

Effects of PCBs on Human Health and Wildlife – Risk Assessments

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Environmental Stewardship
Concepts

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Objectives

- Review the toxicology of PCBs.
- Summarize the EPA risk assessments.
- Summarize effects of PCB's on health.
- Review effects of PCBs on selected wildlife.
- Review biology of selected wildlife.



Experimental/ecological data

- Mink
- Bald Eagle
- Terns and gulls
- Rainbow Trout
- frogs
- Spiny brittle starfish
- alligator
- Snapping turtle
- Otter
- Beluga Whale
- salmon
- Polar Bears
- Big brown bat
- robins
- Mussels, clams



Human Health Information

- Using laboratory experiments
- Occupational exposures in factories
- Fish consumption
- Accidental exposures
- Research on cells in the laboratory
- Epidemiology – Dutch studies most recently



Human health Effects

- Skin rashes- chloracne
- Neurological development
- Behavioral abnormalities
- Children most sensitive
- Immune system impairments
- Recent work on senior adults
- Dioxin-like effects
- Cancer



Effects on wildlife include:

- Reproductive impairment in fish, birds and mink
- Reproductive failure in mink
- Immune suppression in Beluga whales
- Developmental abnormalities in fish, mammals and birds

Risk Assessment

Scoping or problem formulation

Analysis plan

Endpoints

Conceptualization

Analysis

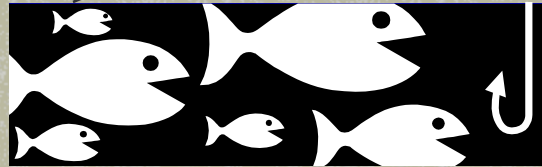
exposure

effects

Risk Characterization

Estimate, description of risk; uncertainty

For example:



PCB



PCB's from sediments diffuse into other animals that fish eat- the exposure path leads to eagles and humans who suffer from reproductive problems.

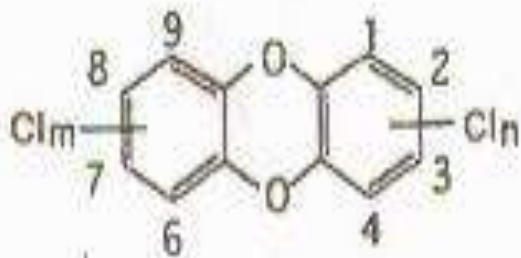
Contaminated sediments



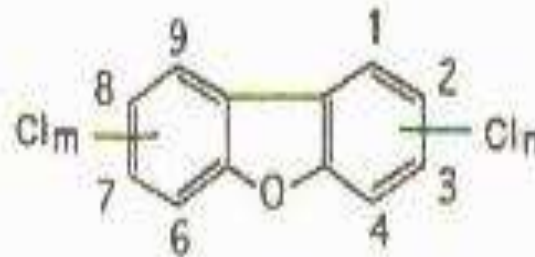
Risk Assessment Problems

- Depends on known or assumed information- unknowns are problematic
- The greatest exposure path gets the attention
- Unknown effects are not assessed
- EPA does not include chemicals without data, or without numerical values
- Single chemicals, single effects

PCDD, PCDF, and PCB Molecules:



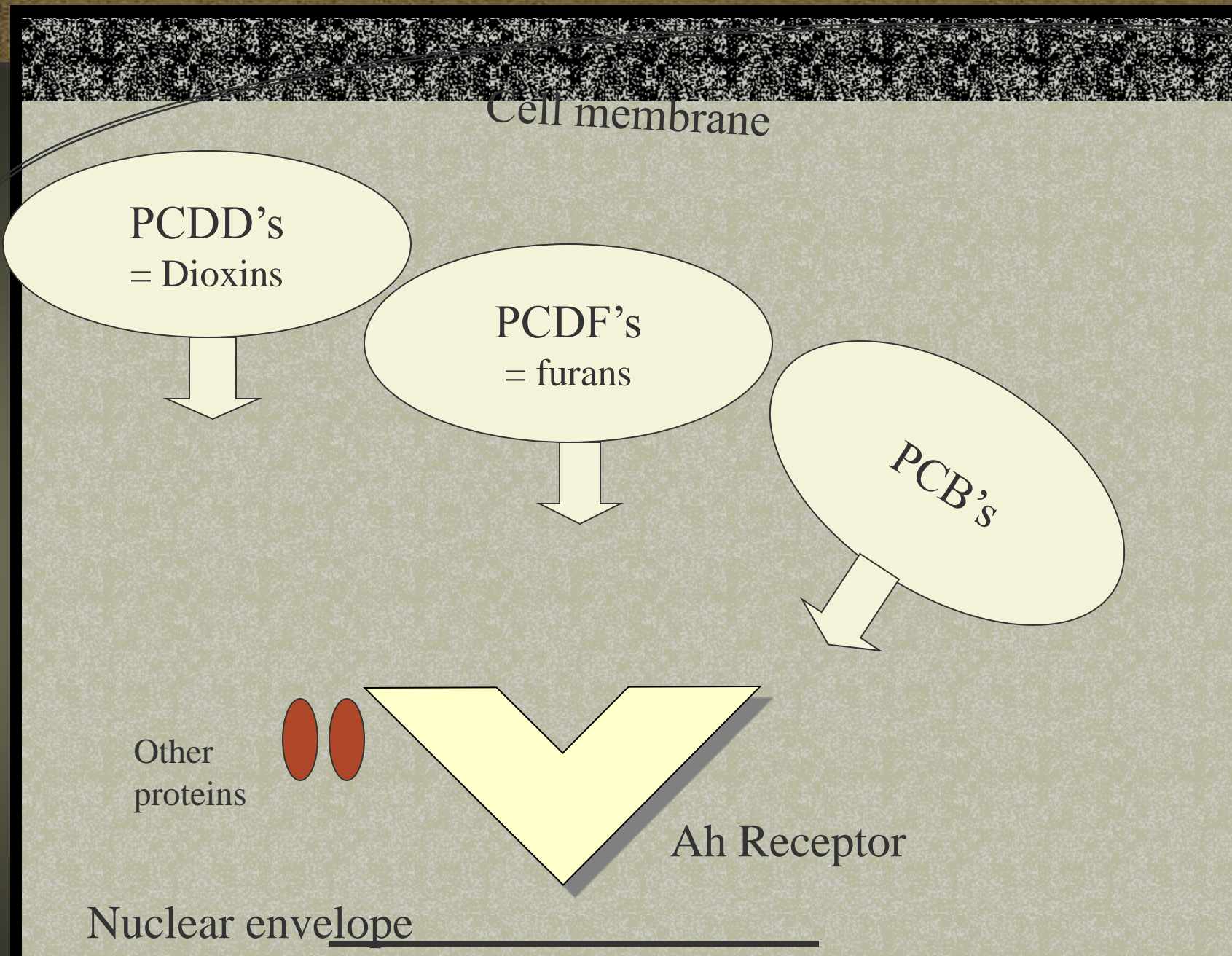
PCDD ($m + n = 1 \sim 8$)



PCDF ($m + n = 1 \sim 8$)



PCB ($m + n = 1 \sim 10$)



Cell membrane

PCDD's
= Dioxins



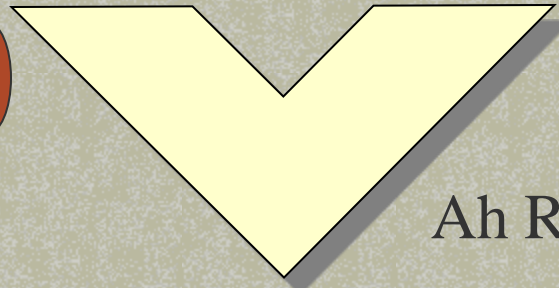
PCDF's
= furans



PCB's



Other
proteins



Ah Receptor

Nuclear envelope

A summary of the suggested WHO TEFs for PCDDs, PCDFs, and dioxinlike PCBs is shown in Table 5.

Table 5. World Health Organization toxic equivalency factors (TEFs) for humans, mammals, fish, and birds

