New POPs
- Candidate Chemicals for Stockholm Convention -

Yasuyuki Shibata

Environmental Chemistry Division
National Institute for Environmental Studies
Tsukuba, Japan

Topics

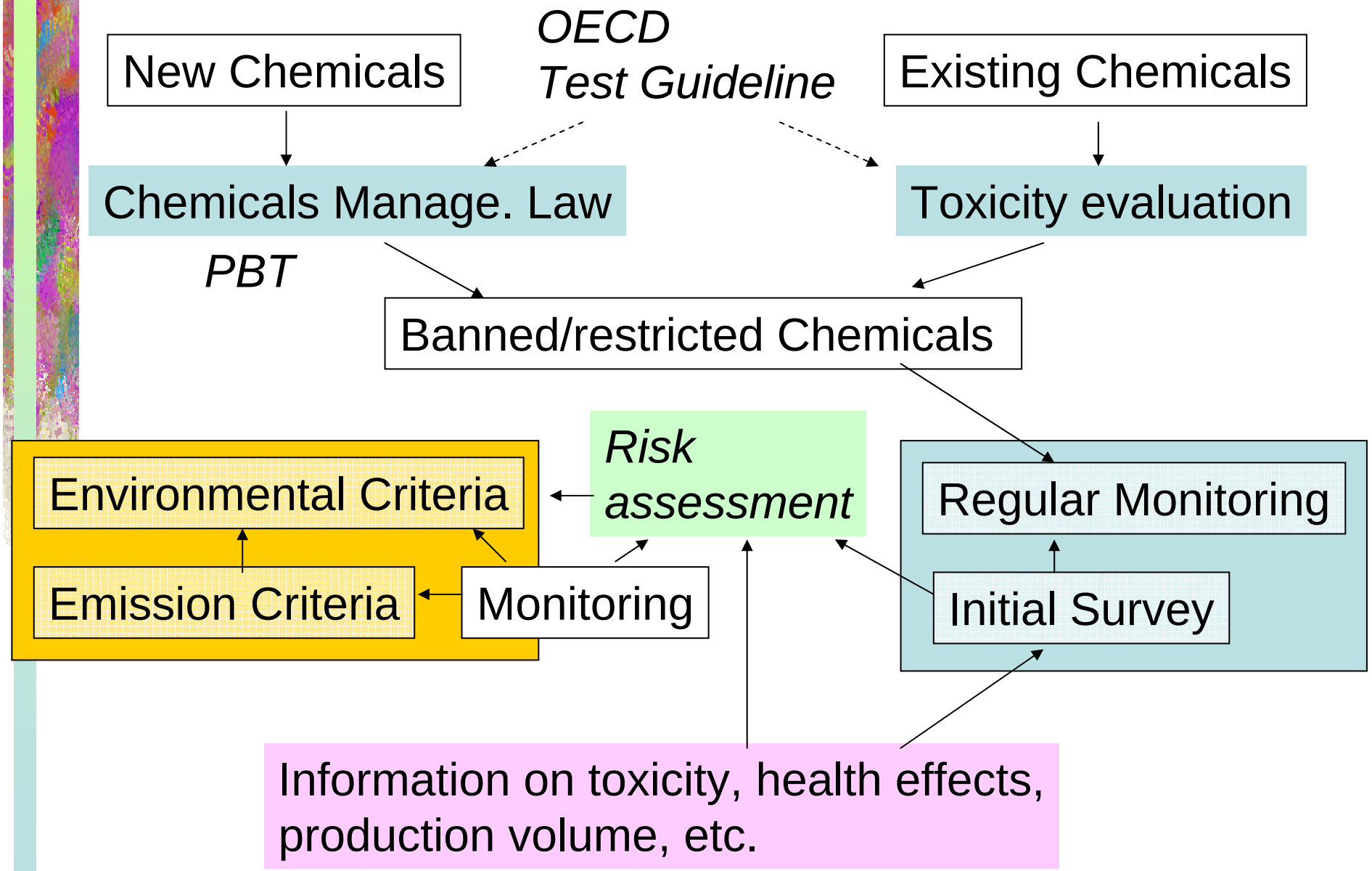
1)Outline of the management of chemicals

2) Brief introduction of POPs candidate chemicals

3) Analysis of PFOS and other fluorosurfactants

4) Effectiveness Evaluation of Stockholm Convention

Outline of Chemical Management in Japan



Priority on Persistent, Bioaccumulative Toxicants
PBT, or POPs (Persistent Organic Pollutants)

Stockholm Convention

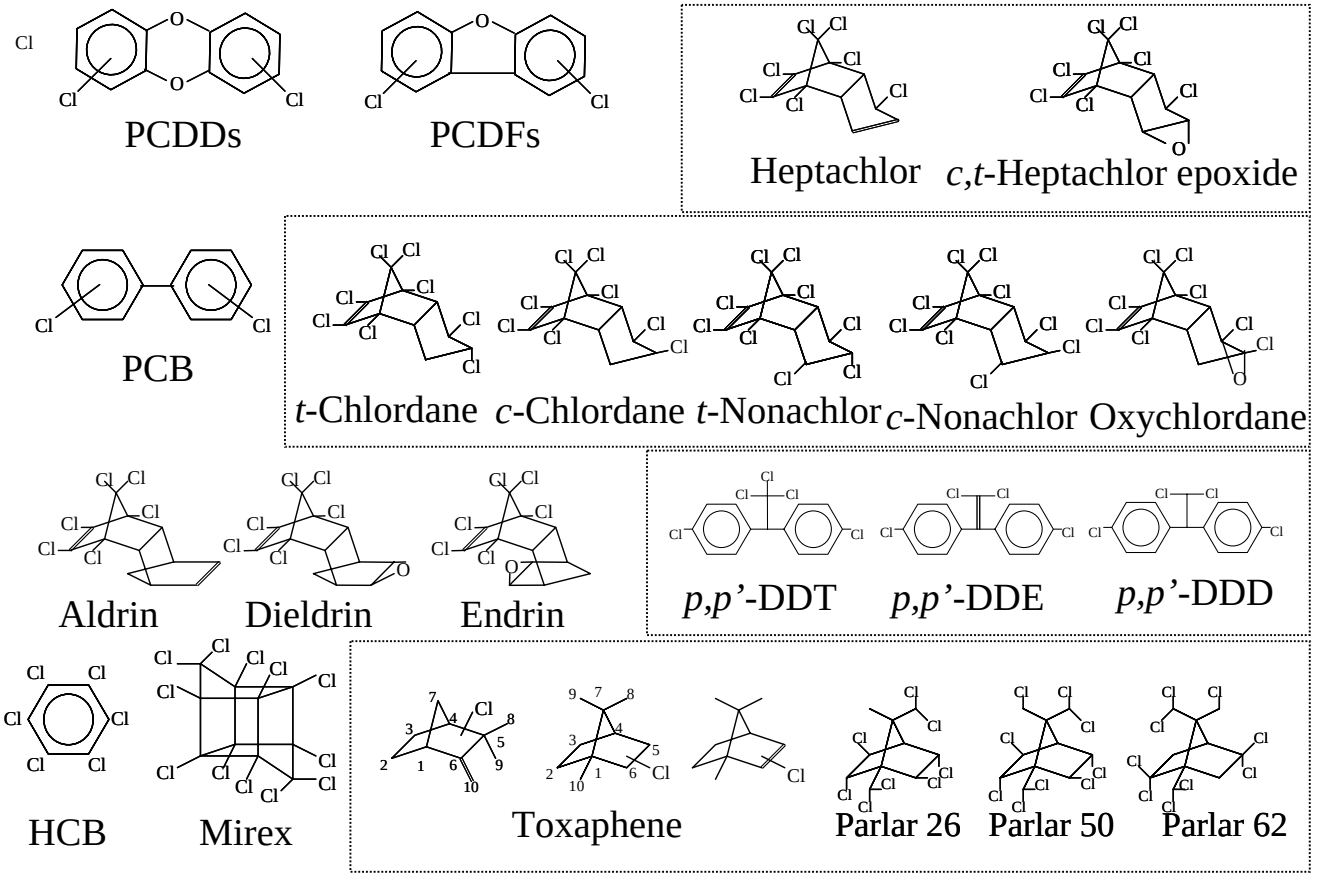
"to protect human health and environment from POPs"

May 2001	Stockholm Convention adopted
May 2004	entry into force
May 2005	First Conference of Parties (COP-1)
May 2006	COP-2
May 2007	COP-3
May 2009	*COP-4*

POPRC on new POPs

Effectiveness Evaluation & GMP

POPs (Persistent Organic Pollutants)



Annex A: prohibited 8 OCPs and PCB

Annex B: restricted DDT

Annex C: unintentional production PCDDs, PCDFs, HCB,PCB

Article 8: Listing of chemicals in Annexes A, B and C

1. A Party may submit a proposal to the Secretariat for listing a chemical in Annexes A, B and/or C. …
2. The Secretariat shall verify whether the proposal contains the information specified in Annex D. … it shall forward the proposal to the Persistent Organic Pollutants Review Committee (POPRC).
3. The Committee shall examine the proposal and apply the screening criteria specified in Annex D in a flexible and transparent way, taking all information provided into account in an integrative and balanced manner.

