NTNU
Norwegian University of
Science and Technology

Master's thesis
2021
Andrine Vindstad Vedal

Master's thesis

**NTNU**
Norwegian University of
Science and Technology
Faculty of Natural Sciences
Department of Biology

Andrine Vindstad Vedal

# Temporal Variations in Organohalogenated Contaminants and Associated Thyroid Hormone Responses in Two Arctic Glaucous Gull (*Larus hyperboreus*) Populations

July 2021

NTNU
Norwegian University of
Science and Technology

NTNU
Norwegian University of
Science and Technology

# Temporal Variations in Organohalogenated Contaminants and Associated Thyroid Hormone Responses in Two Arctic Glaucous Gull (*Larus hyperboreus*) Populations

**Andrine Vindstad Vedal**

Environmental Toxicology and Chemistry
Submission date: July 2021
Supervisor: Bjørn Munro Jenssen, IBI
Co-supervisor: Geir Wing Gabrielsen, Norwegian Polar Institute
Hallvard Strøm, Norwegian Polar Institute

Norwegian University of Science and Technology
Department of Biology

NTNU

Norwegian University of
Science and Technology

IN COLLABORATION WITH

NORWEGIAN POLAR INSTITUTE

# ACKNOWLEDGEMENTS

This project was funded by the Norwegian Polar Institute (NPI) and the Norwegian University of Science and Technology (NTNU), and in part by the Research Council of Norway (project no. 268419). All samples were collected by the NPI and analysed for contaminants by the Norwegian Institute for Air Research (NILU).

I wish to express my sincere gratitude towards my supervisors Bjørn Munro Jenssen (NTNU), Geir Wing Gabrielsen (NPI), and Hallvard Strøm (NPI) for all the valuable advice and feedback. Thank you for letting me take part in this project, and thank you Geir for including me in field work in Ny-Ålesund and providing me this wonderful experience. A special thanks goes to my main supervisor Bjørn for the much appreciated constructive criticism and for improving my scientific writing.

I would like to acknowledge all the people who have participated in the fieldworks on Bjørnøya and in Kongsfjorden during the 2015 – 2019 period, including Hallvard Strøm and Kjetil Sagerup (NPI), and all the people who have contributed to the contaminant analyses at NILU, including Arntraut Götsch, Ola Tilset, Ane Harr, Svenja Neumann, and Eirin Husabø. I would also like to thank Kjetil Sagerup for the help regarding the data from Kongsfjorden, and Dorte Herzke (NILU) and Svenja Neumann (NPI) for the help with the methods and data. Sincere thanks go to Grethe Stavik Eggen (NTNU) for all the good help and guidance during thyroid hormone analyses, and for all the time spent trying to figure out some of the results. I also wish to thank Thomas Ciesielski for insights and help with the lab work.

Finally, I am very thankful to my family and friends for all the support and understanding you have given me during these busy years of studying. I would also like to thank my dearest friends Enghild Kristine Steinkjer and Karen Søreng for proofreading my thesis. A special thanks goes to my fellow glaucous gull partner Eirin Husabø for unforgettable memories in Ny-Ålesund, and the many (late night) hours of valuable discussions.

# ABSTRACT

Polychlorinated biphenyls (PCBs), organochlorinated pesticides (OCPs), and per- and polyfluoralkyl substances (PFASs) are persistent organic pollutants (POPs) found in the pristine Arctic, despite many of them being globally restricted or banned. These organohalogenated contaminants (OHCs) have been related to effects on the thyroid hormone (TH) homeostasis in organisms, causing concern of their potential effects on both individual and population level. The glaucous gull (*Larus hyperboreus*) is one of the top predators in the Arctic accumulating high OHC levels, and the population size on Bjørnøya, Svalbard, has decreased drastically during the past decades. In contrast, the population size in Kongsfjorden, Svalbard, has increased and is now stable. To assess whether TH disruptive effects could have contributed to the population decline on Bjørnøya, the present study aimed to investigate the PCB, OCP, and PFAS concentrations, and their effects on the total and free thyroxine and triiodothyronine ($TT_4$, $FT_4$, $TT_3$, and $FT_3$, respectively) concentrations and ratios in blood plasma of glaucous gulls in these two populations during the 2015 – 2019 period. Glaucous gulls from Bjørnøya had very high OHC concentrations compared to the birds from Kongsfjorden throughout the five-year period. In both populations, female birds had lower OHC concentrations compared to males, indicating that females can get rid of OHCs through maternal transfer of contaminants to the eggs. No differences in neither of the TH concentrations nor ratios were observed between locations, and only $FT_3$ concentrations and $FT_4/FT_3$ ratios differed between sexes in both locations. These results indicated that the high OHC concentrations did not alter the TH levels in these birds. Principal component analyses (PCAs) including both locations supported these findings, while linear mixed-effect models (LMMs) indicated positive effects of PFASs on the TH concentrations, but not on the TH ratios, across the two populations. Other variables that contributed to the variation in the TH concentrations were location, sampling year, sex, body condition index (BCI), and plasma lipid weight percentage. No effects of PCBs and OCPs were found. The results from the present study suggest that these glaucous gulls do not experience significant TH disruptive effects caused by pollutant exposure, and that TH disruptive effects are most likely not contributing to the population decline on Bjørnøya. However, the TH levels are regulated by the thyroid stimulating hormone (TSH), and it cannot be disregarded that the birds were able to maintain relatively constant TH levels despite of the possible TH disruptive effect of PFASs. It should be emphasised that samples were obtained from breeding, and thereby relatively healthy individuals. To be able to rule out biased sampling, analogous to the Healthy Worker Effect (HWE) phenomenon, future studies should consider including early life-stage and non-breeding individuals.

# SAMMENDRAG

Polyklorerte bifenyler (PCBs), organiske klorerte pesticider (OCPer), og per- og polyfluorerte stoffer (PFASer) er persistente organiske forurensninger (POPer) som finnes i det uberørte Arktis, til tross for at produksjonen av mange av dem er globalt begrenset eller forbudt. Disse organiske halogenerte miljøgiftene (OHCene) har blitt relatert til effekter på organismers tyroidhormon (TH)-homeostase, noe som skaper bekymring med tanke på de potensielle effektene på både individ- og populasjonsnivå. Polarmåken (*Larus hyperboreus*) er en av toppredatorene i Arktis som akkumulerer høye OHC-nivåer, og populasjonsstørrelsen på Bjørnøya, Svalbard, har gått ned drastisk de siste tiårene. I motsetning har populasjonsstørrelsen i Kongsfjorden, Svalbard, økt og er nå stabil. Målet med dette studiet var å undersøke PCB-, OCP-, og PFAS-konsentrasjoner, og deres effekter på total og fri tyroksin og trijodtyronin ($TT_4$, $FT_4$, $TT_3$, og $FT_3$, respektivt)-konsentrasjoner og -ratio i blodplasma av polarmåker i disse to populasjonene i løpet av 2015 – 2019 perioden. Dette for å vurdere om TH-forstyrrende effekter bidrar til populasjonsnedgangen på Bjørnøya. Polarmåker fra Bjørnøya hadde veldig høye OHC-konsentrasjoner sammenlignet med fuglene fra Kongsfjorden i løpet av femårsperioden. I begge populasjonene hadde hunfuglene lavere OHC-konsentrasjoner enn hanfuglene, noe som indikerer at hunfugler kan kvitte seg med OHCer via overføring av miljøgifter fra mor til egg. Ingen lokalitetsforskjeller ble funnet i noen av TH-konsentrasjonene eller -ratio, og bare $FT_3$-konsentrasjoner og $FT_4/FT_3$-ratio var signifikant forskjellig mellom kjønn innad i hver lokalitet. Disse resultatene indikerte at de høye OHC-konsentrasjonene ikke påvirket TH-nivåene i disse fuglene. Prinsipal komponent analyser (PCAer) som inkluderte begge lokaliteter støttet dette funnet, mens lineære blandet-effekt modeller (LMMer) indikerte positive effekter av PFASer på TH-konsentrasjoner, men ikke på TH-ratio, på tvers av de to populasjonene. Lokalitet, prøvetakingsår, kjønn, kroppskondisjonsindeks (BCI), og lipidvektprosent i plasma var andre variabler som bidro i variasjonen i TH-nivåene. Ingen effekt av PCBer og OCPer ble funnet. Resultatene av dette studiet foreslår at disse polarmåkene ikke har blitt signifikant påvirket av TH-forstyrrende effekter forårsaket av eksponering for forurensning, og at TH-forstyrrende effekter trolig ikke bidrar i populasjonsnedgangen på Bjørnøya. Derimot så er TH-nivåene regulert av tyroidstimulerende hormon (TSH), og det bør ikke utelukkes at fuglene kunne opprettholde relativt konstante TH-nivåer til tross for den mulige TH-forstyrrende effekten av PFASer. Det bør understrekes at prøver ble tatt fra hekkende, og dermed relativt friske individer. Fremtidige studier burde derfor vurdere å inkludere individer i tidligere livsstadier og ikke-hekkende individer for å kunne utelukke at prøvetakingen er forutinntatt, analogt til «Healthy Worker Effect» fenomenet (HWE; sunne arbeider-effekten).

# ABBREVIATIONS

For abbreviations of all contaminants, see Table 1.

| | |
|---|---|
| POP | Persistent organic pollutant |
| OCP | Organochlorinated pesticide |
| CEAC | Chemicals of emerging Arctic concern |
| PCB | Polychlorinated biphenyl |
| PBDE | Polybrominated diphenyl ether |
| PFAS | Per- and polyfluoralkyl substance |
| OHC | Organohalogenated contaminant |
| *p,p’*-DDT | *p,p′*-Dichlorodiphenyltrichloroethane |
| *p,p’*-DDE | *p,p′*-Dichlorodiphenyldichloroethylene |
| PFOS | Perflurorooctane sulfonic acid |
| PFOSF | Perfluorooctance sulfonyl fluoride |
| PFOA | Perfluorooctanoic acid |
| PFHxS | Perfluorohexane sulfonic acid |
| Lw | Lipid weight |
| OC | Organochlorine |
| HPT | Hypothalamus-pituarity-thyroid |
| TH | Thyroid hormone |
| $T_4$ | Thyroxine |
| $T_3$ | Triiodothyronine |
| TRH | Thyrotropin-releasing hormone |
| TSH | Thyroid stimulating hormone (thyrotropin) |
| TTR | Transthyretin |
| $FT_4$ | Free thyroxine |
| $FT_3$ | Free triiodothyronine |
| $TT_4$ | Total thyroxine |
| $TT_3$ | Total triiodothyronine |
| D1 | Iodothyronine deiodinase type 1 |
| D2 | Iodothyronine deiodinase type 2 |
| TRα | Thyroid hormone receptor alpha |
| TRβ | Thyroid hormone receptor beta |
| D3 | Iodothyronine deiodinase type 3 |
| $RT_3$ | Reverse-triiodothyronine |
| $T_2$ | Diiodothyronine |
| SULT | Sulfotransferase |
| UGT | Uridine diphosphate glucuronosyltransferase |
| BCI | Body condition index |
| 3K+ | Third calendar year or above |
| SEAPOP | Seabird Population |
| NILU | Norwegian Institute for Air Research |
| NTNU | Norwegian University of Science and Technology |
| HCB | Hexachlorobenzene |
| HCH | Hexachlorocyclohexane |
| DDT | Dichlorodiphenyltrichloroethane |
| FOSA | Perfluorooctanesulfonamide |
| PFSA | Perfluoralkyl sulfonic acid |
| PFCA | Perfluoralkyl carboxylic acid |

| | |
|---|---|
| FTS | Fluorotelomer sulfonate |
| GC | Gas chromatography |
| GC-MS | Gas chromatograph mass spectrometry |
| ISTD | Internal standard |
| UHPLC-MS/MS | Ultra-high-pressure liquid chromatography triple-quadrupole mass spectrometry |
| SRM | Standard reference material |
| LOD | Limit of detection |
| SD | Standard deviation |
| LOQ | Limit of quantification |
| RIA | Radioimmunoassay |
| CV | Coefficient of variation |
| n | Number of samples |
| Ww | Wet weight |
| p | Probability of rejecting null hypothesis |
| PCA | Principal component analysis |
| PC | Principal component |
| LMM | Linear mixed-effect model |
| VIF | Variance inflation factor |
| AICc | Aikake's Information Critetion adjusted for sample size |
| ΔAICc | Difference in the second order Aikake's Information Critetion adjusted for sample size |
| CI | Confidence interval |
| SI | Supplementary information |
| $W_i$ | Aikake's weight |
| B | Bjørnøya |
| K | Kongsfjorden |
| HWE | Healthy Worker Effect |

# CONTENTS

ACKNOWLEDGEMENTS ........ III

ABSTRACT ........ V

SAMMENDRAG ........ VII

ABBREVIATIONS ........ IX

CONTENTS ........ XI

1. INTRODUCTION ........ 1

2. MATERIALS AND METHODS ........ 5

  2.1. Sampling areas and field procedures ........ 5

  2.2. OHC analyses ........ 6

    2.2.1. OC analysis ........ 8

      *2.2.1.1. Extraction* ........ 8

      *2.2.1.2. Instrumental analysis* ........ 8

    2.2.2. PFAS analysis ........ 9

      *2.2.2.1. Extraction* ........ 9

      *2.2.2.2. Instrumental analysis* ........ 9

    2.2.3. Quality assurance of analyses of OCs and PFASs ........ 9

  2.3. TH analyses ........ 10

    2.3.1. Quality assurance ........ 10

  2.4. Data and statistical analyses ........ 11

    2.4.1. Multivariate analyses ........ 12

3. RESULTS ........ 15

  3.1. Concentrations and temporal variations of OHCs ........ 15

  3.2. Concentrations and temporal variations of THs ........ 19

  3.3. BCI and plasma lipid weight percentage ........ 19

  3.4. Relationship between TH concentrations and ambient temperature ........ 19

  3.5. Relationship between TH concentrations and OHC concentrations and biological variables ........ 22

4. DISCUSSION ........ 31

  4.1. OHC concentrations ........ 31

  4.2. TH concentrations ........ 34

  4.3. Relationship between TH concentrations and OHC concentrations and biological variables ........ 39

  4.4. Implications of findings and future perspectives ........ 43

5. CONCLUSION ........ 45

REFERENCES ........ 47

SUPPLEMENTARY INFORMATION ........ 57

APPENDIX A: LOD VALUES AND DETECTION RATES ........ 63

APPENDIX B: OHC CONCENTRATIONS AND RATIOS ........ 67

APPENDIX C: TH CONCENTRATIONS AND RATIOS ........ 91

APPENDIX D: BIOMETRICS AND LIPID CONTENT ........ 95

APPENDIX E: PCAS AND CORRELATIONS ........ 99

APPENDIX F: MODEL SELECTIONS ........ 111

APPENDIX G: PARAMETER ESTIMATES ........ 125

# 1. INTRODUCTION

The ubiquitous anthropogenic environmental contaminants have been documented in all regions on Earth, including the pristine Arctic. Persistent organic pollutants (POPs) are among these globally spread contaminants that are deposited in the Arctic through atmospheric and oceanic currents. Due to their persistence, they have remained in the environment despite many of them being banned (Dietz et al., 2019). Both national legislative tools and international collaborations began in the 1970s, and in 2004, a United Nations treaty named the Stockholm Convention came into force, where signatories agreed to reduce or eliminate the production, use, and/or release of "the Dirty Dozen". These are the 12 key POPs, also known as legacy POPs, which include industrial chemicals, unintentionally produced by-products, and organochlorinated pesticides (OCPs) (O'Sullivan and Megson, 2014). There has been a decline of legacy POPs in biota during the past two decades due to the restrictions, although the environmental levels of some have remained fairly constant at high levels the past ten years (Dietz et al., 2019; Muir and de Wit, 2010). Currently, there are 35 groups of chemicals that are included in the Stockholm Convention. This does not, however, entail that there is no need for concern, as thousands of new chemicals are produced every year, among them chemicals of emerging Arctic concern (CEAC) (Dietz et al., 2019; Sonne et al., 2021).

A number of legacy POPs have been detected in the Arctic, including polychlorinated biphenyls (PCBs) and OCPs, as well as relatively newly recognised and emerging POPs, such as polybrominated diphenyl ethers (PBDEs) and per- and polyfluoroalkyl substances (PFASs) (AMAP, 2016; Dietz et al., 2019; Letcher et al., 2010). These organohalogenated contaminants (OHCs) have among the highest detected concentrations in Arctic wildlife and fish, with PCB being the dominating group (Dietz et al., 2019). PCBs consist of 209 different congeners that have been used as coolant and heat-transfer fluids, and carbonless copy paper, and are highly lipophilic and extremely persistent compounds. OCPs of particular concern include *p,p'*-dichlorodiphenyltrichloroethane (*p,p'*-DDT) and chlordane, as their metabolites, *p,p'*-dichlorodiphenyldichloroethylene (*p,p'*-DDE) and oxychlordane, respectively, are highly toxic (AMAP, 2004; Sonne et al., 2021). PCBs, *p,p'*-DDT, and chlordane were among the 12 key POPs that were included in the Stockholm Convention in 2004, and had by then already been banned or restricted for some decades. PBCs are listed under Annex A (elimination) or C (unintentional production), *p,p'*-DDT under Annex B (reduction), and chlordane under Annex A (AMAP, 2004; Stockholm Convention, 2019b).

Compared to the legacy POPs, PFASs have relatively recently caught scientific and regulatory attention, despite being produced for over 60 years (Hekster et al., 2003). PFASs consist of a large number of fluorinated aliphatic compounds with strong carbon-fluoride bonds, making them highly resistant to degradation. Unlike the legacy POPs, PFASs are both hydrophobic and oleophobic, and have an affinity towards proteins. Due to these properties, these compounds have been used as surfactants in a variety of products, and in textiles and aqueous firefighting foams (AMAP, 2004; Sonne et al., 2021). In 2009 and 2019, perfluorooctane sulfonic acid (PFOS), its salts, and perfluorooctane sulfonyl fluoride (PFOSF), and perfluorooctanoic acid (PFOA), its salts, and related compounds were added to the Stockholm Convention under Annex B and A, respectively. Perfluorohexane sulfonic acid (PFHxS), its salts, and related compounds are currently under review (Stockholm Convention, 2019a).

The extreme Arctic climate makes wildlife dependent on fatty tissues as a source of energy, making them subject to lipophilic contaminants, such as legacy POPs, that are stored in lipid-rich tissues when taken up by an animal. Generally low elimination of these contaminants lead to bioaccumulation and biomagnification in the food chain, which is also the case for the persistent and proteinophilic PFASs (Sonne, 2010; Sonne et al., 2017). Besides chemical properties of the contaminants, biological factors may also affect the accumulation of a compound in organisms. These include biotransformation capacity, which often vary among species, sex, maternal transfer (offloading of contaminants to eggs, foetus, and offspring), feeding ecology, and trophic position (Borgå et al., 2004). As a result of their apical position in the food chain, top predators accumulate the highest concentrations measured in the Arctic (Sonne et al., 2017).

Bourne and Bogan (1972) were the first to investigate contaminant levels in wildlife on Svalbard, and discovered concerning hepatic concentrations of PCBs and *p,p*'-DDE in glaucous gulls (*Larus hyperboreus*) on Bjørnøya (Bear Island), measured at 311 and 67 ppm (311000 and 67000 ng/g lipid weight (lw)), respectively. This apex predator feeds opportunistically from the marine food web, and has an especially low capacity in metabolising organochlorines (OCs), making the species vulnerable for contaminant exposure (Henriksen et al., 2000). The glaucous gull is one of the largest gull species, and has a circumpolar, high Arctic distribution. It breeds at the coast or open tundra, and the population on Bjørnøya was recorded as the largest one in the Barents Sea, with approximately 2000 breeding pairs in 1986 (Bakken and Tertitski, 2000; Strøm, 2007b). This number has, however, been steadily decreasing to approximately 650 breeding pairs in 2006, which was the last total census on Bjørnøya, resulting in the entire Svalbard population being listed as "near threatened" (Fauchald et al., 2015; Strøm, 2007a). In

2013, the population size was estimated to be 427 breeding pairs (Fauchald et al., 2015), and during the last decade (2010 – 2020), the population size has decreased with 4% each year (H. Strøm, personal communication, January 15, 2021). In contrast, total censuses in Kongsfjorden (Kings Bay), Svalbard, show that the population has been steadily increasing from 25 to 36 breeding pairs during the 2012 – 2020 period (S. Descamps, personal communication, February 10, 2021), and is now stable (G. W. Gabrielsen, personal communication, June 16, 2021).

Following the first discoveries on Bjørnøya in 1972, several studies have reported high levels of contaminants in glaucous gulls from Svalbard, and linked these levels to biological effects (Bustnes et al., 2003b; Bustnes et al., 2005; Erikstad et al., 2013; Gabrielsen, 2007; Sagerup et al., 2000; Sagerup et al., 2009; Sebastiano et al., 2020; Sonne et al., 2013; Verboven et al., 2009a; Verboven et al., 2009b; Verreault et al., 2007), including endocrine disrupting effects (Haugerud, 2011; Hovden, 2018; Melnes et al., 2017; Verboven et al., 2008; Verboven et al., 2010; Verreault et al., 2004; Verreault et al., 2008). The endocrine system plays a vital role through the ontogenesis, and exposure to endocrine disruptors may have fatal consequences (Letcher et al., 2010). One susceptible part of the endocrine system is the hypothalamus-pituraity-thyroid (HPT) axis that controls the production and release of thyroid hormones (THs), named thyroxine ($T_4$) and triiodothyronine ($T_3$) (Fig. 1). In avians, these amino acid hormones play a key role during development, seasonal/organismal processes, such as reproduction and molting, behaviour, and metabolism and thermoregulation (McNabb, 2007).

The HPT axis functions similarly in avian species as in mammals. In response to an environmental or physiological factor, such as ambient temperature, the release of thyrotropin-releasing hormone (TRH) from the hypothalamus stimulates the anterior pituarity to release thyroid stimulating hormone (TSH (thyrotropin)) (Fig. 1). TSH subsequentially stimulates the thyroid gland to predominantly produce $T_4$, resulting in higher circulating concentrations of $T_4$ than $T_3$ (Fig. 1). In the bloodstream, the THs binds with, and are transported by, TH-binding proteins, which in birds are mainly albumin and transthyretin (TTR). Consequently, the amount of circulating free $T_4$ ($FT_4$) and $T_3$ ($FT_3$) only comprise a small proportion of the total $T_4$ ($TT_4$) and $T_3$ ($TT_3$) levels, respectively. When in the target tissues, $T_4$, which is often considered as the inactive prohormone, is converted into the biological active $T_3$ by iodothyronine deiodinase type 1 (D1) and 2 (D2). Biological actions are mainly mediated through binding of $T_3$ with the nuclear TH receptors (TRα and TRβ), as $T_3$ has higher affinity towards TRs than $T_4$. For optimal function of the HPT axis, increased circulating TH levels exerts negative feedback towards the hypothalamus and pituarity. Excess THs are inactivated by the iodothyronine

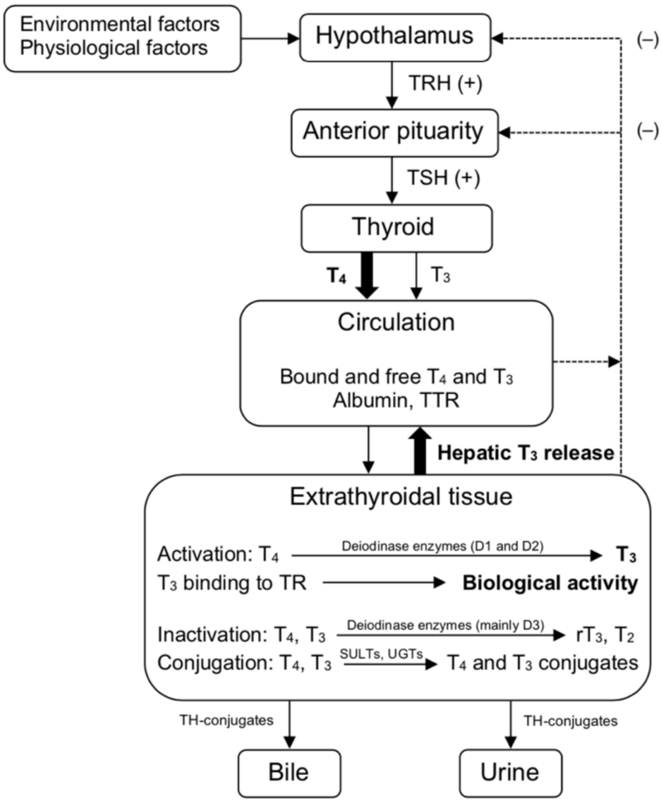

**Fig. 1:** Schematic presentation of the hypothalamus-pituarity-thyroid (HPT) axis in avian species (based on Fig. 4 in Bytingsvik (2012)). See text for more detailed description.

deiodinase type 3 (D3) to reverse-$T_3$ ($rT_3$) and diiodothyronine ($T_2$), or eliminated through conjugation processes mediated by sulfotransferases (SULTs) and uridine diphosphate glucuronosyltransferases (UGTs), followed by biliary and urinary excretion (McNabb, 2007).

Based on the importance of a proper functioning endocrine system, and the effects environmental contaminants may have on this system, it could be questioned whether the observed population decline of glaucous gulls on Bjørnøya (1986 – 2020) is caused, or at least contributed, by the exposure to endocrine disruptors. Therefore, the aim of the present study was to examine the concentrations of selected OHCs, and their effects on the TH status in blood plasma of male and female glaucous gulls, separately, and compare the results between two different populations on Svalbard, one on Bjørnøya and one in Kongsfjorden, over a five-year period. Based on previous findings, it was expected that glaucous gulls from Bjørnøya had higher OHC concentrations their counterparts in Kongsfjorden. It was hypothesised that these higher OHC concentrations in birds from Bjørnøya would be manifested as more pronounced alterations in plasma TH concentrations relative to in birds from Kongsfjorden. It was expected that males had higher OHC concentrations than females due to maternal transfer of chemicals into the eggs. Likewise, the higher OHC concentrations in males was hypothesised to be manifested as more pronounced alterations in TH concentrations relative to female individuals.

# 2. MATERIALS AND METHODS

## 2.1. Sampling areas and field procedures

The blood samples of glaucous gulls were collected between Kapp Kolthoff and Kvalrossbukta on the south east coast of Bjørnøya (74°21´N, 19°06´E), an 178 km$^2$ island belonging to Svalbard, midway between Spitsbergen and mainland Norway, and in Kongsfjorden, located on the west coast of Spitsbergen in the vicinity of Ny-Ålesund (78°55´N, 11°56´E) (Fig. 2). The samplings were conducted in June and/or July each year during the 2015 – 2019 period. A total 101 blood samples from 48 individuals (23 males and 25 females) were sampled on Bjørnøya, and 84 blood samples from 62 individuals (19 males and 43 females) were sampled in Kongsfjorden over the five-year period.

**Fig. 2:** Maps indicating A) the two sampling areas on Svalbard, Bjørnøya in the Barents Sea and Kongsfjorden on Spitsbergen, B) the sampling area on Bjørnøya, between Kapp Kolthoff and Kvalrossbukta, and C) the sampling area in Kongsfjorden, in the vicinity of Ny-Ålesund (source: https://toposvalbard.npolar.no/).

The birds were captured by the use of an automatically triggered nest trap, a net canon, or a hand snare. Standard biometric data was recorded for all individuals, including body mass, and total head, culmen, gonys, tarsus, and wing length. Age and sex were also determined, and a body condition index (BCI) was later calculated based on the biometric data. Age of adult individuals with unknown birth year was determined as third calendar year or above (3K+), and juveniles without flying capabilities as pullus. The glaucous gull have sexual body size dimorphism, and measurements of culmen and total head length were used to distinguish males from females, where male individuals were assumed to have a culmen length below 61.5 mm and a total head length above 142 mm (Bustnes et al., 2000; Cramp, 1983). If not able to distinguish the sex, a molecular sexing method was performed as described by Griffiths et al. (1998). Ring number was recorded for already marked individuals, and individuals that were previously not ring-marked were ringed with numbered steel rings from the Norwegian Ringing Centre, Stavanger Museum, and letter coded rings to simplify identification, as a part of the annual monitoring program SEAPOP (Seabird Population; https://seapop.no/).

Blood samples of 0.5 – 5 mL were taken from the brachial vein on the inside of the wings, using a 10 mL heparinized syringe (VWR International AS, Radnor, USA) with a 0.8×40 mm needle (Hypodermic needles, Microlance ™ 3, VWR International AS, Radnor, USA). The blood samples were kept cool and dark in the field until return to the lab facilities, where they were centrifuged (10 000 rpm, 10 minutes) and frozen within 8 hours after sampling. All samples were stored frozen at -20 °C until analyses at the Norwegian Institute for Air Research (NILU) in Tromsø and the Norwegian University of Science and Technology (NTNU) in Trondheim.

## 2.2. OHC analyses

The analyses of OHCs were carried out in the laboratories at the NILU in Tromsø. A total of 96 and 82 blood plasma samples from Bjørnøya and Kongsfjorden, respectively, were analysed for OCs, including 14 PCB congeners and 17 OCPs, and 22 PFASs (Table 1). The OCPs analysed included hexachlorobenzene (HCB), 3 hexachlorocyclohexanes (HCHs), 6 cyclodienes, mirex, and 6 dichlorodiphenyltrichloroethanes (DDTs). The PFASs analysed included 1 perfluorooctanesulfonamide (FOSA), 8 perfluoralkyl sulfonic acids (PFSAs), 11 perfluoralkyl carboxylic acids (PFCAs), and 2 fluorotelomer sulfonates (FTSs). More specifically, all contaminants were analysed for in samples from both Bjørnøya and Kongsfjorden, except for PCB-149 and 170 that were only analysed for in samples from Bjørnøya, and heptachlor (only analysed for in 2015), *o,p*′-DDT, *o,p*′-DDD, *p,p*′-DDD, and *o,p*′-DDE, which were only analysed in samples from Kongsfjorden. PFPS, PFHpS, PFNS, PFBA, PFPA, and 6:2 FTS were not analysed for in 2015 in samples from Kongsfjorden, and 8:2 FTS was only analysed for in 2018 in samples from Kongsfjorden. The full contaminant names are included (Table 1).

**Table 1:** Overview of the analysed organohalogenated contaminants (OHCs) in blood plasma of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Contaminants analysed included the organochlorines (OCs) polychlorinated biphenyls (PCBs) and organochlorinated pesticides (OCPs), and per- and polyfluoralkyl substances (PFASs). See text for full names of sub groups.

| **Group** | **Sub group** | **Contaminant name** | **Abbreviation** |
|---|---|---|---|
| PCB | PCB | 2,4,4´-Trichlorobiphenyl | PCB-28 |
| | | 2,2´,5,5´-Tetrachlorobiphenyl | PCB-52 |
| | | 2,2´,4,4´,5-Pentachlorobiphenyl | PCB-99 |
| | | 2,2´,4,5,5´-Pentachlorobiphenyl | PCB-101 |
| | | 2,3,3´,4,4´-Pentachlorobiphenyl | PCB-105 |
| | | 2,3´,4,4´,5-Pentachlorobiphenyl | PCB-118 |
| | | 2,2´,3,4,4´,5´-Hexachlorobiphenyl | PCB-138 |
| | | 2,2´,3,4´,5´,6-Hexachlorobiphenyl | PCB-149 |
| | | 2,2´,4,4´,5,5´-Hexachlorobiphenyl | PCB-153 |
| | | 2,2´,3,3´,4,4´,5-Heptachlorobiphenyl | PCB-170 |
| | | 2,2´,3,4,4´,5,5´-Heptachlorobiphenyl | PCB-180 |
| | | 2,2´,3,4,4´,5´,6-Heptachlorobiphenyl | PCB-183 |
| | | 2,2´,3,4´,5,5´,6-Heptachlorobiphenyl | PCB-187 |
| | | 2,2´,3,3´,4,4´,5,5´-Octachlorobiphenyl | PCB-194 |
| OCP | HCB | Hexachlorobenzene | HCB |
| | HCH | α-Hexachlorocyclohexane | α-HCH |
| | | β-Hexachlorocyclohexane | β-HCH |
| | | γ-Hexachlorocyclohexane | γ-HCH (lindane) |
| | Cyclodiene | Oxychlordane | Oxychlordane |
| | | *trans*-Chlordane | *t*-Chlordane |
| | | *cis*-Chlordane | *c*-Chlordane |
| | | *trans*-Nonachlor | *t*-Nonachlor |
| | | *cis*-Nonachlor | *c*-Nonachlor |
| | | Heptachlor | Heptachlor |
| | Mirex | Perchloropentacyclodecane | Mirex |
| | DDT | *o,p´*-Dichlorodiphenyltrichloroethane | *o,p´*-DDT |
| | | *p,p´*-Dichlorodiphenyltrichloroethane | *p,p’*-DDT |
| | | *o,p´*-Dichlorodiphenyldichloroethane | *o,p´*-DDD |
| | | *p,p´*-Dichlorodiphenyldichloroethane | *p,p’*-DDD |
| | | *o,p´*-Dichlorodiphenyldichloroethylene | *o,p´*-DDE |
| | | *p,p´*-Dichlorodiphenyldichloroethylene | *p,p’*-DDE |
| PFAS | FOSA | Perfluorooctane sulfonamide | PFOSA |
| | PFSA | Perfluorobutane sulfonic acid | PFBS |
| | | Perfluoropentane sulfonic acid | PFPS |
| | | Perfluorohexane sulfonic acid | PFHxS |
| | | Perfluoroheptane sulfonic acid | PFHpS |
| | | Branched perflurorooctane sulfonic acid | BrPFOS |
| | | Linear perfluorooctane sulfonic acid | LinPFOS |
| | | Perfluorononane sulfonic acid | PFNS |
| | | Perfluorodecane sulfonic acid | PFDcS |
| | PFCA | Perfluorobutanoic acid | PFBA |
| | | Perfluoropentanoic acid | PFPA |
| | | Perfluorohexanoic acid | PFHxA |
| | | Perfluoroheptanoic acid | PFHpA |
| | | Perfluorooctanoic acid | PFOA |
| | | Perfluoronanoic acid | PFNA |
| | | Perfluorodecanoic acid | PFDcA |
| | | Perfluoroundecanoic acid | PFUnA |
| | | Perfluorododecanoic acid | PFDoA |
| | | Perfluorotridecanoic acid | PFTriA |
| | | Perfluorotetradecanoic acid | PFTeA |
| | FTS | 6:2 Fluorotelomer sulfonate | 6:2 FTS |
| | | 8:2 Fluorotelomer sulfonate | 8:2 FTS |

### 2.2.1. OC analysis

The plasma samples were analysed for OCs following standard procedures as described more in detail by Götsch et al. (2005), Herzke et al. (2005), and Sonne et al. (2010).

#### *2.2.1.1. Extraction*

In summary, 1 g (± 0.1 g) of plasma was transferred to 15 mL glass vials and spiked with 60 µL internal standard ($^{13}$C-labelled POPs solution in *iso*-octane). For protein denaturation and enhanced phase separation, 2 mL deionized water saturated with ammonium sulphate and 2 mL ethanol were added. The extraction was performed twice by adding 6 mL *n*-hexane, thoroughly mixing the sample, and allowing phase separation for approximately 15 minutes. The lipid content in the samples was gravimetrically determined.

To separate the analytes from interfering compounds, clean-up was performed by using florisil (0.15 – 0.25 mm mesh size), which in advance was burnt at 450 °C for 8 hours. One g (± 0.5 g) florisil was packed between two glass fiber frits (Isolute SPE Accessories Frits, 10 µm) in plastic columns, and each sample was passed through a column using a Rapidtrace Automated SPE workstation (Zymark Corporation, Hopkinton, MA, USA). After clean-up, *iso*-octane was added as a keeper solvent to prevent volatile chemicals from evaporating during concentration of the samples to 200 µL.

#### *2.2.1.2. Instrumental analysis*

The extracts were transferred to gas chromatography (GC) vials with insert and added 40 µL of $^{13}$C-labelled PCB-159 recovery standard. The OCs were then quantified using gas chromatograph mass spectrometry (GC-MS). Samples were run with calibration standards ($^{12}$C- and $^{13}$C-labelled equivalents) provided by NILU, producing standard curves used to calculate the concentrations using Equation 2.1.

$$\text{Concentration sample} = \frac{\text{Response factor} \times (\text{Concentration ISTD} \times \text{Area sample})}{\text{Area ISTD}} \tag{2.1}$$

The response factor of the analyte is determined by the area under the curve and concentration of the internal standard (ISTD), Area sample is the known area under the curve of the sample obtained from the GC-MS chromatogram, and Area ISTD is the known area under the curve of the internal standard obtained from the GC-MS chromatogram.

### 2.2.2. PFAS analysis

The analysis of PFASs is described in detail by Herzke et al. (2009) and Hanssen et al. (2013).

#### *2.2.2.1. Extraction*

The extraction was performed using the Powley method (Powley et al., 2005). In summary, 200 µL of blood plasma was transferred to an Eppendorf-centrifuge tube, spiked with 20 µL internal standard ($^{13}$C-labelled PFAS mix), and vortexed. Extraction was performed by adding 1 mL methanol, followed by 3 × 10 min in an ultrasonic bath with vortexing in between. To enhance phase separation and sedimentation, the samples were centrifuged (10000 rpm, 10 min).

For clean-up, the supernatant was transferred to Eppendorf-centrifuge tubes containing 25 mg Supelclean ENVI-Carb 120/400 (Supelco 57210-U, Bellefonte, PA, USA) and 50 µL glacial acetic acid (Merck, Darmstadt, Germany). Samples were then vortexed and centrifuged (10000 rpm, 10 min), followed by transferring 500 µL of supernatant to glass vials where 20 µL of 3,7-diMeo-PFOA recovery standard was added.

#### *2.2.2.2. Instrumental analysis*

Prior instrumental analysis, 50 µL of the sample was added 50 µL of 2 mM $NH_4OAc$ (Sigma-Aldrich, St. Louis, MO, USA) in autosampler vials with insert. The PFASs were then quantified using ultra-high-pressure liquid chromatography triple-quadrupole mass spectrometry (UHPLC-MS/MS). Samples were run with calibration standards ($^{12}$C- and $^{13}$C-labelled equivalents) provided by NILU, producing standard curves used to calculate the concentrations using Equation 2.1.

### 2.2.3. Quality assurance of analyses of OCs and PFASs

Cross-contamination was avoided by using new equipment and glassware rinsed with cyclohexane for each sample, and control analyses were conducted to ensure quality of the method. For the OC and PFAS analyses, one blank sample that was treated equally as the plasma samples were run for each batch, or every 10th or 20th sample, respectively. In addition, standard reference material (SRM 1958 human serum for OHCs; AM-S-W-1904; NIST, MD, USA) was also used to validate the analytical method of OCs.

The recovery standards ($^{13}$C-labelled PCB-159 and 3,7-diMeo-PFOA) added prior instrumental analysis functioned as a quantification standard for performance assessment of the analytical methods.

The limit of detection (LOD) was calculated as the average signal value observed in the blank sample plus 3x the standard deviation (SD) (Table A1). The limit of quantification (LOQ) was not consistently provided, but when provided LOQ was defined as 3x the LOD. Samples below LOQ were treated equally as other samples.

## 2.3. TH analyses

TH analyses were performed by using solid phase radioimmunoassay (RIA) kits manufactured by MP Biomedicals, LCC (New York, USA) (Catalogue No. 06B-254215 ($TT_3$), 06B-258709 ($FT_3$), 06B-254011 ($TT_4$), and 06B-257214 ($FT_4$)) at NTNU, Trondheim, Norway. The kits are based on competitive binding between the THs in the sample and the $^{125}$I-labelled THs for a limited number of available antibody binding sites in the tube. Consequently, the level of radioactivity bound is inversely related to the TH concentration in the sample.

A total of 86 and 64 plasma samples from Bjørnøya and Kongsfjorden were available for TH analyses, respectively. The samples were analysed for $TT_4$, $FT_4$, $TT_3$, and $FT_3$. For $TT_4$ and $FT_4$ analyses, 25 and 50 µL of plasma were added to the pre-coated tubes, respectively, while 100 µL of plasma was added for analyses of $TT_3$ and $FT_3$. One mL of $^{125}$I-labelled tracer solution was then added to the tubes and vortexed. Samples analysed for $TT_4$ were incubated at room temperature for 1 hour, while samples analysed for $FT_4$, $TT_3$, and $FT_3$ were incubated in a water bath at 37 °C for 1.5, 1, and 2.5 hour(s), respectively. All tubes were then thoroughly decantated. For $FT_4$, $TT_3$, and $FT_3$ analyses, tubes were washed with 1 mL distilled water, followed by decantation. Radioactivity was counted with a gamma scintillation counter (Cobra Auto Gamma, model 5003, Packard Instrument Company, Dowers grove, IL, USA).

Each kit was provided with 6 or 7 standards with known concentrations, which were used to obtain a standard curve from which the TH concentration in samples were determined. The standards had a concentration range of 0 – 257 nmol/L for $TT_4$, 0 – 143 pmol/L for $FT_4$, 0 – 12.3 nmol/L for $TT_3$, and 0 – 34.1 pmol/L for $FT_3$.

### 2.3.1. Quality assurance

Replicate precision and assay accuracy were tested in each kit by analysing a blank sample, SRMs (human serum, Immunoassay Plus Control level 1, 2, 3, Bio-Rad Laboratories, CA, USA), the laboratories own bovine (*Bos taurus*) and chicken (*Gallus domesticus*) quality control serums, and selected glaucous gull plasma sample(s). References and controls were treated equally as the plasma samples, and all samples were run in duplicates. Samples from different locations and years were analysed in a random order.

For each sample analysed in duplicate, a coefficient of variation (CV) was calculated as a measure of dispersion of the data. Samples with a CV above 10% were analysed a second time if the amount of plasma allowed it. Remaining samples with a CV above 10% were inspected more closely to determine whether these could be included in the statistical analyses.

Results from one kit analysing $TT_4$ came out different relative to the others. Several samples, including some of the references and controls, had a considerably lower concentration than in other kits. The pattern was inconsistent, and no correction of the data seemed appropriate. It was therefore considered most correct to remove these data ($n = 60$) from further data analyses.

The average CV% for $TT_4$ ($n = 86$) was 5.33 ± 3.82, 4.93 ± 4.27 for $FT_4$ ($n = 142$), 3.48 ± 2.64 for $TT_3$ ($n = 145$), and 4.91 ± 4.62 for $FT_3$ ($n = 135$).

LOD was defined as 1/3 of the lowest standard concentration ($TT_4$: 8.5 nmol/L; $FT_4$: 1.16 pmol/L; $TT_3$: 0.26 nmol/L; $FT_3$: 0.39 pmol/L).

## 2.4. Data and statistical analyses

To ensure homogeneity in age of the glaucous gulls (3K+), one pullus sampled in 2016 on Bjørnøya was removed. Thus, the total sample size for contaminants analysed for in samples from Bjørnøya and Kongsfjorden were 95 and 82, respectively.

Concentration measures are given in plasma wet weight (ww) to enable comparisons, and also as this is considered the most relevant when assessing toxic effects (Henriksen et al., 1998). Plasma lipid weight percentages are included (Table D1 and D2), and may be used to convert concentrations of lipophilic contaminants to lipid weight concentrations if needed. Plasma contaminant concentrations are given in ng/g for comparison with concentrations in other studies, and in nmol/L when investigating the relationship with the THs.

The ratios between THs ($TT_4/TT_3$, $TT_4/FT_4$, $TT_3/FT_3$, and $FT_4/FT_3$) were calculated to further study the hormone balance, and ratio between summed (Σ) contaminant groups (ΣPFSA/ΣPFAS and ΣPFAS/ΣOHC) to study the contaminant proportions. The mean ± SD, median, and range (min – max) concentration of compounds, ratios, and biometric measurements were also calculated.

All statistical analyses were performed using R 4.0.2 (R Core Team, 2020). Contaminants that were detected in minimum 45% of the samples across all sampling years for each location were included in the statistical analyses. The remaining samples below LOD of these contaminants were assigned a value half of the respective LOD. For the graphical presentation, contaminants that had an overall detection rate below 45% in the samples from only one location were included for comparison. In those cases, all detected concentrations were included, and concentrations below LOD were assigned a value half of the respective LOD.

The statistical significance level was set to $p \leq 0.05$. The data were tested for normality using Shapiro-Wilcoxon test. For normally distributed data, Welch's t-test were used to test for differences between locations and sexes, and Mann Whitney U test were applied on non-normally distributed data. Correlations of normally distributed data were tested using Pearson's correlation, and Spearman's rank-order correlation test was used on non-normally distributed data. Because of the increased probability of producing false negatives, the Bonferroni correction was not applied when investigating associations between multiple variables (Moran, 2003).

### 2.4.1. Multivariate analyses

Principal component analysis (PCA) based on correlation matrix were used to calculate the birds BCI, group contaminants to reduce the number of variables in further analysis, and visualise the relationship between all variables. Non-normally distributed variables were log-transformed for approximating normality prior PCA.

The BCI was estimated for each individual as the standardised residual obtained when the body mass was regressed against a body size index, expressed by the scores on a first principal component (PC) from the morphological measurements of total head and wing length. Body mass, total head length, and wing length are usually the best measurements in terms of variation (H. Strøm, personal communication, April 14, 2021). The BCI was calculated separately for males and females to take into account the sexual dimorphic differences.

Grouping of contaminants were done for PCBs, OCPs, and PFASs separately, and positively correlated compounds were summed together based on PCA. If no obvious pattern was observed, either the whole group or those with similar chemical structure were summed.

The relationship between all variables, including contaminant groups, TH variables, BCI, and plasma lipid weight percentage, were then investigated using PCAs, followed by correlation tests to verify possible associations. This was done on both pooled data (both locations and sexes), and separately for each location and each sex. Based on the results, to further reduce the number of variables, variables that were indicated to show a relationship with the TH variables in the PCAs were chosen for regression analysis.

Linear mixed-effect models (LMMs) (R-package *lme4*) were used to investigate the effects of selected predictor variables on the TH levels to account for the repeated measurements (i.e. that some birds were sampled multiple years) and different sample sizes in annual capture in both locations. Therefore, individual identity was entered as a random effect in the models. Fixed predictor variables included location, sampling year, sex, BCI, plasma lipid weight percentage, and a contaminant group. BCI, plasma lipid weight percentage, and contaminant concentration were standardised (mean = 0, standard deviation = 1) to facilitate comparison between effect sizes. To assess the extent of multicollinearity and to avoid using collinear variables in the same model, the variance inflation factor (VIF) (R-package *car*) was calculated, with a VIF value below 3 considered as acceptable (Zuur et al., 2009). Model selections were then performed to find the models that best explained the variation in the data from the specific sets of biological relevant candidate models for each TH and TH ratio, one set per contaminant group. This was done by ranking the models, fitted with maximum likelihood, according to Akaike's Information Criterion adjusted for sample size (AICc) (R-package *MuMIn*). Models with a difference in the second-order AICc (ΔAICc) < 2 relative to the model with the lowest AICc value were considered equally good, and the most parsimonious model were chosen from these for inference (Burnham and Anderson, 2004). Significance of the estimates were assessed using 95% confidence intervals (CIs). The assumptions of LMMs were satisfied without transforming the data.

# 3. RESULTS

Additional data and results other than those presented in this section are either presented in Supplementary information (SI) or Appendix (A – G). SI contains graphs that provide a more detailed visualization of the most important results.

One outlier for plasma lipid weight percentage was removed prior data and statistical analyses. The removal was justified by its relatively high value compared to other individuals in this study and other studies on glaucous gulls, in addition to that the same individual had a value within the normal range in its two other sampling years.

Contaminants with a detection rate above 45% across the five year period for both locations included PCB-28, 52, 99, 101, 105, 118, 138, 153, 180, 183, 187, and 194, HCB, β-HCH, oxychlordane, *t*- and *c*-nonachlor, mirex, *p,p'*-DDE, PFHxS, brPFOS, linPFOS, PFOA, PFNA, PFDcA, PFUnA, PFDoA, PFTriA, and PFTeA (Table A2 and A3). In addition, PCB-149 and 170, *p,p'*-DDT, PFHpS, PFNS, PFDcS, and 8:2 FTS were detected in above 45% of the samples from Bjørnøya, and *t*-chlordane was detected in above 45% of the samples from Kongsfjorden during the five-year period. PCB-149 and 170 were not included in further data and statistical analyses as these were not analysed for in samples from Kongsfjorden.

## 3.1. Concentrations and temporal variations of OHCs

Concentrations of ΣPCBs ($U \geq 201, p < 0.001$), ΣOCPs ($U \geq 84, p < 0.001$), ΣOCs ($U \geq 165, p < 0.001$), ΣPFSAs ($U \geq 0, p < 0.001$), ΣPFCAs (males: $t(46) = -22.69, p < 0.001$; females: $U = 0, p < 0.001$), ΣPFASs (males: $t(45) = -18.64, p < 0.001$; females: $U = 6, p < 0.001$), and ΣOHCs ($U \geq 15$, $p < 0.001$) were in general much higher in male and female glaucous gulls from Bjørnøya than in their counterparts from Kongsfjorden (Fig. 3, Table B1 and B2). More specifically, males from Bjørnøya had 2.5 times higher ΣPCB, 2.8 times higher ΣOCP, 2.6 times higher ΣOC, 27.6 times higher ΣPFSA, 18.9 times higher ΣPFCA, 23.9 times higher ΣPFAS, and 4.0 times higher ΣOHC concentrations than males from Kongsfjorden. Females from Bjørnøya had 3.4 times higher ΣPCB, 4.7 times higher ΣOCP, 3.7 times higher ΣOC, 20.9 times higher ΣPFSA, 19.6 times higher ΣPFCA, 20.4 times higher ΣPFAS, and 5.5 times higher ΣOHC concentrations than females from Kongsfjorden.

Mean concentrations of OCs (ΣPCBs, ΣOCPs, and ΣOCs) increased from 2015 to 2018 in male birds from Bjørnøya, followed by a slight decrease in 2019 (Fig. 3, Table B1). In males from Kongsfjorden, OC concentrations decreased from 2015 to 2017, and increased from 2017 to 2019. In female birds from Bjørnøya, the mean OC concentrations had a higher variation during

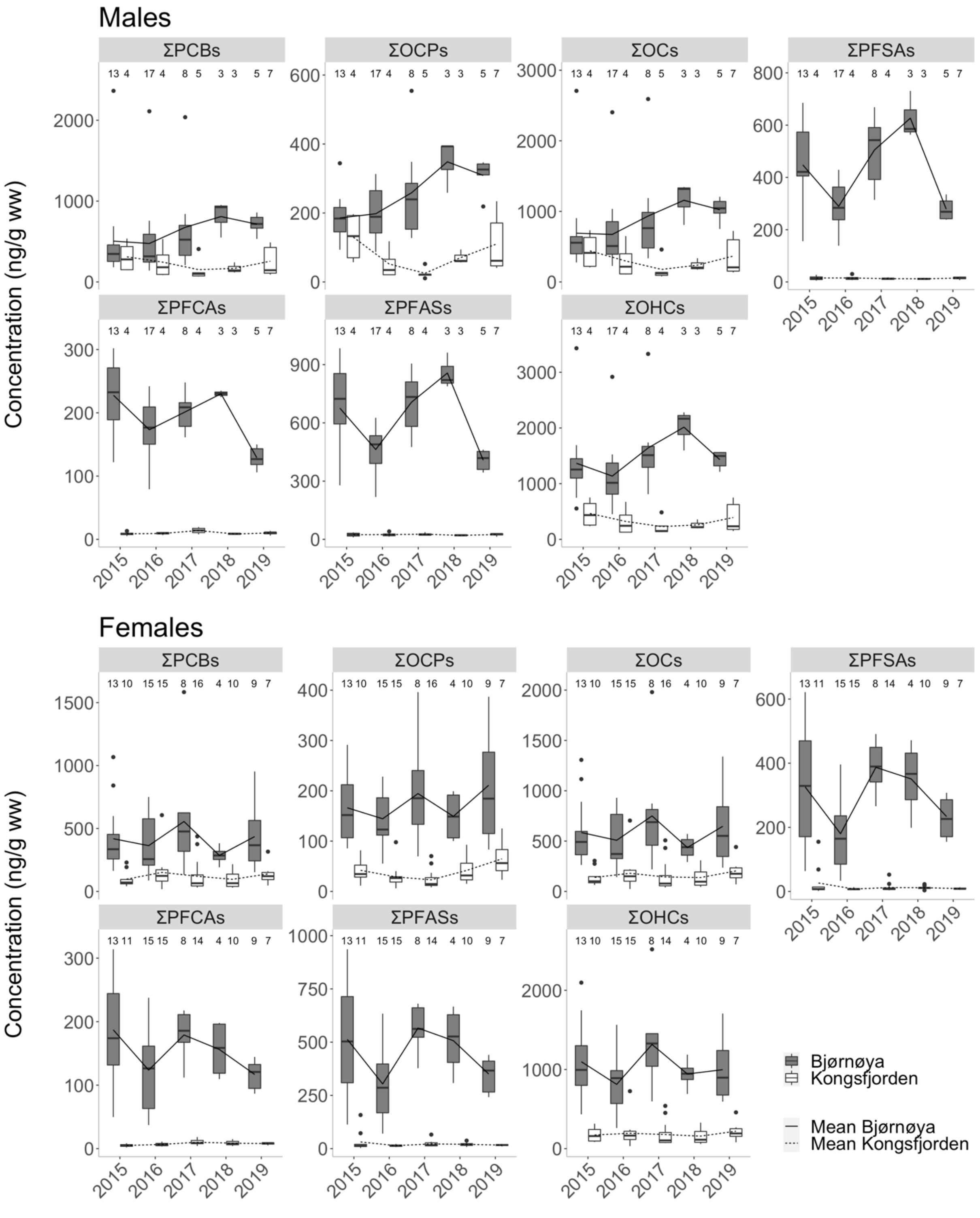

**Fig. 3:** Box plots of ΣPCB, ΣOCP, ΣOC, ΣPFSA, ΣPFCA, ΣPFAS, and ΣOHC concentrations (ng/g ww) in blood plasma of male and female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Lower and upper box boundaries represent the 25th and 75th percentiles (interquartile range), respectively, line inside the box represents the median, and lower and upper box whiskers/error lines represent the smallest and largest value within 1.5 times interquartile range below the 25th and above the 75th percentile, respectively. Filled circles represent outliers. The solid and dashed lines represent the mean concentrations in birds from Bjørnøya and Kongsfjorden, respectively. Numbers below the facet strips indicate the sample size for each year within each location.

the five-year period than females from Kongsfjorden, and males from both locations (Fig. 3, Table B2). Females from Kongsfjorden displayed a similar temporal variation in mean ΣOCP concentrations as males from Kongsfjorden, however the decrease and increase were more subtle compared to the males. In general, female birds from either location and male birds from Kongsfjorden showed no overall increase or decrease of OC concentrations, whereas males from Bjørnøya had an increase in OC concentrations.

With respect to PFASs (ΣPFSAs, ΣPFCAs, ΣPFASs), the temporal variations of mean concentrations were similar for both sexes within each location (Fig. 3, Table B1 and B2). Glaucous gulls from Bjørnøya showed a decrease from 2015 to 2016, followed by an increase in 2017 and 2018 in females and males, respectively, and a decrease in 2019. Birds from Kongsfjorden had low and relatively constant PFAS concentrations across the five-year period. Since the mean ΣOC concentrations were higher relative to the mean ΣPFAS concentrations, ΣOHCs had similar temporal variation as for ΣOCs in birds from both locations.

The temporal variation of mean concentrations of each individual contaminant showed an overall similar pattern as the sum concentrations, with a few exceptions, including decreasing concentrations of PCB-101 in both sexes from Bjørnøya, and a peak above LOD for *t*-chlordane and PFDcS in 2016 and 2017, and 2018, respectively, in both sexes from Kongsfjorden (Fig. SI1, SI2 and SI3, Table B3 and B4).

Overall, male glaucous gulls had the highest concentrations of all contaminant groups. ΣPCBs, however, only differed significantly between sexes in birds from Kongsfjorden ($U = 359$, $p = 0.001$). The following contaminant groups differed significantly between sexes from both locations: ΣOCPs ($U \geq 373$, $p = 0.002$), ΣOCs ($U \geq 351$, $p \leq 0.03$), ΣPFSAs ($U \geq 331$, $p = 0.001$), ΣPFCAs (Bjørnøya: $t(92) = -3.35$, $p = 0.001$; Kongsfjorden: $U = 346$, $p = 0.002$), ΣPFASs (Bjørnøya: $t(93) = -3.73$, $p < 0.001$; Kongsfjorden: $U = 324$, $p = 0.001$), and ΣOHCs ($U \geq 309$, $p = 0.001$).

