Comparison of contaminant levels in liver/fillet of large flounder (*P. flesus)* and those in smaller whole-flounder

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Comparison of contaminant levels in liver/fillet of large flounder (*P. flesus*) and those in smaller whole-flounder

Vergelijking tussen contaminantgehalten in lever/filet van grote bot (*P. flesus*) en die in kleine, hele bot

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Contents

List of Abbreviations

BAC	Background Assessment Concentrations
BDE	Brominated diphenyl ether
Cd	Cadmium
CF	Conversion factor
Cu	Copper
E	Eems-Dollard
EAC	Environmental Assessment Criteria
EC	EC maximum concentrations in foodstuffs to protect public health values
FEQG	Federal Environmental Quality Guidelines
HBCD	Hexabromocyclododecane
HCB	Hexachloro benzene
HCBD	Hexachloro butadiene
Hg	Mercury
N	Noordzeekust
OCP	Organochlorine pesticides
OSPAR	Oslo and Paris Conventions
PBDE	Polybrominated diphenyl ether
PCB	Polychlorinated biphenyls
PFAS	Perfluoroalkylated substances
PFOS	Perfluorooctanesulfonic acid
Pb	Lead
RWS	Rijkswaterstaat
W	Westerschelde
WFD	Water Framework Directive
Zn	Zinc

Executive summary

Background:
In the Netherlands, a whole suite of prioritized organic and inorganic compounds is screened in the flatfish species flounder (*P. flesus*) on three locations in Dutch coastal and estuaries, commissioned by Rijkswaterstaat (RWS). For this, tissue (liver and fillet, the latter only for mercury) and whole-fish samples of flounder are simultaneously collected and analysed under two different directives, Oslo and Paris Conventions (OSPAR) and Water Framework Directive (WFD), respectively. RWS raised the question whether concentrations of contaminants in the whole body are correlated with the concentrations detected in the tissue samples (liver, fillet), and if so, whether concentrations in tissue samples can be predicted based on data from the whole-body samples.

Study goal:
The goal of the present study was to monitor how contaminant concentrations in tissue (liver or fillet) and whole fish are interrelated and if predictive conversion factors (CFs) from whole fish concentrations to the liver and fillet concentrations can be established (Part 1) and whether the contaminant concentrations of only whole-fish samples would be sufficient to predict concentration levels in tissues found in the flounder by applying CFs (Part 2).

Results and discussion:
This report presents the results of screening for similarities and differences between levels of contaminants (organic compounds such as PCBs, PBDEs, PFOS, OCPs and the metals mercury, lead, zinc, copper and cadmium) in liver/fillet samples of flounder for OSPAR (females, body size 15-30 cm), and those in whole-fish samples of flounder for WFD (non-sexed, body size 15-20 cm), sampled at the same three location (Noordzeekust, Westerschelde and Eems-Dollard) and same time (in 2017, 2018, and 2019).

The similarities and differences of average chemical concentrations detected in tissue or whole-fish samples per location were first analysed. Since PCBs (polychlorinated biphenyls) are stored preferably in lipids, the whole body/tissue concentrations, when expressed in wet weight, mirrors the differences in the distribution of lipids in these two matrices. The effect of data normalization on lipid weight is evident, the average concentrations become comparable between tissue (liver) and whole-body burden for PCBs. Though limited data was available due to very low concentrations, the same effects were observed for two BDEs (brominated diphenyl ether, brominated flame retardants) within the two matrices. For metals, the differences between concentrations in tissue/whole fish differ for each metal. The normalization on dry weight mainly increases the concentration levels. Similar to metals, the dry weight normalization did not affect the level of differences between liver and whole-fish samples for PFOS (Perfluorooctanesulfonic acid).

We then calculated the whole body/tissue concentration ratios for each contaminant, location and year based on average concentrations to better understand the effect of data normalization and derive possible conversion factors. As the behaviour of all PCB congeners was similar on lipid weight, a ratio between PCB concentrations in whole-body samples and PCB concentrations in liver tissue of almost one was observed in all locations (1.02). The margin of observed variability for this ratio is comparable for the wet weight and lipid weight results. The studied BDEs (with concentrations above quantification

limits) act similarly to PCBs. For BDE100, however, with concentrations very close to quantification limits, the ratios are showing high variability.

For metals, as the distribution over body parts is different for the metals studied, the ratios of whole fish/liver (or fillet in case of mercury) are calculated individually. Though a large variation of ratios determined over the years and across the sampling locations was observed, there is consistency in the ratio for each metal.

This approach was tested by comparing predicted concentrations, based on conversion factors, with the measured concentrations in fish tissue samples. This showed that the conversion factor can be applied, but differences between the predicted concentrations and the measured concentration were observed, with a margin up to a factor 3. The causes for these differences were briefly investigated and lipid content was shown as an important confounding parameter.

Conclusions:
The study goal was to examine whether concentrations of contaminants in the whole body of small flounder, monitored for WFD can be used to predict concentrations of these contaminants in the tissue samples (liver and fillet) of larger flounder, monitored for OSPAR. In general, the concentration of contaminants in whole body were correlated with the levels in the tissue samples. Whole body/tissue concentration ratios could be calculated, which, in turn, created the baseline for predictive conversion factors from whole-body/tissue (liver and fillet). These factors can be applied to estimate the liver/fillet concentrations based on the whole-body burden of chemicals. Such a quantitative relationship could not be drawn for all chemicals that need to be screened under the umbrella of the two directives, OSPAR and WFD, as the concentrations of some contaminants were sometimes too low to quantify.

This report does not yet justify the replacement of analysis of tissue samples with whole-body samples.

Uitgebreide samenvatting

Achtergrond:
In Nederland wordt een breed scala aan contaminanten, zowel organische als anorganische, gemeten in de platvis Bot (*P. flesus*). Dit vindt plaats op drie locaties in de kustzone en estuaria, in opdracht van RWS. Om de gehalten met de normen te vergelijken worden zowel visweefsels (lever en filet, de laatste alleen voor kwik) als de hele-vis monsters tegelijkertijd verzameld en respectievelijk geanalyseerd voor twee verschillende regelingen: Oslo en Parijs conventie (OSPAR) en Kaderrichtlijn Water (KRW).
RWS heeft daarom de vraag gesteld of de gehalten van contaminanten in de hele vis gecorreleerd zijn met de gehalten in de visweefsels (lever en filet), en zo ja, of de gehalten in de weefselmonsters voorspeld kunnen worden uit de gehalten in de hele-vis monsters.

Doel:
Het doel van deze studie was te onderzoeken hoe de gehalten van contaminanten in weefsels (lever, filet) gerelateerd zijn aan de gehalten in de hele vis, én of conversiefactoren van concentraties in hele vis naar concentraties in lever en filet kunnen worden vastgesteld (deel I). Ook werd onderzocht of de analyseresultaten van alleen hele-vis monsters met behulp van die conversiefactoren voldoende zijn om de gehalten in lever en filet te voorspellen (deel II).

Resultaten en discussie:
Dit rapport laat de overeenkomsten en verschillen zien tussen de concentraties van contaminanten (organische contaminanten als PCBs, PBDEs, PFOS en de metalen lood, zink, koper en cadmium) in lever en filet monsters van bot voor het OSPAR-programma; vrouwen, 15-30 cm lengte en de gehalten in hele vis voor de KRW; geslacht onbekend, 15-20 cm lengte. Deze vissen zijn bemonsterd op dezelfde drie locaties (Noordzeekust, Westerschelde en Eems-Dollard) en tijd (in 2017, 2018 en 2019).

De overeenkomsten en verschillen tussen de gemiddelde contaminant concentraties in weefsels en hele-vis monsters zijn eerst geanalyseerd. Omdat PCBs (poly-gechloreerde bifenylen) vooral in vet worden opgeslagen, geeft de verhouding tussen concentratie in hele-vis/ weefsel, wanneer uitgedrukt op basis van natgewicht vooral de verschillen in vetgehalten tussen de weefsels aan. Het effect van normalisatie op vetgewicht is duidelijk, de concentraties PCBs werden vergelijkbaar tussen de weefselmonsters (lever) en de hele-vis monsters. Ofschoon er maar weinig data was voor de BDEs (gebromineerde difenylethers, vlamvertragers) vanwege erg lage concentraties, werd hetzelfde effect waargenomen tussen de twee monster-types. Bij metalen zijn de verschillen tussen gehalten in weefsel en hele-vis monsters per metaal anders. Normalisatie op drooggewicht zorgt alleen voor hogere gehalten, de verschillen blijven. Ook bij PFOS (Perfluoroctaan sulfonzuur), werden de verschillen tussen de lever en hele-vis monsters niet anders door normalisatie op drooggewicht.

Hierna zijn de hele-vis/weefsel concentratie ratio's berekend voor elk jaar en elke locatie, gebaseerd op gemiddelde concentraties om het effect van datanormalisatie te zien en om mogelijke conversiefactoren (hele-vis naar weefsel) te bepalen. Het gedrag van alle PCBs, uitgedrukt op vetgewicht, is sterk vergelijkbaar; tussen de concentraties PCBs in hele-vis monsters en lever monsters is een ratio van 1 (gemiddeld 1.02) op alle locaties geconstateerd. De mate van variabiliteit van deze ratio is vergelijkbaar, zowel voor de natgewicht als vetgewicht data. De twee BDEs met gehalten boven de bepalingsgrens

vertonen hetzelfde gedrag als de PCBs. De variabiliteit van de ratio's van BDE 100 was echter erg groot, de gemeten gehalten lagen erg dicht bij de bepalingsgrens.
Bij de metalen is de verdeling over weefsels van de vis sterk verschillend per metaal. De ratio's hele-vis/lever (voor kwik hele-vis/filet) zijn daarom voor elk metaal apart berekend. Er is een grote variatie in de ratio's geconstateerd, over de jaren en over de locaties, toch zijn de ratio's wel specifiek voor elk metaal (gehalten altijd hoger in het ene weefsel dan in de andere).
Deze aanpak is getest door de voorspelde concentraties, gebaseerd op de conversiefactoren, te vergelijken met de gemeten concentraties in weefsels. Het resultaat toonde dat de conversiefactoren toegepast kunnen worden, maar verschillen tussen de voorspelde concentraties en de gemeten concentraties, met een foutenmarge tot een factor 3, zijn geconstateerd. De oorzaken van deze verschillen zijn kort onderzocht en vetgehalten blijken een belangrijke factor.

Conclusies

Het doel van dit project was onderzoeken of de concentraties van contaminanten in hele-vis monsters van kleine bot, gemonitord voor KRW, kunnen worden gebruikt om de gehalten in weefselmonsters (lever of filet) van grotere bot, gemonitord voor OSPAR, te voorspellen. Over het algemeen waren de concentraties van contaminanten in hele-vis monsters gecorreleerd met de concentraties in weefselmonsters. Hele-vis/weefsel concentratie ratio's konden worden berekend, hiermee konden de voorspellende conversiefactoren (CFs) worden berekend. De voorspellende CFs kunnen worden toegepast om de concentraties in lever en filet te schatten uit de concentraties in hele-vis monsters. Deze kwantitatieve relaties konden niet worden berekend voor alle contaminanten die voor OSPAR en KRW gemeten moeten worden, omdat de gehalten van bepaalde contaminanten in sommige gevallen te laag waren om te kwantificeren.
Dit rapport rechtvaardigt niet de vervanging van de analyse van weefselmonsters door de analyse van hele-vis monsters.

1 Introduction

Man-made release and enrichment of chemicals in marine ecosystems is a global phenomenon. Life-time accumulation of even trace levels of chemical pollutants in biota can cause immunosuppression, reduced fertility, and permanent genetic changes, all of which can lead to an increased vulnerability of organisms, populations, and ecosystems[1]. Therefore, biota monitoring is an inevitable approach to regulate the risks posed by aquatic pollution. The ultimate protection goal of regulatory directives applying fish monitoring is to prevent adverse effects posed by aquatic chemical pollution on human and animal health as such, and on the ecosystem health[2-4]. Therefore, bioaccumulation of environmental contaminants in species and biomagnification throughout the food web needs to be carefully monitored[5]. Due to their aquatic habitat, fish species are particularly vulnerable through direct or secondary poisoning. Two main exposure pathways of contaminants are considered in fish species; 1) directly from the water through the gills, and 2) indirectly by feeding on small fish, invertebrates, and/or aquatic vegetation[4, 5]. Humans, in turn, are exposed to contaminants via consumption of some portion of the muscle in fish (= fillet). Generally, lipophilic contaminants pre-dominantly bioaccumulate in metabolic active and fatty tissue such as the liver (*e.g.,* PCBs)[6]. Inorganic compounds preferably accumulate in the liver (*e.g.*, Cd) and/or protein-rich tissues such as fillet (*e.g.*, mercury)[7]. Adverse health effects become apparent if chemical and species-specific toxicity thresholds are exceeded in the specific tissue or whole body[8]. Lipophilic compounds can trigger more specific biological perturbations (*e.g.,* receptor-mediated pathways) than generic toxicity triggered by metals (*e.g.,* cytotoxicity or oxidative stress)[3, 7, 9].

The European flounder, *Platichthys flesus* (Linnaeus 1758), is an ecologically important flatfish species omnipresent in coastal and estuarine waters throughout Western Europe [10]. By occupying the benthic position in the food web, *P.flesus* is an ideal bioindicator species to monitor spatial and temporal trends of chemical pollutants in coastal and estuarine environments, and an early warning species for biomagnification of chemicals throughout the aquatic food web [11]. However, the selection of ideal species and sample matrix for biota monitoring in fish is a widely discussed and controversial topic, which is mirrored in discrepancies in sample strategies and is investigated throughout the world[12]. Hence, long term fish monitoring results are often not comparable due to the use of different species as well as matrices [12].

In the Netherlands, a whole suite of prioritized organic and inorganic compounds is screened in *P. flesus* from three locations in Dutch coastal and estuarine waters, commissioned by Rijkswaterstaat (RWS). Many of the analysed priority compounds are well known to bioaccumulate through the food web. To meet the protection goals, tissue (liver and fillet; only for mercury) and whole-fish samples of *P. flesus* are simultaneously collected under two different directives, Oslo and Paris Conventions (OSPAR) and the Water Framework Directive (WFD), respectively. Due to the non-harmonized sampling strategies within fish monitoring, the biological matrices (tissue samples vs whole body), as well as body weight and body size, differ. These non-harmonized standards result in a time intensive and therefore costly monitoring and non-comparable data sets. In addition, the collection of a large amount of fish hampers the achievement of the common ethical goal of reducing, replacing, or refining (3 R's) of animal use [13].

Therefore, RWS raised the question whether concentrations of contaminants in whole-body samples are correlated with the concentrations detected in the tissue samples (liver, fillet), and if so, whether concentrations in tissue samples can be predicted based on data from the whole-body samples.

2 Materials and Methods

2.1 Sampling

Over three years (2017-2019), the European flounder (*P. flesus*) was sampled annually (period late August, beginning of September at three locations in coastal and estuarine waters in the Netherlands. Figure 2.1 shows the three sampling sites as the focus of investigation: Noordzeekust (N), Westerschelde (W), and Eems-Dollard. OSPAR and the WFD require different sampling strategies, regarding the body size of the animals, the sex (only female vs. not determined), and the sample matrix.

- For OSPAR, a total of 50 female *P. flesus* were caught for each year and sampling site (n=450 in total) with body size ranging from 15-30 cm of length. Per location and year, the liver samples of all animals and fillet samples of 25 animals were screened. The organic compounds were analysed in livers of 25 fish, pooled in 5 samples, each pool consisting of livers from five animals. The inorganic analyses (Cd, Cu, Pb, Zn) were carried out on the livers of the other 25 fish, also pooled in five samples (five animals per pool). In the fillet of the 25 animals analysed for inorganics, mercury (Hg) was analysed by pooling the same five animals per sample.
- For the WFD, another 25 animals of shorter length (15-20 cm) simultaneously caught at the same location as OSPAR each year, were used without examining the sex as whole fish to prepare five samples of five pooled fish.

Figure 2.1 *Locations of the three study sites (Noordzeekust, Westerschelde, and Eems-Dollard) in which* P. flesus *were annually sampled (2017-2019).*

2.2 Statistics

D'Agostino-Pearson test confirmed the normal distribution of data. A two-way ANOVA was run using GraphPad™ (Version 8.2.1; San Diego, CA, USA) for statistical differences. Pearson's correlation coefficient was calculated to understand the impact of variables on the concentration levels measured in fish from different locations. The required level of statistical significance was set at $p < 0.05$. Linear regressions were generated using GraphPad™ (Version 8.2.1; San Diego, CA, USA).

2.3 Analysis

The analysis of the flounder samples for the contaminants requested by OSPAR was performed routinely as described in the report Biomonitoring 2019-Deel II. To compare both sample types, the same analytical methods were used except for PCBs and BDEs. For economic reasons HBCD was not analysed in the whole-fish samples. This enabled the analysis of BDEs together with the PCBs, instead of a separate analysis for PCBs and one for BDEs plus HBCD.

3 Project approach

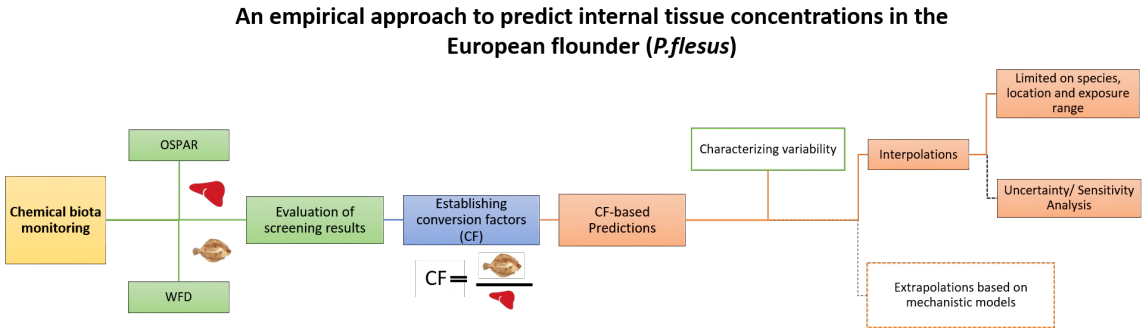


Figure 3.1 *The conceptual framework of the empirical study approach to predict internal tissue concentration in the European flounder (*P. flesus*)*

The goal of the present study was to understand how chemical levels detected in tissue (liver or fillet) and whole fish are interrelated and conversion factors (CF) can be established (Part 1), and whether the analysis of only whole-fish data would be sufficient to predict concentration levels in tissues found in the flounder by applying CF (Part 2).

- Firstly, ('Evaluation of screening results' in Figure 3.1) we compared the average chemical concentrations detected in tissue and whole fish. Organic compounds were compared on wet and lipid weight basis, metals on wet and dry weight basis per location (Chapter 4.1–4.3).
- Secondly, ('Establishing conversion factors' in Figure 3.1) to better understand the effect of data normalization and to derive possible conversion factors, we calculated the whole body/tissue concentration ratios for each location and year based on average concentrations detected. These calculated ratios based on chemical screening, in turn, create the baseline for predictive conversion factors from whole fish to tissue (liver or fillet) (Chapter 4.4).
- Thirdly, in Chapter 5 ('CF-based predictions' in Figure 3.1) we applied the conversion factors to predict concentrations in liver tissue for organic and inorganic chemicals, and in fillet for mercury, to test the goal of the study. Next to this, the variability and uncertainties were briefly addressed (Chapter 5.1).

- Lastly, we finished the report with conclusions (Chapter 6) and focus on how to overcome uncertainties within predictive approaches. We explain the difference between empirical approaches, which allows us to interpolate to exposure scenarios we based our CF factors on, and mechanistic approaches to extrapolate to exposure scenarios outside of concentration ranges the CF factors are based on. We specifically clarify the limitations of our approach.

4 Result and Discussion (Part 1)

The analytical results stated in this report, and the conclusions based on those, only apply to the samples as they have been received and analysed. Raw data of all samples within this project can be found in the Appendix (Chapter 10) Tables I to V.

4.1 Average PCB levels in liver and whole fish

PCBs are omnipresent in our environment, posing a serious health threat to aquatic and humans' life. Although PCBs have been banned in Western countries, their persistent, bioaccumulative and toxic properties cause an everlasting concern. Within chemical monitoring, the non-planar congeners number 28, 52, 101, 138, 153, and 180 are commonly selected as the focus of investigation[3, 9]. Dioxin-like activity through the AhR-mediated pathway has been shown for twelve PCBs, namely the non-ortho CBs number 77, 81, 126, and 169, as well as the mono-ortho CBs number 105, 114, 118, 123, 156, 157, 167 and 189. Generally, an increase in chlorination grade is concomitant with an increase in lipophilicity and, to a lesser extent, toxicity[14]. Generally, different tissues can serve as a surrogate for bioaccumulation of specific contaminants in the body. For example, PCBs are preferably accumulated and stored in body lipids, hence, in fatty tissue such as the liver[16].

The PCBs congeners, detected in all three sample locations over the three consecutive sampling years (2017-2019) are presented. The average of 15 samples (five per year) and the concentrations of 16 PCB compounds (or congeners) in the liver tissue (OSPAR) and whole fish (WFD) for *P. flesus* caught in three different study locations are given in Figure 4.1 on a wet weight basis. Figure 4.2 illustrates the same results on a lipid weight basis. The PCB concentrations are highly different between tissue and whole-body burden if compared on a wet weight basis by showing a large difference in absolute concentrations. Such results are shown in previous studies conducted on the same topic in other species and locations in Europe[2, 8, 12, 15-18]. Since PCBs are stored in lipids the whole body/tissue concentration if given in wet weight represents the differences in the distribution of lipids in these two matrices.

As expected, the effect of data normalization on lipid weight is evident in Figure 4.2, where the average concentrations become comparable between tissue and whole-body burden for PCBs. The levels of small PCBs (low chlorinated, and therefore relatively low molecular weight) in whole fish are similar or even slightly higher than in the liver of *P. flesus*, which corresponds to a chemical equilibrium state. This equilibrium is not expected nor seen for the large PCBs (highly chlorinated, high molecular weight PCBs). The levels of these PCBs are higher in the liver of the larger and older flounder. These first results indicate that the PCBs in the whole small fish normalized on a lipid weight basis can be applied as a predictive mean for levels in the liver in large fish if lipid content is co-screened. Similar observations have been done for selected compounds, however, the present project represents the most comprehensive analysis of such comparison, and can serve as a basis for other studies and directives[12, 15, 16]. Overall, the PCB concentrations will be given in wet weight as well as lipid weight as data normalization makes these values comparable.

