

# ***ATSDR's Great Lakes Human Health Effects Research Program: Body Burden Levels and Associated Health Effects in Vulnerable Populations***

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# *Elements of Presentation*

- **Historical Background**
- **Research Frame Work**
- **Body Burden Levels and Health Effects**
- **Public Health Implications**
- **Public Health Interventions**

# Great Lakes Basin

Minnesota

Ontario

Lake Superior

Wisconsin

Lake Huron

Lake Michigan

Michigan

Lake Ontario

Illinois

Lake Erie

New York

Indiana

Ohio

Pennsylvania



# ***Persistent Toxic Substances (PTSs) in the Great Lakes Basin***

- **Organochlorine Compounds**
  - Polychlorinated biphenyls (PCBs)
  - Hexachlorobenzene (HCB)
  - DDT and its metabolites
  - Dioxins (2,3,7,8-TCDD)
  - Mirex
  - Dieldrin
  - Toxaphene
  - Furans
- **Heavy Metals**
  - Alkylated lead
  - Methylmercury
- **Polycyclic Aromatic Hydrocarbons**
  - Benzo[a]pyrene

# ***ATSDR Great Lakes Research Program***

- **Created by the Great Lakes Critical Programs Act of 1990**
- **Designed to characterize exposure and investigate the association between the consumption of contaminated Great Lakes fish and short- and long-term harmful health effects**

# ***ATSDR's Strategy for Its Great Lakes Health Effects Research Program***

**This strategy is built upon the five traditional elements of disease prevention:**

- **Surveillance**
- **Evaluation**
- **Intervention**
- **Infrastructure development**
- **Impact assessment**

# Great Lakes Basin



# *Vulnerable Populations*

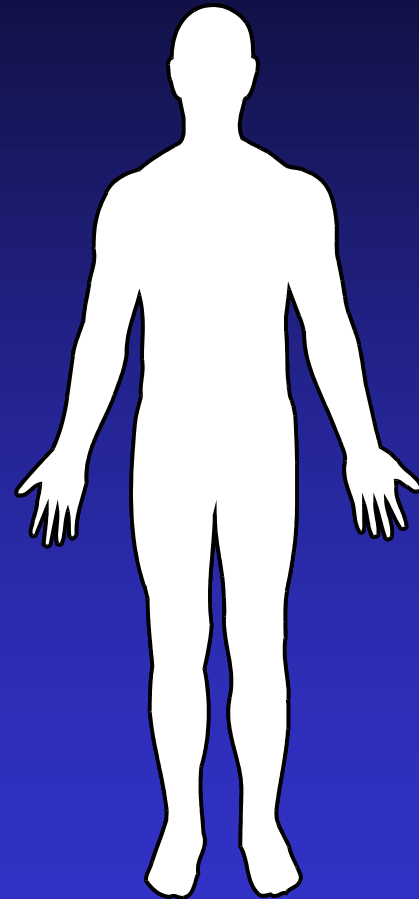
- Pregnant Females
- Nursing Mothers
- Fetuses and Nursing Infants
- Infants and Children
- American Indians
- Sport Anglers
- African-Americans
- Elderly





# *Human Health Endpoints*

- Behavioral
- Reproductive
- Endocrinologic
- Developmental
- Neurologic
- Immunologic



# *Great Lakes Research*

- **Exposure**

- **Levels of some contaminants in Great Lakes sport fish are above the advisory limits set by the state and federal government.**
- **The level for mercury in fish is .5 parts per million (ppm).**

# *Great Lakes Research*

- **Exposure (cont.)**
  - **Fish eaters consume on average two to three times more fish than the general U.S. population.**
  - **Average per capita is 10 - 17.9 grams/day.**
  - **Sport fish consumption is 12 – 54 grams/day.**

# *Exposure (cont,)*

- **Body burden levels of some persistent toxic substances in vulnerable populations are two to eight times higher than those of the general U.S. population.**
- **A significant trend of increasing body burden is associated with increased fish consumption.**

