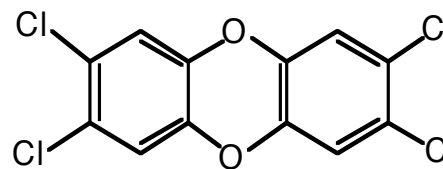
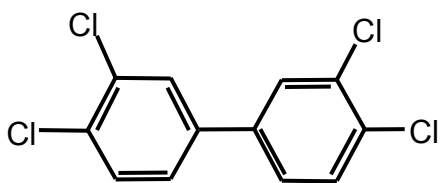


CHE Partnership call  
*Catch of the Day: Health Fish, Healthy Humans*

## Impacts of Chronic Pollution on Fish Populations: *Evolution in Action*

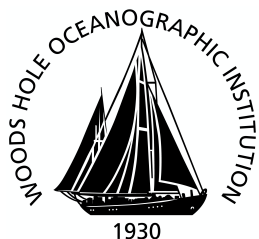


Mark E. Hahn

with many colleagues and collaborators

*Woods Hole Oceanographic Institution, Woods Hole, MA*  
*Boston University Superfund Basic Research Program*

<http://www.busrp.org>



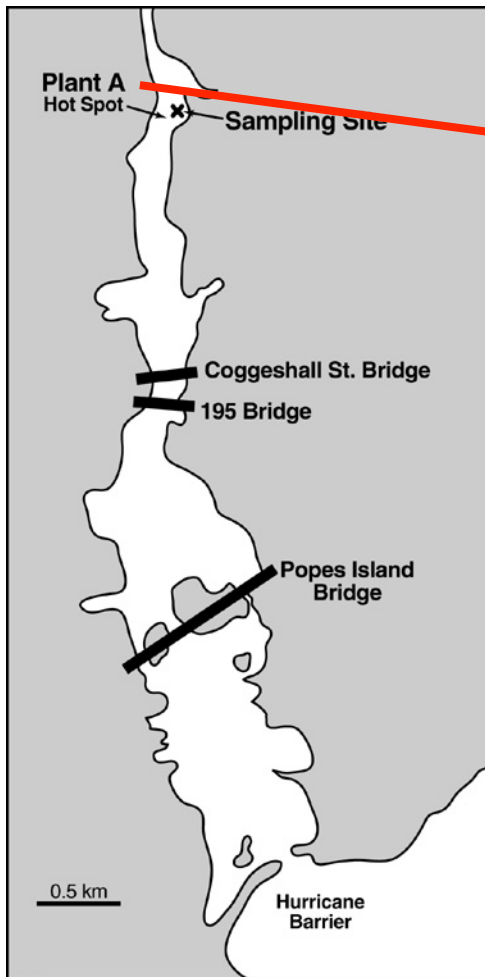
# *Motivation*

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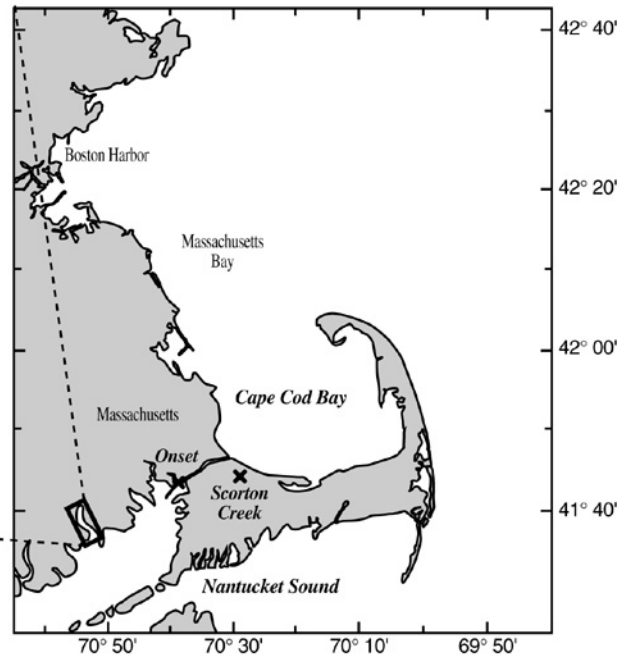
What is the ecological impact of long-term (multi-generational) exposure to contaminants at Superfund sites?