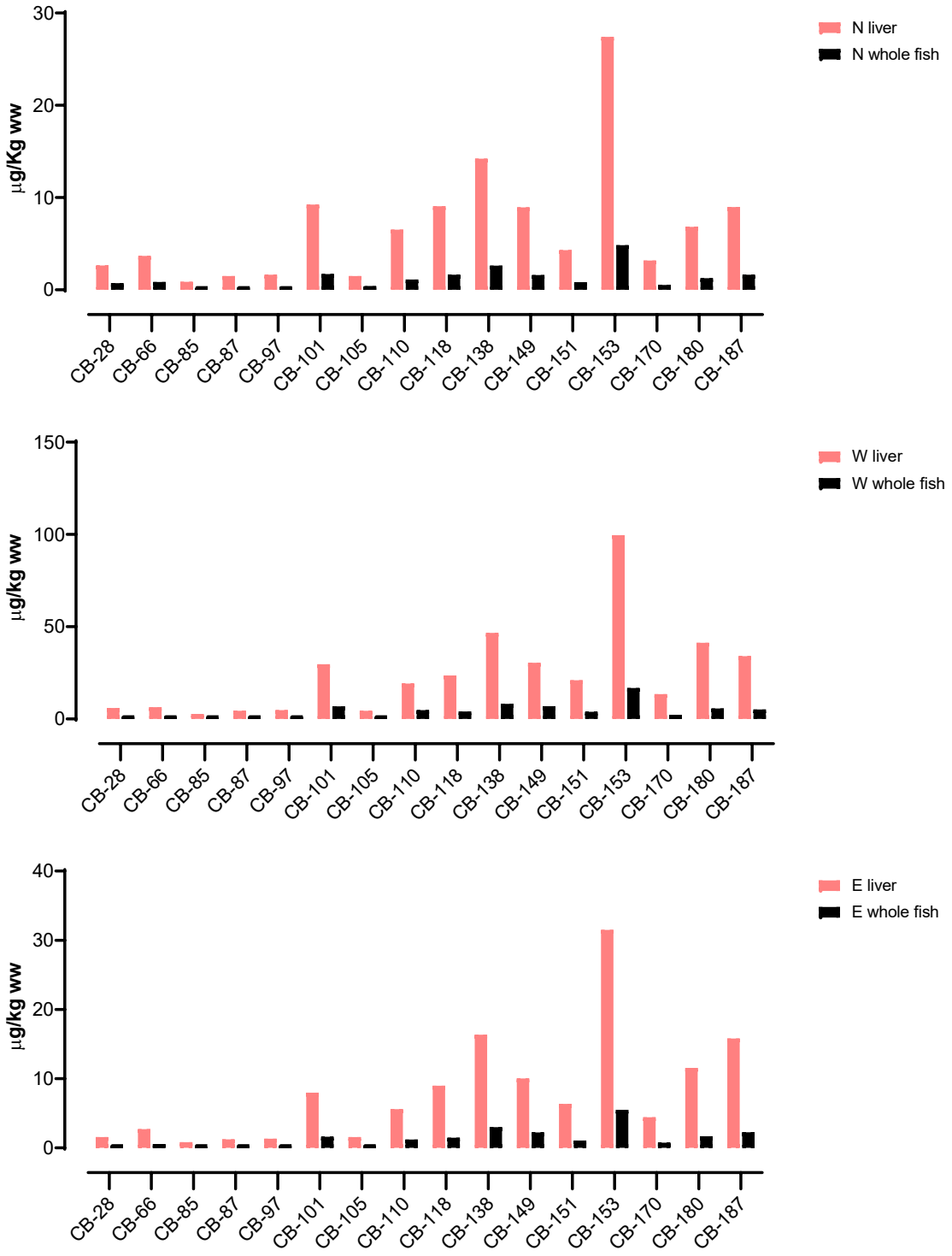


Figure 4.1 *Mean concentrations of PCBs µg/kg wet weight (ww) detected in the liver (red) and whole fish (black) of* P. flesus *sampled annually over three years (2017-2019) at three locations in Dutch waters (Noordzeekust (N), Westerschelde (W), Eems-Dollard (E)).*

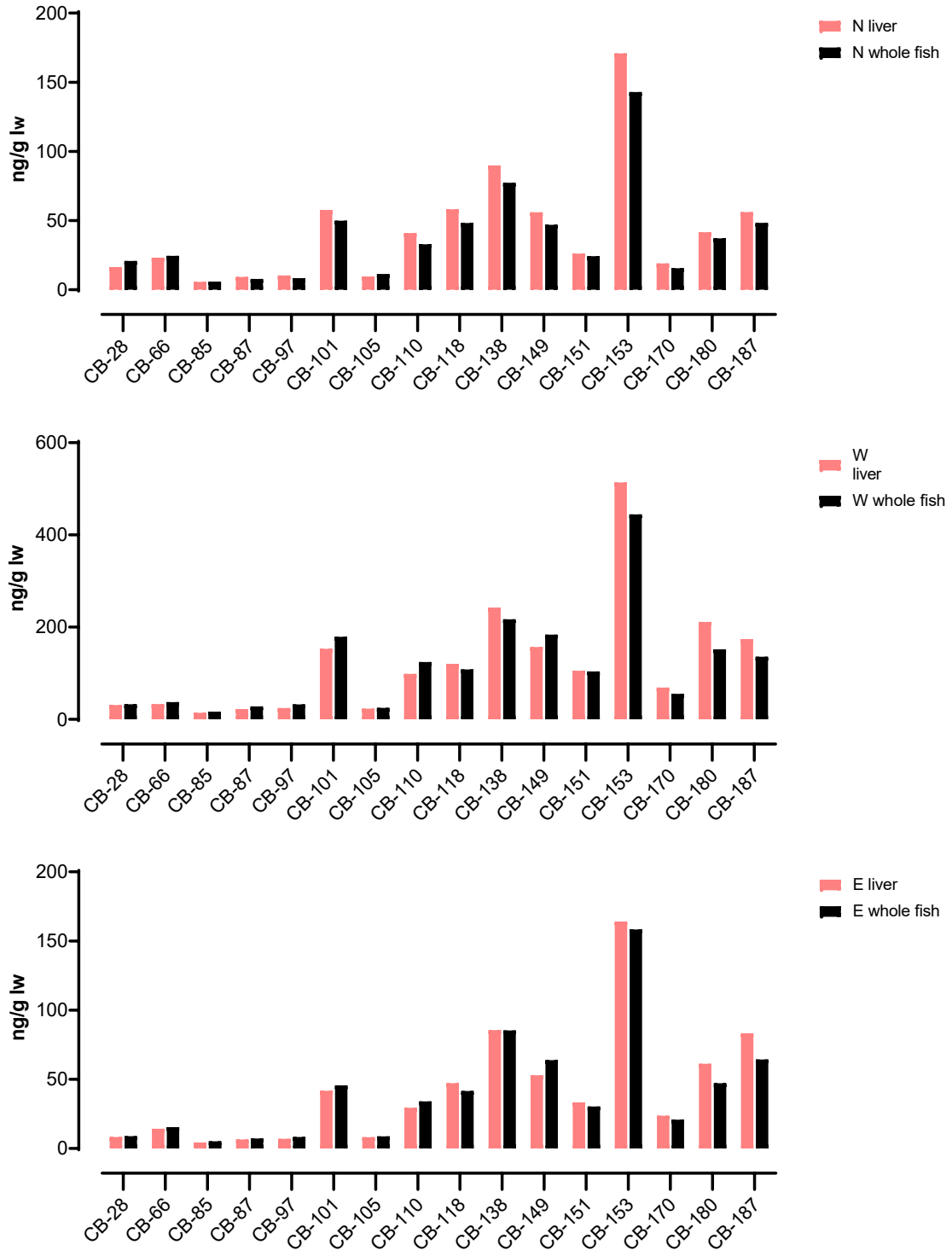


Figure 4.2 *Mean concentrations of PCBs ng/g lipid weight (lw) detected in the liver (red) and whole fish (black) of* P. flesus *sampled annually over three years (2017-2019) at three locations in Dutch waters (Noordzeekust (N), Westerschelde (W), Eems-Dollard (E)).*

4.2 Average non-essential and essential inorganic levels in the liver, filet (only mercury), and whole fish

The chemical properties of the majority of inorganic elements allow that they are readily absorbed by living organisms. Once in the body, they have been found to attach to cellular components, such as enzymes, or structural proteins, and influence their functionality[5]. When the concentrations of these substances reach a toxic threshold, they can trigger responses from the organism, causing adverse health effects[4, 5, 7, 14].

Metallic elements can be divided into those which have an unknown biological function (mercury (Hg), cadmium (Cd), and lead (Pb)), and those compounds with a known biological role (copper (Cu) and zinc (Zn)). Therefore, Hg, Cd, Pb toxicity raises with increasing tissue and body burden[14]. In contrast, Zn and Cu toxicity are triggered either due to increasing concentrations or due to concentration deficiencies[4, 7]. In the case of mercury, fillet samples of *P. flesus* are analysed as a commonly used sample matrix because mercury concentrates within protein-rich tissues carrying functional sulfhydryl group. For Cd, for example, the liver is the first target tissue for accumulation and detoxification via reversible protein binding, and therefore, the tissue of interest[4, 8, 12, 14].

The average of 15 samples (five per year) and the concentrations of three non-essential and two essential metals are given on a wet weight basis and dry weight basis in Figures 4.3-4.4 and 4.5-4.6, respectively. Metal data normalization on dry weight does not have the same effect as that of PCB normalization on lipid weight. The normalization on dry weight mainly increases the concentration levels, and the difference between tissue/whole fish remains high. Since the threshold values of OSPAR are in wet weight, the metal conversion factors and predictions will be given only in wet weight.

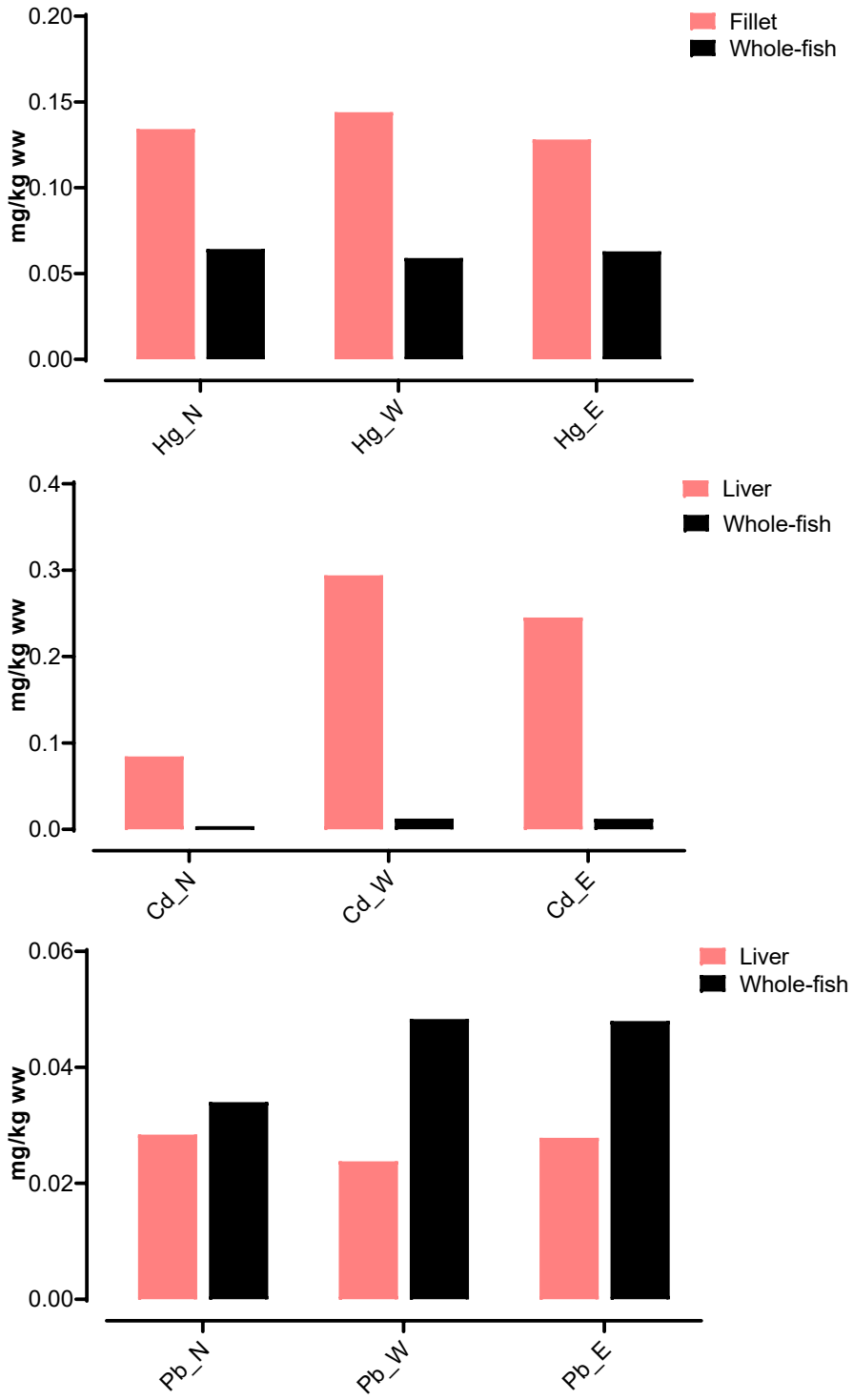


Figure 4.3 *Mean metal concentrations with non-essential mercury (Hg), cadmium (Cd), and lead (Pb) given in wet weight (ww) detected in the liver (red) or fillet (only for mercury) and whole fish (black) of* P. flesus *sampled annually over three years (2017-2019) at three locations in Dutch waters (Noordzeekust (N), Westerschelde (W), Eems-Dollard (E)).*

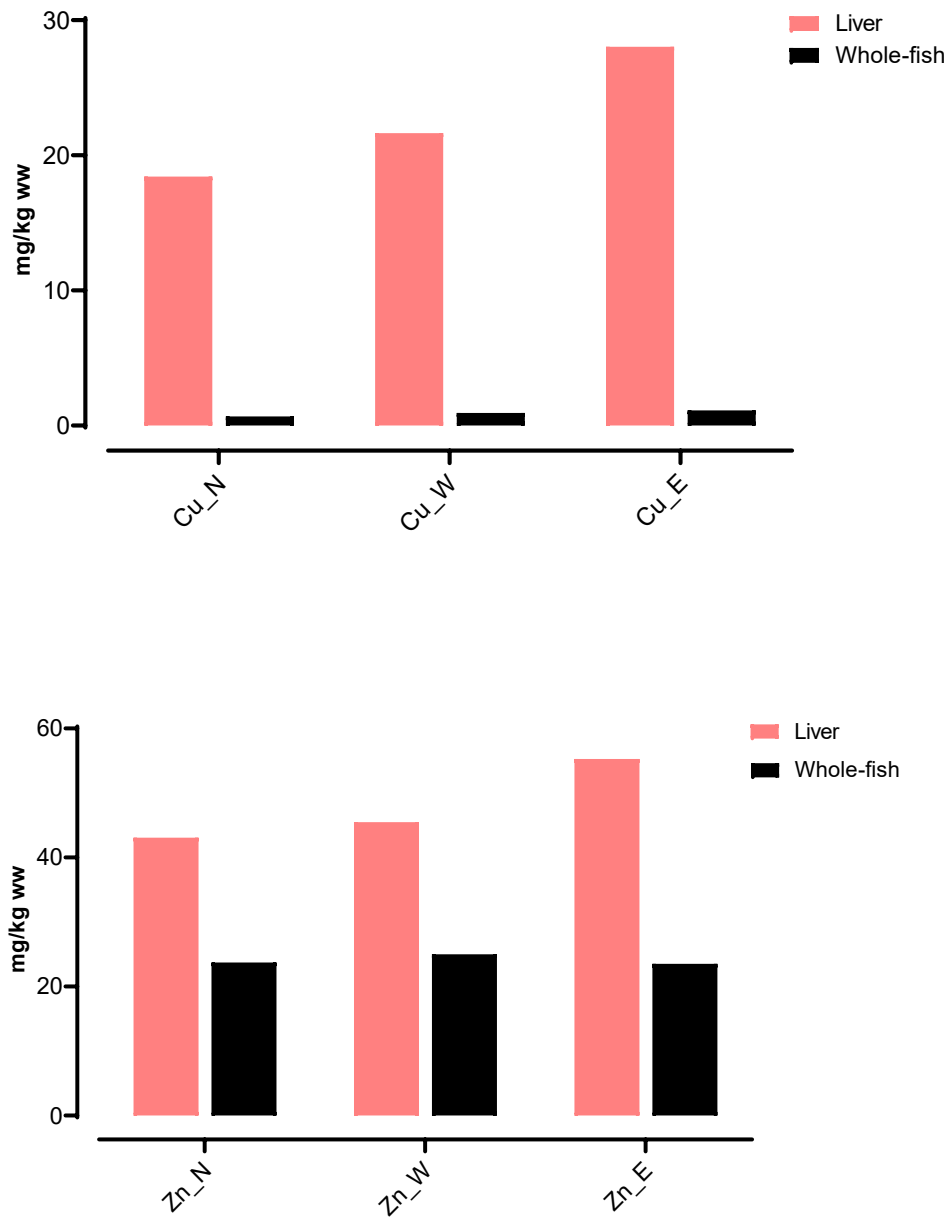


Figure 4.4 *Mean metal concentrations with essential biological function copper (Cu) and zinc (Zn)) given in wet weight (ww) detected in the liver (red) and whole fish (black) of* P. flesus *sampled annually over three years (2017-2019) at three locations in Dutch waters (Noordzeekust (N), Westerschelde (W), Eems-Dollard (E)).*

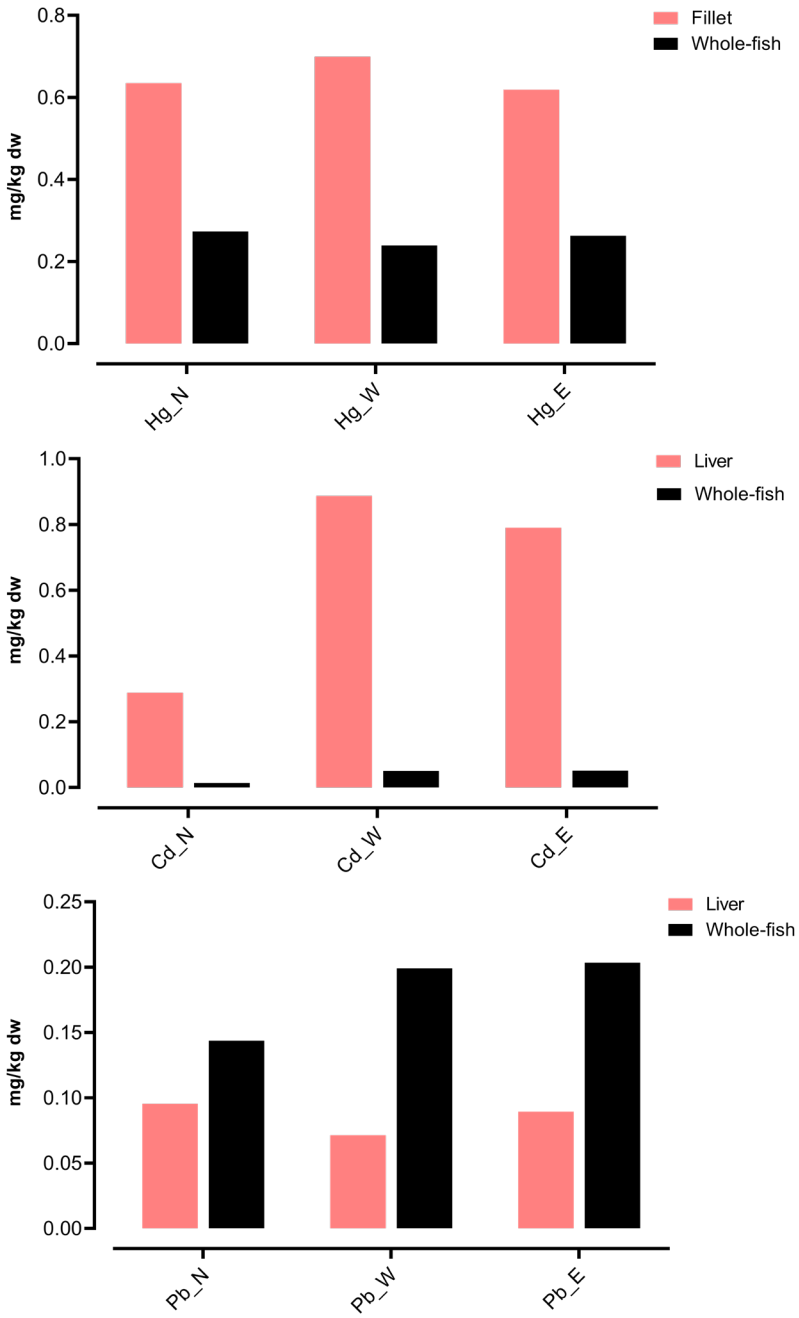


Figure 4.5 *Mean metal concentrations with non-essential mercury (Hg), cadmium (Cd), and lead (Pb) given in dry weight (dw) detected in the liver (red) or fillet (only for mercury) and whole fish (black) of* P. flesus *sampled annually over three years (2017-2019) at three locations in Dutch waters (Noordzeekust (N), Westerschelde (W), Eems-Dollard (E)).*

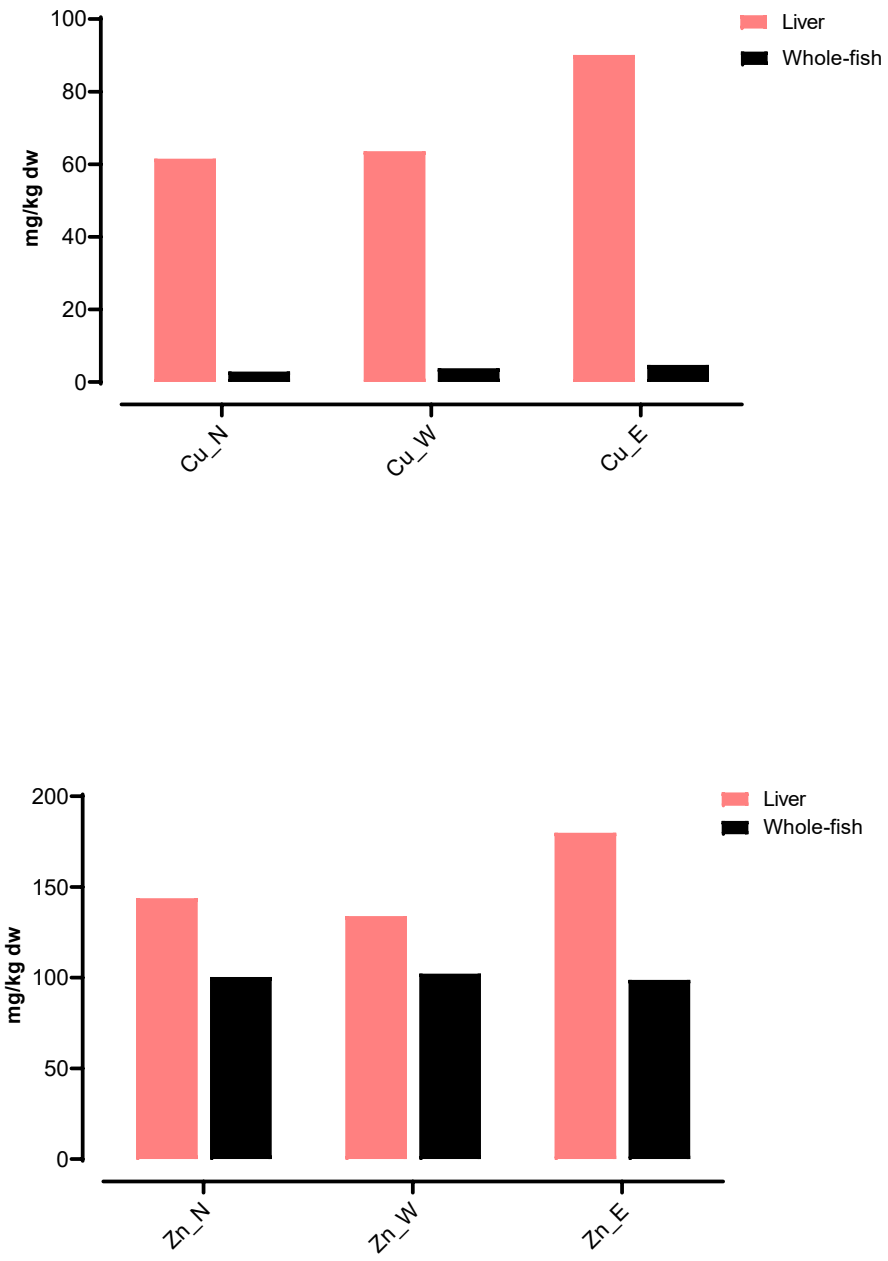


Figure 4.6 *Mean metal concentrations with essential biological function copper (Cu) and zinc (Zn)) given in dry weight (dw) detected in the liver (red) and whole fish (black) of* P. flesus *sampled annually over three years (2017-2019) at three locations in Dutch waters (Noordzeekust (N), Westerschelde (W), Eems-Dollard (E)).*

4.3 Average PFOS and BDE 47, BDE 100 in the liver and whole fish

Concentrations of brominated flame retardants (HBCD and PBDEs), perfluoroalkylated substances (PFAS), and organochlorine pesticides (OCPs), were often not quantified (below limit of quantification). This occurred predominantly at the study site Noordzeekust and in lesser extend at Eems-Dollard. The few compounds (BDE 47, BDE 100, and PFOS), for which relationships could be established, are discussed below.

