

PCBS AND WILDLIFE IN THE HOUSATONIC RIVER

Peter L. deFur

Laura Williams & Leigh Isaac

Environmental Stewardship Concepts

Richmond, Virginia

March 2012

Pdefur@estewards.com

Copyright 2012

My Perspective

- Environmental Biologist
- Consult for communities
- Waters around the nation

- Hudson

Newark Bay

- Delaware

Potomac R

- Willamette

James R

- Duwamish (Seattle)

Brunswick GA

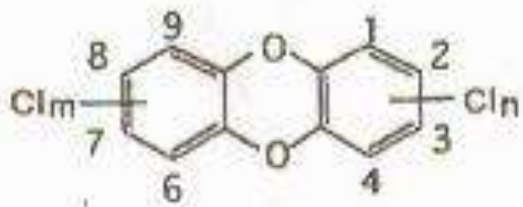
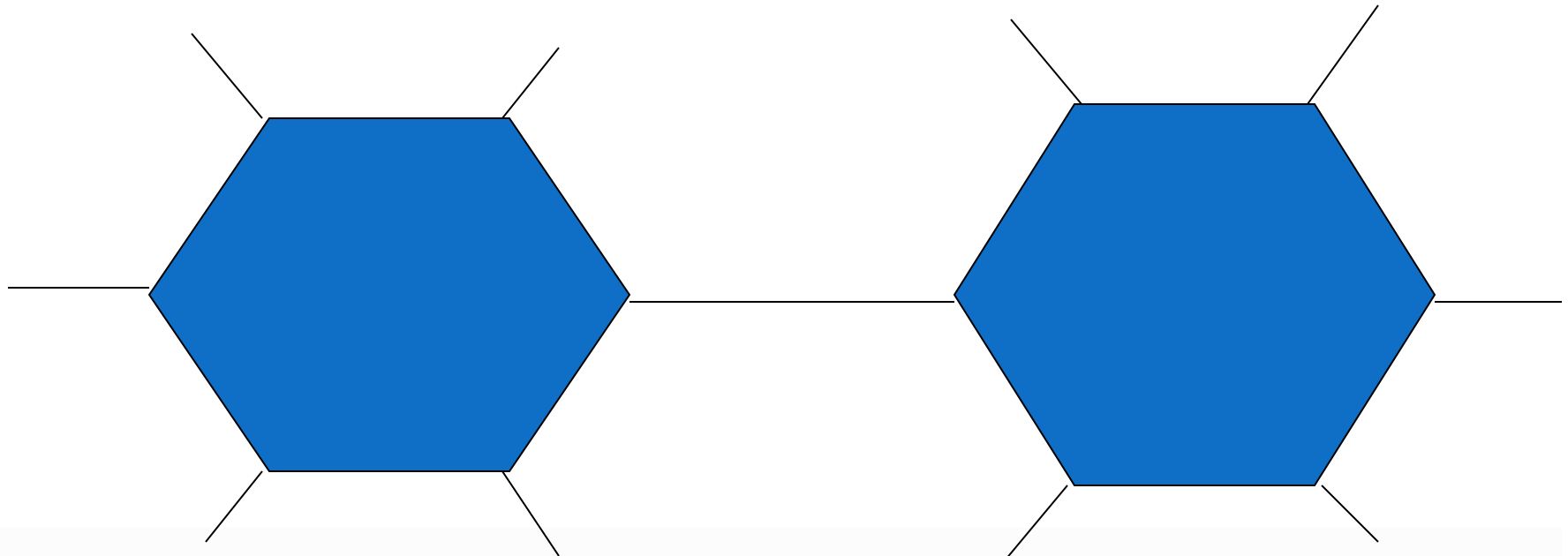
- Fox R, WI

Spokane R WA

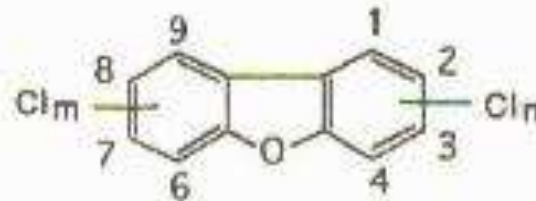
- Neuse NC

Humboldt Bay CA

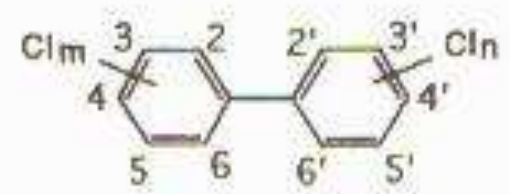
PCDD, PCDF, and PCB Molecules:



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

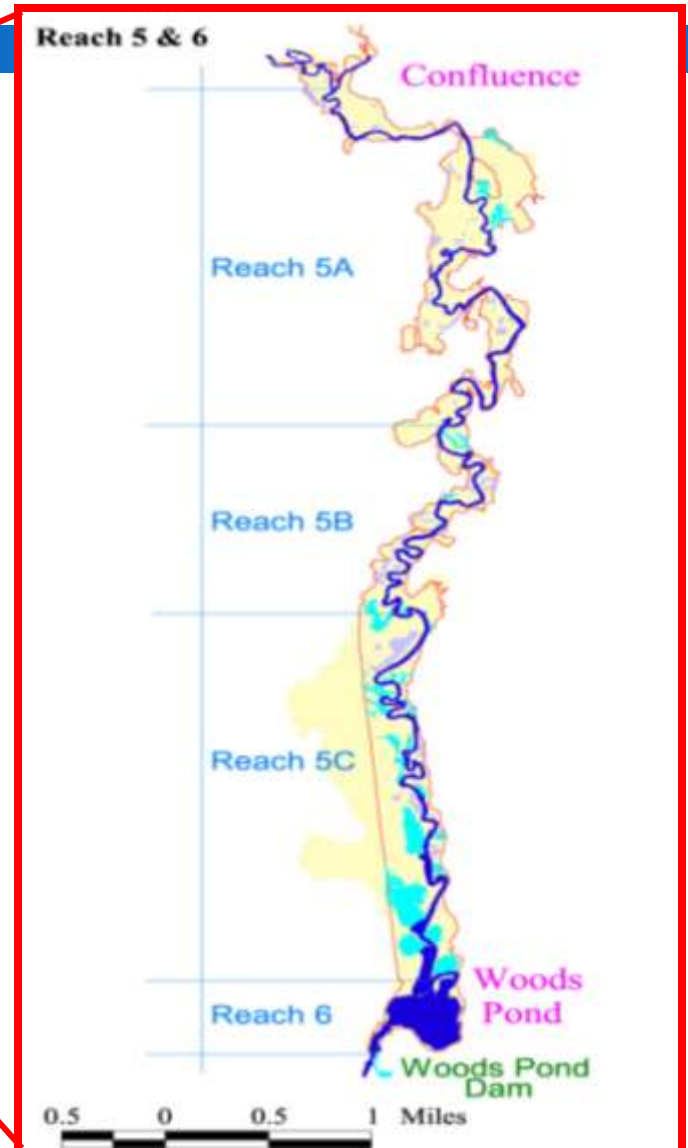
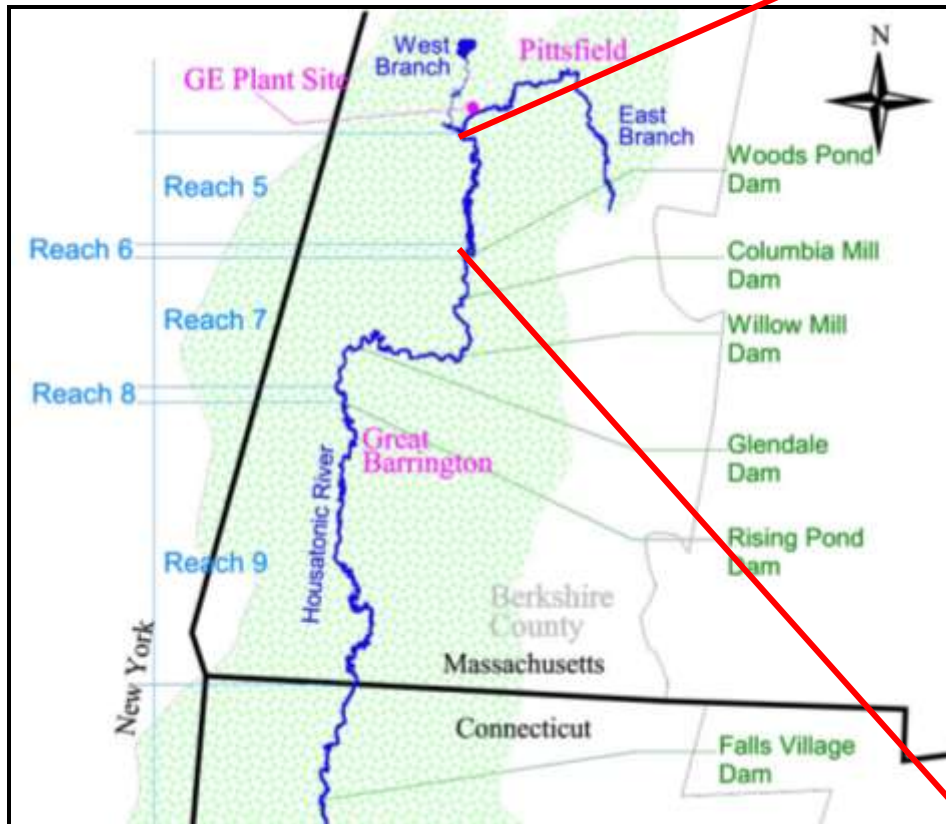