Review steps of POPRC

(1) To check whether a proposed chemical passes POPs Criteria or not
(2) To evaluate according to Risk Profile of the chemical
(3) To evaluate according to socio-economic consideration

Candidate new POPs under review by POPRC

2005	
	PBDE (Pentabromodiphenylether)
	HBB (Hexabromobiphenyl)
	Chlordecone
	γ-HCH (Lindane)
	PFOS(+ their derivatives)
2006	
	OBDE (Octabromodiphenylether)
	PeCB (Pentachlorobenzene)
	short-chained chlorinated paraffin
	α-HCH
	β-HCH
2007	
	Endosulfan

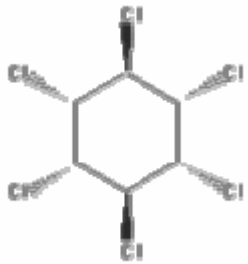
Category of proposed POPs

1) <u>OC Pesticides</u> *long-used chemicals with established analytical methods; many monitoring*
 : α-, β-, γ-HCH
 : chlordecone
 : endosulfan

2) <u>Flame retardants</u> *include organobromine chemicals*
 : PBDEs (PeBDE, OBDE) *many isomers/congeners (except*
 : HxBB *(HxBB)*
 : short-chained chloroparaffins

3) <u>Others</u>
 : PFOS (fluorinated surfactants)
 : PeCB

γ-HCH



Broad-spectrum Insecticide for;

seed, soil treatment

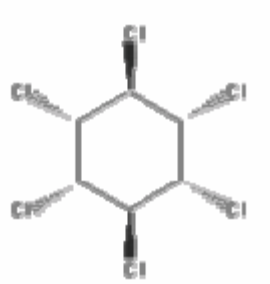
wood and timber protection

pharmaceutical use

Production estimate:

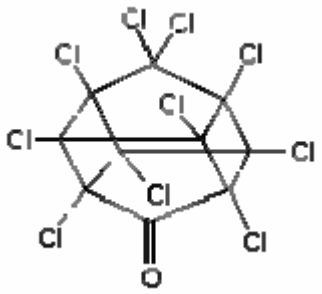
720,000 t (Voldner & Li, 1995)

γ-HCH



Properties	Criteria	Data(or estimates)
*Persistent		
Water	>2 months	30~300 d
Soil	>6 months	
Sediments	>6 months	
*Bioacumulative		
BAF/BCF	>5,000	log BCF= 2.26~3.85
Log $K_{o/w}$	>5	3.5
*Long Range Transport		Arctic birds mammals
*Toxicity/Ecotoxicity		○/○

Chlordecone



Insecticide, and material for production of other insecticide (Kelevan)

Production:

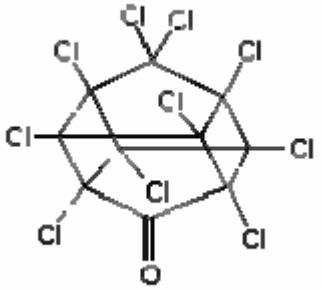
USA 1966~1975 total 1,600 t

12~70 t used domestically

90~99.2% => export for Kelevan production

Africa, Europe, Latin Am.

Chlordecone



Properties	Criteria	Data(or estimates)
*Persistent		
Water	>2 months	
Soil	>6 months	1~2 years
Sediments	>6 months	
*Bioacumulative		
BAF/BCF	>5,000	>60,000
Log $K_{o/w}$	>5	4.5~6.0
*Long Range Transport		
	$t_{1/2air}$>2 d	~50 years
*Toxicity/Ecotoxicity		○/◎

α-,β-,γ-HCHs

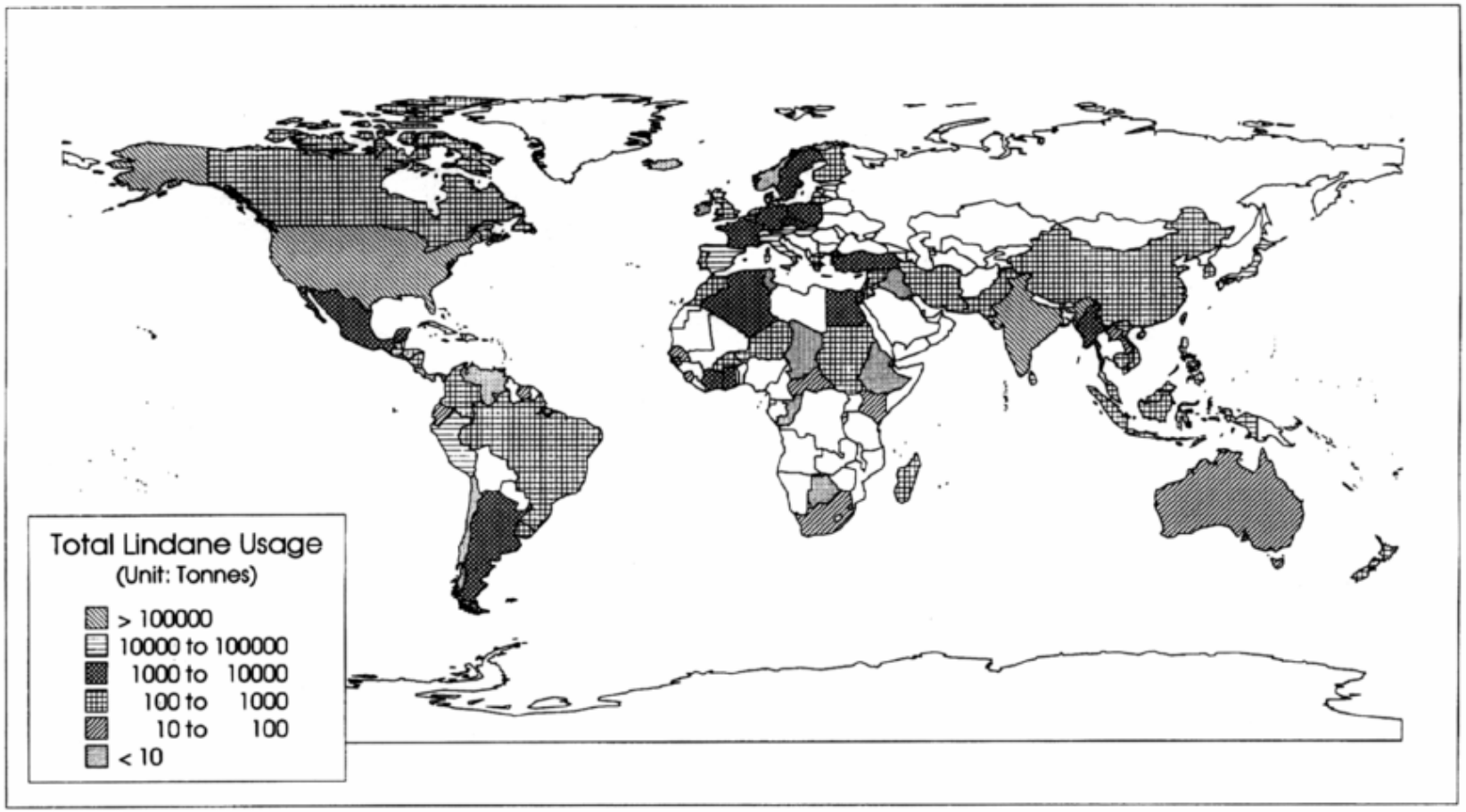
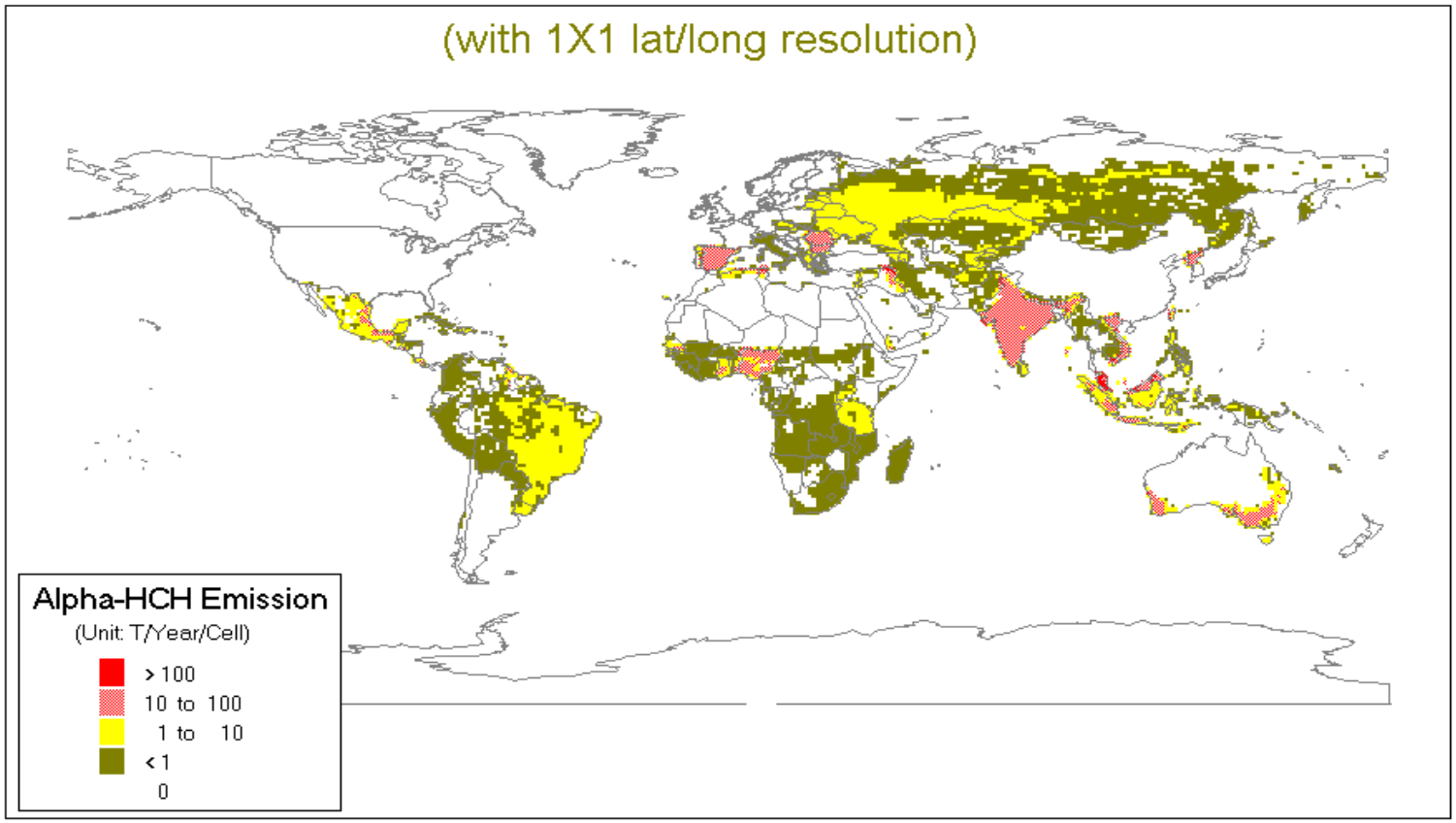