Similar to metals, the dry weight normalization did not affect the margin of differences between liver and whole-fish samples for PFOS (Figure. 4.7). Therefore, PFOS will be given only in wet weight within the next steps of the discussion. Similar to PCBs, BDEs are lipophilic organic contaminants and the normalization of the two BDEs on lipid weight affects the levels within the two matrices, the concentrations become comparable.

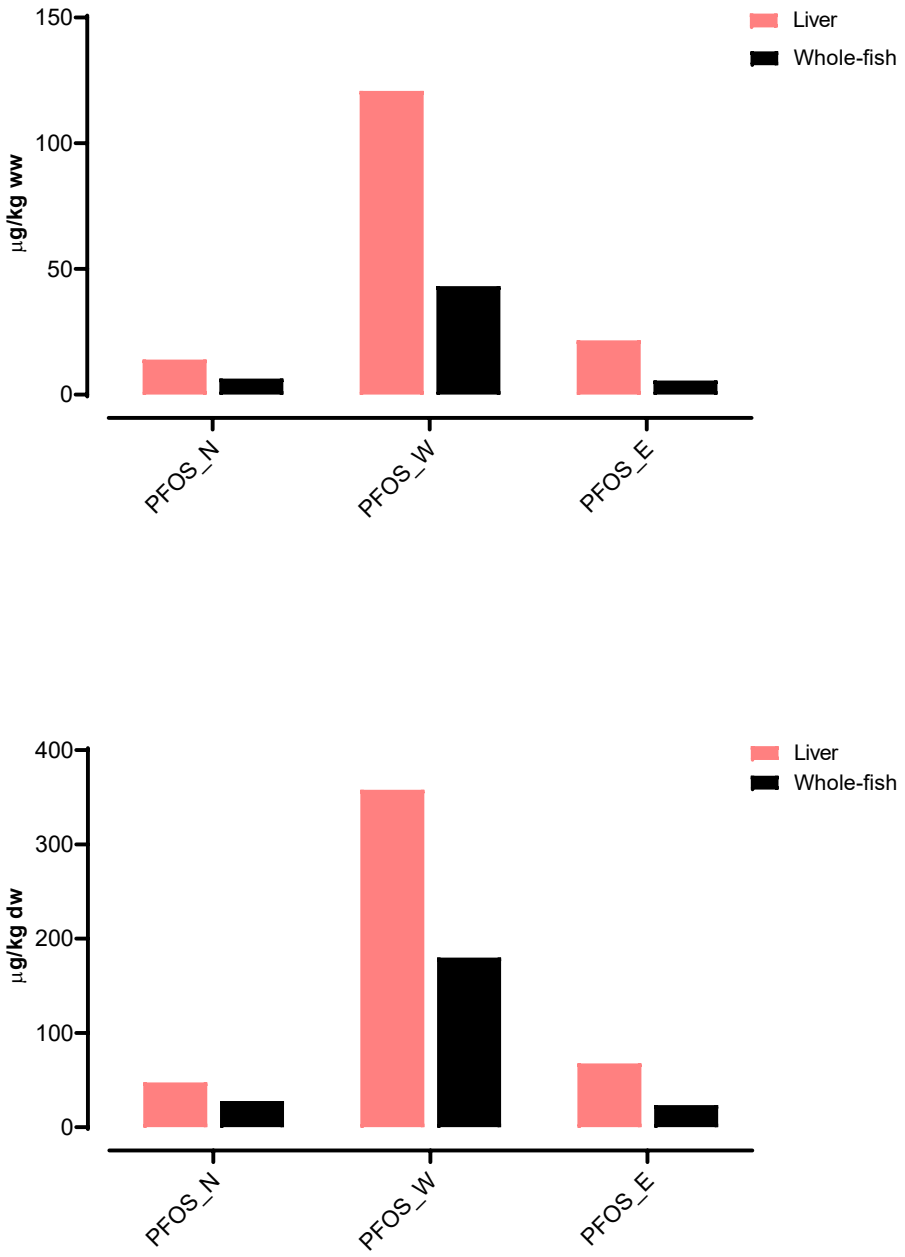


Figure 4.7 *Mean PFOS levels given in wet weight (ww) and dry weight (dw) detected in the liver (red) and whole fish (black) of* P. flesus *sampled annually over three years (2017-2019) at three locations in Dutch waters (Noordzeekust (N), Westerschelde (W), Eems-Dollard (E)).*

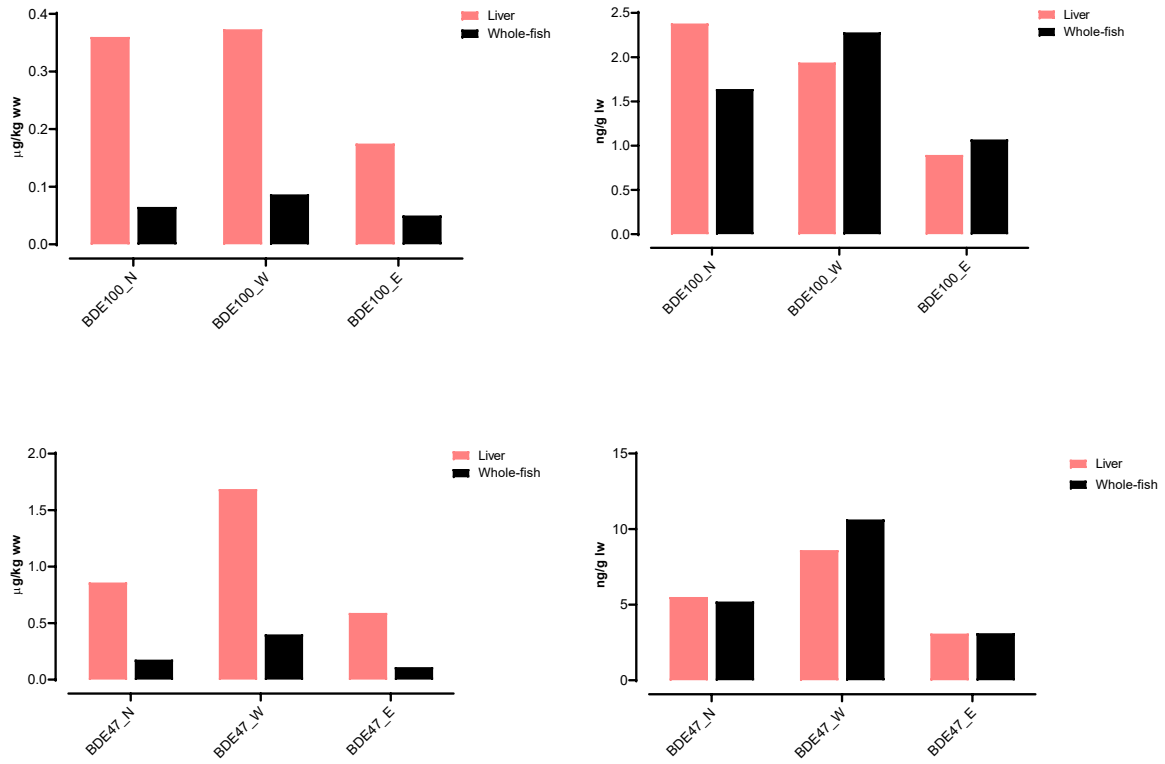


Figure 4.8 *Mean BDE 100 (upper graphs) and BDE 47 (lower graphs) concentrations given in wet weight (left) and lipid weight (right) in the liver (red) and whole fish (black) of* P. flesus *sampled annually over three years (2017-2019) at three locations in Dutch waters (Noordzeekust (N), Westerschelde (W) and Eems-Dollard (E)).*

4.4 Establishing conversion factors

The PCBs analysed in these samples have different chemical properties and show in general a different level of accumulation in fish species. Small PCBs (low chlorinated, low molecular weight) tend to be quick in equilibrium in both small and large fish, while the large PCBs (highly chlorinated, high molecular weight) are taken up so slow that equilibrium (if any) is only obtained in older fish. This must be considered when extrapolating PCB levels from the whole body (15-20 cm) to livers of larger (older) fish (15-30 cm).

To check whether these phenomena occur, the ratios of all PCB congeners between whole-fish samples and liver samples were calculated. The ratio of levels in whole fish/liver for PCB congeners are on wet and lipid weight similar for all PCBs and all locations (Figure 4.9). Yet, sometimes a large variation can be observed (*e.g.*, Noordzeekust). As the behaviour of all PCB congeners was similar, the ratios of sum-PCB are shown in Figure 4.9. On lipid weight, a ratio of almost one was observed in all locations. The sum of ratios for all PCBs is 1.02 in lw and 0.22 in ww. The margin of observed variability for this ratio for the wet weight and lipid weight results are comparable.

For metals, as the distribution over body parts is different for the metals studied, the ratios of whole fish versus liver (or filet in case of mercury) are depicted individually. These Figures (4.10 –4.14) show again that the distribution of metals over body parts can be very different. Still, despite the observed large variation of ratios determined over the years and across the sampling locations, there is consistency in the ratio for each metal.

Mercury levels are higher in fillet samples than in whole fish. Mercury is a well-studied contaminant, similar observations have been done in fish species from Germany [12]. In this literature study, part of the fillet has been removed from the same organisms, and linear correlations were drawn. This resulted in significant linear relationships between the fillet and whole-body burden of mercury. The calculated whole body versus tissue concentration ratios (whole-fish/fillet) of the German study (around 0.7)[12] are in a similar range as those observed within this study.

For BDEs, the ratios have been established only for locations with concentrations above quantification limits. The ratio of BDE 47 is similar to the ratio of PCBs. For BDE 100, however, with concentrations close to quantification limits, the ratios are showing high variability. Predictions based on a low number of data points and such high fluctuating ratios are less reliable.

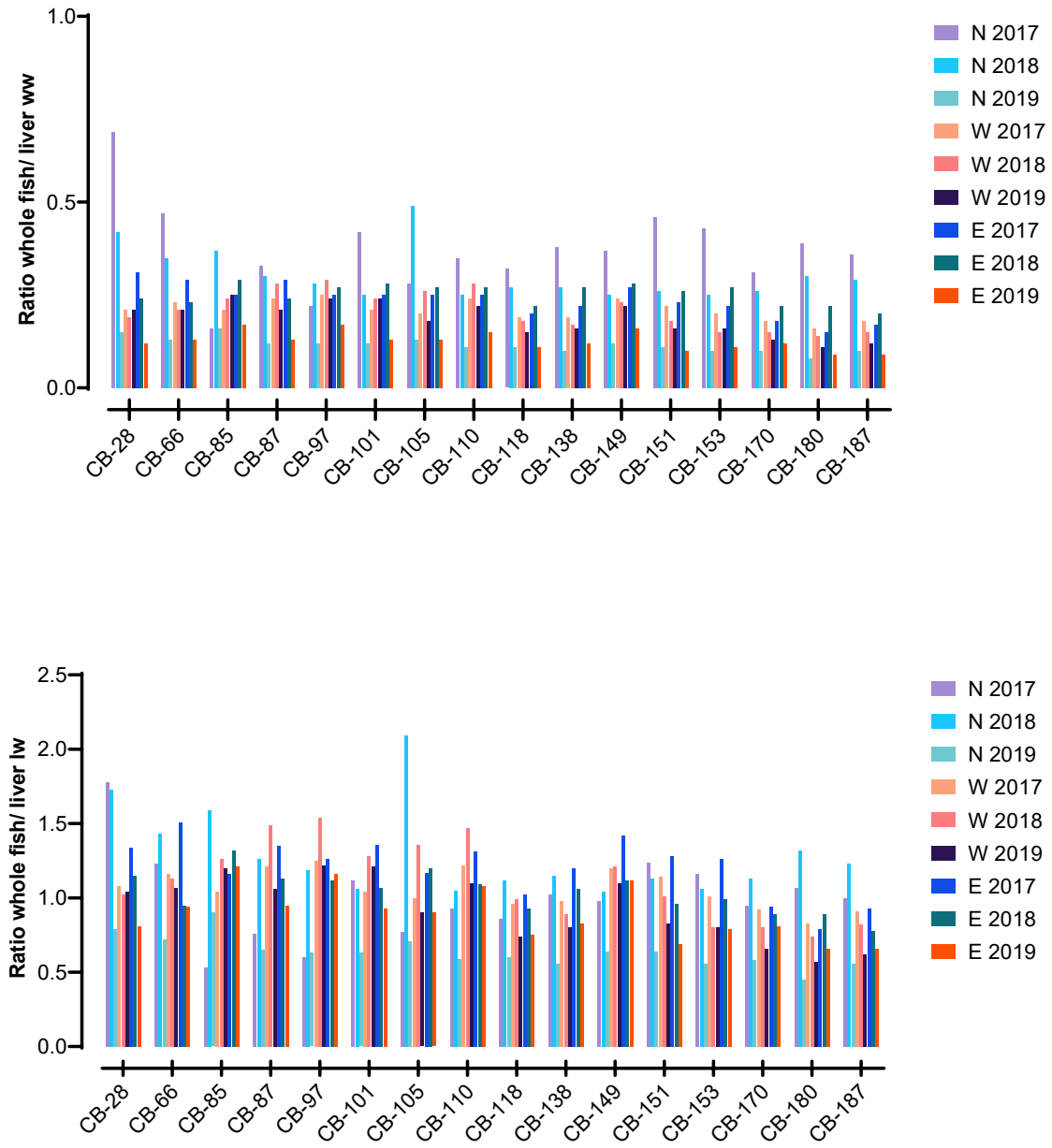


Figure 4.9 *Whole body/tissue concentration ratios (whole fish/liver) for PCBs given in wet weight (ww, top) and lipid weight (lw, bottom) for all three habitats over all three sampling years. (lower concentrations in whole fish < 1, equal concentrations =1, higher concentrations in whole fish >1).*

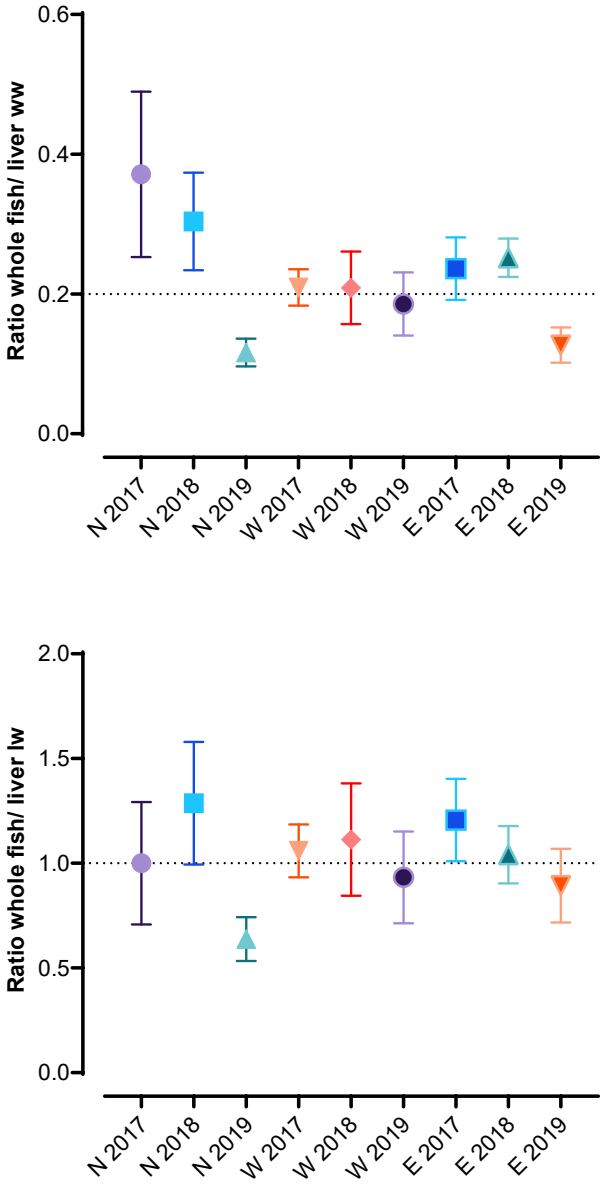


Figure 4.10 Whole body/tissue concentration ratios (whole fish/liver) for sum-PCB given in wet weight (ww, top) and lipid weight (lw, bottom) for all three habitats over all three sampling years. The mean ratio for all PCBs is indicated through a dashed line. (lower concentrations in whole fish < 1, equal concentrations =1, higher concentrations in whole fish >1).

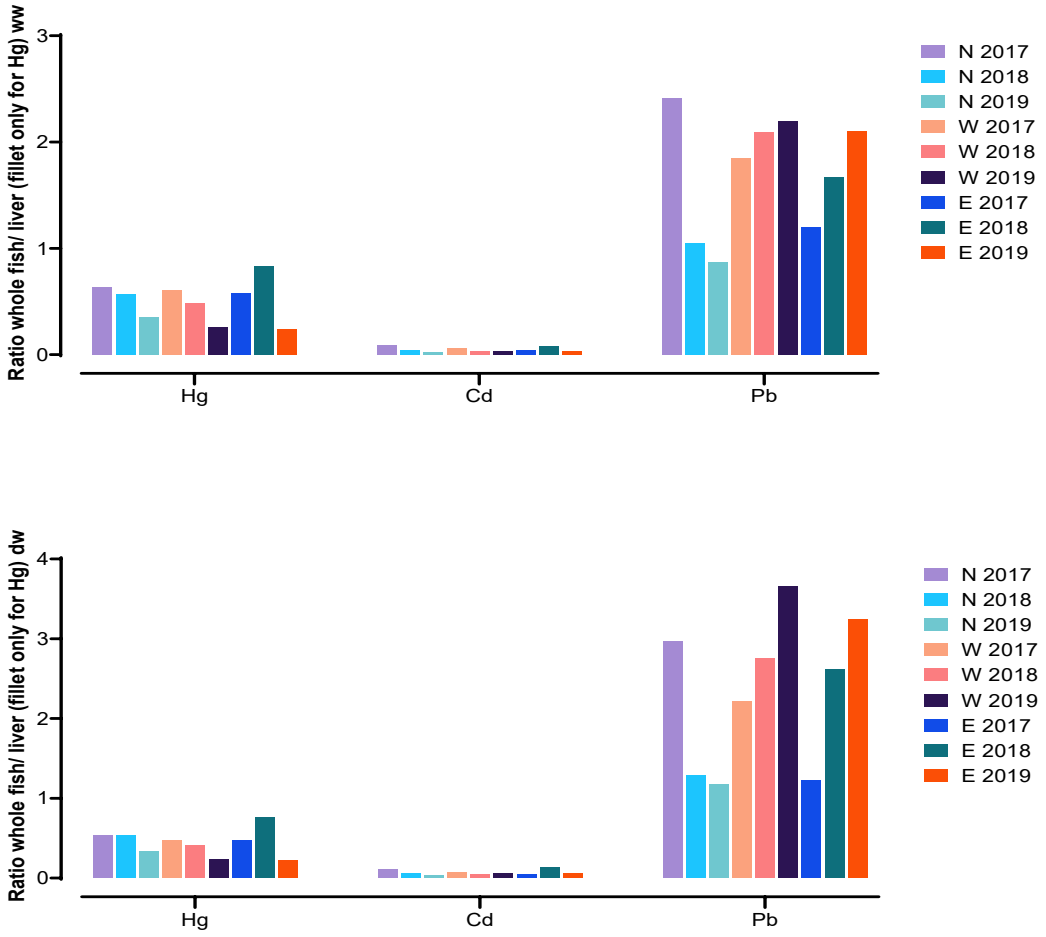


Figure 4.11 *Whole body/tissue concentration ratios (whole fish/liver) for cadmium (Cd) and lead (Pb), and whole fish/fillet for mercury (Hg) given in wet weight (ww, top) and dry weight (dw, bottom) for all three habitats over all three sampling years (lower concentrations in whole fish < 1, equal concentrations =1, higher concentrations in whole fish >1)*