Congener	TEF		
	Humans/mammals	Fish ^a	Birds ^a
2,3,7,8-TCDD	1	1	1
1,2,3,7,8-PentaCDD	1	1	1 ^b
1,2,3,4,7,8-HexaCDD	0.1 ^a	0.5	0.05 ^b
1,2,3,6,7,8-HexaCDD	0.1 ^a	0.01	0.01 ^b
1,2,3,7,8,9-HexaCDD	0.1 ^a	0.01 ^c	0.1 ^b
1,2,3,4,6,7,8-HeptaCDD	0.01	0.001	<0.001 ^b
OctaCDD	0.0001 ^a	<0.0001	0.0001
2,3,7,8-TetraCDF	0.1	0.05	1 ^b
1,2,3,7,8-PentaCDF	0.05	0.05	0.1 ^b
2,3,4,7,8-PentaCDF	0.5	0.5	1 ^b
1,2,3,4,7,8-HexaCDF	0.1	0.1	0.1 ^{b,d}
1,2,3,6,7,8-HexaCDF	0.1	0.1 ^d	0.1 ^{b,d}
1,2,3,7,8,9-HexaCDF	0.1 ^a	0.1 ^{c,d}	0.1 ^d
2,3,4,6,7,8-HexaCDF	0.1 ^a	0.1 ^{d,e}	0.1 ^d
1,2,3,4,6,7,8-HeptaCDF	0.01 ^a	0.01 ^e	0.01 ^e
1,2,3,4,7,8,9-HeptaCDF	0.01 ^a	0.01 ^{c,e}	0.01 ^e
OctaCDF	0.0001 ^a	<0.0001 ^{c,e}	0.0001 ^e
3,4,4',5-TetraCB (81)	0.0001 ^{a,c,d,e}	0.0005	0.1 ^c
3,3',4,4'-TetraCB (77)	0.0001	0.0001	0.05
3,3',4,4',5-PentaCB (126)	0.1	0.005	0.1
3,3',4,4',5,5'-HexaCB (169)	0.01	0.00005	0.001
2,3,3',4,4'-PentaCB (105)	0.0001	<0.000005	0.0001
2,3,4,4',5-PentaCB (114)	0.0005 ^{a,d,e,f}	<0.000005 ^e	0.0001 ^g
2,3',4,4',5-PentaCB (118)	0.0001	<0.000005	0.00001
2',3,4,4',5-PentaCB (123)	0.0001 ^{a,d,f}	<0.000005 ^e	0.00001 ^g
2,3,3',4,4',5-HexaCB (156)	0.0005 ^{d,e}	<0.000005	0.0001
2,3,3',4,4',5'-HexaCB (157)	0.0005 ^{d,e,f}	<0.000005 ^{d,e}	0.0001
2,3',4,4',5,5'-HexaCB (167)	0.00001 ^{a,f}	<0.000005 ^e	0.00001 ^g
2,3,3',4,4',5,5'-HeptaCB (189)	0.0001 ^{a,d}	<0.000005	0.00001 ^g

Abbreviations: CDD, chlorinated dibenzodioxins; CDF, chlorinated benzofurans; CB, chlorinated biphenyls; QSAR, quantitative structure-activity relationship.

^aLimited data set.

^b*In vivo* CYP1A induction after *in vivo* exposure.

^c*In vitro* CYP1A induction.

^dQSAR modeling prediction from CYP1A induction (monkey, pig, chicken, or fish).

^eStructural similarity.

^fNo new data from 1993 review (1).

^gQSAR modeling prediction from class specific TEFs.



Key differences in TEF's

■ PCB	human	fish	birds
■ 4-PCB	0.0001	0.0005	0.1
■ 5-PCB	0.1	0.005	0.1
■ 6-PCB	0.01	0.00001	0.001
■ TCDF	0.1	0.05	1.0



Effects on Mink and Otters

- Reproductive failure – Great Lakes

- Wild populations lost

- Fish consumption is key pathway



Effects on bird species

- Population declines and limitations
- Developmental abnormalities
- Behavioral abnormalities
- Food contamination
- Mortality



Tern



Bald eagle



Effects on fish

- Population declines
- Mortality
- Developmental abnormalities
- Behavioral problems?
- Migration