Fig. 9. Global lindane usage distribution accounted for in the search. The total usage was estimated at 720 000 metric tonnes.

Voldner & Li (1995)

Alpha-HCH Emission in 1990

From current usage in 1990



Li, Y. F., M. T. Scholdz, and B.J. van Heyst, 1999b, "Global gridded emission inventory of alpha-hexachlorocyclohexane", J. Geophys. Res. In press.

Global Chemical Transport Model – α-HCH Concentration at Surface Level

[Koziol and Pudykiewicz 1999]

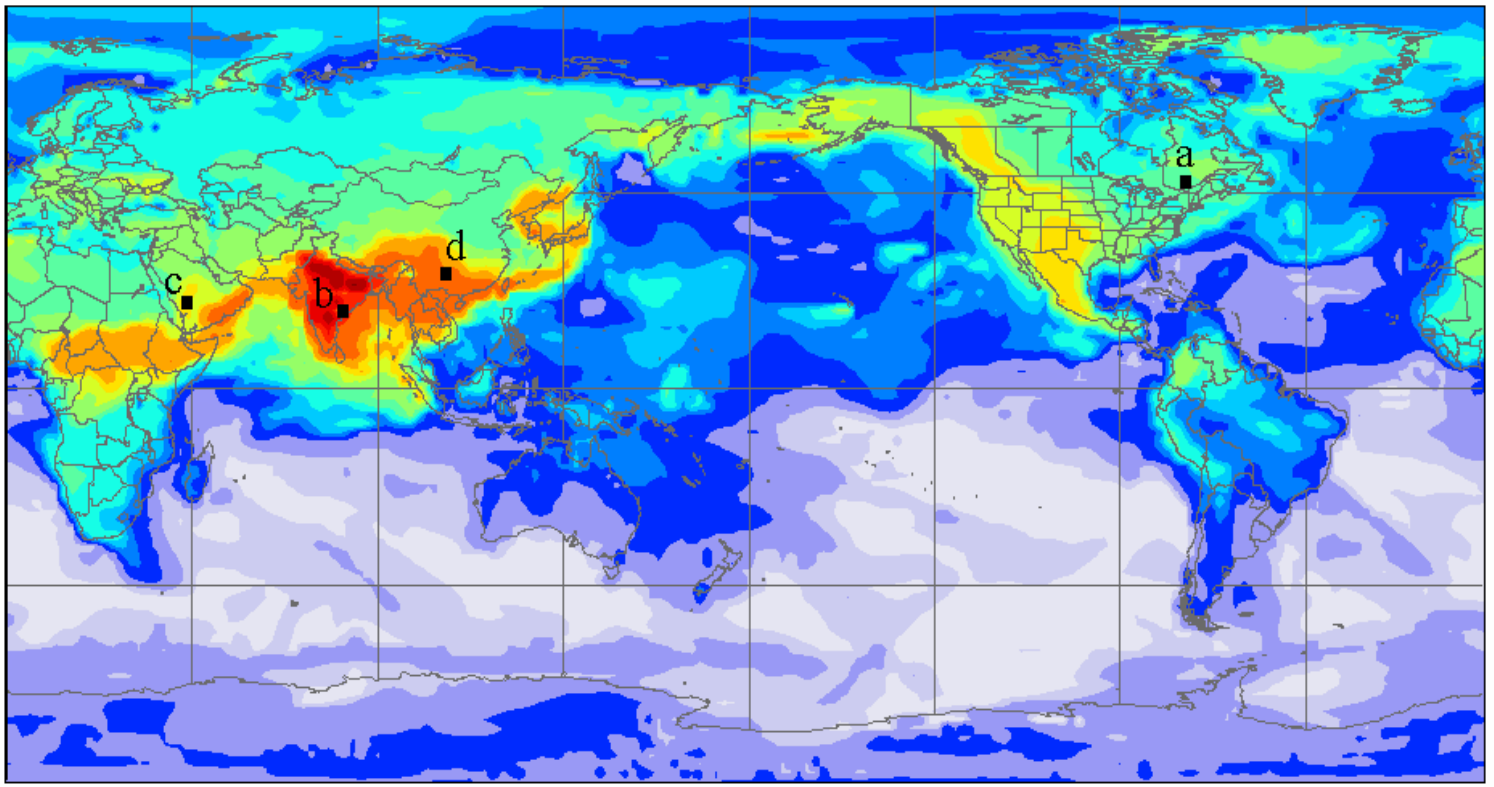
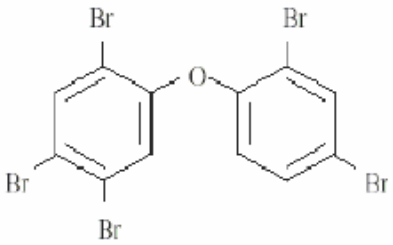


Fig. 9

PeBDE



2,2',4,4',5–pentabromodiphenyl ether (BDE-99)

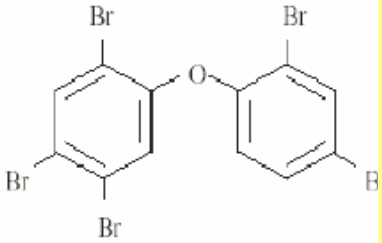
Mixture of tri~heptabrominated flame retardant used for;

- High-impact polystyrene
- ABS
- Polyurethane foams
- polyurethane elastomers
- other plastics

Annual production/consumption;

- 8,500 t (POPRC1-INF5-b; Norway)
- 4,000 t (Env. Health Criteria 162)
- (usage in EU ~10,000t/y in 1989)

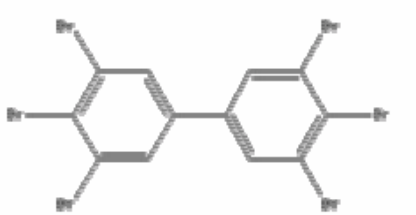
PeBDE



2,2',4,4',5–pentabromodiphenyl ether (BDE-99

Properties	Criteria	Data(or estimates)
*Persistent		
Water	>2 months	150 days
Soil	>6 months	150 days
Sediments	>6 months	600 days
*Bioacumulative		
BAF/BCF	>5,000	>27,400
Log $K_{o/w}$	>5	
*Long Range Transport	$t_{1/2}$air>2 d	10~20 d
*Toxicity/Ecotoxicity		NOAEL =1mg/kg/d

HxBB



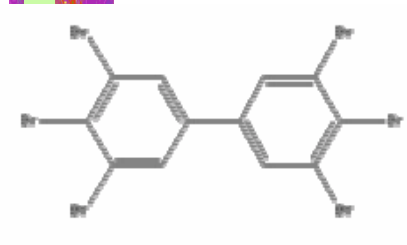
Hexabrominated flame retardant used for;

- ABS (PBB content ~10%; EHC152)
- coatings and lacquers
- polyurethane foams

Production:

USA	hexa	1970~1974	5,369 t
	octa, deca	~1979	(total 6,000 t)
Germany	poly	~1985	
France	deca	~	a few hundreds t/y
UK	deca	~1977	

