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James Hinchcliffe | Biologist EFFOP

Strategic value of marine ingredients in the Baltic

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The strategic value of marine ingredients in the Baltic Sea

Dr. James Hinchcliffe
biologist EFFOP

EFFOP biannual conference

Estonia

June 2024

The golden standard

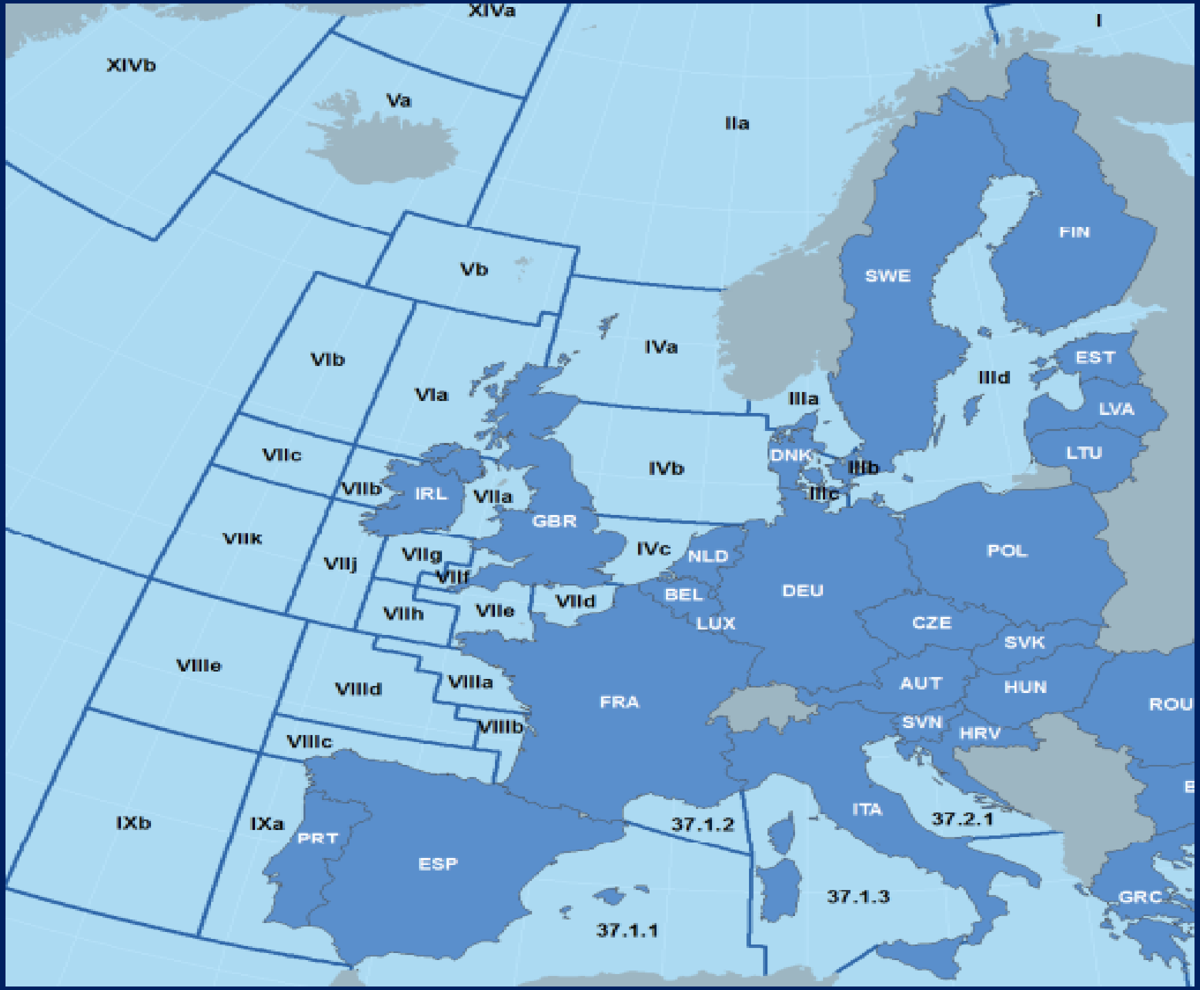
“A feed is only as good as its ingredients”

- High digestibility
- High palatability
- High ease of assimilation in animals
- Efficient extrusion

Nutrient %	Fishmeal	Target range for alternative ingredients	Soybean
Crude protein	65-72	48-80	60
Crude Lipid	5-8	2-20	5.4
Ash	7-15	4-8	8
NFE	<1	<20	*
Starch	<1	<20	*
Lysine	4.72	>3.5	2.8
Methionine	1.75	>1.5	0.9
N-3 fatty acids	*ca.* 2	*	*

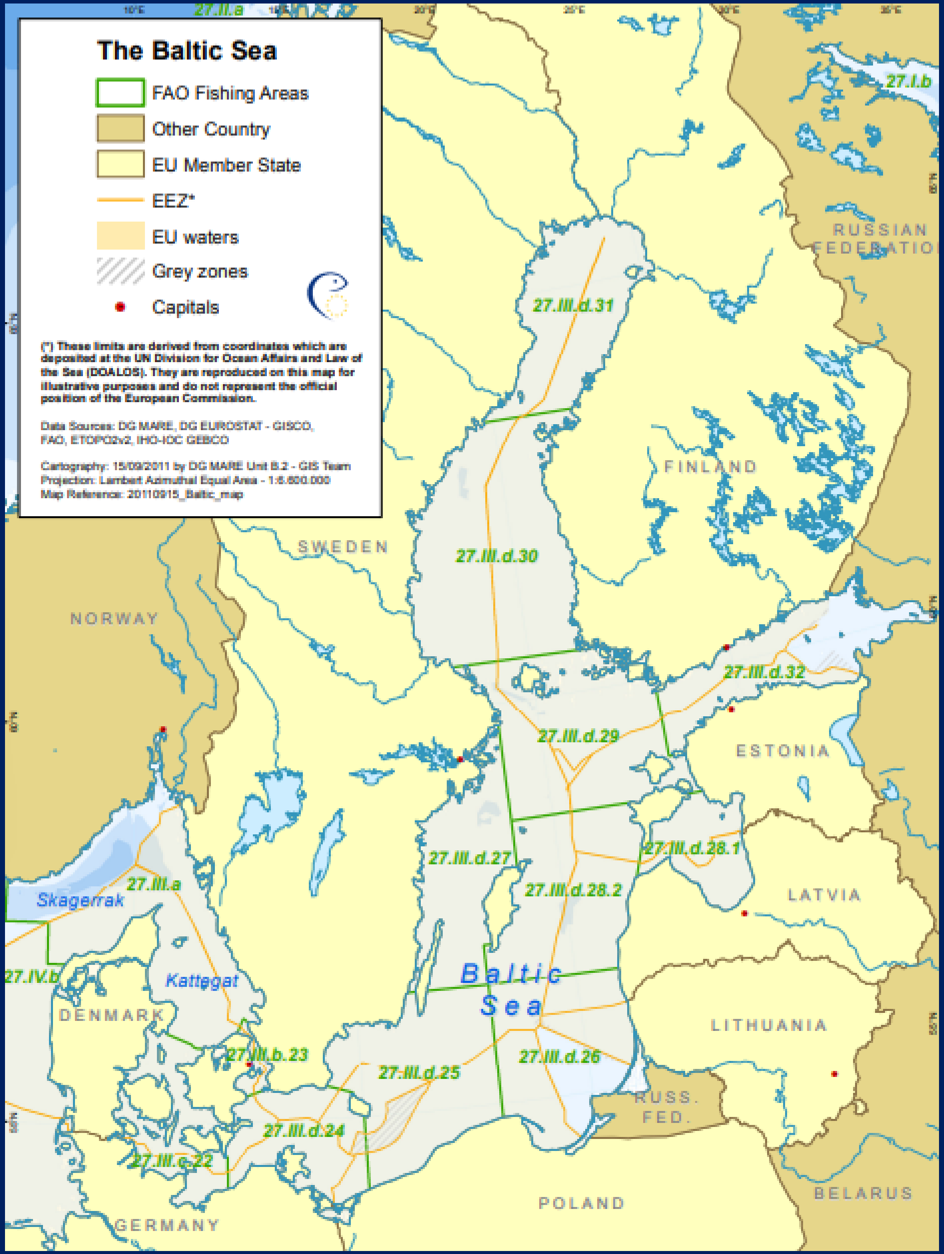
Gatlin et al., 2007
Glencross et al., 2007