Rainbow trout



Blue Sac Disease

PCB's in Lake trout in Great Lakes

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PRINCIPLES AND PROCESSES FOR EVALUATING ENDOCRINE DISRUPTION

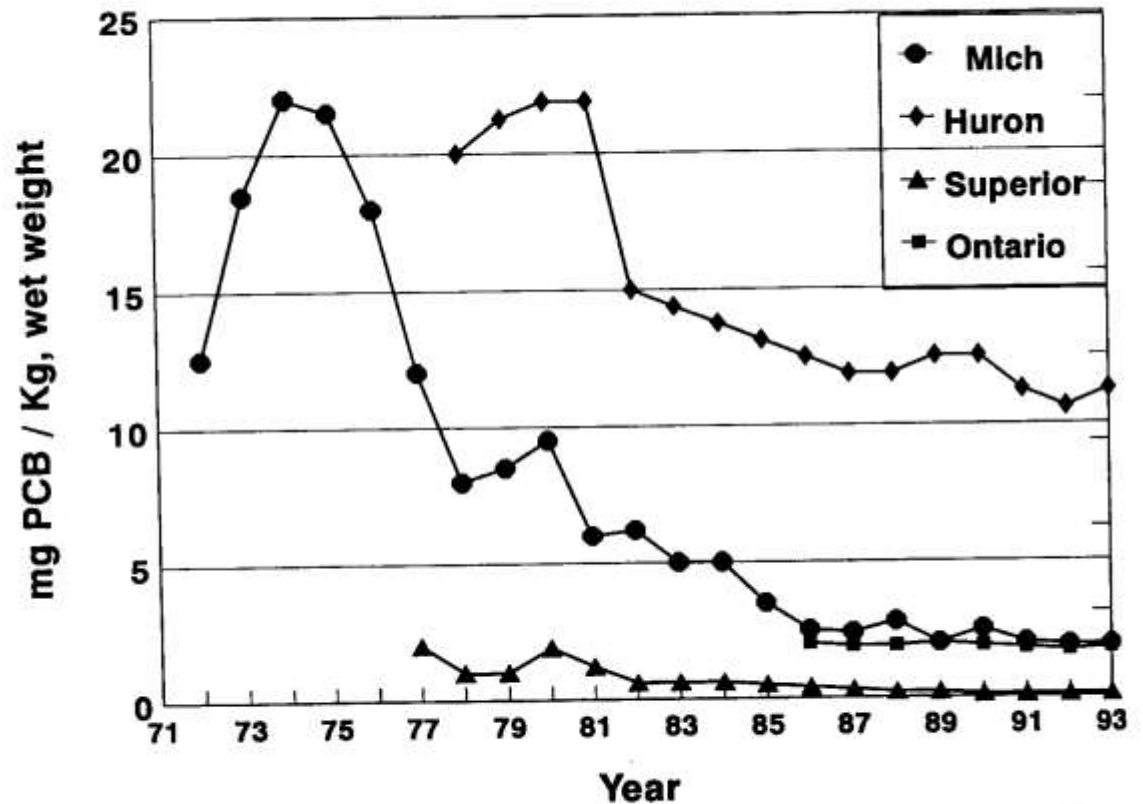
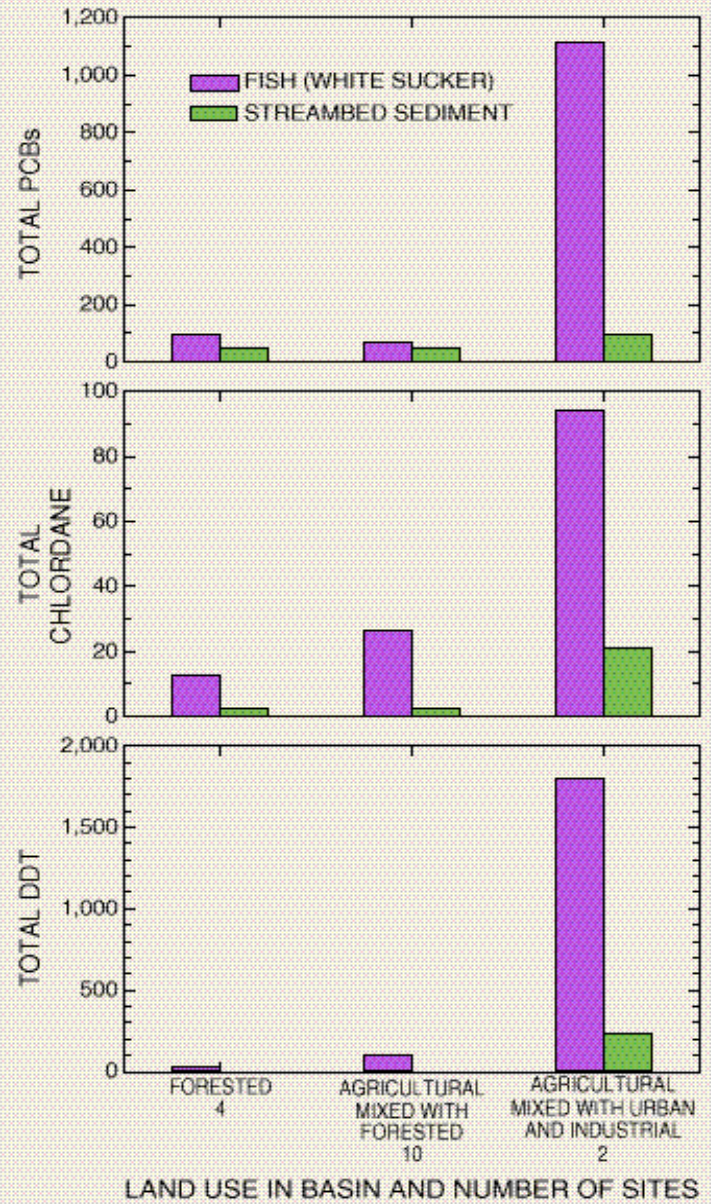


Figure 8-2

Mean total concentrations of PCBs (reported as mg total PCB/kg, w/w) in whole lake trout from North American Great Lakes, 1972–1990. Reprinted with permission from *Michigan Fish Contaminant Monitoring Program 1994 Annual Report*.