- Effects on populations; multiple generations.
- Can some populations adapt?
- How do they do it?
- What are the costs?

# New Bedford Harbor, MA (Acushnet River Estuary)



Acushnet River Estuary  
(New Bedford Harbor)



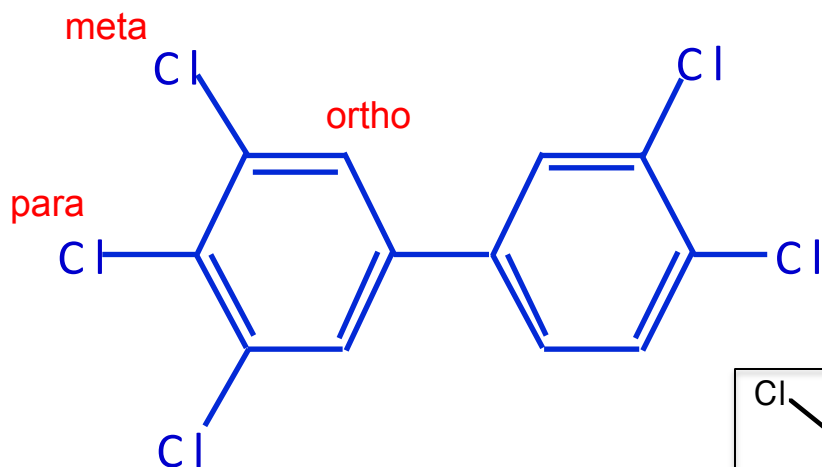
<http://www.epa.gov/nbh/>



Aerovox plant

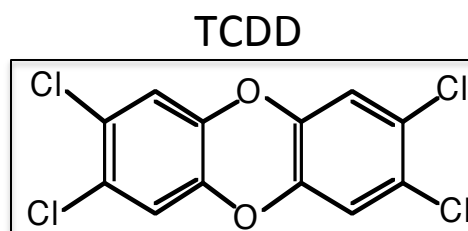
# Polychlorinated biphenyls (PCBs)

- Sources
- 209 possible isomers & congeners
- Structure-activity relationships
- Multiple mechanisms of toxicity
- Dioxin-like effects

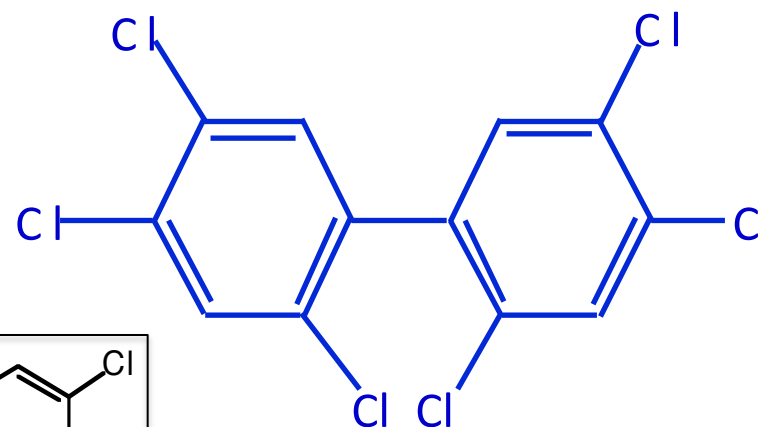


**non-ortho PCB**

3,3',4,4',5-pentachlorobiphenyl (PCB-126)



