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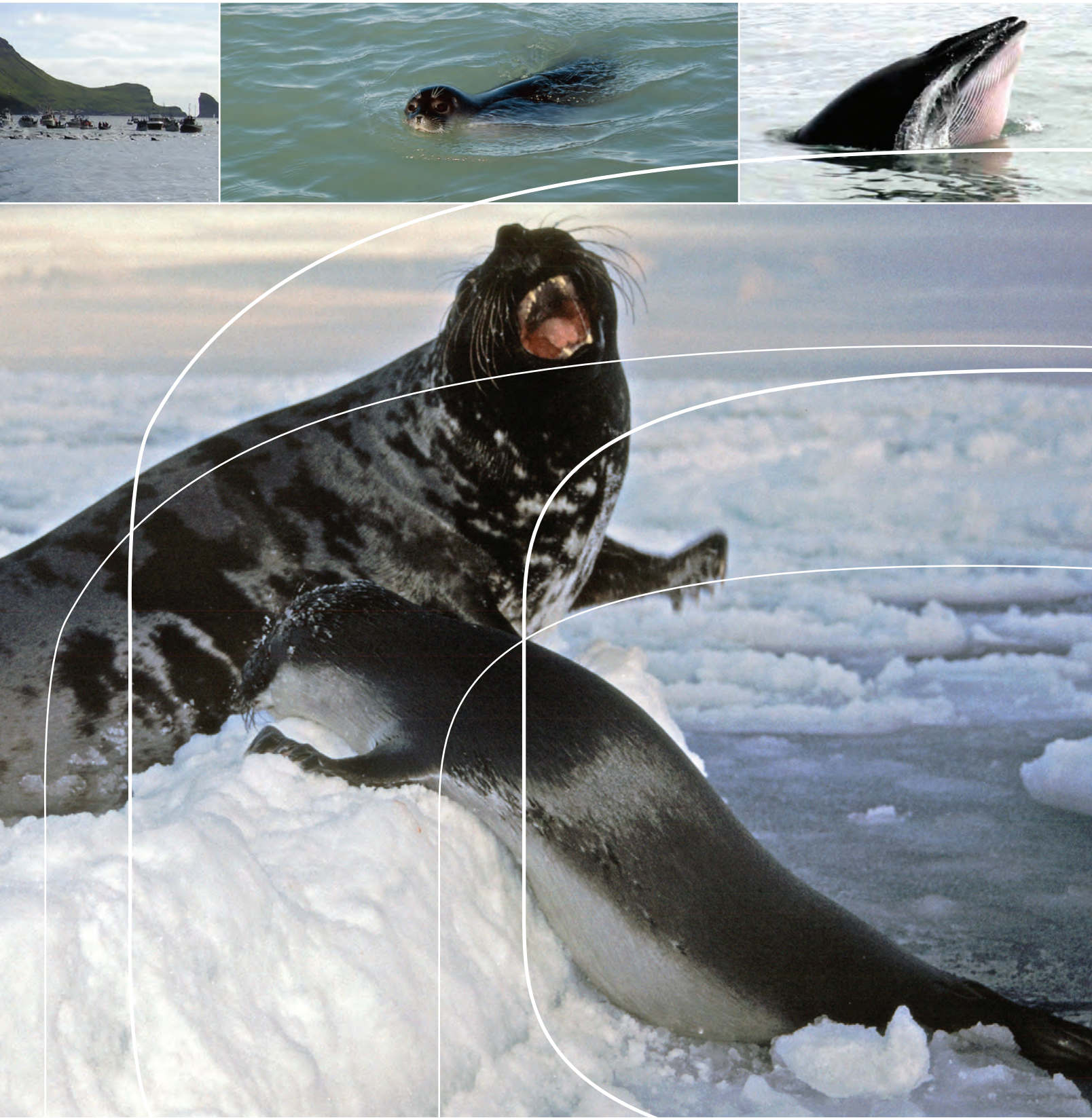


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# “New” POPs in marine mammals in Nordic Arctic and NE Atlantic areas during three decades

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# Content

# Preface

The report describes the findings of a Nordic study aiming to depict possible trends in "new" contaminants in marine mammals in Nordic Arctic waters over three decennia. The "new" contaminants in focus are the brominated flame retardants, BFRs, methoxylated PBDEs, perfluorinated compounds including the PFOS family, and polychlorinated naphthalenes, PCNs. In addition, brominated dioxins and dibenzofurans were analysed in a subset of the samples.

The study aims at giving a wide scope of the presence of a selection of these "new" contaminants in marine mammals in recent time and so far back as is possible with extracting samples from specimen banks.

The marine mammal species analysed were fin whale, minke whale, pilot whale, white-sided dolphins, harbour porpoise, ringed seal and hooded seal.

The study is the result of collaboration between Norway, Denmark/ Greenland, Faroe Island, Iceland and Sweden. The funding for large parts of the project has been made available by the Nordic Council of Ministers via the working group on Akvatiska Ekosystemer.

# Foreword

By *Mr Kári P. Højgaard*, Minister of the Interior, Faroe Islands

Marine mammals are highly valued in the countries surrounded by the North Atlantic Ocean. For centuries, marine mammals have served as a nutritious food resource and provided for warm clothing. In addition, many marine mammals have earned a unique position in the minds of people as mysterious and magnificent creatures inhabiting the vast oceans. Whilst the people still were restrained to onshore activities, the marine mammals were the ultimate explorers of the vast oceans. Consequently, legends and fairy tales developed that still provide children and adults with capturing stories about marine mammals with supernatural characteristics that evoked in their encounter with humans in ancient times. In those times, before humans knew how to pollute and spoil the habitats of the animal kingdom and mankind in general.

I am very pleased to see the continuous effort which the Nordic countries in cooperation put into describing and protecting the marine environment so as to evolve into new joint means to sustain environmental welfare and health. The records show that some of the pollutants which have been subject to concerted international regulatory measures are declining. For the marine mammals, who are the kings and queens in the ocean, the decline is however slower to manifest. This is partly due to the fact, that many marine mammals have a long lifespan and large fat reserves where pollutants are stored, but also because the pollutants may be persistent. Persistence means, that these contaminants do not disappear from the environment in terms of days, weeks or months.

The purpose of the present Nordic project has been to expose the occurrence of a selection of contaminants which at presence are not well known – in particular not in marine mammals. The contaminants analysed encompass compounds which are utilised in modern society in a vast range of ordinary consumer products. Commonly used compounds in our furniture, carpets and curtains, cars and planes, in hamburger wrappings, in our all-weather outdoor clothing and in our cooking utensils. Some of the compounds have been deliberately added to such products and some have been released from the production facilities during manufacture and some are produced during the incineration of our household and industrial waste.

I am pleased to learn, that the report informs us that brominated flame retardants, PBDE, and PFOS were seen to decline since the turn of the millennium, and decreasing tendencies were seen for polychlorinat-

ed naphthalenes. Unfortunately, there are other compounds which resemble PFOS that appear to increase. Thus it seems evident, that when one hazardous compound is restricted, others will emerge with similar properties. The situation puts an immense and continuous challenge on us, who are responsible for initiating regulatory measures in order to protect the environment.

The fact, that the Nordic Counsil and the Nordic Environmental Ministers prioritise timely scientific research in this area illustrates, that the Nordic countries share a common hope and confidence for a cleaner environment in the future. We share the optimism, that one day we will succeed in protecting the environment, the marine mammals and ourselves from these hazardous compounds.

Recognising that the riches of the sea are the existential foundation for many costal people of the Northern Oceans, it is our duty and responsibility to protect the environment so as to facilitate sustainable utilisation of marine resources for the benefit of all.

# Summary

The present report describes the findings from a Nordic study with the aim to show possible trends in "new" contaminants in marine mammals from Nordic Arctic waters and North-East Atlantic areas over a period of three decennia. The species analysed were ringed seal (Greenland), hooded seal (Norway – West Ice), harbour porpoise (Iceland and Norway), white-sided dolphin (Faroe Islands), pilot whale (Faroe Islands), minke whale (Greenland, Iceland and Norway) and fin whale (Iceland). The substances investigated were a wide suite of brominated flame retardants (BFRs), polybrominated dibenzo-p-dioxins/furans (PBDD /PBDF) and methoxylated PBDEs, perfluorinated compounds (PFCs) including PFOS and polychlorinated naphthalenes (PCNs). The BFRs and PCNs were analysed in blubber, whereas the PFCs were analysed in liver with one exception when muscle tissue was used.

The study provides new and valuable insight into a series of "new" contaminants in a range of marine mammals from Nordic Arctic areas and/or North-East Atlantic Ocean. A large number of samples were carefully selected and analysed within this study, but still only a limited number of sampling sites, species and time periods were covered. Notwithstanding, several statistical significant trends were revealed.

Many of the "new" contaminants analysed in the present project appear to decline during the time period studied. This is true for the BDEs, PCNs and PFOS, the PFC that was found in the highest concentration. Rising levels of the larger PFCs were seen, and in addition several BFRs other than BDE were seen in the sample extracts.

The highest concentrations of $\Sigma_{10}$PBDEs were found in toothed whales, including the pilot whales (~1,200 ng/g LW), the white-sided dolphins (~650 ng/g LW) and the harbour porpoises (~250 ng/g LW). BDE-47 was the most abundant congener accounting for 30–75% of the total burden in the different marine mammals. Deca-BDE was analysed in samples of ringed seal, pilot whale and minke whale (Norway), but was not detected in any samples in levels above the detection limits (range 0.5–3.0 ng/g lipid). The methoxylated PBDEs which are at least partly naturally occurring compounds followed the decreasing trend as the PBDEs, but only weak correlation between the PBDEs and methoxylated BDEs was found. Highest levels of methoxylated PBDEs were found in pilot whales and remarkably 6MBDE47 was the most dominant compound. The temporal trend analysis of BFRs showed that the levels of $\Sigma_{10}$PBDEs increased from the 1980s to the late 1990s, thereafter declined during the first part of the 2000s. This trend was seen in all the marine mammals studied and was significant for the fin whales and

white side dolphins. A decline of $\Sigma_{10}$PBDEs during the period 2000–2006 was observed in all species and was largest (44%) for the ringed seals from Greenland.

A selected number of samples were screened for unknown organic brominated compounds and several unidentified bromine containing compounds were seen. In addition, selected samples were analysed for other brominated compounds than BDE including HBB, PBT, BTBPE and DBDPE, PBB-153, TBECH and brominated dioxin and furans. All compounds were below the current LOD except for PBB-153 and HBB. TBECH was tentatively found in pilot whale samples by using low resolution GC/MS, but these results could not be confirmed by using high resolution GC/MS.

PCNs were found in much lower concentration than the PBDEs but are of concern due to their dioxin-like behaviour and toxicity. The highest concentrations of $\Sigma_{14}$PCNs (~4 ng/g LW) were found in pilot whales. Differences in PCN-congener patterns were found between the different mammalian species. In general, no consistent temporal trend of decreasing PCNs in recent years was found for the marine mammals. However, in hooded seals and fin whale significant decreasing trends for $\Sigma_{14}$PCNs were observed. For other species, the decrease could be seen for individual congeners only. Concentrations of PCNs in minke whale from the Norwegian coast in 1999 were not significantly different from those taken in 1993.

Unlike other compounds in his study, which were analysed in blubber, PFCs were analysed in livers except for the fin whale samples where muscle tissue was analysed. Eighteen PFCs were analysed, of which PFOS was found in the highest concentrations. The highest PFOS concentrations were found in the white-sided dolphin (~110 ng/g WW), followed by similar concentrations in ringed seal (NW-Greenland), hooded seal, pilot whale, minke whale (W-Greenland) and harbour porpoise (W-Iceland) (~50ng/g WW). The concentrations of PFOS in the fin whale muscle samples were very low (0.4 ng/g WW), and for most PFCs close to or below the detection limit. A significant decrease in PFOS was found in hooded seals (1990–2007). On the other hand, increasing trends of one or more PFCs were found in samples of ringed seals, in pilot whale, white-sided dolphins and harbour porpoise. For PFUnDA a significantly increasing trend was found for ringed seal, pilot whale and white-sided dolphins indicating that levels of the larger PFCs are still increasing.

Generally, no regional differences were seen in these "new" contaminant distributions. However this could only be studied for the minke whales and the harbour porpoise which were sampled at more than one location.

# 1. Introduction

The present report describes the findings of a Nordic study aiming to depict possible trends in "new" contaminants in marine mammals in mainly Nordic Arctic waters over three decennia. The study is the result of collaboration between Norway, Denmark/Greenland, Faroe Island, Iceland and Sweden. Funding from the Nordic Council of Ministers Aquatic Ecosystems Group made the analyses possible.

The "new" contaminants in focus are the brominated flame retardants, BFRs, with members both from the large molecule ones and the small molecule ones represented. The so-called large BFRs are for instance the brominated diphenyl ethers but also less familiar ones like 1,2-bis (pentabromophenyl) ethane and 1,2-bis (2,4,6-trimopheno-xy)-ethane. The small BFRs include for instance pentabromotoluene and hexabromobenzene. The history of use of these BFRs varies and the term "new" for many of the substances only pertains to the awareness of their existence as environmental pollutants. The present study aims at giving a wide scope of the presence of a selection of the BFRs in recent time.

The other groups of "new" contaminants in focus are the perfluorinated alkylated substances, where PFOS is one member, and polychlorinated naphthalenes which both has been used as a commercial formulation and can be formed during incineration processes. In addition, brominated dioxins and other compounds formed in connection with waste incineration have been studied although in a smaller subsection of the samples.

The marine mammal species analysed are given in Table 1, along with information on from which country and time period the samples were provided and target pollutants analysed in those.

The screening design of this investigation was primarily intended to reveal temporal changes across several species of marine mammals and not to reveal regional differences. In order to be able to study trends in "new" contaminants in marine mammals, it was necessary to be very selective when deciding on what samples to include. Factors connected to age, growth, foraging area, lactation and both feed availability and food preference are known to influence the body burden of pollutants in a marine mammal at a given time. Thus many factors were taken into consideration when samples were selected for the study, and these same factors also provided a challenge for actually being able to find suitable samples in specimen banks. These constraints together meant that finding series of comparable samples of a given species spanning the desired three decennia were challenging and sometimes compromises had to be made.

**Table 1: Overview of marine mammal samples analysed.**

| Country | Species | Time-period yr | Target pollutants |
|---|---|---|---|
| Faroe Islands | Pilot whales | 1986–2007 | BFRs/PCN |
| Faroe Islands | Pilot whales | 1986–2007 | PFCs |
| Faroe Islands | White-sided dolphins | 1997–2006 | BFRs/PCN |
| Faroe Islands | White-sided dolphins | 2001–2006 | PFCs |
| Central East Greenland | Ringed seal | 1986–2006 | BFRs/PCN |
| North West Greenland | Ringed seal | 1984–2006 | PFCs |
| South to central West Greenland | Minke whale | 1998 | BFRs/PCN |
| South to central West Greenland | Minke whale | 1998 | PFCs |
| Iceland | Harbour porpoise | 1991–1997 | BFRs/PCN |
| Iceland | Harbour porpoise | 1991–1997 | PFCs |
| Iceland | Minke whale | 2003–2007 | BFRs/PCN |
| Iceland | Fin whale | 1986–2009 | BFRs/PCN |
| Iceland | Fin whale | 1986–2009 | PFCs |
| Norway | Harbour porpoise | 2000 | BFRs/PCN |
| Norway West Ice | Hooded seal | 1990–2007 | BFRs/PCN |
| Norway West Ice | Hooded seal | 1990–2007 | PFCs |
| Norway | Minke whale | 1993–1999 | BFRs/PCN |

The study has been done in cooperation across countries with coasts to Nordic Arctic areas and/or to the North-East Atlantic Ocean active in research on marine mammals. A wide variety of Nordic expertise and experience in the field of marine mammal ecology and pollution, and chemical analysis was represented in the project group.

The study was done in a project group with members from:

- Norwegian School of Veterinary Science and The Norwegian Polar Institute, Norway
- Aarhus University, Department of Bioscience, Denmark
- Environment Agency and The Faroese Museum of Natural History, the Faroe Islands
- Innovation Centre Iceland, Dep. Analytical Chem. and Marine Research Institute, Iceland

And have been depending on the chemical analysis skills of:

- The University of Örebro, MTM Centre, Sweden

# 2. Presentation of compounds

## 2.1 Brominated flame retardants – polybrominated diphenyl ether

Polybrominated diphenyl ethers, PBDEs, consist of 2 aromatic rings bound together by oxygen and substituted with up to ten bromine atoms. The theoretical number of possible congeners is 209 similar to PCBs and the same IUPAC numbering is used to distinguish the different congeners. The structure of the most abundant PBDEs in commercial PBDE mixtures and the environment are given in Figure 1. The first discovery of PBDE in the environment was made already in 1981 when PBDEs were identified in eel, pike, bream and sea trout from the Viskan-Klosterfjorden, Gothenburg, Sweden (Andersson et al., 1981). But it was not until the middle of the 1990s that PBDE have attracted more attention with the discovery of PBDEs in both humans (Meironyte et al., 1999) and marine mammals (de Boer et al., 1998; Lindström et al., 1999) confirming that several PBDEs tend to bioaccumulate. Compared to occupational related exposure which seems to be dominated by hepta- to decaBDE, lower brominated diphenyl ethers like tetra- to hexaBDEs dominate the exposure via food (Sjödin, 2000). PBDEs are relatively stable in the environment but are known to be subjected to debromination under special conditions or in the laboratory environment (Sánchez-Prado et al., 2006; Gaul et al., 2006). In addition, during photolysis conditions or thermal decompositions of PBDE, the formation of polybrominated dibenzo-*p*-dioxins and furans has been observed (Hagberg et al., 2009). Mainly three technical PBDE-mixtures have been used of which two, the Penta- and the OctaBDE-mixtures, have been voluntarily removed or banned from use in the EU and other parts of the world. The DecaBDE formulation was the last of these three mixtures banned from the Swedish market in the beginning of 2007 and from the total European market in the middle of 2008 (Kemmlein et al., 2009).

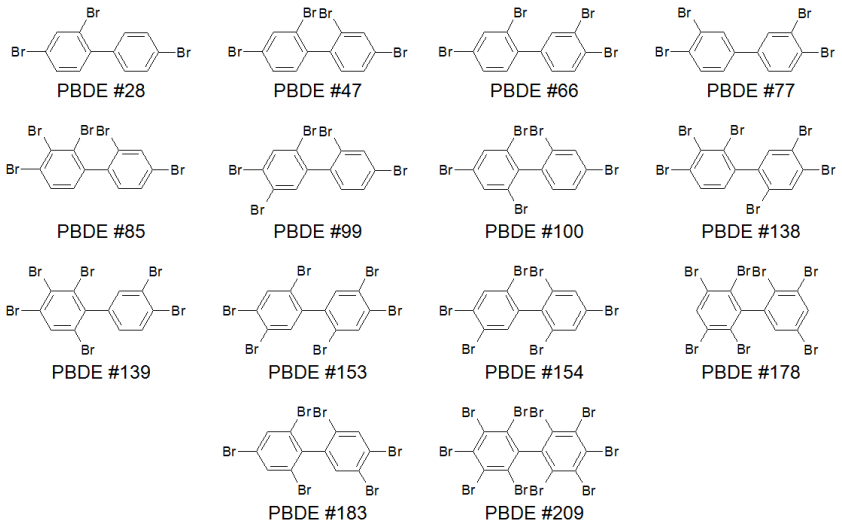


***Figure 1: The structure of the most abundant PBDEs in technical mixtures and the environment.***

## 2.2 Methoxylated brominated diphenyl ethers

The origin of methoxylated brominated diphenyl ethers (Me-O-PBDEs), a PBDE with a methoxy group added to the diphenyl ring (Figure 2) is still debated. The compound class has never been synthesized or produced other than for chemical analytical purposes. First introduced as a metabolite of PBDEs, studies in recent years concludes that this compound class might also be of natural origin. Natural organobromines are known to be biosynthesized by fungus, plants, marine algae and sponges (Gribble, 1998) including Me-O-PBDEs. It has been suggested that organobromine compounds are used in chemical defence, or as hormones, for examples the marine sponge Dysidea can contain up to 25 different brominated diphenyl ethers (Gribble, 2000). Me-O-PBDEs have been reported as natural products present in the marine environment (Malmvarn et al., 2005; Vetter et al., 2002.

In marine wildlife MeO-PBDEs were first analyzed in seal and fish from the Baltic Sea (Haglund et al., 1997). Relatively high levels of MeO-PBDEs have been reported for harbour seals, harbour porpoises, pilot whales and beluga whales (van Bavel et al., 2001; Weijs et al., 2009), Greenland shark (Strid et al., 2010), melon-headed whale and pygmy sperm whale from Australia (Vetter, 2001), tuna from the North Pacific Ocean and albatross from the Indian and South Atlantic Oceans (Wan et al., 2010a) and striped dolphin from Japan (Marsh et al., 2005). Me-O-PBDEs have also been detected in humans plasma and breast milk (Hovander et al., 2002).

By analyzing the natural abundance radiocarbon content of two abundant congeners of Me-O-PBDEs, 6Me-O-PBDE #47 and 2-Me-PBDE #68, isolated from a True's beaked whale (*Mesoplodon mirus*), it was

confirmed that these compounds were of natural origin (Teuten et al., 2005). The presence of 2-MePBDE #68 in concentrations of similar magnitude in a pristine lake and a polluted lake in Sweden, and without correlation to any major BDE precursor found in the samples also pointed in the direction of a non-anthropogenic source of 2-Me-O-PBDE #68 (Kierkegaard et al., 2004). However the presence of Me-O-PBDEs in Arctic biota has also suggested to a result of metabolic processes of bio accumulating precursor PBDEs (Kelly et al., 2008).

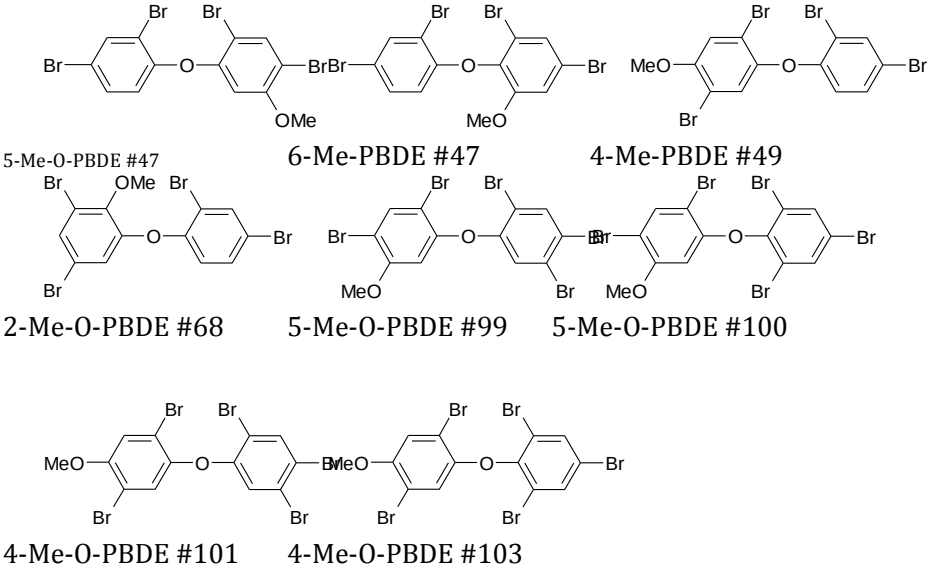


***Figure 2: The structure of the most abundant MeOBDEs found in biological samples.***

The MeOBDE congeners which have been analysed in the present study are given in Table 2.

**Table 2: The abbreviations used for the MeOBDE analysed.**

| Abbreviation | Name |
|---|---|
| 2PMBDE68 | 2,3',4,5'-Tetrabromo-2'-methoxydiphenyl ether |
| 6MBDE47 | 2,2',4,4'-Tetrabromo-6-methoxydiphenyl ether |
| 5MBDE47 | 2,2',4,4'-Tetrabromo-5-methoxydiphenyl ether |
| 4PMBDE49 | 2,2',4,5'-Tetrabromo-4'-methoxydiphenyl ether |
| 5PMBDE100 | 2,2',4,4',6-Pentabromo-5'-methoxydiphenyl ether |
| 4PMBDE103 | 2,2',4,5',6-Pentabromo-4'-methoxydiphenyl ether |
| 5PMBDE99 | 2,2',4,4',5-Pentabromo-5'-methoxydiphenyl ether |
| 4PMBDE101 | 2,2',4,5,5'-Pentabromo-4'-methoxydiphenyl ether |

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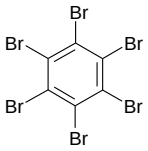
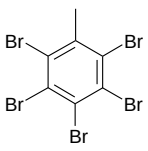
## 2.3 Other brominated flame retardants

### *2.3.1 Hexabromobenzene (HBB)*




Hexabromobenzene is used in electronic goods and plastics as an additive BFR and enters the environment through leaching from the material. In addition HBB may be formed during pyrolysis or photolysis of PBDE-209 (decabromodiphenyl ether). Relatively high levels of HBB were found in pooled herring gull eggs from the Great Lakes of North America (Gaulthier et al., 2007). In addition, HBB has been found in air and in sediments (Chemicals in the Environment, 2001; Watanabe et al., 1986) and in plasma and eggs from Glaucous gulls in the Norwegian Arctic (Verreault et al., 2007).

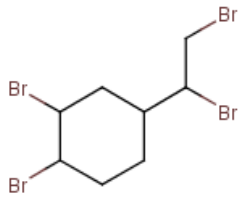
### *2.3.2 Pentabromotoluene (PBT)*




PBT is a relatively unknown flame retardant which is traded under the names Bromcal 81-5 or FR-105 and used in textiles, paint emulsions and polyester resins. PBT has been detected in sediment (Hyötyläinen and Har-

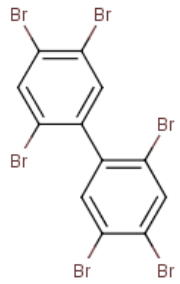
tonen, 2002; Schwarzbauer et al., 2001), air (Hoh et al., 2005) and in some pooled herring gull eggs from the Great Lakes (Gaulthier et al., 2007).

### 2.3.3 1,2-dibromo-4-(1,2-dibromoethyl)cyclohexane (TBECH)



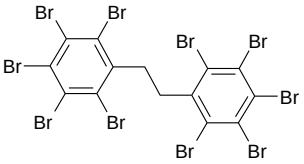

TBECH has been used mainly as an additive flame retardant in polystyrene and polyurethane (Andersson et al., 2006). TBECH can consist as one of the four enantiomeric forms alpha, beta, gamma and delta. The commercial TBECH product consists of predominately the alpha and beta enantiomers (Arsenault et al., 2008). However, with addition of heat as in manufacturing of the products into which TBECH has been added the enantiomers may be converted to the gamma and delta isomers (Arsenault et al., 2008). TBECH has been found to bioaccumulate in fish, and all four enantiomers have been detected in gulls eggs, though the beta isomer was the dominating one (Rattfelt et al., 2006; Gauthier et al., 2009). TBECH, mainly the gamma and delta isomers, have been found to act as androgen hormone receptor agonist (Khalaf et al., 2009).

### 2.3.4 2,2´,4,4´,5,5´-Hexabromo biphenyl (PBB-153)



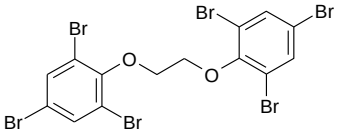

PBB-153 (2,2´,4,4´,5,5´-hexabromo biphenyl) was the major component of Firemaster BP-6 (Matthews et al., 1977). PBB-153 has, along with other brominated biphenyls, been detected in marine mammals from several regions (von der Recke and Vetter, 1986).

### 2.3.5 Decabromodiphenylethane (DBDPE)



DBDPE is an additive type of BFR which is applied in styrenic polymers, wire, cables, engineering resins and elastomeres. DBDPE is sold under different trade names, the most common ones are Saytex 8010 and Firemaster 2100. DBDPE has been detected in fish (walleye) (Law et al., 2007), in captive panda in China (Hu et al., 2008), in air near the Great Lakes (Venier and Hites, 2008), in house dust (Stapleton et al., 2008) and in tree bark (Qui and Hites, 2008)

### 2.3.6 1,2-Bis(2,4,6-tribromophenoxy)ethane (BTBPE)



BTBPE is traded as for example FF-680 or FireMaster 680 and seen as a replacement for the PentaBDE mixture. BTBPE has been detected in environmental samples (Qui and Hites, 2008) and in air and mussels, whitefish and zooplankton (Law et al., 2007). BTBPE was also found in fulmar eggs from the Faroe Islands (Karlsson et al., 2008) and in herring gull eggs around the Great Lakes (Verreault et al., 2007).

### 2.3.7 Polybrominated dibenzo-p-dioxin/furan (PBDD/ PBDF)

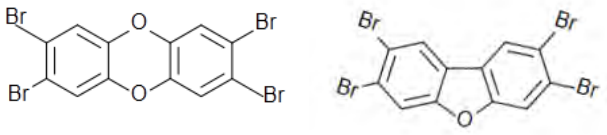


***Figure 2: Examples of a brominated dibenzo-p-dioxine (left) and a brominated fibenzo furane (right).***

It has been shown that PBDDs are formed as a by-product during the manufacture of BFRs and during combustion of materials containing BFRs (Buser, 1986; Sakai et al., 2001). PBDD/Fs have reached detectable levels in both environmental and human samples including waste from TV sets (Wichmann et al., 2002), waste incineration fly ash (Sovocool et al., 1998; Hagberg et al., 2005), fish (Ashizuka, 2008), ambient air (Li et al., 2008; Watanabe et al., 1995) and in human adipose tissue (Choi et al., 2003; Jogsten et al., 2010).

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## 2.4 Polychlorinated naphthalenes

Polychlorinated naphthalenes, PCN, consist of a range of compounds where the basic backbone is a naphthalene molecule with one or more chlorine substituents. In all, 75 possible PCN congeners exist. The PCN isomers analysed in the present study are given in Table 3. The lipid solubility of the PCN congeners, expressed as n-octanol/water partition coefficient, Log KOW, range from about 5.5 for tri-CNs, 5.1–6.1 for tetra-CNs, 5.7–6.5 for penta-CNs and 6.0–6.7 for hexa-CNs with hepta and octa substituted congeners in the range 6.4–6.6 (Bidleman et al., 2010). PCN has potential for long-range transport and PCN congeners, dominated by

the tri- and tetrachlorinated homologues, have been detected in arctic air (Harner et al., 1998).

In PCN, chlorine substitutions in chlorinated congeners occur at sites 1 to 8. Positions 1, 4, 5 and 8 are also referred to as alpha-positions, whereas positions 2, 3, 6 and 7 are beta-positions (Falandysz, 1998).

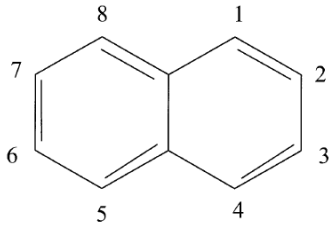


**Table 3: The PCN isomers analysed in the present study. Data on descriptions and CAS nr. are taken from Bidleman et al., 2010, and ChemIDplus Lite.**

| Abbreviation | CAS nr. | Name |
|---|---|---|
| PCN-13 | 50402-52-3 | 1,2,3-trichloronaphthalene |
| PCN-28/36 | 53555-63-8/67922-22-9 | 1,2,3,5-/1,2,5,6-tetrachloronaphthalene |
| PCN-27 | 20020-02-4 | 1,2,3,4-tetrachloronaphthalene |
| PCN-48 | 34588-40-4 | 2,3,6,7-tetrachloronaphthalene |
| PCN-46 | 3432-57-3 | 1,4,5,8-tetrachloronaphthalene |
| PCN-52 | 53555-65-0 | 1,2,3,5,7-pentachloronaphthalene |
| PCN-50 | 67922-26-3 | 1,2,3,4,6-pentachloronaphthalene |
| PCN-53 | 150224-24-1 | 1,2,3,5,8-pentachloronaphthalene |
| PCN-66 | 103426-96-6 | 1,2,3,4,6,7-hexachloronaphthalene |
| PCN-69 | 103426-94-4 | 1,2,3,5,7,8-hexachloronaphthalene |
| PCN-72 | 103426-92-2 | 1,2,4,5,7,8-hexachloronaphthalene |
| PCN-73 | 58863-14-2 | 1,2,3,4,5,6,7-heptachloronaphthalene |
| PCN-75 | 60983-69-9 | 1,2,3,4,5,6,7,8-octachloronaphthalene |

PCN has been produced and used in commercial products like Halowax in USA, Nibren waxes in Germany, Seekay waxes in UK, Clonacire in France and other (Beland and Geer, 1973; Brinkman et al., 1976; Falandysz, 1998; Falandysz et al., 2000). However, the production and application of PCNs diminished after the 1970s, and recent sources are mainly those of thermal processed. Industrial applications of technical PCN products have been as PCB, and indeed PCN may be seen as the predecessor to PCB; it has been used as thermal and electrical insulators in capacitors, transformers, cables etc., as preservatives in wood, paper and textile industry and in sealants, lubricants and coatings in a range of products (Hayward, 1998). The total production has been estimated roughly to 10% of the global PCB production, i.e. 150,000 tonnes in total (Brinkman and De Kok, 1980).

PCN is produced during thermal processes in general, like dioxins and furans (Falandysz, 1998). Some PCNs are regarded as combustion markers, i.e. that their sources are primarily combustion of wastes either containing PCN in the original waste or not, and even combustion of coal and wood (Noma et al., 2004; Lee et al., 2005). The PCNs associated with combustion processes are mainly the tetra- to hexachlorinated congeners (Falandysz, 1998). The PCNs analysed in the present study which

have been identified as combustion markers by one or more studies are PCN nos. 13, 36, 37, 48, 50, 52, 66 and 73 (Bidleman et al., 2010).

PCN is also a by-product in the production and reclamation of metals like aluminium and copper (Theisen et al., 1993; Aittola et al., 1994)

PCNs occurred as impurities in commercial PCB formulations, but then not in distinct patterns, as the ratio among the various PCNs in such blends did vary (Yamashita et al., 2000). Yamashita et al. (2000) also estimated that the PCN emitted from the use of PCB was less than 1% of the total production of PCN in Halowaxes. The same authors also found that, in commercial PCB blends, the dioxin-like toxicity contribution from PCN was less than that contributed by dioxin-like PCBs and polychlorinated dibenzofurans.

Chloralkali plants have also been a source of PCN, and then mainly hexa- and hepta-chlorinated naphthalenes (Järnberg et al., 1997; Falandysz, 1998).

### *2.4.1 Occurrence in marine mammals*

PCN has been detected in beluga whales and ringed seal from Baffin Island in the Canadian arctic sampled in 1993 and 1994 (Helm et al., 2003). The concentration of PCN found in blubber tissue was maximum 383 pg/g LW in beluga and maximum 71 pg/g LW in ringed seal, and the sum of PCNs thus on average less than 1% of the sum of coplanar PCBs. The PCNs found in ringed seal were dominated by tetrachlorinated congeners, whereas no hexachlorinated naphthalenes were detected. In belugas on the other hand, the higher chlorinated congeners were more common, and proportions of tetra- to hexachlorinated congeners ranged from on average approx. 20% for tetrachlorinated congeners to approx. 45% of pentachlorinated congeners. The difference in congener profiles in the two species which are sampled within short distances from each other and which both basically forage on arctic cod was assumed to originate from selective metabolism. PCN has also been analysed in ringed seal, grey seal, harbour porpoise from the Baltic, Svalbard, Greenland and from Kattegat, in pilot whale from Faroe Islands and minke whale and polar bear from Greenland and in orcas from the North-Eastern Pacific ocean (off British Columbia and Alaska/Washington State) and in harbour seal and polar bear from Alaska (Helm et al., 2003; Rayne et al., 2004; Corsolini et al., 2002; Wang et al., 2007; Bidleman et al., 2010). The mean concentrations of Sum PCNs in marine mammals listed in Bidleman et al., 2010 did not exceed 4.8 ng/g LW which was found in harbour seal from Alaska, and second highest levels were detected in pilot whales. In Alaskan polar bear liver tissue, the concentration of Sum PCN were at the same level as in blubber of the previous mentioned species with highest recorded concentrations of Sum PCN. Concentrations of Sum PCN in ringed seal blubber were maximum 0.32 ng/g LW (Muir et al., 2004). In orcas resident off British Columbia/ Alaska and Washing-

ton States, the concentration of Sum PCN was around 20 ng/g LW in blubber, whereas in migrating orcas, which feed at higher trophic levels than their resident counterparts, the mean concentration of Sum PCN was 167 ng/g LW (Rayne et al., 2004), with congeners 50/51 contributing far the largest part (>50%) of Sum PCN.

### *2.4.2 Biomagnification and toxicity*

Polychlorinated naphthalenes in general are not found to biomagnify (Lundgren et al., 2002; Nfon et al., 2008), although some congeners may biomagnify as found for instance in freshwater food webs at Bjørnøya and Lake Ontario (Evenset et al., 2005; Helm et al., 2008). The polychlorinated naphthalene congeners that may biomagnify are the heavier chlorinated ones like penta- and hexaCN, and in particular those with none or one pair of vicinal hydrogen atoms (Falandysz, 1998), like for instance PCN-66.

PCN has been shown to elicit dioxin-like toxic effects like cleft palate, hydronephrosis and induction of aryl hydrocarbon receptor activity (van den Berg et al., 2006). When the chlorine atoms are situated in the 2,3,6,7 positions, the molecule is structurally similar to the most potent dioxin molecule 2,3,7,8 tetrachlorodibenzo -p- dioxin, TCDD, this however, is neither a necessary nor a sufficient prerequisite for dioxin-like effects, as 2,3,6,7 chlorsubstituted PCN (PCN-48) does not induce AhR activity (Blankenship et al., 2000) and also congeners with only partially chlorine substituted beta-positions can elicit relatively high dioxin toxicity (Falandysz, 1998). Relative toxic equivalent factors have been assigned to several PCNs (Villeneuve et al., 2000; Blankesship et al., 2000). The hexachlorinated congeners were found to be the most potent compared to TCDD, with relative potency factors around $10^{-3}$ times that of TCDD (Villeneuve et al., 2000). Overall, the penta- to hepta-chlorinated naphthalenes were comparable to PCB congeners in terms of relative dioxin-like potency. Hexachlorinated naphthalenes like PCN-66, -67 and -68, penta CN (PCN-54) and heptaCN (PCN-73) were among the most potent PCNs (Blankenship et al., 2000; Villeneuve et al., 2000).

### *2.4.3 Regulations*

A suggestion to include Polychlorinated naphthalenes in the Convention on Long-range Transboundary air pollution was adopted by the parties to the 1998 Aarhus protocol on POPs (Persistent Organic Pollutants) in 2009. This amendment has not yet entered into force by the parties that adopted them (www.unece.org).

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## 2.5 Perfluorinated compounds

Perfluorinated compounds, PFCs, are molecules that consist of a carbon chain fully substituted with fluorine and a polar moiety in one end. If the carbon chain backbone is partially fluorinated, the compound is called polyfluorinated. The chain length of the most well-known PFC compound perfluorooctylsulphonate, PFOS, is eight carbon atoms. In the present study PFCs with chain lengths from four to eighteen have been analysed (Table 5). The polar moiety may consist of a variety of groups, like a sulphonyl or sulphate-group, a sulphamide, a carboxylate or salts or esters of these, or, as in the precursors for perfluoropolymers named fluoro-telomers, a hydroxyl group. With the hydrophobic tail and the hydrophilic head, the PFC molecule has common features with surfactants in general, meaning that they are soluble in water, with a tendency to stay at interfaces/surfaces (3M, 1999). This in contrast to "common" persistent organic pollutants, POPs, which normally shares the feature of being lipid soluble and very little soluble in water. Otherwise, in their characteristics as bioaccumulation potential, persistence and toxicity, the PFCs resemble POPs.