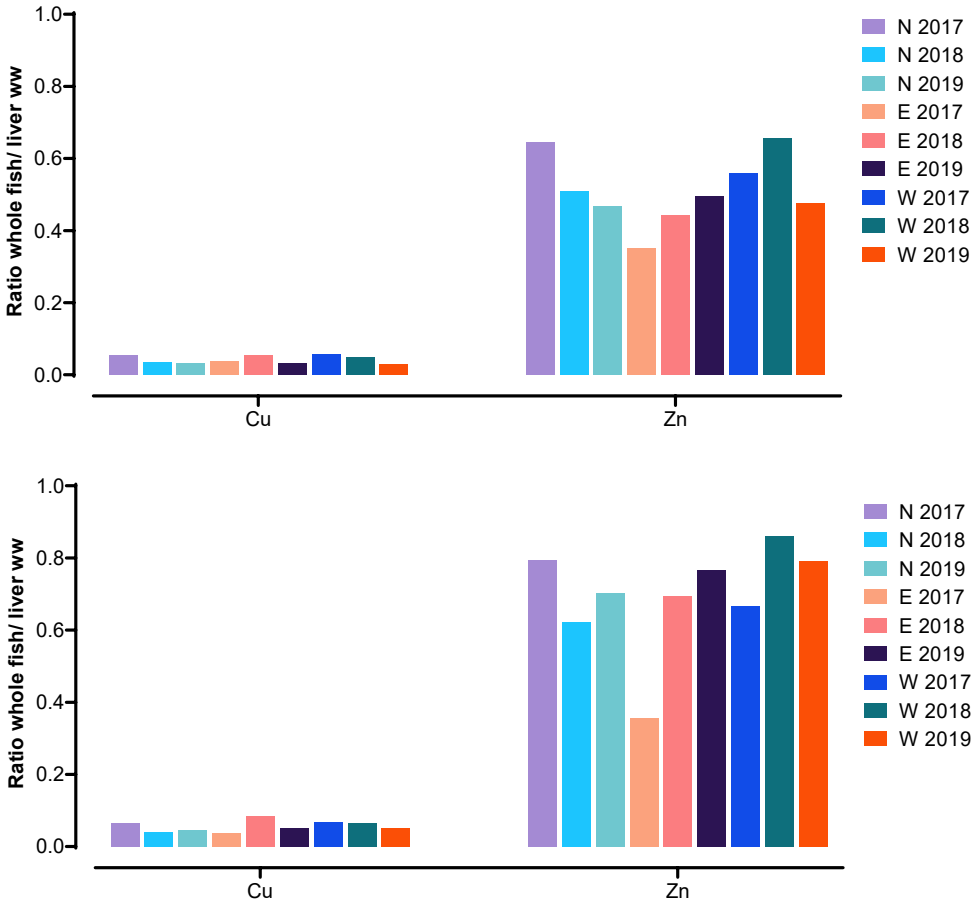


Figure 4.12 *Whole body/tissue concentration ratios (whole fish/liver) for copper (Cu) and zinc (Zn) given in wet weight (ww, top) and dry weight (dw, bottom) for all three habitats over all three sampling years (lower concentrations in whole fish < 1, equal concentrations =1, higher concentrations in whole fish >1).*

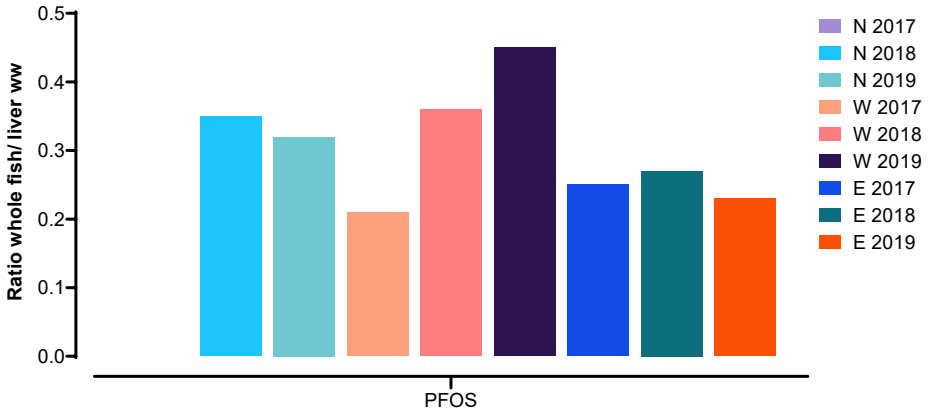
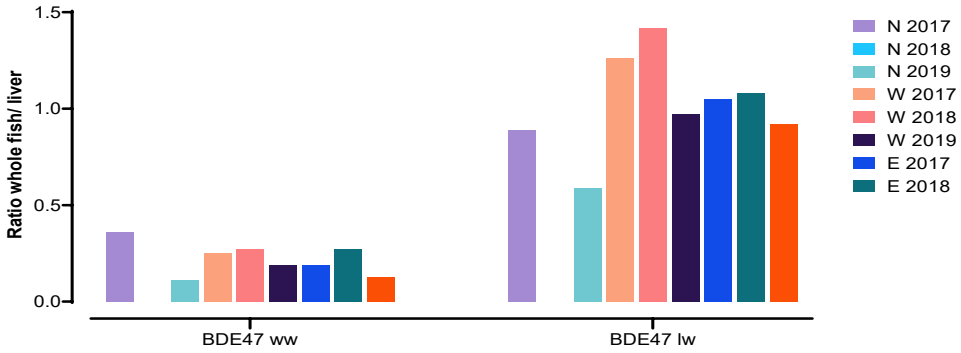


Figure 4.13 Whole body/tissue concentration ratios (whole fish/liver) for PFOS given in wet weight for all three habitats over all three sampling years (lower concentrations in whole fish < 1, equal concentrations =1, higher concentrations in whole fish >1)



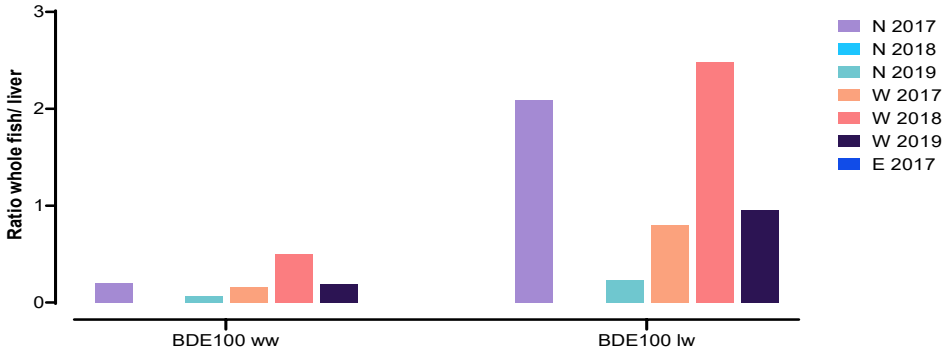


Figure 4.14 *Whole body/tissue concentration ratios (whole fish/liver) for BDE 47 and BDE 100 given in wet weight (ww, left) and lipid weight (lw, right) for all three habitats over all three sampling years. (lower concentrations in whole fish < 1, equal concentrations =1, higher concentrations in whole fish >1).*

5 Results and Discussion (Part 2)

In the previous steps, we derived the ratios of whole fish to the liver (or fillet for mercury). Such ratios have the potential to be applied as a possible conversion factor for predictions of concentrations in liver tissue in future studies (Figure 5.1). The major goal of this approach is to be able to replace the analytical screening efforts of the OSPAR directive for liver tissue with estimations of liver concentrations based on the whole-body burden (whole fish) determined for WFD.

To test and validate the predictive power of these conversion factors, we used the data sets for fish caught in 2019 and based the CFs only on data from 2017-2018. Table 1 illustrates the variability of the derived conversion factors across habitats when the conversion factors are determined for each location. In location Noordzeekust, the variability (the relative standard deviation, % CV) is higher than in the other two locations Westerschelde and Eems-Dollard. By averaging the ratios across all habitats, which is shown in Table 2, the variability of the conversion factor is lower for each chemical and predictions are improved (Factor 3 without generalized CF, Factor 2 with generalized CF). This generalization step enables to consider intraspecies and spatial variability and strengthens the robustness of the CF. Overall, a generalized conversion factor is recommended. As expected, the ratios for PCBs if lipid normalized are around 1 (average for all PCBs 1.02 conversion factor from Table 2).

Similar to PCBs, inorganic compounds also show the applicability of a conversion factor in future studies by applying a factor 3 to take into account the intraspecies variability. Such relationships as drawn within this study are the first of its kind. Studies applying similar approaches mainly focused on mercury and extrapolations from fillet to whole fish. Table 3 and 4 summarize the results of individual conversion factors and the predictions based applied for the data set in 2019.

Conversion factors for PFOS can also be applied while considering a factor of 3 for predictions, based on our data presented in Table 5. For BD E47, however, the study area Noordzeekust could not be predicted due to the insufficient amount of data as too many concentrations were below quantification limits. For BDE 100 only data for Westerschelde could be used for predictions. Therefore, only generalized CFs has been applied (Table 6). The CF of BDE 47 was closer to that of PCBs with lipid weight 1.2 and in wet weight 0.25. BDE 100, in contrast, has higher conversion factors with lipid weight 1.6 and wet weight 0.30. Due to the lack of data, the uncertainties regarding BDEs are increased.

Overall, the approach for predictions presented here is empirical. We concluded that creating generalized (location non-specific) conversion factors results in the lowest variability of the ratios, as with a higher number of samples the variability decreases. Hence, exposure concentrations (ranges found in the whole body, see appendix Table I to V), can be applied for predictions at only the studied three locations and within the same species. For extrapolations to different exposure scenarios (*e.g.,* if the concentrations in flounder are higher than found in the present study), more complex modelling approaches need to be applied (Figure 5.1, dashed lines).

Another option to work with this data is to develop mechanistic models, that can range from simple toxicokinetic models to complex physiologically based toxicokinetic modelling approaches[19]. Such mechanistic models take into account the physiology (*e.g.*, blood flow, lipid levels, etc.) of the species

of interest as well as chemical properties (*e.g.*, blood/tissue partition coefficients), which can simulate the fate of the compound within the body and explain the underlying biological processes. These models also simulate if animals are in an equilibrium state. The empirically observed values can serve as data to validate such models and quantify the variability. Next to this, the uncertainty within such models can be determined easier with well-established approaches. A statistical supplementation of mechanistic models can mathematically suggest reliable probabilities and credibility intervals (Monte Carlo simulations or Bayesian statistics). Linking chemical and physiological processes quantitatively would provide an in-depth understanding of bioaccumulation (external to internal concentrations). In this way, predictions can be done not only from one internal tissue to another, it can also be applied to predict external concentrations. Further, such models can be extrapolated to other species (*e.g.*, plaice), and connected with quantitative knowledge of toxic effects triggered within the species of interest.

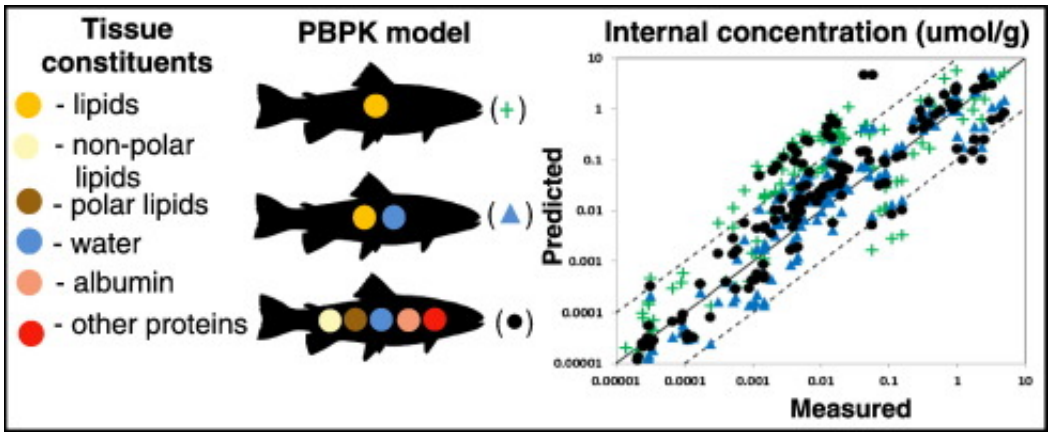


Figure 5.1 *Illustrations of mechanistic modelling to simulate the absorption, distribution, metabolism and elimination of compounds within fish species to ultimately determine internal concentrations (Source: Salmina* et al. *2016)* [19]

Table 1a *Predictions for PCB level in liver tissue in 2019 based on wet weight conversion factors (CF) determined per location (N, W, and E) averaged for the year 2017-2018. Using the measured whole fish PCB concentrations, we predict the concentrations of PCB in the liver tissue (P_liver) and compare the results to measured concentrations in the liver (M_liver). CV % is the coefficient of variation (CV), also known as relative standard deviation (RSD) of CF.*

	Noordzeekust				**Westerschelde**				**Eems-Dollard**			
	CF	CV %	P_Liver	M_Liver	CF	CV %	P_Liver	M_Liver	CF	CV %	P_Liver	M_Liver
CB-28	0.42	64%	1.4	4.1	0.20	5%	3.7	3.6	0.22	45%	1.1	2.1
CB-66	0.32	54%	2.8	6.6	0.22	4%	5.8	6.0	0.22	36%	2.3	3.7
CB-85	0.23	51%	0.9	1.2	0.23	9%	2.7	2.5	0.24	25%	0.8	1.1
CB-87	0.25	45%	1.1	2.3	0.24	15%	4.0	4.7	0.22	37%	1.0	1.6
CB-97	0.20	41%	1.6	2.8	0.26	9%	4.7	5.0	0.23	24%	1.1	1.6
CB-101	0.26	58%	7.3	16.6	0.23	9%	31.4	29.5	0.22	35%	6.7	11.2
CB-105	0.30	60%	1.0	2.3	0.21	20%	3.8	4.5	0.21	35%	1.2	2.0
CB-110	0.24	51%	5.4	11.8	0.25	12%	18.5	20.8	0.22	28%	4.9	7.2
CB-118	0.23	47%	7.5	15.8	0.17	13%	21.4	25.2	0.18	35%	7.5	12.6
CB-138	0.25	55%	10.0	24.4	0.18	9%	41.8	45.0	0.20	38%	13.8	23.8
CB-149	0.24	51%	7.9	16.2	0.23	3%	30.0	30.9	0.24	28%	9.0	13.4
CB-151	0.28	63%	3.4	8.6	0.19	16%	20.3	23.6	0.19	43%	5.1	10.0
CB-153	0.26	62%	19.5	49.0	0.17	15%	94.8	100.0	0.20	41%	26.9	48.5
CB-170	0.22	48%	2.0	4.3	0.15	16%	11.6	13.6	0.17	29%	3.3	4.7
CB-180	0.26	62%	3.6	11.3	0.14	18%	35.4	42.9	0.16	40%	8.4	13.7
CB-187	0.25	53%	6.7	16.2	0.15	19%	30.6	37.8	0.16	35%	13.4	22.1

Table 1b *Predictions for PCB level in liver tissue in 2019 based on lipid normalized conversion factors (CF) determined per location (N, W, and E) averaged for the year 2017-2018. Using the measured whole fish PCB concentrations, we predict the concentrations of PCB in the liver tissue (P_liver) and compare the results to measured concentrations in the liver (M_liver)*

	Noordzeekust				Westerschelde				Eems-Dollard			
	CF	CV %	P_Liver	M_Liver	CF	CV %	P_Liver	M_Liver	CF	CV %	P_Liver	M_Liver
CB-28	1.8	64%	9.3	20.5	1.1	3%	17.1	17.3	1.2	24%	6.4	9.9
CB-66	1.3	54%	18	33.1	1.1	4%	27.2	28.4	1.2	29%	13.6	17.9
CB-85	1.1	51%	5.1	6	1.2	10%	12.5	12.2	1.2	6%	4.9	5
CB-87	1	45%	7.5	11.7	1.3	17%	18.6	21.9	1.2	17%	6.1	7.9
CB-97	0.9	41%	9.9	13.8	1.3	13%	21.5	23.7	1.2	6%	7.4	7.5
CB-101	1.1	58%	48.1	83.2	1.2	10%	145.2	141.8	1.2	19%	40.9	53.4
CB-105	1.4	60%	5.7	11.5	1.1	22%	17.5	21.1	1.2	15%	7.4	9.7
CB-110	1	51%	35.4	59.6	1.3	15%	85.8	98.8	1.2	11%	31.1	34.6
CB-118	1	47%	47.9	79.2	0.9	15%	98.6	119.3	1	16%	46.4	60.7
CB-138	1.1	55%	62.8	122	0.9	10%	196.2	217	1.1	18%	84.1	114.9
CB-149	1	51%	52.1	81.5	1.2	5%	139.6	148.4	1.3	14%	56.9	64.5
CB-151	1.2	63%	21.8	40.2	1	16%	92.7	110.9	1.1	30%	29.8	48.6
CB-153	1.1	62%	124.3	245.4	0.9	14%	443.3	481.9	1.1	23%	163.2	233.5
CB-170	1	48%	11.6	20.8	0.8	17%	53.8	64.2	0.9	7%	20.6	23.1
CB-180	1.2	62%	21.1	55.9	0.7	18%	163.4	202.5	0.8	15%	52.3	66.6
CB-187	1.1	53%	40.9	81.1	0.8	19%	141.7	179	0.9	17%	83.3	107.2

Table 2a *Predictions for PCB level based on wet weight conversion factors (CF) determined averaged for the year 2017-2018 and across sampling locations. Using the measured whole fish concentrations, we predict the PCB concentrations in the liver tissue (P_liver) and compare the results with concentrations measured in the liver (M_Liver) to evaluate the predictive power on an independent data set.*

Generalized CF		**Noordzeekust**		**Westerschelde**		**Eems-Dollard**	
	CF	P_Liver	M_Liver	P_Liver	M_Liver	P_Liver	M_Liver
CB-28	0.28	2.1	4.1	2.7	3.6	0.9	2.1
CB-66	0.25	3.5	6.6	5.1	6.0	2.0	3.7
CB-85	0.23	0.9	1.2	2.7	2.5	0.8	1.1
CB-87	0.24	1.2	2.3	4.1	4.7	0.9	1.6
CB-97	0.23	1.4	2.8	5.3	5.0	1.1	1.6
CB-101	0.24	8.1	16.6	30.4	29.5	6.2	11.2
CB-105	0.24	1.2	2.3	3.3	4.5	1.1	2.0
CB-110	0.24	5.4	11.8	19.5	20.8	4.7	7.2
CB-118	0.20	8.9	15.8	19.2	25.2	6.9	12.6
CB-138	0.21	11.9	24.4	35.1	45.0	13.3	23.8
CB-149	0.24	8.1	16.2	29.1	30.9	9.0	13.4
CB-151	0.22	4.3	8.6	17.5	23.6	4.5	10.0
CB-153	0.21	24.0	49.0	77.2	100.0	25.6	48.5
CB-170	0.18	2.4	4.3	9.8	13.6	3.0	4.7
CB-180	0.18	5.0	11.3	26.9	42.9	7.1	13.7
CB-187	0.19	8.9	16.2	25.1	37.8	11.2	22.1

Table 2b *Predictions for PCB level based on lipid normalized conversion factors (CF) determined averaged for the year 2017-2018 and across sampling locations. Using the measured whole fish concentrations, we predict the PCB concentrations in the liver tissue (P_liver) and compare the results with concentrations measured in the liver (M_Liver) to evaluate the predictive power on an independent data set*

Generalized CF		**Noordzeekust**		**Westerschelde**		**Eems-Dollard**	
	CF	P_Liver	M_Liver	P_Liver	M_Liver	P_Liver	M_Liver
CB-28	1.3	22	20.5	13.3	17.3	5.9	9.9
CB-66	1.2	29.7	33.1	24.6	28.4	13.5	17.9
CB-85	1.1	6.2	6	12.8	12.2	5.3	5
CB-87	1.2	9.1	11.7	19.4	21.9	6.3	7.9
CB-97	1.2	10.2	13.8	24.9	23.7	7.5	7.5
CB-101	1.2	60.5	83.2	148.3	141.8	43.1	53.4
CB-105	1.3	10.2	11.5	15	21.1	6.9	9.7
CB-110	1.2	41.3	59.6	92.3	98.8	31.7	34.6
CB-118	1	46.5	79.2	90.5	119.3	46.3	60.7
CB-138	1.1	71.9	122	166.1	217	90.6	114.9
CB-149	1.2	61	81.5	140.7	148.4	62.2	64.5
CB-151	1.1	29	40.2	81.4	110.9	29.7	48.6
CB-153	1	144.4	245.4	368.7	481.9	175.4	233.5
CB-170	0.9	11.3	20.8	45.4	64.2	20	23.1
CB-180	0.9	23.8	55.9	123.4	202.5	46.8	66.6

Table 3 *Predictions for metals in liver tissue based on wet weight conversion factors (CF) determined per location (N, W, and E) averaged for the year 2017-2018. Using the measured whole fish concentrations, we predict the concentrations in the liver tissue (P_liver) and compare the results to measured concentrations in the liver.*

	Noordzeekust				Westerschelde				Eems-Dollard			
	CF	CV %	P_Liver	M_Liver	CF	CV %	P_Liver	M_Liver	CF	CV %	P_Liver	M_Liver
Hg	0.6	8%	0.11	0.19	0.55	15%	0.09	0.19	0.71	26%	0.05	0.16
Cd	0.1	47%	0.05	0.12	0.05	34%	0.19	0.27	0.06	40%	0.17	0.31
Cu	0	32%	15.2	19.91	0.05	12%	14.1	25.08	0.05	25%	20.9	29.51
Pb	1.7	56%	0.02	0.03	1.97	9%	0.03	0.02	1.43	23%	0.05	0.04
Zn	0.6	17%	39.28	48.53	0.61	11%	41.5	52.99	0.4	17%	68.45	54.71

Table 4 *Predictions for metals based on wet weight conversion factors (CF) determined averaged for the year 2017-2018 and across sampling locations. Using the measured whole fish concentrations, we predict the concentrations in the liver tissue (P_liver) and compare the results with concentrations measured in the liver (M_Liver) to evaluate the predictive power on an independent data set.*

Generalized CF	Noordzeekust		Westerschelde		Eems-Dollard	
	CF	P_Liver	M_Liver	P_Liver	M_Liver	P_Liver	M_Liver
Hg	0.62	0.08	0.19	0.08	0.19	0.06	0.16
Cd	0.06	0.15	0.27	0.15	0.27	0.18	0.31
Cu	0.05	15.83	25.08	15.83	25.08	20.09	29.51
Pb	1.71	0.03	0.02	0.03	0.02	0.05	0.04
Zn	0.53	47.83	52.99	47.83	52.99	51.5	54.71

Table 5 *Predictions for PFOS based on wet weight conversion factors (CF) determined averaged for the year 2017-2018 and across sampling locations. Using the measured whole fish concentrations, we predict the concentrations in the liver tissue (P_liver) and compare the results with concentrations measured in the liver (M_Liver) to evaluate the predictive power on an independent data set.*

Generalized CF			**Noordzeekust**		**Westerschelde**		**Eems-Dollard**	
	CF	CV %	P_Liver	M_Liver	P_Liver	M_Liver	P_Liver	M_Liver
PFOS	0.29	22%	17.0	15.6	217.4	140.0	16.3	21.0

Table 6 *Predictions for BDEs based on lipid normalized conversion factors (CF) determined averaged for the year 2017-2018. Data only for Westerschelde due to the lack of data (below detection limits at other locations). Using the measured whole fish concentrations, we predict the concentrations in the liver tissue (P_liver) and compare the results with concentrations measured in the liver (M_Liver) to evaluate the predictive power on an independent data set.*

Generalized CF		**Westerschelde**		**Eems-Dollard**	
	CF	P_Liver	M_Liver	P_Liver	M_Liver
BDE 100 ww	0.33	1.2	1.6	0.39	0.75
BDE 100 lw	1.6	5.8	7.3	2.7	3.6
BDE 47 ww	0.25	0.26	0.44		
BDE 47 lw	1.2	1.2	2.1		

5.1.1 Characterizing variability

Many contaminants screened during the present biomonitoring project are known to have long biogeological half-lives. Hence, organisms are chronically exposed to such chemicals over time and gradually accumulate these chemicals internally. PCBs, for example, are highly stable, hydrophobic, and persistent, hence, bioaccumulate in species[20]. Many chemicals screened within this project are hydrophobic and accumulate within lipid-rich tissues such as the liver [15]. Correlations of PCB levels with increasing body size have been shown in the literature[21]. Such relationships have also been observed for metals, for example, mercury[16, 17]. Therefore, it is important to characterize variables that can impact the data collected in this present project, and as such, impact the potential application of predicted values within biomonitoring studies.