**TCDD**

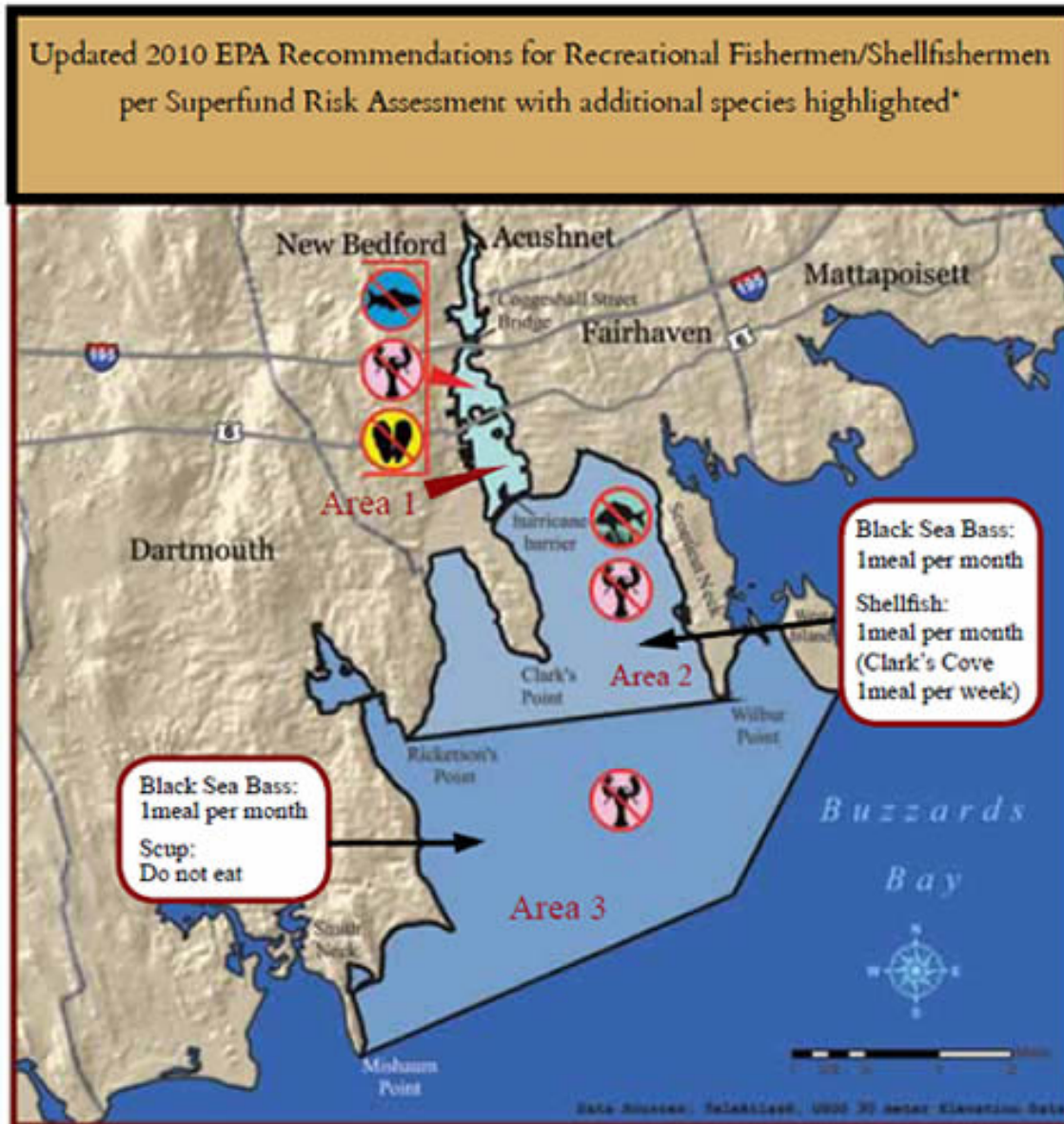


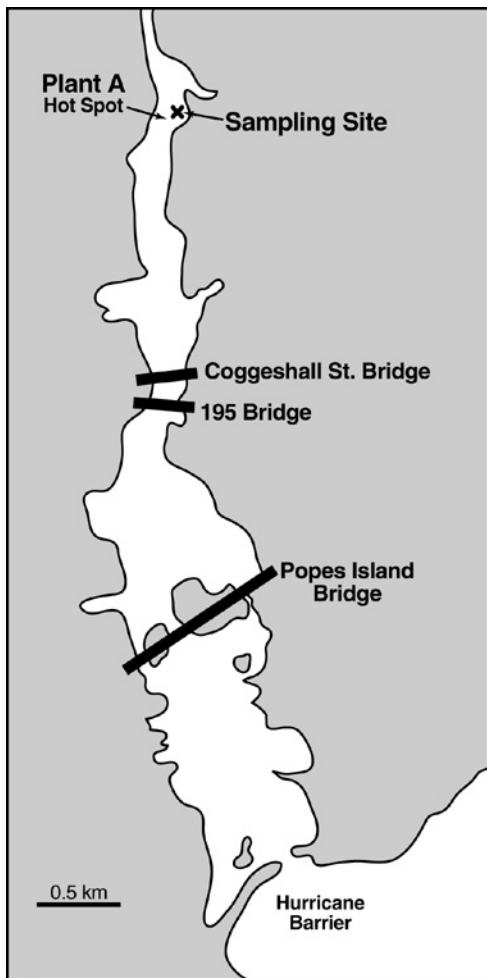
**ortho PCB**

2,2',4,4',5,5'-hexachlorobiphenyl (PCB-153)