The PFCs are produced either by electrochemical fluorination, or by chemical coupling of precursor molecules like fluorotelomer alcohols (Lehmler, 2005). The majority of the production of the company 3M, a major producer of PFCs, was based on electrochemical fluorination of 1-octanesulphonyl fluoride, which yielded a range of molecules, whereof PFOS was one (3M, 1999). One of the differences between these two production methods is that the electrochemical fluorination may produce branched carbon chain backbones of various lengths, typically from 4–9 carbons, whereas the chemical coupling reactions (telomerisation) produce only straight chain products with chain lengths determined by the precursors.

The fluor-carbon bonds in the carbon chain backbone are very stable and do not break or form under natural conditions. Precursors that have been released to the atmosphere has been found to undergo chemical oxidation reactions to form for instance carboxylic acids like the reaction of 8:2 fluorotelomer alcohol or acrylates to form perfluoro carboxylates, like perfluoro octanoic acid, PFOA (Wallington et al., 2006; Butt et al., 2009).The background for the interest in elucidating the fate and transformations of PFCs is that this is a necessary prerequisite for understanding trends and occurrences of PFCs in the natural environment. Modelling studies and measurements indicate that the ocean transport to the Arctic is carrying a larger proportion of perfluoro carboxylic acids input than the atmospheric transport (Wania, 2007; Armitage et al., 2009). Modelling and measurements also indicate that this is the case for PFOS (Paul et al., 2009).

PFCs have been applied in a wide range of applications. PFCs has been used in stain- and waterproofing of textiles, leather, carpets, paper and cardboards, in cleaning agents and in inks, paints, varnishes and waxes and polishing products, and in other applications like fire-fighting foams, in manufacturing of semiconductors, in hydraulic oils and metal surface treatment (Prevedouros et al., 2006; Paul et al., 2009). The total production volume of PFOS-equivalents, i.e. products that were derived from perfluorooctane sulphonyl fluoride, POSF, and which potentially may end up as PFOS in the environment, has been estimated to 96,000 tons in the period 1970–2002, with an estimated emission to the air and water of 45,250 tonnes for the time-period 1970–2010 (Paul et al., 2009). Post 2002, the global total POSF production has been estimated to approx. 1,000 tonnes (Paul et al., 2009).

### *2.5.1 Long-range transport*

The perfluorinated acids are not expected to be protonated in natural environments, and thus they occur as anions which are not volatile, and thus mainly found and transported in ocean currents (Prevedouros et al., 2006; Young et al., 2007). Perfluorinated compounds that are neutral molecules, on the other hand, like fluorinated telomers, are volatile and

may be transported over longer distances in the atmosphere and undergo oxidation and be deposited. Young et al. (2007) detected perfluorinated acids in high Arctic ice caps deposited in the period 1995–2005. PFCs have also been detected in air and snow at several locations in Arctic areas (Shoib et al., 2006; Butt et al., 2010).

**Table 4: Molecular structures of three common PFCs are given. Source: ChemIDPlus Lite.**

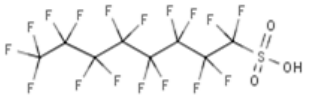
| Name/abbreviation | Molecular structure |
|---|---|
| Perfluorooctylsulphonic acid, PFOS |  |
| Perfluorooctylcarboxylic acid, PFOA |  |
| Perfluorooctylsulphonamide, PFOSA |  |

**Table 5: Overview of the PFCs analysed in the present study. CAS nos. were from ChemIDplus Lite (http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?CHEM) and Butt et al., 2010. The suffix acid is used indiscriminately from the deprotonated form, the "oate".**

| Abbreviation | CAS nr. | Name |
|---|---|---|
| PFBA | 375-22-4 | perfluorobutanoic acid |
| PFPeA | na | perfluoropentanoic acid |
| PFBuS | 29420-49-3 | perfluorobutanesulphonate |
| PFHxA | 307-24-4 | perfluorohexanoic acid (2,2,3,3,4,4,5,5,6,6,6-undecafluorohexanoic acid) |
| PFHpA | 375-85-9 | perfluoroheptanoic acid (perfluoro-n-heptanoic acid) |
| PFHxS | na | perfluorohexanesulphonate |
| PFOA | 335-67-1 | perfluorooctanoic acid |
| PFNA | 375-95-1 | perfluorononaoic acid (perfluoro-n-nonanoic acid) |
| PFOS | 1763-23-1 | perfluorooctane sulphonate |
| PFOSA | 754-91-6 | perfluorooctanesulphonamide |
| PFDS | na | Perfluorodecane sulphonate |
| PFDA | 335-76-2 | perfluorodecanoic acid |
| PFUnDA | 2058-94-8 | perfluoroundecanoic acid (perfluoro-n-undecanoic acid) |
| PFDoDA | 307-55-1 | perfluorododecanoic acid |
| PFTrDA | 72629-94-8 | perfluorotridecanoic acid |
| PFTDA | 376-06-7 | perfluorotetradecanoic acid (tetradecanoic acid, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,12,12,13,13,14,14,14-heptacosafluoro-) |
| PFHxDA | na | perfluorohexadecanoic acid |
| PFOcDA | na | perfluorooctadecanoic acid |

na = not available

### *2.5.2 Occurrence in marine mammals*

PFCs have been studied in a number of marine mammals as reviewed in Butt et al. (2010) and the following is taken from that review: PFOS levels in beluga and narwhale from Eastern Canadian Arctic incl. Hudson Bay, was around 10-20 ng/g. In minke whale liver from Greenland and Iceland, PFOS was from less than LoQ to 71 ng/g. In harbour porpoise from Icelandic waters, mean PFOS concentration was 38 ng/g. In pilot whale livers

from Faroe Islands in 2002, PFOS up to 336 ng/g were detected. In seals from the Arctic areas intermediate PFOS concentrations to those listed for baleen and odontocete whales were recorded. In polar bear from Alaska, Bering Sea, Beaufort Sea, Chukchi Sea, East and West Greenland concentrations of PFOS in liver were markedly higher; up to a mean liver concentration of 2,878 ng/g in polar bear from the East Greenland area.

### *2.5.3 Biomagnification and toxicity*

PFOS is found in high concentration going up the marine food chain tiers, and PFOS thus biomagnifies. Bioconcentration is however not high enough to meet the criteria defined in the Stockholm POP Convention, but in light of the high concentration of PFOS found not least in Arctic biota, and its high persistency, regulation of PFOS has been decided by a number of bodies including the Stockholm POP Convention.

Lau et al. (2007) recently reviewed the toxicity of perfluoroalkylacids, incl. PFOS. PFOS has a long residence time in plasma, estimated to 100 days in rats and 5.4 years in humans. PFCs are a diverse group of substances with different physio-chemical characteristics and biological interactions, so toxicity must be regarded for each compound per se. However, in general terms, exposure studies have shown that PFCs may induce developmental effects (be teratogenic), be carcinogenic, have hormonal effects and be immunotoxic in for instance rats.

### *2.5.4 Regulations*

In 2000, the 3M company informed US-EPA about the phase-out plan of all perfluorosulphonyl fluoride, POSF, based compounds which constituted more than 95% of the perfluorooctane compounds produces by the company, which in 2000 was estimated to be approx. 8,100,000 lbs (approx. 3.67 106 kg) when production at all 3M´s facilities were included (Weppner, 2000). The phase-out would start immediately, in mid 2000, and lead to a cessation of POSF based compounds production at the end of 2002.

In 2006 the marketing and use of perfluorooctane sulphonates, PFOS, was restricted by the EU Directive 2006/122/ECOF the European Parliament and of the council amending the annex I to directive 76/769/EEC.

In 2009, the Conference of the Parties of the Stockholm POP Convention adopted the inclusion of perfluorooctane sulphonic acid and its salts, PFOS, and perfluorooctane sulphonyl fluoride among the substances targeted for restriction in Annex B of the convention text (chm.pops.int). This amendment entered into force in 2010.

A suggestion to include perfluorooctane sulphonate, PFOS, in the Convention on Long-range Transboundary air pollution was adopted by the parties to the 1998 Aarhus protocol on POPs (Persistent Organic Pollutants) in 2009 (www.unece.org).

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# 3. Presentation of marine mammal species

## 3.1 Abbreviations used

The following abbreviations (Table 6) have been used for identifying the various samples in the figures and tables.

**Table 6: Abbreviations applied for analysed species.**

| Species | Location | Short ID sample |
|---|---|---|
| Ringed seal | East or West Greenland | Ri s G |
| Hooded seal | Norway | Ho s N |
| Harbour porpoise | Iceland | Ha p I |
| Harbour porpoise | Norway | Ha p N |
| White-sided dolphin | Faroe Island | Wh d F |
| Long-finned pilot whale | Faroe Island | Pi w F |
| Minke whale | Norway | Mi w N |
| Minke whale | Iceland | Mi w I |
| Minke whale | West Greenland | Mi w G |
| Fin whale | Iceland | Fi w I |

## 3.2 Ringed seal (Phoca hispida)

### *3.2.1 General description*

The ringed seal (*Phoca hispida*) has a circumpolar Arctic distribution and have great importance to the northern communities providing many of the basic needs in the original northern culture. The world population of ringed seals is at least a few million (Reeves, 1998). The total catch of ringed seals in Greenland has been estimated to about 70,000 in the early 1990s (Teilmann and Kapel, 1998). Male and female ringed seals are sexually mature by 5–7 years of age. Pupping usually occurs in March or early April and the period of lactation is 5–7 weeks (Reeves, 1998).

### *3.2.2 Distribution, population, migration and ecology*

Ringed seal is believed to be relatively sedentary although dispersions over long distances have been observed (Kapel et al., 1998; Born et al., 2004). No clear-cut boundaries are known to separate ringed seal stocks (Reeves, 1998). Ringed seal prefer land-fast ice with good snow cover in fjords and bays (MacLaren, 1958) but they also range widely in offshore pack ice (Finley et al., 1983). In winter, ringed seals spend most of the time in the water or in subniveau lairs on the stable ice, but after the

breeding season they haul out on the ice to moult until ice breakup (Vibe, 1950).

### *3.2.3 Feeding ecology*

Ringed seals are euryphagous, eating a variety of crustaceans, mainly the amphipod *Themisto libellula* and fish, mainly polar cod (*Boreogadus saida*) and arctic cod (*Arctogadus glacialis*) (*e.g.* Siegstad et al., 1998; Wathne et al., 2000; Holst et al., 2001).

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## 3.3 Hooded seal (Cystophora cristata) from the West Ice

### *3.3.1 General description*

The hooded seal (*Cystophora cristata*) belongs to the family Phocidae, and is found in the North Atlantic. The seal is named after a cap-like bulge essay on the forehead and nose of the adult male. The longevity of hooded seals is around 35 years. Sexual maturity is attained from 4–6 years for females and 3–4 years for males. In average, males are 2.5 m long and weigh about 300 kg. The females are smaller than the males, in average 2.2 m long and weighing about 160 kg. Pups are born nearly 1 m

long and weighing about 22 kg. The lactation period lasts only 4–5 days (Kovacs et al., 2009).

### *3.3.2 Distribution, population, migration and ecology*

There are four major breeding areas for hooded seals: the Gulf of St. Lawrence, the East of Newfoundland (the "Front"), the Davis Strait and the West Ice in the Greenland Sea. The population density at the West Ice is monitored regularly by the Norwegian Institute of Marine Research (IMR). In 2007 the total population at the West Ice was estimated to 82,400 (Gjøsæter et al., 2010). Apparently, the stock has declined during the period 1946–1980, with subsequent stabilization at a level which is only 10–15% of the 1946-level. Because of this the hooded seal was protected at the West Ice from 2007. Only a few animals have been taken for scientific purposes (413 in 2009). After the breeding season the seals leave the pups and start on feeding migrations. The Greenland Sea stock returns again to the West Ice for moulting in June–July. Except for the breeding and moulting season, these seals migrate between the coasts of Iceland, Faroe Islands, Norway and Svalbard for hunting. Known predators are polar bears, Greenland sharks and killer whales (Gjøsæter et al., 2010).

### *3.3.3 Feeding ecology*

Hooded seal feeding usually takes place in deep water, normally at depths of 100–600 m. The stomach contents from the West Ice hooded seals show that it consumes a variety of species, preferably squid, polar cod, capelin, redfish and halibut. The fat deposits are built up during the feeding season, during the breeding and moulting season these blubber stores decrease rapidly. The females gain about 30 kg of weight prior to lactation. During the short but intensive lactation period, the pups more than double their birth weight (Kovacs et al., 2009).

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Kleivane, L., Severinsen, T., Lydersen, C., Berg, V., Skaare, J., U. 2004. Total blubber burden of organochlorine pollutants in phocid seals; methods and suggested standardization. Sci Tot Environ 320: 109–119.Harbour porpoise (Phocoena phocoena)

### 3.3.4 General description

The harbour porpoise (*Phocoena phocoena*) belongs to the family of Phocoenidae. They are found in cold temperate to sub-polar waters of the Northern Hemisphere (Gaskin, 1984; Read, 1999). The conservation status of the harbour porpoise is "least concern" (www.iucn.org). The maximum age is estimated to be about 20 years. Sexual maturity is attained at an age of 3–5 years. The maximum length of females is about 1.9 m, males are smaller. Maximum weight is 90 kg, but few porpoises reach lengths above 1.5 m and weights above 60 kg.

### 3.3.5 Distribution, population, migration and ecology

Harbour porpoises are usually found in continental shelf waters, although they occasionally travel over deeper offshore waters. They range along the coast lines of USA, Canada, Japan, West Africa, and Western Europe and are also found in the Black Sea, Marmara Sea, and Sea of Azov. Also, they occur around Greenland, Iceland, Faroe Islands, and Great Britain. The population has been estimated at 43,000 in Iceland and 11,000 off North Norway to the Barents Sea (Gilles et al., 2011; Bjørge and Øien, 1995). However, these are minimum estimates from surveys designed for large whales. In the North Sea, the total number of individuals is estimated at 350,000. Changes in population distribution have been observed within the North Atlantic and North Sea areas, mainly explained by shifts in occurrence of prey. The animals generally live together in groups of 2–5 individuals. Known predators are white sharks (*Carcharodon carcharias*) and killer whales (*Orcinus orca*). Another threat is interaction with fishery. Static fishing by-catch in fishing gear is considered as the main anthropogenic mortality factor for harbour porpoises worldwide.

### 3.3.6 Feeding ecology

Harbour porpoises generally prey upon schooling fish species such as herring (*Clupea harengus*), whiting (*Merlangius merlangus*) and cephalopods. Studies in Icelandic waters in the 1990's showed capelin (*Mallotus villosus*) to be the dominant prey species (Víkingsson et al., 2003). Capelin appears also to be the most important prey species in the northern areas off Norway. In the more southern Norwegian waters herring is the dominant prey (Aarefjord et al., 1995). In the North Sea, the main prey are herring, mackerel (*Scomber scombrus*) and tobis (*Ammodytes tobianus*). However, in general the diet of harbour porpoise is diverse, with more than 40 and 30 identified prey species in the Icelandic and Norwegian studies respectively (Aarefjord et al., 1995; Víkingsson et al., 2003).

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## 3.4 Atlantic white-sided dolphin (Lagenorhynchus acutus)

### *3.4.1 General description*

The Atlantic white-sided dolphin (*Lagenorhynchus acutus*) is a numerous predator inhabiting temperate and sub-polar waters of the North Atlantic. The species is mainly a deep-water species that is most abundant in areas of steep topographic relief. They live in shoals, from ten to a hundred animals, but offshore congregations of several hundred animals is not unusual. The white-sided dolphins often occur in mixed schools with pilot whales (*Globicephala melas*) and/or bottlenose dolphins (*Tursiops truncatus*). They can be observed in the productive environment surrounding the Faroes all year round. But, from historical sightings and hunting data, they seem to be most frequent in these waters in summer and autumn.

### *3.4.2 Distribution and movements*

The Faroe Islands are located at 62°N and 7°W, central on the ridge going between Iceland and Shetland. Since the Norse settlement in these islands one thousand years ago, a drive fishery has been practiced on toothed cetaceans for consumption of the meat and blubber. The Faroese area is an important feeding and breeding area in the summertime for many of the North Atlantic cetacean species. For the white-sided dolphin the area around the Faroes seems to be a feeding area, but not a breeding area. The white-sided dolphin shows a pelagic distribution in

Faroese waters in summertime that is also seen further south and west in the North Atlantic. Furthermore, this species has a more southerly distribution during summer than many other cetacean species. The drives of white-sided dolphins mostly occur in summertime, but with a tendency to have also a spring peak. This is consistent with the peak in stranding in Ireland in March–April.

Offshore observations of the white-sided dolphins in the North Atlantic have been demonstrated to be clustered with fin whales (*Balaenoptera physalus*) and great skua (*Stercorarius skua*) and arctic skua (*S. parasiticus*). So, high concentrations of krill which is known to attract fin whales obviously also attract piscivorous dolphin and bird species that predate on fish species living of krill. In the Barents Sea it is found that white-sided dolphins were associated with the shifting capelin (*Mallotus villosus*) distribution. A study on movements behaviours, where animals were tagged in the Faroes, revealed that the animals directed for the slopes of the Faroe Plateau, either north or south-east of the islands, and that they tended to follow these slope areas as they moved. The diving was mostly within the first two hundred meters of the water column. Supposedly, the summer distribution of white-sided dolphins follows that of their main prey.

### *3.4.3 Feeding ecology*

The feeding habit of the Atlantic white-sided dolphin in the Faroe Islands has been assessed by reconstructing the diet from hard prey remains recovered in stomachs (N = 278) of animals taken in the drive hunt in the islands in the years 2001 to 2006. Samples were only assessable in August and September due to seasonality in the occurrence of the species in Faroese waters. Small pelagic and semi-pelagic shoaling fish species dominated the diet of the white-sided dolphins, while cephalopods and polychaets accounted for a negligible fraction of the diet. Blue whiting (*Micromesistius poutassou*) was the overall dominating prey species, occurring in 90–100% of the stomachs and contributing 36–99% by number and 45–97% by weight of prey consumed, irrespective of sampling year. Other primary prey species contributing significantly to the diet in various years were Norway pout (*Trisopterus esmarkii*) (up to 58% by number) and whiting (*Merlangius merlangus*) (up to 39% by mass). Greater argentine (*Argentina silus*) and sandeels (*Ammodytes sp.*) were relatively important in the diet in some years. The fish predated upon by Atlantic white-sided dolphin were generally of small sizes. The overall average fish size was 71 mm and the range mainly between 3 cm and 21 cm, but most frequently less than 10 cm. This corresponds to 0-group and juvenile fish. There was a week tendency that the larger dolphins predated upon larger specimens than smaller dolphins. Also, larger dolphins more frequently predated upon greater argentine and whiting than smaller dolphins that instead preferred sandeels.

## 3.5 The long-finned pilot whale (Globicephala melas)

### *3.5.1 General description*

The long-finned pilot whale (*Globicephala melas*, Traill) is harvested in the Faroe Islands (NE Atlantic) for local subsistence purposes. From July 1st, 1986 to July 1st, 1988, an international team examined 40 of a total of 43 schools of pilot whales landed in the islands in that period. The study comprised 3,488 whales from a total of 3,635 whales landed. The purpose of the examinations was to study the exploited population and its life history, feeding, ecological energetics, pollutant loads, parasitology, and population genetics (Bloch et al., 1993a). The average length, age and weight for pilot whales for the analysed individuals are given in-Table 7). The length distribution divided on sex for the specific pods is shown in Bloch et al. (1993a: Table 5, p: 17–20).

The parameters for this species, taken from Bloch et al. (1993b), Desportes et al. (1993), and Martin and Rothery (1993), were:

- Length at birth: 177.6 cm
- Weight at birth: 75 kg
- Pregnancy: 12 month
- Suckling time: 3.4 year
- Mortality rate: 7.45% (males; 7.37% females)
- Gross birth rate: 7.5%
- Inter-birth interval: 5.1 years

**Table 7: Long-finned pilot whales had at average the following parameters, taken from Bloch (1994). For the value "skinn", see Bloch and Zachariassen (1989).**

| Parameter | Both sexes | Males | Females |
|---|---|---|---|
| Age | 14.6 ± 0.2 years | 12.3 ± 0.3 years | 16.1 ± 0.3 years |
| Length | 401 ± 1.8 cm | 420 ± 3.3 cm | 387 ± 1.8 cm |
| Weight | 783 ± 17.7 kg | 879 ± 38.0 kg | 721 ± 14.9 kg |
| Skind | 6.3 ± 0.0 skind | 9.4 ± 0.01 skind | 5.4 ± 0.0 skind |

An average pod of pilot whales were composed as shown in Table 8. The table (Table 8) was made after examining 40 landed pods of long-finned pilot whales containing 3,128 whales from the period 1986–1988.

**Table 8: The average composition of a pod of long-finned pilot whales. Adapted from Bloch et al. (1993a) and Desportes et al. (1993).**

| Description of status | % |
|---|---|
| Immature males | 26.1 |
| Males in early maturity | 1.5 |
| Males in late maturity | 10.8 |
| Mature males | 1.1 |
| Immature females | 20.2 |
| Mature females with no more information | 3.2 |
| Pregnant females with no more information | 8.9 |
| Pregnant and lactating females | 0.3 |
| Pregnant, non-lactating females | 20.4 |
| Lactating females | 1 |
| Resting females, i.e. mature females which are not pregnant or lactating | 6.6 |

### *3.5.2 Distribution and movements*

All year round the pilot whale can be seen in Faroese waters, but with a peak time of occurrence in July–September (Bloch et al., 1993a). When satellite tagged, the whales moved along the border of the shelf to the deep water (Bloch et al., 2003).

### *3.5.3 Feeding ecology*

The long-finned pilot whale is a squid eater, and if lack of those, they eat fish and prawns (Desportes and Mouritsen, 1993). This places them at the top of the food chain.

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## 3.6 Minke whale (Balaenoptera acutorostrata)

### *3.6.1 General description*

The minke whale (*Balaenoptera acutorostrata*) is the smallest of balaenopterids (rorquals or baleen whales). With a worldwide distribution, it is the most common of the balaenopterids. It attains a length of 8–9 m and a weight of about 5–8 tonnes in the North Atlantic. As with all balaenopterids, the females are somewhat larger than the males. Minke whales may become from 30–50 years old. Sexual maturity is obtained at 5 to 7 years of age. The mating and breeding areas are not known but supposed to be at lower latitudes. Mating occurs in the late winter and gestation lasts about 10 months (Horwood, 1990). Minke whales are black or dark grey dorsally and white on the ventral side. A transverse white band is characteristic for the species in the Northern Hemisphere. Minke whales tend to be solitary animals although they sometimes are seen travelling in pairs or in small groups of 4–6. In this report, only the northern minke whale from the Northern Hemisphere is discussed.

### *3.6.2 Distribution, population, migration and ecology*

For management purposes, the International Whaling Commission (IWC) identified four different stocks of minke whale in North-Atlantic waters (Donovan, 1991): the East-Canadian, West-Greenlandic, Central-Atlantic and North-East-Atlantic populations (Christensen and Øien, 1990).

However, it is not known whether these populations differ biologically. In general, balaenopterids migrate between the cold northern nutritious waters and warmer sub-tropic areas for mating and calving. During the summer (April to September), the minke whales stay in coastal and shelf waters. During the winter (October to March) the minke whales stay in more temperate and sub-tropic waters, where they are thought to mate and calve (Horwood, 1990). Different migration patterns are observed for females, males and juveniles. Females arrive first to the northern areas, followed by the males one to two months later. Juveniles arrive during the summer. The largest animals seem to migrate further to the north during the summer, all the way to the ice edge in the Barents Sea and at Svalbard (Horwood, 1990).

Norway hunts minke whales from North-East-Atlantic and Central-Atlantic populations. The hunting quota for Norway was 885 animals in 2009. Based on counting by the Norwegian Institute of Marine Research (IMR) in 2002–2007, the stock in the North Sea, along the Norwegian coast, Barents Sea and at Svalbard was estimated to be 81,400 individuals. Additionally, 26,700 animals were counted in the management area around the Jan-Mayen Island, which is also utilized by Norwegian whalers.

Iceland hunts minke whales from the Central North Atlantic population. The hunting quota for Iceland in 2009 was 200 animals, although only 81 were taken. According to the 2001 sightings survey of the Marine Research Institute of Iceland (MRI), 67,000 northern minke whales were estimated in the Central North Atlantic stock region, with 44,000 animals in Icelandic coastal waters. An aerial survey conducted in coastal Icelandic waters in 2007 yielded abundance estimates of 10,700 and 15,100, depending on the method of analysis. A survey conducted in Faxaflói bay, SW-Iceland in 2008 showed much higher densities than in 2007, indicating that the unusually low densities in 2007 were due to a temporary shift in distribution within the population area. The aerial survey covered only a small proportion of the Central North Atlantic stock area, and large adjacent areas were poorly covered by vessels because of unfavourable weather conditions. Based on a new stock assessment by the Scientific Committee of the North Atlantic Marine Mammal Commission (NAMMCO), MRI has recommended that annual catches of common minke whales by Icelandic whalers from the Central North Atlantic stock should not exceed 200 animals in 2011 and 2012.

### *3.6.3 Feeding ecology*

Minke whales accumulate fat during summer for use for the rest of the year including energy expenditure during mating and calving in the winter. Minke whales feed on a wide variety of fish and invertebrates. In the North Atlantic, they consume mainly krill (*Thysanoessa spp*. and *Meganychtiphanes spp.*), herring (*Clupea harengus*), capelin (*Mallotus villosus*), sandeel (*Ammodytidae*), cod (*Gadus morhua*), polar cod (*Boreogadus saida*), haddock (*Melanogrammus aeglefinus*), as well as other species of fish and invertebrates (NAMMCO, 1998). The diet varies both spatially and temporally. In general, for the North-East Atlantic stock area krill, herring and cod are the most important prey species. In the North-West capelin appears to make up a larger part of the diet. Norwegian surveys have shown that minke whales that were caught in Lofoten and at the coast of Finnmark preyed mainly on herring and cod, while whales caught in the Barents Sea and near Svalbard preyed mostly on krill and capelin. Interannual variations in diet composition, probably reflecting prey availability, have also been noted in the North-East Atlantic (Haug et al., 1999). In the Central-North Atlantic stock, research in Icelandic waters during 2003–2007, has shown appreciable spatial and temporal variation in diet composition (Víkingsson and Elvarsson, 2010). In this Icelandic study, sandeel was the most common prey (38%) and was particularly dominant in the more southern areas (Figure 3). Large benthic fish together constituted altogether 26% of the diet, with cod and haddock being the most important species. Other important prey species include planktonic crustaceans (krill) and capelin (Figure 3).

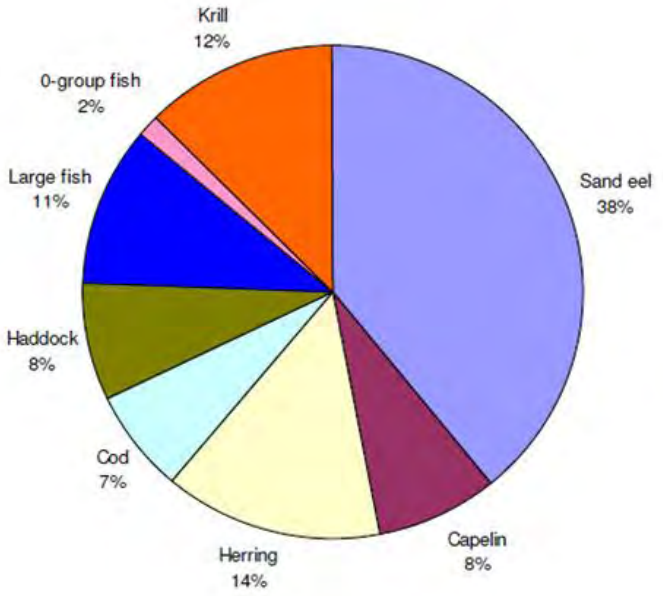


***Figure 3: Preliminary results on diet compostition of minke whales in Icelandic waters during 2003–2007, figure from Víkingsson and Elvarsson (2010).***

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## 3.7 Fin whale (Balaenoptera physalus)

### *3.7.1 General description*

The fin whale (*Balaenoptera physalus*) is a large baleen whale, second in size only to the blue whale (*Balaenoptera musculus*). In the Northern Hemisphere the average length of fin whales is about 19 m for males and 20.5 m for females. Adult fin whales can weigh between 45 and 75 tonnes, depending on the time of year and their individual body condition (Víkingsson et al., 1988; Víkingsson, 2004). Fin whales are dark grey to brownish black in colour along the top of the body, while the throat, belly and undersides of the flippers and tail flukes are white.

The biology of fin whales sampled from the Icelandic catch has been studied between 1977 and 1989 (Lockyer and Sigurjónsson, 1992). In this area, the female fin whale first gives birth at an age between 7 and 12 years, and adult males reach sexual maturity at about 6–10 years of age. The age of sexual maturity for both sexes has varied significantly over time, possibly in response to food availability and/or hunting pressure. Calves are believed to be born at intervals of 2 to 3 years. Calves nurse for 6–8 months and are weaned until they are 10 to 12 m in length. Mating and calving are thought to occur during the winter months, but no specific mating or calving "grounds" have been reported for fin whales. Fin whales can reach up to 100 years in age. Several hybrids of fin and blue whales, some pregnant, have been recorded, and 5 genetically confirmed (Spilleart et al., 1991; Árnason et al., 1991; Bérubé and Aguilar, 1998).

### *3.7.2 Distribution, population, migration, and ecology*

The fin whale has a worldwide distribution, found in all oceans ranging from tropical to polar regions. They are largely pelagic and are rarely seen in near-shore waters. They are migratory, and exhibit seasonal movements between lower latitudes in winter and high latitudes in summer. Some taxonomists classify fin whales from the Northern and Southern Hemispheres as two subspecies, *B.p. physalus* and *B.p. quoyi* respectively. There is generally considered to be at least 3 distinct worldwide populations: Southern Hemisphere, North Atlantic and North Pacific these are further subdivided genetically.

Fin whales have been the main target species in the Central North Atlantic (East Greenland-Iceland stock area) of regular shipboard surveys (NASS, TNASS) conducted in recent decades (Víkingsson et al., 2009).

From the 1995 sightings survey, the number of fin whales in the East Greenland, Iceland, and Jan Mayen stock area (EGI stock area) was estimated at 18,900 animals. Results from a survey conducted in 2001 showed an increase in abundance in comparable areas, with a total population size of around 24,000 fin whales. The abundance estimate from

the 2007 survey (21,000 animals) is not significantly different from the 2001 estimate.

The fin whale falls under the management jurisdiction of the International Whaling Commission (IWC) for those countries that are members. In 1986, the IWC instituted a temporary moratorium on commercial whaling. Greenland continues to hunt fin whales under "aboriginal subsistence" quotas, which do not fall under the moratorium. Iceland withdrew from the IWC in 1992, and rejoined in 2002 with a reservation against the moratorium. Commercial hunting of fin whales in Icelandic waters was resumed in 2006 with the take of 7 animals, and 125 fin whales were taken in 2009.

Fin whales around the Faroe Islands are part of the West Norway-Faroe Islands stock area, but the stock relationships of these whales are unclear.

For the East Greenland-Iceland stock area, recent surveys and modelling suggest that the stock is approaching or at its initial, pre-harvest abundance (NAMMCO, 2000; 2003). Under very conservative assumptions about stock structure and the rate of population growth, it is very likely that the stock can maintain an annual harvest of about 150 whales. If catches were spread over a wider area than they were in the recent past, sustainable catches could probably be higher.

### *3.7.3 Feeding ecology*

Like other large baleen whales, fin whales feed by "gulping" in large swarms of prey. Fin whales are known to have a broad diet including copepods, krill and pelagic fish such as capelin (*Mallotus villosus*) and juvenile herring (*Clupea harengus*) (Martin, 1990; Woodley and Gaskin, 1996; Sigurjónsson and Víkingsson, 1997; Flinn et al., 2002). Squid may also be eaten in some areas. On the whaling grounds off West Iceland the diet is almost entirely (97%) composed of krill (*Meganyctiphanes norvegica*) while pelagic fish species s.a. capelin have also been found in their stomach (Sigurjónsson and Víkingsson, 1997).

Feeding activity varies greatly by season due to variation in prey abundance. It is important for fin whales to build up energy reserves in the form of stored fat and blubber during the summer, since their prey may be less available in their wintering areas. Fin whales have very few natural predators due to their large size. Calves and even adults may occasionally be taken by killer whales (*Orcinus orca*).

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# 4. Materials

## 4.1 Sampling

Samplings of tissues from seals and whales have been done for purposes of food harvesting or for scientific purposes. When shipping samples from the institution holding the samples to the laboratory performing all the analyses, the shipment has been done with the permits required by the Convention on International Trade in Endangered Species of Wild Fauna and Flora, CITES.

## 4.2 Sample selection and preparation

A key issue when selecting samples for trends studies, meaning studies where direct comparison between samples are essential, is that the samples are as comparable as possible. Also, of paramount interest is to reduce the "noise" in the material, which in this case is individual variability in pollutants concentrations. Such variability may stem from food-preference, food-availability and age and sex. The sexual related parameters are those related to reproduction and lactation, which in the case with mammals and lipid soluble pollutants are potentially very influential on the body pool of contaminants, both seen from the side of the deliverer – the female – and the recipient – the pup. Age does influence the contaminant concentration mainly in those cases where the pollutant in question is persistent and bioaccumulating. But because age is not a parameter that can be determined without the application of specialist techniques, this is not necessarily known. The full length of the animals are much easier to establish, and thus in those cases where individuals were chosen without the knowledge of age, the body length was used as a proxy.

The tissues available in storages of the various institutes depend on a variety of factors, like what was originally the intent for collecting the sample and how much sample material has already been spent. Thus, for some species, it was impossible to find a sufficient number of samples of the desired characteristic, and this inevitably led to either a deselection of the species in question, or the replacement of the originally chosen tissue to one that would otherwise meet the criteria, but would not match the tissue chosen for the majority of species. The selection of muscle instead of liver for analyses of PFCs is such an example where the tissue with the known highest occurrence of these pollutants was not available for all species in all regions. The selection of muscle samples instead meant that the possibilities of detecting the pollutants de-

creased, but as long as the majority of compounds could still be detected, this was regarded as a sensible strategy.

## 4.3 Ringed seal samples from Greenland

Samples of ringed seals were obtained by local hunters from Ittoqqortoormiit, central East Greenland (blubber samples) and Avanersuaq, north West Greenland (liver samples). The hunting of seals mainly took place in May and June and the seals were either shot on ice in the water or caught in monofilament nets under the ice. Date of collection, body length, weight and sex were recorded. Blubber samples for chemical analysis were stored in polyethylene plastic bags until arrival at the laboratory of the National Environmental Research Institute (NERI) in Denmark, where they were transferred into rinsed glass containers with rinsed aluminium foil in-between the sample and the lid, and kept at -200C. Teeth for age determination were also taken and age was estimated by counting annual layering in the cementum of the canine tooth after decalcification, thin sectioning (14 µm) and staining in toluidine blue.

In the laboratory, blubber samples were lightly thawed and the outer exposed tissue layer was removed prior to the chemical analysis to minimize possible contamination due to handling and storage. In the laboratory, pooled samples of juvenile ringed seals (0 to 5 years old) were made of ringed seals from each of the years 1986, 2000 and 2006 from Ittoqqortoormiit and from the years 1984, 1998 and 2006 from Avanersuaq. One pooled sample consisted of 4 or 5 individuals (Appendix 1).

## 4.4 Hooded seal samples from the West Ice

Tissue samples of liver (N = 10) and blubber (N = 42) from female hooded seal were made available from the bio-bank at the Norwegian School of Veterinary Science and from IMR. The samples used in the present study were from scientific catches conducted by IMR in March 1990, 1997 and 2007 at the West Ice, in the Greenland Sea north for Jan Mayen, at about 70–73$^{o}$N and 02–18$^{o}$W. This area is the common breeding ground for hooded seals. The catch included mother and pup pairs. At the time of collection, the mean weight of pups was 34 kg. The seals were shot on the ice, and immediately dissected for biological sampling. Samples of blubber were taken at the back (Espeland et al., 1997; Kleivane et al., 2004). The samples were numbered and packed in plastic bags and kept frozen.

For the purpose of the study, about 4–5 g individual liver samples from 1990 (N = 5) and 2007 (N = 5) were pooled for years, and about 2-5 g individual blubber samples from 1990 (N = 5), 1997 (N = 4), and 2007 (N = 5) were pooled for years (Appendix 1). The pooled samples were kept frozen until analyses.

## 4.5 Harbour porpoise samples from Iceland and Norway

### *4.5.1 Icelandic samples*

Samples of liver and blubber from harbour porpoises from Iceland were provided by the bio-bank at the Marine Research Institute of Iceland (MRI). The samples used in the present study were from by-catches collected in SW-Iceland for scientific purposes in the years 1992 and 1997 (March–December) by the staff of MRI. The samples were kept frozen at -20°C until processing in the laboratory. For this study, the samples of blubber were taken both dorsally at the back of the dorsal fin and laterally below the dorsal fin. Six pools of blubber samples were prepared, three for 1992 and three for 1997, 5 animals in each pool. Liver samples from exactly the same animals were also pooled. Solely males were sampled to minimise biological variability. An age stratified sampling took place where the average ages of the pools for both 1992 and 1997 were 0.2, 2.2, and 3.6 years. Corresponding average lengths of the pooled animals were 127, 136 and 140 cm and the corresponding weights were 34, 40 and 43 kg. The blubber samples were taken in 2x2 cm wide cores across the whole thickness of the blubbers to prevent expected contaminant gradients within the blubbers to influence the results. An average amount of about 15 g per individual of both blubber and liver was used for pooling.

### *4.5.2 Norwegian samples*

Samples of blubber from 15 male harbour porpoises from Norway were made available by the bio-bank at the Norwegian Institute of Marine Research (IMR). The samples used in the present study were from animals by-caught in coastal fisheries in March, April, and June 2000 at three locations along the Norwegian coast (Hordaland, N Trøndelag and Finnmark) at latitudes 60–71$^{o}$N and longitudes 5–30$^{o}$E. The animals were stored frozen until dissection. Samples of blubber were taken at the back, in front of the dorsal fin. The mean length of the harbour porpoises was 135 cm ranging from 120 to 148 cm. For the purpose of this study, about 5 g blubber samples from 5 individuals from each of the three geographic locations were pooled. The total number of blubber pools was thus three. The pooled samples were kept frozen until analyses.

## 4.6 White-sided dolphin samples from the Faroe Islands

The samples used in the present study were taken from males collected in 1997, 2001/2002 and 2006 in drive fisheries.

The 1997 samples were taken for the purpose of contaminants analyses by the Environmental Agency by members of the team of scientists that had been involved in similar sampling in the 1986–88 pilot whale ecology and contaminants study. The majority of the samples are part of a larger collection of biological materials taken in the drive fishery in the period 2001–2009, in order to study the ecology of white-sided dolphins in Faroese waters. The samples were taken by skilled sampling crew of the Museum of Natural History. Scientific sampling by the Museum of Natural History typically started 1–2 h post-mortem at the location where the drive had occurred. The necropsy involved teeth for ageing, stomach for diet analysis, sex organs for reproductive studies and tissue samples of muscle, blubber, kidney and liver. Morphometric measures were also taken. The tissue samples of blubber and muscle were typically collected at the side of the section made in order to open the abdominal cavity. The samples were numbered, packed in aluminium foil and plastic bags and placed in the cold storage at -18$^{o}$C, typically 8–20 h post-mortem. For the purpose to study contaminants, a sub-sample was extracted from the frozen material and packed in aluminium foil which was then placed in a PE-plastic bag, or the sample was placed in a polymethyl pentene (TPX) jar.

Pooled samples were prepared that consisted of young males only. One pool consisted of samples from between 3 and 5 individuals (Appendix 1).