Fish tissue and sediment levels of PCB's etc

MEDIAN CONCENTRATIONS IN FISH TISSUE AND STREAMBED SEDIMENT, IN MICROGRAMS PER KILOGRAM



Median concentrations of total organochlorine pesticides and total PCBs in white sucker tissue and streambed sediment are grouped by the predominant land use in the basin to illustrate the effects of land use.

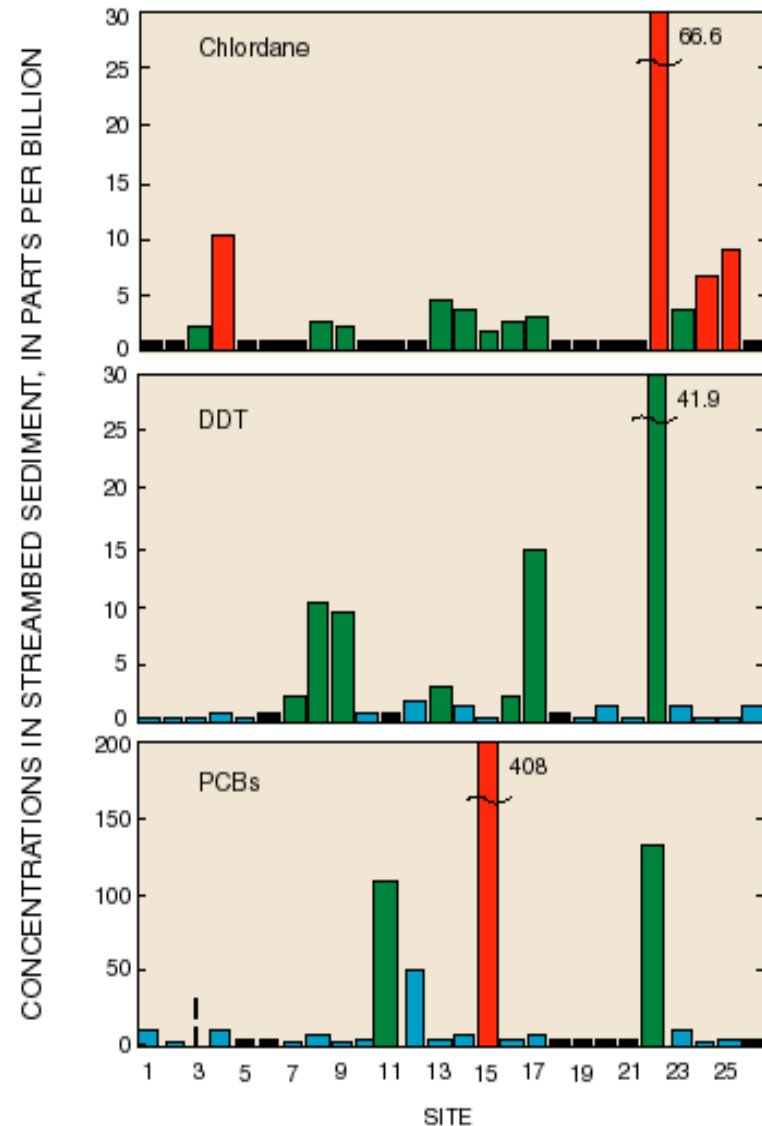
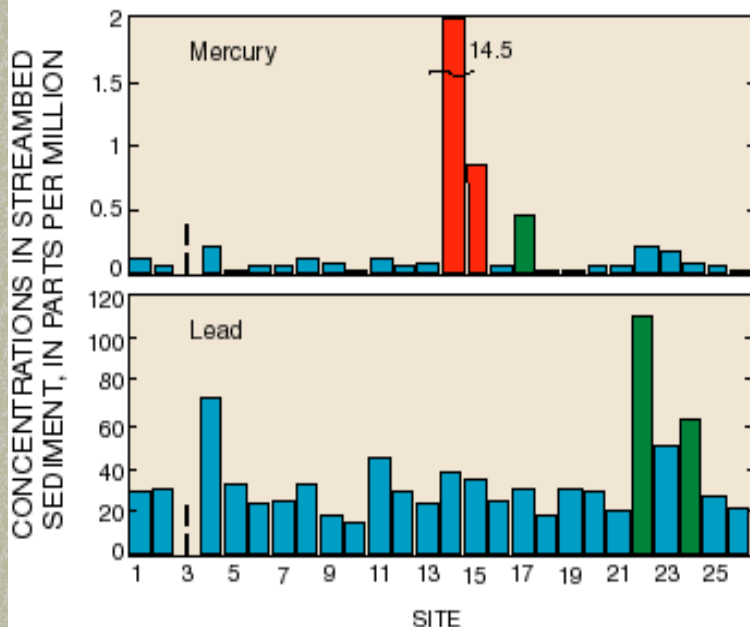
Sites representing basins with a mixture of agricultural, urban, and industrial land uses had the highest concentrations of total PCBs, total DDT, and total chlordane. PCB concentrations were associated with the highest percentages of urban land use, and DDT and chlordane were associated with the highest percentages of agricultural land use.

