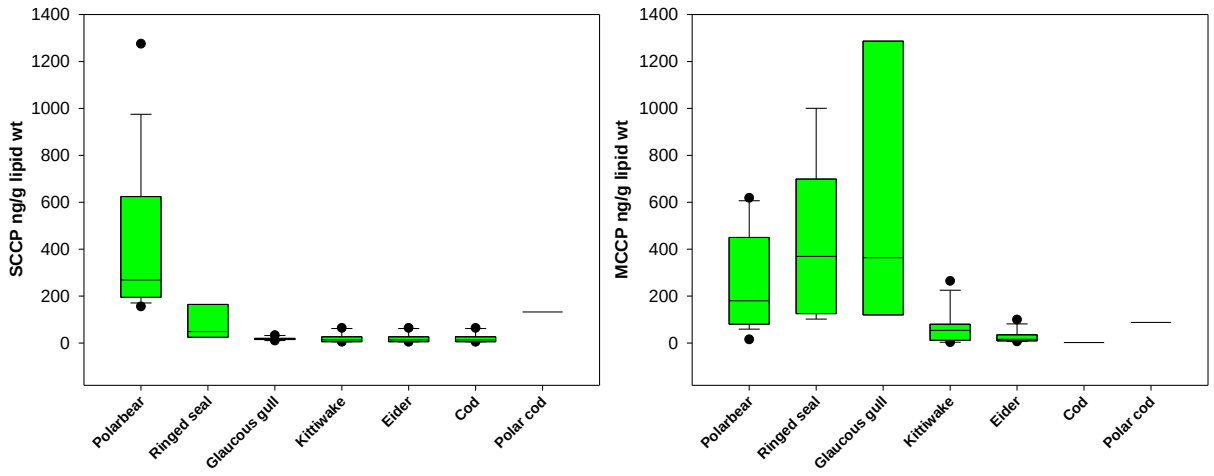

Figure 16. Box plot of the CPs in Arctic biota. For comparison lipid weight is plotted. The boundary of the box is the 25th and 75th percentile, line marks the median, plot with error bars and outlying points. Lines without statistics are below three valid datapoints (>detection limits).

7.3.3 PFAS

PFOS was detected in all Arctic samples. Perfluorinated carboxylic acids were detected in almost all samples. As has been reported earlier, significant amounts of PFOS were found in polar bear plasma (average 205 ng/mL plasma) which was almost 10-fold higher than levels found in ringed seal plasma, indicating potential biomagnification. Atlantic cod and polar cod have a 100 fold lower concentration compared to the sea birds. Similar trends are seen for the longer chained perfluorinated carboxylic acids (PFNA through PFTeA) but the differences get less pronounced as chain length increases (*Table 9*).

Table 9. The percentage of samples above detection limit (DL), mean and standard deviation (in bracket) at ng/mL plasma and ng/g wet weight of other samples in the Arctic environment (Svalbard)

Species	Polar bear	Ringed seal	Glaucous gull	Kittiwake	Common eider	Atlantic cod	Polar cod
Organ	Plasma (n=20)	Plasma (n=10)	Plasma (n=12)	Egg (n=12)	Egg (n=12)	Liver (n=3)	Pooled (n=10)
6:2 FTS	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
PFOS	100% 205 (103)	100% 31.6 (6.34)	100% 29.3 (54.9)	100% 33.3 (30.5)	100% 3.68 (2.30)	100% 0.28 (0.08)	100% 0.17 (-)
PFDcS	5% 0.2 (-)	N.D.	N.D.	33% 0.27 (0.08)	N.D.	N.D.	N.D.
PFOA	100% 5.39 (1.69)	100% 0.31 (0.17)	75% 0.44 (0.20)	42% 0.10 (0.01)	92% 0.26 (0.14)	N.D.	N.D.
PFNA	100% 37.6 (13.9)	100% 7.66 (1.86)	100% 1.72 (1.04)	100% 1.54 (1.46)	100% 2.06 (1.48)	60% 0.13 (0.05)	100% 0.15 (-)
PFDcA	100% 11.4 (5.00)	100% 3.48 (0.42)	100% 1.10 (0.80)	100% 1.98 (1.09)	100% 0.35 (0.27)	50% 0.098 (0.004)	100% 0.10 (-)
PFUnA	100% 25.5 (11.2)	100% 8.81 (1.14)	100% 3.91 (2.40)	100% 12.6 (9.6)	100% 1.19 (1.27)	100% 0.35 (0.07)	100% 0.33 (-)
PFDoA	100% 3.17 (1.16)	100% 0.78 (0.21)	100% 1.03 (0.50)	100% 3.11 (3.14)	92% 0.42 (0.61)	80% 0.09 (0.02)	100% 0.06 (.)
PFTrA	100% 9.12 (3.44)	100% 5.25 (1.45)	92% 8.01 (5.92)	100% 17.6 (18.9)	100% 2.82 (4.85)	90% 0.18 (0.05)	100% 0.23 (-)
PFTeA	70% 0.51 (0.32)	90% 1.42 (0.45)	N.D.	100% 2.39 (1.99)	67% 0.47 (0.66)	N.D.	N.D.
ΣPFAS	298	59.3	45.5	72.8	11.2	1.13	1.04

PFAS are widely distributed in the Norwegian Arctic as it is well illustrated by high detection rates (*Table 9*). However, direct comparison between species is not easy due to the variation in sampled matrices. PFAS data in plasma from polar bear, ringed seal and glaucous gull are available and data from egg for kittiwake and eider duck. Atlantic cod concentrations are based on liver samples while polar cod concentrations are based on analysis of whole individuals pooled in one sample. Since PFAS binds more to proteins than lipids, no lipid normalization of the data was conducted to allow direct comparison of different tissues.

However, when comparing plasma levels, ΣPFAS concentrations are highest in polar bear with average of 298 ng/g ww followed by ringed seal with 59 ng/g ww and glaucous gull (46 ng/g ww). For the eggs, the kittiwake is about 7 times more PFAS contaminated than the eider duck (73 and 11 ng/g ww) caused by their difference in feeding behavior. Atlantic cod liver and polar cod show low ΣPFAS levels with 1.1 and 1.0 ng/g ww, respectively.

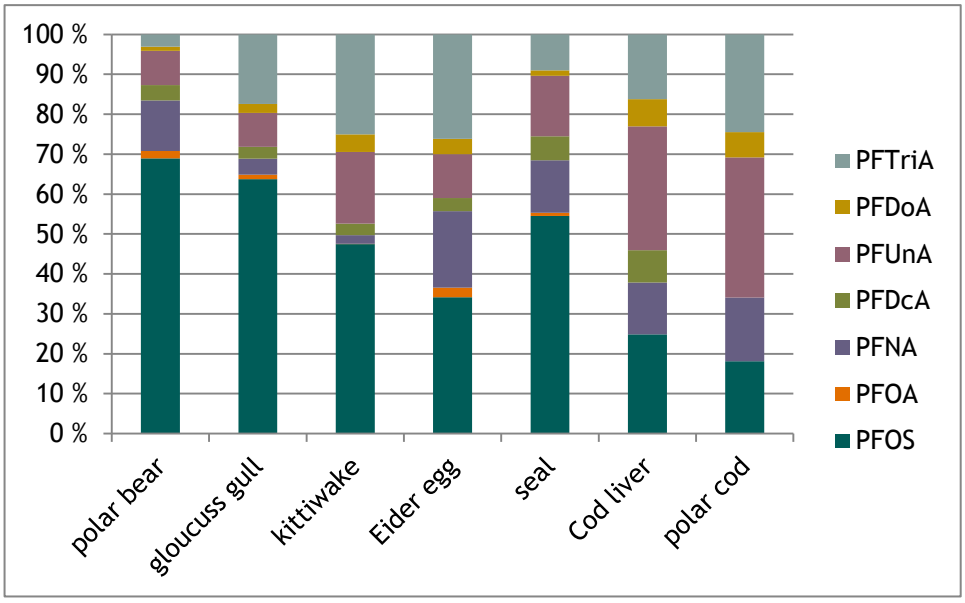

Figure 17. Relative contribution of detected PFAS in Arctic samples

Figure 19 illustrates the relative contribution of detected PFAS in the Arctic samples. Similar to the Atlantic cod samples from the Norwegian mainland the PFOS contribution in cod liver and polar cod is clearly lower than in birds and marine mammals. PFCAs with an uneven chain length are important contributors in the low trophic level organisms mostly caused by the higher water solubility of PFCAs compared to PFS.

Selected background levels from the Arctic marine samples can be directly compared to the respective samples from the Norwegian mainland. This gives a useful insight into eventual additional contamination process as long-rang-transport. So are sumPFAs levels comparable both in the arctic and mainland marine ecosystem, however the relative composition is changing (*Figure 20*).

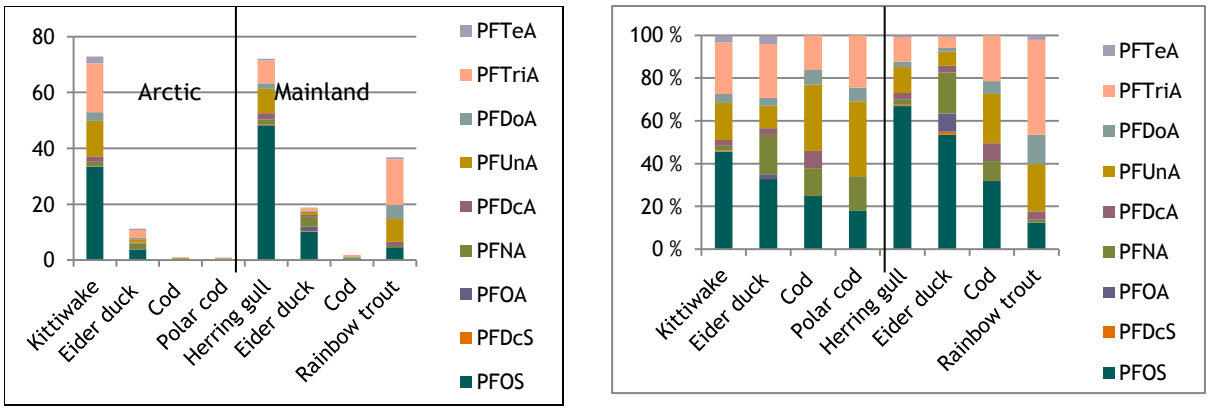

Figure 20. Comparison of PFAS levels in marine samples from the Arctic and the Norwegian mainland (left panel) and relative distribution (right panel). Levels in ng/g ww (left panel and in % (right panel)

The collected bird eggs are best suited for comparison of PFAS background levels from the Norwegian mainland and the Norwegian Arctic. As *Figure 21* shows, the eggs of eider and herring gull collected on the Norwegian mainland are slightly elevated, mostly likely due to the higher PFOS exposure. However, on average, a higher contribution of PFTrA can be identified in the Arctic samples. An ANOVA test comparing SumPFAS results in the sampled eggs of marine seabirds from the Norwegian mainland and Arctic resulted in no significant difference ($p > 0.05$), illustrating a similar background exposure in the Norwegian mainland and Svalbard with PFAS. However, when comparing the SumPFAS in the investigated eider duck eggs from both the Norwegian mainland and Arctic, significant differences could be observed ($p = 0.033$).

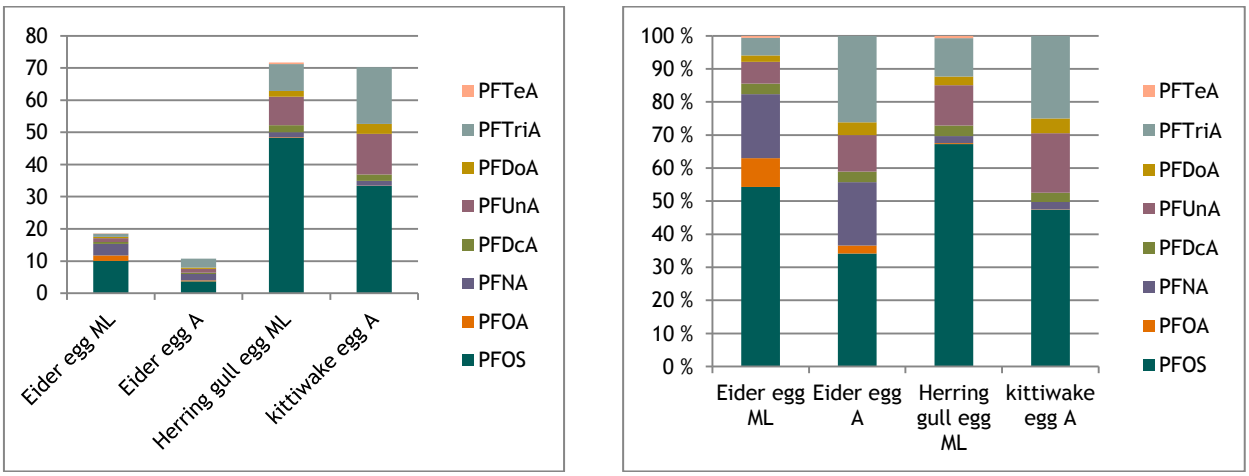

Figure 18. Comparison of PFAS levels in ng/g ww (left panel and in % (right panel)

In general, when comparing all samples analyzed for PFAS within the Screening 2013, levels in plasma of polar bear are highest with almost 300 ng/mL on average. The ringed seals and gulls investigated exhibit similar ΣPFAS levels ranging between 50 and 100 ng/g ww, independently of their origin (Norwegian mainland or Arctic). Background PFAS levels in the terrestrial ecosystems are with ΣPFAS of 1.3 – 37 ng/g ww.

7.3.4 Biomagnifiaction

The sampled arctic species feed on different levels of the marine food chain represented by the variation of □□□levels shown in *Figure 22*. As for the mainland samples no primary consumer was sampled for arctic samples either and the use of literature data is not recommended due to the effect of seasons and location on □□□. For the calculation of a relative trophic position the polar cod was used as the representatives of the lowest trophic feeder in this project.

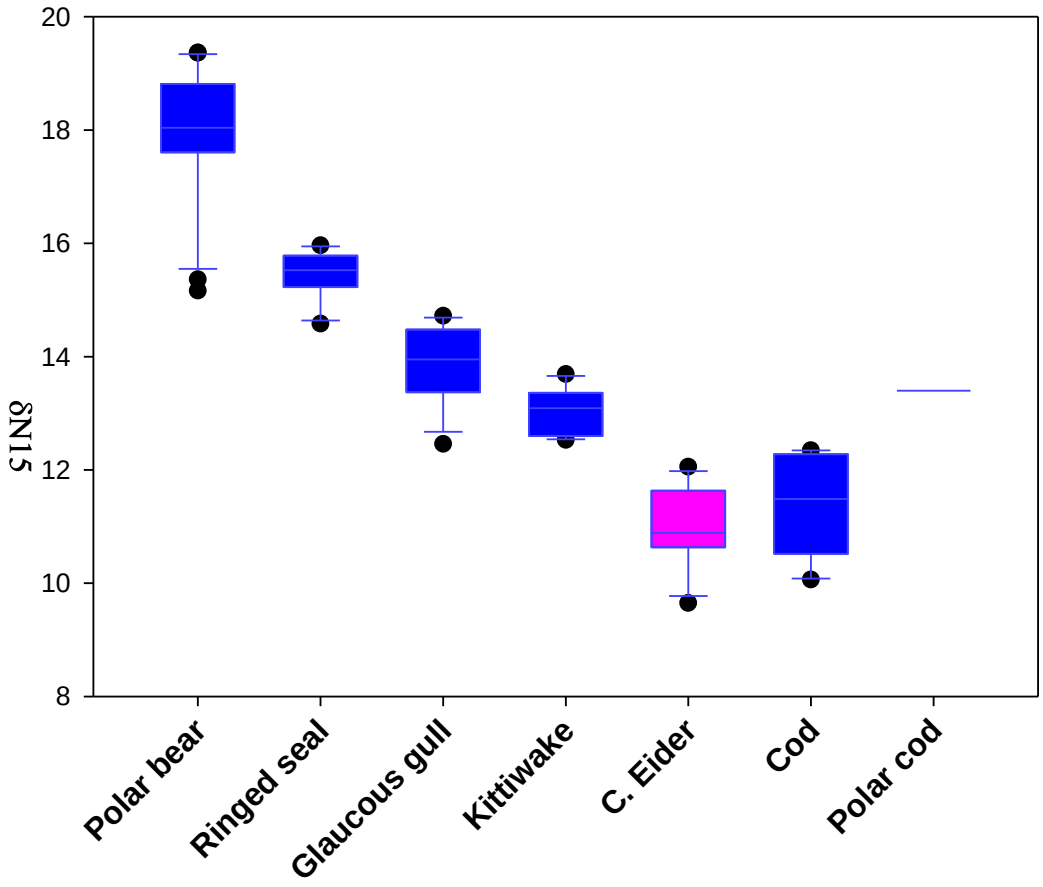

Figure 19. Comparison of $\delta^{15}N$ levels in collected Arctic species (dark blue: pelagic feeder; purple: benthic feeder)

BFR. When comparing the □□□□levels with log-transformed concentrations of BFRs we can observe a linear relationship (*Figure 23*). PBDE 47 seems to be more enriched in glaucous gull compared to ringed seal and polar bear, but not for DBDPE and TBP.

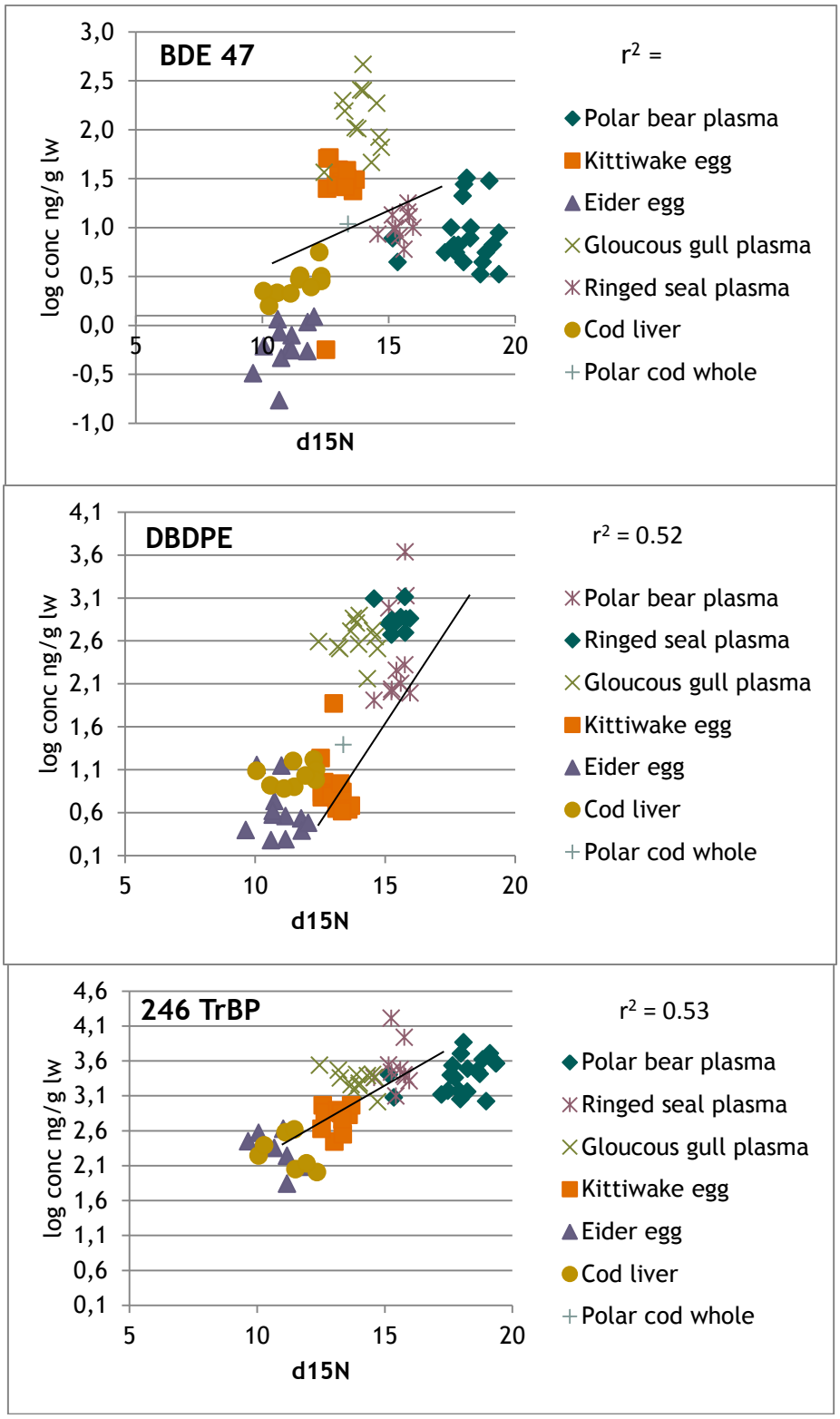

Figure 20. Relationship between BFRs in log ng/g lw to $\delta 15N$ (x-axis)

When considering all samples together, TMFs can be estimated on the basis of relative trophic levels and log-transformed concentrations. The calculation of TMFs results in values ranging between 1.1 and 3.9 for PBDE 47 and DBDPE and 1.8 for the TBP, indicating a biomagnification capacity. R^2 for the linear correlation between log concentration and trophic position varies between 0.49 for DBDPE and 0.08 for PBDE 47.

