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Abstract
The 2023 Screening Programme aimed to investigate the presence of emerging environmental concerning substances 1) at so-called "hot spot" locations, and 2) in marine top predators. Part 1 covered emerging substances that were considered for EU regulation; persistent, mobile and toxic; identified as problematic (Sweden); and UV-stabilizers. Sampling sites were a wastewater treatment plant, indoor dust, agricultural soils, and consumer products. Part 2 covered substances found in the 2021 Screening Programme as well as selected through the LIfeAPEX project. Additionally, in part 2, several classical legacy contaminants were included. A unique sample set was assembled with different types of tissue from whales (killer whale, sperm whale, fin whale, humpback whale, white beaked dolphin, and harbor porpoise) and sharks (greenland shark, porbeagle shark, and spiny dogfish). Highlights from the results in part 1 covered a high detection frequency and concentrations of one phthalate (CAS 6422-86-2) and two UV-stabilizers (CAS 154702-15-5 and 103597-45-1). In part 2, only a small number of the emerging substances were identified, while many of the legacy substances were found at high levels.

Keywords: Emerging contaminants, Environmental monitoring, Urban environment, Marine top predators
Emneord: Nye miljøgifter, Miljøovervåkning, Urbane miljøer, Marine toppredatorer

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Preface

On behalf of the Norwegian Environment Agency (NEA), the Norwegian Institute for Water Research (NIVA) and NILU have carried out the 2023 Screening Programme.

Coordinator at NEA was Bård Nordbø, the project manager at NIVA was Cathrine Brecke Gundersen, and with Maja Nipen coordinating from NILU.

Sampling was carried out by Christian Vogelsang, Anne Luise Ribeiro, Bjørnar Beylich, Marijana Stenrud Brkljacic, Siri Røang Moy, Sophie Mentzel, Sissel Brit Ranneklev, and Anne Karine Halse.

Samples of whales were provided from Professor Katrine Borgå at the University of Oslo, Eve Marie Jourdain from the Norwegian Orca Survey (NOS), and from Pierre Blévin at Akvaplan-niva (APN). Samples of sharks were provided by Claudia Junge and Ingrid Marie Bruvold at the Institute of Marine Research (IMR). Coordination of sampling equipment and chemical data was carried out by Kine Bæk (NIVA). Oda Ellingsen (NIVA) contributed with administrative support.

Chemical analyses were performed by Thomas Rundberget and Laura Röhler (NIVA), Anders Røsrud Borgen, Vladimir Nikiforov, Mikael Harju, Jøran Solnes Skaar, Ingeborg Lysberg, and Hans Gundersen (NILU). Data analyses and reporting were executed by Cathrine Brecke Gundersen, Malcolm Reid, and Anders Ruus (NIVA), Maja Nipen, Pawel Rostkowski, Vladimir Nikiforov, Cleo Lisa Davie-Martin, Anne Karine Halse, and Natascha Schmidt (NILU). IFE, Institute for Energy Technology, analysed the stable isotopes of nitrogen and carbon in the samples.

Quality assurance was performed by Merete Grung and Mari Moren (NIVA). Reporting to Vannmiljø and the NORMAN Database was performed by Cleo Lisa Davie-Martin (NILU).

We thank everyone involved for a nice collaboration.

Oslo, 02.10.2024

Cathrine Brecke Gundersen

Summary

The 2023 Screening Programme aimed to investigate the presence of emerging environmental concerning substances: 1) at so-called "hot spot" locations, and 2) in marine top predators. Part 1 covered substances that are considered for EU regulation (REACH); persistent, mobile and toxic (PMT); identified as problematic by the Swedish chemicals' authority (exposure index); and UV-stabilizers. Part 2 covered substances found in the 2021 Screening Programme as well as selected through the LIfeAPEX project. Additionally, in part 2, several classical legacy contaminants were included.

Functional use and physiochemical properties of the substances were critical factors guiding the design of the sampling campaign. In part 1, many of the substances are associated with plastics, in addition to a range of other uses, e.g. lubricating oil, perfumes, fungicides, hair colour, and electronics. Based on this, selected sampling sites covered a wastewater treatment plant (with low and high degrees of treatment); marine recipient samples in the vicinity of the plant (blue mussels and sediments); indoor dust (private homes and a plastic recycling facility); agricultural soils; and different types of consumer products. The substances in part 2 were susceptible to biotic uptake and bioaccumulation/ biomagnification. Therefore, the focus was on marine species high in the food web. A unique sample set was assembled, consisting of species of whales (*killer whale, sperm whale, fin whale, humpback whale, white beaked dolphin*, and *harbor porpoise*) and sharks (*greenland shark, porbeagle shark*, and *spiny dogfish*) with different types of tissue (*blubber, liver, and muscle*). The samples originated from stranded individuals, bycatch from industrial fishing, or from a scientific survey.

The results from part 1 showed convergence for a few of the substances being found in most of the sample categories. This included the phthalate B-2ETF (CAS 6422-86-2) which is used as a replacement for a legacy phthalate (DINP, CAS 28553-12-0), and the UV-stabilizers UV310 (CAS 154702-15-5) and UV360 (CAS 103597-45-1). In blue mussels, the levels of B-2ETF and UV310 exceeded their predicted-no-effect concentrations (PNECs), and this was also the case for UV360 in marine sediments. This means that adverse effects may occur, although it should be noted that the PNECs in question are associated with relatively high uncertainties by being QSAR derived (in contrast to experimentally derived). The phthalate DIUDP (CAS 96507-80-1) was also identified in most samples, but without quantitative information due to the lack of standard material (i.e. suspect screening). Other substances identified with high site-specific detection frequencies and average concentrations were, at the wastewater treatment plant: OTNE (CAS 54464-57-2), BZDSA (CAS 117-61-3), TBPHT (CAS 31274-51-8), and BEMT (CAS 187393-00-6), in indoor dust: BZBA (CAS 120-51-4), in electronics: UV329 (CAS 3147-75-9), and in agricultural soils: TMPID (CAS 3910-35-8).

In part 2, only a small number of the emerging substances were detected, while many of the classical legacy substances were found. Overall, the samples with the highest number of identified substances and concentrations were, not surprisingly, blubber from top predator whales. Among the emerging substances, both DTBMMP (CAS 2773-50-4) and B-2ETF (CAS 6422-86-2) were found at levels exceeding their respective QSAR derived PNECs. Although for the DTBMMP, this was based on a single detection. For the B-2ETF, there were questions related to possible sample contamination during storage, suggesting more research is needed to confirm these findings. Also, a few substances analysed by suspect screening, were found at high detection frequencies. From the legacy substances, several of the PBDEs, PCBs, as well as mercury stood out with high detection frequencies and concentrations, and thereby demonstrating their role as classical legacy contaminants. A total of 20 substances were found at levels exceeding their respective PNEC values. Note that most applied PNECs were associated with high uncertainty, both by being QSAR derived and by being developed for fish. There were no PNECs available for whales and sharks. Given their high position in the food-chain, these species may be more sensitive compared to fish.

Site specific contamination patterns were investigated but note that due to occasionally limited number of replicates statistical-based conclusions cannot be drawn. At the wastewater treatment plant, the results indicate that high degree removal can partly or completely remove the following substances from the water phase: DABPA (CAS 1745-89-7), UV324 (CAS 70321-86-7), PF201 (CAS 232938-43-1), MABT (CAS 127-25-3), BEMT (CAS 187393-00-6), TBPHT (CAS 31274-51-8), UV1164 (CAS 2725-22-6), and UV310 (CAS 154702-15-5), etc. Interestingly, this included the substances found in the marine recipient samples at levels exceeding their PNECs (e.g. UV310). Indoor dust from private homes revealed a wide range of substances, and even exceeded the number of compounds found in the dust from the plastic recycling facility. This demonstrates the wide range of potential contamination sources in our homes which is not restricted to plastics. From the product testing, the replacement phthalate B-2ETF was found in multiple sample categories, and with high levels in electronics.

Among the species analysed in part 2, the highest levels of most substances were found in killer whales. Particularly one individual of a stranded subadult killer whale showed the highest concentrations of the classical legacy contaminants as well as a few of the emerging contaminants. In fact, the total concentration of PCBs was found to surpass, by more than an order of magnitude, a threshold value for onset of physiological effects. This individual was known to have belonged to a seal eating pod, and it is possible that it has been exposed through mothers' milk of a seal eating female. The contributing factor of environmental contaminants to the death of this young individual is unknown but possible.

From one individual of harbor porpoise, different types of tissue were available to assess the distribution of the substances between blubber, liver and muscle. While, as expected, the lipophilic contaminants were found in the blubber (e.g. PCB), other types dominated in the liver. These covered different forms of PFAS-substances (groups PFCA, nPFAS, and PFAS) and mercury, which are known to bind to proteins in the blood. The overall highest level of mercury was found in muscle from the greenland shark.

Interestingly, for several of the substances in part 2, levels in top predator shark liver appeared higher than, or approximately equal to, those in intermediate predator whale blubber. Porbeagle shark and spiny dogfish are generally more easily accessible than whales and could therefore be considered for future studies. Moreover, with sharks, the different types of tissue (blubber, liver, and muscle) can be more easily obtained, and from which substances with a wide range of different physiochemical properties can be identified.

Sammendrag

Screeningprogrammet 2023 hadde som mål å undersøke forekomsten av nye typer mulig miljøskadelige stoffer 1) ved såkalte "hot spot" steder, og 2) i marine toppredatorer. Del 1 dekket stoffer som vurderes for EU-regulering (REACH); er persistente, mobile og toksiske (PMT); er identifisert som problematiske av svenske kjemikaliemyndigheter (eksponeringsindeksen); og UV-stoffer. Del 2 bestod av stoffer som ble funnet i screeningprogrammet 2021, samt som ble utvalgt gjennom LIfeAPEX-prosjektet. I tillegg ble det i del 2 inkludert en lang rekke klassiske miljøgifter.

Kjente bruksområder samt stoffenes fysisk-kjemiske egenskaper var viktige faktorer for valg av prøvetakingssteder og prøvetyper. Mange av stoffene i del 1 var assosiert med plast, mens de resterende hadde et vidt bruksområde som for eksempel i smøreolje, parfymer, soppmidler, hårfarge og elektronikk. På bakgrunn av dette ble prøver samlet inn fra et avløpsrenseanlegg (med lav og høy rensegrad); marine resipientprøver (blåskjell og sedimenter) i nærheten av renseanlegget; innendørs støv (private hjem og et plastresirkuleringsanlegg); landbruksjord; og forskjellige typer forbrukerprodukter. Stoffene i del 2 var antatt biotilgjengelige og med mulighet for oppkonsentrering/biomagnifisering. Derfor ble marine arter høyt i næringsnettet valgt ut som prøvetype. Et unikt prøvesett bestående av ulike arter hval (*spekkhogger, spermhval, finnhval, knølhval, delfin og nise*) og hai (*håkjerring, håbrann og pigghå*) med ulike vevstyper (*spekk, lever og muskel*) ble satt sammen. Prøvene kom fra strandede individer, bifangst fra industrielt fiske eller fra et vitenskapelig tokt.

Fra del 1 skilte flere av stoffene seg ut ved å bli identifisert i de fleste av prøvetypene. Dette gjaldt ftalatet B-2ETF (CAS 6422-86-2) som brukes som erstatning for allerede regulerte substanser (DINP, CAS 28553-12-0), og UV-stoffene UV310 (CAS 154702-15-5) og UV360 (103597-45-1). I blåskjell ble B-2ETF og UV310 funnet ved nivåer som oversteg deres såkalte ingen-observerte-effekt konsentrasjoner (kalt PNEC – «predicted no-effect concentration»), og det var også tilfellet for UV360 i marine sedimenter. Dette betyr at vi ikke kan utelukke negative miljøeffekter, samtidig som det må bemerkes at disse PNEC-verdiene er forbundet med relativt høy usikkerhet ettersom de er QSAR-utledet (i motsetning til eksperimentelt utledet). Ftalatet DIUDP (CAS 96507-80-1) ble også identifisert i de fleste prøvetyper, men uten kvantitativ informasjon ettersom analytiske standarder ikke var tilgjengelig (dvs. «suspect screening»). Andre stoffer som ble identifisert med høy stedsspesifikk deteksjonsfrekvens og gjennomsnittskonsentrasjoner var, ved avløpsrenseanlegget: OTNE (CAS 54464-57-2), BZDSA (CAS 117-61-3), TBPHT (CAS 31274-51-8) og BEMT (CAS 187393-00-6), i innendørs støv: BZBA (CAS 120-51-4), i elektronikk: UV329 (CAS 3147-75-9), og i landbruksjord: TMPID (CAS 3910-35-8).

I del 2 ble kun et fåtall av de nye mulig miljøskadelige stoffene påvist, mens en lang rekke av de klassiske miljøgiftene ble funnet. Samlet sett var det spekk fra toppredator hvaler som hadde det høyeste antall identifiserte stoffer samt målte nivåer. Blant de nye stoffene ble både DTBMMP (CAS 2773-50-4) og B-2ETF (CAS 6422-86-2) funnet i nivåer som oversteg deres respektive QSAR-avledede PNEC verdier. Merk at for DTBMMP baserte dette seg kun på en enkelt deteksjon. For B-2ETF var det usikkerhet knyttet til mulig kontaminering under lagring, noe som tilsier at videre undersøkelser bør gjennomføres for å kunne bekrefte funnene. Også noen av stoffene analysert ved «suspect screening» ble funnet med høy deteksjonsfrekvens i disse prøvene. Blant de klassiske miljøgiftstoffene skilte flere seg ut med høye deteksjonsfrekvenser og målte nivåer, som flere av PBDE-ene, PCB-ene og kvikksølv, som dermed understreker deres rolle som klassiske miljøgifter. For totalt 20 av stoffene ble det målt verdier som overskred deres respektive PNEC-verdier. Merk at stor usikkerhet var knyttet til disse PNEC verdiene ettersom de var QSAR-utledet og i tillegg utledet for fisk. Det var ingen tilgjengelige PNEC verdier for hval og hai. Siden disse artene befinner seg høyt i næringskjeden kan de være mer sensitive enn fisk.

Stedsspesifikke mønstre i resultatene ble undersøkt, men merk at det på bakgrunn av tidvis få prøvereplikater ikke kan trekkes statistikk-baserte konklusjoner. Resultatene fra avløpsrenseanlegget indikerer at høy rensegradgrad kan delvis eller fullstendig fjerne følgende stoffer fra vannfasen: DABPA (CAS 1745-89-7), UV324 (CAS 70321-86-7), PF201 (CAS 232938-43-1), MABT (CAS 127-25-3), BEMT (CAS 187393-00-6), TBPHT (CAS 31274-51-8), UV1164 (CAS 2725-22-6), og UV310, etc. Bemerkelsesverdig så inkluderte dette også stoffene som hadde blitt funnet i nærliggende marine resipientprøver, ved nivåer som oversteg deres respektive PNEC verdier (f.eks. UV310). I støv fra private hjem ble det funnet en lang rekke ulike stoffer, og med et høyere antall enn i støv fra plast-resirkuleringsanlegget. Dette viser at det er en lang rekke ulike typer kilder til forurensning i private hjem, og at disse trolig ikke er begrenset til plast. Fra produkttestingen ble erstatnings-ftalatet B-2ETF funnet i flere av de ulike kategorier, og med det høyeste nivået i elektronikk.

Blant de ulike artene analysert i del 2 ble spekkhoggere funnet til å ha de høyeste nivåene av de fleste stoffene. Spesielt en ung strandet spekkhogger skilte seg ut med høye nivåer av de klassiske stoffene og i tillegg noen av de nye. Den totale mengden PCB som ble målt oversteg med mer enn en størrelsesorden en terskelverdi for skadelige effekter. Dette individet tilhørte en selspisende flokk, og det er mulig at det har blitt eksponert for miljøgifter gjennom morsmelken til en selspisende hunn. Om miljøgifter har medvirket til dødsfallet til dette unge individet er ukjent, men mulig.

Fra en nise ble ulike typer vev inkludert for å vurdere fordelingen av stoffer mellom spekk, lever og muskel. Som forventet ble de lipofile stoffene funnet i spekk (f.eks. PCB), mens andre typer stoffer dominerte i lever. Disse inkluderte ulike former for PFAS (grupper PFCA, nPFAS, PFAS) og kvikksølv, som er kjente for å binde seg til proteiner i blodet. Det høyeste nivået av kvikksølv ble imidlertid funnet i muskel fra en håkjerring.

Flere av stoffene fra del 2 ble funnet i lever fra toppredator hai ved nivåer som tilsvarte- eller var høyere enn i hvalspekk fra arter middels i næringsnettet. Haiarter som håbrann og pigghå utgjør en mer tilgjengelig prøvetype enn hval, og kan derfor vurderes til framtidige studier. I tillegg vil det for hai være lettere tilgjengelighet av ulike typer vev (spekk, lever og muskel), noe som kan være en fordel ved bestemmelse av stoffer med et bredt spekter av fysiske og kjemiske egenskaper.

1 Introduction

1.1 Aim of the 2023 programme

The overall aim of the 2023 Screening Programme of the Norwegian Environmental Agency was to investigate the presence of worrisome substances 1) at so-called "hot spot" locations, and 2) in marine top predators. The objectives were, for part 1 to:

- Investigate whether the substances are found at hot spot locations
- Investigate whether the substances are found in nature
- assess whether the levels may cause environmental damage,

and for part 2 to:

- Investigate the presence of the substances in marine species high in the food chain
- Investigate the occurrence of the substances in other long-lived marine species
- Assess whether the levels may cause environmental damage
- Give advice on the future use of marine top predators as a matrix in the Screening Programme.

1.2 Information on the substances

Part 1 covered substances for which EU is considering regulation (REACH); substances that are persistent, mobile and toxic (PTM); and substances that have been identified as problematic by the Swedish chemicals' authority (exposure index); and UV-stabilizers. Among the 104 substances included were 54 related to plastics and other similar polymers (resins and paints). The function of the substances is mainly heat- and sun protection, both/either during production or in the final product. Most of the substances have a wide range of uses (polyolephines, PVS, polycarbonate, polyester, etc), and can thereby also be found in a wide range of products. Examples cover textiles, PVC-tubes, urethane foam in furniture, plastics used in agriculture, latex material, face masks and other types of personal protection equipment. A few of the substances have a narrower area of use. For example, UV1164 (CAS 2725-22-6) is an important UV protection in nylon. The remaining substances in part 1 are associated with a corresponding wide range of uses. This covers additives in lubricating oil, perfumes, fungicides, hair colour and other types of colourings, thermal-pressed etiquettes (receipts), and electronics (OLED TV, etc.).

Part 2 cover substances that were found in the 2021 Screening Programme in addition to substances that were selected through the LIfeAPEX project[1]. The total of 58 substances encompasses a wide range of uses and are additives in different types of end products. Several of these have previously been identified in different types of environmental matrices, including marine samples. It is suspected that several of the substances can be taken up in the marine food chain.

The above-mentioned substances, covered in part 1 and 2, are here referred to as "emerging substances". These have been grouped based on their function or areas of use to the categories of colourants, pharmaceutical/agricultural, polymer production, UV stabilizer, and other functions/uses.

As an addition to part 2, several more traditional contaminants were included. These amount to 166 substances which cover groups such as polychlorinated biphenyls (PCBs), flame retardants, dechloranes,

[1] https://lifeapex.eu/

and metals. Several of these have previously been detected in different types of marine samples and have the potential to bioaccumulate and biomagnify. It was therefore of great interest to determine these substances in the samples of marine top predators included here. These substances are herein referred to as the "legacy substances" and these were also included in the *Environmental Contaminants in an Urban Fjord monitoring programme*. See e.g. Ruus et al. (2023) for more information. For a complete list of the substances included, see **Appendix A3**.

1.3 Rationale for sampling locations and sample types

For **part 1** of the programme the main objective was to assess the occurrence and release of the substances at so-called "hot spot" locations, and to assess the potential for release to the nearby environment. Functional use of the substances and their physiochemical properties were critical factors guiding the design of the sampling campaign. Knowledge from previous findings (including the 2021 Screening Programme) was also instrumental. For **part 2** the focus was on marine predators. The final set of samples was the product of the samples that were made available, and thus no new sampling of marine predators has been conducted.

Wastewater is considered a "hot spot" for many substances, as they receive substances from products in everyday use in households as well as residues from industrial and urban environments. Even though wastewater treatment removes substances to a varying degree, not all substances are removed before the treated wastewater is discharged into the environment. The treated wastewater from large parts of the Oslo area is discharged into the Bekkelaget basin of the Oslo fjord. Recipient samples of marine sediments and mussels will indicate if substances in the treated discharge is accumulating and/or taken up in the food web. Blue mussels filter water and can therefore take up substances precent in the water phase and on small particles, while particle-bound substances will tend to accumulate in sediments. House dust accumulates a wide range of substances from consumer products, cosmetics, electronics, and building materials present in homes which makes house dust a suitable matrix for screening for in-use substances. As many of the substances in part 1 are plastic related, we also included dust samples from a plastic recycling facility. Farmland is also considered a potential hotspot for several of the substances covered in part 1. This is because farmland is a relevant recipient for plastic pollution. Typical sources include various types of agricultural plastics (such as covering hay bales and cultivated land) and the application of plastic-contaminated compost and sludge. Additives in the plastic can leach into the farmland soil and thus become available for uptake by plants and animals. Although it is known that many of the substances included in part 1 are plastic related, less is known about which specific types of plastics they are in. To get further insight into the presence of the part 1 substances in various product categories, we also included product testing.

Several of the relevant substances in part 2 have large potential for uptake in organisms. Over time, these substances can both bioaccumulate in an individual and biomagnify in the food web. Given their large fat stores, whales typically accumulate high concentrations of lipophilic pollutants in their blubber. Their longevity, high trophic position and low ability for biotransformation make them ideal sentinel species of chemical pollution in the marine ecosystem. Other long-lived marine predators are also prone to accumulate various types of pollutants. Sharks are long-lived, and their separation from whales in physiology and behaviour may lead to different patterns. Pollutants other than very lipophilic substances may be found at higher levels in other types of tissue. For example, certain substances will bind to protein and can thus be expected in liver or muscle. Samples from different species of whales, along with a few species of sharks were included in part 2. The whales cover species of toothed and baleen whales, that are both long-range migratory and more permanently resident in Norwegian waters. The species of shark differ in size, life expectancy, diet and type of habitat. Moreover, the samples represent individuals of both male and female, and that are of different maturity, as well as different types of tissue.

2 Materials and methods

2.1 Sampling strategy

For an overview of the types and number of samples analysed for emerging and legacy contaminants in part 1 and part 2, see **Table 1** and **Table 2**, respectively.

Table 1. The types and number of samples analysed for the emerging substances in part 1.

PART 1: Hotspots		Number of samples Emerging substances
Wastewater treatment plant (high and low degree)	Water filtered	4
	Water particles	4
	Sludge	2
Marine recipients	Blue mussels	3
	Sediments	3
Private homes	Dust	5
Plastic waste recycling	Dust	2
Agriculture	Soil	4
Product testing	Products	7

Table 2: The types and number of samples analysed for the emerging and legacy substances in part 2.

PART 2: Marine predator		Number of samples	
		Emerging substances	Legacy substances
Whales from high trophic positions			
Killer whale	Blubber	4	3
Sperm whale*	Blubber	6	1
Harbor porpoise	Blubber	3	1
	Liver	1	1
	Muscle	1	1
White beaked dolphin	Muscle	1	1
Whales from intermediate trophic positions			
Fin whale	Blubber	2	1
Humpback whale	Blubber	3	1
Sharks from high trophic positions			
Greenland shark	Muscle	1	1
Porbeagle shark	Muscle	4	--
	Liver	4	3
Sharks from intermediate trophic positions			
Spiny dogfish	Muscle	3	--
	Liver	4	3

*the 6 samples were from the 3 individuals (i.e., biological replicates).

2.1.1. Wastewater treatment plant (Part 1)

Samples were collected from the Bekkelaget RA wastewater treatment plant, which is the second largest wastewater treatment plant in Norway (ca. 500,000 person equivalents). The plant is equipped with sequential simple (mechanical) and advanced (biological-chemical) treatment systems. Thus, the plant allows for sampling of wastewater treated with two different degrees of removal principles, treating the same incoming wastewater. The low degree (primary) treatment consists of mechanical treatment by a coarse screen, a sand- and grease trap, and pre-sedimentation. Scrap material from the coarse screen and sand from the fat trap are landfilled, while grease from the fat trap and settled solids from the pre-sedimentation basin (primary sludge) are transferred to further sludge treatment (anaerobic sludge digestion for biogas production). High degree (tertiary) treatment is achieved by subsequent biologic treatment in a co-precipitation step that also include nitrogen removal (anoxic and aerobic treatment). The resulting effluent goes through a sand filter (polishing step) before the treated wastewater is discharged. Sludge from the biological treatment is co-digested with the primary sludge. The treated water is discharged into the Bekkelaget basin in the Oslo fjord (50 m depth). Bekkelaget RA has also been sampled in several of the previously conducted Screening Programmes.

Samples of water, particles isolated from the water, and sludge were collected to represent both the low and high degree of treatment. To represent the simple/primary treatment, water samples were collected from the effluent from the pre-sedimentation basin while sludge samples were collected from the primary sludge (from the transport belt). To represent the secondary treatment, water samples were collected from the final effluent water, while sludge samples were collected from the final (digested and dewatered) sludge. Moreover, the samples were collected at two different time points, representing summer and autumn conditions, respectively. See **Table 3** for an overview of the samples.

Sampling of water was done by time-proportional twenty-four-hour composite samples using automatic sample collectors, according to NS-EN ISO/IEC 17025. See **Figure 1**. To collect the particulate fraction of water, the water was filtered through 20 µm steel sieve (200 cm diameter). The particles were placed in pre-burned glass jars while the water fraction was collected in water bottles (**Figure 2**). To avoid contamination, two different sieves were used: one for the primary and another for the secondary treated water. The sieves were pre-rinsed using acetone and cyclohexane. The sludge samples were daily grab samples and combined in equal amounts to one composite sample.

Table 3: Information on the samples collected from the wastewater treatment plant.

Condition	Season	Sample type	N
Low degree treatment	Summer	Water, filtered	2
		Water, particles	2
		Sludge	1
	Autumn	Water, filtered	2
		Water, particles	2
		Sludge	1
High degree treatment	Summer	Water, filtered	2
		Water, particles	2
		Sludge	1
	Autumn	Water, filtered	2
		Water, particles	2
		Sludge	1
Total			**20**

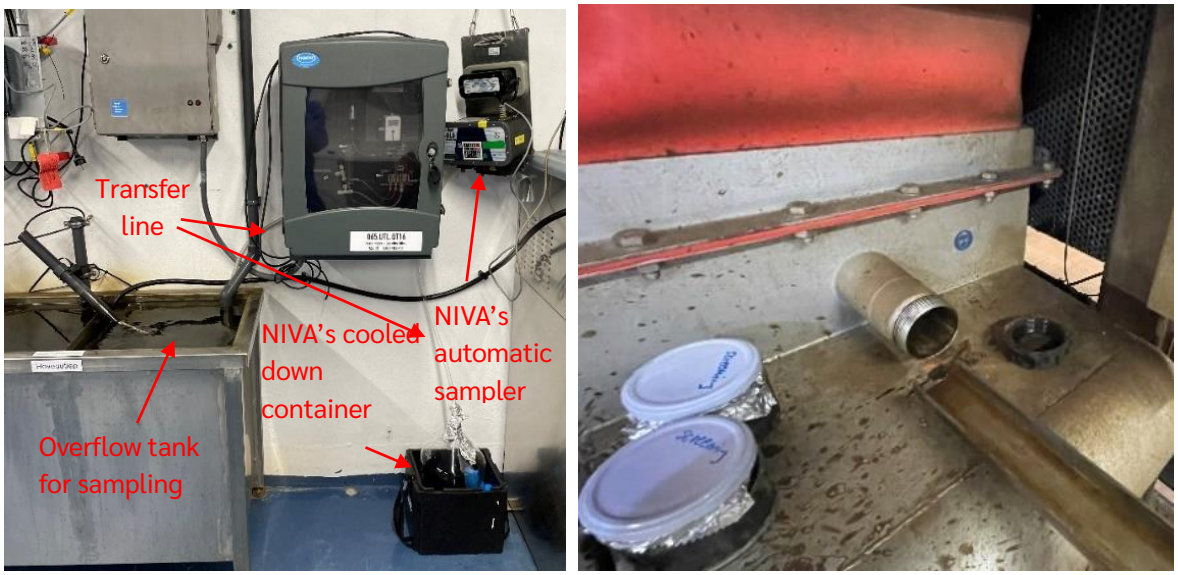

Figure 1: Photo of the automatic water sampler used at the wastewater treatment facility (left) and the site for sludge sample collection (right). Photos: NIVA/Christian Vogelsang.

Figure 2: Photo of water samples collected (left) following low quality treatment (dark coloured) and high-quality treatment (light coloured) and particles isolated from the water phase (right). Photos: NIVA/Christian Vogelsang.

2.1.2. Recipients – treated wastewater (Part 1)

Recipient samples of marine sediments and blue mussels were collected from the Bekkelaget basin in the vicinity of the water discharged from the wastewater treatment plant described in chapter 2.1.1. The samples were collected from three different sites, as outlined in **Figure 3** and **Table 4**.

The sediments were collected from the top layer (0-2 cm) using a small van Veen-grab sampler from a boat **(Figure 4)**. From each site, the sample was made as a composite of four, which is in accordance with The Norwegian Environment Agency's guide for risk assessment of contaminated sediment (TA-2802/2011, sediment guide).

The blue mussels (*Mytilus edulis*) were collected either by hand during low tide or by snorkelling. From each site, approximately 20-30 shells with a size of 2-5 cm were collected. At the site, the shells were rinsed with sea water and placed in polyethylene plastic bags (approved for food storage). Note that it was challenging to find blue mussels, due to the overall decline in numbers. This was especially the case for stations Gressholmen and Bleikøya.

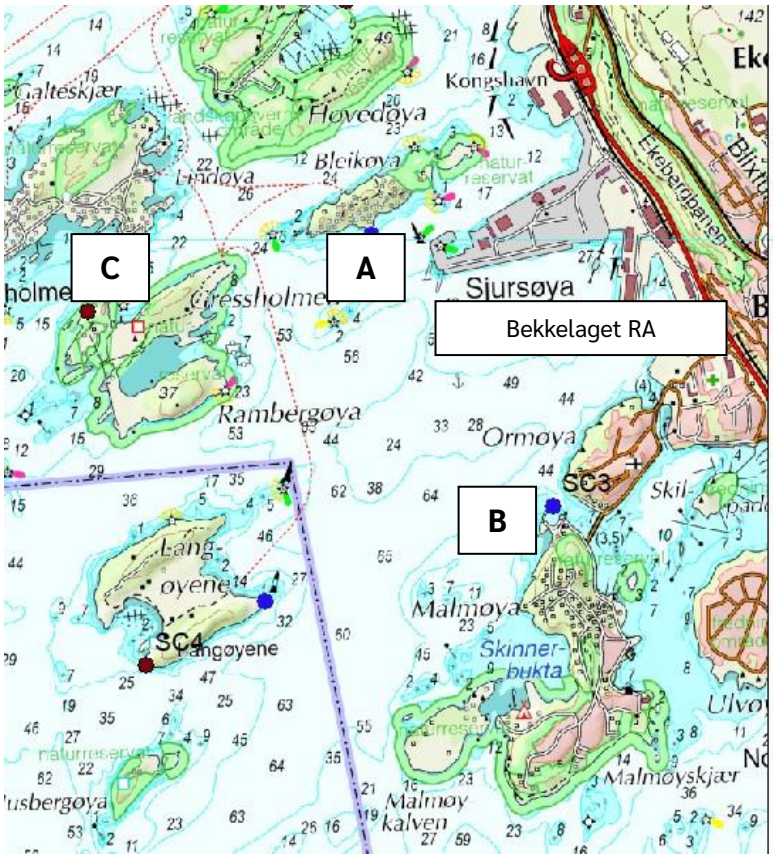

Figure 3: Map showing the three sites for sampling recipient sediment and blue mussel samples as well as the location of the wastewater treatment plant. A: Bleikøya, B: Malmøya, and C: Gressholmen.