The contaminant contribution to ΣOHCs was similar between sexes from both locations. In male and female birds from Bjørnøya, the contribution to ΣOHCs followed the order: ΣPCBs (41.1%) > ΣPFSAs (males: 28.5%; females: 27.2%) > ΣOCPs (males: 16.5%; females: 16.8%) > ΣPFCAs (males: 14.0%; females: 14.9%) > 8:2 FTS (0.01%). In birds from Kongsfjorden, the order was: ΣPCBs (males: 69.0%; females: 68.4%) > ΣOCPs (males: 24.0%; females: 20.1%) > ΣPFSAs (males: 4.1%; females: 7.2%) > ΣPFCAs (males: 2.9%; females: 4.2%).

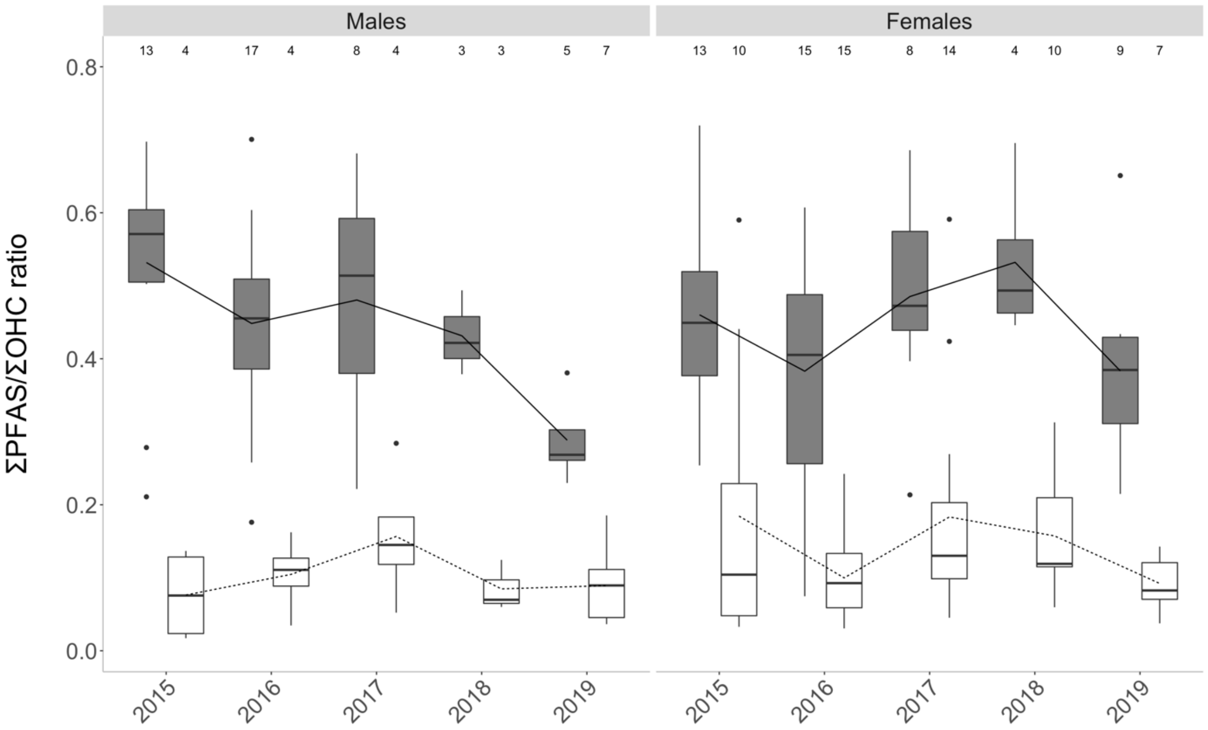

**Fig. 4:** Box plots of ΣPFAS/ΣOHC ratios in blood plasma of male and female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. The ratios were calculated with concentrations in ng/g ww. Lower and upper box boundaries represent the 25th and 75th percentiles (interquartile range), respectively, line inside the box represents the median, and lower and upper box whiskers/error lines represent the smallest and largest value within 1.5 times interquartile range below the 25th and above the 75th percentile, respectively. Filled circles represents outliers. The solid and dashed lines represent the mean ratios in birds from Bjørnøya and Kongsfjorden, respectively. Numbers below the facet strips indicate the sample size for each year within each location.

PCB-153, 138, and 180 were the dominating PCBs in both sexes from both locations (Fig. SI1, Table B3 and B4). The major OCPs in both sexes from Bjørnøya and in females from Kongsfjorden were *p,p'*-DDE, oxychlordane, and HCB. In males from Kongsfjorden, the major OCPs were *p,p'*-DDE, oxychlordane, mirex, and HCB, with the two latter compounds having similar concentrations (Fig. SI2, Table B3 and B4). LinPFOS, PFUnA, and brPFOS were the dominating PFASs in both sexes from Bjørnøya, while linPFOS, PFUnA, and PFTriA had the highest concentrations in both sexes from Kongsfjorden (Fig. SI3, Table B3 and B4).

The ΣPFAS/ΣOHC ratio differed significantly between locations (males: $t(66) = 14.23$, $p < 0.001$; females: $U = 203$, $p < 0.001$) (Fig. 4, Table B1 and B2). Male glaucous gulls from Bjørnøya had a decrease in the mean ΣPFAS/ΣOHC ratio over the five-year period, with ΣPFAS being replaced by ΣOC as the dominating group, while females had a ratio varying around 0.5 across years. Both sexes from Kongsfjorden had a higher proportion of ΣOCs. Mean ΣPFSA concentrations being higher relative to ΣPFCAs in both locations were confirmed by the ΣPFSA/ΣPFAS ratios (Fig. SI4, Table B1 and B2). Differences in the ΣPFSA/ΣPFAS ratio between locations increased from 2017 to 2019 for both sexes, with birds from Bjørnøya having the highest ratio ($U \geq 207$, $p < 0.001$).

## 3.2. Concentrations and temporal variations of THs

$TT_4$, $FT_4$, $TT_3$, and $FT_3$ concentrations in male and female glaucous gulls did not differ between locations within each sex, and did not show any overall increase or decrease as a function of time (Fig. 5, Table C1 and C2). Females had higher temporal variation relative to males, and males from each location had significantly higher $FT_3$ concentrations than females (Bjørnøya: $U = 516$, $p = 0.015$; Kongsfjorden: $t(29) = -2.32$, $p = 0.03$). All TH ratios were relatively constant over time, and did not differ between locations (Fig. SI5, Table C1 and C2). However, females from each location had significantly higher $FT_4/FT_3$ ratio than their male counterparts ($U \geq 488$, $p \leq 0.009$).

## 3.3. BCI and plasma lipid weight percentage

The mean BCI value for both male and female glaucous gulls during the 2015 – 2019 period was 0.00 ± 1.00, with a range between -2.33 – 1.97 and -1.90 – 5.03, respectively. BCI did not differ between locations within each sex, and not between sexes within each location (Fig. 6, Table D1 and D2). In general, males and females from Bjørnøya had a BCI that decreased by a factor of 1.3 and 2.3, respectively, during the five-year period. Birds from Kongsfjorden had no obvious overall decrease or increase. Other biometric measurements are also reported (Table D1 and D2).

Plasma lipid weight percentage did not differ between locations within each sex, and not between sexes within each location (Fig. 6, Table D1 and D2). Both locations and sexes displayed an overall similar temporal variation in the average lipid content, and did not have any obvious overall decrease or increase.

## 3.4. Relationship between TH concentrations and ambient temperature

The annual mean ambient temperature in June on Bjørnøya and in Kongsfjorden during the 2015 – 2019 period (source: https://seklima.met.no/observations/) (data not shown) had a significant negative correlation with the mean $TT_3$ concentrations (both sexes combined) ($r(8) = -0.64$, $p = 0.04$). When separating locations, temperature had a significant positive correlation with the mean $TT_4$ concentrations in glaucous gulls from Kongsfjorden (both sexes combined) ($r(3) = 0.87$, $p = 0.05$).

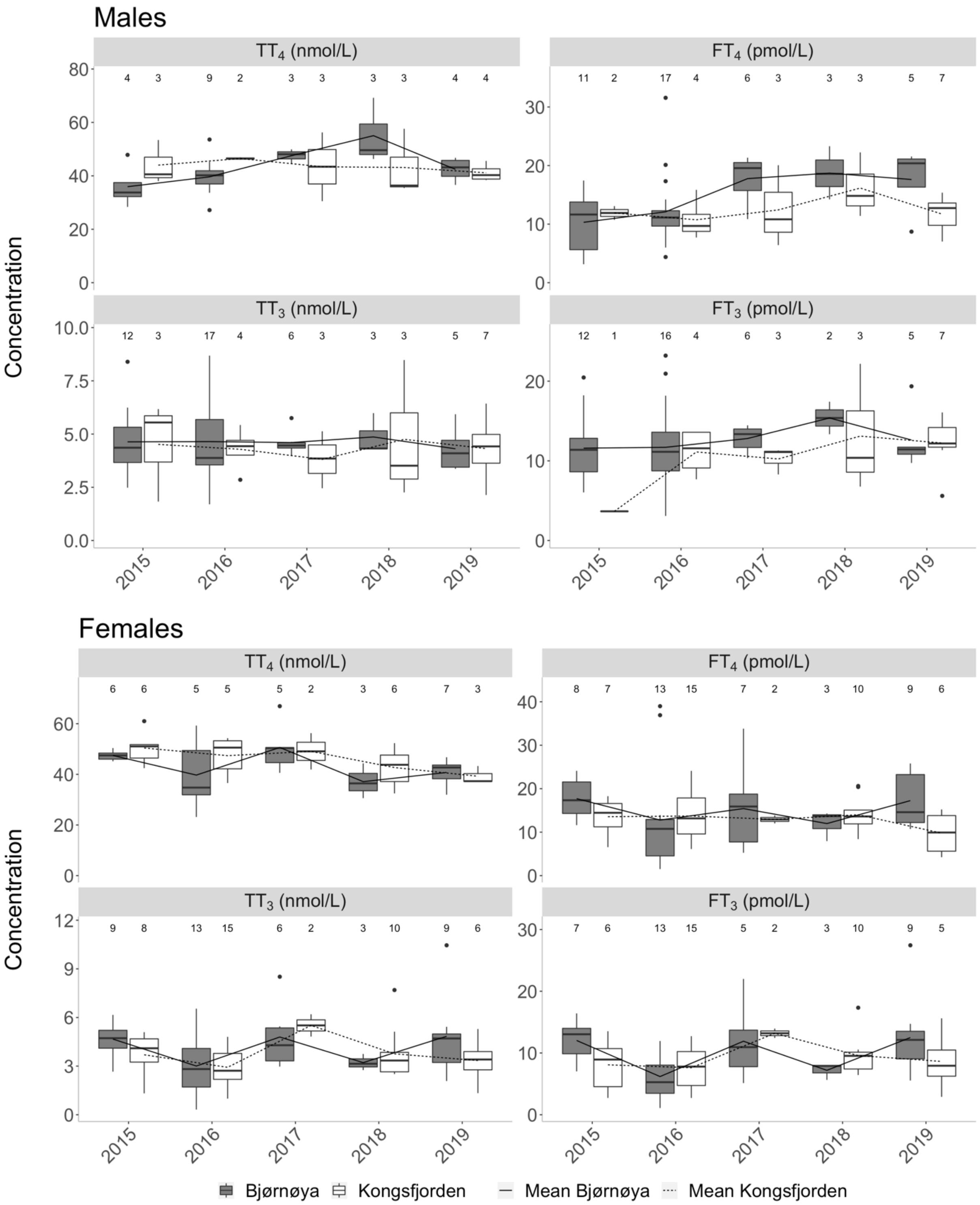

**Fig. 5:** Box plots of thyroid hormone (TH) ($TT_4$ (nmol/L), $FT_4$ (pmol/L), $TT_3$ (nmol/L), $FT_3$ (pmol/L)) concentrations in male and female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Lower and upper box boundaries represent the 25th and 75th percentiles (interquartile range), respectively, line inside the box represents the median, and lower and upper box whiskers/error lines represent the smallest and largest value within 1.5 times interquartile range below the 25th and above the 75th percentile, respectively. Filled circles represent outliers. The solid and dashed lines represent the mean concentrations in birds from Bjørnøya and Kongsfjorden, respectively. Numbers below the facet strips indicate the sample size for each year within each location.

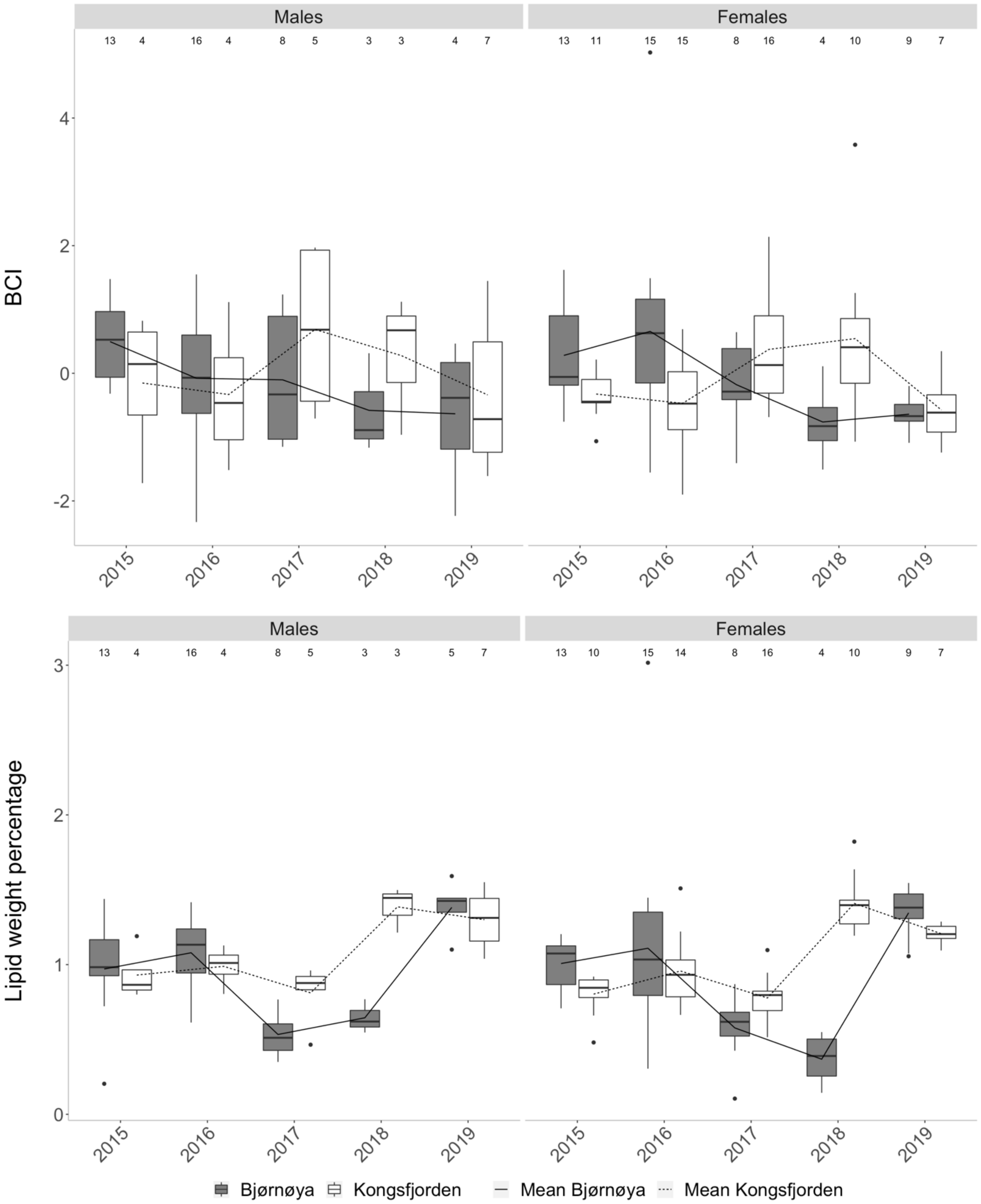

**Fig. 6:** Box plots of body condition index (BCI) and plasma lipid weight percentage in male and female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Lower and upper box boundaries represent the 25th and 75th percentiles (interquartile range), respectively, line inside the box represents the median, and lower and upper box whiskers/error lines represent the smallest and largest value within 1.5 times interquartile range below the 25th and above the 75th percentile, respectively. Filled circles represent outliers. The solid and dashed lines represent the mean value/percentage in birds from Bjørnøya and Kongsfjorden, respectively. Numbers below the facet strips indicate the sample size for each year within each location.

## 3.5. Relationship between TH concentrations and OHC concentrations and biological variables

PCB-52 and PCB-101, and the remaining 10 PCBs formed two distinct groups with correlated congeners in PCA, which were consequently summed together and referred to as $\Sigma PCB_2$ and $\Sigma PCB_{10}$, respectively (Fig. 7, Table E1, Fig. E1). Because of no apparent and consistent correlation pattern, all OCPs were summed together (ΣOCP) (Table E2, Fig. E2), and PFASs were divided based on structure (ΣPFSA, ΣPFCA and 8:2 FTS) (Table E3, Fig. E3).

In general, when including both locations and all variables in PCAs, there did not seem to be any relationship between the TH variables and OHC concentrations (Fig. 8, Table E4 and E5, Fig. E4). However, when locations were analysed separately in PCAs, different relationships were observed (Table E4 and E5, Fig. E4 and E5). Most relationships were observed between THs and PFASs and contaminant ratios, and they were both positive and negative. However, most of the relationships were positive. Glaucous gulls from Bjørnøya had more relationships between THs and contaminants than the birds from Kongsfjorden (Fig. E4). This was also observed when separating sex within each location (Fig. E5). Females from Bjørnøya had more relationships between THs and contaminants than males from Bjørnøya, and each sex had more relationships between THs and contaminants than their counterparts in Kongsfjorden.

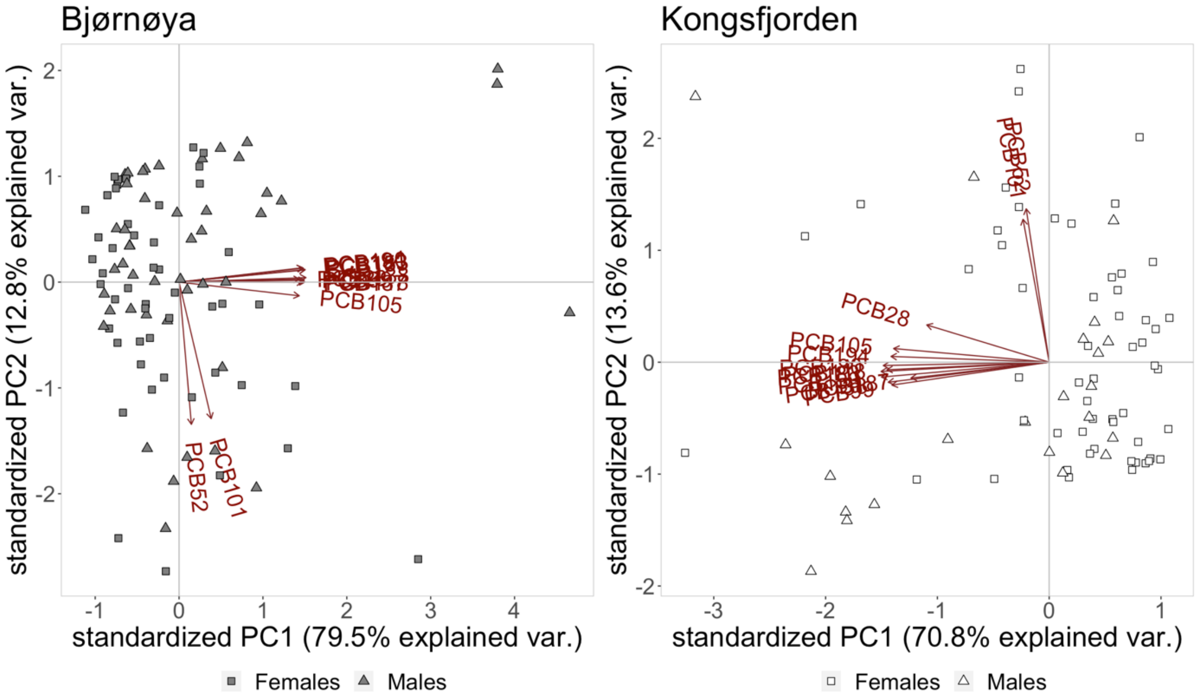

**Fig. 7:** Principal component analysis (PCA) biplots based on correlation matrix with concentrations of polychlorinated biphenyls (PCB) congeners measured in blood plasma of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Squares and triangles represent female and male individuals, respectively.

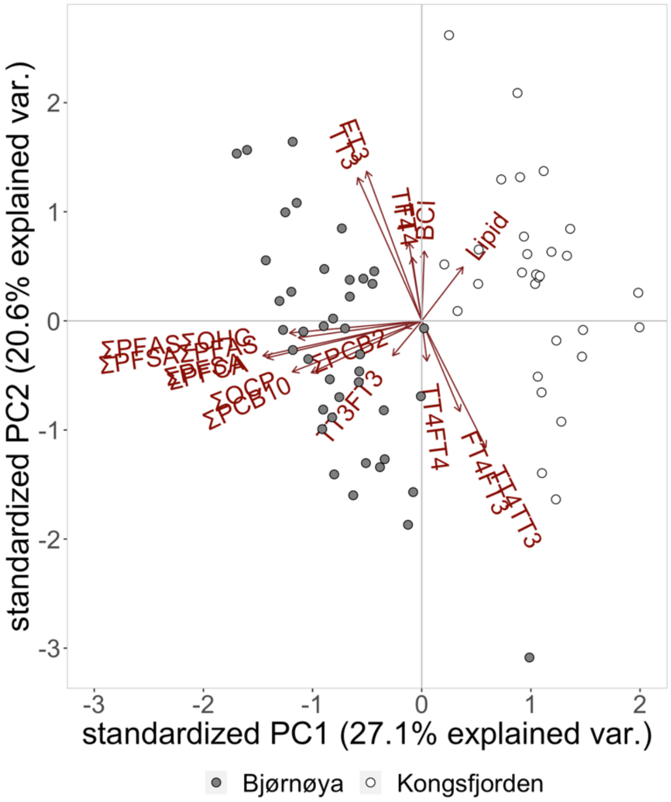

**Fig. 8:** Prinicpal component analysis (PCA) biplot based on correlation matrix of sum organohalogenated contaminant (OHC) concentrations ($\Sigma PCB_2$, $\Sigma PCB_{10}$, ΣOCP, ΣPFSA, ΣPFCA) and ratios (ΣPFSA/ΣPFAS, ΣPFAS/ΣOHC), thyroid hormone (TH) concentrations ($TT_4$, $FT_4$, $TT_3$, $FT_3$) and ratios ($TT_4/TT_3$, $FT_4/FT_3$, $TT_4/FT_4$, $TT_3/FT_3$), and lipid weight percentage (lipid) measured in blood plasma, and body condition index (BCI) of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Circles represent the sampled individuals.

In correlations tests, different relationships between plasma TH levels and OHC concentrations were also observed (Fig. 9 and 10, Fig. E6 – E8), and they were similar to the results from the PCAs. Significant correlations coefficients ($p \leq 0.05$) on pooled data (both locations and sexes) were positive between THs and PFASs, and contaminant ratios, while no significant relationships were observed between THs and OCs (Fig. E6). When separating males and females, more correlations that were significant were observed for females (Fig. E7). Some negative correlations and correlations between THs and OCs occurred when separating locations, however, these were mainly present when including both sexes (Fig. E8). Birds from Bjørnøya had more correlations that were significant between THs and contaminants than birds from Kongsfjorden. As in PCAs, these patterns were also observed when separating sex within each location (Fig. 9 and 10). Females from Bjørnøya showed most relationships between THs and contaminants, and males from Kongsfjorden had few significant relationships between the THs and contaminants. Females from Bjørnøya had a positive correlation between $TT_4$ and 8:2 FTS. However, this contaminant was not analysed further in LMMs as it was the only FTS, had low concentrations, and had concentrations below LOD the only year it was analysed for in Kongsfjorden.

BCI had a significant positive correlation ($p \leq 0.05$) with $TT_3$ concentrations on pooled data (both locations and sexes) (Fig E6). When separating locations, significant positive correlations were only observed between BCI and $TT_3$ and $FT_3$ concentrations in birds from Kongsfjorden, which were only present in males from Kongsfjorden when separating sex within each location (Fig. 9).

BCI had significant negative correlations ($p \leq 0.05$) with OC concentrations (i.e. $\Sigma PCB_{10}$ and ΣOCP), and a significant positive correlation with ΣPFAS/ΣOHC ratio on pooled data (both locations and sexes) (Fig. E6). When separating locations, significant negative correlations between BCI and OCs were only observed in birds from Bjørnøya, and significant positive correlations between BCI and PFASs were mainly observed in female birds from Kongsfjorden (Fig. 10, Fig. E7).

Plasma lipid weight percentage only showed significant correlations ($p \leq 0.05$) with OHCs in birds from Kongsfjorden, which was only present in females when separating sex within each location. The plasma lipid content in female birds from Kongsfjorden was indicated to have a negative relationship with $\Sigma PCB_2$, and positive relationships with ΣOCPs and ΣPFCAs (Fig. 10, Fig. E7).

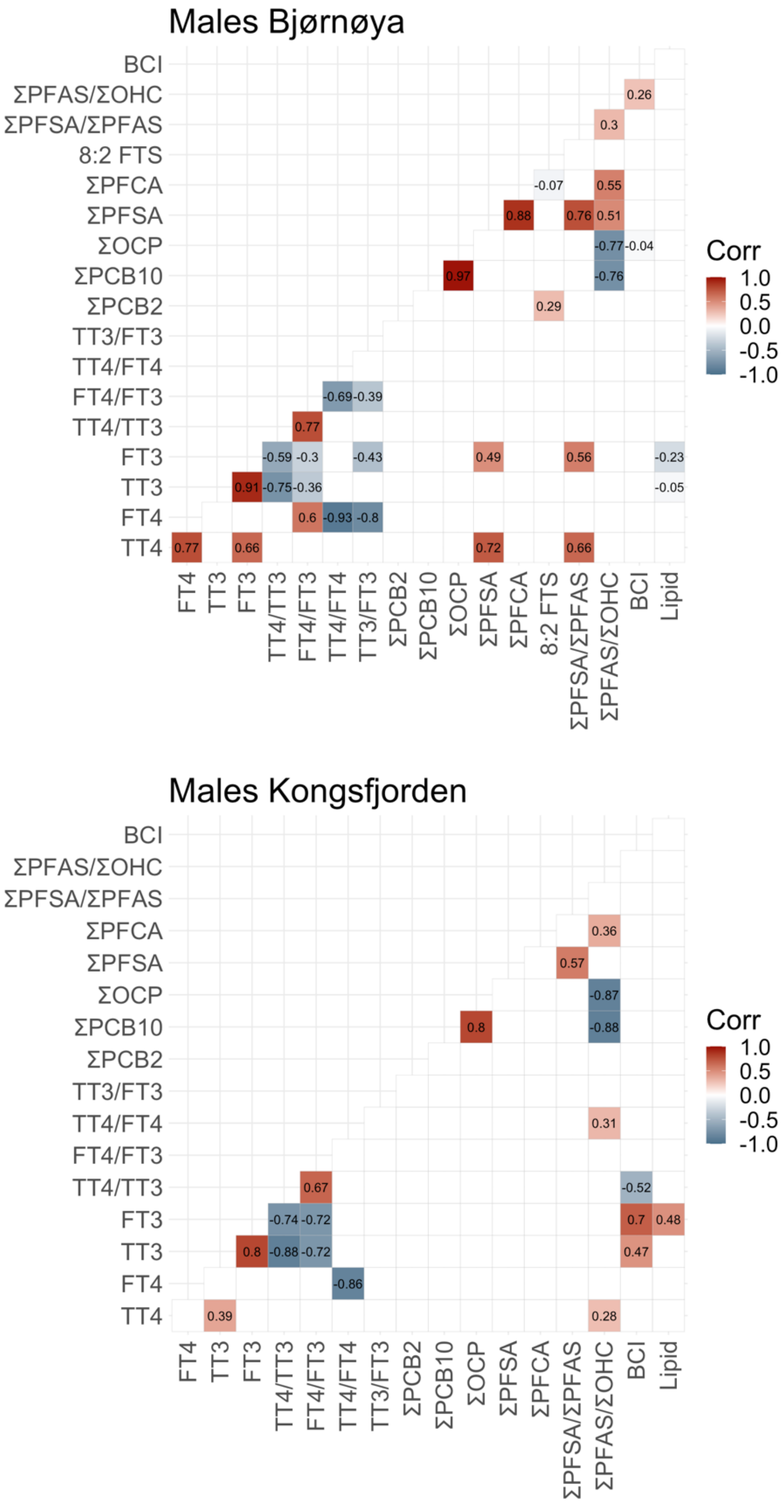

**Fig. 9:** Spearman's rank-order correlations calculated for sum organohalogenated contaminant (OHC) concentrations (Σ$PCB_2$, Σ$PCB_{10}$, ΣOCP, ΣPFSA, ΣPFCA) and ratios (ΣPFSA/ΣPFAS, ΣPFAS/ΣOHC), thyroid hormone (TH) concentrations ($TT_3$, $FT_3$, $TT_4$, $FT_4$) and ratios ($TT_4/TT_3$, $TT_3/FT_3$, $TT_4/FT_4$, $FT_4/FT_3$), and lipid weight percentage (lipid) measured in blood plasma, and body condition index (BCI) of male glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Red and blue indicate positive and negative correlation, respectively, and only significant correlations ($p \leq 0.05$) are shown.

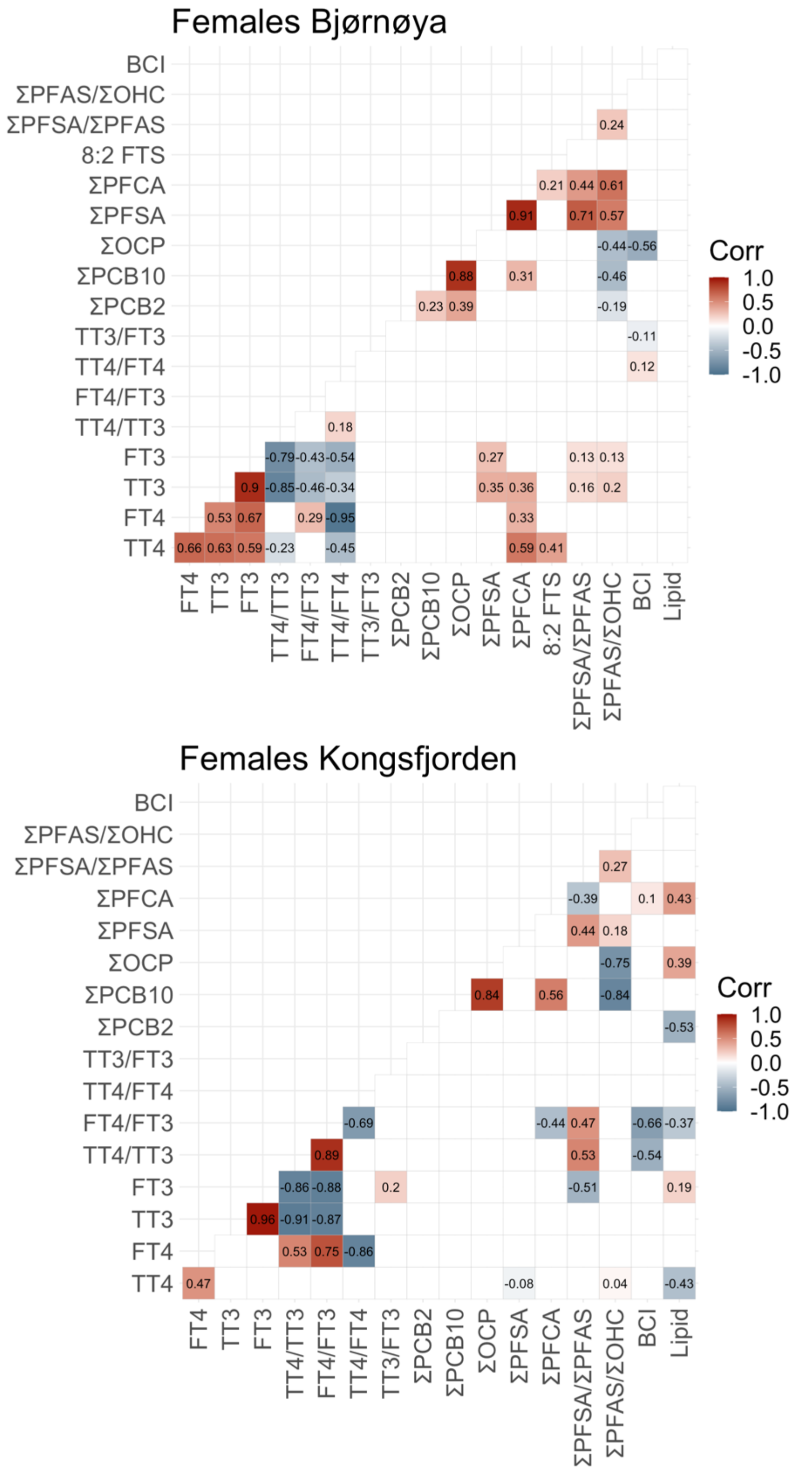

**Fig. 10:** Spearman's rank-order correlations calculated for sum organohalogenated contaminant (OHC) concentrations ($\Sigma PCB_2$, $\Sigma PCB_{10}$, ΣOCP, ΣPFSA, ΣPFCA) and ratios (ΣPFSA/ΣPFAS, ΣPFAS/ΣOHC), thyroid hormone (TH) concentrations ($TT_3$, $FT_3$, $TT_4$, $FT_4$) and ratios ($TT_4/TT_3$, $TT_3/FT_3$, $TT_4/FT_4$, $FT_4/FT_3$), and lipid weight percentage (lipid) measured in blood plasma, and body condition index (BCI) of feale glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Red and blue indicate positive and negative correlation, respectively, and only significant correlations ($p \leq 0.05$) are shown.

Relationships between THs and PFASs and contaminant ratios, and the lack of relationships between THs and OCs, were confirmed by the most parsimonious LMMs (Table 2, Table F1 – F8). Sex, BCI, and plasma lipid weight percentage were also important predictor variables for some of the TH concentrations and ratios, as suggested by PCAs and correlations.

More specifically, $TT_4$ concentrations could only be explained by ΣPFSA/ΣPFAS ratio (Table 2). However, the effect was only significant (95% CI not crossing 0) when including location as a predictor variable. Therefore, the model including location was chosen over the most parsimonious model. $FT_4$ concentrations were affected by ΣPFSAs, ΣPFCAs, and ΣPFSA/ΣPFAS ratio, and concentrations were not explained by any other variable when not including these contaminant groups. $TT_3$ concentrations were affected by ΣPFSAs, ΣPFCAs, ΣPFSA/ΣPFAS ratio, and ΣPFAS/ΣOHC ratio, and $FT_3$ concentrations were affected by ΣPFSAs, ΣPFCAs, and ΣPFAS/ΣOHC ratio. Year of sampling, sex, and plasma lipid weight percentage were also important predictor variables for both $TT_3$ and $FT_3$ concentrations. TH ratios were not explained by any of the contaminant groups, and $TT_4/TT_3$ and $TT_3/FT_3$ ratios were also not explained by any other variable. The $FT_4/FT_3$ ratio was affected by the sex of the individual, and the $TT_4/FT_4$ ratio could only be explained by the birds BCI.

The LMMs had in general low Aikake weights, except for the model explaining the variation in $FT_4$ concentrations (0.40), and the models explaining the variation in $FT_3$ concentrations (0.32 – 0.60) (Table 2).

In LMMs including a contaminant group, the contaminants had a positive and significant effect (95% CI not crossing 0) on the TH levels in glaucous gulls (Table 3, Fig. 11). The highest effect size was observed for ΣPFSA/ΣPFAS ratio on $TT_4$ concentrations and ΣPFSA on $FT_4$ concentrations. The former was the only LMM including location as a predictor variable, and revealed 1.1 times higher $TT_4$ concentrations in birds from Kongsfjorden than in birds from Bjørnøya. The sampling year revealed variation in $TT_3$ and $FT_3$ concentrations compared to the year 2015, however, the differences were mostly non-significant. Males had significantly lower $FT_4$ concentrations, and significantly higher $TT_3$ and $FT_3$ concentrations than females. BCI and plasma lipid weight percentage demonstrated only positive effects on the $TT_3$ and $FT_4$, $TT_3$, and $FT_3$ concentrations, respectively, however, the effect of BCI was not significant.

**Table 2:** Overview of the most parsimonious linear mixed-effect models (LMMs) with an ΔAICc < 2 explaining the variation of thyroid hormone (TH) concentrations and ratios in blood plasma of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. The order of the continuous fixed predictor variables (body condition index (BCI), plasma lipid weight percentage (lipid), contaminant group) are based on the effect size, with the variables having the highest effect size placed first behind any categorical variable (location, year, sex). LMMs with no fixed predictor variables are named intercept (intercept-only/null model). ΔAICc and Aikake weights ($w_i$) of each LMM are included.

| TH | Contaminant group | Fixed predictor variables in LMM | ΔAICc | $w_i$ |
|---|---|---|---|---|
| $TT_4$ | ΣPFSA | Intercept | 0.41 | 0.11 |
| | ΣPFCA | Intercept | 0.00 | 0.15 |
| | ΣPFSA/ΣPFAS | Location + ΣPFSA/ΣPFAS | 0.00 | 0.10 |
| | ΣPFAS/ΣOHC | Intercept | 0.00 | 0.15 |
| | ΣPCB$_2$ | Intercept | 0.00 | 0.14 |
| | ΣPCB$_{10}$ | Intercept | 0.00 | 0.12 |
| | ΣOCP | Intercept | 0.00 | 0.14 |
| $FT_4$ | ΣPFSA | Sex + ΣPFSA + Lipid | 0.00 | 0.40 |
| | ΣPFCA | ΣPFCA + Lipid | 1.53 | 0.11 |
| | ΣPFSA/ΣPFAS | Lipid + ΣPFSA/ΣPFAS | 0.22 | 0.10 |
| | ΣPCB$_2$ | Intercept | 1.54 | 0.03 |
| | ΣOCP | Intercept | 1.72 | 0.03 |
| $TT_3$ | ΣPFSA | ΣPFSA + Lipid | 0.00 | 0.13 |
| | ΣPFCA | Sex + ΣPFCA + Lipid + BCI | 1.73 | 0.07 |
| | ΣPFSA/ΣPFAS | Year + Lipid + ΣPFSA/ΣPFAS | 1.76 | 0.06 |
| | ΣPFAS/ΣOHC | Sex + Lipid + ΣPFAS/ΣOHC | 1.69 | 0.14 |
| | ΣPCB$_2$ | Year + Sex + Lipid | 1.87 | 0.06 |
| $FT_3$ | ΣPFSA | Year + Sex + ΣPFSA + Lipid | 0.00 | 0.35 |
| | ΣPFCA | Year + Sex + ΣPFCA + Lipid | 0.00 | 0.32 |
| | ΣPFSA/ΣPFAS | Year + Sex + Lipid | 1.56 | 0.08 |
| | ΣPFAS/ΣOHC | Year + Sex + ΣPFAS/ΣOHC + Lipid | 0.00 | 0.60 |
| $TT_4/TT_3$ | ΣPFSA | Intercept | 0.00 | 0.09 |
| | ΣPFCA | Intercept | 0.00 | 0.10 |
| | ΣPFSA/ΣPFAS | Intercept | 0.00 | 0.09 |
| | ΣPFAS/ΣOHC | Intercept | 0.00 | 0.10 |
| | ΣPCB$_2$ | Intercept | 0.00 | 0.10 |
| $FT_4/FT_3$ | ΣPFCA | Sex | 1.86 | 0.07 |
| | ΣPFSA/ΣPFAS | Sex | 1.86 | 0.07 |
| | ΣPFAS/ΣOHC | Sex | 1.86 | 0.06 |
| | ΣPCB$_{10}$ | Sex | 1.86 | 0.06 |
| | ΣOCP | Sex | 1.86 | 0.06 |
| $TT_4/FT_4$ | ΣPFCA | BCI | 0.00 | 0.25 |
| | ΣPFSA/ΣPFAS | BCI | 0.00 | 0.23 |
| | ΣPFAS/ΣOHC | BCI | 0.00 | 0.24 |
| | ΣPCB$_2$ | BCI | 0.00 | 0.23 |
| | ΣPCB$_{10}$ | BCI | 0.00 | 0.17 |
| | ΣOCP | BCI | 0.00 | 0.21 |
| $TT_3/FT_3$ | ΣPFSA | Intercept | 0.42 | 0.06 |
| | ΣPFCA | Intercept | 0.42 | 0.05 |
| | ΣPFSA/ΣPFAS | Intercept | 0.42 | 0.05 |

**Table 3:** Parameter estimates and 95% confidence intervals (CIs) from selected linear mixed-effect models (LMMs) relating thyroid hormone (TH) concentrations ($TT_4$ (nmol/L), $FT_4$ (pmol/L), $TT_3$ (nmol/L), $FT_3$ (pmol/L)) to contaminants concentrations (nmol/L) and ratios in blood plasma of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Predictor variables include a contaminant group (ΣPFSA, ΣPFCA, ΣPFSA/ΣPFAS or ΣPFAS/ΣOHC), location, sampling year, sex, body condition index (BCI), and/or plasma lipid weight percentage (lipid). Headings indicate which TH and contaminant group that was investigated in the specific model. Continuous predictor variables were scaled (mean = 0, standard deviation = 1). Estimates of the random effects (individual and residual) are presented as standard deviations (SD).

| | **$TT_4$ ~ ΣPFSA/ΣPFAS** | | **$FT_4$ ~ ΣPFSA** | | **$FT_4$ ~ ΣPFCA** | |
|---|---|---|---|---|---|---|
| | Estimate | CI | Estimate | CI | Estimate | CI |
| Intercept | 41.91 | 39.22 – 44.58 | 14.64 | 13.15 – 16.13 | 13.53 | 12.41 – 14.64 |
| Location Kongsfjord | 4.41 | 0.09 – 8.74 | | | | |
| Sex Male | | | -2.52 | -4.83 – -0.22 | | |
| Lipid | | | 1.42 | 0.37 – 2.44 | 1.13 | 0.08 – 2.16 |
| Contaminant group | 2.60 | 0.49 – 4.69 | 1.95 | 0.82 – 3.08 | 1.32 | 0.23 – 2.41 |
| $SD_{Individual}$ | 4.21 | 0.00 – 6.25 | 2.92 | 0.00 – 4.29 | 2.76 | 0.00 – 4.26 |
| $SD_{Residual}$ | 7.22 | 5.62 – 9.29 | 5.32 | 4.44 – 6.35 | 5.34 | 4.63 – 6.62 |

| | **$FT_4$ ~ ΣPFSA/ΣPFAS** | | **$TT_3$ ~ ΣPFSA** | | **$TT_3$ ~ ΣPFCA** | |
|---|---|---|---|---|---|---|
| | Estimate | CI | Estimate | CI | Estimate | CI |
| Intercept | 13.49 | 12.35 – 14.61 | 4.07 | 3.82 – 4.32 | 3.85 | 3.51 – 4.20 |
| Sex Male | | | | | 0.50 | -0.04 – 1.03 |
| BCI | | | | | 0.22 | -0.04 – 0.48 |
| Lipid | 1.21 | 0.14 – 2.25 | 0.43 | 0.17 – 0.69 | 0.33 | 0.08 – 0.59 |
| Contaminant group | 1.20 | 0.11 – 2.29 | 0.60 | 0.34 – 0.86 | 0.41 | 0.14 – 0.67 |
| $SD_{Individual}$ | 2.87 | 0.00 – 4.36 | 0.00 | 0.00 – 0.83 | 0.00 | 0.00 – 0.74 |
| $SD_{Residual}$ | 5.51 | 4.61 – 6.60 | 1.54 | 1.36 – 1.72 | 1.55 | 1.36 – 1.72 |

| | **$TT_3$ ~ ΣPFSA/ΣPFAS** | | **$TT_3$ ~ ΣPFAS/ΣOHC** | | **$FT_3$ ~ ΣPFSA** | |
|---|---|---|---|---|---|---|
| | Estimate | CI | Estimate | CI | Estimate | CI |
| Intercept | 4.46 | 3.92 – 5.00 | 8.73 | 6.99 – 10.48 | 8.99 | 7.24 – 10.77 |
| Year 2016 | -0.86 | -1.56 – -0.15 | -0.93 | -2.95 – 1.05 | -0.88 | -2.98 – 1.19 |
| Year 2017 | 0.80 | -0.14 – 1.74 | 2.73 | 0.18 – 5.24 | 2.39 | -0.20 – 4.94 |
| Year 2018 | -0.58 | -1.46 – 0.29 | 1.41 | -1.13 – 3.90 | 1.18 | -1.39 – 3.72 |
| Year 2019 | -0.66 | -1.50 – 0.17 | 1.87 | -0.54 – 4.27 | 1.58 | -0.86 – 4.00 |
| Sex Male | | | 2.10 | 0.69 – 3.52 | 1.74 | 0.27 – 0.21 |
| Lipid | 0.59 | 0.30 – 0.90 | 1.10 | 0.31 – 1.89 | 1.06 | 0.27 – 1.86 |
| Contaminant group | 0.35 | 0.09 – 1.61 | 1.52 | 0.76 – 2.29 | 1.33 | 0.52 – 2.15 |
| $SD_{Individual}$ | 0.16 | 0.00 – 0.85 | 1.12 | 0.00 – 2.56 | 0.76 | 0.00 – 2.58 |
| $SD_{Residual}$ | 1.54 | 1.31 – 1.71 | 3.83 | 3.04 – 4.37 | 3.99 | 3.12 – 4.46 |

| | **$FT_3$ ~ ΣPFCA** | | **$FT_3$ ~ ΣPFSA/ΣPFAS** | |
|---|---|---|---|---|
| | Estimate | CI | Estimate | CI |
| Intercept | 8.99 | 7.20 – 10.80 | 8.73 | 6.99 – 10.48 |
| Year 2016 | -1.18 | -3.29 – 0.89 | -0.93 | -2.95 – 1.05 |
| Year 2017 | 2.60 | -0.03 – 5.20 | 2.73 | 0.18 – 5.24 |
| Year 2018 | 1.21 | -1.45 – 3.83 | 1.41 | -1.13 – 3.90 |
| Year 2019 | 1.56 | -0.95 – 4.06 | 1.87 | -0.54 – 4.27 |
| Sex Male | 1.93 | 0.45 – 3.41 | 2.10 | 0.69 – 3.52 |
| Lipid | 0.96 | 0.15 – 1.77 | 1.10 | 0.31 – 1.89 |
| Contaminant group | 1.06 | 0.26 – 1.87 | 1.52 | 0.76 – 2.29 |
| $SD_{Individual}$ | 0.82 | 0.00 – 2.59 | 1.12 | 0.00 – 2.56 |
| $SD_{Residual}$ | 4.04 | 3.17 – 4.53 | 3.83 | 3.04 – 4.37 |

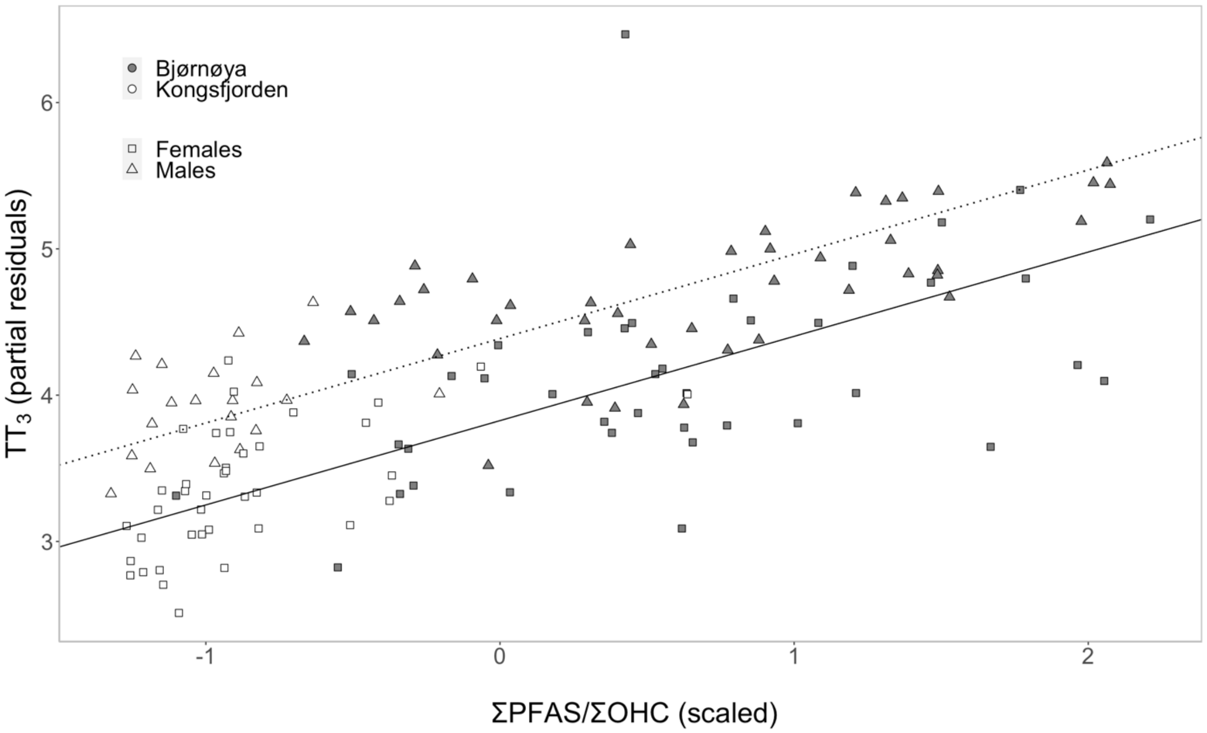

**Fig. 11:** Partial residual plot as a representative illustrating the positive effect of per- and polyfluoroalkyl substance (PFAS) concentrations on thyroid hormone (TH) concentrations in blood plasma of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. The partial residuals were obtained from a linear mixed-effect model (LMM) relating $TT_3$ concentrations (nmol/L) to scaled units of ΣPFAS/ΣOHC ratio and plasma lipid weight percentage. Contaminant ratios were calculated with concentrations in nmol/L. The lines represent the parameter estimate of ΣPFAS/ΣOHC ratio, with a significantly higher intercept for males (dotted) compared to females (solid).

In LMMs not including a contaminant group, the sampling year had an effect on the $TT_3$ and $FT_3$ concentrations in glaucous gulls, however, the differences relative to the year 2015 were mostly non-significant (95% CI crossing 0) (Table G1). Males had significantly higher $TT_3$ and $FT_3$ concentrations, and significantly lower $FT_4/FT_3$ ratios than females. BCI and lipid weight percentage demonstrated significant positive effects on $TT_4/FT_4$ ratios, and $TT_3$ and $FT_3$ concentrations, respectively.

# 4. DISCUSSION

Glaucous gulls from Bjørnøya had significantly higher blood plasma OHC concentrations relative to glaucous gulls from Kongsfjorden during the 2015 – 2019 period, where males within each location had higher contaminant concentrations than females. The two populations showed no differences in the blood plasma TH concentrations and the various TH ratios during the same time period. Sex differences were only found in $FT_3$ concentrations and $FT_4/FT_3$ ratios. These results suggest that the OHCs were not affecting the TH concentrations in these birds. PCAs including both locations supported these findings, while other PCAs and correlation tests suggested mainly positive associations between THs and PFASs. LMMs indicated a positive effect of PFASs on TH concentrations, and no effect of any contaminant group on the TH ratios. Other variables than PFASs that contributed in explaining the TH concentrations were location, sampling year, sex, BCI, and plasma lipid weight percentage.

## 4.1. OHC concentrations

Assessment of OHC concentrations in blood plasma of glaucous gulls from Bjørnøya and Kongsfjorden have previously revealed large differences with respect to contaminant concentration between the two locations, with birds from Bjørnøya having the highest contaminant levels (Haugerud, 2011; Melnes et al., 2017; Verreault et al., 2004; Verreault et al., 2005). This is supported by the present study. PCB, OCP, and PFAS concentrations and their relative contribution to the ΣOHC burden in glaucous gulls within each location were generally in accordance with these previous studies. With respect to temporal changes in concentrations, the mean ΣPCB concentration in males from Bjørnøya has increased by a factor of 1.4 from 2001 (Verreault et al., 2004) to the 2017 – 2019 period in the present study (Table 4). While several studies have reported concentrations of OCs, no studies have reported PFAS concentrations in blood plasma of glaucous gulls exclusively from Bjørnøya. However, one study has reported PFAS concentrations in birds from Spitsbergen and Bjørnøya in 2004 combined, due to no significant concentration differences between the two locations (Verreault et al., 2005). The mean PFOS concentration in birds from Bjørnøya during the 2015 – 2019 period in the present study has increased by a factor of 2.5 since 2004 (Verreault et al., 2005).

In Kongsfjorden, mean concentration of *p,p'*-DDE was 2.6 times higher in female birds from 2010 (Haugerud, 2011) than female birds from the 2015 – 2019 period in the present study (Table 4). However, in the present study, mean concentration of *p,p'*-DDE has increased by a factor of 8.7 and 6.5 in male and female birds from Kongsfjorden, respectively, since the 2011

**Table 4:** Mean ± standard deviation (SD) and range (min – max) concentrations (ng/g ww) of selected organohalogenated (OHC) contaminants previously reported in blood plasma of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya (B) and in Kongsfjorden (K) compared to the concentrations in the present study. Sampling year and number of samples (*n*) are included. $^{+}$ and $^{\dagger}$ denote that 14 and 12 congeners are included in the measurement, respectively, and $^{*}$ denotes that the measurement is in standard error (SE). Mean ΣPCB concentration in males from the present study was only calculated from the 2017 – 2019 period as the concentrations increased during the 2015 – 2019 period, and the mean concentrations in 2015 and 2016 were not different from the previous study. PFOS concentrations in the previous studies were assumed to include both branched and linear PFOS. Therefore, the mean PFOS concentrations from the present study were calculated including both isomers.

| Contaminant group | Location | Year | Concentration (ng/g ww) | | | | | | References |
|---|---|---|---|---|---|---|---|---|---|
| | | | Both sexes | | Males | | Females | | |
| | | | *n* | Mean ± SD (range) | *n* | Mean ± SD (range) | *n* | Mean ± SD (range) | |
| ΣPCB | B | 2001 | | | 32 | $492 \pm 421^{+}$ (75.3 – 1927) | | | Verreault et al. (2004) |
| | B | 2017 – 2019 | | | 16 | $713 \pm 420^{\dagger}$ (208 – 2037) | | | Present study |
| PFOS | B | 2004 | 20 | $134 \pm 16.6^{*}$ (48.1 – 349) | | | | | Verreault et al. (2005) |
| | B | 2015 – 2019 | 95 | 329 ± 161 (32.5 – 734) | | | | | Present study |
| | K | 2010 | | | | | 19 | 31.1 ± 96.8 (3.45 – 430) | Haugerud (2011) |
| | K | 2011 – 2013 | | | | | 24 | 47.2 ± 111 (2.56 – 508) | Melnes et al. (2017) |
| | K | 2015 – 2019 | | | | | 57 | 12.6 ± 21.0 (1.51 – 149) | Present study |
| *p,p'*-DDE | K | 2010 | | | | | 19 | 48.1 ± 30.6 (13.8 – 133) | Haugerud (2011) |
| | K | 2011 – 2013 | | | 15 | 6.00 ± 3.52 (2.13 – 11.9) | 24 | 2.81 ± 2.08 (0.74 – 9.00) | Melnes et al. (2017) |
| | K | 2015 – 2019 | | | 23 | 52.0 ± 55.8 (0.06 – 195) | 57 | 18.2 ± 20.4 (0.06 – 83.9) | Present study |

– 2013 period (Melnes et al., 2017). This has resulted in oxychlordane being replaced by *p,p'*-DDE as the dominating group since the 2011 – 2013 period. In spite of the apparent increase in the mean *p,p'*-DDE concentration in the 2011 – 2013 period, the overall decrease in mean *p,p'*-DDE concentration in glaucous gulls since 2010 could be attributed to the regulations by the Stockholm Convention. In contrast to males from Bjørnøya, the mean PFOS concentration has decreased in female birds from Kongsfjorden. In the present study, females had 2.5 and 3.7 times lower mean PFOS concentrations than female birds from 2010 (Haugerud, 2011) and the 2011 – 2013 period (Melnes et al., 2017), respectively.

