Gonadal Atrophy in Clams Induced by PCB Exposure: Implications for Ecosystem-wide Problems?

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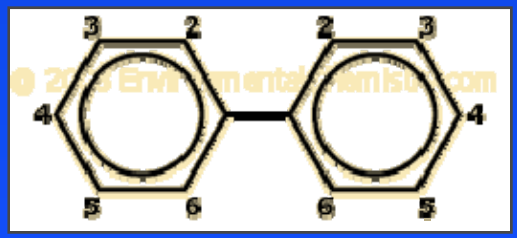
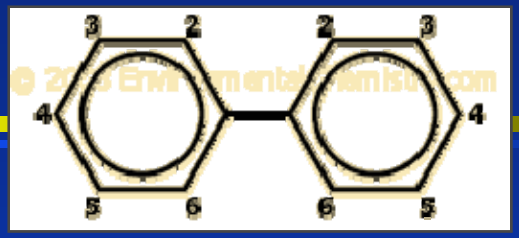
Why are PCB's a concern?

- Longevity (30+ years and still too high locally)
  - Outlawed ~1979
- Soil adsorption, trophic level movement (biomagnification), mass transport
- Human health effects
- Effects in lab studies and medical records
  - Reproductive health concerns (AhR)
  - Interaction with CYP & redox activity
  - Acute and chronic conditions

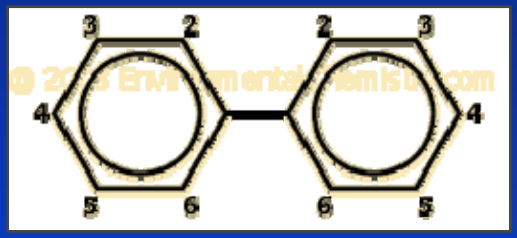


PCB's: Cancer risks



- Breast cancer, prostate cancer
- Liver, gall bladder, biliary tract
- Pancreatic
- Kidney
- Brain
- Non-Hodgkin's lymphoma
- Lung cancer
- Skin cancer

PCB's: Non-cancer risks



- Immune system damage
- Thyroid dysfunction
- Parkinson's, depression, spinal degeneration, peripheral neuropathy
- Heart disease, diabetes, liver damage
- Reproductive and sexual impacts
- Hearing damage
- Chloracne

N&O Article
Late 2005

Soil still toxic 25 years later

PCBs spilled near airport ruin fishing in Lake Crabtree and continue spreading

By Wade Rawlins
Staff Writer

For 15 years ending in 1979, a company named Ward Transformer spilled thousands of gallons of toxic chemicals on its 11 acres at the edge of Raleigh-Durham International Airport.

The toxins have been migrating slowly downstream toward Lake Crabtree, especially when heavy rains carry particles of contaminated soil.

Prominent among the chemicals are polychlorinated biphenyls, or PCBs, which remain in the environment for decades and have been linked to cancer and reproductive problems.

Documents show that U.S. Environmental Protection Agency investigators knew in 1978 and 1979 of high levels of PCB contamination at the transformer recycling facility and found low levels in nearby streams and wetlands. But more than 25 years later, not a shovelful of the tainted soil has been cleaned up.

Four miles downstream at Lake Crabtree County Park, signs warn people not to eat catfish or carp caught in the lake because they contain PCBs. Park officials are angry they didn't learn about the contamination until years after taxpayers spent $2.3 million to create the park, which opened in 1987.

"I've been operating that facility for 18 years not knowing PCBs were in the lake until 18 months ago," said David Carter, director of Wake County Parks. "If this contamination just happened two years ago that would be one thing. But it happened in 1978."

The pollution persists and spreads because, for years, removing it was a low priority. One potential cost of the inaction is that the PCBs could spread farther and pollute fish in Crabtree Creek, which flows through Umstead State Park.

EPA investigators did limited testing at the Ward property in 1993 but inexplicably didn't find high enough levels to require an immediate cleanup. Instead, they told state investigators to start the long process of adding the

SEE WARD, PAGE 16A

CONTAMINATED FISH

Ward Transformer Sales & Service Inc. has reconditioned electrical transformers at its site near Raleigh-Durham International Airport since 1964. Investigators have found cancer-causing polychlorinated biphenyls (PCBs) on the site and in lower levels in the streams and wetlands below the site. The most common way PCBs get into humans is from eating contaminated fish.

About PCBs
PCBs, an oillike chemical used between 1929 and 1990 as a coolant in high-voltage electric transformers, were banned from manufacture in 1979.

PCB health risks
PCBs pervade the environment, decompose slowly and accumulate in the fatty tissues of all organisms in the food chain. In laboratory animals, they have caused reproductive problems, skin lesions and cancerous tumors.
Highly toxic over time in small quantities, PCBs must be disposed of carefully so they won't leak into sewers, water treatment plants and eventually into rivers and streams.

What is an electric transformer?
Electricity on power lines is transmitted at high voltages over long distances, typically about 7,200 volts in neighborhood lines. A transformer uses coils of wire to step the voltage down to about 220 to 240 volts so it can be used in homes.

Fish advisories issued
The state Department of Health and Human Services issued advisories warning against eating catfish or carp from Lake Crabtree and limiting consumption of other fish to one meal per month because of high PCB levels. The state also warns not to eat fish from Brier Creek Reservoir or Brier Creek.

Danger levels

Do not eat any fish from this area.	Limit consumption of fish from these areas.	Fish have been tested, and no advisories have been issued.

MORE DANGER ← → LESS DANGER

Sources: U.S. Environmental Protection Agency, N.C. Department of Health and Human Services, California Energy Commission

JUDSON DREHAM / The News & Observer

"Thus, effects on the immune system, learning, and the developing reproductive system of multiple animals occur at body burdens which are close to those present in the background human population."
-Birnbaum, 2000

PCB Fish Consumption Advisory for Lake Crabtree

Carp

Catfish

Catfish and carp contain high levels of chemicals (PCBs).
Do not eat any catfish or carp from Lake Crabtree.
The PCB levels in other fish are lower but are still a health concern
For all other fish, eat no more than one meal per month.
When in doubt about the fish species, do not eat any of the fish
Swimming, boating, and other recreational activities present no health risks and are not affected by this advisory.