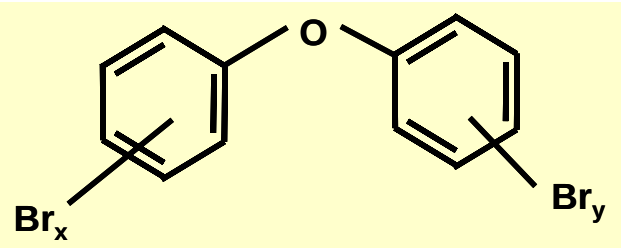
HxBB



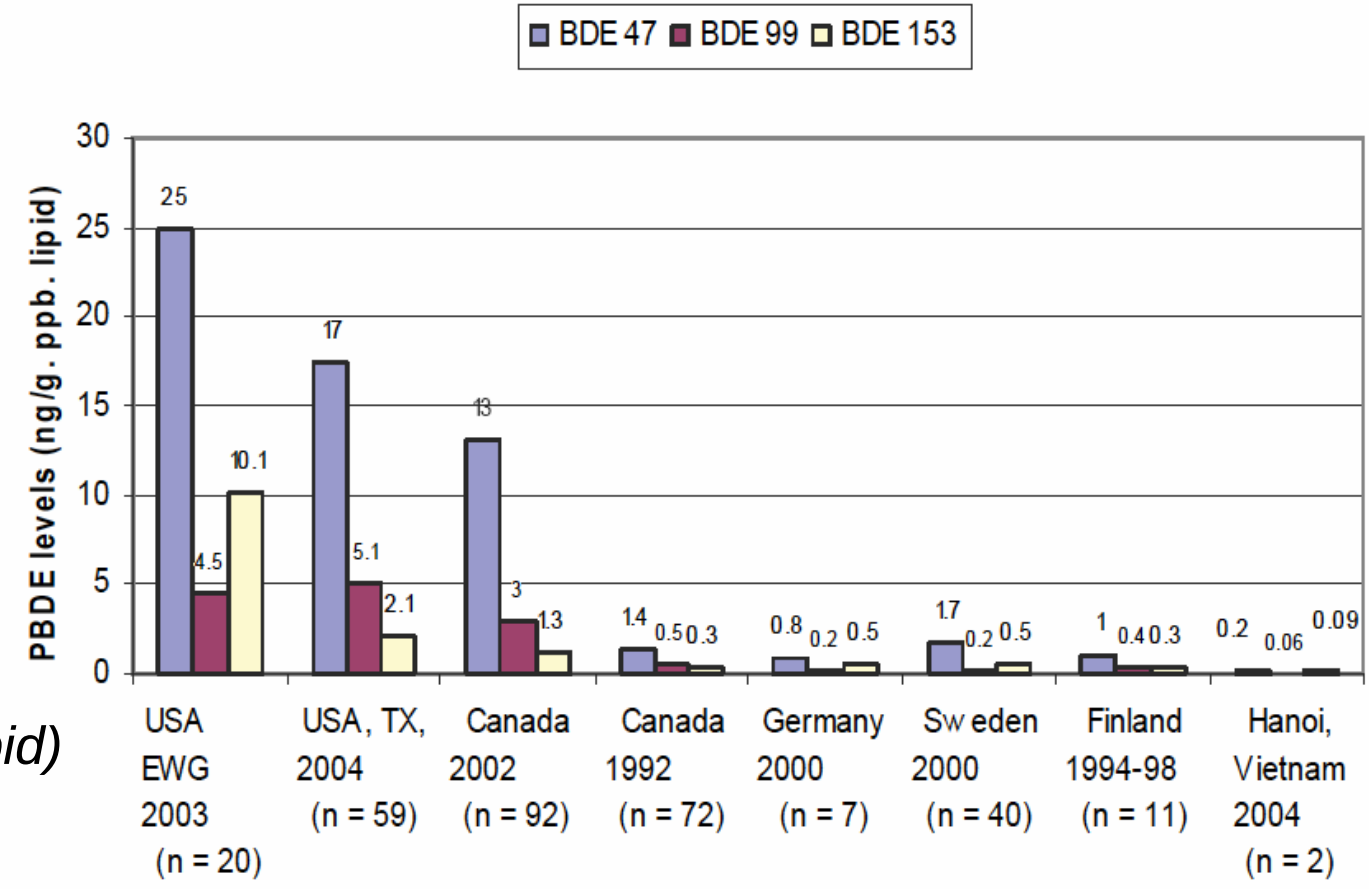
Properties	Criteria	Data(or estimates)
*Persistent		
Water	>2 months	
Soil	>6 months	*Stable*
Sediments	>6 months	
*Bioacumulative		
BAF/BCF	>5,000	>10,000
Log $K_{o/w}$	>5	6.39~7
*Long Range Transport		Arctic Seal
*Toxicity/Ecotoxicity		NOAEL =0.15mg/kg/d

Flame retardants: PBDE, HBB, chlorinated paraffins

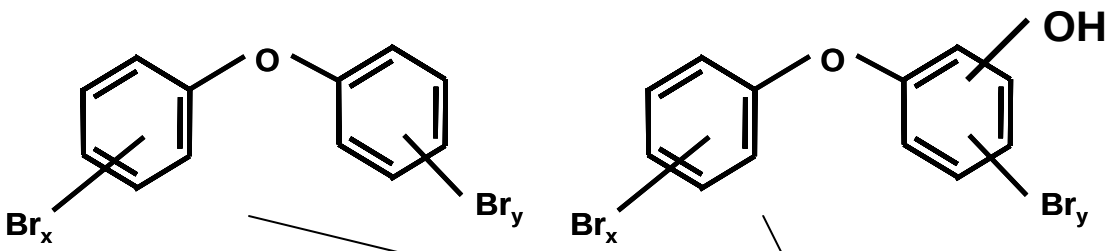
Polybrominated diethylethers
: Pentabrominated (PeBDE)
: Octabrominated (OcBDE)
: Decabrominated (DeBDE)



PBDEs in human Breast milk (ng/g lipid)



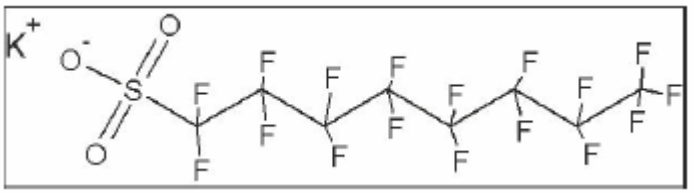
PBDEs



- Adult mammalian toxicity
  - Hepatic enzyme induction and toxicity
    - DBDE – hepatocarcinogen (very high dose)
  - Endocrine disruption
    - Thyroid
    - Estrogen/anti-androgen
- Developmental reproductive Toxicity
  - Penta/Octa, BDE99
    - Delayed puberty both sexes, sex organ wt changes, ovarian tox, decreased sperm counts
- Developmental neurotoxicity
  - Penta/BDE47, 99, 203, 206, 209
    - Deficits in sensory, motor, and cognitive function

AH Receptor
Thyroid H R
Estrogen R

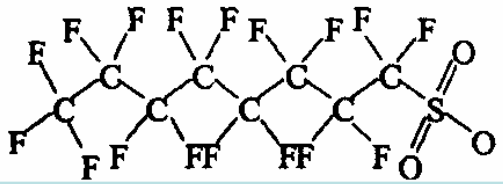
PFOS



Properties	Criteria	Data(or estimates)
*Persistent		
Water	>2 months	
Soil	>6 months	Stable
Sediments	>6 months	
*Bioacumulative		
BAF/BCF	>5,000	2796~3100
Log $K_{o/w}$	>5	1.08
*Long Range Transport		Monitoring
*Toxicity/Ecotoxicity		1.6mg/kg/d (rat)

PFOS (Perfluorooctane sulfonate)

PFOS (Perfluorooctane sulfonate)
$C_8F_{17}SO_3^-$



* Produced from 1950's
  max ~3,500 t /y (2000)
* Used for surface treatment of papers/ clothes/fabrics as water/oil repellants, for semiconductor industries, for fire fighting agents, etc.
*N(L)OAEL for 2nd generation of rats 0.1(0.4) mg kg^{-1}/day

[Chemical Properties of PFOS]
* Vapor pressure 3.31x10^{-4} Pa (20 C)
* Water sol. 519 / 25 mg/L (pure water(20 C) / seawater)
* Henry's Law Const. 3.1x10^{-9} atm•m^3/mole
* BCF 2,796 (Blue gill)

Major application of PFOS-related chemicals

(Nov 2007)

US Production (World))

POSF $C_8F_{17}SO_2F$ — Low MW

PFOS

- Amphoterics
- Amines
- Quarternary Ammonium Salts

FOSA $C_8F_{17}SO_2NH(C_nH_{2n+1})$

- Oxazolidinones
- Amides
- Silanes
- Carboxylates
- Alkoxylates

High MW

FOSE $C_8F_{17}SO_2N(C_nH_{2n+1})C_2H_5OH$

- Adipiates
- Phosphate Esters
- Fatty Acid Esters
- Alcohols
- Urethanes
- Copolymers
- Acrylates

High MW Phosphates

Performance Chemicals — *660t/y(830t/y)* <*92t/y(151t/y)*>

- Fire Extinguishing Forms
- Mining & Oil Surfactants
- ElectroPlating/Etching Bath
- Household Additives
- Chemical Intermediates
- Coatings/Coating Additives
- Carpet Spot Cleaners
- Insecticides Raw Materials