CPs. Of the chlorinated paraffins, a positive relationship between log normalized concentration of SCCPs and □□□ is observed (r^2 = 0.56). However, the linear relationship was observed for MCCPs was much weaker (r^2 = 0.27) indicating potential differences in uptake and excretion mechanisms (*Figure 25*). MCCPs cannot be transformed to SCCP under environmental conditions. This is likely due to the MCCPs being much heavier and display resistance to mass transfer in uptake processes. Both SCCPs as well as MCCPs consists of a large number of compounds, exhibiting varying characteristics. Together with the fact of a relatively large variability between individual samples within a species, a TMF > 1 can only be applied as an indication for bioaccumulcation of S/MCCPs.

When considering all samples together, TMFs can be estimated on the basis of relative trophic levels and log-transformed concentrations. The estimation of the TMFs results in values ranging between 2.3 for the SCCPs and 2.0 for the MCCPs, indicating a biomagnifcation potential for the S/MCCPs. R^2 for the linear correlation between log concentration and trophic position varies between 0.52 for SCCP and 0.31 for MCCP.

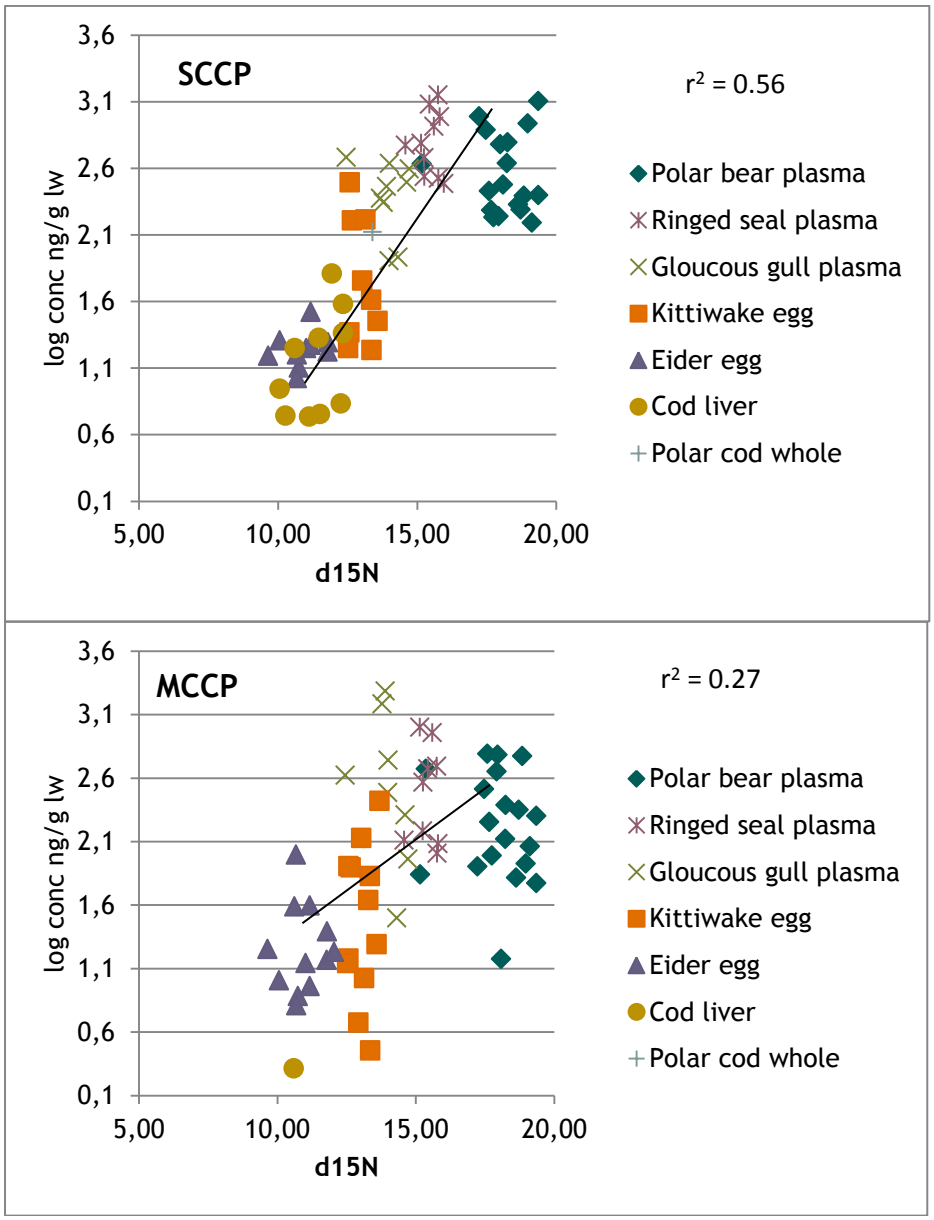

Figure 21. Relationship between CPs in log ng/g lw to δ15N (x-axis)

PFAS. The feeding behavior and relative trophic position between organisms has an influence on PFAS contamination based on the data available. An illustration of the relationship between PFAS levels and □□□ is shown in *Figure 26*. Correlation coefficients r^2 of 0.64 for PFOS and 0.68, 0.75, 0.64, 0.34 and 0.29 for PFNA, PFDcA, PFUnA, PFDoa and PFTrA respectively indicate the bioaccumulation of PFAS with a decreasing trend of linear correlation with increasing chain length for PFCAs.

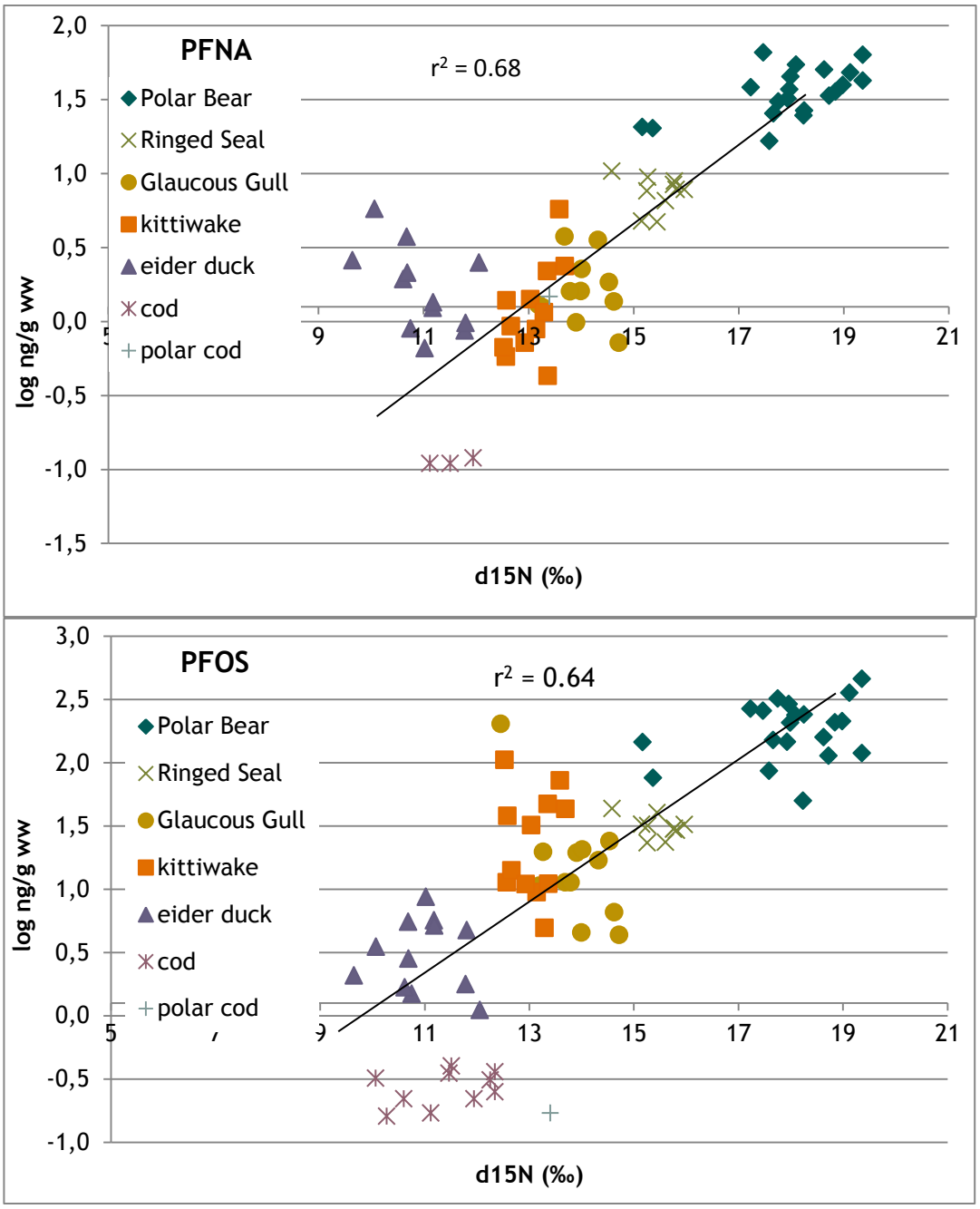

Figure 226. Relationship between PFOS and PFNA levels (Y-axis, ng/g ww) and δ15N (x-axis)

When considering all samples together, estimated TMFs can be calculated on the basis of relative trophic levels and log-transformed concentrations. The calculation of the TMFs results in values ranging between 1.6 and 6.5 with PFOS and PFNA representing the highest estimated TMF values (4.6 and 6.5) and PFTrA the lowest (1.6), similar to the marine data from the Norwegian mainland investigated. R^2 for the linear correlation between log concentration and trophic position varies between 0.65 for PFOS, 0.92 for PFOA and 0.27 for PFDoA. This is in agreement with findings from Kelly et al. 2009, which reported a comparable pattern but with higher TMFs for all PFAS due to the inclusion of species occupying higher trophic levels as in the here reported study.

8. Discussion

8.1 Brominated flame retardants

Three BFRs were screened for in this study, PBDE 47, BEHTBP, DBDPE and in addition the brominated phenols TBP and PBP which are intermediates in the processing of flame retardants. This study presents biotic and abiotic samples from the Arctic (i.e. Svalbard), Northern Norwegian coast of Lofoten, Troms and Finnmark and the terrestrial/freshwater environment of Telemark in the Southern Norway. In all locations, BEHTBP and PBP were sparsely found and at low levels, while PBDE 47, DBDPE and TBP were frequently detected. Although many years have past since the phase-out of the technical mixtures of PBDEs (e.g. pentaBDE and OctaBDE), the main ingredient used in PentaBDE mixtures, is still ubiquitous in all environmental compartments. However, there are indications that PBDE 47 concentrations are decreasing in the environment (de Wit et al 2010, Law et al., 2013). One important result of this study was that DBDPE was found at higher concentrations than the PBDE 47 in a number of samples suggesting that DBDPE, as a replacement product for DecaBDE, is increasing in the environment and/or PBDE 47 is decreasing. TBP was also detected at relatively high concentrations compared to PBDE 47 but it is still uncertain to which levels these chemicals are occurring naturally in the environment or due to anthropogenic (human) activities.

Freshwater and seawater sediments

Studies from the Norwegian national lake survey 2004-2006 (Christensen et al. 2008) reported levels on metals and environmental pollutants in lakes and fish in the northern Norway, Svalbard and Bjørnøya. Levels of PBDE 47 in freshwater top layer sediments in this survey in the provinces of Nordland was from 'not detected' to 109 ng/kg dry weight, in Troms from 10 to 48 ng/kg dry weight and 3.7 to 3110 ng/kg dry weight in Finnmark. The levels in the current study of sediment sampled in a fresh water lake in Telemark and in the marine sediment in Lofoten were below the detection limit. This might suggest that the levels have decreased, however uncertainties exist due to only two sampling locations in the present study.

Norwegian mainland terrestrial, freshwater and marine environment

The levels of DBDPE found in mice of the terrestrial environment suggest this compound to be the predominant BFR of the studied compounds (7.0 to 11.5 ng/g lw) (See Appendix) and higher than PBDE 47. A study on PBDEs in the Norwegian terrestrial biota (Mariussen et al. 2008), sampled in 1990-2004, revealed that PBDEs were lower in concentrations in terrestrial than in marine mammals. Comparing these reported results with the current study, the levels of PBDE 47 in terrestrial biota was in the range of 0.08 to 5.5 ng/g lw in 1995 while the levels were below detection limits in this study. This may also indicate a decreasing trend of PBDE47.

PBDEs were studied in the Norwegian National Lake Survey 2004–2006 (Christensen et al. 2008), trout from lakes from northern Norway (Finnmark, Nordland and Troms) and perch (Finnmark). PBDE 47 were comparable for both species and all locations, with 0.13-0.16 ng/g ww in trout and 0.015 ng/g ww for perch. These results compare reasonably well to findings within this study for trout and perch with average concentrations of 0.37 ng/g ww and 0.12 ng/g ww, respectively (*Table 4a and b*).

Considerable amounts of DBDPE were found in freshwater trout which had levels ranging from 54 to 1226 ng/g lw in the present screening study. BEHTBP was generally below the detection limits in terrestrial samples (N.D. to 1.9 ng/g lw). PBDE 47 and DBDPE were less abundant in perch compared to the trout.

Only a few studies have been conducted of DBDPE in the northern hemisphere. In a study of egg pools of herring gulls (*Larus argentatus*) from seven colonies in the Great Lakes (collected in 1982 to 2006),concentrations of DBDPE in three of the seven colonies ranged between 1.3 to 288 ng/g ww, surpassing decaBDE levels. The authors concluded that these results are an indication of a continual exposure and bioaccumulation of several BFRs in the Great Lakes (Gauthier et al., 2008).

Of the two brominated phenols studied, only TBP was detected with average concentrations of 81, 54 and 27 ng/g ww in the Norwegian terrestrial environment in moose, field mice and shrew, respectively, see *Table 5a*. Similarly, fresh water biota concentrations were 42 ng/g ww in perch and 66 ng/g ww in brown trout (*Table 5b*). These levels are similar to the levels found in the marine samples of northern Norway, with average concentrations of 62 to 69 ng/g ww in cod liver, eider and herring gull eggs while mussels contain lower concentrations (2.5 ng/g ww). The highest levels were found in harbor seals (average of 164 ng/g ww). For comparison, TBP was frequently detected in both brackish and marine sediments in Sweden, Norway and Denmark and in higher levels close to urbanized areas. The detection frequencies in sludge were low (Schlabach et al. 2011). In the same screening TBP was detected in 91% of the biota samples (cod, Arctic char, Guillemot egg, perch, blue mussels) with the concentration

range of <0.03 to 86 ng/g ww, agreeing well with the findings in the here presented study. The highest concentrations were detected in a cod liver sample (Faroe Islands) and mussel and cod liver from the urban influenced marine area of Åsefjorden (Norway). Schlabach et al. (2011) concluded that the levels found were in agreement with the findings of a Norwegian screening in 2010 (Møskeland, 2010).

Norwegian Arctic marine environment

Polar cod and Atlantic cod

BFRs, and particularily PBDEs, have frequently been analyzed in samples from the Arctic. For example in polar cod from Svalbard (Sørmo et al., 2006) where concentration of PBDE 47 was 0.097 ng/g ww), or from the Barents Sea, east of Svalbard, in 2004 with PBDE 47 mean concentrations of 2.5 ng/g lw (Haukås et al., 2007). Polar cods (whole fish) from Svalbard were analyzed in the current study sampled in September 2012 and results of a single pooled sample showed a PBDE 47 concentration of 10.9 ng/g lw (0.19 ng/g ww) which is slightly higher than previous studies. BEHTBP and TBP were not detected in polar cod and low levels of DBDPE (average concentration of 0.42 ng/g ww).

In this present study, Atlantic cod liver was analyzed within 10 individuals sampled from Svalbard and from Lofoten (Northern Norway mainland) in the fall of 2012. Results on the concentration of PBDE 47 were in the range of 1.6 to 5.6 ng/g lw (0.9 to 2.3 ng/g ww) in Svalbard Atlantic cod and in the range of 6.0-19.6 ng/g lw (4.5 to 11.3 ng/g ww) in Lofoten samples. The coastal mainland samples had higher levels of PBDE 47 than Atlantic cod from Svalbard and similar levels to what has previously been reported for Atlantic cod from Northern Norway (Bakke et al. 2008). In that study, lowest concentrations were found in fish from the open sea, while fish at the coast had higher concentrations. PBDE 47 was the main congener in all samples and accounted for 61–79% of ΣPBDE in Atlantic cod. No differences were found between concentrations from Lofoten or Svalbard for other BFRs in Atlantic cod liver. DBDPE concentrations on average were 5.6 ng/g ww in Svalbard and 4.3 ng/g ww in Lofoten, while TBP differed slightly more with an average of 115 ng/g ww in Svalbard and 69 ng/g ww in Lofoten.

Seabirds

PBDE 47 was found to be the predominant PBDE congener in Arctic seabirds. ΣPBDE concentrations generally ranged from 20–100 ng/g lw, while glaucous gulls from Bjørnøya had the highest ΣPBDE concentrations, up to 1400 ng/g lw. Higher ΣPBDE concentrations have been previously detected around Svalbard and northern Norway compared to Candian Arctic (de Wit et al., 2006).

A recent study on seven species from Svalbard included liver and plasma samples from Capelin, Common Eider, Black-legged kittiwake, Ringed seal, Arctic fox, Polar bear and Brünnich's guillemot (Bjørnøya) sampled in 2007-2008 (Sagerup et al. 2010). DBDPE was only detected in one guillemot egg (10% of the samples at 0.6 ng/g ww) while BEHTBP was detected in capelins, eiders, guillemots, kittiwakes and ringed seal with a concentration range of 0.4 to 3.6 ng/g ww. Levels of DBDPE (0.3 to 5.9 ng/g ww) in kittiwake and eider eggs from this present study are higher than what was found in guillemot egg from 2009 (Sagerup et al., 2010). BEHTBP was more frequently detected in kittiwake and eider eggs from the Arctic, but at lower concentrations compared to findings in previous work (Sagerup et al. 2010). In the compilation of Norwegian screening data for selected contaminants (2002-2012)(Arp et al. 2013) earlier studies reported that TBP was more frequently found in biota samples (Norway and Svalbard) (i.e., fish liver, crustaceans, blue mussels and bird liver). TBP were also detected in glaucous gull plasma with concentrations ranging from 14.4 to 40.8 ng/g ww (100-333 ng/g lw) which is in agreement with the data from present study. In 2009, levels of TBP in common eider liver were reported in a high percentage of the samples, but at lower levels (range 0.03 to 0.33 ng/g ww) (Sagerup et al. 2010).