Figure 4: Photos from sampling sediments from a boat (left) and the sediment sample (right). Credit: NIVA.

Table 4: Information on the marine recipient samples collected near the wastewater treatment plant.

Location (in map)	Sample type	Water depth (m)	Composite of	N
Bleikøya (A)	Sediment	20.3, 21.0, 21.4, 22.2	4	1
	Blue mussel		20-30	1
Malmøya (B)	Sediment	18.6, 18,7, 19.0, 19.5	4	1
	Blue mussel		20-30	1
Gressholmen (C)	Sediment	16.2, 16.6, 17.2, 17.2	4	1
	Blue mussel		20-30	1
Total				**6**

2.1.3. Indoor dust (private homes)

Samples of dust were collected from five private homes (**Table 5**). One week prior to sampling, the participants were asked not to vacuum. This was to ensure that sufficient amounts of dust were available at the time of sampling. Sampling was conducted using an industrial vacuum cleaner (Nilfisk GM 80P) equipped with a specially adapted nozzle (Krim. Teknisk Materiel AB, Bålsta, Sweden). Dust that had settled on floors and other surfaces was sampled (Bornehag et al., 2004). Inside the nozzle, a cellulose membrane filter was placed in a filter holder (styrene-acrylonitrile polymer) to be able to collect the dust (**Figure 5**). In homes with low levels of dust, composite samples (*i.e.* samples from multiple surfaces) were collected. After sampling, the filter holder was capped, the sample wrapped in aluminium foil, placed in Ziplock bags, and refrigerated until analysis. The total amount of dust collected was found by weighing the filter before and after sampling using an analytical balance. The area of the sampled surface was measured. Field blank samples were collected and handled in the same manner as dust samples to account for any contributions from sampling equipment and packaging.

Figure 5: Pictures from dust sampling in private homes. Credit: NILU.

2.1.4. Indoor dust (recycling facility)

Two samples of dust were collected from a plastic recycling facility (**Table 5**) using the same equipment and method as described above for dust sampling in private homes (**Figure 5**). Samples were collected near a conveyor belt for plastic waste (**Figure 6**). Field blank samples were collected and handled in the same manner as dust samples.

Figure 6: Pictures from dust sampling at plastic recycling facility. Credit: NILU.

Table 5: Information on the samples of dust.

Location	Sample type	N
Private home A	Dust	1
Private home B	Dust	1
Private home C	Dust	1
Private home D	Dust	1
Private home E	Dust	1
Plastic recycling A	Dust	1
Plastic recycling B	Dust	1
Total		**7**

2.1.5. Agriculture soil

Four samples of different types of agriculture soils were provided from the PROLAND project (PROLAND - Protecting agricultural lands from plastic pollution | NIVA). The samples represented four different practices with regards to the use of mulching films (conventional plastic/biodegradable copolymer, poly(butylene adipate-co-terephthalate, "PBAT", CAS nr. 160479-65-1)) and use of soil improvers (sludge and biogas residue) where micro and macro plastic are frequently detected (**Table 6**). The samples were collected within a defined sampling field area of 20 x 20 m^2. Edges of the field was avoided and only cultivated soil was collected. The grid was placed at least 5 m from the field boundary. Within the defined grid, 15 subsamples of soil were collected using a metal soil auger at approximately 10 cm depth. During sampling the 15 subsamples were transferred to a steel tray (**Figure 7**). After sampling, the soil samples were mixed in the metal tray using a metal spoon or by hands (covered in disposable nitrile gloves). Prior to sampling, the auger, tray, and spoon were washed with tap water. After mixing in the metal tray, the samples were placed in previously burned glass jars covered with burned aluminium-foil. The samples were stored in the dark at 3 °C for 10 days until the samples were handed over to the laboratory.

Table 6: Information on the samples collected from agricultural fields.

Crop type (ID)	Information	Composite of	N
Conventional vegetable production (Haga)	Biodegradable PBAT mulching film and previously use of conventional plastic mulching films	15	1
Ecological vegetable production (Hort)	Biodegradable PBAT, mulching film and compost	15	1
Grain (NO16)	Sludge added in 2023	15	1
Grain (NO18)	Biogas residue added in 2023	15	1
Total			**4**

Figure 7: Photos of two of the agriculture fields sampled. Credit: NIVA.

2.1.6. Suspected hotspots (Part 1)

Various types of commercial products were included since several of the substances were listed as additives for such products. The categories covered boat care products, detergent for textiles, EE products, clothes fabric, furniture fabric, paint and varnish, and toys (**Table 7**). Since several of the substances were non-regulated, the focus was on new products that were currently for sale. Composite samples were prepared to focus on product categories rather than individual products.

The boat care products were purchased at a large warehouse in Oslo. Detergent for textiles was a mix of detergents for furniture and for clothing and were collected from colleagues. EE products were different types of scrap cables (**Figure 8**). Fabric clothes were purchased from different stores that are associated with the term "fast fashion" and located in Oslo. Different types of synthetic furniture fabric were provided from a furniture upholsterer in Oslo. Paint and varnish were collected from colleagues. Different types of plastic toys (**Figure 8**) were purchased from different shops in Oslo.

Table 7: Information on the samples of commercial products.

Product category	Comment	Composite of	N
Boat care products		3	1
Detergent for textiles	For both furniture and clothing		1
EE products			1
Fabric clothes	Synthetic, adult and kids	3	1
Fabric furniture	Synthetic, various	3	1
Paint and varnish			1
Toys	Plastic, soft and hard	3	1
Total			**7**

Figure 8: Photos of products tested of toys (left) and electronics (right). Credit: NIVA.

2.1.7. Whales (Part 2)

Samples from whale are exclusive matrices that can provide valuable information about the occurrence and bioaccumulation of environmental substances in the marine environment. An overview of the whale samples is given in **Table 8**. All the samples included here originated from stranded individuals as access to internal organs was needed to screen for some chemicals which do not necessary accumulate in lipid rich tissue, and because it enabled to collect sufficient amount of tissue as compared to free-living biopsied whales (few cm long skin/blubber fragment). All the whales have been found stranded along the Norwegian coast. See **Figure 9**, **Figure 10**, and **Figure 11** for a selection of photographs.

The present study includes 21 samples from 16 different individuals distributed across six different species (killer whale, sperm whale, fin whale, humpback whale, white beaked dolphin, and harbour porpoise). The species assemblage includes both odontocetes (toothed whales) and mysticetes (baleen whales), spans from planktivorous species (e.g., fin whales) to apex carnivores (e.g., killer whales), covers several feeding habitats including the benthic (e.g., sperm whales) and pelagic compartments (e.g., white beaked dolphin). It also includes both long-range migratory (e.g., humpback whales) and resident species in Norwegian waters (e.g., harbour porpoises). A little late in the process it was discovered that the six samples of sperm whale originated from the same three individuals, provided from two different storages.

For each species, samples of blubber were included. Blubber is intrinsically high in fat/lipid content and therefore likely to accumulate lipophilic substances. One harbour porpoise also included liver and muscle samples in addition to blubber which could provide valuable toxicokinetic information.

The samples have been stored at -20°C after sampling and have been delivered frozen to our laboratory in cool boxes, packed in plastic ziplock or wrapped in aluminium foil (**Figure 12**). The samples may have been treated differently in the time leading up to their arrival at the laboratory. This may lead to differences in the risk for potential contamination of the samples. For samples provided with sufficient material, the outermost part was removed to reduce the effect from potential contamination. However, this was not possible for all the samples.

A few of the individuals have previously been analysed for environmental contaminants, see e.g. (Andvik et al., 2024b). The three sperm whales stranded at Andøya in 2020 have had their stomach content analysed, which revealed the presence of big fish and squids (Similä et al 2022).

Figure 9: Photos of stranded killer whales. Credit: Norwegian Orca Survey (NOS)

Figure 10: Photos of a stranded sperm whale (left) and a humpback whale (right). Credit: Norwegian Orca Survey (NOS).

Figure 11: Photos of stranded white harbor porpoises. Credit: Norwegian orca survey (NOS).

Table 8: Information on the whale (cetacean) samples, and whether the sample was analysed for the additional legacy substances.

Tissue	ID	Location	Year	Sex	Age	Length (cm)	Packaging	Legacy
Killer whale (*Orcinus orca*)								
Blubber	OO11	Sognefjord	2021	Female	Subadult	390	Al-foil	Y
	OO12	Bømlo	2022	Female	Subadult	370	Plastic	N
	OO14	Bø i Vesterålen	2023	Male	Adult	740	Al-foil	Y
	OO5[a]	Skulsfjord, Troms	2016	Male	Subadult	392	Al-foil	Y
Sperm whale (*Physeter macrocephalus*)								
Blubber	SW2 [a]	Andenes, Vesterålen	2020	Male	Adult /45 y	1500	Plastic	N
	SW3 [a]	Bleik, Vesterålen	2020	Male	Adult /25 y	1350	Plastic	Y
	SW4 [a]	Andenes, Vesterålen	2020	Male	Adult/ 49 y	1230	Plastic	N
	APN1[b]	Andenes, Vesterålen	2020	Male	Adult /25 y	1350	Al-foil	N
	APN2[b]	Bleik, Vesterålen	2020	Male	Adult /45 y	1500	Al-foil	N
	APN3[b]	Andenes, Vesterålen	2020	Male	Adult/ 49 y	1230	Al-foil	N
Fin whale (*Balaenoptera physalus*)								
Blubber	FW1 [a]	Kokkvoll, Vannøya	2020	NA	Adult	1920	Plastic	N
Blubber	FW2015	Hvalsund, Hvaler, Norway	2015	NA	NA	1600	NA	Y
Humpback whale (*Megaptera novaeangliae*)								
Blubber	HW1 [a]	Troms	2019	NA	Adult	NA	Plastic	N
	HW2 [a]	Hadsel	2020	NA	Adult	NA	Al-foil	N
	HW3 [a]	Napp, Lofoten	2020	NA	Adult	NA	plastic	Y
White beaked dolphin (*Lagenorhynchus albirostris*)								
Muscle	D1[c]	Kokkvoll, Vannøya	2020	NA	Adult	> 200	Al-foil	Y
Harbor Porpoise (*Phocoena phocoena*)								
Blubber	HP11	Andenes, Vesterålen	2020	Female	Adult	160	Al-foil	N
Blubber	HP2 [a]	Saltstraumen, Bodø	2020	NA	Adult	n.a.	Plastic	N
Blubber	HP8	Andenes, Vesterålen	2020	NA	Adult	136	Al-foil	Y
Liver	HP8							Y
Muscle	HP8							Y

[a]has previously been analysed for dechloranes & CPs, Legacy POPs.
[b]has previously been analysed for PFAS, Hg, SIA, metals.
[c]the stomach content has been analysed.

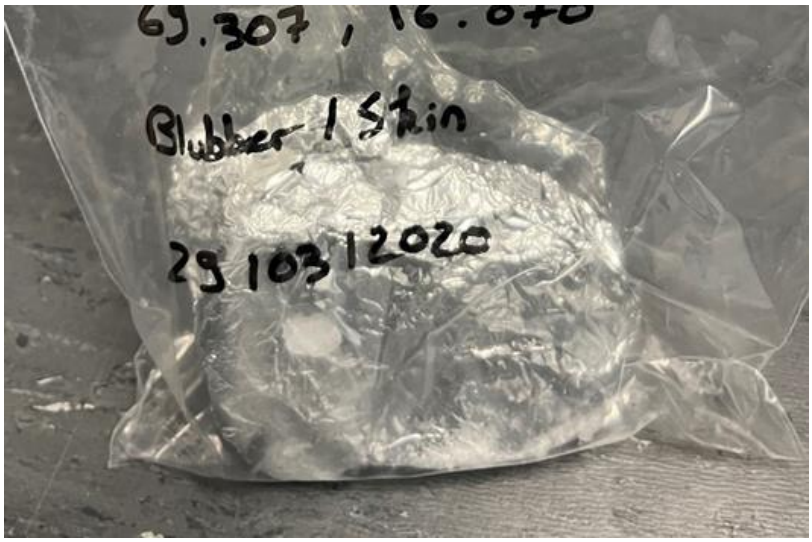

Figure 12: Photograph of one of the aluminium (Al) foil wrapped whale sample. Credit: NIVA.

2.1.8. Sharks (Part 2)

The three species of sharks included here are high in the marine food web and have long (maximum 65 and 75 years for porbeagle shark and spiny dogfish, respectively) and very long (maximum 392 years for greenland shark) lifetimes. This makes them susceptible to elevated levels of various types of environmental contaminants. **Table 9** provides an overview of the shark samples included here, covering intermediate (spiny dogfish) or top (greenland shark and porbeagle shark) predators. Tissue types were both muscle and liver.

The greenland shark (**Figure 13**) is the most northerly living shark. It can become very large (typically 3-4 m) and old, and lives at great ocean depths. It is a predatory fish that eats nearly everything it comes across, covering fish, benthic animals, and even seals. The porbeagle shark (**Figure 14**) can also be quite large (up to 3.5 m). It lives pelagic and typically feeds on fish, octopuses, and even spiny dogfish. The porbeagle shark is migratory. Spiny dogfish (**Figure 15**) is smaller (up to 1.5 m) and more abundant than the former two. It lives over soft bottom and can be found down to great depths, although it is typically found at shallow depths. The spiny dogfish feeds on fish, crustaceans, squid and echinoderms.

The sampled greenland shark was found stranded, and without the head attached. Based on the measured length (> 250 cm) and the findings by Nielsen et al. (2016) the age can be estimated to 70-80 years old. The samples of porbeagle shark were all from individuals collected as bycatch by fishermen at various regions in Norway. One of these sharks was found without the head and contained parasites (ID Hbrl3/Hbrm3). The samples of spiny dogfish had all been collected during a scientific survey in 2021 (Vollen et al., 2021). The samples covered both mature and immature individuals.

The samples arrived at the laboratory in frozen condition and packed in different types of material (plastic or aluminium foil, see **Figure 16**).

Figure 13: Photo of a greenland shark. Credit: Institute of Marine Research.

Figure 14: Photo of a porbeagle shark. Credit: Institute of Marine Research.

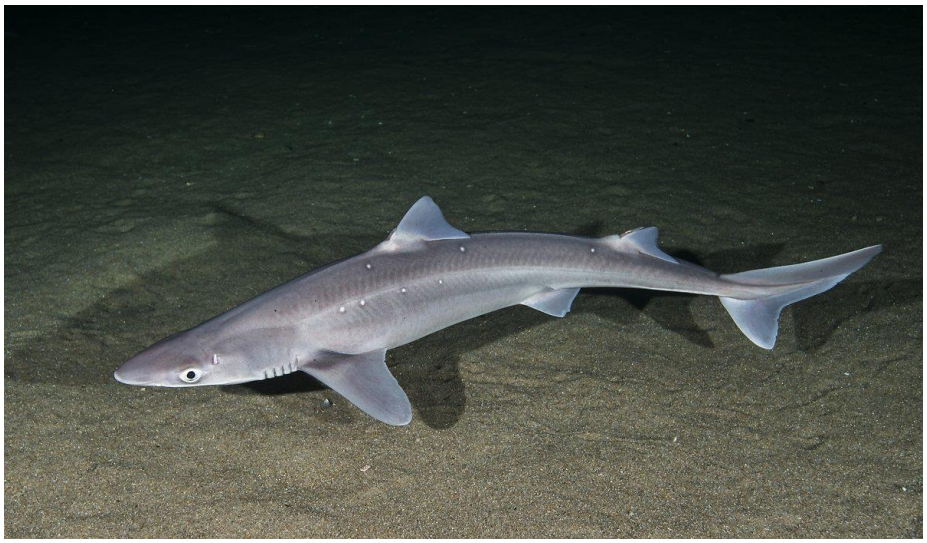

Figure 15: Photo of a spiny dogfish. Credit: Institute of Marine Research /Erling Svensen.

Table 9: Information on the shark samples, and whether the sample was analysed for the additional legacy substances.

Tissue	ID	Location	Year	Sex	Age	Length (cm)	Weight (kg)	Packaging	Legacy
Greenland shark (*Somniosus microcephalus*)									
Muscle	Hkjm1	Tromsø	2023	M	n.a.	>250	n.a.	n.a.	Y
Porbeagle shark (*Lamna nasus*)									
Muscle	Hbr1	Tromsøflaket	2022	F	Mature	194	53.2	Plastic	N
Liver	Hbrl1							Al-foil	N
Muscle	Hbrm	Tromsøflaket	2022	M	Immature	200	58.7	Plastic	N
Liver	Hbrl2							Al-foil	Y
Muscle	Hbrm	Southern Norwegian Sea	2022	M	Mature	>174	70	Plastic	N
Liver	Hbrl3							Al-foil	Y
Muscle	Hbrm4	Helgelandsbanken	2022	Na	n.a.	n.a.	n.a.	Plastic	N
Liver	Hbrl4							Plastic	Y
Spiny dogfish (*Squalus acanthias*)									
Muscle	Pigm1	Kristiansund	2021	M	Mature (12 y)	84	2.3	Plastic	N
Liver	Pigl1							Plastic	Y
Muscle	Pigm2	Kristiansund	2021	F	Mature (11 y)	99	4.6	Plastic	N
Liver	Pigl2							Plastic	Y
Muscle	Pigm3	Sørhuglo	2021	n.a.	n.a.	n.a.	n.a.	Plastic	N
Liver	Pigl3							Plastic	Y
Liver	Pigl4	Sørhuglo	2021	n.a.	n.a.	n.a.	n.a.	Plastic	N

Figure 16: Samples of shark muscle packaged in plastic. Credit: NIVA.

2.2 Analytical methods

Analytical methods are summarized in **Table 10**: Overview of the techniques used for sample extraction and analysis for each group of substance and matrix type, and described in more detail in the **Appendix A.4** and **A.5**. In general, solid samples including biota, sediments, sludges and dust were extracted with an appropriate organic solvent mixture following the addition of internal standards. The same applied to the commercial products which were extracted for 24 h. Liquid samples were extracted via solid phase extraction. Analysis for all substances was via either LCMS or GCMS.

Table 10: Overview of the techniques used for sample extraction and analysis for each group of substance and matrix type.

Group	Water	Particles/sludge/sediment	Biota	Products	Dust/soil	Instrument
PFAS	SPE	SE	SE	SE	SE	LC-HRMS
QAC	SPE	SE	SE	SE	SE	LC-MS
UV	SE	SE	SE	SE	SE	GC-MS
(v)M Organics	SPE	SE	SE	SE	SE	LC-MS
SVOCs	SPE	SE	SE	SE	SE	GC-HRMS
Siloxanes	-	-	-	-	-	-
Triazines, Alternative bisphenols, Phenolic antioxidants	SPE	ASE	SE	SE	ASE	LC-HRMS
OPFRs, OPFR metabolites	-	-	SE	-	-	LC-HRMS
PCBs, PBDEs, other BFRs, S/M/LCCP, Dechloranes	-	-	SE	-	-	GC-HRMS, LC-HRMS
Metals	-	-	UC	-	-	ICP-MS

ASE = Accelerated Solvent Extraction
SE = Solvent Extraction
SPE = Solid Phase Extraction
UC = UltraClave
GC-(HR)MS = Gas Chromatography (High Resolution) Mass Spectrometry
LC-(HR)MS = Liquid Chromatography Mass Spectrometry
ICP-MS = Inductively Coupled Plasma Mass Spectrometer

2.1 Supporting parameters

In all the biological samples, the lipid content was determined. In addition, samples of whale and shark liver and muscle were analysed for the stable isotopes δ15N and δ13C. These parameters can potentially be used to explore a wide range of questions surrounding diet (e.g. trophic position, consumption of animal products or fish, weaning age). The results for the stable isotopes are presented in **Appendix A1.**

2.2 Calculations and data presentation

All calculations were computed using the R programming language (R Core Team, 2023). The detection frequency is based on different sample types and/or sampling sites. For the heatmap tables, presenting detection frequencies and average values, any observation below the method limit of detection (LOD) was replaced by the value of 0.5 * LOD, which was then included into the average value. For method concentration LODs, see **Appendix A6**. Note that we here use LOD rather than the limit of quantification (LOQ) due to the nature of the programme which is screening. For the biological samples, concentrations are presented either "as measured", i.e. ng/g wet weight (w.w.) or lipid normalised, i.e. ng/g lipid weight. Data is presented with one or two significant digits. Illustrations were made using the R packages ggplot2, plyr, dplyr, tidyr, egg, reshape2, and forcats.

2.3 Collection of PNEC and EQS

Toxicity data were obtained mainly in the form of PNECs (predicted-no-effect concentrations). The PNECs are the concentrations of a chemical which marks the limit at which below no observed adverse effects of exposure in an ecosystem is expected. A PNEC is obtained through the application of an assessment factor to ecotoxicological endpoints (EC50 or no observed effect concentration, NOECs) using organisms from at least three trophic levels (usually algae, daphnids, and fish). The assessment factor depends on duration of the test (acute or chronic) and the number of trophic levels with available data. Higher assessment factors are used when only acute data have been used. Also, a higher assessment factor is typically used to encompass for higher uncertainty related to the PNEC value. The minimum requirement for deriving a PNEC is acute toxicity for algae, daphnids, and fish. The PNECs used herein were collected from two databases, by priority, of ECHA (European chemicals agency: https://echa.europa.eu/) and the Ecotoxicology Database from NORMAN (Network of reference laboratories, research centres and related organisations for monitoring of emerging environmental substances) (https://www.norman-network.com/nds/ecotox/lowestPnecsIndex.php). When no experimental derived PNECs were available, QSAR based prediction models can be used for prioritization purposes (Aalizadeh et al., 2017). However, modelled PNECs include additional simplifications and uncertainties compared to experimentally derived PNECs. In addition, most PNEC data have not been fully reviewed and verified by experts. This is particularly applicable to some of the PNECs from NORMAN, as demonstrated by Welch et al. (2023). The environmental compartments of freshwater, marine sediment, and marine biota fish has been used. Note that there are some additional limitations associated with applying a marine biota (fish) PNEC for blue mussels and whale. There are differences between fish and whale/mussels with regard to bioaccumulation, but also with regard to the potential for removing part of the chemical burden e.g. through reproduction, as fishes usually have a higher frequency of reproduction cycles, which means that they can more often remove chemicals from their bodies to the eggs. We consider that the PNEC for fish can be used as an indicator for whales and mussels, but these should however be interpreted with some caution, taking the above-mentioned limitations into account. The PNECs were collected as is, and without any further quality assurance.

In general, environmental quality standards (EQS) are more robust parameters for assessing risk compared to PNECs. For the emerging substances EQS are typically not available. However, for several of the legacy contaminants included in part 2, EQSs are available and have previously been compiled by Ruus et al. (2023). For more information, see Direktoratsgruppen vanndirektivet (2018). Note that the EQSs have likely not been derived for species of sharks and whales.

3 Results and Discussion

Here, the results are presented for the substances that were found at levels above the concentrations limits of detection (LOD) of the respective methods. For part 1, with 44 different samples, this covered 45 of the 104[2] different substances included. In part 2, the 37 different samples collectively contained only 8 of the 58 emerging substances. For the legacy substances in part 2, analysed for in 17 different samples, a total of 78 substances were detected. For the emerging substances, 15 were determined by so-called suspect screening. This means that only qualitative analysis has been conducted due to the lack of commercially available standard materials.

For the complete list of the substances see **Appendix A3** and for concentration LODs see **Appendix A6**. The complete dataset of results is available for download from the database, *Vannmiljø* (https://vannmiljo.miljodirektoratet.no/).

3.1 Detection frequencies and average concentrations

In this section, the results are presented to showcase substances that were detected most frequently in multiple types of samples and/or with high average concentrations. Substances that were not detected above the LODs are not included. Detection frequencies and averages are presented across sample types and categories. Further, the average concentrations are evaluated against environmentally predicted no-effect concentrations (PNEC), when available. These are ecotoxicological threshold values which are associated with varying degrees of uncertainty. For more information on the use of these, see e.g. Welch et al. (2023).

3.1.1. Wastewater treatment plant with recipient samples (part 1)

The samples from the wastewater treatment plant covered filtered water (< 20 µm), particles from the water (>20 µm), and sludge, and came from both the low and high degrees of treatment. Recipient samples were marine sediments and blue mussels from the vicinity of the water discharge from the plant. Many of the substances were found in these samples and at relatively high detection frequencies and concentrations (**Figure 17**).

In the water phase, the highest concentrations were of substances OTNE (2,000 ng L^{-1}) and B-2ETF (700 ng L^{-1}), and with high levels of BZDSA and UV310 (300 ng L^{-1}). In the particulate phase, the highest concentrations were of UV360 (20,000 ng L^{-1}), B-2ETF (10,000 ng L^{-1}), and both TBPHT and UV310 (1,000 ng g^{-1}). In the sludge samples, a lower number of substances were detected. The highest levels were for UV310 (3,000 ng g^{-1}), BEMT (2,000 ng g^{-1}), and both B-2ETF and OTNE (1,000 ng L^{-1}). OTNE is a very common synthetic fragrance known under the tradename iso-E super which is used in products like soap, shampoo, perfumes, and detergents, etc. as well as in tobacco and as a plasticizer. B-2ETF is an alternative phthalate which has been placed on the market as a replacement to legacy phthalates such as DINP. It is used as a plasticizer in plastics production. UV360 is a benzotriazole type UV substance, while UV310 is a triazine type UV substance. BZDSA is used in plant protection products, while both TBPHT and BEMT are used as light stabilisers (UV substances).

[2] *Not analysed were the two siloxanes (TIPSIMA and TIPSIA) that were unstable, and one SVOC (BSAN) due to limited sample material.*

In the recipient samples, a lower number of substances were detected **(Figure 17**). Noteworthy, the types of substances detected partially overlapped with the types of substances found at the highest levels in the wastewater treatment plant samples. This covered UV360, B-2ETF, BEMT, and UV310, which were found in marine sediment and blue mussels.

Additionally, three of the substances analysed by suspect screening were found in several of these samples. The phthalate DIUDP was found in all samples from the wastewater treatment plant and in the recipient samples. SEROLD which is a substance used e.g., in cosmetics, was detected in all samples of water, sludge, and blue mussels. The instrumental signal was relatively high, and especially in the blue mussels. This indicates high concentrations. SYLKL, another cosmetics additive, was also detected in water and sludge samples, but with lower instrumental signals than for SEROLD. Moreover, SYLKL was not detected in any of the recipient samples.

B-2ETF and UV310 were detected in blue mussels at concentrations exceeding the respective PNECs for marine biota, while UV360 was detected in sediment at concentrations exceeding the sediment PNEC. B-2ETF and OTNE concentrations exceeded PNECs for water (**Table 11**). This indicates that the detected concentrations may cause toxic effects. Most of the PNECs in question are however based on QSAR and are therefore associated with additional high uncertainty.

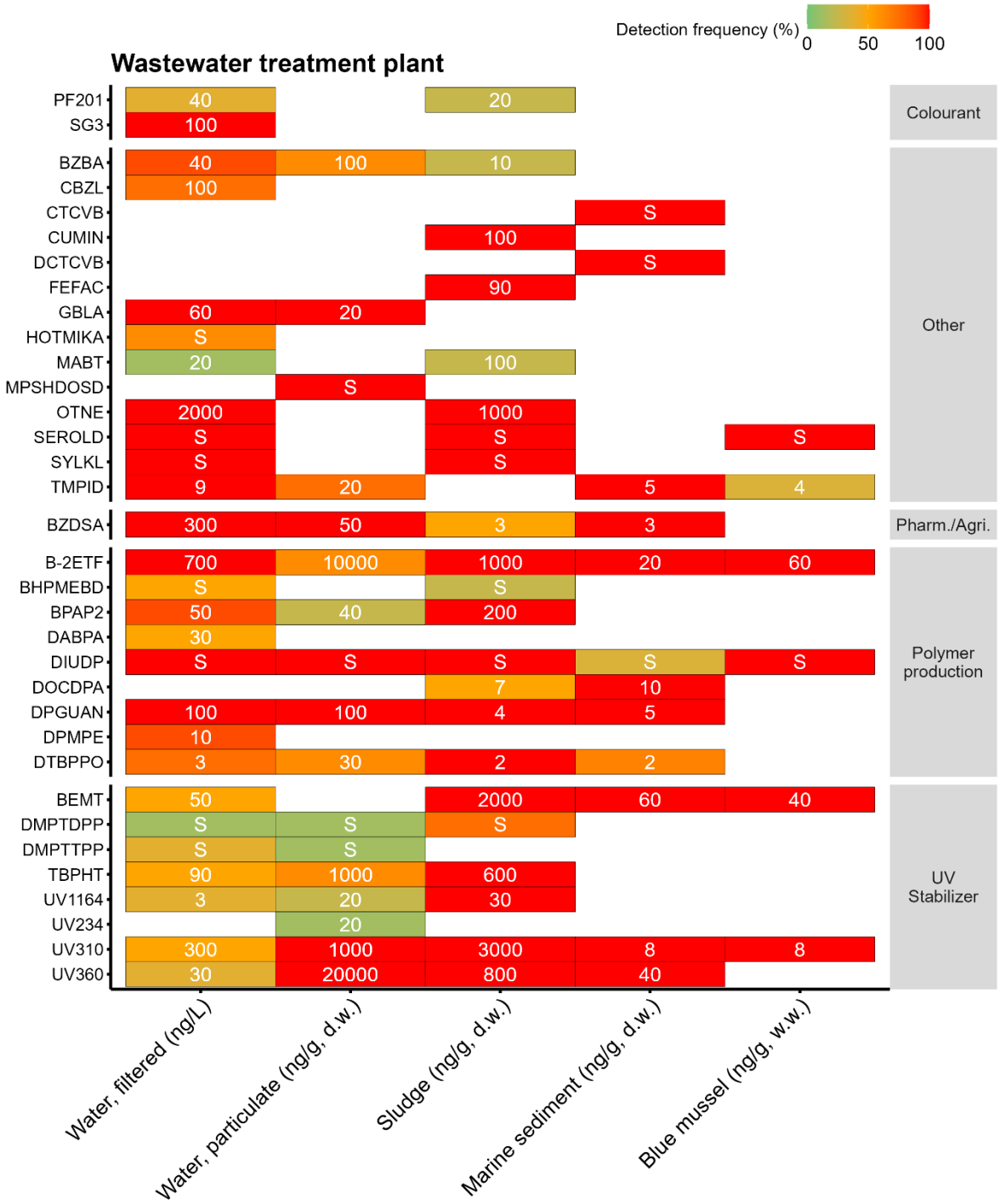

Figure 17: Detection frequencies and average concentrations in samples from the wastewater treatment plant (water filtered: n=8, water particulate: n=8, sludge: n=4) and related recipient samples (marine sediment: n=3, blue mussel: n=3). S indicates suspect screening. Empty cells indicate levels below LOD, i.e. detection frequency = 0. Substance IDs are to the left and substance group names to the right.

Table 11: Available predicted no-effect concentrations (PNEC) for substances quantified in samples from the wastewater treatment plant. Highlighted cells indicate that the average concentration in samples exceed the PNEC value.