European Fishmeal sourcing



Fish species	Latin name	ICES catch area/management area	Status
Anchovy	*Engraulis encrasicolus*	*Subarea 8 (Bay of Biscay)*	
Blue whiting	*Micromesistius poutassou*	*Subareas 1–9, 12, and 14 (Northeast Atlantic and adjacent waters)*	
Boarfish	*Capros aper*	*Subareas 6–8 (Celtic Seas, English Channel, and Bay of Biscay)*	
Capelin	*Mallotus villosus*	*Subareas 1 and 2 (Northeast Arctic), excluding Division 2.a west of 5°W (Barents Sea capelin)*	
Capelin	*Mallotus villosus*	*Subareas 5 and 14 and Division 2.a west of 5°W (Iceland and Faroes grounds, East Greenland, Jan Mayen area)*	
Herring	*Clupea harengus*	*Subarea 4 and divisions 3.a and 7.d, autumn spawners (North Sea, Skagerrak and Kattegat, eastern English Channel)*	
Herring	*Clupea harengus*	*Subareas 1, 2, and 5, and in divisions 4.a and 14.a, Norwegian spring-spawning herring (the Northeast Atlantic and the Arctic Ocean)*	
Herring	*Clupea harengus*	*Subdivisions 20–24, spring spawners (Skagerrak, Kattegat, and western Baltic)*	
Herring	*Clupea harengus*	*Subdivisions 25–29 and 32, excluding the Gulf of Riga (central Baltic Sea)*	
Herring	*Clupea harengus*	*Subdivisions 30 and 31 (Gulf of Bothnia)*	
Herring	*Clupea harengus*	*Subdivision 28.1 (Gulf of Riga)*	
Horse mackerel	*Trachurus trachurus*	*Subarea 8 and divisions 2.a, 4.a, 5.b, 6.a, 7.a–c, and 7.e–k (the Northeast Atlantic)*	
Mackerel	*Scomber scombrus*	*Subareas 1–8 and 14, and in Division 9.a (the Northeast Atlantic and adjacent waters)*	
Norway pout	*Trisopterus esmarkii*	*Subarea 4 and Division 3.a (North Sea, Skagerrak, and Kattegat)*	
Sandeel	*Ammodytes spp.*	*Divisions 4.b–c, Sandeel Area 1r (central and southern North Sea, Dogger Bank)*	
Sandeel	*Ammodytes spp.*	*Divisions 4.b–c and Subdivision 20, Sandeel Area 2r (central and southern North Sea)*	
Sandeel	*Ammodytes spp.*	*Divisions 4.a–b and Subdivision 20, Sandeel Area 3r (northern and central North Sea, Skagerrak)*	
Sandeel	*Ammodytes spp.*	*Divisions 4.a–b, Sandeel Area 4 (northern and central North Sea)*	
Sardine	*Sardina pilchardus*	*Subarea 7 (Southern Celtic Seas, and the English Channel)*	
Sardine	*Sardina pilchardus*	*Divisions 8.a–b and 8.d (Bay of Biscay)*	
Sprat	*Sprattus sprattus*	*Subdivisions 22–32 (Baltic Sea)*	
Sprat	*Sprattus sprattus*	*Division 3.a and Subarea 4 (Skagerrak, Kattegat,and North Sea)*	

ICES advice is a core principle in EFFOPS sourcing



Baltic Sea ecosystem and management

Important whole fish stocks

1. Baltic Herring: subdivisions 20–24, spring spawners (Skagerrak, Kattegat, and western Baltic)
2. Baltic Herring: subdivisions 25–29 and 32, excluding the Gulf of Riga (central Baltic Sea)
3. Baltic Herring: subdivisions 30 and 31 (Gulf of Bothnia)
4. Baltic Herring: subdivision 28.1 (Gulf of Riga)
5. Sprat: Subdivisions 22–32 (Baltic Sea)

ICES fish stock status is indicated by the colors – green and red:
Green = spawning stock biomass above the precautionary reference point, Bpa.
Red = spawning stock biomass below the precautionary reference point, Bpa.

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Baltic Sea ecosystem and management

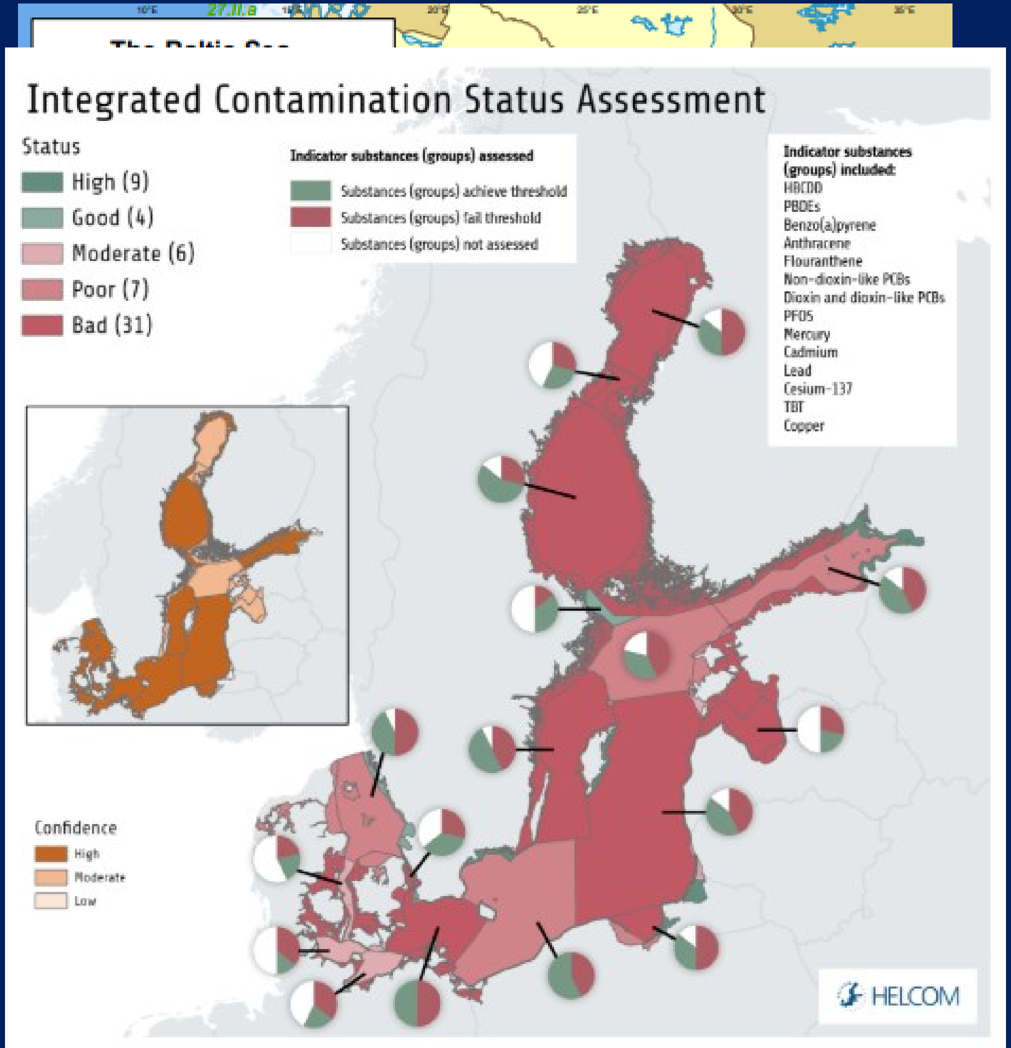

Figure 4.7. The integrated assessment of hazardous substances status in the Baltic Sea, assessed using the CHASE integrated assessment tool. The assessment shows that hazardous substances are a cause for concern in almost all assessed units, and those showing good status generally lack a full and adequate assessment. The integrated assessment is based on 11 core indicators. It integrates concentrations to threshold-derived values (contamination ratios) for fourteen individual hazardous substances or substance groups. The overall assessment is moderated by a parallel assessment of confidence (see inset map on the left) that can be considered an appraisal of the data coverage and assessment quality in any given assessment unit. Source: HELCOM 2023c.

Important whole fish stocks

1. Baltic Herring: subdivisions 20–24, spring spawners (Skagerrak, Kattegat, and western Baltic)
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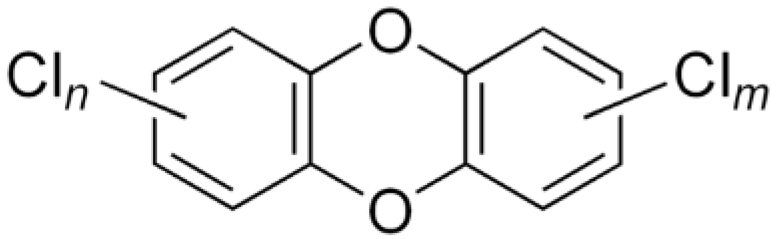
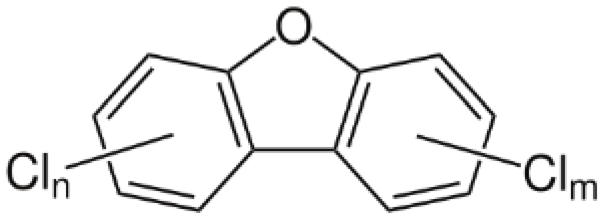
Polychlorinated biphenyls and Dioxins

- Polychlorinated biphenyls (PCBs) are persistent toxic substances and bioaccumulate in the marine food web
- Dioxins are a family of compounds that share distinct chemical structures and characteristics. Numerous dioxin-like compounds have been identified that are considered to have significant toxicity and can cause disease.
- Some PCB’s have toxicological properties similar to dioxins (“dioxin-like PCB’s”)