Surface Treatments — *1,070t/y(2,160t/y)*

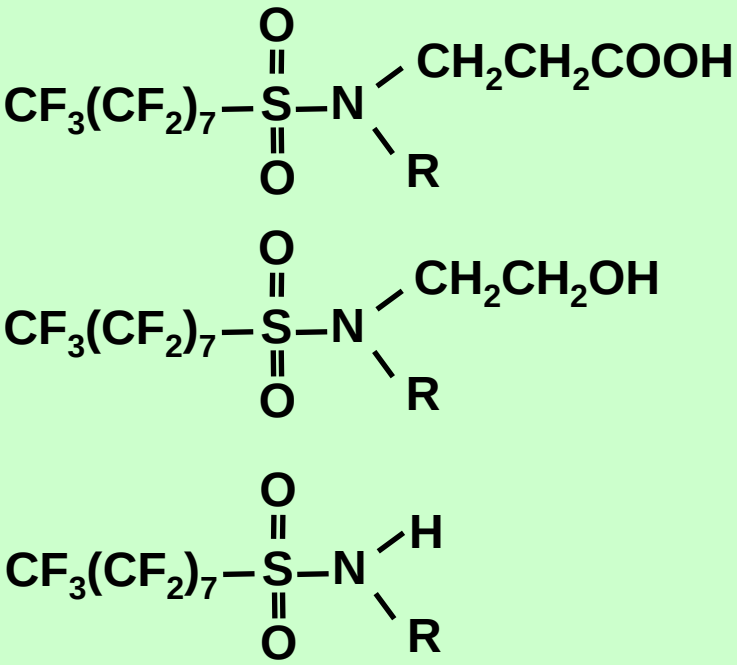
- Carpet Protector
- Fabric/Upholstery Protector
- Apparel & Leather Protector
- Other Protective Products

Paper & Packaging Protectors — *1,210t/y (1,490t/y)*

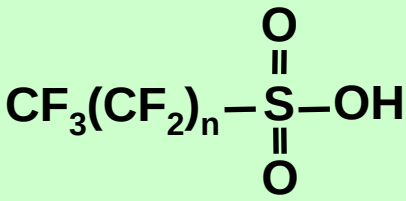
- Food Packaging
- Paper Products

Perfluorosurfactants

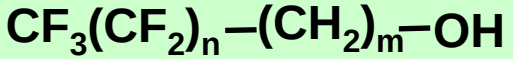
PFOS Amides



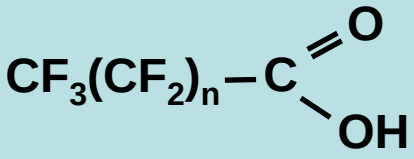
Sulfonic acids



Alcohols



Carboxylic acids



* Surfactants with oil/water repellant activity
  not lipophilic but accumulated in the body
* PPARα (Peroxisome Proliferator Activated Receptor)
  => induce peroxisome containing fatty acid-metabolizing enzymes

Life Cycle Waste Stream Estimates of PFOS

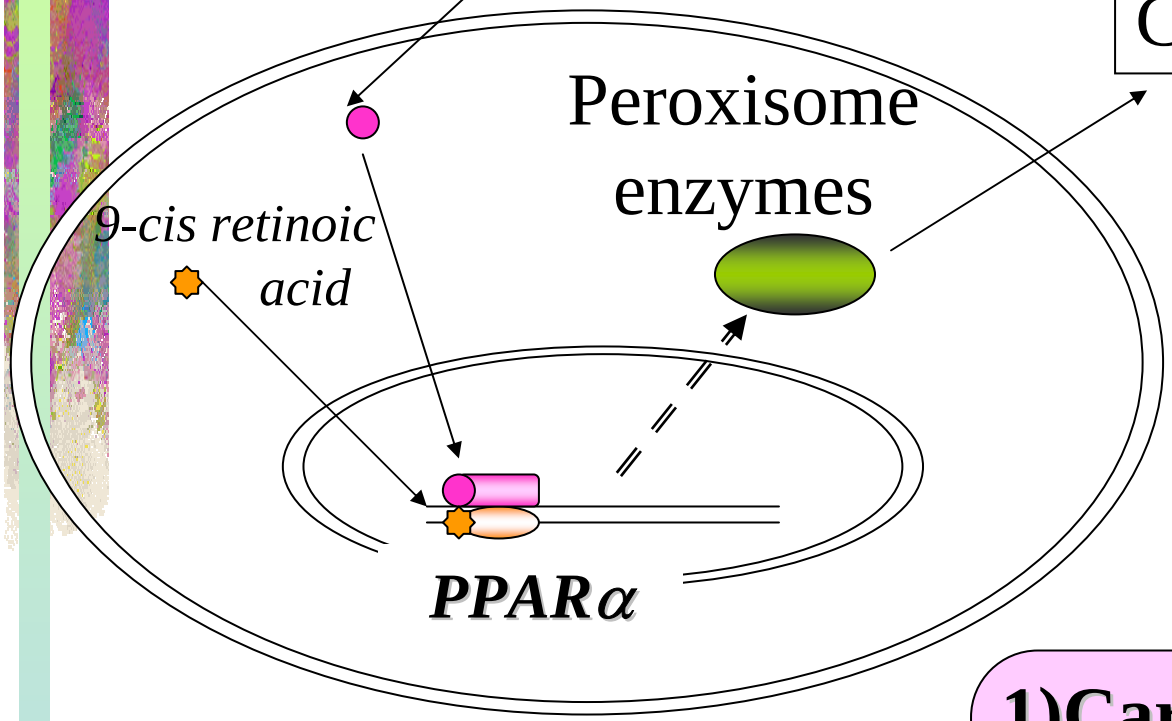
(Battelle Memorial Institute (2000))

Summary of estimated FC waste stream (PFOS equivalent; lbs./y)

	Customers				3M Mfg. Process	
	Suppl.Chain Process.	End use	Disposal	BU Total	3M Mfg. Waste Str.	3M Mfg. Release
Air	2,600	3,300	0	5,900	N/A	19,000
Waste water	110,000	180,000	350	290,000	51,000	10,000
Solid waste	59,000	200,000	1,300,000	1,500,000	1,037,000	-
*Landfill					380,000	N/A
*Incineration					657,000	N/A

: Conservative, worst case assumption based on 1997 sales data

PFOS：Peroxisome proliferators



β–oxidation
H_2O_2 respiration
Cholesterol metabolism

∗Inhibit lipid/sugar metabolism

∗Produce active oxygen species

1)Carcinogenic（promoter）
2)Diabetis, Arterioscleosis
3)Modulation of immune/ inflamation reaction

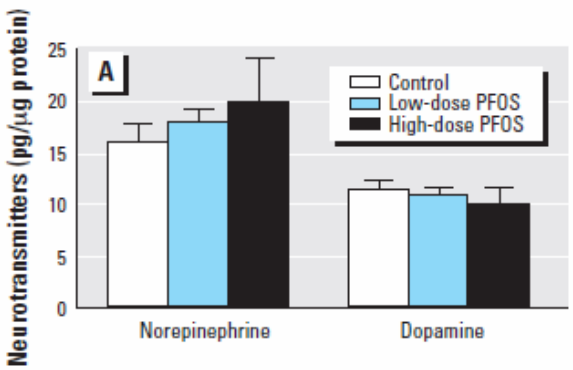
Strong sub-acute/chronic toxicity; Species-specificity

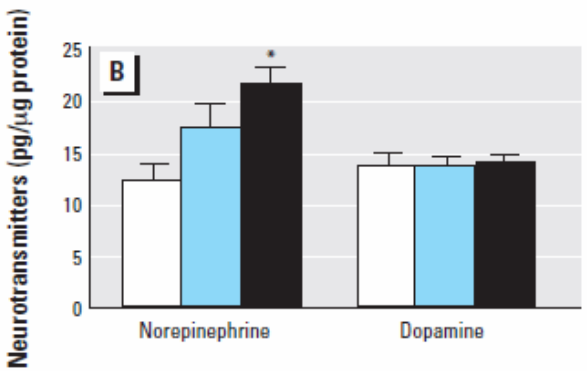
Neuroendocrine effects of PFOS in rats, *EHP 111,1485 (2003)*

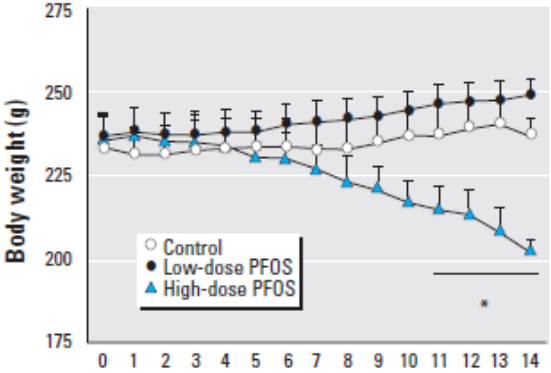
Table 1. PFOS concentrations in serum (ng/mL) and in various tissues (ng/g) on a wet weight basis.