Group	Short name	CAS	Fresh-water (ng/L)	Sediment (ng/g)	Marine Biota (ng/g)	Data Source	Assessment factor
Colourant	PF201	232938-43-1	29000	514	0.25*	Fw, Sed: ECHA, MB: NORMAN	Fw: 10, Sed: EPM, MB: 1000
	SG3	128-80-3	100000	2210	2211*	Fw, Sed: ECHA, MB: NORMAN	Fw: 1000, Sed: EPM, MB: 1000
Other	BZBA	120-51-4	3000	2043	114*	Fw, Sed: ECHA, MB: NORMAN	Fw: 10, Sed: EPM, MB: 1000
	CBZL	86-74-8	260*	33.1*	3.46*	Fw, Sed, MB: NORMAN	1000
	CUMIN	122-03-2	6440*	43.4*	27.1*	Fw, Sed, MB: NORMAN	1000
	OTNE	54464-57-2	330*	91.6*	11.9*	Fw, Sed, MB: NORMAN	1000
	FEFAC	102-20-5	1540	1270	54.6*	Fw, Sed: ECHA, MB: NORMAN	Fw: 100, Sed: EPM, MB: 1000
	GBLA	96-48-0	56000	240	8.5*	Fw, Sed: ECHA, MB: NORMAN	Fw: 1000, Sed: EPM, MB: 1000
	MABT	127-25-3	160*	141*	6.75*	Fw, Sed, MB: NORMAN	1000
	TMPID	3910-35-8	120*	202*	16.6*	Fw, Sed, MB: NORMAN	1000
Pharmaceutical/Agricultural	BZDSA	117-61-3	186000	2033993	46*	Fw, Sed: ECHA, MB: NORMAN	Fw: 1000, Sed: EPM, MB: 1000
Polymer production	B-2ETF	6422-86-2	80	8280	1.46*	Fw, Sed: ECHA, MB: NORMAN	Fw: 10, Sed: 100, MB: 1000
	BPAP2	116-37-0	18000	4970	20,7*	Fw, Sed: ECHA, MB: NORMAN	Fw: 50, Sed: EPM, MB: 1000
	DABPA	1745-89-7	2000	110	n.a.	Fw, Sed: ECHA	Fw: 1000, Sed: EPM
	DOCDPA**	15721-78-5	-	-	-	ECHA	
	DTBPPO	95906-11-9	10*	70.1*	2.79*	Fw, Sed, MB: NORMAN	1000
	DPGUAN	102-06-7	30000	2510	59.9*	Fw, Sed: ECHA, MB: NORMAN	Fw: 10, Sed: EPM, MB: 1000
	DPMPE	6362-80-7	1000	375	6.13*	Fw, Sed: ECHA, MB: NORMAN	Fw: 1000, Sed: EPM, MB: 1000
UV stabilizer	BEMT**	187393-00-6	-	-	-	ECHA	
	TBPHT**	31274-51-8	-	-	-	ECHA	
	UV234**	70321-86-7	-	-	-	ECHA	
	UV360	103597-45-1	1000000	1.4*	0.0084*	Fw: ECHA, Sed, MB: NORMAN	Fw: 100, Sed: 1000, MB: 1000
	UV1164	2725-22-6	3.3	492000	0.011*	Fw, Sed: ECHA, MB: NORMAN	Fw: 1000, Sed: EPM, MB: 1000
	UV310	154702-15-5	2000	17500	4.64*	Fw, Sed: ECHA, MB: NORMAN	Fw: 1000, Sed: EPM, MB: 1000

*: QSAR based PNEC values

**: No hazard identified (ECHA)

EPM: Based on equilibrium partitioning method

Fw: Freshwater

Sed: Sediment

MB: Marine biota

3.1.2. Known and suspected hotspots (part 1)

The samples from known and suspected hotspots covered indoor dust; agricultural soils; and various commercial products. From **Figure 18**, it is evident that the largest number of substances were found in indoor dust. The highest averages were of B-2ETF (100,000 ng g^{-1}), UV360 (9,000 ng g^{-1}), UV310 (4,000 ng g^{-1}), and BZBA (1,000 ng g^{-1}). SEROLD, analysed by suspect screening, was also detected in all dust samples with instrumental signals indicating relatively high concentrations. In the various types of commercial products, a very high average concentration of B-2ETF (50,000 ng g^{-1}) was found. Interestingly, there was considerable overlap between the substances detected in samples from the wastewater treatment plant (**Figure 17**) and in samples of indoor dust (**Figure 18**). This is not unexpected, as both these "hot spots" reflect substances in current-use products.

B-2ETF is an alternative phthalate as described above (ch. 3.1.1). B-2ETF was found in concentrations > 50,000 ng g^{-1} at all investigated sites. Compared to other known indoor pollutants, phthalates are often found in very high concentrations in house dust, see e.g. Bornehag et al. (2005). B-2ETF has previously been detected in floor dust from offices in China in comparable concentrations to the concentrations from the present study (Tang et al., 2020). Interestingly, the phthalate DIUDP (analysed by suspect screening, see ch. 3.1.1.) was not detected in any sample of indoor dust.

UV360 is a benzotriazole type UV substance, while UV310 is a triazine type UV substance. In general, the triazines are used in cosmetics, and products like polymers, paints, textiles or adhesives. UV310 has been found in house dust in China, but interestingly, other triazines than UV310 dominated in the Chinese house dust (Du et al., 2022). UV329 is an ultraviolet light absorber (UVA) of the hydroxyphenyl benzotriazole class, which is used as a light stabilizer for plastics and other organic substrates. BZBA is used in fragrances, as medication (to treat scabies and lice) and as an insect repellent. It has also been found to occur naturally in some plants (Abdel-Baki et al., 2024), but the detection of BZBA in indoor dust suggests the commercial uses of BZBA are more likely sources in this case.

In the agricultural soils, a few of the substances were detected but with relatively large variation between the four types of soils included. The two substances, TMPID (1 ng g^{-1}, d.w.) and BEMT (40 ng g^{-1}, d.w.), were found in all soils. TMPID is used in fragrance, while BEMT is a light stabiliser with a large range of applications (cosmetics, polymers, etc). Additional substances were found in the soil from an organic vegetable farm, covering UV360 (300 ng g^{-1}, d.w.), OTNE (10 ng g^{-1}, d.w.), UV310 (4 ng g^{-1}, d.w.), and TBPHT (2 ng g^{-1}, d.w.). It is noteworthy that these substances are present in agricultural soils. That the highest number of substances were found in the organic soil could be explained by the farm using a biodegradable copolymer mulching film called polybutylene adipate terephthalate (PBAT) (ID Hort, **Table 6**). The plastic film is typically spread over the soil to protect the crop. Subsequently, the plastic is ploughed into the ground after the crop has been harvested. This contrasts with conventional plastic that needs to be removed mechanically following harvesting. A major concern of the biodegradable plastic is that chemical additives and degradation products will leach into the soil and potentially be taken up by the crop. PBAT has been found not to be well degraded in colder climate, typical for Norway (NIBIO, 2024).

There were no PNECs available for the sample types covered here.

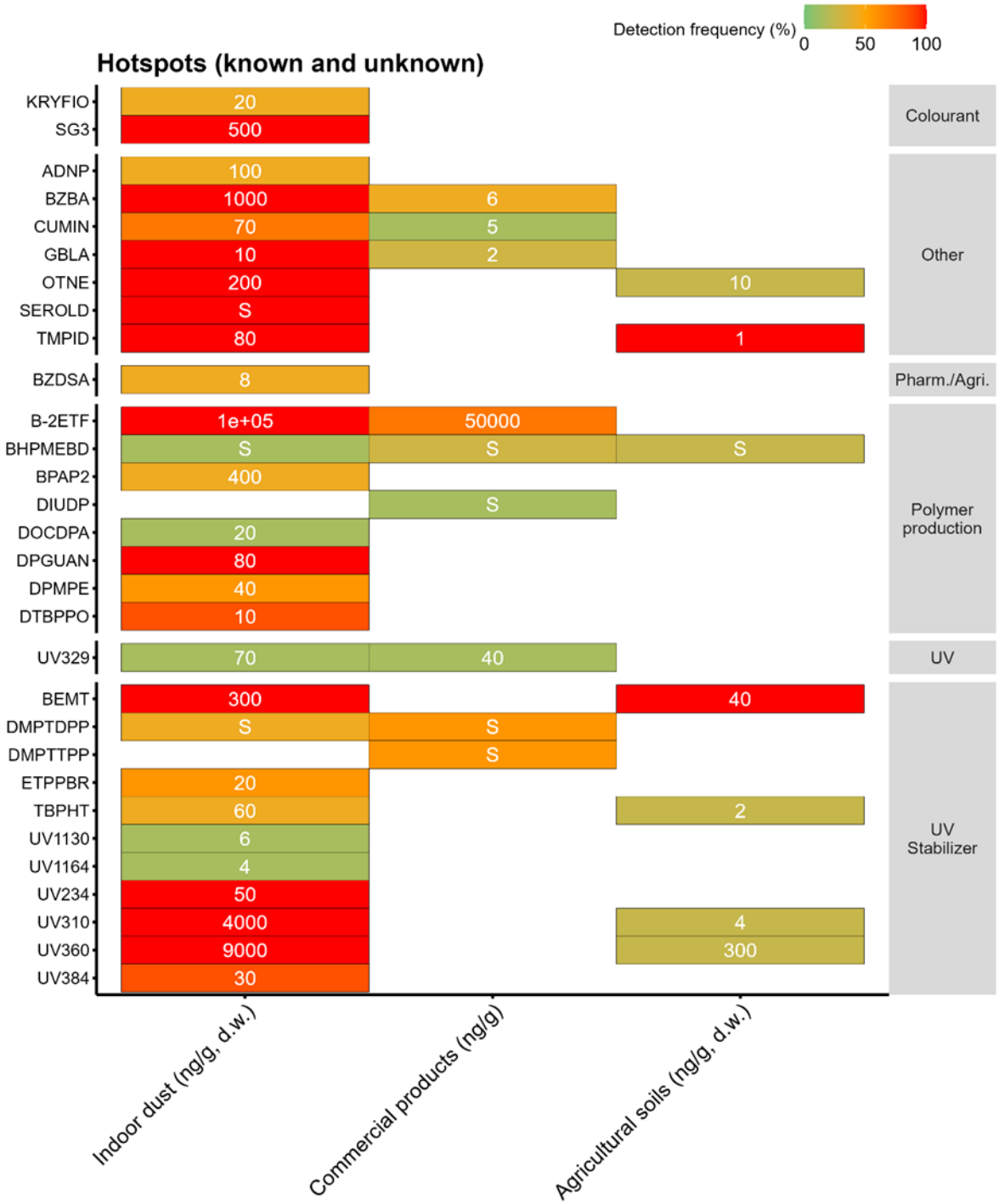

Figure 18: Detection frequencies and average concentrations in samples from the "hot spots" covering indoor dust (n=7), commercial products (n=7), and agricultural soils (n=3). S indicates suspect screening. Empty cells indicate levels below LOD, i.e. detection frequency = 0. Indoor dust covers both private homes and the plastic recycling facility. Substance IDs are to the left and substance group names to the right.

3.1.3. Whales and sharks (part 2)

Detection frequencies and averages are presented for whales and sharks for the emerging substances in **Figure 19** and for the legacy substances In **Figure 20**, **Figure 21**, **Figure 22.** The species have been grouped (**Table 12**) into whale top predators (killer whale, sperm whale, harbor porpoise, and white beaked dolphin), whale intermediate predators (humpback whale and fin whale), shark top predators (greenland shark and porbeagle shark), and shark intermediate predators (spiny dogfish). The results for metals, excluding mercury (Hg) is presented in **Appendix A.2.1.**

Table 12: Species of whales and sharks grouped according to their trophic level.

	Trophic level	Species
Whale	High	Killer whale, Sperm whale, Harbor porpoise, White beaked dolphin
	Intermediate	Humpback whale, Fin whale
Shark	High	Greenland shark, Porbeagle shark
	Intermediate	Spiny dogfish

3.1.3.1. Whales and sharks (part 2) – Emerging substances

Only a few of the emerging substances were detected in the whales and sharks. This covered three substances associated with polymer production (B-2ETF, DIUDP, and DTBMMP) as well as five others associated with a wide range of uses (BDPME, BZBA, CTCVB, DCTCVB, and TMPID) (**Figure 19**). The sample category/type with the highest number of detected substances was blubber from top predator whales. This suggests that these substances are lipophilic and with the potential to biomagnify.

The substance with the highest levels was B-2ETF, in top predator whale blubber (10,000 ng g^{-1}, w.w.) and muscle (5,000 ng g^{-1}, w.w.), and in shark intermediate predator muscle (700 ng g^{-1}, w.w.). The levels of B-2ETF, in addition to DTBMMP (at 30 ng g^{-1}, w.w.) exceeded their respective PNECs (**Table 13**). The PNECs used were QSAR derived. The substance DIUDP was also detected in whale blubber both from intermediate and top predators, as well as in liver from shark intermediate predators. DIUDP was determined by suspect screening rather than target analysis due to the lack of commercially available standard material at the time of sample analysis, but high instrumental signals suggested high concentrations.

Interestingly, both B-2ETF and DIUDP were also found at high levels in the samples from the wastewater treatment plant and associated marine recipient samples (ch. 3.1.1). For comparison, in the Screening Programme 2021, both B-2ETF and DIUDP were detected in blue mussels, and B-2ETF in herring gull eggs. However, at the time, these substances were identified by suspect screening due to the lack of standard material. B-2ETF and DIUDP are phthalates, a group of compounds used extensively as a plastic additive. As the whale and shark samples were not collected and stored with phthalate analysis in mind (ch. 2.1.1 - ch. 2.1.2), it is difficult to specifically attribute the high detected levels to the whale itself. While it is conceivable that the detected levels of B-2ETF and DIUDP could be caused by ingestion of plastic or plastic-contaminated prey by the whale, followed by uptake of the substances through the stomach, we cannot exclude B-2ETF and DIUDP contamination through contact between the sample and plastic materials during sampling, transport and/or storage. We recommend follow-up of these results with samples collected specifically with phthalate analysis in mind. Different types of phthalates have also recently been found in marine mammals off the coast of Norway (Andvik et al., 2024a) and in the Norwegian Arctic (Routti et al., 2021).

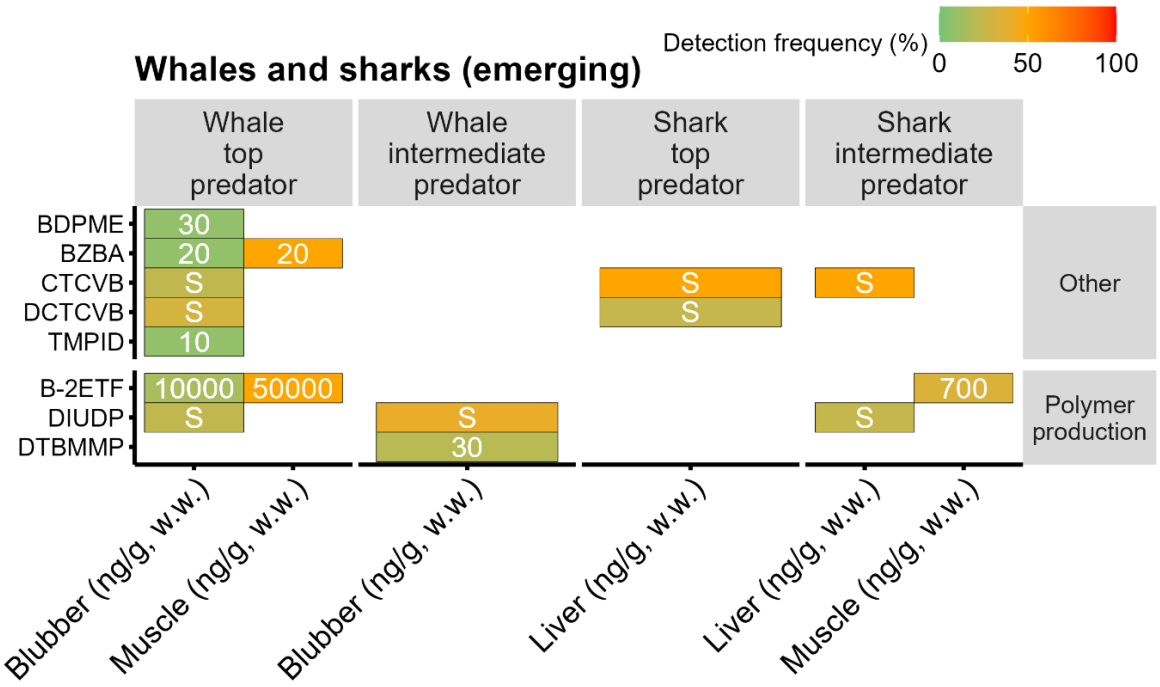

Figure 19: Detection frequencies and average concentrations of emerging substances in samples of whale top predator (blubber: n= 13, muscle: n=2), whale intermediate predator (blubber: n=5), shark top predator (liver: n=4), and shark intermediate predator (liver: n=4, muscle: n=3). S indicates suspect screening. Empty cells indicate levels below LOD, i.e. detection frequency = 0. Substance IDs are to the left and substance group names to the right.

Table 13: Available predicted no-effect concentrations (PNEC) for the emerging substances quantified in samples of whales and sharks. Highlighted cells indicate that the average concentration in samples exceed the PNEC value.

Group	Short name	CAS	Marine Biota (ng/g)	Data Source	Assessment factor
Polymer production	B-2ETF	6422-86-2	1.46*	NORMAN	1000
	DTBMMP	2773-50-4	24.6*	NORMAN	1000
Other	BDPME**	574-42-5	-	ECHA	
	BZBA	120-51-4	114*	NORMAN	1000
	TMPID	3910-35-8	16.6*	NORMAN	1000

*: QSAR based PNEC values

**: No hazard identified (ECHA)

EPM: Based on equilibrium partitioning method

3.1.3.2. Whales and sharks (part 2) – Legacy substances

Among the legacy substances, a large number were found at high detection frequencies and concentrations (**Figure 20, Figure 21, Figure 22)**. Again, the largest number of substances were found in blubber from top predator whales which amounted to 58 different substances.

The highest averages were of HCB (900 ng g^{-1}, **Figure 20**),BDE47, BDE100, BDE153, and BDE154 (100-300 ng g^{-1}, **Figure 21)**, and PCB52, PCB101, PCB118, PCB138, PCB153, and PCB180 (900-8,000 ng g^{-1}, **Figure 21)**. The substance group with the highest detection frequencies and averages in all sample types was the PCBs. Also noteworthy, high levels of mercury were also found in all tissue types (**Figure 21**).

Among the substances with available PNECs, exceeding levels were found for two dechloranes (DDC ANT and DDC DBF); two nBFRs (HCB and PBEB), one nPFAS (PFBSA); several PCBs (CB52, CB101, CB118, CB138, CB153, and CB180), one PFSA (PFOS), two QAC (BAC_C12 and BAC_C14), and one UV-stabilizer (UV327) (**Table 14**). We note that except for HCB, PBEB, and PFOS, all these PNECs are QSAR based and therefore associated with additional uncertainty and should be interpreted with caution. This is particularly the case for the DDC ANT and DDC DBF PNEC values which appear unrealistically low. In addition, the one EQS for the sum of several BDEs (BDE 28, 47, 99, 100, 153, and 154) was found to be exceed in all of the samples analysed.

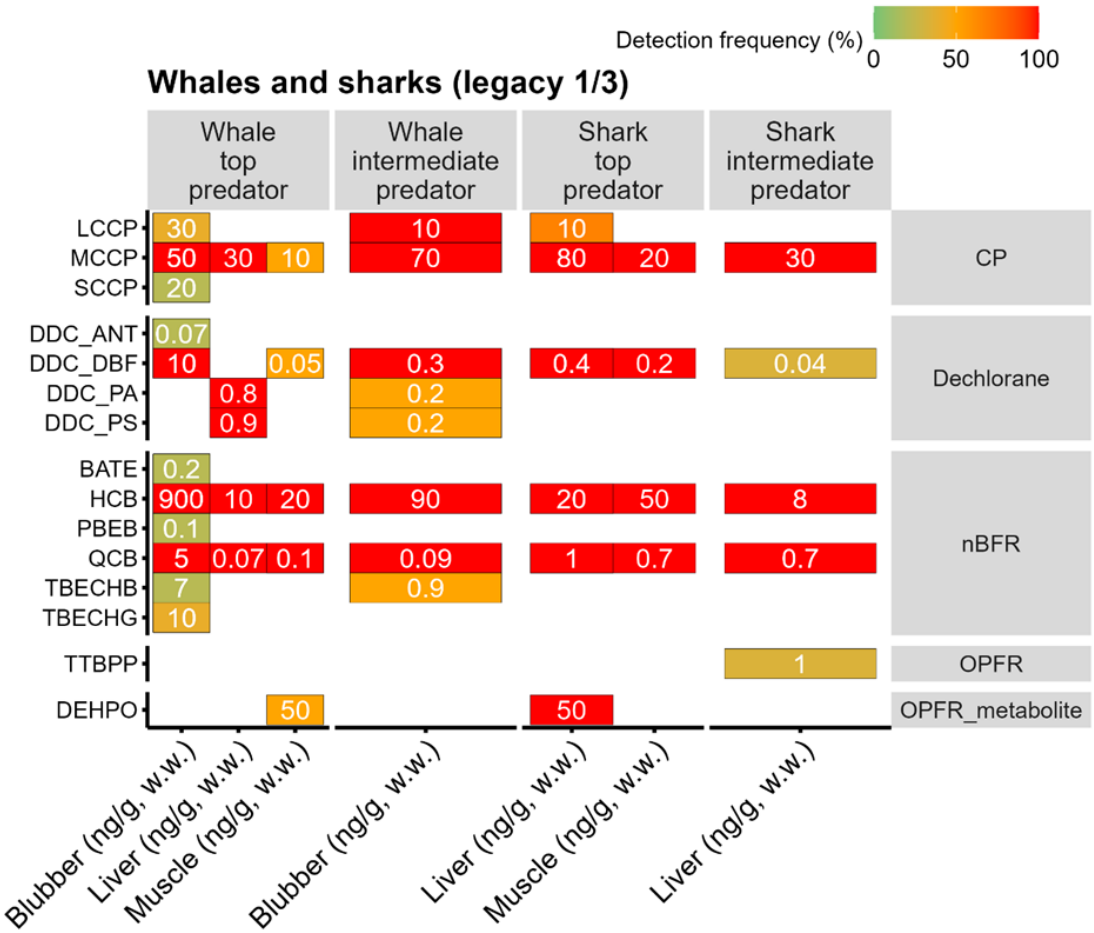

Figure 20: Detection frequencies and average concentrations of legacy substances (part 1 of 3) in samples of whale top predator (blubber: n=5, liver: n= 1, muscle: n=2), whale intermediate predator (blubber: n=2), shark top predator (liver: n=3, muscle: n=1), and shark intermediate predator (liver: n=3). S indicates suspect screening. Empty cells indicate levels below LOD, i.e. detection frequency = 0. Substance IDs are to the left and substance group names to the right.

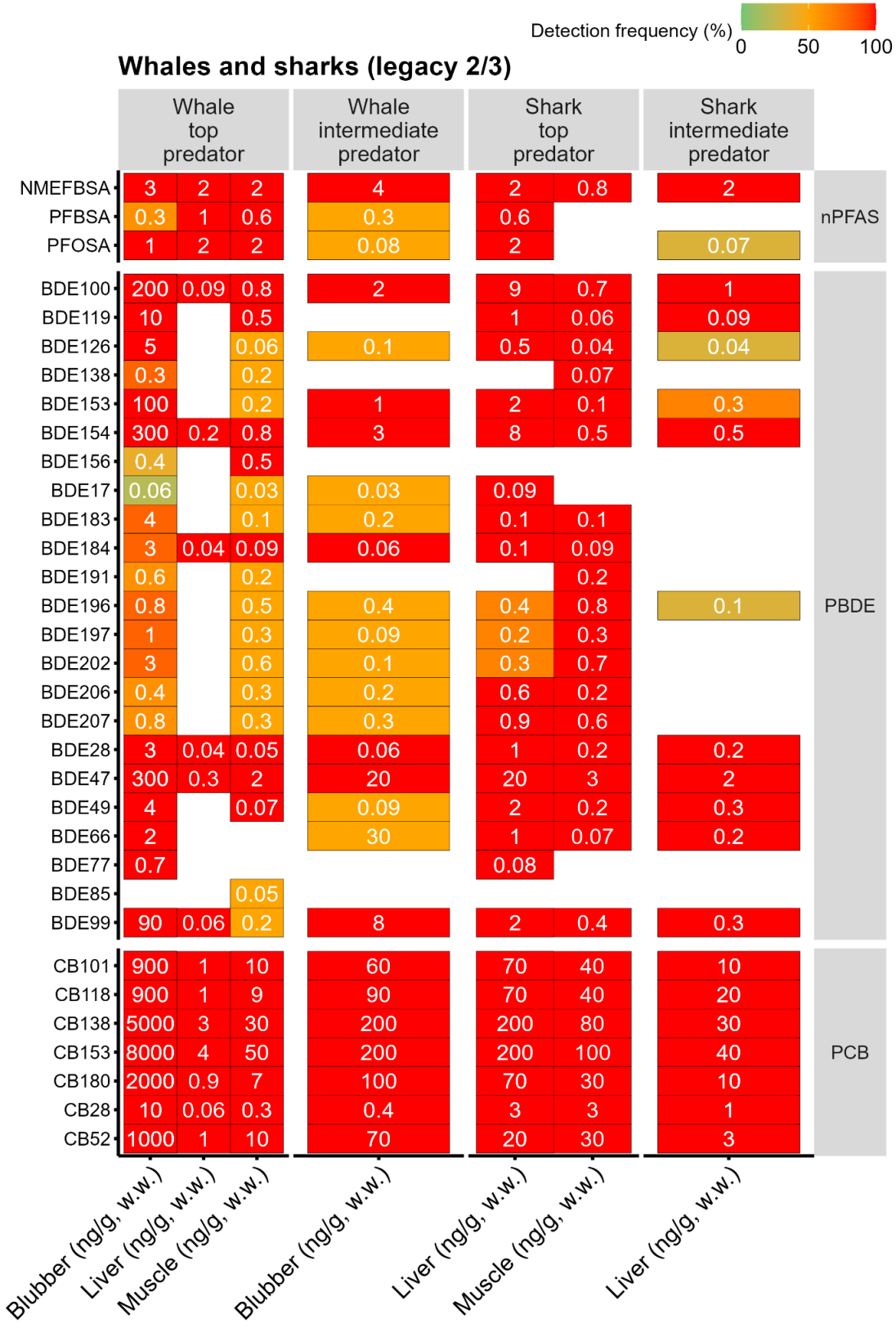

Figure 21: Detection frequencies and average concentrations of legacy substances (part 2 of 3) in samples of whale top predator (blubber: n=5, liver: n= 1, muscle: n=1), whale intermediate predator (blubber: n=2), shark top predator (liver: n=3, muscle: n=1), and shark intermediate predator (liver: n=3). S indicates suspect screening. Empty cells indicate levels below LOD, i.e. detection frequency = 0. Substance IDs are to the left and substance group names to the right.

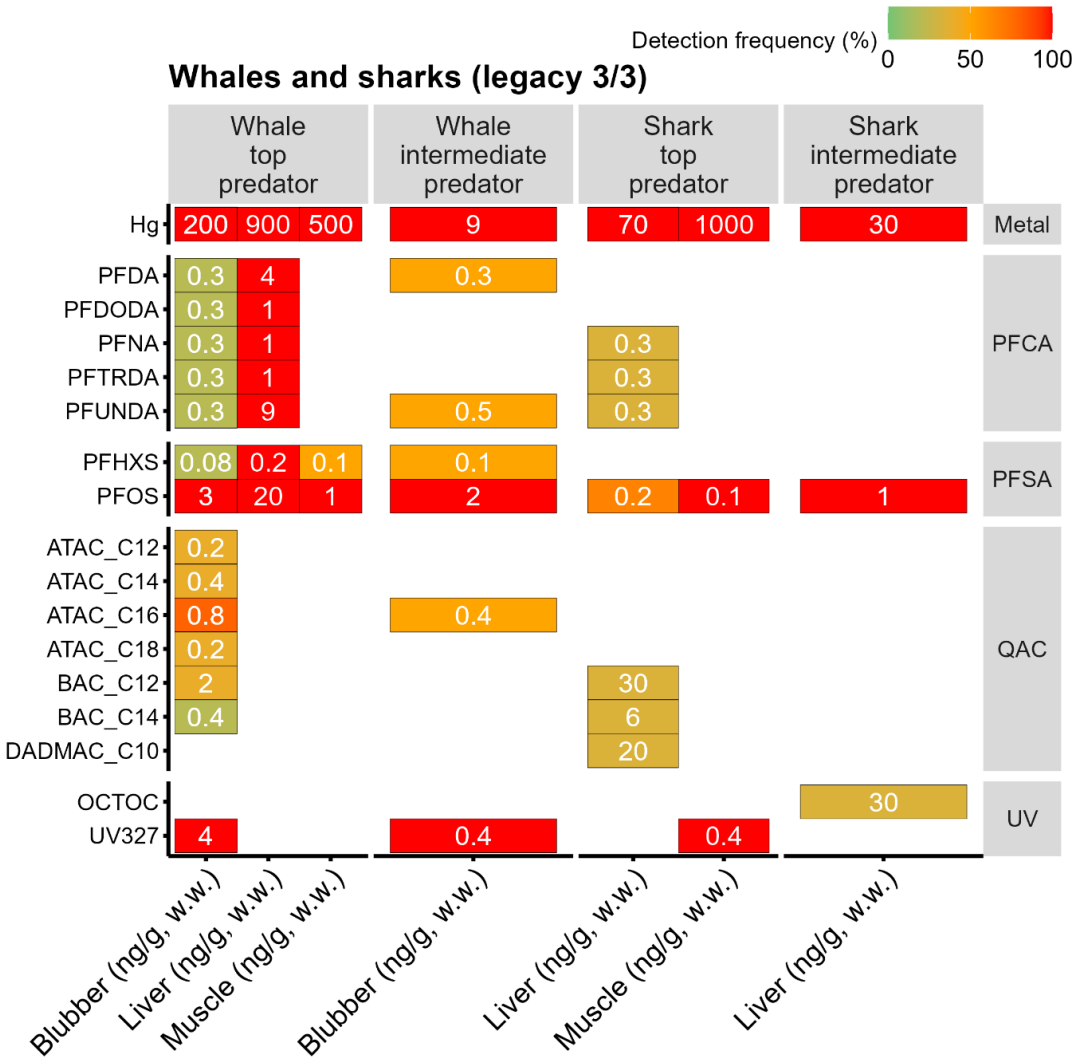

Figure 22: Detection frequencies and average concentrations of legacy substances (part 3 of 3) in samples of whale top predator (blubber: n=5, liver: n= 1, muscle: n=1), whale intermediate predator (blubber: n=2), shark top predator (liver: n=3, muscle: n=1), and shark intermediate predator (liver: n=3). S indicates suspect screening. Empty cells indicate levels below LOD, i.e. detection frequency = 0. Substance IDs are to the left and substance group names to the right.

Table 14: Available predicted no-effect concentrations (PNEC) and environmental quality standards (EQS) for the legacy substances quantified in samples of whales and sharks. Highlighted cells indicate that the average concentration in samples exceed the PNEC/EQS value.