PCDF ($m + n = 1 \sim 8$)



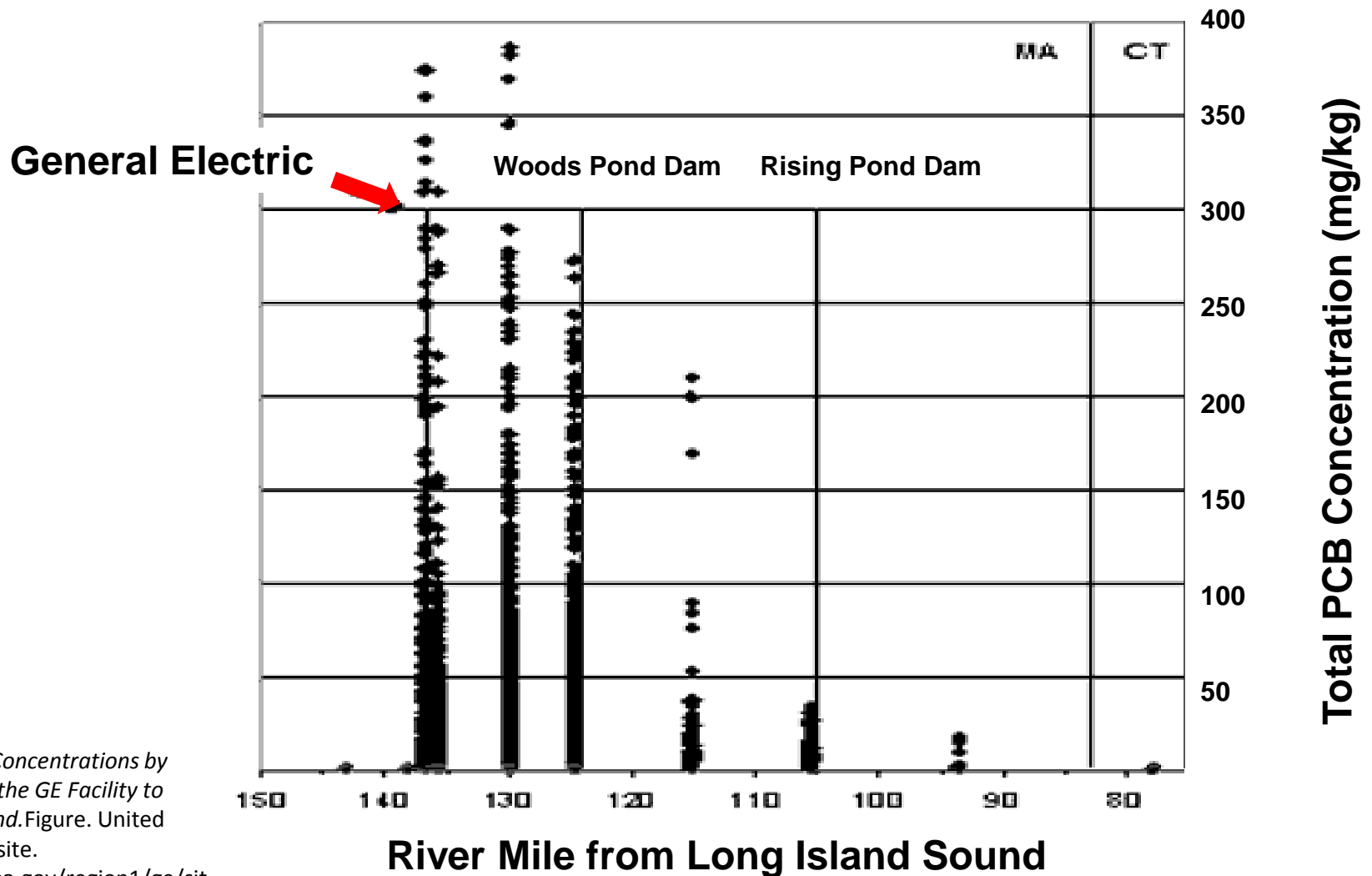
PCB ($m + n = 1 \sim 10$)

Housatonic River Reaches



Map. General Electric - Options for the Housatonic Website.
<<http://www.housatonicoptions.com/maps-of-the-housatonic-river/>>.

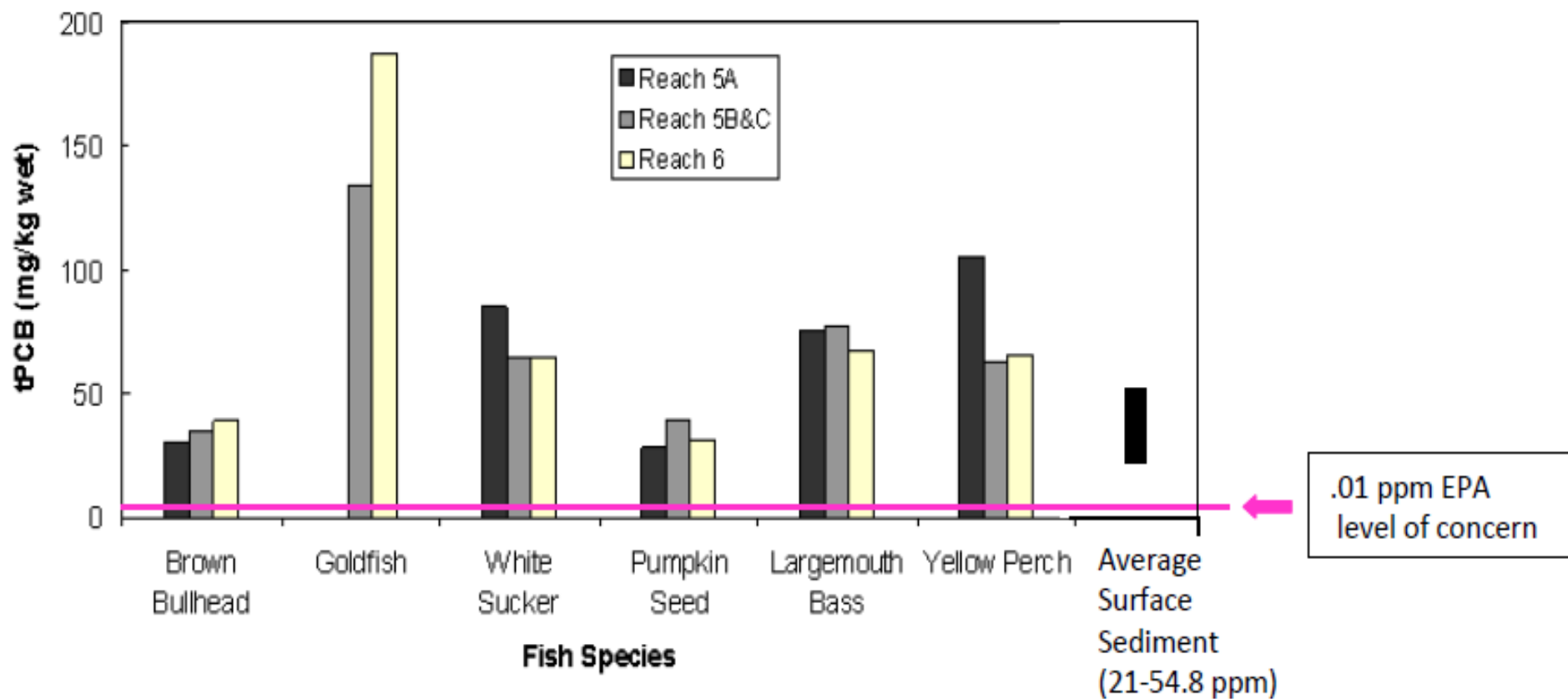
River Sediment Concentrations



Sediment tPCB Concentrations by River Mile from the GE Facility to Long Island Sound. Figure. United States EPA Website. http://www.epa.gov/region1/ge/sit_ehistory.html.

Total PCB Fish Tissue

Mean Total PCB Concentrations in Fish Tissue on the Housatonic



Modified from Figure 2. EPA Fish Collection (1999-2000) Observed Mean tPCB Concentrations – All Ages

EPA Fish Collections(1998-2000). Graph. United States EPA Website. 30 Mar 2012. <<http://www.epa.gov/region1/ge/sitehistory.html>>.