Seals

PBDE data for ringed seal blubber has been summarized by de Wit et al. in a number of locations of Canada, Geenland, and Svalbard (Norway). ΣPBDE concentrations were in the range of 1–100 ng/g lw. Highest concentrations were found in seals from northeast Greenland and Svalbard (30–58 ng/g lw) (de Wit et al., 2006). As part of a time trend study in the Canadian Arctic, blubber samples from ringed seals were sampled in 2006 and analyzed for PBDEs, HBCD, BTBPE and DBDPE (Muir et al., 2007). PBDEs were detected in most blubber samples while DBDPE was not detected. The ΣPBDE concentrations were highest at Arviat (mean 21 ng/g lw) and lowest at Resolute Bay (mean 4.2 ng/g lw) in Canada and consisted mainly of PBDE 47 and PBDE 99 A Nordic study examined BFR in a range of samples spanning three decades (1980s to late 2000) of marine mammals (fin whale, minke whale, pilot whale, white-sided dolphins, harbour porpoise,ringed seal and hooded seal) in the Nordic Arctic and

North east Atlantic. Result on the levels of ΣPBDEs showed a decrease by 44% from 2000 to 2006 in ringed seals from Greenland and showed a higher predominance for PBDE 47 (16-28 ng/g lw in 2006 for pooled blubber samples) (Dam et al. 2011). Ringed seal plasma sampled within this study showed PBDE 47 levels ranging from 6.0 to 17.8 ng/g lw.

In our study, TBP was also detected in ringed seal plasma with 8.7-114 ng/g ww (1200-16000 ng/g lw). In 2009, levels from liver of ringed seal were reported in high percentage of the samples, but at comparably low levels (range 0.03 to 0.33 ng/g ww) (Sagerup et al. 2010).

Polar bear

A study using plasma from female Svalbard polar bears collected in 2002 where determined for ΣPBDE ranged from 270 to 970 ng/g lw and consisted predominantly of PBDE 47 (93%) at a concentration range of 260 to 879 ng/g lw and a mean value of 49.8 ng/g lw (Verreault et al. 2005). Results from this report on the levels of PBDE 47 in plasma showed that concentrations in 20 individual male polar bears from Svalbard in 2007-2008 were in a range of 3.1 to 32.3 ng/g lw (0.03 – 0.29 ng/g ww) with a mean of 10.6 ng/g lw (0.10 ng/g ww), a factor of five lower than results reported from Svalbard in 2002 (Verreault, 2005). The highest DBDPE concentration in our present study was found in male polar bear plasma ranging between 9.4 to 38.7 ng/mL (1044-4300 ng/g lw). BEHTBP was highest in polar bear plasma 0.04 to 0.66 ng/g ww from this study but are slightly lower compared to earlier findings (Sagerup et al. 2010). In present study, TBP was detected in all polar bear plasma samples at levels of 9-66 ng/g ww (1044-7311 ng/g lw).

8.2 Chlorinated paraffins

To our knowledge SCCP and MCCP have only been investigated in the Arctic and Norwegian environment in a few instances.

Early studies from 2003 revealed levels of SCCP in mussels from Oslofjord (Norway) from 14 to 130 ng/g ww and in cod liver 23-750 ng/g ww (Borgen et al. 2003). Brown trout, perch, cod, flounder and eel from the Drammensfjord (Norway) had concentrations of SCCP+MCCP between 46–495 ng/g lw. Perch (SCCP 490 ng/g lw and MCCP <17ng/g lw), brown trout muscle (SCCP 78 ng/g lw, MCCP < 6 ng/g lw) and cod liver (SCCP 69 ng/g lw, MCCP <2 ng/g lw) The lowest concentration was found in an eel sample, the highest in a sample of flounder liver (SCCP 530 ng/g lw, MCCP 230 ng/g lw).

Previous studies revealed CP concentrations in cod liver from Lofoten and Iceland of 17 to 70 ng/g ww for SCCP and for MCCP between 7 and 47 ng/g ww (Reth et al 2006) which is comparable to SCCP and MCCP levels in cod liver from Svalbard in the present study (see appendix). In the same study Arctic chars from Lake Ellasjøen at Bear Island showed comparable concentrations of SCCP at 7-27 ng/g ww and MCCP at 10-47 ng/g ww with present study. Little auk and kittiwake liver and muscle samples had concentrations of SCCP at 588 ng/g ww and MCCP at 5-55 ng/g ww (Reth et al. 2006) which is slightly higher compared to present findings of SCCP (<1.6 to 25 ng/g ww) and MCCP (<0.2 to 17 ng/g ww) in kittiwake and eider eggs from Svalbrad. Glaucous gull plasma had levels of SCCP <1-6.7 ng/g ww and of MCCP <1 to 27ng/g ww) in Svalbard (see appendix). Arp et al. 2013 concluded that from reported evidence on SCCP, which were detected in 90% of all samples analysed, a near ubiquitous presence in the Norwegian environment can be indicated.

8.3 PFAS

Both volatile and ionic PFAS, representing precursors and final products, were investigated. We were not able to detect any of the volatile FTOHs in any of the samples. However, no analyses of air samples were part of the screening project, which is the main compartment for these compounds to partition to. Of the other precursor compounds investigated, (i.e., FT(U)CAs and 6:2 FTS) no sample contained detectable levels of these compounds besides mice liver. PFDcS was also only found very occasionally and close to detection limits. The most detected PFAS were PFOS, PFUnA and PFTrA. In terrestrial/freshwater biota, long-chained PFCAs dominated over PFOS, which was opposite to findings from the marine environment.

Terrestrial ecosystem, Norwegian mainland

The samples collected for the determination of background levels in the terrestrial ecosystem were consisting of soil, mice and moose. Due to a limited project frame, no complete food chain could be sampled. To establish trophic levels on the basis of □□□□ data was therefore not possible for the terrestrial ecosystem. Literature data were used instead to supply data. Müller at al. have also reported PFAS data in liver of Canadian caribou. The authors found a similar PFAS distribution of PFNA > PFDcA > PFUnA > PFOS to the results reported in this study for moose and mice. Levels where with 2.2, 1.9, 1.7 and 0.7 ng/g ww, respectively, which are slightly higher than the levels observed in the Norwegian terrestrial biota.

In the case of the freshwater system investigated, sediment, water, and brown trout were sampled. We were able to establish a BCF of 1500 for PFNA, the only PFAS detected in both the water and the fish, pointing to no considerable biomagnification of this compound.

For comparison, lake water from the Norwegian mainland showed only PFOA and PFNA at levels of 0.6 and 0.3 ng/L. In Klif report TA 2450/2008, high levels of PFOA (> 7 ng/L) were reported in lake Mjøsa compared to much lower PFAS detections in other south Norwegian lakes containing mostly PFHpA (samples from 2003 and 2004).

The sediment sample from the Norwegian lake showed very low SumPFAS levels of 0.05 ng/g dw, mostly due to the detection of PFUnA. Lake sediments reported in Klif report TA 2450/2008 varied between 0.1 and 3.5 ng/ g dw, and were mostly attributed to PFOS.

For lake sediments, a similar picture can be seen. In the Canadian Arctic, SumPFAS concentration in the top sediment layer was approximately 5 and 7 ng/g dw in two lakes compared to approximately 100 ng/g dw in a third one. All three lakes showed varying PFAS profiles. The sediment sample from the Norwegian lake showed very low SumPFAS levels of 0.05 ng/g dw, mostly due to the detection of PFUnA, which was not found in the Canadian lakes. Lake sediments reported in the Klif report TA 2450/2008 varied between 0.1 and 3.5 ng/g dw mostly attributed to PFOS.

Marine ecosystem, comparing mainland and Arctic samples

Within this screening project, the sampling of marine samples was designed in a way to both provide comparable data to Arctic samples as well as acquire samples representing the marine food chain relevant for the Norwegian coast. We collected sea water, sediment, eider duck and herring gull eggs, cod and seal liver from the Norwegian mainland. We were also supplied with plasma samples from polar bear, ringed seal and glaucous gull, cod liver, eider duck and kittiwake eggs, and one pooled sample of polar cod.

Arctic seawater data for PFAS has been reported at varying concentrations for several locations including the Greenland Sea, Labrador Sea, Canadian Arctic, Icelandic and Russian Arctic. In this study, only PFOA was detected at an estimated 0.2 ng/L, which was below LOQ. PFAS levels increase considerably closer to source regions. Large rivers outflows into the marine environment have been identified as major input sources. For example, at the mouth of the river Elbe, elevated concentrations of PFOA (9 ng/L), and PFOS (8 ng/L) were observed, while other PFAS concentrations ranged from 0.6 to 1.7 ng/L. However, concentrations decreased at coastal stations to 3.8 ng/L and 1.8 ng/L for PFOA and PFOS, respectively. These findings are similar to those reported in this study and indicate a dilution of PFAS compounds introduced by river outflow in coastal environments. In the Baltic Sea, even PFAS distributions with low gradients were observed; however, PFOA and PFOS were the major compounds observed (up to 1.1 and 0.9 ng/L) (Ahrens et al. 2011a; Theobald et al. 2011; Theobald et al. 2012).

The sediment samples from the Lofoten station contained SumPFAS of 0.2 ng/g dw, which mostly consists of PFOA and PFNA. In Klif report TA 2450/2008, PFOS is mainly reported at levels ranging between <LOD to 0.7 ng/g dw in sampling locations comparable with the one used in this study. The discrepancies observed for PFOS findings in abiotic samples collected within this study and the ones summarized in Klif report TA 2450/2008 can be attributed to presentimprovements in analytical methodology.

The cod liver samples collected within this study show very similar levels of contamination (*Figure 27*). Comparable SumPFA concentrations of 1.8 and 1.1 ng/g ww detected in cod liver from the Norwegian coast and Arctic indicate no spatial differences in concentration. However, the contribution of PFOS is larger in samples collected near the mainland than those collected in the Arctic. Pooled polar cod showed comparable levels to those found in cod liver. In earlier studies, PFOS levels between 1.5 and 2.2 ng/g ww were reported in cod liver caught in Norwegian fjords which is more than double of what was found in this study at background locations (Bustnes et al. 2010). In Klif report TA 2450/2008, levels of SumPFAS of approximately 8 ng/g ww were reported for a comparable location in Lofoten in 2007. These levels were again higher than results reported in this study possibly indicating a decreasing trend in PFOS exposure.

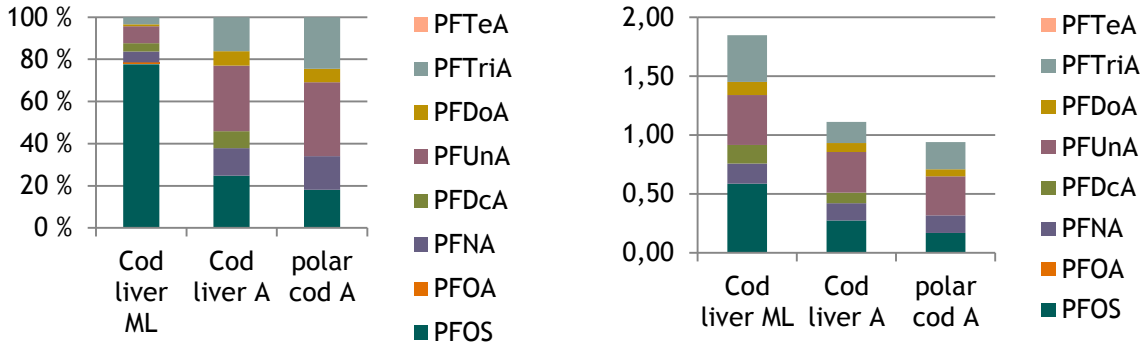

Figure 23 Relative and absolute comparison of PFAS in cod liver from Norwegian mainland and the Arctic (% left panel and ng/g right panel)

The seabird eggs collected on the Norwegian mainland and Svalbard can be used to assess differences in exposure in both locations. $\delta^{15}N$ levels for kittiwake, herring gull and eider duck are quite similar, independently of their location, indicating that the respective species do not occupy a different trophic level (*Figure 28*). However, they are feeding on very different parts of the food web and are difficult to compare. Different prey items will affect isotope enrichment and contaminant exposure making such a comparison inaccurate. $\delta^{13}C$ values provide information regarding the source of dietary carbon, (e.g. marine vs. terrestrial). The differences in $\delta^{13}C$ between Herring gull from the mainland and kittiwake from the Arctic are distinct, indicating a differing feeding habit for the Herring gull compared to the kittiwake.

When comparing the eider eggs, only small differences can be found indicating a very similar selection of feed on both locations (*Figure 28*).

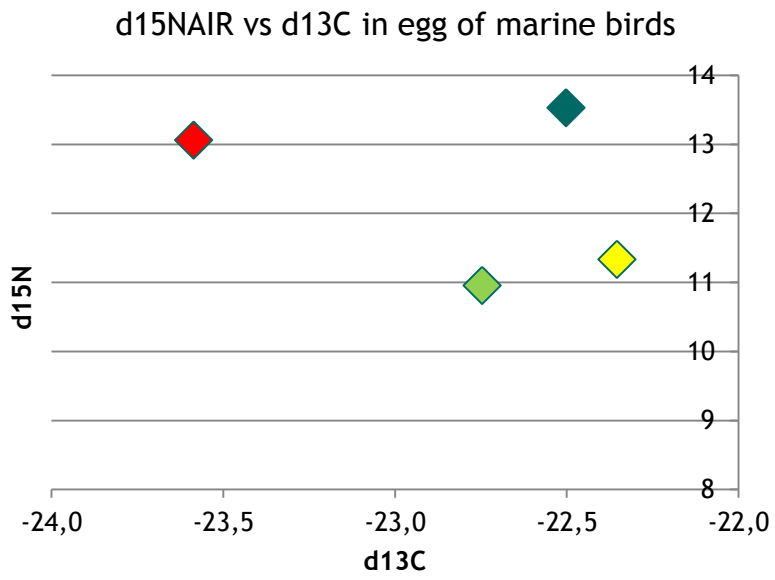

Figure 24. Arithmitic mean values of $\delta^{13}C$ and $\delta^{15}N$ of marine bird eggs collected at the Norwegian mainland (ML) and Svalbard (A) (red: kittiwake (A), green: Eider duck (A), blue: Herring gull (ML), yellow: eider duck (ML)) from this study

Gebbink et al. reported ΣPFAS levels between 9.2 ng/g ww and 560 ng/g ww in gull eggs collected from 15 colonies across Canada, including both remote and urbanized locations. In this study, we detected ΣPFAS of 72 ng/g ww in herring gull eggs and 70 ng/g ww in kittiwake eggs, which is approximately seven times higher to the lowest reported levels from Canada. The populations showing similar levels than the ones studied during the Screening 2013 were herring gull eggs collected on the east coast of Canada (Gebbink et al., 2011).

Figure 29 compares the PFAS results in all marine bird species investigated. The most prominent difference between sampling locations can be found for PFOS, where herring gull from the mainland shows higher levels than observed for kittiwake. For the PFCAs, only PFUnA is higher in herring gull, while other PFCA are very comparable between the two locations and species. A similar picture can be seen for the eider duck where higher PFOS levels were observed for the mainland population by a factor of 2. In contrast, PFTrA is more abundant in the Svalbard eider duck egg compared to the mainland. Herzke at al, 2009 reported PFAS data in eggs of eider duck collected at the remote location of Sklinna in the years 2003/4 of SumPFAS 22 ng/g ww, twice as high as reported here (Herzke et al. 2009).

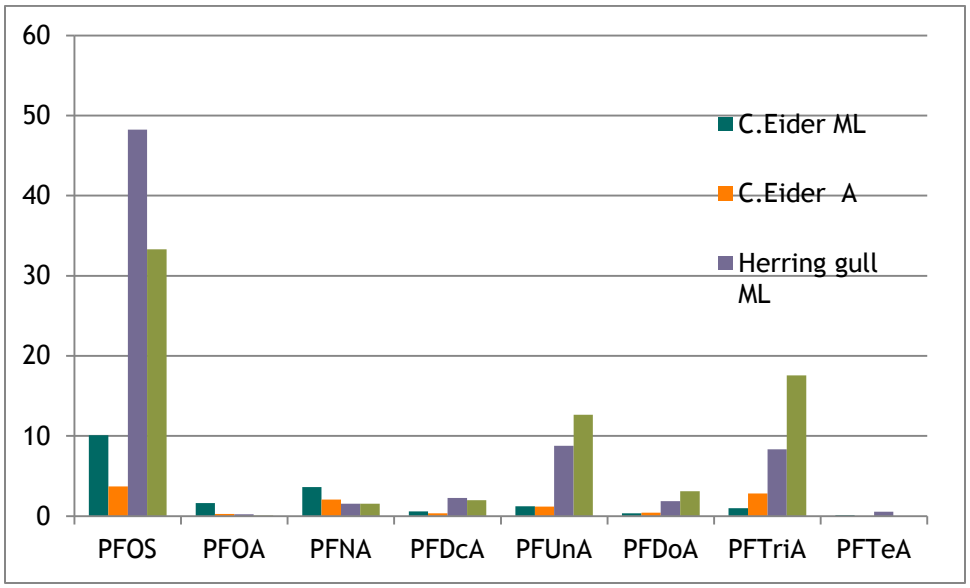

Figure 25. Comparison of PFAS in marine birds collected in the Norwegian mainland (blue and red bars) and the Norwegian Arctic (green and purple bars)

The data on eggs of herring gull reported in the Klif report TA 2450/2008 show very similar levels to those reported in this study with an average of 40 ng/g ww for PFOS and approximately 20 ng/g ww for the PFCAs. PFUnA and PFTrA were also the most prominent PFCAs (samples from 2003).

The Arctic samples of glaucous gull, ring seal and polar bear plasma can be compared with existing literature data. Verrault et al published data on PFAS plasma concentrations from glaucous gulls collected in Svalbard (Verreault et al. 2005b). The authors found levels of 134 ng/g PFOS, 74 ng/g ww PFUnA and 11 ng/g ww PFTrA, which are considerably higher than findings within this study (SumPFAS: 46 ng/g ww) which indicates a decrease in PFAS exposure over time.

Seal data are very difficult to compare with literature due to little available data. However, more focus has been placed on polar bear levels. Analysis of polar bear blood collected from Alaska showed concentrations of 34 ng/g ww PFOS, which is considerably lower than results found in this study (297 ng/g ww). However, maternal transfer studies have reported plasma levels of SumPFAS in the same order of magnitude in samples of female polar bears collected in 2008 on Svalbard (ca 434 ng/g ww) (Nilsen, 2011).

In summary, we can say that polar bears contain the highest levels of PFAS with almost 300 ng/g ww in plasma. Marine gull species (both eggs and plasma) and seal (both liver and plasma) show similar levels, independent of their origin (Norwegian mainland or Norwegian Arctic). Eider duck eggs and cod liver show very low amounts of PFAS. The terrestrial ecosystem is characterized by even lower levels except trout liver (*Figure 30*).