## 4.7 Pilot whale samples from the Faroe Islands

Samples of blubber and liver from pilot whales were made available from the marine mammal tissue bank at the Museum of Natural History in the Faroe Islands (1986–88 samples), and from the tissue bank of the Environment Agency. Sampling to the tissue banks had been done in connection with the traditional pilot whale drive fishery. The 1986–1988 field sampling were done by skilled sampling crew of the Museum of Natural History, and the samples taken in later years were taken by the Environment Agency as part of the environmental monitoring programme. Length was measured and sex was noted and for some of the pilot whales the age was determined. The age determination was done from the teeth as described in Bloch et al. (1993b). Samples of blubber were taken ventrally, at a transect aligned with approx. the posterior end of the dorsal fin. The 1986–88 samples were taken in this way as

described in Bloch et al. (1993a). Samples of liver were taken from the distal part of a liver lobe.

Pooled samples were prepared that comprised of young males only. One pool consisted of samples from between 2 and 8 individuals (Appendix 1).

All tissue samples were kept frozen at ca. -20°C.

## 4.8 Minke whale samples from Norway, Greenland and Iceland

### *4.8.1 Minke whales from Norway, 1993*

A total number of 17 out of 81 blubber samples of minke whale from several locations along the Norwegian coast were obtained from the bio-bank at the Norwegian School for Veterinary Science (NVH). The catching season was from May to September. The whales were part of a scientific catch for the Marine mammal's program, funded by the Research Council of Norway in 1993–1994. The samples were taken from the back of males of lengths ranging from 4.8–8.4 m. From Lofoten/Vesterålen (LO/V), 2 pools of six individuals each were prepared, about 10 g from each individual. One of the LO/V pools comprised whales caught in June–July, while the other LO/V pool of whales were caught in September. A third pooled sample from 1993 was made from subsamples of five individuals caught at Finnmark in August–September, each subsample weighing about 7 g. The whales were caught using a transect method by which the ship follows a certain predefined route, aiming at estimating the minke whale stock. This method secures that the sampling is not affected by the economic value of the animal and the cost of searching, in contrast to commercial hunting. Individual samples of this catch were earlier analysed for PCBs and OCPs (Holm, 2007).

### *4.8.2 Minke whales from Norway, 1999*

A total number of 17 out of 90 blubber samples of minke whale, caught in 1999 along the Norwegian coast, were obtained from the bio-bank at the NVH. These whales were caught for possible commercial export to Japan. From Finnmark (June–July), two pooled samples were prepared which were made out of six individual subsamples, each weighing about 5 g. From the North Sea (May–June), one pooled sample was made out of five individual subsamples each weighing about 5 g. Only a few individuals from this catch were analysed for PCBs and OCPs and a risk assessment was made (Skaare, personal communication).

### *4.8.3 Minke whales from Greenland, 1998*

Liver and blubber samples of minke whales were obtained by licensed whalers from southwest and central West Greenland during the period May to October 1998 (Born et al., 2007). For each whale the following information was available; date, location, sex and body length. All tissue samples were stored at -20$^0$C until processed in the laboratory. The individuals selected for this study were all females except for one male, and the length ranged between 5 and 6 m except one with a length of 7.25 m. Three pools were made, each of 4 individuals.

### *4.8.4 Minke whales from Iceland, 2003–2007*

The samples of minke whales from Icelandic waters derive from the scientific programme on minke whales in Icelandic waters, a programme carried out under the auspices of the Ministry of Fisheries in Iceland during 2003–2007, coordinated and managed by the Marine Research Institute of Iceland (MRI). Altogether 200 animals were caught during these five years from all around Iceland, all animals caught by random sampling from small areas decided prior to sampling. All tissue samples were stored at -20$^o$C until processing in the laboratory. Three pools of blubber were prepared of five males in each pool. All animals selected in this study were caught during May–August 2003–2007. Samples of blubber of widths of about 2x2 cm were taken across the whole core of the blubber, i.e. from skin to meat, since gradients in organic contaminants may be expected across the core. From each animal an average amount of 22 g was taken laterally under the dorsal fin. The pools were length stratified, the average lengths of the pools being 5.1, 7.0 and 8.5 m, the range in lengths being 4.7–8.7 m. Samples of various tissues of the minke whales from the scientific programme have been analysed extensively for various chemical constituents including inorganic and organic contaminants.

## 4.9 Fin whale samples from Iceland

Samples of fin whale muscle and blubber in 1986–1989 and 2009 were taken from male whales of 59–61 feet full length. In addition, blubber samples consisting of female and male whales taken in 1986–1987 (n = 6) and 2006 (n = 6) of full length 62–70 feet, were analysed (Appendix 1).

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# 5. Methods

## 5.1 Chemical analyses

### *5.1.1 PBDE analyses*

The method was as described in Rotander et al., (in prep. a): All organic solvents (methanol, n-hexane, dichloromethane, toluene) used were of pesticide grade and purchased from Sigma Aldrich (Steinheim, Germany). Anhydrous sodium sulphate ($Na_2SO_4$) were obtained from Fluka (Steinheim, Germany), silica gel 60 (70–230 mesh) and sulphuric acid ($H_2SO_4$) of pro analysis grade from Merck (Darmstadt, Germany), potassium hydroxide (KOH) (reagent grade pellets, Ph Eur) from Scharlau (Barcelona, Spain). Prior to use the silica gel was washed with methanol and dichloromethane and activated and stored in 120°C. Tetradecane was used as a keeper and obtained from Sigma Aldrich (Steinheim, Germany). The $^{13}$C-labeled internal standard (BDE-77) was purchased from Cambridge Isotope Laboratories Inc. (Andover, MA, USA), and $^{13}$C #139 was made available by Wellington Inc. (Guelph, Canada). Individual native PBDEs congeners nos. 28, 47, 66, 85, 99, 100, 138, 153, 154, 183 mixed into a quantification standard were also made available from Wellington Laboratories. $^{13}$C-labeled PCB congeners nos. 81, 114 and 178 were used as recovery standards and were provided by Cambridge Isotope Laboratories Inc. (Andover, MA, USA).

10–20 g of pooled blubber made up from 3–6 individuals (Appendix 1) was homogenized in a mortar with anhydrous sodium sulphate and approximately 5 g of the homogenate was transferred to glass columns (18 mm diameter). The internal standards were added and the lipids were eluted with hexane/dichloromethane (1:1, v/v). After solvent evaporation using low-pressure rotary evaporation, the lipid contents were determined gravimetrically. Sample clean up was performed using a multilayer silica column (18 mm diameter) containing KOH silica gel, neutral activated silica, 40% $H_2SO_4$ silica gel, 20% $H_2SO_4$ silica gel, neutral activated silica gel and activated $Na_2SO_4$. The analytes were eluted with hexane. Prior to instrumental analysis the $^{13}$C-labeled PCB-mix used as recovery standards were added. Individual PBDEs congeners nos. 28, 47, 66, 85, 99, 100, 138, 153, 154, 183 ($\sum_{10}$PBDEs) were analyzed by an Agilent 6890 GC coupled to a low-resolution mass spectrometer (Agilent 5975) operating in the NCI mode monitoring m/z 79 and m/z 81. The recovery standard of PCBs nos. 81, 114 and 178 were monitored at m/z 408. The negative chemical ionisation-MS (NCI-MS) operating mode may in many instances be a more sensitive technique than EI-MS for the determination of PBDEs, although

the Br− ions (m/z = 79 and 81) used as quantifier and qualifier are less selective compared with the ions formed in EI (Covaci et al., 2007). $^{13}$C-labeled BDE-77 and BDE-139 were used as internal standards because they can both be used in the NCI mode for most biota samples (Athanasiadou et al., 2008; Karlsson et al., 2006), as well as in the EI mode if co-elution occurs. The samples of white-sided dolphins were analysed by EI-MS due to a co-eluting peak with one of the internal standards (BDE-77). The same chromatographic set-up and parameters as in the NCI mode were used and the analysis was performed in the selective ion recording mode (SIR), monitoring the two most abundant ions of the molecular bromine cluster for QA/QC purposes. Splitless injection was used to inject 1 µl of the final extract and quantification was carried out using the internal standard method. The column used for separation of analytes was a 30 m SGE DB-5 (0.25 mm, 25 µm) and the temperature program was set to initial 180°C for 2 min, ramped 15°C/ min to 205°C, 2°C/ min to 251°C and 6°C/ min to 325°C.

**Quality assurance**

PBDE congeners nos. 28, 47, 66, 100 and 99 were quantified against $^{13}$C-labeled BDE-77 and PBDE congeners nos. 85, 154, 153, 138, 183 against $^{13}$C-labeled BDE-139. The identification of PBDEs was based on accurate isotope ratio and retention time. With every batch of 6–9 samples extracted, an extraction blank was also prepared and analyzed as well as monitoring instrumental blanks of toluene. Detection limits were set to three times the signal to noise (S/N) and calculated for each sample individually. Repeatability was assessed by spiking experiments of six replicates of a whale blubber sample on two separate days, resulting in a relative standard deviation (RSD) between 9% and 29% depending on the BDE isomer. Reproducibility was calculated from four individual analyses of a blubber sample on different days. The RSD was calculated to between 15% and 33%, except for BDE-85 and BDE-138 where levels were close to or below the detection limit.

### *5.1.2 Methoxylated brominated diphenyl ethers*

The method was as described in Rotander et al. (in prep. b): All organic solvents (methanol, n-hexane, dichloromethane, toluene) used were of pesticide grade and purchased from Sigma Aldrich (Steinheim, Germany). Anhydrous sodium sulphate ($Na_2SO_4$) were obtained from Fluka (Steinheim, Germany), silica gel 60 (70–230 mesh) and sulphuric acid ($H_2SO_4$) of pro analysis grade from Merck (Darmstadt, Germany), potassium hydroxide (KOH) (reagent grade pellets, Ph Eur) from Scharlau (Barcelona, Spain). Prior to use the silica gel was washed with methanol and dichloromethane and activated and stored in 120°C. Tetradecane was used as a keeper and obtained from Sigma Aldrich (Steinheim, Germany). The $^{13}$C-labeled internal standard (BDE-77) was purchased from Cambridge Isotope Laboratories Inc. (Andover, MA, USA), and $^{13}$C BDE-

139 was made available by Wellington Inc. (Guelph, Canada). Individual native PBDEs congeners nos. 28, 47, 66, 85, 99, 100, 138, 153, 154, 183 and MeO-BDE congeners nos. 2PMBDE68, 6MBDE47, 5MBDE47, 4PMBDE49, 5PMBDE100, 4PMBDE103, 5PMBDE99, 4PMBDE101 mixed into two separate quantification standard were also made available from Wellington Laboratories. $^{13}$C-labeled PCB congeners nos. 81, 114 and 178 were used as recovery standards and were provided by Cambridge Isotope Laboratories Inc. (Andover, MA, USA).

10–20 g of pooled blubber made up from 3–6 individuals (Appendix 1) was homogenized in a mortar with anhydrous sodium sulphate and approximately 5 g of the homogenate was transferred to glass columns (18 mm diameter). The internal standards were added and the lipids were eluted with hexane/dichloromethane (1:1, v/v). After solvent evaporation using low-pressure rotary evaporation, the lipid contents were determined gravimetrically. Sample clean up was performed using a multilayer silica column (18 mm diameter) containing KOH silica gel, neutral activated silica, 40% $H_2SO_4$ silica gel, 20% $H_2SO_4$ silica gel, neutral activated silica gel and activated $Na_2SO_4$. The analytes were eluted with hexane. Prior to instrumental analysis the $^{13}$C-labeled PCB-mix used as recovery standards were added. Individual PBDEs congeners nos. 28, 47, 66, 85, 99, 100, 138, 153, 154, 183 ($\sum_{10}$PBDEs) and MeO-BDEs 2PMBDE68, 6MBDE47, 5MBDE47, 4PMBDE49, 5PMBDE100, 4PMBDE103, 5PMBDE99 and 4PMBDE101 were analyzed by an Agilent 6890 GC coupled to a low-resolution mass spectrometer (Agilent 5975) operating in the negative chemical ionization (NCI) mode, monitoring m/z 79 and m/z 81. GC/MS analysis monitoring m/z 79 and m/z 81 in the NCI mode has been shown to be a highly sensitive and selective method for the determination of brominated compounds in environmental matrices. The recovery standard of PCBs nos. 81, 114 and 178 were monitored at m/z 408. The samples in which the signal of the internal standard (BDE-77) was disturbed by a co-eluting peak were analyzed by LRGC/MS-EI. Confirmation analysis of MeO-BDEs was performed by HRGC/HRMS using a Micromass Autospec Ultima (Waters Corporation, Milford) operating at 10,000 resolution. The analysis was performed in the selective ion recording (SIR) mode, monitoring the two most abundant ions of the molecular bromine cluster. Splitless injection was used to inject 1 µl of the final extract and quantification was carried out using the internal standard method. The column used for separation of analytes was a 30 m SGE DB-5 (0.25 mm, 25 µm) and the temperature program was set to initial 180°C for 2 min, ramped 15°C/ min to 205°C, 2°C/ min to 251°C and 6°C/ min to 325°C.

**Quality assurance**

PBDE congeners nos. 28, 47, 66, 100, 99 and MeO-BDEs 2PMBDE68, 6MBDE47, 5MBDE47 and 4PMBDE49 were quantified against $^{13}$C-labeled BDE-77. PBDE congeners nos. 85, 154, 153, 138, 183 and MeO-BDEs 5PMBDE100, 4PMBDE103, 5PMBDE99, 4PMBDE101 were quanti-

fied against $^{13}C$-labeled BDE-139. The identification of PBDEs and MeO-BDEs was based on accurate isotope ratio and retention time. With every batch of 6–9 samples extracted, an extraction blank was also prepared and analyzed as well as monitoring instrumental blanks of toluene. Detection limits were set to three times the signal to noise (S/N) and calculated for each sample individually. Repeatability was assessed by spiking experiments of six replicates of a whale blubber sample on two separate days, resulting in a relative standard deviation (RSD) between 9% and 29%. Reproducibility was calculated from four individual analyses of a blubber sample on different days. The RSD was calculated to between 15% and 33%, except for BDE-85, BDE-138, 5MBDE47, 4PMBDE49, 5PMBDE100, 4PMBDE103, 5PMBDE99, 4PMBDE101 where levels were close to or below the limit of detection.

### *5.1.3 Other brominated flame retardants*

Organic solvents used were of pesticide grade and purchased from Riedel de Haën (methanol, n-hexane, dichloromethane, toluene, and xylene). Water used for blank samples and column washing was water, gradient HPLC grade from (Scharlau, Barcelona, Spain) Ethanol was purchased from Kemetyl (Stockholm, Sweden).

Open column chromatography was applied for approximately 1 gram tissue sample. Sample clean-up was performed using three open columns (multilayer silica, AlOx and active carbon). The multilayer silica columns contained KOH silica, neutral activated silica, 40% $H_2SO_4$ silica gel, 20% $H_2SO_4$ silica gel, neutral activated silica gel and activated $Na_2SO_4$ and was eluted with hexane. This column was followed by an AlOx column eluted with hexane/ dichloromethane (95/5 and 50/50 volume %) resulting in two fractions PCB and pesticides and dioxins. For additional clean up and fractionation on planarity an active carbon column, containing Carbopack C (Supelco) dispersed on Celite 545, which was eluted with 10 ml of hexane for non-planar compounds and then 80 ml of toluene to elute the planar fraction containing PCDD/Fs and PBDD/Fs. The non planar fraction was combined with first fraction from the AlOx column for the BFR analysis other than PBDD/DFs. Addition of the $^{13}C$-labeled recovery standards was done prior to instrumental analysis. Throughout the sample preparation the samples were kept shielded from UV light to avoid photo degradation.

A separate standard for the analysis of Deca BDE-209, BDPE (1,2-bis(pentabromophenyl)ethane) and BTBPE (1,2-Bis(2,4,6-tribromophenoxy)ethane) also from Wellington laboratories was prepared for the quantification standard of the "higher" brominated BFRs. The quantification standard for the "lower" brominated BFRs consisted of PBT (pentabromotoluene), HBBz (hexabromobenzene) and HBCD (hexa-bromocyclododecane). Screening experiments for TBECH tetra-

bromoethylcyclohexane were performed using isomeric mixtures of both the α- and β- isomers and the γ- and δ- isomers.

GC low resolution MS was performed using a HP 6890 GC coupled to a HP 5973 MS working in the negative chemical ionization (NCI) mode monitoring m/z 79 and m/z 81 for Deca-BDEs, DBDPE, PBT and HBB. Analytes were separated on a 30 m DB-5MS (0.25 mm id, 25 μm) column. For BTBPE fragment ions 257.8 and 259.8 and for Deca BDE-209 fragment ions 484.7 and 486.7 were monitored simultaneously in the NCI mode. Quantification was done using the internal standard method. Analysis of PBDD/DF was performed by injecting 1ul on a HRGC/HRMS using a Micromass Autospec Ultima (Waters Corporation, Milford) operating at 10,000 resolution. The analysis was performed in the selective ion recording (SIR) mode, monitoring the two most abundant ions of the molecular bromine cluster. Also conformatory analysis of TBECH were performed using the high resolution GC/MS system, using a 30 m DB-1 column (0.25 mm id, 10 μm).

**Quality assurance**

Method performance was controlled by extracting $^{13}C$-labeled internal standards allowing recovery values between 50–150%. With every batch of samples extracted an extraction blank was also prepared and analyzed. The detection levels were in the range 0.1–1 ppb, depending on congener, sample amount and type of tissue.

Screening experiments for TBECH tetrabromoethylcyclohexane using isomeric mixtures of both the α- and β- isomers and the γ- and δ- isomers were performed on both low resolution GC/MS and high resolution GC/MS for confirmation. The confirmation analysis for TBECH were performed on a Micromass high resolution GC/MS system coupled to a HP 6890 GC operating at 10,000 resolution monitoring the three most abundant isomers of the molecular ion cluster. Also confirmation of the co-eluting of BDE-154 and PBB-153 was done on the high resolution GC/MS system. For the analysis of the higher brominated BDEs a 15m column (0.25 mm id, 25 μm) was used instead of the routinely 30 m monitoring the two most abundant molecular ions of the bromine cluster for both BDE-153 (m/z 641.53, 643.53), PBB-153 (m/z 625.54, 627.53), the internal standard BDE-138 (m/z 653.57, 655.57) and the recovery standard PCB-178 (m/z 405.84, 407.84).

The MTM laboratory participates on a regular basis in international intercalibration studies. In studies organized by AMAP, QUASIMEME and the Norwegian Institute of Public Health the MTM laboratory qualified with z-scores between -2 and 2.

### *5.1.4 PCN*

All organic solvents (methanol, n-hexane, dichloromethane, toluene) used were of pesticide grade and purchased from Sigma Aldrich (Steinheim, Germany). Anhydrous sodium sulphate ($Na_2SO_4$) were obtained

from Fluka (Steinheim, Germany), silica gel 60 (70–230 mesh) and sulphuric acid ($H_2SO_4$) of pro analysis grade from Merck (Darmstadt, Germany), potassium hydroxide (KOH) (reagent grade pellets, Ph Eur) from Scharlau (Barcelona, Spain). Prior to use the silica gel was washed with methanol and dichloromethane and activated and stored in 120°C. Tetradecane was used as a keeper and obtained from Sigma Aldrich (Steinheim, Germany). Individual native PCN congeners nos. 13 (Tri), 28/36, 27, 48, 46 (Tetra), 52, 50, 53 (Penta), 66, 69, 72 (Hexa), 73 (Hepta) and 75 (Octa) were made available from Wellington Laboratories. The $^{13}C$-labeled PCBs used as internal standard were purchased from Cambridge Isotope Laboratories Inc. (Andover, MA, USA). $^{13}C$-labeled PCB congeners nos. 81, 114 and 178 were used as recovery standards and were also provided by Cambridge Isotope Laboratories.

**Quality assurance**

PCN congeners nos.13 (Tri), 28/36, 27, 48, 46 (Tetra), 52, 50, 53 (Penta), 66, 69, 72 (Hexa), 73 (Hepta) and 75 (Octa) were quantified against $^{13}C$-labeled PCBs. With every batch of 6–9 samples extracted, an extraction blank was also prepared and analyzed as well as monitoring instrumental blanks of toluene. The identification of PCNs was based on accurate isotope ratio and retention time, and detection limits were set to three times the signal to noise (S/N). Repeatability was assessed by spiking experiments of three replicates of a pilot whale blubber sample on two separate days, resulting in a relative standard deviation (RSD) between 18% and 33%. In each batch two unspiked samples were included, resulting in a RSD between 11% and 30% for the PCN congeners that were found above the limit of detection (LOD). Separation (and thus quantification) of PCN-50 was not possible due to a large co-eluting peak. PCN-50 could not be separated from the peak eluting at retention time 8.32.

### *5.1.5 PFC*

The method was as described in Rotander et al. (in prep. c). Methanol (HPLC) was obtained from Fisher Scientific (Leicestershire, United Kingdom), n-Hexane (>95%, pa for GC) from Fluka (Steinheim, Germany) and acetonitrile (>99%, pa for GC) from Labscan (Dublin, Ireland). Ammonium acetate (>99%, pa for HPLC) was purchased from Fluka (Steinheim, Germany) and ammonium hydroxide (25% in water), sodium acetate, and glacial acetic acid (100%) were purchased from E. Merck (Darmstadt, Germany). All water used was laboratory produced ultra pure water. Native and labelled standards originated from Wellington Laboratories (Guelph, Ontario, Canada) including perfluorobutane sulphonate (PFBuS), perfluorohexane sulphonate (PFHxS), perfluorooctane sulphonate (PFOS), perfluorodecane sulphonate (PFDS), perfluoropentanoic acid (PFPeA), perfluorohexanoic acid (PFHxA), perfluoroheptanoic acid (PFHpA), perfluorooctanoic acid (PFOA), perfluorononaoic acid (PFNA), perfluorodecanoic acid (PFDA), perfluoroundecanoic acid

(PFUnDA), perfluorododecanoic acid (PFDoDA), perfluorotridecanoic acid (PFTrDA), perfluorotetradecanoic acid (PFTDA). As internal standards $^{18}O_2$-PFHxS, $^{13}C_4$-PFOS, $^{13}C_2$-PFHxA, $^{13}C_4$-PFOA, $^{13}C_5$-PFNA, $^{13}C_2$-PFDA, $^{13}C_2$-PFUnDA and $^{13}C_2$-PFDoDA were used. $^{13}C_8$-PFOS, $^{13}C_8$-PFOA (Wellington Laboratories) and 7H-PFHpA (ABCR, Karlsruhe Germany) were used as performance standards. Monomethyl- and dimethyl branched PFOS and PFOA standards were from Wellington Laboratories.

Liver samples were homogenized in a mortar. A sub-sample of 1g was transferred to a 15 mL tube and the mass-labelled internal standards ($^{18}O_2$-PFHxS, $^{13}C_4$-PFOS, $^{13}C_4$-PFOA, $^{13}C_5$-PFNA, $^{13}C_2$-PFDA, $^{13}C_2$-PFUnDA and $^{13}C_2$-PFDoDA) were added followed by 0.4 mL 200 mM NaOH in MeOH. The mixture was vortex mixed and left standing. After 30 min 4 mL acetonitrile was added and the tubes were ultrasonicated for 15 min and subsequently shaken for 15 min. For neutralization, 20 µL 4M HCl in MeOH was added and the supernatant acetonitrile phase was removed after centrifugation (10,000xg, 30 min). The extraction procedure was repeated once. The acetonitrile fractions were combined and reduced to 2 ml by nitrogen evaporation, after which three portions of hexane (corresponding to a volume of 2:1 sample extract:hexane) was added and removed after 30 s of manual shaking. Finally, the sample extracts were transferred into a tube with 50 mg ENVI-Carb (Supelclean, 120/400 mesh, Supelco (Bellefonte, PA)) and 100 µL glacial acetic acid. The carbon solution was mixed using vortex for 30 s and then filtrated through a 0.2 µm GHP membrane (Pall, East Hills, NY, USA) and reduced to 200 µL using nitrogen after which 300 µL 2 mM ammonium acetate in water and the performance standards 7H-PFHpA,$^{13}C_8$-PFOS and $^{13}C_8$-PFOA were added. Analysis was performed using an Acquity UPLC coupled to an Quattro Premier XE (Waters Corporation, Milford) with an atmospheric electrospray interface operating in negative ion mode ((-)ESI-MS/MS). Separation was performed on an Acquity BEH C18 2.1 x 50 mm (100 mm for isomer analysis), 1.7 µm, kept at 50°C. An extra guard column (Waters PFC isolator) was inserted between the pump and injector to trap any fluorochemicals originating from the UPLC system. Injection volume was 10 µL and the flow rate was set to 400 µL/min. The mobile phases consisted of 2 mM ammonium acetate in methanol and 2 mM ammonium acetate in water. Multiple reaction monitoring was employed using the parent and product ions presented in Table S1 in supporting information. Perfluorohexan sulphonate (PFHxS), perfluorooctane sulphonate (PFOS), perfluorohexanoic acid (PFHxA), perfluorooctanoic acid (PFOA), perfluorononaoic acid (PFNA), perfluorodecanoic acid (PFDA), perfluoroundecanoic acid (PFUnDA) and perfluorododecanoic acid (PFDoDA) were quantified against labelled analogues. Perfluorobutanesulphonate (PFBuS) was calculated against $^{18}O_2$-PFHxS, perfluoropentanoic acid (PFPeA) and perfluoroheptanoic acid (PFHpA) against $^{13}C_2$-PFHxA, Perfluorodecane sulphonate PFDS against $^{13}C_4$-PFOS and perfluorotridecanoic acid PFTrDA against $^{13}C_2$-PFDoDA.

**Quality assurance**

Quantification was performed using the internal standard method with non-extracted standards dissolved in 30% methanol in aqueous 2mM ammonium acetate. The mean recoveries for $^{18}O_2$-PFHxS, $^{13}C_4$-PFOS, $^{13}C_4$-PFOA, $^{13}C_5$-PFNA, $^{13}C_2$-PFDA, $^{13}C_2$-PFUnDA and $^{13}C_2$-PFDoDA were 109%, 85%, 69%, 76%, 96%, 77% and 25%, respectively. Native PFCA and PFSA recoveries were assessed for liver tissue by spiking five replicates of a ringed seal liver sample. PFOS could however not be evaluated since the PFOS concentration of the QA/QC liver sample was approximately eight times higher than the spiked concentration. The average matrix spike recoveries ranged between 75% and 110% for all homologues (relative standard deviation (RSD) between 6% and 35%). PFTDA showed an average recovery of 235% and an RSD of 53% and was therefore not evaluated further in this study. Individual samples showed ionization effects for some homologues as well, either enhancement (>150% recovery) or suppression (<50% recovery). The MDL was defined as the mean concentration in the procedural blanks plus three standard deviations. One ml of ultra pure water was used as procedural blank and was prepared for each batch of six liver samples and extracted in the same way as the real samples. Blank concentrations of PFOA (>10% of sample concentrations) were subtracted from the calculated sample concentration and a value was reported only if the calculated sample concentration exceeded the blank concentration three times. Reproducibility was calculated as SD of three individual analyses of a ringed seal liver sample on different days and was found to be between 3% and 31%.

### *5.1.6 Limit of quantification and blank correction*

The criteria for accepting analytical data were that the recovery of the internal standard in a given sample was within 50–150%. For the long chained PFCs, like PFUnDA and PFDoDA, the recovery of $^{13}C$ internal standards were overall low due to ion suppresion. Technically this does not effect the 'laboratory' recovery, but when the recovery standard is not exactly identical to the internal standards this might results in lower 'calculated' recoveries. Therefore, a lower acceptance level of 30% recovery was applied when ion suppresion occured during LC/MS analysis. Analytical results which fell outside these limits are reported as "not quantified", NQ.

Blank correction was not applied apart from in a limited number of samples when the analyte signal in the blank exeeded 10%.

## 5.2 Data treatment

In this screening project we have chosen to work with pooled samples in order to keep chemical analyse cost reasonably low and be able include several marine mammal species sampled in different time periods. The measured contaminant concentration of a pooled sample is comparable to an arithmetic average of levels in the individual samples making up the pool. So, if the contaminant concentrations in the population are normally distributed, pooled-sample concentrations will also have a normal distribution with the same mean but reduced variance compared to individual measurements. However, contaminant concentrations are often better described by a lognormal distribution than a normal distribution which leads to biased estimates of the central tendency of the samples making of the pool (Caudill, 2010). There exists method for correcting this bias but it requires knowledge of the variability of among pools (Caudill et al., 2007), which we do not have. In our project we have chosen approximately the same number of individuals contributing approximately the same volume to each pool, which make our results comparable across species and country.

Preliminary data scrutinizing indicate that contaminant concentrations were more likely log-normally distributed than normally distributed even though samples have been pooled. Data were therefore log-transformed prior to statistical tests. One-sided analyse of variance (ANOVA) followed by Tukey comparisons of means were applied to test for differences between time periods and sampling areas. In some cases statistical tests were performed even if few measurements were below detection limit by replacing those with ½ of the detection limit. Otherwise, when calculating sum parameters, like $\sum_{10}$PBDEs, values less than the detection limit were treated as zero.

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# 6. Results

## 6.1 Brominated flame retardants – PBDE

### *6.1.1 Levels and patterns*

The samples were analysed for BDE-28, BDE-47, BDE-66, BDE-100, BDE-99, BDE-85, BDE-154, BDE-153, BDE-138 and BDE-183 (Appendix 2). The sum of these congeners is given as $\sum_{10}$PBDEs. In addition, samples of ringed seal, pilot whale, and minke whale from Norway were analysed for BDE-209 (Appendix 4). However, BDE-209 was not detected in any sample at detection limits in the range 0.5 to 3.0 ng/g lipid. Overall, when comparing the most recent samples across species and regions (Figure 4), it appears that the highest concentrations of PBDEs are found in toothed whales, like pilot whale, white-sided dolphins and harbour porpoises.

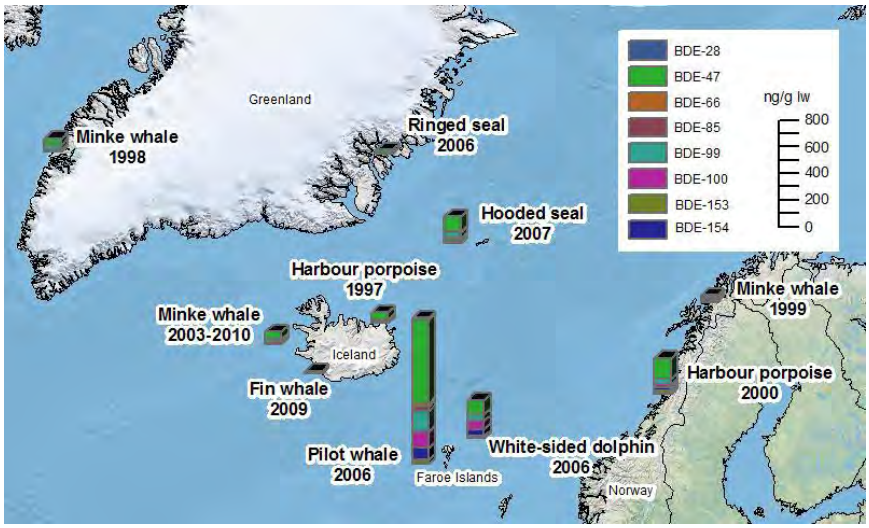


***Figure 4: Diagram depicting the PBDEs in marine mammals from various areas. The most recent samples from the present study are shown.***

The highest mean levels of $\sum_{10}$PBDEs were found in pilot whales from Faroe Islands from 1997 (1203 ng/g LW), followed by white-sided dolphins from Faroe Islands from 2001 (651 ng/g LW) and harbour porpoises from Norway from 2000 (257 ng/g LW).

Large variations in levels of $\sum_{10}$PBDEs were observed in the samples of harbour porpoises from Norway (2000), pilot whales from Faroe Islands (1997) and minke whales from Norway (1999) and Greenland (1998)(Figure 5). The levels of $\sum_{10}$PBDEs in minke whales and harbour

porpoises were higher in Norway compared to corresponding levels in Iceland and Greenland.

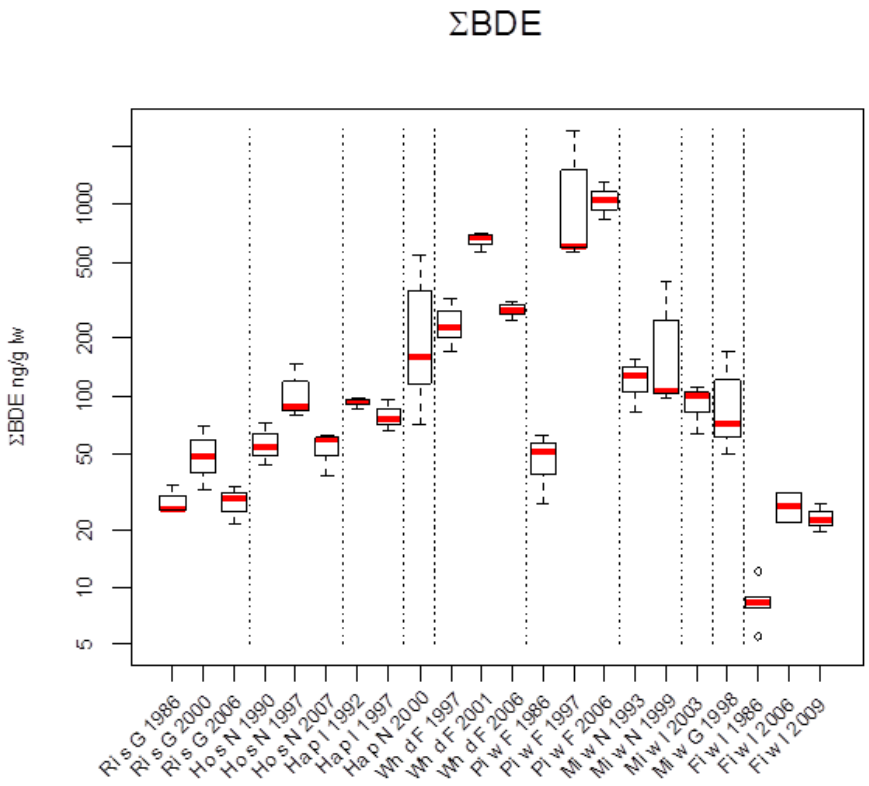


***Figure 5: Boxplot depicting the concentrations of Sum PBDE measured in marine mammal blubber samples. The red horizontal line depicts the median. concentration.***

Generally, the PBDE pattern was dominated by BDE-47, -99, -100, -154 and -153. These congeners were found in 100% of the samples in all species. BDE-47 was the most abundant PBDE congener in most species, with highest levels in pilot whales from 1997 (1389 ng/g LW). The contribution of BDE-47 to $\sum_{10}$PBDEs ranged from around 30% in hooded seals and white-sided dolphins to 75% in ringed seals (Figure 6). BDE-99 was the most abundant BDE congener in the hooded seal samples from 1990 and 1997, whereas the samples from 2007 were dominated by BDE-47.

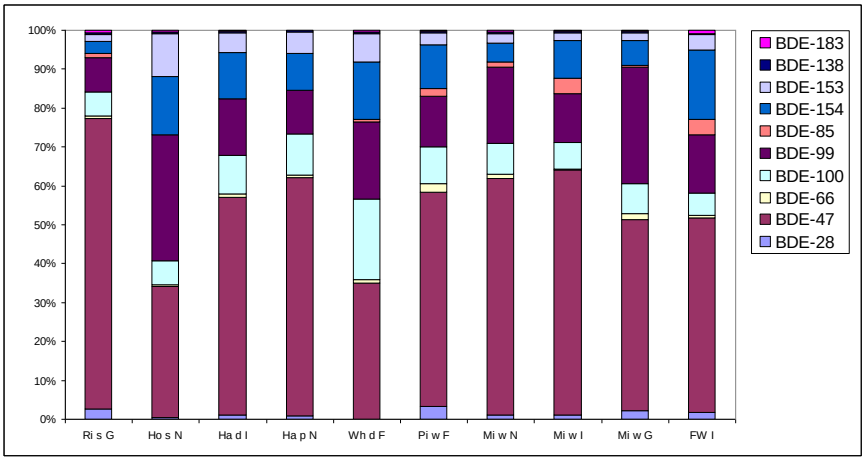


***Figure 6: Relative contribution of BDE congeners to $\sum_{10}$PBDEs in ringed seal from Greenland, hooded seal from Norway, harbour porpoise from Iceland and Norway, white-sided dolphin from Faroe Islands, pilot whale from Faroe Islands, minke whale from Norway, Iceland and Greenland and fin whale from Iceland.***

The congeners BDE-28, -66, -85, -138 and -183 were found in much lower levels. BDE-28 was found in most samples, but was <LOD in 50% of the white-sided dolphins from Faroe Islands. BDE-66 and BDE-85 were detected in very low levels or <LOD, except for pilot whale from Faroe Islands in which these congeners were detected in levels up to 74 and 49 ng/g LW, respectively. The congeners BDE-138 and -183 were present at lowest levels of all PBDEs, levels were <LOD or not quantified (NQ).

### *6.1.2 Time trend*

In several species, levels of $\sum_{10}$PBDEs or two or more single PBDE congeners increased from the 1980s to the late 1990s, after which they declined during the first decade of 2000. However, the time trends for $\sum_{10}$PBDEs were only significant for fin whale and white sided dolphin (Appendix 7, Tables A and C) where only the increase since the 1980es to present could be statistically shown in fin whales. For pilot whale a significant increasing trend was observed from 1986 to 1996, while no significant difference was established in the samples from 1997 to those of 2006. A different sample set of fin whale from Iceland (1986–2006) showed similar increasing trend as the sample set from 1986–2009, and this trend was significant for two of the BDE congeners but not for the sum of congeners. In ringed seal from Greenland higher levels of $\sum_{10}$PBDEs were found in 2000 than in 1986 and 2006, but the difference was overall not statistically significant. In hooded seal, levels of $\sum_{10}$PBDE increased from 1990 to 1997 followed by a decrease towards 2007, and this trend of decreasing concentrations since 1997 was significant for five of the individual congeners, but not when the sum of congeners were combined. Minke whale samples from Iceland, Norway and Greenland were grouped before a geographical trend analysis was made. No

significant spatial trend for minke whale was found. A declining trend was observed for $\sum_{10}$PBDE levels in harbour porpoise from Iceland in the time period of 1992 to 1997, but the trend was not significant.

Within each species the PBDE patterns showed in general little difference between the studied time periods (Figure 7). However, the relative contributions of BDE-28 and BDE-154 to $\sum_{10}$PBDEs in pilot whale were three times higher in 1986 than in 1997 and 2006; while the BDE-99 contribution was two-fold lower in 1986, compared to 1997 and 2006. In harbour porpoise from Iceland, the BDE-47 seemed to increase its contribution to $\sum_{10}$PBDEs in 1997, compared to 1992 (Figure 7).