Effects on Wildlife

- Reproductive impairment in fish, birds and mammals
- Reproductive failure in mink
- Developmental abnormalities in fish, mammals and birds

Effects on Wildlife

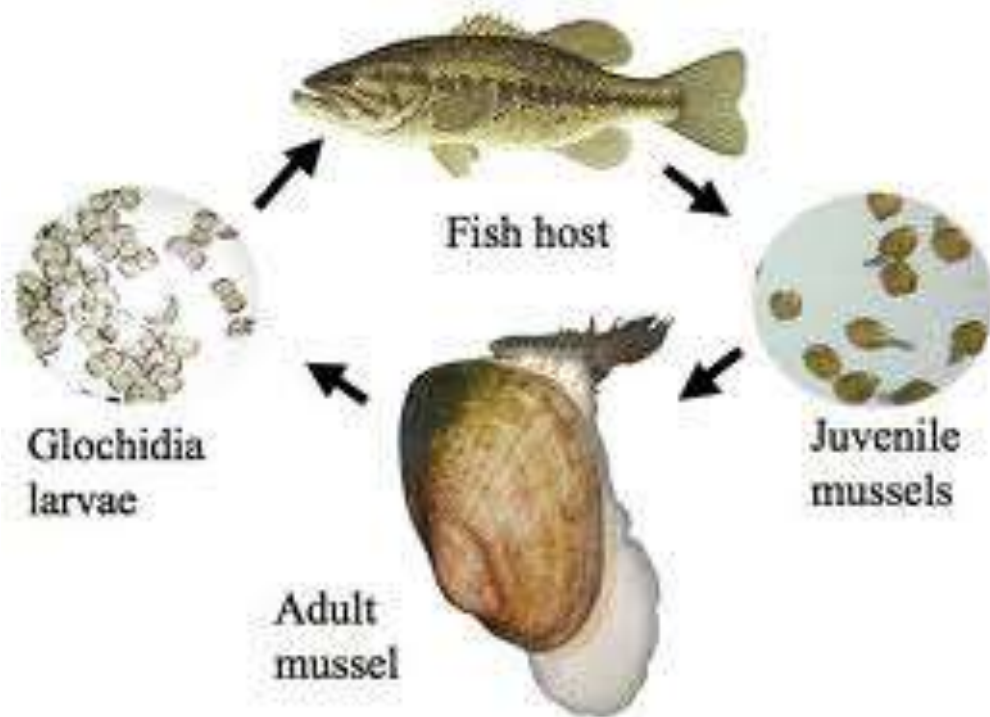
- Biochemical and morphological effects on birds and fish
- Multigenerational effects
- Persistent and high levels in aquatic animals
- Bioaccumulation

Ecological data from...

- Mink
- Bald Eagle
- Snapping Turtles
- Rainbow Trout
- Bottlenose Dolphins
- Benthic Invertebrates
- Blue Crabs
- Waterbirds
- Zebrafish

Effects on Clams

- Biochemical changes
- Causes lesions
- Threat to reproduction



Margaritifera margaritifera

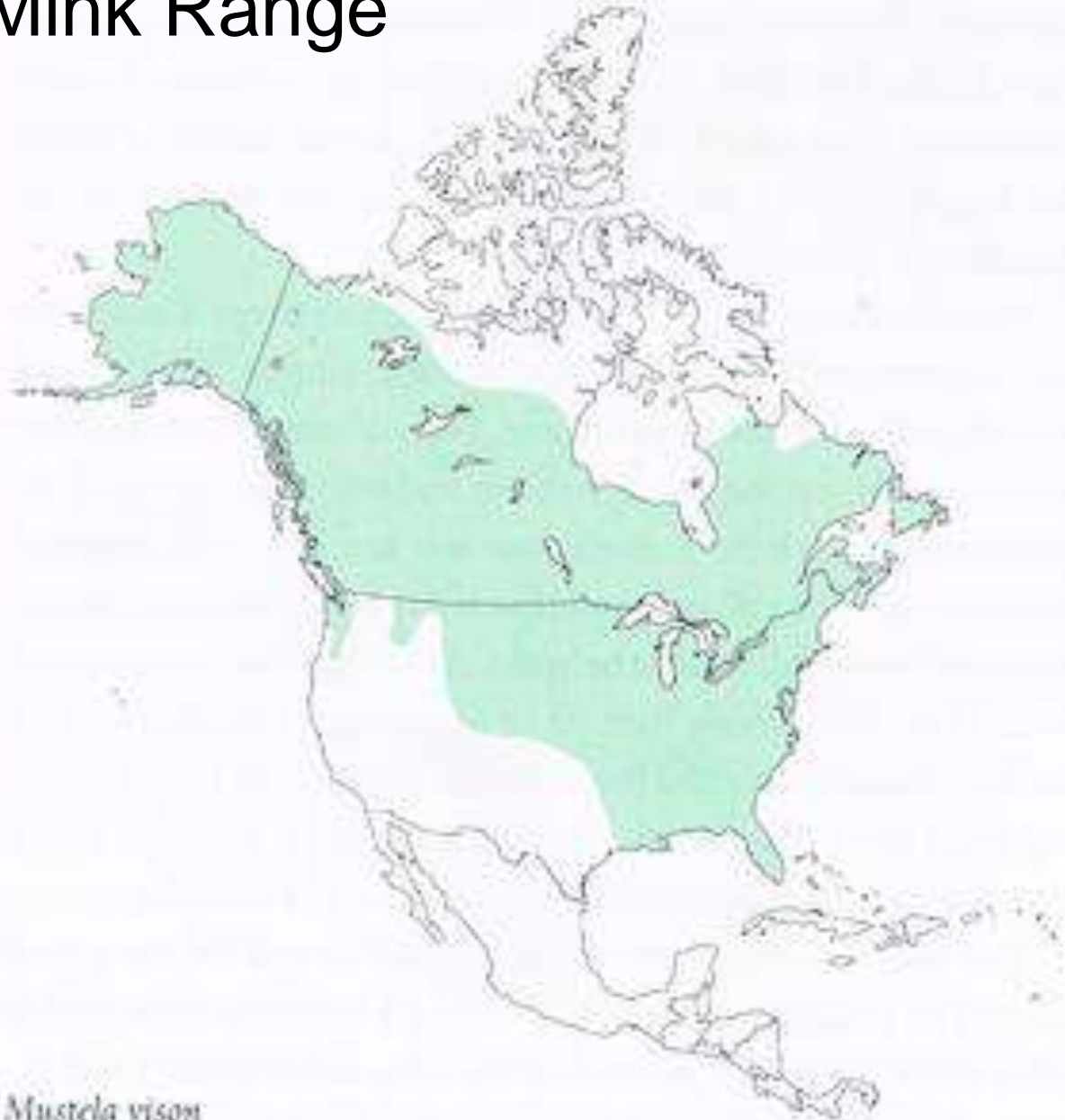


Lampsilis radiata

Effects on Mink

- Reproductive failure
- Wild populations declined or lost
- Fish consumption is key pathway
- Great Lakes

Mink Range



Mustela vison

Mink



- 1 ppm: significant difference in kidney, liver, brain, spleen, heart, and thyroid gland weights
- .5 ppm: litters had greater mortality and lower body weights
- 0.25 ppm: delayed onset of estrus... lessened whelping rate

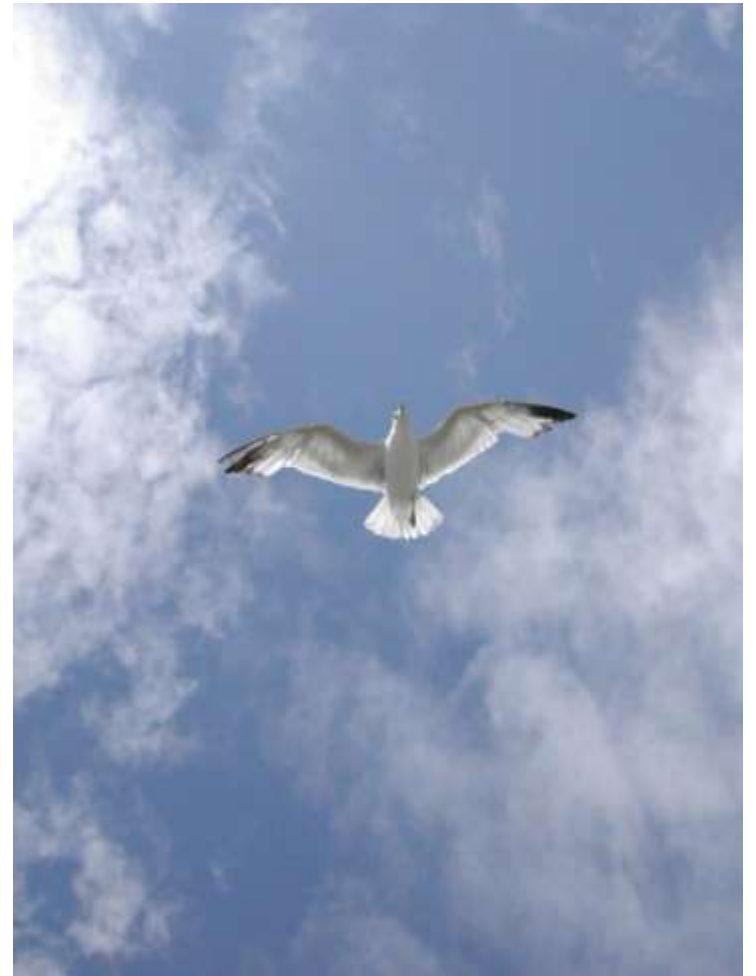
River Otters



Effects on Bird Species

- Mortality
- Population declines and limitations
- Developmental abnormalities
- Behavioral abnormalities
- Still food contamination
- Biochemical and morphological effects