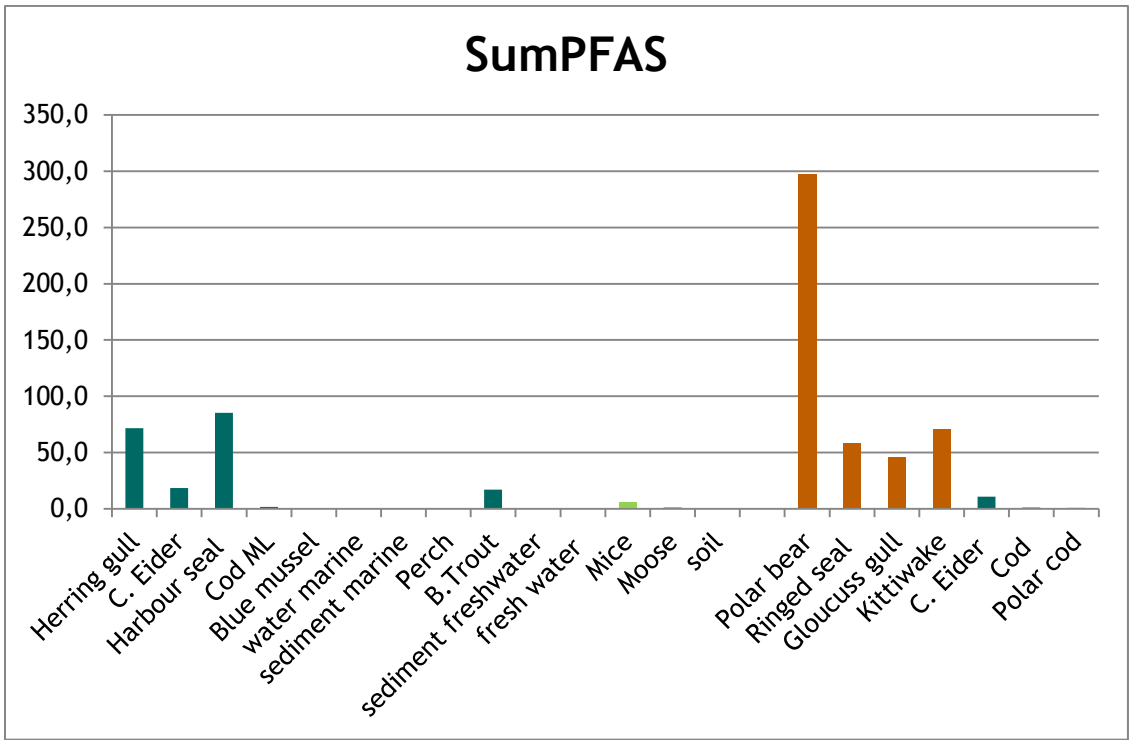

Figure 30. Comparison of SumPFAS (blue: marine/ Mainland, green: terrestrial/Mainland, red: marine/Arctic)

8.4 Biomagnification

PFOS, PFNA, PFCA with a longer carbon chain up to PFTrA, PBDE 47, DBDPE, TBP and S/MCCPs all showed TMFs > 1 in both marine ecosystems from the Norwegian mainland and the Arctic. Stated TMFs are only an estimation because no true food chain rather than representatives of a marine Arctic food web were sampled as well as different tissue types. The here estimated TMFs have to be treated with caution as choice of tissues used will have a significant impact on TMF interpretations as contaminant storage and partitioning properties will differ depending on the tissue investigated. Plasma, liver and egg samples analysed within this study will have different contaminant turnover rates compared to tissues traditionally used in TMF studies (muscle and fat) and may not accurately reflect biomagnification potentialIn the freshwater system did DBDPE and TBP exhibit BSAF > 10000. These data, together with literature supplementing literature data, add to the evidence that biomagnifications takes place in nature between different trophic levels of food chains and from bottom to top of food chains. In addition, the findings of these compounds in remote locations as the Norwegian Arctic and mainland indicate a considerable chemical stability (persistence), and seem not to degrade in the environment to a large degree.

9. Conclusion

The presently reported levels are a valuable dataset on background levels of a variety of emerging compounds. With this knowledge, future changes in environmental occurrence can be assessed together with the impact of point sources and new exposure routes.

We managed to determine background levels for PFAS in the abiotic and biotic parts of the terrestrial and marine ecosystem representing the Norwegian mainland and the Arctic. Different PFAS groups are important contributors in the respective ecosystems. PFCAs play an important role in the terrestrial ecosystem while PFOS is the dominating PFAS in the marine biota samples except for cod. Abiota samples like water and sediment contain mostly PFCAs. All investigated biota samples contained PFAS whereas water and sediment contained no or only very limited amount of PFAS higher than detection limit.

Even if sampling was done at such a remote location as Svalbard, polar bear was the most PFAS-contaminated species investigated during the screening. The other marine biota samples, independent of their origin, from the mainland or Svalbard, contained SumPFAS-levels at at least 3-4 fold lower levels than the average SumPFAS-levels found in polar bear samples. Differences between mainland- and Svalbardsamples were mostly due to an increased PFOS-level on the mainland. Terrestrial biota samples were characterized by a very low PFAS content in the low ng/g range, except trout liver samples.

Since PFAS in general seem to react rapidly to legislation bans and voluntary production stops by the industry, recent levels are difficult to compare with previously published data. PFOS has been reported to decrease followed by a leveling off in a number of ecosystems worldwide whilst PFCAs, and especially long-chained PFCAs, show an increasing trend. In general, PFAS do only degrade very slowly, if at all, and they can act as final products of the degradation of other more unstable compounds (precursors). In the Screening 2013 no precursor compounds such as the volatile FTOHs and FT(U)CAs as well as 6:2 FTS, could be detected, which sometimes is used as a PFOS substitute.

Three BFRs were analysed in this study, namely, PBDE 47 (representing the PentaBDE technical mixture and the historically most frequently used PBDE), DBDPE and BEHTBP. In addition, intermediates from production processes, the brominated phenols TBP and PBP, were investigated. PBDE 47 and DBDPE were the most detected BFRs within this study, with DBDPE dominating over the PBDE 47 in a number of cases. This is indicating a decreasing trend of PBDE 47 and/or increasing DBDPE levels in Norwegian environment due to the ban of PentaBDE. BEHTBP, which is a replacement product for PentaBDE, was only detected in few samples. The brominated phenol PBP was only detected very sparsely. TBP was frequently detected in samples, but no clear differences could be established between Norway mainland terrestrial/fresh water, northern Norway marine and Arctic samples. Since TBP can be formed naturally in the marine environment, interpretation and conclusion of potential sources and environmental risks are difficult. PBDE 47 and DBDPE were mostly detected in the marine samples in addition to mice and shrew liver. In the marine environment PBDE 47 exceeded the levels of DBDPE in Herring gull eggs and Atlantic cod liver, while DBDPE exceeded the levels of PBDE 47 in liver of harbor seal, blue mussel and sediments. In eider duck eggs the levels of these compounds were similar. For comparison, the levels of PBDE 47 were lower than the DBDPE levels in all cases in the terrestrial and the marine Arctic samples, except for the kittiwake egg samples.

Both SCCPs and MCCPs were detected in the majority of the Arctic samples with the exception of only 10% detection of MCCPs in cod liver, indicating a widespread exposure to these chemicals in the marine Arctic. SCCP-levels exceeded the MCCP-levels in polar bear and ringed seal plasma, kittiwake eggs, Atlantic cod liver and polar cod. The opposite was the case for glaucous gull plasma and eider duck eggs. SumCP-levels decreased in the order Ringed Seal > Polar Bear >> Kittiwake > Glaucous Gull > Eider duck > Atlantic cod liver (on a lipid weight basis). Due to the different tissues analysed of the various species, caution has to be applied when comparing and ranking the species.

In agreement with the documentation of the Stockholm convention and the European Chemical Agency (ECHA), PFOS, PFNA and PFCA with a longer carbon chain up to PFTrA, PBDE 47, DBDPE, TBP and S/MCCPs exhibited TMFs > 1 in both the marine ecosystem from the Norwegian mainland and the Arctic. Since no true food chains but rather representatives from food webs, were sampled and the main aim of the Screening 2013 was to assess background samples, all biomagnifications assessments have to be considered as estimates in this report. However, the

acquired data add to the evidence that biomagnification takes place in nature between different trophic levels of food chains and from bottom to top of food chains. In addition, the findings of these compounds in remote locations as the Norwegian Arctic and mainland indicate a considerable chemical stability (persistence) and capacity for long-range transport, and seem not to degrade in the environment to a large degree.

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11. Units and abbreviations

¤C	degrees Celsius
¤g	microgram(s)
ng/ml	nanogram(s) per milliliter
ABS	Acrylonitrile butadiene styrene terpolymer
BCF	bioconcentration factor
BFR	Brominated Flame Retardant
BMF	biomagnification factor
CAS	chemical abstracts service
EPA	Environmental Protection Agency
g	gram(s)
g/kg	gram(s) per kilogram
GC/MS	gas chromatography/mass spectrometry
HIPS	high-impact polystyrene
HPV	high production volume
log K_{AW}	logarithm of the air-water partitioning coefficient
log K_{OA}	logarithm of the octanol-air partitioning coefficient
log P_{OW}	logarithm of the octanol-water partitioning coefficient
LOQ	limit of quantification
LOD	limit of detection
LRT	long range transport
LRTP	long range transport potential
m^3	cubic metre
mg/kg	milligram(s) per kilogram(s)
ng/g dw	nanogram(s) per gram(s) dry weight
ng/g lw	nanogram(s) per gram(s) lipid weight
ng/g ww	nanogram(s) per gram(s) wet weight
ND	not detected
OECD	Organisation for Economic Co-operation and Development
PBT	Polybutyleneterephatlate
PET	Polyethylene terephatale
pg/m^3	picogram(s) per cubic metre
TMF	trophic magnification factor
wt	weight

Appendix 1

Sampling manuals

Analysis of selected brominated flame retardants (BFR) and PFAS in the Klif screening 2012. Sampling manuals for following sample types:

Sediment, soil and water
Biological samples
Sampling forms

Sampling of sediment, soil and water

General remarks

PBDEs and other BFRs are known to be photolytic degradable. Because of the similarity in chemical structure we assume a similar sensitivity to light exposure for the brominated compounds of interest in this study. All samples must therefore be stored in amber glass or wrapped in aluminium foil to prevent exposure to light.

To check for field contamination sampling blanks are used. The sampling blank to be used for sediment, sludge, and soil sampling contains silica particles. The sampling blanks should not be emptied or filled. They shall only be opened and closed at the time of sampling.
The number of sampling blanks is limited. If the number of samples per sample type (sediment, water, soil) and location is one to four the number of sampling blanks is one. If the number of samples per sample type and country is five or more the number of sampling blanks is two. The sites used for blank sampling should be selected at random before the start of sampling.

Disposable gloves and spoons will be provided together with pre-cleaned sample containers.

Treatment of sample containers
All glass containers must be washed and burned at at least 450°C and rinsed with acetone and hexane before use. The preparation of sample containers will be done at NILU, Kjeller.

Sampling

Soil, sediment and water will be sampled at three stations per location which will be pooled together to one sample per location per sample-type. The particulate phase of the water will be analysed as well.

Arrange the sampling bottle to be used (and, if the site is selected for blank sampling, one sampling blank) on a clean spot on the sampling site. Put on the supplied gloves.
Immediately before sampling open the lid of the sampling container (and the sampling blank).
Fill the sample container, if required using the enclosed spoon. If the Al-foil protecting the lids is ruptured replace it with new Al-foil and close the lid on the sample bottles (and sample blank). Label the sample containers. Put each container in a plastic bag.
For water samples the water sampler is applied in addition to the sampling of 2 litres water in PE bottles.
Fill in the sample protocol.

Storage and transport

Store the samples frozen and send to the laboratory as soon as possible in such a way that the samples will reach the laboratory within one day and latest at the 10th of October 2012. To assure that samples reach the destination within short time (usually within the same day), they should be sent early in the morning and not on a Friday (preferably Monday to Wednesday). **When sending the samples a notice including the airway bill number (AWB) of the package must be sent to the receiving address.** The delivery should be marked with "*samples Klif-screening study*" to avoid unnecessary delays during the registration procedure at the analysing institute.

Address

Norwegian Institute for Air Research (NILU)
Att. Stine Marie Bjørneby
Instituttvegen 18
NO-2027 Kjeller
Norway
Stine.Marie.Bjorneby@nilu.no

Biological samples

Sampling
For sampling the normal procedures as described by ICES and JAMP for the monitoring of POPs should be applied. I.e. all samples should be individual samples of 10 individuals.
To avoid contamination liver samples shall be packed and sent as whole pieces.
Fill in the sample protocol.
Storage and transport
All samples shall be packed tightly with aluminium foil and PE-zip lock bags. Store the samples frozen and send to the laboratory as soon as possible in such a way that the samples will reach the laboratory within one day and latest at the 10th of October 2012. To assure that samples reach the destination within short time (usually within the same day), they should be sent early in the morning and not on a Friday (preferably Monday to Wednesday). **When sending the samples a notice including the airway bill number (AWB) of the package must be sent to the addressee.** The delivery should be marked with "*samples Klif screening study*" to avoid unnecessary delays during the registration procedure at the analysing institute.

Address

Norwegian Institute for Air Research (NILU)
Att. Stine Marie Bjørneby
Instituttvegen 18
NO-2027 Kjeller
Norway

Sampling of Water
Sampling procedure
For sampling the sampling principles described in the EMEP sampling protocol chapter 3.13 should be followed: http://tarantula.nilu.no/projects/ccc/manual/index.html.
A total sample volume of at least 500 L is necessary.
Fill in the sampling form.
Storage and transport
Store the samples frozen and send to the laboratory as soon as possible in such a way that the samples will reach the laboratory within one day. To assure that samples reach the destination within short time (usually within the same day), they should be sent early in the morning and not on a Friday (preferably Monday to Wednesday). **When sending the samples a notice including the airway bill number (AWB) of the package must be sent to the addressee.** The delivery should be marked with "*samples Klif-screening study*" to avoid unnecessary delays during the registration procedure at the analysing institute. Please inform the receiver of the samples

Address

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NO-2027 Kjeller
Norway
Stine.Marie.Bjorneby@nilu.no

Sampling form – Sediment, soil, and water

Sample type: □ Sediment
□ Soil
□ Water
□ Sampling blank

Sample name / identity:

UTM-Coordinates for the sample site:

Sampling day: Shipped to NILU: Received at NILU:

Used sampling equipment:

Responsible person:

Sample storage: □ Freezer □ Fridge □ Other

Address

Norwegian Institute for Air Research (NILU)
Att. Stine Marie Bjørneby
Instituttvegen 18
NO-2027 Kjeller
Norway
Stine.Marie.Bjorneby@nilu.no

Sampling form -Biological samples

Sample name:	**Sample material:**

Sampling		**Comments**
Date:		
Site (UTM-coordinates):		
Number and size of individuals used for the pooled sample:		
Age and sex of the individuals		
Storage temp. after sampling:		
Date and site of dissection:		
Total sample amount:		
Special observations:		

Address

Norwegian Institute for Air Research (NILU)
Att. Stine Marie Bjørneby
Instituttvegen 18
NO-2027 Kjeller
Norway
Stine.Marie.Bjorneby@nilu.no

Sampling forms Water samples

Country			
Sampling site			
UTM-coordinates			
Sample taken by : (name)			

Start/Stop Date, time (precise)	Volume L at 20°C	Remarks

Appendix 2

Sample overview

d.w. = dry weight; w.w. = wet weight; l.w. = lipid weight; LOI = loss of ignition (550ºC).

Sample ID	Region	Location	Sample	Species	Matrix amount	Sampling date	UTM 33W	Weight (g)	Length	□□□□	d13C	Age	Gender	Tempe rature	pH	TOC	Salinity	Lipid content (%)	Chloride	DOC
12/1369	Mainland	Sørøya, Finnmark	Egg	Herring gull						-22.56	12.97							7.98		
12/1370	Mainland	Sørøya, Finnmark	Egg	Herring gull						-22.88	13.26							8.8		
12/1371	Mainland	Sørøya, Finnmark	Egg	Herring gull						-22.02	13.55							5.36		
12/1372	Mainland	Sørøya, Finnmark	Egg	Herring gull						-22.45	13.39							7.17		
12/1373	Mainland	Sørøya, Finnmark	Egg	Herring gull						-23.03	13.39							8.5		
12/1374	Mainland	Sørøya, Finnmark	Egg	Herring gull						-22.26	13.75							7.3		
12/1375	Mainland	Sørøya, Finnmark	Egg	Herring gull						-21.49	13.90							10.4		
12/1376	Mainland	Sørøya, Finnmark	Egg	Herring gull						-22.29	13.85							8.38		
12/1377	Mainland	Sørøya, Finnmark	Egg	Herring gull						-23.35	13.62							9		
12/1378	Mainland	Sørøya, Finnmark	Egg	Herring gull						-22.69	13.62							7.8		
12/1379	Mainland	Grinnøya, Troms	Egg	C.Eider						-21,85	10,96							16,3		
12/1380	Mainland	Grinnøya, Troms	Egg	C.Eider						-22,04	10,82							18,63		
12/1381	Mainland	Grinnøya, Troms	Egg	C.Eider						-22,56	11,24							32,57		

Sample ID	Region	Location	Sample	Species	Matrix amount	Sampling date	UTM 33W	Weight (g)	Length	□□□□	d13C	Age	Gender	Tempe rature	pH	TOC	Salinity	Lipid content (%)	Chloride	DOC
12/1382	Mainland	Grinnøya, Troms	Egg	C.Eider						-22,71	10,38							19,3		
12/1383	Mainland	Grinnøya, Troms	Egg	C.Eider						-22,49	11,68							17,6		
12/1384	Mainland	Grinnøya, Troms	Egg	C.Eider						-22,74	11,07							33,08		
12/1385	Mainland	Grinnøya, Troms	Egg	C.Eider						-21,56	10,89							16,8		
12/1386	Mainland	Grinnøya, Troms	Egg	C.Eider						-22,57	12,24							25,33		
12/1387	Mainland	Grinnøya, Troms	Egg	C.Eider						-22,82	11,70							30,9		
12/1388	Mainland	Grinnøya, Troms	Egg	C.Eider						-22,20	12,37							27,02		
12/1910	Mainland	Lofoten, Flakstad kommune	Liver	Cod			04178 42/75 73017	5500	835	-24.62	12.53		m					62.25		
12/1911	Mainland	Lofoten, Flakstad kommune	Liver	Cod			04178 42/75 73018	4000	800	-23.89	12.97		m					62.32		
12/1912	Mainland	Lofoten, Flakstad kommune	Liver	Cod			04178 42/75 73019	2500	650	-24.09	13.18		f					59.8		
12/1913	Mainland	Lofoten, Flakstad kommune	Liver	Cod			04178 42/75 73020	2700	680	-24.75	12.37		f					54.26		
12/1914	Mainland	Lofoten, Flakstad kommune	Liver	Cod			04178 42/75 73021	2700	700	-24.79	12.27		f					56.35		
12/1915	Mainland	Lofoten, Flakstad kommune	Liver	Cod			04178 42/75 73022	2200	620	-24.45	11.34		m					56.69		

Sample ID	Region	Location	Sample	Species	Matrix amount	Sampling date	UTM 33W	Weight (g)	Length	□□□□	d13C	Age	Gender	Tempe rature	pH	TOC	Salinity	Lipid content (%)	Chloride	DOC
12/1916	Mainland	Lofoten, Flakstad kommune	Liver	Cod			04178 42/75 73023	3500	740	-24.30	12.09		f					70.79		
12/1917	Mainland	Lofoten, Flakstad kommune	Liver	Cod			04178 42/75 73024	2500	650	-25.70	11.70		f					74.22		
12/1918	Mainland	Lofoten, Flakstad kommune	Liver	Cod			04178 42/75 73025	2200	630	-24.70	12.48		f					69.74		
12/1919	Mainland	Lofoten, Flakstad kommune	Liver	Cod			04178 42/75 73026	2000	625	-25.35	12.15		m					62.55		
12/2342	Mainland	Terrøya	Liver	Harbor Seal			49102 8/763 8333		190	-20,54	14,33		m					2,99		
12/2343	Mainland	Fjellmoa	Liver	Harbor Seal			05127 000/7 652040		152	-19,58	15,27							2,72		
12/2344	Mainland	Fjellmoa	Liver	Harbor Seal			05126 45/76 52067		154	-19,12	15,80							2,62		
12/2345	Mainland	Fjellmoa	Liver	Harbor Seal			05127 11/76 52019		164	-20,17	13,87		Han					2,67		
12/2346	Mainland	Fjellmoa	Liver	Harbor Seal			05128 46/76 52070		172	-19,79	15,12		Han					3,41		
12/2347	Mainland	Beinøya	Liver	Harbor Seal			05025 42/76 56808		154	-19,74	18,80		Han					2,9		
12/2348	Mainland	Beinøya	Liver	Harbor Seal			05036		183	-20,82	14,64		Hun					3,38		