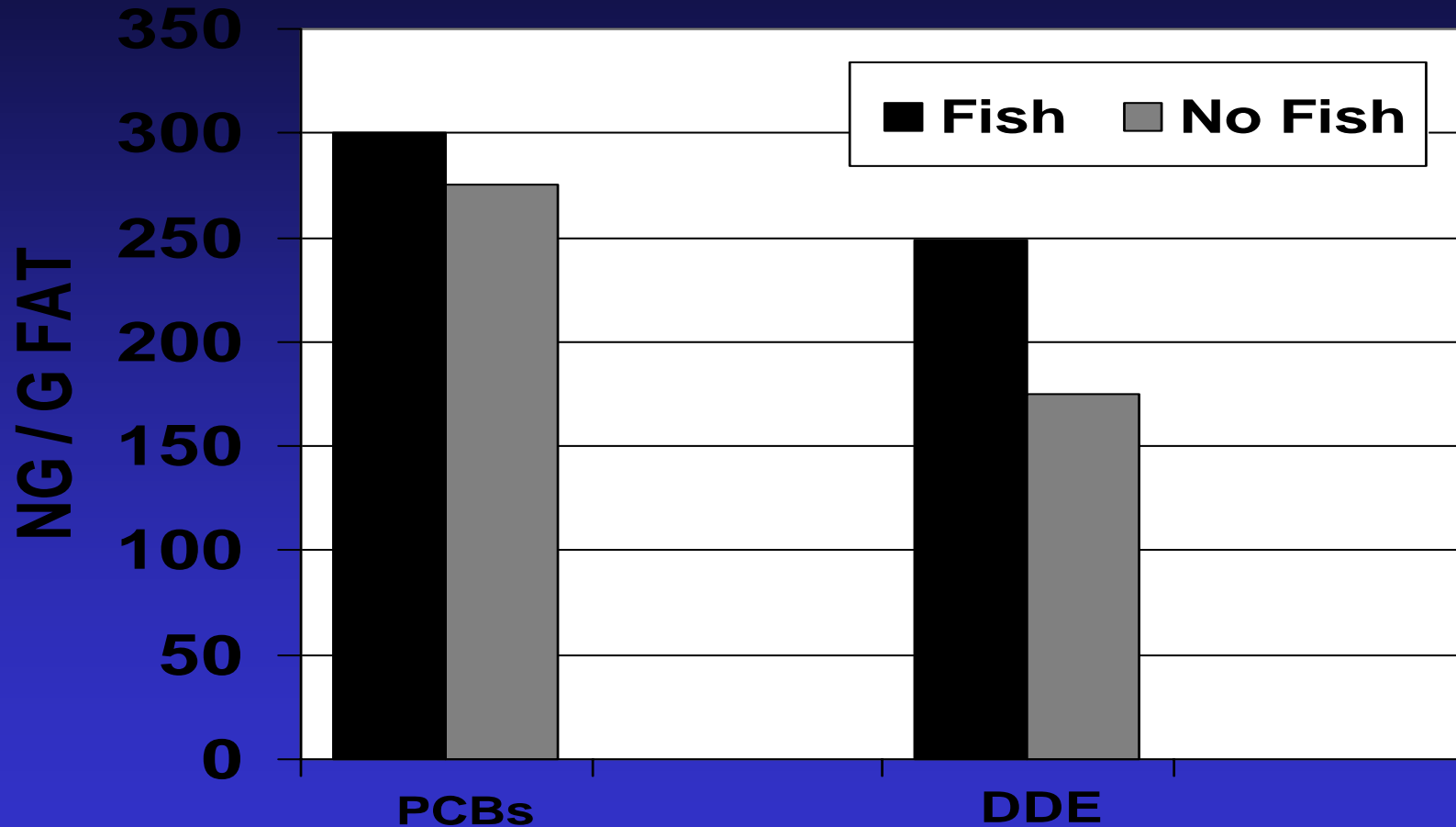
# *Reproductive Effects*

- **New York Angler Cohort Study**
- **One aspect of this study was to determine concentrations of PCBs, DDE, Mirex and HCB in breast milk samples from lactating women.**
- **Milk samples were collected from 213 women selected based on their fish consumption pattern.**

# Reproductive Effects Body Burden Levels

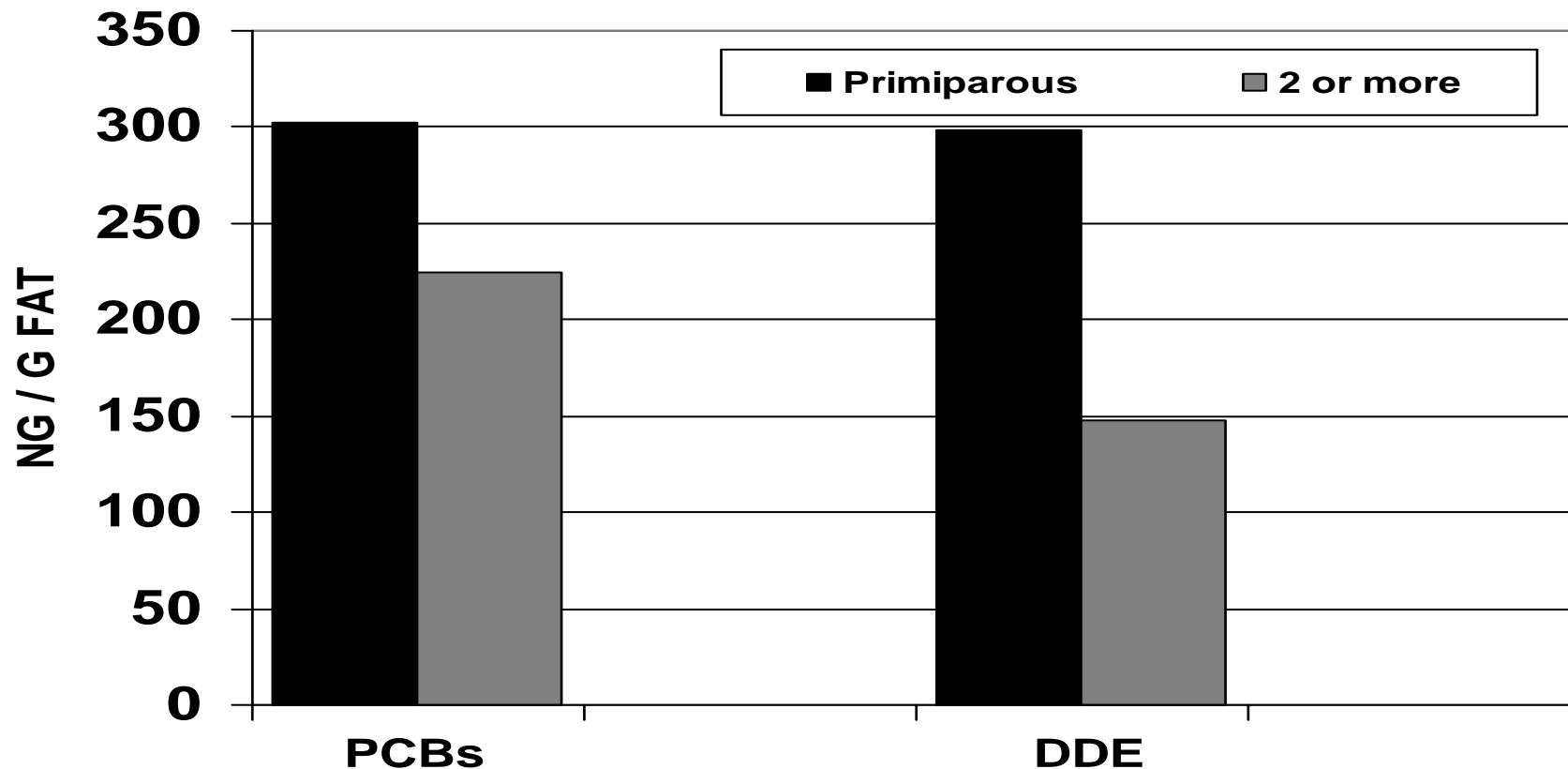
<b>Total PCBs</b>	<b>8.25 ± 4.66</b>
<b>DDE</b>	<b>7.26 ± 11.6</b>
<b>Mirex</b>	<b>0.133 ± 0.278</b>
<b>HCB</b>	<b>0.307 ± 0.422</b>
<b>Fat (g/gmilk)</b>	<b>0.032 ± 0.014</b>