Gulls



Bald Eagle

Kingfisher - Hudson

- More lower numbered PCBs in eggs than other rivers
- Source: Aroclor 1016 and 1242
- Contamination could disrupt reproductive success



Tree Swallows - Housatonic

- Insectivorous – 70% of diet = aquatic
- Average total PCBs in eggs and nestlings- highest reported anywhere for tree swallows- higher than most piscivorous birds

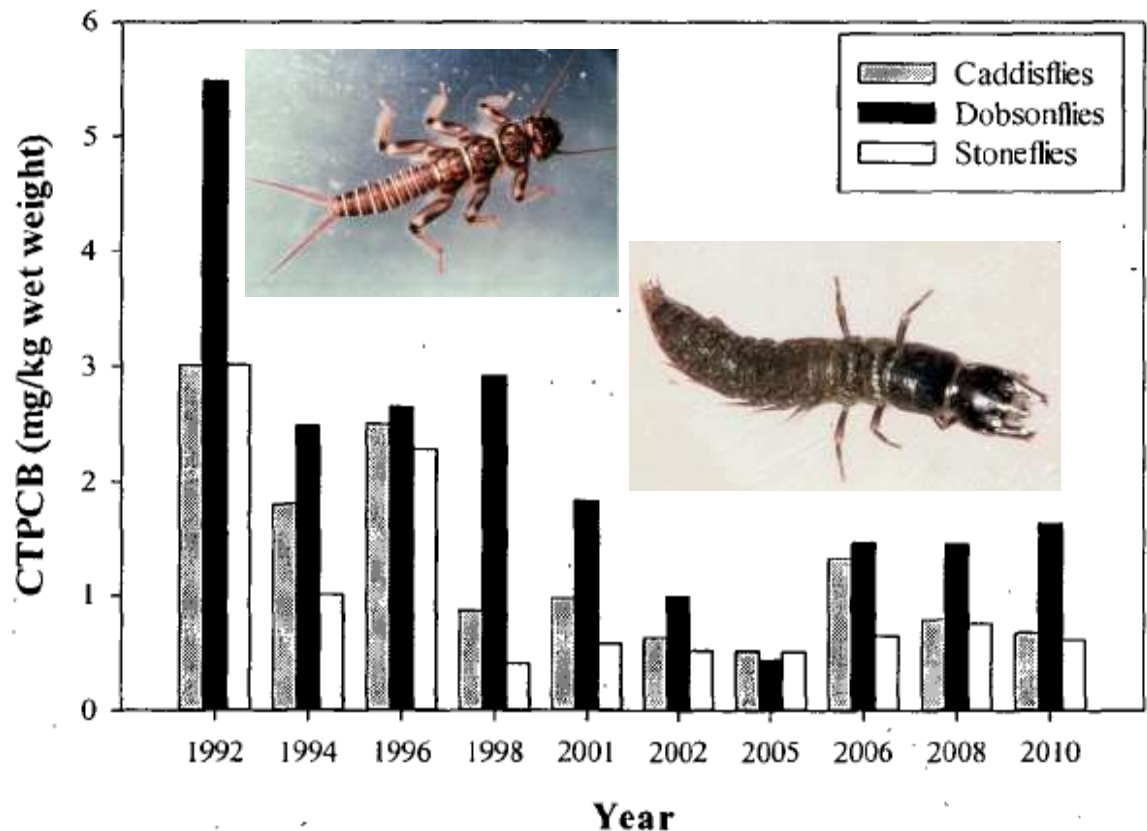


- Small but significant lower hatching success of tree swallows at 8,000-14,000 ppt TEQ (found in the eggs)

Aquatic Insects – Housatonic River

- 2010: West Cornwall
- Collected benthic aquatic insect larvae
- CTPCB=total PCB
- 2010 range:
 - Approximately 0.6 - 2.0 ppm

Total PCB Levels Found In Aquatic Insects



PCB Concentrations in Fishes from the Housatonic River, Connecticut, 1984-2010 and in Benthic insects, 1978-2010. November 2011

Invertebrates – Bioindicators?

- Invertebrate contaminant levels are good indicators of the PRESENCE of contaminants in sediment
- Invertebrate health NOT a good indicator of the HEALTH of the river
- Ex. Invertebrates can metabolize contaminants
 - Induce cytochrome P450
- PCB Aroclor: 4 day LC₅₀
 - Stonefly: 424-878 ppb
 - Rainbow Trout: 114-159 ppb



Effects on Fish

- Developmental abnormalities
 - ▣ Developmental effects on retina in zebrafish
- Population declines
- Behavioral problems?
- Mortality
- Migration
- Morphological deformities



Zebrafish



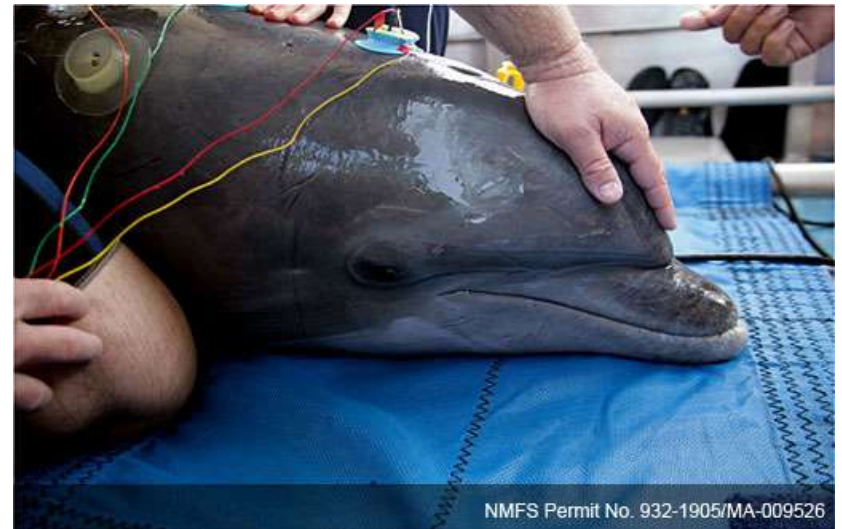
Rainbow Trout



Blue Sac Disease

Bottlenose Dolphins

- ❑ PCB concentrations in male dolphins are among the highest reported values in marine animals
- ❑ Exposed dolphins have been found to experience:
 - ❑ Anemia
 - ❑ Reduced thyroid hormone levels
 - ❑ Decreased immunity



A 2009 study of dolphins off the coast of GA revealed that the animals have the highest PCB levels in marine life ever recorded

<http://oceanservice.noaa.gov/news/weeklynews/feb10/dolphins.html>

Acknowledgements:

- Tim Gray and the Housatonic River Initiative
- Students, scientists, and community members
- J. She, et al., 2007. Chemosphere 67 (9): s307-s317
- L. Needham. 2003. CDC Report on NHANES