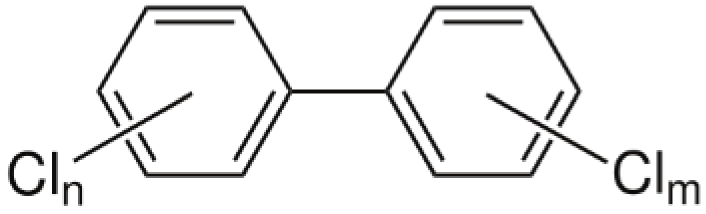
Polychlorinated dibenzo-p-dioxins



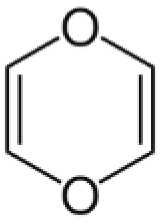
Polychlorinated dibenzofurans



Polychlorinated biphenyls



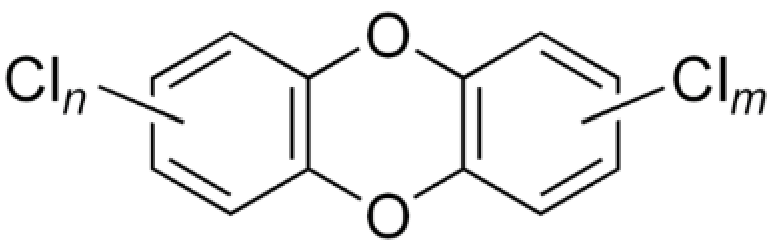
1,4-dioxin



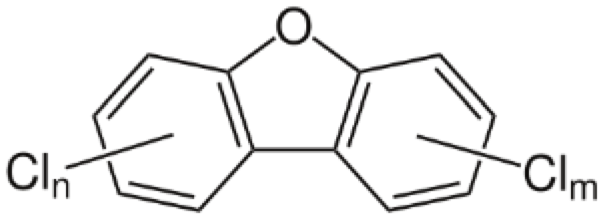
Polychlorinated biphenyls and Dioxins

Characteristic	Dioxins	PCBs	Dioxin-like PCBs
Definition	Polychlorinated dibenzo-p-dioxins (PCDDs)	Polychlorinated biphenyls	PCBs with similar toxicity to dioxins
Formation/Usage	By-products of industrial processes	Synthetic chemicals used in electrical equipment, etc.	Subset of PCBs with structural and toxic similarity to dioxins
Toxicity	Highly toxic, can cause cancer, immune, and reproductive issues	Can cause skin conditions, cancer, immune, and reproductive issues	More toxic than non-dioxin-like PCBs, similar to dioxins
Environmental Persistence	Persistent, accumulate in the environment	Persistent, accumulate in the environment	Persistent, accumulate in the environment