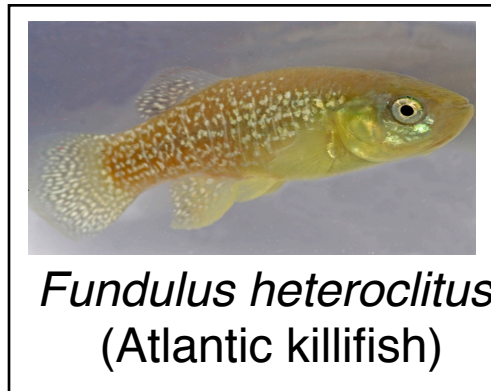


# Fishing closures (2010)



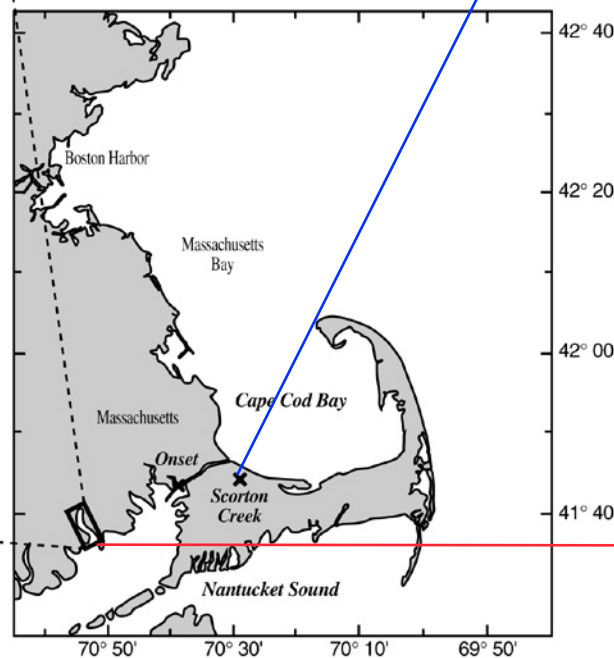


Acushnet River Estuary  
(New Bedford Harbor)