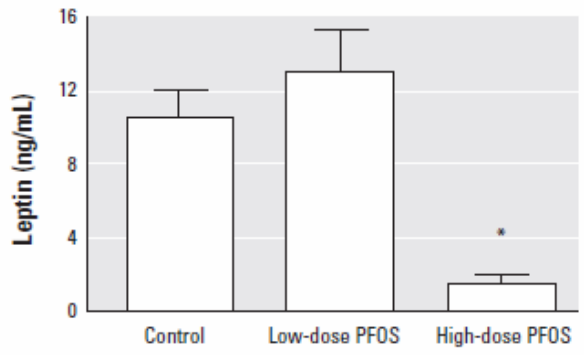
Site	Untreated control	PFOS-treated groups	
		1 mg/kg BW	10 mg/kg BW
Serum	BDL	10,480 ± 1,428	45,446 ± 4,120*
Tissue			
Liver	BDL	26,617 ± 4,044	97,358 ± 25,668*
Heart	BDL	1,280 ± 697	23,490 ± 10,036*
Kidneys	BDL	9,581 ± 4,836	47,799 ± 29,512*
Spleen	BDL	76	15,873
Ovary	BDL	3,028	15,489
Adrenal	BDL	1,539	30,087
Brain			
Hypothalamus	BDL	< 50	15,706
Cortex	BDL	294	4,487
Hippocampus	BDL	115	8,966
Brain stem	BDL	363	5,346
Cerebellum	BDL	289	5,540
Rest of the brain	BDL	396	4,256

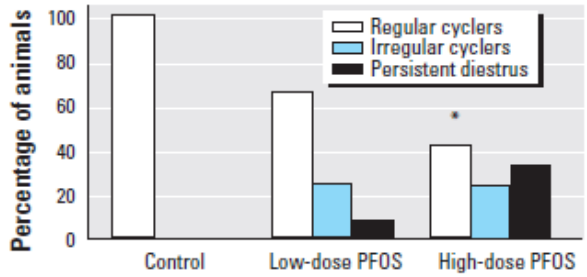
BDL, below detection limit (50 ng/g). Tissues from animals in each group were pooled for the measurement of PFOS concentrations in specific parts of the brain and in spleen, ovaries, and adrenals. $n = 4–5$ in each group of rats.
*$p < 0.05$ relative to the other groups.

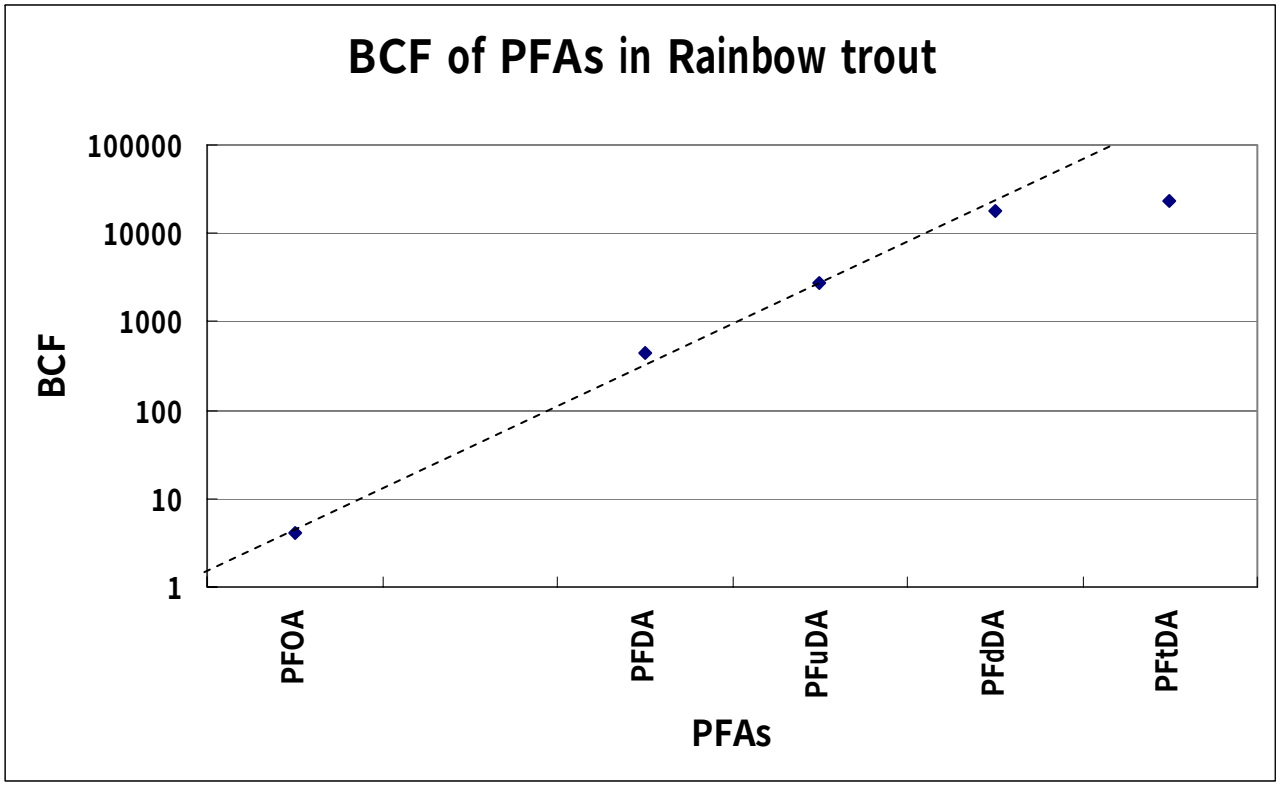












JW Martin et al., Env. Tox. Chem., 22, 196 (2003)

BCF vs carbon chain length of PFAs in rainbow trout

Responses of the Liver to Perfluorinated Fatty Acids with Different Carbon Chain Length in Male and Female Mice: In Relation to Induction of Hepatomegaly, Peroxisomal β-Oxidation and Microsomal 1-Acylglycerophosphocholine Acyltransferase

N. Kudo et al., Biol. Pharm. Bull., 29, 1952 (2007)

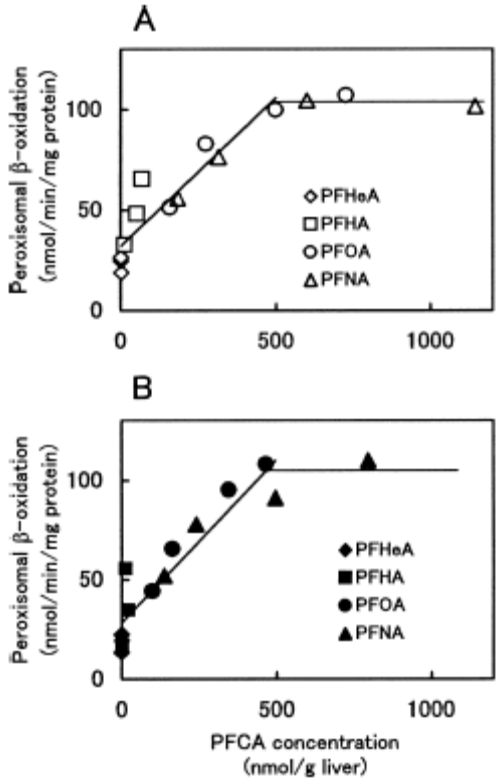


Fig. 5. Relationship between the Concentration of PFCAs and the Activity of Peroxisomal β-Oxidation in the Liver of Mice

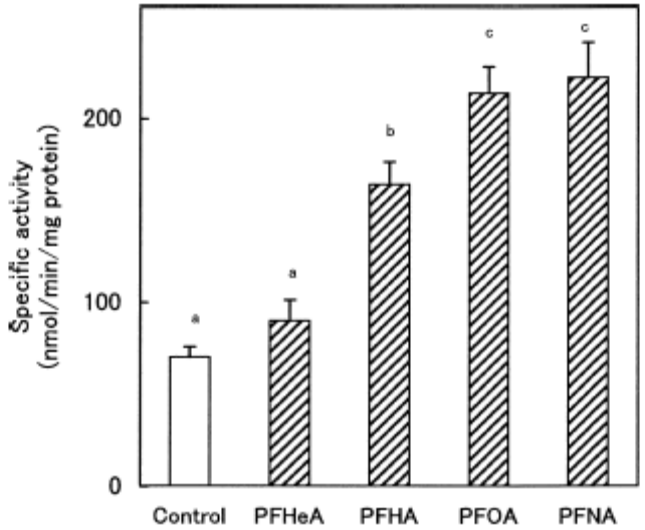


Fig. 2. Effects of PFCAs on the Activity of Microsomal 1-Acly-GPC Acyltransferase in the Liver of Male Mice

Estrogen-Like Properties of Fluorotelomer Alcohols as Revealed by MCF-7 Breast Cancer Cell Proliferation