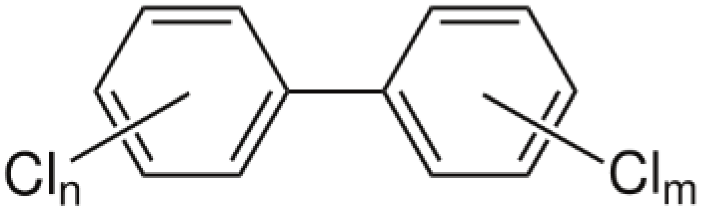
Polychlorinated dibenzo-p-dioxins



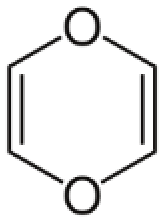
Polychlorinated dibenzofurans

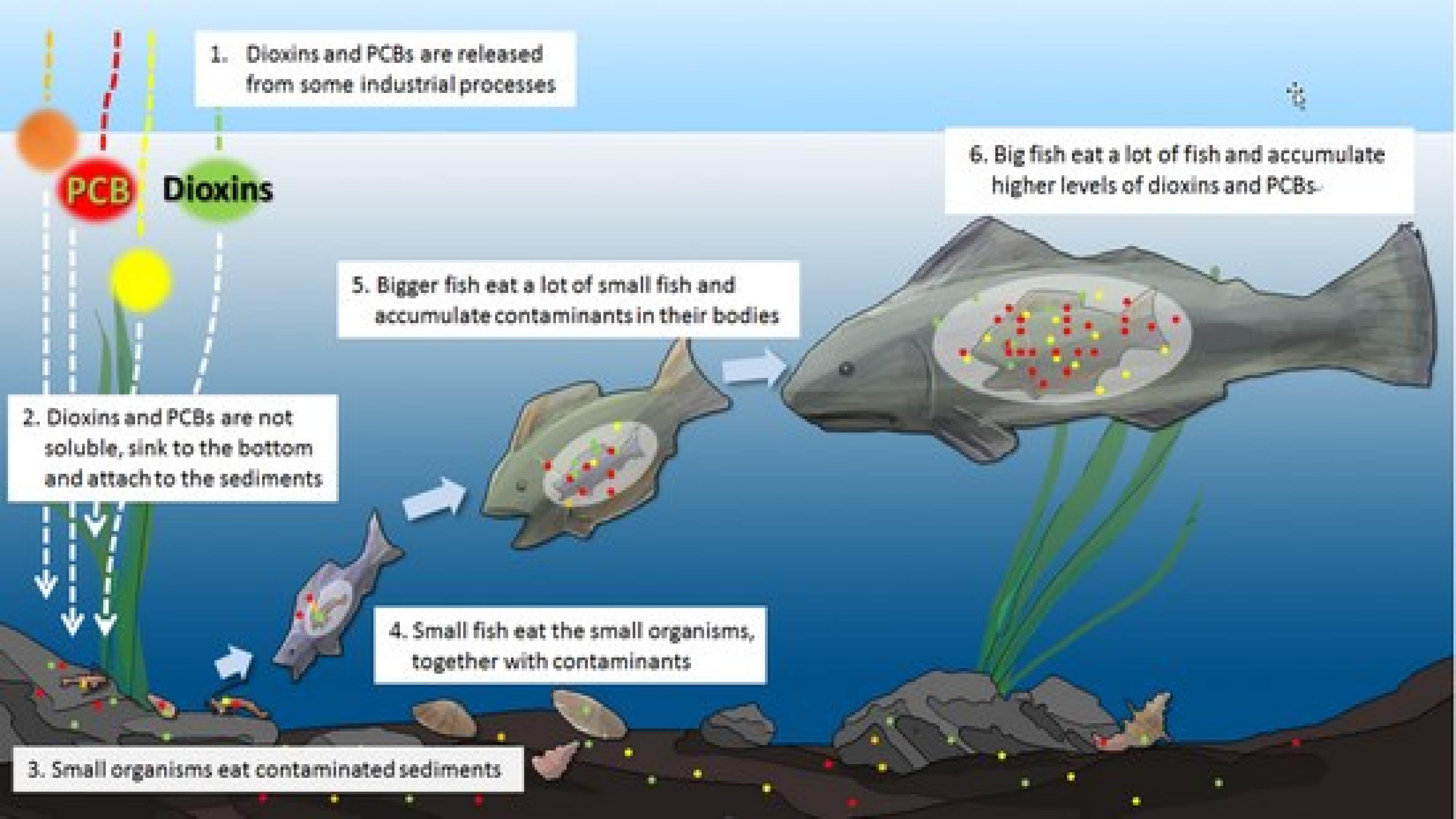


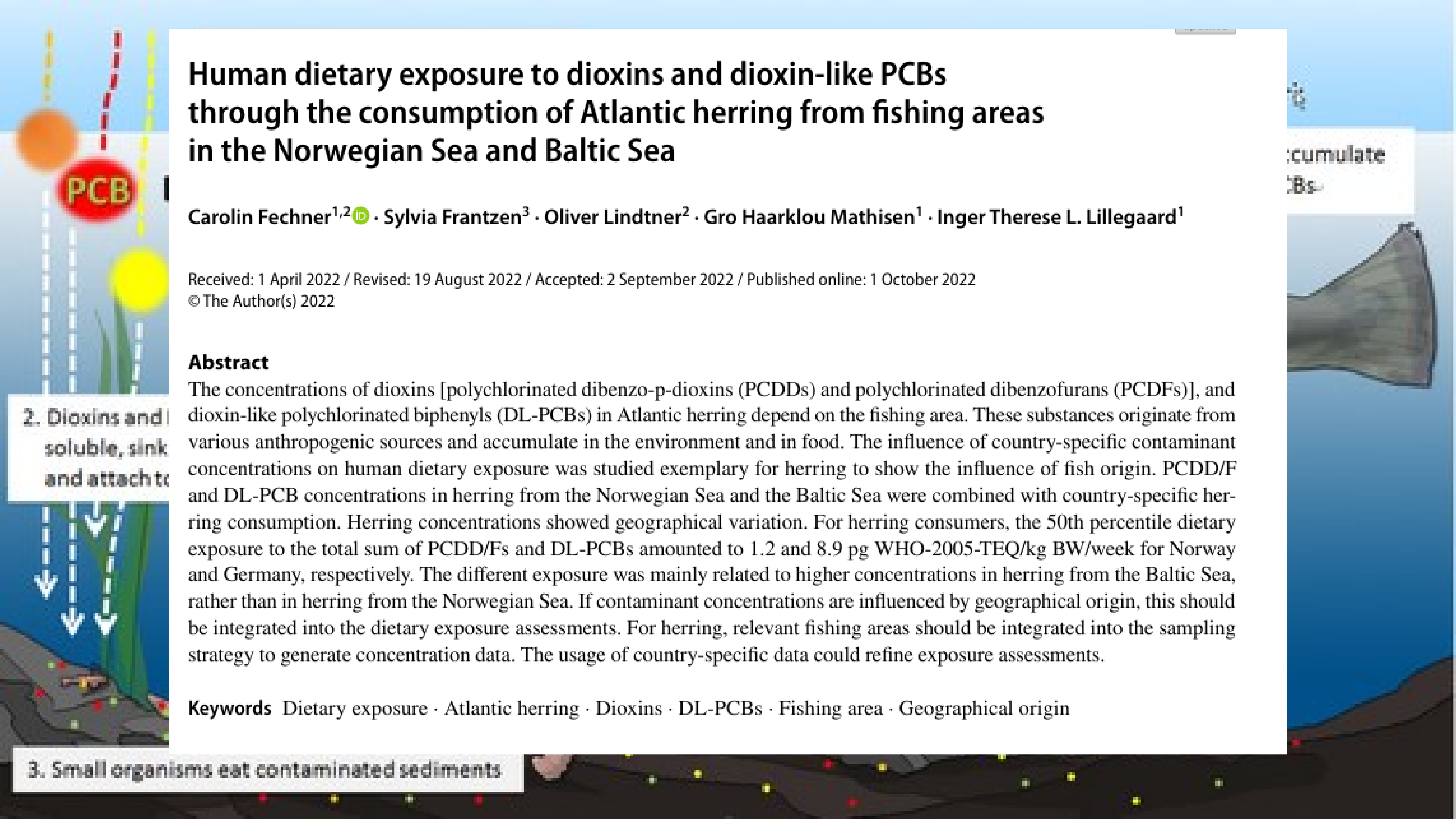
Polychlorinated biphenyls



1,4-dioxin




1. Dioxins and PCBs are released from some industrial processes
PCB
Dioxins
2. Dioxins and PCBs are not soluble, sink to the bottom and attach to the sediments
3. Small organisms eat contaminated sediments
4. Small fish eat the small organisms, together with contaminants
5. Bigger fish eat a lot of small fish and accumulate contaminants in their bodies
6. Big fish eat a lot of fish and accumulate higher levels of dioxins and PCBs



Human dietary exposure to dioxins and dioxin-like PCBs through the consumption of Atlantic herring from fishing areas in the Norwegian Sea and Baltic Sea

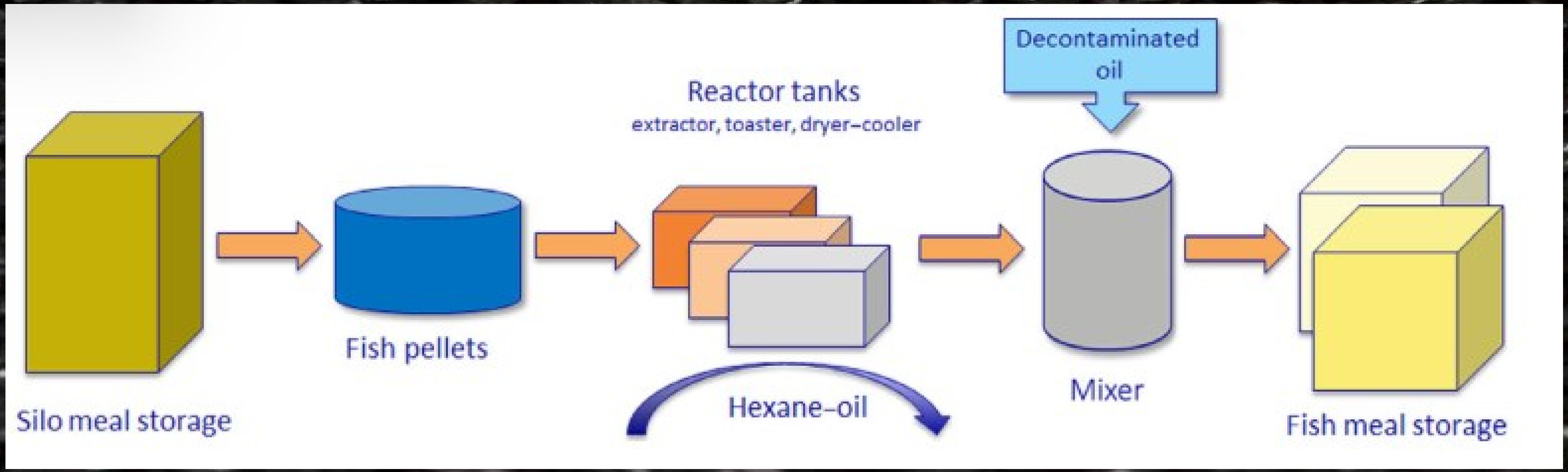
Carolin Fechner[1,2] · Sylvia Frantzen[3] · Oliver Lindtner[2] · Gro Haarklou Mathisen[1] · Inger Therese L. Lillegaard[1]

Received: 1 April 2022 / Revised: 19 August 2022 / Accepted: 2 September 2022 / Published online: 1 October 2022

Abstract
The concentrations of dioxins [polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs)], and dioxin-like polychlorinated biphenyls (DL-PCBs) in Atlantic herring depend on the fishing area. These substances originate from various anthropogenic sources and accumulate in the environment and in food. The influence of country-specific contaminant concentrations on human dietary exposure was studied exemplary for herring to show the influence of fish origin. PCDD/F and DL-PCB concentrations in herring from the Norwegian Sea and the Baltic Sea were combined with country-specific herring consumption. Herring concentrations showed geographical variation. For herring consumers, the 50th percentile dietary exposure to the total sum of PCDD/Fs and DL-PCBs amounted to 1.2 and 8.9 pg WHO-2005-TEQ/kg BW/week for Norway and Germany, respectively. The different exposure was mainly related to higher concentrations in herring from the Baltic Sea, rather than in herring from the Norwegian Sea. If contaminant concentrations are influenced by geographical origin, this should be integrated into the dietary exposure assessments. For herring, relevant fishing areas should be integrated into the sampling strategy to generate concentration data. The usage of country-specific data could refine exposure assessments.

Keywords Dietary exposure · Atlantic herring · Dioxins · DL-PCBs · Fishing area · Geographical origin

How can we safely use the fish as resources?



PCB and Dioxin removal opportunities in Fishmeal

Table 1: Levels of PCDD/F and DL-PCB in the samples of fish oil before and after the decontamination process

	Total of 35 batches			
	Before process	After process	Mean reduction (%)	Range of reduction (%)
PCDD/Fs	8.88 (2.88)	1.42 (1.01)	84	49.3–97.7
DL-PCBs	10.82 (2.16)	4.92 (1.79)	55	21.0–89.0
Sum of above	19.71 (4.78)	6.35 (2.66)	68	35.2–91.8

PCDD/Fs: polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans; DL-PCBs: Dioxin-like polychlorinated biphenyls

EFSA Journal 2017;15(7):4961

Table 2: Levels of the sum of PCDD/Fs and DL-PCBs, and NDL-PCBs in the samples of fish meal before and after the decontamination process

Fish meal	Sum of PCDD/Fs and DL-PCBs				NDL-PCBs			
	Before process	After process	Reduction (%)	Average reduction (%)	Before process	After process	Reduction (%)	Average reduction (%)
Batch A	25.4	0.878	96.5	95.2	92.2	4.94	94.7	93.3
Batch B	21.6	0.858	96.0		90.0	6.09	93.2	
Batch C	23.9	0.673	97.2		87.9	5.36	93.9	
Batch D	14.4	1.22	91.5		62.1	6.95	88.8	
Batch E	24.2	1.45	94.0		92.9	7.52	91.9	

PCDD/F: polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans; DL-PCB: dioxin-like polychlorinated biphenyls; NDL-PCB: non-dioxin-like polychlorinated biphenyls.
Values expressed in ng WHO_{2005}-TEQ/kg (PCDD/Fs and DL-PCBs) or μg/kg (NDL-PCBs).

doi: 10.2903/j.efsa.2018.5174

Table 1: Levels of PCDD/Fs and PCBs in samples from three batches of fish meal before and after the decontamination process (final product)

Contaminant	Batch A		Batch B		Batch C		Mean reduction (%)	Range of reduction (%)
	Before process	After process	Before process	After process	Before process	After process		
PCDD/Fs	1.17	0.37	1.16	0.32	1.31	0.41	70	68–72
DL-PCBs	1.16	0.47	1.15	0.26	1.23	0.46	66	60–77
Sum of above	2.33	0.84	2.31	0.58	2.54	0.87	68	64–75
NDL-PCBs	9.12	4.33	9.13	2.37	9.87	4.39	61	52–74

PCDD/F: polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans; DL-PCB: dioxin-like polychlorinated biphenyls; NDL-PCB: non-dioxin-like polychlorinated biphenyls.
Individual values expressed in ng WHO_{2005}-TEQ/kg (PCDD/Fs and DL-PCBs) or μg/kg (NDL-PCBs).