Sample ID	Region	Location	Sample	Species	Matrix amount	Sampling date	UTM 33W	Weight (g)	Length	□□□□	d13C	Age	Gender	Tempe rature	pH	TOC	Salinity	Lipid content (%)	Chloride	DOC
							64/76 56785													
12/2349	Mainland	Fjellmoa	Liver	Harbor Seal			05126 63/76 52054		111	-19,51	15,62		Han					2,72		
12/2350	Mainland	Beinøya	Liver	Harbor Seal			05032 13/76 56190		133	-19,53	15,96		Han					3,11		
12/2351	Mainland	Anda	Liver	Harbor Seal			05071 14/76 61921		130	-20,11	14,73		Hun					2,59		
12/2523	Mainland	Lofoten, Flakstad	Pool (n=5)	Blue mussel			04265 57/75 55642			-18,39	8,05							1,06		
12/2524	Mainland	Lofoten, Flakstad	Pool (n=5)	Blue mussel			04265 57/75 55642			-18,43	7,91							1		
12/2525	Mainland	Lofoten, Flakstad	Pool (n=5)	Blue mussel			04265 57/75 55642			-18,89	10,06							0,5		
12/2557	Mainland	Lofoten, Flakstad	Marine sediment				04265 57/75 55642							9		0,62				
12/2558	Mainland	Lofoten, Flakstad	Marine sediment				04265 57/75 55642							9		0,43				
12/2559	Mainland	Lofoten, Flakstad	Marine sediment				04265 57/75 55642							9		0,81				

Sample ID	Region	Location	Sample	Species	Matrix amount	Sampling date	UTM 33W	Weight (g)	Length	δ15N	d13C	Age	Gender	Temperature	pH	TOC	Salinity	Lipid content (%)	Chloride	DOC
12/2419	Mainland	Dalsvann	Liver	E. Perch			483828/6584983		279	-29,48	5,63		f	8				2,2		
12/2420	Mainland	Dalsvann	Liver	E. Perch			483828/6584983		264	-26,04	6,50		f	8				2,61		
12/2421	Mainland	Dalsvann	Liver	E. Perch			483828/6584983		266	-25,50	6,63		f	8						
12/2425	Mainland	Dalsvann	Liver	E. Perch			483828/6584983		255	-27,49	8,69		m	8						
12/2426	Mainland	Dalsvann	Liver	Brown trout			483828/6584983		275	-28,08	7,17		m	8				2,78		
12/2427	Mainland	Dalsvann	Liver	Brown trout			483828/6584983		320	-26,80	8,05		m	8				2,5		
12/2428	Mainland	Dalsvann	Liver	Brown trout			483828/6584983		245	-31,22	4,73		m	8						
12/2429	Mainland	Dalsvann	Liver	Brown trout			483828/6584983		283	-27,78	6,29		m	8				2,78		
12/2430	Mainland	Dalsvann	Liver	Brown trout			483828/6584983		232	-31,25	5,05		m	8						
12/2431	Mainland	Dalsvann	Liver	Brown trout			483828/6584983		260	-28,45	5,78		m	8				2,67		
12/2432	Mainland	Dalsvann	Liver	Brown trout			483828/658		234	-31,98	6,05		m	8						

Sample ID	Region	Location	Sample	Species	Matrix amount	Sampling date	UTM 33W	Weight (g)	Length	δ15N	d13C	Age	Gender	Temperature	pH	TOC	Salinity	Lipid content (%)	Chloride	DOC
							4983													
12/2433	Mainland	Færstaulelvi	Liver	Brown trout			483828/6584983		245	-27.22	6.15		m	7						
12/2434	Mainland	Færstaulelvi	Liver	Brown trout			483828/6584983		251	-28.47	6.59		m	7						
12/2560	Mainland	Fresh water	Sediment				6583851/486756							4		8.8				
12/2561	Mainland	Fresh water	Sediment				6583866/486725							4		7.2				
12/2562	Mainland	Fresh water	Sediment				6583891/486682							4		5.36				
12/2564	Mainland	Seljord vest Storvald	Liver	Moose						-22,49	13,4	>2,5	m					4,27		
12/2565	Mainland	Seljord vest Storvald	Liver	Moose						-28,06	3,09	13,5	m					4,67		
12/2566	Mainland	Seljord vest Storvald	Liver	Moose				175		-28,25	1,92	3,5	f					4,68		
12/2567	Mainland	Seljord vest Storvald	Liver	Moose				195		-28,80	4,14	8,5	f					4,8		
12/2568	Mainland	Seljord vest Storvald	Liver	Moose				160		-29,57	1,33	7,5	m					4,2		
12/2569	Mainland	Seljord	Liver	Moose				130		-29,16	1,93	2,5	m					5		

Sample ID	Region	Location	Sample	Species	Matrix amount	Sampling date	UTM 33W	Weight (g)	Length	δ15N	d13C	Age	Gender	Temperature	pH	TOC	Salinity	Lipid content (%)	Chloride	DOC
		vest Storvald																		
12/2570	Mainland	Seljord vest Storvald	Liver	Moose				170		-29,25	2,99	1,5	m					4,71		
12/2571	Mainland	Seljord vest Storvald	Liver	Moose						-29,33	0,81	2,5	m					4,55		
12/2572	Mainland	Seljord vest Storvald	Liver	Moose				182		-29,10	5,62	3,5	m					4,8		
12/2409	Mainland	Færstaulåi	Liver	Field mouse			6585205/483122			-27,60	3,49									
12/2410	Mainland	Færstaulåi	Liver	Field mouse			6585279/482908			-27,12	3,20									
12/2411	Mainland	Færstaulåi	Liver	Field mouse			6585334/482755			-27,65	3,87									
12/2412	Mainland	Færstaulåi	Liver	Field mouse			6585397/482724			-27,58	6,27									
12/2413	Mainland	Færstaulåi	Liver	Field mouse			6585270/483125			-26,06	2,48									
12/2414	Mainland	Færstaulåi	Liver	Field mouse			6585306/482821			-25,66	5,91									
12/2415	Mainland	Færstaulåi	Liver	Field mouse			6585395/482721			-26,76	3,20									

Sample ID	Region	Location	Sample	Species	Matrix amount	Sampling date	UTM 33W	Weight (g)	Length	δ15N	d13C	Age	Gender	Temperature	pH	TOC	Salinity	Lipid content (%)	Chloride	DOC
12/2416	Mainland	Færstaulåi	Liver	Field mouse			6585280/482900			-26,27	5,17									
12/2417	Mainland	Færstaulåi	Liver	Shrew			6585283/483034			-26,47	5,72									
12/2418	Mainland	Færstaulåi	Liver	Shrew			6585295/482824			-26,41	6,58									
12/2500	Mainland	Færstaulåi	Soil				6585383/482718									8,61				
12/2523	Mainland	Lofoten, Flagstad	Sea water				0426567/7555658							8,01					17400	0,79
12/2524	Mainland	Lofoten, Flagstad	Sea water				0426567/7555658							8,01					17400	0,79
12/2525	Mainland	Lofoten, Flagstad	Sea water				0426567/7555658							8,01					17400	0,79
12/2419	Mainland	Dalsvann	Fresh water				6582761/487218							6						4,6
12/2420	Mainland	Dalsvann	Fresh water				6582761/487218							6						4,6
12/2421	Mainland	Dalsvann	Fresh water				6582761/487218							6						4,6

Sample ID	Region	Location	Sample	Species	Lipid content%	D15N	D13C	Age	Gender	ID nummer	Lat	Lon	Lenght	Girth	Weight	Blubber
12/1389	Arctic	Dunerbuka	Plasma	Polar bear	n.d.	-19,71	17,96	25	M	23206	78,118	19,109	231	142		
12/1390	Arctic	Fridtjofhamna	Plasma	Polar bear	n.d.	-20,41	18,25	12	M	23672	77,7768	14,6167	234	172		
12/1391	Arctic	Austfjordneset	Plasma	Polar bear	n.d.	-19,73	19,37	14	M	23682	79,117	16,193	244	163		
12/1392	Arctic	Dunerbukta	Plasma	Polar bear	n.d.	-19,59	19,98	19	M	23706	78,123	19,105	242	150		
12/1393	Arctic	Mohnbukta	Plasma	Polar bear	n.d.	-20,00	17,93	12	M	23711	78,249	19,163	232	170		
12/1394	Arctic	Hambergbukta	Plasma	Polar bear	n.d.	-21,71	15,17	19	M	23785	77,048	16,974	242	160		
12/1395	Arctic	Hellwaldbukta	Plasma	Polar bear	n.d.	-20,89	15,37	7	M	23797	78,683	20,906	202	134		
12/1396	Arctic	Hellwaldbukta	Plasma	Polar bear	n.d.	-19,68	14,47	7	M	23819	78,214	21,489	225	182		
12/1397	Arctic	Murchinsonfjorden	Plasma	Polar bear	n.d.	-18,99	17,23	24	M	23830	78,9731	18,5051	228	152		
12/1398	Arctic	Palanderfjorden	Plasma	Polar bear	n.d.	-19,61	19,36	20	M	23868	79,5684	20,4697	228	150		
12/1399	Arctic	Hambergbukta	Plasma	Polar bear	n.d.	-19,97	18,63	22	M	23885	77,05	17,234	226	164		
12/1400	Arctic	Hornsund/Terskelen	Plasma	Polar bear	n.d.	-19,55	18,73	17	M	23889	77,0172	16,2146	231	169		
12/1401	Arctic	Wahlenbergfjorden	Plasma	Polar bear	n.d.	-20,73	18,09	9	M	23913	79,7147	20,8267	217	137		
12/1402	Arctic	E of Dunerbukta	Plasma	Polar bear	n.d.	-19,49	18,85	15	M	26021	78,15	19,17	242	155		
12/1403	Arctic	Palanderfjorden	Plasma	Polar bear	n.d.	-20,62	18,25	7	M	26067	79,5684	20,4697	224	139		
12/1404	Arctic	Mistakodden	Plasma	Polar bear	n.d.	-20,63	17,75	8	M	26082	78,52	20,21	222	147		
12/1405	Arctic	Heimland	Plasma	Polar bear	n.d.	-20,41	19,13	25	M	26083	78,56	20,702	234	160		
12/1406	Arctic	N of Discobukta	Plasma	Polar bear	n.d.	-19,84	17,66	7	M	26091	77,981	21,195	232	146		
14/1407	Arctic	E of Dunerbukta	Plasma	Polar bear	n.d.	-20,13	17,59	6	M	26094	78,15	19,17	204	130		
12/1408	Arctic	Freemansundet Ø	Plasma	Polar bear	n.d.	-20,72	17,99	4	M	26101	78,268	23,14	199	124		
12/1409	Arctic	Arctic	Egg	Kittiwake	8.16	-23.41	13.59									
12/1410	Arctic		Egg	Kittiwake	7.89	-23.41	13.04									
12/1411	Arctic		Egg	Kittiwake	7	-23.39	12.57									
12/1412	Arctic		Egg	Kittiwake	8.46	-22.99	13.69									
12/1413	Arctic		Egg	Kittiwake	6.55	-23.26	12.66									
12/1414	Arctic		Egg	Kittiwake	8.03	-24.25	13.14									
12/1415	Arctic		Egg	Kittiwake	7.12	-23.20	13.36									
12/1416	Arctic		Egg	Kittiwake	9.07	-23.07	12.58									
12/1418	Arctic		Egg	Kittiwake	7,96	-24,03	12,93									
12/1419	Arctic		Egg	Kittiwake	8,14	-24,46	13,29									

Sample ID	Region	Location	Sample	Species	Lipid content%	D15N	D13C	Age	Gender	ID nummer	Lat	Lon	Lenght	Girth	Weight	Blubber
12/1420	Arctic		Egg	Kittiwake	11,43	-23,89	13,35									
12/1421	Arctic		Egg	Kittiwake	7,58	-23,68	12,53									
12/1422	Arctic		Egg	C. Eider	14,7	-24,00	11,02									
12/1423	Arctic		Egg	C. Eider	16,79	-23,45	11,78									
12/1424	Arctic		Egg	C. Eider	19,79	-22,87	10,75									
12/1425	Arctic		Egg	C. Eider	15,62	-21,89	11,80									
12/1426	Arctic		Egg	C. Eider	17,65	-21,90	11,18									
12/1427	Arctic		Egg	C. Eider	24,41	-22,83	11,18									
12/1428	Arctic		Egg	C. Eider	17,17	-22,84	9,65									
12/1429	Arctic		Egg	C. Eider	14,73	-22,13	10,07									
12/1430	Arctic		Egg	C. Eider	15,56	-21,72	10,62									
12/1431	Arctic		Egg	C. Eider	20,15	-22,96	12,05									
12/1432	Arctic		Egg	C. Eider	17,03	-23,43	10,69									
12/1433	Arctic		Egg	C. Eider	14,73	-22,95	10,68									
12/1434	Arctic	Kongsfjorden	Plasma	Glaucous gull	n.d.	-22,30	13,27									
12/1435	Arctic	Kongsfjorden	Plasma	Glaucous gull	n.d.	-21,60	13,19									
12/1436	Arctic	Kongsfjorden	Plasma	Glaucous gull	n.d.	-21,37	14,53									
12/1437	Arctic	Kongsfjorden	Plasma	Glaucous gull	n.d.	-22,60	14,00									
12/1438	Arctic	Kongsfjorden	Plasma	Glaucous gull	n.d.	-21,04	14,72									
12/1439	Arctic	Kongsfjorden	Plasma	Glaucous gull	n.d.	-20,70	14,32									
12/1440	Arctic	Kongsfjorden	Plasma	Glaucous gull	n.d.	-23,19	12,45									
12/1441	Arctic	Kongsfjorden	Plasma	Glaucous gull	n.d.	-20,35	14,63									
12/1442	Arctic	Kongsfjorden	Plasma	Glaucous gull	n.d.	-20,17	13,91									
12/1443	Arctic	Kongsfjorden	Plasma	Glaucous gull	n.d.	-21,12	13,68									
12/1444	Arctic	Kongsfjorden	Plasma	Glaucous gull	n.d.	-22,44	14,01									
12/1445	Arctic	Kongsfjorden	Plasma	Glaucous gull	n.d.	-21,11	13,79									
12/1446	Arctic		Plasma	Ringed seal	n.d.	-19,98	15,76		F				137	109	77	4,1
12/1447	Arctic		Plasma	Ringed seal	n.d.	-21,92	15,44		F				110	93	46	4,9
12/1448	Arctic		Plasma	Ringed seal	n.d.	-20,79	15,15		F				126	106	65	
12/1449	Arctic		Plasma	Ringed seal	n.d.	-20,61	15,96		M				131	108	68	4,5
12/1450	Arctic		Plasma	Ringed seal	n.d.	-20,59	15,27		F				126	100	57	4,9
12/1451	Arctic		Plasma	Ringed seal	n.d.	-20,69	15,26		F				131	109	67	5,1

Sample ID	Region	Location	Sample	Species	Lipid content%	D15N	D13C	Age	Gender	ID nummer	Lat	Lon	Lenght	Girth	Weight	Blubber
12/1452	Arctic		Plasma	Ringed seal	n.d.	-20,50	15,78		F				127	107	65	4,9
12/1453	Arctic		Plasma	Ringed seal	n.d.	20,65	15,18		F				123	103	60	4,6
12/1455	Arctic		Plasma	Ringed seal	n.d.	-20,63	15,61		F				125	106	65	
12/1456	Arctic		Plasma	Ringed seal	n.d.	-20,21	14,58		F				131	109	69	4,6
12/2326	Arctic		Liver	Cod	41,7	-24,35	12,26									
12/2327	Arctic		Liver	Cod	49,7	-25,30	12,34									
12/2328	Arctic		Liver	Cod	54,7	-25,17	12,34									
12/2329	Arctic		Liver	Cod	45,5	-25,00	10,60									
12/2330	Arctic		Liver	Cod	52,7	-26,13	10,06									
12/2331	Arctic		Liver	Cod	54.0	-25,46	12,27									
12/2332	Arctic		Liver	Cod	51.0	-25,51	11,51									
12/2333	Arctic		Liver	Cod	52.0	-25,03	11,12									
12/2334	Arctic		Liver	Cod	47.0	-24,13	11,46									
12/2335	Arctic		Liver	Cod	56,8	-24,44	11,94									
12/2563	Arctic		Pool	Polar cod	1,72	-22,49	13,40									

Individual results; Chlorinated paraffins

d.w. = dry weight; w.w. = wetweight. n.d. = not determined.