# Relation between fish consumption and PCBs and DDE in breast milk



Differences were significant for total PCBs  
( $P = 0.002$ ), but not for DDE

## Relation between parity and PCBs and DDE in breast milk



Differences were significant for both PCBs and DDE at  $P < 0.001$



## ***Reproductive Effects (cont.)***

- **Significant menstrual cycle length reduction with consumption of more than one fish meal a month**
- **Increased risk of infertility**
- **Reduction in the duration of lactation**

**(Buck et al. 1997; Mendola et al. 1997; Kostyniak et al. 1999; Buck et al. 2000)**

# ***Developmental Effects:***

- **Mothers who consumed on average 2 fish meals a month had newborns with decreases in gestational age by 4.9 days and birth weight by 160 to 190 grams.  
(Fein et al. 1984; Jacobson et al. 1985)**

**In a recent study of Michigan fish consumers investigators observed a significant decline in birth weight ~ 500 grams in newborns of mothers who had PBC serum levels of  $\geq 25$  ppb. (Karmaus and Zhu, 2004)**

# ***Developmental Effects Changes in Sex Ratio (cont.)***

- **Parents exposed to DDE and PCBs had a higher than expected proportion of male children if the father had elevated PCB levels greater than 8 parts per billion (sex ratio, 2.29; 95% confidence interval).**
- **Of the 208 children borne to 101 couples, 126 were males and 82 were females in comparison to the normal sex ratio of 102 males born for every 100 females. (Karmaus et al. 2002)**

# ***Developmental Effects Changes in Sex Ratio (cont.)***

- **A study by Weisskopf et al. 2004 demonstrated that mothers who have serum PCB levels of 4.7 ppb were less likely to have a male child than mothers with the lowest serum level of 0.7 ppb.**

# *Developmental Effects (cont.)*

- Mothers who consumed two or more fish meals/month the risk of a male having a birth defect was significantly elevated (OR = 3.01) in comparison to females: OR = .73) [ New York Cohort - Mendola et al. 2005]

# ***Neurodevelopmental Effects:***

- **In newborns and children:**
  - **Decreased neuromuscular maturity**  
( Jacobson et al. 1984;)
  - **Deficits in visual recognition memory** (Jacobson et al. 1985)
  - **Poorer short term memory** (Jacobson et al. 1990) **and intellectual impairment** (Jacobson & Jacobson 1996)

# *Neurodevelopmental Effects*

- **Oswego Newborn and Infant Study**
- **A Replication of the Jacobson's studies**
- **Improved Methodology**

# *Neurodevelopmental Body Burden Levels*

- Oswego Study
- Measured PCBs, DDE, Mirex, HCB, MeHg and lead
- The median value of MeHg was 0.5ng/mg
- The median value of lead was 1.7ug/dl



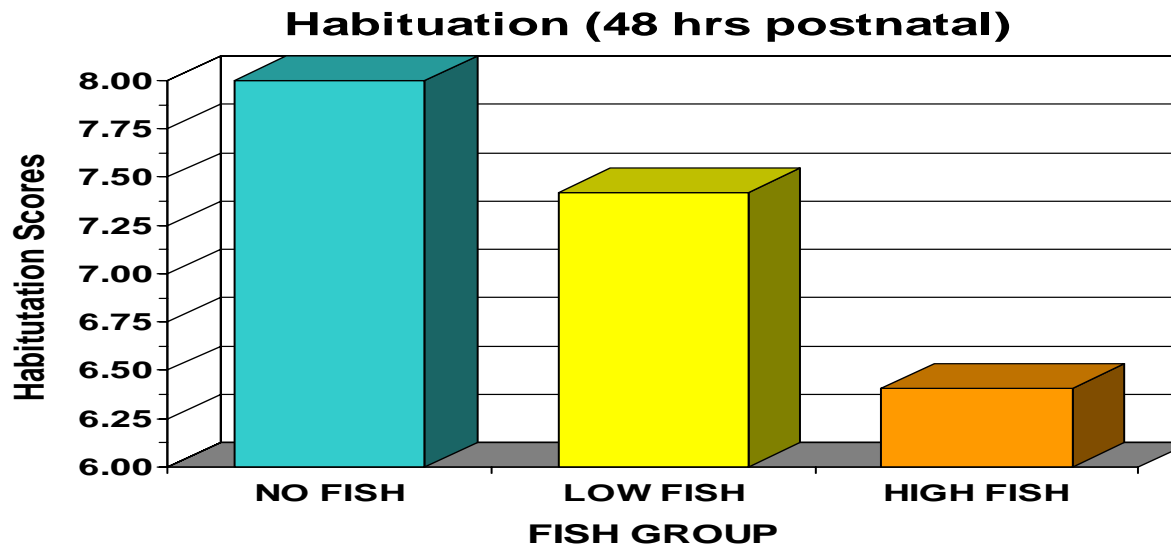
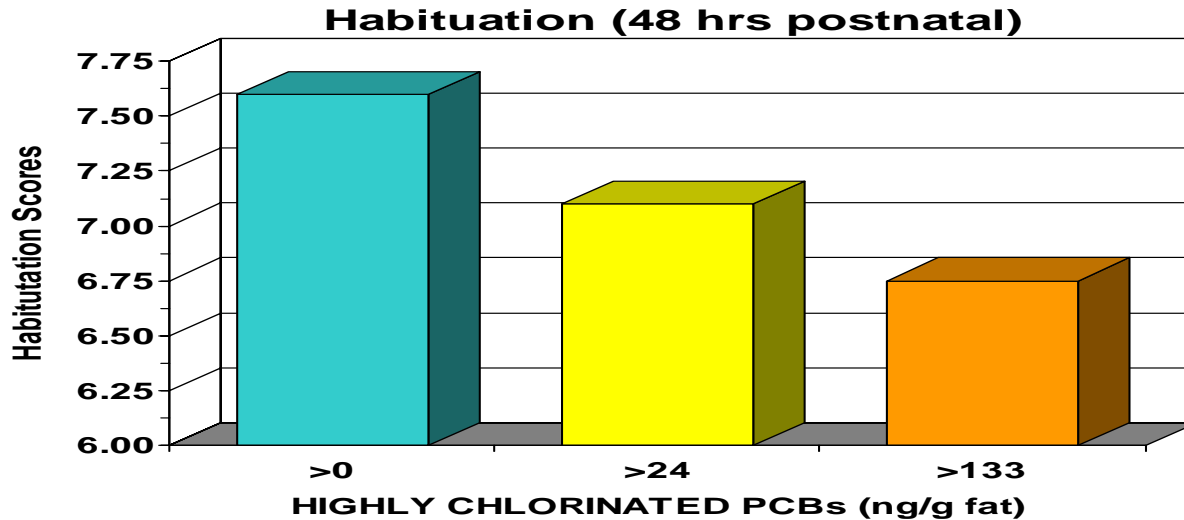
# *Neurodevelopmental (cont.)*