Group	Short name	CAS	Marine Biota (ng/g)	Data Source	Assessment factor	EQS (ng/g)
CP	SCCP	85535-84-8	n.a.	Not found in ECHA or NORMAN	n.a.	6000
	MCCP	85535-85-9	n.a.	Not found in ECHA or NORMAN	n.a.	170
	LCCP	85535-86-0	n.a.	Not found in ECHA or NORMAN	n.a.	
Dechlorane	DDC_ANT	13560-92-4	0.0000015*	NORMAN	1000	
	DDC_DBF	31107-44-5	0.0000035*	NORMAN	1000	
	DDC_PA	135821-74-8	n.a.	Not found in ECHA or NORMAN		
	DDC_PS	135821-03-3	n.a.	Not found in ECHA or NORMAN		
nBFR	BATE	99717-56-3	n.a.	Not found in ECHA or NORMAN		
	HCB	118-74-1	10	NORMAN	n.a.	10
	PBEB	85-22-3	0.058	NORMAN	n.a.	
	QCB	608-93-5	6.77	NORMAN	n.a.	50
	TBECHB	1232836-49-5	n.a.	Not found in ECHA or NORMAN		
	TBECHG		n.a.	Not found in ECHA or NORMAN		
OPFR	TTBPP	78-33-1	7.52*	NORMAN	1000	
OPFR metabolite	DEHPO	298-07-7	180*	NORMAN	1000	
nPFAS	NMEFBSA	68298-12-4	4.47*	NORMAN	1000	
	PFBSA	30334-69-1	0.23*	NORMAN	1000	
	PFOSA	754-91-6	2.52*	NORMAN	1000	
PBDE	BDE17	147217-75-2	1167*	NORMAN	1000	
	BDE28	41318-75-6	2568*	NORMAN	1000	0.0085¥
	BDE47	5436-43-1	1116*	NORMAN	1000	0.0085¥
	BDE49	243982-82-3	1776*	NORMAN	1000	
	BDE66	189084-61-5	2164*	NORMAN	1000	
	BDE77	93703-48-1	4019*	NORMAN	1000	
	BDE85	182346-21-0	825*	NORMAN	1000	
	BDE99	60348-60-9	51165	NORMAN	10	0.0085¥
	BDE100	189084-64-8	2105*	NORMAN	1000	0.0085¥
	BDE119	189084-66-0	4940*	NORMAN	1000	
	BDE126	366791-32-4	3212*	NORMAN	1000	
	BDE138	182677-30-1	292*	NORMAN	1000	
	BDE153	68631-49-2	869*	NORMAN	1000	0.0085¥
	BDE154	207122-15-4	790*	NORMAN	1000	0.0085¥
	BDE156	405237-85-6	306*	NORMAN	1000	
	BDE183	207122-16-5	91.7*	NORMAN	1000	
	BDE184	117948-63-7	79*	NORMAN	1000	
	BDE191	446255-30-7	102*	NORMAN	1000	
	BDE196	446255-39-6	38.2*	NORMAN	1000	
	BDE197	117964-21-3	30.9*	NORMAN	1000	

	BDE202	67797-09-5	64.9*	NORMAN	1000	
	BDE206	63387-28-0	30.8*	NORMAN	1000	
	BDE207	437701-79-6	62.2*	NORMAN	1000	
PCB	CB28	7012-37-5	126*	NORMAN	1000	
	CB52	35693-99-3	486*	NORMAN	1000	
	CB101	37680-73-2	1*	NORMAN	1000	
	CB118	31508-00-6	1.78*	NORMAN	1000	
	CB138	35065-28-2	4.42*	NORMAN	1000	
	CB153	35065-27-1	838*	NORMAN	1000	
	CB180	35065-29-3	58.7*	NORMAN	1000	
Metals	Hg	7439-97-6	20	NORMAN	n.a.	20
	Cr	7440-47-3	5978*	NORMAN	n.a.	
	Fe	7439-89-6	107505000*	NORMAN	n.a.	
	Ni	7440-02-0	7830*	NORMAN	n.a.	
	Cu	7440-50-8	153*	NORMAN	n.a.	
	Zn	7440-66-6	23228*	NORMAN	n.a.	
	As	7440-38-2	5285*	NORMAN	n.a.	
	Se	7782-49-2	15,3*	NORMAN	n.a.	
	Ag	7440-22-4	2881*	NORMAN	n.a.	
	Cd	7440-43-9	11061*	NORMAN	n.a.	
	Sn**	7440-31-5	-	ECHA	n.a.	
	Sb	7440-36-0	41,1*	NORMAN	100	
	Pb	7439-92-1	22296*	NORMAN	n.a.	
PFCA	PFDA	335-76-2	0.82*	NORMAN	1000	
	PFDODA	307-55-1	149*	NORMAN	1000	
	PFNA	375-95-1	16.5	NORMAN	100	
	PFTRDA	72629-94-8	4.1*	NORMAN	1000	
	PFUNDA	2058-94-8	22.3*	NORMAN	1000	
PFSA	PFHXS	355-46-4	15.3*	NORMAN	1000	
	PFOS	1763-23-1	9.1	NORMAN	200	9.1
QAC	ATAC_C12	1119-94-4		Not found in ECHA or NORMAN		
	ATAC_C14	1119-97-7	3.73*	NORMAN	1000	
	ATAC_C16	57-09-0	2.25*	NORMAN	1000	
	ATAC_C18	1120-02-1		Not found in ECHA or NORMAN	1000	
	BAC_C12	139-07-1	3.8*	NORMAN	1000	
	BAC_C14	139-08-2	2.17*	NORMAN	1000	
	DADMAC_C10	2390-68-3		Not found in ECHA or NORMAN	1000	
UV stabilizer	OCTOC	6197-30-4	12587	NORMAN	n.a.	
	UV327	3864-99-1	2.48*	NORMAN	1000	

*: QSAR based PNEC values

**: No hazard identified (ECHA)

EPM: Based on equilibrium partitioning method

¥EQS for the sum of BDEs 28, 47, 99, 100, 153, and 154 (in bold).

3.2 Site specific contamination patterns

Here follows some situation-specific contamination patterns looking at all detected substances together. Note that the number of samples from each site is generally limited, and so there is generally not a foundation for stating exact differences between samples with a high degree of certainty, i.e. no statistical analyses have been used. Instead, any patterns indicated here may form the basis for further investigations. The results are presented by sample averages for part 1 and by individual sample levels in for part 2. Note that all figures are provided with the y-axis $\log_{10}$ transformed. Results for substances analysed using suspect screening have not been included in the figures in this section (n=15).

3.2.1. Wastewater treatment plant (Part 1)

For samples from the wastewater treatment plant, average levels are in **Figure 23** compared between low and high degree of treatment. The low degree treatment consists of mechanical treatment by a coarse screen, a sand- and grease trap, and pre-sedimentation. Higher degree treatment is achieved by subsequent biologic treatment in a co-precipitation step that also include nitrogen removal (anoxic and aerobic treatment).

In the filtrated water (20 µm), a few substances were only detected in samples from the low degree treatment. This can indicate removal during the higher degree treatment, and was the case for the bisphenols DABPA, UV324, and PF201; the SVOC MABT; and the four triazines BEMT, TBPHT, UV1164, and UV310. For most of the remining substances in the filtrated water there was a tendency of reduced concentrations in the high degree- compared to the low degree treated water. This also seemed to be the case for SEROLD, where higher instrumental signals were seen for low degree treated water. Exceptions in the filtrated water samples included DPGUAN, BZDSA, GBLA, and CBLZ that appeared to be unaffected by the high degree treatment.

Interestingly, while partial or complete removal of substances BEMT, UV310, and UV360 is suggested, these were found in the marine recipient samples collected near the discharged high degree purified water (see **Figure 17**). If these substances are stable in the environment, a low supply can lead to elevated levels with time. A low supply can result from episodic incomplete treatment such as during high flow events that leads to hydraulic overload of the biological treatment step, or when part of the fully treated wastewater bypasses the polishing sand filter. Alternatively, there may be another source of these substances to the Bekkelaget basin (e.g. stormwater).

The comparison between low and high degree treatment is not as straight forward for the particulate fraction. The reason is that particles will be removed from the water phase during the low degree of treatment. This means that even though the concentration of a substance is equal in the particles from the two different treatments, the particle load will be much higher in the water from the low degree treatment. Here we have not included information on the particle load. The average concentrations are compared in **Figure 23.** There is no clear trend in the effect from the high degree treatment. For some of the substances the concentration seems to decrease (e.g., BPAP2, DTBPPO, B-2ETF) while the opposite is the case for some of the other substances (e.g., UV324 and MPSHDOSD).

In the sludge samples, the high degree treatment appeared to increase the concentration of most of the substances (**Figure 23**). This is mainly because the higher treatment process reduces the amount of sludge through combustion of the organic material present. This means that substances that are stable towards such treatment will end up at a higher concentration following the treatment. Exceptions from this covered the substances DTBPPO, CUMIN, OTNE, and B-2ETF. Four substances were only found in the sludge following high degree treatment which were DOCDPA, BZDESA, PF201, and MABT.

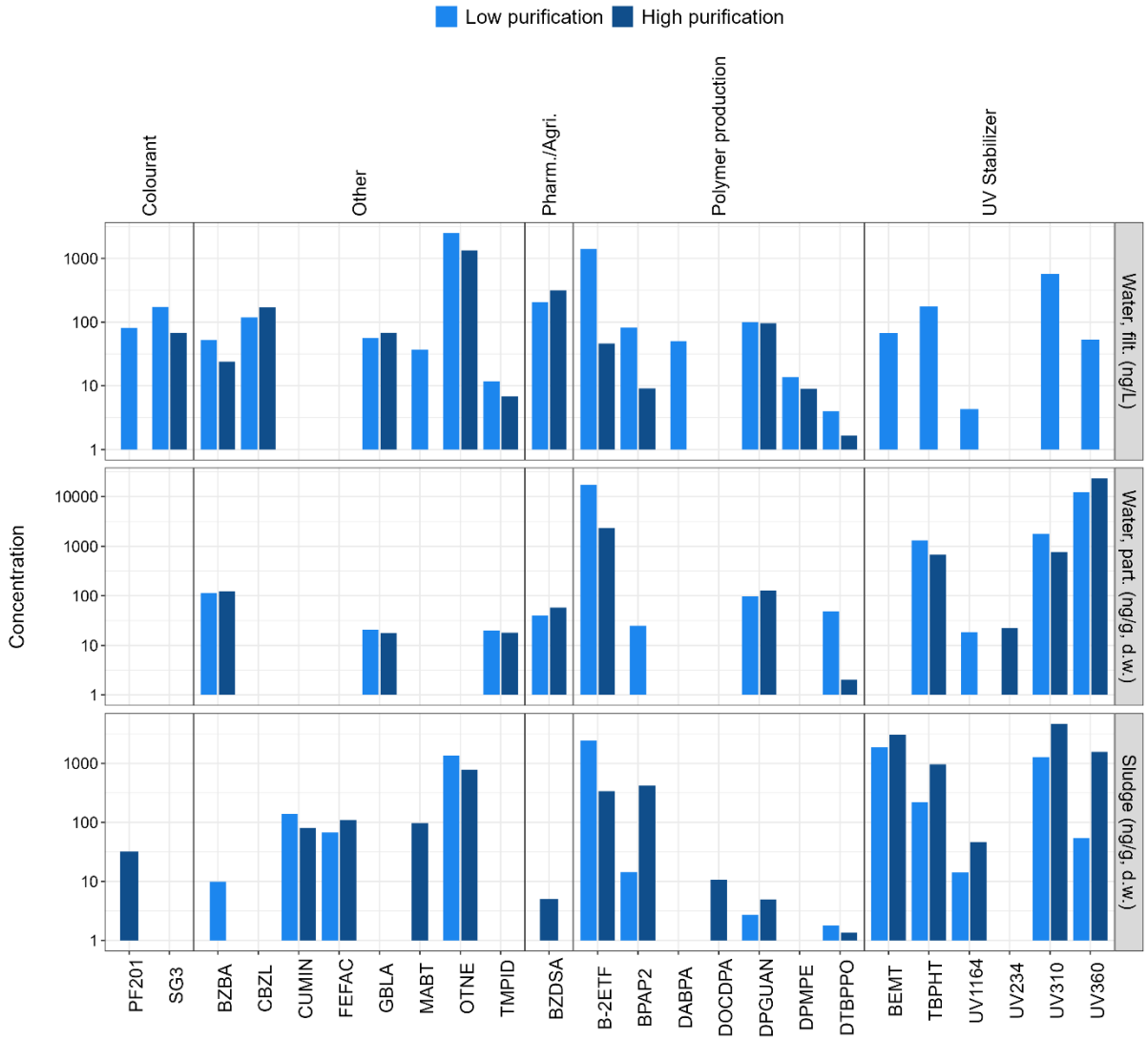

Figure 23: Average concentrations measured in water filtrated (< 20 µm, n=4) and particulate (> 20 µm, n=4), and in sludge (n=2) each from the wastewater treatment plant following low (light blue) or high (dark blue) degree of purification/treatment. Note that the y-axis is log_{10} transformed.

3.2.2. Indoor dust (Part 1)

When comparing the average concentrations in dust from a plastic recycling facility to those in dust from private homes, there are strong similarities (**Figure 24**). In fact, there are even more substances in the private homes than at the plastic recycling facility, covering substances DOCDPA (UV-stabilizer/antioxidant), ADNP (cosmetics – hair colour), BZDSA (used in dyes), and UV329 (UV-stabilizer). This indicates additional sources in the private homes, which is not unexpected given the wide range of products found in homes

Unsurprisingly, the substances detected in highest concentrations at the recycling facility are likely associated with plastics, either in various stages of polymer production (B-2ETF, BPAP2) or as a UV stabilizer (UV310, UV360) (**Figure 24**). The bisphenol A derivate BPAP2 was detected at much higher concentrations in dust from the plastic recycling facility compared to private homes. BPAP2 is used e.g. as an intermediate in the production of corrosion-resistant unsaturated polyesters, which are used in materials for e.g. construction, infrastructure and transportation. It is therefore possible that BPAP2 originates from the infrastructure at the recycling facility, possibly in addition to some plastic products they handle. The substances CUMIN, TMPID, and DPMPE were also found in higher concentrations in dust from the plastic recycling facility. While DPMPE is a substance used in polymer production, CUMIN and TMPID are used e.g. in fragrance. The higher concentrations of the latter two substances at the recycling facility compared to private homes could originate from cleaning product or cosmetics packaging submitted for recycling.

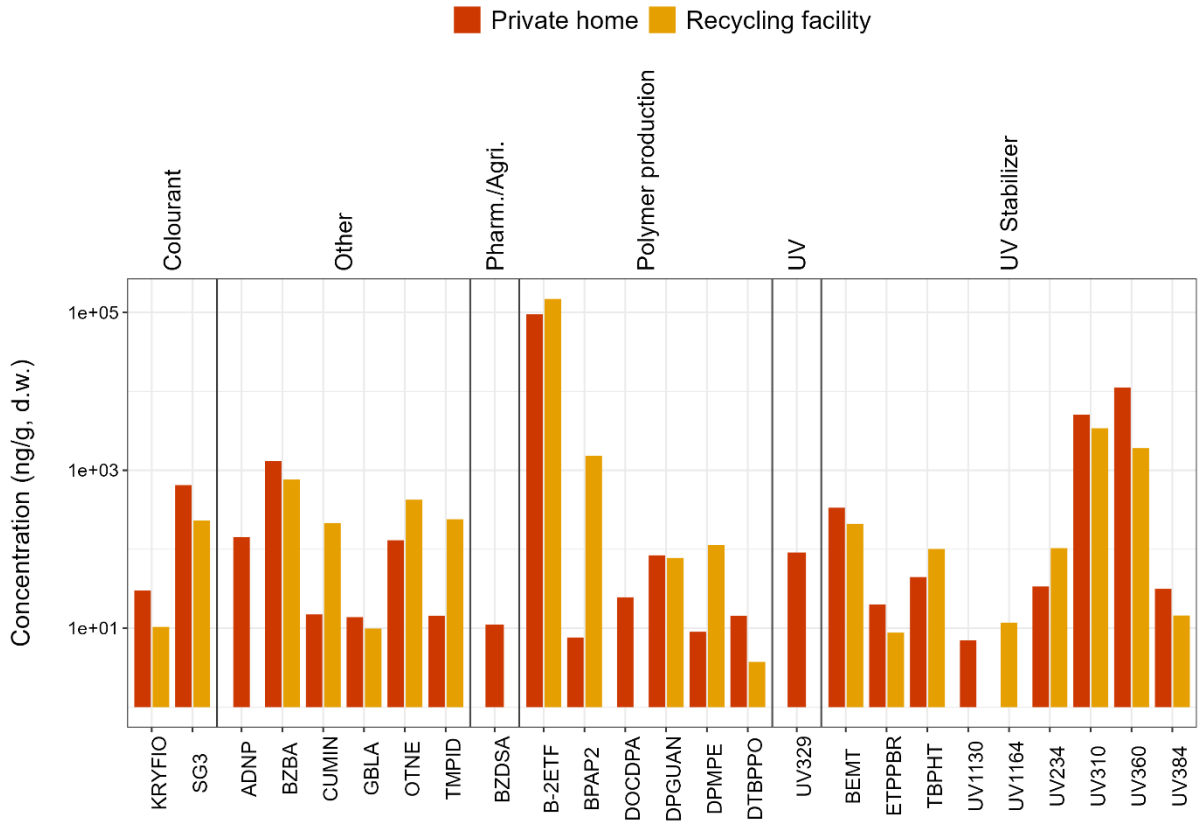

Figure 24: Average concentrations in dust (ng/g, d.w.) from private homes (red) and the plastic recycling facility (orange). Note that the y-axis is log10 transformed.

3.2.3 Commercial products (Part 1)

A range of different types of commercial products were tested for the presence of the substances of interest (**Figure 25**). However, only a few of the substances were identified.

The phthalate B-2ETF was the substance found in the highest number of different products, covering boat care products; electronics; furniture fabric; paint and varnish; and toys. This suggests quite a wide range of uses for this compound, which is also supported by the ubiquity and high concentrations found in dust from houses and a plastic recycling facility. We note that B-2ETF was found at a high concentration in toys. This may be of concern since B-2ETF has similar structure and functionality as legacy phthalates which are with known endocrine disrupting effect (e.g. Wang and Qian (2021). The highest level of B-2ETF was found in electronics. Electronics was also found to contain GBLA and the benzotriazole UV substance UV329. In addition, the phthalate DIUDP, which was analysed using suspect screening, was detected with high signal in electronics. Unlike B-2ETF, however, DIUDP was not detected in samples from any of the other product categories.

The list of detected substances from the direct testing of products is very limited compared to substances detected in samples from the wastewater treatment plant (**Figure 23**) and in samples of indoor dust (**Figure 24**) The list of analysed substances was identical for these three sample categories. This likely reflects the much wider range of in-use products and other sources which are captured in house dust and in wastewater treatment plants, compared to the relatively limited number of products of each category which was included in the product testing (**Table 7**). The number of substances detected can be influenced by the extraction method used which was not specialised to individual substances. Despite less detections, the information gained from product testing is more specific in terms of possible sources and areas of use for the substances compared to results from samples from the wastewater treatment plant and indoor dust.

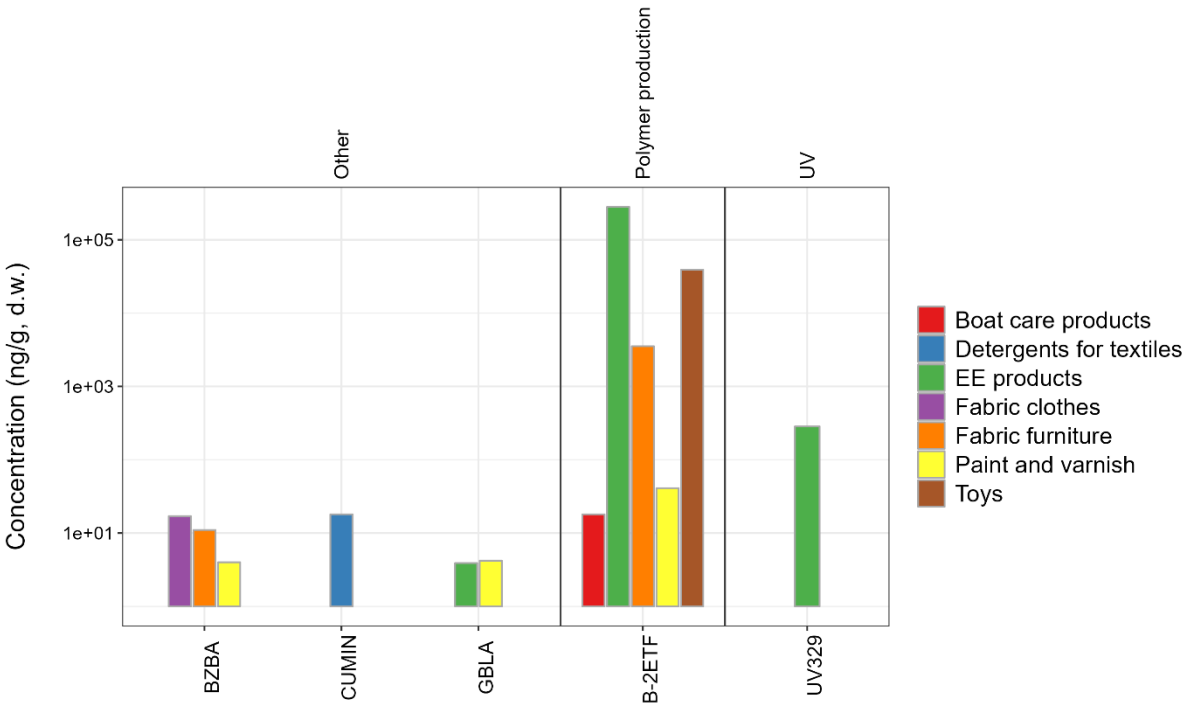

Figure 25: Average concentrations the different types of commercial products tested (ng/g, d.w.). Note that the y-scale is log_{10} transformed.

3.2.4 Whales and sharks –top and intermediate predators (Part 2)

Figure 26 displays the concentration of substances in individual samples of whales and sharks with the various tissue types available. The species have been categorised as intermediate or top predators. As expected, top predator whale blubber showed the highest levels of most substances. This was especially true for the legacy substance groups nBFRs, PBDEs, and PCBs, and a few of the emerging substances related to polymer production. Biomagnification and high concentrations of persistent bioaccumulative substances in marine mammal predators is well documented (Andvik et al., 2020; Lippold et al., 2022; Ruus et al., 2002), and concentrations may reach harmful levels (Desforges et al., 2018; Dietz et al., 2019; Jepson et al., 2016).

Interestingly, for several of the substances, levels in top predator shark liver appeared higher than (or approximately equal to) those in intermediate predator whale blubber. It is worth mentioning that the concentrations depicted in **Figure 26** are on a wet weight basis, however, the whale blubber- and the shark liver samples have comparable lipid content (both ~60%).

Mercury is an element with known biomagnifying properties (Ruus et al., 2015). Methylmercury is readily absorbed from the gastrointestinal tract and binds to sulfhydryl groups of amino acids in proteins. The highest concentration of (total) mercury was found in muscle of the greenland shark specimen (1170 ng g^{-1} w.w.). For comparison, in muscle of white beaked dolphin and harbour porpoise, mercury-concentrations were 469 and 494 ng g^{-1} w.w., respectively (**Figure 27**). The mercury concentration in the one harbour porpoise liver was 856 ng g^{-1} w.w. (**Figure 27**). According to a review by Dietz et al. (2019) an estimated threshold level for low risk of health effects in marine mammals is for mercury at 16,000 ng g^{-1} w.w. For the greenland shark, comparable high levels of mercury have also previously been reported (Biton-Porsmoguer et al., 2024). However, the EQS for mercury (20 ng g^{-1}) was found to be exceeded in several of the samples.

The results indicate the relevance of both whale and shark samples for the purpose of screening multiple contaminants in predatory marine species.

When evaluating the results from these samples it is important to remember that they came from different storage facilities and that they had likely been treated differently. Upon arrival some samples were wrapped in aluminium foil while others were packaged in plastic. Aluminium foil can be a source of contamination with PFAS (Sonego et al., 2023). In **Appendix A.2.2**, the measured concentrations are plotted but colour coded by the packaging material. While there are tendencies of potential contamination this cannot be confirmed without the presence of parallel samples wrapped in both types of materials. For future Screening Programmes focusing on substances where there is reason to suspect blank contamination issues, we recommend sample collection conducted specifically for the purpose, not repurposing of previously collected samples.

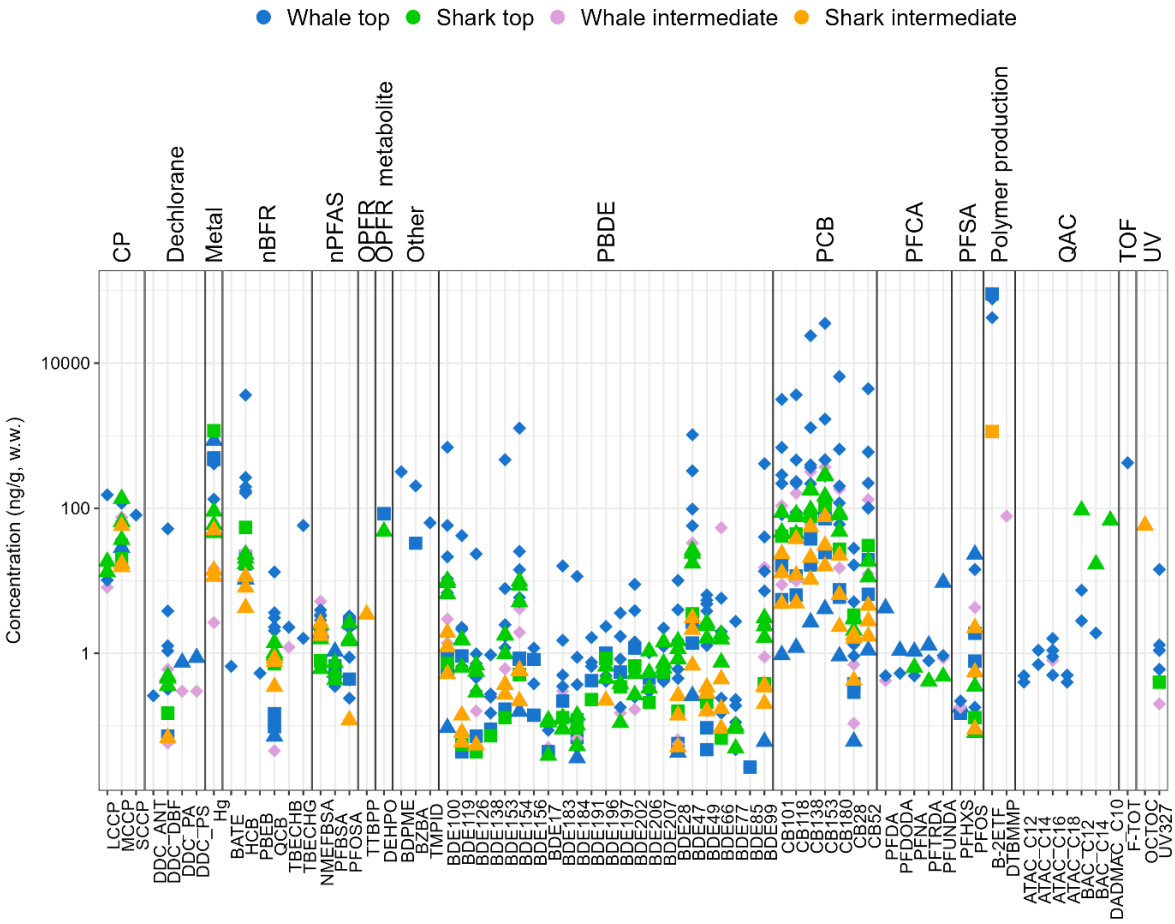

Figure 26: Concentrations in top predator whale (blue) and shark (green), and in intermediate predators of whales (purple) and sharks (orange). The tissue types cover blubber (diamond), liver (triangle), and muscle (square). Note that the y-axis is log_{10} transformed.

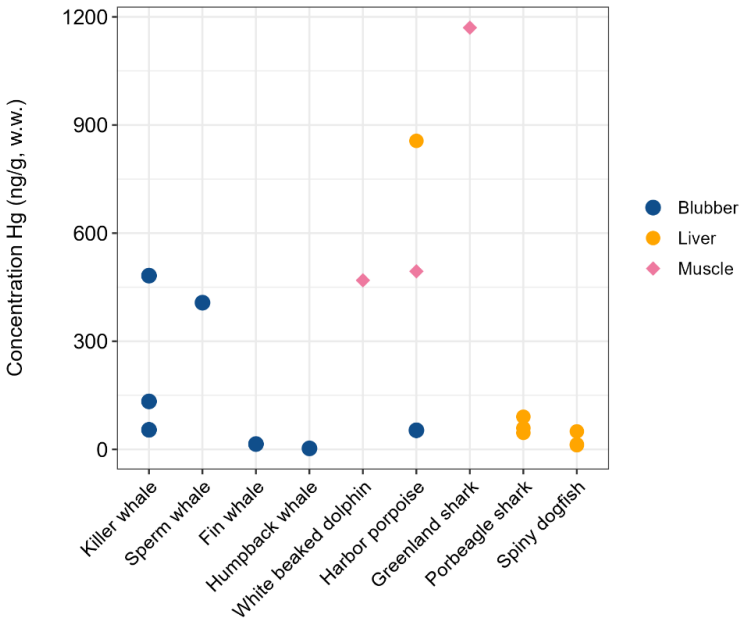

Figure 27: concentration of total mercury (Hg) in blubber (blue circle), liver (orange circle), and muscle (pink diamond) from species of whales and sharks.

3.2.5 Whales – effect from specie (part 2)

Measured levels in blubber from different whale species are presented in **Figure 28** (and lipid normalized in **Appendix A.2.3**). For nearly all the substances, the highest levels were in killer whales. This is especially true for the substance groups PCB and PBDE. Killer whales are apex predators, and some pods/individuals are known to prey on pinnipeds (so called "Bigg's killer whales") (Jourdain et al., 2020).

A suggested equivalent sum-PCB concentration threshold for onset of physiological effects in marine mammals is 9.0 mg kg^{-1} lipid (i.e. 9 000 ng g^{-1} l.w.; (Jepson et al., 2016; Kannan et al., 2000)). In one of the killer whales, a subadult female found dead in Sognefjorden, the total amount of PCB surpassed this threshold by more than an order of magnitude (**Figure 29**). This has also been found in stranded subadult individuals elsewhere, including in Norway (Andvik et al., 2024b). Interestingly, much lower levels were found in the two other killer whales analysed, among which one was comparable in size and age (ID OO5) as the individual with the very high PCB levels (OO11). High PCB levels have been linked to poor health, impaired immune function, increased susceptibility to cancers, infertility, etc. In addition to high PCB levels, this individual had high concentrations of PBDEs, particularly BDE 47, BDE 99, BDE 100, BDE 153, and BDE 154, exceeding the EQS for the sum of these (ch. 3.1.3). Concentrations for these PBDEs were up to three orders of magnitude higher than for the other killer-whales analysed. In addition, very high concentration of dechlorane DDC BDF was found in this individual. High concentrations of this dechlorane in killer whale has also recently been reported by Andvik et al. (2024b). Two emerging substances (BDPME and TMPID) were also detected in this individual and in no other marine biota samples, and which have recently been reported in harbour porpoise by Rebryk et al. (2022). For comparison, the measured levels of legacy contaminants in the subadult killer are in **Appendix A.2.3** plotted together with previously obtained data from other Norwegian killer whales (Andvik et al., 2020; Andvik et al., 2021).

The young age of this individual was likely a contributing factor to the high levels of contaminants. This can be explained by the calf being fed with the mother's milk which is typically high in contaminants. As the individual grows older the contaminant concentration is diluted by the increasing body size (and for females, also reproduction; Hickie et al. 1999). Additionally, this individual is known to be associated with seal eating individuals (Eve M. Jourdain, personal observations) and it is possible that it has been exposed through mothers' milk of a seal-eating female. If so, this would suggest high exposure in a vulnerable life stage, and concentrations of e.g. PCBs were at a level that can be associated with risk of health effects (Andvik et al., 2020). Additional observations of this killer whale were an unnormal thin layer of blubber as well as an empty stomach, which can result from illness (Eve M. Jourdain, personal observations). One consequence of a thinner layer of blubber is an increase in the concentrations of contaminants (while the total body burden remains mostly the same). Mobilization of lipid reserves also implies that stored contaminants are brought into circulation in the animal. This may also have detrimental consequences for the health of the individual. The contributing factor of environmental contaminants to the death of this young individual is unknown but possible.