WARNING

**HOUSATONIC RIVER FISH
CONTAMINATED WITH PCBs**



DO NOT EAT
fish, frogs or turtles from this river

ANGLERS: Please release unharmed any fish
caught in the Housatonic River

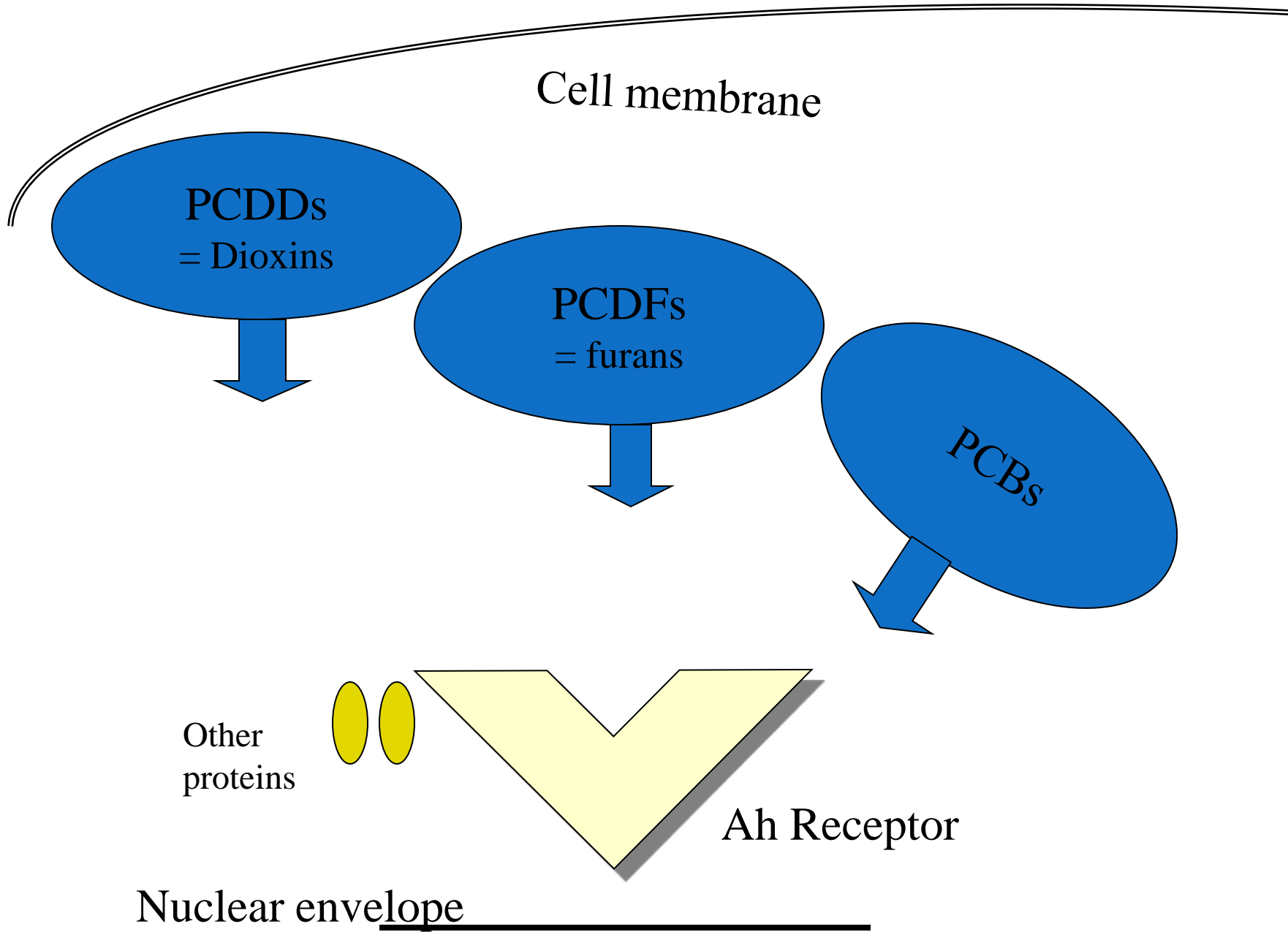


How do PCBs Act?

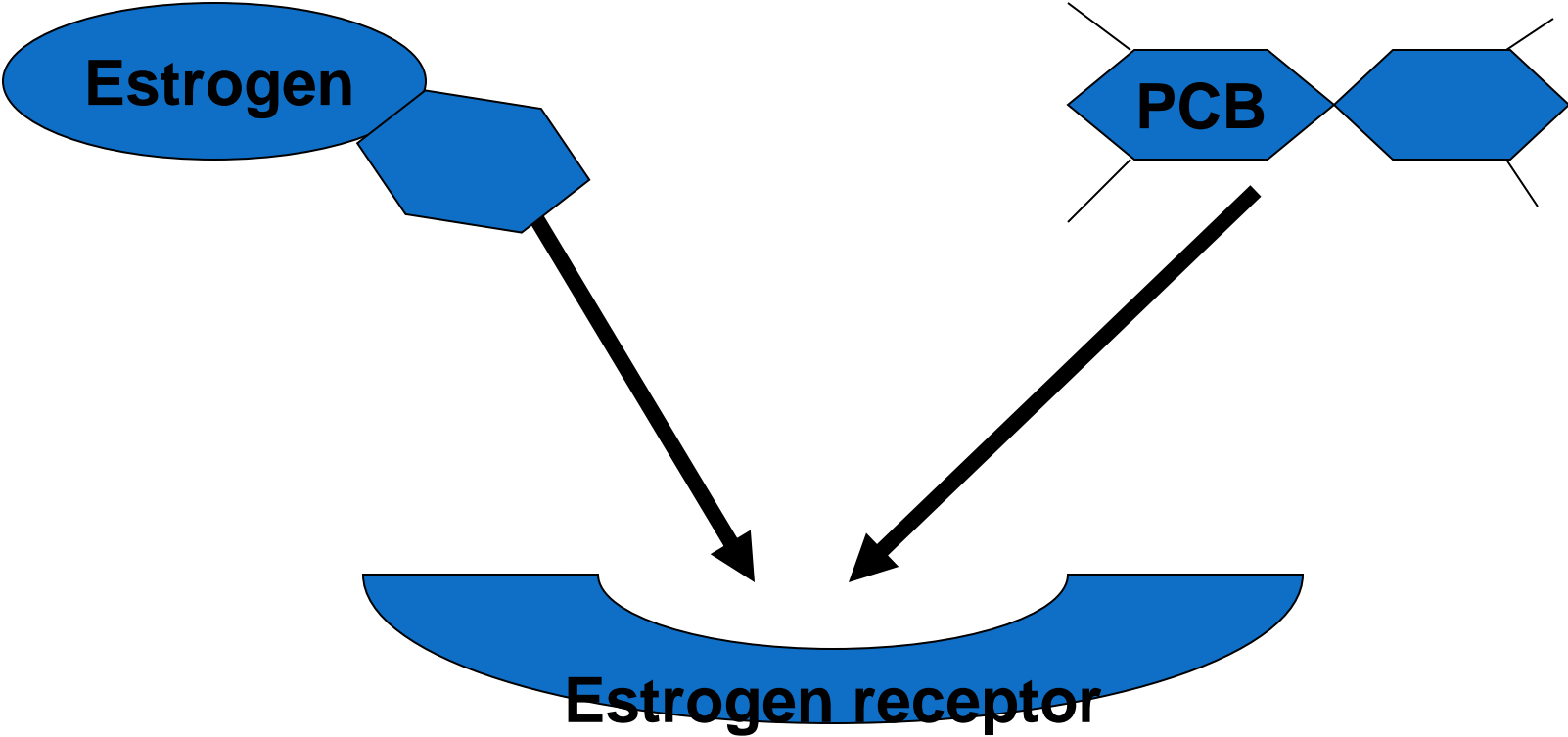
Different ways of affecting living systems:

1. Dioxin-like actions
2. Estrogenic actions
3. Direct actions
4. Neurodevelopment of the brain

Dioxin-like actions



Estrogen-like actions



Important properties of PCBs

- Dissolve in fats and oils, not water
- Do not break down easily, persist throughout food chain
- Accumulate in fatty tissues and organic matter
- Slightly volatile- form vapor in summer
- Most exposures are through food, not water
- Toxic at low levels for long periods

PCBs in Lake trout in Great Lakes

174

PRINCIPLES AND PROCESSES FOR EVALUATING ENDOCRINE DISRUPTION

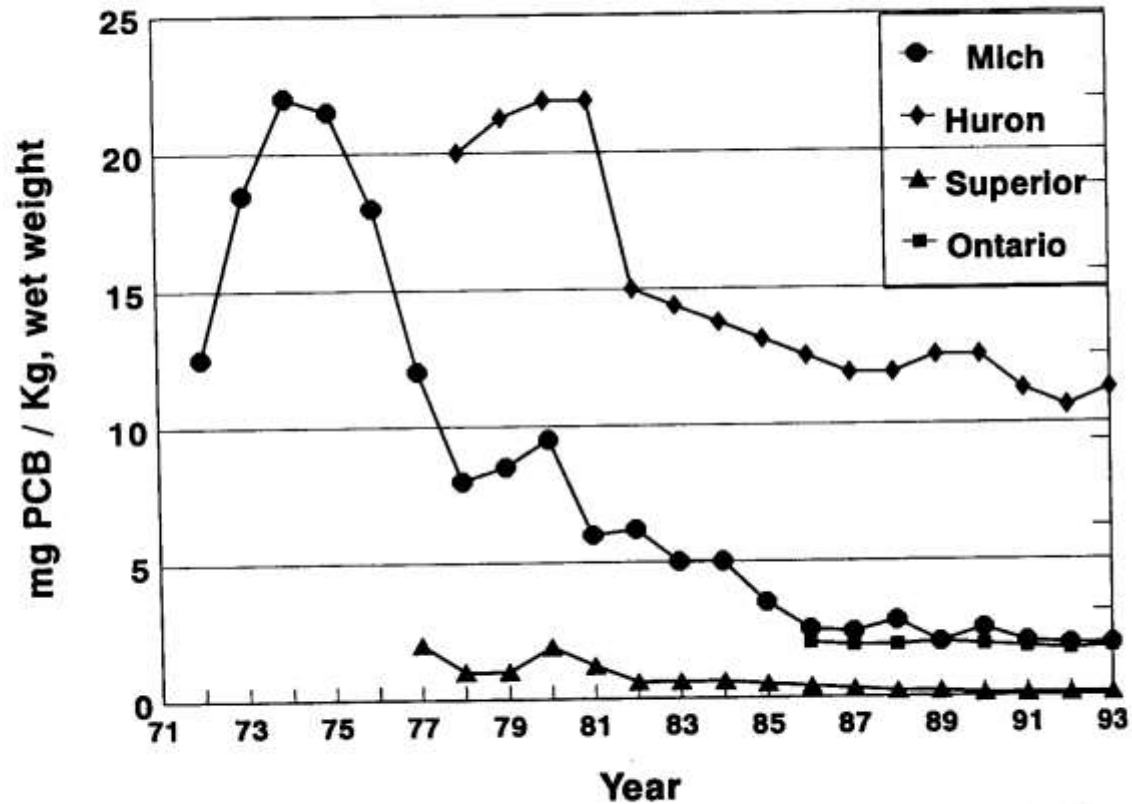


Figure 8-2

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*.