Sample ID	Region	Site	Matrix	Spices	Unit	MCCP	SCCP
12/1389	Arctic	Dunerbuka	Plasma	Polar bear	ng/ml	5,46	3,93
12/1390	Arctic	Fridtjofhamna	Plasma	Polar bear	ng/ml	1,19	11,5
12/1391	Arctic	Austfjordneset	Plasma	Polar bear	ng/ml	1,81	7,80
12/1392	Arctic	Dunerbukta	Plasma	Polar bear	ng/ml	0,76	1,57
12/1393	Arctic	Mohnbukta	Plasma	Polar bear	ng/ml	4,05	3,88
12/1394	Arctic	Hambergbukta	Plasma	Polar bear	ng/ml	0,62	<0,12
12/1395	Arctic	Hellwaldbukta	Plasma	Polar bear	ng/ml	4,24	6,98
12/1396	Arctic	Hellwaldbukta	Plasma	Polar bear	ng/ml	2,95	8,78
12/1397	Arctic	Murchinsonfjorden	Plasma	Polar bear	ng/ml	0,72	2,25
12/1398	Arctic	Palanderfjorden	Plasma	Polar bear	ng/ml	0,53	1,92
12/1399	Arctic	Hambergbukta	Plasma	Polar bear	ng/ml	0,59	1,75
12/1400	Arctic	Hornsund/Terskelen	Plasma	Polar bear	ng/ml	2,02	2,71
12/1401	Arctic	Wahlenbergfjorden	Plasma	Polar bear	ng/ml	0,14	2,23
12/1402	Arctic	E of Dunerbukta	Plasma	Polar bear	ng/ml	5,35	5,62
12/1403	Arctic	Palanderfjorden	Plasma	Polar bear	ng/ml	2,20	1,54
12/1404	Arctic	Mistakodden	Plasma	Polar bear	ng/ml	0,88	1,40
12/1405	Arctic	Heimland	Plasma	Polar bear	ng/ml	1,04	1,74
12/1406	Arctic	N of Discobukta	Plasma	Polar bear	ng/ml	1,62	2,42
14/1407	Arctic	E of Dunerbukta	Plasma	Polar bear	ng/ml	5,57	5,43
12/1408	Arctic	Freemansundet Ø	Plasma	Polar bear	ng/ml	<0,53	2,4
12/1409	Arctic		Egg	Kittiwake	ng/g ww	5,21	<1,6
12/1410	Arctic		Egg	Kittiwake	ng/g ww	1,55	2,25
12/1411	Arctic		Egg	Kittiwake	ng/g ww	9,39	4,01
12/1412	Arctic		Egg	Kittiwake	ng/g ww	1,27	1,98
12/1413	Arctic		Egg	Kittiwake	ng/g ww	17,31	<1,6
12/1414	Arctic		Egg	Kittiwake	ng/g ww	6,33	13,0
12/1415	Arctic		Egg	Kittiwake	ng/g ww	0,76	11,7
12/1416	Arctic		Egg	Kittiwake	ng/g ww	0,26	1,56
12/1418	Arctic		Egg	Kittiwake	ng/g ww	6,42	24,9

Sample ID	Region	Site	Matrix	Spices	Unit	MCCP	SCCP
12/1419	Arctic		Egg	Kittiwake	ng/g ww	0,38	<1,6
12/1420	Arctic		Egg	Kittiwake	ng/g ww	4,97	<1,6
12/1421	Arctic		Egg	Kittiwake	ng/g ww	5,12	3,11
12/1422	Arctic		Egg	C. Eider	ng/g ww	2,04	2,62
12/1423	Arctic		Egg	C. Eider	ng/g ww	2,48	2,82
12/1424	Arctic		Egg	C. Eider	ng/g ww	1,52	2,52
12/1425	Arctic		Egg	C. Eider	ng/g ww	3,85	3,08
12/1426	Arctic		Egg	C. Eider	ng/g ww	1,61	3,32
12/1427	Arctic		Egg	C. Eider	ng/g ww	9,46	8,13
12/1428	Arctic		Egg	C. Eider	ng/g ww	3,08	2,68
12/1429	Arctic		Egg	C. Eider	ng/g ww	1,50	3,00
12/1430	Arctic		Egg	C. Eider	ng/g ww	6,03	<1,6
12/1431	Arctic		Egg	C. Eider	ng/g ww	3,44	<1,6
12/1432	Arctic		Egg	C. Eider	ng/g ww	1,10	1,80
12/1433	Arctic		Egg	C. Eider	ng/g ww	16,62	2,35
12/1434	Arctic	Kongsfjorden	Plasma	Glaucous gull	ng/ml	<0,36	<0,69
12/1435	Arctic	Kongsfjorden	Plasma	Glaucous gull	ng/ml	<0,24	<0,24
12/1436	Arctic	Kongsfjorden	Plasma	Glaucous gull	ng/ml	<1,31	<1,31
12/1437	Arctic	Kongsfjorden	Plasma	Glaucous gull	ng/ml	4,30	1,13
12/1438	Arctic	Kongsfjorden	Plasma	Glaucous gull	ng/ml	1,28	5,53
12/1439	Arctic	Kongsfjorden	Plasma	Glaucous gull	ng/ml	0,44	1,20
12/1440	Arctic	Kongsfjorden	Plasma	Glaucous gull	ng/ml	5,88	6,73
12/1441	Arctic	Kongsfjorden	Plasma	Glaucous gull	ng/ml	2,87	4,39
12/1442	Arctic	Kongsfjorden	Plasma	Glaucous gull	ng/ml	27,02	4,07
12/1443	Arctic	Kongsfjorden	Plasma	Glaucous gull	ng/ml	<0,24	3,33
12/1444	Arctic	Kongsfjorden	Plasma	Glaucous gull	ng/ml	7,73	6,09
12/1445	Arctic	Kongsfjorden	Plasma	Glaucous gull	ng/ml	21,44	3,08
12/1446	Arctic		Plasma	Ringed Seal	ng/ml	3,45	9,9
12/1447	Arctic		Plasma	Ringed Seal	ng/ml	3,30	8,43
12/1448	Arctic		Plasma	Ringed Seal	ng/ml	7,01	4,30
12/1449	Arctic		Plasma	Ringed Seal	ng/ml	<0,48	2,14
12/1450	Arctic		Plasma	Ringed Seal	ng/ml	2,58	2,42
12/1451	Arctic		Plasma	Ringed Seal	ng/ml	1,07	3,35
12/1452	Arctic		Plasma	Ringed Seal	ng/ml	0,71	2,35

Sample ID	Region	Site	Matrix	Spices	Unit	MCCP	SCCP
12/1453	Arctic		Plasma	Ringed Seal	ng/ml	085	6,82
12/1455	Arctic		Plasma	Ringed Seal	ng/ml	6,34	5,76
12/1456	Arctic		Liver	Cod	ng/g ww	0,91	4,16
12/2326	Arctic		Liver	Cod	ng/g ww	<0,88	2,85
12/2327	Arctic		Liver	Cod	ng/g ww	<0,71	19,0
12/2328	Arctic		Liver	Cod	ng/g ww	<0,88	12,6
12/2329	Arctic		Liver	Cod	ng/g ww	0,94	8,11
12/2330	Arctic		Liver	Cod	ng/g ww	<1	4,66
12/2331	Arctic		Liver	Cod	ng/g ww	<1,12	3,00
12/2332	Arctic		Liver	Cod	ng/g ww	<2,03	2,91
12/2333	Arctic		Liver	Cod	ng/g ww	<1,43	2,83
12/2334	Arctic		Liver	Cod	ng/g ww	<1,05	10,0
12/2335	Arctic		Liver	Cod	ng/g ww	<1,15	36,6
12/2563	Arctic		Pool whole fish	Polar cod	ng/g ww	1,51	2,28

Individual results; Brominated flame retardants

d.w. = dry weight; w.w. = wet weight. n.d. = not determined.

Sample ID	Region	Site	Matrix	Unit	PBDE 47	BEHTBP	DBDPE	TBP*	PBP
12/1369	Mainland	Sørøya, Finnmark	Herring gull Egg	ng/g ww	11,9	<0,018	0,39	36,2	<0,03
12/1370	Mainland	Sørøya, Finnmark	Herring gull Egg	ng/g ww	24,8	<0,01	0,45	49,1	<0,03
12/1371	Mainland	Sørøya, Finnmark	Herring gull Egg	ng/g ww	10,2	3,87	0,56	25,4	<0,03
12/1372	Mainland	Sørøya, Finnmark	Herring gull Egg	ng/g ww	8,92	<0,01	0,94	91,4	<0,03
12/1373	Mainland	Sørøya, Finnmark	Herring gull Egg	ng/g ww	9,87	<0,01	0,39	40,3	<0,03
12/1374	Mainland	Sørøya, Finnmark	Herring gull Egg	ng/g ww	11.0	<0.01	0.29	<1.01	<0,03
12/1375	Mainland	Sørøya, Finnmark	Herring gull Egg	ng/g ww	8,59	<0,01	0,40	23,6	<0,03
12/1376	Mainland	Sørøya, Finnmark	Herring gull Egg	ng/g ww	10,6	0,12	0,26	212,8	<0,03
12/1377	Mainland	Sørøya, Finnmark	Herring gull Egg	ng/g ww	8,78	<0,01	0,43	<0,01	<0,03
12/1378	Mainland	Sørøya, Finnmark	Herring gull Egg	ng/g ww	9,15	<0,01	0,32	21,4	<0,03
12/1379	Mainland	Grinnøya, Troms	C. Eider Egg	ng/g ww	0,28	0,03	0,36	64,4	<0,01
12/1380	Mainland	Grinnøya, Troms	C. Eider Egg	ng/g ww	0,25	0,04	0,26	22,5	<0,01
12/1381	Mainland	Grinnøya, Troms	C. Eider Egg	ng/g ww	0,20	0,03	0,44	101	<0,01
12/1382	Mainland	Grinnøya, Troms	C. Eider Egg	ng/g ww	0,22	0,02	0,19	31,5	<0,01
12/1383	Mainland	Grinnøya, Troms	C. Eider Egg	ng/g ww	0,33	0,06	0,55	27,6	<0,01
12/1384	Mainland	Grinnøya, Troms	C. Eider Egg	ng/g ww	0,22	0,03	0,31	252,1	<0,01
12/1385	Mainland	Grinnøya, Troms	C. Eider Egg	ng/g ww	0,42	0,04	0,28	22,1	<0,01
12/1386	Mainland	Grinnøya, Troms	C. Eider Egg	ng/g ww	0,27	0,02	0,20	30,3	<0,01
12/1387	Mainland	Grinnøya, Troms	C. Eider Egg	ng/g ww	0,26	0,02	0,33	<1,01	<0,01
12/1388	Mainland	Grinnøya, Troms	C. Eider Egg	ng/g ww	0,45	0,08	0,40	44,3	<0,01
12/1910	Mainland	Lofoten, Flakstad kommune	Cod Liver	ng/g ww	9,58	<0,01	4,70	68,5	<0,2
12/1911	Mainland	Lofoten, Flakstad kommune	Cod Liver	ng/g ww	10,6	<0,021	3,99	63,4	<0,2
12/1912	Mainland	Lofoten, Flakstad kommune	Cod Liver	ng/g ww	7,60	<0,013	4,32	98,1	<0,2
12/1913	Mainland	Lofoten, Flakstad kommune	Cod Liver	ng/g ww	6,49	0,16	4,79	23,8	<0,2
12/1914	Mainland	Lofoten,	Cod Liver	ng/g ww	11,0	<0,013	3,62	<6	<0,2

Sample ID	Region	Site	Matrix	Unit	PBDE 47	BEHTBP	DBDPE	TBP*	PBP
		Flakstad kommune							
12/1915	Mainland	Lofoten, Flakstad kommune	Cod Liver	ng/g ww	5,74	<0,015	3,32	39,2	<0,2
12/1916	Mainland	Lofoten, Flakstad kommune	Cod Liver	ng/g ww	7,78	<0,02	5,33	119,8	<0,2
12/1917	Mainland	Lofoten, Flakstad kommune	Cod Liver	ng/g ww	4,47	0,12	3,36	<6	<0,2
12/1918	Mainland	Lofoten, Flakstad kommune	Cod Liver	ng/g ww	11,3	0,14	4,46	<6	<0,2
12/1919	Mainland	Lofoten, Flakstad kommune	Cod Liver	ng/g ww	7,10	<0,017	4,99	<6	<0,2
12/2342	Mainland	Terrøya	Harbour Seal liver	ng/g ww	0,93	<0,01	9,89	111	<0,1
12/2343	Mainland	Fjellmoa	Harbour Seal liver	ng/g ww	1,07	<0,01	9,12	236	<0,1
12/2344	Mainland	Fjellmoa	Harbour Seal liver	ng/g ww	0,28	<0,01	8,19	155	<0,1
12/2345	Mainland	Fjellmoa	Harbour Seal liver	ng/g ww	0,19	<0,01	9,05	74,9	<0,1
12/2346	Mainland	Fjellmoa	Harbour Seal liver	ng/g ww	0,34	<0,01	17,6	272	<0,1
12/2347	Mainland	Beinøya	Harbour Seal liver	ng/g ww	0,70	<0,01	8,32	118	<0,1
12/2348	Mainland	Beinøya	Harbour Seal liver	ng/g ww	0,31	0,10	11,2	297	<0,1
12/2349	Mainland	Fjellmoa	Harbour Seal liver	ng/g ww	0,80	<0,01	9,03	205	<0,1
12/2350	Mainland	Beinøya	Harbour Seal liver	ng/g ww	0,40	<0,01	16,7	117	<0,1
12/2351	Mainland	Anda	Harbour Seal liver	ng/g ww	0,32	<0,01	29,7	52,9	<0,1
12/2523	Mainland	Lofoten, Flakstad	Blue mussel	ng/g ww	0,02	<0,01	0,26	2,46	<0,5
12/2524	Mainland	Lofoten, Flakstad	Blue mussel	ng/g ww	0,02	<0,01	0,21	2,36	<0,5
12/2525	Mainland	Lofoten, Flakstad	Blue mussel	ng/g ww	0,01	<0,01	0,40	2,78	<0,5
12/2557	Mainland	Lofoten, Flakstad	Marine sediment	ng/g dw	<0,01	<0,01	0,48	2,65	0,004(<LOQ)
12/2558	Mainland	Lofoten, Flakstad	Marine sediment	ng/g dw	<0,01	<0,01	0,15	1,9	0,006(<LOQ)
12/2559	Mainland	Lofoten, Flakstad	Marine sediment	ng/g dw	<0,01	<0,01	0,10	2,87	0,003 (LOQ)
12/2419	Mainland	Dalsvann	E. Perch Liver	ng/g ww	0,11	<0,015	2,47	31	<1,2
12/2420	Mainland	Dalsvann	E. Perch Liver	ng/g ww	0,10	<0,01	2,76	53,7	<1,2
12/2421	Mainland	Dalsvann	E. Perch Liver	ng/g ww	0,13	<0,021	2,16	<1,1	<1,2
12/2425	Mainland	Dalsvann	Brown trout Liver	ng/g ww	1,55	<0,086	9,78	<5	<0,03
12/2426	Mainland	Dalsvann	Brown trout Liver	ng/g ww	0,32	<0,013	6,52	<5	<0,03
12/2427	Mainland	Dalsvann	Brown trout Liver	ng/g ww	0,15	<0,01	1,34	<5	<0,03
12/2428	Mainland	Dalsvann	Brown trout Liver	ng/g ww	0,36	<0,03	11,5	109	<0,03

Sample ID	Region	Site	Matrix	Unit	PBDE 47	BEHTBP	DBDPE	TBP*	PBP
12/2429	Mainland	Dalsvann	Brown trout Liver	ng/g ww	0,18	0,04	3,98	26	<0,03
12/2430	Mainland	Dalsvann	Brown trout Liver	ng/g ww	0,19	0,05	12,9	39,8	<0,03
12/2431	Mainland	Dalsvann	Brown trout Liver	ng/g ww	0,13	<0,01	9,61	90,2	<0,03
12/2432	Mainland	Dalsvann	Brown trout Liver	ng/g ww	0,40	<0,032	13,8	<5	<0,03
12/2433	Mainland	Færstaulelvi	Brown trout Liver	ng/g ww	0,19	<0,082	32,9	<5	<0,03
12/2434	Mainland	Færstaulelvi	Brown trout Liver	ng/g ww	0,24	0,02	8,76	<5	<0,03
12/2560	Mainland	Dalsvann	Fresh water Sediment	ng/g dw	<0,01	<0,01	0,10	1,68	<0,002
12/2561	Mainland	Dalsvann	Fresh water Sediment	ng/g dw	<0,01	<0,01	0,14	1,61	<0,002
12/2562	Mainland	Dalsvann	Fresh water Sediment	ng/g dw	<0,01	<0,01	0,09	2,96	<0,002
12/2564	Mainland	Seljord vest Storvald	Moose Liver	ng/g ww	<0,01	<0,01	0,49	<4,1	<0,1
12/2565	Mainland	Seljord vest Storvald	Moose Liver	ng/g ww	<0,01	<0,01	0,33	33,7	<0,1
12/2566	Mainland	Seljord vest Storvald	Moose Liver	ng/g ww	<0,01	<0,01	0,51	65,5	<0,1
12/2567	Mainland	Seljord vest Storvald	Moose Liver	ng/g ww	<0,01	<0,01	0,41	96,9	<0,1
12/2568	Mainland	Seljord vest Storvald	Moose Liver	ng/g ww	<0,01	<0,01	0,32	115	<0,1
12/2569	Mainland	Seljord vest Storvald	Moose Liver	ng/g ww	<0,01	<0,01	0,34	168	<0,1
12/2570	Mainland	Seljord vest Storvald	Moose Liver	ng/g ww	<0,01	<0,01	0,31	39,0	<0,1
12/2571	Mainland	Seljord vest Storvald	Moose Liver	ng/g ww	<0,01	<0,01	0,39	70,0	<0,1
12/2572	Mainland	Seljord vest Storvald	Moose Liver	ng/g ww	<0,01	<0,01	0,55	57,2	<0,1
12/2409	Mainland	Færstaulåi	Mouse Liver	ng/g ww	1,49	<0,045	15,7	116	<0,02
12/2410	Mainland	Færstaulåi	Mouse Liver	ng/g ww	0,07	<0,04	9,79	117	<0,02
12/2411	Mainland	Færstaulåi	Mouse Liver	ng/g ww	0,04	<0,025	7,75	17,6	<0,02
12/2412	Mainland	Færstaulåi	Mouse Liver	ng/g ww	0,11	<0,04	12,1	40	<0,20
12/2413	Mainland	Færstaulåi	Mouse Liver	ng/g ww	0,07	<0,05	11,0	32,2	<0,02
12/2414	Mainland	Færstaulåi	Mouse Liver	ng/g ww	0,06	<0,032	7,91	<1,9	<0,02
12/2415	Mainland	Færstaulåi	Mouse Liver	ng/g ww	0,05	<0,031	7,24	30,9	<0,02
12/2416	Mainland	Færstaulåi	Mouse Liver	ng/g ww	0,05	<0,025	24,1	21,8	<0,02
12/2417	Mainland	Færstaulåi	Mouse Liver	ng/g ww	0,07	<0,08	19,1	31,9	<0,02
12/2418	Mainland	Færstaulåi	Mouse Liver	ng/g ww	0,09	<0,07	31,9	22,2	<0,02
12/2500	Mainland	Færstaulåi	Soil	ng/g dw	<0,01	<0,01	1,04	<5,14	<0,002
12/2523	Mainland	Lofoten, Flagstad	Sea water	ng/L	na	na	na	na	na
12/2524	Mainland	Lofoten, Flagstad	Sea water	ng/L	na	na	na	na	na
12/2525	Mainland	Lofoten, Flagstad	Sea water	ng/L	na	na	na	na	na
12/2419	Mainland	Dalsvann	Fresh water	ng/L	na	na	na	na	na
12/2420	Mainland	Dalsvann	Fresh water	ng/L	na	na	na	na	na

Sample ID	Region	Site	Matrix	Unit	PBDE 47	BEHTBP	DBDPE	TBP*	PBP
12/2421	Mainland	Dalsvann	Fresh water	ng/L	na	na	na	na	na
12/1389	Mainland	Dunerbuka	Polar bear Plasma	ng/ml	0,04	0,05	1,88	10,1	<0,02
12/1390	Mainland	Fridtjofhamna	Polar bear Plasma	ng/ml	0,07	0,04	1,63	12,9	<0,02
12/1391	Mainland	Austfjordneset	Polar bear Plasma	ng/ml	0,08	0,66	8,63	33,0	<0,02
12/1392	Mainland	Dunerbukta	Polar bear Plasma	ng/ml	0,27	0,08	0,88	9,40	<0,02
12/1393	Mainland	Mohnbukta	Polar bear Plasma	ng/ml	0,19	0,06	0,97	13,2	<0,02
12/1394	Mainland	Hambergbukta	Polar bear Plasma	ng/ml	0,07	0,05	0,91	22,8	<0,02
12/1395	Mainland	Hellwaldbukta	Polar bear Plasma	ng/ml	0,04	0,12	38,7	10,7	<0,02
12/1396	Mainland	Hellwaldbukta	Polar bear Plasma	ng/ml	0,09	0,20	12,0	13,3	<0,02
12/1397	Mainland	Murchinsonfjorden	Polar bear Plasma	ng/ml	0,05	0,04	1,14	11,8	<0,02
12/1398	Mainland	Palanderfjorden	Polar bear Plasma	ng/ml	0,03	<0,018	0,73	32,9	<0,02
12/1399	Mainland	Hambergbukta	Polar bear Plasma	ng/ml	0,03	0,10	1,53	25,9	<0,02
12/1400	Mainland	Hornsund/Terskelen	Polar bear Plasma	ng/ml	0,04	0,10	3,53	23,2	<0,02
12/1401	Mainland	Wahlenbergfjorden	Polar bear Plasma	ng/ml	0,29	0,20	1,49	65,8	<0,02
12/1402	Mainland	E of Dunerbukta	Polar bear Plasma	ng/ml	0,05	0,06	4,03	37,5	<0,02
12/1403	Mainland	Palanderfjorden	Polar bear Plasma	ng/ml	0,09	0,13	3,19	27,6	<0,02
12/1404	Mainland	Mistakodden	Polar bear Plasma	ng/ml	0,06	0,12	8,57	20,4	<0,02
12/1405	Mainland	Heimland	Polar bear Plasma	ng/ml	0,06	0,52	5,96	45,7	<0,02
12/1406	Mainland	N of Discobukta	Polar bear Plasma	ng/ml	0,05	0,11	14,5	30,5	<0,02
14/1407	Mainland	E of Dunerbukta	Polar bear Plasma	ng/ml	0,06	0,10	18,7	22,3	<0,02
12/1408	Mainland	Freemansundet Ø	Polar bear Plasma	ng/ml	0,25	0,07	10,6	45,5	<0,02
12/1409	Arctic		Kittiwake Egg	ng/g ww	2,14	0,05	0,35	45,5	<0,01
12/1410	Arctic		Kittiwake Egg	ng/g ww	1,87	0,05	5,87	52,7	<0,01
12/1411	Arctic		Kittiwake Egg	ng/g ww	2,72	0,05	0,42	19,4	<0,01
12/1412	Arctic		Kittiwake Egg	ng/g ww	2,11	0,06	0,41	77,5	<0,01
12/1413	Arctic		Kittiwake Egg	ng/g ww	2,02	0,05	0,59	60,1	<0,01
12/1414	Arctic		Kittiwake Egg	ng/g ww	4,18	0,04	0,36	58,7	<0,01
12/1415	Arctic		Kittiwake Egg	ng/g ww	2,10	0,20	0,49	55,4	<0,01
12/1416	Arctic		Kittiwake Egg	ng/g ww	2,88	0,04	0,61	32,0	<0,01
12/1418	Arctic		Kittiwake Egg	ng/g ww	4,07	0,22	0,50	<1,4	<0,01
12/1419	Arctic		Kittiwake Egg	ng/g ww	2,21	0,29	0,70	<1,4	<0,01
12/1420	Arctic		Kittiwake Egg	ng/g ww	2,97	0,04	0,47	80,9	<0,01
12/1421	Arctic		Kittiwake Egg	ng/g ww	2,91	0,04	1,30	43,4	<0,01