- PCBs were divided into 4 groups:
  - 0-0.17ppb
  - >0.18ppb
  - >0.52ppb
  - >1.10ppb

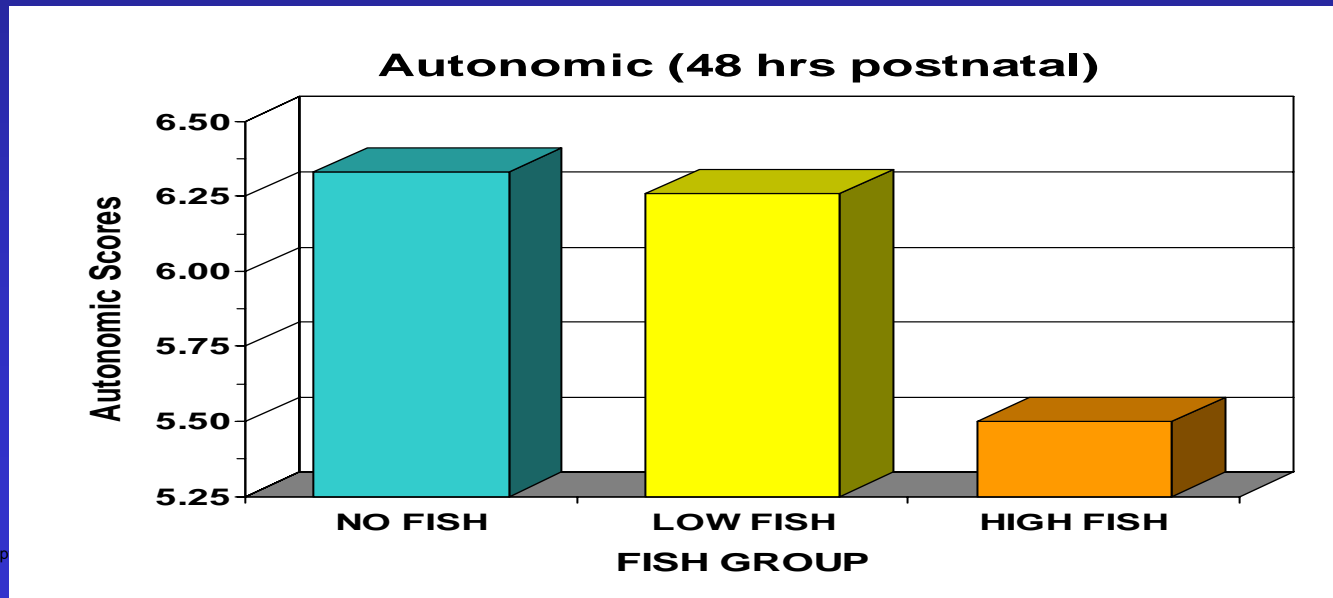
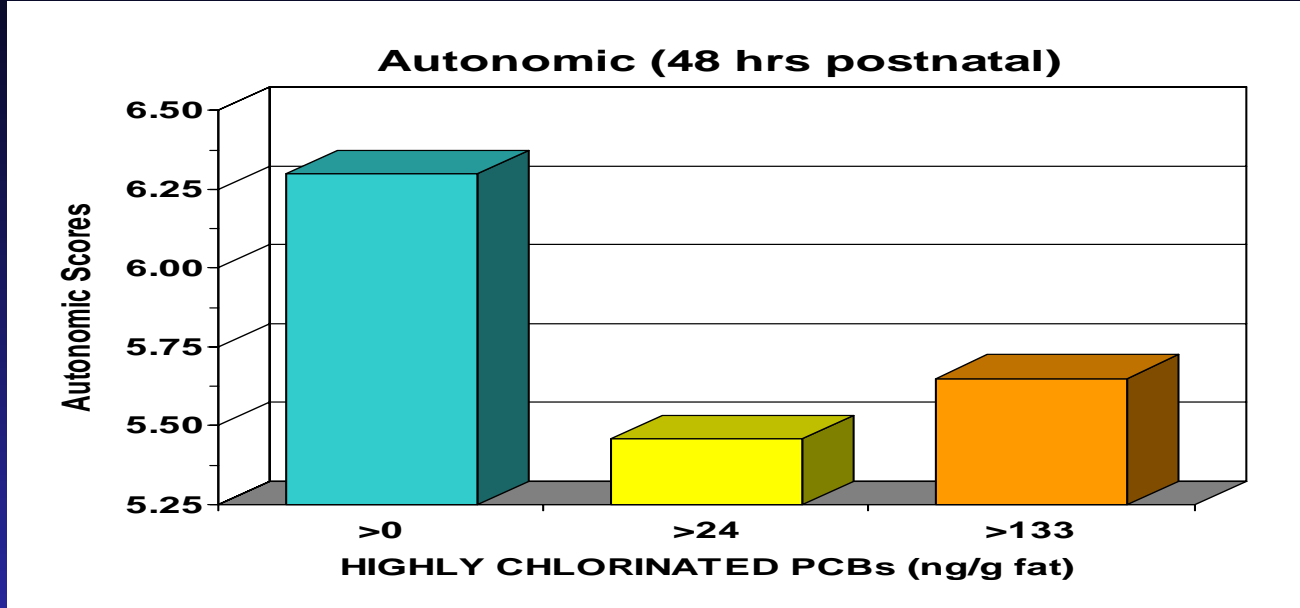
# ***Neurodevelopmental (cont.)***

- **Neurodevelopmental (cont.)**
  - **The relationship between prenatal exposure to PCBs and performance on the Neonatal Behavioral Assessment Scale (NBAS) was assessed. The results indicated significant relationships between the most highly chlorinated PCBs and performance impairment on the habituation and autonomic tests of the NBAS at 25 – 48 hours of birth.**