## Scorton Creek

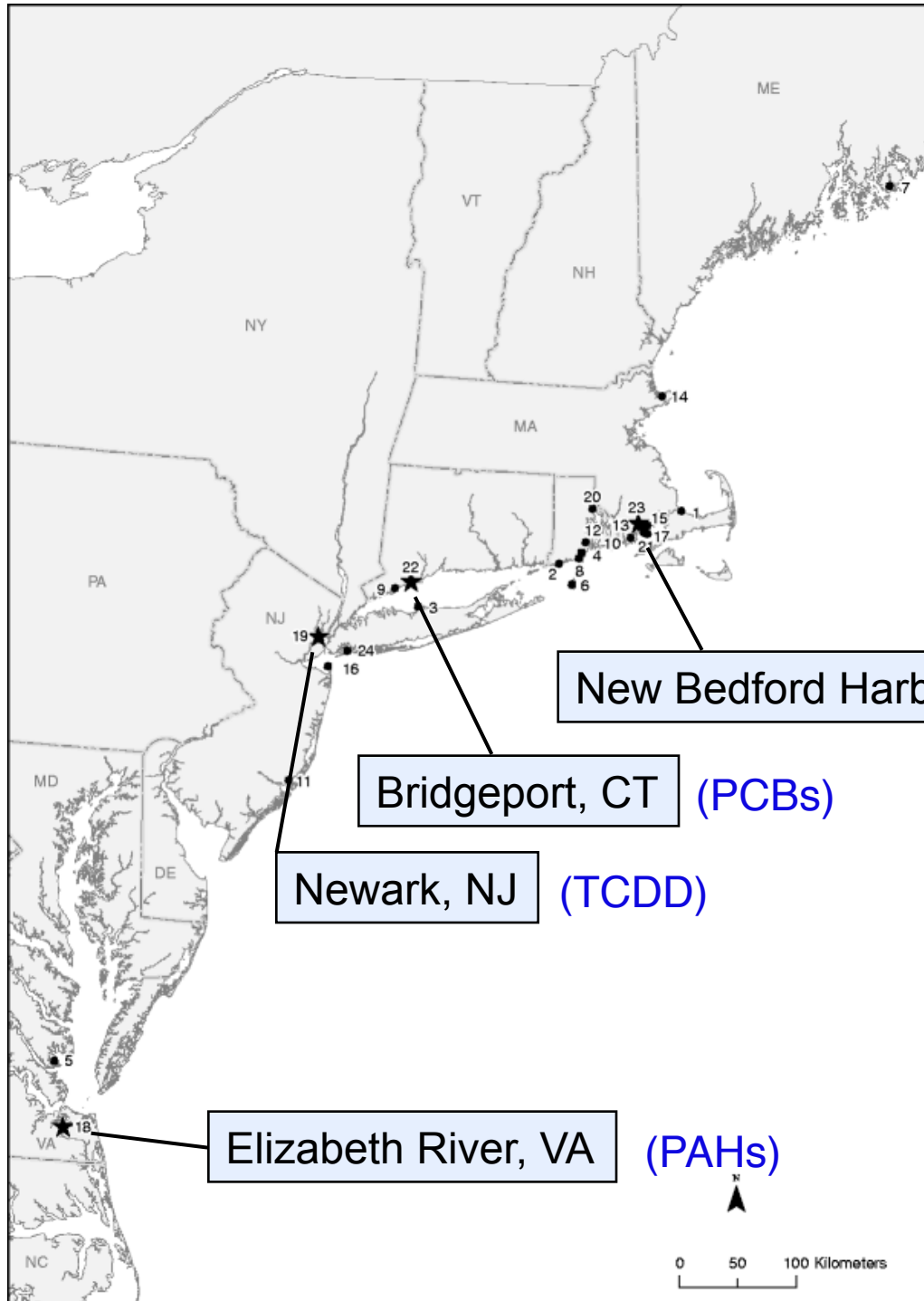
(*Fundulus* [PCB] = 0.177 ppm, dry wt)



## New Bedford Harbor

(*Fundulus* [PCB] = 272 ppm, dry wt)

Resistance to aromatic hydrocarbons in populations of *Fundulus heteroclitus*



New Bedford Harbor, MA (PCBs)

Bridgeport, CT (PCBs)

Newark, NJ (TCDD)

Elizabeth River, VA (PAHs)

Adapted from Nacci et al. (2010) *Estuaries & Coasts* **33**: 853



What is the genetic mechanism of resistance?