Sample ID	Region	Site	Matrix	Unit	PBDE 47	BEHTBP	DBDPE	TBP*	PBP
12/1422	Arctic		C. Eider egg	ng/g ww	0,08	0,09	2,06	62,3	<0,01
12/1423	Arctic		C. Eider egg	ng/g ww	0,09	<0,01	0,57	<2,7	<0,01
12/1424	Arctic		C. Eider egg	ng/g ww	0,09	0,01	1,07	<2,7	<0,01
12/1425	Arctic		C. Eider egg	ng/g ww	0,17	0,01	0,38	18,9	<0,01
12/1426	Arctic		C. Eider egg	ng/g ww	0,14	<0,01	0,64	30,5	<0,01
12/1427	Arctic		C. Eider egg	ng/g ww	0,14	0,21	0,48	16,9	<0,01
12/1428	Arctic		C. Eider egg	ng/g ww	0,06	0,03	0,43	48,2	<0,01
12/1429	Arctic		C. Eider egg	ng/g ww	0,09	0,06	2,10	54,5	<0,01
12/1430	Arctic		C. Eider egg	ng/g ww	0,18	0,03	0,29	<2,7	<0,01
12/1431	Arctic		C. Eider egg	ng/g ww	0,25	<0,01	0,61	<2,7	<0,01
12/1432	Arctic		C. Eider egg	ng/g ww	0,14	<0,01	0,64	<2,7	<0,01
12/1433	Arctic		C. Eider egg	ng/g ww	0,03	<0,01	0,61	33,0	<0,01
12/1434	Arctic	Kongsfjorden	Glaucous gull Plasma	ng/ml	2,18	<0,01	4,52	31,6	<0,2
12/1435	Arctic	Kongsfjorden	Glaucous gull Plasma	ng/ml	2,77	<0,01	4,73	40,8	<10
12/1436	Arctic	Kongsfjorden	Glaucous gull Plasma	ng/ml	2,61	<0,01	7,33	35,5	<10
12/1437	Arctic	Kongsfjorden	Glaucous gull Plasma	ng/ml	6,53	<0,01	5,09	24,7	<10
12/1438	Arctic	Kongsfjorden	Glaucous gull Plasma	ng/ml	0,92	<0,01	4,50	14,4	<10
12/1439	Arctic	Kongsfjorden	Glaucous gull Plasma	ng/ml	0,65	<0,01	2,0	34,2	<10
12/1440	Arctic	Kongsfjorden	Glaucous gull Plasma	ng/ml	0,51	0,03	5,44	47,9	<10
12/1441	Arctic	Kongsfjorden	Glaucous gull Plasma	ng/ml	1,71	<0,01	6,23	32,3	<10
12/1442	Arctic	Kongsfjorden	Glaucous gull Plasma	ng/ml	3,57	<0,01	8,95	35,5	<10
12/1443	Arctic	Kongsfjorden	Glaucous gull Plasma	ng/ml	1,48	<0,01	7,19	25,3	<10
12/1444	Arctic	Kongsfjorden	Glaucous gull Plasma	ng/ml	3,52	0,03	11,0	26,5	<10
12/1445	Arctic	Kongsfjorden	Glaucous gull Plasma	ng/ml	1,43	<0,012	10,2	21,2	<10
12/1446	Arctic		Ringed seal plasma	ng/ml	0,10	<0,029	9,05	17,5	<0,01
12/1447	Arctic		Ringed seal plasma	ng/ml	0,06	<0,035	4,66	8,70	<0,01
12/1448	Arctic		Ringed seal plasma	ng/ml	0,09	<0,016	4,43	24,2	<0,01
12/1449	Arctic		Ringed seal plasma	ng/ml	0,07	<0,016	5,09	14,4	<0,01
12/1450	Arctic		Ringed seal plasma	ng/ml	0,07	<0,01	4,84	19,1	<0,01
12/1451	Arctic		Ringed seal plasma	ng/ml	0,07	<0,01	3,29	114	<0,01
12/1452	Arctic		Ringed seal plasma	ng/ml	0,12	<0,01	3,47	60,4	<0,01
12/1453	Arctic		Ringed seal plasma	ng/ml	0,09	<0,01	4,98	16,5	<0,01
12/1455	Arctic		Ringed seal plasma	ng/ml	0,04	<0,01	5,23	21,1	<0,01
12/1456	Arctic		Ringed seal plasma	ng/ml	0,06	0,04	8,62	16,0	<0,01

Sample ID	Region	Site	Matrix	Unit	PBDE 47	BEHTBP	DBDPE	TBP*	PBP
12/2326	Arctic		Cod Liver	ng/g ww	2,35	<0,024	6,91	<14,9	<0,2
12/2327	Arctic		Cod Liver	ng/g ww	1,58	<0,013	6,27	<14,9	<0,2
12/2328	Arctic		Cod Liver	ng/g ww	1,56	0,07	5,22	55,5	<0,2
12/2329	Arctic		Cod Liver	ng/g ww	0,98	<0,02	3,74	<14,9	<0,2
12/2330	Arctic		Cod Liver	ng/g ww	1,18	<0,014	6,42	92,1	<0,2
12/2331	Arctic		Cod Liver	ng/g ww	0,86	<0,06	<3,45	132	<0,2
12/2332	Arctic		Cod Liver	ng/g ww	1,64	<0,016	4,06	57,0	<0,2
12/2333	Arctic		Cod Liver	ng/g ww	1,11	<0,017	3,96	195	<0,2
12/2334	Arctic		Cod Liver	ng/g ww	1,40	<0,0186	7,44	196	<0,2
12/2335	Arctic		Cod Liver	ng/g ww	1,4	<0,021	6,13	76,4	<0,2
12/2563	Arctic		Polar cod	ng/g ww	0,19	<0,01	0,42	<14,9	<0,2

*: 2,4,6-TBA might be affected by matrix interferences

Individual results; Perfluorinated alkylic substances (PFAS)

d.w. = dry weight; w.w. = wet weight. n.d. = not detected, n.a. not analysed

Sample ID	Region	Site	Matrix	Unit	PFOS	PFDS	PFOA	PFNA	PFDcA	PFUnA	PFDoA	PFTriA	PFTeA
12/1369	Mainland	Sørøya, Finnmark	Herring gull Egg	ng/g ww	21,1	0,30	0,18	1,36	1,10	4,67	1,10	3,14	0,12
12/1370	Mainland	Sørøya, Finnmark	Herring gull Egg	ng/g ww	70,6	<0,02	0,09	1,55	3,40	14,44	3,17	10,9	0,87
12/1371	Mainland	Sørøya, Finnmark	Herring gull Egg	ng/g ww	40,4	0,29	0,09	1,90	2,12	9,99	1,83	5,80	0,44
12/1372	Mainland	Sørøya, Finnmark	Herring gull Egg	ng/g ww	42,2	<0,02	0,09	0,69	2,28	8,95	2,10	7,41	0,36
12/1373	Mainland	Sørøya, Finnmark	Herring gull Egg	ng/g ww	47,0	<0,02	0,14	0,67	1,73	10,4	1,51	7,60	<0,025
12/1374	Mainland	Sørøya, Finnmark	Herring gull Egg	ng/g ww	25,1	<0,02	<0,025	1,13	2,16	6,34	1,54	4,21	<0,025
12/1375	Mainland	Sørøya, Finnmark	Herring gull Egg	ng/g ww	44,6	<0,02	<0,025	<0,035	0,66	4,03	<0,015	11,6	<0,025
12/1376	Mainland	Sørøya, Finnmark	Herring gull Egg	ng/g ww	104	<0,02	0,35	2,47	5,53	17,32	3,48	24,2	1,50
12/1377	Mainland	Sørøya, Finnmark	Herring gull Egg	ng/g ww	31,5	<0,02	0,18	2,06	1,89	5,32	0,76	2,94	0,13
12/1378	Mainland	Sørøya, Finnmark	Herring gull Egg	ng/g ww	55,9	<0,02	0,34	2,12	1,78	6,36	1,16	5,30	0,35
12/1379	Mainland	Grinnøya, Troms	C. Eider Egg	ng/g ww	6,30	0,14	,034	1,05	0,29	0,76	0,22	0,31	<0,025
12/1380	Mainland	Grinnøya, Troms	C. Eider Egg	ng/g ww	6,21	<0,02	0,36	1,58	0,43	1,02	0,25	0,57	0,11
12/1381	Mainland	Grinnøya, Troms	C. Eider Egg	ng/g ww	11,9	0,29	0,36	2,25	0,65	1,43	0,44	0,53	0,09
12/1382	Mainland	Grinnøya, Troms	C. Eider Egg	ng/g ww	10,2	0,32	0,85	1,21	0,35	1,06	0,40	1,07	0,10
12/1383	Mainland	Grinnøya, Troms	C. Eider Egg	ng/g ww	11,7	0,20	3,0	3,46	0,78	1,12	0,36	1,17	0,17
12/1384	Mainland	Grinnøya, Troms	C. Eider Egg	ng/g ww	5,64	0,09	0,31	1,38	0,52	1,01	0,17	0,37	<0,025
12/1385	Mainland	Grinnøya, Troms	C. Eider Egg	ng/g ww	12,0	<0,02	2,66	6,91	0,88	1,03	0,24	0,85	0,12
12/1386	Mainland	Grinnøya, Troms	C. Eider Egg	ng/g ww	15,5	<0,02	3,49	6,74	0,66	1,03	0,20	0,60	0,08
12/1387	Mainland	Grinnøya, Troms	C. Eider Egg	ng/g ww	14,1	<0,02	2,54	6,33	0,78	2,79	0,72	1,27	<0,025
12/1388	Mainland	Grinnøya, Troms	C. Eider Egg	ng/g ww	7,39	<0,02	2,31	5,15	0,53	1,06	0,62	3,08	<0,025
12/1910	Mainland	Lofoten, Flakstad kommune	Cod Liver	ng/g ww	0,59	<0,02	<0,025	0,13	0,12	0,49	0,12	0,54	<0,025
12/1911	Mainland	Lofoten, Flakstad kommune	Cod Liver	ng/g ww	1,21	<0,02	<0,025	0,22	0,14	0,40	0,12	0,47	<0,025
12/1912	Mainland	Lofoten, Flakstad kommune	Cod Liver	ng/g ww	1,08	<0,02	<0,025	0,11	0,19	0,63	0,21	0,65	<0,025
12/1913	Mainland	Lofoten, Flakstad kommune	Cod Liver	ng/g ww	0,57	<0,02	0,09	0,22	0,10	0,38	0,06	0,30	<0,025
12/1914	Mainland	Lofoten, Flakstad kommune	Cod Liver	ng/g ww	0,33	<0,02	<0,025	0,09	0,09	0,51	0,16	0,67	<0,025

Sample ID	Region	Site	Matrix	Unit	PFOS	PFDS	PFOA	PFNA	PFDcA	PFUnA	PFDoA	PFTriA	PFTeA
12/1915	Mainland	Lofoten, Flakstad kommune	Cod Liver	ng/g ww	0,31	Z0,02	<0,025	0,09	0,09	0,26	0,08	0,23	<0,025
12/1916	Mainland	Lofoten, Flakstad kommune	Cod Liver	ng/g ww	0,42	<0,02	<0,025	<0,035	0,09	0,29	0,05	0,11	<0,025
12/1917	Mainland	Lofoten, Flakstad kommune	Cod Liver	ng/g ww	0,14	<0,02	<0,025	<0,035	<0,03	0,17	0,07	0,16	<0,025
12/1918	Mainland	Lofoten, Flakstad kommune	Cod Liver	ng/g ww	0,42	<0,02	0,09	0,09	0,09	0,33	0,08	0,37	<0,025
12/1919	Mainland	Lofoten, Flakstad kommune	Cod Liver	ng/g ww	0,82	<0,02	0,09	0,17	0,23	0,79	0,15	0,46	<0,025
12/2342	Mainland	Terrøya	Harbour Seal liver	ng/g ww	57,0	<0,02	0,48	2,39	2,22	10,1	<0,015	<0,025	<0,025
12/2343	Mainland	Fjellmoa	Harbour Seal liver	ng/g ww	44,6	0,09	1,15	4,35	2,69	4,57	<0,015	1,61	<0,025
12/2344	Mainland	Fjellmoa	Harbour Seal liver	ng/g ww	101	0.13	0.71	12.7	7.28	9.02	<0.015	<0,025	<0,025
12/2345	Mainland	Fjellmoa	Harbour Seal liver	ng/g ww	79,1	<0,02	0,37	4,38	2,72	4,16	<0,015	<0,025	<0,025
12/2346	Mainland	Fjellmoa	Harbour Seal liver	ng/g ww	99,1	<0,02	0,56	3,90	5,99	<0,015	<0,015	<0,025	<0,025
12/2347	Mainland	Beinøya	Harbour Seal liver	ng/g ww	31,5	<0,02	0,39	2,39	1,86	3,99	<0,015	2,08	<0,025
12/2348	Mainland	Beinøya	Harbour Seal liver	ng/g ww	49,1	<0,02	0,25	2.96	2,19	<0,015	<0,015	<0,025	<0,025
12/2349	Mainland	Fjellmoa	Harbour Seal liver	ng/g ww	100	<0,02	0,89	2,68	3,01	13,0	<0,015	7,19	<0,025
12/2350	Mainland	Beinøya	Harbour Seal liver	ng/g ww	46,8	<0,02	0,27	3,16	2,30	5,14	0,88	0,55	<0,025
12/2351	Mainland	Anda	Harbour Seal liver	ng/g ww	54,2	<0,02	2,90	5,35	2,52	4,96	0,79	<0,025	<0,025
12/2523	Mainland	Lofoten, Flakstad	Blue mussel	ng/g ww	na	na	na	na	na	na	na	na	na
12/2524	Mainland	Lofoten, Flakstad	Blue mussel	ng/g ww	na	na	na	na	na	na	na	na	na
12/2525	Mainland	Lofoten, Flakstad	Blue mussel	ng/g ww	na	na	na	na	na	na	na	na	na
12/2523	Mainland	Lofoten, Flagstad	Sea water	ng/L	<0,26	<0,11	0.2(<LOQ)	<0,2	<0,17	<0,09	<0,09	<0,14	<0,14
12/2524	Mainland	Lofoten, Flagstad	Sea water	ng/L	<0,26	<0,11	0.2(<LOQ)	<0,2	<0,17	<0,09	<0,09	<0,14	<0,14
12/2525	Mainland	Lofoten, Flagstad	Sea water	ng/L	<0,26	<0,11	0.2(<LOQ)	<0,2	<0,17	<0,09	<0,09	<0,14	<0,14
12/2557	Mainland	Lofoten, Flakstad	Marine sediment	ng/g dw	<0,018	<0,008	0,06	0,03	<0,012	0,16	<0,006	<0,01	<0,01
2/2558	Mainland	Lofoten, Flakstad	Marine sediment	ng/g dw	<0,018	<0,008	0,07	0,02	<0,012	0,04	<0,006	<0,01	<0,01
12/2559	Mainland	Lofoten, Flakstad	Marine sediment	ng/g dw	<0,018	<0,008	0,12	0,03	0,02	0,03	<0,006	<0,01	<0,01
12/2419	Mainland	Dalsvann	E. Perch Liver	ng/g ww	na	na	na	na	na	na	na	na	na
12/2420	Mainland	Dalsvann	E. Perch Liver	ng/g ww	na	na	na	na	na	na	na	na	na
12/2421	Mainland	Dalsvann	E. Perch Liver	ng/g ww	na	na	na	na	na	na	na	na	na
12/2425	Mainland	Dalsvann	Brown trout Liver	ng/g ww	0,65	<0,04	<0,05	1,07	<0,06	<0,03	<0,03	<0,05	<0,05
12/2426	Mainland	Dalsvann	Brown trout Liver	ng/g ww	4,97	<0,04	<0,05	0,71	1,45	16,2	<0,03	<0,05	<0,05