# Neonatal Behavioral Assessment Scale



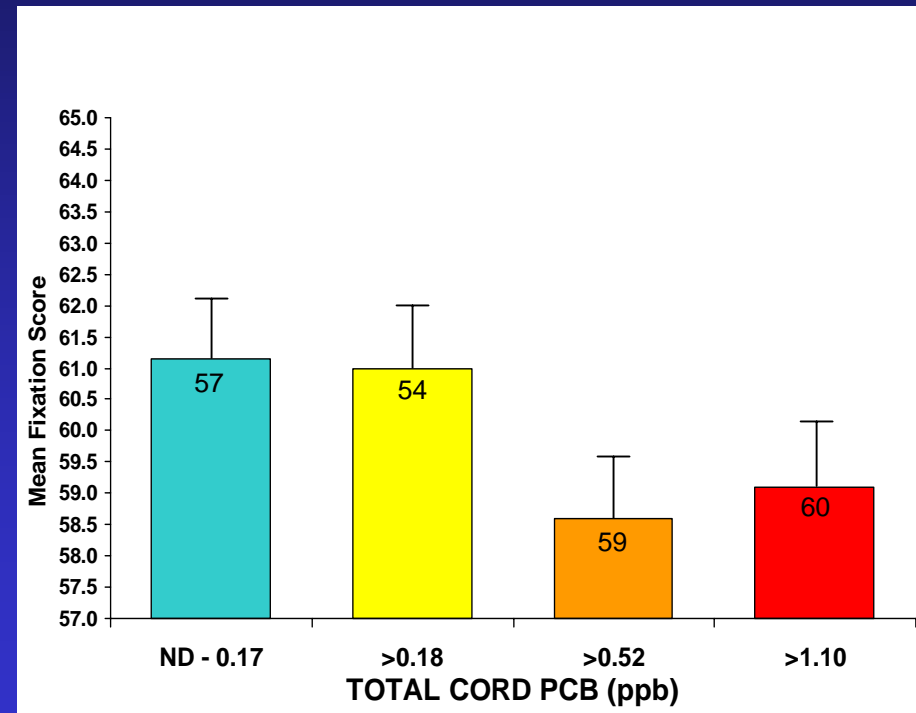
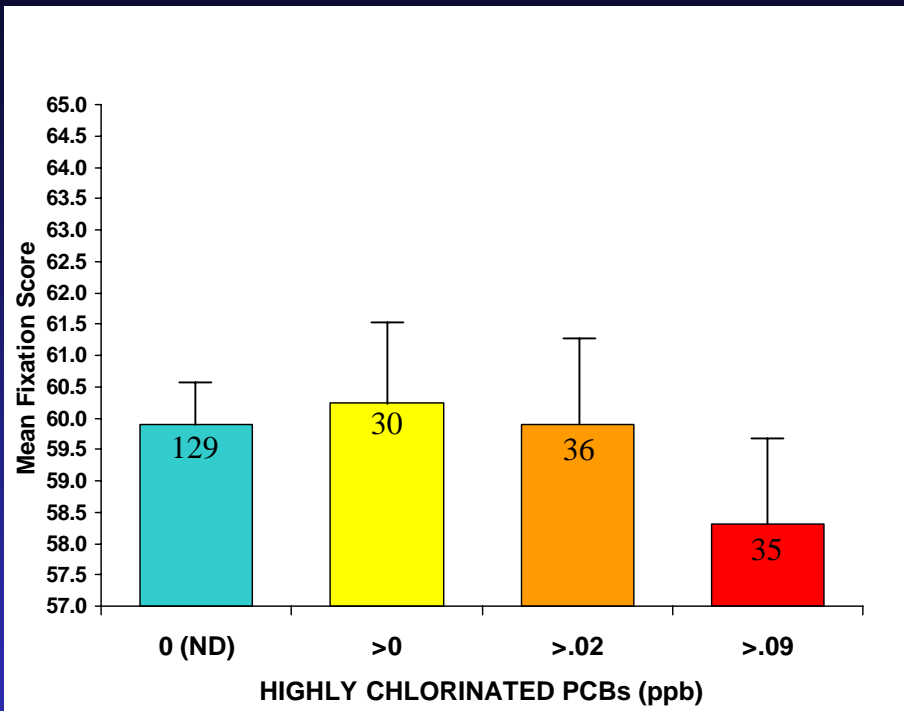
# Neonatal Behavioral Assessment Scale