In general, trophic position has been shown to be an important driver of POP concentrations in several marine mammal species from the European Arctic including killer whales (Andvik et al., 2020; Remili et al., 2021), blue whales and fin whales (Tartu et al., 2020), walruses (Scotter et al., 2019) and polar bears (Blévin et al., 2020; Tartu et al., 2017; Tartu et al., 2018). While variations in POP concentrations do not seem to be influenced by feeding habitats in walruses (Scotter et al., 2019), and fin whales and blue whales (Tartu et al., 2020), minke whales feeding on more benthic and/or coastal prey showed the highest levels of POPs (Andvik et al., 2023). Within the marine mammal community from the Norwegian Arctic (14 species including the polar bear), sperm whales and killer whales were the most contaminated species with ~45 times higher concentrations of legacy POPs ($\sum_{33}$POPs), on average, than blue whales which had the lowest concentrations (Blévin et al. unpublished data).

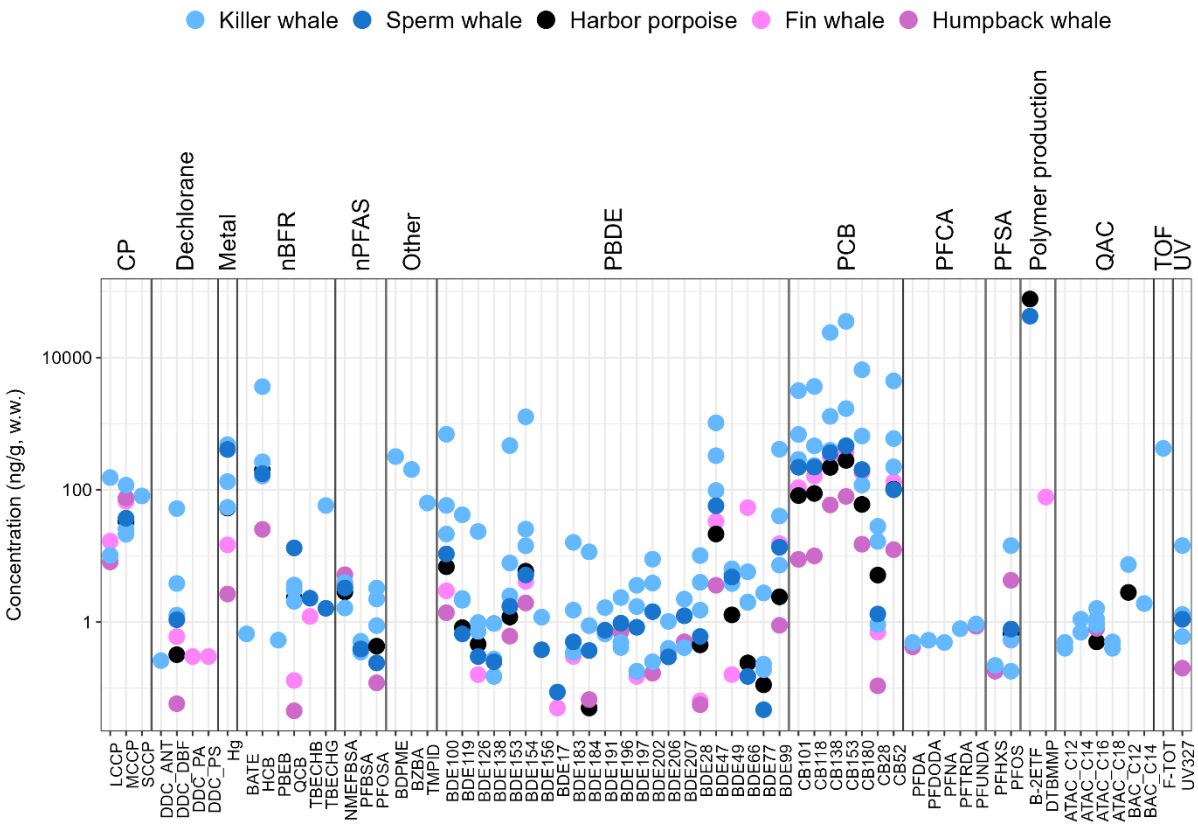

Figure 28: Concentrations measured in whale blubber from species of killer whale (light blue), sperm whale (dark blue), harbor porpoise (black), fin whale (light purple), and humpback whale (dark purple). Note that the y-axis is log_{10} transformed.

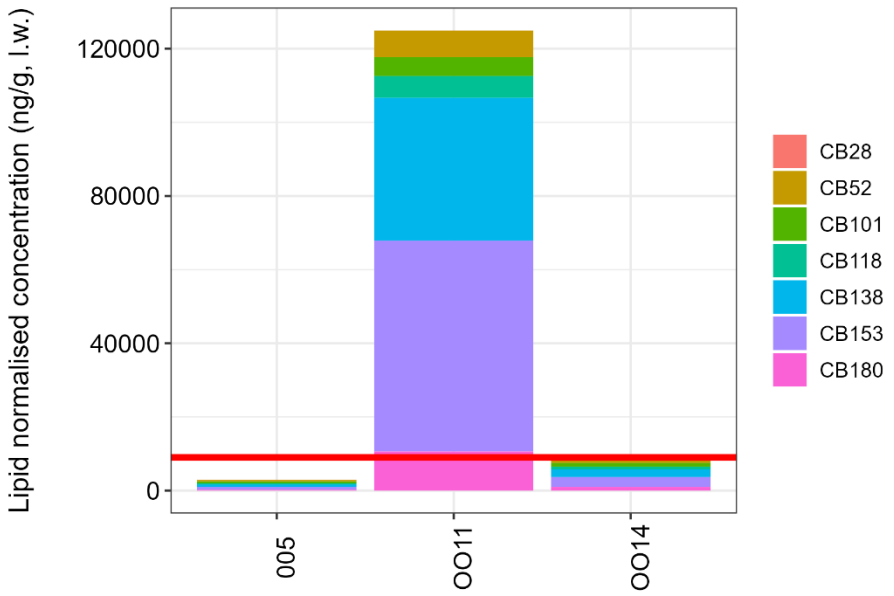

Figure 29:Total concentration of PCBs in the three killer whale samples (OO5, OO11, and OO14). The red line indicates threshold level (9 000 ng/g, l.w.) for onset of physiological effects in marine mammals.

3.2.6 Whale, Harbor porpoise – effect from tissue type (part 2)

Differences in the physiochemical properties of the substances will determine in what type of tissue they can accumulate. For one individual of harbour porpoise samples were provided of blubber, liver, and muscle (**Figure 30**).

As expected, blubber which is very high in fat was with the highest levels of the traditional lipophilic substances PBDE and PCB. Moreover, substances that were only found in the blubber covered two QACs and the UV-stabilizer UV327. Liver was the only tissue identified with PFCAs, and the liver was also high in the CP, two of the dechloranes, mercury, nPFAS, and one PFAS. PFAS-substances are surfactants and typically bind to proteins in blood plasma, see e.g. Zhao et al. (2023). Furthermore, they are often encountered in liver tissue (Rupp et al., 2023). As mentioned, mercury (in the form of methyl mercury) binds to sulfhydryl (thiol) groups of amino acids and is found mainly in protein rich tissues, like muscle. The effect from blubber is evident when looking at the concentrations normalised for the content of fat in the tissue (**Appendix A.2.3**). Then the level of for example PCB is the highest in muscle tissue.

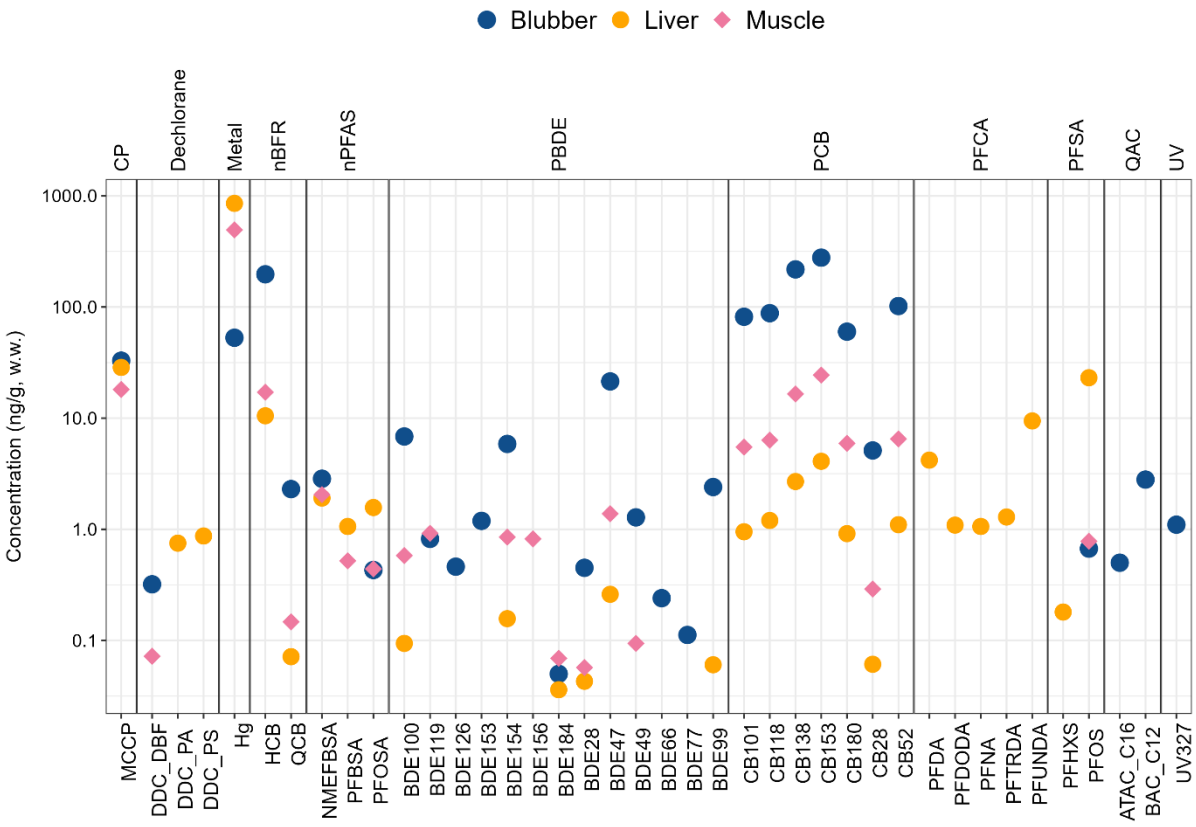

Figure 30: Concentrations in samples of blubber (dark blue), liver (yellow), and muscle (red) from one individual of harbor porpoise. Note that the y-axis is log10 transformed.

3.2.7 Sharks – effect from specie and tissue type

Among the samples of sharks, quantifiable amounts of substances were found in muscle from the greenland shark and in liver from both porbeagle shark and spiny dogfish (**Figure 31**). Note that these were the only samples from sharks in which the legacy substances were determined. Overall, the porbeagle shark liver has the highest concentrations of most contaminants, and followed by greenland shark muscle, and spiny dogfish liver. A few substances were only found in the porbeagle shark liver, covering DEHPO, PFCA, and QAC. The greenland shark had the highest levels of mercury, HCB, and a few of the PDEs. UV327 was only found in the greenland shark muscle. While the exact age of this individual was unknown, greenland shark is one of the longest living animals on the globe providing long time for accumulating contaminants.

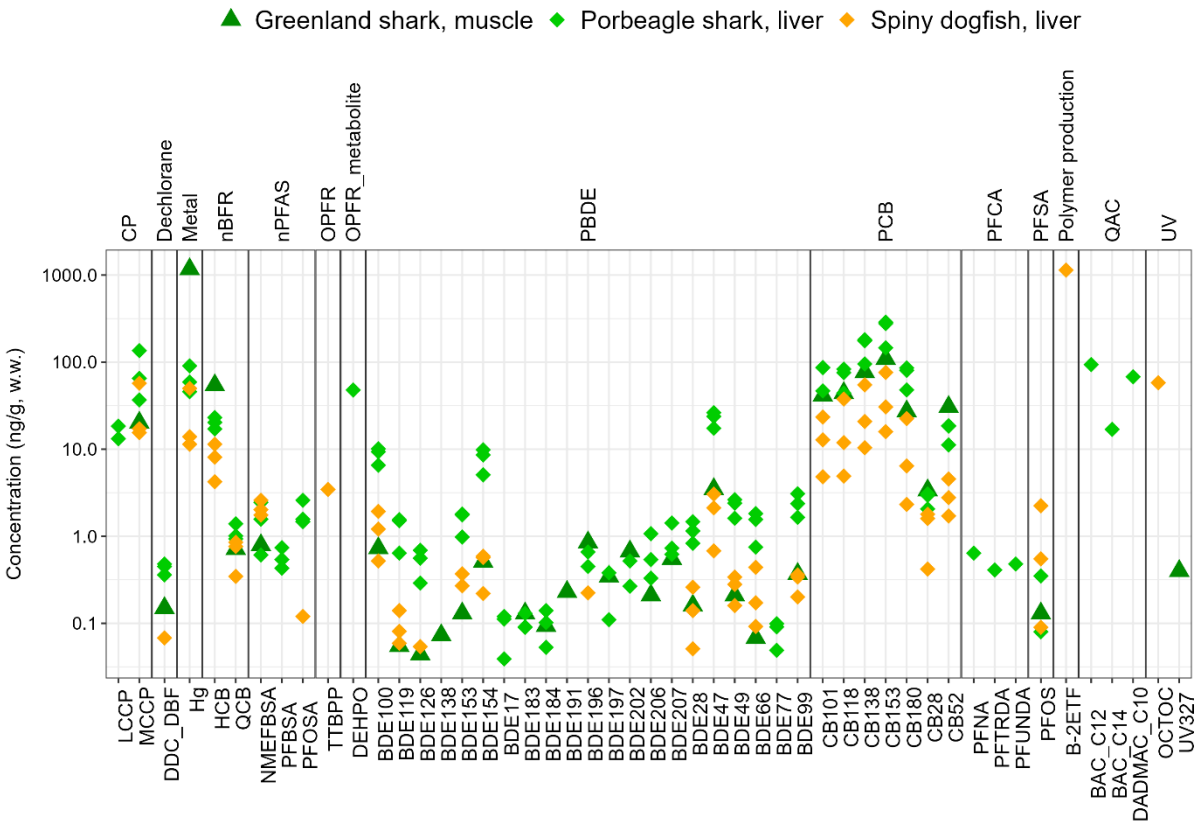

Figure 31: Concentrations in samples of greenland shark muscle (dark green triangle), porbeagle shark liver (light green diamond), and spiny dogfish liver (orange diamond). Note that the y-axis is log10 transformed.

3.3 An overall evaluation of environmental risk

Figure 32 illustrates the lowest PNEC for freshwater, sediment, and marine biota together with the range of concentrations measured in this study (minimum to maximum for substances at levels above the method LOD). Note that only those substances found with available PNEC values have been included.

For several of the substances, levels of environmental concern (based on the lowest PNEC) have been found. This applies to the following; two dechloranes (DDC DBF and DDC ANT); several of the metals (e.g. Cu, As, Se, and Hg); two nBFRs (QCB and HCB); one nPFAS (PFBSA); four substances related to "other" areas of uses (CUMIN, TMPID, BZBA, and OTNE), one PBDE (BDE154); several PCBs (CB52, CB101, CB118, CB138, CB153, CB180); one PFCA (PFNA); PFSA (PFOS); two substance related to polymer production (B-2ETF and DTBMMP), two QACs (BAC_C12 and BAC_C14); and UV stabilisers (UV310, UV1164, UV327, and UV360). In addition, the EQS for the sum of several of the BDEs was exceeded in all the whale and shark samples (not shown in Figure 32).

These results indicate the potential for environmental concern based on the available PNECs and further studies on occurrence of these substances is recommended. However, it is important to emphasise that most of these exceedances were in samples of whales or sharks for which specific PNEC values are not available. The PNECs used here are for fish and is likely not to be directly applicable to the whales and sharks. In addition, many of the used PNEC values are QSAR derived and therefore associated with added uncertainty. Note that the EQSs were likely not derived for sharks and whales and the transferability is uncertain.

Note that substances either not found above the method LOD or determined by suspect screening have not been included. Based on the analyses here it cannot be ruled out that those specific substances are not present in the environment at levels that pose a risk.

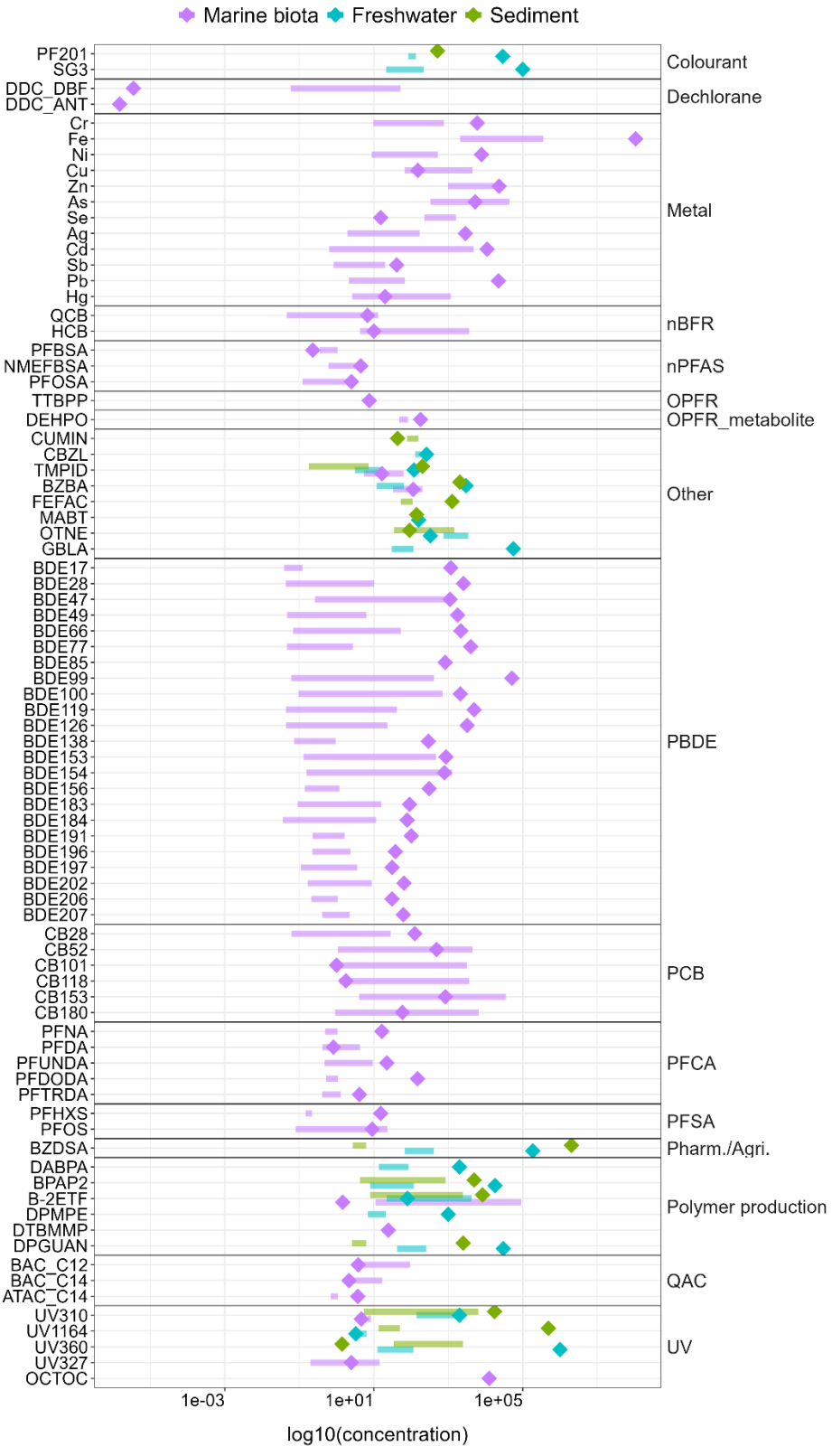

Figure 32: The lowest PNEC for the substances in biota, marine fish (purple ◆), freshwater (blue ◆), and sediment (green ◆) together with the measured concentration range (minimum to maximum, e.g. ▬) of the substances found at levels above the method LOD. Note that the x-axis is log_{10} transformed.

4 Conclusion

The Screening Programme 2023 consisted of two different parts. Part 1 covered 44 samples collected from so-called "hotspot" locations that were analysed for 101 different substances of concern covering a wide range of uses (e.g. plastic additives, UV-additives, phthalates, etc.). In part 2, the focus was on substances susceptible to biotic uptake and bioaccumulation/biomagnification. A total of 37 samples of marine top predators (whales and sharks) were analysed for 58 different substances. In addition, 17 of the samples in part 2 were analysed for additional 166 legacy substances.

The results were assessed based on detection frequencies; comparing the measured concentrations with ecotoxicological threshold values (PNECs); and exploring site-specific contamination patterns.

For part 1, the main findings were that:

- The overall highest detection frequencies and concentrations were of the replacement phthalate, B-2ETF (CAS 6422-86-2), and the UV-stabilizers UV310 (CAS 154702-15-5) and UV360 (CAS 103597-45-1).
- The levels of B-2ETF and UV310 in blue mussels exceeded their respective PNECs, and for UV360 this was also the case in the marine sediments. Note that the PNECs were QSAR derived.
- A high detection frequency was also found for a few substances analysed only qualitatively, i.e. using suspect screening, such as the phthalate DIUDP (CAS 96507-80-1).

For part 2, the main findings were that:

- Only a few of the emerging substances were found in the samples of whales and sharks, and this covered the antioxidant DTBMMP (CAS 2773-50-4) and the phthalate B-2ETF which were at levels exceeding their PNECs. The PNECs were with high uncertainty for being QSAR derived and derived for fish.
- The phthalate DIUDP was identified in several of the samples (suspect screening).
- Many of the legacy substances were found at high detection frequencies and concentrations (e.g. PCBs, PBDE, mercury, etc.). The measured levels of many of the substances may cause ecotoxicological harm as they exceeded their PNECs (QSAR derived and for fish).
- Top predator whale blubber had the highest number of identified substances and measured concentrations. One individual subadult killer whale had concentration of total PCBs surpassing a threshold value for onset of physiological effects by more than an order of magnitude.
- High levels of lipophilic substances were also found in shark liver.
- The highest concentration of mercury was in muscle from a greenland shark.

These findings demonstrate the suitability of whale and shark samples, first and foremost for studying legacy pollutant and especially those that are lipophilic. However, whales and greenland shark are exclusive sample types by being reliant on stranded individuals. With this type of sample there are challenges with having control over potential sample contamination during sampling and sample storage. For samples high in the marine food web, porbeagle shark and spiny dogfish may represent a better option.

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A. Appendix

A1. Supporting parameters, stable isotopes

C:N ratios are high in shark livers, reflecting the high lipid content. According to Sweeting et al (2006), a C:N-ratio of >3.5 implies presence of lipids, that may confound $\delta^{13}C$ interpretation, since lipids are $\delta^{13}C$ -depleted, relative to proteins. This limits the applicability of $\delta^{13}C$ to make assumptions of carbon sources.

$\delta^{15}N$ increases in organisms with higher trophic level because of a greater retention of the heavier isotope (^{15}N). The relative increase of ^{15}N over ^{14}N is typically 3-5 ‰ (ppt) per trophic level (Layman et al. 2012; Post 2002). However, spatial/geographic variability in $\delta^{15}N$ at the base of the food web, along the coast of Norway is known (equivalent to >1 trophic level; Green et al. 2020). Furthermore, sharks have special physiological adaptions, such as urea retention for osmoregulation, which may alter the fractionation of nitrogen isotopes during metabolism (Carlisle et al. 2012).

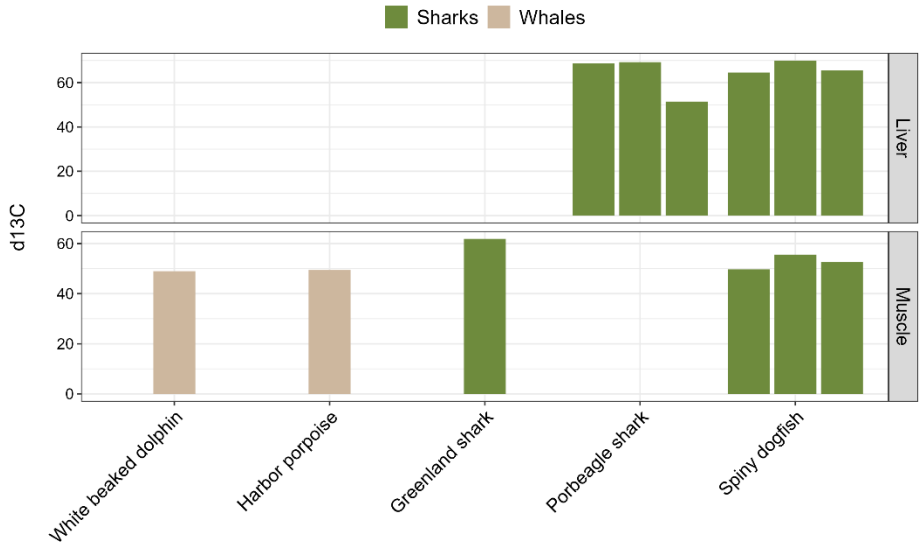


Figure A1: Levels of $\delta^{13}C$ (d13C) in liver and muscle from sharks (green) and whales (beige).

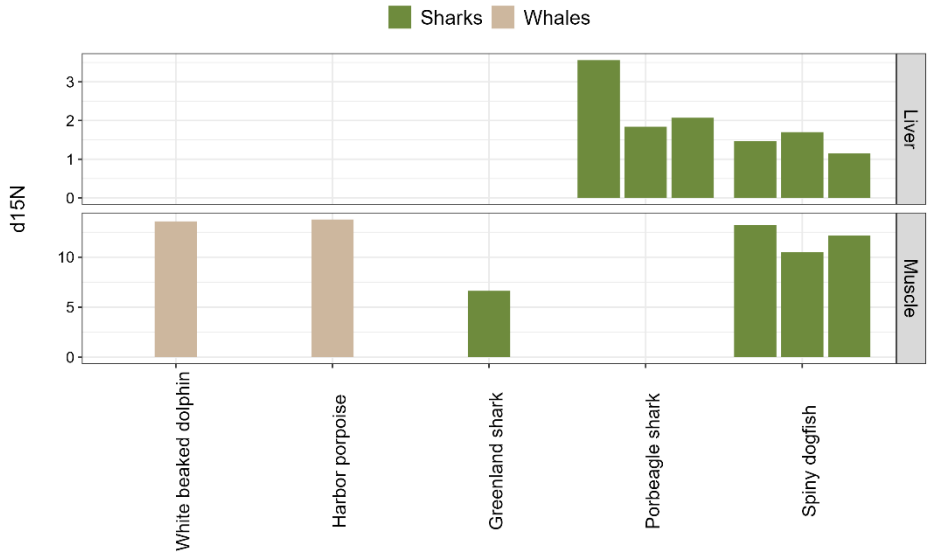


Figure A2: Levels of $\delta^{15}N$ (d15N) in liver and muscle from sharks (green) and whales (beige).

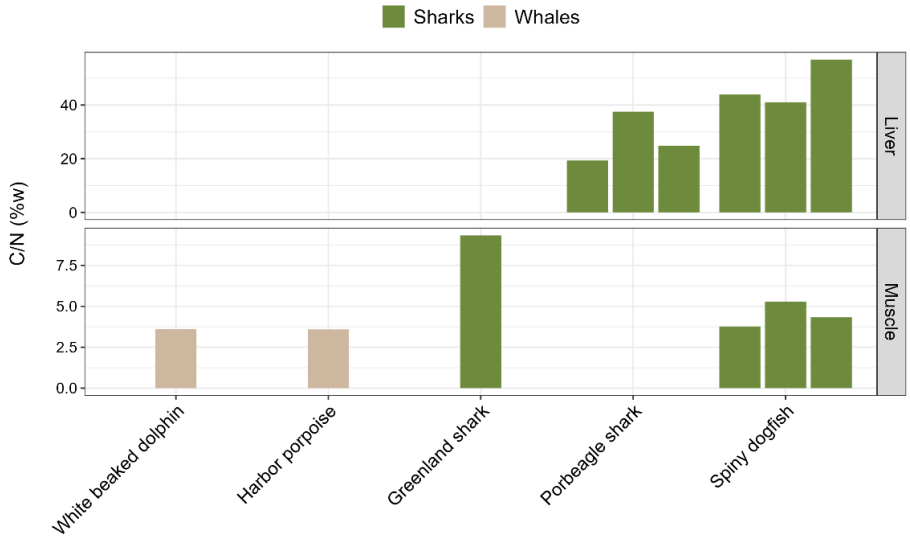


Figure A3: The ratio of $\delta^{13}C$ to $\delta^{15}N$ (C/N (%w) in liver and muscle from sharks (green) and whales (beige).

A2. Additional presentation of the results

A.2.1 Metals in whales and sharks

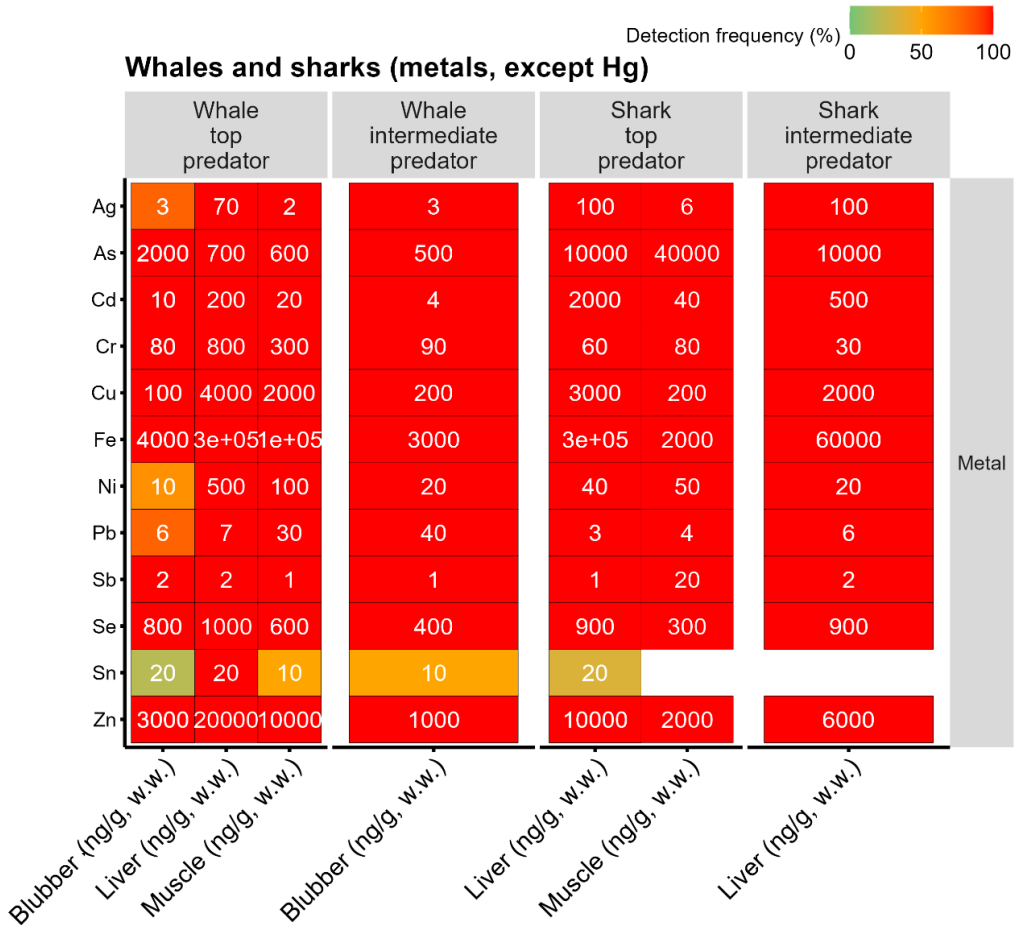


Figure A4: Detection frequencies and average concentrations of metals (excluding mercury) in samples of whale top predator (blubber: n=5, liver: n= 1, muscle: n=1), whale intermediate predator (blubber: n=2), shark top predator (liver: n=3, muscle: n=1), and shark intermediate predator (liver: n=3). S indicates suspect screening. Empty cells indicate levels below LOD, i.e. detection frequency = 0. Substance IDs are to the left and substance group names to the right.