The body size and body length distribution of *P. flesus* caught for both monitoring efforts are significantly different as shown in Figure 5.2. The curve between body weight and body size relation of all samples show a very conservative spatial difference (Figure 5.3 a, R^2=0.96). The lipid levels in the sample matrices for the both directives (liver for OSPAR, and whole fish for the WFD) are significantly different as well (Figure 5.3 c and d), lipid levels in liver being much higher. But, lipid levels of liver do not indicate a strong body size dependency, nor is lipid level of whole-body related to the body size of the animals (Figure 5.3). As the body size and hence the age of the fish caught for monitoring may differ, these covariates can affect the level of contaminant accumulation. All these covariates can, in turn, cause uncertainties when implementing predictive approaches within biomonitoring efforts. Therefore, the sensitivity of such covariates and relationships needs to be considered in future monitoring efforts for the aim of this study.

Finally, we looked at the possible correlation of confounding factors on the levels detected. The graphical illustration of a Pearson correlation matrix (Figure 5.5) shows the complexity of the interaction of biological information (lipid content, body size and average body weight) as well as the concentration of organic contaminants in whole fish versus liver. For example, the lipid content is strongly affecting concentrations of CB-52, CB-101, CB-153, CB-138, closely to a linear relationship. Such correlations of biological properties of the sampling matrix can influence data detected and cause intra- and inter-species variability. Hence, conversion factors derived from real-world exposure scenarios, as such in the present study, can be impacted by such interactions. Within the present project, the chemical-chemical interactions, that can influence the kinetics (uptake, distribution, metabolism, and elimination) within an organism, are not investigated.

Overall, we could clearly show that factors like body size or lipid content can influence the levels observed within the data (Figure 5.4). However, without conducting a sensitivity or uncertainty analysis on the ratios established within this study, which was beyond the scope of the project, it cannot be determined which of those characterized biological or chemical parameters impact the predictions and the extent significantly. Future studies need to focus on ways how to determine such impacts and uncertainty in-depth.

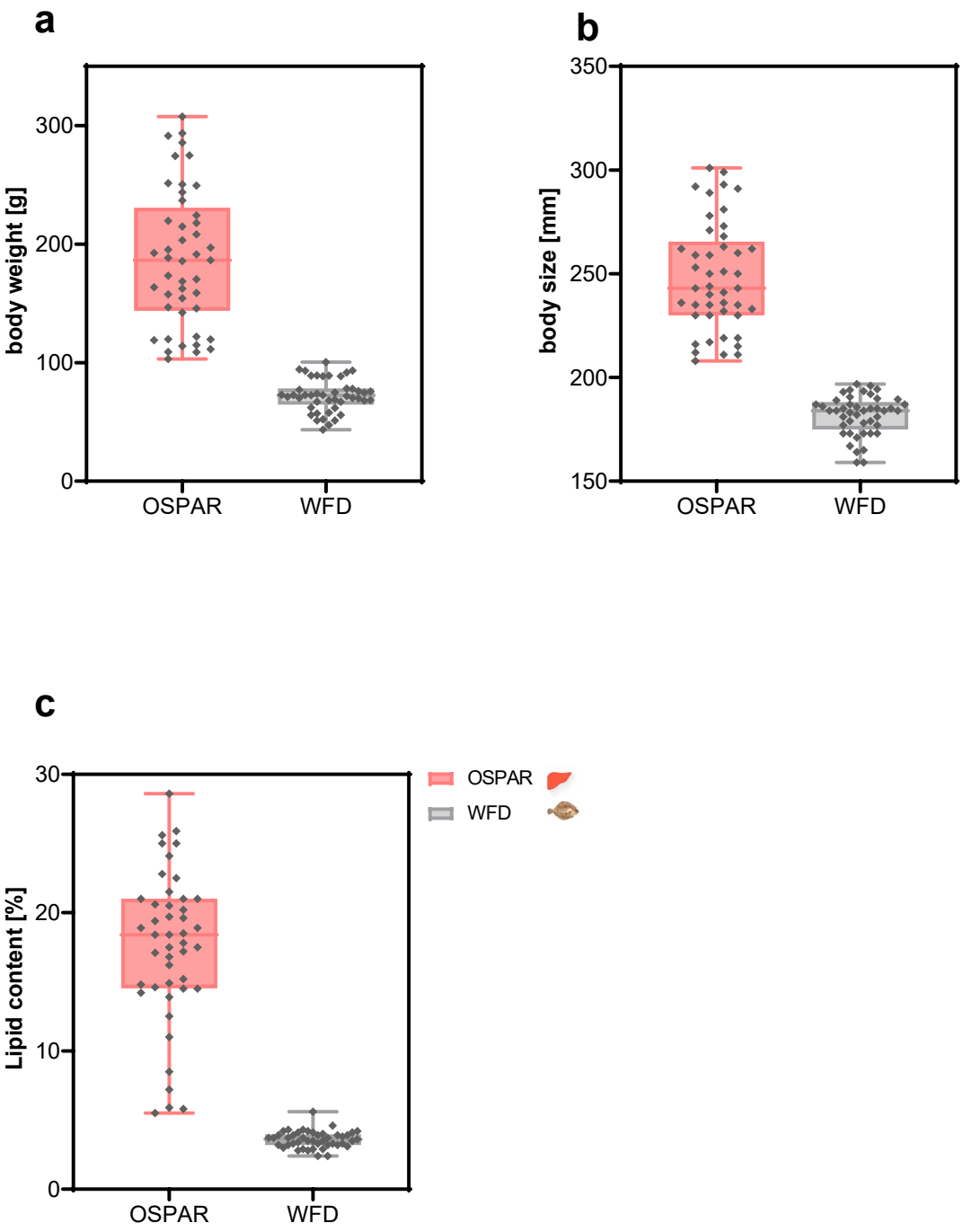


Figure 5.2 *Bodyweight (g; a) and body size (mm; b) of* P. flesus*, and lipid content (%) in the liver and whole fish distributions of* P. flesus *caught under the umbrella of the two different sampling strategies (red=OSPAR and grey= WFD). Whiskers-boxes= 1st and 3rd quartiles, line = median, and grey dots= data from minimum to maximum.*

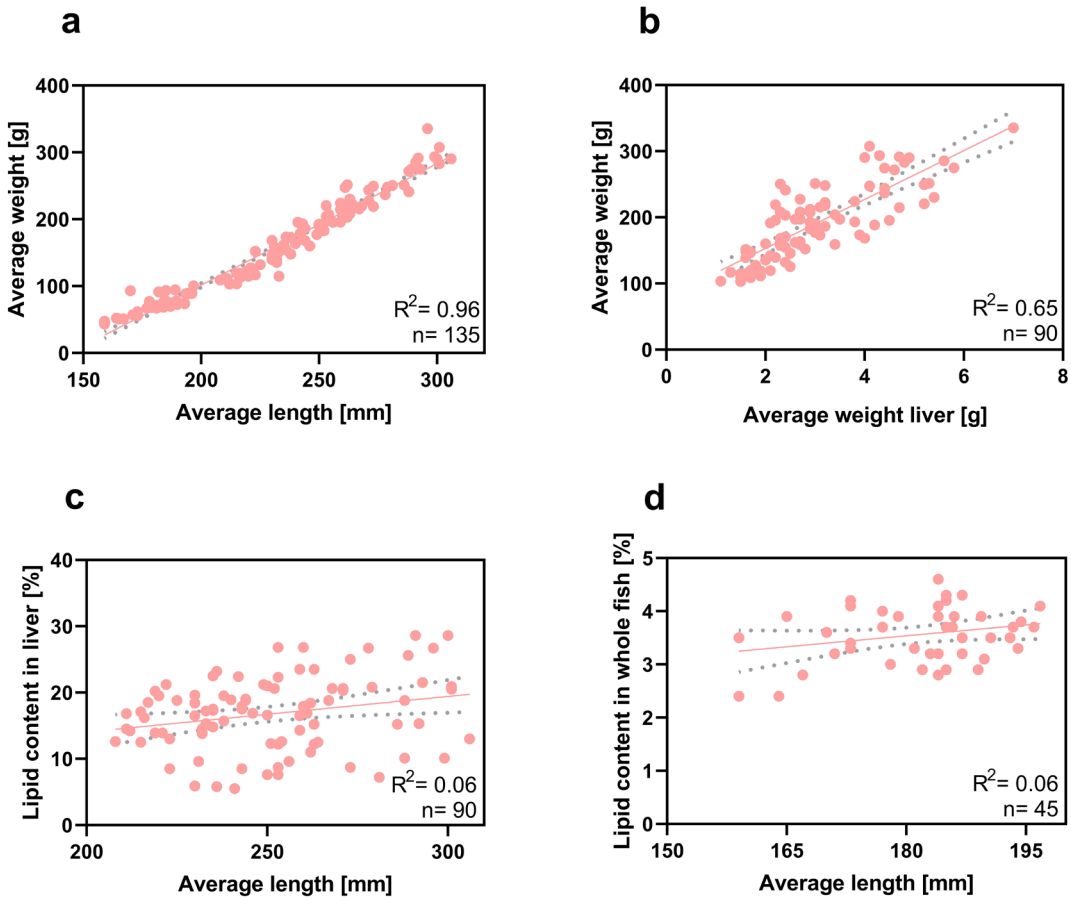


Figure 5.3 *The observed linear correlations (indicated with r^2) of biometric information collected for biomonitoring. Significant relationships could be observed in samples caught for monitoring OSPAR and WFD between covariates such as body size and total body weight [a], and weight of liver and total body weight [b]. Body size and lipid content of the liver (OSPAR) [c] and body size and lipid content of whole fish for WFD [d] had no significant relationship.*

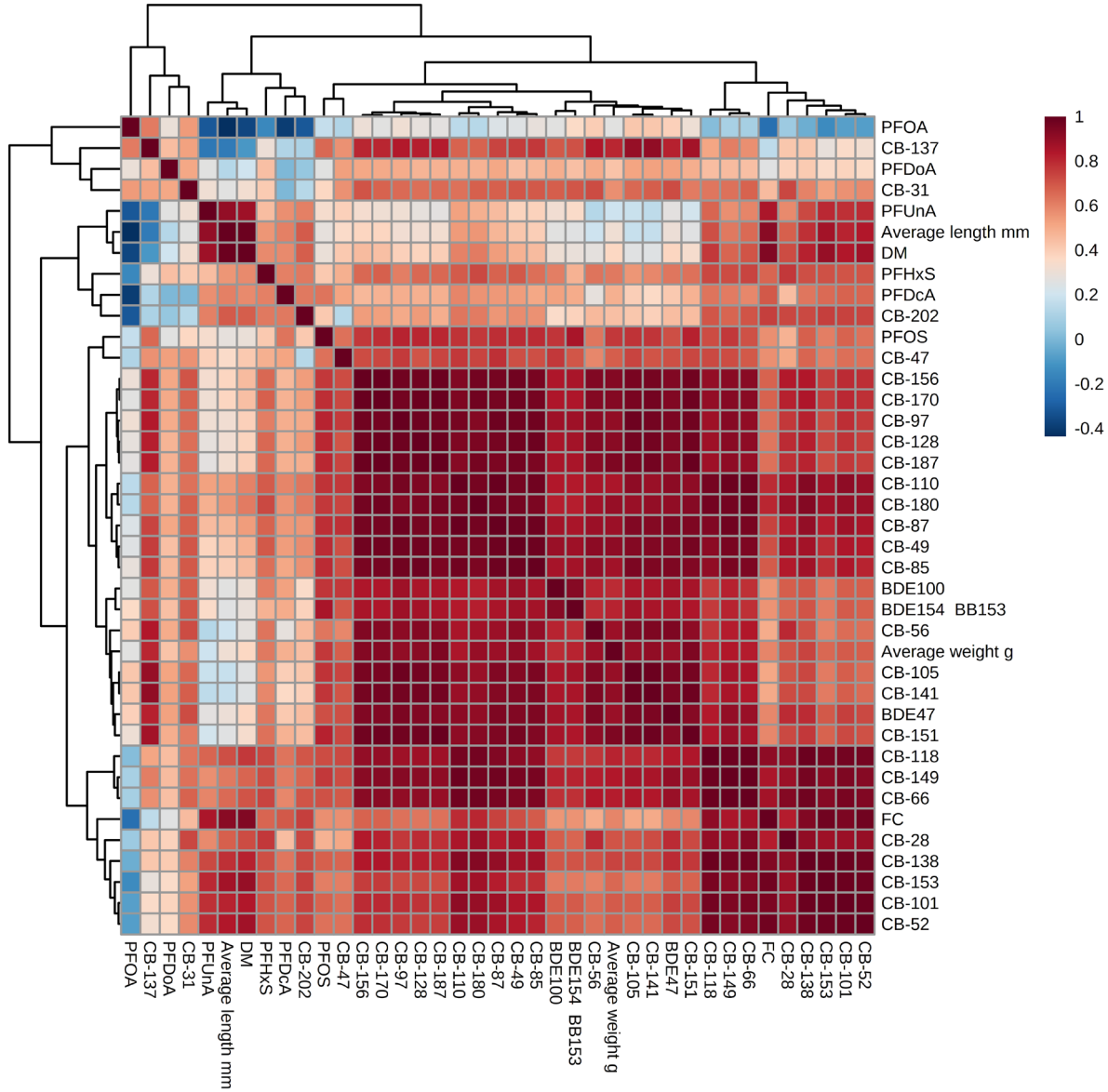


Figure 5.4 *Pearson correlation matrix for chemicals screened within this present study. Grouping of PCB concentration detected in fish in years (2017, 2018, and 2019) and tissue matrix (liver and whole fish) and running a Pearson correlation in MetaboAnalystR 3.0 to understand the relationship between co-variables. [DM= dry matter, FC= fat content]*

5.1.2 Effect of variability

As there is a considerable margin in the estimated concentrations in the liver, these concentrations can be either higher or lower than the actual concentrations. If the actual concentrations in the liver are close to a regulatory limit (BAC, EC, EAC, FEQG), the estimated concentrations can easily change from "below" to "above" the limit and vice versa. To give an insight into this phenomenon, the measured contaminant concentrations in livers of the last decade, depicted in the report Biomonitoring part I, have been visually scored as on average below or above a regulatory limit. At a concentration in liver more than two times (in case of lipophilic organic contaminants) or three times (in case of metals) lower or higher than a particular regulatory limit, an estimated concentration is not likely to change this situation (in compliance or not). However, when the concentrations in the liver are close to a particular regulatory limit, the use of an estimated concentration can easily affect whether or not it complies with this limit. In table 7 below these two scenarios are shown with colour codes.

Table 7 *Overview of the possible effect of estimating liver concentrations.*
Green; low risk, the concentrations in the liver are more than 2 (in case of lipophilic organic contaminants) or 3 times (in case of metals) lower or higher than the regulatory limit. Using an estimated concentration is not likely to have an effect on compliance.
Red; high risk; the concentrations in liver are less than 2 (in case of lipophilic organic contaminants) or 3 times (in case of metals) lower or higher than the regulatory limit. Using an estimated concentration is likely to have an effect on compliance.
Nota bene *The colour only indicates whether or not there is a risk on a different interpretation of the result (does the liver comply to the regulatory limit or not). It does not indicate if the levels comply or not.*

Location	Cadmium		Mercury		Lead		PCB28		PCB52		PCB101		PCB118		PCB138		PCB153		PCB180		BDE-28		BDE-47		BDE-99		BDE-100	
	BAC	EC	BAC	EC	BAC	EC	BAC	EAC	BAC	EAC	BAC	EAC	BAC	EAC	BAC	EAC	BAC	EAC	BAC	EAC	BAC	FEQG	BAC	FEQG	BAC	FEQG	BAC	FEQG
N																												
E																												
W																												

6 Conclusions

The study goal was to examine whether concentrations of contaminants in the whole body of small flounder can be used to predict concentrations of these contaminants in the tissue samples (liver and fillet) of larger flounder (Part 1). In general, the concentration of contaminants in the whole body was correlated with the levels in the tissue samples. With these data, we calculated ratios, which, in turn, created the baseline for predictive conversion factors from whole fish to tissue (liver and fillet). The concentrations of some contaminants, however, were sometimes too low to quantify, especially in the whole-body samples. As result, the quantitative relationship could not be drawn for all chemicals that need to be screened under the umbrella of the two directives, OSPAR and WFD. The low levels in whole-fish samples could therefore be a major limiting factor for the application of this predictive approach.

To test the predictive power of these conversion factors (Part 2), we used the data sets for fish caught in 2019 and based the CFs only on contaminant concentrations detected in fish caught in 2017-2018. These predicted concentrations were similar with the measured concentrations in tissue, but a margin of error up to a factor of 3 was observed. We briefly tried to interpret the variability by looking into biological information that can impact the measurements. Lipid content was shown as an important confounding parameter. We further addressed uncertainties that can hamper the implication of these predictive approaches in real monitoring efforts due to the nature of empirical approaches (lack of mechanistic information).

The data presented within this study is just the first step towards superseding the need for monitoring different matrices of the same fish (*e.g.*, whole fish and liver). The predictive conversion factors can be applied only to estimate the liver/fillet concentrations based on the whole-body burden of chemicals. The large uncertainties need to be considered and further examined before this predictive approach can be applied. Therefore, this report alone does not justify the replacement of analysis of tissue samples by whole-body analysis.

7 Quality Assurance

Wageningen Marine Research utilises an ISO 9001:2015 certified quality management system. This certificate is valid until 15 December 2021. The organisation has been certified since 27 February 2001. The certification was issued by DNV GL.

Furthermore, the chemical laboratory at IJmuiden has EN-ISO/IEC 17025:2017 accreditation for test laboratories with number L097. This accreditation is valid until 1th of April 2021 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation. The chemical laboratory at IJmuiden has thus demonstrated its ability to provide valid results according a technically competent manner and to work according to the ISO 17025 standard. The scope (L097) of de accredited analytical methods can be found at the website of the Council for Accreditation (www.rva.nl).

The quality characteristic Q is not mentioned in the appendices with results.

The quality of the test methods is ensured in various ways. The accuracy of the analysis is regularly assessed by participation in inter-laboratory performance studies including those organized by QUASIMEME. If no inter-laboratory study is available, a second-level control is performed. In addition, a first-level control is performed for each series of measurements.
In addition to the line controls the following general quality controls are carried out:

- Blank research.
- Recovery.
- Internal standard
- Injection standard.
- Sensitivity.

The above controls are described in Wageningen Marine Research working instruction ISW 2.10.2.105. If desired, information regarding the performance characteristics of the analytical methods is available at the chemical laboratory at IJmuiden.

If the quality cannot be guaranteed, appropriate measures are taken.

8 References

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9 Justification

Report C065/20a
Project Number: 316100131

The scientific quality of this report has been peer reviewed by a colleague scientist and a member of the Management Team of Wageningen Marine Research

Approved: A.C. Sneekes
Researcher

Signature:

Date: 01-12-2020

Approved: Drs. J. Asjes
manager

Signature:

Date: 01-12-2020

10 Appendix

The supplementary information consists of tables with the raw data.