(3 large river sites not included)

EXPLANATION

Probability of organic contaminants or metals in streambed sediment causing adverse effects on aquatic life — Mercury and lead concentrations were adjusted for particle-size distribution for screening purposes

- High
- Intermediate
- Low
- Not detected
- Not sampled
- △ Site location and number



Beluga whales

- Compounds that dissolve in fat
- Immune system impairment
- Developmental problems





...Even alligators are affected



Juvenile alligators in Lake Apopka, FL

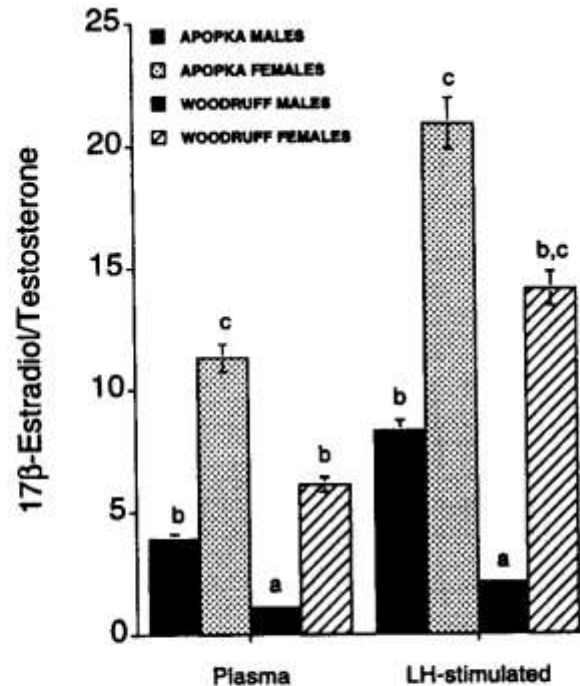


Figure 11-3b Sex steroid ratio (E_2/T) for juvenile alligators from Lake Apopka and Lake Woodruff. Values given are group means for plasma from untreated and LH-stimulated animals. Significantly different values are indicated by different letters within each comparison. Data from Guillette et al. (1994).

Alligators - sexual development- Lake Apopka, FL

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PRINCIPLES AND PROCESSES FOR EVALUATING ENDOCRINE DISRUPTION

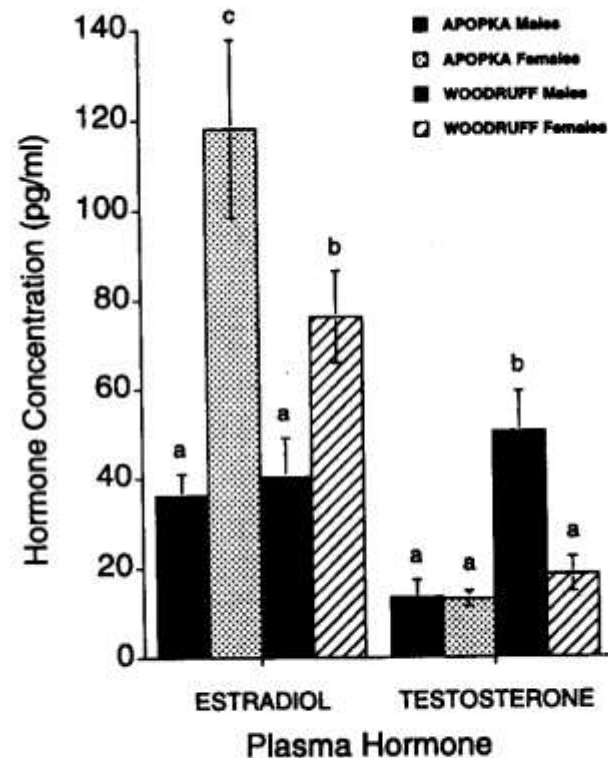


Figure 11-3a Plasma sex steroid concentrations (17 β -estradiol and testosterone) from 8-month old juvenile alligators from Lake Apopka and Lake Woodruff. Hormone determinations were split by gender, verified by gonadal sex of each animal.