A.2.2 Effect from packaging materials

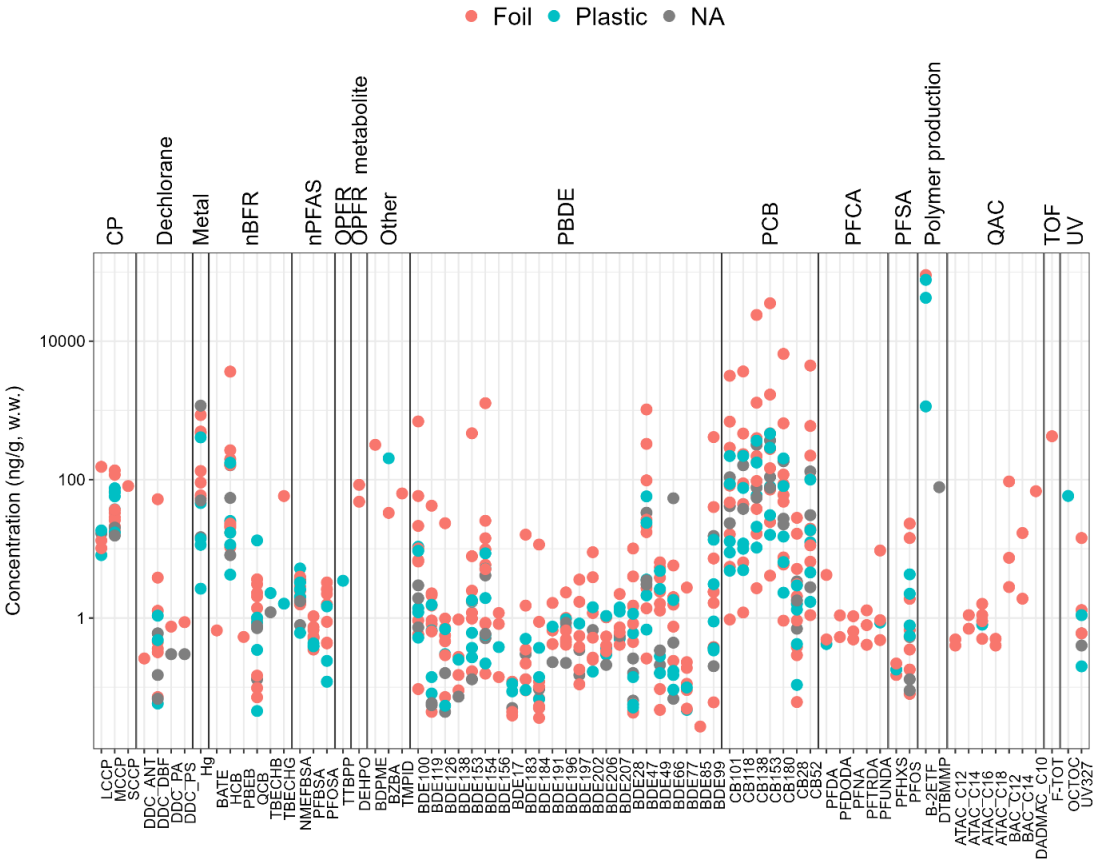


Figure A5: Concentrations (ng/g, w.w.) in whale blubber and shark liver that were packaged in aluminium foil (red), plastic (green) or unknown (NA).

A.2.3 Effect from fat content

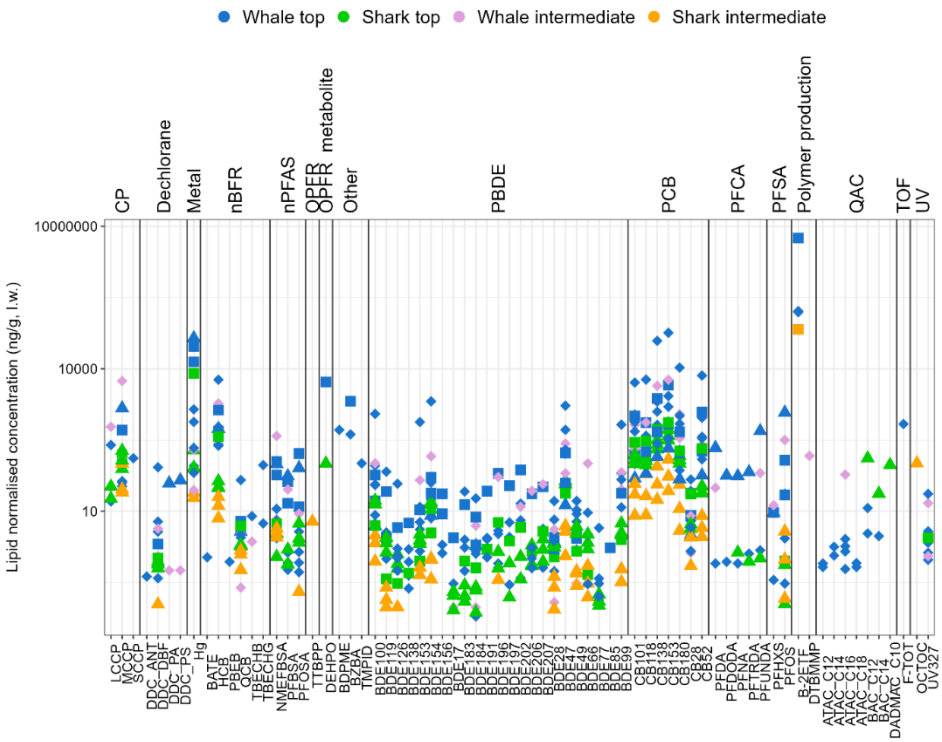


Figure A6: Lipid normalised concentrations (ng/g, l.w.) in top predator whale (blubber) and shark (green), and in intermediate predator whales (purple) and sharks (orange). The tissue types cover blubber (diamond), liver (triangle), and muscle (square). Note that the y-axis is log_{10} transformed.

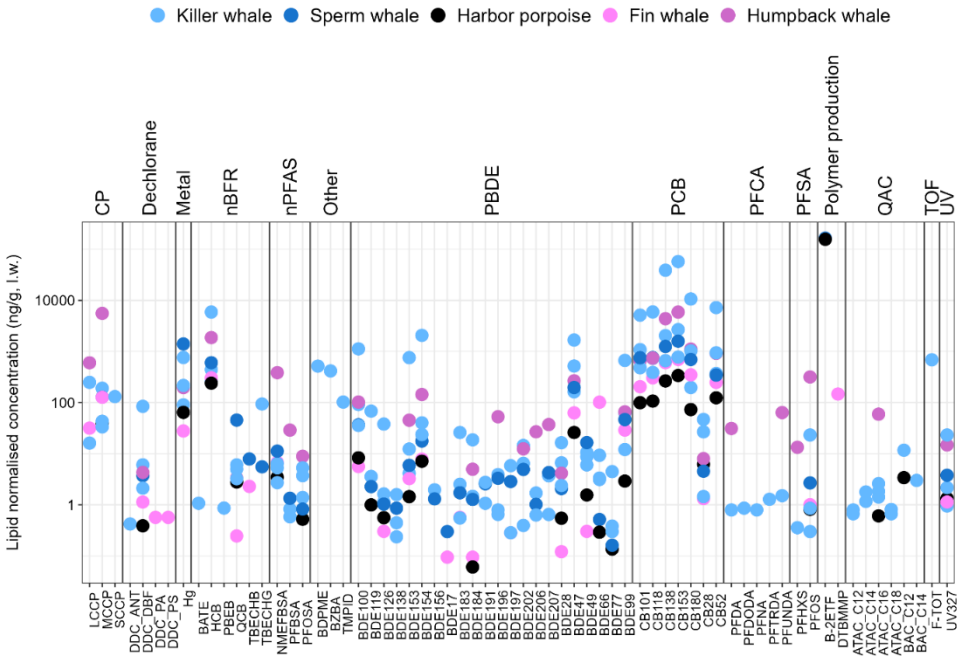


Figure A7: Lipid normalised concentrations (ng/g, l.w.) in whale blubber from the different species included. Blue/black indicates top predators and pink/purple intermediate predators. Note that the y-axis is log_{10} transformed.

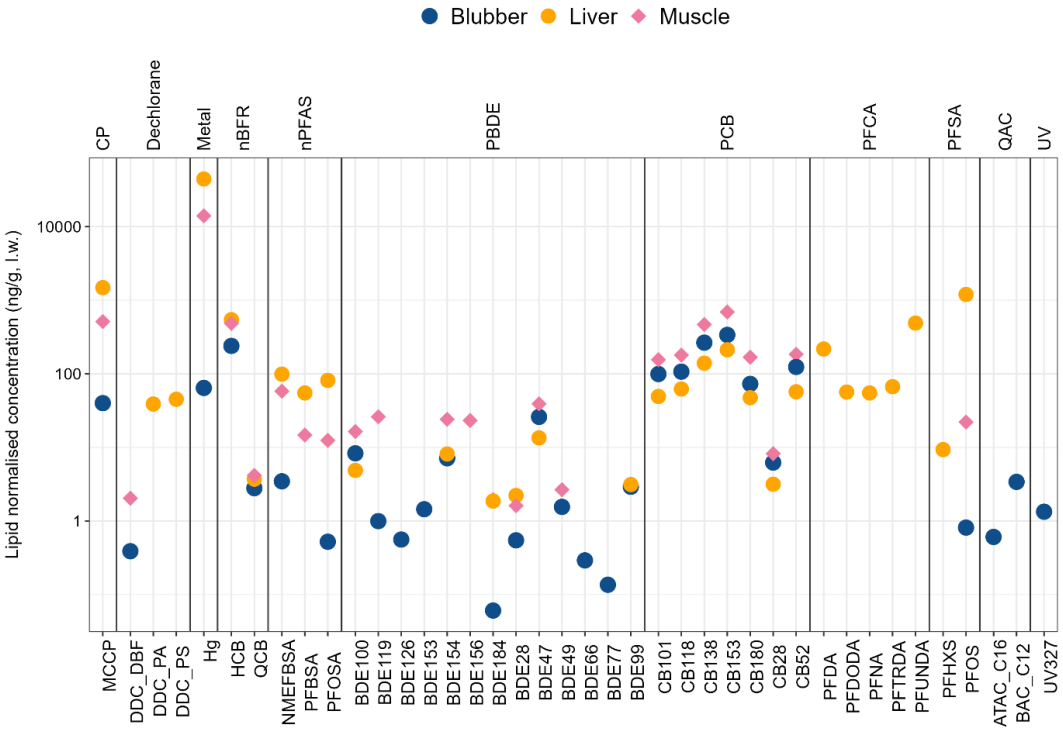


Figure A8: Lipid normalised concentrations (ng/g, l.w.) in one individual of Harbor porpoise by blubber (dark blue), liver (yellow), and muscle (red).

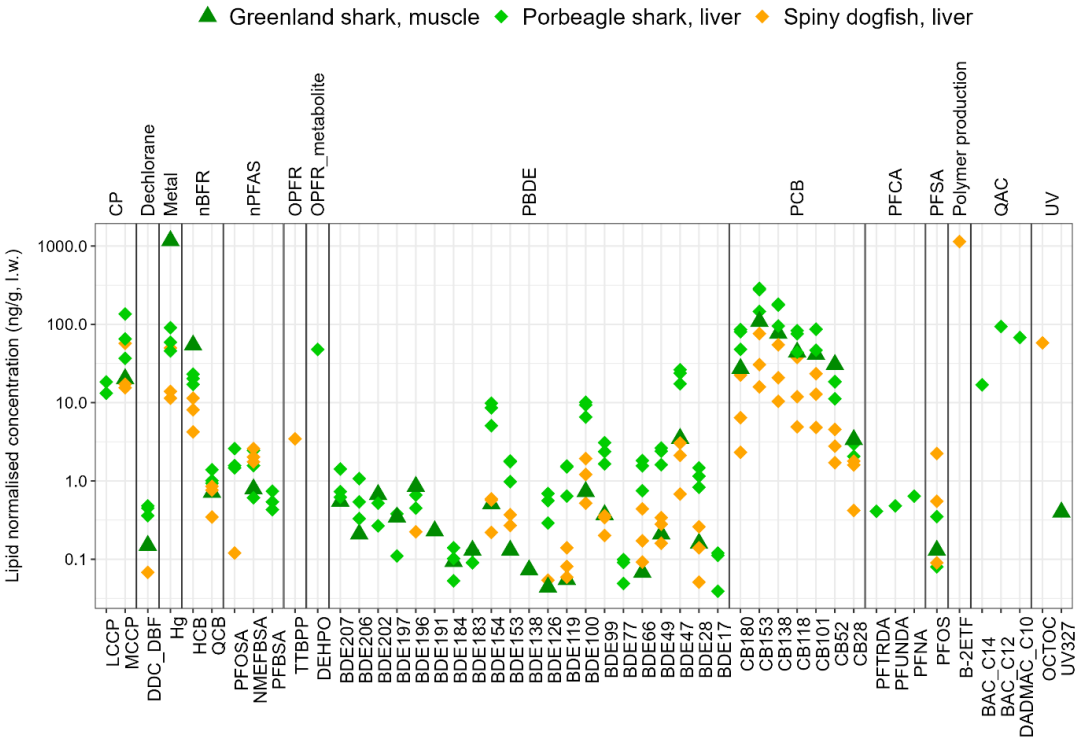
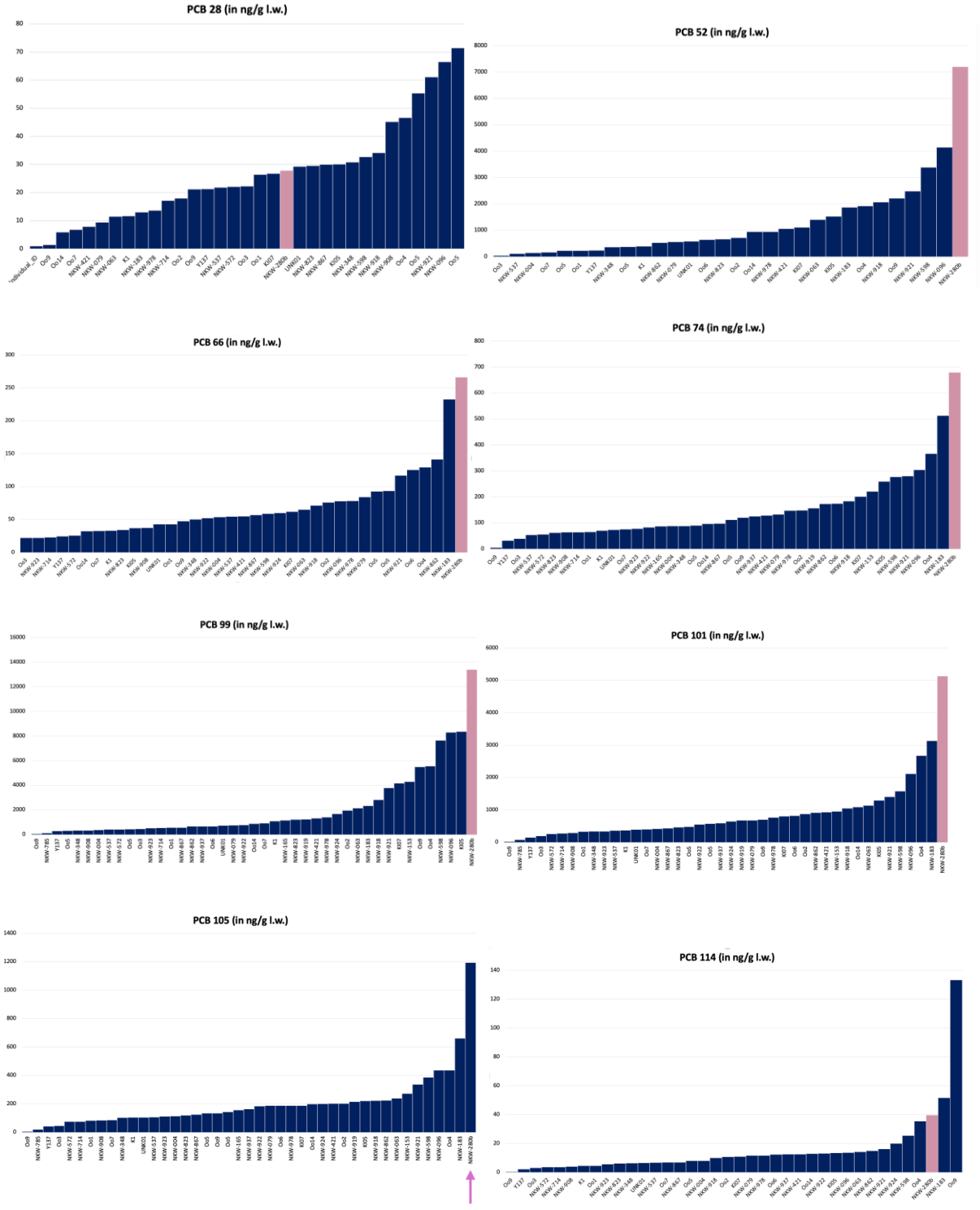
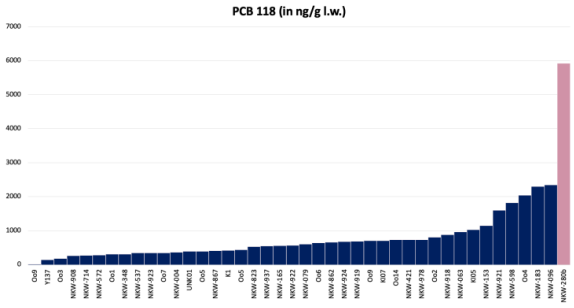


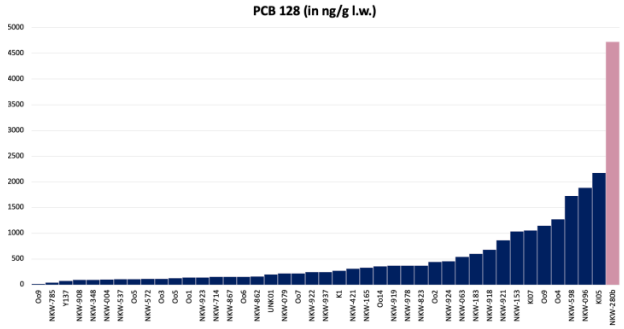
Figure A9: Lipid normalised concentrations (ng/g, l.w.) in greenland shark muscle (dark green triangle), Porbeagle shark liver (light green diamond), and spiny dogfish liver (orange diamond).

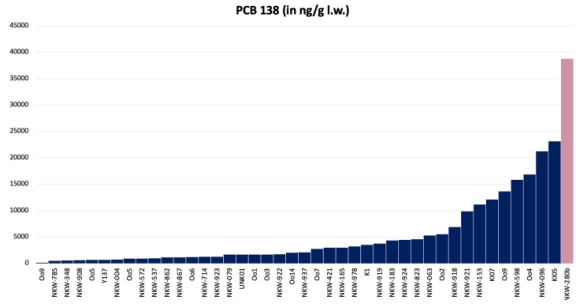
A.2.3 Elevated levels in subadult killer whale in comparison to other available data

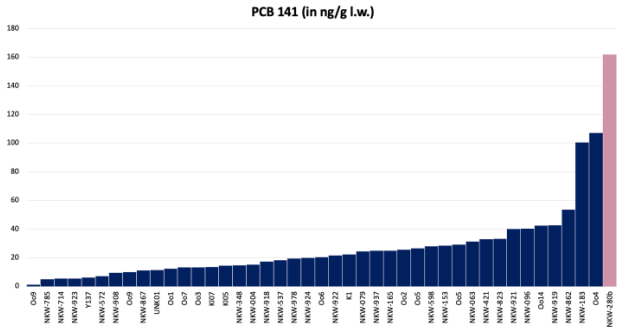
Here follows a presentation of the measured levels of selected PCBs, HCBs, and BDEs in the subadult killer whale (Sognefjorden) in comparison to previously measured levels in other killer whales from Norway. The figures show individual blubber concentrations for 43 different killer whales sampled between 2015 and 2023 and covering 32 biopsies and 11 strandings. The results from the subadult killer whale from the Screening Programme are highlighted by pink/red or by a pink arrow. The additional data has previously been published (Andvik et al., 2020; Andvik et al., 2021).

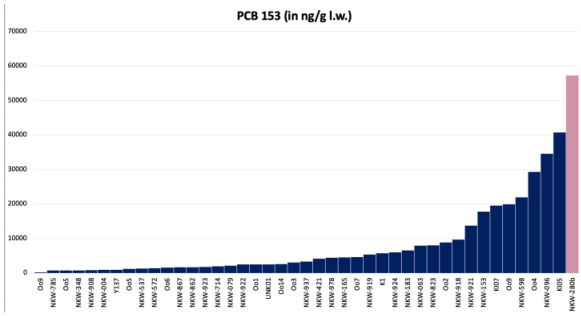


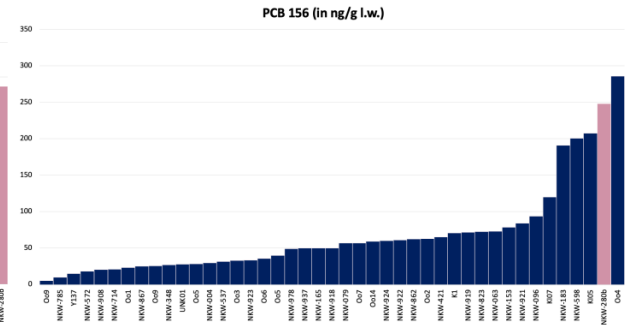

PCB 118 (in ng/g l.w.)

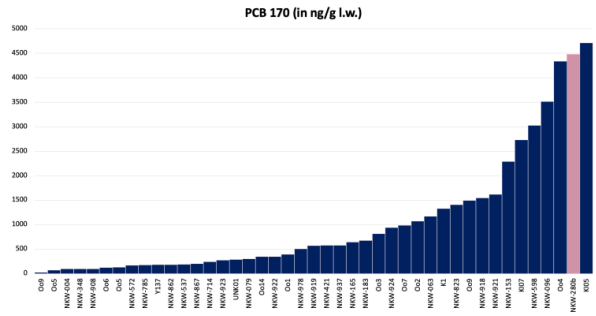

PCB 128 (in ng/g l.w.)

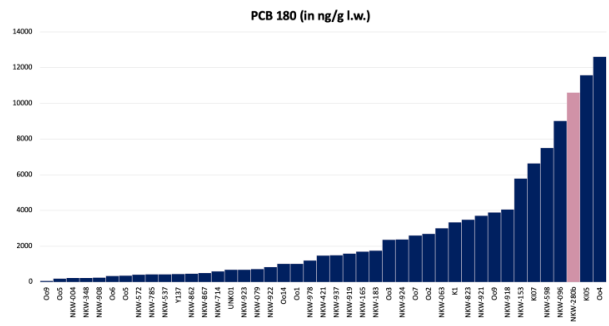

PCB 138 (in ng/g l.w.)

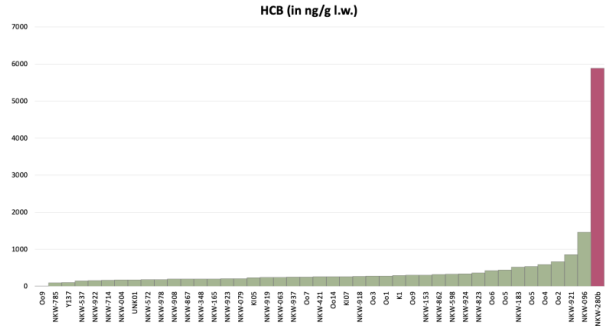

PCB 141 (in ng/g l.w.)

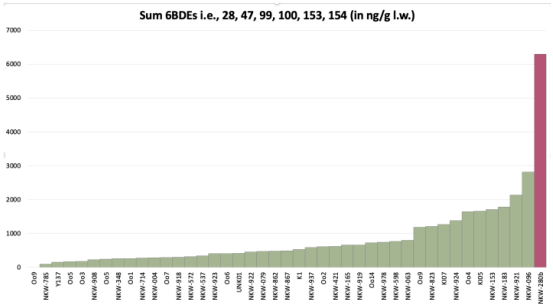

PCB 153 (in ng/g l.w.)


PCB 156 (in ng/g l.w.)


PCB 170 (in ng/g l.w.)


PCB 180 (in ng/g l.w.)


HCB (in ng/g l.w.)


Sum 6BDEs i.e., 28, 47, 99, 100, 153, 154 (in ng/g l.w.)

A3. Information on the substances

Table A1. Overview over the substances in part 1.

ID	CAS no.	Name	Function category	Method ID
UV310	154702-15-5	Iscotrizinol	UV Stabilizer	Triazine
UV1164	2725-22-6	2-[4,6-Bis(2,4-dimethylphenyl)-1,3,5-triazin-2-yl]-5-(octyloxy)phenol	UV Stabilizer	Triazine
BEMT	187393-00-6	Bemotrizinol	UV Stabilizer	Triazine
UV1577	147315-50-2	2-(4,6-Diphenyl-1,3,5-triazin-2-yl)-5-(hexyloxy)phenol	UV Stabilizer	Triazine
TBHPT	3135-19-1	2,4,6-Tri(4'-butoxy-2'-hydroxyphenyl)-triazine	UV Stabilizer	Triazine
TBRPT	890148-78-4	2,4,6-Tris(3-bromophenyl)-1,3,5-triazine	UV Stabilizer	Triazine
UV1579	106556-36-9	2-(4,6-Diphenyl-1,3,5-triazin-2-yl)-5-methoxyphenol	UV Stabilizer	Triazine
DPDT	38369-95-8	2-(2,4-Dihydroxyphenyl)-4,6-diphenyl-1,3,5-triazine	UV Stabilizer	Triazine
DBPCLT	182918-13-4	2,4-Bis([1,1′-biphenyl]-4-yl)-6-chloro-1,3,5-triazine	UV Stabilizer	Triazine
23BPDT	864377-31-1	2-(3-Bromophenyl)-4,6-diphenyl-1,3,5-triazine	UV Stabilizer	Triazine
22BPDT	77989-15-2	2-(2-Bromophenyl)-4,6-diphenyl-1,3,5-triazine	UV Stabilizer	Triazine
TBPHT	31274-51-8	2,4,6-Tribiphenyl-4-yl-1,3,5-triazine	UV Stabilizer	Triazine
DMPTDPP	178905-31-2	2-[4,6-Bis(2,4-dimethylfenyl)-1,3,5-triazin-2-yl]-5[3-(dodecyloxy)-2-hydroxypropoxy]phenol	UV Stabilizer	Triazine
DMPTTPP	178905-32-3	2-[4,6-Bis(2,4-dimethylphenyl)-1,3,5-triazin-2-yl]-5-[2-hydroxy-3-(tridecyloxy)propoxy]phenol	UV Stabilizer	Triazine
BEHAMBT	80584-90-3	1-[N,N-Bis(2-ethylhexyl)aminomethyl]-4-methyl-1H-benzotriazole	UV Stabilizer	NIVA_UV
2BBTMP	70693-49-1	2-(2H-Benzotriazol-2-yl)-4,6-bis(1,1,3,3-tetramethylbutyl)phenol	UV Stabilizer	NIVA_UV
2BHMPTP	209324-18-5	2-(2H-Benzotriazol-2-yl)-6-[[3-(1,1-dimethylethyl)-2-hydroxy-5-methylphenyl]methyl]-4-(1,1,3,3-tetramethylbutyl)phenol	UV Stabilizer	NIVA_UV
UV360	103597-45-1	2,2′-Methylenebis[6-(2H-benzotriazol-2-yl)-4-(1,1,3,3-tetramethylbutyl)phenol]	UV Stabilizer	NIVA_UV
UV234	70321-86-7	2-(2H-Benzotriazol-2-yl)-4,6-bis(1-methyl-1-phenylethyl)phenol	UV Stabilizer	NIVA_UV
2BMTP	104487-30-1	2-(2H-Benzotriazol-2-yl)-4-methyl-6-tetracosylphenol	UV Stabilizer	NIVA_UV
TFMBTP	207738-63-4	2-(1-Methyl-1-phenylethyl)-4-(1,1,3,3-tetramethylbutyl)-6-[5-(trifluoromethyl)-2H-benzotriazol-2-yl]phenol	UV Stabilizer	NIVA_UV
UV320	3846-71-7	2-(2′-Hydroxy-3′5-di-tert-butylphenyl) benzotriazole	UV Stabilizer	NIVA_UV
2BDOMP	23328-53-2	2-(2-Hydroxy-3-dodecyl-5-methylphenyl)benzotriazole	UV Stabilizer	NIVA_UV
DTBNTP	28122-40-9	2,4-Di-tert-butyl-6-(2H-naphtho[1,2-d][1,2,3]triazol-2-yl)phenol	UV Stabilizer	NIVA_UV
NTTMP	27876-55-7	2-(2H-Naphtho[1,2-d]triazol-2-yl)-4-(1,1,3,3-tetramethylbutyl)phenol	UV Stabilizer	NIVA_UV
2BDMP	3147-76-0	2-(2H-Benzotriazol-2-yl)-4-(1,1-dimethylethyl)phenol	UV Stabilizer	NIVA_UV
NTOP	138615-32-4	2-(2H-Naphtho[1,2-d][1,2,3]triazol-2-yl)-4-octylphenol	UV Stabilizer	NIVA_UV
DTAPBO	94109-79-2	2-(2′-Hydroxy-3′,5′-di-tert-amylphenyl)benzotriazole N-oxide	UV Stabilizer	NIVA_UV
CLBDMP	3287-17-0	2-(2′-Hydroxy-5′-tert-butylphenyl)-5-chlorobenzotriazole	UV Stabilizer	NIVA_UV
UV384	84268-23-5	Octyl 3-[3-(2H-benzotriazol-2-yl)-5-tert-butyl-4-hydroxyphenyl]propionate	UV Stabilizer	NIVA_UV