The high concentrations of OHCs in birds from Bjørnøya and increasing concentrations of some of the contaminants, such as the PCBs, despite many of them being restricted or banned, highlights their persistence in biota and also reflects the apical position of the species (Dietz et al., 2019; Letcher et al., 2010; Verreault et al., 2010). The reasons for the differences in contaminant concentrations between the two populations are still unknown. However, studies have revealed that trophic position may play a role in the exposure to contaminants, suggesting that glaucous gulls from Bjørnøya are feeding on a higher trophic level relative to the glaucous gulls from Kongsfjorden (Borgå et al., 2004; Bustnes et al., 2000; Sagerup et al., 2002). Feeding ecology could also possibly explain why birds from Bjørnøya have a higher proportion of PFASs than birds from Kongsfjorden, reflecting low OHC concentrations in species on lower trophic levels (Haukås et al., 2007). The topic related to the impact of trophic position between the two populations is currently under investigation in another master project (Husabø, 2021), and has therefore only been discussed briefly herein.

It has been proposed that low food availability and high energy costs during breeding could result in metabolization of stored body fat, consequently remobilising lipophilic contaminants, causing higher blood plasma concentrations in addition to lowering the birds body mass (Bustnes et al., 2012; Melnes et al., 2017). In the present study, BCI did not differ between the two locations. Hence, food scarcity on Bjørnøya, which has previously been suggested as a possible contributor to the population decline on Bjørnøya (Verreault et al., 2010), could not explain the higher OC concentrations in birds from Bjørnøya than in birds from Kongsfjorden.

Temporal variation in contaminant concentrations, which were especially apparent in birds from Bjørnøya compared to birds from Kongsfjorden, and ratios may be due to changes in diet, migration to different wintering areas, and differences in transportation of contaminants to the Arctic (Borgå et al., 2004; Bustnes et al., 2010; Macdonald et al., 2005). These factors could also explain the differences in concentrations within the two locations when comparing with the previous studies (Table 4). It is also possible that different migration patterns could explain or contribute to the differences in OHC concentrations between the two locations.

The exact age of the glaucous gulls was not known. This could consequently explain some of the variation in OHC concentrations observed between individuals. However, it is proposed that age is not a very important factor explaining variation in OHC concentrations in seabirds, as glaucous gulls and kittiwakes (*Rissa tridactyla*) have shown to reach an equilibrium with the OC exposure from the diet before the first breeding (Borgå et al., 2004; Bustnes et al., 2003a; Henriksen, 1995).

Herein, the BCI had a negative relationship with OCs in glaucous gulls from Bjørnøya, and a positive relationship with PFASs that was mainly observed in birds from Kongsfjorden. Thus, BCI could therefore explain some of the variation in contaminant concentrations between individuals. These associations were also observed in male glaucous gulls from Kongsfjorden during the 2011 – 2013 period (Melnes et al., 2017). The authors proposed that the negative relationship between BCI and OCs could be due to high energy costs during breeding season, thereby releasing OCs from body fat to the bloodstream. The positive relationship between BCI and PFASs was suggested to be an indirect result of higher protein content in their diet, causing higher plasma protein levels and higher associated PFAS concentrations.

The differences in temporal variation in OC concentrations between males and females, and higher concentrations in males in general, were most likely due to that females are able to readily excrete lipophilic contaminants through deposition of eggs during breeding season (Verreault et al., 2006; Verreault et al., 2010). Since PFASs bind to proteins, and proteins are a limiting resource during egg production, in contrast to the lipids, it is possible that the maternal investment could result in greater transfer of lipophilic contaminants than protein associated contaminants (Bolton et al., 1993; Hitchcock et al., 2019; Knudtzon et al., 2021). This could explain why males and females displayed similar patterns in mean PFAS concentrations. However, mean PFAS concentrations were also higher in males than in females, suggesting that there is some protein associated maternal transfer of PFASs to the egg.

Another important consideration in relation to the OHC concentrations is the amount of lipids and proteins in the analysed tissues, as lipophilic and proteinophilic contaminants, respectively, are associated with these (Haukås et al., 2007) Herein, plasma lipid weight percentage did not differ between the two locations or sexes, hence not explaining the differences in OC concentrations. However, plasma lipid weight percentage did show a negative and positive relationship with $\Sigma PCB_2$ and ΣOCPs, respectively, in females from Kongsfjorden, suggesting that plasma lipid content could explain some variation between individuals. Hovden (2018) reported higher, but not significantly, hepatic ΣPFSA concentrations in pre-breeding female glaucous gulls than in males. The author suggested that this difference could be due to the higher circulating protein levels in females, as PFSAs have been reported to have higher affinity towards plasma proteins than PFCAs. Although an *in silico* study on glaucous gulls found that PFCAs had higher affinity to TTR than PFSAs (Mortensen et al., 2020), PFASs can also be associated with albumin due to their structural similarity to fatty acids (Weiss et al., 2009). Plasma protein content was not analysed in the present study, and a potential influence of protein content on PFAS concentrations can therefore not be ruled out.

## 4.2. TH concentrations

As a consequence of the large population differences in PCB, OCP, and PFAS concentrations between glaucous gulls from Bjørnøya and Kongfjorden, and the fact that these contaminants are related to thyroid disruptive effects in both humans, laboratory animals, and wildlife, including the glaucous gull (Coperchini et al., 2020; Dietz et al., 2019; Melnes et al., 2017; Nøst et al., 2012; Verreault et al., 2004; Verreault et al., 2013; Zoeller, 2007), effects on the TH concentrations in the birds from Bjørnøya were expected. In contradiction to this hypothesis, the TH concentrations and ratios in the present study revealed no differences between glaucous gulls breeding on Bjørnøya and in Kongsfjorden during the 2015 – 2019 period. This is surprising, especially as mean ΣOHC concentrations in birds from Bjørnøya exceeded the general threshold of concern at 1 ppm (1000 ng/g) (Letcher et al., 2010). However, to our knowledge, no specific threshold levels of OHCs have been reported for TH disruption in birds or other animals. There are few exposure studies relating PCB exposure to changes in plasma TH concentrations in avian species. A study on American kestrels (*Falco sparverius*) reported significantly supressed $T_3$ concentrations (43% and 23% in males and females, respectively) in PCB (Aroclor 1248:1254:1260) exposed birds fed 7000 ng PCB/g body weight/day, compared to the control group (Smits et al., 2002). No differences were observed in $T_4$ concentrations. This dosage resulted in plasma PCB concentrations of 3800 ng/g ww at the end of the dosing period, which is almost 2 times higher than the highest ΣPCB concentration (2037 ng/g ww) measured in the glaucous gulls in the present study. To our knowledge, no exposure studies exist relating PFAS exposure to changes in TH concentrations in birds.

The results from the present study are in accordance with reports that adult herring gulls (*Larus argentatus*) from differently PCB contaminated sites in the Great Lakes did not differ in $T_4$ concentrations (McNabb and Fox, 2003). On the other hand, other studies comparing differently contaminated colonies of glaucous gulls on Bjørnøya (Verreault et al., 2004) and populations of northern fulmars (*Fulmarus glacialis*) (Verreault et al., 2013) reported significantly different TH concentrations between the colonies and populations. However, the study on glaucous gulls did not report the TH concentrations for each colony separately, and only referred to the regression analyses (Verreault et al., 2004).

The TH concentrations and ratios in the present study were in general accordance with previously reported concentrations in glaucous gulls from Bjørnøya (Verreault et al., 2004; Verreault et al., 2007) and Kongsfjorden (Haugerud, 2011; Melnes et al., 2017). $TT_4$ and $TT_3$ concentrations, and thereby also the $TT_4/TT_3$ ratio, were overall similar, while $FT_4$ and $FT_3$ concentrations were lower and higher, respectively, in the present study than in these previous studies (Table 5). Consequently, this also resulted in lower $FT_4/FT_3$ and $TT_3/FT_3$ ratios, and higher $TT_4/FT_4$ ratio in the present study. The concentration ranges were, however,

**Table 5:** Mean ± standard deviation (SD) and min – max concentrations and ratios of thyroid hormones (THs) previously reported in blood plasma of glaucous gulls (*Larus hyperboreus*) from Bjørnøya (B), Kongsfjorden (K), and Adventfjorden and Sassendalen (S) compared to the concentrations and ratios in the present study. $TT_3$ and $TT_4$ were measured in nmol/L, and $FT_3$ and $FT_4$ in pmol/L. $TT_3/FT_3$ and $TT_4/FT_4$ ratios reported from the present study were calculated with original units for easier comparison. Sampling year and number of samples (*n*) are included.

| TH | Location | Year | Concentration | | | | References |
|---|---|---|---|---|---|---|---|
| | | | Males | | Females | | |
| | | | *n* | Mean ± SD (min – max) | *n* | Mean ± SD (min – max) | |
| $TT_4$ (nmol/L) | B | 2001 | 32 | 28.9 ± 11.6 (1.61 – 62.6) | 34 | 34.3 ± 13.4 (1.61 – 56.5) | Verreault et al. (2004) |
| | B | 2004 | 11 | 22.4 ± 1.67 (15.1 – 36.6) | 12 | 22.7 ± 1.37 (13.9 – 31.0) | Verreault et al. (2007) |
| | K | 2010 | | | 19 | 22.7 ± 8.55 (8.91 – 39.1) | Haugerud (2011) |
| | K | 2011 – 2013 | 15 | 24.5 ± 11.5 (13.2 – 43.7) | 24 | 30.7 ± 9.59 (10.6 – 50.9) | Melnes et al. (2017) |
| | S | 2017 | 7 | 28.5 ± 5.60 (18.4 – 34.2) | 8 | 35.3 ± 14.3 (1.89 – 7.32) | Hovden (2018) |
| | B | 2015 – 2019 | 23 | 42.5 ± 9.11 (27.2 – 69.2) | 26 | 43.6 ± 9.16 (23.2 – 66.9) | Present study |
| | K | 2015 – 2019 | 15 | 43.3 ± 7.82 (30.5 – 57.6) | 22 | 46.0 ± 7.59 (32.5 – 61.0) | Present study |
| $TT_3$ (nmol/L) | B | 2001 | 32 | 3.86 ± 1.20 (1.80 – 7.63) | 34 | 3.02 ± 1.02 (1.38 – 5.25) | Verreault et al. (2004) |
| | B | 2004 | 11 | 4.02 ± 0.41 (1.80 – 6.60) | 12 | 2.69 ± 0.31 (0.90 – 5.10) | Verreault et al. (2007) |
| | K | 2010 | | | 19 | 1.81 ± 0.97 (0.89 – 4.37) | Haugerud (2011) |
| | K | 2011 – 2013 | 15 | 2.21 ± 1.02 (1.72 – 4.38) | 24 | 2.38 ± 0.97 (0.82 – 4.59) | Melnes et al. (2017) |
| | S | 2017 | 7 | 3.30 ± 1.50 (0.66 – 4.75) | 8 | 3.24 ± 1.74 (1.89 – 7.32) | Hovden (2018) |
| | B | 2015 – 2019 | 43 | 4.61 ± 1.51 (1.70 – 8.68) | 40 | 4.08 ± 1.96 (0.31 – 10.45) | Present study |
| | K | 2015 – 2019 | 20 | 4.33 ± 1.66 (1.83 – 8.48) | 41 | 3.47 ± 1.39 (1.00 – 7.69) | Present study |
| $TT_4/TT_3$ | B | 2001 | 32 | 8.25 ± 4.70 (0.54 – 26.7) | 34 | 13.1 ± 7.85 (0.54 – 41.0) | Verreault et al. (2004) |
| | K | 2010 | | | 19 | 15.1 ± 8.28 (4.96 – 31.2) | Haugerud (2011) |
| | B | 2015 – 2019 | 23 | 10.6 ± 3.23 (4.63 – 19.8) | 24 | 14.0 ± 13.0 (5.94 – 72.5) | Present study |
| | K | 2015 – 2019 | 14 | 11.6 ± 4.49 (5.95 ± 22.2) | 20 | 12.9 ± 4.96 (4.68 – 22.9) | Present study |
| $FT_4$ (pmol/L) | B | 2001 | 32 | 27.1 ± 9.63 (14.4 – 51.4) | 34 | 36.7 ± 12.7 (11.4 – 65.1) | Verreault et al. (2004) |
| | B | 2004 | 11 | 24.3 ± 2.16 (16.0 – 44.2) | 12 | 25.3 ± 1.55 (16.7 – 34.3) | Verreault et al. (2007) |
| | K | 2010 | | | 19 | 21.6 ± 9.20 (7.15 – 43.1) | Haugerud (2011) |
| | K | 2011 – 2013 | 15 | 30.3 ± 41.4 (4.94 – 133) | 24 | 22.6 ± 9.37 (6.26 – 41.5) | Melnes et al. (2017) |
| | S | 2017 | 7 | 14.2 ± 2.44 (10.6 – 17.7) | 8 | 17.1 ± 8.90 (7.56 – 33.5) | Hovden (2018) |
| | B | 2015 – 2019 | 42 | 13.6 ± 6.10 (3.15 – 31.6) | 40 | 15.2 ± 8.72 (1.50 – 39.0) | Present study |
| | K | 2015 – 2019 | 19 | 12.3 ± 4.19 (6.41 – 22.2) | 40 | 13.1 ± 4.71 (4.24 – 24.1) | Present study |
| $FT_3$ (pmol/L) | B | 2001 | 32 | 4.32 ± 1.75 (1.50 – 9.30) | 34 | 3.38 ± 1.32 (1.25 – 5.90) | Verreault et al. (2004) |
| | B | 2004 | 11 | 4.71 ± 0.57 (2.30 – 7.90) | 12 | 2.96 ± 0.42 (0.80 – 6.70) | Verreault et al. (2007) |
| | K | 2010 | | | 19 | 2.73 ± 1.39 (0.86 –6.14) | Haugerud (2011) |
| | K | 2011 – 2013 | 15 | 3.23 ± 1.83 (0.80 – 6.12) | 24 | 2.97 ± 1.61 (0.55 – 6.57) | Melnes et al. (2017) |
| | S | 2017 | 7 | 8.43 ± 4.41 (1.00 – 13.1) | 8 | 6.99 ± 4.34 (2.26 – 16.6) | Hovden (2018) |
| | B | 2015 – 2019 | 41 | 12.1 ± 4.51 (3.08 – 23.2) | 37 | 9.68 ± 5.35 (1.09 – 27.4) | Present study |
| | K | 2015 – 2019 | 18 | 11.3 ± 4.25 (3.67 – 22.2) | 38 | 8.64 ± 3.59 (2.72 – 17.3) | Present study |

**Table 6 Continued:** Mean ± standard deviation (SD) and min – max concentrations and ratios of thyroid hormones (THs) previously reported in blood plasma of glaucous gulls (*Larus hyperboreus*) from Bjørnøya (B), Kongsfjorden (K), and Adventfjorden and Sassendalen (S) compared to the concentrations and ratios in the present study. $TT_3$ and $TT_4$ were measured in nmol/L, and $FT_3$ and $FT_4$ in pmol/L. $TT_3/FT_3$ and $TT_4/FT_4$ ratios reported from the present study were calculated with original units for easier comparison. Sampling year and number of samples (*n*) are included.

| TH | Location | Year | Concentration | | | | References |
|---|---|---|---|---|---|---|---|
| | | | Males | | Females | | |
| | | | *n* | Mean ± SD (min – max) | *n* | Mean ± SD (min – max) | |
| $FT_4/FT_3$ | B | 2001 | 32 | 7.18 ± 3.96 (1.94 – 21.4) | 34 | 12.9 ± 7.68 (2.79 – 40.7) | Verreault et al. (2004) |
| | B | 2015 – 2019 | 40 | 1.23 ± 0.61 (0.35 – 3.13) | 36 | 1.79 ± 0.84 (0.75 – 4.72) | Present study |
| | K | 2015 – 2019 | 18 | 1.23 ± 0.63 (0.57 – 2.93) | 38 | 1.76 ± 0.77 (0.62 – 3.45) | Present study |
| $TT_4/FT_4$ | B | 2001 | 32 | 1.07 ± 0.29 (0.11 – 1.55) | 34 | 0.92 ± 0.27 (0.11 – 1.32) | Verreault et al. (2004) |
| | B | 2015 – 2019 | 22 | 4.05 ± 1.93 (1.94 – 9.00) | 24 | 3.89 ± 3.93 (1.61 – 21.2) | Present study |
| | K | 2015 – 2019 | 13 | 3.39 ± 0.96 (2.17 – 5.20) | 20 | 3.49 ± 1.71 (1.99 – 10.1) | Present study |
| $TT_3/FT_3$ | B | 2001 | 32 | 0.94 ± 0.16 (0.67 – 1.34) | 34 | 0.93 ± 0.17 (0.68 – 1.43) | Verreault et al. (2004) |
| | B | 2015 – 2019 | 41 | 0.41 ± 0.13 (0.29 – 1.09) | 37 | 0.44 ± 0.11 (0.26 – 0.84) | Present study |
| | K | 2015 – 2019 | 18 | 0.37 ± 0.06 (0.30 – 0.50) | 38 | 0.40 ± 0.07 (0.30 – 0.57) | Present study |

overlapping, and all TH concentrations were similar as those reported in glaucous gulls from Adventfjorden and Sassendalen, located near Longyearbyen on the west coast of Spitsbergen (Hovden, 2018).

Established TH baseline levels in glaucous gulls are currently lacking, making it difficult to presume that the observed concentrations were within the normal ranges for this species. It should also be noted that the low sample size within some of the sampling years may have resulted in uncertainty in relation to being representative for the entire population.

Several biological and physical factors are known to influence the TH concentrations and ratios. These include nutritional parameters (food availability, food source, iodine content), ambient temperature, and reproductive condition, where food availability and ambient temperature are considered to be the most important ones in birds (McNabb, 2007). It is possible that the inter-annual variations observed in TH concentrations could be due to annual differences in food availability. In partial food restriction, decreased plasma levels of $T_3$, in combination with increased activity of D3 that inactivates $T_4$ and $T_3$, have been reported in chickens and rats (*Rattus norvegicus*) (Darras et al., 1995). Another study proposed that during restricted food availability, animals will consume less nutrients that are important for the thyroid activity, including calories, thereby decreasing the TH production (Lartey et al., 2015).

In the present study, the $TT_4$ and $TT_3$ concentrations were positively and negatively associated with the annual average ambient temperature in June, respectively, during the 2015 – 2019 period. This is in accordance with previous experiments on chickens (*Gallus gallus*), which exposed the birds to both cold and warm temperatures (Cogburn and Freeman, 1987; Collin et al., 2003). Also, the study on northern fulmars found that the population with lowest $TT_3$ concentrations were exposed to the highest average temperature during the month of sampling relative to the other populations (Verreault et al., 2013). It is therefore possible that ambient temperature could have contributed to the variation in the TH levels in the present study. On the other hand, the daily temperature may vary considerably, and the average temperature in June may not necessarily represent the specific temperature at the day of sampling. Thus, it is not clear whether the daily changes in ambient temperature observed in Svalbard would have had an effect on the TH concentrations.

The variation in TH concentrations and ratios within each sex across the five-year period were generally similar. The higher variation in mean TH concentrations observed in females relative to males could be caused by sex difference in relation to reproductive condition (McNabb, 2007). However, the reason why females from Bjørnøya and Kongsfjorden had similar temporal variation in the TH levels is not known. It could be questioned whether a common factor, in combination with egg laying, could have caused this, such as food availability and conditions in the wintering areas. The incubation period can be a costly process, as mentioned previously, possibly making female birds more susceptible to these other factors that could alter the TH levels (Hanssen et al., 2005; Sebastiano et al., 2021). The high contaminant concentrations could also be one such factor, and may explain why females from Bjørnøya had more associations between THs and PFASs than females from Kongsfjorden, and also why females in general had more associations between THs and PFASs than the males in the present study, as also reported in great black-backed gulls (*Larus marinus*) (Sebastiano et al., 2021).

## 4.3. Relationship between TH concentrations and OHC concentrations and biological variables

Although there were no differences in the TH levels between the highly polluted birds from Bjørnøya and the less polluted birds from Kongsfjorden, as supported by the PCAs including both locations, the other PCAs and correlations suggested that TH concentrations and ratios in glaucous gulls were affected by the contaminants. Relationships were mainly observed between THs and PFASs, and they were mainly positive. It is, however, important to note that correlations do not imply causation. Nevertheless, results from PCAs and correlations were used to support the results from the LMMs.

The LMMs, which included both locations and sexes, confirmed positive effects of PFASs on the TH concentrations. No effects on THs were identified for OCs, and no effects of contaminants were identified on the TH ratios. This is partly in accordance with previous studies on glaucous gulls, which have reported different results. These include positive associations between PFASs and TH concentrations (Haugerud, 2011; Hovden, 2018; Melnes et al., 2017), no or negative associations or effects of OCs on TH concentrations and TH ratios (Haugerud, 2011; Melnes et al., 2017; Verreault et al., 2004; Verreault et al., 2007), and no or negative associations between PFASs and $TT_4/TT_3$ ratio (Haugerud, 2011). Differences in reported effects or associations between the present and previous studies could be attributed to changes in OHC concentrations, such as the increase in PFOS concentrations in birds from Bjørnøya since 2004. Positive associations between PFASs and $TT_3$ concentrations were also reported in great black-backed gulls, however, the same study found no associations between

PFASs and $TT_3$ concentrations in lesser black-backed gulls (*Larus fuscus graellsii*) and herring gulls (*Larus argentatus*) (Sebastiano et al., 2021).

Despite that the results from the LMMs indicated that PFASs had positive effects on the TH concentrations, no differences in TH levels between the birds from Bjørnøya and the birds from Kongsfjorden indicate that the glaucous gulls were able to maintain constant TH concentrations regardless of the high OHC concentrations. This may be supported by the fact that concentrations of these hormones are kept relatively constant, at least under normal circumstances. The TSH regulates the circulating TH concentrations under negative feedback control in the HPT axis, and it could be hypothesised that if PFASs were positively affecting the TH concentrations, the TSH concentrations should be less than normal, or less in birds from Bjørnøya than in birds from Kongsfjorden (Hulbert, 2000; McNabb, 2007). This pattern was observed in the previous master project on glaucous gulls from Adventfjorden and Sassendalen, where high hepatic concentrations of PFASs (i.e. PFTeA and PFOS) were related to low plasma TSH concentrations (Hovden, 2018). However, a follow-up study found no relationship between hepatic PFAS and OC concentrations and plasma TSH concentrations when investigating a larger sample size (Jenssen B.M., personal communication, June 4, 2021), suggesting that the TSH is not affected by OHC exposure in glaucous gulls. However, if their plasma PFAS concentrations were less than in the birds from Bjørnøya, an effect of PFASs on the TSH levels should not be ruled out in the present study.

It has been suggested that the similar TH concentrations in glaucous gulls from Bjørnøya and Kongsfjorden could be due to that the positive effects of PFASs "compensated" for the negative effects of OCs (Melnes et al., 2017). Although this could explain why the two populations did not differ in their TH concentrations, the present study does not support this hypothesis, as the LMMs did not indicate effects of OCs on the TH concentrations or ratios.

The disruptive mechanism(s) of PFASs on the thyroid homeostasis is still largely unknown, and there are several potential effects that may result in altered TH levels. These may include interference with the synthesis and secretion, transport, action, and metabolism of the THs, including effects on deiodinases, SULTs, and UGTs, and also effects on the thyroid gland integrity (Boas et al., 2012; Coperchini et al., 2020; Ghassabian and Trasande, 2018). When assessing disruptive effects on the TH homeostasis, altered TH ratios are considered to be the most relevant measurements (Nøst et al., 2012). No effects of PFASs, or other contaminant groups, were observed for any of the TH ratios in glaucous gulls in the present study.

Nevertheless, increased plasma TH concentrations in response to PFAS exposure could be explained by competitive binding with the plasma TH transport proteins albumin and TTR. Although PFASs are structurally different from THs, they resemble fatty acids, which are also known to bind to albumin (Weiss et al., 2009). To our knowledge, no scientific report exists on comparison of binding affinity of PFASs and THs with albumin in birds. However, the recent *in silico* study on glaucous gulls revealed similar or weaker binding of PFASs than THs with TTR (Mortensen et al., 2020). This suggests that binding with TTR, and thereby displacement of THs, may be of less importance with respect to thyroid disruptive effects of PFASs in glaucous gulls. This may be supported by the fact that if PFASs were to displace $T_4$ and $T_3$ from their transport proteins to a large degree, the clearance of these THs could increase, resulting in lower plasma concentrations of $T_4$ and $T_3$, as previously shown for $T_4$ and OCs (Bastomsky, 1974; Zoeller, 2010).

However, albumin has been shown to be the main transporter of several PFASs in human plasma (Forsthuber et al., 2020). Because albumin is the main transporter of THs in birds, it is therefore possible that the positive effects of PFASs on plasma concentrations of THs were a result of high plasma protein concentrations (Ask et al., 2021). This could explain the positive association between PFAS concentrations and $TT_4$ and $TT_3$ concentrations in the present study, since all of these compounds would have more proteins to bind to. The amount of circulating free THs is regulated (McNabb, 2007), and it is possible that this regulation keep the $TT_4/FT_4$ and $TT_3/FT_3$ ratios constant with increasing levels of $TT_4$ and $TT_3$, respectively, thereby possibly causing an indirect positive effect of PFASs on $FT_4$ and $FT_3$. This could explain the positive effect of PFASs on $FT_4$ and $FT_3$, and that no effects of PFASs were indicated on $TT_4/FT_4$ and $TT_3/FT_3$ ratios in the present study.

Binding of PFASs with TRs have also been demonstrated in the *in silico* study on glaucous gulls (Mortensen et al., 2020), and studies on other species have found that PFASs alter TH-responsive gene expression in the same manner as $T_3$, including in herring gulls (Ren et al., 2015; Vongphachan et al., 2011). Based on this, it is reasonable to suggest that these agonistic effects of PFASs could be observed in glaucous gulls, potentially causing increased synthesis of $T_4$ and $T_3$. However, increased TH synthesis due to PFAS exposure should also be reflected in $TT_4$ concentrations, and the ΣPFSA/ΣPFAS ratio were the only contaminant group that had an effect on $TT_4$ concentrations in the present study. Although it is possible that this could explain at least some of the positive effects of PFASs on TH concentrations, Mortensen et al. (2020) found that PFCAs, and not PFSAs, had affinity towards the TRs in glaucous gulls.

Therefore, the positive effects of ΣPFSA on $FT_4$, $TT_3$, and $FT_3$ concentrations, and thereby also the effect of ΣPFSA/ΣPFAS ratio on $TT_4$, $FT_4$, and $TT_3$ concentrations are mostly likely not explained by binding of PFSAs with the TRs.

In addition to effects of PFASs, the multivariate analyses suggest that the TH concentrations in glaucous gulls could be explained by location, sampling year, sex, BCI, and plasma lipid weight percentage. Because collinear variables were not included in the LMMs explaining the TH concentrations, an indirect effect of one included variable (e.g. PFAS) on another may not occur. Location only explained variation in $TT_4$ concentrations, and it is not clear why birds from Kongsfjorden were indicated to have higher $TT_4$ concentrations than birds from Bjørnøya. Differences in diet could contribute to location differences in TH levels. For instance, higher iodine contents in the diet favors formation of $T_4$ (Verreault et al., 2004). However, this should also be reflected as higher $TT_4/TT_3$ ratios in birds from Kongsfjorden.

LMMs revealed higher $TT_3$ and $FT_3$ concentrations, and lower $FT_4$ concentrations and $FT_4/FT_3$ ratios in males than in females, with differences in $FT_3$ concentrations and $FT_4/FT_3$ ratios being confirmed by statistical significance tests on the data. Lower $FT_4/FT_3$ ratios in males were consequently a result of their higher $FT_3$ concentrations. This supports that other factors than contaminant concentrations, like reproductive condition (McNabb, 2007), may have contributed to these sex differences.

The positive effect of BCI on $TT_3$ concentrations and $TT_4/FT_4$ ratio indicated by the LMMs, is in accordance with body condition influencing TH levels in birds (McNabb, 2000; Melnes et al., 2017), although BCI did not affect the other THs. Also, an effect of BCI could be due to food availability, where low BCI would reflect food scarcity (Bustnes et al., 2008). Food restriction and lower nutrient intake have been suggested to decrease TH concentrations (Darras et al., 1995; Lartey et al., 2015), as previously discussed. If BCI was related to food intake in these glaucous gulls, this could support the positive effect of BCI on $TT_3$ concentrations and $TT_4/FT_4$ ratios, and also the positive associations between BCI and $TT_3$ and $FT_3$ concentrations observed in male birds from Kongsfjorden in the present study.

The LMMs indicated positive effects of plasma lipid weight percentage on the $FT_4$, $TT_3$, and $FT_3$ concentrations. The birds diet is reflected in their plasma lipid content (Bustnes et al., 2000; Bustnes et al., 2012), suggesting that these positive effects were due to the birds feeding ecology. This is in accordance with the fact that nutritional parameters, such as food source, are important factors contributing to variations in TH levels in birds (McNabb, 2007).

It should be kept in mind that all LMMs with a ΔAICc > 2 are considered equally good, and an effect of the variables included in these should not be ruled out (Burnham and Anderson, 2004). For this reason, effects of all contaminant groups on TH concentrations and TH ratios were possible. What should also be noted is the general low Aikake weights of the LMMs, with a few exceptions, meaning that the LMMs contained a low percentage of the total explanation that could be found in the full set of candidate models. This means that there were model selection uncertainties, suggesting that the included variables were in general poor predictors for the TH concentrations and ratios (Symonds and Moussalli, 2011). This makes sense in regard to the contaminant groups, as there were no differences in TH concentrations between the two differently contaminated populations.

It should also be taken into consideration that samples from the present study were only obtained from breeding, and thereby relatively healthy birds. This raises the question whether biased sampling might have influenced the results, analogous to the Healthy Worker Effect (HWE) phenomenon observed in human occupational disease studies. The HWE could be explained as the underestimated risk of death due to the severe ill and chronically disabled workers being excluded from employment, thereby resulting in workers with lower death rates than the general population (Shah, 2009). It is therefore possible that birds that were not fit to reproduce due to reduced health would have revealed different results. Also, individuals in their early life-stages that do not have the ability to tackle or adapt to high OHC concentrations may not survive to reproduce. Indeed, it has been shown that the survival and return rate of glaucous gulls on Bjørnøya are negatively affected by OHC exposure (Bustnes et al., 2003c; Bustnes et al., 2005; Erikstad et al., 2013).

## 4.4. Implications of findings and future perspectives

The results from the present study add to the suggestions that the TH concentrations in itself are not contributing to the decline of the heavily polluted glaucous gulls on Bjørnøya (McNabb and Fox, 2003; Melnes et al., 2017; Verreault et al., 2007). However, future studies should measure the TSH concentrations in these two populations to confirm if there is an effect on the HPT axis in these birds. If the TH concentrations were regulated by the TSH, and the effects of PFASs on the TH levels were positive, low TSH concentrations in birds from Bjørnøya could be expected, as previously suggested herein. Hyperthyroidism is characterised by normal or high TH (i.e. $FT_4$ and $FT_3$) concentrations, depending on the severity, in combination with low TSH concentrations. Hyperthyroidism could cause severe effects on an individual level, which in humans include body weight loss, fatigue, and muscle weakness (Gurgul and Sowinski, 2011). Such reduced individual fitness could have negative consequences on the population level.

If the TSH was not affected by OHC concentrations in the glaucous gulls, effects on the HPT axis do not seem to be an important factor contributing to the population decline on Bjørnøya. Therefore, aside from measuring the TSH levels, it is recommended to focus on other endpoints than the HPT axis when investigating the potential causes of the glaucous gull population decline, including immune system and metabolic parameters. Elimination processes could be of particular interest, as initiation of pathways to cope with contaminant exposure could allocate energy from other important processes in the individual, possibly affecting the bird's overall fitness.

In light of the results from previous studies on glaucous gulls (Haugerud, 2011; Hovden, 2018; Melnes et al., 2017) and great black-backed gulls (Sebastiano et al., 2021), the present study suggests that it is possible that some relationships between contaminant levels and the measured endpoints could be detected when only studying the levels within one population. However, variations in the measured endpoint caused by other factors could be interpreted as an effect of or association with the OHC concentrations. It is therefore recommended to compare the measured biological effects between different populations of the study species, as done herein and in previous studies (McNabb and Fox, 2003; Verreault et al., 2013).

When investigating endpoints that could contribute to the explanation of the population decline observed on Bjørnøya, or when assessing the biological effects of contaminant exposure in wildlife in general, the selection of individuals should also be taken into consideration. To avoid biased sampling by only obtaining samples from breeding (i.e. healthy) individuals, analogous to the HWE phenomenon, future studies are recommended to include early life-stage and non-breeding individuals.

# 5. CONCLUSION

The present study is the first to compare biological effects of OHCs in two highly differently contaminated populations of glaucous gulls over a five-year period. The birds from Bjørnøya had much higher plasma ΣPCB, ΣOCP, and ΣPFAS concentrations than birds from Kongsfjorden (approximately 3.0, 3.2, and 22.2 times higher, respectively). The main results showed that the plasma TH concentrations and the various TH ratios in the high contaminated birds from Bjørnøya did not differ from the low contaminated birds from Kongsfjorden. Thus, the hypothesis that altered TH concentrations due to the high OHC concentrations could have contributed to the population decline on Bjørnøya was rejected. This was not expected, as previous studies have reported altered TH concentrations with increasing contaminant exposure. However, despite no differences in TH levels between the two populations and that PCAs including both locations did not suggest any association between the OHCs and THs, the LMMs indicated positive effects of PFASs on $TT_4$, $FT_4$, $TT_3$ and $FT_3$ concentrations across the two populations. Because the circulating TH concentrations are regulated by the TSH in the HPT axis, it could be hypothesised that the THs could maintain relatively constant levels despite possible effects of PFASs. It is also possible that biased sampling, analogous to the HWE phenomenon, could have influenced the results. Future studies investigating the population decline on Bjørnøya, and biological effect studies in wildlife in general, are therefore recommended to include early life-stage and non-breeding individuals.

In combination with previous studies, the results from the present study demonstrate the complexity when assessing biological effects in wildlife, and that several factors, including toxicological, environmental, and physiological factors, may contribute to the biological outcome. Caution should therefore be made when comparing results within and between different populations of the same species, and also when extrapolating and comparing results between different species.

# REFERENCES

AMAP, AMAP assessment 2002: persistent organic pollutants in the Arctic. In: S. J. Wilson, G. Packman, Eds.), Oslo, Norway, 2004, pp. 1-293.

AMAP, AMAP assessment 2015: temporal trends in persistent organic pollutants in the Arctic. In: C. Symon, (Ed.), Oslo, Norway, 2016, pp. 1-81.

Ask, A. V., Jenssen, B. M., Tartu, S., Angelier, F., Chastel, O., Gabrielsen, G. W., 2021. Per- and polyfluoroalkyl substances are positively associated with thyroid hormones in an arctic seabird. Environmental Toxicology and Chemistry. 40**,** 820-831.

Bakken, V., Tertitski, G. M., Glaucous gull Larus hyperboreus. In: T. Anker-Nilssen, et al., Eds.), The status of marine birds breeding in the Barents Sea region, Tromsø, Norway, 2000, pp. 94-96.

Bastomsky, C., 1974. Effects of a polychlorinated biphenyl mixture (Aroclor 1254) and DDT on biliary thyroxine excretion in rats. Endocrinology. 95**,** 1150-1155.

Boas, M., Feldt-Rasmussen, U., Main, K. M., 2012. Thyroid effects of endocrine disrupting chemicals. Molecular and Cellular Endocrinology. 355**,** 240-248.

Bogan, J. A., Bourne, W. R. P., 1972. Organochlorine levels in atlantic seabirds. Nature. 240**,** 358-358.

Bolton, M., Monaghan, P., Houston, D. C., 1993. Proximate determination of clutch size in lesser black-backed gulls: the roles of food supply and body condition. Canadian Journal of Zoology. 71**,** 273-279.

Borgå, K., Fisk, A. T., Hoekstra, P. F., Muir, D. C., 2004. Biological and chemical factors of importance in the bioaccumulation and trophic transfer of persistent organochlorine contaminants in arctic marine food webs. Environmental Toxicology and Chemistry: An International Journal. 23**,** 2367-2385.

Burnham, K. P., Anderson, D. R., 2004. Multimodel inference: understanding AIC and BIC in model selection. Sociological Methods & Research. 33**,** 261-304.

Bustnes, J. O., Erikstad, K. E., Bakken, V., Mehlum, F., Skaare, J. U., 2000. Feeding ecology and the concentration of organochlorines in glaucous gulls. Ecotoxicology. 9**,** 179-186.

Bustnes, J. O., Bakken, V., Skaare, J. U., Erikstad, K. E., 2003a. Age and accumulation of persistent organochlorines: A study of arctic-breeding glaucous gulls (*Larus hyperboreus*). Environmental Toxicology and Chemistry: An International Journal. 22**,** 2173-2179.

Bustnes, J. O., Erikstad, K. E., Skaare, J. U., Bakken, V., Mehlum, F., 2003b. Ecological effects of organochlorine pollutants in the Arctic: a study of the glaucous gull Ecological Applications. 13, 504-515.

Bustnes, J. O., Erikstad, K. E., Skaare, J. U., Bakken, V., Mehlum, F., 2003c. Ecological effects of organochlorine pollutants in the Arctic: a study of the glaucous gull. Ecological Applications. 13, 504-515.

Bustnes, J. O., Miland, Ø., Fjeld, M., Erikstad, K. E., Skaare, J. U., 2005. Relationships between ecological variables and four organochlorine pollutants in an Artic glaucous gull (*Larus hyperboreus*) population. Environmental Pollution. 136, 175-185.

Bustnes, J. O., Fauchald, P., Tveraa, T., Helberg, M., Skaare, J. U., 2008. The potential impact of environmental variation on the concentrations and ecological effects of pollutants in a marine avian top predator. Environment International. 34, 193-201.

Bustnes, J. O., Gabrielsen, G. W., Verreault, J., 2010. Climate variability and temporal trends of persistent organic pollutants in the Arctic: a study of glaucous gulls. Environmental Science & Technology. 44, 3155-3161.

Bustnes, J. O., Moe, B., Hanssen, S. A., Herzke, D., Fenstad, A. A., Nordstad, T., Borgå, K., Gabrielsen, G. W., 2012. Temporal dynamics of circulating persistent organic pollutants in a fasting seabird under different environmental conditions. Environmental Science & Technology. 46, 10287-10294.

Bytingsvik, J., Organohalogenated contaminants (OHCs) in polar bear mother-cub pairs from Svalbard, Norway: maternal transfer, exposure assessment and thyroid hormone disruptive effects in polar bear cubs (Doctoral thesis). Norwegian University of Science and Technology, Trondheim, Norway, 2012.

Cogburn, L. A., Freeman, R. M., 1987. Response surface of daily thyroid hormone rhythms in young chickens exposed to constant ambient temperature. General and Comparative Endocrinology. 68, 113-123.

Collin, A., Buyse, J., Van As, P., Darras, V. M., Malheiros, R. D., Moraes, V. M., Reyns, G. E., Taouis, M., Decuypere, E., 2003. Cold-induced enhancement of avian uncoupling protein expression, heat production, and triiodothyronine concentrations in broiler chicks. General and Comparative Endocrinology. 130, 70-77.

Coperchini, F., Croce, L., Ricci, G., Magri, F., Rotondi, M., Imbriani, M., Chiovato, L., 2020. Thyroid disrupting effects of old and new generation PFAS. Frontiers in Endocrinology. 11, 1-18.

Cramp, S., 1983. Handbook of the birds of Europe, the Middle East and North Africa: the birds of the Western Palearctic: 3. Waders to gulls. Oxford University Press, Oxford.

Darras, V., Cokelaere, M., Dewil, E., Arnouts, S., Decuypere, E., Kühn, E., 1995. Partial food restriction increases hepatic inner ring deiodinating activity in the chicken and the rat. General and Comparative Endocrinology. 100**,** 334-338.

Dietz, R., Letcher, R. J., Desforges, J.-P., Eulaers, I., Sonne, C., Wilson, S., Andersen-Ranberg, E., Basu, N., Barst, B. D., Bustnes, J. O., 2019. Current state of knowledge on biological effects from contaminants on arctic wildlife and fish. Science of the Total Environment. 696**,** 1-40.

Erikstad, K. E., Sandvik, H., Reiertsen, T. K., Bustnes, J. O., Strøm, H., Erikstad, K. E., 2013. Persistent organic pollution in a high-Arctic top predator: sex-dependent thresholds in adult survival. Proceedings. Biological sciences. 280**,** 1-7.

Fauchald, P., Anker-Nilssen, T., Barrett, R., Bustnes, J. O., Bårdsen, B.-J., Christensen-Dalsgaard, S. N., Descamps, S., Engen, S., Erikstad, K. E., Hanssen, S. A., Lorentsen, S.-H., Moe, B., Reiertsen, T. K., Strøm, H., Systad, G. H., Glaucous gull Larus hyperboreus. The status and trends of seabirds breeding in Norway and Svalbard, Tromsø, Norway, 2015, pp. 30-31.

Forsthuber, M., Kaiser, A. M., Granitzer, S., Hassl, I., Hengstschläger, M., Stangl, H., Gundacker, C., 2020. Albumin is the major carrier protein for PFOS, PFOA, PFHxS, PFNA and PFDA in human plasma. Environment International. 137**,** 1-5.

Gabrielsen, G. W., Levels and effects of persistent organic pollutants in Arctic animals. Arctic alpine ecosystems and people in a changing environment. Springer, 2007, pp. 377-412.

Ghassabian, A., Trasande, L., 2018. Disruption in thyroid signaling pathway: a mechanism for the effect of endocrine-disrupting chemicals on child neurodevelopment. Frontiers in Endocrinology. 9**,** 1-8.

Griffiths, R., Double, M. C., Orr, K., Dawson, R. J., 1998. A DNA test to sex most birds. Molecular Ecology. 7**,** 1071-1075.

Gurgul, E., Sowinski, J., 2011. Primary hyperthyroidism-diagnosis and treatment. Indications and contraindications for radioiodine therapy. Nuclear Medicine Review. 14**,** 29-32.

Götsch, A., Mariussen, E., von der Recke, R., Herzke, D., Berger, U., Vetter, W., 2005. Analytical strategies for successful enantioselective separation of atropisomeric polybrominated biphenyls 132 and 149 in environmental samples. Journal of Chromatography A. 1063**,** 193-199.

Hanssen, L., Dudarev, A. A., Huber, S., Odland, J. Ø., Nieboer, E., Sandanger, T. M., 2013. Partition of perfluoroalkyl substances (PFASs) in whole blood and plasma, assessed in maternal and umbilical cord samples from inhabitants of arctic Russia and Uzbekistan. Science of the Total Environment. 447**,** 430-437.

Hanssen, S. A., Hasselquist, D., Folstad, I., Erikstad, K. E., 2005. Cost of reproduction in a long-lived bird: incubation effort reduces immune function and future reproduction. Proceedings of the Royal Society B: Biological Sciences. 272**,** 1039-1046.

Haugerud, A. J., Levels and effects of organohalogenated contaminants on thyroid hormone levels in glaucous gulls (*Larus hyperboreus*) from Kongsfjorden, Svalbard (Master's thesis). Norwegian University of Science and Technology, Trondheim, Norway, 2011.

Haukås, M., Berger, U., Hop, H., Gulliksen, B., Gabrielsen, G. W., 2007. Bioaccumulation of per-and polyfluorinated alkyl substances (PFAS) in selected species from the Barents Sea food web. Environmental Pollution. 148**,** 360-371.

Hekster, F. M., Laane, R. W., De Voogt, P., 2003. Environmental and toxicity effects of perfluoroalkylated substances. Reviews of Environmental Contamination and Toxicology. 99-121.

Henriksen, E. O., Levels and congener pattern of PCBs in kittiwakes, *Rissa tridactyla*, in relation to mobilization of body-lipids associated with reproduction (Master's thesis). University of Tromsø, Tromsø, Norway, 1995.

Henriksen, E. O., Gabrielsen, G. W., Utne Skaare, J., 1998. Validation of the use of blood samples to assess tissue concentrations of organochlorines in glaucous gulls, *Larus hyperboreus*. Chemosphere (Oxford). 37**,** 2627-2643.

Henriksen, E. O., Gabrielsen, G. W., Trudeau, S., Wolkers, J., Sagerup, K., Skaare, J. U., 2000. Organochlorines and possible biochemical effects in glaucous gulls (*Larus hyperboreus*) from Bjørnøya, the Barents Sea. Archives of Environmental Contamination and Toxicology. 38**,** 234-243.

Herzke, D., Berger, U., Kallenborn, R., Nygård, T., Vetter, W., 2005. Brominated flame retardants and other organobromines in Norwegian predatory bird eggs. Chemosphere. 61**,** 441-449.

Herzke, D., Nygård, T., Berger, U., Huber, S., Røv, N., 2009. Perfluorinated and other persistent halogenated organic compounds in European shag (*Phalacrocorax aristotelis*) and common eider (*Somateria mollissima*) from Norway: A suburban to remote pollutant gradient. Science of the Total Environment. 408**,** 340-348.

Hitchcock, D. J., Andersen, T., Varpe, Ø., Borgå, K., 2019. Effects of maternal reproductive investment on sex-specific pollutant accumulation in seabirds: a meta-analysis. Environmental Science & Technology. 53, 7821-7829.

Hovden, T. S., Thyroid hormone status and thyroid gland histology in PFAS- and mercury contaminated glaucous gulls (*Larus hyperboreus*) from Svalbard (Master's thesis). Norwegian University of Science and Technology, Trondheim, Norway, 2018.

Hulbert, A., 2000. Thyroid hormones and their effects: a new perspective. Biological Reviews. 75, 519-631.

Husabø, E., Contrasting body burdens of organohalogenated contaminants (OHCs) in two Arctic glaucous gull *Larus hyperboreus* colonies in relation to their dietary ecology (Master's thesis). University of Tromsø Tromsø, Norway, 2021.

Knudtzon, N. C., Thorstensen, H., Ruus, A., Helberg, M., Bæk, K., Enge, E. K., Borgå, K., 2021. Maternal transfer and occurrence of siloxanes, chlorinated paraffins, metals, PFAS and legacy POPs in herring gulls (*Larus argentatus*) of different urban influence. Environment International. 152, 1-10.

Lartey, L. J., Werneck-de-Castro, J. P., InSug, O., Unterman, T. G., Bianco, A. C., 2015. Coupling between nutrient availability and thyroid hormone activation. Journal of Biological Chemistry. 290, 30551-30561.

Letcher, R. J., Bustnes, J. O., Dietz, R., Jenssen, B. M., Jørgensen, E. H., Sonne, C., Verreault, J., Vijayan, M. M., Gabrielsen, G. W., 2010. Exposure and effects assessment of persistent organohalogen contaminants in Arctic wildlife and fish. The Science of the Total Environment. 408, 2995-3043.

Macdonald, R., Harner, T., Fyfe, J., 2005. Recent climate change in the Arctic and its impact on contaminant pathways and interpretation of temporal trend data. Science of the Total Environment. 342, 5-86.

McNabb, F. A., Thyroids. In: G. C. Whittow, (Ed.), Sturkie's Avian Physiology Academic Press, San Diego, 2000, pp. 461-472.

McNabb, F. A., Fox, G. A., 2003. Avian thyroid development in chemically contaminated environments: is there evidence of alterations in thyroid function and development? Evolution & Development. 5, 76-82.

McNabb, F. A., 2007. The hypothalamic-pituitary-thyroid (HPT) axis in birds and its role in bird development and reproduction. Critical reviews in toxicology. 37, 163-193.

Melnes, M., Gabrielsen, G. W., Herzke, D., Sagerup, K., Jenssen, B. M., 2017. Dissimilar effects of organohalogenated compounds on thyroid hormones in glaucous gulls. Environmental Research. 158**,** 350-357.

Moran, M. D., 2003. Arguments for rejecting the sequential Bonferroni in ecological studies. Oikos. 100**,** 403-405.

Mortensen, Å.-K., Mæhre, S., Kristiansen, K., Heimstad, E. S., Gabrielsen, G. W., Jenssen, B. M., Sylte, I., 2020. Homology modeling to screen for potential binding of contaminants to thyroid hormone receptor and transthyretin in glaucous gull (*Larus hyperboreus*) and herring gull (*Larus argentatus*). Computational Toxicology. 13**,** 1-8.

Muir, D. C., de Wit, C. A., 2010. Trends of legacy and new persistent organic pollutants in the circumpolar arctic: overview, conclusions, and recommendations. Science of the Total Environment. 408**,** 3044-3051.

Nøst, T. H., Helgason, L. B., Harju, M., Heimstad, E. S., Gabrielsen, G. W., Jenssen, B. M., 2012. Halogenated organic contaminants and their correlations with circulating thyroid hormones in developing Arctic seabirds. Science of the Total Environment. 414**,** 248-256.

O'Sullivan, G., Megson, D., Brief overview: discovery, regulation, properties, and fate of POPs. Environmental Forensics for Persistent Organic Pollutants. Elsevier, 2014, pp. 1-20.

Powley, C. R., George, S. W., Ryan, T. W., Buck, R. C., 2005. Matrix effect-free analytical methods for determination of perfluorinated carboxylic acids in environmental matrixes. Analytical Chemistry. 77**,** 6353-6358.

R Core Team, R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria, 2020.

Ren, X.-M., Zhang, Y.-F., Guo, L.-H., Qin, Z.-F., Lv, Q.-Y., Zhang, L.-Y., 2015. Structure-activity relations in binding of perfluoroalkyl compounds to human thyroid hormone T3 receptor. Archives of Toxicology. 89**,** 233-242.

Sagerup, K., Henriksen, E., Skorping, A., Skaare, J., Gabrielsen, G., Sagerup, K., 2000. Intensity of parasitic nematodes increases with organochlorine levels in the glaucous gull. Journal of Applied Ecology. 37**,** 532-539.

Sagerup, K., Henriksen, E. O., Skaare, J. U., Gabrielsen, G. W., 2002. Intraspecific variation in trophic feeding levels and organochlorine concentrations in glaucous gulls (*Larus hyperboreus*) from Bjørnøya, the Barents Sea. Ecotoxicology. 11**,** 119-125.

Sagerup, K., Helgason, L. B., Polder, A., Strøm, H., Josefsen, T. D., Skåre, J. U., Gabrielsen, G. W., 2009. Persistent organic pollutants and mercury in dead and dying glaucous gulls (*Larus hyperboreus*) at Bjørnøya (Svalbard). Science of the Total Environment. 407**,** 6009-6016.

Sebastiano, M., Angelier, F., Blevin, P., Ribout, C., Sagerup, K., Descamps, S., Herzke, D., Moe, B., Barbraud, C., Bustnes, J. O., 2020. Exposure to PFAS is associated with telomere length dynamics and demographic responses of an arctic top predator. Environmental Science & Technology. 54**,** 10217-10226.

Sebastiano, M., Jouanneau, W., Blévin, P., Angelier, F., Parenteau, C., Gernigon, J., Lemesle, J., Robin, F., Pardon, P., Budzinski, H., 2021. High levels of fluoroalkyl substances and potential disruption of thyroid hormones in three gull species from South Western France. Science of The Total Environment. 765**,** 1-11.

Shah, D., 2009. Healthy worker effect phenomenon. Indian Journal of Occupational and Environmental Medicine. 13**,** 77-79.

Smits, J., Fernie, K., Bortolotti, G., Marchant, T., 2002. Thyroid hormone suppression and cell-mediated immunomodulation in American kestrels (*Falco sparverius*) exposed to PCBs. Archives of Environmental Contamination and Toxicology. 43**,** 0338-0344.

Sonne, C., 2010. Health effects from long-range transported contaminants in Arctic top predators: an integrated review based on studies of polar bears and relevant model species. Environment International. 36**,** 461-491.

Sonne, C., Bustnes, J. O., Herzke, D., Jaspers, V. L., Covaci, A., Halley, D. J., Moum, T., Eulaers, I., Eens, M., Ims, R. A., 2010. Relationships between organohalogen contaminants and blood plasma clinical-chemical parameters in chicks of three raptor species from Northern Norway. Ecotoxicology and Environmental Safety. 73**,** 7-17.

Sonne, C., Maehre, S. A. B., Sagerup, K., Harju, M., Heimstad, E. S., Leifsson, P. S., Dietz, R., Gabrielsen, G. W., 2013. A screening of liver, kidney, and thyroid gland morphology in organochlorine-contaminated glaucous gulls (*Larus hyperboreus*) from Svalbard. Toxicological and Environmental Chemistry. 95**,** 172-186.

Sonne, C., Letcher, R. J., Jenssen, B. M., Desforges, J.-P., Eulaers, I., Andersen-Ranberg, E., Gustavson, K., Styrishave, B., Dietz, R., 2017. A veterinary perspective on One Health in the Arctic. Acta Veterinaria Scandinavica. 59**,** 1-11.

Sonne, C., Dietz, R., Jenssen, B. M., Lam, S. S., Letcher, R. J., 2021. Emerging contaminants and biological effects in Arctic wildlife. Trends in Ecology & Evolution. 36**,** 421-429.

Stockholm Convention, The new POPs under the Stockholm Convention. Vol. 2020, 2019a.

Stockholm Convention, The 12 initial POPs under the Stockholm Convention. Vol. 2020, 2019b.

Strøm, H., Distribution of seabirds on Bjørnøya. In: T. Anker-Nilssen, (Ed.), SEAPOP studies in the Lofoten and Barents Sea Area in 2006, Trondheim, Norway, 2007a, pp. 50-52.

Strøm, H., Bjørnøya. In: T. Anker-Nilssen, (Ed.), SEAPOP studies in the Lofoten and Barents Sea Area in 2006, Trondheim, Norway, 2007b, pp. 31-32.

Symonds, M. R., Moussalli, A., 2011. A brief guide to model selection, multimodel inference and model averaging in behavioural ecology using Akaike's information criterion. Behavioral Ecology and Sociobiology. 65**,** 13-21.

Verboven, N., Verreault, J., Letcher, R. J., Gabrielsen, G. W., Evans, N. P., 2008. Maternally derived testosterone and 17β-estradiol in the eggs of Arctic-breeding glaucous gulls in relation to persistent organic pollutants. Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology. 148**,** 143-151.

Verboven, N., Verreault, J., Letcher, R., Gabrielsen, G., Evans, N., 2009a. Differential investment in eggs by Arctic-breeding glaucous gulls (*Larus Hyperboreus*) exposed to persistent organic pollutants. The Auk. 126**,** 123-133.

Verboven, N., Verreault, J., Letcher, R. J., Gabrielsen, G. W., Evans, N. P., 2009b. Nest temperature and parental behaviour of Arctic-breeding glaucous gulls exposed to persistent organic pollutants. Animal Behaviour. 77**,** 411-418.

Verboven, N., Verreault, J., Letcher, R. J., Gabrielsen, G. W., Evans, N. P., 2010. Adrenocortical function of Arctic-breeding glaucous gulls in relation to persistent organic pollutants. General and Comparative Endocrinology. 166**,** 25-32.

Verreault, J., Skaare, J. U., Jenssen, B. M., Gabrielsen, G. W., 2004. Effects of organochlorine contaminants on thyroid hormone levels in Arctic breeding glaucous gulls, *Larus hyperboreus*. Environmental Health Perspectives. 112**,** 532-537.

Verreault, J., Houde, M., Gabrielsen, G. W., Berger, U., Haukås, M., Letcher, R. J., Muir, D. C. G., 2005. Perfluorinated alkyl substances in plasma, liver, brain, and eggs of glaucous gulls (*Larus hyperboreus*) from the Norwegian Arctic. Environmental Science & Technology. 39**,** 7439-7445.

Verreault, J., Villa, R. A., Gabrielsen, G. W., Skaare, J. U., Letcher, R. J., 2006. Maternal transfer of organohalogen contaminants and metabolites to eggs of Arctic-breeding glaucous gulls. Environmental Pollution. 144**,** 1053-1060.

Verreault, J., Bech, C., Letcher, R. J., Ropstad, E., Dahl, E., Gabrielsen, G. W., 2007. Organohalogen contamination in breeding glaucous gulls from the Norwegian Arctic:

associations with basal metabolism and circulating thyroid hormones. Environmental Pollution. 145, 138-145.

Verreault, J., Verboven, N., Gabrielsen, G. W., Letcher, R. J., Chastel, O., 2008. Changes in prolactin in a highly organohalogen contaminated Arctic top predator seabird, the glaucous gull. General and comparative endocrinology. 156, 569-576.