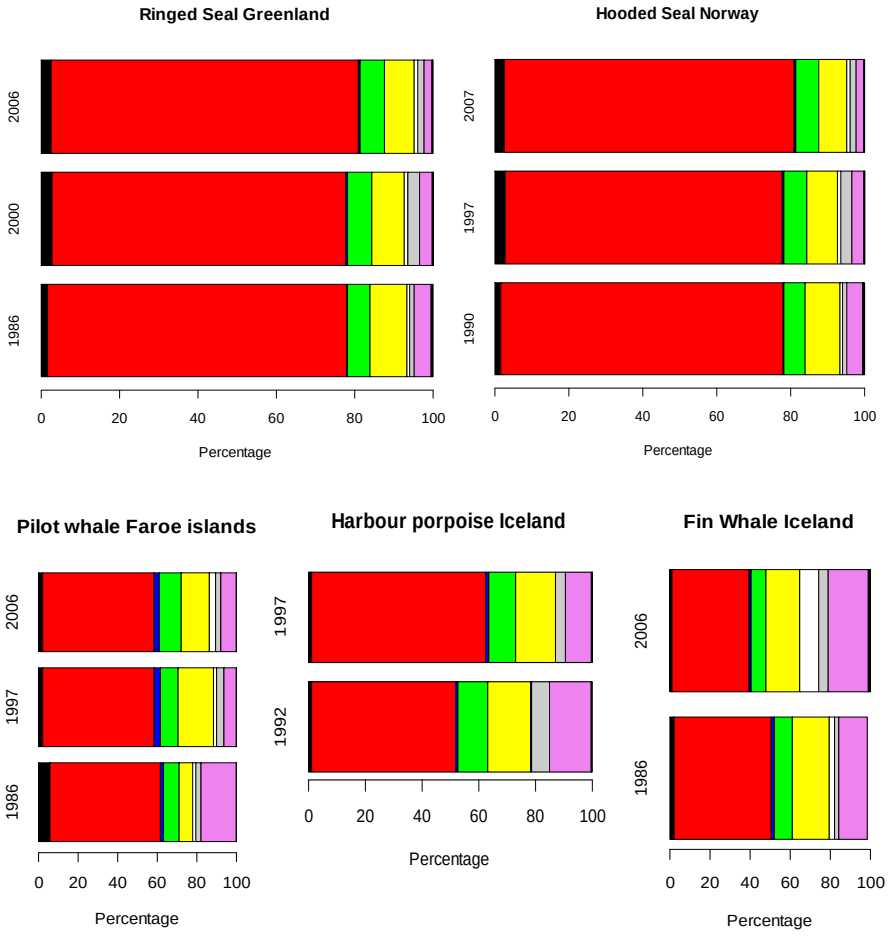


***Figure 7: Relative composition of various BDE congeners in blubber tissue from ringed seal from Greenland, hooded seal from Norway (West Ice), pilot whale from the Faroe Islands and harbour porpoise and fin whale from Island. BDE-28 = black, BDE-47 = red, BDE-100 = green, BDE-99 = yellow, BDE-85 = white, BDE-153 = grey, BDE-154 = violet.***

### 6.1.3 Discussion

The levels of $\sum_{10}$PBDEs in ringed seals from Greenland collected in 1998 and 2006 were about 3–4 times higher than in ringed seals from Svalbard from 1998 and 2004, respectively (Wolkers et al., 2008), higher than findings in ringed seal from the Barents Sea region in 2002 (Savinov et al., 2011) and from West Greenland in 1982–2000 (Vorkamp et al., 2008), and slightly higher than findings in ringed seal from East Greenland in 2001 (Riget et al., 2006). However, Letcher et al. (2009), found $\sum_{10}$PBDE levels in ringed seal from Greenland in 2002 that were three times higher than corresponding levels in the present study. The high predominance of BDE-47 in ringed seals was consistent with findings by others (Riget et al., 2006; Savinov et al., 2011; Vorkamp et al., 2008; Wolkers et al., 2008).

Levels of $\sum_{10}$PBDEs in the studied ringed seals from Greenland declined by 44% from 2000 to 2006 which is in accordance with findings by others (Wolkers et al., 2008).

The hooded seals in the present study were females and caught at the breeding area at the West Ice. The mean levels of $\sum_{10}$PBDEs in the hooded seals from 1997 (105 ng/g LW) were higher than the levels measured in 1990 and 2007, thus showing a peak level in 1997. The $\sum_{10}$PBDEs levels in 1997 were more than two times higher than in blubber from female hooded seals from the Gulf of St. Lawrence in 2001 (Wolkers et al., 2006), and twelve times higher than female hooded seals from the coast of Massachusetts, USA, in 2004–2005 (Montie et al., 2010). The PBDE pattern found in the hooded seals from the Gulf of St. Lawrence was dominated by tetra-BDEs (Wolkers et al., 2006) while the pattern in the seals from the West Ice (present study, 1997) was dominated by penta-BDEs. However, in the Norwegian hooded seals from 2007 this pattern changed to a higher prevalence of tetra-BDEs, as was mentioned earlier. This development might indicate general changes of BDE patterns in the food chain for hooded seal in the Atlantic Ocean. The migration patterns of hooded seals are not well known. Recent data from satellite linked time depth recorders (SLTDRs) reveal that choice of feeding areas appear to be closely related to areas of high topographic relief (Andersen and Wiersma, 2009). This study also points out the important aspects of oceanographic processes and distribution of prey that might influence diving and migration behaviour. The observed changed BDE patterns during time in this study might therefore as well be related to different migration behaviour.

The levels of $\sum_{10}$PBDEs in the harbour porpoises from Norway which were caught in 2000, ranged from 71 to 540 ng/g LW and were the highest PBDE levels measured in harbour porpoises in this study. The median, 161 ng/g LW, was about two times higher than the median of the harbour porpoises from Iceland, but 14-fold lower than in stranded harbour porpoises from the Belgian North Sea coast (Covaci et al., 2002), and 16-fold lower compared to harbour porpoises from UK, stranded in 2000 (Law et

al., 2010). Kleivane et al. (1995) described a decreasing PCB spatial gradient in harbour porpoises from Kattegat to the Barents Sea, a gradient which seems similar to the gradient for PBDEs which we find in the present study when compared with stranded porpoises from the Southern North Sea coasts. The different PBDE levels are suggested to be caused by the porpoise's ability to adapt to local oceanic conditions and changes of feeding strategies in different locations (Fontaine et al., 2007).

Only a few other studies report on PBDE levels in white-sided dolphins. The highest levels of $\sum_{10}$PBDE found in the white-sided dolphins from Faroe Islands in 2001–2002, were within the range of PBDE levels in white sided dolphins from Massachusetts, USA, stranded in the time period 1993 to 2000 (Tuerk et al., 2005). This study found that body length was of greater statistical influence than age and sex in this animal and suggested a metabolic elimination and/or growth dilution for males and off-loading for females via lactation (Tuerk et al., 2005). Tuerk et al. (2005) did not find the culmination of PBDE levels as in the present study but suggested that there might be a lag period for higher concentrations of PBDEs in this pelagic marine species or that concentrations already had peaked before the first collection in 1993. In the present study we found a significant time trend for white sided dolphins with peak levels in 2002.

PBDE levels in long-finned pilot whales are in general among the highest levels that are measured in Arctic/North-Atlantic biota. The high POP levels are of great concern for health authorities in Faroe Islands because the whales are an important part of the traditional diet for the local population. The median $\sum_{10}$PBDE levels in the long-finned pilot whales from Faroe Islands in 1997 and 2006 were higher than in killer whales from the Norwegian coast from 2002 (500 ng/g LW) (Wolkers et al., 2007), much higher than in polar bears from Svalbard, Norway from 2002–2003 (30 ng/g LW) (Sørmo et al., 2006) but 3-fold lower than in off-shore killer whales (Krahn et al., 2007) from the Eastern North Pacific Ocean. Earlier investigations in 1994–1996 showed similar or higher levels of sum PBDEs (sum of 19 congeners) in pools of pilot whales from the Faroe Islands (Lindström et al., 1999).

Minke whale has been a popular marine mammal species for human consumption in the Nordic countries. In the 1990s the levels of pollutants in Minke whales were surveyed by the Norwegian authorities for human health risk assessment purposes. No brominated compounds were measured then. After 2000, the hunting of the minke whales got strictly regulated and reduced due to international protests. It was therefore difficult to obtain minke whale blubber from the last decade. The present study included minke whales from Norway (1993 and 1999), minke whales from Greenland (1998) and from the Icelandic waters (2003–2007). Compared to $\sum_{5}$PBDEs (BDE-47, -99, -100, -153, -154) in blubber from minke whales caught in the Pacific Ocean, Japan, in 1999 (Marsh et al., 2005), mean levels of sum of corresponding PBDE congeners in the present min-

ke whales are 2.5 times higher. However, mean of $\sum_{10}$PBDE levels in blubber from mature minke whales from Iceland 2003–2007 (91 ng/g LW) are three fold lower than in blubber from mature minke whales caught off the Korean coast in 2006 (270 ng/g LW, Moon et al., 2010). In the Korean study PBDE levels in mature males were, however, almost four times higher than the immature males (Moon et al., 2010). The PBDE levels in one of the Norwegian minke whale samples from 1999 was about four times higher than the other samples from that year. This pool was made from animals caught in the North Sea while the other animals were caught along the north Norwegian coast. Also levels of $\sum_{10}$PBDEs in blubber of minke whale stranded on the coast of Northumberland, UK, in 2001 (Law et al., 2005) were in the same range as the minke whale results from Iceland, Norway and Greenland.

The $\sum_{10}$PBDE levels in the fin whales from the Icelandic waters were among the lowest in this study. This was not unexpected because this whale is a baleen whale and feeds on deeper waters and on lower trophic levels than toothed whales, such as white-sided dolphins and pilot whales. The median levels of $\sum_{10}$PBDEs in the fin whales from 2006 and 2009 were somewhat lower compared to $\sum_{13}$PBDEs in stranded fin whale from UK in 2000 (Law et al., 2003).There is limited knowledge on PBDEs in fin whales in literature. With the observed increase of PBDE levels in the Icelandic fin whales from 1986 to 2009, it is of importance to include this species also in future studies.

## 6.2 Methoxylated brominated diphenyl ethers

### *6.2.1 Levels*

The methoxylated polybrominated diphenyl ethers, MeOBDE, analysed were 2PMDBE68, 6MBDE47, 5MBDE47, 4PMBDE49, 5PMBDE100, 4PMBDE103 and 5PMBDE101. Of these, 2PMDBE68 and 6MBDE47 were detected and quantified in every one of the in all 67 pooled samples of marine mammal blubber, whereas the other congeners could not be detected in any sample (Appendix 3). Invariably, the congener 6MBDE47 occurred in higher concentration than 2PMBDE68, with ratios between the congener 6MBDE47 to 2PMBDE68 varying from 2 to 120.

The highest concentration of 6MBDE47 measured was 653 ng/g LW and the lowest was 0.3 ng/g LW. A relative presentation of MeOBDE in the various species and from the various locations is given in Figure 8.

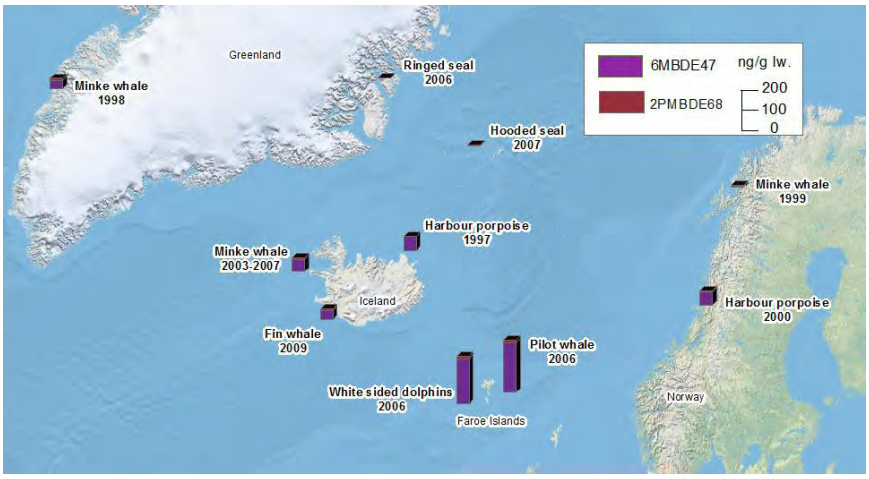


***Figure 8: Methoxylated polybrominated diphenyl ethers in marine mammals are shown. The most recent data only for the various species are shown.***

### *6.2.2 Species difference*

The highest concentration of 6MBDE47 was found in a sample of pilot whale from 1986, and the lowest in a sample of ringed seal from Greenland in 2006.

The concentration of MeOBDE follows the general trend of PBDE, where the highest concentrations are found in the toothed whale species pilot whale, white-sided dolphins and harbour porpoise. With minke whale the situation with MeOBDE is however different to that of PBDE; while PBDE occurred in similar concentrations in minke whale samples taken in the three countries, with somewhat higher concentration in minke whale from Norway than from Iceland and Greenland, the MeOBDE concentration is markedly lower in minke whales from Norwegian waters than from those of Iceland and West Greenland. Also, a somewhat different pattern is seen with the MeOBDE concentration in fin whales, which for PBDE were the species where the overall lowest concentrations occurred, whereas for MeOBDE fin whale carries more or less the same concentration of Sum MeOBDE as minke whale from Iceland and West Greenland.

### *6.2.3 Temporal trends*

A time trend could not be detected using statistical methods, but a visual inspection reveals that in pilot whale as in ringed seal, the concentration of MeOBDE decrease from the earliest period (1980s) to the more recent samples (Figure 9). This is also true for hooded seal from the West Ice and harbour porpoise from Iceland.

The fact that the highest concentrations of these methoxylated PBDEs are occurring in highest concentrations in toothed whales support the finding that these are lipid soluble and biomagnifying compounds. The fact that the highest mean concentration measured for most of the

mammal species was found in the samples from the earliest time periods, suggests that the larger part of these compounds are not metabolites of PBDE.

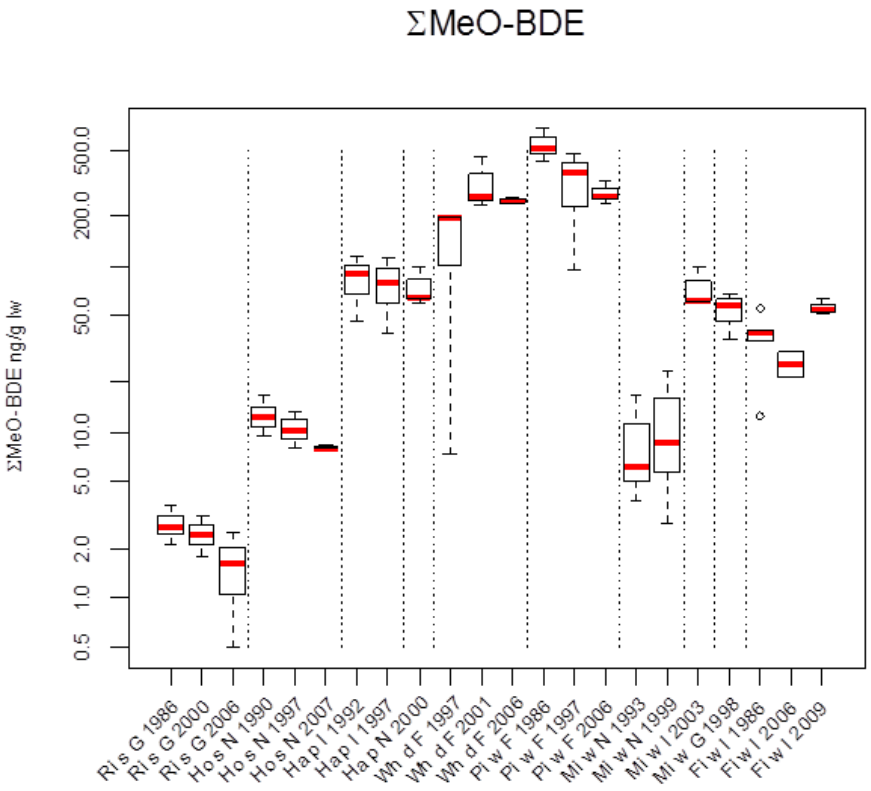


***Figure 9: A boxplot depicting the concentrations of Sum MeOBDE found in blubber samples of marine mammals in the various time periods. The Sum MeOBDE is composed of 6MBDE47 and 2PMBDE68.***

### *6.2.4 Proportions*

The ratio of the two methoxylated species that could be quantified, 6MBDE47 to 2PMBDE68, varied from 2 to 120, with the median ratio 7. Overall, the magnitude of the ratio was found to correlate with the absolute concentration of 6MBDE47, mirroring the fact that it was this compound which dominated the Sum MeOBDE. However, the maximum ratio between 6MBDE47 and 2PMBDE68 of 120 was found in a sample of white-sided dolphins from the Faroe Islands in 1997. The concentration of 6MBDE47 was not particularly elevated in this sample, but the concentration of 2PMBDE68 was low.

## 6.3 Brominated flame retardants – non-PBDEs

### *6.3.1 Large, non-PBDE flame retardant*

The samples identified by DL-numbers DL-08-008:1 to DL-08-008:24 (Appendix 1) were analysed also for a selection of other brominated flame retardants in addition to PBDE. These samples include ringed seal from East Greenland, pilot whale from the Faroe Islands and minke whale from Norway. The compounds analysed are sorted into large and small BFRs, depending on the molecular weight. The group of large BFRs comprise PBB-153, BTBPE, and DBDPE in addition to the PBDS nos. BDE-154 and the decabrominated congener BDE-209.

Of the large BFRs measured, DBDPE and BTBPE were all under the detection limit, which ranged from 0.5–3.0 ng/ g lipids depending on sample size and GC/MS conditions (Appendix 4). Although these compounds have been found in sediment and indoor air, it seems that the bioaccumulation potential of these compounds is limited.

The results from both the low and high resolution analysis confirm the presence of PBB-153, which elutes very closely to BDE-154, as shown in Figure 10. The results of both GC/MS analyses were in good agreement. It is interesting to note that levels of PBB-153 are decreasing relatively to the levels of BDE-154 for the time period 1986–2006/07.

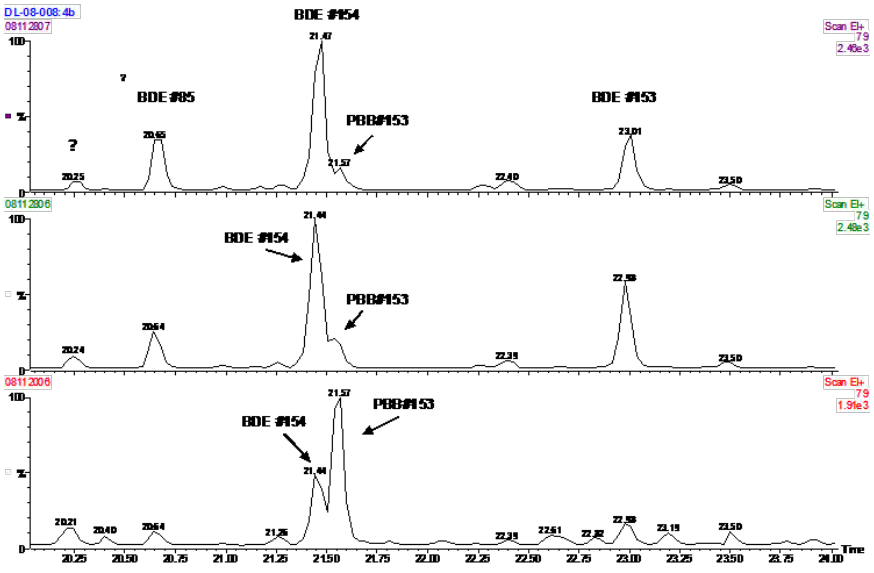


***Figure 10: Low resolution GC/MS chromatogram m/z 79, on samples of blubber from pilot whale, Faroe Island, illustrating the analysis of BDE-154 and PBB-153. The uppermost panel is a sample from 2006/07, the middle panel a sample from 1997, and in the bottom panel a chromatogram on a sample from 1986 is shown.***

### 6.3.2 *Small nonPBDE flame retardants*

Three small BFRs were analysed; 1,2-dibromo-4-(1,2-dibromoethyl) cyclohexane (TBECH) which can consist of 4 enantiomers (alpha, beta, gamma and delta), pentabromotoluene (PBT), and hexabromobenzene (HBB).

The commercial TBECH product consists of predominately the alpha and beta enantiomers, which were both analysed by low resolution NCI GC/MS and a confirmatory analysis by high resolution GC/MS. The analysis of TBECH is problematic because of thermal degradation on both GC columns and injectors. The low resolution revealed peaks at the same retention times as the alpha and beta enantiomers, but the high resolution GC/MS analysis using the molecular ion of TBECH could not confirm this. All results are therefore reported as not confirmed NC. TBECH has been confirmed in Beluga whale samples from the Canadian Arctic samples (Tomy et al., 2008).

Due to some analytical problems not all samples were analysed for the two small aromatic BFRs (PBT and HBB). PBT was not found in any of the samples, but HBB was found in several of the more recent samples at levels in the low ng/g range.

### 6.3.3 *Screening for "new" BFRs.*

In all 24 samples of ringed seal from Greenland, pilot whale from the Faroe Islands and minke whale from Norway, were screened for unknown Br-containing organic compounds. All samples contained several peaks that could not be identified with"'known" BFRs. This is illustrated below by a chromatogram of the screening of the Pilot whale sample from 1986 (Figure 11).

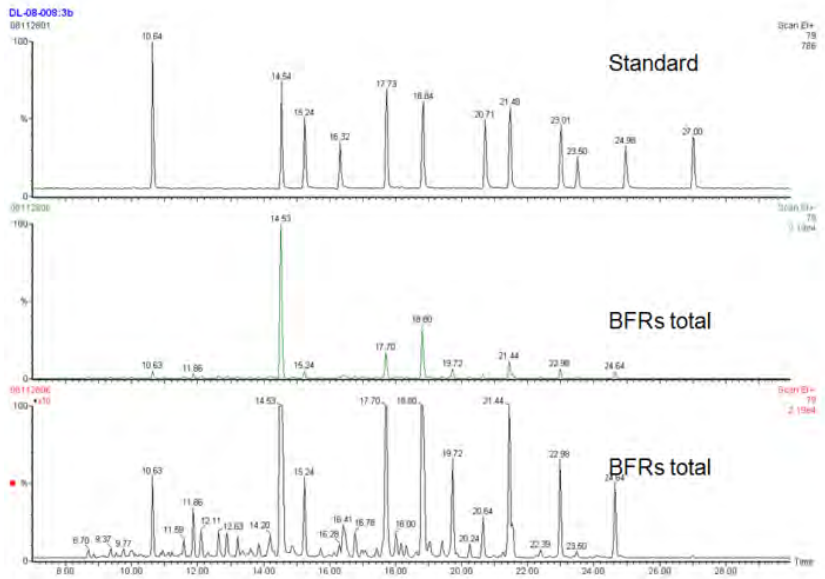


***Figure 11: Screening m/z 79 for organic bromo compounds in pilot whale, Faroe Islands, illustrating a large number of unidentified bromine containing compounds when comparing the sample to a standard BDE mix.***

## 6.4 Polychlorinated naphthalenes

### *6.4.1 Levels*

The samples were analysed for the following 14 PCN congeners: 13, 28/36, 27, 48, 46, 52, 50, 53, 66, 69, 72, 73 and 75 (Appendix 5).

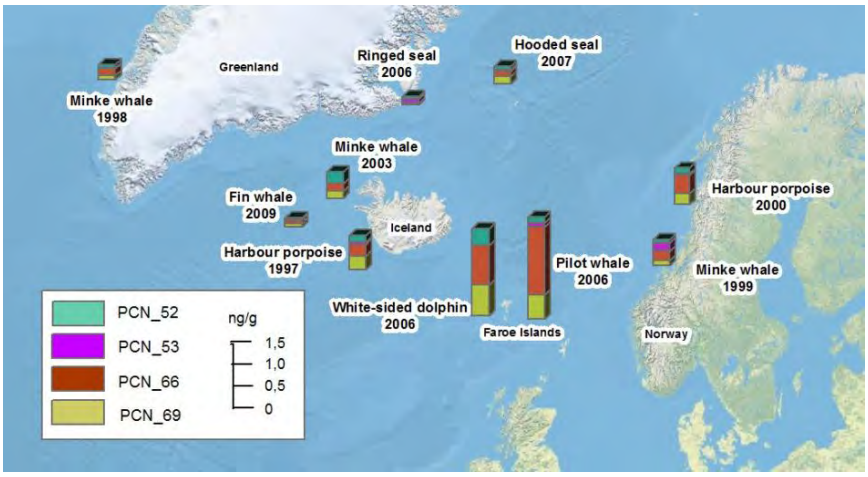


***Figure 12: Concentrations of four congeners of PCN occurring in highest concentrations are shown. The figure represent the most recent samples of the various species analysed for each geographic sampling location.***

PCN-28/36, PCN-27 and PCN-46 concentrations were all below detection limits. This was also the case for PCN-13 except for four samples of white-sided dolphin from Faroe Islands with concentrations just above detection limits, and for PCN-50 in one fin whale sample from Iceland. In the case of PCN-48 22% of the samples were below the detection limits including most of the ringed seal samples from East Greenland and all minke whale samples from Norway. The PCN-52 concentrations ranged from below the detection limits to 0.73 ng/g LW in a sample of white-sided dolphin from Faroe Islands. PCN-53 concentrations ranged from below detection limits to 0.88 ng/g LW in a sample of pilot whale from Faroe Islands. Several ringed seal samples from East Greenland had PCN-66 below detection limits as did one fin whale sample from Iceland, but otherwise PCN-66 could be detected in the rest of the samples. PCN-69 was detected in all samples but one fin whale sample from Iceland (1986–87). The maximum concentration of PCN-66 was 3.91 ng/g LW, and was found in a pilot whale sample from Faroe Islands in 1997, and the maximum concentration of PCN-69 was 2.30 ng/g LW, and was found in a sample of white-sided dolphin from Faroe Islands in 2001.

In the following more detailed analyses only PCN congeners 52, 53, 66 and 69 will be discussed. ΣPCN is the sum concentration of these four congeners.

### 6.4.2 Species differences

Table 9 shows the mean concentrations of selected PCN congeners and ΣPCN and Figure 13 shows boxplots of ΣPCN in each species and sampling year combination.

**Table 9: Mean concentrations of selected PCN congeners in ng/g LW.**

| Species | Location | Year | PCN-52 | PCN-53 | PCN-66 | PCN-69 | Sum-PCN |
|---|---|---|---|---|---|---|---|
| Ringed seal | East Greenland | 1986 | 0.18 | 0.13 | 0.07 | 0.08 | 0.46 |
| | | 2000 | 0.14 | 0.24 | <DL | 0.1 | 0.52 |
| | | 2006 | 0.06 | 0.11 | <DL | 0.05 | 0.31 |
| Hooded seal | Norway | 1990 | 0.26 | 0.07 | 0.21 | 0.17 | 0.71 |
| | | 1997 | 0.19 | 0.05 | 0.17 | 0.2 | 0.62 |
| | | 2007 | 0.1 | 0.04 | 0.12 | 0.2 | 0.46 |
| Harbour porpoise | Iceland | 1992 | 0.28 | 0.08 | 0.47 | 0.36 | 1.19 |
| | | 1997 | 0.19 | 0.05 | 0.31 | 0.36 | 0.92 |
| | Norway | 2000 | 0.17 | 0.05 | 0.52 | 0.34 | 1.09 |
| White-s. dolphin | Faroe Islands | 1997 | 0.49 | 0.12 | 1.2 | 1.07 | 2.87 |
| | | 2001 | 0.63 | 0.16 | 1.77 | 0.67 | 4.22 |
| | | 2006 | 0.43 | 0.1 | 1.03 | 0.83 | 2.4 |
| Pilot whale | Faroe Islands | 1986 | 0.31 | 0.75 | 1.83 | 0.51 | 3.4 |
| | | 1997 | 0.3 | 0.41 | 2.9 | 0.59 | 4.2 |
| | | 2006 | 0.15 | 0.12 | 1.79 | 0.64 | 2.71 |
| Minke whale | Norway | 1993 | 0.06 | 0.16 | 0.25 | 0.09 | 0.57 |
| | | 1999 | 0.09 | 0.22 | 0.24 | 0.14 | 0.69 |
| | Iceland | 2003 | 0.3 | <DL | 0.2 | 0.18 | 0.76 |
| | W. Greenland | 1998 | 0.1 | <DL | 0.19 | 0.1 | 0.48 |
| Fin whale | Iceland | 1986 | 0.09 | <DL | 0.19 | 0.04 | 0.36 |
| | | 2006 | 0.02 | <DL | 0.07 | 0.05 | 0.18 |
| | | 2009 | 0.05 | <DL | 0.09 | 0.09 | 0.24 |

In general the highest ΣPCN concentrations were found in pilot whale and white-sided dolphin from the Faroe Islands and the lowest concentrations were found in fin whale from Iceland. There was no significant difference in ΣPCN concentrations among the minke whale samples from Norway, Iceland and West Greenland (ANOVA, $p = 0.24$) or among the harbour porpoises samples from Iceland and Norway (ANOVA, $p = 0.55$).

### 6.4.3 Temporal trends

In general, no consistent temporal trend of ΣPCN was found across species and geographical areas. However, it should be noted that in no occasion was the ΣPCN concentration highest in the most recent samples, except in minke whale from Norway with slightly higher concentrations in 1999 than in 1993.

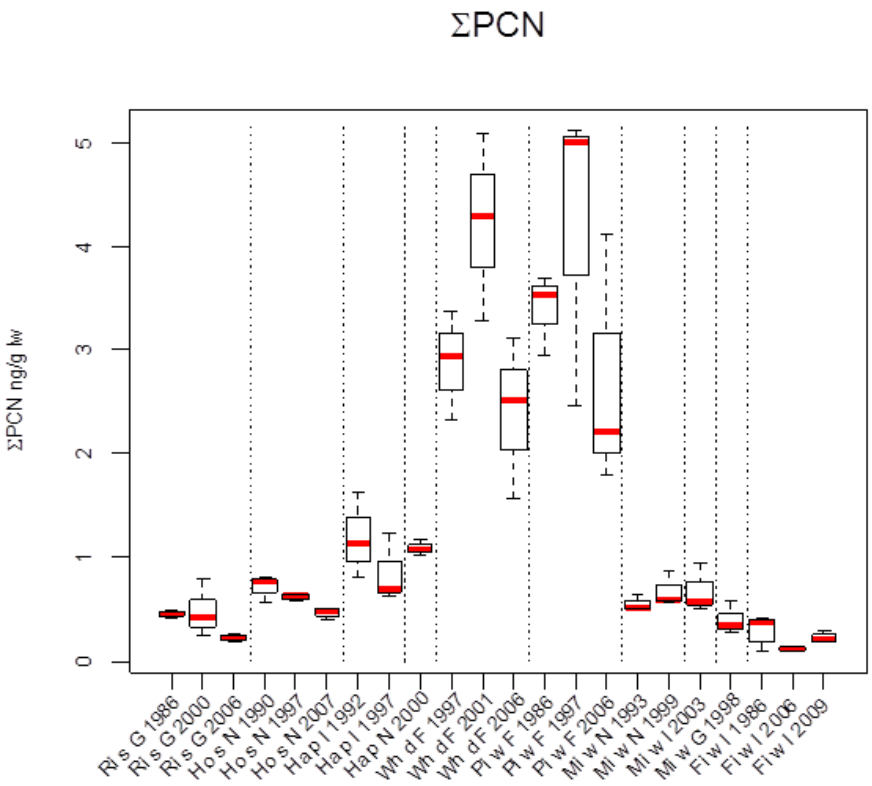


***Figure 13: Boxplots of ΣPCN in each species and sampling year combination.***

A significantly decreasing trend in ΣPCN concentration was found in hooded seals from Norway only, and this was found for the period from 1990 to 2007 (ANOVA, p = 0.03). In ringed seals from East Greenland the median concentration decreased from 1986 to 2006 (Figure 13) although not significantly (ANOVA, p = 0.07). Also in harbour porpoise and fin whale from Iceland were ΣPCN concentrations lower in the most recent samples compared to the earlier samples.

In pilot whale and white-sided dolphin the highest, although not significantly so, ΣPCN concentrations were found in the samples in the middle of the covered period *i.e.* in 1997 and 2001, respectively (Figure 13). This may be an indication that PCN concentrations have peaked during the late 1990s to early 2000s in toothed whales from the Faroe Islands area.

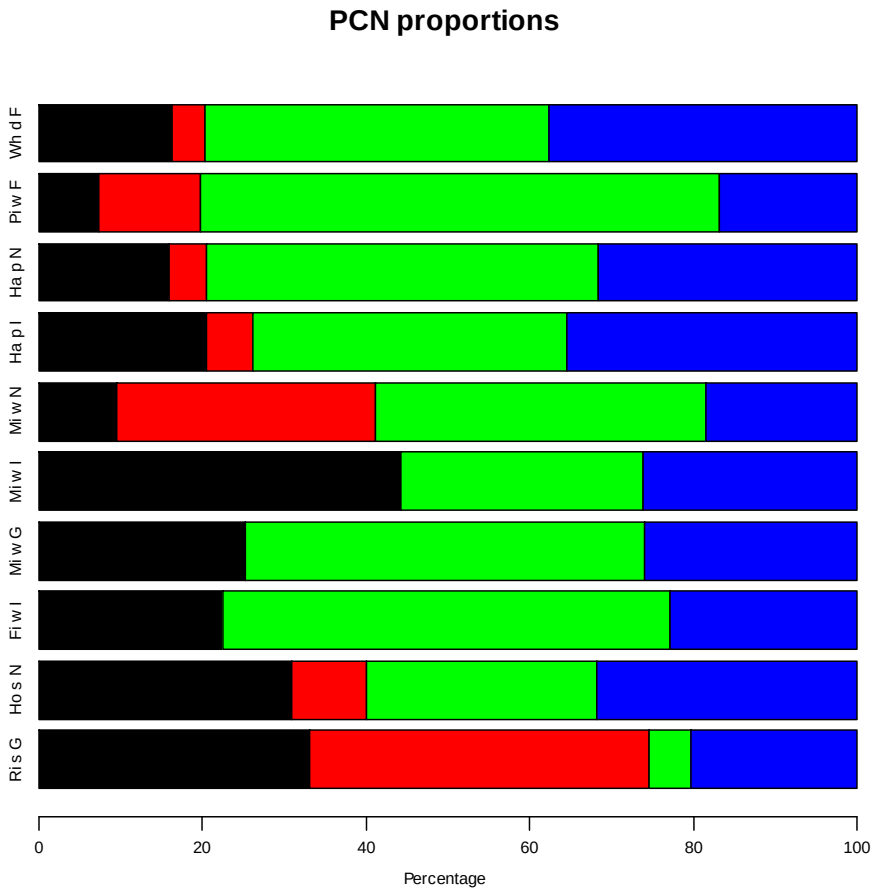


***Figure 14: PCN-52 in black, PCN-53 in red, PCN-66 in green and PCN-69 in blue bars.***

### *6.4.4 PCN congeners, levels, proportions and temporal trends*

The mean PCN congener concentrations for each species and sampling period are shown in Table 9, and in Figure 14 the congener proportions as a mean across years of sampling are given. In general, the highest concentrations of all four congeners are found in pilot whale and white-sided dolphin from Faroe Islands. PCN-53 was below detection limits in all samples of fin whale from Iceland and in minke whale samples from Iceland and Greenland. PCN-66 was also below detection limits in all samples of ringed seal from East Greenland except in two samples from 1986. There were more cases with statistically significant temporal trends at the congener level than was seen for the sum of PCN congeners (Appendix 7, Tables D and E). PCN-52 decreased significantly in ringed seals from East Greenland (ANOVA, $p = 0.03$) and in hooded seals from Norway (ANOVA, $p < 0.01$). The latter showed also a significant decrease of PCN-53 (ANOVA, $p < 0.01$).

There were considerable differences in congener proportions among species, which probably are related to differences in feeding biology and metabolite capacity. The PCN congener occurring in largest proportion was different between species but also between localities. However, in the majority of samples, the highest proportion consisted of PCN-66. In ringed seal from Greenland, and in minke whale from Norway PCN-53 provided a large if not the largest proportion of PCN. That this is not species dependent is clear from the observation that minke whale from Greenland and Iceland did contain insignificant amounts of this PCN-53 congener. Also, no measurable proportion of PCN-53 was detected in Icelandic fin whales. The proportion of PCN-52 appeared to decrease in the order seal ≈ baleen whale > toothed whale, while the opposite appear to be the case for PCN-66 and PCN-69. However, geographical differences may also have an influence as is illustrated by the different congener patterns in the minke whale samples from Iceland, West Greenland and Norway (Figure 14).

## 6.5 Perfluorinated alkylated compounds

### *6.5.1 Levels*

The PFCs analysed are given in Table 5. In all 45 pooled samples of marine mammals sampled in the period 1984 to 2009 were analysed. The relative distribution of PFCs in the most recent samples of the marine mammals analysed from the various regions are shown in Figure 15.

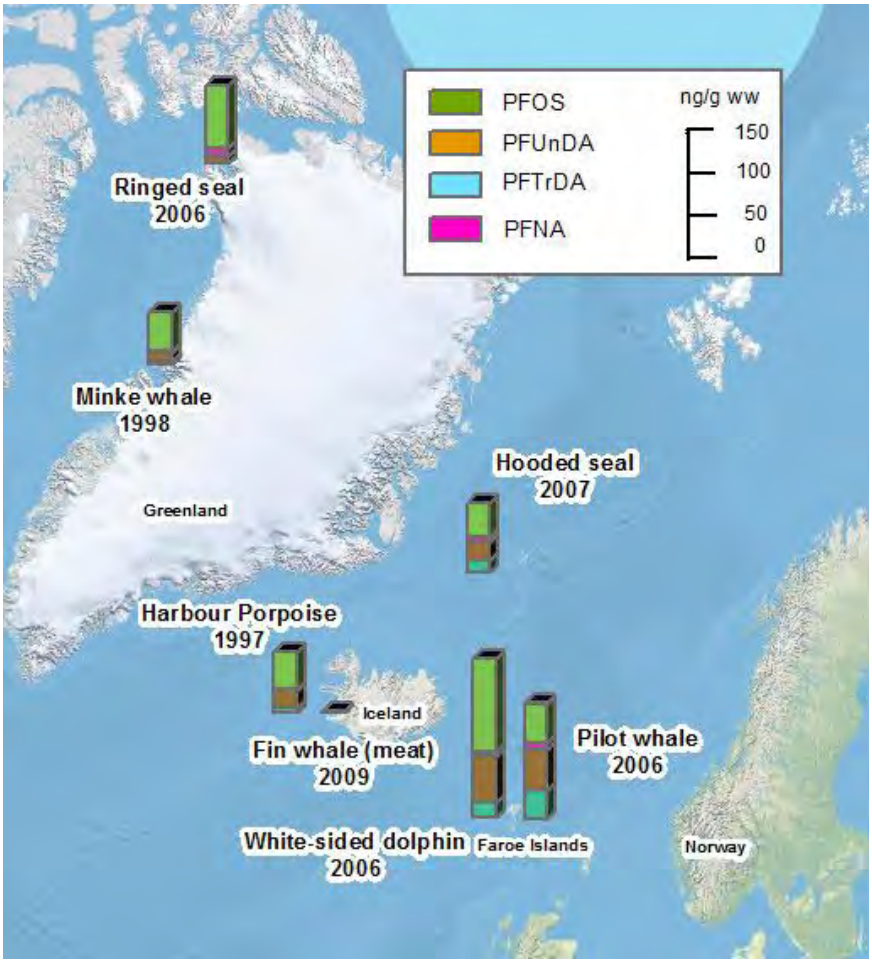


***Figure 15: PFCs concentrations in liver tissue, unless otherwise stated, from marine mammals are shown. The figure gives the concentration of the PFCs occurring in highest concentrations, and the most recent samples of the various marine mammals from the respective sampling locations are shown.***

Of the 45 samples, 6 were composed of meat samples, these were fin whale from Iceland in 1986–89 and 2009, but all the others were composed of liver tissues. In all 17 perfluorinated compounds of the types carboxylates and sulphonates were analysed. However, in no sample could all 17 compounds be quantified, the maximum number of PFCs quantified in any one sample was 10.

In all 13 perfluorinated carboxylates were analysed, covering substances with 4 to 18 carbons. PFBA, PFHxDA and PFOcDA could not be quantified in any sample due to unsatisfactory recovery of C13 marked standards.