MB2BMP	30653-05-5	2,2′-Methylenebis[4-methyl-6-(2H-benzotriazol-2-yl)phenol]	UV Stabilizer	NIVA_UV
2BMPP	2170-39-0	2-(2H-Benzotriazol-2-yl)-4-methyl-6-(2-propen-1-yl)phenol	UV Stabilizer	NIVA_UV
BHEP	96549-95-0	2-[2′-Hydroxy-5′-(2-hydroxyethyl)phenyl]-2H-benzotriazole	UV Stabilizer	NIVA_UV
2TBCLBEP	124883-10-9	2-(5-Chloro-2H-benzotriazol-2-yl)-6-(1,1-dimethylethyl)-4-ethenylphenol	UV Stabilizer	NIVA_UV
UV1130	84268-33-7	2-[3′-tert-Butyl-2′-hydroxy-5′-(2-methoxycarbonylethyl)phenyl]benzotriazole	UV Stabilizer	NIVA_UV
BTHPE	83741-30-4	1-[3-(2H-Benzotriazol-2-yl)-4-hydroxyphenyl]ethanone	UV Stabilizer	NIVA_UV
HDBTBP	84268-08-6	1,1′-(1,6-Hexanediyl) bis[3-(2H-benzotriazol-2-yl)-5-(1,1-dimethylethyl)-4-hydroxybenzenepropanoate]	UV Stabilizer	NIVA_UV
DMO2BP	84755-44-2	2,4-Bis(1,1-dimethylethyl)-6-(1-oxido-2H-benzotriazol-2-yl)phenol	UV Stabilizer	NIVA_UV
ETPPBR	1530-32-1	Ethyltriphenylfosfonium bromide	UV Stabilizer	NIVA_vM
DBSNMA	10584-98-2	2-Ethylhexyl 4,4-dibutyl-10-ethyl-7-oxo-8-oxa-3,5-dithia-4-stannatetradecanoate	UV Stabilizer	NIVA_UV
AOZKF	4066-02-8	2,2′-Methylenebis(4-methyl-6-cyclohexylphenol)	Polymer Production	Bisphenol
DABPA	1745-89-7	4,4'-Isopropylidenebis(2-allylphenol)	Polymer Production	Bisphenol
XYLENOL	5384-21-4	4,4'-methylenedi-2,6-xylenol	Polymer Production	Bisphenol
T4HPE	27955-94-8	Tris(4-hydroxyphenyl)ethane	Polymer Production	Bisphenol
TMBPA	5613-46-7	4,4’-isopropylidenedi-2,6-xylol	Polymer Production	Bisphenol
BPAP2	116-37-0	Bisphenol A bis(2-hydroxypropyl) ether	Polymer Production	Bisphenol
BHPMEBD	147504-92-5	4,6-Bis[1-(4-hydroxyphenyl)-1-methylethyl]-1,3-benzenediol	Polymer Production	Bisphenol
B-2ETF	6422-86-2	Dioctyl terephthalate	Polymer Production	SVOC
DPMPE	6362-80-7	1,1′-(1,1-Dimethyl-3-methylene-1,3-propanediyl)bis[benzene]	Polymer Production	SVOC
DIUDP	96507-80-1	1,2-Benzenedicarboxylic acid, decyl isoundecyl ester	Polymer Production	SVOC
TCTDT	2149571-40-2	(1S,4R,4aS,9aR)-4,4a,9,9a-Tetrahydro-1,4-methano-1H-fluorene	Polymer production	SVOC
ETTSDD	38233-76-0	2-Ethylidene-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene	Polymer production	SVOC
TIPSIMA	134652-60-1	Tris(1-methylethyl)silyl 2-methyl-2-propenoate	Polymer Production	Siloxane
TIPSIA	157859-20-6	Tris(1-methylethyl)silyl 2-propenoate	Polymer Production	Siloxane
DOCDPA	15721-78-5	Bis(4-(1,1,3,3-tetramethylbutyl)phenyl)amine	Polymer Production	NIVA_UV
FBCLBA	107934-68-9	4,4′-(9H-Fluoren-9-ylidene)bis[2-chlorobenzenamine]	Polymer Production	NIVA_UV
PEPEPO	68540-61-4	1-Methyl-1-[4-methyl-2(or 3)-(1-methylethyl)phenyl]ethyl 1-methyl-1-phenylethyl peroxide	Polymer Production	NIVA_UV
BNDTT	89347-09-1	2,5-Bis(tert-nonyldithio)-1,3,4-thiadiazole	Polymer Production	NIVA_UV
DTBPPO	95906-11-9	Tris(2,4-di-tert-butylphenyl) phosphate	Polymer Production	NIVA_UV
UV329	3147-75-9	2-(2-Hydroxy-5-tert-octylphenyl)benzotriazole	Polymer Production	NIVA_UV
BENAZOL P	2440-22-4	2-(2H-Benzotriazol-2-yl)-4-methylphenol	Polymer Production	NIVA_UV
DPGUAN	102-06-7	Diphenylguanidine	Polymer Production	NIVA_UV
M1UV328	84268-36-0	3-[3-(2H-Benzotriazol-2-yl)-5-tert-butyl-4-hydroxyphenyl]propionic acid	Polymer Production	NIVA_UV
AAMPSA	15214-89-8	2-Acrylamido-2-methylpropanesulfonic acid	Polymer Production	NIVA_vM
NAAHPS	52556-42-0	Sodium 3-(allyloxy)-2-hydroxypropanesulphonate	Polymer Production	NIVA_vM
TEDA	280-57-9	Triethylenediamine	Polymer Production	NIVA_vM
35DMPZ	67-51-6	3,5-Dimethyl-1H-pyrazole	Polymer Production	NIVA_vM

34DMPZ	2820-37-3	3,4-Dimethylpyrazole	Polymer Production	NIVA_vM
AO1098	23128-74-7	Antioxidant 1098	Polymer Production	NIVA_UV
SORFEN	284461-73-0	Sorafenib	Pharmaceutical/Agricultural	NIVA_UV
QUOX	124495-18-7	Quinoxyfen	Pharmaceutical/Agricultural	NIVA_UV
BZDSA	117-61-3	2,2′-Benzidinedisulfonic acid	Pharmaceutical/Agricultural	NIVA_vM
34DMPZP	202842-98-6	3,4-Dimethylpyrazole phosphate	Pharmaceutical/Agricultural	NIVA_vM
MPDCH	97398-80-6	(trans,trans)-4-Methoxy-4′-propyl-1,1′-bicyclohexyl	Other Functions	SVOC
CUMIN	122-03-2	Cuminal	Other Functions	SVOC
4NAS	100-17-4	4-Nitroanisole	Other Functions	SVOC
DESHDC	72903-27-6	Diethyl 1,4-cyclohexanedicarboxylate	Other Functions	SVOC
CBZL	86-74-8	Carbazole	Other Functions	SVOC
BDPME	574-42-5	Bis(diphenylmethyl) ether	Other Functions	SVOC
TLDS	103-19-5	Bis(4-methylphenyl) disulfide	Other Functions	SVOC
TMPID	3910-35-8	1,1,3-Trimethyl-3-phenylindane	Other Functions	SVOC
FPIMPTH	898566-17-1	2-(4-Fluorophenyl)-5-[(5-iodo-2-methylphenyl)methyl]thiophene	Other Functions	SVOC
BZBA	120-51-4	Benzyl benzoate	Other Functions	SVOC
FEFAC	102-20-5	Phenethyl phenylacetate	Other Functions	SVOC
MABT	127-25-3	Methyl abietate	Other Functions	SVOC
OTNE*	54464-57-2	1-[1,6-Dimethyl-3-(4-methyl-3-penten-1-yl)-3-cyclohexen-1-yl]ethanone	Other Functions	SVOC
AETT	88-29-9	7-Acetyl-6-ethyl-1,1,4,4-tetramethyltetralin	Other Functions	SVOC
DMPSHEN	54464-54-9	dimethylacetylhexenylcyclohexene	Other Functions	SVOC
SYLKL	676532-44-8	Sylkolide	Other Functions	SVOC
SEROLD	477218-42-1	Serenolide	Other Functions	SVOC
EMOPCC	59151-19-8	Ethyl 2-methyl-4-oxo-6-pentyl-2-cyclohexene-1-carboxylate	Other Functions	SVOC
CTCVB	4714-35-6	1-Chloro-4-(1,2,2-trichloroethenyl)benzene	Other Functions	SVOC
DCTCVB	88218-49-9	1,4-Dichloro-2-(1,2,2-trichloroethenyl)benzene	Other Functions	SVOC
MPSHDOSD	125962-78-9	8-[4-(4-Methylphenyl)-3-cyclohexen-1-yl]-1,4-dioxaspiro[4.5]decane	Other Functions	SVOC
HOTMIKA	93777-71-0	2,3-Dihydro-6-hydroxy-1,1,3,3-tetramethyl-1H-indene-5-carboxaldehyde	Other Functions	SVOC
BSAN	1678-25-7	Benzenesulfonanilide	Other Functions	SVOC
BMATA	561-41-1	4,4'-Bis(dimethylamino)-4"-(methylamino)trityl alcohol	Other Functions	NIVA_UV
DTBTP	824407-02-5	2,4-Bis(1,1-dimethylethyl)-6-(2H-1,2,3-triazol-2-yl)phenol	Other Functions	NIVA_UV
CYANA	108-80-5	Cyanuric acid	Other Functions	NIVA_vM
ADNP	96-91-3	2-Amino-4,6-dinitrophenol	Other Functions	NIVA_vM
GBLA	96-48-0	γ-Butyrolactone	Other Functions	NIVA_vM
PF201	232938-43-1	Pergafast 201	Colourant	Pergfast
SG3	128-80-3	Solvent green 3	Colourant	NIVA_UV
KRYFIO	548-62-9	N-[4-[Bis[4-(dimethylamino)phenyl]methylene]-2,5-cyclohexadien-1-ylidene]-N-methylmethanaminium	Colourant	NIVA_UV

*OTNE is an isomer to substance DMPSHEN, where standard was available. Analysed as an additional substance.

Table A2: Overview over the substances in part 2.

ID	CAS no.	Name	Function category	Method ID
BEHAMBT	80584-90-3	1-[N,N-Bis(2-ethylhexyl)aminomethyl]-4-methyl-1H-benzotriazole	UV Stabilizer	NIVA_UV
2BHMPTP	209324-18-5	2-(2H-Benzotriazol-2-yl)-6-[[3-(1,1-dimethylethyl)-2-hydroxy-5-methylphenyl]methyl]-4-(1,1,3,3-tetramethylbutyl)phenol	UV Stabilizer	NIVA_UV
UV360	103597-45-1	2,2′-Methylenebis[6-(2H-benzotriazol-2-yl)-4-(1,1,3,3-tetramethylbutyl)phenol]	UV Stabilizer	NIVA_UV
UV234	70321-86-7	2-(2H-Benzotriazol-2-yl)-4,6-bis(1-methyl-1-phenylethyl)phenol	UV Stabilizer	NIVA_UV
2BMTP	104487-30-1	2-(2H-Benzotriazol-2-yl)-4-methyl-6-tetracosylphenol	UV Stabilizer	NIVA_UV
TFMBTP	207738-63-4	2-(1-Methyl-1-phenylethyl)-4-(1,1,3,3-tetramethylbutyl)-6-[5-(trifluoromethyl)-2H-benzotriazol-2-yl]phenol	UV Stabilizer	NIVA_UV
DTBPPO	95906-11-9	Tris(2,4-di-tert-butylphenyl) phosphate	UV Stabilizer	NIVA_UV
UV320	3846-71-7	2-(2′-Hydroxy-3′5-di-tert-butylphenyl) benzotriazole	UV Stabilizer	NIVA_UV
2BDOMP	23328-53-2	2-(2-Hydroxy-3-dodecyl-5-methylphenyl)benzotriazole	UV Stabilizer	NIVA_UV
DTBNTP	28122-40-9	2,4-Di-tert-butyl-6-(2H-naphtho[1,2-d][1,2,3]triazol-2-yl)phenol	UV Stabilizer	NIVA_UV
NTTMP	27876-55-7	2-(2H-Naphtho[1,2-d]triazol-2-yl)-4-(1,1,3,3-tetramethylbutyl)phenol	UV Stabilizer	NIVA_UV
2BDMP	3147-76-0	2-(2H-Benzotriazol-2-yl)-4-(1,1-dimethylethyl)phenol	UV Stabilizer	NIVA_UV
NTOP	138615-32-4	2-(2H-Naphtho[1,2-d][1,2,3]triazol-2-yl)-4-octylphenol	UV Stabilizer	NIVA_UV
DTAPBO	94109-79-2	2-(2′-Hydroxy-3′,5′-di-tert-amylphenyl)benzotriazole N-oxide	UV Stabilizer	NIVA_UV
CLBDMP	3287-17-0	2-(2′-Hydroxy-5′-tert-butylphenyl)-5-chlorobenzotriazole	UV Stabilizer	NIVA_UV
UV384	84268-23-5	Octyl 3-[3-(2H-benzotriazol-2-yl)-5-tert-butyl-4-hydroxyphenyl]propionate	UV Stabilizer	NIVA_UV
DABPA	1745-89-7	4,4'-Isopropylidenebis(2-allylphenol)	Polymer Production	Bisphenol
B-2ETF	6422-86-2	Dioctyl terephthalate	Polymer Production	SVOC
DPMPE	6362-80-7	1,1′-(1,1-Dimethyl-3-methylene-1,3-propanediyl)bis[benzene]	Polymer Production	SVOC
DIUDP	96507-80-1	1,2-Benzenedicarboxylic acid, decyl isoundecyl ester	Polymer Production	SVOC
TCTDT	2149571-40-2	(1S,4R,4aS,9aR)-4,4a,9,9a-Tetrahydro-1,4-methano-1H-fluorene	Polymer production	SVOC
ETTSDD	38233-76-0	2-Ethylidene-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene	Polymer production	SVOC
DOCDPA	15721-78-5	Bis(4-(1,1,3,3-tetramethylbutyl)phenyl)amine	Polymer Production	NIVA_UV
FBCLBA	107934-68-9	4,4′-(9H-Fluoren-9-ylidene)bis[2-chlorobenzenamine]	Polymer Production	NIVA_UV
PEPEPO	68540-61-4	1-Methyl-1-[4-methyl-2(or 3)-(1-methylethyl)phenyl]ethyl 1-methyl-1-phenylethyl peroxide	Polymer Production	NIVA_UV
BNDTT	89347-09-1	2,5-Bis(tert-nonyldithio)-1,3,4-thiadiazole	Polymer Production	NIVA_UV
2BBTMP	70693-49-1	2-(2H-Benzotriazol-2-yl)-4,6-bis(1,1,3,3-tetramethylbutyl)phenol	Polymer Production	NIVA_UV
UV329	3147-75-9	2-(2-Hydroxy-5-tert-octylphenyl)benzotriazole	Polymer Production	NIVA_UV
BENAZOL P	2440-22-4	2-(2H-Benzotriazol-2-yl)-4-methylphenol	Polymer Production	NIVA_UV
SORFEN	284461-73-0	Sorafenib	Pharmaceutical/Agricultural	NIVA_UV
QUOX	124495-18-7	Quinoxyfen	Pharmaceutical/Agricultural	NIVA_UV
MPDCH	97398-80-6	(trans,trans)-4-Methoxy-4′-propyl-1,1′-bicyclohexyl	Other Functions	SVOC
CUMIN	122-03-2	Cuminal	Other Functions	SVOC

4NAS	100-17-4	4-Nitroanisole	Other Functions	SVOC
DESHDC	72903-27-6	Diethyl 1,4-cyclohexanedicarboxylate	Other Functions	SVOC
CBZL	86-74-8	Carbazole	Other Functions	SVOC
BDPME	574-42-5	Bis(diphenylmethyl) ether	Other Functions	SVOC
TLDS	103-19-5	Bis(4-methylphenyl) disulfide	Other Functions	SVOC
TMPID	3910-35-8	1,1,3-Trimethyl-3-phenylindane	Other Functions	SVOC
FPIMPTH	898566-17-1	2-(4-Fluorophenyl)-5-[(5-iodo-2-methylphenyl)methyl]thiophene	Other Functions	SVOC
BZBA	120-51-4	Benzyl benzoate	Other Functions	SVOC
FEFAC	102-20-5	Phenethyl phenylacetate	Other Functions	SVOC
MABT	127-25-3	Methyl abietate	Other Functions	SVOC
OTNE*	54464-57-2	1-[1,6-Dimethyl-3-(4-methyl-3-penten-1-yl)-3-cyclohexen-1-yl]ethanone	Other Functions	SVOC
AETT	88-29-9	7-Acetyl-6-ethyl-1,1,4,4-tetramethyltetralin	Other Functions	SVOC
DMPSHEN	54464-54-9	dimethylacetylhexenylcyclohexene	Other Functions	SVOC
SYLKL	676532-44-8	Sylkolide	Other Functions	SVOC
SEROLD	477218-42-1	Serenolide	Other Functions	SVOC
EMOPCC	59151-19-8	Ethyl 2-methyl-4-oxo-6-pentyl-2-cyclohexene-1-carboxylate	Other Functions	SVOC
CTCVB	4714-35-6	1-Chloro-4-(1,2,2-trichloroethenyl)benzene	Other Functions	SVOC
DCTCVB	88218-49-9	1,4-Dichloro-2-(1,2,2-trichloroethenyl)benzene	Other Functions	SVOC
MPSHDOSD	125962-78-9	8-[4-(4-Methylphenyl)-3-cyclohexen-1-yl]-1,4-dioxaspiro[4.5]decane	Other Functions	SVOC
HOTMIKA	93777-71-0	2,3-Dihydro-6-hydroxy-1,1,3,3-tetramethyl-1H-indene-5-carboxaldehyde	Other Functions	SVOC
BSAN	1678-25-7	Benzenesulfonanilide	Other Functions	SVOC
SG3	128-80-3	Solvent green 3	Colourant	NIVA_UV
DTBMMP	2773-50-4	2,6-Bis(1,1-dimethylethyl)-4-(4-morpholinylmethyl)phenol	Polymer production	Antioxidant
DTBTMBPD	205927-03-3	(1S)-3,3′-Bis(1,1-dimethylethyl)-5,5′,6,6′-tetramethyl[1,1′-biphenyl]-2,2′-diol	Other function	Antioxidant
MDBHPP	6386-38-5	Methyl 3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate	Polymer production	Antioxidant

*OTNE is an isomer to substance DMPSHEN, where standard was available. Analysed as an additional substance.

Table A3: Overview over the legacy substances in part 2.

ID	CAS no.	Name	Function category	Method ID
CB28	7012-37-5	2,4,4′-Trichlorobiphenyl	Polychlorinated biphenyls	PCB
CB52	35693-99-3	2,2′,5,5′-Tetrachlorobiphenyl	Polychlorinated biphenyls	PCB
CB101	37680-73-2	2,2′,4,5,5′-Pentachlorobiphenyl	Polychlorinated biphenyls	PCB
CB118	31508-00-6	2,3′,4,4′,5-Pentachlorobiphenyl	Polychlorinated biphenyls	PCB
CB138	35065-28-2	2,2′,3,4,4′,5′-Hexachlorobiphenyl	Polychlorinated biphenyls	PCB
CB153	35065-27-1	2,2′,4,4′,5,5′-Hexachlorobiphenyl	Polychlorinated biphenyls	PCB
CB180	35065-29-3	2,2′,3,4,4′,5,5′-Heptachlorobiphenyl	Polychlorinated biphenyls	PCB
BDE17	147217-75-2	2,2′,4-Tribromodiphenyl ether	Polybrominated diphenyl ethers	PBDE
BDE28	41318-75-6	2,4,4′-Tribromodiphenyl ether	Polybrominated diphenyl ethers	PBDE
BDE47	5436-43-1	2,2′,4,4′-Tetrabromodiphenyl ether	Polybrominated diphenyl ethers	PBDE
BDE49	243982-82-3	2,2′,4,5′-Tetrabromodiphenyl ether	Polybrominated diphenyl ethers	PBDE
BDE66	189084-61-5	2,3′,4,4′-Tetrabromodiphenyl ether	Polybrominated diphenyl ethers	PBDE
BDE71	189084-62-6	2,3′,4′,6-Tetrabromodiphenyl ether	Polybrominated diphenyl ethers	PBDE
BDE77	93703-48-1	3,3′,4,4′-Tetrabromodiphenyl ether	Polybrominated diphenyl ethers	PBDE
BDE85	182346-21-0	2,2′,3,4,4′-Pentabromodiphenyl ether	Polybrominated diphenyl ethers	PBDE
BDE99	60348-60-9	2,2′,4,4′,5-Pentabromodiphenyl ether	Polybrominated diphenyl ethers	PBDE
BDE100	189084-64-8	2,2′,4,4′,6-Pentabromodiphenyl ether	Polybrominated diphenyl ethers	PBDE
BDE119	189084-66-0	2,3′,4,4′,6-Pentabromodiphenyl ether	Polybrominated diphenyl ethers	PBDE
BDE126	366791-32-4	3,3′,4,4′,5-Pentabromodiphenyl ether	Polybrominated diphenyl ethers	PBDE
BDE138	182677-30-1	2,2′,3,4,4′,5′-Hexabromodiphenyl ether	Polybrominated diphenyl ethers	PBDE
BDE153	68631-49-2	2,2′,4,4′,5,5′-Hexabromodiphenyl ether	Polybrominated diphenyl ethers	PBDE
BDE154	207122-15-4	2,2′,4,4′,5,6′-Hexabromodiphenyl ether	Polybrominated diphenyl ethers	PBDE
BDE156	405237-85-6	1,2,3,4-Tetrabromo-5-(3,4-dibromophenoxy)benzene	Polybrominated diphenyl ethers	PBDE
BDE183	207122-16-5	2,2′,3,4,4′,5′,6-Heptabromodiphenyl ether	Polybrominated diphenyl ethers	PBDE
BDE184	117948-63-7	2,2′,3,4,4′,6,6′-Heptabromodiphenyl ether	Polybrominated diphenyl ethers	PBDE
BDE191	446255-30-7	2,3,3′,4,4′,5′,6-Heptabromodiphenyl ether	Polybrominated diphenyl ethers	PBDE
BDE196	446255-39-6	2,2′,3,3′,4,4′,5,6′-Octabromodiphenyl ether	Polybrominated diphenyl ethers	PBDE
BDE197	117964-21-3	2,2′,3,3′,4,4′,6,6′-Octabromodiphenyl ether	Polybrominated diphenyl ethers	PBDE
BDE202	67797-09-5	1,1′-Oxybis[2,3,5,6-tetrabromobenzene]	Polybrominated diphenyl ethers	PBDE
BDE206	63387-28-0	2,2′,3,3′,4,4′,5,5′,6-Nonabromodiphenyl ether	Polybrominated diphenyl ethers	PBDE
BDE207	437701-79-6	2,2′,3,3′,4,4′,5,6,6′-Nonabromodiphenyl ether	Polybrominated diphenyl ethers	PBDE
BDE209	1163-19-5	Decabromodiphenyl ether	Polybrominated diphenyl ethers	PBDE

Table A3: Overview over the legacy substances in part 2, continued...

ID	CAS no.	Name	Function category	Method ID
SCCP	85535-84-8	Shortchain chlorinated paraffins (C10-C13)	Chlorinated paraffins	CP
MCCP	85535-85-9	Medium chain chlorinated paraffins (C14-C17)	Chlorinated paraffins	CP
LCCP	85535-86-0	Long chain chlorinated paraffins (C18+)	Chlorinated paraffins	CP
ATE	3278-89-5	Allyl 2,4,6-tribromophenyl ether	New brominated flame retardants	nBFR
TBECHA	1232836-48-4	α-Tetrabromoethylcyclohexane	New brominated flame retardants	nBFR
TBECHB	1232836-49-5	β-Tetrabromoethylcyclohexane	New brominated flame retardants	nBFR
TBECHG		g-Tetrabromoethylcyclohexane	New brominated flame retardants	nBFR
BATE	99717-56-3	2-Bromoallyl 2,4,6-tribromophenyl ether	New brominated flame retardants	nBFR
PBT	87-83-2	Pentabromotoluene	New brominated flame retardants	nBFR
PBEB	85-22-3	Pentabromoethylbenzene	New brominated flame retardants	nBFR
PBBZ	608-90-2	1,2,3,4,5-Pentabromobenzene	New brominated flame retardants	nBFR
HBBZ	87-82-1	1,2,3,4,5,6-Hexabromobenzene	New brominated flame retardants	nBFR
DPTE	35109-60-5	2,3-Dibromopropyl 2,4,6-tribromophenyl ether	New brominated flame retardants	nBFR
EHTBB	183658-27-7	2-Ethylhexyl 2,3,4,5-tetrabromobenzoate	New brominated flame retardants	nBFR
BTBPE	37853-59-1	1,2-Bis(2,4,6-tribromophenoxy)ethane	New brominated flame retardants	nBFR
BEHTBP	26040-51-7	Bis(2-ethylhexyl) tetrabromophthalate	New brominated flame retardants	nBFR
DBDPE	84852-53-9	Decabromodiphenylethane	New brominated flame retardants	nBFR
QCB	608-93-5	Pentachlorobenzene	New brominated flame retardants	nBFR
HCB	118-74-1	Hexachlorobenzene	New brominated flame retardants	nBFR
HCBD	87-68-3	Hexachlorobutadiene	New brominated flame retardants	nBFR
DBALD	20389-65-5	Dibromoaldrin	Dechloranes (acid stable)	Dechlorane
DDC_BBF	3560-90-2	Dechlorane 601	Dechloranes (acid stable)	Dechlorane
DDC_DBF	31107-44-5	Dechlorane 602	Dechloranes (acid stable)	Dechlorane
DDC_ANT	13560-92-4	Dechlorane 603	Dechloranes (acid stable)	Dechlorane
HCTBPH	34571-16-9	Dechlorane 604	Dechloranes (acid stable)	Dechlorane
DDC_PS	135821-03-3	syn-Dechlorane plus	Dechloranes (acid stable)	Dechlorane
DDC_PA	135821-74-8	anti-Dechlorane plus	Dechloranes (acid stable)	Dechlorane
Cr	7440-47-3	Chromium	Metals	Metal
Fe	7439-89-6	Iron	Metals	Metal
Ni	7440-02-0	Nickel	Metals	Metal
Cu	7440-50-8	Copper	Metals	Metal
Zn	7440-66-6	Zinc	Metals	Metal
As	7440-38-2	Arsenic	Metals	Metal
Se	7782-49-2	Selenium	Metals	Metal
Ag	7440-22-4	Silver	Metals	Metal
Cd	7440-43-9	Cadmium	Metals	Metal
Sn	7440-31-5	Tin	Metals	Metal
Sb	7440-36-0	Antimony	Metals	Metal
Pb	7439-92-1	Lead	Metals	Metal
Hg	7439-97-6	Mercury	Metals	Metal

Table A3: Overview over the legacy substances in part, continued...

ID	CAS no.	Name	Function category	Method ID
TEP	78-40-0	Triethyl phosphate	Organic phosphorous flame retardants	OPFR
TCEP	115-96-8	Tris(2-chloroethyl) phosphate	Organic phosphorous flame retardants	OPFR
TPRP	513-08-6	Tripropyl phosphate	Organic phosphorous flame retardants	OPFR
TCPP	13674-84-5	Tris(2-chloroisopropyl) phosphate	Organic phosphorous flame retardants	OPFR
TDCP	13674-87-8	Tris(1,3-dichloro-2-propyl) phosphate	Organic phosphorous flame retardants	OPFR
TPHP	115-86-6	Triphenyl phosphate	Organic phosphorous flame retardants	OPFR
TIBP	126-71-6	Triisobutyl phosphate	Organic phosphorous flame retardants	OPFR
TBP	126-73-8	Tributyl phosphate	Organic phosphorous flame retardants	OPFR
TBEP	78-51-3	Tris(2-butoxyethyl) phosphate	Organic phosphorous flame retardants	OPFR
DPHBP	2752-95-6	Butyl diphenyl phosphate	Organic phosphorous flame retardants	OPFR
DBPHP	2528-36-1	Dibutyl phenyl phosphate	Organic phosphorous flame retardants	OPFR
TCRP	1330-78-5	Tricresyl phosphate	Organic phosphorous flame retardants	OPFR
EHDPP	1241-94-7	2-Ethylhexyl diphenyl phosphate	Organic phosphorous flame retardants	OPFR
TIPPP	26967-76-0	Tris(isopropylphenyl) phosphate	Organic phosphorous flame retardants	OPFR
TEHP	78-42-2	Tris(2-ethylhexyl) phosphate	Organic phosphorous flame retardants	OPFR
TTBPP	78-33-1	Tris(4-tert-butylphenyl) phosphate	Organic phosphorous flame retardants	OPFR
BCEP	3040-56-0	Bis(2-chloroethyl) phosphate	OPFR metabolites	OPFR_metabolite
BCPP	789440-10-4	Bis(2-chloro-1-methylethyl) hydrogen phosphate	OPFR metabolites	OPFR_metabolite
DPPO	838-85-7	Diphenyl phosphate	OPFR metabolites	OPFR_metabolite
DBP	107-66-4	Dibutyl phosphate	OPFR metabolites	OPFR_metabolite
BDCPP	72236-72-7	Bis(1,3-dichloro-2-propyl) phosphate	OPFR metabolites	OPFR_metabolite
BBOEP	14260-97-0	Bis(2-butoxyethyl) phosphate	OPFR metabolites	OPFR_metabolite
DEHPO	298-07-7	Bis(2-ethylhexyl) phosphate	OPFR metabolites	OPFR_metabolite
DADMAC_C8	3026-69-5	Dimethyldioctylammonium	Quaternary ammonium compounds	QAC
DADMAC_C10	2390-68-3	Didecyldimethylammonium	Quaternary ammonium compounds	QAC
DADMAC_C12	3282-73-3	Didodecyldimethylammonium	Quaternary ammonium compounds	QAC
DADMAC_C14	68105-02-2	Dimethylditetradecylammonium	Quaternary ammonium compounds	QAC
DADMAC_C16	70755-47-4	Dihexadecyldimethylammonium	Quaternary ammonium compounds	QAC
DADMAC_C18	3700-67-2	Dimethyldioctadecylammonium	Quaternary ammonium compounds	QAC
BAC_C8	959-55-7	Benzyldimethyloctylammonium	Quaternary ammonium compounds	QAC
BAC_C10	965-32-2	Benzyldimethyldecylammonium	Quaternary ammonium compounds	QAC
BAC_C12	139-07-1	Benzyldimethyldodecylammonium	Quaternary ammonium compounds	QAC
BAC_C14	139-08-2	Benzyldimethyltetradecylammonium	Quaternary ammonium compounds	QAC
BAC_C16	122-18-9	Benzyldimethylhexadecylammonium	Quaternary ammonium compounds	QAC
BAC_C18	122-19-0	Benzyldimethyloctadecylammonium	Quaternary ammonium compounds	QAC
ATAC_C8	2083-68-3	Trimethyloctylammonium	Quaternary ammonium compounds	QAC
ATAC_C10	2082-84-0	Decyltrimethylammonium	Quaternary ammonium compounds	QAC

Table A3: Overview over the legacy substances in part 2, continued...

ID	CAS no.	Name	Function category	Method ID
ATAC_C12	1119-94-4	Dodecyltrimethylammonium	Quaternary ammonium compounds	QAC
ATAC_C14	1119-97-7	Tetradecyltrimethylammonium	Quaternary ammonium compounds	QAC
ATAC_C16	57-09-0	Hexadecyltrimethylammonium	Quaternary ammonium compounds	QAC
ATAC_C18	1120-02-1	Trimethyloctadecylammonium	Quaternary ammonium compounds	QAC
ATAC_C20	7342-61-2	Eicosyltrimethylammonium chloride	Quaternary ammonium compounds	QAC
ATAC_C22	17301-53-0	Behenyltrimethylammonium chloride	Quaternary ammonium compounds	QAC
HOMO	118-56-9	homosalate	UV compounds	UV
BP3	131-57-7	Benzophenone-3	UV compounds	UV
EHMCZ	177352-99-7	2-Ethylhexyl (2Z)-3-(4-methoxyphenyl)-2-propenoate	UV compounds	UV
EHMC	5466-77-3	2-Ethylhexyl 4-methoxycinnamate	UV compounds	UV
UV329	3147-75-9	2-(2-Hydroxy-5-tert-octylphenyl)benzotriazole	UV compounds	UV
UV328	25973-55-1	2-(2H-Benzotriazol-2-yl)-4,6-bis(1,1-dimethylpropyl)phenol	UV compounds	UV
UV327	3864-99-1	2-(5-Chloro-2H-benzotriazol-2-yl)-4,6-bis(1,1-dimethylethyl)phenol	UV compounds	UV
OCTOC	6197-30-4	Octocrylene	UV compounds	UV
PFBA	375-22-4	Perfluorinated butanoic acid	Perfluorinated carboxylate acids	PFCA
PFPA	422-64-0	Perfluorinated pentanoic acid	Perfluorinated carboxylate acids	PFCA
PFHXA	307-24-4	Perfluorinated hexanoic acid	Perfluorinated carboxylate acids	PFCA
PFHPA	375-85-9	Perfluorinated heptanoic acid	Perfluorinated carboxylate acids	PFCA
PFOA	335-67-1	Perfluorinated octanoic acid	Perfluorinated carboxylate acids	PFCA
PFNA	375-95-1	Perfluorinated nonanoic acid	Perfluorinated carboxylate acids	PFCA
PFDA	335-76-2	Perfluorinated decanoic acid	Perfluorinated carboxylate acids	PFCA
PFUNDA	2058-94-8	Perfluorinated undecanoic acid	Perfluorinated carboxylate acids	PFCA
PFDODA	307-55-1	Perfluorinated dodecanoic acid	Perfluorinated carboxylate acids	PFCA
PFTRDA	72629-94-8	Perfluorinated tridecanoic acid	Perfluorinated carboxylate acids	PFCA
PFTEDA	376-06-7	Perfluorinated tetradecanoic acid	Perfluorinated carboxylate acids	PFCA
PFHXDA	67905-19-5	Perfluorinated hexadecanoic acid	Perfluorinated carboxylate acids	PFCA
PFOCDA	16517-11-6	Perfluorinated octadecanoic acid	Perfluorinated carboxylate acids	PFCA
PFBS	375-73-5	Perfluorinated butane sulfonic acid	Perfluoroalkane sulfonic acids	PFSA
PFPS	2706-91-4	Perfluorinated pentane sulfonic acid	Perfluoroalkane sulfonic acids	PFSA
PFHXS	355-46-4	Perfluorinated hexane sulfonic acid	Perfluoroalkane sulfonic acids	PFSA
PFHPS	375-92-8	Perfluorinated heptane sulfonic acid	Perfluoroalkane sulfonic acids	PFSA
PFOS	1763-23-1	Perfluorinated octane sulfonic acid (linear)	Perfluoroalkane sulfonic acids	PFSA
BRPFOS	1763-23-1	Perfluorinated octane sulfonic acid (branched)	Perfluoroalkane sulfonic acids	PFSA
PFNS	68259-12-1	Perfluorinated nonane sulfonic acid	Perfluoroalkane sulfonic acids	PFSA
PFDS	67906-42-7	Perfluorinated decane sulfonic acid	Perfluoroalkane sulfonic acids	PFSA

Table A3: Overview over the legacy substances in part 2, continued...