Research Article

Decontaminated fishmeal and fish oil from the Baltic Sea are promising feed sources for Arctic char (*Salvelinus alpinus* L.)—studies of flesh lipid quality and metabolic profile

Ken Cheng[1], Liane Wagner[1], Ali A. Moazzami[2], Pedro Gómez-Requeni[1], AnnaLotta Schiller Vestergren[1], Eva Brännäs[3], Jana Pickova[1,4] and Sofia Trattner[1]

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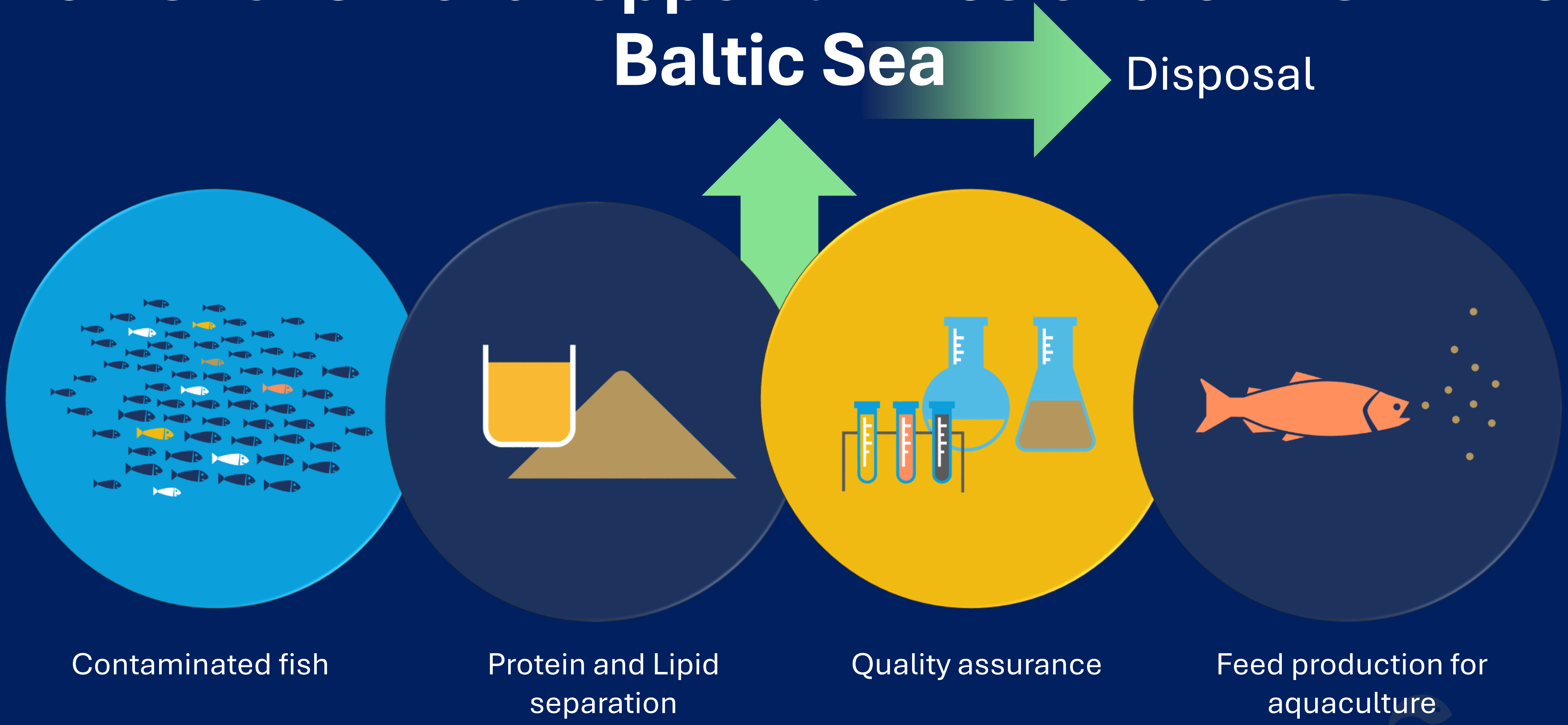
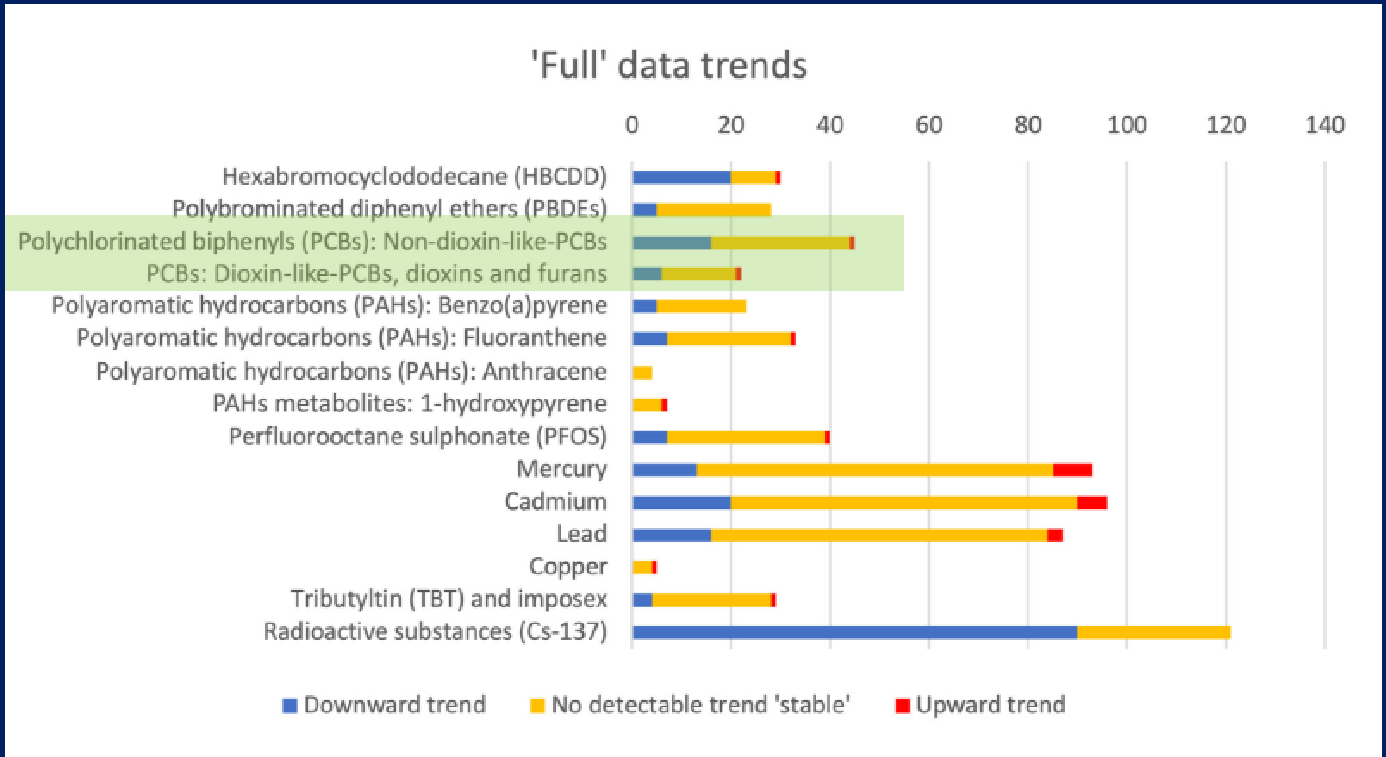
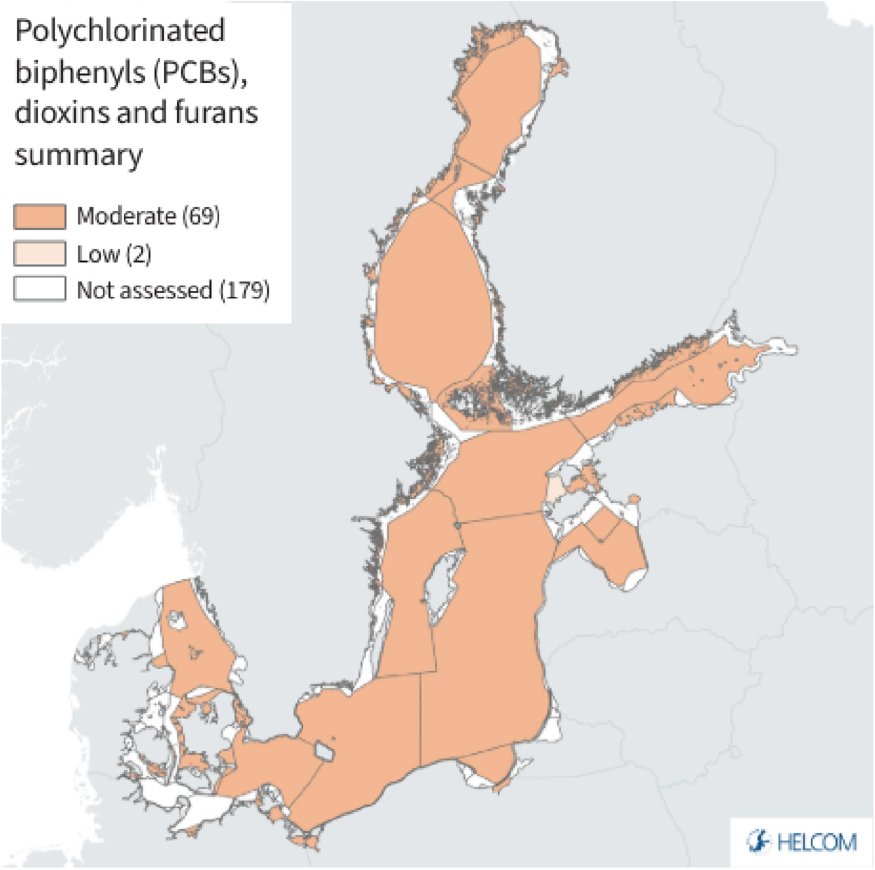
[4] Faculty of Fisheries and Protection of Waters, University of South Bohemia in Ceske Budejovice, CENAKVA, Vodnany, Czech Republic

Hollistic removal opportunities of dioxins in the Baltic Sea



Dioxins and PCBs in the Baltic sea. Now. 2023





luation (left) and confidence in the evaluation (right) based on monitoring in biota
units (defined in the HELCOM Monitoring and Assessment Strategy Annex 4).

