Vulnerabilities of Atlantic Sturgeon and Shortnose Sturgeon to TCDD and PCB-Induced Early Life-Stage Toxicities

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Objectives

- Determine if sturgeons are sensitive to AHR-mediated early life stage toxicities
- Compare sensitivities of sturgeons to that of other fishes
- Compare sensitivities of sturgeons to environmental levels of PCBs and TCDD

Life History of Atlantic Sturgeon

- Distributed along the Atlantic coast from the Satilla River, GA, to the St. Lawrence River, QC
- Anadromous
- Subadults and adults are highly migratory in coastal waters returning after 5-20 years to natal estuaries to spawn
- Recommended for federal listing under U.S. ESA as five DPS of which four are designated as Endangered
- Benthic
- Large and highly adhesive eggs
- "Poster" species in the Hudson

Life History of Shortnose Sturgeon

- Distributed along the Atlantic coast from the Altamaha River, GA, to the Saint John River, NB
- Amphidromous
- Restricted to natal estuaries for entire life histories except at extremes of distribution
- Federally listed under U.S. ESA since 1973 as a single DPS
- Benthic
- Large and highly adhesive eggs

Threats to sturgeons

- Overharvest
  - Within natal rivers
  - Bycatch in coastal fisheries
- Habitat Alteration
  - Dams precluding access to spawning areas
  - Channel alterations
- Chemical Contaminants
  - PCBs and PCDD/Fs

Early life stage toxicities in fishes

- Sensitive response to PCDD/Fs, coplanar PCBs, and some PAHs
- Mediated by activation of the AHR pathway
- Relevant at the population level
  - Lake trout extirpation in the Great Lakes
- Usually due to structural and functional impairment of the heart
- Manifestations include pericardial and yolk sac edema, craniofacial malformations, aberrant spinal curvature, and reduced survivorship



Methods

- Collect Atlantic sturgeon broodstock from the Saint John River, NB, and shortnose sturgeon from the Connecticut and Saint John Rivers
- Breed adults in the lab and transport embryos to the NEFSC NOAA lab in NJ
- Optimize conditions to rear embryos under controlled and replicable laboratory conditions

Methods

- Waterborne expose embryos for 26-27 hr to six graded doses of both TCDD (0.001 ppb to 100 ppb) and PCB126 (0.01 ppb to 1000 ppb)
- Rear embryos in clean water until hatching
- Quantify CYP1A mRNA expression with semi-quantitative and quantitative RT-PCR
- Evaluate early life stage toxicities in treated larvae
- Estimate uptake of PCB126 in embry[illegible]ng scintillation counting of ^{3H}PCB126