M. Maras, et al., EHP 114, 100 (2006)

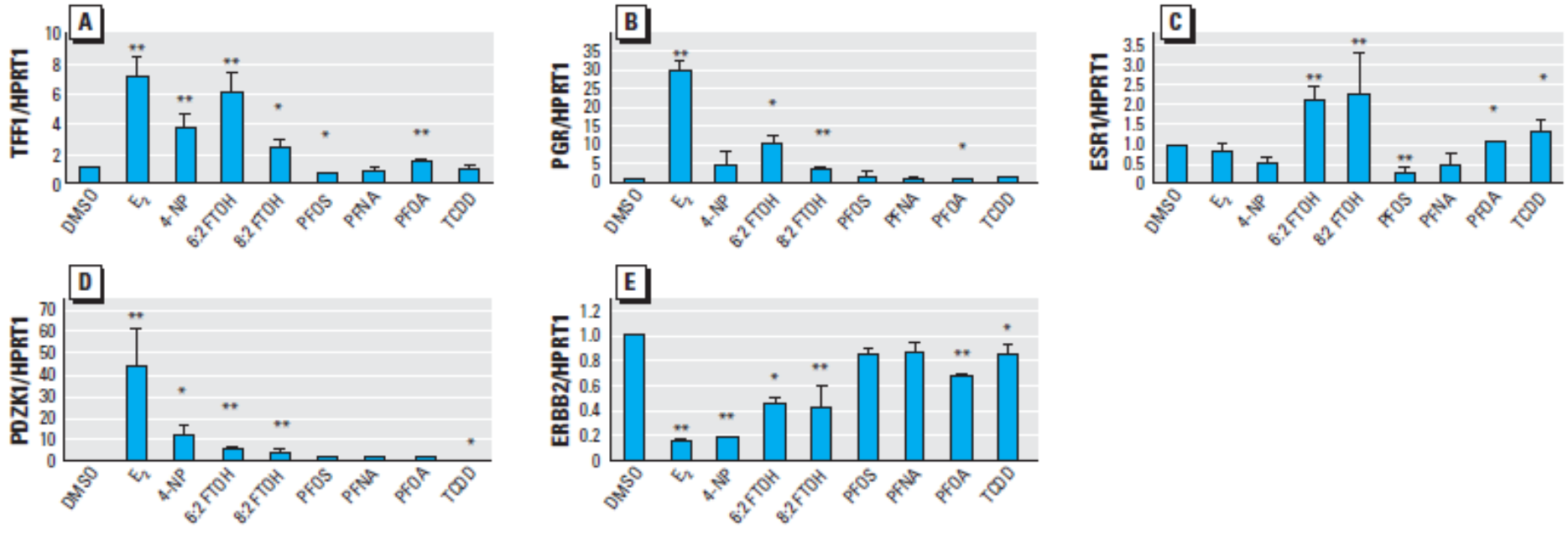
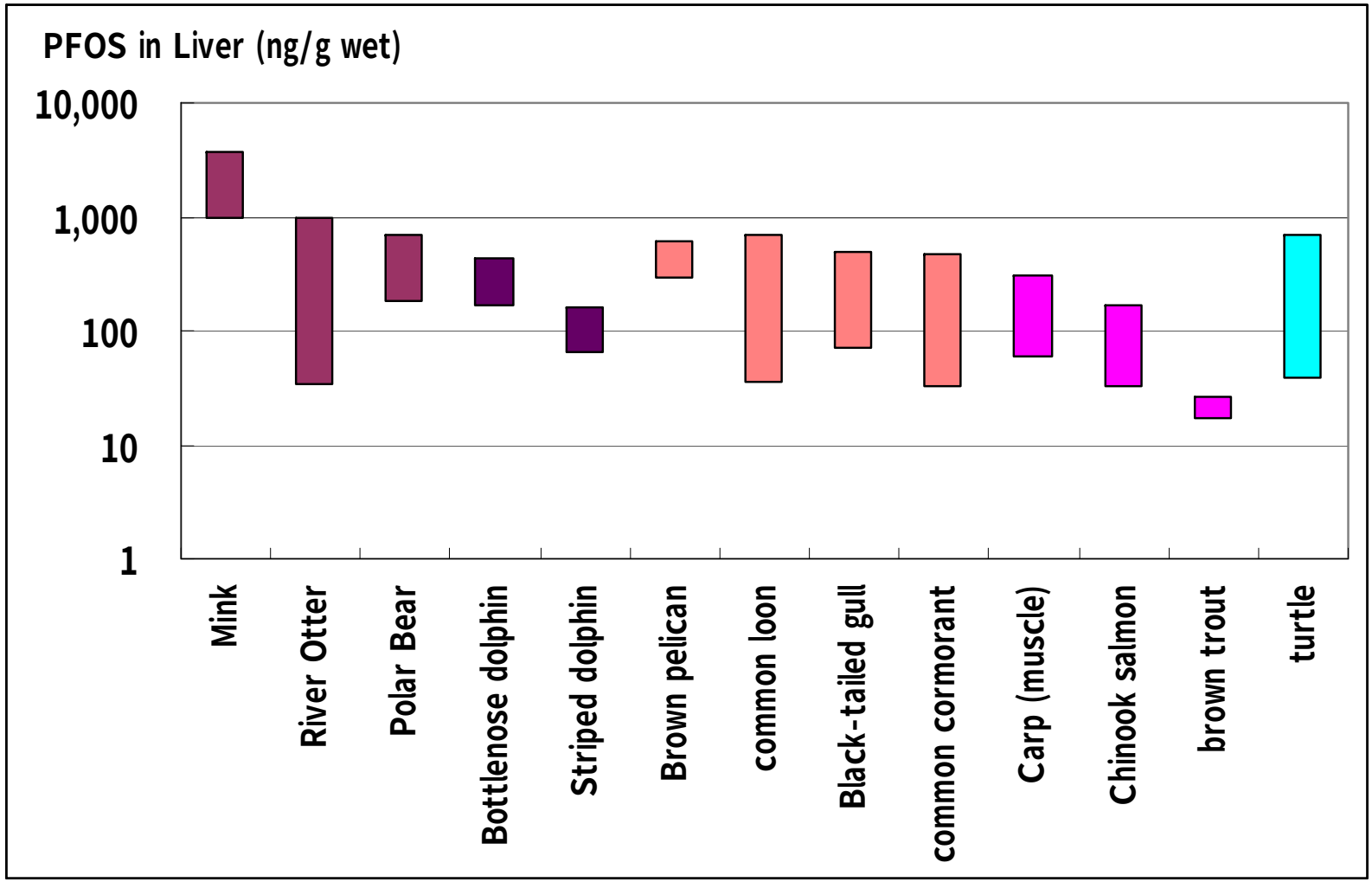


Figure 3. Effect of perfluorinated chemicals on mRNA expression of estrogen-responsive genes in MCF-7 cells were treated with 0.1% DMSO, 1 nM E_2, 10 µM 4-NP, 30 µM 6:2 FTOH, 10 µM 8:2 FTOH, 50 µM PFOS, 50 µM PFNA, 50 µM PFOA, or 10 nM TCDD. After exposure to the test compounds for 48 hr, mRNA levels of *TFF1* (*A*), *PGR* (*B*), *ESR1* (*C*), *PDZK1* (*D*), and *ERBB2* (*E*) were measured by real-time PCR and normalized using *HPRT1* as an internal control. Results are means from three replicate measurements and are expressed as fold relative to 0.1% DMSO; error bars indicate SD.

*$p < 0.05$. **$p \leq 0.001$.

PFOS Levels in wildlife (ng/g wet)



Giesy & Kannan (2001)

Monitoring of PFOS and other fluorosurfactants At National Institute for Environmental Studies (NIES)

Analysis of PFOS and related chemicals

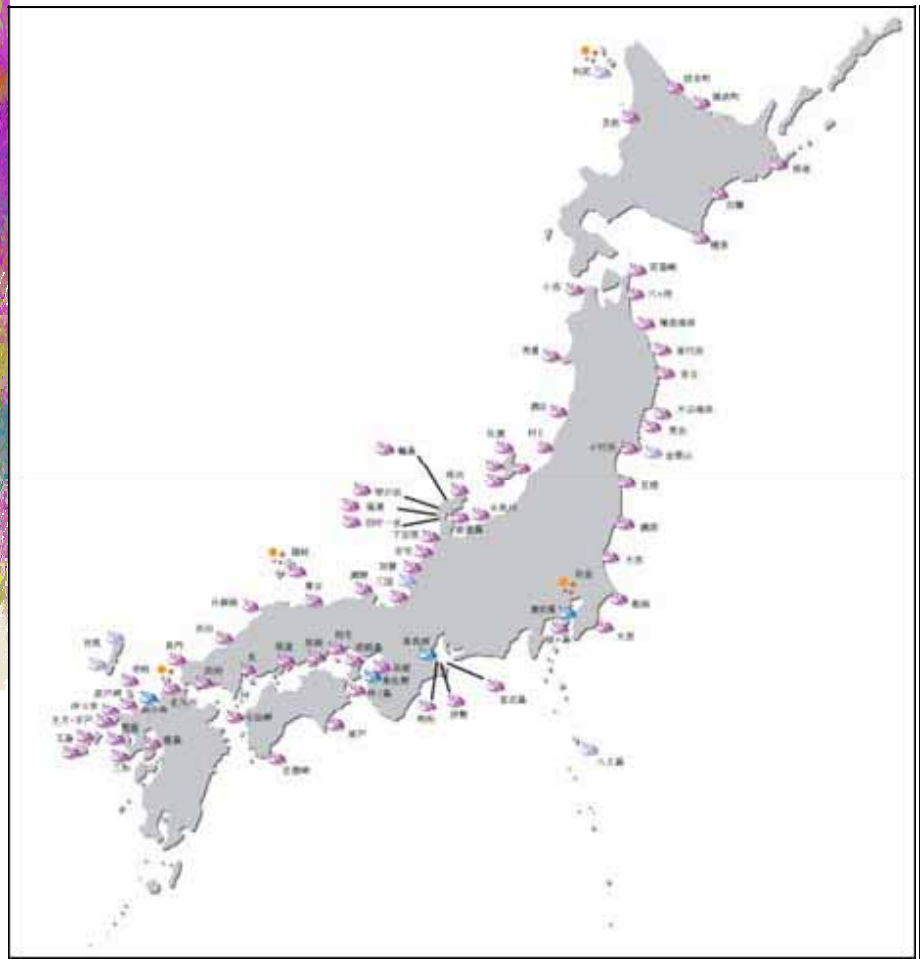
Important points
1) To reduce blank levels
2) Alkaline digestion for biological samples