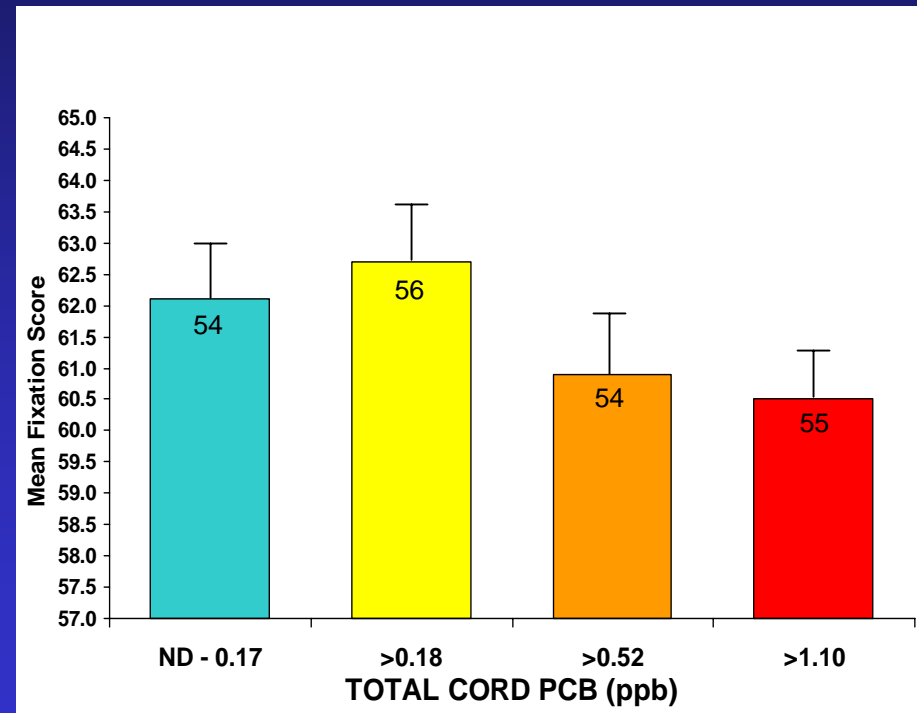
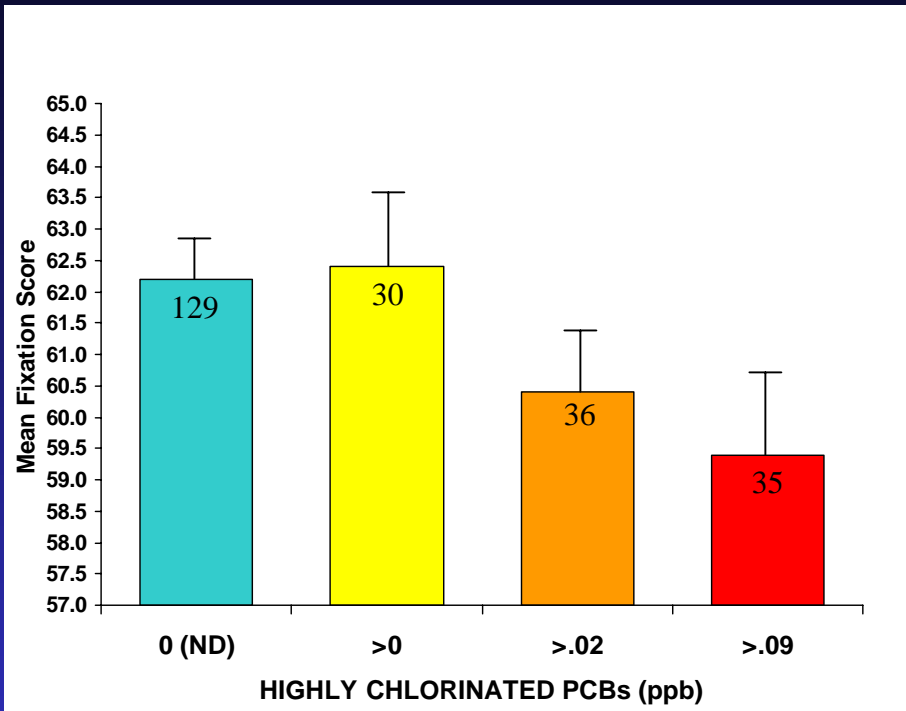
# *Great Lakes Research*

- **Neurodevelopmental (cont.)**
  - **The relationship between prenatal exposure to PCBs and performance on the Fagan Test of Infant Intelligence (FTII) was also assessed at 6 months and again at 12 months. The results indicated a significant relationship between exposure to PCBs and poor performance on the FTII. No significant relationship was found between exposure to DDE or methylmercury on any tests of the FTII.**