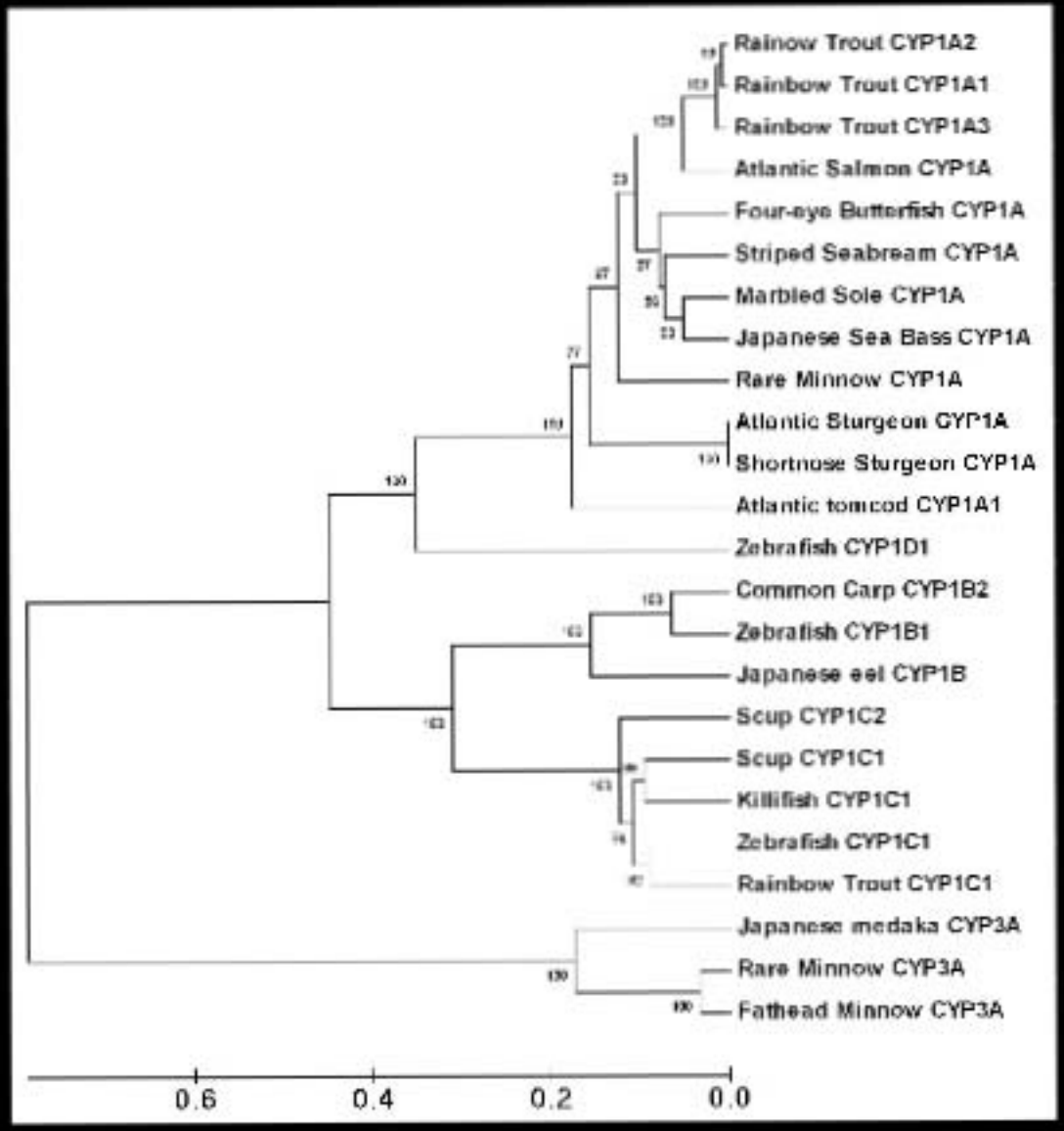
Early Life Stage Toxicities

- Hatching success
- Duration to hatch
- Eleven morphometric characters
- Eye development index
- Viabililty of unfed larvae