NC State Health Director

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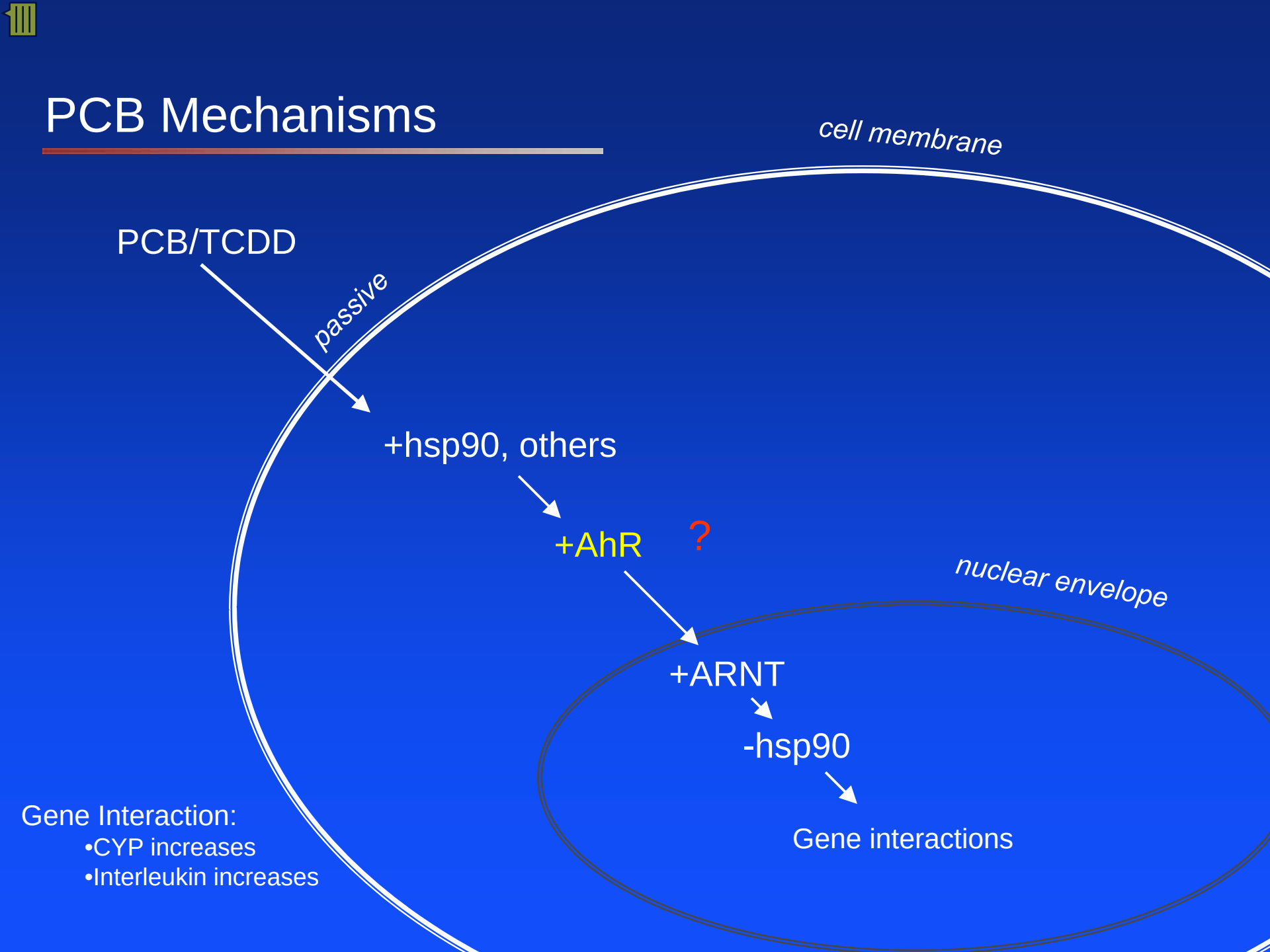
NC State Health Director

*A "meal" is 6 ounces of cooked fish for adults, or 2 ounces of cooked fish for children under 15.