Children's health studies

- Neurodevelopment
- Cognitive function impaired by PCB's
- Not extremely high levels in tissue, blood, breast milk
- Development of the immune system
- Dioxin- like effects on reproductive development, thyroid function, etc.



Risk Assessment Issues

- Concentrates on consumption of contaminated fish where demonstrated
- Few data in Connecticut- almost no recent data
- Connecticut floodplain is discounted
- Other animals in the Housatonic River valley



Health Risk Assessment Issues

- Does not include non-cancer effects of dioxin-like compounds
- Uses the old dioxin cancer value
- No inhalation
- Background or existing exposures are not considered
- Subsistence fishing is not included
- No tribal issues considered at all



Ecological Risk Assessment Issues

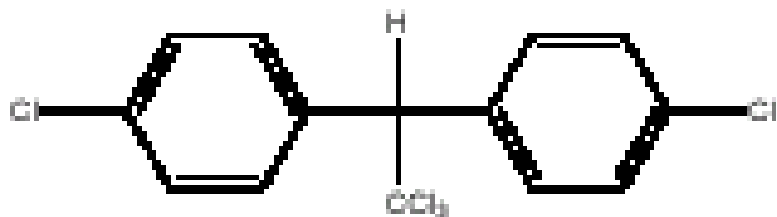
- EPA accepts a reproducing population of sick fish (or other animals)
- Other species are found in the region- bears, pheasant



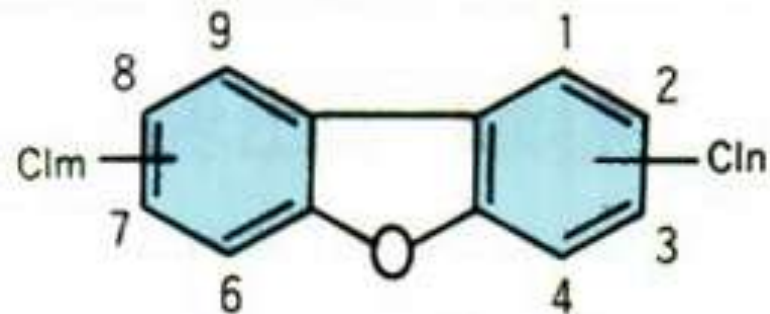
Risk assessments high points

- Large database
- Innovative analytical approaches
- Used experimental data on wildlife
- Extensive ecological survey as baseline
- Real data on Housatonic River
- Included residential exposures
- Measured wildlife