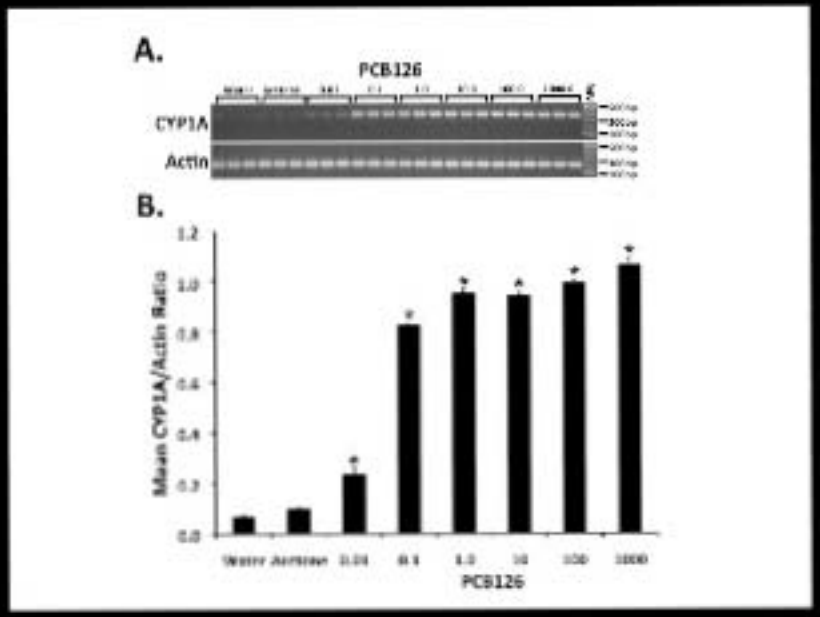
Cytochrome P4501A Expression

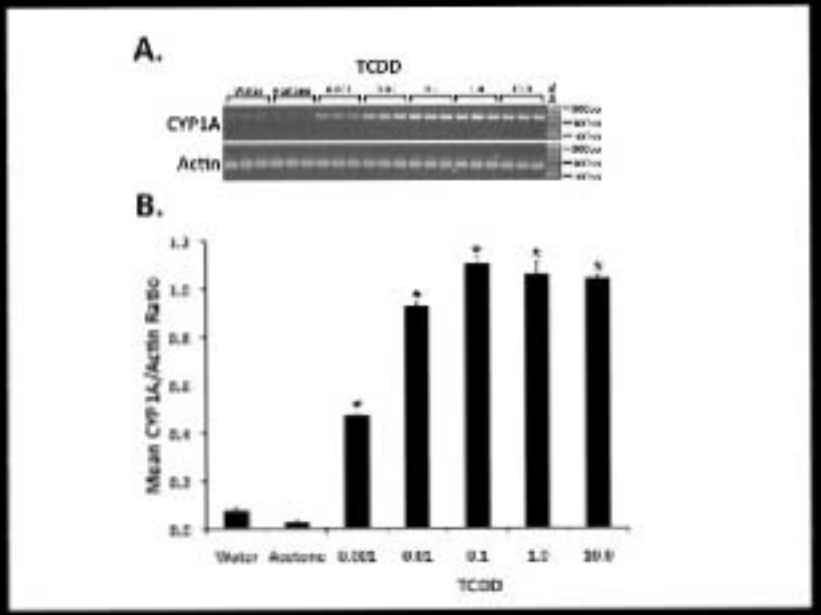
- Transcription mediated by activation of AHR2 pathway in other fishes
- Induced by exposure to PCDD/Fs, coplanar PCBs, and some PAHs
- Induction predictive of sensitivity to early life stage toxicities because of role of AHR2

UPGMA Dendrogram of Atlantic and Shortnose Sturgeon CYP1A and CYP1 and CYP3 Sequences from other Fishes