# FAGAN SCORES - 6 Months



# FAGAN SCORES - 12 Months

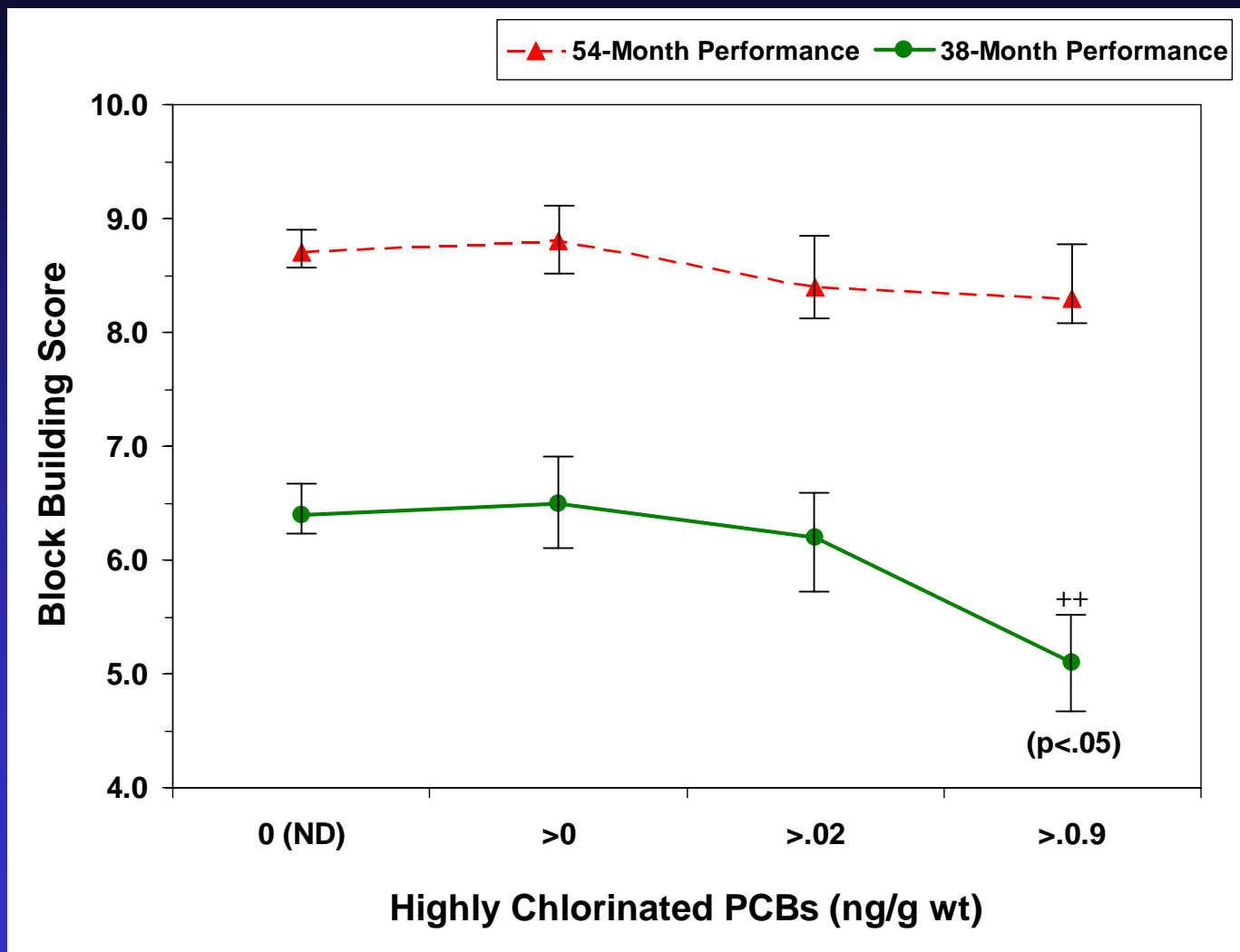


# *Great Lakes Research*

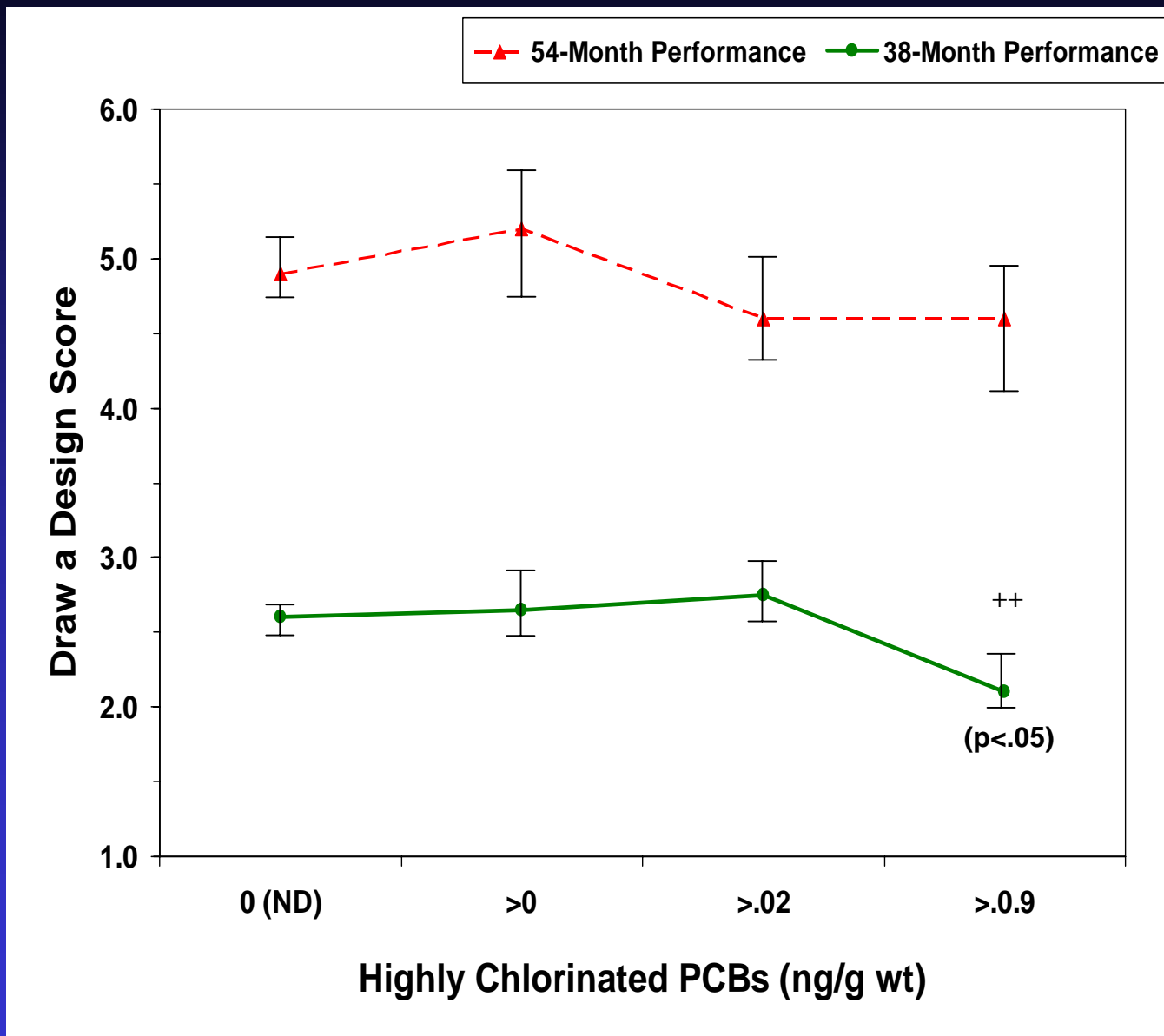
- **Neurodevelopmental (cont.)**
  - **The relationship between prenatal exposure to PCBs and methylmercury (MeHg) and performance on the McCarthy Scales of Children's Abilities was assessed in 212 children. Negative associations between prenatal MeHg exposure and McCarthy performance were found in subjects with higher levels of prenatal PCB exposure at 38 months. However, no relationship between PCBs and/or MeHg and McCarthy performance was observed when the children were reassessed at 54 months.**



# McCarthy Scales of Children's Abilities



# McCarthy Scales of Children's Abilities



# ***Endocrine Effects:***

- **A study was conducted to investigate PCBs, DDE, and fish consumption with thyroid hormones in men and woman and steroid hormones in men.**
- **Body burden levels were 4.7 ppb for PCBs, and 4.6 ppb for DDE for men; and 2.6 ppb for PCBs and 3.3 ppb for DDE for women.**
- **Men consumed fish for 34 years and women consumed fish for 29.9 years.**

# *Endocrine Effects*

- **Serum PCB levels and consumption of Great Lakes fish were significantly associated with lower levels of thyroxine ( $T_4$ ) in women and men.**
- **In contrast, fish consumption, but not PCB serum levels was significantly and inversely associated with triiodothyronine ( $T_3$ ) in men. (Persky et al. 2001).**

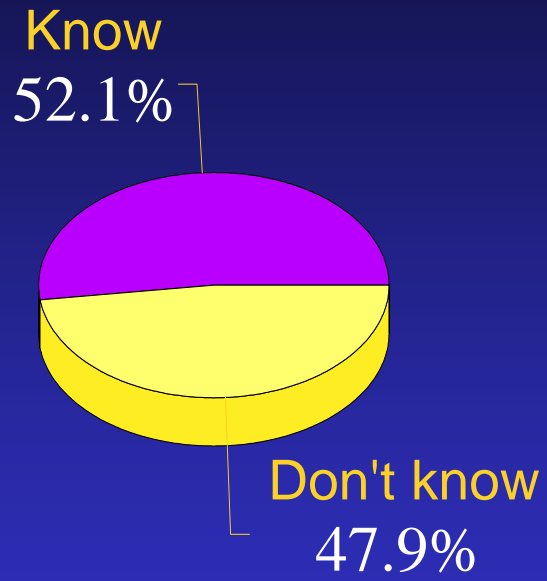
# ***Impairments in Memory and Learning***

- The levels of PCBs and DDE were elevated in both groups
- Mean serum levels for PCBs were 16 ppb for high fish consumers and 6 ppb for low consumers.
- DDE values were 16 ppb and 7 ppb respectively for high and low consumers.