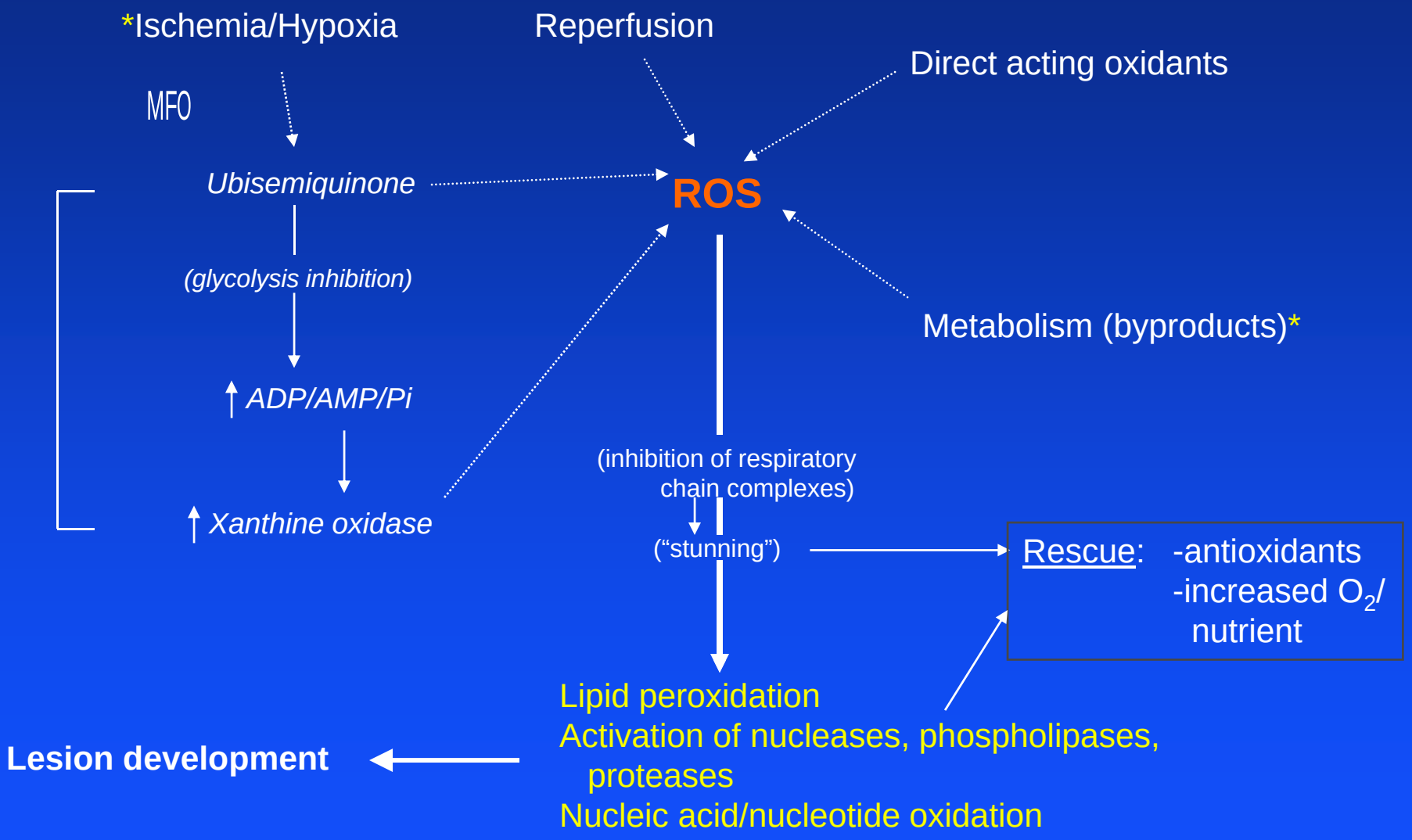
PCB Mechanisms



Gene Interaction:

- •CYP increases
- •Interleukin increases

Reactive Oxygen Generation



Adapted from Halestrap, Bioch Biophys Acta 1998

Hypothesis: Exposure to PCB's (Aroclor 1260) results in oxidative stress and cell injury in *Corbicula fluminea* clams

Asiatic clam (*Corbicula fluminea)*

Hypothesis: Exposure to PCB's (Aroclor 1260) results in oxidative stress and cell injury in *Corbicula fluminea* clams

Specific Aims:

1- Determine environmental and tissue PCB concentrations in the field.

2- Measure changes in oxidation biomarkers due to laboratory and field exposure.

3- Compare values of TOSC, GSH concentrations, GST activity, cellular pathology, and antioxidant levels with PCB concentrations in a downstream gradient.

Experimental Design

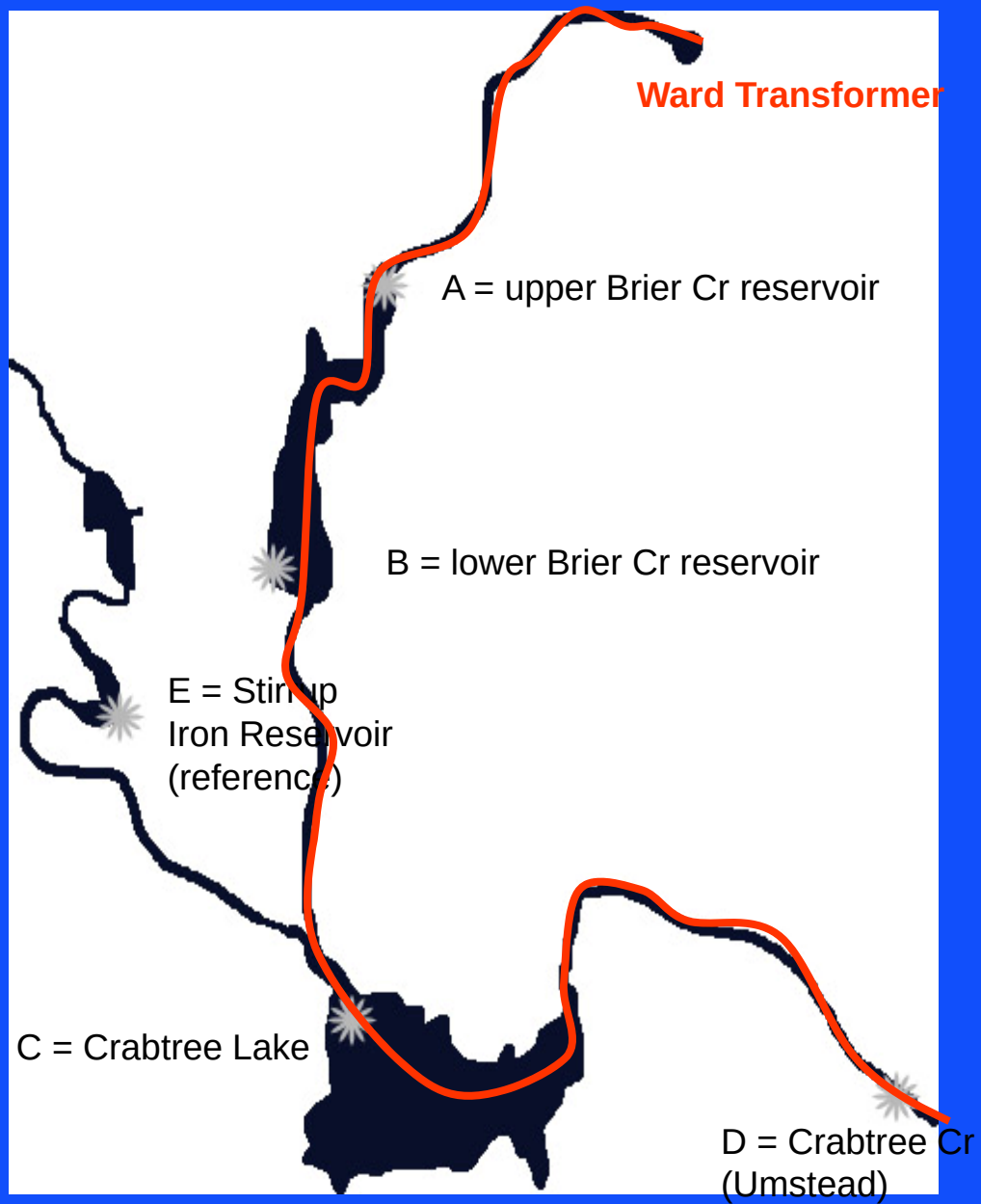
Brier Creek System
Including Lake Crabtree