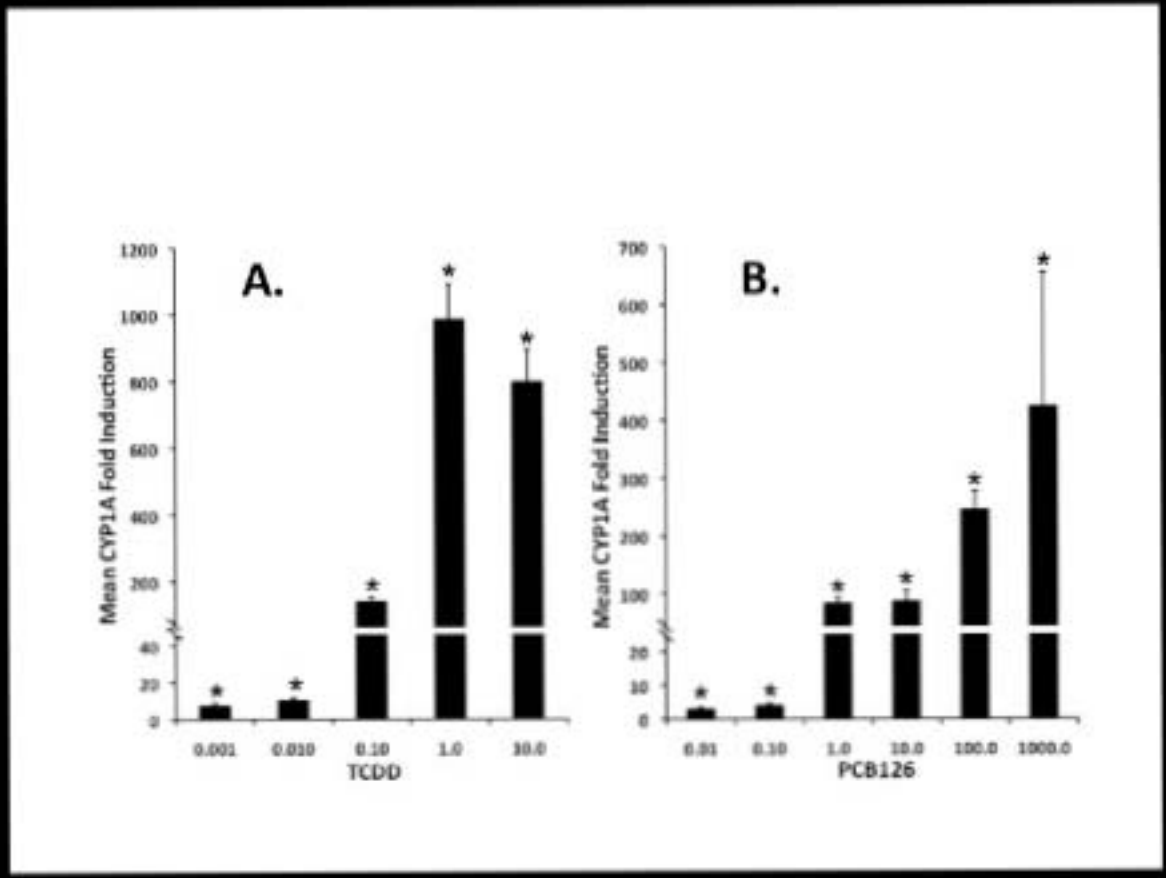


Semi-quantitative RT-PCR analysis of CYP1A in PCB126 and TCDD treated Atlantic sturgeon larva (ppb)