Table I *Sample analysis ID and the respective biometric information of all biota samples caught for this present project. Lipid level is determined in liver, except in the WFD samples consisting of whole fish.*

Sample Analysis ID	Sample matrix	Year	N	Average weight [g]	Average weight liver [g]	Lipid Level (%)	Average length [mm]	STD	CV [%]
N1	Filet	2017	5	152.2	2.8	13	223	12	5%
N2	Filet	2017	5	230.2	5.4	15.2	263	18	7%
N3	Filet	2017	5	247.6	4.1	16.9	261	41	16%
N4	Filet	2017	5	220.4	5.2	7.6	253	2	1%
N5	Filet	2017	5	159	3.4	9.6	231	17	7%
N6	Liver	2017	5	168.6	4	13	230	16	7%
N7	Liver	2017	5	188.4	4.2	15.2	243	22	9%
N8	Liver	2017	5	173.4	3.9	16.9	236	12	5%
N9	Liver	2017	5	195.4	4.5	7.6	241	9	4%
N10	Liver	2017	5	251.4	5.3	9.6	262	44	17%
N11	Whole fish	2017	5	89.2		2.8	184	11	6%
N12	Whole fish	2017	5	93.4		2.9	185	12	7%
N13	Whole fish	2017	5	77.2		3	178	10	6%
N14	Whole fish	2017	5	94.4		2.9	189	9	5%
N15	Whole fish	2017	5	91.6		2.9	182	14	8%
N16	Filet	2018	5	151.6	1.6	15.3	233	26	11%
N17	Filet	2018	5	241	2.4	10.1	288	23	8%
N18	Filet	2018	5	219	2.2	8.7	273	22	8%
N19	Filet	2018	5	207.4	2.9	12.6	254	36	14%
N20	Filet	2018	5	197	2.7	12.2	253	40	16%
N21	Liver	2018	5	122	1.8	13.9	219	18	8%
N22	Liver	2018	5	170.4	2.4	17.5	243	27	11%
N23	Liver	2018	5	146.8	1.7	14.5	232	15	6%
N24	Liver	2018	5	250.4	2.3	7.2	281	39	14%
N25	Liver	2018	5	307.6	4.1	20.5	301	17	6%
N26	Whole fish	2018	5	74.8		3.5	190.6	7	4%
N27	Whole fish	2018	5	71.8		3.2	187	6	3%
N28	Whole fish	2018	5	78.2		3.9	189.4	8	4%
N29	Whole fish	2018	5	72.5		3.1	189.8	10	5%
N30	Whole fish	2018	5	72.6		3.7	185.8	9	6%
N31	Filet	2019	5	290.6	4	18.6	306	27	9%

Sample Analysis ID	Sample matrix	Year	N	Average weight [g]	Average weight liver [g]	Lipid Level (%)	Average length [mm]	STD	CV [%]
N32	Filet	2019	5	251	3	12.8	286	22	8%
N33	Filet	2019	5	160.2	2	10.1	246	58	24%
N34	Filet	2019	5	190.2	3	16.1	250	55	22%
N35	Filet	2019	5	195.4	2.2	14.7	256	35	14%
N36	Liver	2019	5	291.4	4.7	25.9	292	36	12%
N37	Liver	2019	5	293.6	4.3	21	299	28	9%
N38	Liver	2019	5	197	2.6	24.1	253	45	18%
N39	Liver	2019	5	109	1.5	14.9	208	4	2%
N40	Liver	2019	5	208.2	2.3	14.6	263	43	16%
N41	Whole fish	2019	5	88.6		3.7	193.4	11	6%
N42	Whole fish	2019	5	100.4		4.1	196.8	9	5%
N43	Whole fish	2019	5	93.2		3.6	312.2	267	85%
N44	Whole fish	2019	5	89		3.3	194	3	1%
N45	Whole fish	2019	5	88.6		3.8	194.4	8	4%
W1	Filet	2017	5	162	2.6	17.5	235	14	6%
W2	Filet	2017	5	135.4	2	13.8	232	20	9%
W3	Filet	2017	5	116.8	1.3	8.5	223	7	3%
W4	Filet	2017	5	139	1.6	14.1	232	12	5%
W5	Filet	2017	5	127.6	1.8	13.9	221	16	7%
W6	Liver	2017	5	185.8	3	12.5	251	40	16%
W7	Liver	2017	5	192.6	2.9	19.4	250	49	20%
W8	Liver	2017	5	186.4	3.2	21	244	47	19%
W9	Liver	2017	5	158.8	2.7	17.8	235	23	10%
W10	Liver	2017	5	154.4	2.4	17.5	236	36	15%
W11	Whole fish	2017	5	73.8		3.5	193	10	5%
W12	Whole fish	2017	5	67		3.3	181	14	8%
W13	Whole fish	2017	5	89		3.7	196	3	2%
W14	Whole fish	2017	5	78		3.7	185	9	5%
W15	Whole fish	2017	5	69.8		3.5	187	7	4%
W16	Filet	2018	5	222.6	3.2	12.3	264	53	20%
W17	Filet	2018	5	208	2.7	16.6	260	48	18%
W18	Filet	2018	5	173.2	3.1	19	238	39	16%
W19	Filet	2018	5	177	3	17.3	249	38	15%
W20	Filet	2018	5	271.8	4.6	23.2	288	12	4%
W21	Liver	2018	5	224.2	3.8	15.2	259	44	17%
W22	Liver	2018	5	214.8	4.7	18.9	259	38	15%
W23	Liver	2018	5	236.8	4.4	25	278	7	3%
W24	Liver	2018	5	243.8	4.4	19.7	271	50	18%

Sample Analysis ID	Sample matrix	Year	N	Average weight [g]	Average weight liver [g]	Lipid Level (%)	Average length [mm]	STD	CV [%]
W25	Liver	2018	5	217.8	3.2	22.8	260	50	19%
W26	Whole fish	2018	5	61.8		3.4	173	14	8%
W27	Whole fish	2018	5	57.2		3.2	171	14	8%
W28	Whole fish	2018	5	68.2		3.9	179	9	5%
W29	Whole fish	2018	5	57.8		4.1	173	15	9%
W30	Whole fish	2018	5	72.8		3.9	179	11	6%
W31	Filet	2019	5	290	4.9	28.6	300	37	12%
W32	Filet	2019	5	283.2	4.8	20.9	301	48	16%
W33	Filet	2019	5	179.2	3	22.4	242	38	16%
W34	Filet	2019	5	204.2	3.4	22.3	253	48	19%
W35	Filet	2019	5	168.2	2.3	18.8	244	24	10%
W36	Liver	2019	5	285.6	5.6	28.6	291	48	16%
W37	Liver	2019	5	249.4	5.2	25	273	42	15%
W38	Liver	2019	5	274.8	5.8	21.5	293	17	6%
W39	Liver	2019	5	103	1.5	14.2	212	8	4%
W40	Liver	2019	5	203.2	2.4	18.4	262	26	10%
W41	Whole fish	2019	5	68.4		3.2	184	16	9%
W42	Whole fish	2019	5	67		4	177	18	10%
W43	Whole fish	2019	5	70.2		3.9	184	11	6%
W44	Whole fish	2019	5	55.8		4.2	173	9	5%
W45	Whole fish	2019	5	55.8		4.2	173	9	5%
E1	Filet	2017	5	103.6	1.1	12.5	215	7	3%
E2	Filet	2017	5	197.2	3.5	26.8	253	29	11%
E3	Filet	2017	5	114.8	1.6	19.5	220	18	8%
E4	Filet	2017	5	125.6	2.5	21.2	222	9	4%
E5	Filet	2017	5	132.2	2.4	18.8	225	6	3%
E6	Liver	2017	5	119.8	1.7	20.2	219	19	9%
E7	Liver	2017	5	114	1.6	18.5	217	2	1%
E8	Liver	2017	5	142.2	2.1	18.4	230	25	11%
E9	Liver	2017	5	114.8	1.5	17.2	233	18	8%
E10	Liver	2017	5	163.6	2.7	18.9	240	31	13%
E11	Whole fish	2017	5	75.6		3.9	186	11	6%
E12	Whole fish	2017	5	68		3.7	177	17	10%
E13	Whole fish	2017	5	62		3.3	173	19	11%
E14	Whole fish	2017	5	71.2		3.3	181	7	4%
E15	Whole fish	2017	5	70.2		3.2	183	8	4%
E16	Filet	2018	5	212.2	2.9	23.5	263	41	16%
E17	Filet	2018	5	139.4	2.2	16.5	230	26	11%

Sample Analysis ID	Sample matrix	Year	N	Average weight [g]	Average weight liver [g]	Lipid Level (%)	Average length [mm]	STD	CV [%]
E18	Filet	2018	5	335.6	7	26.7	296	58	20%
E19	Filet	2018	5	182.8	2.9	20.6	252	22	9%
E20	Filet	2018	5	193	3.8	17.9	243	27	11%
E21	Liver	2018	5	119.6	2.1	16.2	216	10	5%
E22	Liver	2018	5	119	1.9	17.1	215	6	3%
E23	Liver	2018	5	145.8	2.5	19.6	230	33	14%
E24	Liver	2018	5	108.8	1.7	16.8	211	5	2%
E25	Liver	2018	5	111.4	1.9	14.5	211	4	2%
E26	Whole fish	2018	5	72.6		4.2	185	14	8%
E27	Whole fish	2018	5	68.8		4.6	184	12	7%
E28	Whole fish	2018	5	72.6		4.3	185	6	3%
E29	Whole fish	2018	5	74.6		4.3	187	9	5%
E30	Whole fish	2018	5	76		4.1	184	14	8%
E31	Filet	2019	5	227.6	2.7	20.3	271	39	14%
E32	Filet	2019	5	248	3.2	20.8	279	17	6%
E33	Filet	2019	5	215.6	3.1	18.8	267	35	13%
E34	Filet	2019	5	195.8	2.2	14.3	259	33	13%
E35	Filet	2019	5	147.8	1.7	15.7	238	8	3%
E36	Liver	2019	5	219.6	3.2	20.6	268	31	12%
E37	Liver	2019	5	274.4	4.4	25.6	289	33	11%
E38	Liver	2019	5	157.6	2.3	14.8	235	41	17%
E39	Liver	2019	5	162.4	2.3	22.5	235	12	5%
E40	Liver	2019	5	191.4	2.1	21	250	41	16%
E41	Whole fish	2019	5	51.2		3.9	165	10	6%
E42	Whole fish	2019	5	51.2		2.8	167	10	6%
E43	Whole fish	2019	5	43.4		2.4	159	9	6%
E44	Whole fish	2019	5	52.2		2.4	164	12	7%
E45	Whole fish	2019	5	47.4		3.5	159	6	4%

Table II *Metal concentration in wet weight (mg/kg) for each sample ID.*

Sample Analysis ID	Total Hg	Cd	Cu	Pb	Zn
N1	0.08	0.026	9.2	0.012	33
N2	0.098	0.023	12	0.016	35
N3	0.058	0.036	13	0.011	36
N4	0.12	0.023	11	0.01	35
N5	0.1	0.024	11	0.01	33
N11	0.05	0.002	0.57	0.019	23
N12	0.06	0.002	0.61	0.017	21
N13	0.062	0.0031	0.59	0.045	22
N14	0.054	0.0027	0.61	0.027	23
N15	0.058	0.0023	0.61	0.044	22
N16	0.087	0.068	33	0.042	49
N17	0.12	0.15	22	0.031	46
N18	0.13	0.12	20	0.034	46
N19	0.14	0.079	21	0.035	44
N20	0.13	0.081	22	0.047	45
N26	0.072	0.005	0.79	0.064	23
N27	0.06	0.004	0.79	0.038	23
N28	0.076	0.004	0.78	0.029	22
N29	0.068	0.004	0.76	0.035	24
N30	0.069	0.005	0.8	0.038	25
N31	0.21	0.13	19.5	0.049	49
N32	0.2	0.11	18.2	0.036	48
N33	0.2	0.2	14.3	0.033	43
N34	0.17	0.096	21.5	0.032	48
N35	0.17	0.099	28.7	0.028	56
N41	0.068	0.0035	0.67	0.03	22
N42	0.063	0.0027	0.68	0.022	23
N43	0.073	0.004	0.64	0.034	23
N44	0.062	0.0032	0.68	0.034	28
N45	0.07	0.0026	0.65	0.034	32
W1	0.12	0.19	15	0.016	36
W2	0.11	0.25	20	0.027	44
W3	0.12	0.32	26	0.029	52
W4	0.09	0.24	16	0.047	36
W5	0.1	0.22	30	0.024	53
W11	0.062	0.013	1.2	0.048	22
W12	0.069	0.021	1.3	0.055	26
W13	0.065	0.014	1.3	0.046	23
W14	0.063	0.014	1.1	0.059	26
W15	0.065	0.013	1.1	0.043	25
W16	0.16	0.49	12	0.013	32
W17	0.14	0.41	17	0.016	39
W18	0.11	0.27	20	0.028	41
W19	0.12	0.3	17	0.023	37
W20	0.13	0.32	25	0.021	46
W26	0.065	0.016	0.98	0.043	24
W27	0.06	0.014	0.9	0.058	25
W28	0.066	0.011	0.77	0.041	26
W29	0.066	0.013	0.84	0.038	26
W30	0.062	0.012	0.87	0.029	26
W31	0.21	0.37	26.9	0.02	58
W32	0.22	0.35	27.8	0.02	58
W33	0.15	0.21	24.7	0.026	50

W34	0.21	0.28	27.7	0.023	54
W35	0.17	0.19	19.4	0.024	46
W41	0.053	0.012	0.75	0.097	25
W42	0.045	0.01	0.85	0.05	26
W43	0.045	0.0081	0.65	0.042	25
W44	0.05	0.0084	0.77	0.038	25
W45	0.05	0.0084	0.77	0.038	25
E1	0.15	0.27	37	0.033	74
E2	0.19	0.33	29	0.022	58
E3	0.09	0.14	25	0.03	59
E4	0.089	0.21	26	0.022	52
E5	0.085	0.19	27	0.023	62
E11	0.075	0.0082	1	0.032	22
E12	0.064	0.0096	1.1	0.032	22
E13	0.064	0.0097	1.1	0.034	21
E14	0.06	0.013	1.1	0.026	20
E15	0.068	0.011	1.1	0.03	21
E16	0.094	0.14	25	0.023	50
E17	0.084	0.23	25	0.022	47
E18	0.1	0.23	32	0.019	55
E19	0.099	0.19	23	0.018	52
E20	0.13	0.15	22	0.019	46
E26	0.081	0.017	1.5	0.041	23
E27	0.083	0.013	1.3	0.041	26
E28	0.083	0.017	1.4	0.035	21
E29	0.086	0.015	1.2	0.029	21
E30	0.086	0.015	1.4	0.025	20
E31	0.15	0.23	38.3	0.044	57
E32	0.22	0.33	31.8	0.037	58
E33	0.17	0.21	24.8	0.027	49
E34	0.15	0.48	26	0.044	55
E35	0.12	0.35	28.5	0.035	55
E41	0.038	0.0086	1	0.059	24
E42	0.041	0.013	0.98	0.074	27
E43	0.034	0.011	0.97	0.083	27
E44	0.041	0.012	0.85	0.11	30
E45	0.04	0.011	1	0.069	28

Table III *BDE and HBCD concentrations for each sample ID given in wet weight (µg/kg). Below limit of quantification is indicated with '<'.*

Sample Analysis ID	BDE100	BDE153	BDE154 + BB153	BDE183	BDE28	BDE47	BDE66	BDE45	BDE99	HBCD	HCB	HCBD	Heptachloor
N6	<0.1	0.1	0.4	<0.09	<0.07	0.2	<0.2	<0.1	<0.09	<1.2	0.4	<0.3	<0.3
N7	0.2	<0.08	0.4	<0.09	<0.07	0.4	<0.2	<0.1	<0.09	<1.2	0.5	<0.3	<0.3
N8	<0.1	<0.07	0.3	<0.08	<0.06	0.2	<0.2	<0.1	<0.07	<1.0	<0.08	<0.3	<0.3
N9	<0.09	<0.06	0.5	<0.07	<0.05	0.2	<0.1	<0.09	<0.06	<0.8	0.3	<0.3	<0.3
N10	0.2	<0.07	0.5	<0.08	<0.06	0.3	<0.2	<0.1	<0.07	<1.0	0.6	<0.3	<0.3
N11	<0.030	<0.020	<0.016	<0.021	<0.018	<0.084	<0.087	<0.033	<0.021		<0.12	nb	
N12	<0.031	<0.021	<0.016	<0.022	<0.019	0.095	<0.091	<0.034	<0.022		<0.12	nb	
N13	<0.031	<0.021	<0.016	<0.022	<0.019	0.093	<0.091	<0.034	<0.022		<0.12	nb	
N14	<0.030	<0.020	<0.016	<0.022	<0.019	<0.086	<0.089	<0.033	<0.021		<0.12	nb	
N15	<0.030	<0.020	<0.016	<0.021	<0.018	<0.084	<0.087	<0.033	<0.021		<0.10	nb	
N21	<0.1	<0.07	<0.08	<0.1	<0.2	0.4	<0.3	<0.1	<0.1	<2.1	1.8	<0.4	<1.4
N22	<0.1	<0.07	<0.07	<0.09	<0.2	1	<0.3	<0.1	0.2	<2.0	1.7	<0.4	<1.3
N23	<0.1	<0.07	<0.08	<0.1	<0.2	0.7	<0.4	<0.1	<0.1	<2.2	1.8	<0.4	<1.3
N24	<0.1	<0.08	<0.09	<0.1	<0.2	0.5	<0.4	<0.1	<0.1	<2.4	0.9	<0.4	<1.3
N25	<0.1	<0.08	<0.09	<0.1	<0.2	1	<0.4	<0.1	<0.1	<2.4	1.7	<0.4	<1.3
N26	0.1	0.06	0.06	<0.05	<0.02	0.3	<0.02	<0.03	0.06		<0.5	<0.02	
N27	0.08	0.06	0.06	<0.05	<0.02	0.2	<0.02	<0.03	0.06		<0.5	<0.02	
N28	0.09	0.06	0.06	<0.05	<0.02	0.3	<0.02	<0.03	0.06		<0.4	<0.02	
N29	0.09	0.06	0.06	<0.05	<0.02	0.3	<0.02	<0.03	0.06		<0.4	<0.02	
N30	0.1	0.06	0.06	<0.05	<0.02	0.3	<0.02	<0.03	0.06		<0.4	<0.02	
N36	0.6	<0.09	0.4	<0.3	<0.05	2.1	<0.05	<0.2	0.3	<0.6	<0.14	<0.64	<0.61
N37	0.6	<0.1	0.4	<0.4	<0.05	1.5	<0.05	<0.2	<0.2	<0.7	<0.16	<0.71	<0.67
N38	0.5	<0.1	0.2	<0.4	<0.06	1.2	<0.06	<0.2	0.3	<0.8	<0.15	<0.69	<0.65
N39	0.4	<0.1	0.2	<0.4	<0.06	1.1	<0.06	<0.2	0.2	<0.8	<0.15	<0.67	<0.64
N40	0.5	<0.1	0.2	<0.4	<0.05	1.4	<0.05	<0.2	0.2	<0.7	<0.15	<0.66	<0.63
N41	0.04	<0.04	<0.04	<0.05	<0.02	0.2	<0.02	<0.03	<0.03		0.3	<0.02	
N42	<0.03	<0.04	<0.04	<0.05	<0.02	0.1	<0.02	<0.03	<0.03		0.3	<0.02	
N43	0.03	<0.04	<0.04	<0.05	<0.02	0.1	<0.02	<0.03	<0.03		0.3	<0.02	
N44	0.04	<0.04	0.05	<0.05	<0.02	0.2	<0.02	<0.03	<0.03		0.3	<0.02	
N45	<0.03	<0.04	<0.04	<0.05	<0.02	0.2	<0.02	<0.03	<0.03		0.3	<0.02	

W6	0.3	0.3	0.5	<0.07	<0.05	1.2	<0.2	<0.1	<0.07	<0.9	0.5	<0.3	<0.3
W7	0.4	0.2	0.5	<0.09	0.1	1.7	<0.2	<0.1	<0.08	<1.1	1.1	<0.3	<0.3
W8	0.9	0.3	0.8	<0.08	0.3	3.2	<0.2	<0.1	0.1	<1.1	1.6	<0.3	<0.3
W9	0.5	0.2	0.5	<0.09	0.2	1.6	<0.2	<0.1	<0.09	<1.2	1.3	<0.3	<0.3
W10	0.3	0.2	0.3	<0.08	0.1	1.2	<0.2	<0.1	<0.08	<1.1	1.4	<0.3	<0.3
W11	0.05	<0.021	0.025	<0.022	<0.019	0.37	<0.090	<0.034	<0.021		<0.15	nb	
W12	0.052	<0.021	0.02	<0.022	<0.019	0.35	<0.090	<0.034	<0.021		<0.15	nb	
W13	0.13	0.021	0.079	<0.021	0.066	0.64	<0.088	<0.033	<0.021		<0.17	nb	
W14	0.057	<0.020	0.026	<0.022	0.021	0.37	<0.089	<0.033	<0.021		nb	nb	
W15	0.089	<0.020	0.038	<0.021	<0.018	0.49	<0.087	<0.033	<0.021		<0.15	nb	
W21	0.3	<0.06	<0.07	<0.08	<0.2	1.6	<0.3	<0.09	0.3	<1.8	<0.8	<0.4	<1.4
W22	0.1	<0.06	<0.06	<0.08	<0.2	1.6	<0.3	<0.09	0.2	<1.7	<0.8	<0.5	<1.7
W23	<0.1	<0.08	<0.08	<0.1	<0.2	1.1	<0.4	<0.1	0.2	<2.3	<1.0	<0.4	<1.5
W24	0.2	<0.07	<0.08	<0.1	<0.2	2.5	<0.3	<0.1	0.2	<2.1	<1.1	<0.5	<1.7
W25	0.2	<0.07	<0.08	<0.1	<0.2	1.7	<0.4	<0.1	0.2	<2.2	1	<0.4	<1.4
W26	0.1	0.05	0.07	<0.05	<0.02	0.4	<0.02	<0.03	0.05		<0.2	<0.02	
W27	0.1	0.06	0.08	<0.05	<0.02	0.4	<0.02	<0.03	0.04		<0.2	<0.01	
W28	0.1	0.06	0.09	<0.05	<0.03	0.5	<0.02	<0.03	0.06		<0.3	<0.02	
W29	0.1	0.07	0.09	<0.05	<0.02	0.6	<0.02	<0.03	0.07		<0.8	<0.04	
W30	0.1	0.06	0.08	<0.05	<0.02	0.4	<0.02	<0.03	0.05		<0.2	<0.02	
W36	0.4	0.1	0.3	<0.3	<0.05	1.1	<0.05	<0.2	<0.2	<0.7	<0.15	<0.68	<0.65
W37	0.7	<0.1	0.3	<0.4	<0.05	3.3	<0.05	<0.2	0.3	<0.7	<0.14	<0.61	<0.58
W38	0.4	0.2	0.4	<0.4	<0.06	1.4	<0.05	<0.2	0.2	<0.7	<0.14	<0.61	<0.58
W39	0.3	0.1	0.2	<0.3	<0.05	0.8	<0.05	<0.2	<0.2	<0.7	<0.15	<0.69	<0.66
W40	0.4	<0.1	0.3	<0.4	<0.05	1.3	<0.05	<0.2	<0.2	<0.7	<0.14	<0.65	<0.61
W41	0.06	<0.04	0.05	<0.05	<0.02	0.2	<0.02	<0.03	<0.03		0.09	<0.02	
W42	0.08	<0.04	0.07	<0.05	<0.02	0.3	<0.02	<0.03	<0.03		0.1	<0.02	
W43	0.1	<0.04	0.08	<0.05	<0.02	0.4	<0.02	<0.03	0.03		0.1	<0.02	
W44	0.09	<0.04	0.06	<0.05	<0.02	0.3	<0.02	<0.03	0.03		0.1	<0.02	
W45	0.09	<0.04	0.06	<0.05	<0.02	0.3	<0.02	<0.03	0.03		0.1	<0.02	
E6	0.1	0.2	0.5	<0.06	0.2	0.8	<0.1	<0.08	<0.05	<0.7	2.6	<0.4	<0.4
E7	<0.2	0.2	0.6	<0.1	0.1	0.4	<0.2	<0.2	<0.1	<1.5	2.7	<0.4	<0.4
E8	0.1	<0.06	0.4	<0.07	0.08	0.5	<0.1	<0.09	<0.06	<0.9	2.6	<0.3	<0.3