Sample ID	Region	Site	Matrix	Unit	PFOS	PFDS	PFOA	PFNA	PFDcA	PFUnA	PFDoA	PFTriA	PFTeA
12/2427	Mainland	Dalsvann	Brown trout Liver	ng/g ww	<0,09	<0,04	<0,05	<0,07	<0,06	<0,03	<0,03	<0,05	<0,05
12/2428	Mainland	Dalsvann	Brown trout Liver	ng/g ww	<0,09	<0,04	<0,05	0,38	<0,06	<0,03	<0,03	<0,05	<0,05
12/2429	Mainland	Dalsvann	Brown trout Liver	ng/g ww	4,70	<0,04	0,09	0,31	1,48	6,69	4,66	6,66	0,26
12/2430	Mainland	Dalsvann	Brown trout Liver	ng/g ww	1,46	<0,04	0,09	0,37	<0,06	11,5	5,98	32,7	<0,05
12/2431	Mainland	Dalsvann	Brown trout Liver	ng/g ww	4,77	<0,04	<0,05	0,23	1,64	7,09	6,26	<0,05	<0,05
12/2432	Mainland	Dalsvann	Brown trout Liver	ng/g ww	7,47	<0,04	<0,05	0,09	<0,06	2,19	<0,03	<0,05	<0,05
12/2433	Mainland	Færstaulelvi	Brown trout Liver	ng/g ww	5,54	<0,04	0,09	0,78	1,52	8,57	<0,03	<0,05	<0,05
12/2434	Mainland	Færstaulelvi	Brown trout Liver	ng/g ww	3,10	<0,04	<0,05	0,22	1,15	4,76	3,37	9,65	1,28
12/2560	Mainland	Dalsvann	Fresh water Sediment	ng/g dw	<0,018	<0,008	<0,01	<0,014	<0,012	<0,006	<0,006	<0,01	<0,01
12/2561	Mainland	Dalsvann	Fresh water Sediment	ng/g dw	<0,018	<0,008	<0,01	<0,014	<0,012	<0,006	<0,006	<0,01	<0,01
12/2562	Mainland	Dalsvann	Fresh water Sediment	ng/g dw	<0,018	<0,008	<0,01	<0,014	<0,012	0,16	<0,006	<0,01	<0,01
12/2419	Mainland	Dalsvann	Fresh water	ng/L	<0,26	<0,11	0,49	0,3 (<LOQ)	<0,17	<0,09	<0,09	<0,14	<0,14
12/2420	Mainland	Dalsvann	Fresh water	ng/L	<0,26	<0,11	0,77	0,3 (<LOQ)	<0,17	<0,09	<0,09	<0,14	<0,14
12/2421	Mainland	Dalsvann	Fresh water	ng/L	<0,26	<0,11	0,4 (<LOQ)	0,3 (<LOQ)	<0,17	<0,09	<0,09	<0,14	<0,14
12/2564	Mainland	Seljord vest Storvald	Moose Liver	ng/g ww	0,35	<0,02	<0,025	0,35	0,26	0,30	0,06	0,09	<0,025
12/2565	Mainland	Seljord vest Storvald	Moose Liver	ng/g ww	0,42	<0,02	<0,025	0,09	0,33	0,28	0,05	<0,025	<0,025
12/2566	Mainland	Seljord vest Storvald	Moose Liver	ng/g ww	0,83	<0,02	<0,025	0,84	0,27	0,22	0,09	<0,025	<0,025
12/2567	Mainland	Seljord vest Storvald	Moose Liver	ng/g ww	0,26	<0,02	<0,025	0,14	0,33	0,32	0,05	0,09	<0,025
12/2568	Mainland	Seljord vest Storvald	Moose Liver	ng/g ww	0,39	<0,02	<0,025	0,27	0,33	0,27	0,09	<0,025	<0,025
12/2569	Mainland	Seljord vest Storvald	Moose Liver	ng/g ww	0,25	<0,02	<0,025	0,19	0,20	0,13	0,09	<0,025	<0,025
12/2570	Mainland	Seljord vest Storvald	Moose Liver	ng/g ww	0,26	<0,02	<0,025	0,17	0,25	0,21	0,09	<0,025	<0,025
12/2571	Mainland	Seljord vest Storvald	Moose Liver	ng/g ww	0,45	<0,02	<0,025	0,09	0,11	0,07	<0,015	<0,025	<0,025
12/2572	Mainland	Seljord vest Storvald	Moose Liver	ng/g ww	0,65	<0,02	<0,025	0,35	0,50	0,47	0,10	0,09	<0,025
12/2409	Mainland	Færstaulåi	Mouse Liver	ng/g ww	1,12	<0,08	<0,1	<0,14	0,56	0,71	0,87	<0,1	<1,7
12/2410	Mainland	Færstaulåi	Mouse Liver	ng/g ww	0,09	<0,08	<0,1	0,59	0,37	0,70	<0,06	0,81	<0,1
12/2411	Mainland	Færstaulåi	Mouse Liver	ng/g ww	1,16	<0,08	<0,1	<0,14	0,49	0,60	0,30	2,18	0,55
12/2412	Mainland	Færstaulåi	Mouse Liver	ng/g ww	0,95	<0,08	<0,1	<0,14	0,71	1,04	0,30	2,62	1,70
12/2413	Mainland	Færstaulåi	Mouse Liver	ng/g ww	1,02	<0,08	<0,1	1,12	0,51	1,30	0,41	3,48	1,56
12/2414	Mainland	Færstaulåi	Mouse Liver	ng/g ww	0,83	<0,08	<0,1	0,66	0,09	1,17	0,45	5,29	1,72
12/2415	Mainland	Færstaulåi	Mouse Liver	ng/g ww	0,86	<0,08	<0,1	<0,14	0,36	0,91	0,22	1,52	0,57
12/2416	Mainland	Færstaulåi	Mouse Liver	ng/g ww	0,92	<0,08	<0,1	0,09	0,49	0,71	0,25	1,92	<0,1
12/2417	Mainland	Færstaulåi	Mouse Liver	ng/g ww	0,09	<0,08	<0,1	<0,14	0,42	0,71	0,09	<0,1	<0,1
12/2418	Mainland	Færstaulåi	Mouse Liver	ng/g ww	2,32	<0,08	<0,1	<0,14	0,49	1,01	0,41	0,82	<0,1
12/2500	Mainland	Færstaulåi	Soil	ng/g dw	0,22	0,06	0,25	0,12	<0,012	<0,006	<0,006	<0,01	<0,01

Sample ID	Region	Site	Matrix	Unit	PFOS	PFDS	PFOA	PFNA	PFDcA	PFUnA	PFDoA	PFTriA	PFTeA
12/1389	Arctic	Dunerbuka	Polar bear Plasma	ng/ml	290	<0,08	5,3	37,2	10,1	21,3	3,24	6,4	0,4
12/1390	Arctic	Fridtjofhamna	Polar bear Plasma	ng/ml	50,0	<0,08	5,9	24,8	3,2	10,7	1,33	5,7	<0,1
12/1391	Arctic	Austfjordneset	Polar bear Plasma	ng/ml	119	<0,08	6,3	42,6	8,2	14,8	1,95	6,3	<0,1
12/1392	Arctic	Dunerbukta	Polar bear Plasma	ng/ml	212	<0,08	6,4	39,7	9,5	23,3	2,98	6,6	0,3
12/1393	Arctic	Mohnbukta	Polar bear Plasma	ng/ml	146	<0,08	4,5	32,2	7,5	18,3	3,35	7,4	0,5
12/1394	Arctic	Hambergbukta	Polar bear Plasma	ng/ml	146	<0,08	2,9	2037	9,0	23,3	2,78	6,6	0,1
12/1395	Arctic	Hellwaldbukta	Polar bear Plasma	ng/ml	75,9	0,2	2,0	20,3	4,0	11,5	2,48	4,2	0,4
12/1396	Arctic	Hellwaldbukta	Polar bear Plasma	ng/ml	257	<0,08	4,7	65,9	12,8	26,1	2,81	11,0	0,4
12/1397	Arctic	Murchinsonfjorden	Polar bear Plasma	ng/ml	267	<0,08	6,3	38,3	14,0	27,4	3,77	11,2	0,2
12/1398	Arctic	Palanderfjorden	Polar bear Plasma	ng/ml	459	<0,08	6,9	63,6	24,3	53,7	5,90	16,6	1,2
12/1399	Arctic	Hambergbukta	Polar bear Plasma	ng/ml	159	<0,08	7,7	50,5	12,8	28,0	2,77	7,2	0,3
12/1400	Arctic	Hornsund/Terskelen	Polar bear Plasma	ng/ml	113	<0,08	6,2	33,6	8,2	16,0	1,97	5,7	<0,1
12/1401	Arctic	Wahlenbergfjorden	Polar bear Plasma	ng/ml	237	<0,08	3,9	54,6	16,3	27,1	2,64	12,2	0,4
12/1402	Arctic	E of Dunerbukta	Polar bear Plasma	ng/ml	208	<0,08	6,9	35,8	11,3	27,1	3,13	8,8	0,5
12/1403	Arctic	Palanderfjorden	Polar bear Plasma	ng/ml	240	<0,08	4,6	26,7	12,5	28,5	4,07	11,2	0,7
12/1404	Arctic	Mistakodden	Polar bear Plasma	ng/ml	321	<0,08	3,9	30,7	16,6	30,6	3,86	13,8	0,7
12/1405	Arctic	Heimland	Polar bear Plasma	ng/ml	357	<0,08	8,4	48,3	17,5	51,7	5,63	15,1	<0,1
12/1406	Arctic	N of Discobukta	Polar bear Plasma	ng/ml	151	<0,08	5,5	25,6	10,3	25,6	2,81	10,7	<0,1
14/1407	Arctic	E of Dunerbukta	Polar bear Plasma	ng/ml	86,2	<0,08	2,9	16,6	5,9	14,3	1,82	6,9	<0,1
12/1408	Arctic	Freemansundet Ø	Polar bear Plasma	ng/ml	207	<0,08	6,8	45,3	14,2	29,8	4,20	8,90	1,1
12/1409	Arctic		Kittiwake Egg	ng/g ww	72,3	0,39	<0,025	5,75	4,01	28,2	4,60	32,2	4,7
12/1410	Arctic		Kittiwake Egg	ng/g ww	32,0	0,26	<0,025	1,42	2,14	10,8	2,18	8,06	1,23
12/1411	Arctic		Kittiwake Egg	ng/g ww	11,3	0,23	0,10	0,58	1,00	5,8	1,65	10,6	2,1
12/1412	Arctic		Kittiwake Egg	ng/g ww	43,2	0,21	0,10	2,37	3,02	17,7	3,59	20,0	2,2
12/1413	Arctic		Kittiwake Egg	ng/g ww	14,1	<0,02	<0,025	0,93	0,96	5,9	1,53	8,54	1,27
12/1414	Arctic		Kittiwake Egg	ng/g ww	9,45	<0,02	0,10	0,89	1,17	5,8	1,31	8,98	1,06
12/1415	Arctic		Kittiwake Egg	ng/g ww	11,0	<0,02	<0,025	0,43	0,95	5,5	1,59	11,2	1,3
12/1416	Arctic		Kittiwake Egg	ng/g ww	38,0	<0,02	0,10	1,39	2,34	13,2	2,67	11,5	3,0
12/1418	Arctic		Kittiwake Egg	ng/g ww	11,0	<0,02	<0,025	0,72	1,24	7,02	1,86	9,34	1,63
12/1419	Arctic		Kittiwake Egg	ng/g ww	4,95	<0,02	<0,025	1,16	1,08	5,25	1,23	7,32	1,36
12/1420	Arctic		Kittiwake Egg	ng/g ww	47,3	<0,02	0,08	2,20	2,37	12,3	2,54	9,65	1,19
12/1421	Arctic		Kittiwake Egg	ng/g ww	105	<0,02	<0,025	0,67	3,53	34,1	12,6	73,4	7,8
12/1422	Arctic		C. Eider egg	ng/g ww	8,69	<0,02	<0,025	0,66	1,07	5,02	2,23	18,0	2,1
12/1423	Arctic		C. Eider egg	ng/g ww	1,77	<0,02	0,12	0,87	0,27	0,32	0,16	0,74	<0,025

Sample ID	Region	Site	Matrix	Unit	PFOS	PFDS	PFOA	PFNA	PFDcA	PFUnA	PFDoA	PFTriA	PFTeA
12/1424	Arctic		C. Eider egg	ng/g ww	1,49	<0,02	0,22	0,90	0,16	0,44	0,14	0,94	<0,025
12/1425	Arctic		C. Eider egg	ng/g ww	4,73	<0,02	0,33	0,98	0,30	0,81	0,29	1,37	0,11
12/1426	Arctic		C. Eider egg	ng/g ww	5,66	<0,02	0,25	1,24	0,24	1,43	0,43	2,85	0,38
12/1427	Arctic		C. Eider egg	ng/g ww	5,15	<0,02	0,66	1,35	0,58	1,43	0,30	1,90	0,26
12/1428	Arctic		C. Eider egg	ng/g ww	2,08	<0,02	0,20	2,60	0,27	0,59	0,12	0,76	0,18
12/1429	Arctic		C. Eider egg	ng/g ww	3,5	<0,02	0,22	5,78	0,23	0,99	0,20	1,11	0,21
12/1430	Arctic		C. Eider egg	ng/g ww	1,67	<0,02	0,18	1,94	0,24	1,08	0,46	2,11	0,33
12/1431	Arctic		C. Eider egg	ng/g ww	1,11	<0,02	0,19	2,51	0,13	0,56	0,07	0,49	<0,025
12/1432	Arctic		C. Eider egg	ng/g ww	2,82	<0,02	0,24	2,14	0,17	0,43	0,17	2,20	<0,025
12/1433	Arctic		C. Eider egg	ng/g ww	5,52	<0,02	0,23	3,74	0,57	1,13	<0,015	1,31	0,19
12/1434	Arctic	Kongsfjorden	Glaucous gull Plasma	ng/ml	19,8	<0,08	<0,1	1,25	1,29	9,64	1,81	16,3	<0,1
12/1435	Arctic	Kongsfjorden	Glaucous gull Plasma	ng/ml	10,6	<0,08	0,1(<LOQ)	1,30	0,97	3,77	1,23	6,29	<0,1
12/1436	Arctic	Kongsfjorden	Glaucous gull Plasma	ng/ml	24,0	<0,08	<0,1	1,85	2,97	6,62	1,08	13,5	<0,1
12/1437	Arctic	Kongsfjorden	Glaucous gull Plasma	ng/ml	4,54	<0,08	0,57	1,61	0,30	1,70	0,55	2,50	<0,1
12/1438	Arctic	Kongsfjorden	Glaucous gull Plasma	ng/ml	4,35	<0,08	0,79	0,72	0,30	1,27	0,29	<0,1	<0,1
12/1439	Arctic	Kongsfjorden	Glaucous gull Plasma	ng/ml	17	<0,08	0,2	3,56	1,97	5,22	1,49	13	<0,1
12/1440	Arctic	Kongsfjorden	Glaucous gull Plasma	ng/ml	202	<0,08	0,67	0,30	0,30	2,73	0,40	3,79	<0,1
12/1441	Arctic	Kongsfjorden	Glaucous gull Plasma	ng/ml	6,56	<0,08	0,48	1,37	0,38	1,30	0,47	1,82	<0,1
12/1442	Arctic	Kongsfjorden	Glaucous gull Plasma	ng/ml	19,4	<0,08	0,39	0,99	0,85	2,70	1,05	1,28	<0,1
12/1443	Arctic	Kongsfjorden	Glaucous gull Plasma	ng/ml	11,3	<0,08	0,35	3,76	1,35	4,26	1,05	9,77	<0,1
12/1444	Arctic	Kongsfjorden	Glaucous gull Plasma	ng/ml	20,6	<0,08	0,35	2,27	1,43	3,90	1,33	16,3	<0,1
12/1445	Arctic	Kongsfjorden	Ringed seal plasma	ng/ml	11,3	<0,08	0,20	1,60	1,14	3,77	1,61	3,52	<0,1
12/1446	Arctic		Ringed seal plasma	ng/ml	29,8	<0,08	0,58	8,45	3,20	6,97	0,68	4,38	1,24
12/1447	Arctic		Ringed seal plasma	ng/ml	40,3	<0,08	0,20	4,72	4,23	9,42	0,34	4,53	1,38
12/1448	Arctic		Ringed seal plasma	ng/ml	32,5	<0,08	0,20	4,79	3,27	8,59	0,83	5,07	1,29
12/1449	Arctic		Ringed seal plasma	ng/ml	32,4	<0,08	0,33	7,82	3,37	9,35	0,94	6,43	2,15
12/1450	Arctic		Ringed seal plasma	ng/ml	31,8	<0,08	0,20	9,46	3,71	9,10	0,84	5,72	1,61
12/1451	Arctic		Ringed seal plasma	ng/ml	23,3	<0,08	0,20	7,66	3,12	7,77	0,75	4,01	0,92
12/1452	Arctic		Ringed seal plasma	ng/ml	30,3	<0,08	0,20	8,93	3,68	9,46	0,98	5,02	1,32
12/1453	Arctic		Ringed seal plasma	ng/ml	29,2	<0,08	0,32	7,82	3,84	10,1	0,94	6,26	<0,1
12/1455	Arctic		Ringed seal plasma	ng/ml	23,5	<0,08	0,20	6,56	2,74	7,19	0,50	2,96	1,09
12/1456	Arctic		Ringed seal plasma	ng/g ww	43,4	<0,08	0,66	10,4	3,59	10,1	0,96	8,10	2,20
12/2326	Arctic		Cod Liver	ng/g ww	0,31	<0,02	<0,025	<0,035	0,09	0,50	0,06	0,27	<0,025
12/2327	Arctic		Cod Liver	ng/g ww	0,36	<0,02	<0,025	0,24	<0,03	0,35	0,08	0,21	<0,025

Sample ID	Region	Site	Matrix	Unit	PFOS	PFDS	PFOA	PFNA	PFDcA	PFUnA	PFDoA	PFTriA	PFTeA
12/2328	Arctic		Cod Liver	ng/g ww	0,25	<0,08	<0,025	<0,035	<0,03	0,40	0,10	0,17	<0,025
12/2329	Arctic		Cod Liver	ng/g ww	0,22	<0,02	<0,025	<0,035	<0,03	0,27	<0,015	0,11	<0,025
12/2330	Arctic		Cod Liver	ng/g ww	0,32	<0,02	<0,025	0,10	0,10	0,32	0,08	0,19	<0,025
12/2331	Arctic		Cod Liver	ng/g ww	0,16	<0,02	<0,025	0,10	<0,03	0,23	0,10	0,17	<0,025
12/2332	Arctic		Cod Liver	ng/g ww	0,40	<0,02	<0,025	0,11	0,10	0,32	0,10	<0,025	<0,025
12/2333	Arctic		Cod Liver	ng/g ww	0,17	<0,02	<0,025	0,11	0,10	0,32	0,10	0,20	<0,025
12/2334	Arctic		Cod Liver	ng/g ww	0,35	<0,02	<0,025	<0,035	<0,03	0,37	<0,015	0,15	<0,025
12/2335	Arctic		Polar cod	ng/g ww	0,22	<0,02	<0,025	0,12	0,10	0,37	0,06	0,15	<0,025
12/2563	Arctic		Polar bear Plasma	ng/ml	0,17	<0,02	<0,025	0,15	0,1	0,33	0,06	0,23	<0,025

Klima- og forurensningsdirektoratet
Postboks 8100 Dep, 0032 Oslo
Besøksadresse: Strømsveien 96
Telefon: 22 57 34 00
Telefaks: 22 67 67 06
E-post: postmottak@klif.no
Internett: www.klif.no

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Dorte Herzke (NILU)	Miljødirektoratet Bård Nordbø	M 40-2013
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Mikael Harju, Dorte Herzke, Halvard Kaasa

Tittel - norsk og engelsk

Perfluorinated alkylated substances (PFAS), brominated flame retardants (BFR) and chlorinated paraffins (CP) in the Norwegian environment – Screening 2013

Perfluorerte alkylerte stoffer (PFAS), bromerte flammehemmere (BFR) og klorerte parafiner (CP) i det norske miljøet – Screening 2013

Sammendrag – summary
NILU gjennomførte screeningprosjektet i 2013. Denne rapporten beskriver resultatene og disse er sammenlignet og diskutert med tidligere funn i både Norge og andre regioner.
NILU carried out the screening 2013, This report describes the results, comparing and discussing them with other findings in both Norway and other regions.

4 emneord	4 subject words
Perfluorerte stoffer	Perfluorinated compounds
Bromerte flammehemmere	Brominated flame retardants
Bakgrunnsnivåer	Background levels
Klorparafiner	Chlorinated paraffins

Miljødirektoratet
Telefon: 03400/73 58 05 00 | Faks: 73 58 05 01
E-post: post@miljodir.no
Nett: www.miljødirektoratet.no
Post: Postboks 5672 Sluppen, 7485 Trondheim
Besøksadresse Trondheim: Brattørkaia 15, 7010 Trondheim
Besøksadresse Oslo: Strømsveien 96, 0602 Oslo

Statlig program for forurensningsovervåking omfatter overvåking av forurensningsforholdene i luft og nedbør, skog, vassdrag, fjorder og havområder.

Overvåkingsprogrammet dekker langsiktige undersøkelser av:
•overgjødsling•forsuring (sur nedbør)
•ozon (ved bakken og i stratosfæren)
•klimagasser
•miljøgifter

Overvåkingsprogrammet skal gi informasjon om tilstanden og utviklingen av forurensningssituasjonen, og påvise eventuell uheldig utvikling på et tidlig tidspunkt. Programmet skal dekke myndighetenes informasjonsbehov om forurensningsforholdene, registrere virkningen av iverksatte tiltak for å redusere forurensningen, og danne grunnlag for vurdering av nye tiltak. Miljødirektoratet er ansvarlig for gjennomføringen av overvåkingsprogrammet.