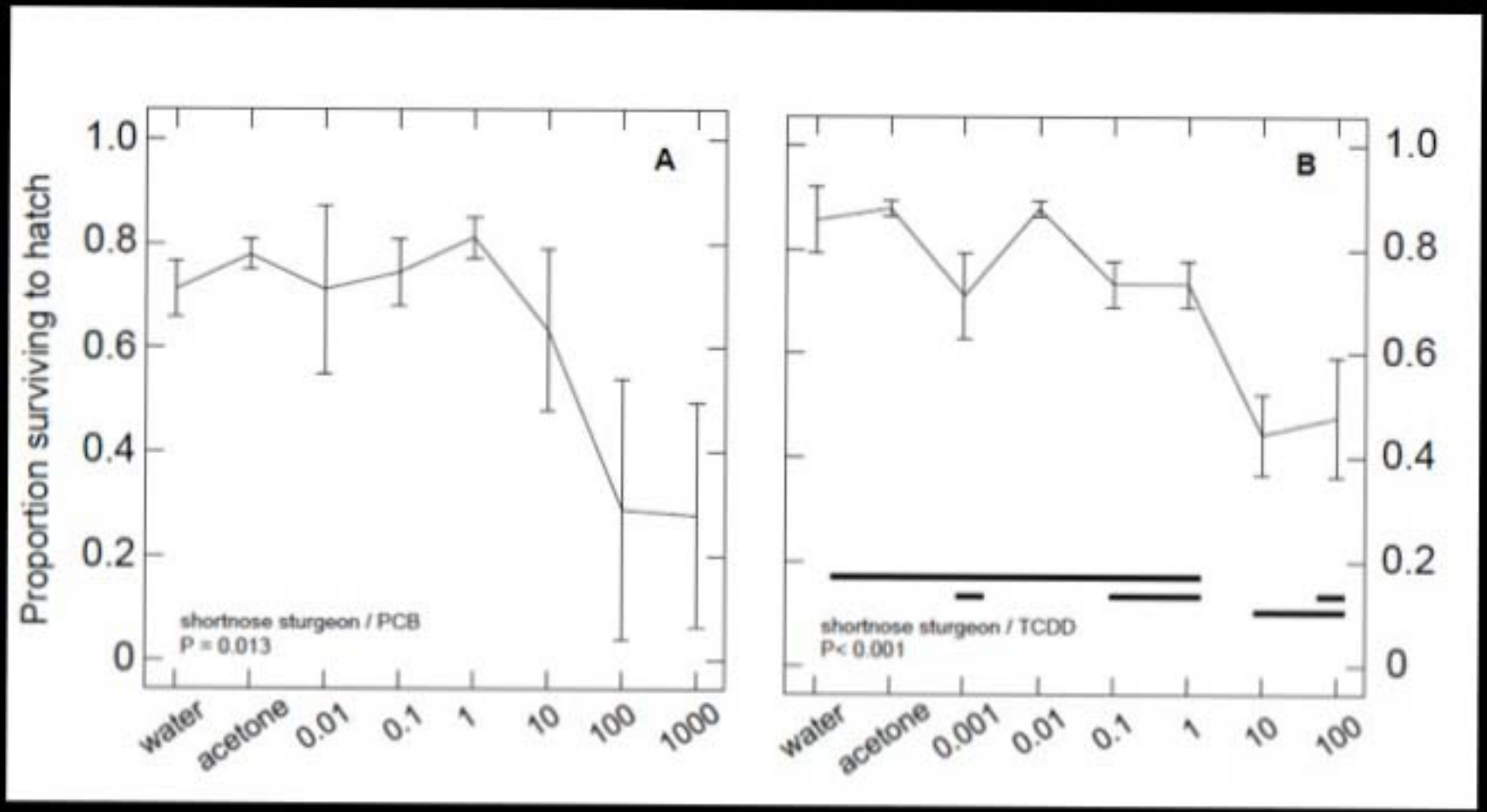




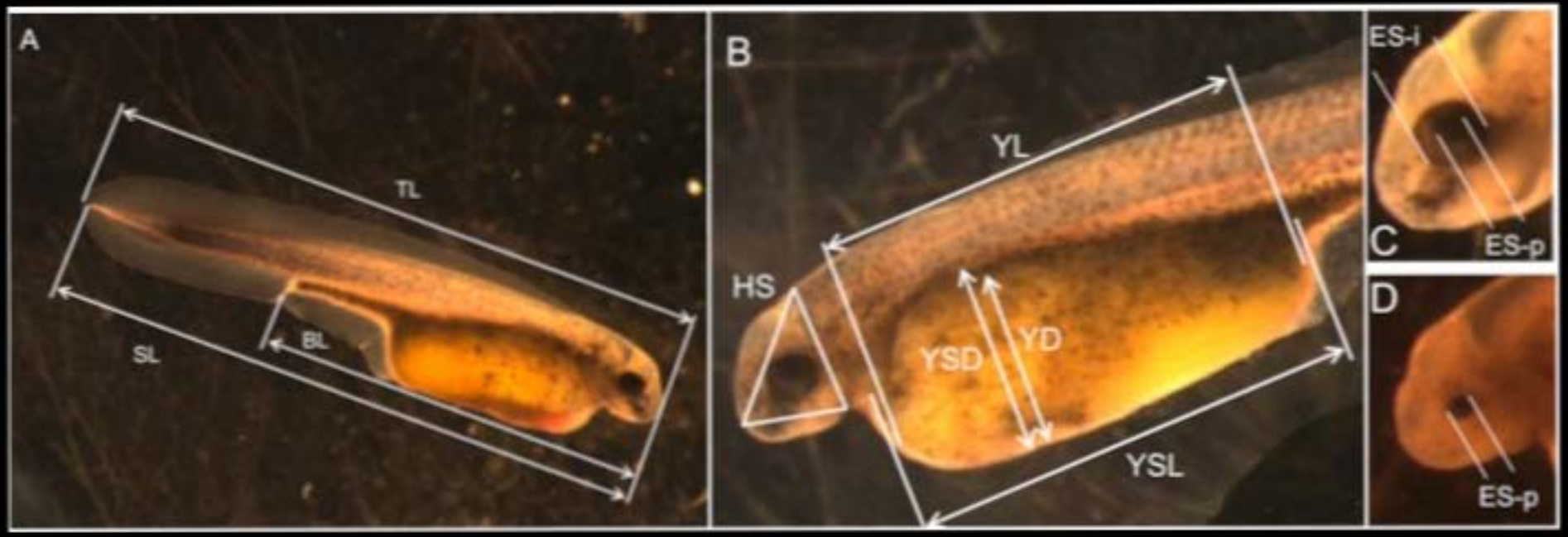
Quantitative Real-Time RT-PCR Analysis of CYP1A in TCDD and PCB126 Treated Shortnose Sturgeon Larvae (ppb)