Dioxins and PCBs in the Baltic sea. Now. 2023

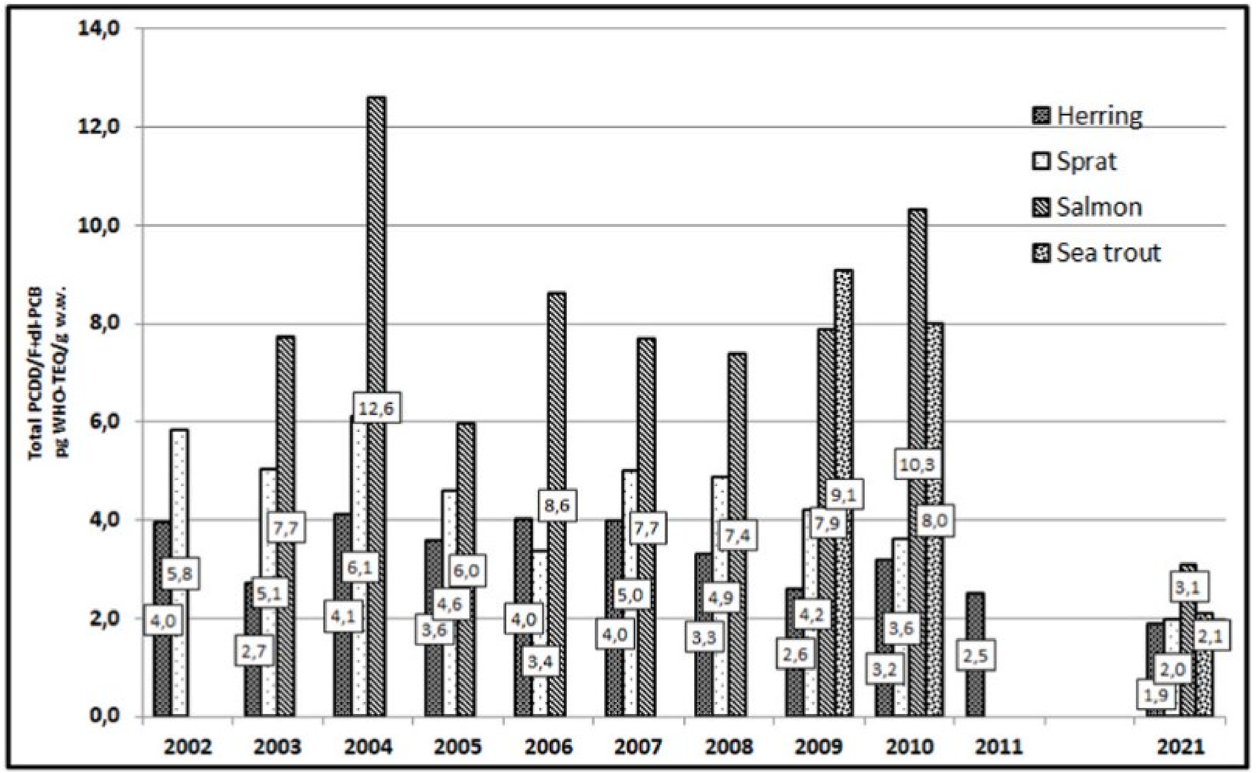
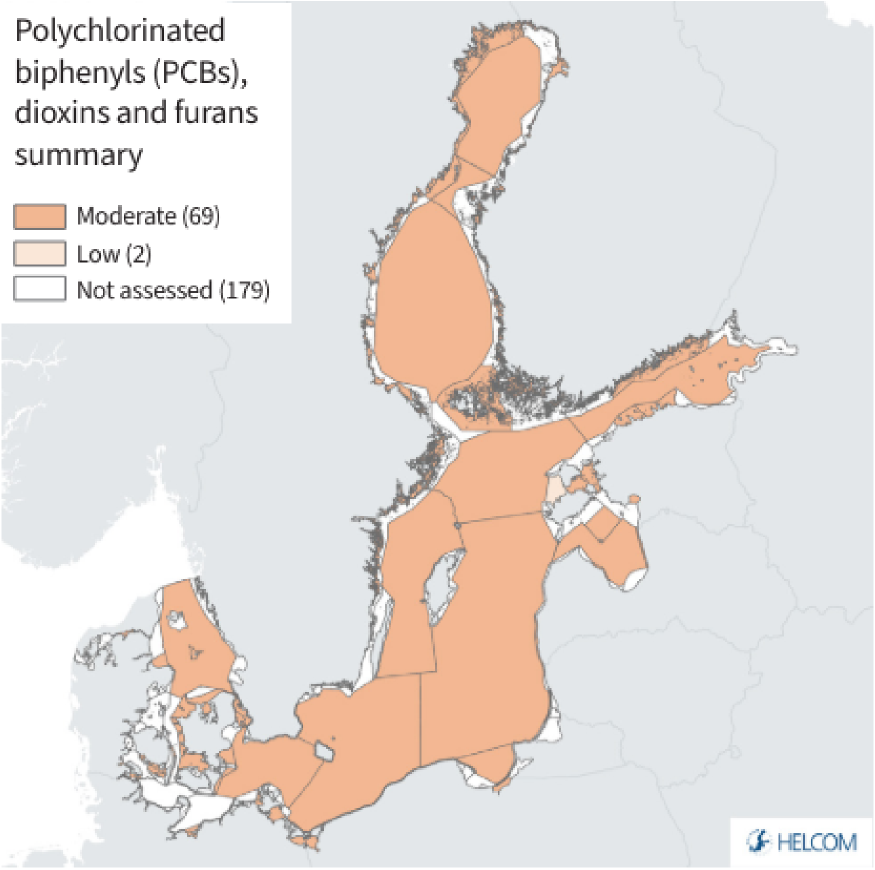


Fig. 2. Changes in concentrations of dioxins and dl-PCBs in Baltic fishes in 2002–2021 (2002–2006, Niemirycz et al., 2017, 2007–2010, Piskorska--Pliszczynska et al., 2012, 2021 – results of the current study).



luation (left) and confidence in the evaluation (right) based on monitoring in biota
units (defined in the HELCOM Monitoring and Assessment Strategy Annex 4).