Lab exposures:
4L beakers in water bath for constant temperature/lighting

12 clams per beaker

0, 1, 10, 100 ppb Aroclor 1260 renewed twice weekly by static replacement

21 days exposure



Field Study Design

Collection and Holding (7-10d)

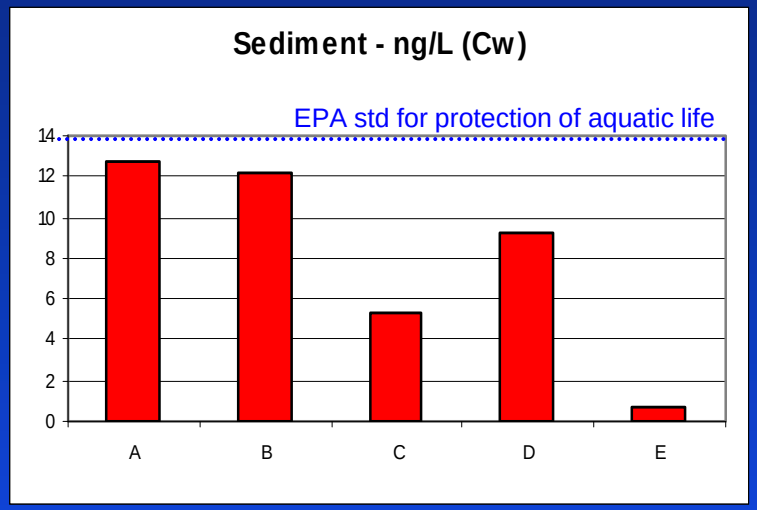
Deployment in the field (21d) + PSDs (LDPE and PDMS)

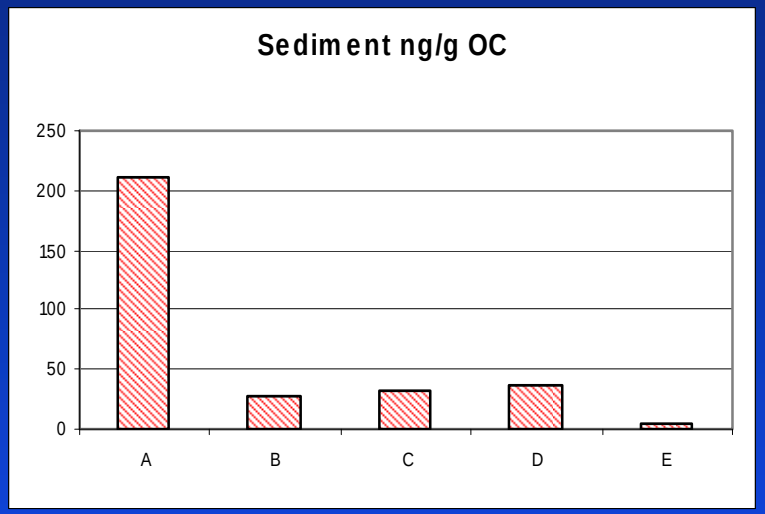
Re-collect

4 composite samples (10-12 clams per composite) per site and 3 clams/site for histological evaluation

Results – PCB concentrations in the field

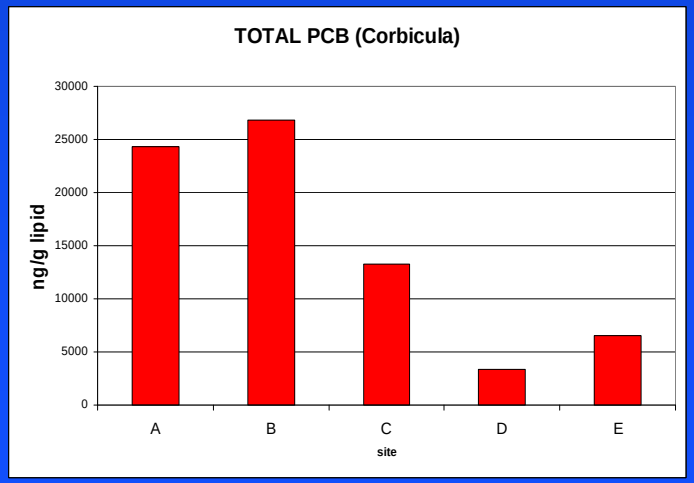
Sediment and estimated water concentrations