ID	CAS no.	Name	Function category	Method ID
PFUNS	749786-16-1	Perfluoroundecane sulfonic acid	Perfluoroalkane sulfonic acids	PFSA
PFDOS	79780-39-5	Perfluorododecane sulfonic acid	Perfluoroalkane sulfonic acids	PFSA
PFTRS	791563-89-8	Perfluorotridecane sulfonic acid	Perfluoroalkane sulfonic acids	PFSA
PFTS	1379460-39-5	Perfluorotetradecane sulfonic acid	Perfluoroalkane sulfonic acids	PFSA
PFBSA	30334-69-1	Perfluorobutylsulphonamide	Polyfluorinated neutral compounds	nPFAS
NMEFBSA	68298-12-4	n-(methyl)nonafluorobutanesulfonamide	Polyfluorinated neutral compounds	nPFAS
NETFBSA	40630-67-9	N-ethyl-perfluorobutane-1-sulfonamide	Polyfluorinated neutral compounds	nPFAS
PFOSA	754-91-6	Perfluorooctane sulfonamide	Polyfluorinated neutral compounds	nPFAS
NMEFOSA	31506-32-8	N-Methyl perfluorooctane sulphonamide	Polyfluorinated neutral compounds	nPFAS
NETFOSA	4151-50-2	N-Ethyl perfluorooctane sulfonamide	Polyfluorinated neutral compounds	nPFAS
NMEFOSE	24448-09-7	N-Methyl perfluorooctane sulfonamidoethanol	Polyfluorinated neutral compounds	nPFAS
NETFOSE	1691-99-2	N-Ethyl perfluorooctane sulfonamidoethanol	Polyfluorinated neutral compounds	nPFAS
ETFOSAA	2991-50-6	N-Ethyl perfluorooctane sulfonamidoacetic acid	Polyfluorinated neutral compounds	nPFAS
42FTS	757124-72-4	4:2 Fluorotelomer sulfonic acid	New perflourinated compounds	PFAS_new
62FTS	27619-97-2	6:2 Fluorotelomer sulfonic acid	New perflourinated compounds	PFAS_new
82FTS	39108-34-4	8:2 Fluorotelomer sulfonic acid	New perflourinated compounds	PFAS_new
102FTS	120226-60-0	10:2 Fluorotelomer sulfonic acid	New perflourinated compounds	PFAS_new
122FTS	149246-64-0	12:2 Fluorotelomer sulfonic acid	New perflourinated compounds	PFAS_new
ADONA	919005-14-4	2,2,3-Trifluoro-3-[1,1,2,2,3,3-hexafluoro-3-(trifluoromethoxy)propoxy]propanoic acid	New perflourinated compounds	PFAS_new
PFECHS	646-83-3	1,2,2,3,3,4,5,5,6,6-Decafluoro-4-(1,1,2,2,2-pentafluoroethyl)cyclohexanesulfonic acid	New perflourinated compounds	PFAS_new
HFPODA	13252-13-6	2,3,3,3-Tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)propanoic acid (Gen-X)	New perflourinated compounds	PFAS_new
F-TOT		Total extractable organic fluorine	Total fluorine	TOF

A.4 Details on the emerging substances analytical methods

A.4.1 QAC Substances (NIVA)

Biota samples were homogenised and then extraction was carried out with two sequential volumes of acetonitrile. Excess sodium chloride was added for salting-out and then the upper acetonitrile phase was removed for analysis. Analysis was performed via LC-HRMS.

Sediment, sludge, soil and dust samples were extracted with a 9:1 mixture of methanol and ethyl acetate. Extracts were evaporated and reconstituted in methanol for analysis. Quantitative analysis was performed by LC-HRMS.

Aqueous samples were extracted via solid phase extraction (SPE) on Waters HLB columns. SPE elution was done with a 1:1:1 mixture of methanol, dichloromethane, and ethyl acetate. Analysis was performed by LC-HRMS.

A.4.2 PFAS Substances (NIVA)

Biota, sediment, sludge, soil and dust samples were homogenised, and extraction was carried out with two sequential volumes of acetonitrile. The extracts were combined, and excess sodium chloride was added for salting-out. The upper acetonitrile phase was then removed and passed through a 0.22 µm Nylon centrifuge filter before being transferred to vials for analysis by LC-HRMS.

Aqueous samples were extracted via solid phase extraction (SPE) on Waters WAX columns. SPE elution was with 5 mL of 0.1% ammonia in Methanol. The eluents were then evaporated to 100µL and re-diluted in 1 mL of mobile phase for analysis via LC-HRMS.

A.4.3 UV Substances (NIVA)

Biota, sediment, sludge, soil and dust samples were homogenised. Samples were weighed and spiked with 1 mL zinc chloride solution. A volume of 30 mL cyclohexane/ethylacetate/acetonitrile (50/40/10) was then added before extraction with aid of an ultrasound bath and shaking. Excess sodium chloride and sodium sulphate are then added to salt out and dry the extracts. Extraction was repeated and extracts combined. The combined extracts were dried down and reconstituted in 1 mL of cyclohexane/ethylacetate (20/80) ahead of cleanup via Gel-Phase Chromatography (GPC), and final analysis via GC-MS/MS.

Aqueous samples were extracted via liquid-liquid extraction with dichloromethane. Extracts are dried down and reconstituted in cyclohexane/ethylacetate (20/80) ahead of cleanup via Gel-Phase Chromatography (GPC), and final analysis via GC-MS/MS.

A.4.4 (Very) Mobile Organic Substances (NIVA)

Sediment, sludge, soil and dust samples were homogenised, and extraction was carried out with two sequential volumes of acetonitrile. The extracts were combined, and excess sodium chloride was added for salting-out. The upper acetonitrile phase was then removed and passed through a 0.22 µm Nylon centrifuge filter before being transferred to vials for analysis by LC-MS.

Aqueous samples were extracted via solid phase extraction (SPE) on Waters WAX columns or Waters HLB columns as appropriate. SPE elution was with 5 mL of 0.1% ammonia in Methanol. The eluents were then evaporated to 100µL and re-diluted in 1 mL of mobile phase for analysis via LC-MS.

A.4.5 SVOCs

Before extraction, a mixture of internal standards was added. Biota, sediment, and sludge samples were homogenised and then extraction was carried out with mixture of acetonitrile and hexane. Hexane layer was separated and concentrated, if necessary. ABN cartridges (for air samples) were extracted with ethyl acetate and concentrated by evaporation in a gentle stream pf nitrogen. Granulate, particles (with filters) and dust samples were extracted with acetone. Extracts were concentrated, if necessary. Aqueous samples were extracted with a mixture of dichloromethane and ethyl acetate. Analysis was performed with full-scan GC-HRMS. The instrument used was Thermo Q Exactive GC-Orbitrap-HRAM-MS operated at mass-resolution 60000. Mass-range was adjusted to optimize sensitivity, depending on the sample type. Quantification was made with help of calibration solutions in case of availability of authentic specimens. In case of lack of authentic specimens, the mass-spectra and retention times were estimated based on literature data for related substances. Due to unavoidable ambiguity, only detection/not detection was reported in lack of authentic specimens.

A.4.6 Siloxanes

Decomposes. Not analysed.

A.4.7 Triazines, Alternative bisphenols, Phenolic antioxidants

Biological samples were weighed (0.1 or 0.2 g), and internal standards were added. The samples were extracted with 4 mL ethyl acetate/n-hexane (4:1) in ultrasonic bath for 30 minutes, the top phase was transferred to a clean glass and the extraction was repeated before the two top phases were combined. The extract was evaporated to dryness using miVac and dissolved in 0.5 mL Acetonitrile before clean-up using EZ-POP SPE-cartridges and LCTech Freestyle SPE-robot.

Solid samples (House Dust, Sediment, Sludge, Soil, and Particles) were extracted using ASE in a 10 mL or 22 mL stainless steel cells with ethyl acetate / n-Hexane 4:1, 150 °C, 10 min, 2 cycles, 50% rinse volume, 90 s purge.

For water samples 100 mL of the sample was added internal standards and homogenised. Extraction and cleanup was conducted using Oasis HLB 500 mg 6 cc cartridges using LCTech Freestyle SPE-robot.

Extracts were evaporated to dryness and dissolved in 100 µL distilled MeOH/MQ water 1:1 and recovery standard was added. A sample aliquot was prepared in an insert-glass for LC/MS analysis.

The samples were analysed using a Agilent UHPLC-HR-QTOF-MS operated in negative or positive electrospray mode.

A.5 Details on the legacy substances analytical methods

A.5.1 OPFRs and OPFR metabolites

OPFRs and their metabolites were analyzed in a subset of samples by the following method. 0.1g of the sample was homogenized in a metal Precellys tube with metal beads, 20µL of labeled internal standards (d10-BBNP, d10-BPP, d8-BCEP), and 3mL of 1% formic acid in acetonitrile. The mixture was processed twice at 5500 rpm for 20 seconds, followed by centrifugation at 4400 rpm for 10 minutes. The supernatant was collected and pooled. The extract was concentrated to 2mL and diluted with 2mL of 1% formic acid in Milli-Q water. It was then loaded onto a conditioned and equilibrated OASIS WAX SPE column, washed, and dried. OPFRs are eluted with ethyl acetate, and metabolites with 5% NH4OH in methanol. The fractions were evaporated and stored appropriately. The OPFR metabolite fraction was prepared with 20µL d4-MOP and analyzed via LC-Exploris using a Waters C18 column, while the OPFR fraction was analyzed on a UPLC Phenyl column with standard procedures.

A.5.2 PCBs, PBDEs, other BFRs, S/M/LCCP, Dechloranes

Polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDE), other brominated flame retardants (BFRs), and short-, medium- and long chained chlorinated paraffins (S/M/LCCP) and dechloranes were analysed in a subset of marine biota samples using the following method. Prior to extraction, a mixture of isotope labelled PCBs, PBDEs, CPs and dechloranes were added. The biota-samples were extracted with organic solvents and concentrated under nitrogen flow, followed by a clean-up procedure using concentrated sulphuric acid and a silica column to remove lipids and other interferences prior to analysis. The compounds were quantified on GC-HRMS (Waters Autospec) and/or GC-QToF (Agilent 7200B). LCCPs were analyzed with Agilent UHPLC-HR-QTOF-MS operated in negative electrospray mode with acetonitrile and water mixed with TMAC (tetramethyl ammonium chloride).

A.5.3 Metals

Samples were digested in a closed-vessel microwave technique system (UltraClave, Milsetone). Approximately 0,6 g of each sample was added 5 ml HNO_3 (s.p.) and 3 ml deionized water. The samples were digested using stepwise heating to 250°C and a holding time of 30 minutes at 250°C. After cooling, the digests were quantitatively transferred to polypropylene tubes and diluted to a total volume of 50 ml with deionized water.

Determination of metals were performed using a NexION 5000 Multi-Quadrupole ICP Mass Spectrometer (PerkinElmer). From the digested samples, aliquots of 1.0 ml or 0.1 ml were diluted to 10 ml using deionized water or 2% HNO3 for a total acid matrix of 2%. Quantification was performed by external calibration using multi element mixtures delivered by Teknolab AS and Spectrascan all made from high purity NIST traceable primary element solutions of 99,99% or better. All calibration solutions were prepared in nitric acid solutions free of chloride to avoid common Cl molecular ions in the ICP-MS, at a nitric acid concentration of 2% to match the matrix of the samples. An analysis program containing the target elements was designed using appropriate reaction gases for each element to avoid expected interferences such as polyatomic ions and doubly charged species. Additionally, to reduce risk of matric matrix interferences and signal suppression due to matrix effects the analytes were determined in diluted samples.

Quality control (QC) samples were used to check the external calibration and certified reference materials (Oyster Tissue 1566b, NIST and Rye Grass ERM-CD28, Joint Research Centre) were digested with the samples to check the efficiency of the digestion. Blank samples were run after highly concentrated samples to check for appropriate washout and carry-over between samples. All samples, standards, blanks, QC-samples and CRM used In as internal standard added to the sample line at a constant rate of approximately 1 ng.ml-1 in a HNO3 acidified matrix of 2% (v/v).

A6. Method limits of detection (LOD)

For a few of the substances, the LOD is presented by a range of values. The reason for this is varying LODs depending on the amount of sample material available.

Table A4. For part 1, method concentration limit of detection (LOD) for the different sample types.

ParameterID	CASnr	Method ID	Water, filtered (ng/L)	Water particulate (ng/g, d.w.)	Sludge/sediment/soil (ng/g, d.w.)	Blue mussel (ng/g, w.w.)	Dust (ng/g, d.w.)
AOZKF	4066-02-8	Bisphenol	4	16-90	2	2	20
PF201	232938-43-1	Pergfast	9	36-210	4.5	4.5	45
DABPA	1745-89-7	Bisphenol	4.5	18-110	2.3	2.3	23
XYLENOL	5384-21-4	Bisphenol	5	20-110	2.5	2.5	25
T4HPE	27955-94-8	Bisphenol	13	52-300	6.5	6.5	65
TMBPA	5613-46-7	Bisphenol	6.5	26/150	3.3	3.3	33
BHPMEBD	147504-92-5	Bisphenol	S	S	S	S	S
UV310	154702-15-5	Triazine	2.5	10	1.25	1	10
UV1164	2725-22-6	Triazine	2	14-46	1	1	1
BEMT	187393-00-6	Triazine	50	50-200	1	1	1
UV1577	147315-50-2	Triazine	5	20-110	2.5	2.5	2.5
TBHPT	3135-19-1	Triazine	5	20-110	2.5	2.5	2.5
BPAP2	116-37-0	Bisphenol	5	20-110	2.5	2.5	2.5
TBRPT	890148-78-4	Triazine	50	200-1100	25	25	25
UV1579	106556-36-9	Triazine	4	16-90	2	2	2
DPDT	38369-95-8	Triazine	4	16-90	2	2	2
DBPCLT	182918-13-4	Triazine	20	80-450	10	10	10
23BPDT	864377-31-1	Triazine	5	20-110	2.5	2.5	2.5
22BPDT	77989-15-2	Triazine	5	20-110	2.5	2.5	2.5
TBPHT	31274-51-8	Triazine	2	287-425	1	1	1
DMPTDPP	178905-31-2	Triazine	S	S	S	S	S
DMPTTPP	178905-32-3	Triazine	S	S	S	S	S
B-2ETF	6422-86-2	SVOC		3000	10		
MPDCH	97398-80-6	SVOC	5	30	10	10	50
CUMIN	122-03-2	SVOC	5	15	3	3	15
4NAS	100-17-4	SVOC	1	5	5	5	25
DESHDC	72903-27-6	SVOC	5	20	5	5	25
CBZL	86-74-8	SVOC	100	100	10	10	50
BDPME	574-42-5	SVOC	1	25-100	5	5	25
TLDS	103-19-5	SVOC	1	5	5	5	25
TMPID	3910-35-8	SVOC		25		5	
DPMPE	6362-80-7	SVOC	10	100	2	5	10
FPIMPTH	898566-17-1	SVOC	1	5	2	2	10
BZBA	120-51-4	SVOC	25	200	1	1	
FEFAC	102-20-5	SVOC	5	20	1-5	50	250
MABT	127-25-3	SVOC	10/50	20	10	50	250
OTNE	54464-57-2	SVOC		500000-3000000	10	10	
AETT	88-29-9	SVOC	1	5	5	5	25
DMPSHEN	54464-54-9	SVOC	S	S	S	S	S
SYLKL	676532-44-8	SVOC	S	S	S	S	S
SEROLD	477218-42-1	SVOC	S	S	S	S	S
DIUDP	96507-80-1	SVOC	S	S	S	S	S
EMOPCC	59151-19-8	SVOC	S	S	S	S	S
CTCVB	4714-35-6	SVOC	S	S	S	S	S
DCTCVB	88218-49-9	SVOC	S	S	S	S	S
TCTDT	2149571-40-2	SVOC	S	S	S	S	S
ETTSDD	38233-76-0	SVOC	S	S	S	S	S
MPSHDOSD	125962-78-9	SVOC	S	S	S	S	S
HOTMIKA	93777-71-0	SVOC	S	S	S	S	S
BSAN	1678-25-7	SVOC	n.a.	n.a.	n.a.	n.a.	n.a.
TIPSIMA	134652-60-1	Siloxane	decomposes	decomposes	decomposes	decomposes	decomposes
TIPSIA	157859-20-6	Siloxane	decomposes	decomposes	decomposes	decomposes	decomposes

Table A4. For part 1, method concentration limit of detection (LOD) for the different samples types, continued.

ParameterID	CASnr	Method ID	Water, filtered (ng/L)	Water particulate (ng/g, d.w.)	Sludge/sediment/soil (ng/g, d.w.)	Blue mussel (ng/g, w.w.)	Dust (ng/g, d.w.)
DOCDPA	15721-78-5	NIVA_UV	5	10	5	5	5
FBCLBA	107934-68-9	NIVA_UV	2	4	2	2	2
PEPEPO	68540-61-4	NIVA_UV	200	400	200	200	200
BNDTT	89347-09-1	NIVA_UV	10	20	10	10	10
BEHAMBT	80584-90-3	NIVA_UV	10	20	10	10	10
SG3	128-80-3	NIVA_UV		40	20	20	
SORFEN	284461-73-0	NIVA_UV	1	2	1	1	1
2BBTMP	70693-49-1	NIVA_UV	10	20	10	10	10
2BHMPTP	209324-18-5	NIVA_UV	10	20	10	10	10
UV360	103597-45-1	NIVA_UV	10	20	10	10	10
UV234	70321-86-7	NIVA_UV	10	20	10	10	10
2BMTP	104487-30-1	NIVA_UV	10	20	10	10	10
TFMBTP	207738-63-4	NIVA_UV	10	20	10	10	10
DTBPPO	95906-11-9	NIVA_UV	1	2	1	1	2
UV329	3147-75-9	NIVA_UV	10	20	10	10	10
QUOX	124495-18-7	NIVA_UV	2	4	2	2	2
UV320	3846-71-7	NIVA_UV	10	20	10	10	10
2BDOMP	23328-53-2	NIVA_UV	10	20	10	10	10
DTBNTP	28122-40-9	NIVA_UV	10	20	10	10	10
NTTMP	27876-55-7	NIVA_UV	10	20	10	10	10
2BDMP	3147-76-0	NIVA_UV	20	40	20	20	20
NTOP	138615-32-4	NIVA_UV	10	20	10	10	10
BENAZOL P	2440-22-4	NIVA_UV	20	40	20	20	20
DTAPBO	94109-79-2	NIVA_UV	20	40	10	10	10
CLBDMP	3287-17-0	NIVA_UV	10	20	10	10	10
UV384	84268-23-5	NIVA_UV	10	20	10	10	10
DPGUAN	102-06-7	NIVA_UV				1	
BMATA	561-41-1	NIVA_UV	200	400	200	200	200
MB2BMP	30653-05-5	NIVA_UV	10	20	10	10	10
2BMPP	2170-39-0	NIVA_UV	20	40	20	20	20
M1UV328	84268-36-0	NIVA_UV	50	100	50	50	50
DTBTP	824407-02-5	NIVA_UV	10	20	10	10	10
BHEP	96549-95-0	NIVA_UV	20	40	20	20	20
2TBCLBEP	124883-10-9	NIVA_UV	10	20	10	10	10
UV1130	84268-33-7	NIVA_UV	10	20	10	10	10
BTHPE	83741-30-4	NIVA_UV	10	20	10	10	10
HDBTBP	84268-08-6	NIVA_UV	10	20	10	10	10
DMO2BP	84755-44-2	NIVA_UV	10	20	10	10	10
KRYFIO	548-62-9	NIVA_UV	10	20	10	10	10
CYANA	108-80-5	NIVA_vM	50	400	200	200	200
AAMPSA	15214-89-8	NIVA_vM	2	4	2	2	2
NAAHPS	52556-42-0	NIVA_vM	2	4	2	2	2
ETPPBR	1530-32-1	NIVA_vM	10	20	10	10	10
ADNP	96-91-3	NIVA_vM	20	40	20	20	20
GBLA	96-48-0	NIVA_vM	2	2	2	2	2
BZDSA	117-61-3	NIVA_vM	2	2	2	2	2
TEDA	280-57-9	NIVA_vM	20	40	20	20	20
35DMPZ	67-51-6	NIVA_vM	2	4	2	2	2
34DMPZP	202842-98-6	NIVA_vM	2	4	2	2	2
34DMPZ	2820-37-3	NIVA_vM	2	4	2	2	2
DBSNMA	10584-98-2	NIVA_TBT	2	4	2	2	2
AO1098	23128-74-7	NIVA_GPC	2	4	2	2	2

Table A5. For part 2, method concentration limit of detection (LOD, ng g^{-1}) for the different samples types.

ID	CAS no.	Method ID	LOD
DTBMMP	2773-50-4	Antioxidant	25
DTBTMBPD	205927-03-3	Antioxidant	3
MDBHPP	6386-38-5	Antioxidant	9
CB28	7012-37-5	PCB	0.02-0.04
CB52	35693-99-3	PCB	0.03-0.05
CB101	37680-73-2	PCB	0.06-0.09
CB118	31508-00-6	PCB	0.03-0.06
CB138	35065-28-2	PCB	0.06-0.1
CB153	35065-27-1	PCB	0.1-0.2
CB180	35065-29-3	PCB	0.03-0.05
BDE17	147217-75-2	PBDE	0.02-0.2
BDE28	41318-75-6	PBDE	0.02
BDE47	5436-43-1	PBDE	0.10
BDE49	243982-82-3	PBDE	0.02-0.03
BDE66	189084-61-5	PBDE	0.02-0.04
BDE71	189084-62-6	PBDE	0.01-0.2
BDE77	93703-48-1	PBDE	0.01-0.04
BDE85	182346-21-0	PBDE	0.01-0.3
BDE99	60348-60-9	PBDE	0.02
BDE100	189084-64-8	PBDE	0.01
BDE119	189084-66-0	PBDE	0.04-0.2
BDE126	366791-32-4	PBDE	0.03-0.2
BDE138	182677-30-1	PBDE	0.04-0.2
BDE153	68631-49-2	PBDE	0.08-0.4
BDE154	207122-15-4	PBDE	0.02
BDE156	405237-85-6	PBDE	0.06-0.4
BDE183	207122-16-5	PBDE	0.04-0.08
BDE184	117948-63-7	PBDE	0.04-0.1
BDE191	446255-30-7	PBDE	0.08-0.2
BDE196	446255-39-6	PBDE	0.07-0.4
BDE197	117964-21-3	PBDE	0.05-0.3
BDE202	67797-09-5	PBDE	0.08-0.2
BDE206	63387-28-0	PBDE	0.1-0.4
BDE207	437701-79-6	PBDE	0.09-0.4
BDE209	1163-19-5	PBDE	1.67
SCCP	85535-84-8	CP	18-30
MCCP	85535-85-9	CP	6
LCCP	85535-86-0	CP	7
ATE	3278-89-5	nBFR	0.06-0.3
TBECHA	1232836-48-4	nBFR	0.3-69
TBECHB	1232836-49-5	nBFR	0.20-43
TBECHG		nBFR	0.2-6
BATE	99717-56-3	nBFR	0.09-0.1
PBT	87-83-2	nBFR	0.1
PBEB	85-22-3	nBFR	0.1
PBBZ	608-90-2	nBFR	0.1
HBBZ	87-82-1	nBFR	0.2
DPTE	35109-60-5	nBFR	0.08
EHTBB	183658-27-7	nBFR	0.1
BTBPE	37853-59-1	nBFR	0.2
BEHTBP	26040-51-7	nBFR	0.6-3
DBDPE	84852-53-9	nBFR	4
QCB	608-93-5	nBFR	0.03-0.05
HCB	118-74-1	nBFR	0.05-0.09
HCBD	87-68-3	nBFR	n.a.
DBALD	20389-65-5	Dechlorane	0.4
DDC_BBF	3560-90-2	Dechlorane	0.07
DDC_DBF	31107-44-5	Dechlorane	0.04-0.05
DDC_ANT	13560-92-4	Dechlorane	0.05
HCTBPH	34571-16-9	Dechlorane	0.07-1
DDC_PS	135821-03-3	Dechlorane	0.1-0.2
DDC_PA	135821-74-8	Dechlorane	0.2

Table A5. For part 2, method concentration limit of detection (LOD, ng g^{-1}) for the different samples types, continued…

ID	CAS no.	Method ID	LOD
Cr	7440-47-3	Metal	2
Fe	7439-89-6	Metal	24
Ni	7440-02-0	Metal	2
Cu	7440-50-8	Metal	3
Zn	7440-66-6	Metal	27
As	7440-38-2	Metal	2
Se	7782-49-2	Metal	10
Ag	7440-22-4	Metal	1
Cd	7440-43-9	Metal	0.1
Sn	7440-31-5	Metal	3
Sb	7440-36-0	Metal	0.2
Pb	7439-92-1	Metal	0.4
Hg	7439-97-6	Metal	0.6
TEP	78-40-0	OPFR	8
TCEP	115-96-8	OPFR	0.5
TPRP	513-08-6	OPFR	0.5
TCPP	13674-84-5	OPFR	31
TDCP	13674-87-8	OPFR	1
TPHP	115-86-6	OPFR	2
TIBP	126-71-6	OPFR	3
TBP	126-73-8	OPFR	6
TBEP	78-51-3	OPFR	2
DPHBP	2752-95-6	OPFR	0.5
DBPHP	2528-36-1	OPFR	0.5
TCRP	1330-78-5	OPFR	1
EHDPP	1241-94-7	OPFR	0.5
TIPPP	26967-76-0	OPFR	1
TEHP	78-42-2	OPFR	8
TTBPP	78-33-1	OPFR	1
BCEP	3040-56-0	OPFR_metabolite	22
BCPP	789440-10-4	OPFR_metabolite	2
DPPO	838-85-7	OPFR_metabolite	17
DBP	107-66-4	OPFR_metabolite	7300
BDCPP	72236-72-7	OPFR_metabolite	2
BBOEP	14260-97-0	OPFR_metabolite	2
DEHPO	298-07-7	OPFR_metabolite	46
DADMAC_C8	3026-69-5	QAC	0.1
DADMAC_C10	2390-68-3	QAC	0.1
DADMAC_C12	3282-73-3	QAC	0.1
DADMAC_C14	68105-02-2	QAC	0.1
DADMAC_C16	70755-47-4	QAC	0.1
DADMAC_C18	3700-67-2	QAC	0.1
BAC_C8	959-55-7	QAC	0.1
BAC_C10	965-32-2	QAC	0.1
BAC_C12	139-07-1	QAC	0.1
BAC_C14	139-08-2	QAC	0.1
BAC_C16	122-18-9	QAC	0.1
BAC_C18	122-19-0	QAC	0.1
ATAC_C8	2083-68-3	QAC	0.1
ATAC_C10	2082-84-0	QAC	0.1
ATAC_C12	1119-94-4	QAC	0.1
ATAC_C14	1119-97-7	QAC	0.1
ATAC_C16	57-09-0	QAC	0.1
ATAC_C18	1120-02-1	QAC	0.1
ATAC_C20	7342-61-2	QAC	0.1
ATAC_C22	17301-53-0	QAC	0.1
HOMO	118-56-9	UV	1-10
BP3	131-57-7	UV	1-10
EHMC	5466-77-3	UV	0.5-1
UV328	25973-55-1	UV	0.1-0.4
UV327	3864-99-1	UV	0.1-0.2
OCTOC	6197-30-4	UV	7-25

Table A6: For part 2, method concentration limit of detection (LOD, ng g^{-1}) for the different samples types.

ID	CAS no.	Method ID	LOD
PFBA	375-22-4	PFCA	0.5
PFPA	422-64-0	PFCA	0.5
PFHXA	307-24-4	PFCA	0.5
PFHPA	375-85-9	PFCA	0.5
PFOA	335-67-1	PFCA	0.5
PFNA	375-95-1	PFCA	0.4
PFDA	335-76-2	PFCA	0.4
PFUNDA	2058-94-8	PFCA	0.4
PFDODA	307-55-1	PFCA	0.4
PFTRDA	72629-94-8	PFCA	0.4
PFTEDA	376-06-7	PFCA	0.4
PFHXDA	67905-19-5	PFCA	0.4
PFOCDA	16517-11-6	PFCA	0.4
PFBS	375-73-5	PFSA	0.2
PFPS	2706-91-4	PFSA	0.1
PFHXS	355-46-4	PFSA	0.1
PFHPS	375-92-8	PFSA	0.1
PFOS	1763-23-1	PFSA	
BRPFOS	1763-23-1	PFSA	0.05
PFNS	68259-12-1	PFSA	0.1
PFDS	67906-42-7	PFSA	0.1
PFUNS	749786-16-1	PFSA	0.1
PFDOS	79780-39-5	PFSA	0.1
PFTRS	791563-89-8	PFSA	0.1
PFTS	1379460-39-5	PFSA	0.1
PFBSA	30334-69-1	nPFAS	0.3
NMEFBSA	68298-12-4	nPFAS	0.3
NETFBSA	40630-67-9	nPFAS	0.3
PFOSA	754-91-6	nPFAS	0.1
NMEFOSA	31506-32-8	nPFAS	0.3
NETFOSA	4151-50-2	nPFAS	0.3
NMEFOSE	24448-09-7	nPFAS	0.1
NETFOSE	1691-99-2	nPFAS	0.1
ETFOSAA	2991-50-6	nPFAS	0.3
42FTS	757124-72-4	PFAS_new	0.3
62FTS	27619-97-2	PFAS_new	0.3
82FTS	39108-34-4	PFAS_new	0.3
102FTS	120226-60-0	PFAS_new	0.3
122FTS	149246-64-0	PFAS_new	0.3
ADONA	919005-14-4	PFAS_new	0.3
PFECHS	646-83-3	PFAS_new	0.3
HFPODA	13252-13-6	PFAS_new	0.3
F-TOT		TOF	230

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