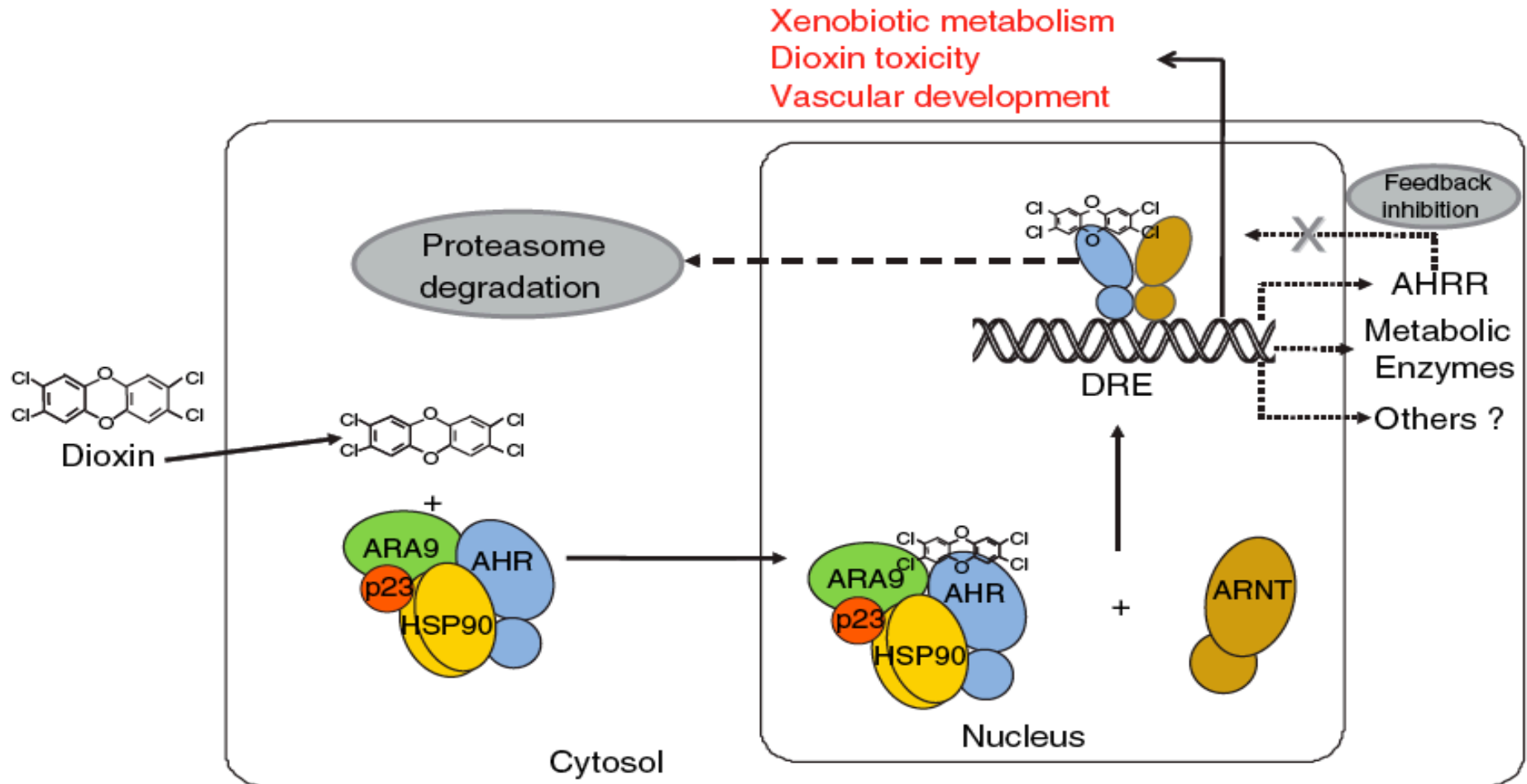
Hypothesis:

Population-specific variants of a gene (AHR) required for PCB toxicity.

Sample multiple fish in multiple populations (sensitive and resistant) and sequence AHR genes.