PFHxA and PFHpA were not detected in any of the 45 pooled samples, at detection limits from 0.01 to 0.06 ng/g WW (Appendix 6). PFPeA was detected in two samples only, which were samples of hooded seal, one sample in 1990 and one from 2007. PFOA, PFNA and PFDA were detected in 80%, 89% and 93% of the samples, respectively. PFUnDA,

PFDoDA, PFTrDA and PFTDA were quantified in 76%, 51%, 51% and 31% respectively.

Perfluoroalkyl sulphonates with 4, 6, 8 and 10 carbons in the perfluorinated tail was analysed. PFBuS was not detected in any sample at detection limits from 0.01 to 0.03 ng/g WW. PFHxS, PFOS and PFDS were detected in 87%, 100% and 62% of the 45 pooled samples respectively.

When all samples of a species and locations were seen combined, PFOS was the PFC compound which occurred in highest concentrations in all species except in fin whale. A boxplot depicting the variability in the concentration of PFOS in the various samples across species and times are given in Figure 16. The PFC occurring in second highest concentration following PFOS was PFUnDA, except in ringed seal where PFNA occurred in second highest concentrations. PFUnDA occurred at very similar concentrations as PFDA. In fin whale, PFUnDA occurred in highest concentration and PFOS in second highest.

Fin whale muscle samples from 1986–1989 and 2009, in all 6 pooled samples, contained overall low concentrations of PFCs, where 1 to 6 of the analysed PFCs were detected in the samples.

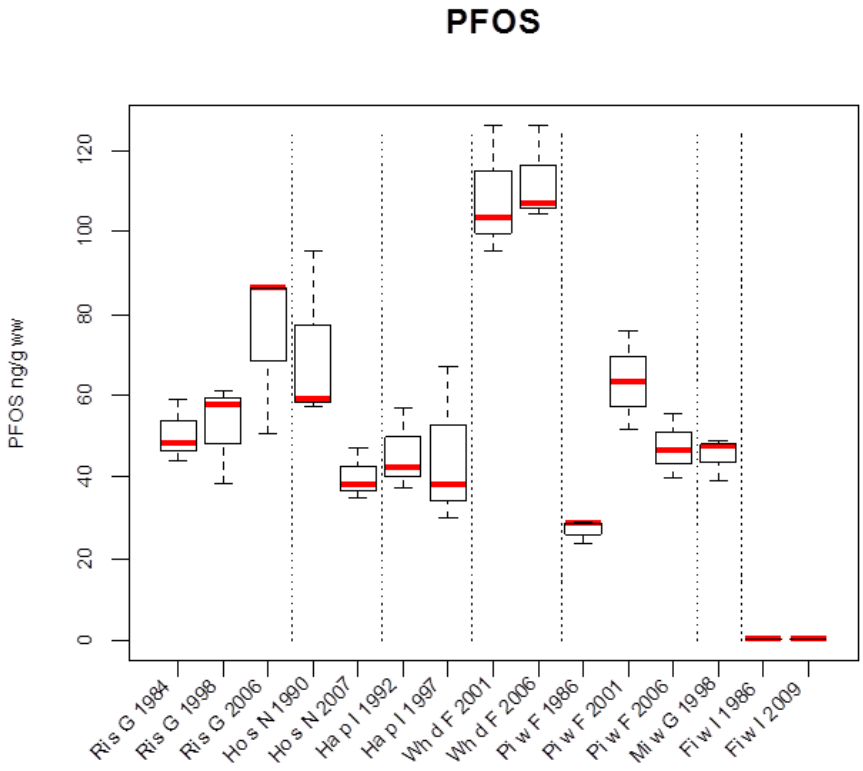


***Figure 16: The concentration of PFOS in tissues of liver (muscle for fin whale from Iceland) from the various species of marine mammals from the sampled periods and regions are shown.***

### 6.5.2 Species differences

Comparing the most recent samples across species shows that the highest mean concentration of PFOS decreases in the order white-sided dolphins Faroe Islands > ringed seal Greenland > pilot whale Faroe Islands ≈ hooded seal Norway ≈ minke whale Greenland ≈ harbour porpoises Iceland (Figure 15). The concentration of PFOS in fin whale from Iceland is difficult to assess comparatively because the tissue analysed was different from the other species, and the concentration difference between PFOS liver and PFOS muscle in fin whale is not known. However, if the distribution between liver and muscle in fin whale is as in pilot whale, then the ratio between PFOS in liver and muscle tissue would be approx. 20. And multiplying the measured fin whale muscle PFOS concentration by 20 gives a value which would place fin whale from Icelandic waters at the very low end of the range of PFOS concentrations in this material of selected marine mammal species.

### 6.5.3 Temporal trends

The results of the statistical analyses are given in tables F and G in Appendix 7. Visual inspection of the boxplot of PFOS in ringed seal from West Greenland (Figure 17) indicates a clear increasing trend from 1984 to 2006. The individual variation is however, of such a magnitude that the difference between the years is not statistically significant (ANOVA, log-transformed data $p = 0.21$). With PFNA on the other hand, the difference is significant ($p < 0.01$), depicting a clear increasing trend from 1984 until 2006.

Hooded seals from 1990 and 2007 were analysed (Figure 18), and the concentration of PFOS in 2007 was significantly lower than in 1990 (ANOVA, log transformed data, $p = 0.043$), though PFUnDA did not increase, and neither did PFNA.

White-sided dolphin liver samples from the Faroe Islands were available from 2001/2002 and 2006. Visual inspection of the boxplots (Figure 19) indicate that PFOS, but especially PFNA, increase from 2001/2002 to 2006. However, the difference indicated was not statistically significant (ANOVA, log-transformed data, $p = 0.71$ and 0.31 respectively).

The concentration of PFOS and PFNA in pilot whale from the Faroe Islands, indicate that the PFOS concentration peaked in 2001 whereas PFNA continues to increase until 2006 (Figure 20). However, only the samples from the first years (actually samples from 1986 and 1987 are represented with the label 1986) are significantly different from the samples taken in later years.

Sum PFCs did not change significantly in fin whales from Iceland from 1988 to 2009 (Figure 21).

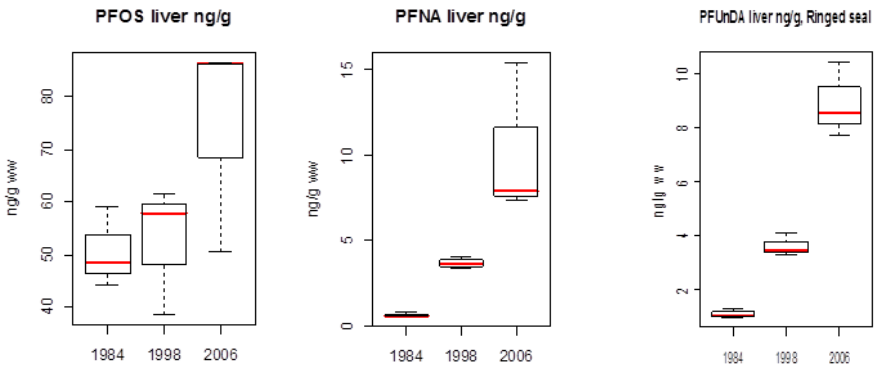


*Figure 17: PFCs in pooled samples (3 pools per year, each pool combining 4 individuals) of ringed seal liver. Samples were taken in West Greenland.*

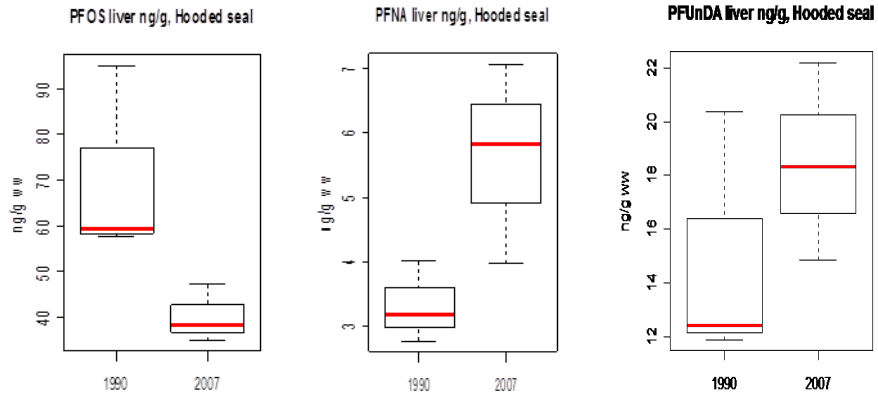


*Figure 18: PFCs in pooled samples (3 pools per year, each pool combining 5 individuals) of hooded seal from the West Ice, Norway.*

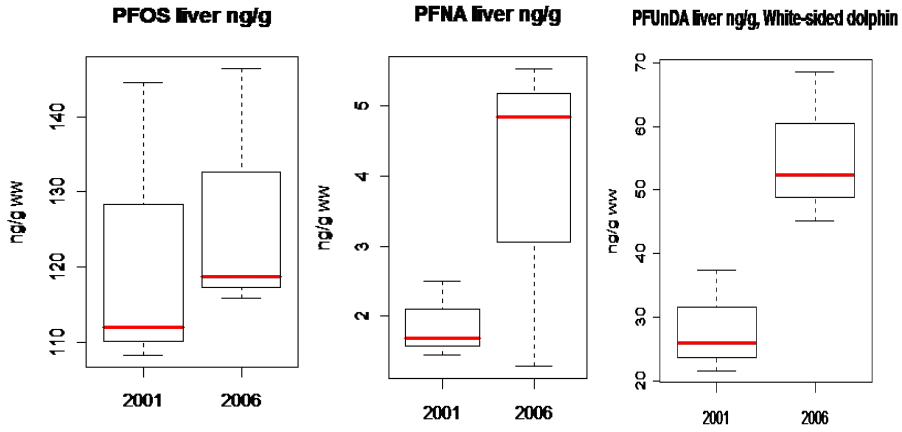


*Figure 19: PFCs in pooled samples (3 pools per year, each pool combining 3–5 individuals) of white-sided dolphin liver, Faroe Islands. Samples labelled 2001 were taken in 2001 and 2002.*

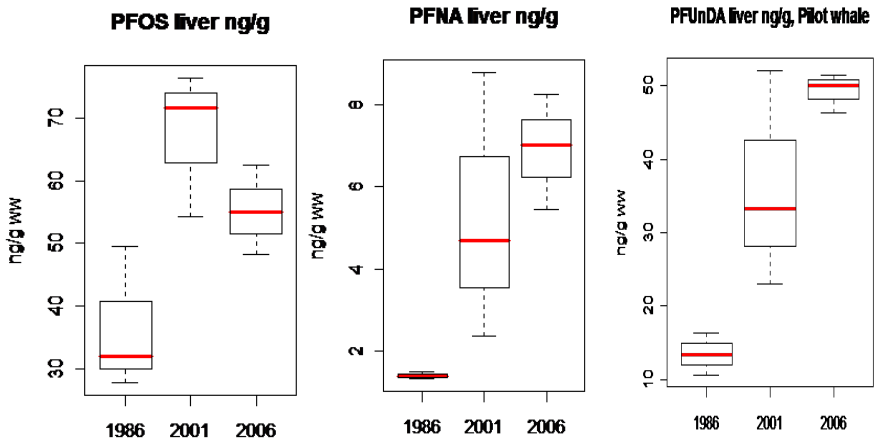


*Figure 20: PFCs in pooled samples (3 pools per year, each pool combining 2–7 individuals) of pilot whale liver, Faroe Islands.*

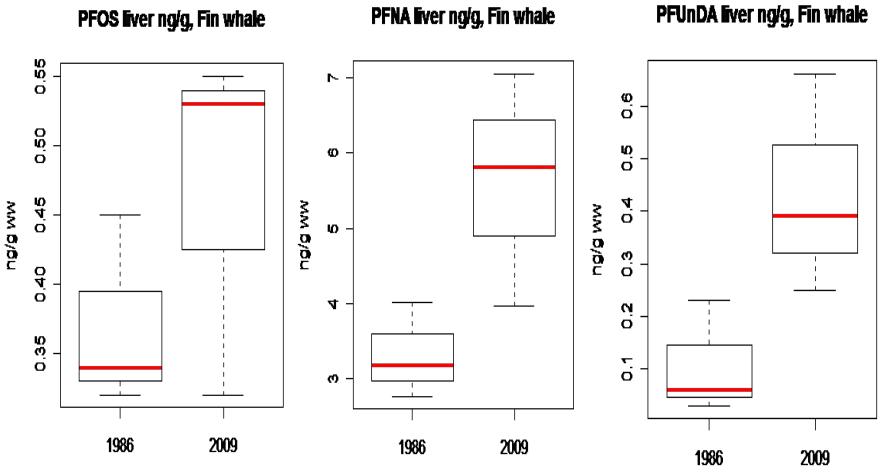


*Figure 21: PFCs in pooled samples (3 pools per year, each pool combining 5 individuals) of fin whale, Iceland. Samples labelled 1986 were taken in the years 1986 to 1989. Please note that the tissue analysed was muscle.*

### 6.5.4 PFC proportions

Overviews of the relative proportions of the various PFCs are given inFigure 22, for ringed seal, pilot whale, hooded seal and harbour porpoise.

PFOS which makes up 93% of Sum PFCs in ringed seal in West Greenland in 1984 decreases to make up lower proportions of Sum PFC in recent years. The decrease in proportion in some instances stems from a distinct decrease in PFOS concentration, as in hooded seal, but in other instances, it is merely a question of other PFCs increasing relatively more than PFOS, like in ringed seal from West Greenland and in pilot whale from the Faroe Islands (see also Appendix 6). There are instances though, where the most recent samples contain higher proportions of PFOS than the older samples, as is seen with harbour porpoise from Iceland; in these, the relative proportion of PFOS actually increases

while at the same time the actual PFOS concentration remains the same. This then reflects a decrease in the other PFCs, in particular PFUnDA.

The proportion of PFNA generally increases as the proportion of PFOS decreases. However, the PFUnDA proportion overall makes up a larger proportion of Sum PFCs, although the relative increase is not as pronounced as for PFNA.

The tendency seen in pilot whale and ringed seal for which data are available also in the 1980s, is that the ratios between PFOS and PFUnDA decrease dramatically going in pilot whale from two in the earliest samples to less than one in the most recent samples, and in ringed seal from 50 in the earliest samples to 10 in the most recent. Fin whale muscle samples were also available from the 1980s, but in these samples only PFOS and PFTrDA could be detected, and in samples taken in 2009, only one additional PFC that is PFUnDA, could be quantified. Thus, assessment of proportions are less meaningful in this instance. However, in fin whale PFOS contributed 50% of Sum PFCs in 1988, and in 2009, this percentage was 44%.

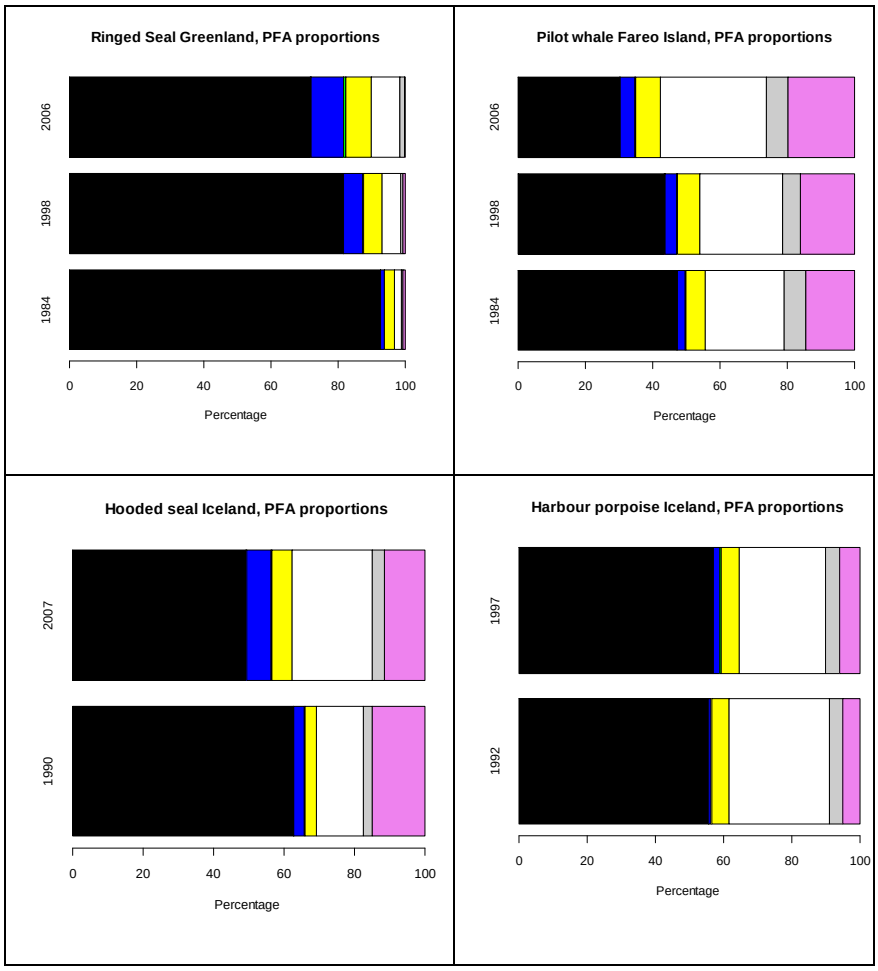


***Figure 22: PFCs proportions in ringed seal, Greenland; pilot whale, Faroe Islands; hooded seal and harbour porpoise, both Iceland.***
Black– PFOS, red – PFOA, blue – PFNA, green – PFHxS, yellow – PFDA, white – PFUnDA, grey – PFTrDA and pink – PFDoDA.

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# 7. Conclusions

The present report describes findings of "new" contaminants in marine mammals. The contaminants analysed include brominated flame retardants, both polybrominated diphenyl ethers (PBDEs) and other kinds which in this work is referred to as non-PBDEs, and subdivided into large and small brominated flame retardants. The study comprises also analyses of perfluorinated compounds (PFCs) and polychlorinated naphthalenes (PCNs) in marine mammals, and in some samples brominated dioxins and furans were analysed. The marine mammals analysed were ringed seal, hooded seal, harbour porpoise, white-sided dolphin, pilot whale, minke whale and fin whale. The marine mammals analysed were taken from localities in Nordic Arctic waters and North-East Atlantic areas over a period of three decennia (1984–2007). In general, the highest levels of "new" contaminants were found in toothed whales. High and moderate levels (250–1,200 ng/g LW) of PBDEs were found in blubber of several whale species studied. Temporal trend analysis showed that PBDEs increased from the 1980s to the 1990s, thereafter declining in the first part of the 2000s. Of the PFC compounds which were analysed in liver and muscle, the PFOS was found in the highest concentration (110 ng/g LW). Temporal trend analysis showed a decreasing trend for PFOS from 1990s/2000s and onwards, while PFNA and PFUnDA are increasing. PCNs were found in low concentrations in blubber (4 ng/g LW). In general, decreasing trends were found for the PCNs, and statistical significant decreasing trends were found for hooded seal from the West Ice and for fin whale from Iceland.

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Greenland: The ringed seal sampling was funded by the Danish Environmental Protection Agency within the Danish Cooperation for Environment in the Arctic (DANCEA). Several persons have been involved in organizing the sampling in the field during the years and especially Hanne Tuborg, Rune Dietz, Kurt Thomsen. Birger Sandell, Sigga Joensen and Christian Sonne are thanks. In addition Lene Bruun, Sigga Joensen and Maja Kierkegaard contributed to the age determination in the lab.

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Faroe Islands: The white-sided dolphin samples from 2001, 2002 and 2006, as well as the pilot whale 1986 samples were kindly provided by the Faroese Museum of Natural History. The other white-sided dolphin and pilot whale samples were retrieved from the Environment Specimen Bank of the Environment Agency. The assistance of one of the author´s collegues, Sanna í Túni Nielsen, in producing some of the graphic presentations, and Katrin Hoydal for assisting with field and laboratory sample preparation is gratefully acknowledged.

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# Norsk oppsummering

Denne rapporten beskriver funnene fra et nordisk studium som hadde som mål å undersøke mulige trender av «nye» miljøgifter i marine pattedyr fra Nord-Atlanteren og Grønnland over tre tiår. Pattedyrene som ble undersøkt var ringsel (Grønland), klappmyss (Norge-Vestisen), nise (Island og Norge), kvitskjeving og grindhval (Færøyene), vågehval (Grønland, Island og Norge) og finnhval (Island). Stoffer som ble inkludert i analysen var bromerte flammehemmere (BFRer) som polybromerte difenyletere (PBDE), bromerte dibenzo-p-dioksiner og furaner (PBDD/PBDF) og metoksylerte polybromerte difenyletere. Andre stoffer som ble undersøkt var perfluorforbindelser (PFC) inkludert PFOS, og klorerte naftalener (PCN). Bromerte flammehemmere og naftalener ble analysert i spekk, mens fluorforbindelsene (PFOS) ble analysert i lever.

Undersøkelsen har bidratt med ny og verdifull viten om en rekke «nye» miljøgifter i flere arter av marine pattedyr fra nordiske arktiske områder og/eller nordøst Atlanterhavet. Et stort antall prøver ble utvalgt og analysert i denne undersøkelsen. Kun et begrenset antall av lokaliteter og arter inngår i undersøkelsen. På tross av dette ble det funnet flere statistisk signifikante tendenser i materialet.

Mange av de «nye» miljøgiftene som er undersøkt i dette prosjektet avtar i løpet av den tidsperioden som studien omfatter. Dette gjelder for PBDE, PCN og PFOS, som er den PFC som ble funnet i høyest konsentrasjon. Det ble sett økende nivåer av PFC med lengre alkylkjeder.

De høyeste konsentrasjonene av $\Sigma_{10}$PBDEer ble funnet i tannhvalene. Grindhval hadde de høyeste konsentrasjonene (~1,200 ng/g lipidvekt), fulgt av kvitskjeving (springer) (~650 ng/g lipidvekt) og nise (~250 ng/g lipidvekt). BDE-47 var den vanligste kongeneren av PBDE og utgjorde 30–75 % av $\Sigma_{10}$PBDEer i de marine pattedyrene. Deka-BDE ble analysert i prøver av ringsel, grindhval og vågehval. Det ble ikke påvist i nivåer over deteksjonsgrensen (i området 0.5–3.0 ng/g fedt). De metoksylerte BRFer viser det samme bildet som PBDE. De fleste metoksylerte forbindelsene ble funnet i grindhval og 6MBDE47 var den mest dominerende. Analysen av de bromerte forbindelser viser at nivåene av $\Sigma_{10}$PBDEer økte fra 1980 tallet til slutten av 1990 tallet, for deretter å avta i første halvdel av 2000 tallet. Denne trenden ble sett i alle undersøkte marine pattedyr og var av signifikant for finnhval og kvitskjeving. Nedgangen av $\Sigma_{10}$PBDEer i perioden 2000–2006 ble observert for alle arter og var størst (44 %) i ringsel fra Grønland.

Et utvalg av prøver ble analysert for ukjente bromerte forbindelser. Det ble funnet mange ikke-identifiserte bromholdige forbindelser. Dessuten ble utvalgte prøver analysert for bromerte flammehemmere andre

enn PBDEer. Dette var bla. HBB, PBT, BTBPE og DBDPE, PBB-153, TBECH og PBDD/DF). Alle disse forbindelsene var under deteksjonsgrensen, med unntak for PBB-153 og HBB. TBECH ble midlertidig påvist i grindhval prøver ved hjelp av LRGC/MS. Disse funnene ble ikke bekreftet ved bruk av HRGC/MS.

Klorerte naftalener ble funnet i mye lavere konsentrasjon enn PBDEer. Naftalene er relevante på grunn av deres dioksin-lignende opptreden og giftighet. De høyeste konsentrasjonene av $\Sigma_{14}$PCN (~ 4 ng/g lipidvekt) ble funnet i grindhval. Det ble funnet forskjeller i mønsteret av PCNer mellom de ulike pattedyr artene. Det ble ikke funnet noen entydig trend av minkende PCN i marine pattedyr i de siste årene, men det ble påvist signifikant minking i $\Sigma_{14}$PCN i klappmyss og finnhval. For de andre artene ser vi kun en reduksjon for enkelte kongenere. Konsentrasjonen av PCN i vågehval fra norskekysten i 1999 var ikke statistisk forskjellig fra de prøver som ble tatt av samme art i 1993.

I motsetning til de andre forbindelsene i denne undersøkelsen som ble analysert i spekk, ble PFC analysert i lever med unntak for finnhval hvor en benyttet muskelvev. Atten PFCer ble undersøkt, og av disse ble PFOS funnet i høyest konsentrasjon. De høyeste PFOS konsentrasjonene ble funnet i kvitskjeving (~ 110 ng/g våtvekt), etterfulgt av tilnærmet lik konsentrasjon i ringsel, klappmyss, grindhval, vågehval (Vest-Grønland) og nise fra Island (~ 50 ng/g våtvekt). I finnhval var konsentrasjonen av de fleste PFCer lavere enn deteksjonsgrensen. Konsentrasjoner av PFOS ble påvist i prøver fra denne arten, men nivåene var bare 0.4 ng/g våtvekt. Det ble funnet signifikant minkende konsentrasjoner av PFOS i klappmyss (1990–2007). Det ble funnet økende konsentrasjoner av noen eller flere PFCer i prøver av ringsel, grindhval, kvitskjeving og nise.

For PFUnDA ble det funnet signifikant økende konsentrasjoner i ringsel, grindehval og kvitskjeving. Dette kan indikere at innholdet av de større PFCene fremdeles øker.

Generelt ble det ikke funnet noen regionale forskjeller for «nye» miljøgifter i marine pattedyr fra Nord-Atlanteren. Dette kunne imidlertid bare undersøkes for vågehval og nise hvor prøvene ble tatt fra mer enn én lokalitet.

# Appendix

# Appendix 1: Samples analysed

| Lab. ID | Pool no. | ID-No | Species | Collection year | Collection date | Area | Sex | Age yrs | Age, pool mean | Length, cm | Length, pool mean | Liver sample, g | Blubber sample, g |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DL-08-008:10 | | 1701 | Ringed seal | 1986 | | Ittoqqortoormiit | male | 2 | 2.4 | | | | 4.51 |
| | Pool 1 | 1703 | Ringed seal | 1986 | | Ittoqqortoormiit | male | 4 | | | | | 4.54 |
| | | 1708 | Ringed seal | 1986 | | Ittoqqortoormiit | male | 1 | | | | | 4.52 |
| | | 1711 | Ringed seal | 1986 | | Ittoqqortoormiit | female | 3 | | | | | 4.43 |
| | | 1714 | Ringed seal | 1986 | | Ittoqqortoormiit | female | 2 | | | | | 4.56 |
| DL-08-008:11 | | 1717 | Ringed seal | 1986 | | Ittoqqortoormiit | male | 3 | 3.6 | | | | 4.15 |
| | Pool 2 | 1718 | Ringed seal | 1986 | | Ittoqqortoormiit | female | 3 | | | | | 4.08 |
| | | 1719 | Ringed seal | 1986 | | Ittoqqortoormiit | female | 5 | | | | | 4.11 |
| | | 1720 | Ringed seal | 1986 | | Ittoqqortoormiit | female | 4 | | | | | 4.13 |
| | | 1724 | Ringed seal | 1986 | | Ittoqqortoormiit | female | 3 | | | | | 4.11 |
| DL-08-008:12 | | 1728 | Ringed seal | 1986 | | Ittoqqortoormiit | male | 3 | 2.8 | | | | 4.25 |
| | Pool 3 | 1729 | Ringed seal | 1986 | | Ittoqqortoormiit | male | 4 | | | | | 4.29 |
| | | 1732 | Ringed seal | 1986 | | Ittoqqortoormiit | male | 3 | | | | | 4.24 |
| | | 1734 | Ringed seal | 1986 | | Ittoqqortoormiit | female | 3 | | | | | 4.28 |
| | | 1737 | Ringed seal | 1986 | | Ittoqqortoormiit | male | 1 | | | | | 4.3 |
| DL-08-008:13 | | 21549 | Ringed seal | 2000 | | Ittoqqortoormiit | female | 1 | 1.25 | | | | 6.9 |
| | Pool 4 | 21551 | Ringed seal | 2000 | | Ittoqqortoormiit | male | 2 | | | | | 6.91 |
| | | 21553 | Ringed seal | 2000 | | Ittoqqortoormiit | male | 1 | | | | | 6.86 |
| | | 21554 | Ringed seal | 2000 | | Ittoqqortoormiit | female | 1 | | | | | 6.85 |
| DL-08-008:14 | | 21555 | Ringed seal | 2000 | | Ittoqqortoormiit | female | 4 | 4.5 | | | | 6.29 |
| | Pool 5 | 21557 | Ringed seal | 2000 | | Ittoqqortoormiit | female | 5 | | | | | 6.21 |
| | | 21558 | Ringed seal | 2000 | | Ittoqqortoormiit | male | 4 | | | | | 6.21 |
| | | 21559 | Ringed seal | 2000 | | Ittoqqortoormiit | female | 5 | | | | | 6.26 |
| DL-08-008:15 | | 21560 | Ringed seal | 2000 | | Ittoqqortoormiit | male | 5 | 3.5 | | | | 5.5 |
| | Pool 6 | 21561 | Ringed seal | 2000 | | Ittoqqortoormiit | male | 3 | | | | | 5.55 |
| | | 21562 | Ringed seal | 2000 | | Ittoqqortoormiit | female | 1 | | | | | 5.55 |
| | | 21566 | Ringed seal | 2000 | | Ittoqqortoormiit | female | 5 | | | | | 5.5 |
| DL-08-008:16 | | 34902 | Ringed seal | 2006 | | Ittoqqortoormiit | male | 2 | 3.0 | | | | 5.72 |
| | Pool 7 | 34905 | Ringed seal | 2006 | | Ittoqqortoormiit | female | 3 | | | | | 5.72 |
| | | 34908 | Ringed seal | 2006 | | Ittoqqortoormiit | female | 4 | | | | | 5.72 |
| | | 34910 | Ringed seal | 2006 | | Ittoqqortoormiit | female | 3 | | | | | 5.7 |
| DL-08-008:17 | | 34911 | Ringed seal | 2006 | | Ittoqqortoormiit | female | 0 | 1.25 | | | | 5.21 |
| | Pool 8 | 34912 | Ringed seal | 2006 | | Ittoqqortoormiit | male | 1 | | | | | 5.24 |
| | | 34916 | Ringed seal | 2006 | | Ittoqqortoormiit | male | 4 | | | | | 5.15 |
| | | 34919 | Ringed seal | 2006 | | Ittoqqortoormiit | female | 0 | | | | | 5.17 |

| Lab. ID | Pool no. | ID-No | Species | Collection year | Collection date | Area | Sex | Age yrs | Age, pool mean | Length, cm | Length, pool mean | Liver sample, g | Blubber sample, g |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DL-08-008:18 | Pool 9 | 34931 | Ringed seal | 2006 | | Ittoqqortoormiit | male | 0 | 0 | | | | 5.65 |
| | | 34944 | Ringed seal | 2006 | | Ittoqqortoormiit | female | 0 | | | | | 5.7 |
| | | 34945 | Ringed seal | 2006 | | Ittoqqortoormiit | female | 0 | | | | | 5.61 |
| | | 34946 | Ringed seal | 2006 | | Ittoqqortoormiit | male | 0 | | | | | 5.64 |
| DL-08-008:25PFC | Pool 1 | 100 | Ringed seal | 1984 | | Avanersuaq | male | 2 | 2.5 | | | 3.37 | |
| | | 101 | Ringed seal | 1984 | | Avanersuaq | male | 2 | | | | 3.35 | |
| | | 104 | Ringed seal | 1984 | | Avanersuaq | male | 4 | | | | 3.37 | |
| | | 108 | Ringed seal | 1984 | | Avanersuaq | male | 2 | | | | 3.46 | |
| DL-08-008:26PFC | Pool 2 | 109 | Ringed seal | 1984 | | Avanersuaq | female | 4 | 2.5 | | | 3.46 | |
| | | 110 | Ringed seal | 1984 | | Avanersuaq | female | 2 | | | | 3.46 | |
| | | 111 | Ringed seal | 1984 | | Avanersuaq | male | 1 | | | | 3.55 | |
| | | 112 | Ringed seal | 1984 | | Avanersuaq | female | 3 | | | | 3.49 | |
| DL-08-008:27PFC | Pool 3 | 117 | Ringed seal | 1984 | | Avanersuaq | male | 2 | 3.0 | | | 3.47 | |
| | | 119 | Ringed seal | 1984 | | Avanersuaq | male | 4 | | | | 3.44 | |
| | | 122 | Ringed seal | 1984 | | Avanersuaq | male | 2 | | | | 3.38 | |
| | | 129 | Ringed seal | 1984 | | Avanersuaq | female | 4 | | | | 3.39 | |
| DL-08-008:28PFC | Pool 1 | 20703 | Ringed seal | 1998 | | Avanersuaq | female | 3 | 2.0 | | | 3.5 | |
| | | 20704 | Ringed seal | 1998 | | Avanersuaq | male | 3 | | | | 3.52 | |
| | | 20705 | Ringed seal | 1998 | | Avanersuaq | male | 1 | | | | 3.47 | |
| | | 20706 | Ringed seal | 1998 | | Avanersuaq | male | 1 | | | | 3.46 | |
| DL-08-008:29PFC | Pool 2 | 20710 | Ringed seal | 1998 | | Avanersuaq | male | 4 | 3.25 | | | 3.52 | |
| | | 20712 | Ringed seal | 1998 | | Avanersuaq | female | 4 | | | | 3.38 | |
| | | 20715 | Ringed seal | 1998 | | Avanersuaq | male | 3 | | | | 3.43 | |
| | | 20718 | Ringed seal | 1998 | | Avanersuaq | female | 2 | | | | 3.33 | |
| DL-08-008:30PFC | Pool 3 | 20719 | Ringed seal | 1998 | | Avanersuaq | male | 3 | 1.75 | | | 3.28 | |
| | | 20720 | Ringed seal | 1998 | | Avanersuaq | female | 1 | | | | 3.31 | |
| | | 20722 | Ringed seal | 1998 | | Avanersuaq | male | 2 | | | | 3.33 | |
| | | 20723 | Ringed seal | 1998 | | Avanersuaq | male | 1 | | | | 3.29 | |
| DL-08-008:31PFC | Pool 1 | 35002 | Ringed seal | 2006 | | Avanersuaq | male | 3 | 1.5 | | | 4.18 | |
| | | 35004 | Ringed seal | 2006 | | Avanersuaq | female | 1 | | | | 4.18 | |
| | | 35005 | Ringed seal | 2006 | | Avanersuaq | male | 1 | | | | 4.2 | |
| | | 35006 | Ringed seal | 2006 | | Avanersuaq | male | 1 | | | | 4.17 | |
| DL-08-008:32PFC | Pool 2 | 35007 | Ringed seal | 2006 | | Avanersuaq | male | 3 | 2.3 | | | 3.11 | |
| | | 35008 | Ringed seal | 2006 | | Avanersuaq | female | 1 | | | | 3.11 | |
| | | 35009 | Ringed seal | 2006 | | Avanersuaq | ? | 2 | | | | 3.09 | |
| | | 35010 | Ringed seal | 2006 | | Avanersuaq | male | 3 | | | | 3.21 | |
| DL-08-008:33PFC | Pool 3 | 35011 | Ringed seal | 2006 | | Avanersuaq | male | 4 | 2.8 | | | 3.11 | |
| | | 35012 | Ringed seal | 2006 | | Avanersuaq | female | 3 | | | | 3.12 | |
| | | 35013 | Ringed seal | 2006 | | Avanersuaq | female | 3 | | | | 3.15 | |
| | | 35020 | Ringed seal | 2006 | | Avanersuaq | male | 1 | | | | 3.06 | |

| Lab. ID | Pool no. | ID-No | Species | Collection year | Collection date | Area | Sex | Age yrs | Age, pool mean | Length, cm | Length, pool mean | Liver sample, g | Blubber sample, g |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DL-08-008-56 / | | 303 | Hooded seal | 1990 | | West Ice | female | 9 | 7.2 | 207 | 184 | 4.51 | 4.51 |
| DL-08- | | 305 | Hooded seal | 1990 | | West Ice | female | 4 | | 170 | | 4.62 | 4.42 |
| 008:52PFC | KL-1990-1 | 311 | Hooded seal | 1990 | | West Ice | female | 8 | | 194 | | 4.64 | 4.58 |
| | | 317 | Hooded seal | 1990 | | West Ice | female | 7 | | 177 | | 4.39 | 4.57 |
| | | 320 | Hooded seal | 1990 | | West Ice | female | 8 | | 173 | | 4.51 | 4.61 |
| DL-08-008-57 / | | 323 | Hooded seal | 1990 | | West Ice | female | 5 | 5.8 | 182 | 174 | 4.72 | 4.52 |
| DL-08- | | 328 | Hooded seal | 1990 | | West Ice | female | | | 178 | | 4.63 | 4.64 |
| 008:53PFC | KL-1990-2 | 334 | Hooded seal | 1990 | | West Ice | female | 8 | | 171 | | 4.77 | 4.68 |
| | | 343 | Hooded seal | 1990 | | West Ice | female | 6 | | 168 | | 4.80 | 4.55 |
| | | 362 | Hooded seal | 1990 | | West Ice | female | 4 | | 171 | | 4.79 | 4.56 |
| DL-08-008-58 / | | 365 | Hooded seal | 1990 | | West Ice | female | 18 | 9.2 | 194 | 177 | 4.71 | 4.50 |
| DL-08- | | 370 | Hooded seal | 1990 | | West Ice | female | 8 | | 147 | | 4.71 | 4.67 |
| 008:54PFC | KL-1990-3 | 384 | Hooded seal | 1990 | | West Ice | female | 5 | | 183 | | 4.73 | 4.67 |
| | | 400 | Hooded seal | 1990 | | West Ice | female | 9 | | 179 | | 4.75 | 4.70 |
| | | 401 | Hooded seal | 1990 | | West Ice | female | 6 | | 182 | | 4.70 | 4.56 |
| DL-08-008-59 | | 6 | Hooded seal | 1997 | 19970318 | West Ice | female | 08 | 7.5 | 110 | 118 | | 2.51 |
| | KL-1997-1 | 25 | Hooded seal | 1997 | 19970321 | West Ice | female | 05 | | 120 | | | 2.61 |
| | | 13 | Hooded seal | 1997 | 19970320 | West Ice | female | 06 | | 102 | | | 2.44 |
| | | 22 | Hooded seal | 1997 | 19970321 | West Ice | female | 11 | | 140 | | | 2.56 |
| DL-08-008-60 | | 7 | Hooded seal | 1997 | 19970319 | West Ice | female | 09 | 6.8 | 151 | 126 | | 2.53 |
| | KL-1997-2 | 19 | Hooded seal | 1997 | 19970321 | West Ice | female | 06 | | 114 | | | 2.62 |
| | | 31 | Hooded seal | 1997 | 19970321 | West Ice | female | 04 | | 115 | | | 2.61 |
| | | 36 | Hooded seal | 1997 | 19970322 | West Ice | female | 08 | | 125 | | | 2.48 |
| DL-08-008-61 | | 39 | Hooded seal | 1997 | 19970322 | West Ice | female | 09 | 7.3 | 136 | 122 | | 2.40 |
| | KL-1997-3 | 41 | Hooded seal | 1997 | 19970322 | West Ice | female | 06 | | 105 | | | 2.46 |
| | | 43 | Hooded seal | 1997 | 19970322 | West Ice | female | 07 | | 113 | | | 2.58 |
| | | 45 | Hooded seal | 1997 | 19970322 | West Ice | female | 07 | | 133 | | | 2.49 |
| DL-08-008-62 / | | 1 | Hooded seal | 2007 | 20070322 | West Ice | female | | | 185 | 191 | 4.4 | 4.5 |
| DL-08- | | 3 | Hooded seal | 2007 | 20070322 | West Ice | female | | | 177 | | 4.7 | 4.5 |
| 008:55PFC | KL-2007-1 | 5 | Hooded seal | 2007 | 20070322 | West Ice | female | | | 196 | | 4.4 | 4.5 |
| | | 7 | Hooded seal | 2007 | 20070322 | West Ice | female | | | 192 | | 4.3 | 4.6 |
| | | 42 | Hooded seal | 2007 | 20070327 | West Ice | female | | | 204 | | 4.6 | 4.4 |
| DL-08-008-63 / | | 12 | Hooded seal | 2007 | 20070323 | West Ice | female | | | 192 | 189 | 4.5 | 5 |
| DL-08- | | 14 | Hooded seal | 2007 | 20070323 | West Ice | female | | | 180 | | 4.5 | 5.1 |
| 008:56PFC | KL-2007-2 | 16 | Hooded seal | 2007 | 20070323 | West Ice | female | | | 185 | | 4.5 | 5.1 |
| | | 19 | Hooded seal | 2007 | 20070324 | West Ice | female | | | 200 | | 4.5 | 5.1 |
| | | 10 | Hooded seal | 2007 | 20070323 | West Ice | female | | | 186 | | 4.5 | 5.2 |
| DL-08-008-64 / | | 27 | Hooded seal | 2007 | 20070324 | West Ice | female | | | 203 | 192 | 4.8 | 4.8 |
| DL-08- | | 30 | Hooded seal | 2007 | 20070326 | West Ice | female | | | 186 | | 4.7 | 4.8 |
| 008:57PFC | KL-2007-3 | 33 | Hooded seal | 2007 | 20070326 | West Ice | female | | | 188 | | 4.6 | 4.7 |
| | | 36 | Hooded seal | 2007 | 20070326 | West Ice | female | | | 190 | | 4.7 | 4.8 |
| | | 45 | Hooded seal | 2007 | 20070327 | West Ice | female | | | 192 | | 4.7 | 4.7 |