reference

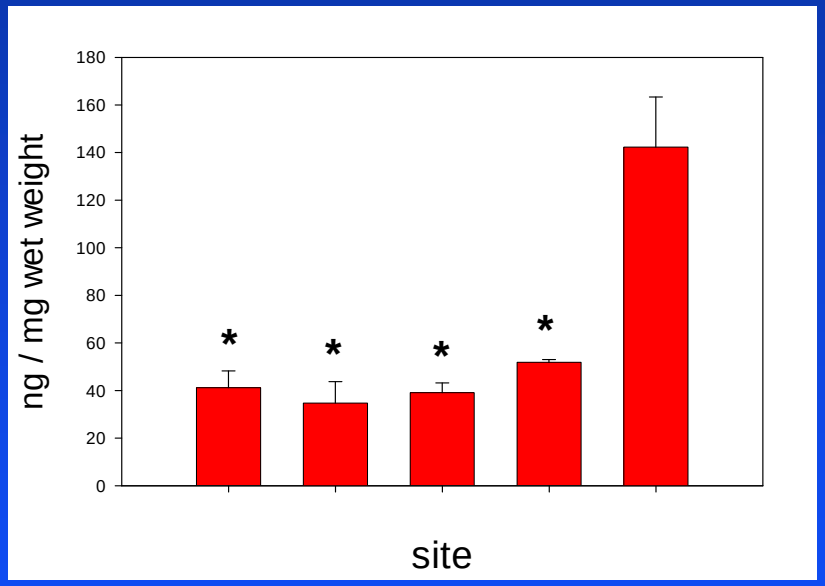
reference

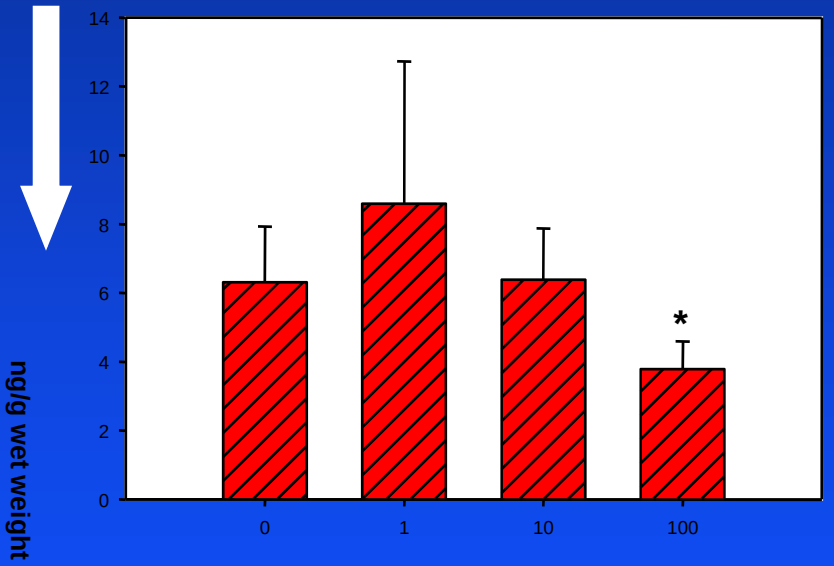


Tissue concentrations

Results - antioxidants

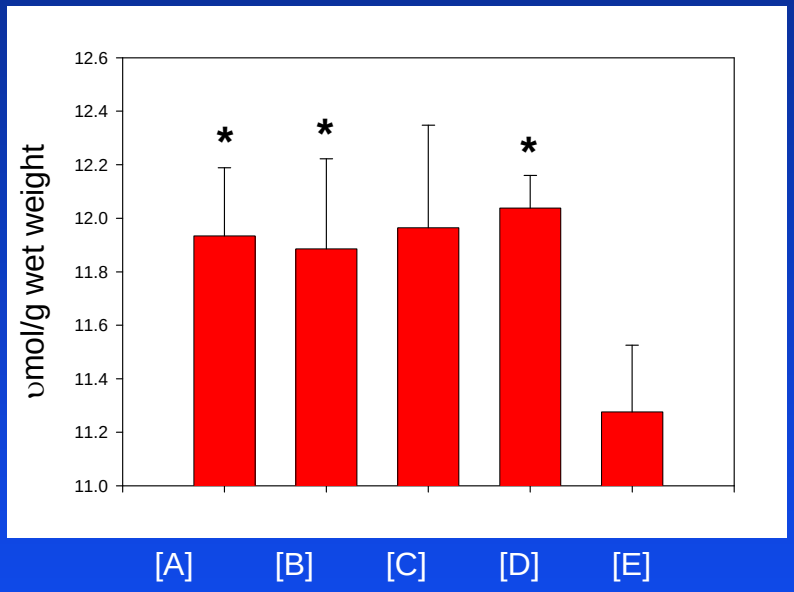