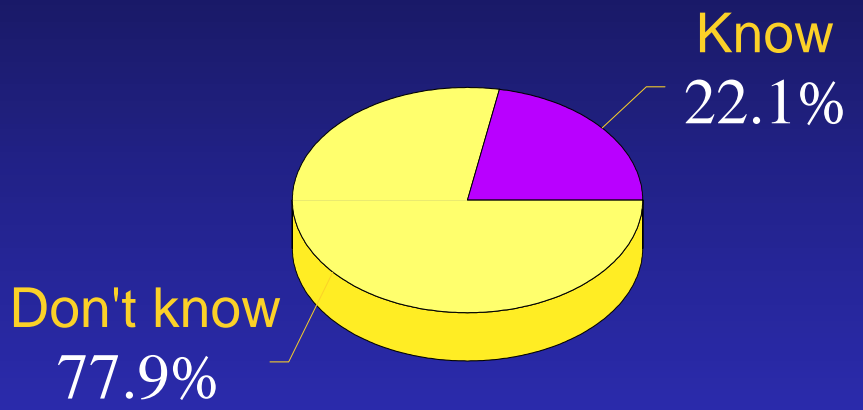
# ***Impairments in Memory and Learning***

- **Exposure to PCBs, not DDE, was associated with lower scores on several measures of memory and learning. These included the Weschler Memory Scale, verbal delayed recall and California Learning Test.**
- **PCB exposure did not affect executive and visual-spatial functions. (Schantz et al. 2001)**

# Minorities Don't Know About Polluted Fish

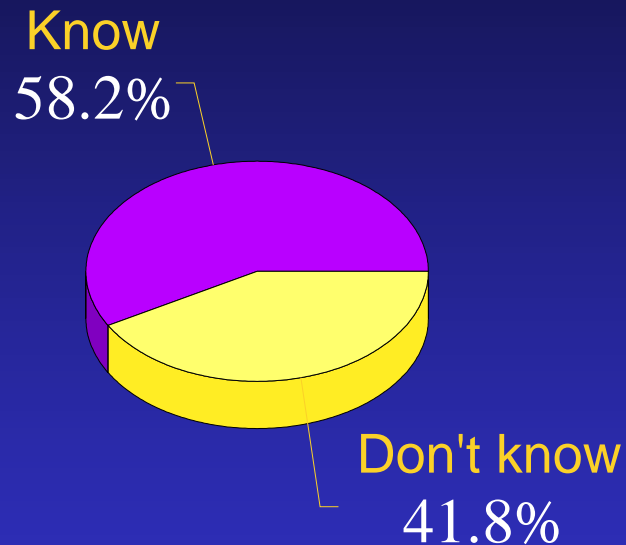


**White**

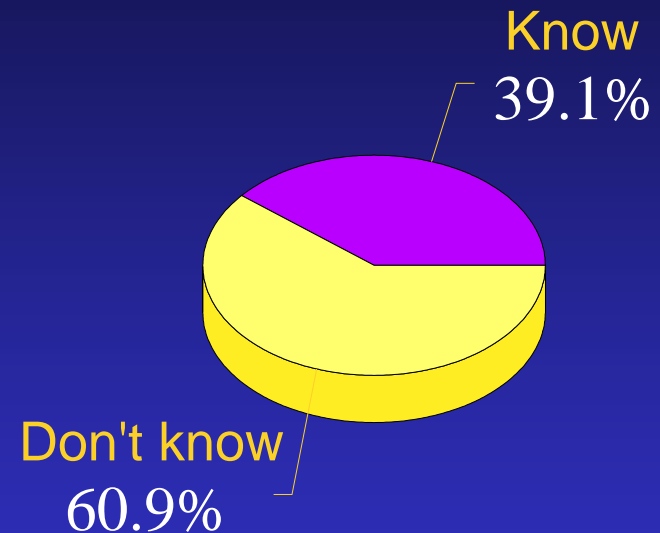


**Minorities**

# Women Don't Know About Polluted Fish



**Men**



**Women**



# *Public Health Interventions*

- **Surveillance**
- **Evaluation**
- **Prevention**
  - **Risk Communication –**
  - **Health Education Infrastructure**
- **Impact Assessment**

# ***Public Health Interventions***

**Based on these research findings, ATSDR has initiated several activities to reduce exposure to toxic chemicals via fish consumption:**

- Develop fish advisories with other government agencies**
- Conduct health fairs and public meetings**
- Provide information on cooking practices to reduce exposure**

# ***Public Health Interventions (cont.)***

- **Educate health care providers**
- **Prepare documents describing potential adverse health outcomes from exposure**
- **Involve at-risk communities in all activities**

# Emerging Evidence of Illness Associated With Exposure



Neurologic  
Problems

Respiratory  
Illness

Cancer and  
Immune System  
Function

Birth Defects  
and Reproductive  
Disorders

**“The ATSDR Great Lakes Human Health Effects Research Program, established in 1992, is now yielding compelling data concerning human exposure to chemical contaminants and the health consequences that are associated with these exposures.”**

**The Pew Environmental Health Commission  
John Hopkins School of Public Health, 2001**

# *Conclusion*

- **Bioaccumulation and bioavailability are two phenomena that can help us explain scenario specific health effects.**
- **Health effects of emerging chemicals (PFOS etc) can be confounding factors and should also be evaluated.**
- **Chemical by chemical basis evaluation might not be adequate, hence chemical mixtures and potential interactions need to be considered in population risk assessments**

# ***Conclusion (cont).***

- **The ultimate objective of the Great Lakes community-based research:
  - to empower communities by providing the means to make informed decisions on environmental public health issues.**