| Lab. ID | Pool no. | ID-No | Species | Collection year | Collection date | Area | Sex | Age yrs | Age, pool mean | Length, cm | Length, pool mean | Liver sample, g | Blubber sample, g |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DL-08-008-65 | Sample 2000 A | 2000-34 | Harbour porpoise | 2000 | 04-04-00 | Finnmark 70-71$^0$ N | male | | | 147 | 136 | | 4.5 |
| | | 2000-37 | Harbour porpoise | 2000 | 02-05-00 | Finnmark 70-71$^0$ N | male | | | 120 | | | 4.6 |
| | | 2000-51 | Harbour porpoise | 2000 | 03-04-00 | Finnmark 70-71$^0$ N | male | | | 148 | | | 4.7 |
| | | VF-01-2000 | Harbour porpoise | 2000 | 06-06-00 | Finnmark 70-71$^0$ N | male | | | 135 | | | 4.6 |
| | | VF-03-2000 | Harbour porpoise | 2000 | 08-06-00 | Finnmark 70-71$^0$ N | male | | | 129 | | | 4.7 |
| DL-08-008-66 | Sample 2000 B | 2000-1 | Harbour porpoise | 2000 | 17-04-00 | N-Trøndelag 65-66$^0$ N | male | | | 142 | 135 | | 4.9 |
| | | 2000-11 | Harbour porpoise | 2000 | 16-03-00 | N-Trøndelag 65-66$^0$ N | male | | | 128.5 | | | 4.9 |
| | | 2000-22 | Harbour porpoise | 2000 | 07-03-00 | N-Trøndelag 65-66$^0$ N | male | | | 121 | | | 4.9 |
| | | 2000-44 | Harbour porpoise | 2000 | 04-04-00 | N-Trøndelag 65-66$^0$ N | male | | | 136 | | | 4.8 |
| | | 2000-47 | Harbour porpoise | 2000 | 12-04-00 | N-Trøndelag 65-66$^0$ N | male | | | 145 | | | 4.8 |
| DL-08-008-67 | Sample 2000 C | 2000-21 | Harbour porpoise | 2000 | 09-03-00 | Hordaland, 60$^0$ N | male | | | 136.5 | 131 | | 4.6 |
| | | 2000-29 | Harbour porpoise | 2000 | 23-03-00 | Hordaland, 60$^0$ N | male | | | 130 | | | 4.7 |
| | | 2000-33 | Harbour porpoise | 2000 | 24-03-00 | Hordaland, 60$^0$ N | male | | | na | | | 4.7 |
| | | 2000-5 | Harbour porpoise | 2000 | 27-03-00 | Hordaland, 60$^0$ N | male | | | 133 | | | 4.7 |
| | | 2000-50 | Harbour porpoise | 2000 | 21-03-00 | Hordaland, 60$^0$ N | male | | | 125 | | | 4.7 |
| DL-08-008:40PFC | Group 1 | SV-42 | Harbour porpoise | 1992 | 28.03.1992 | SW-Iceland | male | 0 | 0.2 | 112 | 123 | 15.0 | 13.1 |
| | | SV-47 | Harbour porpoise | 1992 | 28.03.1992 | SW-Iceland | male | 0 | | 123.3 | | 15.3 | 16.2 |
| | | SV-70 | Harbour porpoise | 1992 | 01.04.1992 | SW-Iceland | male | 0 | | 114.6 | | 15.0 | 11.1 |
| | | SV-224 | Harbour porpoise | 1992 | 10.04.1992 | SW-Iceland | male | 0 | | 136.2 | | 16.1 | 13.4 |
| | | SV-106 | Harbour porpoise | 1992 | | SW-Iceland | male | 1 | | 126.4 | | 16.2 | 9.0 |
| DL-08-008:41PFC | Group 2 | SV-152 | Harbour porpoise | 1992 | 04.04.1992 | SW-Iceland | male | 2 | 2.2 | 143.3 | 137 | 16.3 | 15.8 |
| | | SV-218 | Harbour porpoise | 1992 | 10.04.1992 | SW-Iceland | male | 2 | | 140.5 | | 14.1 | 16.9 |
| | | SV-401 | Harbour porpoise | 1992 | 04.12.1992 | SW-Iceland | male | 2 | | 129.3 | | 15.5 | 14.0 |
| | | SV-137 | Harbour porpoise | 1992 | 04.04.1992 | SW-Iceland | male | 2 | | 134.9 | | 15.3 | 17.5 |
| | | SV-138 | Harbour porpoise | 1992 | | SW-Iceland | male | 3 | | 139 | | 11.6 | 15.9 |
| DL-08-008:42PFC | Group 3 | SV-205 | Harbour porpoise | 1992 | | SW-Iceland | male | 3 | 3.6 | 146 | 140 | 16.6 | 18.9 |
| | | SV-334 | Harbour porpoise | 1992 | | SW-Iceland | male | 3 | | 131.1 | | 16.3 | 17.1 |
| | | SV-384 | Harbour porpoise | 1992 | | SW-Iceland | male | 3 | | 140.1 | | 18.7 | 14.9 |
| | | SV-196 | Harbour porpoise | 1992 | 05.04.1992 | SW-Iceland | male | 4 | | 140 | | 18.7 | 19 |
| | | SV-80 | Harbour porpoise | 1992 | 01.04.1992 | SW-Iceland | male | 5 | | 145 | | 16.4 | 18.6 |
| DL-08-008:43PFC | Group 1 | B-2 | Harbour porpoise | 1997 | 13.10.1997 | SW-Iceland | male | 0 | 0.2 | 118 | 132 | 10.0 | 9.1 |
| | | AK-1 | Harbour porpoise | 1997 | 01.04.1997 | SW-Iceland | male | 0 | | 125.5 | | 17.6 | 19.9 |
| | | AK-62 | Harbour porpoise | 1997 | 20.05.1997 | SW-Iceland | male | 0 | | 134.5 | | 17.4 | 20.8 |
| | | AK-19 | Harbour porpoise | 1997 | 07.04.1997 | SW-Iceland | male | 0 | | 140.5 | | 17.6 | 17.4 |
| | | AK-20 | Harbour porpoise | 1997 | 06.04.1997 | SW-Iceland | male | 1 | | 140.5 | | 19.1 | 15.7 |
| DL-08-008:44PFC | Group 2 | B-4 | Harbour porpoise | 1997 | 13.10.1997 | SW-Iceland | male | 2 | 2.2 | 136.5 | 135 | 11.0 | 2.9 |
| | | B-5 | Harbour porpoise | 1997 | 13.10.1997 | SW-Iceland | male | 2 | | 133 | | 9.2 | 11.3 |
| | | AK-49 | Harbour porpoise | 1997 | 29.04.1997 | SW-Iceland | male | 2 | | 146.5 | | 16.6 | 17.5 |
| | | AK-10 | Harbour porpoise | 1997 | 07.04.1997 | SW-Iceland | male | 2 | | 128.5 | | 13.3 | 13.4 |
| | | B-13 | Harbour porpoise | 1997 | 13.10.1997 | SW-Iceland | male | 3 | | 129.5 | | 14.5 | 10.9 |

| Lab. ID | Pool no. | ID-No | Species | Collection year | Collection date | Area | Sex | Age yrs | Age, pool mean | Length, cm | Length, pool mean | Liver sample, g | Blubber sample, g |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DL-08-008:45PFC | Group 3 | AK-70 | Harbour porpoise | 1997 | 28.05.1997 | SW-Iceland | male | 3 | 3.6 | 144 | 140 | 17.49 | 17.5 |
| | | B-10 | Harbour porpoise | 1997 | 13.10.1997 | SW-Iceland | male | 3 | | 141 | | 18 | 10.5 |
| | | AK-3 | Harbour porpoise | 1997 | 01.04.1997 | SW-Iceland | male | 3 | | 144 | | 17.5 | 18.3 |
| | | B-3 | Harbour porpoise | 1997 | 13.10.1997 | SW-Iceland | male | 4 | | 126 | | 17.1 | 6.3 |
| | | AK-2 | Harbour porpoise | 1997 | 01.04.1997 | SW-Iceland | male | 5 | | 143 | | 15.5 | 18 |
| DL-08-008-35 | pool 1-1997 | 26 | White-sided dolphin | 1997 | 210897 | Klaksvík | male | | | 215 | 223 | | 10.57 |
| | | 34 | White-sided dolphin | 1997 | 210897 | Klaksvík | male | | | 225 | | | 10.2 |
| | | 13 | White-sided dolphin | 1997 | 210897 | Klaksvík | male | | | 230 | | | 10.63 |
| DL-08-008-36 | pool 2-1997 | 45 | White-sided dolphin | 1997 | 210897 | Klaksvík | male | | | 235 | 237 | | 10.6 |
| | | 47 | White-sided dolphin | 1997 | 210897 | Klaksvík | male | | | 235 | | | 10.68 |
| | | 5 | White-sided dolphin | 1997 | 210897 | Klaksvík | male | | | 240 | | | 10.4 |
| DL-08-008-37 | pool 3-1997 | 16 | White-sided dolphin | 1997 | 210897 | Klaksvík | male | | | 240 | 240 | | 10.68 |
| | | 21 | White-sided dolphin | 1997 | 210897 | Klaksvík | male | | | 240 | | | 10.47 |
| | | 46 | White-sided dolphin | 1997 | 210897 | Klaksvík | male | | | 240 | | | 10.61 |
| | | 57 | White-sided dolphin | 1997 | 210897 | Klaksvík | male | | | 240 | | | 10.78 |
| DL-08-008-41 | 1-2001/02 | 091701-0015 | White-sided dolphin | 2001 | 091701 | Syðrugøta | male | 10 | 10.2 | 221 | 229 | 3.3 | 3.13 |
| | | 091701-0017 | White-sided dolphin | 2001 | 091701 | Syðrugøta | male | 11 | | 226 | | 3.6 | |
| | | 091701-0010 | White-sided dolphin | 2001 | 091701 | Syðrugøta | male | 12 | | 229 | | 3.61 | |
| | | 091801-0113 | White-sided dolphin | 2001 | 091801 | Tórshavn | male | 8 | | 232 | | 3.28 | 3.23 |
| | | 091801-0106 | White-sided dolphin | 2001 | 091801 | Tórshavn | male | 10 | | 236 | | 3.67 | 3.17 |
| DL-08-008-42 | 2-2001/02 | 091701-0026 | White-sided dolphin | 2001 | 091701 | Syðrugøta | male | 10 | 12.8 | 237 | 233 | 3.4 | 3.49 |
| | | 091701-0019 | White-sided dolphin | 2001 | 091701 | Syðrugøta | male | 14 | | 240 | | | 3.21 |
| | | 090302-0313 | White-sided dolphin | 2002 | 090302 | Hvalvík | male | 11 | | 219 | | 3.2 | 2.9 |
| | | 090302-0315 | White-sided dolphin | 2002 | 090302 | Hvalvík | male | 11 | | 233 | | 3.09 | 3.4 |
| | | 090302-0327 | White-sided dolphin | 2002 | 090302 | Hvalvík | male | 18 | | 237 | | 3.05 | 3.23 |
| DL-08-008-43 | 3-2001/02 | 091702-0455 | White-sided dolphin | 2002 | 091702 | Gøta | male | 9 | 8.8 | 237 | 232 | 3.11 | 3.37 |
| | | 091702-0461 | White-sided dolphin | 2002 | 091702 | Gøta | male | 8 | | 225 | | 3.41 | 3.26 |
| | | 091702-0462 | White-sided dolphin | 2002 | 091702 | Gøta | male | 8 | | 229 | | 3.21 | 3.24 |
| | | 091702-0466 | White-sided dolphin | 2002 | 091702 | Gøta | male | 9 | | 239 | | 3.69 | 3.01 |
| | | 091702-0468 | White-sided dolphin | 2002 | 091702 | Gøta | male | 10 | | 230 | | 3.19 | 3.56 |
| DL-08-008:19PFC / DL-08-008-40 | pool 1-2006 | 080806-0005 | White-sided dolphin | 2006 | 80806 | Gøta | male | | | 215 | 217 | 3.73 | 3.09 |
| | | 080806-0007 | White-sided dolphin | 2006 | 80806 | Gøta | male | | | 216 | | 3.25 | 3.12 |
| | | 080806-0035 | White-sided dolphin | 2006 | 80806 | Gøta | male | | | 219 | | 3.09 | 3.29 |

| Lab. ID | Pool no. | ID-No | Species | Collection year | Collection date | Area | Sex | Age yrs | Age, pool mean | Length, cm | Length, pool mean | Liver sample, g | Blubber sample, g |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DL-08-008:20PFC / DL-08-008-38 | pool 2-2006 | 080806-0003 | White-sided dolphin | 2006 | 80806 | Gøta | male | | | 221 | 225 | 2.5 | 3 |
| | | 080806-0116 | White-sided dolphin | 2006 | 80806 | Gøta | male | | | 226 | | 2.67 | 3.04 |
| | | 080806-0117 | White-sided dolphin | 2006 | 80806 | Gøta | male | | | 228 | | 2.63 | 2.96 |
| DL-08-008:21PFC / DL-08-008-39 | pool 3-2006 | 080806-0010 | White-sided dolphin | 2006 | 80806 | Gøta | male | | | 236 | 240 | 3.07 | 3.19 |
| | | 080806-0014 | White-sided dolphin | 2006 | 80806 | Gøta | male | | | 241 | | 3.41 | 3.23 |
| | | 080806-0032 | White-sided dolphin | 2006 | 80806 | Gøta | male | | | 242 | | 3.15 | 3.3 |
| DL-08-008:7 | 1-1986 | 66 | Pilot whale | 1986 | 12-07-86 | Leynar | male | 6 | 8.1 | 435 | 401 | | 2.7 |
| | | 114 | Pilot whale | 1986 | 12-07-86 | Leynar | male | 6 | | 400 | | | 2.8 |
| | | 113 | Pilot whale | 1986 | 12-07-86 | Leynar | male | 12 | | 385 | | | 2.7 |
| | | 123 | Pilot whale | 1986 | 12-07-86 | Leynar | male | 5 | | 368 | | | 2.7 |
| | | 128 | Pilot whale | 1986 | 12-07-86 | Leynar | male | 12 | | 463 | | | 2.8 |
| | | 0 | Pilot whale | 1986 | 12-07-86 | Leynar | male | 4 | | 367 | | | 2.8 |
| | | 104 | Pilot whale | 1986 | 12-07-86 | Leynar | male | 13 | | 422 | | | 2.8 |
| | | 14 | Pilot whale | 1986 | 12-07-86 | Leynar | male | 7 | | 367 | | | 2.9 |
| DL-08-008:8 | 2-1986 | 28 | Pilot whale | 1986 | 01-11-86 | Miðvágur | male | 6 | 6.2 | 391 | 401 | | 7.9 |
| | | 27 | Pilot whale | 1986 | 01-11-86 | Miðvágur | male | 4 | | 353 | | | 8.2 |
| | | 132 | Pilot whale | 1986 | 01-11-86 | Miðvágur | male | 8 | | 450 | | | 8.1 |
| | | 6 | Pilot whale | 1986 | 01-11-86 | Miðvágur | male | 6 | | 408 | | | 8.2 |
| | | 9 | Pilot whale | 1986 | 01-11-86 | Miðvágur | male | 4 | | 351 | | | 7.6 |
| | | 68 | Pilot whale | 1986 | 01-11-86 | Miðvágur | male | 9 | | 452 | | | 8 |
| DL-08-008:9 | 3-1986 | 46 | Pilot whale | 1986 | 01-11-86 | Miðvágur | male | na | 7.5 | 454 | 405 | | 9.9 |
| | | 106 | Pilot whale | 1986 | 01-11-86 | Miðvágur | male | 6 | | 357 | | | 9.9 |
| | | 90 | Pilot whale | 1986 | 01-11-86 | Miðvágur | male | 6 | | 400 | | | 10 |
| | | 28 | Pilot whale | 1986 | 26-10-86 | Funningsfjørður | male | 12 | | 452 | | | 10.1 |
| | | 32 | Pilot whale | 1986 | 26-10-86 | Funningsfjørður | male | 6 | | 360 | | | 9.9 |
| DL-08-008:1 | 1-1997 | 3 | Pilot whale | 1997 | 02-12-97 | Leynar | male | 12* | 9.8* | 438 | 420 | | 5.27 |
| | | 13 | Pilot whale | 1997 | 02-12-97 | Leynar | male | 11* | | 440 | | | 5.15 |
| | | 14 | Pilot whale | 1997 | 02-12-97 | Leynar | male | 10* | | 420 | | | 5.32 |
| | | 17 | Pilot whale | 1997 | 02-12-97 | Leynar | male | 7* | | 381 | | | 4.81 |
| | | 47 | Pilot whale | 1997 | 02-12-97 | Leynar | male | 9* | | 419 | | | 5.15 |
| DL-08-008:2 | feb-97 | 15 | Pilot whale | 1997 | 06-09-97 | Bø | male | 6* | 7.9* | | | | 5.89 |
| | | 8 | Pilot whale | 1997 | 06-09-97 | Bø | male | 7* | | | | | 5.94 |
| | | 20 | Pilot whale | 1997 | 06-09-97 | Bø | male | 8* | | | | | 5.92 |
| | | 24 | Pilot whale | 1997 | 06-09-97 | Bø | male | 8* | | | | | 6.12 |
| | | 31 | Pilot whale | 1997 | 06-09-97 | Bø | male | 8* | | | | | 6.17 |
| | | 2 | Pilot whale | 1997 | 06-09-97 | Bø | male | 9* | | | | | 6.15 |
| | | 12 | Pilot whale | 1997 | 06-09-97 | Bø | male | 9* | | | | | 6.33 |

| Lab. ID | Pool no. | ID-No | Species | Collection year | Collection date | Area | Sex | Age yrs | Age, pool mean | Length, cm | Length, pool mean | Liver sample, g | Blubber sample, g |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DL-08-008:3 | | 5 | Pilot whale | 1997 | 26-08-97 | Sandavágur | male | 5* | 5.5* | 390 | 403 | | 6.85 |
| | | 12 | Pilot whale | 1997 | 26-08-97 | Sandavágur | male | 5* | | 390 | | | 6.97 |
| | 3-1997 | 15 | Pilot whale | 1997 | 26-08-97 | Sandavágur | male | 7* | | 440 | | | 7.05 |
| | | 21 | Pilot whale | 1997 | 26-08-97 | Sandavágur | male | 5* | | 410 | | | 6.84 |
| | | 22 | Pilot whale | 1997 | 26-08-97 | Sandavágur | male | 5* | | 380 | | | 6.76 |
| | | 23 | Pilot whale | 1997 | 26-08-97 | Sandavágur | male | 6* | | 410 | | | 6.73 |
| DL-08-008:4 | | 10 | Pilot whale | 2006 | 28-aug-06 | Hvannasund | male | 9* | 7.2* | 430 | 398 | | 10.71 |
| | | 13 | Pilot whale | 2006 | 28-aug-06 | Hvannasund | male | 6* | | 366 | | | 10.34 |
| | 1-2006/07 | 15 | Pilot whale | 2006 | 28-aug-06 | Hvannasund | male | 9* | | 450 | | | 10.08 |
| | | 18 | Pilot whale | 2006 | 28-aug-06 | Hvannasund | male | 6* | | 360 | | | 10.27 |
| | | 34 | Pilot whale | 2006 | 28-aug-06 | Hvannasund | male | 6* | | 385 | | | 10.58 |
| DL-08-008:5 | | 15 | Pilot whale | 2006 | 06-sep-06 | Leynar | male | 5* | 8.0* | | | | 11.64 |
| | | 23 | Pilot whale | 2006 | 06-sep-06 | Leynar | male | 9* | | | | | 11.26 |
| | 2-2006/07 | 24 | Pilot whale | 2006 | 06-sep-06 | Leynar | male | 8* | | | | | 11.7 |
| | | 25 | Pilot whale | 2006 | 06-sep-06 | Leynar | male | 9* | | | | | 11.3 |
| | | 46 | Pilot whale | 2006 | 06-sep-06 | Leynar | male | 9* | | | | | 11.51 |
| | | 50 | Pilot whale | 2006 | 06-sep-06 | Leynar | male | 8* | | | | | 11.59 |
| DL-08-008:6 | | 22 | Pilot whale | 2007 | 03-jul-07 | Sandagerði | male | 6* | 6.7* | 380 | 396 | | 10.88 |
| | | 28 | Pilot whale | 2007 | 03-jul-07 | Sandagerði | male | 7* | | 405 | | | 10.97 |
| | 3-2006/07 | 6 | Pilot whale | 2007 | 13-jul-07 | Syðrugøta | male | 5* | | 360 | | | 10.86 |
| | | 10 | Pilot whale | 2007 | 13-jul-07 | Syðrugøta | male | 7* | | 410 | | | 10.72 |
| | | 19 | Pilot whale | 2007 | 13-jul-07 | Syðrugøta | male | 9* | | 450 | | | 10.25 |
| | | 43 | Pilot whale | 2007 | 13-jul-07 | Syðrugøta | male | 6* | | 370 | | | 10.24 |
| DL-08- | | 072287-0027 | Pilot whale | 1987 | 22-jul-87 | Leynar | male | 7 | 7.3 | 378 | 393 | 7.8 | |
| 008:7PFC | | 072287-0038 | Pilot whale | 1987 | 22-jul-87 | Leynar | male | 7 | | 358 | | 8.5 | |
| | 1-1986/87 | 072287-0041 | Pilot whale | 1987 | 22-jul-87 | Leynar | male | 6 | | 356 | | 7.9 | |
| | | 072287-0060 | Pilot whale | 1987 | 22-jul-87 | Leynar | male | 6 | | 380 | | 7.94 | |
| | | 072287-0061 | Pilot whale | 1987 | 22-jul-87 | Leynar | male | 8 | | 438 | | 8.03 | |
| | | 072287-0065 | Pilot whale | 1987 | 22-jul-87 | Leynar | male | 10 | | 448 | | 7.88 | |
| DL-08- | | 081987-0007 | Pilot whale | 1987 | 19-aug-87 | Vágur | male | 5 | 7.2 | 380 | 416 | 8.36 | |
| 008:8PFC | | 081987-0013 | Pilot whale | 1987 | 19-aug-87 | Vágur | male | 9 | | 450 | | 7.92 | |
| | 2-1986/87 | 081987-0014 | Pilot whale | 1987 | 19-aug-87 | Vágur | male | 8 | | 430 | | 8.31 | |
| | | 081987-0029 | Pilot whale | 1987 | 19-aug-87 | Vágur | male | 6 | | 410 | | 8.42 | |
| | | 081987-0038 | Pilot whale | 1987 | 19-aug-87 | Vágur | male | 8 | | 410 | | 8.48 | |
| DL-08- | | 080287-0252 | Pilot whale | 1987 | 02-aug-87 | Miðvágur | male | 6 | 6.2 | 408 | 400 | 8.03 | |
| 008:9PFC | | 080287-0268 | Pilot whale | 1987 | 02-aug-87 | Miðvágur | male | 8 | | 428 | | 8.47 | |
| | | 080287-0295 | Pilot whale | 1987 | 02-aug-87 | Miðvágur | male | 6 | | 398 | | 8.09 | |
| | | 091186-0189 | Pilot whale | 1986 | 11-sep-86 | Sandur | male | 4 | | 360 | | 8.38 | |
| | 3-1986/87 | 091586-0006 | Pilot whale | 1986 | 15-sep-86 | Øravík | male | 8 | | 422 | | 8.38 | |
| | | 091586-0009 | Pilot whale | 1986 | 15-sep-86 | Øravík | male | 5 | | 354 | | 8.09 | |
| | | 091586-0032 | Pilot whale | 1986 | 15-sep-86 | Øravík | male | na | | 433 | | 8.27 | |

| Lab. ID | Pool no. | ID-No | Species | Collection year | Collection date | Area | Sex | Age yrs | Age, pool mean | Length, cm | Length, pool mean | Liver sample, g | Blubber sample, g |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DL-08-008:10PFC | 1-2001 /02 (4) | 060701-0036 | Pilot whale | 2001 | 05-jul-01 | Miðvágur | male | | | 345 | 406 | 10.22 | |
| | | 060701-0037 | Pilot whale | 2001 | 05-jul-01 | Miðvágur | male | | | 418 | | 10.07 | |
| | | 270601-0055 | Pilot whale | 2001 | 27-jun-01 | Vestmanna | male | | | 455 | | 9.74 | |
| DL-08-008:11PFC | 2-2001 /02 (5) | 060701-0066 | Pilot whale | 2001 | 05-jul-01 | Miðvágur | male | | | 445 | 400 | 10.15 | |
| | | 060701-0074 | Pilot whale | 2001 | 05-jul-01 | Miðvágur | male | | | 354 | | 9.87 | |
| | | 030902-0008 | Pilot whale | 2002 | 03-sep-02 | Sandagerði | male | | | 450 | | 10.04 | |
| | | 030902-0020 | Pilot whale | 2002 | 03-sep-02 | Sandagerði | male | | | 350 | | 10.09 | |
| DL-08-008:12PFC | 3-2001 /02 (6) | 030902-0013 | Pilot whale | 2002 | 03-sep-02 | Sandagerði | male | | | 400 | 395 | 10.1 | |
| | | 030902-0023 | Pilot whale | 2002 | 03-sep-02 | Sandagerði | male | | | 390 | | 10.31 | |
| | | 030902-0034 | Pilot whale | 2002 | 03-sep-02 | Sandagerði | male | | | 350 | | 10.18 | |
| | | 030902-0042 | Pilot whale | 2002 | 03-sep-02 | Sandagerði | male | | | 440 | | 10.22 | |
| DL-08-008:13PFC | 1-2006 /07 (7) | 280806-0026 | Pilot whale | 2006 | 28-aug-06 | Hvannasund | male | | | 348 | 381 | 10.05 | |
| | | 280806-0010 | Pilot whale | 2006 | 28-aug-06 | Hvannasund | male | | | 430 | | 10.18 | |
| | | 280806-0013 | Pilot whale | 2006 | 28-aug-06 | Hvannasund | male | | | 366 | | 10.08 | |
| DL-08-008:14PFC | 2-2006/07 (8) | 280806-0015 | Pilot whale | 2006 | 28-aug-06 | Hvannasund | male | | | 450 | 398 | 10.01 | |
| | | 280806-0018 | Pilot whale | 2006 | 28-aug-06 | Hvannasund | male | | | 360 | | 10.17 | |
| | | 280806-0034 | Pilot whale | 2006 | 28-aug-06 | Hvannasund | male | | | 385 | | 10 | |
| DL-08-008:15PFC | 3-2006/07 (9) | 030707-0022 | Pilot whale | 2007 | 03-jul-07 | Sandagerði | male | | | 380 | 393 | 10.1 | |
| | | 030707-0028 | Pilot whale | 2007 | 03-jul-07 | Sandagerði | male | | | 405 | | 10.04 | |
| DL-08-008:21 | 1993-A | LV3-KVAA-15 | Minke whale | 1993 | 21-06-1993 | Lofoten/Vesterålen | male | | | 642 | 597 | | 9.6 |
| | | LV4-KVAA-16 | Minke whale | 1993 | 30-06-1993 | Lofoten/Vesterålen | male | | | 592 | | | 9.5 |
| | | LV5-KVAA-17 | Minke whale | 1993 | 30-06-1993 | Lofoten/Vesterålen | male | | | 482 | | | 9.9 |
| | | LV6-KVAA-18 | Minke whale | 1993 | 01-07-1993 | Lofoten/Vesterålen | male | | | 606 | | | 9.7 |
| | | LV7-KVAA-19 | Minke whale | 1993 | 03-07-1993 | Lofoten/Vesterålen | male | | | 525 | | | 9.3 |
| | | LV8-KVAA-20 | Minke whale | 1993 | 04-07-1993 | Lofoten/Vesterålen | male | | | 732 | | | 9.3 |
| DL-08-008:20 | 1993-B | LV13-KVAG-27 | Minke whale | 1993 | 02-09-1993 | Lofoten/Vesterålen | male | | | 795 | 742 | | 9.8 |
| | | LV16-KVAF-17 | Minke whale | 1993 | 07-09-1993 | Lofoten/Vesterålen | male | | | 840 | | | 9.6 |
| | | LV17-KVAF-19 | Minke whale | 1993 | 07-09-1993 | Lofoten/Vesterålen | male | | | 745 | | | 9.4 |
| | | LV18II-KVAF-21 | Minke whale | 1993 | 08-09-1993 | Lofoten/Vesterålen | male | | | 620 | | | 9.4 |
| | | LV19-KVAF-22 | Minke whale | 1993 | 12-09-1993 | Lofoten/Vesterålen | male | | | 650 | | | 9.5 |
| | | LV20-KVAF-23 | Minke whale | 1993 | 14-09-1993 | Lofoten/Vesterålen | male | | | 800 | | | 9.7 |

| Lab. ID | Pool no. | ID-No | Species | Collection year | Collection date | Area | Sex | Age yrs | Age, pool mean | Length, cm | Length, pool mean | Liver sample, g | Blubber sample, g |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DL-08-008:19 | | F9-KVAI-11 | Minke whale | 1993 | 28-08-1993 | Finnmark | male | | | 835 | 813.2 | | 7.1 |
| | | F10-KVAF-31 | Minke whale | 1993 | 28-08-1993 | Finnmark | male | | | 815 | | | 7.2 |
| | 1993-C | F11-KVAF-30 | Minke whale | 1993 | 13-09-1993 | Finnmark | male | | | 840 | | | 7.2 |
| | | F13-KVAG-22 | Minke whale | 1993 | 14-09-1993 | Finnmark | male | | | 741 | | | 6.8 |
| | | F14-KVAF-25 | Minke whale | 1993 | 15-09-1993 | Finnmark | male | | | 835 | | | 7.2 |
| DL-08-008:22 | | Ulvos-1 | Minke whale | 1999 | 02-06-1999 | Finnmark | male | | | 701 | 692 | | 4.2 |
| | | Nybræna-3 | Minke whale | 1999 | 04-06-1999 | Finnmark | male | | | 685 | | | 4.4 |
| | Sample 1999 A | Nybræna-5 | Minke whale | 1999 | 08-06-1999 | Finnmark | male | | | 660 | | | 5.1 |
| | | Ulvos-7 | Minke whale | 1999 | 08-06-1999 | Finnmark | male | | | 778 | | | 5.3 |
| | | Nybræna-9 | Minke whale | 1999 | 26-06-1999 | Finnmark | male | | | 640 | | | 5.0 |
| | | Nybræna-15 | Minke whale | 1999 | 05-07-1999 | Finnmark | male | | | 685 | | | 4.2 |
| DL-08-008:23 | | Nybræna-4 | Minke whale | 1999 | 08-06-1999 | Finnmark | male | | | 800 | 802 | | 5.5 |
| | | Nybræna-11 | Minke whale | 1999 | 26-06-1999 | Finnmark | male | | | 790 | | | 5.7 |
| | Sample 1999 B | Nybræna-12 | Minke whale | 1999 | 02-07-1999 | Finnmark | male | | | 780 | | | 5.0 |
| | | Nybræna-13 | Minke whale | 1999 | 02-07-1999 | Finnmark | male | | | 840 | | | 5.8 |
| | | Nybræna-16 | Minke whale | 1999 | 06-07-1999 | Finnmark | male | | | 830 | | | 5.0 |
| | | Nybræna-17 | Minke whale | 1999 | 07-07-1999 | Finnmark | male | | | 770 | | | 5.2 |
| DL-08-008:24 | | Feie-6 | Minke whale | 1999 | 18-05-1999 | Nordsjøen | male | | | 810 | 818 | | 4.9 |
| | | Feie-11 | Minke whale | 1999 | 14-06-1999 | Nordsjøen | male | | | 790 | | | 5.2 |
| | Sample 1999 C | Feie-14 | Minke whale | 1999 | 16-06-1999 | Nordsjøen | male | | | 835 | | | 5.1 |
| | | Feie-15 | Minke whale | 1999 | 18-06-1999 | Nordsjøen | male | | | 845 | | | 5.7 |
| | | Feie-16 | Minke whale | 1999 | 18-06-1999 | Nordsjøen | male | | | 812 | | | 5.7 |
| DL-08-008-31 | | A0509 | Minke whale | 2005 | 10-08-05 | 6622Nx1647W | male | | | 470 | 515 | | 19.3 |
| | | C0503 | Minke whale | 2005 | 19-07-05 | 6408Nx1552W | male | | | 480 | | | 31.5 |
| | Grupp 1 | A0304 | Minke whale | 2003 | 26-08-03 | 6610Nx1916W | male | | | 510 | | | 22.0 |
| | | B0301 | Minke whale | 2003 | 18-08-03 | 6459Nx2255W | male | | | 520 | | | 21.1 |
| | | C0509 | Minke whale | 2005 | 03-08-05 | 6438Nx2308W | male | | | 570 | | | 21.8 |
| DL-08-008-29 | | B0602 | Minke whale | 2006 | 24-06-06 | 634417Nx231686W | male | | | 700 | 703 | | 16.7 |
| | | D0605 | Minke whale | 2006 | 02-08-06 | 634650Nx162527W | male | | | 700 | | | 25.4 |
| | Grupp 2 | B0702 | Minke whale | 2006 | 14-05-06 | 641692Nx223886W | male | | | 700 | | | 14.2 |
| | | C0510 | Minke whale | 2005 | 03-08-05 | 6439Nx2334W | male | | | 700 | | | 20.6 |
| | | B0605 | Minke whale | 2006 | 17-07-06 | 641760Nx222730W | male | | | 710 | | | 11.5 |
| DL-08-008-30 | | B0407 | Minke whale | 2004 | 22-06-04 | 6349Nx2311W | male | | | 810 | 853 | | 22.6 |
| | | D0608 | Minke whale | 2006 | 14-08-06 | 641417Nx222904W | male | | | 850 | | | 20.4 |
| | Grupp 3 | B0303 | Minke whale | 2003 | 27-08-03 | 6350Nx2249W | male | | | 850 | | | 32.5 |
| | | C0616 | Minke whale | 2006 | 12-08-06 | 660398Nx223620W | male | | | 860 | | | 28.8 |
| | | C0506 | Minke whale | 2005 | 27-07-05 | 6427Nx2259W | male | | | 870 | | | 21.3 |
| DL-08-008-32/ | | 21301 | Minke whale | 1998 | | West Greenland | female | | | 530 | 534 | 7.17 | 7.35 |
| DL-08- | | 21306 | Minke whale | 1998 | | West Greenland | female | | | 510 | | 7.15 | 7.26 |
| 008:22PFC | Pool 1 | 21307 | Minke whale | 1998 | | West Greenland | female | | | 500 | | 7.15 | 7.32 |
| | | 21313 | Minke whale | 1998 | | West Greenland | female | | | 594 | | 7.16 | 7.31 |

| Lab. ID | Pool no. | ID-No | Species | Collection year | Collection date | Area | Sex | Age yrs | Age, pool mean | Length, cm | Length, pool mean | Liver sample, g | Blubber sample, g |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DL-08-008-33 / DL-08-008:23PFC | Pool 2 | 21314 | Minke whale | 1998 | | West Greenland | female | | | 510 | 568 | 5.47 | 6.3 |
| | | 21318 | Minke whale | 1998 | | West Greenland | female | | | 725 | | 5.51 | 6.36 |
| | | 21323 | Minke whale | 1998 | | West Greenland | female | | | 520 | | 5.45 | 6.3 |
| | | 21326 | Minke whale | 1998 | | West Greenland | female | | | 515 | | 5.45 | 6.32 |
| DL-08-008-34 / DL-08-008:24PFC | Pool 3 | 21327 | Minke whale | 1998 | | West Greenland | female | | | 570 | 565 | 5.22 | 6.22 |
| | | 21328 | Minke whale | 1998 | | West Greenland | female | | | 580 | | 5.23 | 6.21 |
| | | 21331 | Minke whale | 1998 | | West Greenland | male | | | 600 | | 5.25 | 6.21 |
| | | 21332 | Minke whale | 1998 | | West Greenland | female | | | 510 | | 5.24 | 6.2 |
| DL-08-008-28 | Grupp 1 1986-87 | 86113 | Fin whale | 1986 | 11-09-86 | West of Iceland | female | 12 | 16 | 1920 | 1971 | | 80.5 |
| | | 87028 | Fin whale | 1987 | 27-06-87 | West of Iceland | female | 20 | | 2103 | | | 129.1 |
| | | 87035 | Fin whale | 1987 | 30-06-87 | West of Iceland | male | 16 | | 1890 | | | 46.9 |
| DL-08-008-27 | Grupp 2 1986-87 | 86024 | Fin whale | 1986 | 01-07-86 | West of Iceland | male | 26 | 30 | 2012 | 2114 | | 230.8 |
| | | 87036 | Fin whale | 1987 | 01-07-87 | West of Iceland | female | 35 | | 2195 | | | 61.0 |
| | | 87066 | Fin whale | 1987 | 10-07-87 | West of Iceland | female | 28 | | 2134 | | | 57.3 |
| DL-08-008-25 | Grupp 1 2006 | H06-04 | Fin whale | 2006 | 27-10-06 | West of Iceland | female | 12 | 16 | 1951 | 1992 | | 36.3 |
| | | H06-02 | Fin whale | 2006 | 23-10-06 | West of Iceland | female | 20 | | 2073 | | | 165.4 |
| | | H06-07 | Fin whale | 2006 | 31-10-06 | West of Iceland | male | 16 | | 1951 | | | 146.1 |
| DL-08-008-26 | Grupp 2 2006 | H06-06 | Fin whale | 2006 | 31-10-06 | West of Iceland | male | 26 | 30 | 1890 | 2032 | | 147.3 |
| | | H06-03 | Fin whale | 2006 | 25-10-06 | West of Iceland | female | 34 | | 2134 | | | 112.3 |
| | | H06-01 | Fin whale | 2006 | 21-10-06 | West of Iceland | female | 31 | | 2073 | | | 83.0 |
| DL-08-008-44 / DL-08-008:46PFC | Group 1 1986-89 | 87033 | Fin whale | 1987 | 870629 | West of Iceland | male | 13 | 12 | 1829 | 1817 | 14.6# | 16.7 |
| | | 89032 | Fin whale | 1989 | 890701 | West of Iceland | male | 11 | | 1829 | | 16.9# | 10.9 |
| | | 87074 | Fin whale | 1987 | 870715 | West of Iceland | male | 8 | | 1798 | | 16.3# | 15.3 |
| | | 87025 | Fin whale | 1987 | 870626 | West of Iceland | male | 16 | | 1798 | | 12.2# | 17.7 |
| | | 87026 | Fin whale | 1987 | 870627 | West of Iceland | male | 14 | | 1829 | | 14.6# | 19.4 |
| DL-08-008-45 / DL-08-008:47PFC | Group 2 1986-89 | 86115 | Fin whale | 1986 | 860923 | West of Iceland | male | 36 | 21 | 1829 | 1823 | 14.7# | 15.9 |
| | | 88014 | Fin whale | 1988 | 880629 | West of Iceland | male | 14 | | 1798 | | 18.8# | 30 |
| | | 88035 | Fin whale | 1988 | 880709 | West of Iceland | male | 14 | | 1798 | | 22.4# | 38 |
| | | 89003 | Fin whale | 1989 | 890621 | West of Iceland | male | 36 | | 1859 | | 17# | 12 |
| | | 88040 | Fin whale | 1988 | 880711 | West of Iceland | male | 5 | | 1829 | | 14.9# | 15.9 |

| Lab. ID | Pool no. | ID-No | Species | Collection year | Collection date | Area | Sex | Age yrs | Age, pool mean | Length, cm | Length, pool mean | Liver sample, g | Blubber sample, g |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DL-08-008-46 / | | 88041 | Fin whale | 1988 | 880711 | West of Iceland | male | 4 | 12 | 1798 | 1823 | 17.9# | 17.3 |
| DL-08- | | 89023 | Fin whale | 1989 | 890628 | West of Iceland | male | 31 | | 1829 | | 15# | 20.7 |
| 008:48PFC | Group 3 1986-89 | 87062 | Fin whale | 1987 | 870708 | West of Iceland | male | 10 | | 1829 | | 15.4# | 35.8 |
| | | 87053 | Fin whale | 1987 | 870705 | West of Iceland | male | 8 | | 1829 | | 15.4# | 16.4 |
| | | 89059 | Fin whale | 1989 | 890714 | West of Iceland | male | 8 | | 1829 | | 16.8# | 23.2 |
| DL-08- | | F09/079 | Fin whale | 2009 | 15-08-09 | West of Iceland | male | 14 | 26.7 | 1798 | 1817 | »15# | »15 |
| 008:49PFC | | F09/122 | Fin whale | 2009 | 24-09-09 | West of Iceland | male | 19 | | 1829 | | »15# | »15 |
| | Group 1 2009 | F09/093 | Fin whale | 2009 | 28-08-09 | West of Iceland | male | 55 | | 1829 | | »15# | »15 |
| | | F09/050 | Fin whale | 2009 | 26-07-09 | West of Iceland | male | 16 | | 1829 | | »15# | »15 |
| | | F09/003 | Fin whale | 2009 | 20-06-09 | West of Iceland | male | 29 | | 1798 | | »15# | »15 |
| DL-08- | | F09/073 | Fin whale | 2009 | 11-08-09 | West of Iceland | male | 20 | 22.2 | 1859 | 1841 | »15# | »15 |
| 008:50PFC | | F09/064 | Fin whale | 2009 | 02-08-09 | West of Iceland | male | 30 | | 1829 | | »15# | »15 |
| | Group 2 2009 | F09/007 | Fin whale | 2009 | 25-06-09 | West of Iceland | male | 24 | | 1859 | | »15# | »15 |
| | | F09/030 | Fin whale | 2009 | 12-07-09 | West of Iceland | male | 15 | | 1829 | | »15# | »15 |
| | | F09/067 | Fin whale | 2009 | 08-08-09 | West of Iceland | male | 14 | | 1829 | | »15# | »15 |
| DL-08- | | F09/037 | Fin whale | 2009 | 16-07-09 | West of Iceland | male | 12 | 17.6 | 1829 | 1823 | »15# | »15 |
| 008:51PFC | | F09/052 | Fin whale | 2009 | 26-07-09 | West of Iceland | male | 25 | | 1829 | | »15# | »15 |
| | Group 3 2009 | F09/121 | Fin whale | 2009 | 22-09-09 | West of Iceland | male | 14 | | 1829 | | »15# | »15 |
| | | F09/124 | Fin whale | 2009 | 24-09-09 | West of Iceland | male | 20 | | 1829 | | »15# | »15 |
| | | F09/085 | Fin whale | 2009 | 17-08-09 | West of Iceland | male | 17 | | 1798 | | »15# | »15 |

* These numbers are the size measure skinn.