Effects on Bivalves

- Clams had reduced levels of Glutathione
 - An antioxidant
- Oxidative stress
- Three types of lesions:
 - Gonadal atrophy, accumulation of Brown cells
 - Generalized edema
 - Necrosis and inflammation of digestive glands and foot processes
- Threat to bivalve reproduction

Benthic Invertebrates

- Decreased metabolism rates
 - ▣ Regulated by enzymes
- Multigenerational exposure
 - ▣ Developmental effects present in second generation of exposure
- Deep-burrowing organisms contained 36 times higher PCB concentrations in tissue than similar surface-dwelling organisms

- Decreased mortality rates

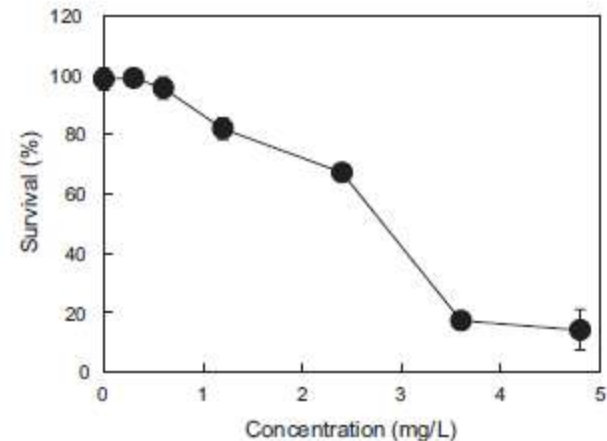


Fig. 1. Survivorship of nauplius *Tigrionus japonicus* exposed to polychlorinated biphenyl (PCB) 126 (3,3',4,4',5-pentachlorobiphenyl) during 96-h acute toxicity tests. Data are mean \pm standard deviation ($n = 8$).

Guo et al., 2011

Blue Crabs

- Bioaccumulation
 - PCB concentrations in sediments reflected in concentrations in crabs
 - TEQs are higher in the hepatopancreas (digestive gland) of the crabs than in the sediment



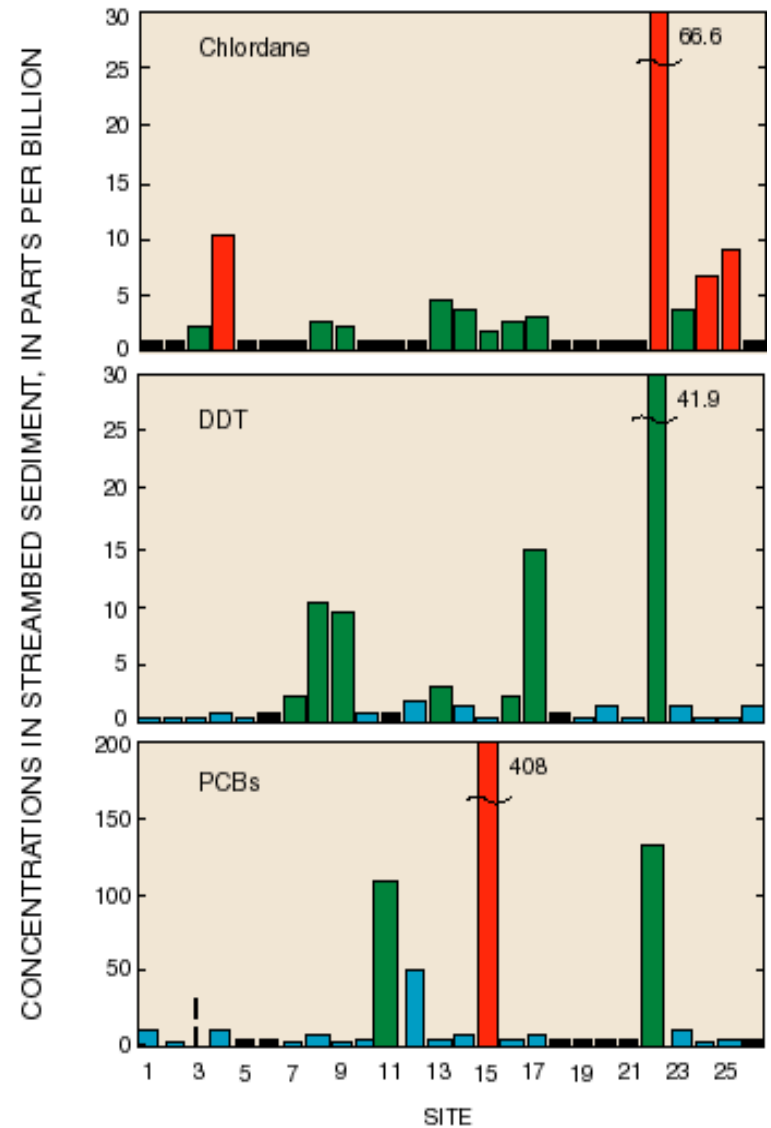
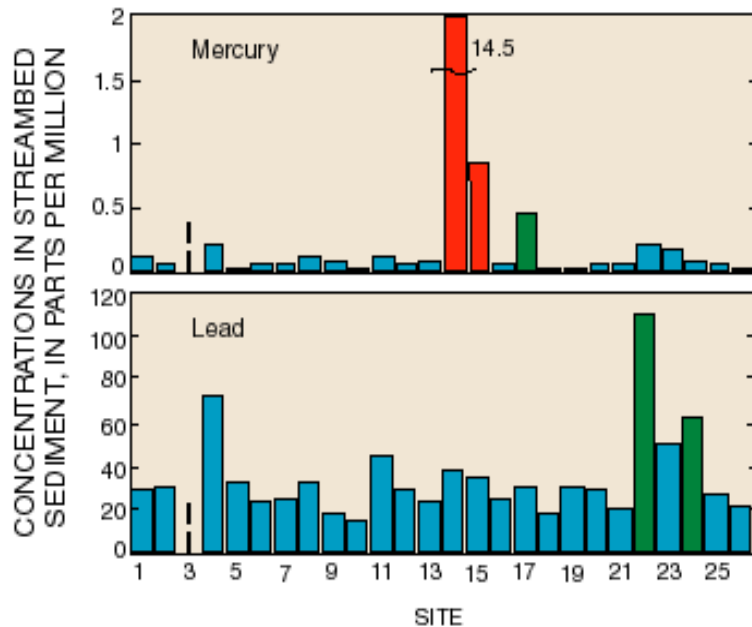
Chronological Examination of Human Exposure

- **1929-** PCBs first introduced
- **1938-** First DDT manufactured
- **1939-45 (WWII)-** First widespread human exposure to chemicals
- **1940-50-** First generation exposed postnatally
- **1950-70-** First generation exposed in the womb
- **1970-2000-** First generation exposed in the womb reaches reproductive age