E9	0.1	0.2	0.5	<0.06	0.1	0.4	<0.1	<0.09	<0.06	<0.8	2.4	<0.3	<0.3
E10	0.1	0.1	0.9	<0.08	0.3	0.8	<0.2	<0.1	0.2	<1.0	1.9	<0.3	<0.3
E11	<0.032	<0.022	<0.017	<0.023	0.031	0.1	<0.094	<0.035	<0.022		0.48	nb	
E12	<0.033	<0.022	<0.018	<0.024	0.034	0.12	<0.10	<0.036	<0.023		0.45	nb	
E13	<0.032	<0.022	<0.017	<0.023	0.034	0.12	<0.094	<0.035	<0.022		0.39	nb	
E14	<0.034	<0.023	<0.018	<0.024	0.033	0.11	<0.10	<0.038	<0.024		0.36	nb	
E15	<0.034	<0.023	<0.018	<0.024	0.028	0.11	<0.10	<0.037	<0.023		0.41	nb	
E21	<0.1	<0.07	<0.08	<0.1	<0.2	0.5	<0.4	<0.1	0.2	<2.2	2	<0.4	<1.2
E22	<0.1	<0.08	<0.08	<0.1	<0.2	0.4	<0.4	<0.1	<0.1	<2.3	1.6	<0.4	<1.2
E23	<0.1	<0.08	<0.08	<0.1	<0.2	0.5	<0.4	<0.1	<0.1	<2.3	1.9	<0.3	<1.2
E24	<0.1	<0.08	<0.08	<0.1	<0.2	0.5	<0.4	<0.1	<0.1	<2.3	1.7	<0.4	<1.2
E25	<0.1	<0.07	<0.08	<0.1	<0.2	0.3	<0.4	<0.1	<0.1	<2.2	1.2	<0.3	<1.2
E26	0.04	0.06	0.06	<0.05	<0.03	0.2	<0.02	<0.03	0.05		<0.5	<0.03	
E27	0.06	0.06	0.06	<0.05	<0.02	0.1	<0.02	<0.03	0.05		<0.5	<0.02	
E28	0.04	0.05	0.06	<0.05	<0.02	0.1	<0.02	<0.03	0.05		<0.5	<0.02	
E29	0.04	0.05	0.06	<0.05	<0.02	0.1	<0.02	<0.03	0.04		<0.5	<0.02	
E30	0.05	0.05	0.05	<0.05	<0.02	0.1	<0.02	<0.03	0.04		<0.5	<0.01	
E36	0.3	<0.1	0.3	<0.4	<0.05	0.8	<0.05	<0.2	<0.2	<0.7	<0.14	<0.64	<0.61
E37	0.3	<0.09	0.3	<0.3	<0.05	0.9	<0.05	<0.2	<0.2	<0.6	<0.14	<0.63	<0.60
E38	0.2	0.1	0.2	<0.4	<0.05	0.6	<0.05	<0.2	<0.2	<0.7	<0.13	<0.58	<0.55
E39	0.3	<0.1	0.3	<0.3	<0.05	0.7	<0.05	<0.2	0.2	<0.7	<0.13	<0.58	<0.55
E40	0.2	<0.1	0.2	<0.3	<0.05	0.7	<0.05	<0.2	<0.2	<0.7	<0.14	<0.64	<0.61
E41	<0.03	<0.04	0.05	<0.05	<0.02	0.1	<0.02	<0.03	<0.03		0.5	<0.02	
E42	<0.03	<0.04	<0.04	<0.05	<0.02	0.1	<0.02	<0.03	<0.03		0.3	<0.02	
E43	<0.03	<0.04	<0.04	<0.05	<0.02	0.09	<0.02	<0.03	<0.03		0.3	<0.02	
E44	<0.03	<0.03	<0.04	<0.05	<0.02	0.09	<0.02	<0.03	<0.03		0.3	<0.02	
E45	<0.03	<0.04	<0.04	<0.05	<0.02	0.1	<0.02	<0.03	<0.03		0.4	<0.02	

Table IV *PFOS concentrations for each sample ID given in wet weight (µg/kg). Below limit of quantification is indicated with '<'.*

Sample Analysis ID	PFBA	PFBS	PFDcA	PFDoA	PFDS	PFHpA	PFHpS	PFHxA	PFHxS	PFNA	PFOA	PFOS	PFPeA	PFTeA	PFTrA	PFUnA
N6	<0.6	<0.5	<0.2	<0.2	<0.2	<0.6	<0.6	<0.6	<0.2	<0.2	<0.6	3.2	<0.6	<0.6	<0.6	0.2
N7	<0.6	<0.6	<0.2	<0.2	<0.2	<0.6	<0.6	<0.6	<0.2	<0.2	<0.6	7.8	<0.6	<0.6	<0.6	0.2
N8	<0.9	<0.8	<0.3	<0.3	<0.3	<0.9	<0.9	<0.9	<0.3	<0.3	<0.9	2.7	<0.9	<0.9	<0.9	0.3
N9	<0.6	<0.6	<0.2	<0.2	<0.2	<0.6	<0.7	<0.6	<0.2	<0.2	<0.6	3.6	<0.6	<0.6	<0.6	0.2
N10	<0.5	<0.5	<0.2	<0.2	<0.2	<0.5	<0.5	<0.5	<0.2	<0.2	<0.5	3.5	<0.5	<0.5	<0.5	0.4
N11	nb	<0.3	<0.2	<0.2	<0.3	<0.3	<0.3	<0.8	<0.3	<0.2	0.3	<0.3	<0.8	<0.3	<0.2	0.2
N12	nb	<0.2	<0.1	<0.1	<0.2	<0.2	<0.2	<0.6	<0.2	<0.1	0.5	<0.2	<0.6	<0.2	<0.1	0.3
N13	nb	<0.3	<0.1	<0.1	<0.3	<0.3	<0.3	<0.7	<0.3	<0.1	0.8	<0.3	<0.7	<0.3	<0.1	<0.1
N14	nb	<0.2	<0.1	<0.1	<0.3	<0.3	<0.3	<0.7	<0.3	<0.1	0.5	<0.3	<0.7	<0.3	<0.1	<0.1
N15	nb	<0.3	<0.2	<0.2	<0.3	<0.3	<0.3	<0.8	<0.3	<0.2	0.5	<0.3	<0.8	<0.3	0.7	<0.2
N21	nb	<3.2	<1.7	<1.7	<0.3	<1.7	<1.5	<1.7	<1.5	<1.7	<1.7	22	<1.7	<3.4	<1.7	<1.7
N22	nb	<2.7	<1.5	<1.5	<0.3	<1.5	<1.3	<1.5	<1.3	<1.5	<1.5	24	<1.5	<2.9	<1.5	<1.5
N23	nb	<3.2	<1.7	<1.7	1.8	<1.7	<1.6	<1.7	<1.5	<1.7	<1.7	20	<1.7	<3.5	<1.7	<1.7
N24	nb	<2.6	<1.4	<1.4	0.3	<1.4	<1.3	<1.4	<1.3	<1.4	<1.4	17	<1.4	<2.8	<1.4	<1.4
N25	nb	<3.5	<1.9	<1.9	1	<1.9	<1.7	<1.9	<1.7	<1.9	<1.9	28	<1.9	<3.7	<1.9	<1.9
N26	nb	<0.5	<0.2	<0.6	<0.2	<0.6	<0.5	<0.6	<0.5	<0.2	<0.2	5.4	<0.6	<1.2	<1.2	<0.2
N27	nb	<0.5	1.7	<0.6	<0.2	<0.6	<0.5	<0.6	<0.5	<0.2	<0.2	7.1	<0.6	<1.1	<1.1	<0.2
N28	nb	<0.6	1.4	<0.7	<0.3	<0.7	<0.6	<0.7	<0.6	<0.3	<0.3	6.5	<0.7	<1.4	<1.4	<0.3
N29	nb	<0.6	<0.3	<0.8	<0.3	<0.8	<0.7	<0.8	<0.7	<0.3	<0.3	11	<0.8	<1.5	<1.5	<0.3
N30	nb	<0.6	<0.3	<0.7	<0.3	<0.7	<0.6	<0.7	<0.6	<0.3	<0.3	9.3	<0.7	<1.4	<1.4	<0.3
N36	<0.7	<0.1	1	0.6	<0.1	<0.1	<0.1	<0.1	<0.1	0.6	0.6	11	<0.1	<0.1	<0.1	0.5
N37	<0.6	<0.1	1.5	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	1	1.6	15	<0.1	<0.1	<0.1	0.6
N38	<0.8	<0.1	3.7	0.5	<0.2	<0.2	<0.2	<0.2	<0.2	1	1.3	16	<0.2	<0.2	<0.2	1.1
N39	<0.9	<0.1	0.8	0.3	<0.2	<0.2	<0.2	<0.2	<0.2	1.2	1.4	29	<0.2	<0.2	<0.2	0.7
N40	<0.7	<0.1	1.3	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	0.6	0.6	6.9	<0.1	<0.1	<0.1	0.4
N41	<0.7	<0.6	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.6	1	0.9	4.2	<0.7	<0.7	<0.7	<0.7
N42	<0.7	<0.6	<0.7	<0.7	<0.6	<0.7	<0.6	<0.7	<0.6	0.9	0.8	3.9	<0.7	<0.7	<0.7	<0.7
N43	<0.2	<0.2	0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.4	0.6	5.5	<0.2	<0.2	<0.2	<0.2

N44	<0.2	<0.2	0.7	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.8	0.7	6.9	<0.2	<0.2	<0.2	<0.2
N45	<0.2	<0.2	0.6	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.4	0.4	4.2	<0.2	<0.2	<0.2	<0.2
W6	<1.0	<1.0	<0.4	1.7	<0.4	<1.0	<1.1	<1.0	2.9	<0.4	1.3	110	<1.0	<1.0	<1.0	6.2
W7	<1.1	<1.1	<0.4	3.3	<0.4	<1.1	<1.1	<1.1	6.4	<0.4	<1.1	120	<1.1	<1.1	<1.1	11
W8	<1.2	<1.2	<0.5	2.8	<0.5	<1.2	<1.3	<1.2	7	<0.5	14	120	<1.2	<1.2	<1.2	6.9
W9	<0.5	<0.5	<0.2	2.1	<0.2	<0.5	<0.5	<0.5	5.5	<0.2	3.5	91	<0.5	<0.5	<0.5	4.9
W10	<1.0	<1.0	<0.4	0.8	<0.4	<1.0	<1.0	<1.0	3.1	<0.4	<1.0	82	<1.0	<1.0	<1.0	4.1
W11	nb	<0.2	2.9	0.9	<0.3	<0.3	<0.3	<0.7	<0.3	0.2	1	17	<0.7	0.6	0.9	1.7
W12	nb	<0.2	1.4	2.6	<0.3	<0.3	<0.3	<0.7	<0.3	<0.1	0.7	24	<0.7	0.6	1	2.1
W13	nb	<0.2	3.3	2.2	<0.2	<0.2	<0.2	<0.6	<0.2	0.6	1.1	24	<0.6	1.3	1	2.7
W14	nb	<0.2	1.8	1.9	<0.2	<0.2	<0.2	<0.6	<0.2	1.2	1.7	16	<0.6	0.6	0.9	2.7
W15	nb	<0.2	3.8	0.8	<0.2	<0.2	<0.2	<0.6	<0.2	0.8	1.4	37	<0.6	0.6	1.1	1.9
W21	nb	<2.2	<1.2	<1.2	0.6	<1.2	<1.1	<1.2	<1.0	<1.2	<1.2	100	<1.2	<2.3	<1.2	<1.2
W22	nb	<2.5	<1.4	<1.4	1.6	<1.4	<1.2	<1.4	<1.2	<1.4	<1.4	140	<1.4	<2.8	<1.4	<1.4
W23	nb	<2.4	<1.3	<1.3	0.6	<1.3	<1.2	<1.3	<1.2	<1.3	<1.3	120	<1.3	<2.6	<1.3	<1.3
W24	nb	<2.1	<1.1	<1.1	0.4	<1.1	<1.0	<1.1	<1.0	<1.1	<1.1	120	<1.1	<2.2	<1.1	<1.1
W25	nb	<2.4	<1.3	<1.3	<0.2	<1.3	<1.2	<1.3	<1.2	<1.3	<1.3	110	<1.3	<2.6	<1.3	<1.3
W26	nb	<0.5	1.7	<0.5	<0.2	<0.5	<0.5	<0.5	1.8	<0.2	<0.2	42	<0.5	<1.1	<1.1	<0.2
W27	nb	<0.7	2.3	<0.9	<0.3	<0.9	<0.8	<0.9	1.6	<0.3	<0.3	40	<0.9	<1.7	<1.7	3.2
W28	nb	<0.6	1.3	<0.8	<0.3	<0.8	<0.7	5.4	1.4	<0.3	<0.3	48	<0.8	<1.5	<1.5	<0.3
W29	nb	<0.6	3.2	<0.7	<0.2	<0.7	<0.6	<0.7	1.8	<0.3	<0.3	41	<0.7	<1.3	<1.3	4.8
W30	nb	<0.8	3.6	<0.9	<0.3	<0.9	<0.8	<0.9	2.3	<0.4	<0.4	43	<0.9	<1.8	<1.8	4.4
W36	<0.8	<0.1	6.8	1.9	<0.2	<0.2	1.6	<0.2	4.2	1.8	1.1	110	<0.2	<0.2	2.3	5.4
W37	<0.8	<0.1	10	2.6	<0.1	<0.2	2.1	<0.2	7.3	2.3	1.1	130	<0.2	<0.2	3.1	6.8
W38	<0.7	<0.1	7	1.9	<0.1	<0.1	1.7	<0.1	4.7	1.6	0.7	170	<0.1	<0.1	1.7	4.9
W39	<0.7	<0.1	5.6	1.6	<0.1	<0.1	2.2	<0.1	4.8	1.7	0.7	160	<0.1	<0.1	2.4	5.2
W40	<0.5	<0.09	10	3.1	<0.1	<0.1	2.4	<0.1	7.8	2.1	2.2	130	<0.1	<0.1	3.7	5.9
W41	<0.2	<0.2	4.9	0.9	<0.2	<0.2	0.9	<0.2	2.7	2	1.2	64	<0.2	<0.2	<0.2	3.2
W42	<0.3	<0.3	6.1	1.2	<0.3	<0.3	1	<0.3	2.8	2.1	1.1	73	<0.3	<0.3	<0.3	4.5
W43	<0.2	<0.2	5.1	0.8	<0.2	<0.2	0.9	<0.2	2.2	1.8	0.5	67	<0.2	<0.2	<0.2	3.2
W44	<0.2	<0.2	4.4	1.2	<0.2	<0.2	0.6	<0.2	1.3	1.5	0.6	56	<0.2	<0.2	<0.2	3.2
W45	<0.2	<0.2	4.4	1.2	<0.2	<0.2	0.6	<0.2	1.3	1.5	0.6	56	<0.2	<0.2	<0.2	3.2
E6	<1.2	<1.2	<0.5	<0.5	<0.5	<1.2	<1.3	<1.2	<0.5	<0.5	<1.2	19	<1.2	<1.2	<1.2	1

E7	<0.8	<0.8	<0.3	<0.3	<0.3	<0.8	<0.8	<0.8	<0.3	<0.3	<0.8	21	<0.8	<0.8	<0.8	0.6
E8	<0.9	<0.9	<0.4	<0.4	<0.4	<0.9	<1.0	<0.9	<0.3	<0.4	<0.9	15	<0.9	<0.9	<0.9	0.2
E9	<1.6	<1.6	<0.6	<0.6	<0.6	<1.6	<1.7	<1.6	<0.6	<0.6	<1.6	19	<1.6	<1.6	<1.6	0.8
E10	<1.0	<1.0	<0.4	<0.4	<0.4	<1.0	<1.1	<1.0	<0.4	<0.4	<1.0	21	<1.0	<1.0	<1.0	1.9
E11	nb	<0.2	0.4	0.7	<0.2	<0.2	<0.2	<0.6	<0.2	1.6	0.5	5.5	<0.6	1.3	0.7	0.6
E12	nb	<0.2	<0.1	<0.1	<0.2	<0.2	<0.2	<0.6	<0.2	0.7	1.8	4.2	<0.6	0.8	0.4	0.5
E13	nb	<0.2	2.8	<0.1	<0.2	<0.2	<0.2	<0.6	<0.2	0.8	0.9	5.4	<0.6	0.9	0.4	1
E14	nb	<0.2	1.9	<0.1	<0.2	<0.3	<0.2	<0.7	<0.2	1.2	0.8	5	<0.7	0.8	<0.1	0.5
E15	nb	<0.2	1.2	<0.1	<0.2	<0.2	<0.2	<0.5	<0.2	1	0.9	3.9	<0.5	<0.2	0.9	0.5
E21	nb	<2.7	<1.5	<1.5	0.7	<1.5	<1.3	<1.5	<1.3	<1.5	<1.5	28	<1.5	<2.9	<1.5	<1.5
E22	nb	<2.0	<1.1	<1.1	4.4	<1.1	<1.0	<1.1	<1.0	<1.1	<1.1	30	<1.1	<2.2	<1.1	<1.1
E23	nb	<2.5	<1.4	<1.4	<0.2	<1.4	<1.2	<1.4	<1.2	<1.4	<1.4	19	<1.4	<2.7	<1.4	<1.4
E24	nb	<3.1	<1.7	<1.7	<0.3	<1.7	<1.5	<1.7	<1.5	<1.7	<1.7	31	<1.7	<3.3	<1.7	<1.7
E25	nb	<3.8	<2.1	<2.1	8.6	<2.1	<1.8	<2.1	<1.8	<2.1	<2.1	27	<2.1	<4.1	<2.1	<2.1
E26	nb	<0.7	1.4	<0.9	<0.3	<0.9	<0.8	<0.9	<0.8	<0.3	<0.3	7.8	<0.9	<1.7	<1.7	<0.3
E27	nb	<0.6	1.8	<0.8	<0.3	<0.8	<0.7	<0.8	<0.7	<0.3	<0.3	7.9	<0.8	<1.5	<1.5	<0.3
E28	nb	<0.6	0.9	<0.7	<0.3	<0.7	<0.6	<0.7	<0.6	<0.3	<0.3	4.9	<0.7	<1.4	<1.4	<0.3
E29	nb	<0.7	<0.3	<0.8	<0.3	<0.8	<0.7	<0.8	<0.7	<0.3	<0.3	8.3	<0.8	<1.6	<1.6	<0.3
E30	nb	<0.6	0.9	<0.7	<0.2	<0.7	<0.6	<0.7	<0.6	<0.3	<0.3	7.5	<0.7	<1.4	<1.4	<0.3
E36	<0.4	<0.07	1.5	0.6	<0.08	<0.08	<0.08	<0.08	<0.08	1.5	0.9	14	<0.08	<0.08	1.3	1.6
E37	<0.7	<0.1	2.4	0.5	<0.1	<0.1	<0.1	<0.1	<0.1	1.6	0.7	15	<0.1	<0.1	0.7	1.3
E38	<0.5	<0.09	1.4	0.2	<0.10	<0.1	<0.10	<0.1	<0.10	2.1	1.5	21	<0.1	<0.1	0.3	0.9
E39	<0.8	<0.1	1.8	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	2.1	2.1	17	<0.1	<0.1	<0.1	0.7
E40	<0.6	<0.1	3.8	0.6	<0.1	<0.1	<0.1	<0.1	<0.1	1.8	1	27	<0.1	<0.1	0.9	1.6
E41	<0.2	<0.2	0.9	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1.3	0.8	7.1	<0.2	<0.2	<0.2	<0.2
E42	<0.2	<0.1	0.8	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1	0.6	3.9	<0.2	<0.2	<0.2	<0.2
E43	<0.2	<0.2	0.9	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.9	0.5	4.2	<0.2	<0.2	<0.2	<0.2
E44	<0.2	<0.1	0.9	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	1	0.6	4.7	<0.2	<0.2	<0.2	<0.2
E45	<0.1	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.8	0.6	3.8	<0.1	<0.1	<0.1	<0.1

Table V *PCB concentrations for each sample ID given in wet weight (µg/kg). Below limit of quantification is indicated with '<'.*

Sample Analysis ID	CB-206	CB-202	CB-194	CB-187	CB-180	CB-170	CB-156	CB-153	CB-151	CB-149	CB-141	CB-138	CB-137	CB-128+174
N6	<0.2	<0.1	<0.2	1.5	0.9	0.3	<0.2	4.8	0.7	1.7	<0.2	2.7	<0.1	nb
N7	<0.2	<0.1	<0.2	3.4	1.9	0.7	0.4	8.1	1.1	2.9	<0.2	4.7	<0.1	nb
N8	<0.2	<0.1	<0.2	1.2	0.6	<0.2	<0.2	3.5	0.5	1.1	<0.2	2.1	<0.1	nb
N9	<0.2	<0.1	<0.2	1.4	0.7	<0.2	<0.2	3.9	0.6	1.4	<0.2	2.3	<0.1	nb
N10	<0.2	0.3	<0.2	5.6	3	1	0.5	14	2.1	4.5	<0.2	8.1	<0.1	nb
N11	nb	0.11	nb	0.77	0.44	0.16	0.064	2.24	0.37	0.7	<0.043	1.15	<0.029	
N12	nb	0.15	nb	1.04	0.53	0.2	0.087	3.12	0.53	1.01	0.07	1.55	<0.030	
N13	nb	0.15	nb	0.96	0.58	0.24	0.084	3.01	0.44	0.9	0.1	1.64	<0.030	
N14	nb	0.16	nb	1.09	0.7	0.25	0.11	3.32	0.48	0.78	0.082	1.68	<0.029	
N15	nb	0.13	nb	0.87	0.49	0.18	0.077	2.92	0.46	0.85	0.068	1.49	<0.028	
N21	<2.1	<1.4	<4.3	6.3	8.3	4.3	0.6	15	2.5	5.1	<0.2	8.5	<0.1	nb
N22	<2.0	<1.3	<3.9	9	11	4.9	1	27	4.7	10	0.7	14	<0.1	nb
N23	<2.1	<1.4	<4.1	8.3	6.4	3.3	1.1	27	4	7.4	0.5	16	<0.1	nb
N24	<2.0	<1.3	<4.0	4.1	2.9	1.3	0.3	16	2.4	5.1	<0.2	8.1	<0.1	nb
N25	<2.1	<1.4	<4.2	13	10	4.3	1.5	47	7	14	0.8	25	<0.1	nb
N26	<0.2	0.1	0.3	2.3	2	0.9	0.3	6.7	1.1	2.2	0.3	4.1	0.06	
N27	<0.2	0.1	0.3	1.9	1.6	0.8	0.3	5.6	1	1.9	0.3	3.4	0.04	
N28	<0.2	0.1	0.3	2.1	1.7	0.8	0.3	6	0.9	2	0.2	3.6	0.04	
N29	<0.2	0.2	0.6	2.7	3.6	1.2	0.3	7.4	1.3	2	0.4	4.1	0.08	
N30	<0.2	0.2	0.5	2.6	2.6	1	0.3	7.1	1.1	2.1	0.3	4.1	0.06	
N36	<0.73	<0.47	<0.36	19.3	14.4	5.38	1.31	61.1	10.7	20.8	1.57	29.9	<0.21	NB
N37	<0.81	<0.52	<0.39	19	12.5	4.89	1.14	53.6	9.02	16	0.99	27	<0.23	NB
N38	<0.78	<0.50	<0.38	18.4	14.2	5.57	1.26	55.7	9	18	1.39	28.2	<0.22	NB
N39	<0.76	<0.49	<0.37	11.3	8.44	2.9	<0.43	34.8	5.82	12.1	0.78	17	<0.21	NB
N40	<0.75	<0.49	<0.37	12.9	7.13	2.52	<0.43	39.6	nb	13.9	0.52	19.7	<0.21	NB
N41	<0.04	nb	nb	1.6	0.9	0.4	0.2	5	1	1.9	0.1	2.6	<0.03	
N42	<0.04	nb	nb	1.4	0.6	0.3	0.1	4.3	0.8	1.7	0.09	2.2	<0.03	
N43	<0.04	nb	nb	1.4	0.7	0.4	0.1	4.3	0.8	1.7	0.1	2.1	<0.03	
N44	<0.04	nb	nb	2	1.3	0.6	0.2	6.4	1.1	2.4	0.2	3.1	0.03	
N45	<0.04	nb	nb	1.9	1.1	0.5	0.2	5.2	1	1.9	0.1	2.5	0.03	
W6	<0.2	1.3	2.6	21	26	8.3	3.2	55	10	19	3.7	29	0.4	nb