PFAS

PFAS in global Fishmeals

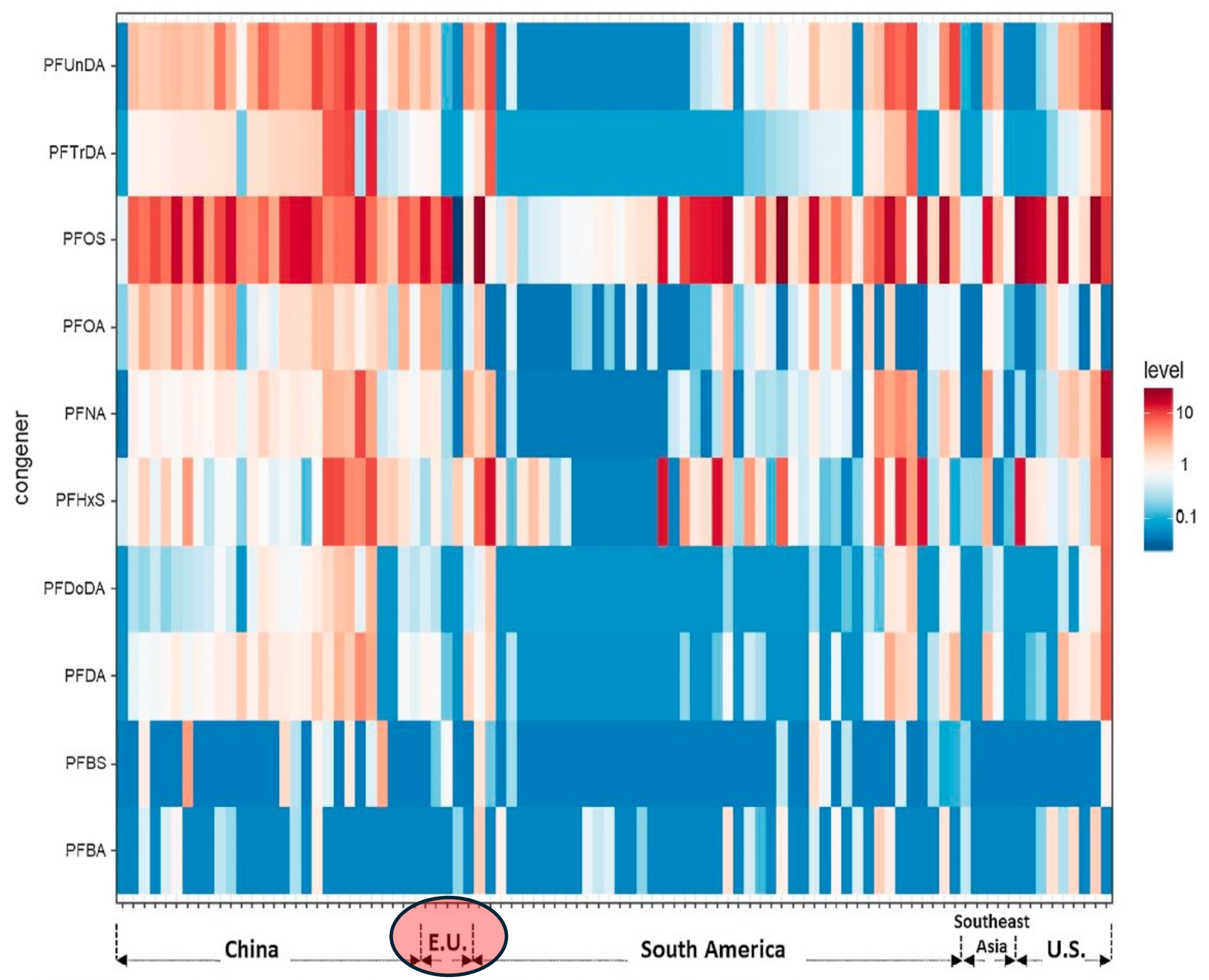


Fig. 3. The composition profiles of the analyzed PFAAs (log transformed) in fishmeal samples among different sampling areas.

Journal of Hazardous Materials 367 (2019) 559–567

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The occurrence of perfluoroalkyl acids in an important feed material (fishmeal) and its potential risk through the farm-to-fork pathway to humans

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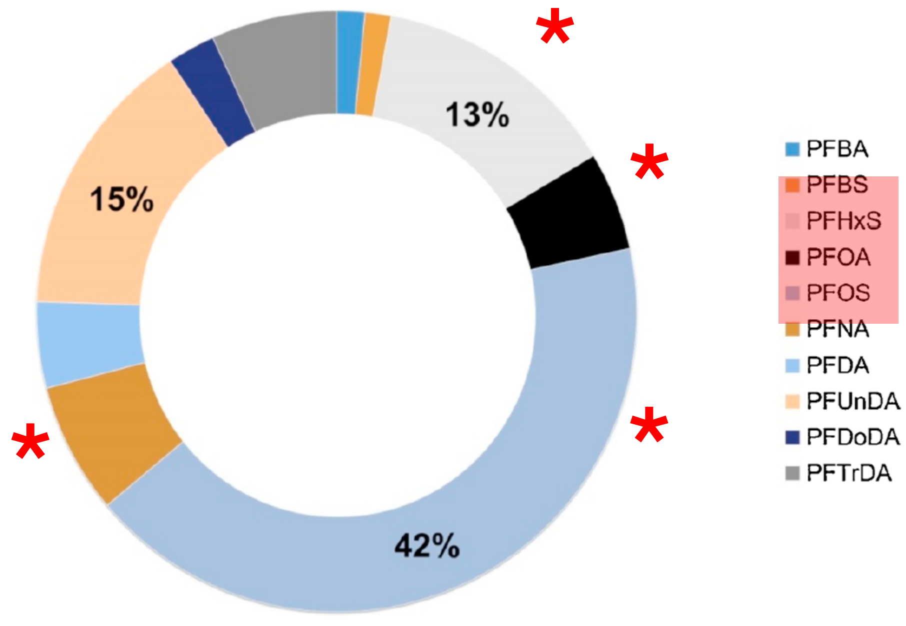

Fig. 1. PFAA congener composition in fishmeal (n = 92).

PFAS in Fishmeal

Table 1
Concentrations and detection frequency of PFAAs in fishmeal (ng/g).

		PFBA	PFBS	PFHxS	PFOA	PFOS	PFNA	PFDA	PFUnDA	PFDoDA	PFTrDA	Total PFAAs
DF (%)		32.6	26.1	88.0	71.7	98.9	72.8	60.9	72.8	48.9	62.0	100
United States	min	0.04	0.04	0.35	0.04	0.88	0.04	0.05	0.05	0.06	0.07	6.39
(n = 9)	max	1.97	0.85	6.78	1.69	24.3	19.25	7.89	26.8	7.29	6.13	84.9
	geomean	0.25	0.06	1.13	0.19	6.48	1.03	0.70	1.48	0.25	0.45	20.6
	mean	0.70	0.14	1.94	0.48	11.3	3.67	1.88	5.74	1.17	1.27	28.3
	median	0.21	0.04	1.05	0.24	12.9	1.74	1.06	2.98	0.19	0.44	19.1
China	min	0.04	0.04	0.11	0.12	0.51	0.04	0.05	0.05	0.06	0.07	1.42
(n = 28)	max	1.03	3.96	9.76	4.28	16.8	9.47	4.69	12.1	2.81	12.6	52.0
	geomean	0.07	0.11	1.04	1.40	6.81	0.99	0.80	2.85	0.41	1.13	18.9
	mean	0.15	0.46	2.06	1.90	8.37	1.44	1.19	4.03	0.68	2.22	22.5
	median	0.04	0.04	0.75	1.66	6.55	0.97	0.89	2.96	0.38	1.17	21.5
	min	0.04	0.04	0.27	0.04	0.02	0.04	0.05	0.05	0.06	0.07	2.47
	max	1.99	1.36	14.7	2.29	27.1	3.01	1.84	9.70	1.99	8.10	45.3
	geomean	0.12	0.18	1.93	0.18	1.49	0.65	0.44	0.86	0.26	0.52	15.6
	mean	0.46	0.45	4.69	0.59	8.83	1.56	0.90	3.32	0.59	2.07	23.5
	median	0.04	0.14	1.94	0.15	1.11	1.55	0.73	2.39	0.34	0.65	16.7
South America (n = 45)	min	0.04	0.04	0.04	0.04	0.22	0.04	0.05	0.05	0.06	0.07	1.06
	max	1.88	1.48	14.6	3.25	27.8	4.80	3.25	10.1	2.29	7.55	42.1
	geomean	0.11	0.06	0.49	0.16	2.51	0.18	0.13	0.28	0.09	0.17	6.18
	mean	0.28	0.12	2.33	0.48	6.03	0.69	0.38	1.33	0.21	0.52	12.4
	median	0.04	0.04	0.55	0.15	1.67	0.22	0.05	0.35	0.06	0.07	4.78
Southeast Asia	min	0.04	0.04	0.04	0.04	0.45	0.04	0.05	0.05	0.06	0.07	1.02
(n = 5)	max	0.04	0.04	14.19	0.88	24.0	4.25	2.54	3.99	0.42	0.86	38.8
	geomean	0.04	0.04	0.54	0.16	3.15	0.23	0.19	0.24	0.11	0.16	6.72
	mean	0.04	0.04	3.49	0.37	8.42	1.01	0.68	1.31	0.16	0.29	15.8
	median	0.04	0.04	0.20	0.12	2.41	0.23	0.05	0.05	0.06	0.07	8.15
Total	min	0.04	0.04	0.04	0.04	0.02	0.04	0.05	0.05	0.06	0.07	1.02
	max	1.99	3.96	14.7	4.28	27.8	19.2	7.89	26.8	7.29	12.6	84.9
	geomean	0.10	0.07	0.73	0.34	3.72	0.40	0.30	0.73	0.17	0.36	10.4
	mean	0.27	0.25	2.40	0.94	7.54	1.26	0.82	2.70	0.46	1.21	17.8
	median	0.04	0.04	0.75	0.47	5.16	0.53	0.51	1.40	0.06	0.35	14.9

DF (%) = Detection frequency.

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Journal of Hazardous Materials

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The occurrence of perfluoroalkyl acids in an important feed material (fishmeal) and its potential risk through the farm-to-fork pathway to humans