α-tocopherol

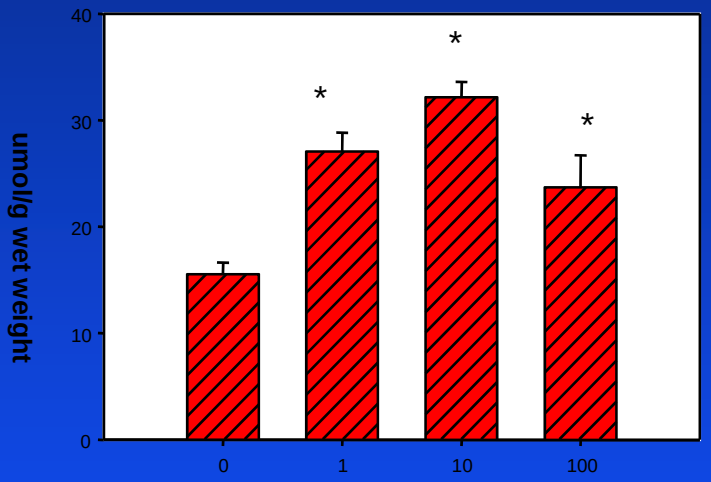




Results - antioxidants

GSH

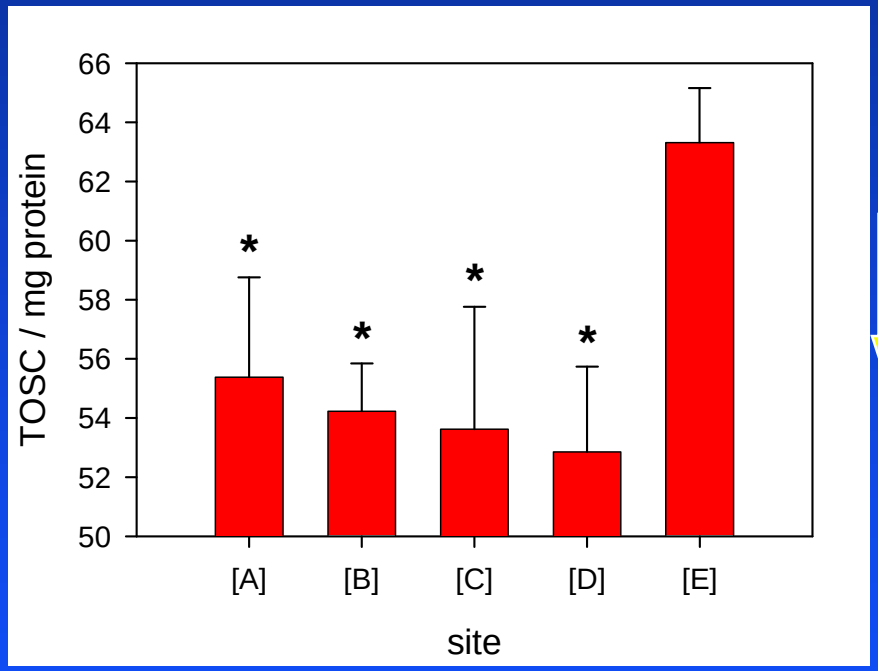


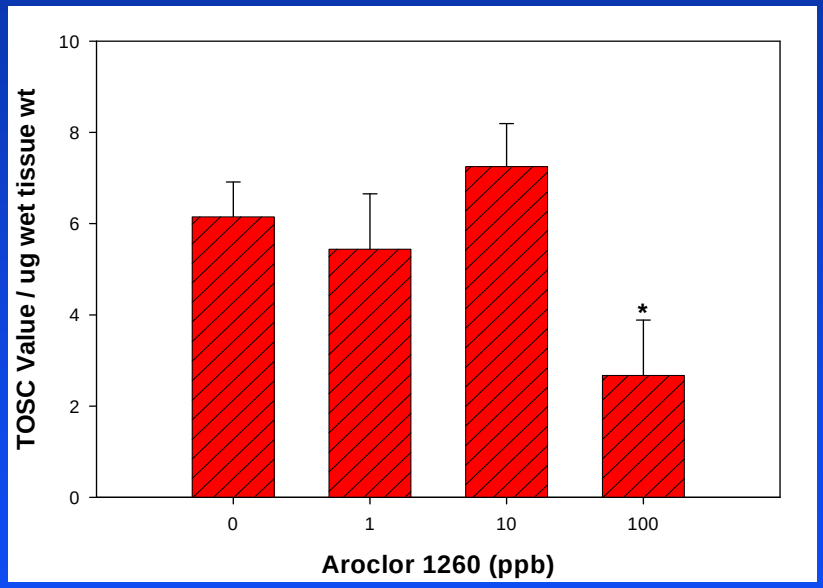


Results - antioxidants