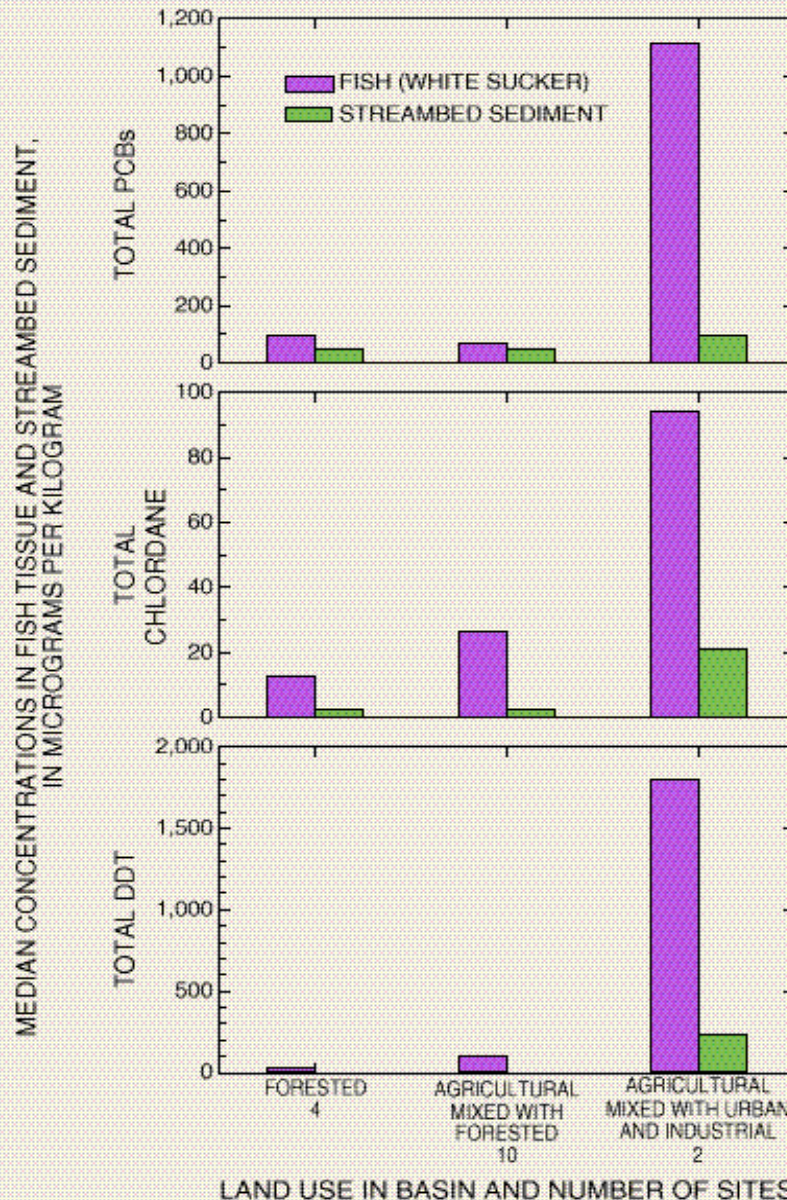
EXPLANATION

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



Fish Tissue and Sediment Levels of PCBs etc.

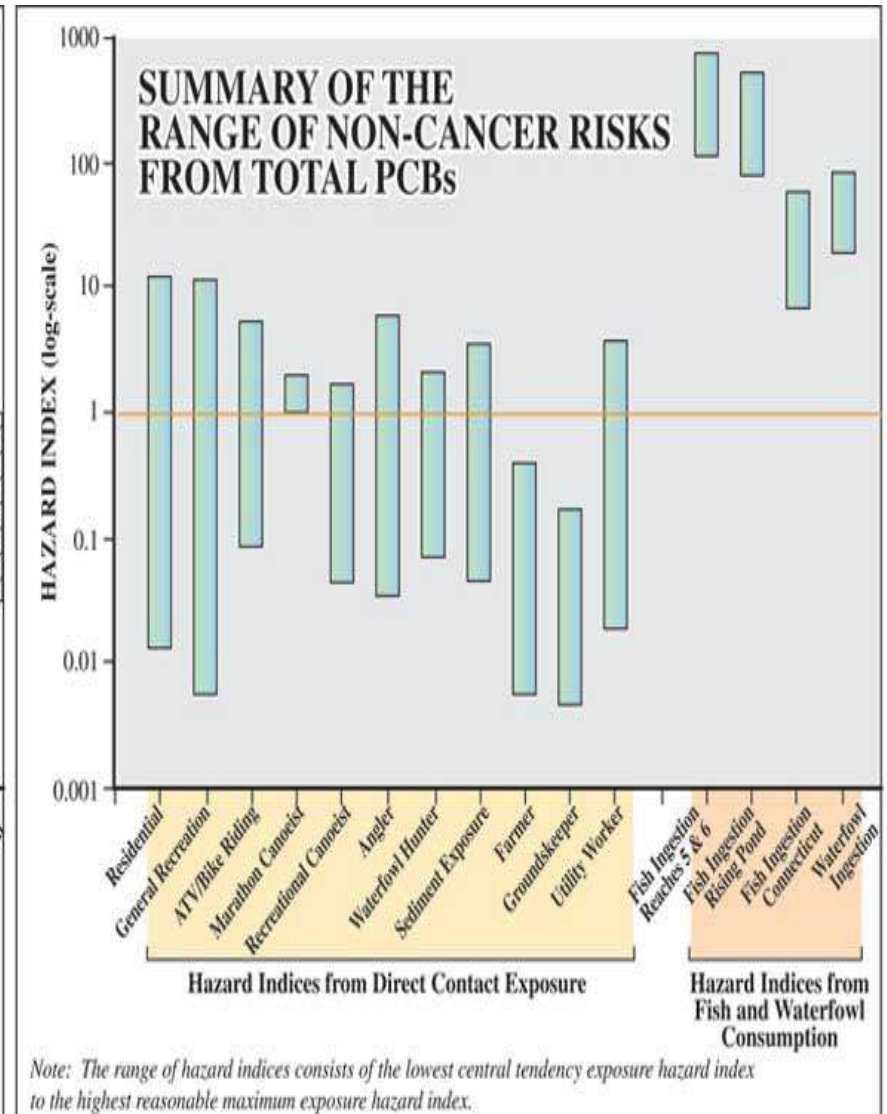
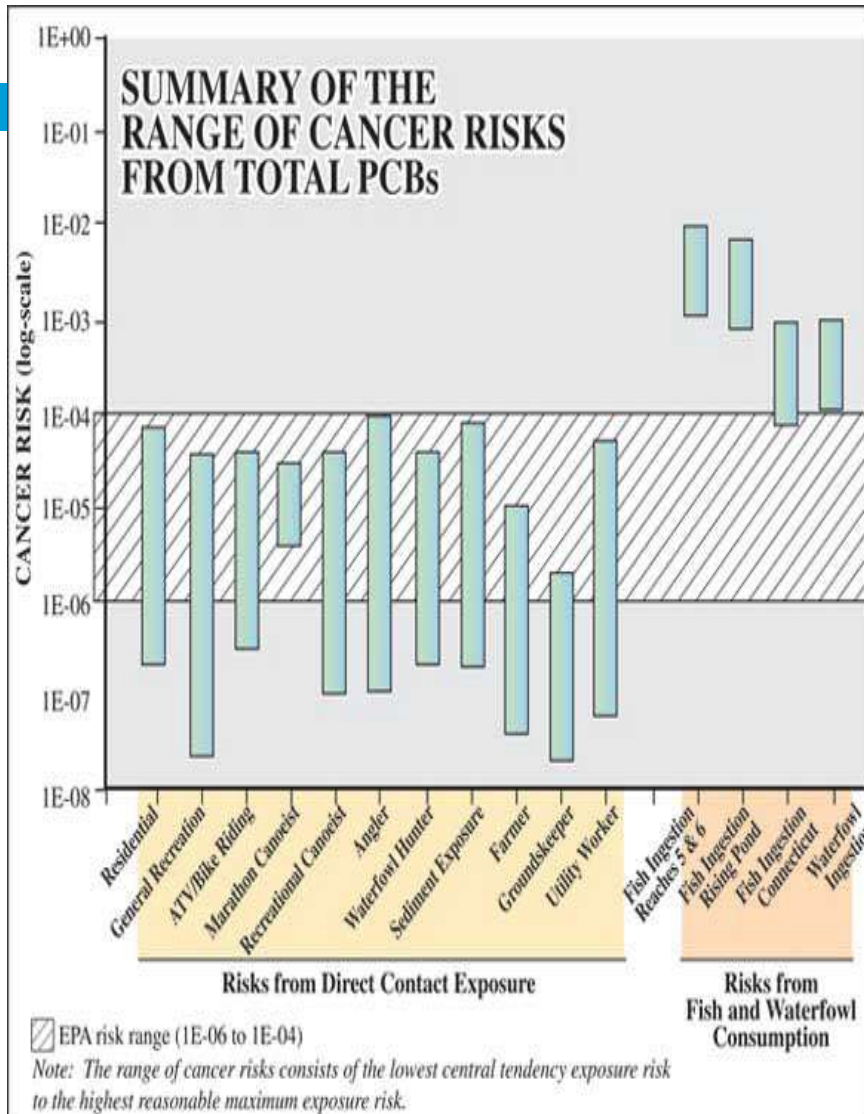


Median concentrations of total organochlorine pesticides and total PCBs in white sucker tissue and streambed sediment are grouped by the predominant land use in the basin to illustrate the effects of land use.