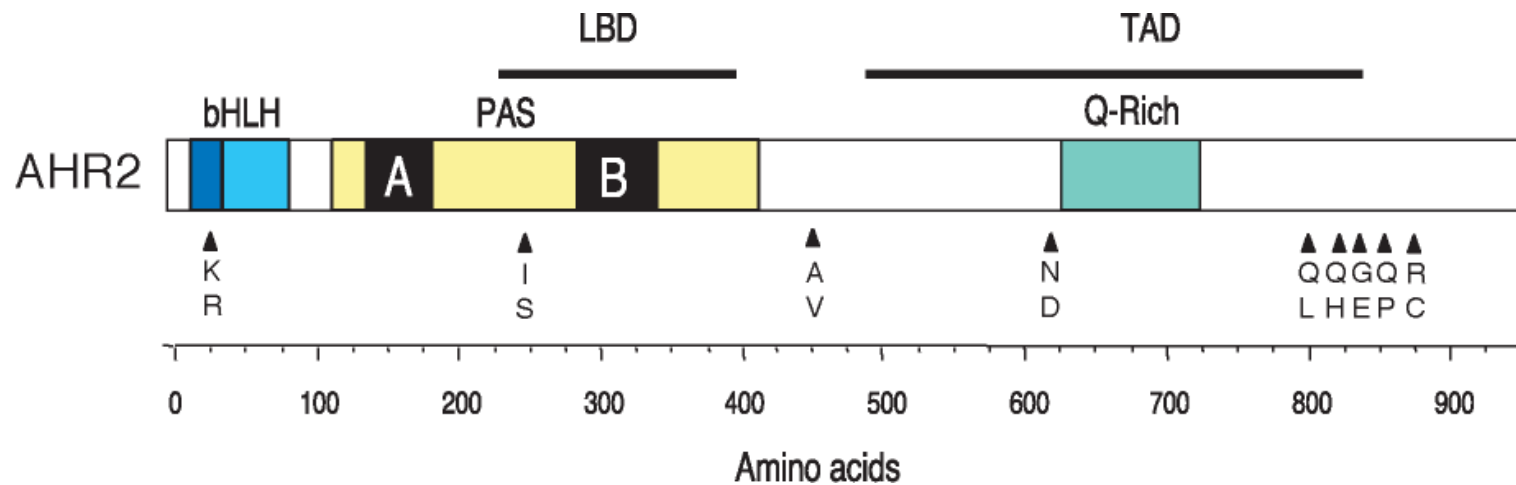


# Aryl Hydrocarbon Receptor (AHR)



# AHR2 allelic diversity in *Fundulus heteroclitus*

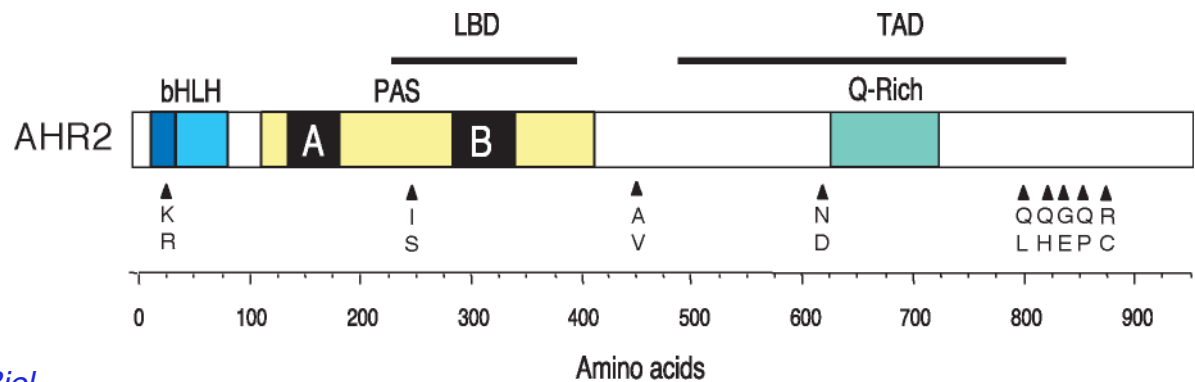
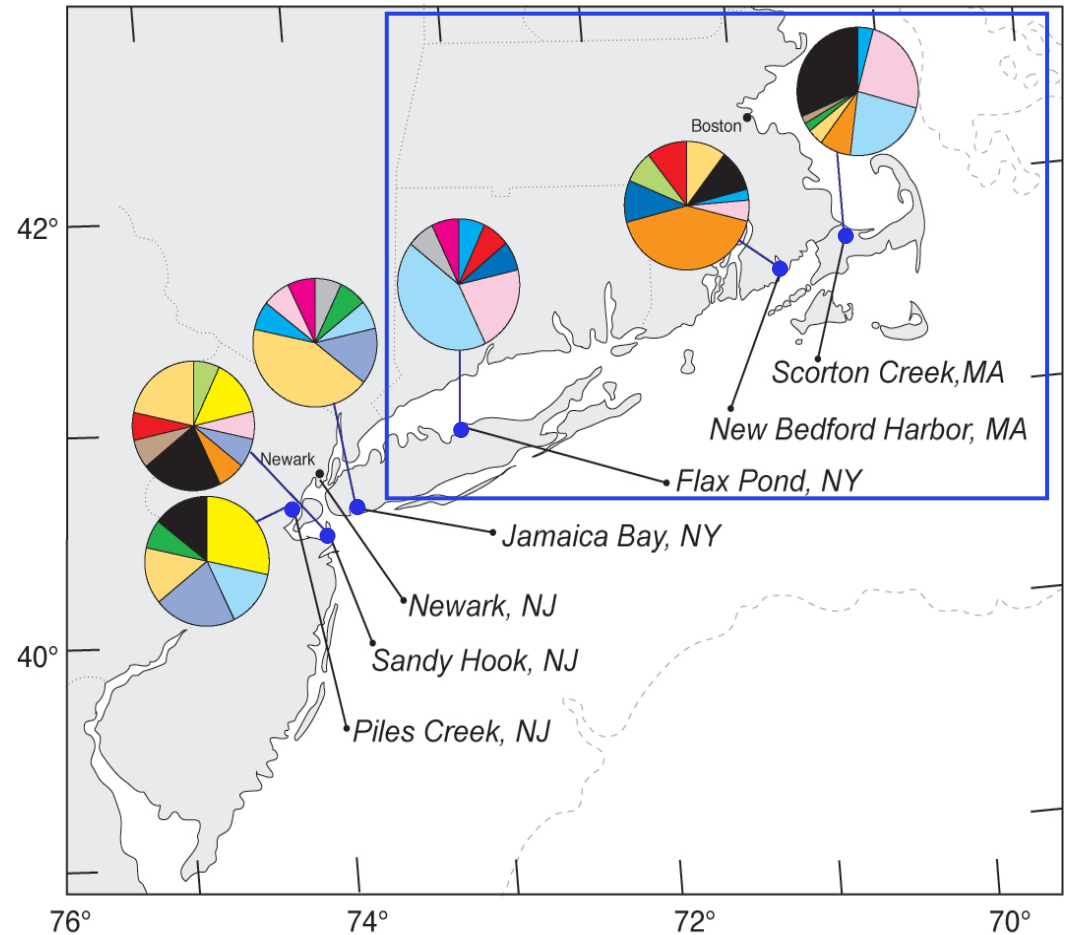
- Killifish AHR loci are highly polymorphic
- 30 single-nucleotide polymorphisms (SNPs) in AHR2 (out of 2853 nucleotides)
- 9 amino acid differences out of 951 amino acids (1%)
- 26 allelic variants (types of AHR2 gene)