Contaminants come as mixtures in the environment

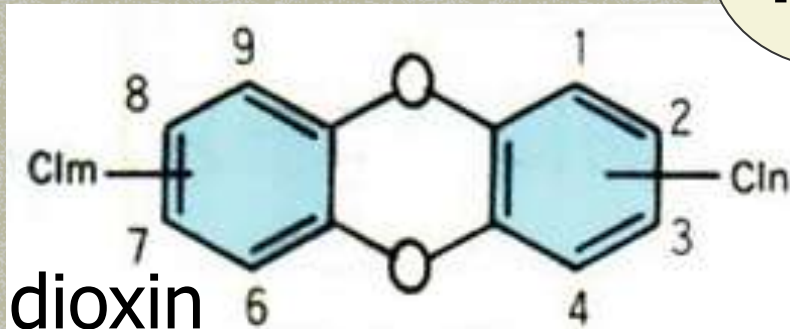


DDT



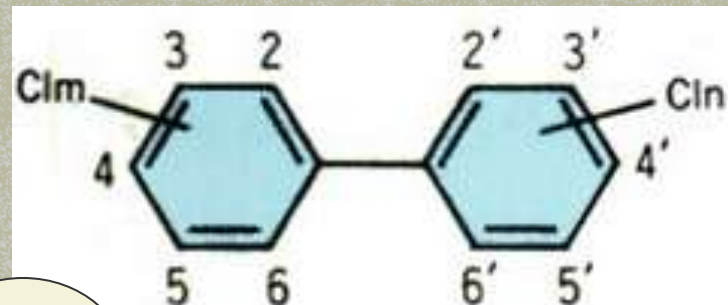
furans

Hg



dioxin

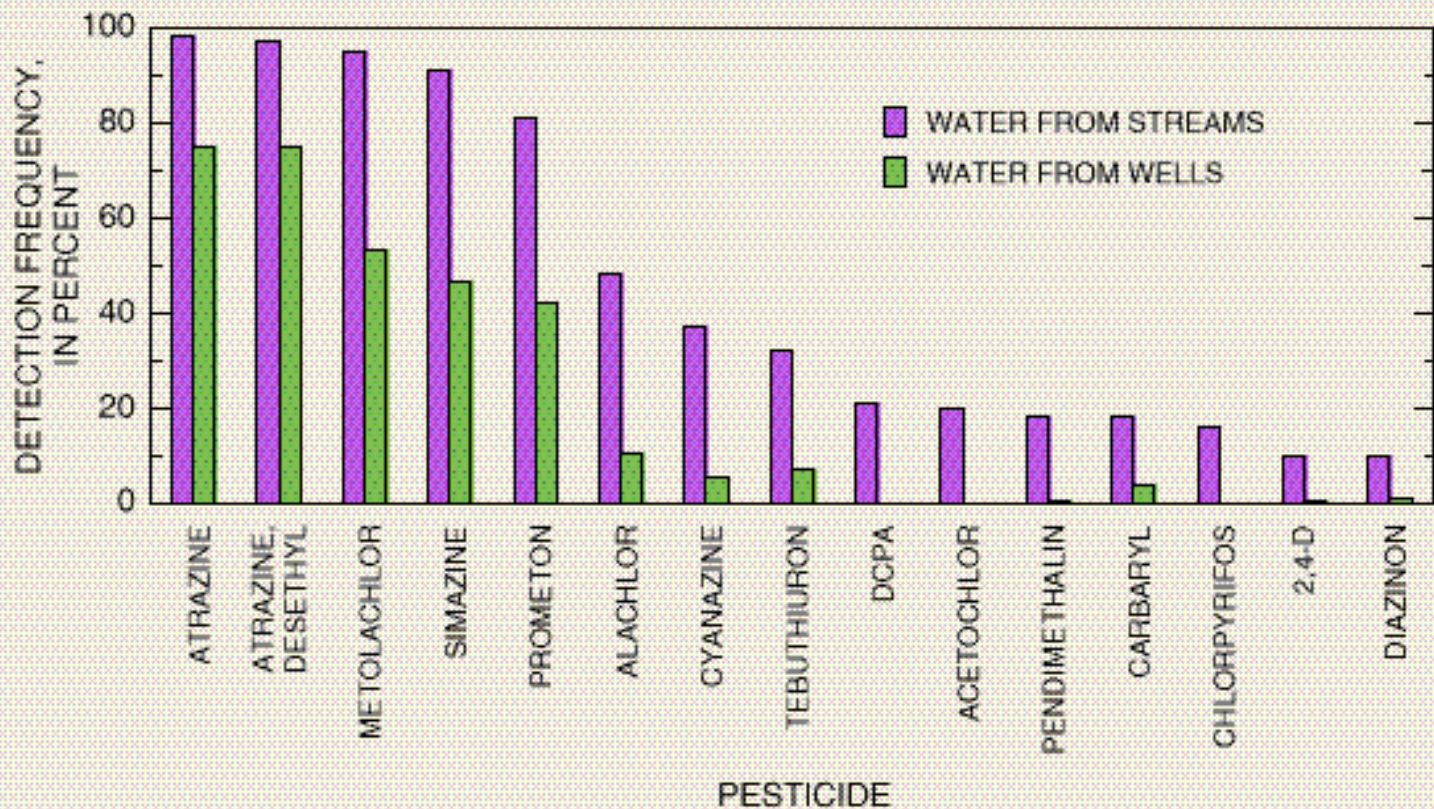
Cd



Pb

PCB's

PCB's occur with pesticides in the environment



The six most frequently detected pesticides were the same for water from wells and water from streams.



Summary and Conclusions

- PCB's are widespread and most abundant in aquatic sediments
- PCB's persist
- Low levels continue to affect humans, mink, fish and birds
- PCB's occur with pesticides, metals and other organic contaminants
- EPA concluded that there are substantial risks to humans and wildlife



Partial Bibliography

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- Dr Tim Kubiak



Mink Range Map



Mustela vison

Beluga Whale Range Map