# The fin whale 1986–1989 and 2009 samples are muscle tissue.

# Appendix 2: Polybrominated diphenyl ethers analyses results in ng/g LW.

| Sample | Year | Location | DL-nr | BDE-28 | BDE-47 | BDE-66 | BDE-100 | BDE-99 | BDE-85 | BDE-154 | BDE-153 | BDE-138 | BDE-183 | Sum PBDE[$] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pilot whale | 1986 | Faroe Islands | 7 | 1.42 | 29.2 | 1.41 | 5.77 | 3.86 | 0.72 | 7.22 | 1.10 | <0.10 | <0.08 | 51 |
| Pilot whale | 1986 | Faroe Islands | 8 | 4.23 | 37.1 | 0.31 | 3.42 | 4.15 | 1.00 | 9.49 | 1.66 | <0.10 | 0.18 | 61 |
| Pilot whale | 1986 | Faroe Islands | 9 | 2.30 | 11.30 | 0.27 | 1.74 | 1.89 | 0.53 | 8.05 | 0.68 | <0.10 | 0.19 | 27 |
| Pilot whale | 1997 | Faroe Islands | 1 | 11.2 | 304 | 19.4 | 59.1 | 100 | 10.0 | 42.4 | 21.2 | <0.10 | 0.95 | 568 |
| Pilot whale | 1997 | Faroe Islands | 2 | 10.8 | 347 | 20.6 | 57.9 | 113 | 8.77 | 33.6 | 20.5 | <0.10 | 0.69 | 613 |
| Pilot whale | 1997 | Faroe Islands | 3 | 41.8 | 1389 | 74.0 | 207 | 430 | 37.0 | 152 | 93.8 | <0.10 | 3.33 | 2428 |
| Pilot whale | 2006/07 | Faroe Islands | 4 | 17.5 | 608 | 26.1 | 101 | 147 | 29.8 | 78.4 | 32.8 | <0.10 | 0.89 | 1041 |
| Pilot whale | 2006/07 | Faroe Islands | 5 | 16.3 | 489 | 25.2 | 93.0 | 121 | 21.3 | 48.9 | 24.4 | <0.10 | 0.58 | 840 |
| Pilot whale | 2006/07 | Faroe Islands | 6 | 21.1 | 711 | 25.3 | 151 | 185 | 48.6 | 124 | 39.7 | <0.10 | 1.23 | 1307 |
| Ringed seal | 1986 | Greenland (East) | 10 | 0.61 | 19.6 | <0.06 | 0.95 | 2.55 | 0.23 | 1.02 | 0.29 | <0.10 | 0.16 | 25 |
| Ringed seal | 1986 | Greenland (East) | 11 | 0.44 | 17.6 | 0.11 | 2.07 | 3.07 | 0.27 | 1.31 | 0.29 | <0.10 | 0.16 | 25 |
| Ringed seal | 1986 | Greenland (East) | 12 | 0.50 | 27.6 | <0.04 | 1.93 | 2.46 | <0.08 | 1.24 | 0.46 | <0.10 | <0.10 | 34 |
| Ringed seal | 2000 | Greenland (East) | 13 | 1.22 | 55.1 | 0.26 | 3.74 | 3.23 | 0.75 | 2.82 | 2.10 | <0.10 | <0.10 | 69 |
| Ringed seal | 2000 | Greenland (East) | 14 | 1.64 | 34.2 | 0.30 | 3.28 | 5.54 | 0.60 | 1.49 | 1.59 | <0.10 | <0.10 | 49 |
| Ringed seal | 2000 | Greenland (East) | 15 | 1.32 | 22.9 | 0.33 | 2.26 | 3.46 | 0.27 | 0.62 | 0.62 | <0.10 | <0.10 | 32 |
| Ringed seal | 2006 | Greenland (East) | 16 | 0.57 | 21.4 | <0.10 | 1.85 | 2.94 | 0.46 | 0.66 | 0.55 | <0.10 | <0.10 | 28 |
| Ringed seal | 2006 | Greenland (East) | 17 | 0.78 | 15.8 | 0.15 | 1.53 | 1.54 | 0.34 | 0.60 | 0.28 | <0.10 | <0.10 | 21 |
| Ringed seal | 2006 | Greenland (East) | 18 | 0.86 | 28.0 | <0.10 | 1.94 | 1.73 | <0.10 | 0.33 | 0.50 | <0.10 | <0.10 | 33 |
| Minke whale | 1993 | Norway | 19 | 1.13 | 74.2 | 1.81 | 10.9 | 28.1 | 0.97 | 6.14 | 2.99 | 0.12 | <0.10 | 126 |
| Minke whale | 1993 | Norway | 20 | 1.20 | 54.1 | 1.17 | 5.71 | 14.3 | 0.80 | 3.53 | 1.39 | <0.10 | <0.10 | 82 |
| Minke whale | 1993 | Norway | 21 | 2.09 | 101 | 1.83 | 13.4 | 29.3 | 0.80 | 3.22 | 1.72 | <0.10 | <0.10 | 153 |
| Minke whale | 1999 | Norway | 22 | 1.17 | 64.5 | 0.79 | 8.23 | 14.4 | 1.72 | 4.29 | 0.96 | 0.86 | 0.40 | 97 |
| Minke whale | 1999 | Norway | 23 | 0.76 | 58.9 | 1.00 | 7.54 | 23.7 | 2.23 | 7.31 | 3.58 | 0.13 | <0.10 | 105 |
| Minke whale | 1999 | Norway | 24 | 1.62 | 212 | 5.42 | 30.4 | 88.4 | 3.82 | 27.4 | 19.7 | <0.10 | <0.10 | 389 |
| Fin whale | 86–89 | Iceland | 27 | 0.2 | 5.7 | <0.1 | 0.8 | 2.3 | 0.3 | 2.4 | 0.3 | <0.1 | 0.1 | 12 |
| Fin whale | 86–90 | Iceland | 28 | 0.1 | 2.4 | <0.1 | 0.3 | 1.0 | 0.2 | 1.0 | 0.2 | <0.1 | 0.1 | 5 |
| Fin whale | 2006 | Iceland | 25 | 0.4 | 13 | 0.2 | 0.7 | 1.3 | 0.2 | 2.7 | 1.0 | 0.1 | 0.2 | 19.5 |
| Fin whale | 2006 | Iceland | 26 | 0.3 | 13 | 0.1 | 1.9 | 4.9 | 2.5 | 5.7 | 1.5 | 0.1 | 0.3 | 31 |
| Minke whale | 2003–07 | Iceland | 29 | 1.0 | 63 | 0.3 | 8.0 | 17 | 5.7 | 13 | 2.9 | 0.1 | 0.2 | 111 |
| Minke whale | 2003–07 | Iceland | 30 | 0.7 | 41 | 0.1 | 3.9 | 7.1 | 2.5 | 7.0 | 1.5 | <0.1 | 0.1 | 64 |
| Minke whale | 2003–07 | Iceland | 31 | 1.4 | 68 | 0.5 | 7.3 | 12 | 2.7 | 6.3 | 1.5 | 0.1 | 0.1 | 99 |
| Minke whale | 1998 | Greenland | 32 | 3.1 | 69 | 3.6 | 14 | 63 | 0.4 | 10 | 5.4 | 0.05 | 0.2 | 170 |
| Minke whale | 1998 | Greenland | 33 | 1.3 | 29 | 1.0 | 4.0 | 9.6 | 0.3 | 3.6 | 0.9 | 0.1 | 0.1 | 50 |
| Minke whale | 1998 | Greenland | 34 | 1.6 | 35 | 0.6 | 4.6 | 24 | 0.6 | 4.0 | 1.1 | 0.1 | 0.1 | 71 |
| White-sided dolphins | 1997 | Faroe Islands | 35* | <0.04 | 70 | 1.7 | 39 | 41 | 1.2 | 4.2 | 15 | 0.1 | NQ | 172 |
| White-sided dolphins | 1997 | Faroe Islands | 36* | 0.2 | 79 | 1.6 | 43 | 49 | 2.5 | 37 | 15 | 1.9 | NQ | 230 |
| White-sided dolphins | 1997 | Faroe Islands | 37* | 0.1 | 110 | 2.6 | 60 | 73 | 2.2 | 53 | 23 | 0.9 | NQ | 325 |
| White-sided dolphins | 2001/02 | Faroe Islands | 41* | <0.1 | 221 | 5.7 | 160 | 160 | 2.7 | 101 | 58 | 0.7 | NQ | 710 |
| White-sided dolphins | 2001/02 | Faroe Islands | 42* | <0.1 | 210 | 4.1 | 144 | 140 | 2.8 | 108 | 64 | 0.1 | NQ | 673 |
| White-sided dolphins | 2001/02 | Faroe Islands | 43* | 0.2 | 204 | 3.0 | 118 | 111 | 5.4 | 88 | 38 | 2.1 | NQ | 570 |
| White-sided dolphins | 2006 | Faroe Islands | 38* | <0.04 | 94 | 1.5 | 62 | 47 | 1.6 | 52 | 22 | 0.3 | NQ | 279 |
| White-sided dolphins | 2006 | Faroe Islands | 39* | <0.04 | 112 | 2.2 | 63 | 54 | 1.7 | 53 | 21 | 0.3 | NQ | 308 |
| White-sided dolphins | 2006 | Faroe Islands | 40* | <0.1 | 102 | 2.0 | 51 | 36 | 2.2 | 43 | 11 | 0.6 | NQ | 249 |
| Fin whale | 86–89 | Iceland | 44* | 0.1 | 5.1 | 0.1 | 0.6 | 2.0 | <0.1 | 0.6 | 0.2 | <0.2 | <0.1 | 9 |
| Fin whale | 86–90 | Iceland | 45* | 0.4 | 3.8 | 0.1 | 0.5 | 1.7 | 0.2 | 0.6 | 0.3 | 0.1 | NQ | 8 |
| Fin whale | 86–91 | Iceland | 46* | 1.1 | 2.6 | 0.1 | 0.4 | 2.4 | 0.1 | 0.9 | 0.7 | 0.2 | NQ | 8 |
| Fin whale | 2009 | Iceland | 49* | 0.2 | 7.6 | 0.1 | 1.6 | 5.4 | 0.4 | 3.1 | 0.9 | 0.1 | NQ | 19 |

| Sample | Year | Location | DL-nr | BDE-28 | BDE-47 | BDE-66 | BDE-100 | BDE-99 | BDE-85 | BDE-154 | BDE-153 | BDE-138 | BDE-183 | Sum PBDE$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fin whale | 2009 | Iceland | 50* | 1.9 | 9.9 | 0.1 | 1.3 | 4.9 | 0.2 | 2.9 | 1.2 | 0.1 | NQ | 22 |
| Fin whale | 2009 | Iceland | 51* | 4.0 | 10 | 0.2 | 1.4 | 5.5 | 0.6 | 3.7 | 0.9 | 0.1 | NQ | 27 |
| Harbour porpoise | 1992 | Iceland | 47 | 0.9 | 51 | 1.2 | 9.4 | 19 | <0.3 | 8.9 | 2.8 | <0.3 | <0.2 | 94 |
| Harbour porpoise | 1992 | Iceland | 48 | 0.9 | 52 | 0.8 | 8.0 | 14 | <0.2 | 16 | 6.7 | <0.3 | 0.3 | 98 |
| Harbour porpoise | 1992 | Iceland | 52* | 1.1 | 38 | 0.7 | 11 | 9.2 | <0.8 | 16 | 8.4 | <0.6 | 0.4 | 85 |
| Harbour porpoise | 1997 | Iceland | 53 | 0.81 | 43 | 0.6 | 6.4 | 9.1 | <0.1 | 4.4 | 1.8 | <0.2 | <0.1 | 67 |
| Harbour porpoise | 1997 | Iceland | 54 | 0.9 | 59 | 0.7 | 9.3 | 13 | <0.1 | 8.9 | 3.2 | <0.2 | 0.1 | 96 |
| Harbour porpoise | 1997 | Iceland | 55 | 0.8 | 44 | 0.6 | 7.4 | 11 | <0.1 | 8.8 | 3.1 | <0.2 | 0.1 | 75 |
| Harbour porpoise | 2000 | Norway | 65 | 0.8 | 53 | 0.4 | 7.3 | 4.5 | <0.2 | 4.1 | 0.8 | <0.1 | <0.1 | 71 |
| Harbour porpoise | 2000 | Norway | 66 | 2.9 | 301 | 4.2 | 56 | 87 | <0.2 | 46 | 44 | <0.2 | 0.5 | 540 |
| Harbour porpoise | 2000 | Norway | 67 | 1.2 | 88 | 0.8 | 18 | 19 | <0.2 | 23 | 12 | <0.1 | 0.2 | 161 |
| Hooded seal | 1990 | Norway (West ice) | 56 | 0.4 | 16 | 0.2 | 3.7 | 22 | <0.1 | 7.6 | 4.5 | 0.3 | 0.3 | 54 |
| Hooded seal | 1990 | Norway (West ice) | 57 | 0.3 | 15 | 0.2 | 3.2 | 16 | <0.1 | 5.5 | 2.8 | <0.2 | 0.2 | 44 |
| Hooded seal | 1990 | Norway (West ice) | 58 | 0.4 | 19 | 0.3 | 4.8 | 28 | <0.1 | 12 | 5.6 | 0.4 | 0.3 | 71 |
| Hooded seal | 1997 | Norway (West ice) | 59 | 0.7 | 47 | 0.9 | 9.2 | 61 | <0.1 | 15 | 14 | 0.4 | 0.4 | 148 |
| Hooded seal | 1997 | Norway (West ice) | 60 | 0.5 | 29 | 0.6 | 5.7 | 30 | <0.1 | 11 | 11 | <0.3 | 0.4 | 87 |
| Hooded seal | 1997 | Norway (West ice) | 61 | 0.4 | 25 | 0.5 | 4.9 | 27 | <0.1 | 11 | 9.1 | <0.2 | 0.4 | 78 |
| Hooded seal | 2007 | Norway (West ice) | 62 | 0.2 | 19 | 0.2 | 1.9 | 7.2 | <0.1 | 5.4 | 4.3 | <0.1 | 0.1 | 38 |
| Hooded seal | 2007 | Norway (West ice) | 63 | 0.2 | 21 | 0.3 | 3.7 | 15 | <0.3 | 12 | 9.2 | <0.3 | 0.3 | 61 |
| Hooded seal | 2007 | Norway (West ice) | 64 | 0.2 | 19 | 0.2 | 3.4 | 13 | <0.3 | 12 | 10 | <0.4 | 0.3 | 59 |

* All congeners quantified against C13-PBDE-77.

NQ: not quantified.

$ = $\sum_{10}$PBDEs

# Appendix 3: Methoxylated brominated diphenyl ethers analyses results in ng/g LW.

| Sample | Year | DL-nr | 2PMBDE68 | 6MBDE47 | 5MBDE47 | 4PMBDE49 | 5PMBDE100 | 4PMBDE103 | 5PMBDE99 | 4PMBDE101 | Sum MeO-BDE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pi w F | 1986 | **7C** | 12 | 416 | <1.2 | <1.2 | <1.2 | <1.2 | <1.2 | <1.2 | 428 |
| Pi w F | 1986 | **8** | 21 | 496 | <0.04 | <0.05 | <0.04 | <1.2 | <0.03 | <0.02 | 517 |
| Pi w F | 1986 | **9** | 23 | 653 | <0.04 | <0.05 | <0.04 | <0.36 | <0.03 | <0.02 | 677 |
| Pi w F | 1997 | **1C** | 18 | 461 | <0.4 | <0.4 | <0.4 | <0.4 | <0.4 | <0.4 | 479 |
| Pi w F | 1997 | **2C** | 4.3 | 90 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | 94 |
| Pi w F | 1997 | **3C** | 14.0 | 350 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | 364 |
| Pi w F | 2006/07 | **4C** | 18 | 307 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | 326 |
| Pi w F | 2006/07 | **5C** | 13 | 228 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | 241 |
| Pi w F | 2006/07 | **6C** | 11 | 247 | <0.7 | <0.7 | <0.7 | <0.7 | <0.7 | <0.7 | 258 |
| Ri s G | 1986 | **10** | 0.5 | 2.2 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | 3 |
| Ri s G | 1986 | **11** | 0.5 | 1.6 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | 2 |
| Ri s G | 1986 | **12** | 0.8 | 2.8 | <0.04 | <0.04 | <0.04 | <0.32 | <0.03 | <0.02 | 4 |
| Ri s G | 2000 | **13** | 0.9 | 2.2 | <0.04 | <0.05 | <0.04 | <0.38 | <0.03 | <0.02 | 3 |
| Ri s G | 2000 | **14** | 0.6 | 1.8 | <0.04 | <0.04 | <0.04 | <0.32 | <0.03 | <0.02 | 2 |
| Ri s G | 2000 | **15** | 0.4 | 1.4 | <0.05 | <0.05 | <0.05 | <0.43 | <0.04 | <0.02 | 2 |
| Ri s G | 2006 | **16** | 0.4 | 2.1 | <0.03 | <0.03 | <0.03 | <0.26 | <0.02 | <0.01 | 2 |
| Ri s G | 2006 | **17** | 0.4 | 1.2 | <0.04 | <0.04 | <0.04 | <0.34 | <0.03 | <0.02 | 2 |
| Ri s G | 2006 | **18** | 0.2 | 0.3 | <0.03 | <0.04 | <0.03 | <0.30 | <0.03 | <0.02 | 0 |
| Mi w N | 1993 | **19** | 1.3 | 4.9 | <0.04 | <0.04 | <0.04 | <0.36 | <0.03 | <0.02 | 6 |
| Mi w N | 1993 | **20** | 0.9 | 2.9 | <0.05 | <0.05 | <0.05 | <0.43 | <0.04 | <0.02 | 4 |
| Mi w N | 1993 | **21** | 3.3 | 13 | <0.07 | <0.08 | <0.07 | <0.62 | <0.05 | <0.04 | 17 |
| Mi w N | 1999 | **22** | 0.9 | 1.9 | <0.08 | <0.09 | <0.08 | <0.73 | <0.06 | <0.04 | 3 |
| Mi w N | 1999 | **23** | 1.7 | 6.9 | <0.06 | <0.06 | <0.06 | <0.51 | <0.04 | <0.03 | 9 |
| Mi w N | 1999 | **24** | 5.6 | 18 | <0.06 | <0.06 | <0.05 | <0.50 | <0.04 | <0.03 | 23 |
| Fi w I | 1986–87 | **27** | 4.6 | 36 | <0.1 | <0.1 | <0.3 | <0.3 | <0.3 | <0.3 | 41 |
| Fi w I | 1986–87 | **28** | 1.4 | 11 | <1.1 | <1.1 | <1.3 | <1.3 | <1.3 | <1.3 | 12 |
| Fi w I | 1986–89 | **44** | 4.6 | 35 | <0.3 | <0.3 | <1.1 | <1.1 | <1.1 | <1.1 | 40 |
| Fi w I | 1986–89 | **45*** | 6.8 | 48 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 55 |
| Fi w I | 1986–89 | **46*** | 5.0 | 30 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 35 |
| Fi w I | 2006 | **25** | 4.0 | 17 | <0.1 | <0.1 | <0.4 | <0.4 | <0.4 | <0.4 | 21 |
| Fi w I | 2006 | **26** | 4.3 | 26 | <0.2 | <0.2 | <0.4 | <0.4 | <0.4 | <0.4 | 30 |
| Fi w I | 2009 | **49*** | 8.2 | 55 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 63 |
| Fi w I | 2009 | **50*** | 7.2 | 47 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 54 |
| Fi w I | 2009 | **51*** | 6.8 | 44 | <0.1 | <0.1 | <0.1 | <0.2 | <0.4 | <0.1 | 51 |
| Mi w I | 2003–07 | **29** | 13 | 86 | <0.2 | <0.2 | <0.6 | <0.6 | <2.5 | <2.5 | 99 |
| Mi w I | 2003–07 | **30** | 6.9 | 55 | <0.1 | <0.1 | <0.4 | <0.4 | <0.4 | <0.4 | 62 |
| Mi w I | 2003–07 | **31** | 8.8 | 52 | <0.2 | <0.2 | <0.2 | <0.1 | <0.1 | <0.1 | 60 |
| Mi w G | 1998 | **32*** | 11 | 47 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 58 |
| Mi w G | 1998 | **33*** | 6.7 | 29 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 36 |
| Mi w G | 1998 | **34*** | 11 | 56 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 67 |
| Wh d F | 1997 | **35*** | 1.6 | 195 | <0.1 | <0.2 | <0.1 | <0.1 | <0.1 | <0.1 | 196 |
| Wh d F | 1997 | **36*** | 8.4 | 186 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 195 |
| Wh d F | 1997 | **37** | 1.8 | 5.6 | <0.3 | <0.2 | <1.0 | <0.8 | <0.1 | <0.2 | 7 |
| Wh d F | 2001/02 | **41*** | 14 | 245 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 259 |
| Wh d F | 2001/02 | **42*** | 13 | 220 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 233 |
| Wh d F | 2001/02 | **43*** | 13 | 438 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 451 |
| Wh d F | 2006 | **38*** | 9.3 | 236 | <0.1 | <0.2 | <0.1 | <0.1 | <0.1 | <0.1 | 245 |

| Sample | Year | DL-nr | 2PMBDE68 | 6MBDE47 | 5MBDE47 | 4PMBDE49 | 5PMBDE100 | 4PMBDE103 | 5PMBDE99 | 4PMBDE101 | Sum MeO-BDE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Wh d F | 2006 | **39*** | 13 | 225 | <0.1 | <0.2 | <0.1 | <0.1 | <0.1 | <0.1 | 238 |
| Wh d F | 2006 | **40*** | 10 | 249 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 259 |
| Ha p I | 1992 | **47** | 3.2 | 43 | <0.1 | <0.03 | <0.6 | <0.1 | <0.1 | <0.1 | 46 |
| Ha p I | 1992 | **48** | 4.4 | 110 | <0.3 | <0.4 | <1.4 | <1.4 | <1.4 | <1.4 | 114 |
| Ha p I | 1992 | **52** | 3.4 | 86 | <0.2 | <0.2 | <1.0 | <1.0 | <1.0 | <1.0 | 89 |
| Ha p I | 1997 | **53** | 3.28 | 36 | <0.1 | <0.02 | <0.4 | <0.1 | <0.01 | <0.02 | 39 |
| Ha p I | 1997 | **54** | 4.8 | 107 | <0.3 | <0.3 | <1.0 | <1.0 | <1.0 | <1.0 | 112 |
| Ha p I | 1997 | **55** | 3.4 | 76 | <0.3 | <0.3 | <1.0 | <1.0 | <1.0 | <1.0 | 79 |
| Ha p N | 2000 | **65** | 4.8 | 95 | <0.3 | <0.3 | <1.3 | <1.3 | <1.3 | <1.3 | 100 |
| Ha p N | 2000 | **66** | 4.9 | 60 | <0.3 | <0.3 | <1.2 | <1.2 | <1.2 | <1.2 | 65 |
| Ha p N | 2000 | **67** | 3.3 | 56 | <0.3 | <0.3 | <1.2 | <1.2 | <1.2 | <1.2 | 59 |
| Ho s N | 1990 | **56** | 1.2 | 11 | <0.4 | <0.4 | <0.4 | <0.4 | <0.4 | <0.4 | 12 |
| Ho s N | 1990 | **57** | 1.2 | 8.3 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | 10 |
| Ho s N | 1990 | **58** | 2.3 | 14 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | 16 |
| Ho s N | 1997 | **59** | 2.3 | 11 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | 13 |
| Ho s N | 1997 | **60** | 1.6 | 8.6 | <0.6 | <0.6 | <0.6 | <0.6 | <0.6 | <0.6 | 10 |
| Ho s N | 1997 | **61** | 1.2 | 6.8 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | 8 |
| Ho s N | 2007 | **62** | 1.3 | 6.6 | <0.6 | <0.6 | <0.6 | <0.6 | <0.6 | <0.6 | 8 |
| Ho s N | 2007 | **63** | 1.5 | 6.4 | <0.8 | <0.8 | <0.8 | <0.8 | <0.8 | <0.8 | 8 |
| Ho s N | 2007 | **64** | 1.6 | 6.7 | <0.7 | <0.7 | <0.7 | <0.7 | <0.7 | <0.7 | 8 |

* All congeners quantified against C13-PBDE#77.

# Appendix 4: Other brominated flame retardants analyses results in ng/g LW.

| Sample | Year | DL-nr | BDE -154 | PBB -153 | BTBPE | Deca BDE-209 | DecaBD-ethane (DBDPE) | HBB | PBT | TBECH |
|---|---|---|---|---|---|---|---|---|---|---|
| Ri s G | 1986 | DL-08-008:10 | 0.11 | 0.76 | ND | ND | ND | ND | ND | NC |
| Ri s G | 1986 | DL-08-008:11 | 0.41 | 0.96 | ND | ND | ND | ND | ND | NC |
| Ri s G | 1986 | DL-08-008:12 | 0.24 | 1.14 | ND | ND | ND | NA | NA | NC |
| Ri s G | 2000 | DL-08-008:13 | 2.37 | 1.39 | ND | ND | ND | NA | NA | NC |
| Ri s G | 2000 | DL-08-008:14 | 0.60 | 0.71 | ND | ND | ND | NA | NA | NC |
| Ri s G | 2000 | DL-08-008:15 | 0.29 | 0.48 | ND | ND | ND | NA | NA | NC |
| Ri s G | 2006 | DL-08-008:16 | NA | NA | ND | ND | ND | NA | NA | NC |
| Ri s G | 2006 | DL-08-008:17 | 0.37 | 0.11 | ND | ND | ND | NA | NA | NC |
| Ri s G | 2006 | DL-08-008:18 | 0.37 | 0.18 | ND | ND | ND | NA | NA | NC |
| Pi w F | 1986 | DL-08-008:7 | 13.62 | 31.41 | ND | ND | ND | ND | ND | NC |
| Pi w F | 1986 | DL-08-008:8 | 11.68 | 17.80 | ND | ND | ND | NA | NA | NC |
| Pi w F | 1986 | DL-08-008:9 | 9.98 | 20.86 | ND | ND | ND | NA | NA | NC |
| Pi w F | 1997 | DL-08-008:1 | 34.98 | 11.08 | ND | ND | ND | 3.70 | ND | NC |
| Pi w F | 1997 | DL-08-008:2 | 32.72 | 6.81 | ND | ND | ND | 4.65 | ND | NC |
| Pi w F | 1997 | DL-08-008:3 | 149.62 | 21.56 | ND | ND | ND | 9.01 | ND | NC |
| Pi w F | 2006/07 | DL-08-008:4 | 75.56 | 8.16 | ND | ND | ND | 5.57 | ND | NC |
| Pi w F | 2006/07 | DL-08-008:5 | 54.29 | 8.04 | ND | ND | ND | 6.12 | ND | NC |
| Pi w F | 2006/07 | DL-08-008:6 | 145.36 | 15.85 | ND | ND | ND | 13.86 | ND | NC |
| Mi w N | 1993 | DL-08-008:19 | 4.52 | 1.55 | ND | ND | ND | 7.64 | ND | NC |
| Mi w N | 1993 | DL-08-008:20 | 2.97 | 0.68 | ND | ND | ND | 2.74 | ND | NC |
| Mi w N | 1993 | DL-08-008:21 | 3.00 | 0.44 | ND | ND | ND | 2.67 | ND | NC |
| Mi w N | 1999 | DL-08-008:22 | 2.93 | 0.37 | ND | ND | ND | 1.56 | ND | NC |
| Mi w N | 1999 | DL-08-008:23 | 6.46 | 0.91 | ND | ND | ND | 2.75 | ND | NC |
| Mi w N | 1999 | DL-08-008:24 | 24.89 | 3.66 | ND | ND | ND | 8.77 | ND | NC |

ND: <0.5–3.0 ng/g

NC: not confirmed by high resolution GC/MS

NA: not analysed

# Appendix 5: Polychlorinated naphthalene analyses results in ng/g LW.

| Sample | Year | DL-nr | PCN-13 | PCN-28/36 | PCN-27 | PCN-48 | PCN-46 | PCN-52 | PCN-50 | PCN-53 | PCN-66 | PCN-69 | PCN-72 | PCN-73 | PCN-75 | Sum PCN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pi w F | 1986 | 7C | <0.2 | <0.1 | <0.1 | 1.1 | <0.3 | 0.30 | <0.2 | 0.26 | 2.3 | 0.83 | <0.1 | <0.1 | <0.1 | 4.75 |
| Pi w F | 1986 | 8 | <0.2 | <0.1 | <0.2 | <0.2 | <0.3 | 0.12 | <0.4 | 1.1 | 1.9 | 0.42 | <0.1 | <0.1 | <0.1 | 3.56 |
| Pi w F | 1986 | 9 | <0.2 | <0.1 | <0.3 | <0.3 | <0.5 | 0.50 | <0.7 | 0.88 | 1.3 | 0.28 | <0.1 | <0.1 | <0.1 | 2.94 |
| Pi w F | 1997 | 1C | <0.2 | <0.1 | <0.2 | 0.82 | <0.5 | 0.39 | <0.1 | 0.84 | 3.2 | 0.69 | <0.1 | <0.1 | <0.1 | 5.99 |
| Pi w F | 1997 | 2C | <0.1 | <0.1 | <0.1 | 0.81 | <0.1 | 0.16 | <0.1 | 0.13 | 1.6 | 0.57 | <0.1 | <0.1 | <0.1 | 3.28 |
| Pi w F | 1997 | 3C | <0.1 | <0.1 | <0.1 | 0.94 | <0.1 | 0.36 | <0.1 | 0.25 | 3.9 | 0.50 | <0.1 | <0.1 | <0.1 | 5.95 |
| Pi w F | 2006/07 | 4C | <0.1 | <0.1 | <0.1 | 0.61 | <0.1 | 0.23 | <0.1 | 0.17 | 3.1 | 0.61 | <0.1 | <0.1 | <0.1 | 4.72 |
| Pi w F | 2006/07 | 5C | <0.1 | <0.1 | <0.1 | 0.32 | <0.1 | 0.12 | <0.1 | 0.09 | 0.98 | 0.60 | <0.1 | <0.1 | <0.1 | 2.10 |
| Pi w F | 2006/07 | 6C | <0.1 | <0.1 | <0.1 | 0.41 | <0.1 | 0.11 | <0.1 | 0.09 | 1.3 | 0.72 | <0.1 | <0.1 | <0.1 | 2.63 |
| Ri s G | 1986 | 10 | <0.1 | <0.1 | <0.1 | 0.50 | <0.2 | 0.15 | <0.2 | 0.07 | <0.1 | 0.10 | <0.1 | <0.1 | <0.1 | 0.82 |
| Ri s G | 1986 | 11 | <0.2 | <0.1 | <0.1 | 0.61 | <0.2 | 0.23 | <0.2 | 0.09 | <0.1 | 0.08 | <0.1 | <0.1 | <0.1 | 1.00 |
| Ri s G | 1986 | 12 | <0.1 | <0.1 | <0.3 | <0.3 | <0.3 | 0.15 | <0.1 | 0.23 | <0.04 | 0.07 | <0.1 | <0.1 | <0.1 | 0.44 |
| Ri s G | 2000 | 13 | <0.2 | <0.1 | <0.3 | <0.2 | <0.3 | 0.21 | <0.1 | 0.41 | <0.1 | 0.17 | <0.1 | <0.1 | <0.1 | 0.80 |
| Ri s G | 2000 | 14 | <0.1 | <0.1 | <0.2 | <0.2 | <0.2 | 0.14 | <0.1 | 0.19 | <0.03 | 0.08 | <0.1 | <0.1 | <0.1 | 0.40 |
| Ri s G | 2000 | 15 | <0.2 | <0.1 | <0.2 | <0.2 | <0.2 | 0.07 | <0.1 | 0.12 | <0.04 | 0.05 | <0.1 | <0.1 | <0.1 | 0.24 |
| Ri s G | 2006 | 16 | <0.1 | <0.1 | <0.2 | <0.2 | <0.1 | 0.06 | <0.1 | 0.11 | <0.1 | 0.05 | <0.1 | <0.1 | <0.1 | 0.23 |
| Ri s G | 2006 | 17 | <0.2 | <0.1 | <0.2 | <0.2 | <0.1 | 0.05 | <0.1 | 0.08 | <0.1 | 0.05 | <0.1 | <0.1 | <0.1 | 0.18 |
| Ri s G | 2006 | 18 | <0.1 | <0.1 | <0.2 | <0.3 | <0.2 | 0.08 | <0.1 | 0.13 | <0.1 | 0.05 | <0.1 | <0.1 | <0.1 | 0.26 |
| Mi w N | 1993 | 19 | <0.2 | <0.1 | <0.1 | <0.2 | <0.1 | 0.07 | <0.1 | 0.16 | 0.18 | 0.09 | <0.1 | <0.1 | <0.1 | 0.50 |
| Mi w N | 1993 | 20 | <0.2 | <0.1 | <0.1 | <0.2 | <0.1 | 0.07 | <0.1 | 0.15 | 0.20 | 0.08 | <0.1 | <0.1 | <0.1 | 0.51 |
| Mi w N | 1993 | 21 | <0.3 | <0.1 | <0.2 | <0.2 | <0.2 | <0.1 | <0.2 | 0.18 | 0.38 | 0.09 | <0.1 | <0.1 | <0.1 | 0.66 |
| Mi w N | 1999 | 22 | <0.3 | <0.1 | <0.2 | <0.2 | <0.4 | <0.1 | <0.2 | 0.20 | 0.27 | 0.09 | <0.1 | <0.1 | <0.1 | 0.57 |
| Mi w N | 1999 | 23 | <0.2 | <0.1 | <0.2 | <0.1 | <0.2 | 0.09 | <0.2 | 0.19 | 0.18 | 0.13 | <0.1 | <0.1 | <0.1 | 0.60 |
| Mi w N | 1999 | 24 | <0.2 | <0.1 | <0.3 | <0.3 | <0.2 | 0.12 | <0.2 | 0.28 | 0.27 | 0.20 | <0.1 | <0.1 | <0.1 | 0.88 |
| Fi w I | 1986–87 | 27 | <0.03 | <0.02 | <0.03 | 0.19 | <0.1 | <0.1 | <0.1 | <0.1 | 0.17 | 0.02 | <0.1 | <0.1 | <0.1 | 0.38 |
| Fi w I | 1986–87 | 28 | <0.02 | <0.02 | <0.02 | 0.66 | <0.1 | 0.10 | <0.1 | <0.04 | <0.1 | <0.02 | <0.1 | <0.1 | <0.1 | 0.77 |
| Fi w I | 1986–89 | 44 | <0.02 | <0.02 | <0.03 | 0.55 | <0.1 | 0.10 | <0.2 | <0.1 | 0.23 | 0.05 | <0.1 | <0.1 | <0.1 | 0.93 |
| Fi w I | 1986–89 | 45 | <0.02 | <0.03 | <0.1 | 0.54 | <0.1 | 0.12 | <0.2 | <0.1 | 0.24 | 0.06 | <0.2 | <0.2 | <0.2 | 0.96 |
| Fi w I | 1986–89 | 46 | <0.02 | <0.02 | <0.03 | 0.39 | <0.1 | 0.08 | <0.2 | <0.1 | 0.26 | 0.05 | <0.1 | <0.1 | <0.1 | 0.77 |
| Fi w I | 2006 | 25 | <0.1 | <0.1 | <0.1 | 0.15 | <0.1 | <0.04 | <0.2 | <0.1 | 0.09 | 0.05 | <0.1 | <0.1 | <0.1 | 0.29 |
| Fi w I | 2006 | 26 | <0.1 | <0.03 | <0.04 | 0.07 | <0.1 | <0.02 | <0.1 | <0.1 | 0.04 | 0.05 | <0.1 | <0.1 | <0.1 | 0.16 |
| Fi w I | 2009 | 49 | <0.02 | <0.02 | <0.03 | 0.51 | <0.2 | 0.08 | 0.20 | <0.02 | 0.12 | 0.10 | <0.1 | <0.1 | <0.1 | 1.00 |
| Fi w I | 2009 | 50 | <0.02 | <0.02 | <0.02 | 0.07 | <0.2 | 0.03 | <0.2 | <0.02 | 0.08 | 0.08 | <0.1 | <0.1 | <0.1 | 0.27 |
| Fi w I | 2009 | 51 | <0.02 | <0.02 | <0.02 | 0.06 | <0.2 | 0.03 | <0.2 | <0.02 | 0.08 | 0.09 | <0.1 | <0.1 | <0.1 | 0.25 |
| Mi w I | 2003–07 | 29 | <0.1 | <0.1 | <0.1 | 3.1 | <0.2 | 0.50 | <0.2 | <0.2 | 0.22 | 0.23 | <0.2 | <0.2 | <0.2 | 4.04 |
| Mi w I | 2003–07 | 30 | <0.03 | <0.03 | <0.04 | 1.4 | <0.2 | 0.21 | <0.2 | <0.2 | 0.14 | 0.16 | <0.2 | <0.2 | <0.1 | 1.92 |
| Mi w I | 2003–07 | 31 | <0.04 | <0.04 | <0.04 | 1.3 | <0.2 | 0.19 | <0.2 | <0.1 | 0.24 | 0.14 | <0.2 | <0.2 | <0.2 | 1.85 |
| Mi w G | 1998 | 32 | <0.02 | <0.04 | <0.1 | 0.27 | <0.3 | 0.12 | <0.1 | <0.2 | 0.31 | 0.14 | <0.1 | <0.2 | <0.1 | 0.83 |
| Mi w G | 1998 | 33 | <0.04 | <0.03 | <0.1 | 0.21 | <0.2 | 0.08 | <0.1 | <0.1 | 0.12 | 0.08 | <0.1 | <0.1 | <0.1 | 0.49 |
| Mi w G | 1998 | 34 | <0.02 | <0.04 | <0.1 | 0.35 | <0.1 | 0.10 | <0.1 | <0.2 | 0.15 | 0.09 | <0.1 | <0.1 | <0.1 | 0.70 |
| Wh d F | 1997 | 35 | <0.02 | <0.1 | <0.3 | 2.2 | <0.2 | 0.38 | <0.1 | 0.12 | 1.2 | 0.61 | <0.1 | <0.1 | <0.1 | 4.48 |
| Wh d F | 1997 | 36 | 0.03 | <0.2 | <0.2 | 1.3 | <0.7 | 0.41 | <0.2 | 0.13 | 1.1 | 1.3 | <0.1 | <0.1 | <0.1 | 4.33 |
| Wh d F | 1997 | 37 | 0.03 | <0.2 | <0.2 | 2.7 | <0.8 | 0.67 | <0.2 | 0.10 | 1.3 | 1.3 | <0.1 | <0.1 | <0.1 | 6.11 |
| Wh d F | 2001/02 | 41 | <0.02 | <0.1 | <0.2 | 2.8 | <0.6 | 0.47 | <0.2 | 0.12 | 1.5 | 1.2 | <0.2 | <0.2 | <0.2 | 6.00 |
| Wh d F | 2001/02 | 42 | <0.03 | <0.2 | <0.3 | 4.6 | <0.7 | 0.73 | <0.2 | 0.16 | 1.9 | 1.5 | <0.2 | <0.2 | <0.2 | 8.85 |
| Wh d F | 2001/02 | 43 | <0.04 | <0.2 | <0.3 | 4.6 | <0.8 | 0.70 | <0.3 | 0.19 | 1.9 | 2.3 | <0.2 | <0.2 | <0.2 | 9.71 |
| Wh d F | 2006 | 38 | 0.02 | <0.2 | <0.2 | 1.5 | <0.5 | 0.36 | <0.1 | 0.10 | 1.0 | 0.10 | <0.1 | <0.1 | <0.1 | 3.15 |