# AHR2 variants

Different pattern of AHR2 variants in NBH vs reference sites SC or FP

Role for AHR. Other genes may also be involved.



## What are the costs of PCB resistance?

- Enhanced PCB accumulation and trophic transfer.
- Altered sensitivity to other chemicals?
- Altered sensitivity to other environmental stressors (e.g. hypoxia)?
- Mal-adaptation when site is cleaned up?



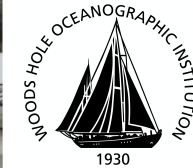
# Acknowledgments

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Jed Goldstone  
Ann Tarrant



Gloria Callard  
Jennifer Schlezinger  
Dave Sherr  
Tom Webster  
Veronica Vieira



**Boston University**  
**Superfund Research Program**



## Additional Information

<http://www.epa.gov/nbh/>

<http://www.whoi.edu/science/B/people/mhahn/hahn.html>

Nacci, D.E., Champlin, D., Jayaraman, S., 2010. Adaptation of the estuarine fish *Fundulus heteroclitus* (Atlantic killifish) to polychlorinated biphenyls (PCBs). *Estuaries and Coasts* **33**, 853–864.

Oleksiak, M.F., Karchner, S.I., Jenny, M.J., Franks, D.G., Mark Welch, D.B., Hahn, M.E., 2011. Transcriptomic assessment of resistance to effects of an aryl hydrocarbon receptor (AHR) agonist in embryos of Atlantic Killifish (*Fundulus heteroclitus*) from a Marine Superfund Site. *BMC Genomics* **12**, 263.

Reitzel, A.M., Karchner, S.I., Franks, D.G., Evans, B.R., Nacci, D.E., Champlin, D., Vieira, V.M., Hahn, M.E., 2014. Genetic Variation at Aryl Hydrocarbon Receptor (AHR) Loci in populations of Atlantic Killifish (*Fundulus heteroclitus*) inhabiting Polluted and Reference Habitats. *BMC Evolutionary Biology* **14**, 6.

Proestou, D.A., Flight, P., Champlin, D., Nacci, D., 2014. Targeted approach to identify genetic loci associated with evolved dioxin tolerance in Atlantic killifish (*Fundulus heteroclitus*). *BMC Evolutionary Biology* **14**, 7.

Wirgin, I., Roy, N.K., Loftus, M., Chambers, R.C., Franks, D.G., Hahn, M.E., 2011. Mechanistic Basis of Resistance to PCBs in Atlantic Tomcod from the Hudson River. *Science* **331**, 1322-1325 (DOI: 1310.1126/science.1197296).