Verreault, J., Gabrielsen, G. W., Bustnes, J. O., The Svalbard glaucous gull as bioindicator species in the European Arctic: insight from 35 years of contaminants research. In: D. M. Whitacre, (Ed.), Reviews of Environmental Contamination and Toxicology Volume 205. Springer New York, New York, NY, 2010, pp. 77-116.

Verreault, J., Helgason, L. B., Gabrielsen, G. W., Dam, M., Braune, B. M., 2013. Contrasting retinoid and thyroid hormone status in differentially-contaminated northern fulmar colonies from the Canadian Arctic, Svalbard and the Faroe Islands. Environment International. 52, 29-40.

Vongphachan, V., Cassone, C. G., Wu, D., Chiu, S., Crump, D., Kennedy, S. W., 2011. Effects of perfluoroalkyl compounds on mRNA expression levels of thyroid hormone-responsive genes in primary cultures of avian neuronal cells. Toxicological Sciences. 120, 392-402.

Weiss, J. M., Andersson, P. L., Lamoree, M. H., Leonards, P. E., van Leeuwen, S. P., Hamers, T., 2009. Competitive binding of poly-and perfluorinated compounds to the thyroid hormone transport protein transthyretin. Toxicological Sciences. 109, 206-216.

Zoeller, T. R., 2007. Environmental chemicals impacting the thyroid: targets and consequences. Thyroid. 17, 811-817.

Zoeller, T. R., 2010. Environmental chemicals targeting thyroid. Hormones. 9, 28-40.

Zuur, A., Ieno, E. N., Walker, N., Saveliev, A. A., Smith, G. M., 2009. Mixed effects models and extensions in ecology with R. Springer Science & Business Media, New York, USA.

# SUPPLEMENTARY INFORMATION

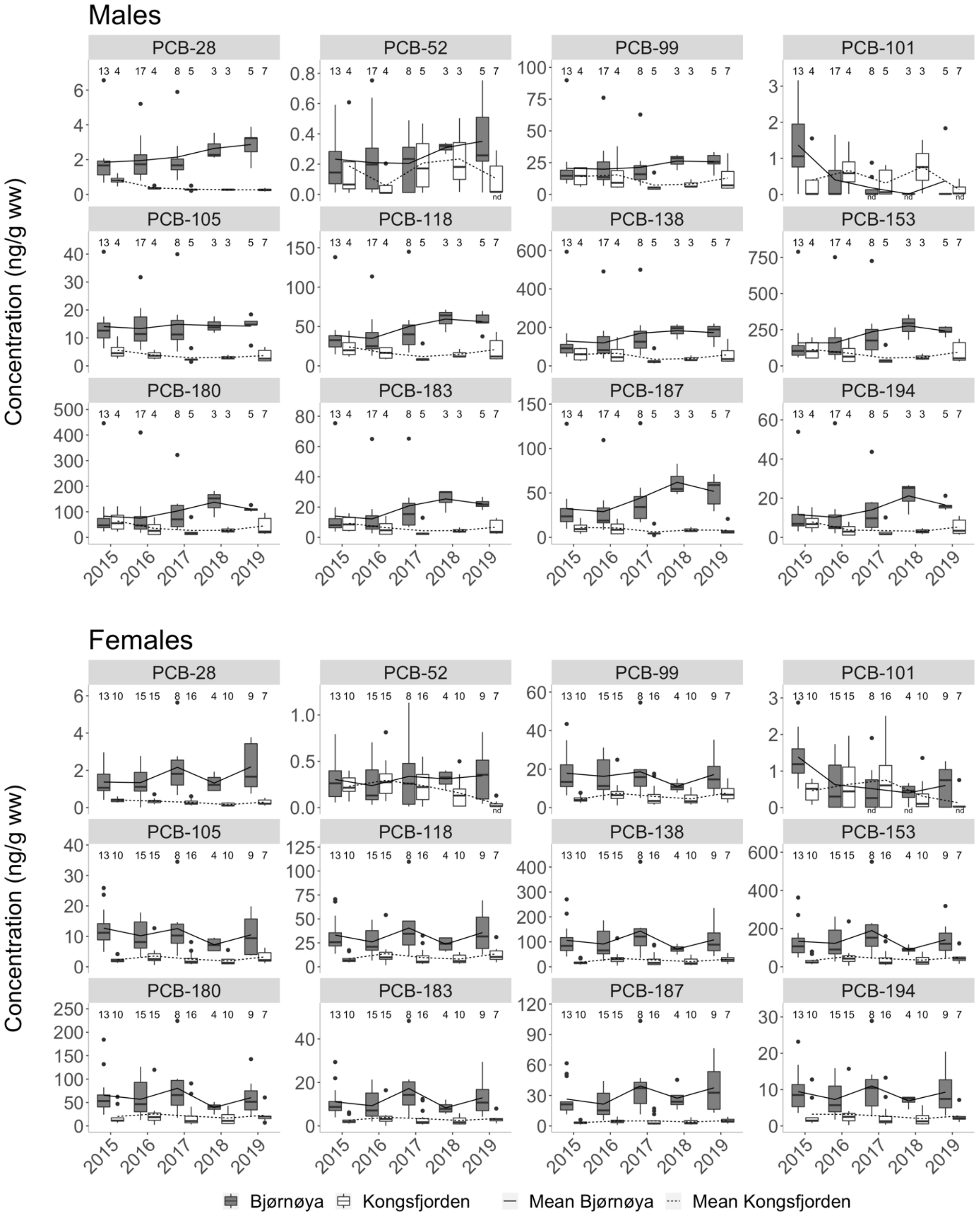

**Figure S1:** Box plots of concentrations (ng/g ww) of polychlorinated biphenyl (PCB) congeners in blood plasma of male and female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Lower and upper box boundaries represent the 25th and 75th percentiles (interquartile range), respectively, line inside the box represents the median, and lower and upper box whiskers/error lines represent the smallest and largest value within 1.5 times interquartile range below the 25th and above the 75th percentile, respectively. Filled circles represent outliers. The solid and dashed lines represent the mean concentrations in birds from Bjørnøya and Kongsfjorden, respectively. Numbers below the facet strips indicate the sample size for each year within each location, and "nd" above x-axis indicates a detection rate below 45%.

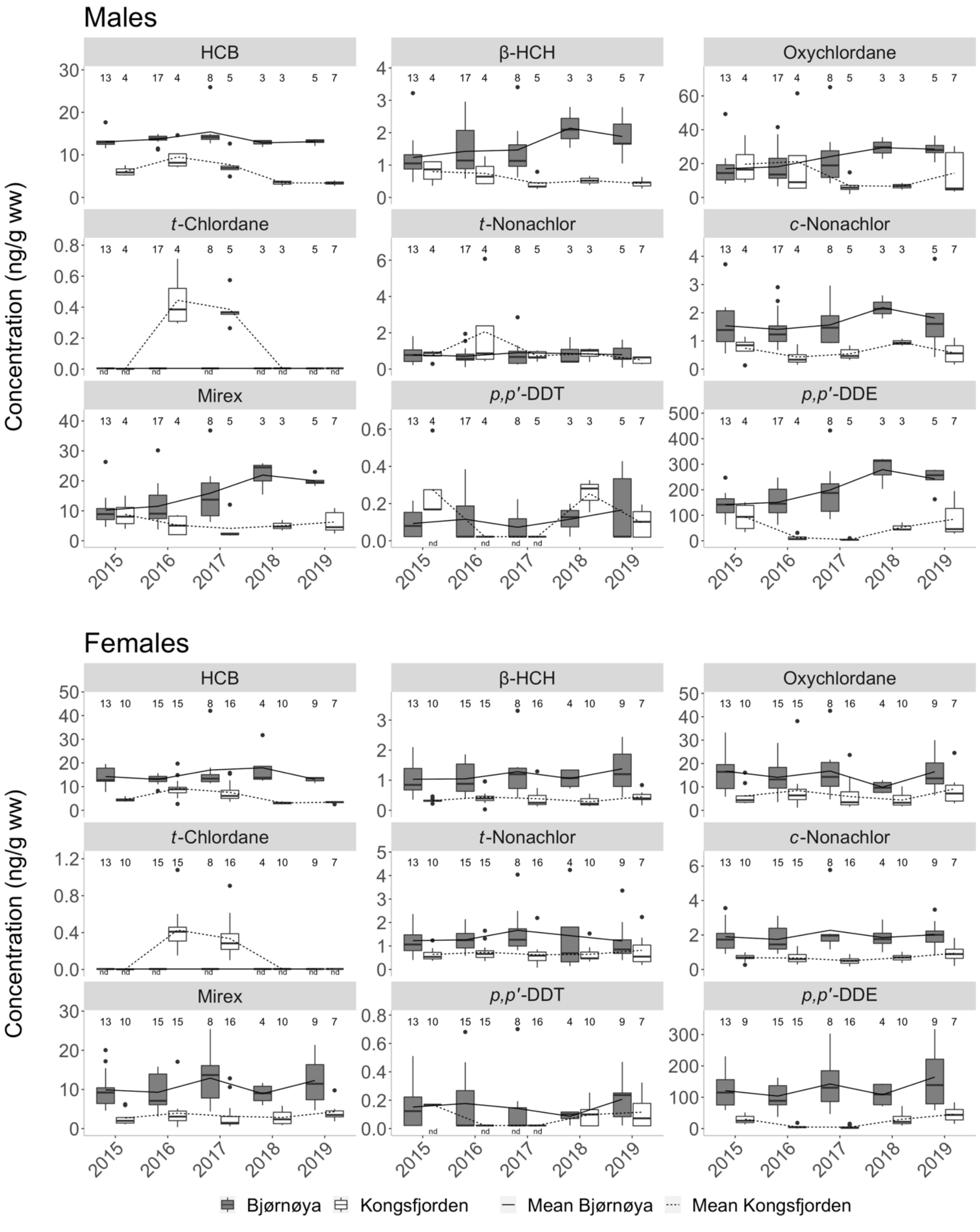

**Figure S2:** Box plots of concentrations (ng/g ww) of organochlorinated pesticides (OCPs) in blood plasma of male and female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Lower and upper box boundaries represent the 25th and 75th percentiles (interquartile range), respectively, line inside the box represents the median, and lower and upper box whiskers/error lines represent the smallest and largest value within 1.5 times interquartile range below the 25th and above the 75th percentile, respectively. Filled circles represent outliers. The solid and dashed lines represent the mean concentrations in birds from Bjørnøya and Kongsfjorden, respectively. Numbers below the facet strips indicate the sample size for each year within each location, and "nd" above x-axis indicates a detection rate below 45%.

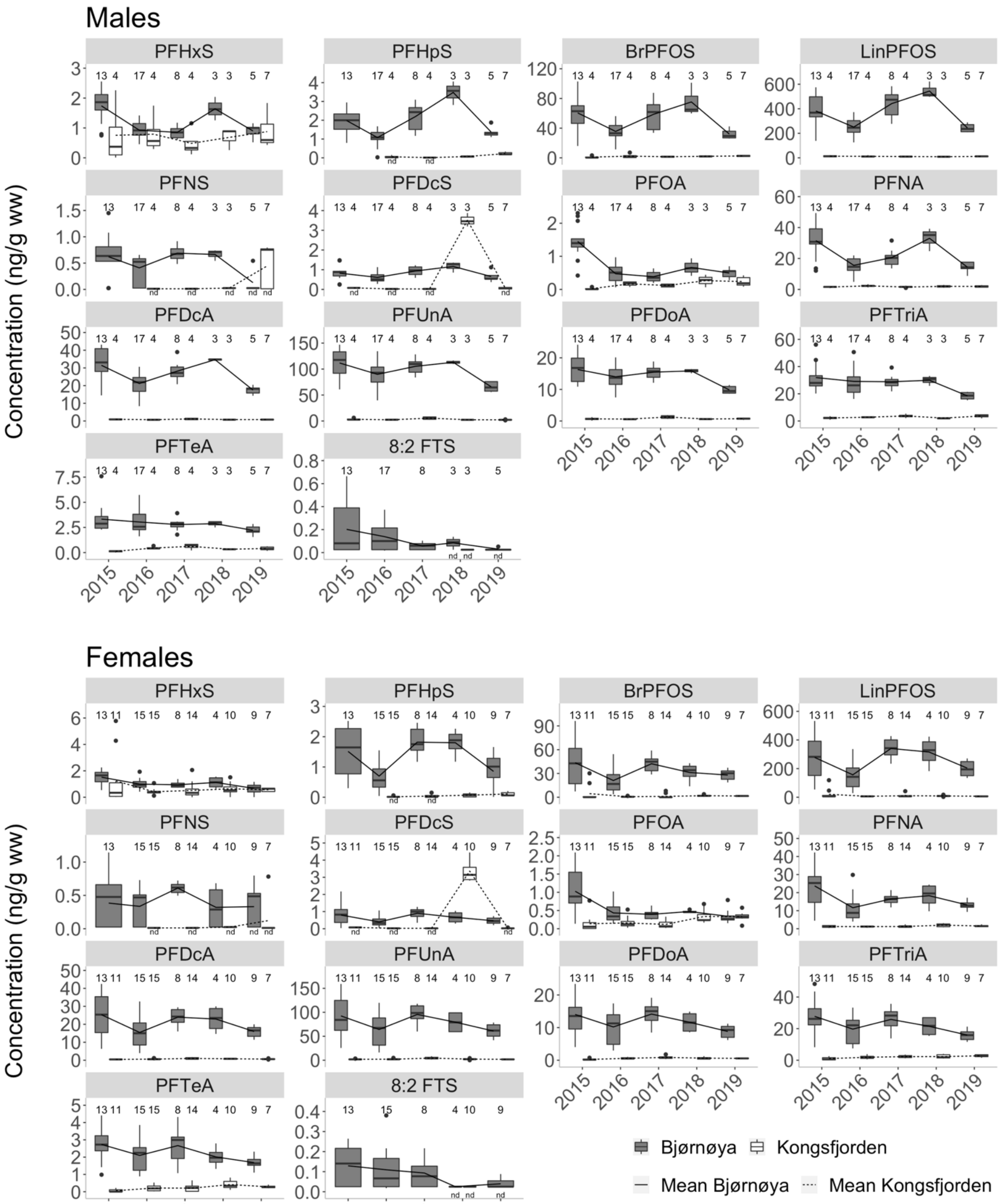

**Figure S3:** Box plots of concentrations (ng/g ww) of per- and polyfluoroalkyl substances (PFASs) in blood plasma of male and female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Lower and upper box boundaries represent the 25th and 75th percentiles (interquartile range), respectively, line inside the box represents the median, and lower and upper box whiskers/error lines represent the smallest and largest value within 1.5 times interquartile range below the 25th and above the 75th percentile, respectively. Filled circles represent outliers. The solid and dashed lines represent the mean concentrations in birds from Bjørnøya and Kongsfjorden, respectively. Numbers below the facet strips indicate the sample size for each year within each location, and “nd” above x-axis indicates a detection rate below 45%.

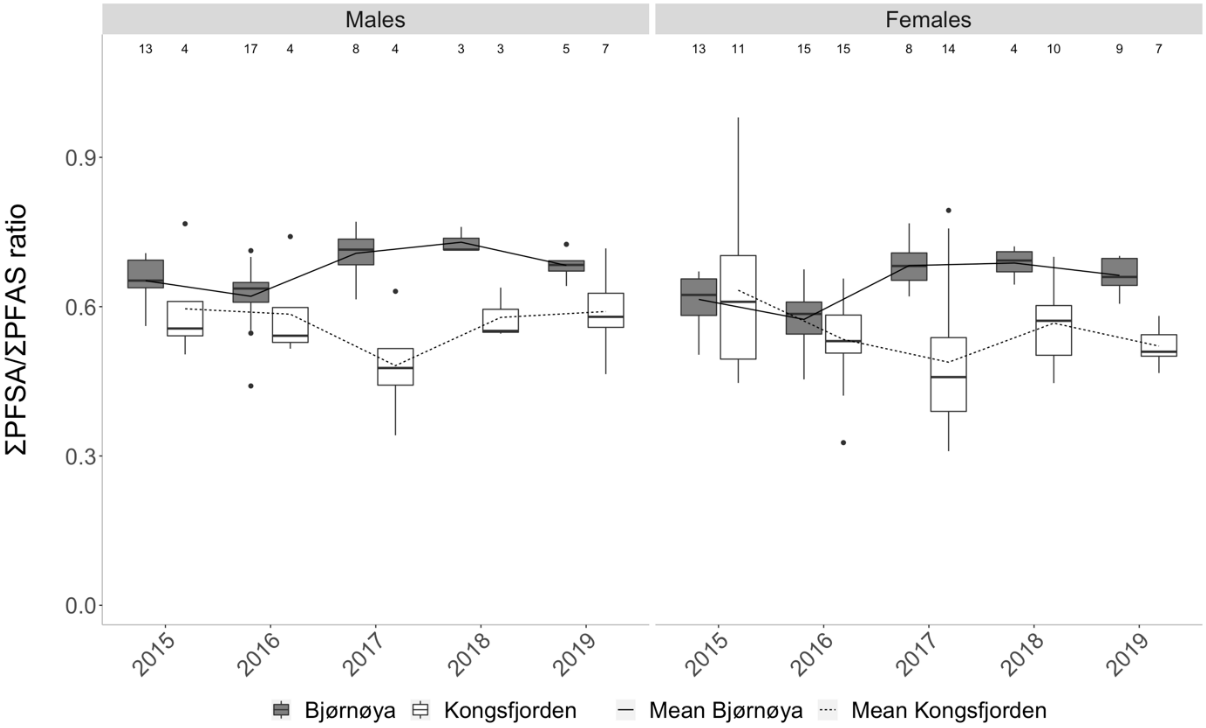

**Figure S4**: Box plots of ΣPFSA/ΣPFAS ratios in blood plasma of male and female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. The ratios were calculated with concentrations in ng/g ww. Lower and upper box boundaries represent the 25th and 75th percentiles (interquartile range), respectively, line inside the box represents the median, and lower and upper box whiskers/error lines represent the smallest and largest value within 1.5 times interquartile range below the 25th and above the 75th percentile, respectively. Filled circles represent outliers. The solid and dashed lines represent the mean ratios in birds from Bjørnøya and Kongsfjorden, respectively. Numbers below the facet strips indicate the sample size for each year within each location.

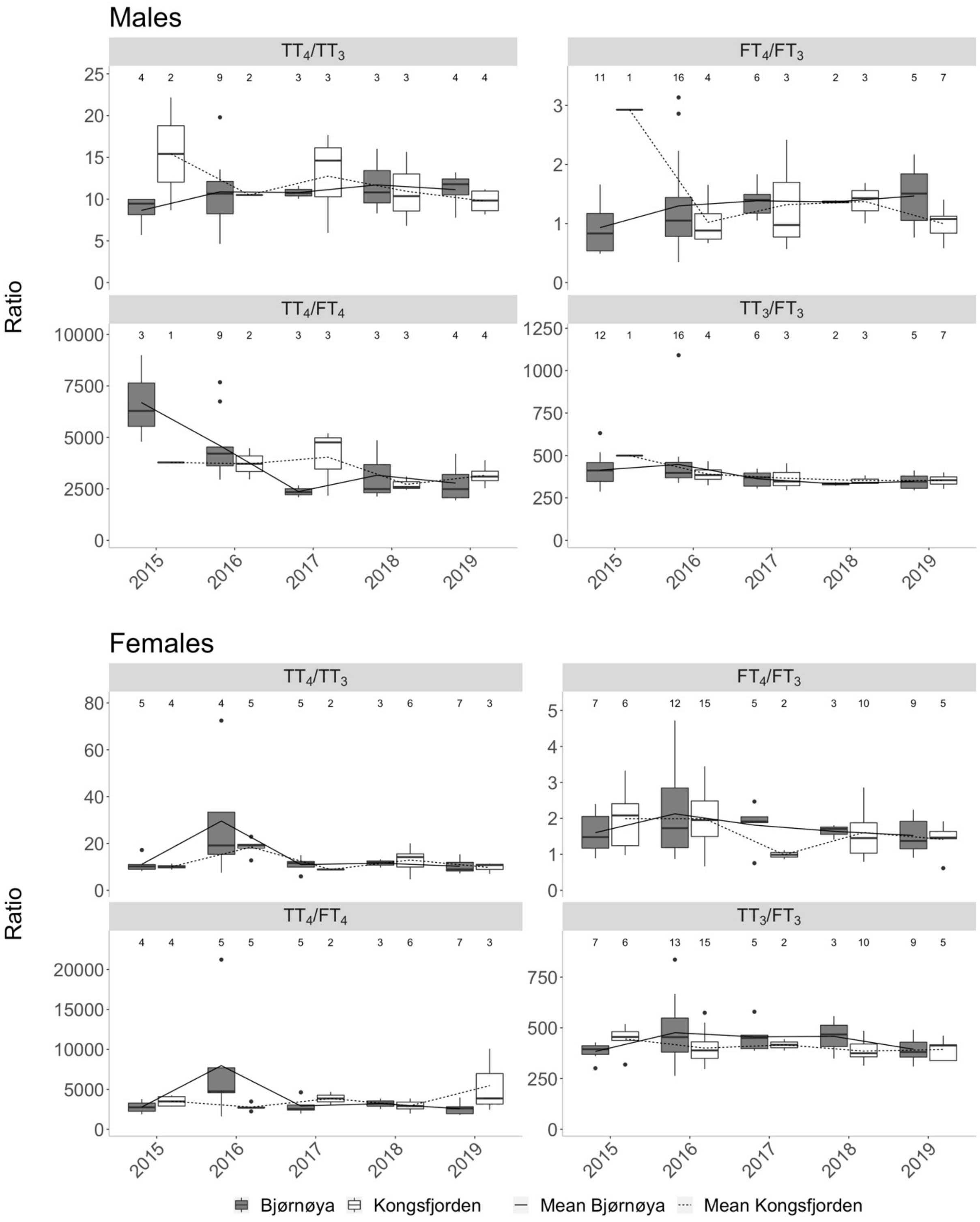

**Figure S1:** Box plots of thyroid hormone (TH) ratios in blood plasma of male and female glaucous gull (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. $TT_4/TT_3$, $TT_4/FT_4$, and $TT_3/FT_3$ ratios were calculated with concentrations in nmol/L, and $FT_4/FT_3$ ratios were calculated in pmol/L. Lower and upper box boundaries represent the 25th and 75th percentiles (interquartile range), respectively, line inside the box represents the median, and lower and upper box whiskers/error lines represent the smallest and largest value within 1.5 times interquartile range below the 25th and above the 75th percentile, respectively. Filled circles represent outliers. The solid and dashed lines represent the mean ratios in birds from Bjørnøya and Kongsfjorden, respectively. Numbers below the facet strips indicate the sample size for each year within each location.

# APPENDIX A: LOD values and detection rates

**Table A1:** Limit of detection (LOD) values for organohalogenated contaminants (OHCs) analysed for in blood plasma of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019.

| | **Bjørnøya** | **Kongsfjorden** | | | |
|---|---|---|---|---|---|
| | **2015 – 2019** | **2015** | **2016 – 2017** | **2018** | **2019** |
| **PCB-28** | 0.032 | 0.016 | 0.095 | 0.035 | 0.035 |
| **PCB-52** | 0.025 | 0.021 | 0.021 | 0.033 | 0.033 |
| **PCB-99** | 0.018 | 0.017 | 0.018 | 0.046 | 0.046 |
| **PCB-101** | 0.024 | 0.025 | 0.023 | 0.053 | 0.053 |
| **PCB-105** | 0.028 | 0.095 | 0.027 | 0.050 | 0.050 |
| **PCB-118** | 0.021 | 0.142 | 0.021 | 0.045 | 0.045 |
| **PCB-138** | 0.058 | 0.061 | 0.020 | 0.043 | 0.043 |
| **PCB-149** | 0.019 | NA | NA | NA | NA |
| **PCB-153** | 0.104 | 0.073 | 0.122 | 0.038 | 0.038 |
| **PCB-170** | 0.076 | NA | NA | NA | NA |
| **PCB-180** | 0.075 | 0.056 | 0.073 | 0.129 | 0.129 |
| **PCB-183** | 0.060 | 0.044 | 0.058 | 0.106 | 0.106 |
| **PCB-187** | 0.073 | 0.051 | 0.071 | 0.124 | 0.124 |
| **PCB-194** | 0.010 | 0.209 | 0.098 | 0.057 | 0.057 |
| **Heptachlor** | NA | 0.047 | NA | NA | NA |
| **HCB** | 0.065 | 0.037 | 0.408 | 0.051 | 0.051 |
| **α-HCH** | 0.050 | 0.046 | 0.049 | 0.062 | 0.062 |
| **β-HCH** | 0.066 | 0.068 | 0.065 | 0.094 | 0.094 |
| **γ-HCH** | 0.022 | 0.014 | 0.030 | 0.059 | 0.059 |
| **Oxychlordane** | 0.052 | 0.083 | 0.284 | 0.044 | 0.044 |
| ***t*-Chlordane** | 0.010 | 0.003 | 0.009 | 0.010 | 0.010 |
| ***c*-Chlordane** | 0.018 | 0.005 | 0.017 | 0.020 | 0.020 |
| ***t*-Nonachlor** | 0.009 | 0.004 | 0.009 | 0.010 | 0.010 |
| ***c*-Nonachlor** | 0.003 | 0.003 | 0.003 | 0.004 | 0.004 |
| **Mirex** | 0.062 | 0.024 | 0.022 | 0.026 | 0.026 |
| ***o,p'*-DDT** | NA | 0.238 | 0.043 | 0.036 | 0.036 |
| ***p,p'*-DDT** | 0.044 | 0.337 | 0.044 | 0.039 | 0.039 |
| ***o,p'*-DDD** | NA | 0.076 | 0.042 | 0.013 | 0.013 |
| ***p,p'*-DDD** | NA | 0.068 | 0.043 | 0.014 | 0.014 |
| ***o,p'*-DDE** | NA | 0.047 | 0.043 | 0.009 | 0.009 |
| ***p,p'*-DDE** | 0.127 | 0.066 | 0.124 | 0.230 | 0.230 |
| **PFOSA** | 0.020 | 0.100 | 0.024 | 0.020 | 0.024 |
| **PFBS** | 0.050 | 0.038 | 0.049 | 0.050 | 0.049 |
| **PFPS** | 0.050 | NA | 0.024 | 0.050 | 0.024 |
| **PFHxS** | 0.020 | 0.010 | 0.055 | 0.020 | 0.024 |
| **PFHpS** | 0.020 | NA | 0.024 | 0.020 | 0.123 |
| **BrPFOS** | 0.135 | 0.246 | 0.024 | 0.135 | 0.092 |
| **LinPFOS** | 0.794 | 0.153 | 0.024 | 0.794 | 1.212 |
| **PFNS** | 0.075 | NA | 0.024 | 0.050 | 0.024 |
| **PFDcS** | 0.075 | 0.153 | 0.049 | 0.075 | 0.049 |
| **PFBA** | 0.050 | NA | 0.117 | 0.050 | 0.117 |
| **PFPA** | 0.112 | NA | 0.109 | 0.050 | 0.109 |
| **PFHxA** | 0.025 | 0.007 | 0.024 | 0.025 | 0.066 |
| **PFHpA** | 0.042 | 0.007 | 0.041 | 0.130 | 0.070 |
| **PFOA** | 0.130 | 0.013 | 0.127 | 0.130 | 0.166 |
| **PFNA** | 0.050 | 0.015 | 0.000 | 0.050 | 0.020 |
| **PFDcA** | 0.030 | 0.100 | 0.029 | 0.030 | 0.053 |
| **PFUnA** | 0.058 | 0.026 | 0.056 | 0.058 | 0.034 |
| **PFDoA** | 0.043 | 0.020 | 0.042 | 0.043 | 0.046 |
| **PFTriA** | 0.083 | 0.015 | 0.045 | 0.083 | 0.049 |
| **PFTeA** | 0.050 | 0.010 | 0.049 | 0.050 | 0.084 |
| **6:2 FTS** | 0.050 | NA | 0.024 | 0.050 | 0.024 |
| **8:2 FTS** | 0.050 | NA | NA | 0.050 | NA |

**Table A2:** Detection rates (%) of organohalogenated contaminants (OHCs) analysed for in blood plasma of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya, Svalbard, 2015 – 2019. Contaminants with a detection rate above 45% across all years were included in statistical analyses.

| | **2015** | **2016** | **2017** | **2018** | **2019** | **All years** |
|---|---|---|---|---|---|---|
| **PCB-28** | 100 | 97 | 100 | 100 | 100 | 99 |
| **PCB-52** | 96 | 88 | 69 | 100 | 93 | 88 |
| **PCB-99** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PCB-101** | 96 | 50 | 38 | 43 | 50 | 60 |
| **PCB-105** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PCB-118** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PCB-138** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PCB-149** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PCB-153** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PCB-170** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PCB-180** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PCB-183** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PCB-187** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PCB-194** | 100 | 100 | 100 | 100 | 100 | 100 |
| **HCB** | 100 | 100 | 100 | 100 | 100 | 100 |
| **α-HCH** | 0 | 0 | 0 | 0 | 0 | 0 |
| **β-HCH** | 100 | 100 | 100 | 100 | 100 | 100 |
| **γ-HCH** | 0 | 0 | 13 | 14 | 0 | 2 |
| **Oxychlordane** | 100 | 100 | 100 | 100 | 100 | 100 |
| ***t*-Chlordane** | 0 | 0 | 0 | 0 | 0 | 0 |
| ***c*-Chlordane** | 38 | 47 | 13 | 0 | 14 | 31 |
| ***t*-Nonachlor** | 100 | 100 | 100 | 100 | 100 | 100 |
| ***c*-Nonachlor** | 100 | 100 | 100 | 100 | 100 | 100 |
| **Mirex** | 100 | 100 | 100 | 100 | 100 | 100 |
| ***p,p'*-DDT** | 62 | 47 | 38 | 71 | 64 | 54 |
| ***p,p'*-DDE** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PFOSA** | 0 | 0 | 0 | 0 | 0 | 0 |
| **PFBS** | 0 | 0 | 0 | 0 | 0 | 0 |
| **PFPS** | 0 | 0 | 0 | 0 | 0 | 0 |
| **PFHxS** | 100 | 100 | 100 | 100 | 93 | 99 |
| **PFHpS** | 100 | 100 | 100 | 100 | 86 | 98 |
| **BrPFOS** | 100 | 100 | 100 | 100 | 100 | 100 |
| **LinPFOS** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PFNS** | 65 | 63 | 100 | 71 | 43 | 67 |
| **PFDcS** | 96 | 94 | 100 | 100 | 100 | 97 |
| **PFBA** | 0 | 0 | 0 | 0 | 0 | 0 |
| **PFPA** | 0 | 3 | 0 | 0 | 7 | 2 |
| **PFHxA** | 0 | 0 | 0 | 0 | 0 | 0 |
| **PFHpA** | 65 | 9 | 6 | 14 | 36 | 28 |
| **PFOA** | 100 | 97 | 100 | 100 | 100 | 99 |
| **PFNA** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PFDcA** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PFUnA** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PFDoA** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PFTriA** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PFTeA** | 100 | 100 | 100 | 100 | 100 | 100 |
| **6:2 FTS** | 0 | 0 | 0 | 0 | 0 | 0 |
| **8:2 FTS** | 58 | 72 | 63 | 29 | 29 | 57 |

**Table A3:** Detection rates (%) of organohalogenated contaminants (OHCs) analysed for in blood plasma of glaucous gulls (*Larus hyperboreus*) breeding in Kongsfjorden, Svalbard, 2015 – 2019. Contaminants with a detection rate below 45% across all years were not included in statistical analyses.

| | **2015** | **2016** | **2017** | **2018** | **2019** | **All years** |
|---|---|---|---|---|---|---|
| **PCB-28** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PCB-52** | 93 | 84 | 86 | 62 | 36 | 74 |
| **PCB-99** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PCB-101** | 79 | 63 | 62 | 54 | 21 | 57 |
| **PCB-105** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PCB-118** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PCB-138** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PCB-153** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PCB-180** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PCB-183** | 100 | 95 | 100 | 100 | 100 | 99 |
| **PCB-187** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PCB-194** | 100 | 100 | 100 | 100 | 100 | 100 |
| **Heptachlor** | 0 | NA | NA | NA | NA | 0 |
| **HCB** | 100 | 100 | 100 | 100 | 100 | 100 |
| **α-HCH** | 0 | 0 | 0 | 0 | 0 | 0 |
| **β-HCH** | 100 | 95 | 100 | 100 | 100 | 99 |
| **γ-HCH** | 0 | 0 | 0 | 0 | 0 | 0 |
| **Oxychlordane** | 100 | 100 | 100 | 100 | 100 | 100 |
| ***t*-Chlordane** | 0 | 100 | 100 | 0 | 0 | 49 |
| ***c*-Chlordane** | 93 | 0 | 0 | 15 | 7 | 20 |
| ***t*-Nonachlor** | 100 | 100 | 100 | 100 | 100 | 100 |
| ***c*-Nonachlor** | 100 | 100 | 100 | 100 | 100 | 100 |
| **Mirex** | 100 | 100 | 100 | 100 | 100 | 100 |
| ***o,p'*-DDT** | 0 | 0 | 0 | 8 | 57 | 11 |
| ***p,p'*-DDT** | 8 | 0 | 0 | 69 | 79 | 26 |
| ***o,p'*-DDD** | 0 | 0 | 0 | 0 | 0 | 0 |
| ***p,p'*-DDD** | 0 | 0 | 0 | 0 | 0 | 0 |
| ***o,p'*-DDE** | 8 | 0 | 0 | 0 | 0 | 1 |
| ***p,p'*-DDE** | 100 | 95 | 95 | 100 | 100 | 96 |
| **PFOSA** | 0 | 0 | 0 | 0 | 7 | 1 |
| **PFBS** | 0 | 0 | 0 | 0 | 0 | 0 |
| **PFPS** | NA | 0 | 0 | 0 | 0 | 0 |
| **PFHxS** | 100 | 100 | 94 | 92 | 100 | 97 |
| **PFHpS** | NA | 16 | 28 | 62 | 71 | 41 |
| **BrPFOS** | 47 | 79 | 56 | 100 | 100 | 75 |
| **LinPFOS** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PFNS** | NA | 0 | 0 | 0 | 36 | 8 |
| **PFDcS** | 0 | 0 | 0 | 100 | 36 | 23 |
| **PFBA** | NA | 0 | 0 | 0 | 14 | 3 |
| **PFPA** | NA | 0 | 0 | 62 | 0 | 13 |
| **PFHxA** | 7 | 0 | 0 | 46 | 0 | 9 |
| **PFHpA** | 0 | 0 | 0 | 31 | 0 | 5 |
| **PFOA** | 53 | 95 | 94 | 92 | 79 | 84 |
| **PFNA** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PFDcA** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PFUnA** | 100 | 100 | 100 | 92 | 100 | 99 |
| **PFDoA** | 87 | 100 | 100 | 100 | 100 | 97 |
| **PFTriA** | 100 | 100 | 100 | 100 | 100 | 100 |
| **PFTeA** | 47 | 79 | 67 | 100 | 100 | 77 |
| **6:2 FTS** | NA | 0 | 0 | 0 | 0 | 0 |
| **8:2 FTS** | NA | NA | NA | 0 | NA | 0 |

# APPENDIX B: OHC concentrations and ratios

**Table B1:** Mean ± standard deviation (SD), median, range (min – max) concentrations (ng/g ww) and ratios of summed (Σ) organohalogenated contaminants (OHCs) in blood plasma of male glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya (B) and in Kongsfjorden (K), Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| OHC group | Location | | 2015 | 2016 | 2017 | 2018 | 2019 | All years |
|---|---|---|---|---|---|---|---|---|
| **ΣPCBs** | **B** | Mean ± SD | 505.16 ± 574.48 | 475.78 ± 459.18 | 675.89 ± 590.53 | 809.04 ± 225.24 | 714.81 ± 126.29 | 566.60 ± 483.30 |
| | | Median | 346.84 | 317.15 | 523.26 | 925.33 | 717.80 | 410.39 |
| | | Range | 182.26 – 2363.70 | 141.25 – 2111.07 | 207.84 – 2037.85 | 549.42 – 952.36 | 532.33 – 859.79 | 141.25 – 2363.70 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 310.83 ± 192.42 | 245.11 ± 208.84 | 152.53 ± 143.62 | 167.67 ± 65.96 | 256.67 ± 181.57 | 229.83 ± 165.78 |
| | | Median | 278.84 | 181.72 | 100.49 | 143.08 | 145.49 | 145.49 |
| | | Range | 149.30 – 536.35 | 84.92 – 532.08 | 67.08 – 407.19 | 117.53 – 242.39 | 91.06 – 489.21 | 67.08 – 536.35 |
| | | *n* | 4 | 4 | 5 | 3 | 7 | 23 |
| **ΣOCPs** | **B** | Mean ± SD | 185.64 ± 64.98 | 197.75 ± 73.52 | 258.57 ± 140.86 | 348.43 ± 77.80 | 308.82 ± 52.29 | 226.81 ± 96.79 |
| | | Median | 183.99 | 189.04 | 239.51 | 393.29 | 326.01 | 215.30 |
| | | Range | 93.50 – 344.25 | 86.98 – 313.00 | 127.49 – 554.13 | 258.60 – 393.42 | 218.86 – 346.78 | 86.98 – 554.13 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 129.92 ± 74.32 | 52.02 ± 45.91 | 25.20 ± 15.80 | 70.74 ± 20.60 | 110.22 ± 79.63 | 79.89 ± 66.59 |
| | | Median | 132.92 | 34.67 | 21.43 | 61.20 | 61.45 | 56.64 |
| | | Range | 57.17 – 196.69 | 20.65 – 118.06 | 10.70 – 52.26 | 56.64 – 94.38 | 40.54 – 234.19 | 10.70 – 234.19 |
| | | *n* | 4 | 4 | 5 | 3 | 7 | 23 |
| **ΣOCs** | **B** | Mean ± SD | 690.80 ± 629.80 | 673.53 ± 510.86 | 934.46 ± 728.96 | 1157.47 ± 302.93 | 1023.63 ± 176.13 | 793.41 ± 561.06 |
| | | Median | 555.76 | 509.16 | 762.77 | 1318.75 | 1043.81 | 629.92 |
| | | Range | 275.76 – 2707.95 | 228.23 – 2404.46 | 335.32 – 2591.98 | 808.02 – 1345.65 | 751.20 – 1206.57 | 228.23 – 2707.95 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 440.75 ± 264.84 | 297.12 ± 254.45 | 177.73 ± 159.13 | 238.41 ± 86.50 | 366.89 ± 260.23 | 309.72 ± 225.81 |
| | | Median | 411.75 | 216.23 | 121.92 | 204.28 | 206.94 | 206.47 |
| | | Range | 206.47 – 733.04 | 105.89 – 650.14 | 77.78 – 459.44 | 174.17 – 336.77 | 135.70 – 723.40 | 77.78 – 733.04 |
| | | *n* | 4 | 4 | 5 | 3 | 7 | 23 |
| **ΣPFSAs** | **B** | Mean ± SD | 447.70 ± 165.44 | 289.41 ± 86.77 | 505.28 ± 136.81 | 626.69 ± 91.18 | 278.70 ± 42.45 | 392.52 ± 160.22 |
| | | Median | 421.20 | 283.67 | 542.66 | 585.52 | 268.54 | 367.99 |
| | | Range | 156.15 – 685.31 | 138.75 – 429.14 | 314.09 – 668.75 | 563.36 – 731.19 | 238.41 – 334.90 | 138.75 – 731.19 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 15.01 ± 9.52 | 15.32 ± 10.33 | 12.62 ± 3.98 | 11.99 ± 3.68 | 15.05 ± 4.95 | 14.23 ± 6.36 |
| | | Median | 13.61 | 11.85 | 12.04 | 11.72 | 15.84 | 12.97 |
| | | Range | 5.27 – 27.54 | 7.15 – 30.44 | 8.64 – 17.77 | 8.46 – 15.80 | 7.34 – 20.23 | 5.27 – 30.44 |

**Table B1 Continued:** Mean ± standard deviation (SD), median, range (min – max) concentrations (ng/g ww) and ratios of summed (Σ) organohalogenated contaminants (OHCs) in blood plasma of male glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya (B) and in Kongsfjorden (K), Svalbard, 2015 – 2019. Number of samples analysed (n) are included.

| **OHC group** | **Location** | | **2015** | **2016** | **2017** | **2018** | **2019** | **All years** |
|---|---|---|---|---|---|---|---|---|
| **ΣPFSAs** | **K** | *n* | 4 | 4 | 4 | 3 | 7 | 22 |
| **ΣPFCAs** | **B** | Mean ± SD | 227.77 ± 61.68 | 173.24 ± 44.62 | 201.47 ± 29.29 | 230.07 ± 5.09 | 128.83 ± 17.98 | 192.44 ± 54.26 |
| | | Median | 232.51 | 176.74 | 208.67 | 230.44 | 126.81 | 186.76 |
| | | Range | 121.93 – 302.04 | 79.22 – 241.95 | 161.25 – 247.99 | 224.80 – 234.97 | 105.93 – 149.99 | 79.22 – 302.04 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 8.83 ± 3.32 | 9.37 ± 1.91 | 13.91 ± 5.14 | 8.53 ± 1.48 | 10.06 ± 2.47 | 10.20 ± 3.37 |
| | | Median | 8.46 | 9.93 | 14.13 | 8.96 | 10.80 | 9.82 |
| | | Range | 5.18 – 13.24 | 6.72 – 10.89 | 7.92 – 19.44 | 6.88 – 9.76 | 5.99 – 13.41 | 5.18 – 19.44 |
| | | *n* | 4 | 4 | 4 | 3 | 7 | 22 |
| **ΣPFASs** | **B** | Mean ± SD | 675.68 ± 221.11 | 462.78 ± 118.99 | 706.80 ± 154.54 | 856.84 ± 92.26 | 407.57 ± 53.29 | 585.08 ± 203.71 |
| | | Median | 723.74 | 489.05 | 733.41 | 820.62 | 418.58 | 571.19 |
| | | Range | 278.29 – 984.36 | 217.99 – 626.10 | 475.36 – 905.56 | 788.18 – 961.71 | 344.37 – 461.74 | 217.99 – 984.36 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 23.84 ± 11.25 | 24.69 ± 11.62 | 26.53 ± 7.31 | 20.53 ± 4.78 | 25.11 ± 6.40 | 24.44 ± 7.88 |
| | | Median | 24.50 | 21.90 | 23.72 | 21.48 | 27.34 | 24.03 |
| | | Range | 10.45 – 35.92 | 13.88 – 41.09 | 21.45 – 37.21 | 15.34 – 24.76 | 13.33 – 31.30 | 10.45 – 41.09 |
| | | *n* | 4 | 4 | 4 | 3 | 7 | 22 |
| **ΣOHCs** | **B** | Mean ± SD | 1366.48 ± 688.02 | 1136.31 ± 546.77 | 1641.26 ± 740.13 | 2014.31 ± 366.57 | 1431.19 ± 157.36 | 1378.49 ± 622.61 |
| | | Median | 1253.93 | 1015.57 | 1511.72 | 2166.27 | 1496.80 | 1289.60 |
| | | Range | 554.05 – 3431.69 | 450.90 – 2918.20 | 810.69 – 3329.93 | 1596.20 – 2280.46 | 1212.93 – 1566.73 | 450.90 – 3431.69 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 464.59 ± 255.66 | 321.82 ± 258.06 | 229.24 ± 170.68 | 258.93 ± 86.63 | 392.00 ± 262.87 | 344.70 ± 225.04 |
| | | Median | 434.94 | 243.71 | 150.65 | 219.62 | 234.44 | 235.29 |
| | | Range | 236.14 – 752.36 | 126.40 – 673.44 | 130.92 – 484.73 | 198.93 – 358.25 | 149.03 – 750.73 | 126.40 – 752.36 |
| | | *n* | 4 | 4 | 4 | 3 | 7 | 22 |
| **ΣPFAS/ΣOHC** | **B** | Mean ± SD | 0.53 ± 0.14 | 0.45 ± 0.13 | 0.48 ± 0.16 | 0.43 ± 0.06 | 0.29 ± 0.06 | 0.46 ± 0.14 |
| | | Median | 0.57 | 0.46 | 0.51 | 0.42 | 0.27 | 0.48 |
| | | Range | 0.21 – 0.70 | 0.18 – 0.70 | 0.22 – 0.68 | 0.38 – 0.49 | 0.23 – 0.38 | 0.18 – 0.70 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 0.08 ± 0.06 | 0.10 ± 0.05 | 0.16 ± 0.10 | 0.08 ± 0.03 | 0.09 ± 0.05 | 0.10 ± 0.06 |
| | | Median | 0.08 | 0.11 | 0.14 | 0.07 | 0.09 | 0.11 |
| | | Range | 0.02 – 0.14 | 0.03 – 0.16 | 0.05 – 0.28 | 0.06 – 0.12 | 0.04 – 0.19 | 0.02 – 0.28 |
| | | *n* | 4 | 4 | 4 | 3 | 7 | 22 |

**Table B1 Continued:** Mean ± standard deviation (SD), median, range (min – max) concentrations (ng/g ww) and ratios of summed (Σ) organohalogenated contaminants (OHCs) in blood plasma of male glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya (B) and in Kongsfjorden (K), Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| **OHC group** | **Location** | | **2015** | **2016** | **2017** | **2018** | **2019** | **All years** |
|---|---|---|---|---|---|---|---|---|
| **ΣPFSA/ΣPFAS** | **B** | Mean ± SD | 0.65 ± 0.05 | 0.62 ± 0.06 | 0.71 ± 0.05 | 0.73 ± 0.03 | 0.68 ± 0.03 | 0.66 ± 0.06 |
| | | Median | 0.65 | 0.64 | 0.71 | 0.71 | 0.68 | 0.66 |
| | | Range | 0.56 – 0.71 | 0.44 – 0.71 | 0.61 – 0.77 | 0.71 – 0.76 | 0.64 – 0.73 | 0.44 – 0.77 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 0.60 ± 0.12 | 0.58 ± 0.10 | 0.48 ± 0.12 | 0.58 ± 0.05 | 0.59 ± 0.08 | 0.57 ± 0.10 |
| | | Median | 0.56 | 0.54 | 0.48 | 0.55 | 0.58 | 0.55 |
| | | Range | 0.50 – 0.77 | 0.52 – 0.74 | 0.34 – 0.63 | 0.55 – 0.64 | 0.46 – 0.72 | 0.34 – 0.77 |
| | | *n* | 4 | 4 | 4 | 3 | 7 | 22 |

**Table B2:** Mean ± standard deviation (SD), median, range (min – max) concentrations (ng/g ww) and ratios of summed (Σ) organohalogenated contaminants (OHCs) in blood plasma of female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya (B) and in Kongsfjorden (K), Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| OHC group | Location | | 2015 | 2016 | 2017 | 2018 | 2019 | All years |
|---|---|---|---|---|---|---|---|---|
| **ΣPCBs** | **B** | Mean ± SD | 418.92 ± 267.66 | 363.71 ± 215.43 | 555.66 ± 457.90 | 286.46 ± 78.43 | 436.12 ± 254.25 | 416.69 ± 280.65 |
| | | Median | 335.39 | 256.75 | 476.34 | 285.79 | 367.42 | 339.88 |
| | | Range | 163.67 – 1067.35 | 87.04 – 750.47 | 133.29 – 1583.71 | 191.80 – 382.47 | 152.89 – 953.19 | 87.04 – 1583.71 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 97.34 ± 63.04 | 151.39 ± 135.85 | 120.77 ± 125.00 | 96.25 ± 70.46 | 139.14 ± 87.57 | 122.64 ± 106.53 |
| | | Median | 71.03 | 123.73 | 64.89 | 65.31 | 121.25 | 90.94 |
| | | Range | 41.32 – 230.08 | 18.03 – 606.17 | 30.85 – 437.31 | 29.85 – 216.62 | 47.12 – 316.27 | 18.03 – 606.17 |
| | | *n* | 10 | 15 | 16 | 10 | 7 | 58 |
| **ΣOCPs** | **B** | Mean ± SD | 166.27 ± 68.29 | 144.41 ± 53.57 | 194.47 ± 103.97 | 149.24 ± 52.05 | 211.08 ± 114.42 | 171.02 ± 81.18 |
| | | Median | 151.79 | 123.01 | 185.25 | 148.78 | 184.48 | 159.11 |
| | | Range | 85.60 – 291.38 | 55.35 – 228.28 | 69.75 – 396.16 | 100.24 – 199.17 | 83.27 – 386.91 | 55.35 – 396.16 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 42.03 ± 22.58 | 28.91 ± 20.94 | 23.06 ± 18.07 | 41.78 ± 26.34 | 64.81 ± 35.08 | 36.11 ± 26.22 |
| | | Median | 34.59 | 26.63 | 14.69 | 31.76 | 56.31 | 27.59 |
| | | Range | 11.46 – 81.74 | 6.21 – 97.88 | 8.25 – 70.24 | 15.26 – 92.82 | 23.09 – 125.18 | 6.21 – 125.18 |
| | | *n* | 10 | 15 | 16 | 10 | 7 | 58 |
| **ΣOCs** | **B** | Mean ± SD | 585.18 ± 325.50 | 508.12 ± 263.92 | 750.12 ± 555.37 | 435.70 ± 123.29 | 647.21 ± 364.79 | 587.71 ± 351.97 |
| | | Median | 491.50 | 372.09 | 688.29 | 439.66 | 551.90 | 506.36 |
| | | Range | 262.93 – 1306.73 | 142.39 – 930.12 | 219.32 – 1979.87 | 292.04 – 571.45 | 236.17 – 1340.09 | 142.39 – 1979.87 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 139.37 ± 83.89 | 180.29 ± 156.45 | 143.83 ± 142.88 | 138.03 ± 96.59 | 203.96 ± 121.63 | 158.75 ± 126.89 |
| | | Median | 100.88 | 150.87 | 78.63 | 97.07 | 175.86 | 116.71 |
| | | Range | 63.98 – 304.53 | 24.25 – 704.05 | 39.10 – 507.55 | 45.11 – 309.44 | 70.22 – 441.45 | 24.25 – 704.05 |
| | | *n* | 10 | 15 | 16 | 10 | 7 | 58 |
| **ΣPFSAs** | **B** | Mean ± SD | 325.93 ± 185.13 | 180.05 ± 114.80 | 387.01 ± 80.66 | 350.83 ± 120.50 | 233.58 ± 59.03 | 276.32 ± 145.80 |
| | | Median | 329.14 | 164.43 | 389.64 | 366.63 | 226.07 | 265.77 |
| | | Range | 63.56 – 621.70 | 33.41 – 395.95 | 265.77 – 491.01 | 198.47 – 471.58 | 154.72 – 307.79 | 33.41 – 621.70 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 26.43 ± 46.52 | 7.55 ± 2.57 | 12.15 ± 12.76 | 11.69 ± 5.42 | 8.87 ± 2.78 | 13.21 ± 21.85 |
| | | Median | 7.52 | 7.33 | 7.46 | 11.32 | 8.13 | 7.54 |
| | | Range | 1.56 – 154.90 | 4.37 – 13.45 | 3.61 – 52.45 | 3.53 – 22.76 | 5.29 – 12.85 | 1.56 – 154.90 |
| | | *n* | 11 | 15 | 14 | 10 | 7 | 57 |
| **ΣPFCAs** | **B** | Mean ± SD | 187.03 ± 83.25 | 123.69 ± 63.31 | 179. 03 ± 39.35 | 156.22 ± 47.07 | 116.84 ± 22.42 | 150.93 ± 65.47 |

**Table B2 Continued:** Mean ± standard deviation (SD), median, range (min – max) concentrations (ng/g ww) and ratios of summed (Σ) organohalogenated contaminants (OHCs) in blood plasma of female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya (B) and in Kongsfjorden (K), Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| OHC group | Location | | 2015 | 2016 | 2017 | 2018 | 2019 | All years |
|---|---|---|---|---|---|---|---|---|
| **ΣPFCAs** | **B** | Median | 173.88 | 126.41 | 185.64 | 158.70 | 120.84 | 138.43 |
| | | Range | 49.81 – 313.90 | 37.17 – 237.69 | 111.92 – 217.59 | 109.54 – 197.94 | 86.70 – 144.49 | 37.17 – 313.90 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 5.05 ± 2.07 | 6.71 ± 2.56 | 10.10 ± 3.99 | 8.67 ± 3.62 | 7.98 ± 1.57 | 7.72 ± 3.42 |
| | | Median | 4.90 | 6.26 | 8.91 | 7.95 | 8.72 | 7.63 |
| | | Range | 1.94 – 8.52 | 3.39 – 11.01 | 4.22 – 18.33 | 4.11 – 15.02 | 5.09 – 9.25 | 1.94 – 18.33 |
| | | *n* | 11 | 15 | 14 | 10 | 7 | 57 |
| **ΣPFASs** | **B** | Mean ± SD | 513.08 ± 267.21 | 303.86 ± 176.09 | 566.14 ± 104.76 | 507.07 ± 165.30 | 350.46 ± 78.01 | 427.34 ± 206.94 |
| | | Median | 503.29 | 286.05 | 562.06 | 526.56 | 366.67 | 398.78 |
| | | Range | 113.40 – 935.86 | 70.60 – 633.81 | 377.76 – 680.69 | 308.03 – 667.14 | 242.09 – 440.45 | 70.60 – 935.86 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 31.48 ± 45.89 | 14.26 ± 4.33 | 22.25 ± 14.59 | 20.36 ± 8.67 | 16.85 ± 4.14 | 20.93 ± 21.92 |
| | | Median | 13.50 | 14.29 | 16.72 | 18.27 | 16.96 | 15.83 |
| | | Range | 3.50 – 158.00 | 7.75 – 22.23 | 11.29 – 66.10 | 7.90 – 37.78 | 10.38 – 22.10 | 3.50 – 158.00 |
| | | *n* | 11 | 15 | 14 | 10 | 7 | 57 |
| **ΣOHCs** | **B** | Mean ± SD | 1098.27 ± 511.28 | 811.98 ± 337.36 | 1316.26 ± 589.60 | 942.78 ± 203.09 | 997.66 ± 398.70 | 1015.05 ± 456.82 |
| | | Median | 994.79 | 890.96 | 1328.28 | 946.52 | 896.86 | 946.23 |
| | | Range | 433.74 – 2096.77 | 261.16 – 1563.93 | 597.08 – 2517.61 | 690.68 – 1187.38 | 593.56 – 1706.76 | 261.16 – 2517.61 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 172.64 ± 86.74 | 194.55 ± 158.79 | 178.40 ± 150.59 | 158.39 ± 101.58 | 220.80 ± 123.05 | 183.43 ± 129.24 |
| | | Median | 158.93 | 165.17 | 104.25 | 113.01 | 192.07 | 151.70 |
| | | Range | 84.75 – 314.86 | 32.00 – 726.29 | 69.99 – 540.04 | 58.81 – 329.05 | 80.60 – 458.67 | 32.00 – 726.29 |
| | | *n* | 10 | 15 | 14 | 10 | 7 | 56 |
| **ΣPFAS/ΣOHC** | **B** | Mean ± SD | 0.46 ± 0.14 | 0.38 ± 0.16 | 0.49 ± 0.15 | 0.53 ± 0.11 | 0.38 ± 0.12 | 0.43 ± 0.15 |
| | | Median | 0.45 | 0.41 | 0.47 | 0.49 | 0.38 | 0.44 |
| | | Range | 0.25 – 0.72 | 0.07 – 0.61 | 0.21 – 0.69 | 0.45 – 0.70 | 0.21 – 0.65 | 0.07 – 0.72 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 0.18 ± 0.19 | 0.10 ± 0.05 | 0.18 ± 0.15 | 0.16 ± 0.08 | 0.09 ± 0.04 | 0.15 ± 0.12 |
| | | Median | 0.10 | 0.09 | 0.13 | 0.12 | 0.08 | 0.11 |
| | | Range | 0.03 – 0.59 | 0.03 – 0.24 | 0.05 – 0.59 | 0.06 – 0.31 | 0.04 – 0.14 | 0.03 – 0.59 |
| | | *n* | 10 | 15 | 14 | 10 | 7 | 56 |
| **ΣPFSA/ΣPFAS** | **B** | Mean ± SD | 0.61 ± 0.05 | 0.57 ± 0.06 | 0.68 ± 0.05 | 0.69 ± 0.03 | 0.66 ± 0.03 | 0.63 ± 0.07 |
| | | Median | 0.62 | 0.59 | 0.68 | 0.69 | 0.66 | 0.64 |
| | | Range | 0.50 – 0.67 | 0.45 – 0.67 | 0.62 – 0.77 | 0.64 – 0.72 | 0.61 – 0.70 | 0.45 – 0.77 |