| Sample | Year | DL-nr | PCN-13 | PCN-28/36 | PCN-27 | PCN-48 | PCN-46 | PCN-52 | PCN-50 | PCN-53 | PCN-66 | PCN-69 | PCN-72 | PCN-73 | PCN-75 | Sum PCN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wh d F | 2006 | 39 | 0.02 | <0.1 | <0.1 | 1.3 | <0.4 | 0.45 | <0.1 | 0.08 | 1.0 | 0.99 | <0.1 | <0.1 | <0.1 | 3.90 |
| Wh d F | 2006 | 40 | <0.03 | <0.1 | <0.2 | 2.4 | <0.5 | 0.49 | <0.2 | 0.12 | 1.1 | 1.4 | <0.2 | <0.2 | <0.2 | 5.40 |
| Ha p I | 1992 | 47 | <0.04 | <0.2 | <0.1 | 5.9 | <0.4 | 0.11 | <0.1 | 0.06 | 0.37 | 0.26 | <0.2 | <0.1 | <0.1 | 6.73 |
| Ha p I | 1992 | 48 | <0.03 | <0.1 | <0.2 | 1.0 | <0.5 | 0.57 | <0.2 | 0.10 | 0.56 | 0.40 | <0.1 | <0.1 | <0.1 | 2.66 |
| Ha p I | 1992 | 52 | <0.02 | <0.1 | <0.1 | 0.5 | <0.2 | 0.16 | <0.1 | 0.08 | 0.47 | 0.42 | <0.1 | <0.1 | <0.1 | 1.67 |
| Ha p I | 1997 | 53 | <0.03 | <0.1 | <0.1 | 3.4 | <0.2 | 0.09 | <0.1 | 0.05 | 0.28 | 0.21 | <0.1 | <0.1 | <0.1 | 4.00 |
| Ha p I | 1997 | 54 | <0.4 | <0.1 | <0.2 | 1.2 | <0.7 | <0.3 | <0.1 | <0.1 | 0.33 | 0.36 | <0.1 | <0.1 | <0.1 | 1.87 |
| Ha p I | 1997 | 55 | <0.03 | <0.1 | <0.1 | 2.3 | <0.2 | 0.32 | <0.1 | 0.06 | 0.33 | 0.52 | <0.1 | <0.1 | <0.1 | 3.50 |
| Ha p N | 2000 | 65 | <0.1 | <0.1 | <0.1 | 2.3 | <0.2 | 0.21 | <0.2 | 0.05 | 0.50 | 0.31 | <0.1 | <0.1 | <0.1 | 3.39 |
| Ha p N | 2000 | 66 | <0.1 | <0.1 | <0.1 | 0.5 | <0.2 | 0.13 | <0.2 | 0.04 | 0.54 | 0.31 | <0.1 | <0.1 | <0.1 | 1.52 |
| Ha p N | 2000 | 67 | <0.1 | <0.1 | <0.1 | 1.9 | <0.2 | 0.18 | <0.2 | 0.06 | 0.52 | 0.41 | <0.1 | <0.1 | <0.1 | 3.04 |
| Ho s N | 1990 | 56 | <0.02 | <0.1 | <0.1 | 1.4 | <0.1 | 0.30 | <0.1 | 0.08 | 0.25 | 0.17 | <0.1 | <0.1 | <0.1 | 2.24 |
| Ho s N | 1990 | 57 | <0.1 | <0.1 | <0.1 | 0.8 | <0.2 | 0.23 | <0.2 | 0.06 | 0.14 | 0.13 | <0.1 | <0.1 | <0.1 | 1.37 |
| Ho s N | 1990 | 58 | <0.1 | <0.1 | <0.1 | 1.1 | <0.2 | 0.26 | <0.2 | 0.08 | 0.23 | 0.20 | <0.1 | <0.1 | <0.1 | 1.92 |
| Ho s N | 1997 | 59 | <0.1 | <0.1 | <0.1 | 0.7 | <0.1 | 0.19 | <0.1 | 0.05 | 0.19 | 0.22 | <0.1 | <0.1 | <0.1 | 1.38 |
| Ho s N | 1997 | 60 | <0.1 | <0.1 | <0.1 | 0.9 | <0.2 | 0.20 | <0.2 | 0.06 | 0.16 | 0.21 | <0.3 | <0.3 | <0.3 | 1.49 |
| Ho s N | 1997 | 61 | <0.1 | <0.1 | <0.1 | 0.8 | <0.2 | 0.18 | <0.2 | 0.05 | 0.16 | 0.18 | <0.2 | <0.2 | <0.2 | 1.34 |
| Ho s N | 2007 | 62 | <0.1 | <0.1 | <0.03 | 0.3 | <0.2 | 0.10 | <0.2 | 0.03 | 0.09 | 0.17 | <0.1 | <0.1 | <0.1 | 0.66 |
| Ho s N | 2007 | 63 | <0.1 | <0.1 | <0.03 | 0.4 | <0.2 | 0.10 | <0.2 | 0.04 | 0.13 | 0.22 | <0.3 | <0.3 | <0.3 | 0.88 |
| Ho s N | 2007 | 64 | <0.1 | <0.1 | <0.03 | 0.3 | <0.2 | 0.10 | <0.2 | 0.04 | 0.15 | 0.21 | <0.3 | <0.3 | <0.3 | 0.80 |

# Appendix 6: Perfluorinated compounds analyses results in ng/g WW.

| Sample | Year | DL-nr | PFBA | PFPeA | PFBuS | PFHxA | PFHpA | PFHxS | PFOA | PFNA | PFOS | PFDS | PFDA | PFUnDA | PFDoDA | PFTrDA | PFTDA | PFHxDA | PFOcDA | Sum PFCs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pi w F | 1986 | 7 | NQ | <0.02 | <0.01 | <0.01 | <0.01 | 0.08 | 0.19 | 1.51 | 23.71 | 0.09 | 3.17 | 13.44 | NQ | NQ | NQ | NQ | NQ | 42.19 |
| Pi w F | 1986 | 8 | NQ | <0.08 | <0.02 | <0.01 | <0.01 | 0.15 | <0.08 | 1.32 | 28.84 | 0.06 | 2.81 | 10.60 | NQ | NQ | NQ | NQ | NQ | 43.78 |
| Pi w F | 1986 | 9 | NQ | <0.04 | <0.02 | <0.02 | <0.01 | 0.15 | 0.20 | 1.38 | 29.03 | 0.09 | 3.93 | 16.35 | NQ | NQ | NQ | NQ | NQ | 51.13 |
| Pi w F | 2001/02 | 10 | NQ | <0.03 | <0.01 | <0.01 | <0.01 | 0.31 | 0.24 | 2.38 | 51.49 | 0.38 | 5.04 | 22.99 | NQ | NQ | NQ | NQ | NQ | 82.84 |
| Pi w F | 2001/02 | 11 | NQ | <0.03 | <0.01 | <0.02 | <0.01 | 0.33 | 0.28 | 4.70 | 63.39 | 0.29 | 7.61 | 33.21 | NQ | NQ | NQ | NQ | NQ | 109.81 |
| Pi w F | 2001/02 | 12 | NQ | <0.03 | <0.01 | <0.02 | <0.01 | 0.29 | 0.43 | 8.80 | 75.87 | 0.92 | 16.00 | 52.06 | NQ | NQ | NQ | NQ | NQ | 154.36 |
| Pi w F | 2006/07 | 13 | NQ | <0.02 | <0.01 | <0.02 | <0.01 | 0.49 | 0.33 | 8.27 | 55.44 | 0.36 | 11.40 | 46.35 | NQ | NQ | NQ | NQ | NQ | 122.63 |
| Pi w F | 2006/07 | 14 | NQ | <0.01 | <0.01 | <0.03 | <0.01 | 0.45 | 0.32 | 7.01 | 46.73 | 0.81 | 11.78 | 51.50 | 11.27 | 48.84 | 21.09 | NQ | NQ | 199.80 |
| Pi w F | 2006/07 | 15 | NQ | <0.01 | <0.01 | <0.01 | <0.01 | 0.25 | 0.22 | 5.46 | 39.67 | 0.67 | 11.64 | 50.06 | 9.39 | 21.93 | 5.22 | NQ | NQ | 144.51 |
| Wh d F | 2001/02 | 16 | NQ | <0.01 | <0.01 | <0.01 | <0.01 | 0.36 | 0.18 | 1.44 | 103.9 | 1.09 | 6.87 | 21.65 | 4.22 | 13.39 | 5.41 | NQ | NQ | 158.49 |
| Wh d F | 2001/02 | 17 | NQ | <0.01 | <0.01 | <0.01 | <0.01 | 0.42 | 0.10 | 1.69 | 95.14 | 0.47 | 6.83 | 25.96 | NQ | NQ | NQ | NQ | NQ | 130.61 |
| Wh d F | 2001/02 | 18 | NQ | <0.03 | <0.01 | <0.02 | <0.01 | 0.32 | 0.15 | 2.50 | 126.2 | 1.92 | 10.03 | 37.41 | 6.00 | 17.52 | 6.57 | NQ | NQ | 208.59 |
| Wh d F | 2006 | 19 | NQ | <0.01 | <0.01 | <0.02 | <0.01 | 0.43 | 0.05 | 1.28 | 107.0 | 1.38 | 12.93 | 45.11 | 6.57 | 16.12 | 3.33 | NQ | NQ | 194.21 |
| Wh d F | 2006 | 20 | NQ | <0.01 | <0.02 | <0.02 | <0.01 | 0.51 | 0.28 | 5.54 | 126.0 | 2.15 | 17.53 | 68.49 | 10.18 | 25.91 | 6.21 | NQ | NQ | 262.81 |
| Wh d F | 2006 | 21 | NQ | <0.01 | <0.01 | <0.01 | <0.01 | 0.62 | 0.23 | 4.84 | 104.4 | 1.31 | 10.92 | 52.41 | 7.33 | 15.67 | 2.80 | NQ | NQ | 200.51 |
| Mi w G | 1998 | 22 | NQ | <0.01 | <0.02 | <0.01 | <0.01 | 0.22 | 0.24 | 2.74 | 47.62 | 0.58 | 3.66 | 14.34 | 1.71 | 4.62 | 1.23 | NQ | NQ | 76.96 |
| Mi w G | 1998 | 23 | NQ | <0.02 | <0.02 | <0.01 | <0.01 | 0.18 | 0.18 | 1.35 | 39.46 | 0.55 | 2.74 | 9.54 | 1.38 | 3.61 | 1.07 | NQ | NQ | 60.05 |
| Mi w G | 1998 | 24 | NQ | <0.01 | <0.03 | <0.01 | <0.01 | 0.03 | 0.13 | 0.61 | 48.86 | 0.15 | 10.62 | 9.71 | 1.35 | 1.85 | 0.25 | NQ | NQ | 73.57 |
| Ri s G | 1984 | 25 | NQ | <0.02 | <0.01 | <0.01 | <0.01 | 0.07 | 0.07 | 0.76 | 48.49 | <0.01 | 1.42 | 0.97 | NQ | NQ | NQ | NQ | NQ | 51.77 |
| Ri s G | 1984 | 26 | NQ | <0.01 | <0.01 | <0.01 | <0.01 | 0.10 | <0.06 | 0.54 | 59.14 | <0.01 | 1.56 | 1.33 | 0.37 | 0.54 | <0.03 | NQ | NQ | 63.59 |
| Ri s G | 1984 | 27 | NQ | <0.01 | <0.01 | <0.01 | <0.01 | 0.10 | <0.06 | 0.53 | 44.20 | <0.01 | 1.68 | 1.04 | 0.35 | 0.36 | <0.04 | NQ | NQ | 48.25 |
| Ri s G | 1998 | 28 | NQ | <0.01 | <0.01 | <0.01 | <0.01 | 0.16 | 0.11 | 4.01 | 61.52 | <0.01 | 3.83 | 4.10 | 0.56 | 0.66 | <0.04 | NQ | NQ | 74.95 |
| Ri s G | 1998 | 29 | NQ | <0.01 | <0.01 | <0.01 | <0.01 | 0.13 | 0.09 | 3.63 | 38.57 | <0.01 | 3.50 | 3.29 | 0.49 | 0.54 | <0.03 | NQ | NQ | 50.23 |
| Ri s G | 1998 | 30 | NQ | <0.01 | <0.01 | <0.04 | <0.01 | 0.18 | 0.06 | 3.31 | 57.92 | <0.01 | 3.13 | 3.45 | NQ | NQ | NQ | NQ | NQ | 68.06 |
| Ri s G | 2006 | 31 | NQ | <0.01 | <0.01 | <0.01 | <0.01 | 0.71 | 0.16 | 15.40 | 86.27 | <0.01 | 9.10 | 10.41 | NQ | NQ | NQ | NQ | NQ | 122.05 |
| Ri s G | 2006 | 32 | NQ | <0.01 | <0.01 | <0.01 | <0.01 | 0.73 | 0.08 | 7.27 | 50.66 | <0.01 | 6.37 | 7.68 | 1.12 | 0.36 | <0.4 | NQ | NQ | 74.27 |
| Ri s G | 2006 | 33 | NQ | <0.01 | <0.01 | <0.01 | <0.01 | 0.66 | 0.16 | 7.83 | 86.60 | <0.01 | 7.69 | 8.55 | 1.27 | 0.38 | 0.32 | NQ | NQ | 113.45 |
| Ha p I | 1992 | 40 | NQ | <0.01 | <0.02 | <0.07 | <0.02 | 0.18 | 0.09 | 0.73 | 37.67 | 0.14 | 4.06 | 22.46 | NQ | NQ | NQ | NQ | NQ | 65.33 |
| Ha p I | 1992 | 41 | NQ | <0.01 | <0.03 | <0.04 | <0.02 | 0.12 | 0.09 | 0.60 | 42.44 | <0.01 | 4.59 | NQ | NQ | NQ | NQ | NQ | NQ | 47.84 |
| Ha p I | 1992 | 42 | NQ | <0.01 | <0.03 | <0.06 | <0.02 | 0.17 | 0.09 | 0.40 | 56.92 | 0.12 | 3.94 | 27.26 | 3.54 | 5.37 | 0.60 | NQ | NQ | 98.40 |
| Ha p I | 1997 | 43 | NQ | <0.01 | <0.03 | <0.06 | <0.02 | 0.36 | 0.09 | 1.55 | 66.99 | 0.20 | 5.40 | 20.30 | 3.69 | 5.40 | 0.76 | NQ | NQ | 104.72 |
| Ha p I | 1997 | 44 | NQ | <0.01 | <0.02 | <0.05 | <0.02 | 0.15 | 0.09 | 1.28 | 38.54 | 0.13 | 3.24 | NQ | NQ | NQ | NQ | NQ | NQ | 43.44 |
| Ha p I | 1997 | 45 | NQ | <0.01 | <0.01 | <0.06 | <0.01 | 0.16 | 0.06 | 1.90 | 30.24 | <0.02 | 4.46 | NQ | NQ | NQ | NQ | NQ | NQ | 36.82 |
| Fi w I | 1986–89 | 46 | NQ | <0.01 | <0.01 | <0.02 | <0.01 | <0.02 | <0.01 | <0.01 | 0.32 | <0.01 | 0.04 | NQ | 0.08 | 0.15 | <0.01 | NQ | NQ | 0.58 |
| Fi w I | 1986–89 | 47 | NQ | <0.01 | <0.01 | <0.02 | <0.01 | <0.01 | <0.01 | <0.01 | 0.34 | <0.01 | 0.06 | NQ | 0.07 | 0.35 | <0.02 | NQ | NQ | 0.81 |
| Fi w I | 1986–89 | 48 | NQ | <0.01 | <0.01 | <0.03 | <0.01 | <0.01 | <0.01 | <0.01 | 0.45 | <0.01 | <0.01 | NQ | 0.11 | 0.27 | <0.1 | NQ | NQ | 0.83 |
| Fi w I | 2009 | 49 | NQ | <0.01 | <0.01 | <0.03 | <0.01 | <0.01 | <0.01 | <0.01 | 0.53 | <0.01 | NQ | NQ | NQ | NQ | NQ | NQ | NQ | 0.53 |
| Fi w I | 2009 | 50 | NQ | <0.01 | <0.01 | <0.03 | <0.01 | <0.01 | <0.01 | <0.01 | 0.32 | <0.01 | <0.01 | NQ | NQ | NQ | NQ | NQ | NQ | 0.32 |
| Fi w I | 2009 | 51 | NQ | <0.01 | <0.01 | <0.03 | <0.01 | <0.02 | <0.01 | 0.08 | 0.55 | <0.01 | 0.08 | 0.66 | 0.24 | 0.71 | <0.1 | NQ | NQ | 2.31 |
| Ho s N | 1990 | 52 | NQ | 0.022 | <0.01 | <0.01 | <0.01 | 0.11 | 0.13 | 2.76 | 57.56 | 0.10 | 2.43 | NQ | NQ | NQ | NQ | NQ | NQ | 63.10 |
| Ho s N | 1990 | 53 | NQ | <0.01 | <0.01 | <0.01 | <0.01 | 0.11 | 0.15 | 3.18 | 59.12 | 0.12 | 3.97 | 11.89 | NQ | NQ | NQ | NQ | NQ | 78.55 |
| Ho s N | 1990 | 54 | NQ | <0.01 | <0.01 | <0.01 | <0.01 | 0.17 | 0.24 | 4.01 | 95.08 | 0.22 | 4.72 | 20.38 | NQ | NQ | NQ | NQ | NQ | 124.82 |
| Ho s N | 2007 | 55 | NQ | <0.01 | <0.02 | <0.01 | <0.01 | 0.25 | 0.34 | 7.05 | 34.86 | 0.05 | 4.20 | NQ | NQ | NQ | NQ | NQ | NQ | 46.74 |
| Ho s N | 2007 | 56 | NQ | <0.01 | <0.01 | <0.01 | <0.01 | 0.18 | 0.23 | 5.82 | 47.20 | 0.17 | 6.06 | 22.18 | 3.01 | 15.13 | 7.00 | NQ | NQ | 106.99 |
| Ho s N | 2007 | 57 | NQ | 0.022 | <0.01 | <0.01 | <0.01 | 0.18 | 0.17 | 3.97 | 38.25 | 0.05 | 3.94 | NQ | NQ | NQ | NQ | NQ | NQ | 46.57 |

NQ: not quantified.

# Appendix 7: Tables presenting results of statistical analyses

**Table A: Temporal trend. Results of ANOVA of flame retardants polybrominated diphenyl ethers, PBDE, hexabromobenzene, HBB, and polybrominated biphenyl congener no. 153, PBB 153, in blubber tissue. P values are given and bold indicate significance at 5% level. – denote no test performed because of too many values below DL or QL.**

| Species | Location | Time periods | BDE congeners | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **ΣBDE** | **28** | **47** | **66** | **85** | **99** | **100** | **153** | **154** | **138** | **183** | **HBB** | **PBB-153** |
| Ringed seal | Greenland (East) | 1986, 2000, 2006 | 0.09 | <0.01 | 0.18 | 0.02 | 0.32 | 0.05 | 0.07 | 0.02 | 0.1 | - | - | - | 0.06 |
| Pilot whale | Faroe Islands | 1986, 1997, 2006/7 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | - | 0.01 | 0.40* | 0.13 |
| White-sided dolphin | Faroe Islands | 1997, 2001, 2006 | <0.01 | - | <0.01 | 0.02 | 0.1 | <0.01 | <0.01 | <0.01 | 0.13 | 0.96 | - | NA | NA |
| Minke whale | Norway | 1993, 1999 | 0.56 | 0.49 | 0.69 | 0.96 | 0.01 | 0.62 | 0.63 | 0.45 | 0.23 | - | - | 0.84 | 0.69 |
| Hooded seal | Norway | 1990, 1997, 2007 | 0.05 | <0.01 | 0.02 | <0.01 | - | 0.02 | 0.05 | 0.04 | 0.42 | - | 0.24 | NA | NA |
| Fin whale blubber | Iceland | 1986/87, 2006 | 0.12 | 0.03 | 0.11 | - | 0.05 | 0.14 | 0.18 | 0.06 | 0.22 | - | 0.08 | NA | NA |
| Fin whale blubber | Iceland | 1986/89, 2009 | <0.01 | 0.42 | 0.01 | 0.37 | 0.1 | <0.01 | <0.01 | 0.05 | <0.01 | - | - | NA | NA |
| Harbour porpoise | Iceland | 1992, 1997 | 0.23 | 0.23 | 0.82 | 0.13 | - | 0.41 | 0.22 | 0.13 | 0.11 | - | 0.12 | NA | NA |
| Minke whale; Iceland 2003/7 , Norway 1993, 1999, Greenland 1998 | | | 0.33 | 0.27 | 0.38 | 0.06 | <0.01 | 0.11 | - | 0.67 | 0.37 | - | - | - | - |
| Harbour porpoise; Iceland 1992, 1997, Norway 2000 | | | 0.26 | 0.27 | 0.16 | 0.65 | - | 0.73 | 0.23 | 0.6 | 0.44 | - | 0.4 | NA | NA |

*only data from 1997 and 2006/7.

**Table B: Temporal trend. Results of ANOVA of methoxylated brominated diphenyl ethers in blubber tissue. P values are given and bold indicate significance at 5% level.**

| Species | Location | Time periods | 2PMBDE68 | 6MBDE47 |
|---|---|---|---|---|
| Ringed seal | Greenland (East) | 1986, 2000, 2006 | 0.13 | 0.28 |
| Pilot whale | Faroe Islands | 1986, 1997, 2006/7 | 0.45 | 0.24 |
| White-sided dolphin | Faroe Islands | 1997, 2001, 2006 | 0.1 | 0.26 |
| Minke whale | Norway | 1993, 1999 | 0.71 | 0.92 |
| Hooded seal | Norway | 1990, 1997, 2007 | 0.88 | 0.06 |
| Fin whale muscle | Iceland | 1986/89, 2009 | 0.5 | 0.94 |
| Harbour porpoise | Iceland | 1992, 1997 | 0.82 | 0.81 |
| Minke whale - Iceland 2003/6, Norway 1993, 1999, Greenland 1998 | | | 0.01 | 0.01 |
| Harbour porpoise – Iceland 1992, 1997, Norway 2000 | | | 0.62 | 0.96 |

**Table C: PBDE and MeOBDE. Summary of the results of Tukey comparisons of mean test in cases with significantly differences between samples or ANOVA, in case of only two samples. Samples with the same letter were not significantly different at 5% level. The letter a is always given to the sample with the highest concentration.**

| Species | Year/period | ΣBDE | 28 | 47 | 66 | 85 | 99 | 100 | 153 | 154 | 183 | 2PMBDE68 | 6MBDE47 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ringed seal East Greenland | 1986 | | b | | b | | | | b | | | | |
| | 2000 | | a | | a | | | | a | | | | |
| | 2006 | | b | | ab | | | | ab | | | | |
| Pilot whale Faroe Island | 1986 | b | b | b | b | b | b | b | b | b | b | | |
| | 1997 | a | a | a | a | a | a | a | a | a | a | | |
| | 2006/7 | a | a | a | a | a | a | a | a | a | a | | |
| White-sided dolphin Faroe Island | 1997 | b | | b | b | | b | b | b | | | | |
| | 2001 | a | | a | a | | a | a | a | | | | |
| | 2006 | b | | b | b | | b | b | b | | | | |
| Minke whale Norway | 1993 | | | | | | b | | | | | | |
| | 1999 | | | | | | a | | | | | | |
| Hooded seal Norway | 1990 | | ab | ab | b | | ab | | ab | | | | |
| | 1997 | | a | a | a | | a | | a | | | | |
| | 2007 | | b | b | b | | b | | b | | | | |
| Fin whale (16 and 30 years old) Iceland | 1986/87 | | b | | | b | | | | | | | |
| | 2006 | | a | | | a | | | | | | | |
| Fin whale Iceland | 1986/89 | b | | b | | | b | b | | b | | | |
| | 2009 | a | | a | | | a | a | | a | | | |
| Minke whale spatial pattern | Iceland 2003/7 | | | | | b | | | | | | a | a |
| | Norway 1993 | | | | | a | | | | | | b | b |
| | Norway 1999 | | | | | b | | | | | | ab | b |
| | Greenland 1998 | | | | | a | | | | | | a | a |
| Harbour porpoise spatial pattern | Iceland 1992 | | | | | | | | | | | | |
| | Iceland 1997 | | | | | | | | | | | | |
| | Norway 2000 | | | | | | | | | | | | |

**Table D: Temporal trend. Results of ANOVA of PCN in blubber tissue. P values are given and bold indicate significance at 5% level. – denote no test performed because of too many values below DL.**

| Species | Location | Time periods | ΣPCN | 52 | 53 | 66 | 69 |
|---|---|---|---|---|---|---|---|
| Ringed seal | Greenland (East) | 1986, 2000, 2006 | 0.07 | 0.03 | 0.09 | 0.07 | 0.23 |
| Pilot whale | Faroe Island | 1986, 1997, 2006/7 | 0.25 | 0.1 | 0.88 | 0.39 | 0.31 |
| White-sided dolphin | Faroe Island | 1997, 2001, 2006 | 0.08 | 0.24 | 0.08 | <0.01 | 0.35 |
| Minke whale | Norway | 1993, 1999 | 0.3 | 0.18 | 0.09 | 0.96 | 0.14 |
| Hooded seal | Norway | 1990, 1997, 2007 | 0.03 | <0.01 | <0.01 | 0.1 | 0.28 |
| Fin whale | Iceland | 1986/87, 2006 | 0.94 | - | - | 0.62 | 0.07 |
| Fin whale | Iceland | 1986/89, 2009 | 0.02 | 0.07 | - | <0.01 | <0.01 |
| Harbour porpoise | Iceland | 1992, 1997 | 0.42 | 0.67 | 0.07 | 0.04 | 0.91 |
| Minke whale - Iceland 2003/6, Greennland 1998, Norway 1993, 1999 | | | 0.24 | <0.01 | - | 0.71 | 0.07 |
| Harbour porpoise – Iceland 1992, 1997, Norway 2000 | | | 0.55 | 0.85 | 0.06 | <0.01 | 0.99 |

**Table E: Polychlorinated naphthalenes, PCN. Summary of the results of Tukey comparisons of mean test in cases with significantly differences between samples or ANOVA, in case of only two samples. Samples with the same letter were not significantly different at 5% level. The letter a is always given to the sample with the highest concentration.**

| Species | Period/year | ΣPCN | 52 | 53 | 66 | 69 |
|---|---|---|---|---|---|---|
| Ringed seal East Greenland | 1986 | | a | | | |
| | 2000 | | ab | | | |
| | 2006 | | b | | | |
| Pilot whale Faroe Island | 1986 | | | | | |
| | 1997 | | | | | |
| | 2006/7 | | | | | |
| White-sided dolphin Faroe Island | 1997 | | | | b | |
| | 2001 | | | | a | |
| | 2006 | | | | b | |
| Minke whale Norway | 1993 | | | | | |
| | 1999 | | | | | |
| Hooded seal, Norway | 1990 | a | a | a | | |
| | 1997 | ab | b | a | | |
| | 2007 | b | c | b | | |
| Minke whale spatial pattern | Norway 1993 | | b | | | |
| | Norway 1999 | | b | | | |
| | Iceland 2003/6 | | a | | | |
| | Greenland 1998 | | b | | | |
| Fin whale Iceland 16/30 | 1986/87 | | | | | |
| | 2006 | | | | | |
| Fin whale Iceland | 1986/89 | a | | | a | a |
| | 2009 | b | | | b | b |
| Harbour porpoise Iceland | 1992 | | | | a | |
| | 1997 | | | | b | |
| Harbour porpoise spatial | Iceland 1992 | | | | | a |
| | Iceland 1997 | | | | | b |
| | Norway 2000 | | | | a | |

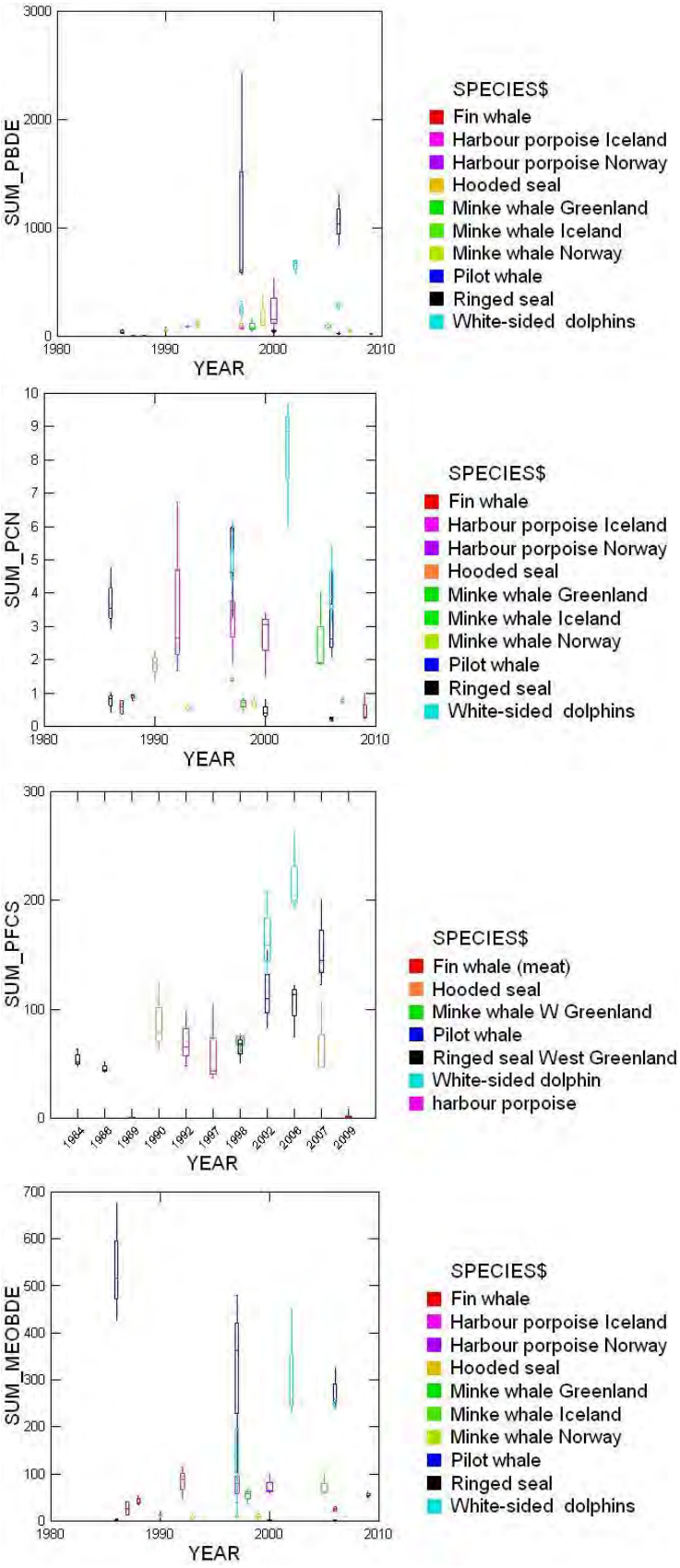
**Table F: Temporal trend. Results of ANOVA of perfluorocompounds, PFCs, in liver tissue. P values are given and bold indicate significance at 5% level. – denote no test performed because of too many values below DL.**

| Species | Location | Time periods | PFOS | PFNA | PFOA | PFHxS | PFDA | PFUnDA | PFDoDA | PFTrDA | PFTDA |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ringed seal | Greenland (West) | 1984, 1998, 2006 | 0.21 | <0.01 | 0.03 | <0.01 | <0.01 | <0.01 | - | 0.92 | - |
| Pilot whale | Faroe Islands | 1986, 2001/2, 2006/7 | <0.01 | <0.01 | 0.14 | <0.01 | 0.01 | <0.01 | - | - | 0.57 |
| White-sided dolphin | Faroe Islands | 2001/2, 2006 | 0.71 | 0.31 | 0.92 | 0.06 | 0.04 | 0.03 | 0.05 | 0.23 | 0.64 |
| Harbour porpoise | Iceland | 1992,1997 | 0.86 | <0.01 | 0.37 | 0.41 | 0.9 | 0.21 | 0.81 | 0.46 | 0.57 |
| Fin whale meat tissue | Iceland | 1986/89, 2009 | 0.35 | - | - | - | - | 0.06 | 0.55 | - | 0.05 |
| Hooded seal | Norway (West Ice) | 1990, 2007 | 0.04 | 0.06 | 0.27 | 0.07 | 0.33 | 0.33 | 0.42 | 0.32 | 0.05 |

**Table G: Perfluorocompounds, PFCs. Summary of the results of Tukey comparisons of mean test in cases with significantly differences between samples or ANOVA, in case of only two samples. Samples with the same letter were not significantly different at 5% level. The letter a is always given to the sample with the highest concentration.**

| Species/ location | Year | PFOS | PFNA | PFOA | PFHxS | PFDA | PFUnDA | PFDoDA | PFTrDA |
|---|---|---|---|---|---|---|---|---|---|
| Ringed seal West Greenland | 1984 | | c | b | c | c | c | | |
| | 1998 | | b | ab | b | b | b | | |
| | 2006 | | a | a | a | a | a | | |
| Pilot whale Faroe Island | 1986 | b | b | | b | b | b | | |
| | 2001 | a | a | | ab | a | a | | |
| | 2006 | a | a | | a | a | a | | |
| White-sided dolphin Faroe Island | 2001 | | | | | b | b | b | |
| | 2006 | | | | | a | a | a | |
| Harbour porpoise Iceland | 1992 | | b | | | | | | |
| | 1997 | | a | | | | | | |
| Fin whale* Iceland | 1986/89 | | | | | | | | |
| | 2009 | | | | | | | | |
| Hooded seal Norway | 1990 | a | | | | | | | |
| | 2007 | b | | | | | | | |

* meat tissue




***Boxplots showing sum of compound groups for all species analysed on a year axis.***

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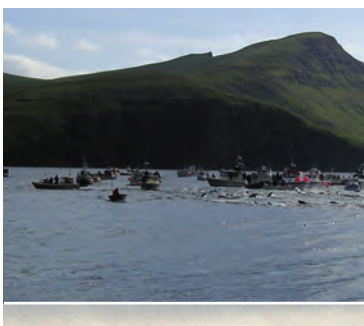
# “New” POPs in marine mammals in Nordic Arctic and NE Atlantic areas during three decades

Marine mammals hold a special position in the hearts of people inhabiting Nordic Arctic areas and in coastal communities around the North Atlantic Ocean as they are an essential part of the diet and traditional life-style. However, marine mammals are in a particularly vulnerable position as regards environmental pollutants, because of the large fat stores in their bodies which serve as a “magnet” to a large number of persistent and toxic pollutants.

A Nordic Council of Ministers supported collaboration between Norway, Denmark/Greenland, Faroe Island, Iceland and Sweden set out to look for possible trends in “new” contaminants in marine mammals in Nordic Arctic waters. The “new” contaminants in focus are the brominated flame retardants including the PBDEs, methoxylated PBDEs, perfluorinated compounds including the PFOS family, and polychlorinated naphthalenes. In addition, a subset of the samples was analysed for brominated dioxins and dibenzofurans. The marine mammals studied were fin whale, minke whale, pilot whale, white-sided dolphins, harbour porpoise, ringed seal and hooded seal.

The study aims at giving a wide scope of the presence of these “new” contaminants in marine mammals in recent time and going back to the 1980s using samples from specimen banks.



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