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)

Current risks from Housatonic site



From EPA's August 2009 Fact Sheet

PCBs are present in breast milk

- CDC shows PCBs present in the US population at concentrations of 2.7 ng/g (=parts/billion) in blood serum
- PCBs accounting for 40% of dioxin-like activity in serum
- Recent study in NW US reported PCBs in breast milk consistent with results around the world

L. Needham. 2003. CDC Report on NHANES



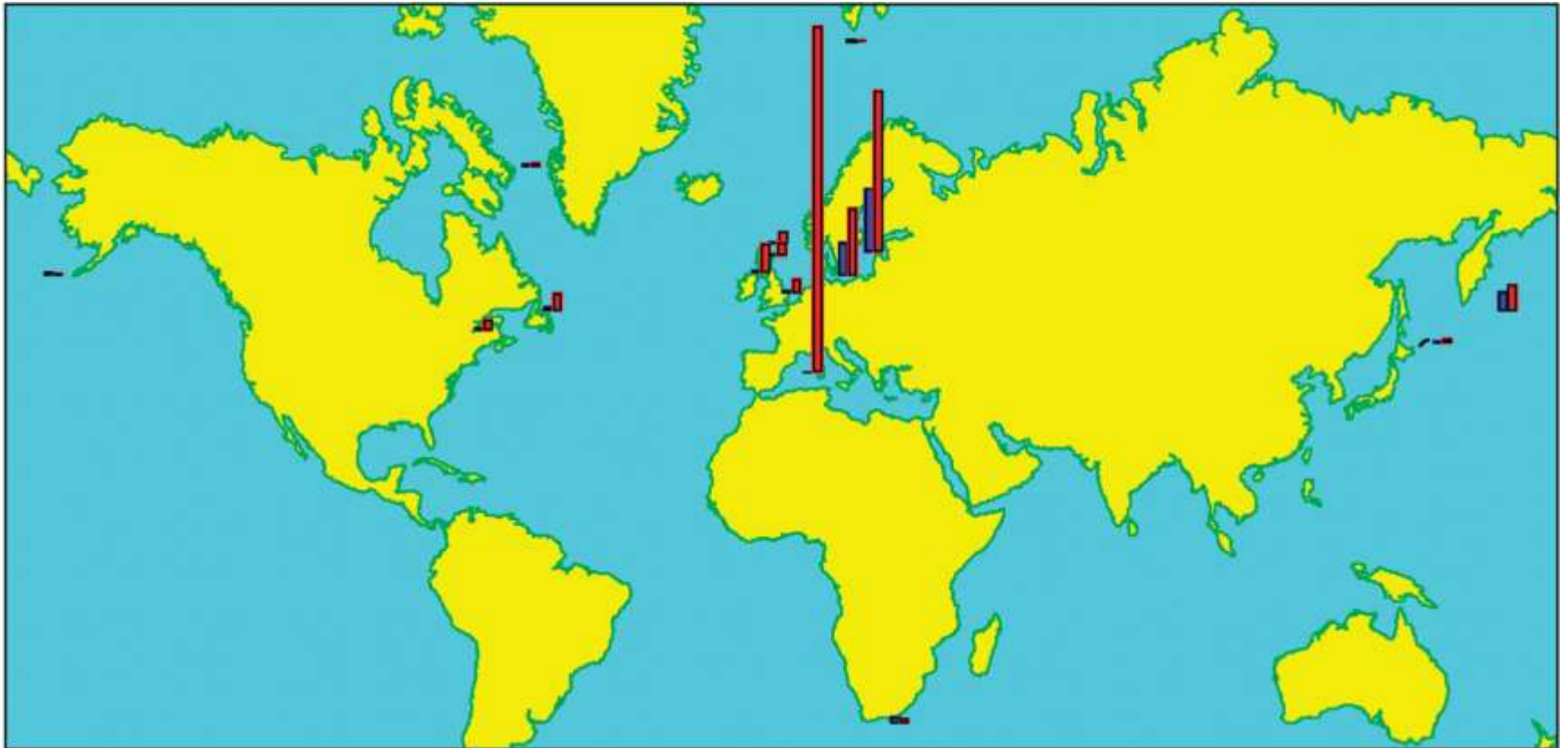
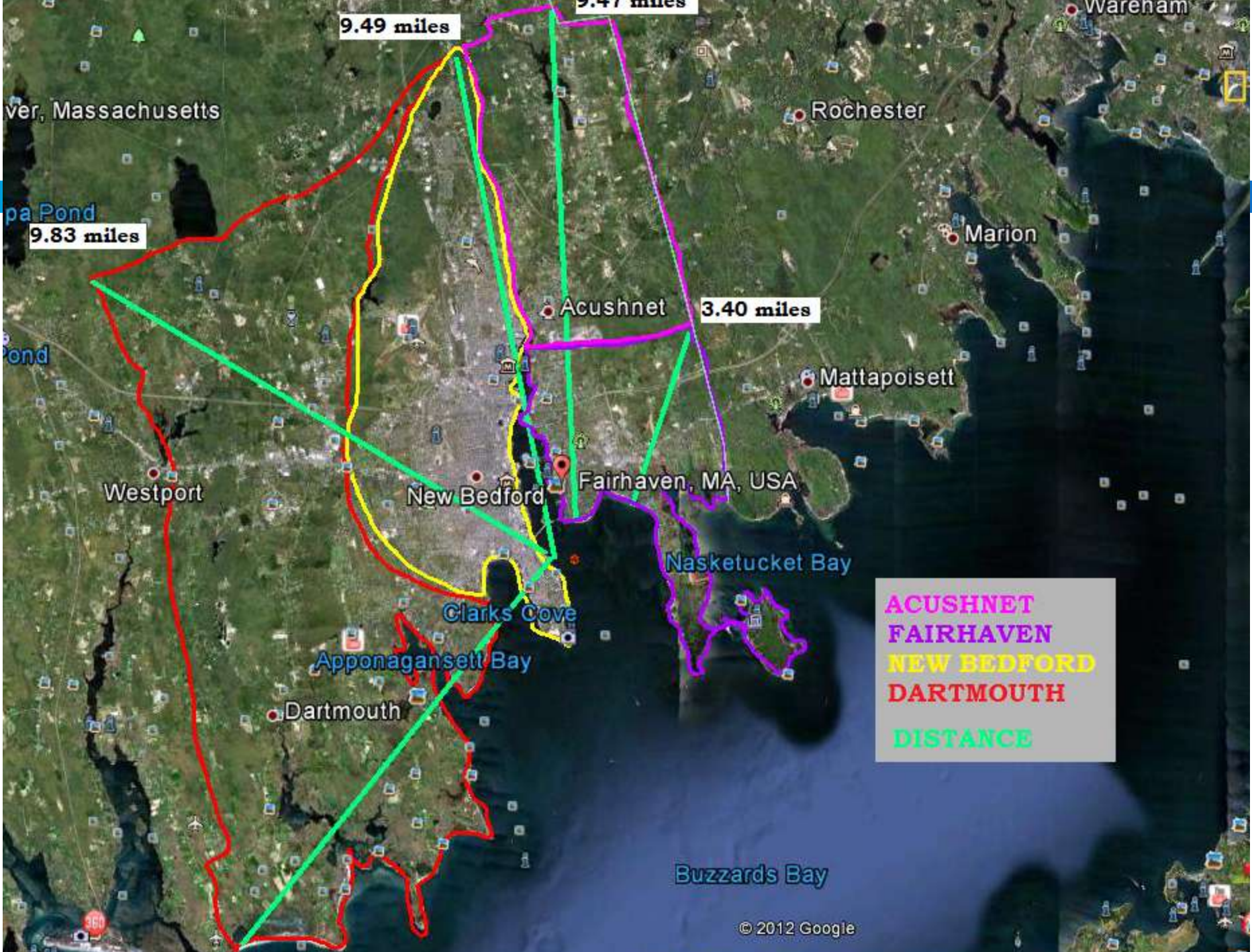


Figure 6.5 - TEQs (pg/g lipid weight) and PCB concentrations (ng/g lipid weight) in human milk from 18 countries around the world. TEQs 1987/88 = blue bars and 1993/94 = red bars; highest bar = 40 pg/g TEQ lipid weight.

Source: International Program on Chemical Safety "Global Assessment of the State-of-the-Science of Endocrine Disruptors" 2002

Behavioral effects of PCBs

- Sagiv et al.(2012): New Bedford, Massachusetts
 - 1993-1998: 788 newborns from four towns near New Bedford Harbor
 - Born to mothers who lived near the contaminated harbor and dumpsites— within 10 miles
 - Boys who were exposed to higher levels of PCBs in the womb scored lower on focus and concentration tests



Lake Ontario Findings

“The findings of poorer reflex functioning and greater autonomic immaturity from the high-fish group are consistent with Jacobson’s findings... these babies are more reactive to unpleasant events than non-exposed babies in an additional test.”

-Jacobson 1983-92



Dioxin affects male reproduction

- PCBs and dioxin can act through the same mechanism
- R. Peterson and Co-workers at Univ. Wisconsin (1992, *Advances in Modern Environmental Toxicology*.)
- Dosed pregnant rats on day 15 of gestation
- Male offspring- reproductive problems that include structure, function, behavior

Living in the Vicinity

- Industrial contamination of the local environment may be an important source of exposure
- Boys within 2 km had PCB serum levels 63% higher than boys who grew up greater than 5 km from the factory. (Burns et al 2009)
- The environmental (soil, house dust) and human (breast milk, serum) samples were also higher in areas closer to the plant (Sergeyev et al 2007, 2008)
- Children born before or during dredging had higher cord serum PCB levels than children born after dredging (Choi et al 2006)

Good News- Bad News

- **PCB levels are declining in the developed world**
- **Other chemicals are on the rise**
- **PCB levels remain at levels not considered safe**
- **Further declines can be expected ONLY by removing PCBs from various sources**
- **Local and world –wide problem**