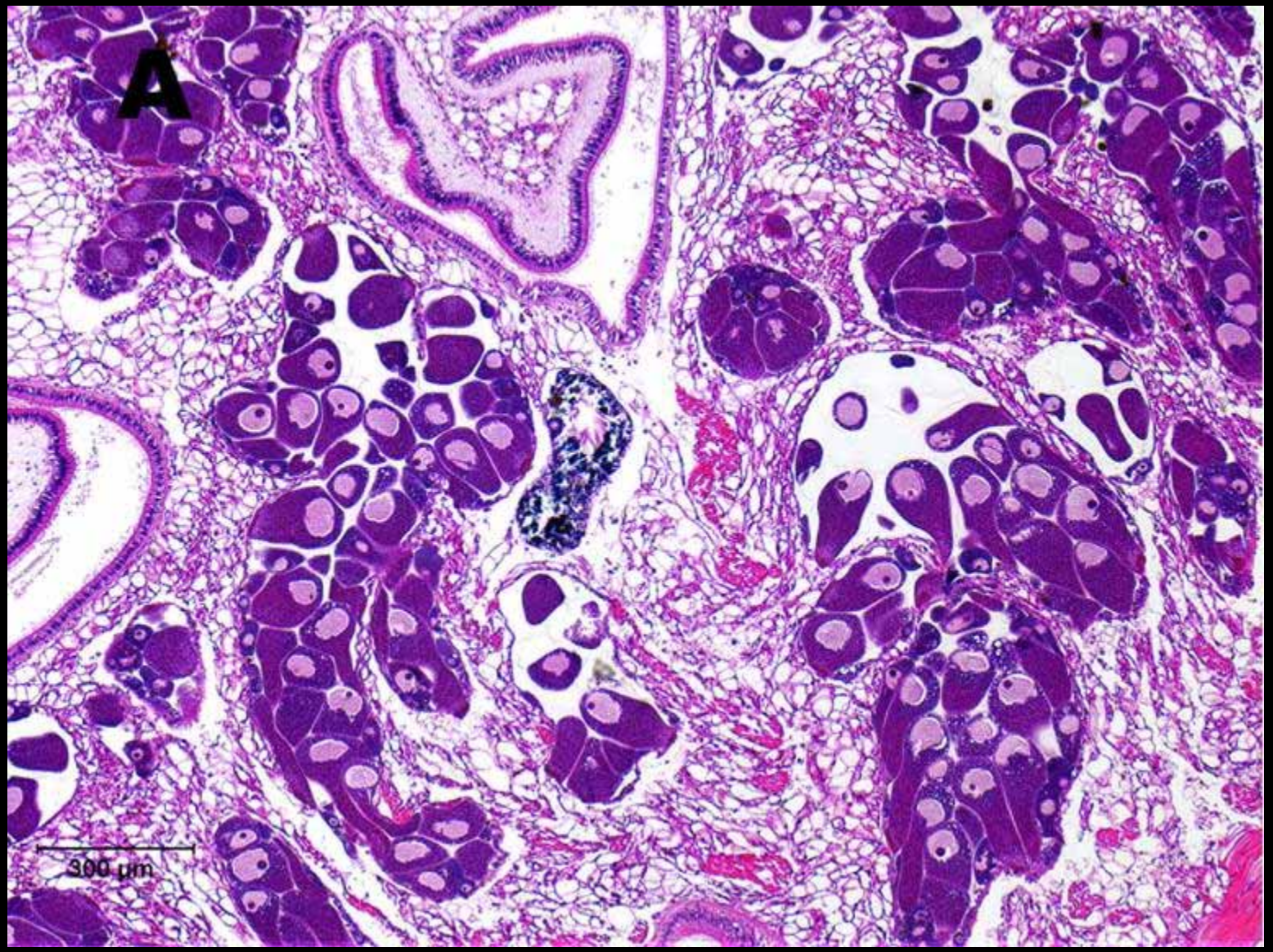
Total Oxidant Scavenging Capacity

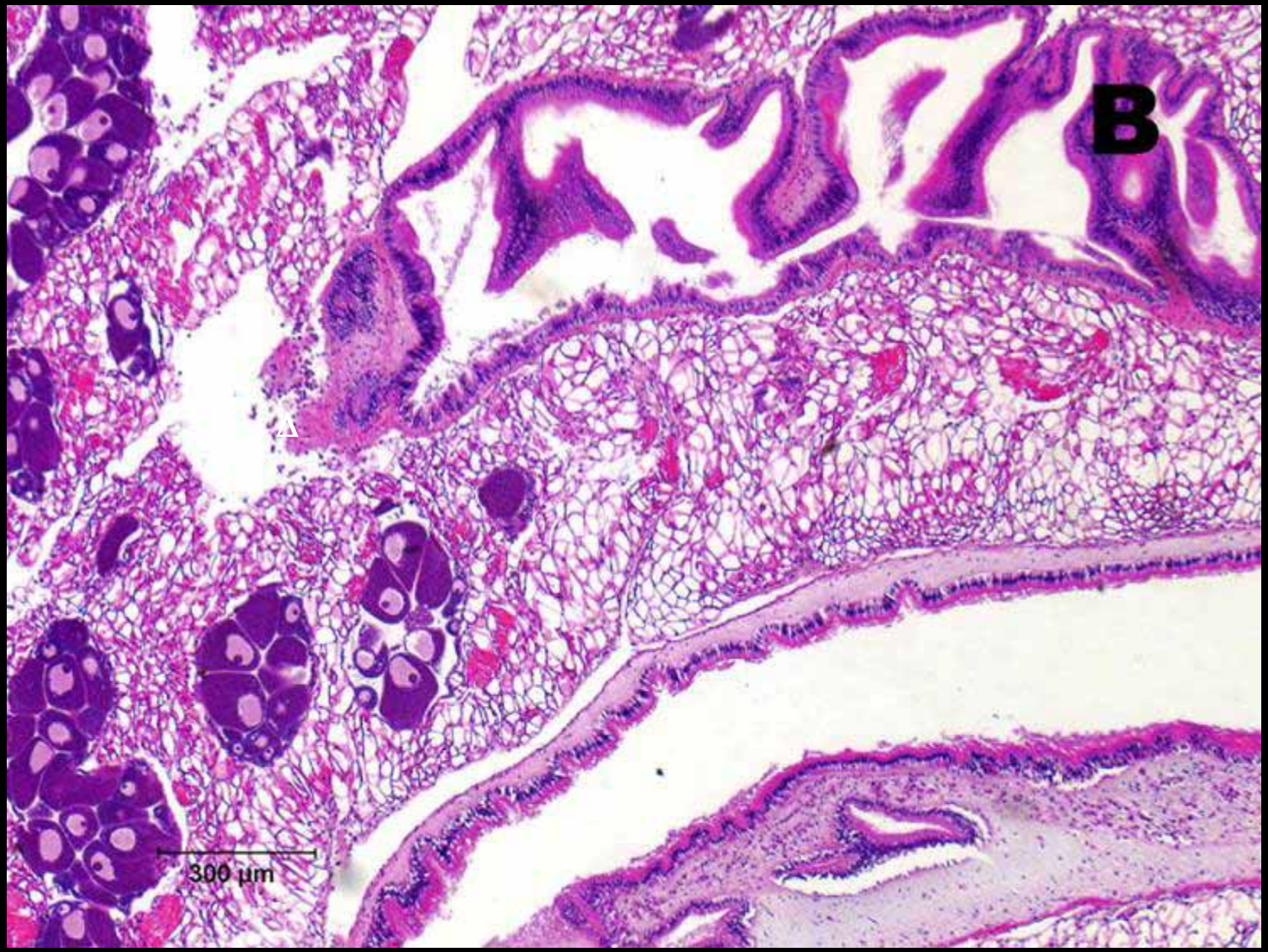
(The higher the value, the more ability the sample has to quench radicals.)