Survivorship to hatch in PCB126 and TCDD treated shortnose sturgeon (ppb)



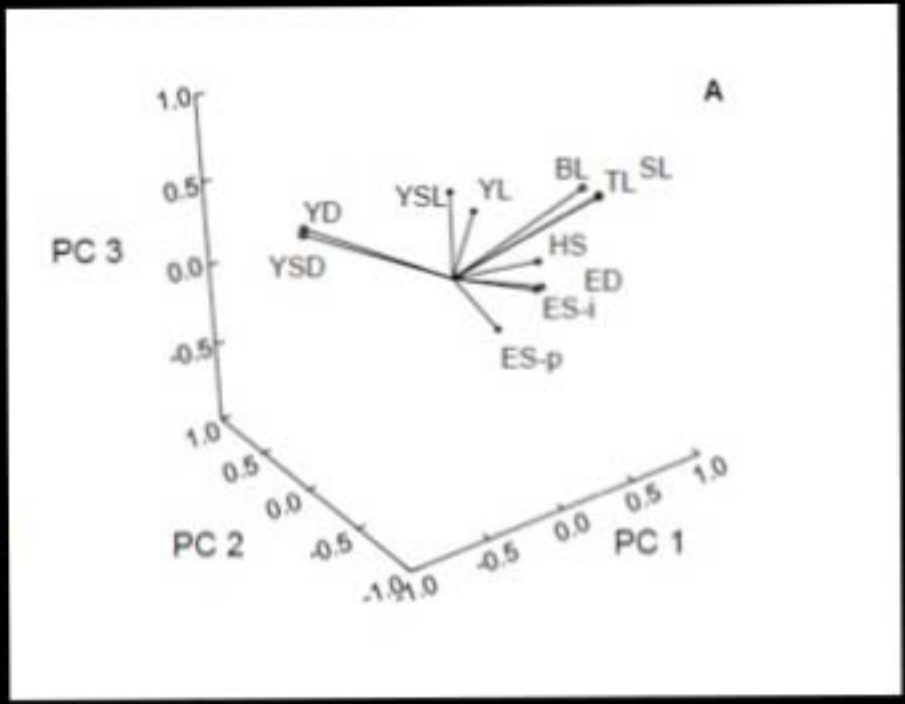
Eleven morphometric characters in TCDD and PCB126 treated Atlantic and shortnose sturgeon