W7	<0.2	2.6	6.7	43	57	19	8.1	110	25	30	9.2	56	0.9	nb
W8	<0.2	1.8	5.7	37	50	17	5.8	120	25	44	9.5	58	1.2	nb
W9	<0.2	1.6	3.3	29	35	11	4.4	84	17	30	5.4	41	0.6	nb
W10	<0.2	1.7	3.5	27	32	10	4.1	66	14	22	4.4	33	0.5	nb
W11	nb	0.64	nb	5.09	5.77	1.99	0.7	14.7	3.6	5.95	1.13	6.94	0.13	
W12	nb	0.72	nb	5.86	7.53	2.62	0.86	16.5	4.08	6.04	1.38	7.95	0.17	
W13	nb	0.85	nb	5.92	6.76	2.44	0.88	19.1	4.38	7.87	1.28	9.1	0.16	
W14	nb	1.03	nb	6.27	6.42	2.6	1.07	19.8	4.28	7.87	1.22	9.25	0.21	
W15	nb	0.74	nb	5.43	6.28	2.25	0.81	17	3.98	6.67	1.23	8.94	0.16	
W21	<2.2	<1.5	<4.4	26	35	12	3.9	100	15	27	4.2	50	1	nb
W22	<2.7	1.8	<5.4	34	46	16	5.3	100	18	24	6.2	51	1.1	nb
W23	<2.3	<1.5	<4.6	27	32	10	4.5	69	20	20	4.1	28	0.8	nb
W24	<2.7	2.8	<5.4	45	56	18	6.3	190	30	52	10	82	1.7	nb
W25	<2.2	<1.5	<4.5	33	35	12	4.4	100	22	35	6.5	47	1.1	nb
W26	<0.2	0.2	0.6	4.9	5.5	2	0.7	16	3.7	6.6	1.3	7.8	0.2	
W27	<0.2	0.2	0.5	4.6	5.8	2	0.7	16	3.6	6.4	1.2	8	0.2	
W28	<0.2	0.3	0.5	5.4	5.8	2	0.8	19	4.2	8.1	1.4	10	0.2	
W29	<0.2	<0.03	0.3	5.1	5.7	2.3	1	17	4.1	8.2	1.5	10	0.3	
W30	<0.2	0.2	0.6	5	5.4	1.9	0.8	16	3.8	6.5	1.3	8.2	0.2	
W36	<0.77	<0.50	<0.38	46	51	15.9	5.7	96	28	25.2	5.62	38.3	0.88	NB
W37	<0.70	<0.45	<0.34	43	53.7	17.5	6.15	126	30.5	45.7	9.04	62.8	1.1	NB
W38	<0.70	<0.45	<0.34	33.9	37.9	12.4	3.82	92.9	19.5	29	4.88	43	0.54	NB
W39	<0.79	<0.51	<0.38	27.9	32.2	10.3	2.74	82.1	16.5	25.3	4.28	38	0.48	NB
W40	<0.74	<0.47	<0.36	38.3	39.8	12	4.25	103	23.5	29.1	5.46	42.7	0.71	NB
W41	0.08	nb	nb	3.2	2.9	1.1	0.4	12	2.8	5.2	0.7	5.2	0.1	
W42	0.1	nb	nb	4.1	4.4	1.7	0.6	15	3.6	6.3	0.9	6.8	0.1	
W43	0.1	nb	nb	5.2	5.5	2	0.7	18	4.3	7.8	1.2	8.4	0.2	
W44	0.1	nb	nb	5.4	5.9	2.1	0.8	18	4.3	7.5	1.2	8.2	0.2	
W45	0.1	nb	nb	5.4	5.9	2.1	0.8	18	4.3	7.5	1.2	8.2	0.2	
E6	<0.2	1.5	2.2	16	15	5.5	2.2	28	5.5	10	1.3	15	0.2	nb
E7	<0.2	1.1	1.7	14	13	5.1	1.9	27	5.1	8.2	1.1	15	0.2	nb
E8	<0.2	1.2	1.8	13	12	4.4	1.6	25	4.6	8.3	1	13	0.2	nb
E9	<0.2	1	1.6	12	11	4.2	1.7	19	4	6.8	0.8	11	<0.1	nb
E10	<0.2	0.9	1.6	13	12	4.5	1.8	25	4.5	10	1	15	0.1	nb

E11	nb	0.34	nb	2.23	1.68	0.76	0.28	4.99	1.03	1.95	0.19	2.63	0.039	
E12	nb	0.37	nb	2.57	2.06	0.92	0.33	6.51	1.25	2.52	0.27	3.5	0.044	
E13	nb	0.34	nb	2.22	1.72	0.75	0.29	5.89	1.16	2.41	0.26	3.12	0.041	
E14	nb	0.35	nb	2.29	1.92	0.85	0.3	5.69	1.14	2.27	0.26	3.07	0.042	
E15	nb	0.34	nb	2.38	1.83	0.83	0.3	5.76	1.05	2.21	0.24	3.03	0.042	
E21	<1.9	<1.3	<3.9	12	7	2.9	1	20	4	7.6	0.6	11	<0.1	nb
E22	<1.9	<1.3	<3.8	12	6.6	2.8	1.2	15	3.1	5.1	0.4	8	<0.1	nb
E23	<1.9	<1.2	<3.7	12	10	4.3	1.3	25	5.3	10	1	14	0.1	nb
E24	<1.9	<1.3	<3.8	13	11	5.4	1.5	28	5.9	11	1.1	15	<0.1	nb
E25	<1.8	<1.2	<3.6	9.5	7.2	3.6	1.1	18	3.7	6.7	0.6	9.3	<0.1	nb
E26	<0.2	0.2	0.3	2.5	1.9	0.9	0.3	5.4	1.1	2.3	0.3	3.1	0.03	
E27	<0.2	0.2	0.2	2.4	1.7	0.8	0.3	5.7	1.1	2.5	0.3	3.3	0.05	
E28	<0.2	0.2	0.3	2.2	1.9	0.8	0.3	5	1	2.2	0.2	2.9	0.04	
E29	<0.2	0.2	0.4	2.5	2.2	1	0.3	5.9	1.2	2.4	0.3	3.4	0.04	
E30	<0.2	0.1	0.3	2.1	1.8	0.8	0.3	4.8	1	2.1	0.3	2.8	0.05	
E36	<0.73	<0.47	<0.35	25.0	16.0	5.86	1.95	55.2	10.8	14.4	1.36	27.7	<0.20	NB
E37	<0.71	<0.46	<0.35	26.5	16.4	5.35	1.74	62.9	9.5	17.6	1.63	30.6	<0.20	NB
E38	<0.65	<0.42	<0.32	18.5	11.9	4.19	1.18	38.9	8.19	11.1	0.88	19.3	<0.18	NB
E39	<0.66	<0.42	<0.32	22.4	13.4	4.37	1.25	48.0	9.70	14.9	1.21	23.6	<0.19	NB
E40	<0.73	<0.47	<0.35	18.2	10.8	3.85	1.14	37.3	11.6	8.9	0.66	17.9	<0.21	NB
E41	0.06	nb	nb	2.1	1.3	0.6	0.2	5.6	1	2.1	0.2	3	0.04	
E42	0.06	nb	nb	2.3	1.5	0.7	0.2	5.9	1.1	2.4	0.2	3.1	0.04	
E43	0.06	nb	nb	1.8	1.1	0.4	0.2	4.5	0.8	1.7	0.1	2.3	<0.03	
E44	<0.04	nb	nb	1.9	1	0.4	0.2	4.9	0.9	1.9	0.1	2.5	0.03	
E45	0.07	nb	nb	2.3	1.6	0.7	0.2	6	1.1	2.5	0.2	3.1	0.04	

Table V *Continued; PCB concentrations for each sample ID given in wet weight (µg/kg). Below limit of d quantification is indicated with '<'.*

Sample Analysis ID	CB-128	CB-118	CB-110	CB-105	CB-101	CB-97	CB-87	CB-85	CB-66	CB-56	CB-52	CB-49	CB-47	CB-31	CB-28
N6	0.4	2	1.2	0.4	1.7	0.3	0.3	0.2	0.6	<0.3	1.3	0.8	<2.4	<0.2	0.4
N7	0.8	3.3	2.1	0.6	2.8	0.6	0.5	0.4	1	0.5	1.7	1.1	<3.0	1.1	0.3
N8	0.3	1.6	0.9	<0.2	1.2	<0.2	<0.2	<0.2	0.6	<0.4	1.1	0.8	<3.2	1.3	0.4
N9	0.4	1.7	1	0.3	1.2	0.3	0.3	0.2	0.5	<0.4	1	0.8	<3.1	1	<0.2
N10	1	5.2	3.1	0.8	4.2	0.9	<0.08	1.2	1.4	0.6	2.6	1.8	<3.3	1.3	0.6
N11	0.17	0.8	0.51	0.11	0.72	<0.084	0.12	0.056	0.35	0.1	0.62	0.42	<0.39	0.21	0.28
N12	0.25	1.03	0.67	0.17	1.12	0.14	0.12	0.1	0.47	0.11	0.82	0.56	<0.44	0.28	0.33
N13	0.25	0.88	0.58	0.15	0.86	0.11	0.13	0.1	0.38	0.1	0.63	0.42	<0.30	0.22	0.28
N14	0.25	0.92	0.56	0.15	0.95	0.095	0.1	0.079	0.37	0.091	0.65	0.44	<0.29	0.24	0.29
N15	0.22	0.82	0.56	0.16	0.98	0.11	0.13	0.074	0.36	0.11	0.65	0.45	<0.36	0.24	0.28
N21	<4.3	6.5	4.4	1.2	6.7	1.2	1.1	0.7	2.5	0.9	4	3.1	<6.7	2.2	2.4
N22	<3.9	10	8.5	1.6	12	1.9	1.7	1	3.8	1.1	7.2	5.2	<5.4	2.8	3.2
N23	<4.1	8.7	5.4	1.4	7.8	1.3	1.2	0.6	4	1.1	6.3	4.8	<7.8	2.8	3.3
N24	<4.0	5	3.7	0.8	5.3	0.8	0.8	0.4	2.4	0.7	4.2	3.1	<6.3	1.5	1.9
N25	<4.2	13	8.4	2.3	13	1.9	1.8	1.4	5.5	1.3	8.7	6.2	<7.5	3.5	4.1
N26	0.6	2.4	1.6	1.6	2.4	0.4	0.4	0.3	1.3	0.3	1.9	1.4	<1.1	1	1.3
N27	0.6	2.1	1.5	0.5	2.2	0.4	0.4	0.3	1.2	0.3	1.8	1.4	<1.1	1	1.1
N28	0.6	2.3	1.6	0.4	2.2	0.4	0.4	0.3	1.3	0.3	1.9	1.5	<1.2	1.1	1.4
N29	0.6	2.3	1.4	0.5	2.3	0.4	0.4	0.3	1.2	0.3	1.8	1.4	2.3	0.9	1.2
N30	0.6	2.4	1.5	0.6	2.2	0.4	0.4	0.3	1.3	0.3	1.8	1.4	<1.6	1	1.3
N36	4.04	19.5	15.2	2.81	21.7	3.87	3.2	1.69	8.46	1.64	13.3	11.7	5.65	4.31	5.31
N37	3.83	18.3	12.3	2.6	17.5	2.76	2.5	1.42	7.28	1.34	10.9	9.6	5.12	3.4	4.35
N38	3.96	17.4	13.1	2.81	17.9	2.81	2.37	1.38	7.01	1.17	11	9.5	4.79	3.44	4.34
N39	2.59	11	8.6	1.63	11.8	2.03	1.59	0.88	4.66	0.9	7.49	5.92	3.36	2.48	2.95
N40	NB	12.8	10	1.7	13.9	2.31	2	0.75	5.55	1.05	9.33	7.34	4.05	2.66	3.43
N41	0.5	1.7	1.2	0.3	1.8	0.3	0.2	0.2	0.8	0.2	1.4	0.9	0.6	0.4	0.6
N42	0.3	1.6	1.2	0.3	1.8	0.3	0.3	0.2	0.9	0.2	1.7	1.1	0.7	0.6	0.7
N43	0.3	1.5	1.1	0.3	1.8	0.3	0.3	0.2	0.8	0.1	1.4	1	0.6	0.5	0.6
N44	0.5	2	1.6	0.3	2.3	0.4	0.3	0.2	1	0.2	1.6	1.1	0.7	0.5	0.6
N45	0.4	1.9	1.3	0.3	1.9	0.3	0.3	0.2	0.9	0.1	1.5	0.9	0.7	0.4	0.5

W6	4.2	14	12	2.9	18	3	2.4	1.8	4.3	1.1	8.3	5.5	<6.8	3.9	4.6
W7	7.2	32	23	6.3	42	5.6	5.2	3.2	7.7	1.9	21	11	<10	6.4	9
W8	7.7	26	24	5.5	38	5.8	5.9	3.8	8.7	2.1	20	13	<13	9.4	12
W9	5.9	21	18	4.1	28	4.7	4	3	7	1.7	16	11	<8.7	8.1	11
W10	4.9	17	14	3.4	23	3.8	3.3	2.5	5.8	1.2	14	9.5	<10	6.8	8.6
W11	1	3.48	3.73	0.74	5.6	0.9	0.87	0.5	1.45	0.49	2.78	1.94	1.43	1.06	1.99
W12	1.14	3.76	3.7	0.78	5.5	0.95	0.9	0.5	1.43	0.46	2.71	1.74	1.31	0.93	1.85
W13	1.34	4.3	4.52	0.96	6.71	1.21	1.07	0.65	1.56	0.55	3.05	2.15	1.59	0.96	1.93
W14	1.59	5.44	6.02	1.09	6.8	1.57	1.15	0.72	1.85	0.6	2.92	2.14	1.55	1.22	2.1
W15	1.16	3.97	4.16	0.84	6.07	1.11	0.96	0.6	1.45	0.46	2.89	1.89	1.42	0.82	1.69
W21	6.1	19	17	3.8	24	3.9	4	2.7	6.2	1.4	12	7.8	<11	2.4	4.5
W22	6.2	22	16	4.3	25	4	3.6	2.3	5.7	1.2	11	6.3	<10	1.7	4
W23	<4.6	19	11	2.7	18	3.4	2.7	1.4	4.3	1.1	14	6.4	<6.8	2.4	4.2
W24	9.4	35	27	6.9	48	6.7	6.3	5.1	10	1.5	18	12	<15	3.1	7.9
W25	5.2	23	22	4.6	34	5.5	5.1	2.7	6.9	1.5	16	9.3	<10	2.3	4.9
W26	1	4	4.5	0.8	7	1.2	1.1	0.7	1.3	0.3	3.1	1.9	<1.6	<0.5	0.9
W27	1	3.9	4.4	0.9	6.9	1.1	1.1	0.6	1.3	0.3	2.9	1.8	<1.5	<0.5	0.8
W28	1.2	4.6	5.4	1.1	7.8	1.5	1.3	0.7	1.5	0.4	3.5	2.2	1.8	<0.6	1
W29	1.4	5.3	7.4	2	7.4	1.8	1.5	0.8	1.8	0.5	3.5	2	<1.6	0.9	1.3
W30	1	4	4.3	1	6.3	1.2	1.1	0.6	1.2	0.3	3.1	1.7	<1.6	<0.4	0.9
W36	5.08	28.3	16.5	4.05	23.8	4.81	4.2	1.97	5.22	0.99	16.9	8.93	4.91	2.14	3.84
W37	7.22	31.4	34.3	6.75	43.5	7.49	7.59	3.47	8.88	1.73	21.1	12.2	7.65	2.31	4.8
W38	5.79	22.7	19	4.02	26.3	4.46	4.13	2.19	5.68	1.11	11.6	7.66	4.68	1.75	3.23
W39	5.53	18.2	15.9	3.24	23.3	3.76	3.27	2.19	4.23	0.8	8.98	6.07	3.63	1.31	2.59
W40	6.4	25.4	18.2	4.19	30.4	4.51	4.12	2.71	5.86	0.81	13.8	8.82	5.42	1.82	3.77
W41	0.8	2.6	3.1	0.5	5.3	0.8	0.7	0.4	0.9	0.2	2.1	1.4	0.9	0.2	0.5
W42	1.1	3.5	4.3	0.8	7	1.1	0.9	0.6	1.3	0.3	3.2	2	1.3	0.4	0.8
W43	1.3	4.2	5.2	0.9	8.1	1.4	1.1	0.7	1.4	0.3	3.8	2.3	1.7	0.4	0.9
W44	1.2	4.2	5.2	0.9	7.8	1.4	1.1	0.7	1.4	0.3	3.5	2	1.4	0.3	0.8
W45	1.2	4.2	5.2	0.9	7.8	1.4	1.1	0.7	1.4	0.3	3.5	2	1.4	0.3	0.8
E6	2.7	9.1	5.9	1.7	7.7	1.5	1.2	1	2.4	0.9	3.8	2.3	<4.8	1.6	1.4
E7	2.6	8.2	5.4	1.6	6.6	1.2	1	0.8	2	0.8	3.7	2.1	<4.7	1.6	1.2
E8	2.1	7.2	4.5	1.2	6.6	1.2	0.9	0.7	1.7	0.7	3.7	2.4	<3.5	1.8	1.8
E9	2	6.6	4.1	1.2	5.4	1.1	0.9	0.7	1.7	0.8	3	1.8	<4.7	1.6	1.1

E10	2.6	7.8	5.3	1.6	7.1	1.5	1.1	0.8	2.1	0.9	3.2	2.2	<8.5	1.2	0.9
E11	0.47	1.44	1.11	0.31	1.49	0.28	0.24	0.16	0.55	0.19	0.73	0.46	<0.36	0.22	0.33
E12	0.59	1.61	1.29	0.33	1.81	0.33	0.27	0.19	0.6	0.21	0.79	0.5	<0.42	0.22	0.36
E13	0.54	1.47	1.3	0.32	1.87	0.33	0.26	0.17	0.57	0.19	0.77	0.52	<0.49	0.21	0.33
E14	0.56	1.4	1.22	0.3	1.67	0.29	0.26	0.17	0.53	0.18	0.73	0.46	<0.40	0.19	0.3
E15	0.55	1.46	1.19	0.32	1.55	0.28	0.24	0.17	0.52	0.19	0.67	0.43	<0.40	0.18	0.28
E21	<3.9	6.5	4.6	1.2	6.1	1.1	1.1	0.6	2.4	0.9	3.2	<2.0	<4.1	0.8	1.3
E22	<3.8	6.5	3.9	1.1	5.3	1	1	0.6	2.4	0.8	3.3	2.2	<4.7	1	1.5
E23	<3.7	7	5.3	1.3	7.3	1.3	1.1	0.7	2.6	0.8	3.8	2.2	<3.9	1.1	1.5
E24	<3.8	7.7	5.4	1.4	7.1	1.3	1.2	0.7	2.6	0.8	3.4	2.3	<4.9	0.9	1.4
E25	<3.6	5.4	3.4	0.9	4.6	0.9	0.8	0.4	1.9	0.7	2.5	<1.6	<5.3	0.9	1.1
E26	0.5	1.7	1.2	0.5	1.7	0.3	0.3	0.2	0.6	0.2	<0.9	0.5	<0.5	<0.3	0.4
E27	0.5	1.7	1.4	0.4	1.8	0.4	0.3	0.2	0.6	0.2	<0.9	0.5	<0.5	<0.3	0.4
E28	0.4	1.5	1.2	0.3	1.6	0.3	0.3	0.2	0.6	0.2	<0.9	0.5	<0.5	<0.3	0.4
E29	0.5	1.6	1.3	0.3	1.7	0.3	0.3	0.2	0.6	0.2	<0.9	0.5	<0.5	<0.3	0.4
E30	0.5	1.4	1.2	0.3	1.5	0.3	0.3	0.2	0.5	0.2	<0.7	0.4	<0.5	<0.3	0.4
E36	5.02	14.2	7.79	2.40	11.5	1.58	1.69	1.29	3.97	<0.65	4.00	2.98	1.94	1.13	2.07
E37	3.82	15.7	9.44	2.69	15.4	2.23	2.25	1.37	4.81	0.69	5.18	3.71	2.19	1.45	2.53
E38	4.16	10.1	5.61	1.54	8.47	1.2	1.24	0.78	2.84	<0.59	2.95	2.16	1.43	0.9	1.54
E39	4.73	12.0	7.93	1.98	12.3	1.84	1.92	1.16	4.02	0.72	4.46	3.66	1.90	1.42	2.43
E40	NB	10.8	5.33	1.54	8.26	1.01	1.14	0.67	3.01	<0.66	3.5	1.96	<1.29	1.01	1.71
E41	0.5	1.5	1.1	0.3	1.5	0.3	0.2	0.2	0.6	0.1	0.5	0.5	0.2	0.2	0.3
E42	0.6	1.4	1.2	0.3	1.5	0.3	0.2	0.2	0.5	0.1	0.5	0.4	0.2	0.1	0.2
E43	0.4	1.1	0.9	0.2	1.2	0.2	0.2	0.1	0.4	<0.08	0.4	0.3	0.2	0.1	0.2
E44	0.4	1.2	1	0.2	1.4	0.2	0.2	0.2	0.4	<0.08	0.5	0.4	0.2	0.1	0.2
E45	0.6	1.5	1.3	0.3	1.7	0.3	0.3	0.2	0.6	0.1	0.7	0.5	0.3	0.2	0.3

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