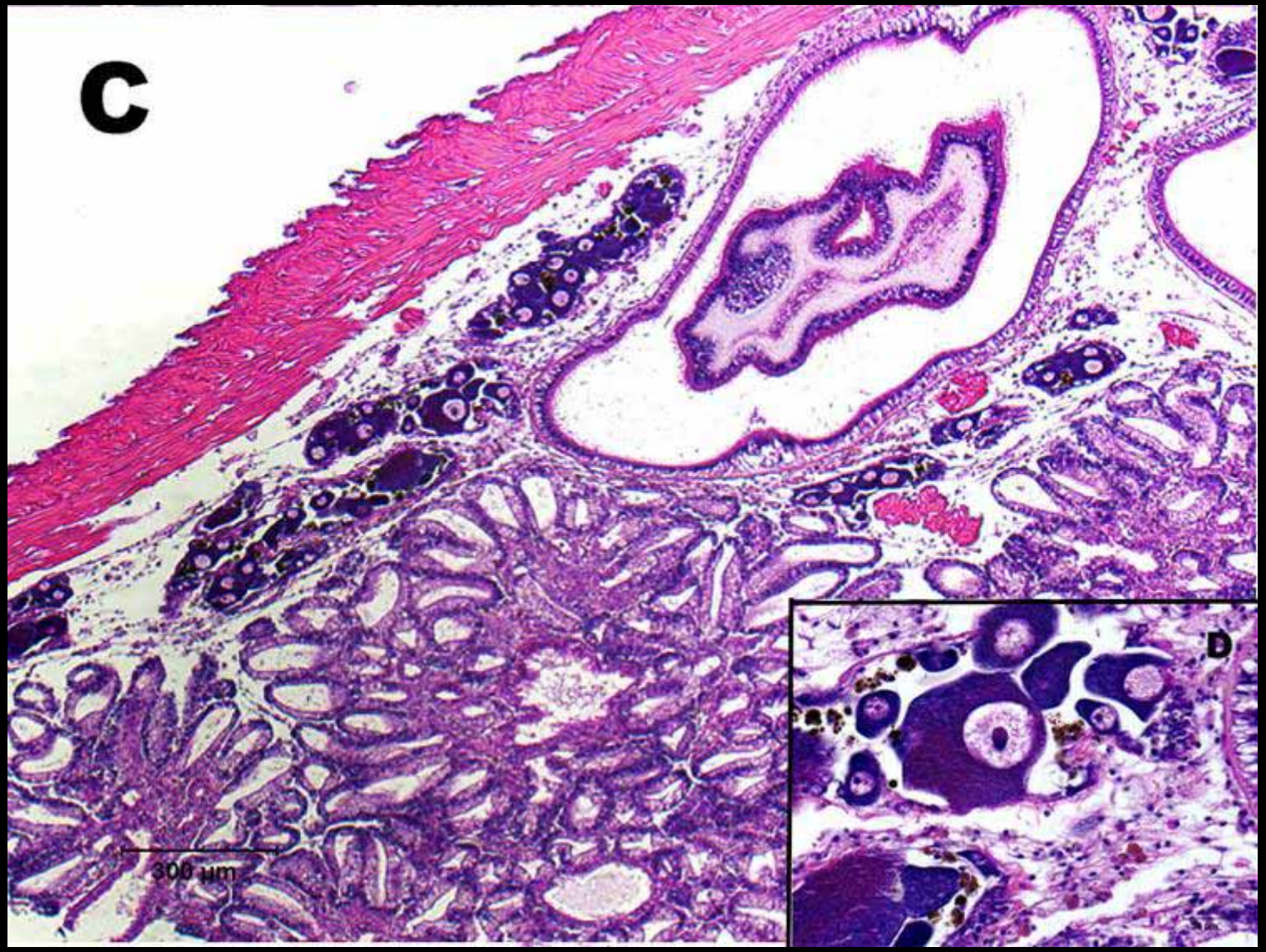




Results - histopathology



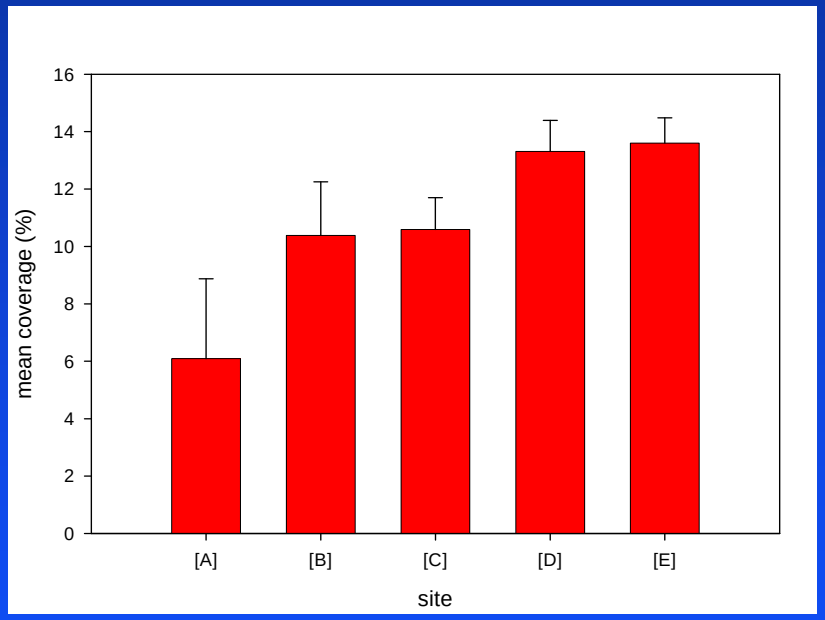

B
A
300 µm

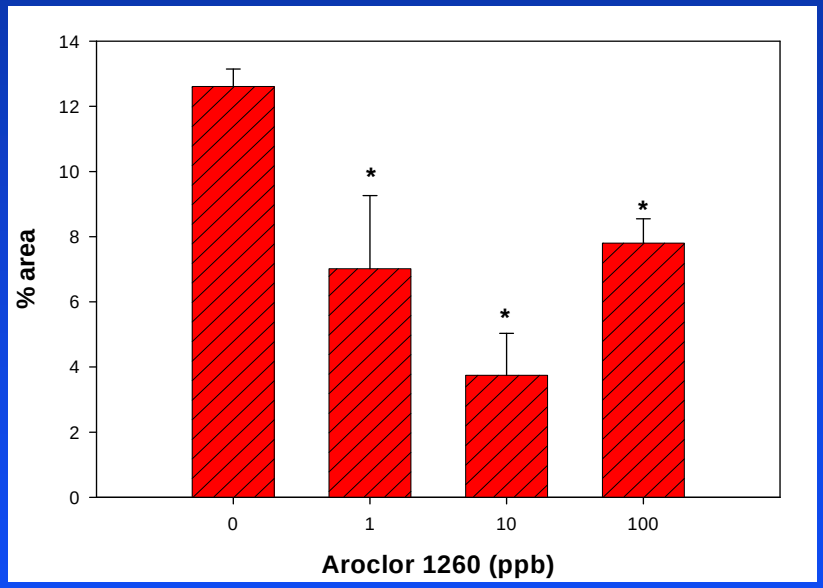

C
300 µm
D


E
300 µm
30 µm

Results - morphometry

% Gonad Cross-sectional Area





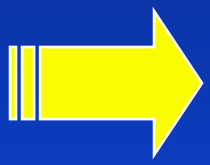
Results - Summary

- Oxidative damage results from Aroclor 1260 exposure in the laboratory (no confounding factors) and in the field.
- Tissue pathology is observed at all tested concentrations.
- Reproductive effects are due to Aroclor exposure.

Summary

What does it mean?

- **Antioxidant systems are compromised**
- **Biological energy demands are increased**
- **Inflammation due to tissue destruction**



Leads to reduced ability to cope with environmental change and possible infection/predation.

Gonadal changes, inflammation/necrosis, and decreased antioxidant capacities are a concern at the population level and may be responsible for decreases in fecundity and recruitment in native, endangered bivalves inhabiting PCB contaminated systems.

Acknowledgements

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