**Table B2 Continued:** Mean ± standard deviation (SD), median, range (min – max) concentrations (ng/g ww) and ratios of summed (Σ) organohalogenated contaminants (OHCs) in blood plasma of female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya (B) and in Kongsfjorden (K), Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| **OHC group** | **Location** | | **2015** | **2016** | **2017** | **2018** | **2019** | **All years** |
|---|---|---|---|---|---|---|---|---|
| **ΣPFSA/ΣPFAS** | **B** | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 0.63 ± 0.19 | 0.53 ± 0.08 | 0.49 ± 0.15 | 0.57 ± 0.08 | 0.52 ± 0.04 | 0.55 ± 0.13 |
| | | Median | 0.61 | 0.53 | 0.46 | 0.57 | 0.51 | 0.52 |
| | | Range | 0.45 – 0.98 | 0.33 – 0.66 | 0.31 – 0.79 | 0.45 – 0.70 | 0.47 – 0.58 | 0.31 – 0.98 |
| | | *n* | 11 | 15 | 14 | 10 | 7 | 57 |

**Table B3:** Mean ± standard deviation (SD), median, range (min – max) concentrations (ng/g ww) of organohalogenated contaminants (OHCs) in blood plasma of male glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya (B) and in Kongsfjorden (K), Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| OHC | Location | | 2015 | 2016 | 2017 | 2018 | 2019 | All years |
|---|---|---|---|---|---|---|---|---|
| **PCB-28** | **B** | Mean ± SD | 1.85 ± 1.48 | 1.95 ± 1.10 | 2.15 ± 1.63 | 2.64 ± 0.78 | 2.87 ± 0.91 | 2.10 ± 1.28 |
| | | Median | 1.66 | 1.73 | 1.67 | 2.27 | 3.24 | 1.76 |
| | | Range | 0.68 – 6.56 | 0.79 – 5.21 | 0.82 – 5.89 | 2.12 – 3.54 | 1.51 – 3.89 | 0.68 – 6.56 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 0.83 ± 0.31 | 0.37 ± 0.09 | 0.30 ± 0.12 | 0.26 ± 0.06 | 0.26 ± 0.07 | 0.39 ± 0.25 |
| | | Median | 0.81 | 0.34 | 0.27 | 0.27 | 0.27 | 0.30 |
| | | Range | 0.46 – 1.22 | 0.30 – 0.51 | 0.21 – 0.50 | 0.20 – 0.32 | 0.17 – 0.37 | 0.17 – 1.22 |
| | | *n* | 4 | 4 | 5 | 3 | 7 | 23 |
| **PCB-52** | **B** | Mean ± SD | 0.23 ± 0.20 | 0.21 ± 0.22 | 0.20 ± 0.18 | 0.31 ± 0.04 | 0.35 ± 0.29 | 0.24 ± 0.21 |
| | | Median | 0.14 | 0.20 | 0.23 | 0.32 | 0.26 | 0.23 |
| | | Range | 0.01 – 0.59 | 0.01 – 0.75 | 0.01 – 0.49 | 0.27 – 0.34 | 0.01 – 0.75 | 0.01 – 0.75 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 0.19 ± 0.28 | 0.06 ± 0.10 | 0.21 ± 0.19 | 0.23 ± 0.25 | 0.10 ± 0.12 | 0.15 ± 0.18 |
| | | Median | 0.07 | 0.01 | 0.17 | 0.18 | 0.02 | 0.05 |
| | | Range | 0.01 – 0.61 | 0.01 – 0.20 | 0.01 – 0.47 | 0.02 – 0.50 | 0.02 – 0.29 | 0.01 – 0.61 |
| | | *n* | 4 | 4 | 5 | 3 | 7 | 23 |
| **PCB-99** | **B** | Mean ± SD | 20.59 ± 21.36 | 19.86 ± 16.35 | 21.31 ± 18.00 | 26.24 ± 6.33 | 25.68 ± 7.15 | 21.37 ± 16.68 |
| | | Median | 14.67 | 13.58 | 15.86 | 28.57 | 25.69 | 15.50 |
| | | Range | 8.49 – 89.86 | 6.73 – 76.10 | 6.88 – 62.84 | 19.08 – 31.07 | 14.78 – 33.33 | 6.73 – 89.86 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 14.09 ± 8.15 | 15.36 ± 15.37 | 7.31 ± 5.59 | 8.06 ± 3.37 | 12.87 ± 10.53 | 11.68 ± 9.40 |
| | | Median | 14.64 | 9.14 | 5.35 | 6.13 | 7.14 | 6.13 |
| | | Range | 5.90 – 21.18 | 5.23 – 37.93 | 4.05 – 17.20 | 6.10 – 11.94 | 4.53 – 32.45 | 4.05 – 37.93 |
| | | *n* | 4 | 4 | 5 | 3 | 7 | 23 |
| **PCB-101** | **B** | Mean ± SD | 1.37 ± 0.88 | 0.40 ± 0.54 | 0.18 ± 0.33 | 0.01 ± 0.00 | 0.38 ± 0.81 | 0.61 ± 0.79 |
| | | Median | 1.06 | 0.01 | 0.01 | 0.01 | 0.01 | 0.14 |
| | | Range | 0.01 – 3.16 | 0.01 – 1.65 | 0.01 – 0.88 | 0.01 – 0.01 | 0.01 – 1.83 | 0.01 – 3.16 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 0.40 ± 0.77 | 0.66 ± 0.61 | 0.31 ± 0.40 | 0.76 ± 0.74 | 0.14 ± 0.19 | 0.39 ± 0.52 |
| | | Median | 0.01 | 0.59 | 0.06 | 0.76 | 0.03 | 0.03 |
| | | Range | 0.01 – 1.55 | 0.01 – 1.46 | 0.01 – 0.81 | 0.03 – 1.51 | 0.03 – 0.43 | 0.01 – 1.55 |
| | | *n* | 4 | 4 | 5 | 3 | 7 | 23 |

**Table B3 Continued:** Mean ± standard deviation (SD), median, range (min – max) concentrations (ng/g ww) of organohalogenated contaminants (OHCs) in blood plasma of male glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya (B) and in Kongsfjorden (K), Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| OHC | Location | | 2015 | 2016 | 2017 | 2018 | 2019 | All years |
|---|---|---|---|---|---|---|---|---|
| **PCB-105** | **B** | Mean ± SD | 14.06 ± 8.76 | 13.36 ± 6.60 | 14.86 ± 10.98 | 14.46 ± 2.97 | 14.22 ± 4.17 | 13.98 ± 7.55 |
| | | Median | 12.61 | 11.42 | 11.23 | 13.78 | 14.75 | 12.71 |
| | | Range | 6. 23 – 40.83 | 5.69 – 31.73 | 5.16 – 39.97 | 11.89 – 17.71 | 7.26 – 18.41 | 5.16 – 40.83 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 5.59 ± 3.49 | 3.85 ± 1.52 | 2.90 ± 1.96 | 3.02 ± 0.83 | 3.68 ± 2.22 | 3.79 ± 2.22 |
| | | Median | 4.55 | 3.62 | 2.28 | 2.71 | 2.57 | 2.71 |
| | | Range | 2.69 – 10.57 | 2.39 – 5.76 | 1.47 – 6.35 | 2.38 – 3.95 | 1.69 – 6.79 | 1.47 – 10.57 |
| | | *n* | 4 | 4 | 5 | 3 | 7 | 23 |
| **PCB-118** | **B** | Mean ± SD | 38.71 ± 31.33 | 34.88 ± 23.82 | 50.01 ± 41.05 | 59.41 ± 14.85 | 56.30 ± 12.37 | 42.52 ± 28.73 |
| | | Median | 32.63 | 25.03 | 40.10 | 64.07 | 55.21 | 36.99 |
| | | Range | 14.69 – 138.06 | 12.84 – 113.54 | 16.99 – 144.94 | 42.79 – 71.38 | 37.43 – 69.84 | 12.84 – 144.94 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 24.05 ± 14.73 | 16.26 ± 8.12 | 11.82 ± 9.36 | 14.73 ± 5.88 | 20.81 ± 14.68 | 17.84 ± 11.67 |
| | | Median | 19.82 | 16.62 | 8.58 | 11.99 | 11.85 | 11.91 |
| | | Range | 11.91 – 44.66 | 8.34 – 23.45 | 6.31 – 28.47 | 10.72 – 21.49 | 8.36 – 43.15 | 6.31 – 44.66 |
| | | *n* | 4 | 4 | 5 | 3 | 7 | 23 |
| **PCB-138** | **B** | Mean ± SD | 128.70 ± 143.16 | 119.41 ± 105.55 | 169.76 ± 142.68 | 183.08 ± 40.85 | 172.86 ± 48.51 | 140.76 ± 116.08 |
| | | Median | 91.47 | 82.00 | 125.43 | 195.88 | 189.09 | 102.43 |
| | | Range | 46.66 – 593.03 | 38.32 – 490.55 | 52.79 – 499.60 | 137.37 – 215.99 | 98.57 – 219.82 | 38.32 – 593.03 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 60.22 ± 36.29 | 65.45 ± 59.08 | 34.26 ± 32.49 | 37.85 ± 14.34 | 57.79 ± 44.04 | 51.83 ± 39.37 |
| | | Median | 60.39 | 44.94 | 24.36 | 30.10 | 35.33 | 30.10 |
| | | Range | 25.34 – 94.75 | 22.63 – 149.30 | 12.79 – 91.64 | 29.05 – 54.40 | 22.12 – 140.05 | 12.79 – 149.30 |
| | | *n* | 4 | 4 | 5 | 3 | 7 | 23 |
| **PCB-153** | **B** | Mean ± SD | 158.87 ± 194.46 | 159.35 ± 165.61 | 253.37 ± 212.33 | 276.70 ± 88.61 | 241.36 ± 30.65 | 189.00 ± 170.52 |
| | | Median | 103.27 | 95.80 | 175.40 | 294.95 | 235.63 | 128.65 |
| | | Range | 58.90 – 788.70 | 42.29 – 751.15 | 68.99 – 725.15 | 180.39 – 354.76 | 197.28 – 274.07 | 42.29 – 788.70 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 113.52 ± 72.07 | 87.29 ± 77.32 | 54.33 ± 51.24 | 59.34 ± 22.66 | 95.75 ± 70.33 | 83.62 ± 62.32 |
| | | Median | 101.58 | 63.76 | 35.59 | 51.91 | 52.12 | 52.12 |
| | | Range | 52.75 – 198.17 | 28.21 – 193.44 | 24.33 – 145.05 | 41.34 – 84.78 | 31.31 – 187.14 | 24.33 – 198.17 |
| | | *n* | 4 | 4 | 5 | 3 | 7 | 23 |
| **PCB-180** | **B** | Mean ± SD | 82.95 ± 112.13 | 75.03 ± 91.47 | 103.03 ± 96.74 | 137.58 ± 53.04 | 110.33 ± 9.75 | 90.05 ± 90.79 |
| | | Median | 47.24 | 46.85 | 70.30 | 152.39 | 107.80 | 56.00 |

**Table B3 Continued:** Mean ± standard deviation (SD), median, range (min – max) concentrations (ng/g ww) of organohalogenated contaminants (OHCs) in blood plasma of male glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya (B) and in Kongsfjorden (K), Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| OHC | Location | | 2015 | 2016 | 2017 | 2018 | 2019 | All years |
|---|---|---|---|---|---|---|---|---|
| **PCB-180** | **B** | Range | 23.49 – 446.22 | 17.68 – 409.96 | 28.07 – 322.06 | 78.71 – 181.64 | 100.60 – 126.32 | 17.68 – 446.22 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 63.72 ± 44.33 | 35.14 ± 32.16 | 27.11 ± 29.47 | 27.46 ± 12.04 | 45.12 ± 34.81 | 40.40 ± 32.93 |
| | | Median | 55.30 | 25.68 | 15.31 | 25.09 | 22.69 | 22.88 |
| | | Range | 22.88 – 121.39 | 10.46 – 78.76 | 10.17 – 79.40 | 16.78 – 40.52 | 13.96 – 95.58 | 10.17 – 121.39 |
| | | *n* | 4 | 4 | 5 | 3 | 7 | 23 |
| **PCB-183** | **B** | Mean ± SD | 14.04 ± 18.91 | 12.17 ± 14.42 | 20.77 ± 19.30 | 25.38 ± 7.87 | 22.14 ± 3.27 | 16.14 ± 15.86 |
| | | Median | 8.06 | 7.27 | 15.37 | 29.89 | 21.69 | 10.96 |
| | | Range | 3.84 – 75.38 | 2.68 – 64.96 | 6.71 – 65.19 | 16.30 – 29.96 | 18.12 – 26.78 | 2.68 – 75.38 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 9.23 ± 5.82 | 6.41 ± 5.74 | 4.37 ± 4.80 | 4.47 ± 1.82 | 6.75 ± 4.78 | 6.31 ± 4.77 |
| | | Median | 8.52 | 4.72 | 2.49 | 3.87 | 3.65 | 3.87 |
| | | Range | 3.95 – 15.93 | 2.05 – 14.16 | 1.85 – 12.95 | 3.02 – 6.51 | 2.37 – 12.83 | 1.85 – 15.93 |
| | | *n* | 4 | 4 | 5 | 3 | 7 | 23 |
| **PCB-187** | **B** | Mean ± SD | 32.24 ± 30.32 | 28.88 ± 23.36 | 44.21 ± 36.46 | 62.05 ± 18.24 | 51.76 ± 17.49 | 37.15 ± 28.19 |
| | | Median | 23.63 | 18.88 | 34.10 | 54.53 | 58.88 | 31.67 |
| | | Range | 9.82 – 127.93 | 8.38 – 109.54 | 17.00 – 128.52 | 48.77 – 82.84 | 29.42 – 71.02 | 8.38 – 128.51 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 11.11 ± 7.78 | 10.50 ± 8.19 | 6.19 ± 5.23 | 8.34 ± 3.03 | 8.04 ± 5.75 | 8.64 ± 5.95 |
| | | Median | 9.28 | 8.57 | 4.43 | 7.23 | 6.03 | 6.03 |
| | | Range | 3.96 – 21.94 | 3.89 – 20.97 | 2.53 – 15.44 | 6.02 – 11.77 | 4.65 – 20.80 | 2.53 – 21.94 |
| | | *n* | 4 | 4 | 5 | 3 | 7 | 23 |
| **PCB-194** | **B** | Mean ± SD | 11.54 ± 13.27 | 10.28 ± 12.97 | 14.03 ± 13.22 | 21.17 ± 8.25 | 16.54 ± 2.76 | 12.68 ± 12.13 |
| | | Median | 6.88 | 5.33 | 9.76 | 25.23 | 15.99 | 10.10 |
| | | Range | 3.12 – 53.90 | 2.09 – 58.28 | 3.54 – 43.67 | 11.69 – 26.61 | 14.13 – 21.24 | 2.09 – 58.28 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 7.89 ± 5.43 | 3.75 ± 3.27 | 3.42 ± 3.81 | 3.14 ± 1.51 | 5.34 ± 4.05 | 4.80 ± 3.95 |
| | | Median | 6.73 | 2.95 | 1.64 | 3.04 | 3.36 | 3.04 |
| | | Range | 2.70 – 15.42 | 1.14 – 7.95 | 1.17 – 10.17 | 1.68 – 4.69 | 1.38 – 10.96 | 1.14 – 15.42 |
| | | *n* | 4 | 4 | 5 | 3 | 7 | 23 |
| **HCB** | **B** | Mean ± SD | 13.07 ± 1.51 | 13.69 ± 1.00 | 15.42 ± 4.31 | 12.85 ± 0.85 | 13.10 ± 0.63 | 13.70 ± 2.16 |
| | | Median | 12.98 | 13.89 | 14.19 | 13.27 | 13.24 | 13.38 |
| | | Range | 11.58 – 17.66 | 11.26 – 14.93 | 12.74 – 25.92 | 11.87 – 13.40 | 12.10 – 13.68 | 11.26 – 25.92 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |

**Table B3 Continued:** Mean ± standard deviation (SD), median, range (min – max) concentrations (ng/g ww) of organohalogenated contaminants (OHCs) in blood plasma of male glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya (B) and in Kongsfjorden (K), Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| OHC | Location | | 2015 | 2016 | 2017 | 2018 | 2019 | All years |
|---|---|---|---|---|---|---|---|---|
| **HCB** | **K** | Mean ± SD | 6.13 ± 1.12 | 9.51 ± 3.49 | 7.70 ± 2.92 | 3.43 ± 0.70 | 3.39 ± 0.43 | 5.87 ± 3.07 |
| | | Median | 5.89 | 8.16 | 6.95 | 3.62 | 3.49 | 5.16 |
| | | Range | 5.16 – 7.58 | 7.10 – 14.63 | 4.93 – 12.66 | 2.65 – 4.01 | 2.70 – 3.98 | 2.65 – 14.63 |
| | | *n* | 4 | 4 | 5 | 3 | 7 | 23 |
| ***β*-HCH** | **B** | Mean ± SD | 1.24 ± 0.69 | 1.42 ± 0.74 | 1.47 ± 0.90 | 2.14 ± 0.63 | 1.88 ± 0.66 | 1.47 ± 0.75 |
| | | Median | 1.05 | 1.14 | 1.13 | 2.09 | 1.66 | 1.24 |
| | | Range | 0.47 – 3.22 | 0.58 – 2.96 | 0.62 – 3.41 | 1.53 – 2.79 | 1.05 – 2.79 | 0.47 – 3.41 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 0.80 ± 0.37 | 0.74 ± 0.41 | 0.43 ± 0.21 | 0.52 ± 0.14 | 0.43 ± 0.12 | 0.56 ± 0.28 |
| | | Median | 0.87 | 0.64 | 0.34 | 0.52 | 0.46 | 0.46 |
| | | Range | 0.36 – 1.11 | 0.41 – 1.27 | 0.26 – 0.79 | 0.38 – 0.67 | 0.27 – 0.64 | 0.26 – 1.27 |
| | | *n* | 4 | 4 | 5 | 3 | 7 | 23 |
| **Oxychlordane** | **B** | Mean ± SD | 16.98 ± 10.78 | 18.15 ± 10.24 | 24.14 ± 18.46 | 29.38 ± 6.40 | 28.52 ± 5.81 | 20.72 ± 12.10 |
| | | Median | 14.43 | 13.54 | 18.93 | 29.72 | 28.00 | 18.03 |
| | | Range | 8.00 – 49.28 | 6.51 – 41.55 | 8.37 – 65.15 | 22.82 – 35.60 | 20.78 – 36.60 | 6.51 – 65.15 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 19.63 ± 12.68 | 21.20 ± 27.07 | 6.90 ± 4.82 | 6.62 ± 1.99 | 14.43 ± 12.56 | 13.86 ± 14.27 |
| | | Median | 16.48 | 9.00 | 5.80 | 6.73 | 5.29 | 7.15 |
| | | Range | 8.78 – 36.78 | 5.30 – 61.50 | 1.97 – 14.83 | 4.59 – 8.56 | 3.51 – 30.30 | 1.97 – 61.50 |
| | | *n* | 4 | 4 | 5 | 3 | 7 | 23 |
| ***t*-Chlordane** | **B** | Mean ± SD | 0.005 ± 0.00 | 0.005 ± 0.00 | 0.005 ± 0.00 | 0.005 ± 0.00 | 0.005 ± 0.00 | 0.005 ± 0.00 |
| | | Median | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 |
| | | Range | 0.005 – 0.005 | 0.005 – 0.005 | 0.005 – 0.005 | 0.005 – 0.005 | 0.005 – 0.005 | 0.005 – 0.005 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 0.002 ± 0.00 | 0.44 ± 0.19 | 0.39 ± 0.11 | 0.01 ± 0.00 | 0.01 ± 0.00 | 0.16 ± 0.22 |
| | | Median | 0.002 | 0.39 | 0.37 | 0.01 | 0.01 | 0.01 |
| | | Range | 0.002 – 0.002 | 0.30 – 0.71 | 0.26 – 0.57 | 0.01 – 0.01 | 0.01 – 0.01 | 0.00 – 0.71 |
| | | *n* | 4 | 4 | 5 | 3 | 7 | 23 |
| ***t*-Nonachlor** | **B** | Mean ± SD | 0.78 ± 0.47 | 0.71 ± 0.47 | 0.91 ± 0.87 | 0.85 ± 0.79 | 0.80 ± 0.60 | 0.78 ± 0.56 |
| | | Median | 0.77 | 0.56 | 0.67 | 0.41 | 0.57 | 0.57 |
| | | Range | 0.22 – 1.82 | 0.11 – 1.95 | 0.25 – 2.85 | 0.39 – 1.77 | 0.08 – 1.62 | 0.08 – 2.85 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 0.77 ± 0.32 | 2.06 ± 2.69 | 0.73 ± 0.26 | 0.85 ± 0.40 | 0.51 ± 0.20 | 0.92 ± 1.16 |
| | | Median | 0.89 | 0.86 | 0.65 | 1.02 | 0.64 | 0.65 |

**Table B3 Continued:** Mean ± standard deviation (SD), median, range (min – max) concentrations (ng/g ww) of organohalogenated contaminants (OHCs) in blood plasma of male glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya (B) and in Kongsfjorden (K), Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| OHC | Location | | 2015 | 2016 | 2017 | 2018 | 2019 | All years |
|---|---|---|---|---|---|---|---|---|
| ***t*-Nonachlor** | **K** | Range | 0.29 – 1.00 | 0.44 – 6.08 | 0.40 – 1.03 | 0.39 – 1.14 | 0.27 – 0.68 | 0.27 – 6.08 |
| | | *n* | 4 | 4 | 5 | 3 | 7 | 23 |
| ***c*-Nonachlor** | **B** | Mean ± SD | 1.54 ± 0.87 | 1.41 ± 0.62 | 1.57 ± 0.71 | 2.18 ± 0.41 | 1.81 ± 1.31 | 1.57 ± 0.79 |
| | | Median | 1.39 | 1.23 | 1.47 | 2.14 | 1.61 | 1.41 |
| | | Range | 0.56 – 3.72 | 0.67 – 2.90 | 0.92 – 2.96 | 1.79 – 2.61 | 0.43 – 3.91 | 0.43 – 3.91 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 0.74 ± 0.43 | 0.43 ± 0.32 | 0.54 ± 0.22 | 0.95 ± 0.12 | 0.57 ± 0.37 | 0.62 ± 0.33 |
| | | Median | 0.85 | 0.33 | 0.47 | 0.93 | 0.56 | 0.69 |
| | | Range | 0.13 – 1.15 | 0.16 – 0.88 | 0.32 – 0.84 | 0.83 – 1.08 | 0.16 – 1.11 | 0.13 – 1.15 |
| | | *n* | 4 | 4 | 5 | 3 | 7 | 23 |
| **Mirex** | **B** | Mean ± SD | 10.23 ± 5.60 | 11.52 ± 6.64 | 15.89 ± 10.08 | 21.94 ± 5.68 | 20.03 ± 1.79 | 13.52 ± 7.53 |
| | | Median | 8.90 | 9.06 | 13.73 | 24.50 | 19.51 | 10.90 |
| | | Range | 4.62 – 26.32 | 3.78 – 30.18 | 6.28 – 36.81 | 15.43 – 25.88 | 18.31 – 23.00 | 3.78 – 36.81 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 8.80 ± 4.82 | 5.20 ± 3.66 | 4.13 ± 4.44 | 5.04 ± 1.77 | 6.26 ± 3.58 | 5.89 ± 3.85 |
| | | Median | 8.07 | 5.07 | 2.15 | 4.75 | 4.53 | 4.53 |
| | | Range | 3.99 – 15.06 | 2.02 – 8.63 | 1.77 – 12.05 | 3.43 – 6.94 | 2.42 – 10.92 | 1.77 – 15.06 |
| | | *n* | 4 | 4 | 5 | 3 | 7 | 23 |
| ***p,p'*-DDT** | **B** | Mean ± SD | 0.09 ± 0.07 | 0.12 ± 0.12 | 0.07 ± 0.08 | 0.12 ± 0.09 | 0.17 ± 0.20 | 0.11 ± 0.11 |
| | | Median | 0.08 | 0.02 | 0.02 | 0.13 | 0.02 | 0.04 |
| | | Range | 0.02 – 0.22 | 0.02 – 0.38 | 0.02 – 0.22 | 0.02 – 0.20 | 0.02 – 0.43 | 0.02 – 0.43 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 0.27 ± 0.21 | 0.02 ± 0.00 | 0.02 ± 0.00 | 0.25 ± 0.09 | 0.10 ± 0.08 | 0.12 ± 0.14 |
| | | Median | 0.17 | 0.02 | 0.02 | 0.28 | 0.10 | 0.02 |
| | | Range | 0.17 – 0.59 | 0.02 – 0.02 | 0.02 – 0.02 | 0.15 – 0.33 | 0.02 – 0.19 | 0.02 – 0.59 |
| | | *n* | 4 | 4 | 5 | 3 | 7 | 23 |
| ***p,p'*-DDE** | **B** | Mean ± SD | 141.72 ± 48.87 | 150.73 ± 57.65 | 199.11 ± 112.82 | 278.97 ± 65.77 | 242.50 ± 47.35 | 174.94 ± 77.87 |
| | | Median | 141.60 | 145.21 | 187.40 | 313.28 | 256.98 | 164.49 |
| | | Range | 62.96 – 247.29 | 62.00 – 247.94 | 84.71 – 432.17 | 203.14 – 320.50 | 162.73 – 278.69 | 62.00 – 432.17 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 93.05 ± 58.47 | 12.43 ± 12.71 | 4.38 ± 3.75 | 53.32 ± 16.27 | 84.62 ± 64.99 | 52.00 ± 55.79 |
| | | Median | 93.72 | 7.06 | 4.08 | 44.35 | 45.80 | 34.81 |
| | | Range | 33.46 – 151.31 | 4.45 – 31.15 | 0.06 – 10.27 | 43.52 – 72.10 | 27.81 – 194.91 | 0.06 – 194.91 |
| | | *n* | 4 | 4 | 5 | 3 | 7 | 23 |

**Table B3 Continued:** Mean ± standard deviation (SD), median, range (min – max) concentrations (ng/g ww) of organohalogenated contaminants (OHCs) in blood plasma of male glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya (B) and in Kongsfjorden (K), Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| OHC | Location | | 2015 | 2016 | 2017 | 2018 | 2019 | All years |
|---|---|---|---|---|---|---|---|---|
| **PFHxS** | **B** | Mean ± SD | 1.74 ± 0.56 | 0.93 ± 0.28 | 0.85 ± 0.21 | 1.64 ± 0.39 | 0.90 ± 0.25 | 1.19 ± 0.54 |
| | | Median | 1.86 | 0.92 | 0.85 | 1.63 | 1.00 | 1.05 |
| | | Range | 0.75 – 2.55 | 0.46 – 1.42 | 0.61 – 1.18 | 1.26 – 2.04 | 0.52 – 1.16 | 0.46 – 2.55 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 0.75 ± 1.04 | 0.79 ± 0.66 | 0.48 ± 0.46 | 0.68 ± 0.37 | 0.88 ± 0.52 | 0.74 ± 0.60 |
| | | Median | 0.37 | 0.56 | 0.33 | 0.89 | 0.60 | 0.56 |
| | | Range | 0.01 – 2.26 | 0.30 – 1.75 | 0.12 – 1.16 | 0.26 – 0.91 | 0.43 – 1.83 | 0.01 – 2.26 |
| | | *n* | 4 | 4 | 4 | 3 | 7 | 22 |
| **PFHpS** | **B** | Mean ± SD | 1.98 ± 0.65 | 1.08 ± 0.43 | 2.19 ± 0.71 | 3.48 ± 0.63 | 1.37 ± 0.30 | 1.72 ± 0.85 |
| | | Median | 2.00 | 1.08 | 2.43 | 3.56 | 1.32 | 1.49 |
| | | Range | 0.80 – 2.95 | 0.03 – 1.68 | 1.17 – 3.09 | 2.81 – 4.06 | 1.10 – 1.88 | 0.03 – 4.06 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | | 0.06 ± 0.07 | 0.01 ± 0.00 | 0.07 ± 0.06 | 0.22 ± 0.08 | 0.11 ± 0.11 |
| | | Median | | 0.03 | 0.01 | 0.07 | 0.19 | 0.10 |
| | | Range | | 0.01 – 0.15 | 0.01 – 0.01 | 0.01 – 0.13 | 0.15 – 0.34 | 0.01 – 0.34 |
| | | *n* | | 4 | 4 | 3 | 7 | 18 |
| **BrPFOS** | **B** | Mean ± SD | 60.53 ± 27.76 | 35.60 ± 12.98 | 58.65 ± 20.40 | 75.35 ± 22.54 | 32.11 ± 6.90 | 48.87 ± 23.62 |
| | | Median | 62.84 | 33.12 | 61.73 | 65.00 | 29.40 | 43.31 |
| | | Range | 15.97 – 102.87 | 11.38 – 56.20 | 33.68 – 87.57 | 59.84 – 101.20 | 26.08 – 42.33 | 11.38 – 102.87 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 1.00 ± 1.53 | 2.30 ± 3.26 | 1.49 ± 0.81 | 2.07 ± 1.09 | 2.56 ± 0.98 | 1.97 ± 1.64 |
| | | Median | 0.30 | 1.04 | 1.45 | 1.85 | 2.57 | 1.69 |
| | | Range | 0.12 – 3.30 | 0.01 – 7.10 | 0.67 – 2.41 | 1.10 – 3.25 | 1.25 – 3.87 | 0.01 – 7.10 |
| | | *n* | 4 | 4 | 4 | 3 | 7 | 22 |
| **LinPFOS** | **B** | Mean ± SD | 382.00 ± 137.36 | 250.79 ± 74.11 | 441.96 ± 115.85 | 544.39 ± 68.02 | 243.54 ± 35.29 | 339.48 ± 136.28 |
| | | Median | 368.41 | 245.71 | 473.73 | 513.34 | 235.75 | 315.06 |
| | | Range | 138.32 – 575.02 | 125.98 – 372.29 | 277.23 – 583.83 | 497.43 – 622.39 | 209.37 – 289.14 | 125.98 – 622.39 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 13.25 ± 7.23 | 12.23 ± 6.65 | 10.64 ± 3.10 | 9.24 ± 2.28 | 11.61 ± 3.70 | 11.52 ± 4.60 |
| | | Median | 13.00 | 10.52 | 9.86 | 8.99 | 12.26 | 11.05 |
| | | Range | 5.02 – 21.98 | 6.30 – 21.59 | 7.85 – 15.01 | 7.10 – 11.64 | 5.50 – 15.04 | 5.02 – 21.98 |
| | | *n* | 4 | 4 | 4 | 3 | 7 | 22 |
| **PFNS** | **B** | Mean ± SD | 0.62 ± 0.42 | 0.41 ± 0.26 | 0.69 ± 0.15 | 0.66 ± 0.11 | 0.13 ± 0.23 | 0.50 ± 0.33 |
| | | Median | 0.64 | 0.53 | 0.67 | 0.71 | 0.03 | 0.57 |

**Table B3 Continued:** Mean ± standard deviation (SD), median, range (min – max) concentrations (ng/g ww) of organohalogenated contaminants (OHCs) in blood plasma of male glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya (B) and in Kongsfjorden (K), Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| OHC | Location | | 2015 | 2016 | 2017 | 2018 | 2019 | All years |
|---|---|---|---|---|---|---|---|---|
| **PFNS** | **B** | Range | 0.03 – 1.45 | 0.03 – 0.66 | 0.48 – 0.92 | 0.54 – 0.74 | 0.03 – 0.54 | 0.03 – 1.45 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | | 0.01 ± 0.00 | 0.01 ± 0.00 | 0.03 ± 0.00 | 0.45 ± 0.41 | 0.18 ± 0.32 |
| | | Median | | 0.01 | 0.01 | 0.03 | 0.75 | 0.01 |
| | | Range | | 0.01 – 0.01 | 0.01 – 0.01 | 0.03 – 0.03 | 0.01 – 0.80 | 0.01 – 0.80 |
| | | *n* | | 4 | 4 | 3 | 7 | 18 |
| **PFDcS** | **B** | Mean ± SD | 0.82 ± 0.37 | 0.61 ± 0.27 | 0.93 ± 0.24 | 1.17 ± 0.27 | 0.65 ± 0.29 | 0.77 ± 0.33 |
| | | Median | 0.89 | 0.51 | 0.96 | 1.28 | 0.54 | 0.73 |
| | | Range | 0.25 – 1.48 | 0.28 – 1.13 | 0.59 – 1.22 | 0.86 – 1.36 | 0.37 – 1.12 | 0.25 – 1.48 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 0.08 ± 0.00 | 0.02 ± 0.00 | 0.02 ± 0.00 | 3.51 ± 0.34 | 0.06 ± 0.04 | 0.52 ± 1.22 |
| | | Median | 0.08 | 0.02 | 0.02 | 3.46 | 0.06 | 0.04 |
| | | Range | 0.08 – 0.08 | 0.02 – 0.02 | 0.02 – 0.02 | 3.19 – 3.87 | 0.02 – 0.11 | 0.02 – 3.87 |
| | | *n* | 4 | 4 | 4 | 3 | 7 | 22 |
| **PFOA** | **B** | Mean ± SD | 1.45 ± 0.52 | 0.47 ± 0.24 | 0.38 ± 0.17 | 0.66 ± 0.26 | 0.50 ± 0.16 | 0.75 ± 0.55 |
| | | Median | 1.40 | 0.51 | 0.35 | 0.64 | 0.55 | 0.58 |
| | | Range | 0.42 – 2.31 | 0.07 – 0.97 | 0.19 – 0.63 | 0.41 – 0.94 | 0.28 – 0.70 | 0.07 – 2.31 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 0.02 ± 0.03 | 0.17 ± 0.07 | 0.12 ± 0.06 | 0.27 ± 0.19 | 0.24 ± 0.14 | 0.17 ± 0.13 |
| | | Median | 0.01 | 0.19 | 0.12 | 0.29 | 0.19 | 0.15 |
| | | Range | 0.01 – 0.07 | 0.07 – 0.23 | 0.06 – 0.18 | 0.07 – 0.44 | 0.08 – 0.43 | 0.01 – 0.44 |
| | | *n* | 4 | 4 | 4 | 3 | 7 | 22 |
| **PFNA** | **B** | Mean ± SD | 31.55 ± 11.47 | 15.57 ± 4.93 | 20.54 ± 5.72 | 33.04 ± 7.47 | 14.38 ± 3.71 | 21.96 ± 10.46 |
| | | Median | 30.79 | 14.62 | 20.38 | 35.16 | 14.26 | 19.73 |
| | | Range | 12.10 – 49.34 | 4.90 – 21.98 | 13.56 – 31.57 | 24.74 – 39.22 | 8.74 – 17.85 | 4.90 – 49.34 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 1.53 ± 0.50 | 2.31 ± 0.85 | 1.53 ± 0.39 | 1.98 ± 0.91 | 1.93 ± 0.57 | 1.86 ± 0.64 |
| | | Median | 1.64 | 2.28 | 1.63 | 1.91 | 1.83 | 1.78 |
| | | Range | 0.84 – 2.02 | 1.30 – 3.37 | 0.97 – 1.89 | 1.11 – 2.92 | 1.28 – 2.81 | 0.84 – 3.37 |
| | | *n* | 4 | 4 | 4 | 3 | 7 | 22 |
| **PFDcA** | **B** | Mean ± SD | 31.48 ± 9.79 | 21.19 ± 5.76 | 28.17 ± 5.56 | 34.66 ± 0.60 | 17.48 ± 2.43 | 25.79 ± 8.60 |
| | | Median | 33.09 | 21.94 | 27.14 | 34.79 | 18.22 | 25.04 |
| | | Range | 14.47 – 43.15 | 8.39 – 30.63 | 20.78 – 38.97 | 34.00 – 35.18 | 14.29 – 20.44 | 8.39 – 43.15 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |

**Table B3 Continued:** Mean ± standard deviation (SD), median, range (min – max) concentrations (ng/g ww) of organohalogenated contaminants (OHCs) in blood plasma of male glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya (B) and in Kongsfjorden (K), Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| OHC | Location | | 2015 | 2016 | 2017 | 2018 | 2019 | All years |
|---|---|---|---|---|---|---|---|---|
| **PFDcA** | **K** | Mean ± SD | 0.96 ± 0.25 | 0.73 ± 0.28 | 1.17 ± 0.53 | 0.79 ± 0.15 | 0.81 ± 0.23 | 0.88 ± 0.32 |
| | | Median | 0.90 | 0.68 | 1.11 | 0.73 | 0.77 | 0.77 |
| | | Range | 0.74 – 1.29 | 0.46 – 1.11 | 0.70 – 1.76 | 0.68 – 0.97 | 0.52 – 1.20 | 0.46 – 1.76 |
| | | *n* | 4 | 4 | 4 | 3 | 7 | 22 |
| **PFUnA** | **B** | Mean ± SD | 111.74 ± 29.84 | 89.86 ± 23.88 | 105.28 ± 15.28 | 113.03 ± 3.45 | 65.93 ± 9.71 | 97.64 ± 26.53 |
| | | Median | 117.55 | 92.93 | 109.76 | 112.86 | 64.60 | 96.85 |
| | | Range | 60.87 – 147.01 | 39.75 – 134.39 | 83.83 – 128.29 | 109.67 – 116.56 | 55.72 – 75.99 | 39.75 – 147.01 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 3.30 ± 1.97 | 2.31 ± 0.61 | 5.49 ± 2.98 | 2.38 ± 0.23 | 2.28 ± 0.56 | 3.07 ± 1.87 |
| | | Median | 2.60 | 2.45 | 5.57 | 2.27 | 2.22 | 2.40 |
| | | Range | 1.82 – 6.20 | 1.52 – 2.81 | 2.41 – 8.41 | 2.23 – 2.65 | 1.28 – 3.13 | 1.28 – 8.41 |
| | | *n* | 4 | 4 | 4 | 3 | 7 | 22 |
| **PFDoA** | **B** | Mean ± SD | 16.30 ± 4.04 | 13.99 ± 3.55 | 15.47 ± 2.18 | 15.87 ± 0.68 | 9.86 ± 1.25 | 14.57 ± 3.67 |
| | | Median | 16.80 | 13.68 | 15.77 | 16.05 | 9.48 | 14.31 |
| | | Range | 10.86 – 24.17 | 7.47 – 20.14 | 12.10 – 18.83 | 15.12 – 16.44 | 8.64 – 11.41 | 7.47 – 24.17 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 0.67 ± 0.47 | 0.60 ± 0.18 | 1.27 ± 0.56 | 0.62 ± 0.09 | 0.73 ± 0.24 | 0.78 ± 0.40 |
| | | Median | 0.66 | 0.56 | 1.27 | 0.61 | 0.74 | 0.69 |
| | | Range | 0.11 – 1.25 | 0.45 – 0.84 | 0.67 – 1.87 | 0.53 – 0.71 | 0.33 – 1.05 | 0.11 – 1.87 |
| | | *n* | 4 | 4 | 4 | 3 | 7 | 22 |
| **PFTriA** | **B** | Mean ± SD | 31.93 ± 10.43 | 29.11 ± 9.63 | 28.84 ± 5.42 | 29.93 ± 3.72 | 18.47 ± 2.75 | 28.76 ± 9.09 |
| | | Median | 27.97 | 26.21 | 28.39 | 30.86 | 18.64 | 26.90 |
| | | Range | 20.20 – 56.10 | 16.23 – 50.65 | 21.79 – 39.28 | 25.84 – 33.10 | 15.21 – 21.41 | 15.21 – 56.10 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 2.23 ± 1.08 | 2.79 ± 0.35 | 3.70 ± 1.35 | 2.16 ± 0.48 | 3.67 ± 1.06 | 3.05 ± 1.12 |
| | | Median | 2.21 | 2.73 | 3.64 | 1.93 | 3.64 | 2.87 |
| | | Range | 0.94 – 3.55 | 2.49 – 3.20 | 2.12 – 5.40 | 1.85 – 2.72 | 1.95 – 4.75 | 0.94 – 5.40 |
| | | *n* | 4 | 4 | 4 | 3 | 7 | 22 |
| **PFTeA** | **B** | Mean ± SD | 3.32 ± 1.44 | 3.04 ± 1.16 | 2.79 ± 0.63 | 2.88 ± 0.33 | 2.21 ± 0.50 | 2.98 ± 1.11 |
| | | Median | 2.88 | 2.57 | 2.84 | 3.02 | 2.09 | 2.70 |
| | | Range | 2.29 – 7.59 | 1.62 – 5.73 | 1.79 – 3.92 | 2.50 – 3.11 | 1.55 – 2.85 | 1.55 – 7.59 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | 0.13 ± 0.10 | 0.46 ± 0.15 | 0.62 ± 0.29 | 0.33 ± 0.03 | 0.41 ± 0.17 | 0.39 ± 0.22 |
| | | Median | 0.14 | 0.42 | 0.71 | 0.33 | 0.37 | 0.35 |

**Table B3 Continued:** Mean ± standard deviation (SD), median, range (min – max) concentrations (ng/g ww) of organohalogenated contaminants (OHCs) in blood plasma of male glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya (B) and in Kongsfjorden (K), Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| OHC | Location | | 2015 | 2016 | 2017 | 2018 | 2019 | All years |
|---|---|---|---|---|---|---|---|---|
| **PFTeA** | **K** | Range | 0.01 – 0.23 | 0.33 – 0.67 | 0.22 – 0.84 | 0.31 – 0.37 | 0.17 – 0.62 | 0.01 – 0.84 |
| | | *n* | 4 | 4 | 4 | 3 | 7 | 22 |
| **8:2 FTS** | **B** | Mean ± SD | 0.20 ± 0.23 | 0.14 ± 0.13 | 0.06 ± 0.03 | 0.08 ± 0.06 | 0.03 ± 0.01 | 0.13 ± 0.15 |
| | | Median | 0.08 | 0.10 | 0.06 | 0.09 | 0.03 | 0.06 |
| | | Range | 0.03 – 0.66 | 0.02 – 0.37 | 0.03 – 0.10 | 0.03 – 0.14 | 0.03 – 0.05 | 0.02 – 0.66 |
| | | *n* | 13 | 17 | 8 | 3 | 5 | 46 |
| | **K** | Mean ± SD | | | | 0.03 ± 0.00 | | 0.03 ± 0.00 |
| | | Median | | | | 0.03 | | 0.03 |
| | | Range | | | | 0.03 – 0.03 | | 0.03 – 0.03 |
| | | *n* | | | | 3 | | 3 |

**Table B4:** Mean ± standard deviation (SD), median, range (min – max) concentrations (ng/g ww) of organohalogenated contaminants (OHCs) in blood plasma of female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| **OHC** | **Location** | | **2015** | **2016** | **2017** | **2018** | **2019** | **All years** |
|---|---|---|---|---|---|---|---|---|
| **PCB-28** | **B** | Mean ± SD | 1.37 ± 0.77 | 1.34 ± 0.79 | 2.17 ± 1.58 | 1.32 ± 0.50 | 2.19 ± 1.25 | 1.64 ± 1.06 |
| | | Median | 1.06 | 1.12 | 1.81 | 1.22 | 1.66 | 1.35 |
| | | Range | 0.42 – 2.97 | 0.02 – 2.77 | 0.68 – 5.64 | 0.89 – 1.93 | 0.75 – 3.77 | 0.02 – 5.64 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 0.41 ± 0.11 | 0.35 ± 0.13 | 0.28 ± 0.15 | 0.16 ± 0.09 | 0.29 ± 0.15 | 0.30 ± 0.15 |
| | | Median | 0.40 | 0.36 | 0.23 | 0.12 | 0.21 | 0.29 |
| | | Range | 0.28 – 0.60 | 0.18 – 0.72 | 0.12 – 0.61 | 0.06 – 0.28 | 0.11 – 0.53 | 0.06 – 0.72 |
| | | *n* | 10 | 15 | 16 | 10 | 7 | 58 |
| **PCB-52** | **B** | Mean ± SD | 0.30 ± 0.23 | 0.24 ± 0.21 | 0.34 ± 0.38 | 0.31 ± 0.10 | 0.34 ± 0.25 | 0.30 ± 0.25 |
| | | Median | 0.26 | 0.13 | 0.26 | 0.33 | 0.36 | 0.26 |
| | | Range | 0.06 – 0.79 | 0.03 – 0.70 | 0.01 – 1.13 | 0.19 – 0.40 | 0.04 – 0.82 | 0.01 – 1.13 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 0.23 ± 0.11 | 0.29 ± 0.19 | 0.24 ± 0.18 | 0.16 ± 0.17 | 0.04 ± 0.04 | 0.21 ± 0.17 |
| | | Median | 0.21 | 0.28 | 0.22 | 0.13 | 0.02 | 0.19 |
| | | Range | 0.07 – 0.40 | 0.07 – 0.81 | 0.01 – 0.55 | 0.02 – 0.50 | 0.02 – 0.13 | 0.01 – 0.81 |
| | | *n* | 10 | 15 | 16 | 10 | 7 | 58 |
| **PCB-99** | **B** | Mean ± SD | 17.86 ± 11.08 | 16.25 ± 9.52 | 18.63 ± 15.67 | 11.07 ± 3.05 | 17.19 ± 9.36 | 16.81 ± 10.58 |
| | | Median | 13.39 | 11.25 | 15.87 | 10.72 | 14.68 | 13.73 |
| | | Range | 6.38 – 43.43 | 3.90 – 31.20 | 5.01 – 54.55 | 7.83 – 14.99 | 6.45 – 35.31 | 3.90 – 54.55 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 4.53 ± 1.83 | 7.45 ± 5.50 | 5.81 ± 5.19 | 4.56 ± 2.94 | 7.66 ± 4.42 | 6.02 ± 4.48 |
| | | Median | 3.99 | 6.44 | 3.48 | 3.32 | 6.69 | 4.84 |
| | | Range | 2.45 – 7.70 | 1.15 – 24.87 | 1.57 – 17.61 | 1.64 – 10.56 | 2.61 – 15.26 | 1.15 – 24.87 |
| | | *n* | 10 | 15 | 16 | 10 | 7 | 58 |
| **PCB-101** | **B** | Mean ± SD | 1.38 ± 0.67 | 0.63 ± 0.70 | 0.52 ± 0.68 | 0.40 ± 0.29 | 0.61 ± 0.53 | 0.79 ± 0.71 |
| | | Median | 1.19 | 0.30 | 0.26 | 0.46 | 0.75 | 0.75 |
| | | Range | 0.52 – 2.87 | 0.01 – 1.74 | 0.01 – 1.90 | 0.01 – 0.67 | 0.01 – 1.27 | 0.01 – 2.87 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 0.46 ± 0.27 | 0.64 ± 0.68 | 0.75 ± 0.80 | 0.31 ± 0.43 | 0.13 ± 0.28 | 0.52 ± 0.61 |
| | | Median | 0.52 | 0.45 | 0.61 | 0.10 | 0.03 | 0.36 |
| | | Range | 0.08 – 0.79 | 0.01 – 1.96 | 0.01 – 2.51 | 0.03 – 1.36 | 0.03 – 0.75 | 0.01 – 2.51 |
| | | *n* | 10 | 15 | 16 | 10 | 7 | 58 |

**Table B4 Continued:** Mean ± standard deviation (SD), median, range (min – max) concentrations (ng/g ww) of organohalogenated contaminants (OHCs) in blood plasma of female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| OHC | Location | | 2015 | 2016 | 2017 | 2018 | 2019 | All years |
|---|---|---|---|---|---|---|---|---|
| **PCB-105** | **B** | Mean ± SD | 12.69 ± 6.51 | 10.19 ± 5.03 | 12.55 ± 9.71 | 7.24 ± 2.35 | 10.50 ± 6.38 | 11.05 ± 6.44 |
| | | Median | 11.18 | 8.12 | 10.27 | 7.15 | 9.38 | 9.43 |
| | | Range | 4.91 – 25.87 | 3.14 – 17.82 | 3.56 – 34.50 | 5.13 – 9.55 | 3.72 – 19.86 | 3.14 – 34.50 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 2.33 ± 1.04 | 3.53 ± 2.87 | 2.50 ± 2.03 | 1.93 ± 1.45 | 3.24 ± 2.11 | 2.73 ± 2.11 |
| | | Median | 1.99 | 2.53 | 1.66 | 1.29 | 2.20 | 2.06 |
| | | Range | 1.32 – 4.18 | 0.57 – 12.68 | 0.83 – 8.13 | 0.83 – 5.51 | 1.25 – 6.26 | 0.57 – 12.68 |
| | | *n* | 10 | 15 | 16 | 10 | 7 | 58 |
| **PCB-118** | **B** | Mean ± SD | 33.10 ± 19.25 | 25.98 ± 13.50 | 40.46 ± 31.34 | 23.61 ± 7.77 | 35.68 ± 19.72 | 31.82 ± 19.74 |
| | | Median | 25.68 | 20.96 | 34.50 | 24.15 | 31.68 | 26.60 |
| | | Range | 13.59 – 70.61 | 6.57 – 49.12 | 11.21 – 109.70 | 15.74 – 30.42 | 12.54 – 69.32 | 6.57 – 109.70 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 8.48 ± 4.58 | 13.71 ± 12.13 | 9.60 ± 8.71 | 8.05 ± 4.79 | 13.54 ± 9.05 | 10.68 ± 8.80 |
| | | Median | 6.87 | 9.84 | 5.31 | 5.95 | 10.32 | 7.85 |
| | | Range | 4.56 – 17.29 | 1.70 – 54.08 | 2.91 – 32.57 | 3.22 – 15.35 | 4.75 – 30.97 | 1.70 – 54.08 |
| | | *n* | 10 | 15 | 16 | 10 | 7 | 58 |
| **PCB-138** | **B** | Mean ± SD | 106.08 ± 68.18 | 91.27 ± 54.31 | 143.14 ± 121.73 | 71.04 ± 17.91 | 108.09 ± 61.70 | 105.11 ± 72.37 |
| | | Median | 83.87 | 65.50 | 121.22 | 71.47 | 88.92 | 87.09 |
| | | Range | 40.95 – 270.47 | 22.85 – 186.16 | 35.05 – 421.16 | 49.12 – 92.08 | 42.49 – 235.57 | 22.85 – 421.16 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 18.28 ± 9.15 | 33.57 ± 25.23 | 27.25 ± 27.03 | 20.85 ± 14.36 | 30.24 ± 15.04 | 26.60 ± 21.23 |
| | | Median | 14.89 | 30.37 | 15.75 | 14.23 | 28.37 | 19.59 |
| | | Range | 8.31 – 36.10 | 4.78 – 114.61 | 7.54 – 88.40 | 6.33 – 48.64 | 10.88 – 55.63 | 4.78 – 114.61 |
| | | *n* | 10 | 15 | 16 | 10 | 7 | 58 |
| **PCB-153** | **B** | Mean ± SD | 133.67 ± 90.58 | 122.83 ± 75.22 | 189.82 ± 161.24 | 89.53 ± 22.63 | 141.36 ± 83.34 | 137.33 ± 96.98 |
| | | Median | 107.23 | 90.66 | 152.36 | 89.70 | 120.67 | 108.56 |
| | | Range | 48.96 – 362.58 | 27.78 – 263.30 | 41.39 – 550.30 | 61.65 – 117.07 | 46.71 – 318.32 | 27.78 – 550.30 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 33.12 ± 22.18 | 54.42 ± 54.04 | 42.35 ± 45.46 | 34.93 ± 26.62 | 49.67 ± 34.87 | 43.48 ± 40.58 |
| | | Median | 23.05 | 43.01 | 21.67 | 23.59 | 42.25 | 31.56 |
| | | Range | 13.65 – 79.40 | 5.39 – 237.90 | 9.44 – 160.30 | 10.93 – 79.22 | 15.60 – 122.73 | 5.39 – 237.90 |
| | | *n* | 10 | 15 | 16 | 10 | 7 | 58 |
| **PCB-180** | **B** | Mean ± SD | 65.49 ± 45.06 | 56.93 ± 35.32 | 80.40 ± 65.90 | 39.38 ± 11.16 | 60.40 ± 37.91 | 62.24 ± 43.16 |
| | | Median | 53.12 | 46.59 | 65.96 | 40.94 | 51.65 | 51.20 |

**Table B4 Continued:** Mean ± standard deviation (SD), median, range (min – max) concentrations (ng/g ww) of organohalogenated contaminants (OHCs) in blood plasma of female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Number of samples analysed (n) are included.

| **OHC** | **Location** | | **2015** | **2016** | **2017** | **2018** | **2019** | **All years** |
|---|---|---|---|---|---|---|---|---|
| **PCB-180** | **B** | Range | 24.03 – 184.24 | 12.87 – 126.53 | 17.45 – 224.23 | 24.45 – 51.20 | 19.15 – 142.58 | 12.87 – 224.23 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 20.32 ± 18.70 | 25.47 ± 27.58 | 20.97 ± 25.18 | 16.88 ± 14.31 | 22.92 ± 17.49 | 21.55 ± 21.95 |
| | | Median | 11.32 | 18.83 | 10.44 | 10.95 | 20.02 | 13.78 |
| | | Range | 6.72 – 62.15 | 2.28 – 119.83 | 3.20 – 90.76 | 4.15 – 42.89 | 7.04 – 60.75 | 2.28 – 119.83 |
| | | *n* | 10 | 15 | 16 | 10 | 7 | 58 |
| **PCB-183** | **B** | Mean ± SD | 11.08 ± 7.30 | 9.30 ± 5.91 | 17.22 ± 14.14 | 8.34 ± 2.89 | 12.94 ± 7.90 | 11.66 ± 8.47 |
| | | Median | 8.72 | 7.11 | 14.29 | 7.86 | 10.73 | 9.11 |
| | | Range | 3.95 – 29.37 | 2.04 – 21.31 | 3.74 – 48.30 | 5.56 – 12.10 | 4.21 – 29.52 | 2.04 – 48.30 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 2.66 ± 1.76 | 3.91 ± 3.72 | 3.37 ± 3.76 | 2.52 ± 1.99 | 3.40 ± 2.19 | 3.24 ± 3.00 |
| | | Median | 1.91 | 3.24 | 1.72 | 1.70 | 3.17 | 2.34 |
| | | Range | 1.08 – 6.22 | 0.03 – 16.40 | 0.66 – 12.45 | 0.69 – 5.83 | 1.18 – 7.99 | 0.03 – 16.40 |
| | | *n* | 10 | 15 | 16 | 10 | 7 | 58 |
| **PCB-187** | **B** | Mean ± SD | 26.45 ± 16.47 | 21.47 ± 13.01 | 39.40 ± 29.14 | 27.32 ± 12.63 | 37.51 ± 22.49 | 29.14 ± 19.66 |
| | | Median | 21.30 | 15.28 | 37.22 | 23.87 | 32.74 | 23.46 |
| | | Range | 11.36 – 61.67 | 5.58 – 44.31 | 11.34 – 103.39 | 16.13 – 45.40 | 13.08 – 76.51 | 5.58 – 103.39 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 3.29 ± 1.31 | 4.88 ± 2.41 | 4.96 ± 4.97 | 3.91 ± 2.60 | 5.24 ± 2.31 | 4.50 ± 3.21 |
| | | Median | 2.90 | 4.69 | 2.47 | 2.86 | 4.84 | 3.46 |
| | | Range | 1.36 – 6.08 | 0.97 – 9.18 | 1.26 – 17.11 | 1.20 – 8.61 | 2.26 – 8.95 | 0.97 – 17.11 |
| | | *n* | 10 | 15 | 16 | 10 | 7 | 58 |
| **PCB-194** | **B** | Mean ± SD | 9.45 ± 5.68 | 7.29 ± 4.43 | 11.02 ± 8.41 | 6.90 ± 1.61 | 9.30 ± 5.73 | 8.81 ± 5.63 |
| | | Median | 8.52 | 5.72 | 10.44 | 7.54 | 7.44 | 7.67 |
| | | Range | 3.58 – 23.19 | 1.74 – 15.91 | 2.59 – 28.91 | 4.54 – 7.99 | 2.84 – 20.46 | 1.74 – 28.91 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 3.23 ± 3.92 | 3.17 ± 3.65 | 2.71 ± 3.43 | 2.00 ± 1.82 | 2.76 ± 2.01 | 2.80 ± 3.15 |
| | | Median | 1.47 | 2.52 | 1.29 | 1.28 | 2.17 | 1.71 |
| | | Range | 0.82 – 12.78 | 0.25 – 15.72 | 0.32 – 13.28 | 0.41 – 5.71 | 1.11 – 7.16 | 0.25 – 15.72 |
| | | *n* | 10 | 15 | 16 | 10 | 7 | 58 |
| **HCB** | **B** | Mean ± SD | 14.27 ± 3.78 | 13.05 ± 1.90 | 17.01 ± 10.33 | 17.94 ± 9.23 | 13.09 ± 0.89 | 14.42 ± 5.36 |
| | | Median | 12.78 | 13.30 | 13.38 | 13.75 | 13.63 | 13.30 |
| | | Range | 7.75 – 19.56 | 8.22 – 15.70 | 11.39 – 42.02 | 12.51 – 31.75 | 11.54 – 13.96 | 7.75 – 42.02 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |

**Table B4 Continued:** Mean ± standard deviation (SD), median, range (min – max) concentrations (ng/g ww) of organohalogenated contaminants (OHCs) in blood plasma of female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| OHC | Location | | 2015 | 2016 | 2017 | 2018 | 2019 | All years |
|---|---|---|---|---|---|---|---|---|
| **HCB** | **K** | Mean ± SD | 4.50 ± 0.70 | 9.22 ± 4.09 | 7.56 ± 3.95 | 3.13 ± 0.40 | 3.40 ± 0.45 | 6.20 ± 3.79 |
| | | Median | 4.43 | 8.89 | 6.08 | 3.14 | 3.42 | 4.78 |
| | | Range | 3.69 – 5.96 | 2.69 – 19.72 | 3.60 – 15.83 | 2.61 – 3.81 | 2.54 – 3.89 | 2.54 – 19.72 |
| | | *n* | 10 | 15 | 16 | 10 | 7 | 58 |
| **β-HCH** | **B** | Mean ± SD | 1.03 ± 0.55 | 1.05 ± 0.53 | 1.28 ± 0.90 | 1.06 ± 0.33 | 1.38 ± 0.69 | 1.14 ± 0.62 |
| | | Median | 0.85 | 0.88 | 1.20 | 1.07 | 1.20 | 0.94 |
| | | Range | 0.35 – 2.10 | 0.40 – 1.86 | 0.40 – 3.31 | 0.72 – 1.35 | 0.43 – 2.44 | 0.35 – 3.31 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 0.32 ± 0.07 | 0.44 ± 0.24 | 0.39 ± 0.30 | 0.29 ± 0.14 | 0.45 ± 0.21 | 0.38 ± 0.22 |
| | | Median | 0.32 | 0.39 | 0.25 | 0.22 | 0.40 | 0.34 |
| | | Range | 0.22 – 0.46 | 0.03 – 0.96 | 0.13 – 1.29 | 0.14 – 0.55 | 0.17 – 0.84 | 0.03 – 1.29 |
| | | *n* | 10 | 15 | 16 | 10 | 7 | 58 |
| **Oxychlordane** | **B** | Mean ± SD | 16.73 ± 8.82 | 14.09 ± 6.86 | 16.79 ± 12.15 | 9.88 ± 2.77 | 16.51 ± 7.92 | 15.33 ± 8.35 |
| | | Median | 16.45 | 13.22 | 14.28 | 9.65 | 13.66 | 13.22 |
| | | Range | 5.82 – 33.26 | 3.48 – 28.83 | 4.66 – 42.55 | 7.30 – 12.90 | 6.40 – 30.01 | 3.48 – 42.55 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 6.14 ± 4.33 | 8.46 ± 8.73 | 5.89 ± 5.97 | 4.37 ± 2.93 | 9.16 ± 7.55 | 6.73 ± 6.42 |
| | | Median | 4.35 | 6.37 | 3.43 | 3.25 | 7.20 | 4.48 |
| | | Range | 3.03 – 16.09 | 1.13 – 38.14 | 1.54 – 23.67 | 1.72 – 10.23 | 2.99 – 24.54 | 1.13 – 38.14 |
| | | *n* | 10 | 15 | 16 | 10 | 7 | 58 |
| ***t*-Chlordane** | **B** | Mean ± SD | 0.005 ± 0.00 | 0.005 ± 0.00 | 0.005 ± 0.00 | 0.005 ± 0.00 | 0.005 ± 0.00 | 0.005 ± 0.00 |
| | | Median | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 |
| | | Range | 0.005 – 0.005 | 0.005 – 0.005 | 0.005 – 0.005 | 0.005 – 0.005 | 0.005 – 0.005 | 0.005 – 0.005 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 0.002 ± 0.00 | 0.43 ± 0.22 | 0.33 ± 0.22 | 0.01 ± 0.00 | 0.01 ± 0.00 | 0.20 ± 0.25 |
| | | Median | 0.002 | 0.41 | 0.28 | 0.01 | 0.01 | 0.12 |
| | | Range | 0.002 – 0.002 | 0.15 – 1.08 | 0.10 – 0.91 | 0.01 – 0.01 | 0.01 – 0.01 | 0.00 – 1.08 |
| | | *n* | 10 | 15 | 16 | 10 | 7 | 58 |
| ***t*-Nonachlor** | **B** | Mean ± SD | 1.23 ± 0.65 | 1.26 ± 0.47 | 1.67 ± 1.09 | 1.44 ± 1.90 | 1.21 ± 0.94 | 1.33 ± 0.86 |
| | | Median | 1.06 | 1.25 | 1.27 | 0.69 | 0.85 | 1.08 |
| | | Range | 0.40 – 2.36 | 0.58 – 2.14 | 0.82 – 4.04 | 0.14 – 4.24 | 0.40 – 3.36 | 0.14 – 4.24 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 0.64 ± 0.27 | 0.73 ± 0.35 | 0.63 ± 0.48 | 0.64 ± 0.36 | 0.82 ± 0.74 | 0.68 ± 0.43 |
| | | Median | 0.54 | 0.66 | 0.59 | 0.47 | 0.55 | 0.58 |

**Table B4 Continued:** Mean ± standard deviation (SD), median, range (min – max) concentrations (ng/g ww) of organohalogenated contaminants (OHCs) in blood plasma of female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| OHC | Location | | 2015 | 2016 | 2017 | 2018 | 2019 | All years |
|---|---|---|---|---|---|---|---|---|
| ***t*-Nonachlor** | **K** | Range | 0.37 – 1.24 | 0.36 – 1.65 | 0.08 – 2.19 | 0.34 – 1.53 | 0.19 – 2.23 | 0.08 – 2.23 |
| | | *n* | 10 | 15 | 16 | 10 | 7 | 58 |
| ***c*-Nonachlor** | **B** | Mean ± SD | 1.90 ± 0.85 | 1.74 ± 0.76 | 2.28 ± 1.45 | 1.85 ± 0.79 | 2.02 ± 0.80 | 1.93 ± 0.91 |
| | | Median | 1.74 | 1.45 | 1.96 | 1.76 | 2.01 | 1.74 |
| | | Range | 0.90 – 3.56 | 0.91 – 3.12 | 1.17 – 5.77 | 1.00 – 2.90 | 0.82 – 3.47 | 0.82 – 5.77 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 0.68 ± 0.21 | 0.67 ± 0.29 | 0.50 ± 0.21 | 0.69 ± 0.19 | 0.94 ± 0.54 | 0.66 ± 0.30 |
| | | Median | 0.69 | 0.60 | 0.50 | 0.69 | 0.89 | 0.64 |
| | | Range | 0.27 – 1.00 | 0.28 – 1.36 | 0.17 – 0.89 | 0.37 – 1.03 | 0.21 – 1.83 | 0.17 – 1.83 |
| | | *n* | 10 | 15 | 16 | 10 | 7 | 58 |
| **Mirex** | **B** | Mean ± SD | 9.89 ± 4.81 | 9.27 ± 4.49 | 12.89 ± 6.98 | 8.92 ± 2.63 | 12.30 ± 5.67 | 10.55 ± 5.19 |
| | | Median | 9.21 | 7.10 | 13.68 | 9.03 | 11.45 | 9.48 |
| | | Range | 4.59 – 20.04 | 3.05 – 15.83 | 4.38 – 25.41 | 5.96 – 11.64 | 4.69 – 21.38 | 3.05 – 25.41 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 2.71 ± 1.88 | 3.94 ± 3.87 | 3.15 ± 3.58 | 2.84 ± 1.87 | 4.31 ± 2.60 | 3.36 ± 3.04 |
| | | Median | 1.99 | 3.07 | 1.46 | 2.38 | 3.49 | 2.62 |
| | | Range | 1.13 – 6.23 | 0.39 – 17.08 | 0.62 – 12.84 | 0.87 – 5.83 | 1.87 – 9.77 | 0.39 – 17.08 |
| | | *n* | 10 | 15 | 16 | 10 | 7 | 58 |
| ***p,p'*-DDT** | **B** | Mean ± SD | 0.15 ± 0.15 | 0.18 ± 0.21 | 0.14 ± 0.24 | 0.09 ± 0.05 | 0.21 ± 0.15 | 0.16 ± 0.18 |
| | | Median | 0.12 | 0.02 | 0.02 | 0.10 | 0.24 | 0.12 |
| | | Range | 0.02 – 0.51 | 0.02 – 0.68 | 0.02 – 0.70 | 0.02 – 0.12 | 0.02 – 0.47 | 0.02 – 0.70 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 0.17 ± 0.00 | 0.02 ± 0.00 | 0.02 ± 0.00 | 0.10 ± 0.08 | 0.12 ± 0.12 | 0.07 ± 0.08 |
| | | Median | 0.17 | 0.02 | 0.02 | 0.10 | 0.07 | 0.02 |
| | | Range | 0.17 – 0.17 | 0.02 – 0.02 | 0.02 – 0.02 | 0.02 – 0.25 | 0.02 – 0.32 | 0.02 – 0.32 |
| | | *n* | 10 | 15 | 16 | 10 | 7 | 58 |
| ***p,p'*-DDE** | **B** | Mean ± SD | 121.07 ± 53.26 | 103.78 ± 40.83 | 142.41 ± 83.07 | 108.07 ± 39.08 | 164.38 ± 99.52 | 126.15 ± 66.76 |
| | | Median | 114.97 | 88.72 | 130.45 | 109.17 | 138.83 | 114.97 |
| | | Range | 59.07 – 230.64 | 37.36 – 162.10 | 46.78 – 302.89 | 70.92 – 143.00 | 58.79 – 317.38 | 37.36 – 317.38 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 30.04 ± 14.21 | 5.01 ± 4.24 | 4.60 ± 4.47 | 29.82 ± 21.07 | 45.74 ± 24.34 | 18.20 ± 20.36 |
| | | Median | 25.16 | 4.67 | 2.32 | 21.60 | 43.89 | 11.20 |
| | | Range | 13.37 – 51.68 | 0.06 – 18.31 | 1.23 – 15.49 | 9.15 – 72.25 | 15.13 – 83.87 | 0.06 – 83.87 |
| | | *n* | 9 | 15 | 16 | 10 | 7 | 57 |

**Table B4 Continued:** Mean ± standard deviation (SD), median, range (min – max) concentrations (ng/g ww) of organohalogenated contaminants (OHCs) in blood plasma of female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| OHC | Location | | 2015 | 2016 | 2017 | 2018 | 2019 | All years |
|---|---|---|---|---|---|---|---|---|
| **PFHxS** | **B** | Mean ± SD | 1.52 ± 0.56 | 0.99 ± 0.41 | 0.95 ± 0.22 | 1.12 ± 0.45 | 0.67 ± 0.37 | 1.08 ± 0.51 |
| | | Median | 1.65 | 0.94 | 0.89 | 1.13 | 0.72 | 0.94 |
| | | Range | 0.54 – 2.25 | 0.42 – 1.93 | 0.73 – 1.38 | 0.64 – 1.56 | 0.01 – 1.17 | 0.01 – 2.25 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 1.24 ± 1.95 | 0.41 ± 0.22 | 0.51 ± 0.56 | 0.64 ± 0.44 | 0.57 ± 0.13 | 0.66 ± 0.94 |
| | | Median | 0.34 | 0.37 | 0.33 | 0.53 | 0.65 | 0.41 |
| | | Range | 0.03 – 5.78 | 0.12 – 1.07 | 0.00 – 2.06 | 0.01 – 1.51 | 0.41 – 0.70 | 0.00 – 5.78 |
| | | *n* | 11 | 15 | 14 | 10 | 7 | 57 |
| **PFHpS** | **B** | Mean ± SD | 1.51 ± 0.84 | 0.70 ± 0.48 | 1.82 ± 0.47 | 1.80 ± 0.47 | 0.85 ± 0.58 | 1.22 ± 0.75 |
| | | Median | 1.65 | 0.56 | 1.75 | 1.88 | 1.01 | 1.17 |
| | | Range | 0.30 – 2.52 | 0.04 – 1.55 | 1.17 – 2.46 | 1.17 – 2.26 | 0.01 – 1.66 | 0.01 – 2.52 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | | 0.02 ± 0.01 | 0.04 ± 0.04 | 0.07 ± 0.06 | 0.11 ± 0.06 | 0.05 ± 0.05 |
| | | Median | | 0.01 | 0.01 | 0.07 | 0.06 | 0.01 |
| | | Range | | 0.01 – 0.06 | 0.01 – 0.15 | 0.01 – 0.16 | 0.06 – 0.20 | 0.01 – 0.20 |
| | | *n* | | 15 | 14 | 10 | 7 | 46 |
| **BrPFOS** | **B** | Mean ± SD | 43.51 ± 29.34 | 21.07 ± 15.00 | 42.27 ± 10.64 | 31.24 ± 12.71 | 27.98 ± 6.94 | 32.58 ± 20.22 |
| | | Median | 42.74 | 16.75 | 44.87 | 34.14 | 30.29 | 29.63 |
| | | Range | 7.30 – 96.24 | 3.73 – 54.34 | 28.69 – 58.94 | 13.76 – 42.91 | 18.67 – 37.22 | 3.73 – 96.24 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 4.54 ± 10.01 | 0.66 ± 0.53 | 1.08 ± 2.44 | 1.96 ± 1.06 | 1.53 ± 0.50 | 1.85 ± 4.64 |
| | | Median | 0.12 | 0.54 | 0.01 | 1.76 | 1.61 | 0.64 |
| | | Range | 0.12 – 30.19 | 0.01 – 1.76 | 0.01 – 8.08 | 0.52 – 3.88 | 0.85 – 2.24 | 0.01 – 30.19 |
| | | *n* | 11 | 15 | 14 | 10 | 7 | 57 |
| **LinPFOS** | **B** | Mean ± SD | 278.21 ± 154.66 | 156.55 ± 98.99 | 340.47 ± 70.48 | 315.69 ± 106.47 | 203.29 ± 52.22 | 240.43 ± 125.34 |
| | | Median | 282.23 | 142.38 | 342.79 | 328.53 | 194.64 | 234.30 |
| | | Range | 54.26 – 532.83 | 28.81 – 336.40 | 234.30 – 427.02 | 182.43 – 423.24 | 134.31 – 271.03 | 28.81 – 532.83 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 20.65 ± 34.84 | 6.48 ± 2.06 | 10.55 ± 10.07 | 9.09 ± 4.30 | 6.77 ± 2.22 | 10.71 ± 16.48 |
| | | Median | 6.18 | 6.16 | 6.61 | 8.45 | 6.08 | 6.56 |
| | | Range | 1.39 – 118.93 | 3.66 – 10.73 | 3.54 – 42.31 | 2.59 – 17.68 | 4.01 – 10.14 | 1.39 – 118.93 |
| | | *n* | 11 | 15 | 14 | 10 | 7 | 57 |
| **PFNS** | **B** | Mean ± SD | 0.38 ± 0.39 | 0.34 ± 0.27 | 0.61 ± 0.08 | 0.32 ± 0.35 | 0.33 ± 0.30 | 0.39 ± 0.30 |
| | | Median | 0.48 | 0.47 | 0.62 | 0.29 | 0.49 | 0.50 |

**Table B4 Continued:** Mean ± standard deviation (SD), median, range (min – max) concentrations (ng/g ww) of organohalogenated contaminants (OHCs) in blood plasma of female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| OHC | Location | | 2015 | 2016 | 2017 | 2018 | 2019 | All years |
|---|---|---|---|---|---|---|---|---|
| **PFNS** | **B** | Range | 0.03 – 1.14 | 0.03 – 0.73 | 0.50 – 0.72 | 0.03 – 0.68 | 0.03 – 0.80 | 0.03 – 1.14 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | | 0.01 ± 0.00 | 0.01 ± 0.00 | 0.03 ± 0.00 | 0.12 ± 0.29 | 0.03 ± 0.11 |
| | | Median | | 0.01 | 0.01 | 0.03 | 0.01 | 0.01 |
| | | Range | | 0.01 – 0.01 | 0.01 – 0.01 | 0.03 – 0.03 | 0.01 – 0.78 | 0.01 – 0.78 |
| | | *n* | | 15 | 14 | 10 | 7 | 46 |
| **PFDcS** | **B** | Mean ± SD | 0.80 ± 0.59 | 0.40 ± 0.28 | 0.90 ± 0.34 | 0.67 ± 0.36 | 0.47 ± 0.18 | 0.62 ± 0.42 |
| | | Median | 0.82 | 0.33 | 1.00 | 0.66 | 0.45 | 0.50 |
| | | Range | 0.04 – 2.17 | 0.04 – 1.07 | 0.35 – 1.28 | 0.30 – 1.04 | 0.21 – 0.74 | 0.04 – 2.17 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 0.08 ± 0.00 | 0.02 ± 0.00 | 0.02 ± 0.00 | 3.36 ± 0.61 | 0.03 ± 0.02 | 0.62 ± 1.30 |
| | | Median | 0.08 | 0.02 | 0.02 | 3.14 | 0.02 | 0.02 |
| | | Range | 0.08 – 0.08 | 0.02 – 0.02 | 0.02 – 0.02 | 2.81 – 4.45 | 0.02 – 0.07 | 0.02 – 4.45 |
| | | *n* | 11 | 15 | 14 | 10 | 7 | 57 |
| **PFOA** | **B** | Mean ± SD | 1.03 ± 0.56 | 0.43 ± 0.26 | 0.40 ± 0.13 | 0.47 ± 0.04 | 0.34 ± 0.19 | 0.57 ± 0.43 |
| | | Median | 0.88 | 0.34 | 0.41 | 0.46 | 0.27 | 0.45 |
| | | Range | 0.14 – 2.09 | 0.14 – 1.02 | 0.25 – 0.64 | 0.45 – 0.53 | 0.15 – 0.79 | 0.14 – 2.09 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 0.14 ± 0.23 | 0.16 ± 0.13 | 0.12 ± 0.11 | 0.34 ± 0.18 | 0.33 ± 0.15 | 0.20 ± 0.18 |
| | | Median | 0.06 | 0.12 | 0.07 | 0.24 | 0.33 | 0.14 |
| | | Range | 0.01 – 0.77 | 0.03 – 0.53 | 0.02 – 0.33 | 0.17 – 0.68 | 0.08 – 0.58 | 0.01 – 0.77 |
| | | *n* | 11 | 15 | 14 | 10 | 7 | 57 |
| **PFNA** | **B** | Mean ± SD | 23.73 ± 11.50 | 11.63 ± 7.31 | 16.47 ± 2.95 | 18.31 ± 6.95 | 13.18 ± 2.31 | 16.46 ± 8.82 |
| | | Median | 25.32 | 8.77 | 16.46 | 19.55 | 12.83 | 14.54 |
| | | Range | 4.45 – 42.26 | 3.96 – 29.83 | 11.83 – 21.41 | 9.67 – 24.47 | 9.32 – 17.17 | 3.96 – 42.26 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 1.21 ± 0.56 | 1.17 ± 0.36 | 1.24 ± 0.53 | 1.97 ± 0.87 | 1.53 ± 0.50 | 1.38 ± 0.62 |
| | | Median | 1.09 | 1.19 | 1.32 | 2.15 | 1.43 | 1.33 |
| | | Range | 0.39 – 2.05 | 0.54 –1.74 | 0.48 – 2.45 | 0.80 – 3.08 | 1.07 – 2.45 | 0.39 – 3.08 |
| | | *n* | 11 | 15 | 14 | 10 | 7 | 57 |
| **PFDcA** | **B** | Mean ± SD | 25.31 ± 12.43 | 15.46 ± 8.63 | 23.97 ± 4.99 | 22.93 ± 7.45 | 15.99 ± 3.14 | 20.17 ± 9.46 |
| | | Median | 25.40 | 15.04 | 24.30 | 23.53 | 16.58 | 18.53 |
| | | Range | 6.34 – 42.48 | 3.95 – 32.70 | 16.04 – 29.49 | 14.66 – 29.99 | 11.41 – 19.98 | 3.95 – 42.48 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |

**Table B4 Continued:** Mean ± standard deviation (SD), median, range (min – max) concentrations (ng/g ww) of organohalogenated contaminants (OHCs) in blood plasma of female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| OHC | Location | | 2015 | 2016 | 2017 | 2018 | 2019 | All years |
|---|---|---|---|---|---|---|---|---|
| | **K** | Mean ± SD | 0.44 ± 0.16 | 0.61 ± 0.28 | 0.98 ± 0.47 | 0.78 ± 0.27 | 0.64 ± 0.21 | 0.70 ± 0.36 |
| | | Median | 0.45 | 0.56 | 0.80 | 0.81 | 0.61 | 0.61 |
| | | Range | 0.16 – 0.72 | 0.26 – 1.18 | 0.33 – 1.77 | 0.39 – 1.25 | 0.37 – 1.06 | 0.16 – 1.77 |
| | | *n* | 11 | 15 | 14 | 10 | 7 | 57 |
| **PFUnA** | **B** | Mean ± SD | 92.46 ± 42.98 | 64.18 ± 33.98 | 95.55 ± 22.12 | 79.41 ± 22.92 | 60.87 ± 13.23 | 77.44 ± 33.98 |
| | | Median | 84.17 | 67.33 | 98.59 | 79.09 | 61.88 | 73.89 |
| | | Range | 25.63 – 159.25 | 16.19 – 119.88 | 59.94 – 117.85 | 59.55 – 99.90 | 41.75 – 78.68 | 16.19 – 159.25 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 1.93 ± 0.86 | 2.09 ± 1.01 | 4.43 ± 2.23 | 2.24 ± 1.13 | 1.83 ± 0.37 | 2.63 ± 1.69 |
| | | Median | 1.82 | 1.99 | 4.00 | 2.13 | 1.77 | 2.10 |
| | | Range | 0.68 – 3.43 | 0.78 – 4.89 | 1.51 – 8.40 | 0.03 – 4.28 | 1.26 – 2.36 | 0.03 – 8.40 |
| | | *n* | 11 | 15 | 14 | 10 | 7 | 57 |
| **PFDoA** | **B** | Mean ± SD | 14.02 ± 5.79 | 10.20 ± 5.08 | 14.15 ± 3.78 | 11.63 ± 3.30 | 8.82 ± 1.90 | 11.72 ± 4.90 |
| | | Median | 13.55 | 11.29 | 15.04 | 11.53 | 9.27 | 11.29 |
| | | Range | 4.03 – 23.38 | 2.96 – 17.41 | 8.48 – 19.15 | 8.55 – 14.90 | 6.18 – 11.19 | 2.96 – 23.38 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 0.25 ± 0.22 | 0.58 ± 0.27 | 0.87 ± 0.41 | 0.64 ± 0.35 | 0.57 ± 0.17 | 0.59 ± 0.36 |
| | | Median | 0.16 | 0.54 | 0.78 | 0.51 | 0.56 | 0.54 |
| | | Range | 0.01 – 0.75 | 0.20 – 1.03 | 0.33 – 1.78 | 0.27 – 1.26 | 0.30 – 0.84 | 0.01 – 1.78 |
| | | *n* | 11 | 15 | 14 | 10 | 7 | 57 |
| **PFTriA** | **B** | Mean ± SD | 27.75 ± 11.37 | 19.69 ± 8.84 | 25.82 ± 7.80 | 21.46 ± 6.39 | 15.94 ± 3.05 | 22.29 ± 9.38 |
| | | Median | 26.18 | 22.08 | 28.25 | 21.76 | 15.87 | 22.13 |
| | | Range | 8.24 – 48.27 | 7.48 – 33.29 | 13.79 – 35.67 | 15.34 – 27.00 | 11.61 – 21.25 | 7.48 – 48.27 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 1.02 ± 0.91 | 1.88 ± 0.95 | 2.26 ± 0.77 | 2.30 ± 1.20 | 2.79 ± 0.80 | 2.00 ± 1.05 |
| | | Median | 0.54 | 1.85 | 2.13 | 1.87 | 2.89 | 2.02 |
| | | Range | 0.08 – 2.58 | 0.53 – 3.89 | 1.18 – 3.59 | 1.05 – 4.02 | 1.54 – 3.63 | 0.08 – 4.02 |
| | | *n* | 11 | 15 | 14 | 10 | 7 | 57 |
| **PFTeA** | **B** | Mean ± SD | 2.73 ± 0.96 | 2.10 ± 0.90 | 2.67 ± 1.04 | 2.01 ± 0.61 | 1.68 ± 0.33 | 2.28 ± 0.91 |
| | | Median | 2.73 | 2.25 | 2.99 | 1.97 | 1.64 | 2.25 |
| | | Range | 0.98 – 4.41 | 0.89 – 3.86 | 1.07 – 4.32 | 1.32 – 2.79 | 1.11 – 2.32 | 0.89 – 4.41 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | 0.06 ± 0.08 | 0.21 ± 0.16 | 0.21 ± 0.19 | 0.41 ± 0.26 | 0.28 ± 0.08 | 0.23 ± 0.20 |
| | | Median | 0.01 | 0.19 | 0.22 | 0.34 | 0.27 | 0.20 |

**Table B4 Continued:** Mean ± standard deviation (SD), median, range (min – max) concentrations (ng/g ww) of organohalogenated contaminants (OHCs) in blood plasma of female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Number of samples analysed (n) are included.

| **OHC** | **Location** | | **2015** | **2016** | **2017** | **2018** | **2019** | **All years** |
|---|---|---|---|---|---|---|---|---|
| **PFTeA** | **K** | Range | 0.01 – 0.22 | 0.02 – 0.53 | 0.02 – 0.66 | 0.11 – 0.82 | 0.20 – 0.41 | 0.01 – 0.82 |
| | | n | 11 | 15 | 14 | 10 | 7 | 57 |
| **8:2 FTS** | **B** | Mean ± SD | 0.13 ± 0.10 | 0.11 ± 0.10 | 0.09 ± 0.08 | 0.03 ± 0.00 | 0.04 ± 0.02 | 0.09 ± 0.09 |
| | | Median | 0.14 | 0.07 | 0.08 | 0.03 | 0.03 | 0.06 |
| | | Range | 0.03 – 0.26 | 0.02 – 0.38 | 0.03 – 0.22 | 0.03 – 0.03 | 0.03 –0.09 | 0.02 – 0.38 |
| | | *n* | 13 | 15 | 8 | 4 | 9 | 49 |
| | **K** | Mean ± SD | | | | 0.03 ± 0.00 | | 0.03 ± 0.00 |
| | | Median | | | | 0.03 | | 0.03 |
| | | Range | | | | 0.03 – 0.03 | | 0.03 – 0.03 |
| | | *n* | | | | 10 | | 10 |

# APPENDIX C: TH concentrations and ratios

**Table C1:** Mean ± standard deviation (SD), median, range (min – max) concentrations and ratios of thyroid hormones (THs) in blood plasma of male glaucous gulls *(Larus hyperboreus*) breeding on Bjørnøya (B) and in Kongsfjorden (K), Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included. $TT_3$ and $TT_4$ were measured in nmol/L, and $FT_3$ and $FT_4$ in pmol/L. $TT_4/TT_3$, $TT_3/FT_3$, and $TT_4/FT_4$ ratios were calculated with concentrations in nmol/L, and $FT_4/FT_3$ in pmol/L.

| TH | Location | | 2015 | 2016 | 2017 | 2018 | 2019 | All years |
|---|---|---|---|---|---|---|---|---|
| **$TT_3$** | **B** | Mean ± SD | 4.63 ± 1.64 | 4.65 ± 1.88 | 4.60 ± 0.60 | 4.86 ± 0.97 | 4.31 ± 1.06 | 4.61 ± 1.51 |
| | | Median | 4.36 | 3.88 | 4.46 | 4.32 | 4.10 | 4.31 |
| | | Range | 2.48 – 8.39 | 1.70 – 8.68 | 3.99 – 5.75 | 4.29 – 5.98 | 3.37 – 5.93 | 1.70 – 8.68 |
| | | *n* | 12 | 17 | 6 | 3 | 5 | 43 |
| | **K** | Mean ± SD | 4.52 ± 2.35 | 4.29 ± 1.06 | 3.81 ± 1.34 | 4.75 ± 3.29 | 4.31 ± 1.37 | 4.33 ± 1.66 |
| | | Median | 5.54 | 4.43 | 3.85 | 3.51 | 4.42 | 4.41 |
| | | Range | 1.83 – 6.17 | 2.85 – 5.43 | 2.46 – 5.13 | 2.26 – 8.48 | 2.14 – 6.43 | 1.83 – 8.48 |
| | | *n* | 3 | 4 | 3 | 3 | 7 | 20 |
| **$FT_3$** | **B** | Mean ± SD | 11.59 ± 4.40 | 11.70 ± 5.71 | 12.80 ± 1.66 | 15.38 ± 2.89 | 12.61 ± 3.85 | 12.12 ± 4.51 |
| | | Median | 11.38 | 11.13 | 13.35 | 15.38 | 11.44 | 11.54 |
| | | Range | 6.04 – 20.46 | 3.08 – 23.21 | 10.34 – 14.46 | 13.34 – 17.42 | 9.73 – 19.36 | 3.08 – 23.21 |
| | | *n* | 12 | 16 | 6 | 2 | 5 | 41 |
| | **K** | Mean ± SD | 3.67 | 11.12 ± 2.97 | 10.23 ± 1.68 | 13.11 ± 8.06 | 12.24 ± 3.36 | 11.32 ± 4.25 |
| | | Median | 3.67 | 11.57 | 11.10 | 10.38 | 12.18 | 11.32 |
| | | Range | 3.67 – 3.67 | 7.68 – 13.64 | 8.29 – 11.30 | 6.77 – 22.17 | 5.60 – 16.07 | 3.67 – 22.17 |
| | | *n* | 1 | 4 | 3 | 3 | 7 | 18 |
| **$TT_4$** | **B** | Mean ± SD | 35.94 ± 8.34 | 39.63 ± 7.40 | 47.54 ± 2.69 | 55.05 ± 12.38 | 42.43 ± 4.63 | 42.52 ± 9.11 |
| | | Median | 33.77 | 40.20 | 48.09 | 49.61 | 43.18 | 41.92 |
| | | Range | 28.37 – 47.86 | 27.17 – 53.60 | 44.62 – 49.92 | 46.32 – 69.22 | 36.61 – 46.76 | 27.17 – 69.22 |
| | | *n* | 4 | 9 | 3 | 3 | 4 | 23 |
| | **K** | Mean ± SD | 44.02 ± 8.24 | 46.48 ± 0.64 | 43.40 ± 12.88 | 43.14 ± 12.55 | 41.14 ± 3.29 | 43.28 ± 7.82 |
| | | Median | 40.57 | 46.48 | 43.43 | 36.37 | 40.28 | 41.65 |
| | | Range | 38.05 – 53.43 | 46.03 – 46.93 | 30.52 – 56.27 | 35.42 – 57.63 | 38.43 – 45.59 | 30.52 – 57.63 |
| | | *n* | 3 | 2 | 3 | 3 | 4 | 15 |
| **$FT_4$** | **B** | Mean ± SD | 10.31 ± 4.73 | 12.10 ± 6.32 | 17.77 ± 4.13 | 18.71 ± 4.54 | 17.62 ± 5.39 | 13.57 ± 6.10 |
| | | Median | 11.64 | 11.13 | 19.56 | 18.59 | 20.38 | 12.63 |
| | | Range | 3.15 – 17.44 | 4.38 – 31.57 | 10.86 – 21.34 | 14.23 – 23.30 | 8.71 – 21.55 | 3.15 – 31.57 |
| | | *n* | 11 | 17 | 6 | 3 | 5 | 42 |
| | **K** | Mean ± SD | 11.90 ± 1.66 | 10.74 ± 3.57 | 12.43 ± 6.96 | 16.16 ± 5.54 | 11.70 ± 3.13 | 12.34 ± 4.19 |
| | | Median | 11.90 | 9.69 | 10.82 | 14.82 | 12.74 | 11.72 |
| | | Range | 10.73 – 13.07 | 7.71 – 15.85 | 6.41 – 20.05 | 11.41 – 22.25 | 7.03 – 15.37 | 6.41 – 22.25 |

**Table C1 Continued:** Mean ± standard deviation (SD), median, range (min – max) concentrations and ratios of thyroid hormones (THs) in blood plasma of male glaucous gulls *(Larus hyperboreus*) breeding on Bjørnøya (B) and in Kongsfjorden (K), Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included. $TT_3$ and $TT_4$ were measured in nmol/L, and $FT_3$ and $FT_4$ in pmol/L. $TT_4/TT_3$, $TT_3/FT_3$, and $TT_4/FT_4$ ratios were calculated with concentrations in nmol/L, and $FT_4/FT_3$ in pmol/L.

| **TH** | **Location** | | **2015** | **2016** | **2017** | **2018** | **2019** | **All years** |
|---|---|---|---|---|---|---|---|---|
| **$FT_4$** | **K** | n | 2 | 4 | 3 | 3 | 7 | 19 |
| **$TT_4/TT_3$** | **B** | Mean ± SD | 8.65 ± 2.02 | 10.88 ± 4.30 | 10.79 ± 0.78 | 11.70 ± 3.94 | 11.13 ± 2.35 | 10.63 ± 3.23 |
| | | Median | 9.45 | 10.65 | 10.73 | 10.80 | 11.78 | 10.65 |
| | | Range | 5.70 – 9.99 | 4.63 – 19.79 | 10.04 – 11.59 | 8.29 – 16.02 | 7.78 – 13.20 | 4.63 – 19.79 |
| | | *n* | 4 | 9 | 3 | 3 | 4 | 23 |
| | **K** | Mean ± SD | 15.41 ± 9.56 | 10.49 ± 0.03 | 12.75 ± 6.08 | 10.94 ± 4.46 | 9.75 ± 1.51 | 11.56 ± 4.49 |
| | | Median | 15.41 | 10.49 | 14.61 | 10.35 | 9.83 | 10.49 |
| | | Range | 8.65 – 22.17 | 10.47 – 10.51 | 5.95 – 17.68 | 6.80 – 15.67 | 8.17 – 11.17 | 5.95 – 22.17 |
| | | *n* | 2 | 2 | 3 | 3 | 4 | 14 |
| **$TT_3/FT_3$** | **B** | Mean ± SD | 413.77 ± 96.69 | 446.93 ± 178.69 | 362.57 ± 48.84 | 332.46 ± 15.61 | 347.27 ± 49.01 | 407.14 ± 129.47 |
| | | Median | 411.41 | 397.06 | 370.39 | 332.46 | 346.03 | 386.75 |
| | | Range | 286.96 – 631.72 | 338.07 – 1090.97 | 305.14 – 422.13 | 321.42 – 343.50 | 294.07 – 411.69 | 286.96 – 1090.97 |
| | | *n* | 12 | 16 | 6 | 2 | 5 | 41 |
| | **K** | Mean ± SD | 499.15 | 389.87 ± 59.41 | 365.64 ± 80.47 | 351.75 ± 26.65 | 352.47 ± 34.73 | 371.00 ± 56.17 |
| | | Median | 499.15 | 384.57 | 346.82 | 338.64 | 353.95 | 359.86 |
| | | Range | 499.15 – 499.15 | 324.04 – 466.29 | 296.24 – 453.85 | 334.19 – 382.41 | 303.27 – 400.10 | 296.24 – 499.15 |
| | | *n* | 1 | 4 | 3 | 3 | 7 | 18 |
| **$TT_4/FT_4$** | **B** | Mean ± SD | 6690.78 ± 2131.22 | 4599.19 ± 1589.94 | 2366.00 ± 289.21 | 3161.48 ± 1484.97 | 2778.08 ± 1030.70 | 4052.72 ± 1927.92 |
| | | Median | 6287.36 | 4213.58 | 2340.30 | 2492.09 | 2487.28 | 3858.50 |
| | | Range | 4790.09 – 8994.87 | 2948.13 – 7680.00 | 2090.50 – 2667.21 | 2129.02 – 4863.31 | 1936.76 – 4201.00 | 1936.76 – 8994.87 |
| | | *n* | 3 | 9 | 3 | 3 | 4 | 22 |
| | **K** | Mean ± SD | 3780.96 | 3719.57 ± 1073.78 | 4041.10 ± 1639.26 | 2716.41 ± 343.46 | 3154.34 ± 562.63 | 3393.08 ± 954.73 |
| | | Median | 3780.96 | 3719.57 | 4757.45 | 2590.23 | 3098.13 | 3105.11 |
| | | Range | 3780.96 – 3780.96 | 2960.29 – 4478.85 | 2165.59 – 5200.26 | 2453.87 – 3105.11 | 2530.95 – 3890.16 | 2165.59 – 5200.26 |
| | | *n* | 1 | 2 | 3 | 3 | 4 | 13 |
| **$FT_4/FT_3$** | **B** | Mean ± SD | 0.93 ± 0.42 | 1.30 ± 0.81 | 1.39 ± 0.28 | 1.37 ± 0.04 | 1.47 ± 0.57 | 1.23 ± 0.61 |
| | | Median | 0.83 | 1.05 | 1.40 | 1.37 | 1.51 | 1.14 |
| | | Range | 0.49 – 1.66 | 0.35 – 3.13 | 1.05 – 1.83 | 1.34 – 1.39 | 0.76 – 2.17 | 0.35 – 3.13 |
| | | *n* | 11 | 16 | 6 | 2 | 5 | 40 |
| | **K** | Mean ± SD | 2.93 | 1.02 ± 0.45 | 1.32 ± 0.97 | 1.37 ± 0.34 | 1.00 ± 0.27 | 1.23 ± 0.63 |
| | | Median | 2.93 | 0.88 | 0.97 | 1.43 | 1.08 | 1.04 |
| | | Range | 2.93 – 2.93 | 0.67 – 1.66 | 0.57 – 2.42 | 1.00 – 1.69 | 0.58 – 1.40 | 0.57 – 2.93 |
| | | *n* | 1 | 4 | 3 | 3 | 7 | 18 |

**Table C2:** Mean ± standard deviation (SD), median, range (min – max) concentrations and ratios of thyroid hormones (THs) in blood plasma of female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included. TT$_3$ and TT$_4$ were measured in nmol/L, and FT$_3$ and FT$_4$ in pmol/L. TT$_4$/TT$_3$, TT$_3$/FT$_3$, and TT$_4$/FT$_4$ ratios were calculated with concentrations in nmol/L, and FT$_4$/FT$_3$ in pmol/L.

| **TH** | **Location** | | **2015** | **2016** | **2017** | **2018** | **2019** | **All years** |
|---|---|---|---|---|---|---|---|---|
| **TT$_3$** | **B** | Mean ± SD | 4.67 ± 1.08 | 3.01 ± 1.94 | 4.80 ± 2.08 | 3.22 ± 0.50 | 4.84 ± 2.37 | 4.08 ± 1.96 |
| | | Median | 4.72 | 2.82 | 4.29 | 3.15 | 4.71 | 4.06 |
| | | Range | 2.66 – 6.16 | 0.32 – 6.54 | 2.97 – 8.51 | 2.76 – 3.75 | 2.08 – 10.45 | 0.32 – 10.45 |
| | | *n* | 9 | 13 | 6 | 3 | 9 | 40 |
| | **K** | Mean ± SD | 3.70 ± 1.47 | 2.92 ± 1.03 | 5.51 ± 0.97 | 3.76 ± 1.60 | 3.34 ± 1.33 | 3.47 ± 1.39 |
| | | Median | 4.10 | 2.72 | 5.51 | 3.35 | 3.41 | 3.39 |
| | | Range | 1.32 – 5.09 | 1.00 – 4.81 | 4.82 – 6.20 | 2.51 – 7.69 | 1.34 – 5.29 | 1.00 – 7.69 |
| | | *n* | 8 | 15 | 2 | 10 | 6 | 41 |
| **FT$_3$** | **B** | Mean ± SD | 12.03 ± 3.26 | 6.18 ± 3.59 | 11.91 ± 6.50 | 7.19 ± 1.34 | 12.50 ± 6.41 | 9.68 ± 5.35 |
| | | Median | 13.03 | 5.27 | 10.95 | 7.91 | 12.12 | 9.05 |
| | | Range | 7.02 – 16.41 | 1.09 – 11.94 | 5.12 – 21.99 | 5.64 – 8.02 | 5.55 – 27.45 | 1.09 – 27.44 |
| | | *n* | 7 | 13 | 5 | 3 | 9 | 37 |
| | **K** | Mean ± SD | 8.09 ± 4.29 | 7.61 ± 3.15 | 13.19 ± 1.08 | 9.59 ± 3.08 | 8.63 ± 4.78 | 8.64 ± 3.59 |
| | | Median | 8.94 | 7.80 | 13.19 | 9.54 | 7.94 | 8.46 |
| | | Range | 2.72 – 13.53 | 2.72 – 12.73 | 12.43 – 13.96 | 6.43 – 17.34 | 2.89 – 15.61 | 2.72 – 17.34 |
| | | *n* | 6 | 15 | 2 | 10 | 5 | 38 |
| **TT$_4$** | **B** | Mean ± SD | 47.45 ± 1.94 | 39.71 ± 14.45 | 50.62 ± 10.03 | 37.12 ± 6.90 | 40.75 ± 4.99 | 43.58 ± 9.16 |
| | | Median | 47.48 | 34.77 | 50.39 | 36.43 | 42.71 | 44.48 |
| | | Range | 45.15 – 50.38 | 23.16 – 59.27 | 40.59 – 66.93 | 30.59 – 44.34 | 31.96 – 46.76 | 23.16 – 66.93 |
| | | *n* | 6 | 5 | 5 | 3 | 7 | 26 |
| | **K** | Mean ± SD | 50.41 ± 6.45 | 47.38 ± 7.68 | 49.09 ± 10.15 | 42.69 ± 7.64 | 39.26 ± 3.49 | 45.97 ± 7.59 |
| | | Median | 51.05 | 50.57 | 49.09 | 43.78 | 37.30 | 46.03 |
| | | Range | 42.46 – 61.01 | 36.58 – 54.30 | 41.91 – 56.27 | 32.46 – 52.31 | 37.18 – 43.29 | 32.46 – 61.01 |
| | | *n* | 6 | 5 | 2 | 6 | 3 | 22 |
| **FT$_4$** | **B** | Mean ± SD | 17.71 ± 4.88 | 12.78 ± 11.86 | 15.43 ± 9.99 | 11.98 ± 3.51 | 17.26 ± 6.03 | 15.18 ± 8.72 |
| | | Median | 17.34 | 10.76 | 15.90 | 13.70 | 14.60 | 13.81 |
| | | Range | 11.62 – 24.11 | 1.50 – 38.99 | 5.26 – 33.81 | 7.94 – 14.30 | 10.73 – 25.81 | 1.50 – 38.99 |
| | | *n* | 8 | 13 | 7 | 3 | 9 | 40 |
| | **K** | Mean ± SD | 13.56 ± 4.22 | 13.72 ± 5.38 | 12.93 ± 1.30 | 14.02 ± 4.10 | 9.77 ± 4.86 | 13.13 ± 4.71 |
| | | Median | 14.45 | 13.18 | 12.93 | 13.62 | 9.92 | 13.34 |
| | | Range | 6.54 – 18.28 | 6.12 – 24.15 | 12.01 – 13.85 | 8.40 – 20.62 | 4.24 – 15.23 | 4.24 – 24.10 |
| | | *n* | 7 | 15 | 2 | 10 | 6 | 40 |
| **TT$_4$/TT$_3$** | **B** | Mean ± SD | 11.11 ± 3.57 | 29.57 ± 29.13 | 10.96 ± 3.35 | 11.59 ± 1.76 | 10.26 ± 3.06 | 13.97 ± 12.99 |

**Table C2 Continued:** Mean ± standard deviation (SD), median, range (min – max) concentrations and ratios of thyroid hormones (THs) in blood plasma of female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included. TT$_3$ and TT$_4$ were measured in nmol/L, and FT$_3$ and FT$_4$ in pmol/L. TT$_4$/TT$_3$, TT$_3$/FT$_3$, and TT$_4$/FT$_4$ ratios were calculated with concentrations in nmol/L, and FT$_4$/FT$_3$ in pmol/L.

| TH | Location | | 2015 | 2016 | 2017 | 2018 | 2019 | All years |
|---|---|---|---|---|---|---|---|---|
| **TT$_4$/TT$_3$** | **B** | Median | 10.20 | 19.13 | 11.60 | 11.83 | 8.92 | 10.63 |
| | | Range | 8.18 – 17.20 | 7.55 – 72.47 | 5.94 – 15.03 | 9.73 – 13.22 | 7.22 – 15.36 | 5.94 – 72.47 |
| | | *n* | 5 | 4 | 5 | 3 | 7 | 24 |
| | **K** | Mean ± SD | 10.06 ± 1.05 | 18.47 ± 3.67 | 8.88 ± 0.27 | 12.94 ± 5.47 | 9.73 ± 2.36 | 12.86 ± 4.96 |
| | | Median | 10.02 | 19.02 | 8.88 | 14.18 | 10.78 | 11.38 |
| | | Range | 8.83 – 11.37 | 12.77 – 22.90 | 8.69 – 9.08 | 4.68 – 20.07 | 7.03 – 11.39 | 4.68 – 22.90 |
| | | *n* | 4 | 5 | 2 | 6 | 3 | 20 |
| **TT$_3$/FT$_3$** | **B** | Mean ± SD | 383.72 ± 43.03 | 476.07 ± 161.81 | 455.51 ± 76.53 | 457.74 ± 105.01 | 394.66 ± 56.41 | 434.53 ± 112.41 |
| | | Median | 394.81 | 454.25 | 449.71 | 467.49 | 380.90 | 409.84 |
| | | Range | 301.00 – 428.11 | 263.50 – 835.95 | 387.18 – 579.28 | 348.20 – 557.55 | 309.40 – 490.36 | 263.50 – 835.95 |
| | | *n* | 7 | 13 | 5 | 3 | 9 | 37 |
| | **K** | Mean ± SD | 444.95 ± 68.71 | 400.36 ± 77.81 | 416.07 ± 39.81 | 385.38 ± 54.08 | 393.50 ± 53.77 | 403.38 ± 66.25 |
| | | Median | 455.00 | 388.59 | 416.07 | 374.74 | 412.71 | 398.85 |
| | | Range | 318.97 – 518.68 | 296.52 – 574.21 | 387.92 – 444.21 | 313.76 – 485.42 | 338.10 – 461.36 | 296.52 – 574.21 |
| | | *n* | 6 | 15 | 2 | 10 | 5 | 38 |
| **TT$_4$/FT$_4$** | **B** | Mean ± SD | 2792.71 ± 835.91 | 7971.37 ± 7718.22 | 2922.58 ± 1025.58 | 3213.16 ± 653.64 | 2568.56 ± 762.40 | 3885.83 ± 3930.43 |
| | | Median | 2754.08 | 4749.32 | 2552.85 | 3237.68 | 2618.17 | 2823.44 |
| | | Range | 1872.81 – 3789.86 | 1605.46 – 21228.99 | 1979.74 – 4625.98 | 2547.61 – 3854.21 | 1811.88 – 3981.87 | 1605.46 – 21228.99 |
| | | *n* | 4 | 5 | 5 | 3 | 7 | 24 |
| | **K** | Mean ± SD | 3514.98 ± 730.16 | 2780.87 ± 443.71 | 3855.32 ± 1172.02 | 2947.63 ± 690.39 | 5466.46 ± 4059.88 | 3488.00 ± 1707.21 |
| | | Median | 3484.82 | 2702.88 | 3855.32 | 2908.26 | 3867.83 | 2981.92 |
| | | Range | 2839.41 – 4250.87 | 2252.59 – 3483.63 | 3026.58 – 4684.06 | 1985.80 – 3863.94 | 2449.25 – 10082.30 | 1985.80 – 10082.30 |
| | | *n* | 4 | 5 | 2 | 6 | 3 | 20 |
| **FT$_4$/FT$_3$** | **B** | Mean ± SD | 1.60 ± 0.62 | 2.13 ± 1.23 | 1.81 ± 0.64 | 1.64 ± 0.21 | 1.52 ± 0.52 | 1.79 ± 0.84 |
| | | Median | 1.48 | 1.73 | 1.91 | 1.71 | 1.37 | 1.72 |
| | | Range | 0.89 – 2.40 | 0.87 – 4.72 | 0.75 – 2.47 | 1.41 – 1.81 | 0.90 – 2.24 | 0.75 – 4.72 |
| | | *n* | 7 | 13 | 5 | 3 | 9 | 36 |
| | **K** | Mean ± SD | 1.99 ± 0.90 | 1.99 ± 0.77 | 0.99 ± 0.18 | 1.61 ± 0.75 | 1.41 ± 0.49 | 1.76 ± 0.77 |
| | | Median | 2.08 | 1.95 | 0.99 | 1.45 | 1.47 | 1.58 |
| | | Range | 0.98 – 3.33 | 0.67 – 3.45 | 0.86 – 1.11 | 0.79 – 2.86 | 0.62 – 1.92 | 0.62 – 3.45 |
| | | *n* | 6 | 15 | 2 | 10 | 5 | 38 |

# APPENDIX D: Biometrics and lipid content

**Table D1:** Mean ± standard deviation (SD), median, range (min – max) of biometric measurements, body condition index (BCI) and blood plasma lipid weight percentage of male glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| | | **Bjørnøya** | | | | **Kongsfjorden** | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean ± SD | Median | Range | *n* | Mean ± SD | Median | Range | *n* |
| **2015** | **Body mass (g)** | 1795 ± 92 | 1775 | 1635 – 1965 | 13 | 1738 ± 149 | 1785 | 1530 – 1850 | 4 |
| | **Total head length (mm)** | 149.4 ± 4.3 | 147.5 | 142.7 – 156.2 | 13 | 151.5 ± 3.9 | 152.5 | 146.0 – 155.0 | 4 |
| | **Tarsus length (mm)** | 76.2 ± 3.2 | 76.4 | 71.1 – 81.5 | 13 | 73.6 ± 4.8 | 74.9 | 66.7 – 78.0 | 4 |
| | **Culmen length (mm)** | 64.1 ± 3.5 | 65.0 | 57.8 – 70.5 | 13 | 62.1 ± 1.6 | 62.1 | 60.2 – 64.0 | 4 |
| | **Gonys length (mm)** | 23.0 ± 1.1 | 22.8 | 21.2 – 24.8 | 13 | 22.6 ± 0.8 | 22.8 | 21.5 – 23.2 | 4 |
| | **Wing length (mm)** | 486 ± 7 | 487 | 474 – 498 | 13 | 483 ± 5 | 482 | 477 – 489 | 4 |
| | **BCI** | 0.50 ± 0.61 | 0.53 | -0.32 – 1.48 | 13 | -0.15 ± 1.15 | 0.14 | -1.72 – 0.82 | 4 |
| | **Lipid weight percentage** | 0.97 ± 0.30 | 0.98 | 0.20 – 1.44 | 13 | 0.93 ± 1.18 | 0.87 | 0.80 – 1.19 | 4 |
| **2016** | **Body mass (g)** | 1747 ± 112 | 1730 | 1490 – 1910 | 16 | 1728 ± 147 | 1700 | 1580 – 1930 | 4 |
| | **Total head length (mm)** | 151.6 ± 3.8 | 152.9 | 143.6 – 157.0 | 17 | 150.3 ± 4.9 | 150.5 | 144.0 – 156.0 | 4 |
| | **Tarsus length (mm)** | 75.2 ± 2.8 | 75.4 | 71.0 – 81.5 | 17 | 76.6 ± 4.8 | 77.2 | 71.8 – 80.0 | 4 |
| | **Culmen length (mm)** | 64.1 ± 3.3 | 64.1 | 57.9 – 70.2 | 17 | 65.2 ± 2.9 | 65.2 | 61.9 – 68.3 | 4 |
| | **Gonys length (mm)** | 23.0 ± 0.8 | 23.2 | 21.5 – 24.5 | 17 | 22.6 ± 0.5 | 22.7 | 21.9 – 23.1 | 4 |
| | **Wing length (mm)** | 484 ± 6 | 485 | 474 – 495 | 17 | 487 ± 18 | 490 | 462 - 505 | 4 |
| | **BCI** | -0.08 ± 0.98 | -0.07 | -2.33 – 1.55 | 16 | -0.33 ± 1.14 | -0.46 | -1.52 – 1.12 | 4 |
| | **Lipid weight percentage** | 1.08 ± 0.24 | 1.13 | 0.61 – 1.42 | 16 | 0.99 ± 0.14 | 1.01 | 0.80 – 1.13 | 4 |
| **2017** | **Body mass (g)** | 1779 ± 110 | 1780 | 1650 – 1920 | 8 | 1758 ± 111 | 1770 | 1630 – 1880 | 5 |
| | **Total head lenght (mm)** | 154.3 ± 3.2 | 153.9 | 150.1 – 159.0 | 8 | 151.2 ± 2.5 | 152.0 | 147.0 – 153.0 | 5 |
| | **Tarsus length (mm)** | 76.3 ± 2.5 | 76.1 | 73.0 – 81.5 | 8 | 75.9 ± 2.6 | 75.0 | 73.2 – 79.4 | 5 |
| | **Culmen length (mm)** | 66.5 ± 1.9 | 66.6 | 63.7 – 69.1 | 8 | 65.2 ± 3.6 | 66.1 | 59.6 – 69.1 | 5 |
| | **Gonys length (mm)** | 23.5 ± 1.1 | 23.4 | 21.8 – 25.3 | 8 | 22.3 ± 0.3 | 22.4 | 21.9 – 22.5 | 5 |
| | **Wing length (mm)** | 485 ± 7 | 485 | 478 – 495 | 8 | 471 ± 5 | 472 | 463 – 476 | 5 |
| | **BCI** | -0.10 ± 1.02 | -0.33 | -1.15 – 1.23 | 8 | 0.69 ± 1.27 | 0.68 | -0.71 – 1.97 | 5 |
| | **Lipid weight percentage** | 0.53 ± 0.16 | 0.51 | 0.35 – 0.77 | 8 | 0.81 ± 0.20 | 0.88 | 0.47 – 0.96 | 5 |
| **2018** | **Body mass (g)** | 1787 ± 76 | 1770 | 1720 – 1870 | 3 | 1773 ± 65 | 1770 | 1710 – 1840 | 3 |
| | **Total head length (mm)** | 157.0 ± 3.1 | 157.8 | 153.6 – 159.7 | 3 | 150.0 ± 0.0 | 150.0 | 150.0 – 150.0 | 3 |
| | **Tarsus length (mm)** | 77.3 ± 3.9 | 78.3 | 73.0 – 80.5 | 3 | 76.0 ± 3.0 | 75.3 | 73.4 – 79.3 | 3 |
| | **Culmen length (mm)** | 67.4 ± 2.3 | 66.5 | 65.6 – 70.0 | 3 | 62.8 ± 0.4 | 62.6 | 62.5 – 63.2 | 3 |