Bivalve samples

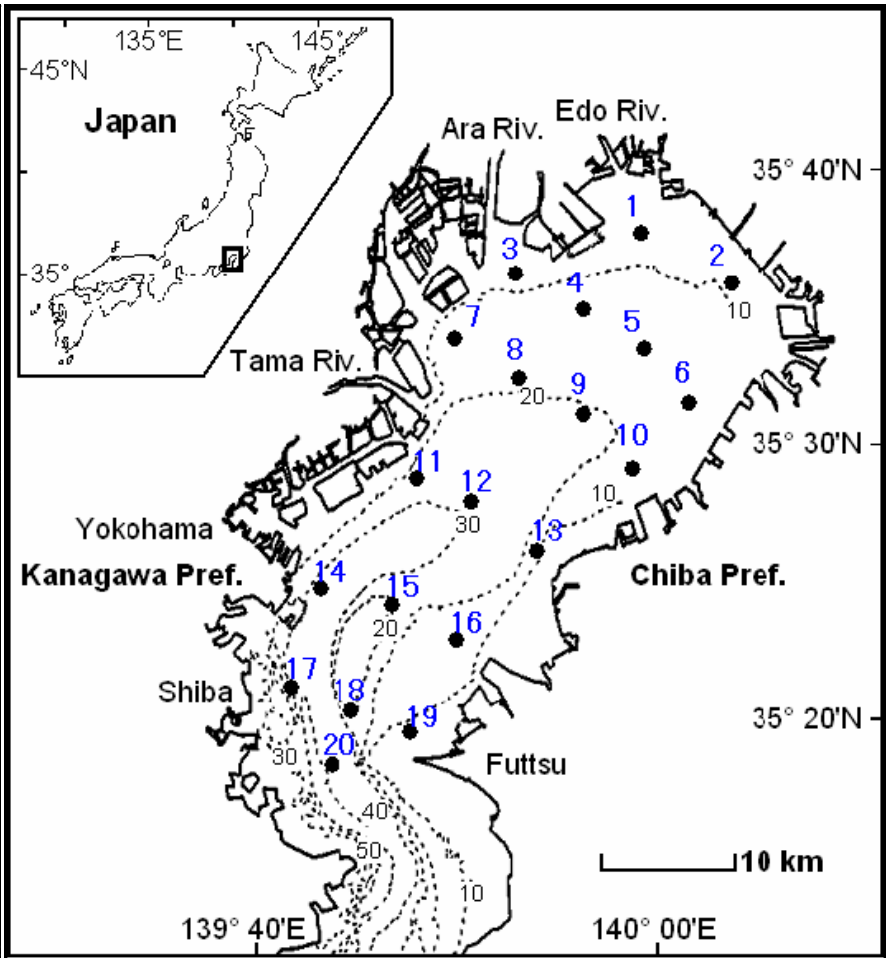
	PFOA(n=3)		PFOS(n=3)	
	Recovery (%)	Concentration ng/g wet	Recovery (%)	Concentration ng/g wet
1) Alkali + Ion pair	101 ± 2	10.5 ± 0.2	86 ± 1	0.63 ± 0.01
2) Ion pair	94 ± 19	1.3 ± 0.1	119 ± 1	0.16 ± 0.00
3) PFE + Alkali + Ion pair	86 ± 3	5.8 ± 0.4	71 ± 40	0.68 ± 0.02
4) PFE + Ion pair	71 ± 16	2.6 ± 0.1	87 ± 4	0.17 ± 0.01

Yoshikane et al (Dioxin 2006)

Environmental Monitoring and Specimen Banking at NIES

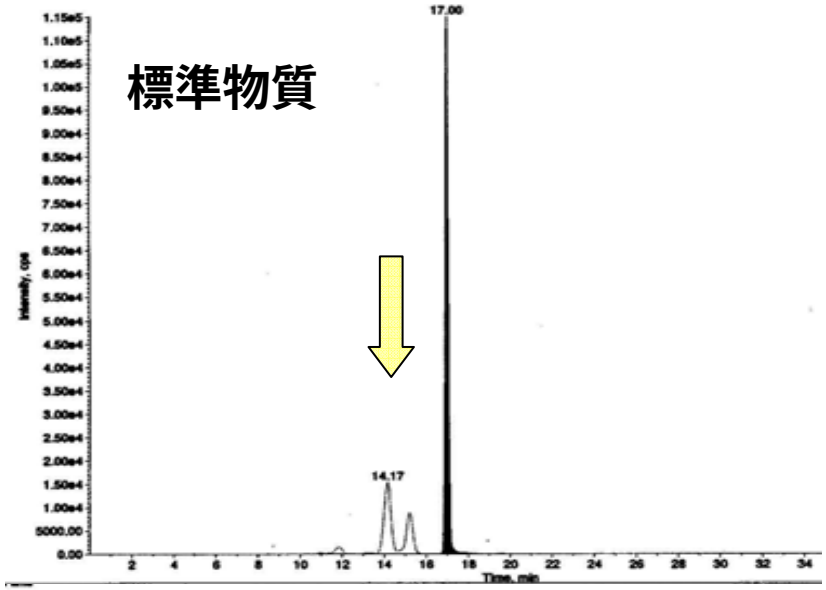


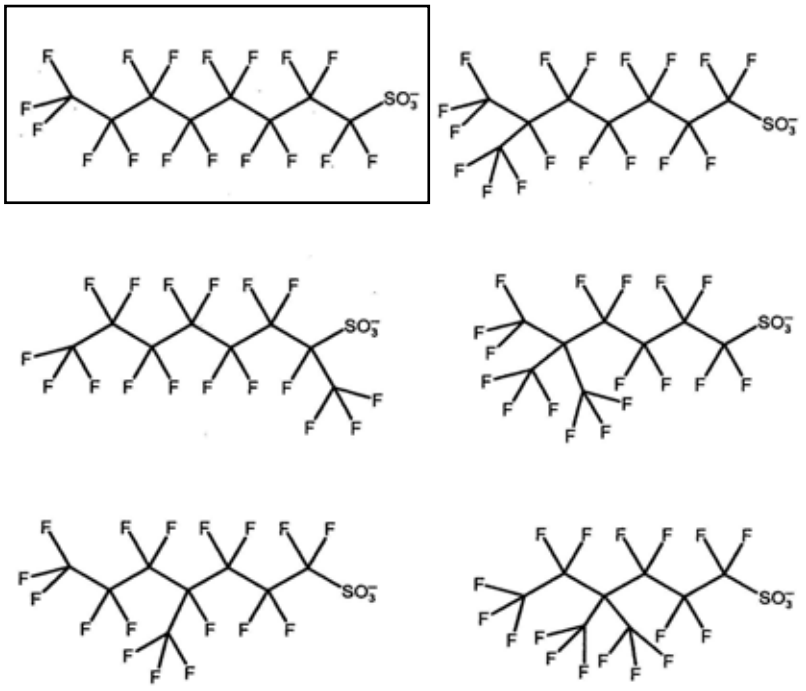
Mussel sampling along Japanese coastline



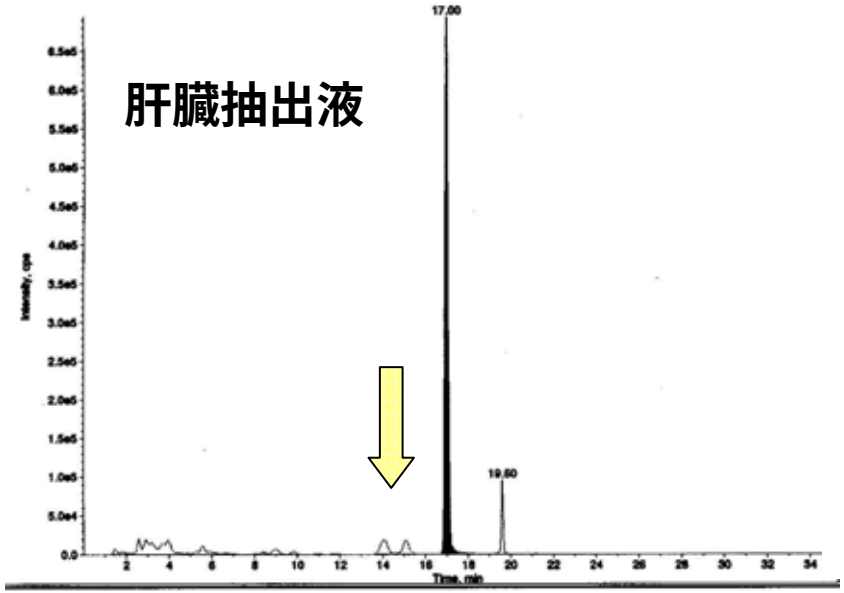
Intensive Survey in Tokyo Bay

標準物質


17.00
14.17
Intensity, cps
Time, min



肝臓抽出液


17.00
19.60
Intensity, cps
Time, min

Effectriveness Evaluation Of Stockholm Convention

Country monitoring reports from Parties

1st Global Report By CG

Regional Reports By ROG

Regional monitoring activities

COP-4 in May 200

Establishment of Monitoring Network needed with Specimen Banking as effective back-up

Effectiveness Evaluation
: to be conducted 4 years interval