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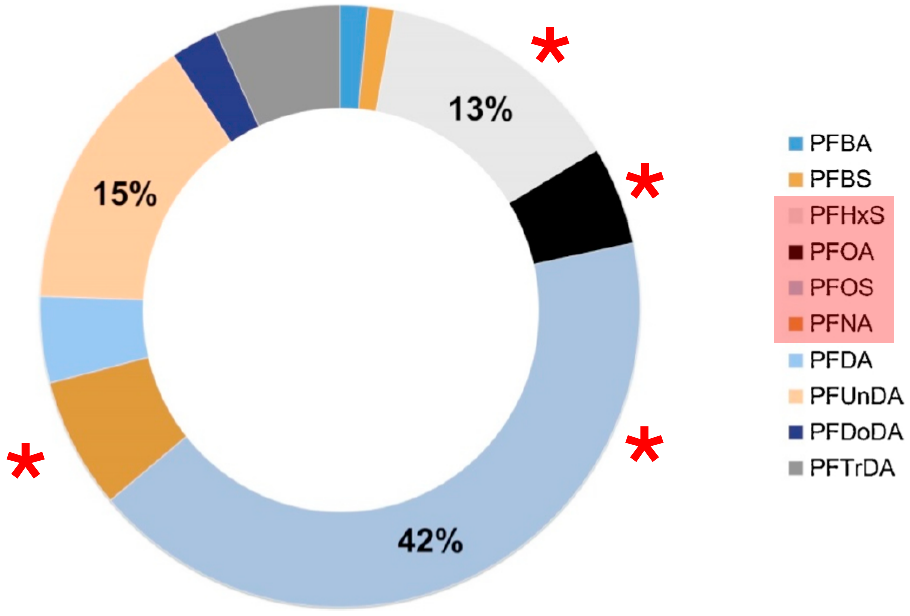
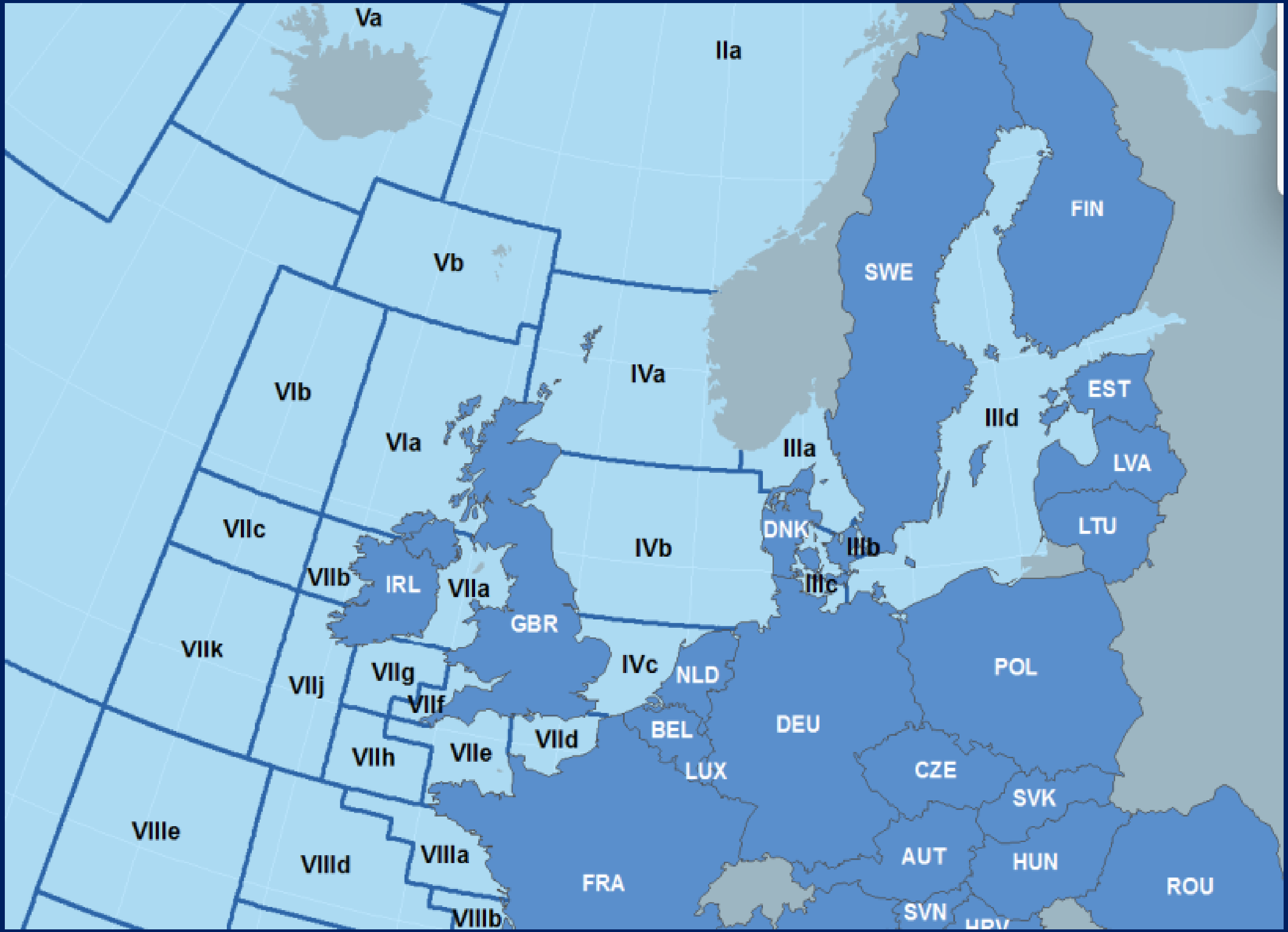


Fig. 1. PFAA congener composition in fishmeal (n = 92).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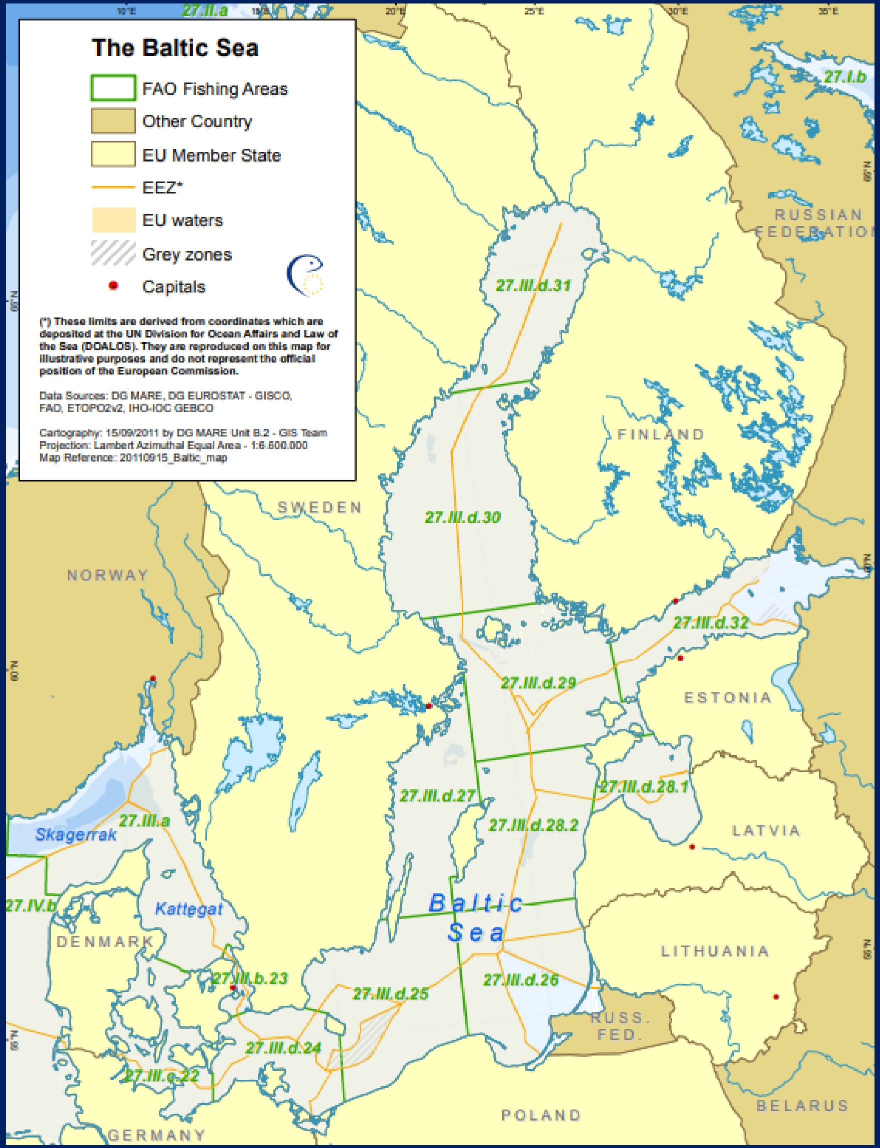
The Baltic Sea
FAO Fishing Areas
Other Country
EU Member State
EEZ*
EU waters
Grey zones
Capitals
(*) These limits are derived from coordinates which are deposited at the UN Division for Ocean Affairs and Law of the Sea (DOALOS). They are reproduced on this map for illustrative purposes and do not represent the official position of the European Commission.
Data Sources: DG MARE, DG EUROSTAT - GISCO, FAO, ETOPO2v2, IHO-IOC GEBCO
Cartography: 15/09/2011 by DG MARE Unit B.2 - GIS Team
Projection: Lambert Azimuthal Equal Area - 1:6.600.000
Map Reference: 20110915_Baltic_map
27.II.a
27.I.b
RUSSIAN FEDERATION
27.III.d.31
FINLAND
SWEDEN
27.III.d.30
NORWAY
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ESTONIA
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Skagerrak
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LATVIA
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POLAND
BELARUS
GERMANY

EFFOP submits PFAS data to EFSA

We are pleased to announce that EFFOP has successfully submitted a comprehensive dataset on PFAS in fishmeal to the European Food Safety Authority (EFSA). EFFOP has shared a robust dataset comprising data from 175 distinct fishmeal batches. The dataset will lay the ground for risk management strategies concerning future PFAS levels in feed.

EFFOP's investigation stands as the most extensive of its kind to date in monitoring PFAS levels within fishmeal.

Read more

Marine Ingredients have evolved into strategic ingredients

Marine ingredients have evolved into "*Strategic ingredients*"

Enabling feed producers to utilize lower cost ingredients to provide the mass of nutrients in feeds while marine ingredients provide those critical nutrients that are harder to replace for ensuring optimal animal health and welfare

The future of the animal feed sector will rely on increasing circularity in resource use coupled with the application of novel extraction technologies