**Table D1 Continued:** Mean ± standard deviation (SD), median, range (min – max) of biometric measurements, body condition index (BCI) and blood plasma lipid weight percentage of male glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| | | **Bjørnøya** | | | | **Kongsfjorden** | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean ± SD | Median | Range | *n* | Mean ± SD | Median | Range | *n* |
| **2018** | **Gonys length (mm)** | 23.9 ± 0.8 | 24.1 | 23.1 – 24.6 | 3 | 22.5 ± 0.9 | 22.5 | 21.6 – 23.4 | 3 |
| | **Wing length (mm)** | 491 ± 5 | 492 | 486 – 495 | 3 | 485 ± 10 | 482 | 476 – 496 | 3 |
| | **BCI** | -0.58 ± 0.79 | -0.89 | -1.17 – 0.31 | 3 | 0.28 ± 1.10 | 0.67 | -0.96 – 1.12 | 3 |
| | **Lipid weight percentage** | 0.65 ± 0.11 | 0.62 | 0.55 – 0.77 | 3 | 1.39 ± 0.15 | 1.45 | 1.21 – 1.50 | 3 |
| **2019** | **Body mass (g)** | 1738 ± 150 | 1750 | 1520 – 1880 | 5 | 1730 ± 129 | 1700 | 1590 – 1930 | 7 |
| | **Total head length (mm)** | 158.6 ± 3.0 | 159.8 | 154.3 – 160.7 | 4 | 151.9 ± 2.1 | 152.0 | 149.0 – 155.0 | 7 |
| | **Tarsus length (mm)** | 76.5 ± 4.4 | 74.9 | 72.4 – 81.6 | 5 | 74.8 ± 2.8 | 75.6 | 70.0 – 78.3 | 7 |
| | **Culmen length (mm)** | 66.5 ± 3.1 | 66.1 | 62.0 – 69.7 | 5 | 62.6 ± 0.9 | 62.9 | 61.4 – 63.6 | 7 |
| | **Gonys length (mm)** | 23.7 ± 1.1 | 24.0 | 22.2 – 25.1 | 5 | 24.3 ± 2.6 | 23.1 | 22.6 – 29.9 | 7 |
| | **Wing length (mm)** | 485 ± 8 | 484 | 472 – 494 | 5 | 484 ± 6 | 485 | 473 – 491 | 7 |
| | **BCI** | -0.63 ± 1.20 | -0.39 | -2.23 – 0.47 | 4 | -0.34 ± 1.20 | -0.72 | -1.61 – 1.45 | 7 |
| | **Lipid weight percentage** | 1.38 ± 0.18 | 1.43 | 1.10 – 1.59 | 5 | 1.30 ± 0.20 | 1.31 | 1.04 – 1.55 | 7 |
| **All years** | **Body mass (g)** | 1768 ± 107 | 1750 | 1490 – 1965 | 45 | 1743 ± 116 | 1710 | 1530 – 1930 | 23 |
| | **Total head length (mm)** | 152.4 ± 4.6 | 152.9 | 142.7 – 160.7 | 45 | 151.1 ± 2.9 | 151.0 | 144.0 – 156.0 | 23 |
| | **Tarsus length (mm)** | 76.0 ± 3.0 | 75.8 | 71.0 – 81.6 | 46 | 75.3 ± 3.2 | 75.3 | 66.7 – 80.0 | 23 |
| | **Culmen length (mm)** | 65.0 ± 3.2 | 65.3 | 57.8 – 70.5 | 46 | 63.5 ± 2.4 | 63.0 | 59.6 – 69.1 | 23 |
| | **Gonys length (mm)** | 23.2 ± 1.0 | 23.2 | 21.2 – 25.3 | 46 | 23.0 ± 1.6 | 22.6 | 21.5 – 29.9 | 23 |
| | **Wing length (mm)** | 485 ± 7 | 485 | 472 – 498 | 46 | 481 ± 10 | 482 | 462 – 505 | 23 |
| | **BCI** | 0.00 ± 0.93 | 0.13 | -2.33 – 1.55 | 44 | 0.00 ± 1.15 | -0.05 | -1.72 – 1.97 | 23 |
| | **Lipid weight percentage** | 1.09 ± 0.97 | 0.99 | 0.20 – 7.12 | 46 | 1.09 ± 0.28 | 1.04 | 0.47 – 1.55 | 23 |

**Table D2:** Mean ± standard deviation (SD), median, range (min – max) of biometric measurements, body condition index (BCI) and blood plasma lipid weight percentage of female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| | | **Bjørnøya** | | | | **Kongsfjorden** | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean ± SD | Median | Range | *n* | Mean ± SD | Median | Range | *n* |
| **2015** | **Body mass (g)** | 1440 ± 100 | 1425 | 1265 – 1625 | 13 | 1395 ± 47 | 1380 | 1330 – 1480 | 11 |
| | **Total head length (mm)** | 136.2 ± 3.6 | 136.2 | 129.4 – 142.3 | 13 | 137.0 ± 1.7 | 137.0 | 134.0 – 139.0 | 11 |
| | **Tarsus length (mm)** | 70.7 ± 2.4 | 70.8 | 65.8 – 75.2 | 13 | 66.7 ± 5.3 | 68.0 | 57.1 – 73.1 | 10 |
| | **Culmen length (mm)** | 57.3 ± 1.7 | 57.2 | 54.7 – 60.0 | 13 | 57.0 ± 1.7 | 57.1 | 53.5 – 60.3 | 11 |
| | **Gonys length (mm)** | 20.9 ± 1.2 | 20.9 | 19.4 – 24.1 | 13 | 20.5 ± 0.7 | 20.5 | 19.4 – 21.8 | 11 |
| | **Wing length (mm)** | 459 ± 8 | 459 | 442 – 474 | 13 | 462 ± 14 | 461 | 445 – 485 | 11 |
| | **BCI** | 0.28 ± 0.81 | -0.06 | -0.76 – 1.62 | 13 | -0.33 ± 0.37 | -0.44 | -1.06 – 0.22 | 11 |
| | **Lipid weight percentage** | 1.01 ± 0.15 | 1.07 | 0.71 – 1.20 | 13 | 0.80 ± 1.14 | 0.85 | 0.48 – 0.92 | 10 |
| **2016** | **Body mass (g)** | 1482 ± 135 | 1490 | 1300 – 1850 | 15 | 1360 ± 95 | 1350 | 1150 – 1500 | 15 |
| | **Total head length (mm)** | 137.9 ± 3.8 | 136.8 | 130.3 – 142.6 | 15 | 136.5 ± 3.5 | 137.0 | 129.0 – 141.0 | 15 |
| | **Tarsus length (mm)** | 68.6 ± 2.6 | 67.5 | 66.1 – 74.2 | 14 | 70.4 ± 2.1 | 70.3 | 67.8 – 74.6 | 15 |
| | **Culmen length (mm)** | 57.0 ± 1.9 | 57.4 | 52.9 – 59.5 | 15 | 57.2 ± 2.2 | 57.5 | 51.1 – 59.6 | 15 |
| | **Gonys length (mm)** | 20.7 ± 0.5 | 20.8 | 19.6 – 21.2 | 15 | 20.8 ± 0.7 | 20.6 | 19.8 – 22.2 | 15 |
| | **Wing length (mm)** | 458 ± 7 | 458 | 446 – 474 | 15 | 456 ± 8 | 457 | 442 – 473 | 15 |
| | **BCI** | 0.66 ± 1.51 | 0.63 | -1.56 – 5.03 | 15 | -0.47 ± 0.79 | -0.47 | -1.90 – 0.69 | 15 |
| | **Lipid weight percentage** | 1.11 ± 0.63 | 1.03 | 0.31 – 3.02 | 15 | 0.96 ± 0.22 | 0.93 | 0.66 – 1.51 | 14 |
| **2017** | **Body mass (g)** | 1434 ± 88 | 1440 | 1260 – 1550 | 8 | 1447 ± 96 | 1455 | 1290 – 1655 | 16 |
| | **Total head length (mm)** | 141.2 ± 4.2 | 140.9 | 134.7 – 148.4 | 8 | 136.5 ± 3.4 | 136.5 | 131.0 – 143.0 | 16 |
| | **Tarsus length (mm)** | 70.8 ± 2.3 | 71.1 | 65.8 – 73.1 | 8 | 70.1 ± 1.9 | 69.5 | 67.0 – 74.7 | 16 |
| | **Culmen length (mm)** | 57.8 ± 2.2 | 58.6 | 53.9 – 60.3 | 8 | 58.0 ± 2.2 | 58.3 | 53.6 – 61.8 | 16 |
| | **Gonys length (mm)** | 21.3 ± 0.5 | 21.4 | 20.4 – 21.8 | 8 | 20.5 ± 0.9 | 20.3 | 19.0 – 21.9 | 16 |
| | **Wing length (mm)** | 460 ± 4 | 460 | 454 – 466 | 8 | 458 ± 10 | 454 | 444 – 480 | 16 |
| | **BCI** | -0.18 ± 0.66 | -0.29 | -1.41 – 0.64 | 8 | 0.37 ± 0.84 | 0.13 | -0.69 – 2.14 | 16 |
| | **Lipid weight percentage** | 0.58 ± 0.23 | 0.62 | 0.11 – 0.87 | 8 | 0.78 ± 0.13 | 0.80 | 0.52 – 1.10 | 16 |
| **2018** | **Body mass (g)** | 1409 ± 70 | 1395 | 1340 – 1505 | 4 | 1497 ± 136 | 1485 | 1290 – 1770 | 10 |
| | **Total head length (mm)** | 143.8 ± 2.7 | 143.7 | 140.9 – 146.8 | 4 | 137.6 ± 3.1 | 138.0 | 132.0 – 143.0 | 10 |
| | **Tarsus length (mm)** | 70.6 ± 0.5 | 70.7 | 70.0 – 71.2 | 4 | 72.4 ± 2.9 | 71.8 | 68.7 – 77.6 | 10 |
| | **Culmen length (mm)** | 59.1 ± 1.1 | 58.9 | 58.2 – 60.5 | 4 | 58.5 ± 1.7 | 59.0 | 55.0 – 60.6 | 10 |
| | **Gonys length (mm)** | 21.7 ± 0.5 | 21.8 | 20.1 – 22.0 | 4 | 21.3 ± 1.0 | 21.3 | 19.8 – 22.6 | 10 |
| | **Wing length (mm)** | 464 ± 4 | 462 | 461 – 470 | 4 | 466 ± 8 | 464 | 458 – 480 | 10 |

**Table D2 Continued:** Mean ± standard deviation (SD), median, range (min – max) of biometric measurements, body condition index (BCI) and blood plasma lipid weight percentage of female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Number of samples analysed (*n*) are included.

| | | **Bjørnøya** | | | | **Kongsfjorden** | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean ± SD | Median | Range | *n* | Mean ± SD | Median | Range | *n* |
| **2018** | **BCI** | -0.76 ± 0.67 | -0.83 | -1.51 – 0.11 | 4 | 0.54 ± 1.28 | 0.41 | -1.07 – 3.58 | 10 |
| | **Lipid weight percentage** | 0.37 ± 0.19 | 0.39 | 0.14 – 0.55 | 4 | 1.41 ± 0.20 | 1.40 | 1.19 – 1.82 | 10 |
| **2019** | **Body mass (g)** | 1382 ± 35 | 1380 | 1350 – 1460 | 9 | 1351 ± 74 | 1360 | 1270 – 1490 | 7 |
| | **Total head length (mm)** | 140.9 ± 2.3 | 140.3 | 138.6 – 146.2 | 9 | 136.6 ± 2.7 | 137.0 | 133.5 – 141.0 | 7 |
| | **Tarsus length (mm)** | 70.3 ± 2.2 | 69.7 | 67.5 – 73.8 | 9 | 69.1 ± 2.9 | 69.7 | 65.1 – 73.5 | 7 |
| | **Culmen length (mm)** | 57.5 ± 1.5 | 57.9 | 55.3 – 59.5 | 9 | 57.0 ± 1.8 | 57.0 | 54.5 – 59.3 | 7 |
| | **Gonys length (mm)** | 21.4 ± 0.8 | 21.4 | 19.4 – 22.7 | 9 | 20.2 ± 1.0 | 20.3 | 18.9 – 21.6 | 7 |
| | **Wing length (mm)** | 458 ± 7 | 458 | 445 – 471 | 9 | 456 ± 3.6 | 456 | 450 – 462 | 7 |
| | **BCI** | -0.64 ± 0.30 | -0.67 | -1.09 – -0.20 | 9 | -0.58 ± 0.56 | -0.62 | -1.24 – 0.35 | 7 |
| | **Lipid weight percentage** | 1.35 ± 0.17 | 1.38 | 1.06 – 1.55 | 9 | 1.21 ± 0.07 | 1.20 | 1.09 – 1.29 | 7 |
| **All years** | **Body mass (g)** | 1439 ± 104 | 1410 | 1260 – 1850 | 49 | 1412 ± 106 | 1390 | 1150 – 1770 | 59 |
| | **Total head length (mm)** | 139.0 ± 4.2 | 139.3 | 129.4 – 148.4 | 49 | 136.8 ± 3.0 | 137.0 | 129.0 – 143.0 | 59 |
| | **Tarsus length (mm)** | 70.0 ± 2.4 | 70.4 | 65.8 – 75.2 | 48 | 69.9 ± 3.4 | 69.9 | 57.1 – 77.6 | 59 |
| | **Culmen length (mm)** | 57.5 ± 1.8 | 57.8 | 52.9 – 60.5 | 49 | 57.6 ± 2.0 | 57.4 | 51.1 – 61.8 | 59 |
| | **Gonys length (mm)** | 21.0 ± 0.8 | 21.0 | 19.4 – 24.1 | 49 | 20.7 ± 0.9 | 20.6 | 18.9 – 22.6 | 59 |
| | **Wing length (mm)** | 459 ± 7 | 459 | 442 – 474 | 49 | 459 ± 10 | 458 | 442 – 485 | 59 |
| | **BCI** | 0.07 ± 1.10 | -0.19 | -1.56 – 5.03 | 49 | -0.06 ± 0.92 | -0.18 | -1.90 – 3.58 | 59 |
| | **Lipid weight percentage** | 0.98 ± 0.47 | 1.00 | 0.11 – 3.02 | 49 | 0.99 ± 0.29 | 0.90 | 0.48 – 1.82 | 57 |

# APPENDIX E: PCAs and correlations

**Table E1:** Principal component (PC) loadings from principal component analyses (PCAs) based on correlation matrix of polychlorinated biphenyl (PCB) congeners measured in blood plasma of male and female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019.

| | **All individuals** | | **Bjørnøya** | | **Kongsfjorden** | | **Males** | | **Females** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **PC1** | **PC2** | **PC1** | **PC2** | **PC1** | **PC2** | **PC1** | **PC2** | **PC1** | **PC2** |
| **PCB-28** | -0.29 | -0.04 | 0.31 | 0.01 | -0.25 | 0.17 | -0.29 | 0.14 | -0.29 | -0.01 |
| **PCB-52** | -0.03 | -0.70 | 0.03 | -0.71 | -0.05 | 0.71 | 0.00 | 0.71 | -0.10 | 0.69 |
| **PCB-99** | -0.32 | 0.03 | 0.32 | 0.01 | -0.32 | -0.11 | -0.31 | -0.05 | -0.32 | -0.05 |
| **PCB-101** | -0.01 | -0.70 | 0.08 | -0.68 | -0.05 | 0.66 | 0.05 | 0.66 | -0.08 | 0.71 |
| **PCB-105** | -0.31 | -0.05 | 0.30 | -0.07 | -0.31 | 0.06 | -0.30 | 0.13 | -0.32 | 0.00 |
| **PCB-118** | -0.32 | 0.01 | 0.32 | 0.00 | -0.33 | -0.03 | -0.33 | 0.02 | -0.32 | -0.05 |
| **PCB-138** | -0.32 | 0.02 | 0.32 | 0.02 | -0.32 | -0.09 | -0.33 | 0.00 | -0.32 | -0.05 |
| **PCB-153** | -0.32 | 0.05 | 0.32 | 0.06 | -0.34 | -0.07 | -0.32 | -0.07 | -0.32 | -0.06 |
| **PCB-180** | -0.32 | 0.03 | 0.32 | 0.07 | -0.33 | -0.02 | -0.32 | -0.06 | -0.32 | -0.04 |
| **PCB-183** | -0.32 | 0.04 | 0.32 | 0.06 | -0.34 | -0.04 | -0.32 | -0.05 | -0.31 | -0.07 |
| **PCB-187** | -0.31 | -0.01 | 0.31 | 0.00 | -0.28 | -0.07 | -0.31 | 0.09 | -0.31 | -0.04 |
| **PCB-194** | -0.32 | 0.01 | 0.31 | 0.07 | -0.32 | 0.03 | -0.32 | -0.03 | -0.31 | -0.03 |

**Table E2:** Principal component (PC) loadings from principal component analyses (PCAs) based on correlation matrix of organochlorinated pesticides (OCPs) measured in blood plasma of male and female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019.

| | **All individuals** | | **Bjørnøya** | | **Kongsfjorden** | | **Males** | | **Females** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **PC1** | **PC2** | **PC1** | **PC2** | **PC1** | **PC2** | **PC1** | **PC2** | **PC1** | **PC2** |
| **HCB** | -0.34 | -0.09 | 0.09 | -0.35 | -0.27 | 0.53 | -0.32 | -0.14 | -0.34 | -0.44 |
| **β-HCH** | -0.44 | -0.13 | 0.46 | -0.14 | -0.49 | 0.05 | -0.47 | 0.01 | -0.41 | -0.23 |
| **Oxychlordane** | -0.41 | -0.20 | 0.45 | -0.11 | -0.47 | -0.03 | -0.41 | -0.15 | -0.40 | -0.17 |
| ***t*-Chlordane** | NA | NA | NA | NA | -0.03 | 0.63 | NA | NA | NA | NA |
| ***t*-Nonachlor** | -0.22 | 0.87 | 0.15 | 0.57 | -0.34 | 0.09 | -0.15 | 0.87 | -0.30 | 0.78 |
| ***c*-Nonachlor** | -0.37 | 0.34 | 0.35 | 0.43 | -0.23 | -0.08 | -0.33 | 0.37 | -0.40 | 0.25 |
| **Mirex** | -0.44 | -0.18 | 0.47 | -0.11 | -0.48 | -0.09 | -0.46 | -0.13 | -0.42 | -0.18 |
| ***p,p'*-DDT** | NA | NA | 0.06 | 0.55 | NA | NA | NA | NA | NA | NA |
| ***p,p'*-DDE** | -0.38 | -0.19 | 0.45 | -0.15 | -0.25 | -0.55 | -0.41 | -0.23 | -0.35 | 0.15 |

**Table E3:** Principal component (PC) loadings from principal component analyses (PCAs) based on correlation matrix of per- and polyfluoralkyl substances (PFASs) measured in blood plasma of male and female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019.

| | **All individuals** | | **Bjørnøya** | | **Kongsfjorden** | | **Males** | | **Females** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **PC1** | **PC2** | **PC1** | **PC2** | **PC1** | **PC2** | **PC1** | **PC2** | **PC1** | **PC2** |
| **PFHxS** | -0.20 | -0.78 | 0.16 | 0.48 | 0.03 | 0.53 | -0.21 | -0.76 | -0.18 | -0.77 |
| **PFHpS** | NA | NA | 0.26 | 0.12 | NA | NA | NA | NA | NA | NA |
| **BrPFOS** | -0.31 | -0.20 | 0.31 | 0.08 | 0.02 | 0.52 | -0.32 | -0.06 | -0.30 | -0.29 |
| **LinPFOS** | -0.34 | 0.00 | 0.31 | 0.02 | 0.18 | 0.43 | -0.34 | 0.12 | -0.34 | -0.07 |
| **PFNS** | NA | NA | 0.20 | -0.27 | NA | NA | NA | NA | NA | NA |
| **PFDcS** | NA | NA | 0.27 | -0.11 | NA | NA | NA | NA | NA | NA |
| **PFOA** | -0.25 | -0.42 | 0.17 | 0.58 | 0.10 | 0.36 | -0.27 | -0.50 | -0.25 | -0.35 |
| **PFNA** | -0.34 | 0.04 | 0.31 | 0.24 | 0.33 | 0.23 | -0.33 | 0.01 | -0.35 | 0.04 |
| **PFDcA** | -0.35 | 0.15 | 0.33 | -0.01 | 0.44 | -0.10 | -0.34 | 0.20 | -0.35 | 0.13 |
| **PFUnA** | -0.34 | 0.20 | 0.32 | -0.13 | 0.31 | -0.23 | -0.33 | 0.23 | -0.34 | 0.18 |
| **PFDoA** | -0.34 | 0.20 | 0.31 | -0.20 | 0.44 | -0.15 | -0.34 | 0.19 | -0.34 | 0.20 |
| **PFTriA** | -0.34 | 0.17 | 0.29 | -0.24 | 0.46 | -0.04 | -0.34 | 0.15 | -0.35 | 0.17 |
| **PFTeA** | -0.31 | 0.21 | 0.25 | -0.29 | 0.40 | -0.04 | -0.32 | 0.05 | -0.31 | 0.27 |
| **8:2 FTS** | NA | NA | 0.12 | 0.26 | NA | NA | NA | NA | NA | NA |

**Table E4:** Principal component (PC) loadings from principal component analyses (PCAs) based on correlation matrix of sum organohalogenated contaminant (OHC) concentrations (ΣPCB$_2$, ΣPCB$_{10}$, ΣOCP, ΣPFSA, ΣPFCA) and ratios (ΣPFSA/ΣPFAS, ΣPFAS/ΣOHC), thyroid hormone (TH) concentrations (TT$_3$, FT$_3$, TT$_4$, FT$_4$) and ratios (TT$_4$/TT$_3$, TT$_3$/FT$_3$, TT$_4$/FT$_4$, FT$_4$/FT$_3$), and lipid weight percentage (lipid) measured in blood plasma, and body condition index (BCI) of male and female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019.

| | **All individuals** | | **Bjørnøya** | | **Kongsfjorden** | | **Males** | | **Females** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **PC1** | **PC2** | **PC1** | **PC2** | **PC1** | **PC2** | **PC1** | **PC2** | **PC1** | **PC2** |
| **Lipid** | 0.12 | 0.17 | -0.03 | -0.17 | 0.19 | 0.03 | 0.17 | 0.19 | -0.09 | 0.19 |
| **ΣPCB$_2$** | -0.05 | -0.02 | 0.03 | 0.06 | -0.07 | -0.19 | -0.07 | 0.10 | 0.05 | -0.09 |
| **ΣPCB$_{10}$** | -0.31 | -0.17 | 0.10 | -0.43 | -0.03 | 0.50 | -0.16 | -0.37 | 0.36 | -0.10 |
| **ΣOCP** | -0.36 | -0.16 | 0.09 | -0.39 | -0.01 | 0.47 | -0.24 | -0.34 | 0.39 | -0.10 |
| **ΣPFSA** | -0.45 | -0.11 | 0.32 | 0.07 | 0.20 | 0.20 | -0.39 | -0.20 | 0.44 | -0.07 |
| **ΣPFCA** | -0.44 | -0.12 | 0.36 | 0.04 | 0.18 | 0.10 | -0.42 | -0.18 | 0.44 | -0.09 |
| **TT$_3$** | -0.18 | 0.46 | 0.03 | 0.09 | 0.40 | -0.11 | -0.28 | 0.36 | 0.14 | 0.47 |
| **FT$_3$** | -0.16 | 0.48 | 0.36 | 0.09 | 0.39 | -0.09 | -0.26 | 0.37 | 0.10 | 0.47 |
| **TT$_4$** | -0.04 | 0.25 | 0.39 | 0.03 | -0.02 | -0.26 | -0.13 | 0.16 | 0.07 | 0.23 |
| **FT$_4$** | -0.03 | 0.20 | 0.31 | -0.16 | -0.20 | -0.29 | -0.12 | -0.03 | 0.10 | 0.22 |
| **BCI** | 0.01 | 0.22 | 0.22 | -0.33 | 0.33 | -0.13 | -0.04 | 0.23 | -0.02 | 0.20 |
| **TT$_4$/TT$_3$** | 0.18 | -0.41 | 0.07 | 0.19 | -0.41 | 0.01 | 0.25 | -0.35 | -0.13 | -0.44 |
| **TT$_3$/FT$_3$** | -0.08 | -0.11 | -0.33 | -0.10 | -0.03 | 0.03 | 0.02 | -0.14 | 0.18 | 0.03 |
| **TT$_4$/FT$_4$** | 0.01 | -0.13 | -0.09 | 0.07 | 0.22 | 0.16 | 0.05 | 0.06 | -0.10 | -0.15 |
| **FT$_4$/FT$_3$** | 0.11 | -0.29 | -0.20 | 0.36 | -0.43 | -0.08 | 0.15 | -0.35 | -0.01 | -0.33 |
| **ΣPFSA/ΣPFAS** | -0.35 | -0.05 | -0.15 | -0.35 | -0.02 | -0.15 | -0.39 | -0.07 | 0.31 | -0.14 |
| **ΣPFAS/ΣOHC** | -0.37 | -0.04 | 0.28 | 0.01 | 0.15 | -0.45 | -0.38 | -0.04 | 0.36 | -0.04 |

**Table E5:** Principal component (PC) loadings from principal component analyses (PCAs) based on correlation matrix of sum organohalogenated contaminant (OHC) concentrations ($\Sigma PCB_2$, $\Sigma PCB_{10}$, ΣOCP, ΣPFSA, ΣPFCA) and ratios (ΣPFSA/ΣPFAS, ΣPFAS/ΣOHC), thyroid hormone (TH) concentrations ($TT_3$, $FT_3$, $TT_4$, $FT_4$) and ratios ($TT_4/TT_3$, $TT_3/FT_3$, $TT_4/FT_4$, $FT_4/FT_3$), and lipid weight percentage (lipid) measured in blood plasma, and body condition index (BCI) of male and female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019.

| | **Males Bjørnøya** | | **Males Kongsfjorden** | | **Females Bjørnøya** | | **Females Kongsfjorden** | |
|---|---|---|---|---|---|---|---|---|
| | **PC1** | **PC2** | **PC1** | **PC2** | **PC1** | **PC2** | **PC1** | **PC2** |
| **Lipid** | -0.26 | -0.07 | -0.22 | 0.28 | -0.13 | 0.24 | -0.17 | -0.03 |
| **$\Sigma PCB_2$** | 0.09 | -0.06 | -0.16 | -0.32 | -0.07 | 0.30 | 0.27 | 0.03 |
| **$\Sigma PCB_{10}$** | 0.03 | 0.43 | 0.24 | 0.23 | -0.21 | 0.40 | -0.11 | -0.50 |
| **ΣOCP** | 0.03 | 0.40 | 0.22 | 0.37 | -0.18 | 0.42 | -0.13 | -0.45 |
| **ΣPFSA** | 0.27 | -0.09 | -0.09 | -0.23 | -0.30 | -0.18 | -0.25 | -0.16 |
| **ΣPFCA** | 0.36 | -0.03 | -0.21 | 0.08 | -0.29 | -0.12 | -0.04 | -0.08 |
| **$TT_3$** | -0.03 | -0.13 | -0.37 | 0.14 | -0.06 | -0.20 | -0.33 | 0.16 |
| **$FT_3$** | 0.28 | -0.16 | -0.36 | 0.19 | -0.37 | -0.06 | -0.33 | 0.23 |
| **$TT_4$** | 0.33 | -0.14 | -0.18 | 0.01 | -0.37 | -0.01 | 0.15 | 0.11 |
| **$FT_4$** | 0.35 | 0.08 | -0.06 | 0.37 | -0.31 | -0.14 | 0.32 | 0.10 |
| **BCI** | 0.29 | 0.30 | -0.25 | 0.13 | -0.26 | -0.07 | -0.21 | 0.35 |
| **$TT_4/TT_3$** | 0.14 | -0.05 | 0.36 | -0.10 | 0.00 | -0.41 | 0.35 | -0.17 |
| **$TT_3/FT_3$** | -0.18 | 0.23 | 0.03 | -0.14 | 0.35 | -0.01 | -0.13 | -0.16 |
| **$TT_4/FT_4$** | -0.24 | -0.02 | -0.07 | -0.45 | -0.05 | -0.08 | -0.29 | -0.08 |
| **$FT_4/FT_3$** | -0.24 | -0.32 | 0.35 | 0.07 | 0.28 | 0.00 | 0.37 | -0.14 |
| **ΣPFSA/ΣPFAS** | -0.02 | 0.41 | -0.20 | 0.25 | 0.15 | -0.05 | 0.23 | 0.11 |
| **ΣPFAS/ΣOHC** | 0.35 | 0.06 | -0.33 | -0.25 | -0.21 | 0.10 | 0.06 | 0.44 |

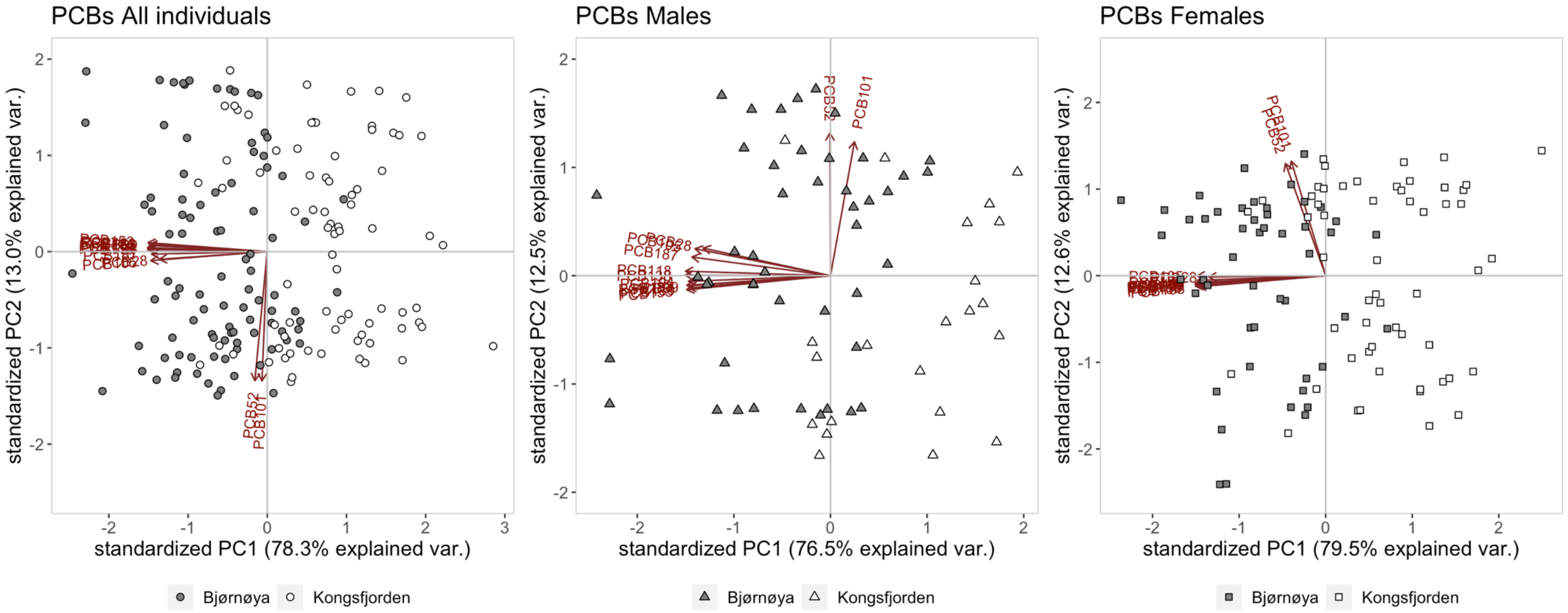

**Fig. E1:** Principal component analysis (PCA) biplots based on correlation matrix of concentrations of polychlorinated biphenyl (PCB) congeners measured in blood plasma of male and female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Circles (sex not specified), triangles (males) and squares (females) represent the sampled individuals.

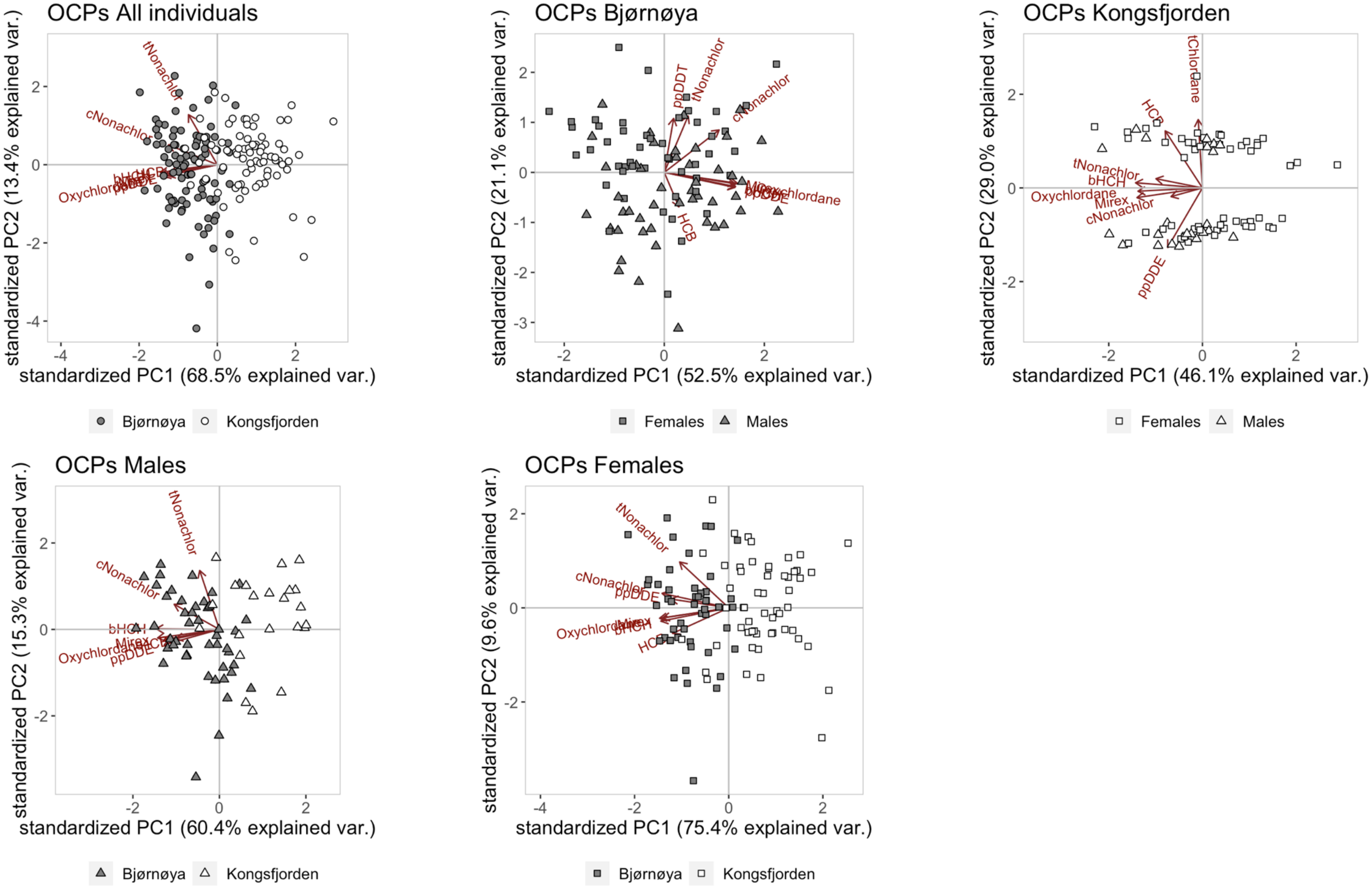

**Fig. E2:** Principal component analysis (PCA) biplots based on correlation matrix of concentrations of organochlorinated pesticides (OCPs) measured in blood plasma of male and female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Circles (sex not specified), triangles (males) and squares (females) represent the sampled individuals.

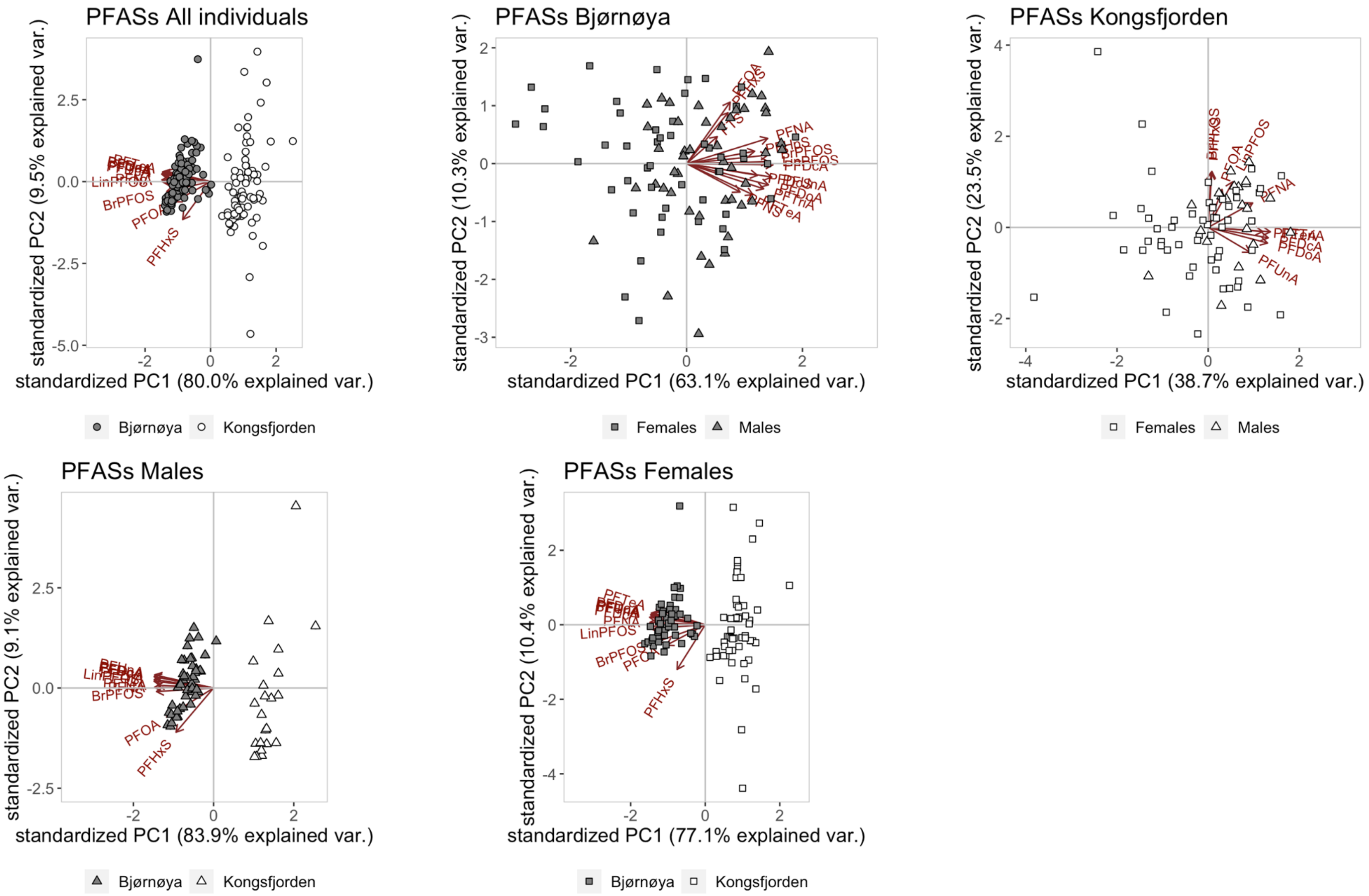

**Fig. E3:** Principal component analysis (PCA) biplots based on correlation matrix of concentrations of per- and polyfluorinated substances (PFASs) measured in blood plasma of male and female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Circles (sex not specified), triangles (males) and squares (females) represent the sampled individuals.

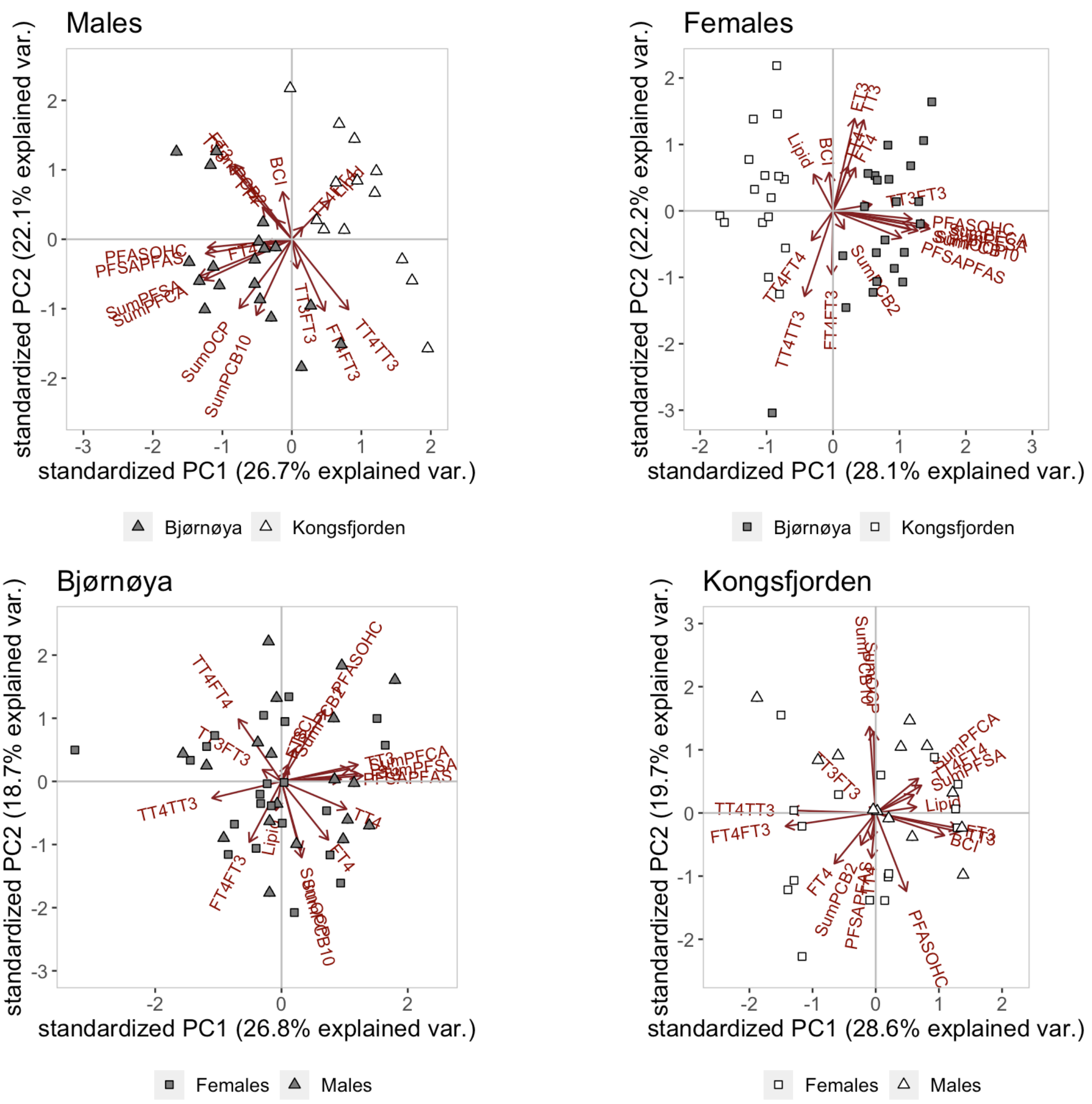

**Fig. E4:** Principal component analysis (PCA) biplots based on correlation matrix of sum organohalogenated contaminant (OHC) concentrations (ΣPCB2, ΣPCB10, ΣOCP, ΣPFSA, ΣPFCA) and ratios (ΣPFSA/ΣPFAS, ΣPFAS/ΣOHC), thyroid hormone (TH) concentrations (TT3, FT3, TT4, FT4) and ratios (TT4/TT3, TT3/FT3, TT4/FT4, FT4/FT3), and lipid weight percentage (lipid) measured in blood plasma, and body condition index (BCI) of male and female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Triangles (males) and squares (females) represent the sampled individuals.

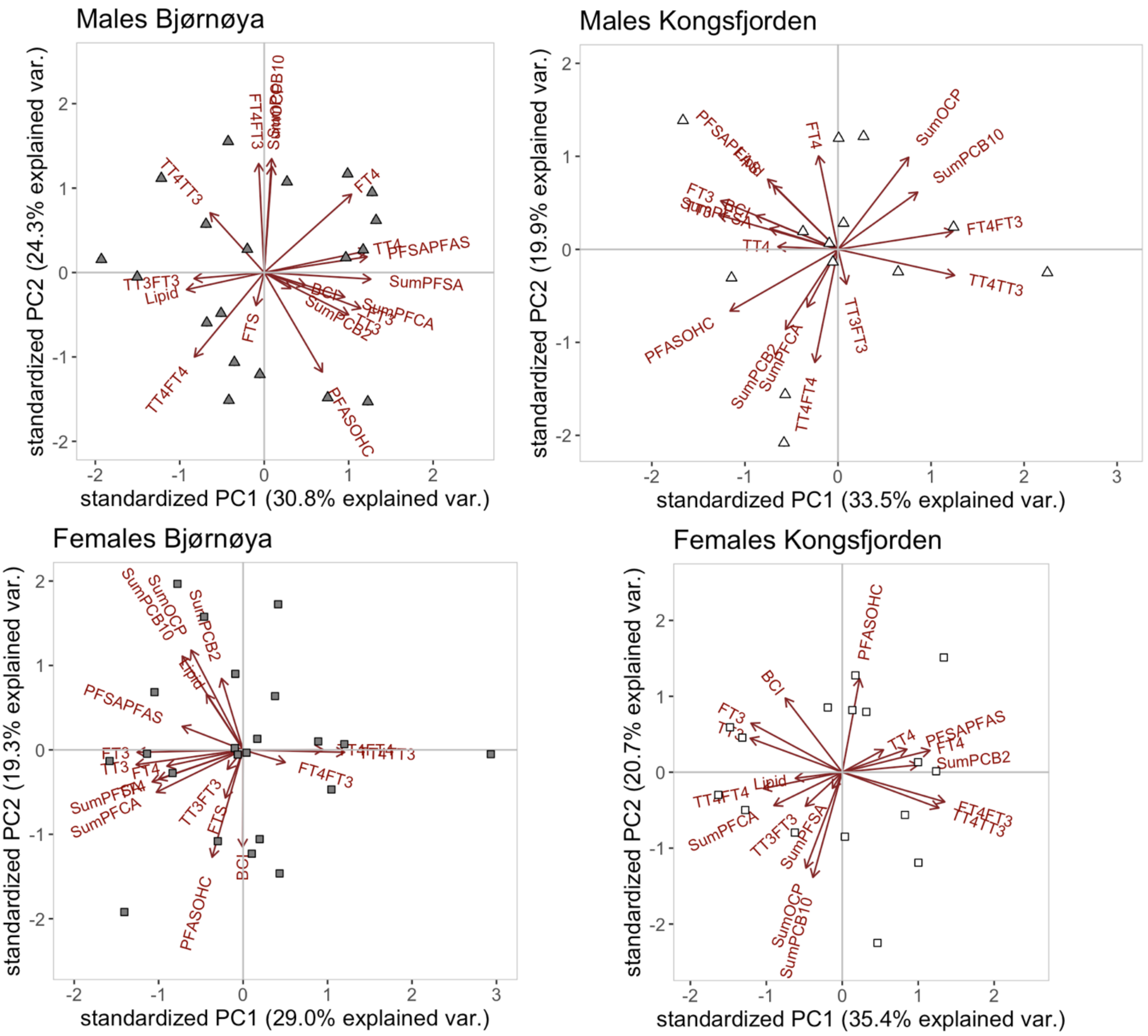

**Fig. E5:** Principal component analysis (PCA) biplots based on correlation matrix of sum organohalogenated contaminant (OHC) concentrations (ΣPCB2, ΣPCB10, ΣOCP, ΣPFSA, ΣPFCA) and ratios (ΣPFSA/ΣPFAS, ΣPFAS/ΣOHC), thyroid hormone (TH) concentrations (TT3, FT3, TT4, FT4) and ratios (TT4/TT3, TT3/FT3, TT4/FT4, FT4/FT3), and lipid weight percentage (lipid) measured in blood plasma, and body condition index (BCI) of male and female glaucous gulls (Larus hyperboreus) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Triangles (males) and squares (females) represent the sampled individuals.

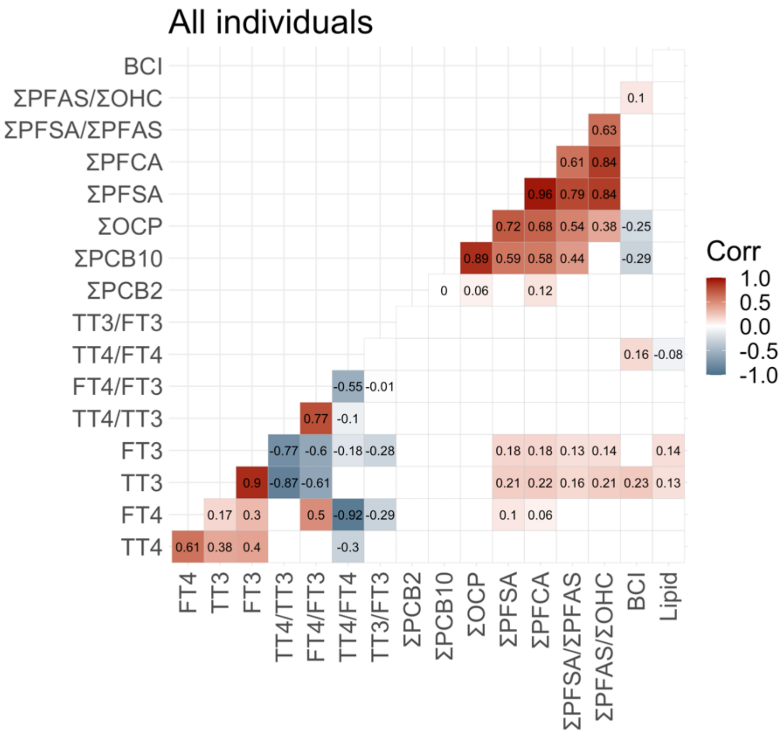

**Fig. E6:** Spearman's rank-order correlations calculated for sum organohalogenated contaminant (OHC) concentrations (ΣPCB2, ΣPCB10, ΣOCP, ΣPFSA, ΣPFCA) and ratios (ΣPFSA/ΣPFAS, ΣPFAS/ΣOHC), thyroid hormone (TH) concentrations (TT3, FT3, TT4, FT4) and ratios (TT4/TT3, TT3/FT3, TT4/FT4, FT4/FT3), and lipid weight percentage (lipid) measured in blood plasma, and body condition index (BCI) of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Red and blue indicate positive and negative correlation, respectively, and only significant correlations ($p \leq 0.05$) are shown.

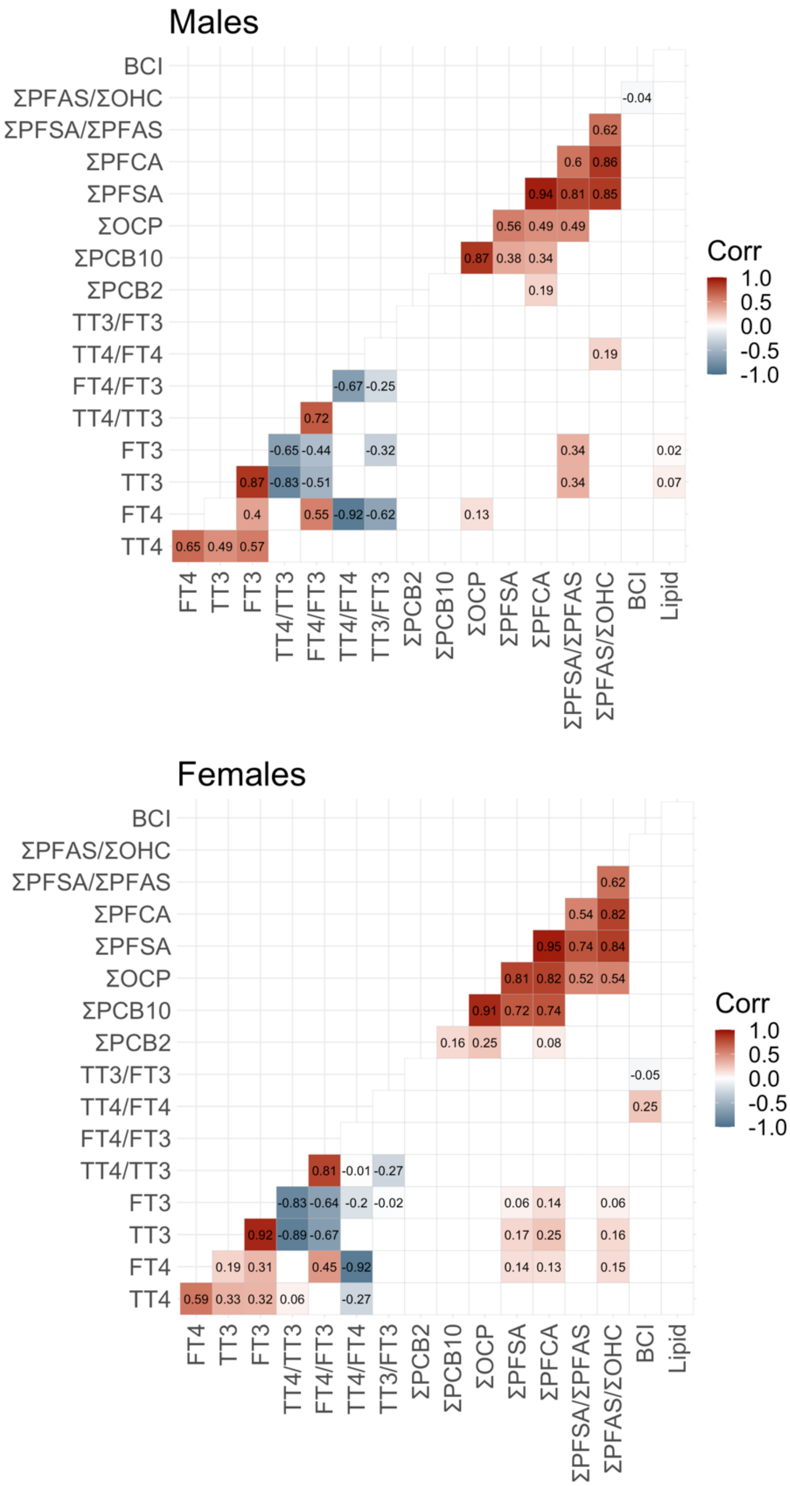

**Fig. E7:** Spearman's rank-order correlations calculated for sum organohalogenated contaminant (OHC) concentrations (ΣPCB2, ΣPCB10, ΣOCP, ΣPFSA, ΣPFCA) and ratios (ΣPFSA/ΣPFAS, ΣPFAS/ΣOHC), thyroid hormone (TH) concentrations (TT3, FT3, TT4, FT4) and ratios (TT4/TT3, TT3/FT3, TT4/FT4, FT4/FT3), and lipid weight percentage (lipid) measured in blood plasma, and body condition index (BCI) of male and female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Red and blue indicate positive and negative correlation, respectively, and only significant correlations ($p \leq 0.05$) are shown.

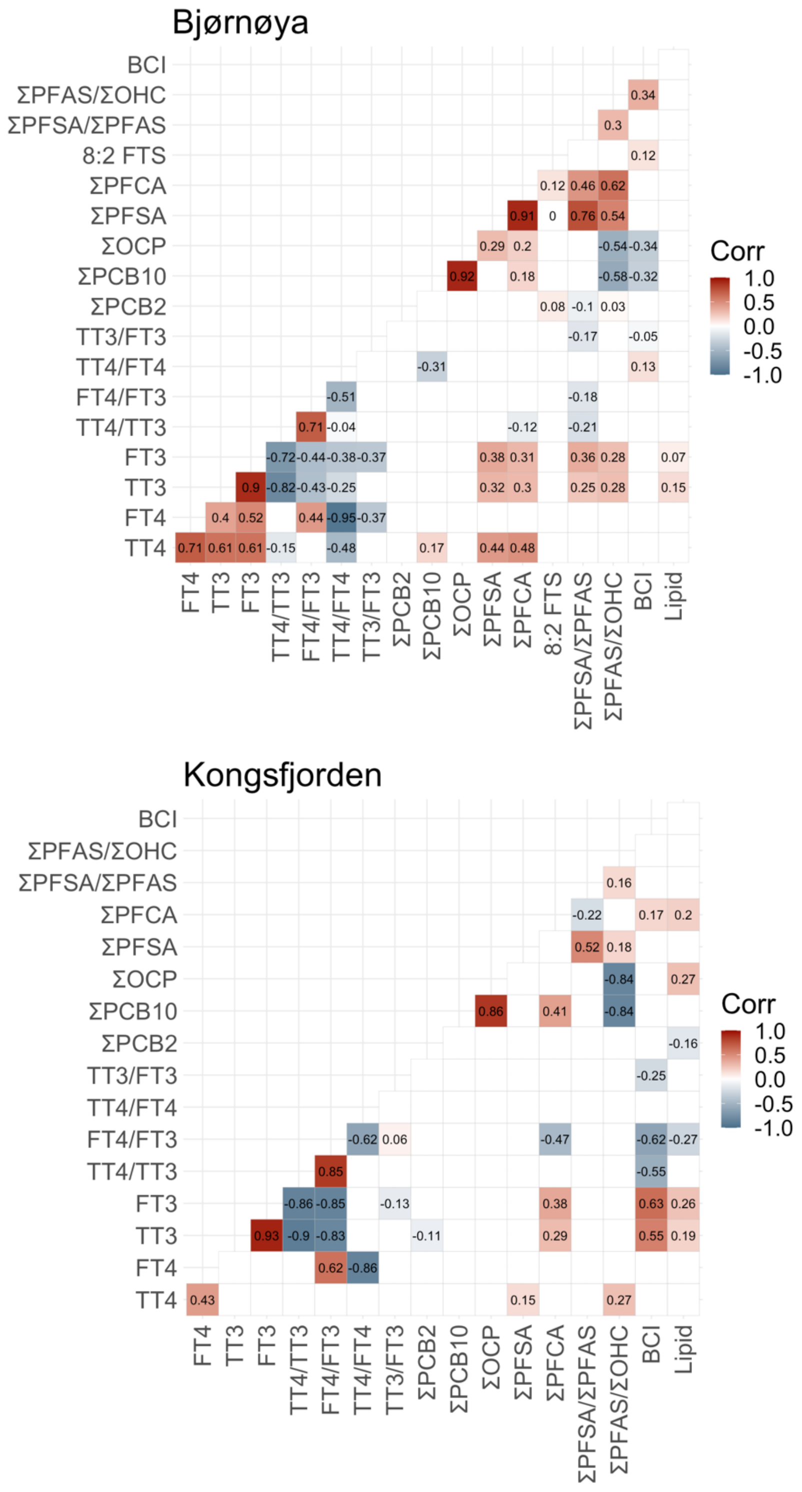

**Fig. E8:** Spearman's rank-order correlations calculated for sum organohalogenated contaminant (OHC) concentrations (ΣPCB2, ΣPCB10, ΣOCP, ΣPFSA, ΣPFCA) and ratios (ΣPFSA/ΣPFAS, ΣPFAS/ΣOHC), thyroid hormone (TH) concentrations (TT3, FT3, TT4, FT4) and ratios (TT4/TT3, TT3/FT3, TT4/FT4, FT4/FT3), and lipid weight percentage (lipid) measured in blood plasma, and body condition index (BCI) of male and female glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. Red and blue indicate positive and negative correlation, respectively, and only significant correlations ($p \leq 0.05$) are shown.

# APPENDIX F: Model selections

**Table F1:** The relative evidence for candidate linear-mixed effect models (*i*) explaining the variation in total T$_4$ (TT$_4$) concentrations in blood plasma of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015-2019. Predictor variables include a contaminant group (ΣPFSAs, ΣPFCAs, ΣPFSA/ΣPFAS, ΣPFAS/ΣOHC, ΣPCB$_2$, ΣPCB$_{10}$, ΣOCP), each analysed seperately, location, sampling year, sex, and plasma lipid weight percentage (lipid). Models are ranked on the basis of differences in the second-order Akaike's Information Criterion (ΔAICc) between each model and the model with the lowest AICc value and Aikaike weights ($w_i$). Model complexity is given by the number of parameters (df) in the model. Top five models with lowest ΔAICc or models with ΔAICc < 2 are presented. Model used for inference (shown in bold) were chosen based on the principle of parsimony from models with ΔAICc < 2. Continuous predictor variables are scaled (mean = 0, standard deviation = 1).

| *i* | Intercept | Lipid | Location | Sex | Year | Contaminant group | df | AICc | ΔAICc | $w_i$ |
|---|---|---|---|---|---|---|---|---|---|---|
| **TT$_4$ ~ ΣPFSAs** | | | | | | | | | | |
| 1 | 43.87 | | | | | 1.59 | 4 | 602.98 | 0.00 | 0.14 |
| 2 | 45.13 | | | + | | 1.83 | 5 | 603.33 | 0.35 | 0.11 |
| **3** | **43.79** | | | | | | **3** | **603.39** | **0.41** | **0.11** |
| 4 | 45.99 | | | | + | | 7 | 604.43 | 1.46 | 0.07 |
| 5 | 44.73 | | | + | | | 4 | 604.50 | 1.52 | 0.06 |
| 6 | 42.99 | | + | | | | 4 | 604.73 | 1.75 | 0.06 |
| **TT$_4$ ~ ΣPFCAs** | | | | | | | | | | |
| **1** | **43.79** | | | | | | **3** | **603.39** | **0.00** | **0.15** |
| 2 | 45.99 | | | | + | | 7 | 604.43 | 1.04 | 0.09 |
| 3 | 44.73 | | | + | | | 4 | 604.50 | 1.11 | 0.08 |
| 4 | 42.99 | | + | | | | 4 | 604.73 | 1.34 | 0.08 |
| 5 | 43.83 | | | | | 0.89 | 4 | 604.74 | 1.36 | 0.07 |
| 6 | 46.17 | 1.45 | | | + | | 8 | 605.18 | 1.79 | 0.06 |
| **TT$_4$ ~ ΣPFSA/ΣPFAS** | | | | | | | | | | |
| **1** | **41.92** | | **+** | | | **2.59** | **5** | **601.20** | **0.00** | **0.10** |
| 2 | 44.13 | 1.97 | + | | + | 3.09 | 10 | 601.21 | 0.01 | 0.10 |
| 3 | 45.13 | 2.17 | + | + | + | 3.33 | 11 | 601.47 | 0.27 | 0.09 |
| 4 | 43.66 | | + | | + | 2.74 | 9 | 601.71 | 0.51 | 0.08 |
| 5 | 43.05 | | + | + | | 2.74 | 6 | 601.73 | 0.53 | 0.08 |
| 6 | 45.97 | 2.30 | | | + | 2.27 | 9 | 601.89 | 0.69 | 0.07 |
| 7 | 46.98 | 2.50 | | + | + | 2.47 | 10 | 602.33 | 1.13 | 0.06 |
| 8 | 44.47 | | + | + | + | 2.90 | 10 | 602.62 | 1.42 | 0.05 |
| 9 | 43.83 | | | | | 1.57 | 4 | 602.93 | 1.73 | 0.04 |
| **TT$_4$ ~ ΣPFAS/ΣOHC** | | | | | | | | | | |
| **1** | **43.79** | | | | | | **3** | **603.39** | **0.00** | **0.15** |

**Table F1 Continued:** The relative evidence for candidate linear-mixed effect models (*i*) explaining the variation in total T$_4$ (TT4) concentrations in blood plasma of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015-2019. Predictor variables include a contaminant group (ΣPFSAs, ΣPFCAs, ΣPFSA/ΣPFAS, ΣPFAS/ΣOHC, ΣPCB$_2$, ΣPCB$_{10}$, ΣOCP), each analysed separately, location, sampling year, sex, and plasma lipid weight percentage (lipid). Models are ranked on the basis of differences in the second-order Akaike's Information Criterion (ΔAICc) between each model and the model with the lowest AICc value and Aikaike weights ($w_i$). Model complexity is given by the number of parameters (df) in the model. Top five models with lowest ΔAICc or models with ΔAICc < 2 are presented. Model used for inference (shown in bold) were chosen based on the principle of parsimony from models with ΔAICc < 2. Continuous predictor variables are scaled (mean = 0, standard deviation = 1).

| *i* | **Intercept** | **Lipid** | **Location** | **Sex** | **Year** | **Contaminant group** | **df** | **AICc** | **ΔAICc** | $w_i$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 45.99 | | | | + | | 7 | 604.43 | 1.04 | 0.09 |
| 3 | 44.73 | | | + | | | 4 | 604.50 | 1.11 | 0.09 |
| 4 | 42.99 | | + | | | | 4 | 604.73 | 1.34 | 0.08 |
| 5 | 43.82 | | | | | 0.72 | 4 | 605.03 | 1.64 | 0.07 |
| 6 | 46.17 | 1.45 | | | + | | 8 | 605.18 | 1.79 | 0.06 |
| **TT$_4$ ~ ΣPCB$_2$** | | | | | | | | | | |
| **1** | **43.79** | | | | | | **3** | **603.39** | **0.00** | **0.14** |
| 2 | 45.99 | | | | + | | 7 | 604.43 | 1.04 | 0.08 |
| 3 | 44.73 | | | + | | | 4 | 604.50 | 1.11 | 0.08 |
| 4 | 42.99 | | + | | | | 4 | 604.73 | 1.34 | 0.07 |
| 5 | 46.17 | 1.45 | | | + | | 8 | 605.18 | 1.79 | 0.06 |
| 6 | 43.79 | | | | | -0.46 | 4 | 605.36 | 1.98 | 0.05 |
| **TT$_4$ ~ ΣPCB$_{10}$** | | | | | | | | | | |
| **1** | **43.79** | | | | | | **3** | **603.39** | **0.00** | **0.12** |
| 2 | 45.99 | | | | + | | 7 | 604.43 | 1.04 | 0.07 |
| 3 | 44.73 | | | + | | | 4 | 604.50 | 1.11 | 0.07 |
| 4 | 42.99 | | + | | | | 4 | 604.73 | 1.34 | 0.06 |
| 5 | 43.81 | | | | | 0.65 | 4 | 605.14 | 1.75 | 0.05 |
| 6 | 46.17 | 1.45 | | | + | | 8 | 605.18 | 1.79 | 0.05 |
| 7 | 42.42 | | + | | | 1.44 | 5 | 605.27 | 1.89 | 0.05 |
| **TT$_4$ ~ ΣOCPs** | | | | | | | | | | |
| **1** | **43.79** | | | | | | **3** | **603.39** | **0.00** | **0.14** |
| 2 | 45.99 | | | | + | | 7 | 604.43 | 1.04 | 0.08 |
| 3 | 44.73 | | | + | | | 4 | 604.50 | 1.11 | 0.08 |
| 4 | 42.99 | | + | | | | 4 | 604.73 | 1.34 | 0.07 |
| 5 | 46.17 | 1.45 | | | + | | 8 | 605.18 | 1.79 | 0.06 |

**Table F2:** The relative evidence for candidate linear-mixed effect models (*i*) explaining the variation in free $T_4$ ($FT_4$) concentrations in blood plasma of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015-2019. Predictor variables include a contaminant group ($\Sigma$PFSAs, $\Sigma$PFCAs, $\Sigma$PFSA/$\Sigma$PFAS, $\Sigma PCB_2$, $\Sigma$OCP), each analysed separately, location, sampling year, sex, body condition index (BCI) and plasma lipid weight percentage (lipid). Models are ranked on the basis of differences in the second-order Akaike's Information Criterion ($\Delta$AICc) between each model and the model with the lowest AICc value and Aikaike weights ($w_i$). Model complexity is given by the number of parameters (df) in the model. Top five models with lowest $\Delta$AICc or models with $\Delta$AICc < 2 are presented. Model used for inference (shown in bold) were chosen based on the principle of parsimony from models with $\Delta$AICc < 2. Continuous predictor variables are scaled (mean = 0, standard deviation = 1).

| *i* | Intercept | BCI | Lipid | Location | Sex | Year | Contaminant group | df | AICc | ΔAICc | $w_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **$FT_4$ ~ $\Sigma$PFSAs** | | | | | | | | | | | |
| **1** | **14.64** | | **1.41** | | **+** | | **1.95** | **6** | **888.22** | **0.00** | **0.40** |
| 2 | 14.65 | -0.46 | 1.47 | | + | | 2.00 | 7 | 889.62 | 1.39 | 0.20 |
| 3 | 13.54 | | 1.33 | | | | 1.61 | 5 | 890.65 | 2.42 | 0.12 |
| 4 | 13.52 | -0.41 | 1.39 | | | | 1.65 | 6 | 892.22 | 3.99 | 0.05 |
| 5 | 14.11 | | 1.57 | | + | + | 1.77 | 10 | 892.78 | 4.56 | 0.04 |
| **$FT_4$ ~ $\Sigma$PFCAs** | | | | | | | | | | | |
| 1 | 14.52 | | 1.16 | | + | | 1.60 | 6 | 891.60 | 0.00 | 0.24 |
| **2** | **13.53** | | **1.13** | | | | **1.32** | **5** | **893.13** | **1.53** | **0.11** |
| 3 | 14.53 | -0.40 | 1.21 | | + | | 1.64 | 7 | 893.22 | 1.62 | 0.10 |
| 4 | 14.49 | | | | + | | 1.45 | 5 | 894.24 | 2.64 | 0.06 |
| 5 | 14.01 | | 1.38 | | + | + | 1.58 | 10 | 894.25 | 2.65 | 0.06 |
| **$FT_4$ ~ PFSA/PFAS** | | | | | | | | | | | |
| 1 | 14.26 | | 1.23 | | + | | 1.31 | 6 | 893.88 | 0.00 | 0.11 |
| **2** | **13.49** | | **1.21** | | | | **1.20** | **5** | **894.09** | **0.22** | **0.10** |
| 3 | 14.87 | | 1.25 | + | + | | 1.10 | 7 | 895.09 | 1.22 | 0.06 |
| 4 | 13.93 | | 1.22 | + | | | 1.02 | 6 | 895.63 | 1.76 | 0.05 |
| 5 | 14.27 | -0.35 | 1.28 | | + | | 1.33 | 7 | 895.65 | 1.78 | 0.05 |
| **$FT_4$ ~ $\Sigma PCB_2$** | | | | | | | | | | | |
| 1 | 15.13 | | 1.11 | + | + | | | 6 | 896.31 | 0.00 | 0.07 |
| 2 | 14.27 | | 1.08 | + | | | | 5 | 896.35 | 0.04 | 0.07 |
| 3 | 13.47 | | 1.00 | | | | | 4 | 896.57 | 0.26 | 0.06 |
| 4 | 15.28 | | 1.07 | + | + | | -0.65 | 7 | 897.20 | 0.89 | 0.04 |
| 5 | 14.08 | | 1.01 | | + | | | 5 | 897.25 | 0.93 | 0.04 |
| 6 | 14.38 | | 1.05 | + | | | -0.60 | 6 | 897.42 | 1.11 | 0.04 |
| 7 | 15.35 | | 1.54 | + | + | + | | 10 | 897.44 | 1.13 | 0.04 |
| 8 | 14.41 | | 1.49 | + | | + | | 9 | 897.73 | 1.42 | 0.03 |
| **9** | **13.53** | | | | | | | **3** | **897.85** | **1.54** | **0.03** |
| 10 | 15.20 | -0.41 | 1.16 | + | + | | | 7 | 897.95 | 1.63 | 0.03 |

**Table F2 Continued:** The relative evidence for candidate linear-mixed effect models (*i*) explaining the variation in free $T_4$ ($FT_4$) concentrations in blood plasma of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015-2019. Predictor variables include a contaminant group (ΣPFSAs, ΣPFCAs, ΣPFSA/ΣPFAS, $\Sigma PCB_2$, ΣOCP), each analysed separately, location, sampling year, sex, body condition index (BCI) and plasma lipid weight percentage (lipid). Models are ranked on the basis of differences in the second-order Akaike's Information Criterion (ΔAICc) between each model and the model with the lowest AICc value and Aikaike weights ($w_i$). Model complexity is given by the number of parameters (df) in the model. Top five models with lowest ΔAICc or models with ΔAICc < 2 are presented. Model used for inference (shown in bold) were chosen based on the principle of parsimony from models with ΔAICc < 2. Continuous predictor variables are scaled (mean = 0, standard deviation = 1).

| *i* | Intercept | BCI | Lipid | Location | Sex | Year | Contaminant group | df | AICc | ΔAICc | $w_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 14.30 | -0.36 | 1.13 | + | | | | 6 | 898.08 | 1.76 | 0.03 |
| 12 | 13.49 | | 0.97 | | | | -0.41 | 5 | 898.18 | 1.87 | 0.03 |
| 13 | 14.19 | | | + | | | | 4 | 898.22 | 1.91 | 0.03 |
| **$FT_4$ ~ ΣOCPs** | | | | | | | | | | | |
| 1 | 14.43 | | 0.91 | | + | | 1.06 | 6 | 896.14 | 0.00 | 0.06 |
| 2 | 15.13 | | 1.11 | + | + | | | 6 | 896.31 | 0.18 | 0.06 |
| 3 | 14.27 | | 1.08 | + | | | | 5 | 896.35 | 0.21 | 0.06 |
| 4 | 13.47 | | 1.00 | | | | | 4 | 896.57 | 0.44 | 0.05 |
| 5 | 14.47 | | | | + | | 1.15 | 5 | 896.86 | 0.73 | 0.05 |
| 6 | 13.51 | | 0.93 | | | | 0.74 | 5 | 896.97 | 0.84 | 0.04 |
| 7 | 14.08 | | 1.01 | | + | | | 5 | 897.25 | 1.11 | 0.04 |
| 8 | 15.35 | | 1.54 | + | + | + | | 10 | 897.44 | 1.30 | 0.03 |
| 9 | 14.41 | | 1.49 | + | | + | | 9 | 897.73 | 1.59 | 0.03 |
| 10 | 13.56 | | | | | | 0.82 | 4 | 897.79 | 1.66 | 0.03 |
| 11 | 14.89 | | 1.00 | + | + | | 0.66 | 7 | 897.82 | 1.68 | 0.03 |
| **12** | **13.53** | | | | | | | **3** | **897.85** | **1.72** | **0.03** |
| 13 | 15.20 | -0.41 | 1.16 | + | + | | | 7 | 897.95 | 1.81 | 0.03 |
| 14 | 14.30 | -0.36 | 1.13 | + | | | | 6 | 898.08 | 1.94 | 0.02 |

**Table F3:** The relative evidence for candidate linear-mixed effect models (*i*) explaining the variation in total $T_3$ ($TT_3$) concentrations (nmol/L) in blood plasma of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015-2019. Predictor variables include a contaminant group (ΣPFSAs, ΣPFCAs, ΣPFSA/ΣPFAS, ΣPFAS/ΣOHC, $\Sigma PCB_2$), each analysed separately, location, sampling year, sex, body condition index (BCI) and plasma lipid weight percentage (lipid). Models were ranked on the basis of differences in the second-order Akaike's Information Criterion (ΔAICc) between each model and the model with the lowest AICc value and Aikaike weights ($w_i$). Model complexity is given by the number of parameters (df) in the model. Top five models with lowest ΔAICc or models with ΔAICc < 2 are presented. Model used for inference (shown in bold) were chosen from models with ΔAICc < 2 based on the principle of parsimony. Continuous predictor variables are scaled (mean = 0, standard deviation = 1).

| *i* | **Intercept** | **BCI** | **Lipid** | **Location** | **Sex** | **Year** | **Contaminant group** | **df** | **AICc** | **ΔAICc** | $w_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **$TT_3$ ~ ΣPFSAs** | | | | | | | | | | | |
| **1** | **4.07** | | **0.43** | | | | **0.60** | **5** | **525.95** | **0.00** | **0.13** |
| 2 | 3.89 | 0.20 | 0.39 | | + | | 0.50 | 7 | 526.13 | 0.18 | 0.12 |
| 3 | 4.07 | 0.19 | 0.40 | | | | 0.57 | 6 | 526.14 | 0.19 | 0.12 |
| 4 | 3.90 | | 0.42 | | + | | 0.53 | 6 | 526.17 | 0.22 | 0.12 |
| 5 | 4.34 | | 0.56 | | | + | 0.49 | 9 | 526.23 | 0.28 | 0.12 |
| 6 | 4.31 | 0.19 | 0.52 | | | + | 0.47 | 10 | 526.32 | 0.37 | 0.11 |
| 7 | 4.14 | 0.20 | 0.51 | | + | + | 0.40 | 11 | 526.37 | 0.42 | 0.11 |
| 8 | 4.18 | | 0.55 | | + | + | 0.43 | 10 | 526.45 | 0.50 | 0.10 |
| **$TT_3$ ~ ΣPFCAs** | | | | | | | | | | | |
| 1 | 4.10 | 0.22 | 0.46 | | + | + | 0.34 | 11 | 528.51 | 0.00 | 0.18 |
| 2 | 4.14 | | 0.50 | | + | + | 0.36 | 10 | 528.99 | 0.48 | 0.14 |
| 3 | 4.29 | 0.21 | 0.46 | | | + | 0.41 | 10 | 529.25 | 0.74 | 0.12 |
| 4 | 4.33 | | 0.49 | | | + | 0.42 | 9 | 529.49 | 0.98 | 0.11 |
| **5** | **3.85** | **0.22** | **0.33** | | **+** | | **0.41** | **7** | **530.24** | **1.73** | **0.07** |
| **$TT_3$ ~ ΣPFSA/ΣPFAS** | | | | | | | | | | | |
| 1 | 4.18 | 0.22 | 0.53 | | + | + | 0.27 | 11 | 530.30 | 0.00 | 0.13 |
| 2 | 4.23 | | 0.58 | | + | + | 0.29 | 10 | 530.81 | 0.50 | 0.10 |
| 3 | 4.36 | 0.21 | 0.50 | + | + | + | | 11 | 531.26 | 0.95 | 0.08 |
| 4 | 4.44 | | 0.53 | + | + | + | | 10 | 531.44 | 1.13 | 0.08 |
| 5 | 4.42 | 0.22 | 0.55 | | | + | 0.33 | 10 | 531.74 | 1.44 | 0.07 |
| 6 | 4.30 | 0.21 | 0.53 | + | + | + | 0.21 | 12 | 531.74 | 1.44 | 0.07 |
| 7 | 4.36 | | 0.57 | + | + | + | 0.21 | 11 | 531.85 | 1.55 | 0.06 |
| 8 | 4.17 | 0.25 | 0.48 | | + | + | | 10 | 532.03 | 1.72 | 0.06 |
| **9** | **4.46** | | **0.60** | | | **+** | **0.35** | **9** | **532.06** | **1.76** | **0.06** |
| **$TT_3$ ~ ΣPFAS/ΣOHC** | | | | | | | | | | | |
| 1 | 4.09 | | 0.56 | | | | | | | | |
| 2 | 4.07 | 0.15 | 0.54 | | + | + | 0.48 | 11 | 521.71 | 1.05 | 0.19 |
| 3 | 4.32 | | 0.56 | | | + | 0.56 | 9 | 522.33 | 1.68 | 0.14 |
| **4** | **3.83** | | **0.44** | | **+** | | **0.58** | **6** | **522.34** | **1.69** | **0.14** |

**Table F3 Continued:** The relative evidence for candidate linear-mixed effect models (*i*) explaining the variation in total $T_3$ ($TT_3$) concentrations (nmol/L) in blood plasma of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015-2019. Predictor variables include a contaminant group (ΣPFSAs, ΣPFCAs, ΣPFSA/ΣPFAS, ΣPFAS/ΣOHC, $ΣPCB_2$), each analysed separately, location, sampling year, sex, body condition index (BCI) and plasma lipid weight percentage (lipid). Models were ranked on the basis of differences in the second-order Akaike's Information Criterion (ΔAICc) between each model and the model with the lowest AICc value and Aikaike weights ($w_i$). Model complexity is given by the number of parameters (df) in the model. Top five models with lowest ΔAICc or models with ΔAICc < 2 are presented. Model used for inference (shown in bold) were chosen from models with ΔAICc < 2 based on the principle of parsimony. Continuous predictor variables are scaled (mean = 0, standard deviation = 1).

| *i* | **Intercept** | **BCI** | **Lipid** | **Location** | **Sex** | **Year** | **Contaminant group** | **df** | **AICc** | **ΔAICc** | $w_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 3.82 | 0.14 | 0.42 | | + | | 0.54 | 7 | 523.35 | 2.69 | 0.08 |
| **$TT_3$ ~ $ΣPCB_2$** | | | | | | | | | | | |
| 1 | 4.36 | 0.21 | 0.50 | + | + | + | | 11 | 531.26 | 0.00 | 0.15 |
| 2 | 4.44 | | 0.53 | + | + | + | | 10 | 531.44 | 0.18 | 0.14 |
| 3 | 4.17 | 0.25 | 0.48 | | + | + | | 10 | 532.03 | 0.77 | 0.11 |
| 4 | 4.54 | | 0.53 | + | + | + | -0.15 | 11 | 532.62 | 1.36 | 0.08 |
| 5 | 4.46 | 0.20 | 0.50 | + | + | + | -0.13 | 12 | 532.70 | 1.44 | 0.08 |
| **6** | **4.22** | | **0.52** | | **+** | **+** | | **9** | **533.13** | **1.87** | **0.06** |

**Table F4:** The relative evidence for candidate linear-mixed effect models (*i*) explaining the variation in free $T_3$ ($FT_3$) concentrations (pmol/L) in blood plasma of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015-2019. Predictor variables include a contaminant group (ΣPFSAs, ΣPFCAs, ΣPFSA/ΣPFAS, ΣPFAS/ΣOHC), each analysed separately, location, sampling year, sex, body condition index (BCI) and plasma lipid weight percentage (lipid). Models were ranked on the basis of differences in the second-order Akaike's Information Criterion (ΔAICc) between each model and the model with the lowest AICc value and Aikaike weights ($w_i$). Model complexity is given by the number of parameters (df) in the model. Top five models with lowest ΔAICc or models with ΔAICc < 2 are presented. Model used for inference (shown in bold) were chosen from models with ΔAICc < 2 based on the principle of parsimony. Continuous predictor variables are scaled (mean = 0, standard deviation = 1).

| *i* | **Intercept** | **BCI** | **Lipid** | **Location** | **Sex** | **Year** | **Contaminant group** | **df** | **AICc** | **ΔAICc** | $w_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **$FT_3$ ~ ΣPFSAs** | | | | | | | | | | | |
| **1** | **9.01** | | **1.07** | | **+** | **+** | **1.32** | **10** | **746.80** | **0.00** | **0.35** |
| 2 | 8.94 | 0.39 | 0.99 | | + | + | 1.26 | 11 | 748.04 | 1.24 | 0.19 |
| 3 | 9.44 | | 1.02 | | + | | 1.44 | 6 | 749.02 | 2.23 | 0.12 |
| 4 | 9.71 | | 1.08 | | | + | 1.60 | 9 | 749.78 | 2.99 | 0.08 |
| 5 | 9.42 | 0.30 | 0.97 | | + | | 1.39 | 7 | 750.62 | 3.83 | 0.05 |
| **$FT_3$ ~ ΣPFCAs** | | | | | | | | | | | |
| **1** | **9.00** | | **0.96** | | **+** | **+** | **1.05** | **10** | **750.54** | **0.00** | **0.32** |
| 2 | 8.92 | 0.45 | 0.88 | | + | + | 1.00 | 11 | 751.42 | 0.88 | 0.20 |
| 3 | 8.60 | 0.59 | | | + | + | 1.07 | 10 | 753.37 | 2.83 | 0.08 |
| 4 | 8.67 | | | | + | + | 1.15 | 9 | 753.53 | 2.99 | 0.07 |
| 5 | 9.90 | | 1.07 | + | + | + | | 10 | 754.41 | 3.87 | 0.05 |
| **$FT_3$ ~ ΣPFSA/ΣPFAS** | | | | | | | | | | | |
| 1 | 9.41 | | 1.17 | | + | + | 0.75 | 10 | 753.29 | 0.00 | 0.17 |
| 2 | 9.29 | 0.50 | 1.05 | | + | + | 0.71 | 11 | 753.85 | 0.56 | 0.13 |
| 3 | 9.90 | | 1.07 | + | + | + | | 10 | 754.41 | 1.12 | 0.10 |
| **4** | **9.49** | | **1.04** | | **+** | **+** | | **9** | **754.85** | **1.56** | **0.08** |
| 5 | 9.66 | | 1.15 | + | + | + | 0.58 | 11 | 754.92 | 1.63 | 0.08 |
| 6 | 9.36 | 0.55 | 0.93 | | + | + | | 10 | 755.04 | 1.75 | 0.07 |
| **$FT_3$ ~ ΣPFAS/ΣOHC** | | | | | | | | | | | |
| **1** | **8.74** | | **1.10** | | **+** | **+** | **1.51** | **10** | **742.01** | **0.00** | **0.60** |
| 2 | 8.71 | 0.24 | 1.05 | | + | + | 1.45 | 11 | 743.97 | 1.96 | 0.23 |
| 3 | 8.41 | | | | + | + | 1.50 | 9 | 747.09 | 5.08 | 0.05 |
| 4 | 9.68 | | 1.12 | | | + | 1.67 | 9 | 747.85 | 5.84 | 0.03 |
| 5 | 9.23 | | 1.05 | | + | | 1.45 | 6 | 747.86 | 5.84 | 0.03 |

**Table F5:** The relative evidence for candidate linear-mixed effect models (*i*) explaining the variation in total $T_4$/total $T_3$ ($TT_4/TT_3$) ratio in blood plasma of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015-2019. Predictor variables include a contaminant group (ΣPFSAs, ΣPFCAs, ΣPFSA/ΣPFAS, ΣPFAS/ΣOHC, Σ$PCB_2$), each analysed separately, location, sampling year, and sex. Models are ranked on the basis of differences in the second-order Akaike's Information Criterion (ΔAICc) between each model and the model with the lowest AICc value and Aikaike weights ($w_i$). Model complexity is given by the number of parameters (df) in the model. Top five models with lowest ΔAICc or models with ΔAICc < 2 are presented. Model used for inference (shown in bold) were chosen based on the principle of parsimony from models with ΔAICc < 2. Continuous predictor variables are scaled (mean = 0, standard deviation = 1).

| *i* | **Intercept** | **BCI** | **Location** | **Sex** | **Year** | **Contaminant group** | **df** | **AICc** | **ΔAICc** | $w_i$ |
|---|---|---|---|---|---|---|---|---|---|---|
| **$TT_4/TT_3$ ~ ΣPFSAs** | | | | | | | | | | |
| **1** | **12.34** | | | | | | **3** | **563.88** | **0.00** | **0.09** |
| 2 | 11.99 | | | + | + | | 8 | 564.03 | 0.16 | 0.09 |
| 3 | 13.46 | | | + | | | 4 | 564.09 | 0.21 | 0.08 |
| 4 | 12.34 | | | | | -1.17 | 4 | 564.34 | 0.46 | 0.07 |
| 5 | 12.34 | -1.13 | | | | | 4 | 564.46 | 0.58 | 0.07 |
| 6 | 13.43 | -1.09 | | + | | | 5 | 564.81 | 0.94 | 0.06 |
| 7 | 10.76 | | | | + | | 7 | 564.94 | 1.06 | 0.06 |
| 8 | 12.34 | -1.10 | | | | -1.15 | 5 | 565.02 | 1.14 | 0.05 |
| 9 | 13.27 | | | + | | -0.93 | 5 | 565.29 | 1.41 | 0.05 |
| 10 | 12.15 | -0.94 | | + | + | | 9 | 565.31 | 1.43 | 0.05 |
| **$TT_4/TT_3$ ~ ΣPFCAs** | | | | | | | | | | |
| **1** | **12.34** | | | | | | **3** | **563.88** | **0.00** | **0.10** |
| 2 | 11.99 | | | + | + | | 8 | 564.03 | 0.16 | 0.09 |
| 3 | 13.46 | | | + | | | 4 | 564.09 | 0.21 | 0.09 |
| 4 | 12.34 | -1.13 | | | | | 4 | 564.46 | 0.58 | 0.07 |
| 5 | 12.34 | | | | | -1.06 | 4 | 564.66 | 0.78 | 0.06 |
| 6 | 13.43 | -1.09 | | + | | | 5 | 564.81 | 0.94 | 0.06 |
| 7 | 10.76 | | | | + | | 7 | 564.94 | 1.06 | 0.06 |
| 8 | 12.15 | -0.94 | | + | + | | 9 | 565.31 | 1.43 | 0.05 |
| 9 | 12.34 | -1.11 | | | | -1.04 | 5 | 565.33 | 1.45 | 0.05 |
| 10 | 13.34 | | | + | | -0.89 | 5 | 565.36 | 1.48 | 0.05 |
| 11 | 12.12 | | | + | + | -0.84 | 9 | 565.63 | 1.75 | 0.04 |
| **$TT_4/TT_3$ ~ ΣPFSA/ΣPFAS** | | | | | | | | | | |
| **1** | **12.34** | | | | | | **3** | **563.88** | **0.00** | **0.09** |
| 2 | 11.99 | | | + | + | | 8 | 564.03 | 0.16 | 0.09 |
| 3 | 13.46 | | | + | | | 4 | 564.09 | 0.21 | 0.08 |
| 4 | 12.34 | -1.13 | | | | | 4 | 564.46 | 0.58 | 0.07 |
| 5 | 13.43 | -1.09 | | + | | | 5 | 564.81 | 0.94 | 0.06 |

**Table F5 Continued:** The relative evidence for candidate linear-mixed effect models (*i*) explaining the variation in total $T_4$/total $T_3$ ($TT_4/TT_3$) ratio in blood plasma of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015-2019. Predictor variables include a contaminant group (ΣPFSAs, ΣPFCAs, ΣPFSA/ΣPFAS, ΣPFAS/ΣOHC, ΣPCB$_2$), each analysed separately, location, sampling year, and sex. Models are ranked on the basis of differences in the second-order Akaike's Information Criterion (ΔAICc) between each model and the model with the lowest AICc value and Aikaike weights ($w_i$). Model complexity is given by the number of parameters (df) in the model. Top five models with lowest ΔAICc or models with ΔAICc < 2 are presented. Model used for inference (shown in bold) were chosen based on the principle of parsimony from models with ΔAICc < 2. Continuous predictor variables are scaled (mean = 0, standard deviation = 1).

| *i* | **Intercept** | **BCI** | **Location** | **Sex** | **Year** | **Contaminant group** | **df** | **AICc** | **ΔAICc** | $w_i$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 10.76 | | | | + | | 7 | 564.94 | 1.06 | 0.05 |
| 7 | 12.34 | | | | | -0.90 | 4 | 565.07 | 1.19 | 0.05 |
| 8 | 12.15 | -0.94 | | + | + | | 9 | 565.31 | 1.43 | 0.05 |
| 9 | 12.34 | -1.12 | | | | -0.88 | 5 | 565.72 | 1.85 | 0.04 |
| **$TT_4/TT_3$ ~ ΣPFAS/ΣOHC** | | | | | | | | | | |
| **1** | **12.37** | | | | | | **3** | **557.81** | **0.00** | **0.10** |
| 2 | 13.55 | | | + | | | 4 | 557.93 | 0.12 | 0.09 |
| 3 | 12.16 | | | + | + | | 8 | 558.14 | 0.33 | 0.08 |
| 4 | 12.37 | -1.15 | | | | | 4 | 558.37 | 0.57 | 0.07 |
| 5 | 13.52 | -1.11 | | + | | | 5 | 558.62 | 0.81 | 0.07 |
| 6 | 12.37 | | | | | -0.88 | 4 | 559.05 | 1.25 | 0.05 |
| 7 | 10.82 | | | | + | | 7 | 559.07 | 1.26 | 0.05 |
| 8 | 12.48 | | | + | + | -1.11 | 9 | 559.11 | 1.30 | 0.05 |
| 9 | 12.37 | -0.97 | | + | + | | 9 | 559.39 | 1.58 | 0.04 |
| 10 | 13.50 | | | + | | -0.80 | 5 | 559.40 | 1.59 | 0.04 |
| 11 | 11.24 | | | | + | -1.22 | 8 | 559.73 | 1.92 | 0.04 |
| **$TT_4/TT_3$ ~ ΣPCB$_2$** | | | | | | | | | | |
| **1** | **12.37** | | | | | | **3** | **557.81** | **0.00** | **0.10** |
| 2 | 13.55 | | | + | | | 4 | 557.93 | 0.12 | 0.09 |
| 3 | 12.16 | | | + | + | | 8 | 558.14 | 0.33 | 0.08 |
| 4 | 12.37 | -1.15 | | | | | 4 | 558.37 | 0.57 | 0.07 |
| 5 | 13.52 | -1.11 | | + | | | 5 | 558.62 | 0.81 | 0.07 |
| 6 | 10.82 | | | | + | | 7 | 559.07 | 1.26 | 0.05 |
| 7 | 12.37 | -0.97 | | + | + | | 9 | 559.39 | 1.58 | 0.04 |
| 8 | 12.37 | | | | | -0.64 | 4 | 559.51 | 1.71 | 0.04 |
| 9 | 12.37 | -1.34 | | | | -0.92 | 5 | 559.63 | 1.82 | 0.04 |
| 10 | 13.52 | | | + | | -0.58 | 5 | 559.78 | 1.98 | 0.04 |

**Table F6:** The relative evidence for candidate linear-mixed effect models (*i*) explaining the variation in free $T_4$/free $T_3$ ($FT_4/FT_3$) ratio in blood plasma of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015-2019. Predictor variables include a contaminant group (ΣPFCAs, ΣPFSA/ΣPFAS, ΣPFAS/ΣOHC, $\Sigma PCB_2$, ΣOCP), each analysed separately, location, sampling year, sex, and plasma lipid weight percentage (lipid). Models are ranked on the basis of differences in the second-order Akaike's Information Criterion (ΔAICc) between each model and the model with the lowest AICc value and Aikaike weights ($w_i$). Model complexity is given by the number of parameters (df) in the model. Top five models with lowest ΔAICc or models with ΔAICc < 2 are presented. Model used for inference (shown in bold) were chosen based on the principle of parsimony from models with ΔAICc < 2. Continuous predictor variables are scaled (mean = 0, standard deviation = 1).

| *i* | Intercept | BCI | Lipid | Location | Sex | Year | Contaminant group | df | AICc | ΔAICc | $w_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **$FT_4/FT_3$ ~ ΣPFCAs** | | | | | | | | | | | |
| 1 | 1.91 | -0.16 | 0.12 | | + | + | | 10 | 265.97 | 0.00 | 0.17 |
| 2 | 1.87 | -0.13 | | | + | + | | 9 | 266.74 | 0.77 | 0.12 |
| 3 | 1.80 | -0.09 | | | + | | | 5 | 267.50 | 1.53 | 0.08 |
| **4** | **1.80** | | | | **+** | | | **4** | **267.83** | **1.86** | **0.07** |
| 5 | 1.93 | -0.16 | 0.12 | | + | + | -0.05 | 11 | 267.96 | 1.99 | 0.06 |
| **$FT_4/FT_3$ ~ ΣPFSA/ΣPFAS** | | | | | | | | | | | |
| 1 | 1.91 | -0.16 | 0.12 | | + | + | | 10 | 265.97 | 0.00 | 0.17 |
| 2 | 1.87 | -0.13 | | | + | + | | 9 | 266.74 | 0.77 | 0.11 |
| 3 | 1.80 | -0.09 | | | + | | | 5 | 267.50 | 1.53 | 0.08 |
| **4** | **1.80** | | | | **+** | | | **4** | **267.83** | **1.86** | **0.07** |
| 5 | 1.89 | -0.15 | 0.12 | + | + | + | | 11 | 268.25 | 2.28 | 0.05 |
| **$FT_4/FT_3$ ~ ΣPFAS/ΣOHC** | | | | | | | | | | | |
| 1 | 1.91 | -0.16 | 0.12 | | + | + | | 10 | 265.97 | 0.00 | 0.14 |
| 2 | 1.87 | -0.13 | | | + | + | | 9 | 266.74 | 0.77 | 0.10 |
| 3 | 1.80 | -0.09 | | | + | | | 5 | 267.50 | 1.53 | 0.07 |
| 4 | 1.93 | -0.15 | 0.11 | | + | + | -0.06 | 11 | 267.65 | 1.68 | 0.06 |
| **5** | **1.80** | | | | **+** | | | **4** | **267.83** | **1.86** | **0.06** |
| **$FT_4/FT_3$ ~ $\Sigma PCB_{10}$** | | | | | | | | | | | |
| 1 | 1.91 | -0.16 | 0.12 | | + | + | | 10 | 265.97 | 0.00 | 0.16 |
| 2 | 1.87 | -0.13 | | | + | + | | 9 | 266.74 | 0.77 | 0.11 |
| 3 | 1.80 | -0.09 | | | + | | | 5 | 267.50 | 1.53 | 0.08 |
| **4** | **1.80** | | | | **+** | | | **4** | **267.83** | **1.86** | **0.06** |
| 5 | 1.89 | -0.15 | 0.12 | + | + | + | | 11 | 268.25 | 2.28 | 0.05 |
| **$FT_4/FT_3$ ~ ΣOCPs** | | | | | | | | | | | |
| 1 | 1.91 | -0.16 | 0.12 | | + | + | | 10 | 265.97 | 0.00 | 0.15 |
| 2 | 1.87 | -0.13 | | | + | + | | 9 | 266.74 | 0.77 | 0.10 |
| 3 | 1.80 | -0.09 | | | + | | | 5 | 267.50 | 1.53 | 0.07 |
| **4** | **1.80** | | | | **+** | | | **4** | **267.83** | **1.86** | **0.06** |
| 5 | 1.92 | -0.15 | 0.11 | | + | + | 0.03 | 11 | 268.14 | 2.17 | 0.05 |

**Table F7:** The relative evidence for candidate linear-mixed effect models (*i*) explaining the variation in total $T_4$/free $T_4$ ($TT_4/FT_4$) ratio in blood plasma of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015-2019. Predictor variables include a contaminant group (ΣPFCAs, ΣPFSA/ΣPFAS, ΣPFAS/ΣOHC, $\Sigma PCB_2$, $\Sigma PCB_{10}$, ΣOCP), each analysed separately, location, sampling year, and sex. Models are ranked on the basis of differences in the second-order Akaike's Information Criterion (ΔAICc) between each model and the model with the lowest AICc value and Aikaike weights ($w_i$). Model complexity is given by the number of parameters (df) in the model. Top five models with lowest ΔAICc or models with ΔAICc < 2 are presented. Model used for inference (shown in bold) were chosen based on the principle of parsimony from models with ΔAICc < 2. Continuous predictor variables are scaled (mean = 0, standard deviation = 1).

| *i* | **Intercept** | **BCI** | **Location** | **Sex** | **Year** | **Contaminant group** | **df** | **AICc** | **ΔAICc** | $w_i$ |
|---|---|---|---|---|---|---|---|---|---|---|
| **$TT_4/FT_4$ ~ ΣPFCAs** | | | | | | | | | | |
| **1** | **3896.44** | **648.18** | | | | | **4** | **1443.94** | **0.00** | **0.25** |
| 2 | 4272.31 | 654.02 | + | | | | 5 | 1444.81 | 0.87 | 0.16 |
| 3 | 4214.29 | 501.51 | | | + | | 8 | 1445.82 | 1.88 | 0.10 |
| 4 | 3893.57 | 647.83 | | | | -32.48 | 5 | 1446.21 | 2.27 | 0.08 |
| 5 | 3867.47 | 647.87 | | + | | | 5 | 1446.21 | 2.28 | 0.08 |
| **$TT_4/FT_4$ ~ ΣPFSA/ΣPFAS** | | | | | | | | | | |
| **1** | **3896.44** | **648.18** | | | | | **4** | **1443.94** | **0.00** | **0.23** |
| 2 | 4272.31 | 654.02 | + | | | | 5 | 1444.81 | 0.87 | 0.15 |
| 3 | 4214.29 | 501.51 | | | + | | 8 | 1445.82 | 1.88 | 0.09 |
| 4 | 3902.06 | 654.21 | | | | 119.41 | 5 | 1446.06 | 2.13 | 0.08 |
| 5 | 3867.47 | 647.87 | | + | | | 5 | 1446.21 | 2.28 | 0.07 |
| **$TT_4/FT_4$ ~ ΣPFAS/ΣOHC** | | | | | | | | | | |
| **1** | **3911.95** | **648.98** | | | | | **4** | **1426.29** | **0.00** | **0.24** |
| 2 | 4276.93 | 656.13 | + | | | | 5 | 1427.24 | 0.96 | 0.15 |
| 3 | 3923.78 | 597.38 | | | | 210.72 | 5 | 1428.06 | 1.78 | 0.10 |
| 4 | 4296.49 | 494.46 | | | + | | 8 | 1428.14 | 1.85 | 0.09 |
| 5 | 3892.27 | 648.83 | | + | | | 5 | 1428.57 | 2.29 | 0.08 |
| **$TT_4/FT_4$ ~ $\Sigma PCB_2$** | | | | | | | | | | |
| **1** | **3911.95** | **648.98** | | | | | **4** | **1426.29** | **0.00** | **0.23** |
| 2 | 4276.93 | 656.13 | + | | | | 5 | 1427.24 | 0.96 | 0.14 |
| 3 | 4296.49 | 494.46 | | | + | | 8 | 1428.14 | 1.85 | 0.09 |
| 4 | 3892.27 | 648.83 | | + | | | 5 | 1428.57 | 2.29 | 0.07 |
| 5 | 3912.14 | 649.67 | | | | 4.28 | 5 | 1428.57 | 2.29 | 0.07 |
| **$TT_4/FT_4$ ~ $\Sigma PCB_{10}$** | | | | | | | | | | |
| **1** | **3911.95** | **648.98** | | | | | **4** | **1426.29** | **0.00** | **0.17** |
| 2 | 4276.93 | 656.13 | + | | | | 5 | 1427.24 | 0.96 | 0.11 |
| 3 | 4427.64 | 488.10 | + | | | -473.83 | 6 | 1427.54 | 1.26 | 0.09 |

**Table F7 Continued:** The relative evidence for candidate linear-mixed effect models (*i*) explaining the variation in total $T_4$/free $T_4$ ($TT_4/FT_4$) ratio in blood plasma of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015-2019. Predictor variables include a contaminant group (ΣPFCAs, ΣPFSA/ΣPFAS, ΣPFAS/ΣOHC, $\Sigma PCB_2$, $\Sigma PCB_{10}$, ΣOCP), each analysed separately, location, sampling year, and sex. Models are ranked on the basis of differences in the second-order Akaike's Information Criterion (ΔAICc) between each model and the model with the lowest AICc value and Aikaike weights ($w_i$). Model complexity is given by the number of parameters (df) in the model. Top five models with lowest ΔAICc or models with ΔAICc < 2 are presented. Model used for inference (shown in bold) were chosen based on the principle of parsimony from models with ΔAICc < 2. Continuous predictor variables are scaled (mean = 0, standard deviation = 1).

| *i* | Intercept | BCI | Location | Sex | Year | Contaminant group | df | AICc | ΔAICc | $w_i$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 3889.44 | 555.59 | | | | -249.31 | 5 | 1427.89 | 1.60 | 0.08 |
| 5 | 4296.49 | 494.46 | | | + | | 8 | 1428.14 | 1.85 | 0.07 |
| **$TT_4/FT_4$ ~ ΣOCPs** | | | | | | | | | | |
| **1** | **3911.95** | **648.98** | | | | | **4** | **1426.29** | **0.00** | **0.21** |
| 2 | 4276.93 | 656.13 | + | | | | 5 | 1427.24 | 0.96 | 0.13 |
| 3 | 4296.49 | 494.46 | | | + | | 8 | 1428.14 | 1.85 | 0.08 |
| 4 | 3907.46 | 633.39 | | | | -40.14 | 5 | 1428.56 | 2.27 | 0.07 |
| 5 | 3892.27 | 648.83 | | + | | | 5 | 1428.57 | 2.29 | 0.07 |

**Table F8:** The relative evidence for candidate linear-mixed effect models (*i*) explaining the variation in total $T_3$/free $T_3$ ($TT_3/FT_3$) ratio in blood plasma of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015-2019 Predictor variables include a contaminant group (ΣPFSAs, ΣPFCAs, ΣPFSA/ΣPFAS), each analysed separately, location, sampling year, sex, and plasma lipid weight percentage (lipid). Models are ranked on the basis of differences in the second-order Akaike's Information Criterion (ΔAICc) between each model and the model with the lowest AICc value and Aikaike weights ($w_i$). Model complexity is given by the number of parameters (df) in the model. Top five models with lowest ΔAICc or models with ΔAICc < 2 are presented. Model used for inference (shown in bold) were chosen based on the principle of parsimony from models with ΔAICc < 2. Continuous predictor variables are scaled (mean = 0, standard deviation = 1).

| *i* | **Intercept** | **BCI** | **Lipid** | **Location** | **Sex** | **Year** | **Contaminant group** | **df** | **AICc** | **ΔAICc** | $w_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **$TT_3/FT_3$ ~ ΣPFSAs** | | | | | | | | | | | |
| 1 | 426.53 | | | + | | | | 4 | 1567.17 | 0.00 | 0.07 |
| 2 | 439.80 | | | + | + | | | 5 | 1567.49 | 0.32 | 0.06 |
| **3** | **412.00** | | | | | | | **3** | **1567.58** | **0.42** | **0.06** |
| 4 | 424.11 | | 16.19 | | | + | | 8 | 1568.15 | 0.98 | 0.04 |
| 5 | 425.31 | 9.00 | | + | | | | 5 | 1568.36 | 1.19 | 0.04 |
| 6 | 411.97 | 10.44 | | | | | | 4 | 1568.41 | 1.24 | 0.04 |
| 7 | 420.06 | | | | | + | | 7 | 1568.45 | 1.28 | 0.04 |
| 8 | 437.09 | | 16.57 | | + | + | | 9 | 1568.51 | 1.34 | 0.04 |
| 9 | 421.37 | | | | + | | | 4 | 1568.54 | 1.37 | 0.03 |
| 10 | 445.66 | | 17.24 | + | + | + | | 10 | 1568.68 | 1.51 | 0.03 |
| 11 | 438.40 | 8.92 | | + | + | | | 6 | 1568.71 | 1.54 | 0.03 |
| 12 | 426.05 | | 6.84 | + | | | | 5 | 1568.83 | 1.66 | 0.03 |
| 13 | 429.80 | | 16.72 | + | | + | | 9 | 1568.87 | 1.70 | 0.03 |
| 14 | 432.53 | | | | + | + | | 8 | 1568.93 | 1.76 | 0.03 |
| 15 | 439.09 | | 7.97 | + | + | | | 6 | 1569.04 | 1.87 | 0.03 |
| **$TT_3/FT_3$ ~ ΣPFCAs** | | | | | | | | | | | |
| 1 | 426.53 | | | + | | | | 4 | 1567.17 | 0.00 | 0.07 |
| 2 | 439.80 | | | + | + | | | 5 | 1567.49 | 0.32 | 0.06 |
| **3** | **412.00** | | | | | | | **3** | **1567.58** | **0.42** | **0.05** |
| 4 | 424.11 | | 16.19 | | | + | | 8 | 1568.15 | 0.98 | 0.04 |
| 5 | 425.31 | 9.00 | | + | | | | 5 | 1568.36 | 1.19 | 0.04 |
| 6 | 411.97 | 10.44 | | | | | | 4 | 1568.41 | 1.24 | 0.04 |
| 7 | 420.06 | | | | | + | | 7 | 1568.45 | 1.28 | 0.03 |
| 8 | 437.09 | | 16.57 | | + | + | | 9 | 1568.51 | 1.34 | 0.03 |
| 9 | 421.37 | | | | + | | | 4 | 1568.54 | 1.37 | 0.03 |
| 10 | 445.66 | | 17.24 | + | + | + | | 10 | 1568.68 | 1.51 | 0.03 |
| 11 | 438.40 | 8.92 | | + | + | | | 6 | 1568.71 | 1.54 | 0.03 |
| 12 | 412.53 | | | | | | 9.12 | 4 | 1568.83 | 1.66 | 0.03 |
| 13 | 426.05 | | 6.84 | + | | | | 5 | 1568.83 | 1.66 | 0.03 |

**Table F8 Continued:** The relative evidence for candidate linear-mixed effect models (*i*) explaining the variation in total $T_3$/free $T_3$ ($TT_3/FT_3$) ratio in blood plasma of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015-2019 Predictor variables include a contaminant group (ΣPFSAs, ΣPFCAs, ΣPFSA/ΣPFAS), each analysed separately, location, sampling year, sex, and plasma lipid weight percentage (lipid). Models are ranked on the basis of differences in the second-order Akaike's Information Criterion (ΔAICc) between each model and the model with the lowest AICc value and Aikaike weights ($w_i$). Model complexity is given by the number of parameters (df) in the model. Top five models with lowest ΔAICc or models with ΔAICc < 2 are presented. Model used for inference (shown in bold) were chosen based on the principle of parsimony from models with ΔAICc < 2. Continuous predictor variables are scaled (mean = 0, standard deviation = 1).

| *i* | Intercept | BCI | Lipid | Location | Sex | Year | Contaminant group | df | AICc | ΔAICc | $w_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 | 429.80 | | 16.72 | + | | + | | 9 | 1568.87 | 1.70 | 0.03 |
| 15 | 432.53 | | | | + | + | | 8 | 1568.93 | 1.76 | 0.03 |
| 16 | 439.09 | | 7.97 | + | + | | | 6 | 1569.04 | 1.87 | 0.03 |
| 17 | 424.80 | | | | + | | 12.45 | 5 | 1569.10 | 1.94 | 0.02 |
| **$TT_3/FT_3$ ~ ΣPFSA/ΣPFAS** | | | | | | | | | | | |
| 1 | 426.53 | | | + | | | | 4 | 1567.17 | 0.00 | 0.06 |
| 2 | 439.80 | | | + | + | | | 5 | 1567.49 | 0.32 | 0.05 |
| **3** | **412.00** | | | | | | | **3** | **1567.58** | **0.42** | **0.05** |
| 4 | 424.11 | | 16.19 | | | + | | 8 | 1568.15 | 0.98 | 0.04 |
| 5 | 425.31 | 9.00 | | + | | | | 5 | 1568.36 | 1.19 | 0.03 |
| 6 | 411.97 | 10.44 | | | | | | 4 | 1568.41 | 1.24 | 0.03 |
| 7 | 420.06 | | | | | + | | 7 | 1568.45 | 1.28 | 0.03 |
| 8 | 437.09 | | 16.57 | | + | + | | 9 | 1568.51 | 1.34 | 0.03 |
| 9 | 421.37 | | | | + | | | 4 | 1568.54 | 1.37 | 0.03 |
| 10 | 445.66 | | 17.24 | + | + | + | | 10 | 1568.68 | 1.51 | 0.03 |
| 11 | 438.40 | 8.92 | | + | + | | | 6 | 1568.71 | 1.54 | 0.03 |
| 12 | 426.05 | | 6.84 | + | | | | 5 | 1568.83 | 1.66 | 0.03 |
| 13 | 429.80 | | 16.72 | + | | + | | 9 | 1568.87 | 1.70 | 0.03 |
| 14 | 432.53 | | | | + | + | | 8 | 1568.93 | 1.76 | 0.02 |
| 15 | 472.23 | | | + | | | -68.98 | 5 | 1569.02 | 1.85 | 0.02 |
| 16 | 439.09 | | 7.97 | + | + | | | 6 | 1569.04 | 1.87 | 0.02 |

# APPENDIX G: Parameter estimates

**Table G1:** Parameter estimates and 95% confidence intervals (CIs) from selected linear mixed-effect models (LMMs) relating thyroid hormone (TH) concentrations ($TT_3$ (nmol/L), $FT_3$ (pmol/L)) and ratios ($FT_4/FT_3$, $TT_4/FT_4$) to organohalogenated contaminant (OHC) concentrations (nmol/L) and ratios in blood plasma of glaucous gulls (*Larus hyperboreus*) breeding on Bjørnøya and in Kongsfjorden, Svalbard, 2015 – 2019. The selected LMMs did not show any effect of the specific contaminant group on the TH levels. Predictor variables include sampling year, sex, body condition index (BCI), and/or plasma lipid weight percentage (lipid). Headings indicate which TH and contaminant group that was investigated in the specific model. All parsimonious LMMs testing the effect of contaminant groups on $FT_4/FT_3$ and $TT_4/FT_4$ ratios revealed the same results, indicated by "PFASs and OCs", and estimates from one LMM for each TH ratio were used as a representative. Continuous predictor variables were scaled (mean = 0, standard deviation = 1). Estimates of the random effects (individual and residual) are presented as standard deviations (SD).

| | **$TT_3$ ~ $\Sigma PCB_2$** | | **$FT_3$ ~ $\Sigma PFSA/\Sigma PFAS$** | | **$FT_4/FT_3$ ~ PFASs and OCs** | |
|---|---|---|---|---|---|---|
| | Estimate | CI | Estimate | CI | Estimate | CI |
| Intercept | 4.22 | 3.62 – 4.82 | 9.49 | 7.68 – 11.30 | 1.80 | 1.61 – 1.99 |
| Year 2016 | -0.97 | -1.67 – -0.27 | -2.03 | -4.08 – 0.00 | | |
| Year 2017 | 0.66 | -0.28 – 1.59 | 2.34 | -0.33 – 5.00 | | |
| Year 2018 | -0.50 | -1.40 – 0.39 | 0.06 | -2.51 – 2.62 | | |
| Year 2019 | -0.61 | -1.45 – 0.23 | 0.39 | -2.01 – 2.78 | | |
| Sex Male | 0.64 | 0.11 – 1.16 | 2.41 | 0.94 – 3.88 | -0.61 | -0.90 – -0.33 |
| Lipid | 0.52 | 0.21 – 1.16 | 1.04 | 0.21 – 1.87 | | |
| $SD_{Individual}$ | 0.33 | 0.00 – 0.97 | 0.66 | 0.00 – 2.64 | 0.54 | 0.37 – 0.68 |
| $SD_{Residual}$ | 1.52 | 1.21 – 1.71 | 4.16 | 3.26 – 4.65 | 0.48 | 0.39 – 0.60 |
| | **$TT_4/FT_4$ ~ PFASs and OCs** | | | | | |
| | Estimate | CI | | | | |
| Intercept | 3.90 | 3.24 – 4.56 | | | | |
| BCI | 0.65 | 0.16 – 1.14 | | | | |
| $SD_{Individual}$ | 2.22 | 1.04 – 2.87 | | | | |
| $SD_{Residual}$ | 1.44 | 1.03 – 2.28 | | | | |