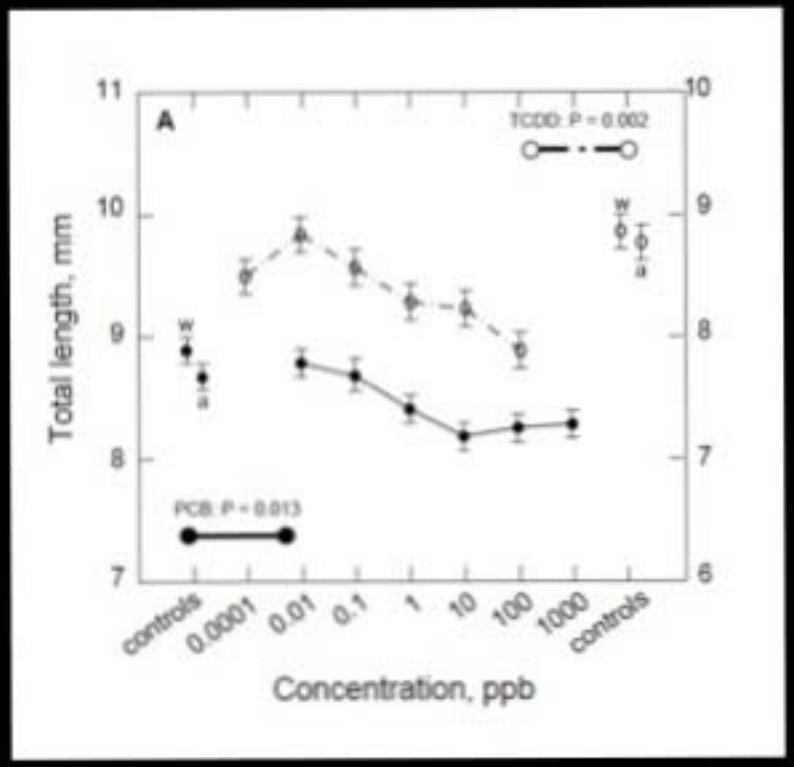
Results

Morphometric responses in shortnose sturgeon

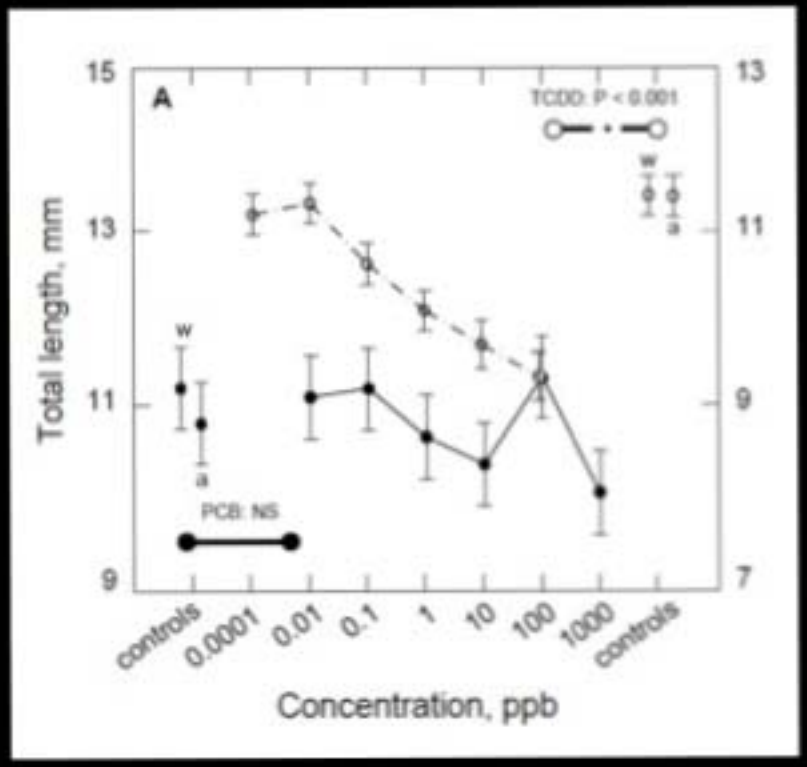
- PC axis 1 *(49.0%)*
  - Total length, standard length, yolk sac length, yolk length, body length and head size
- PC axis 2 *(21.6%)*
  - Yolk sac depth, yolk depth and eye development
- PC axis 3 *(10.8%)*
  - eye diameters



Total length in TCDD and PCB126 treated Atlantic sturgeon and shortnose sturgeon

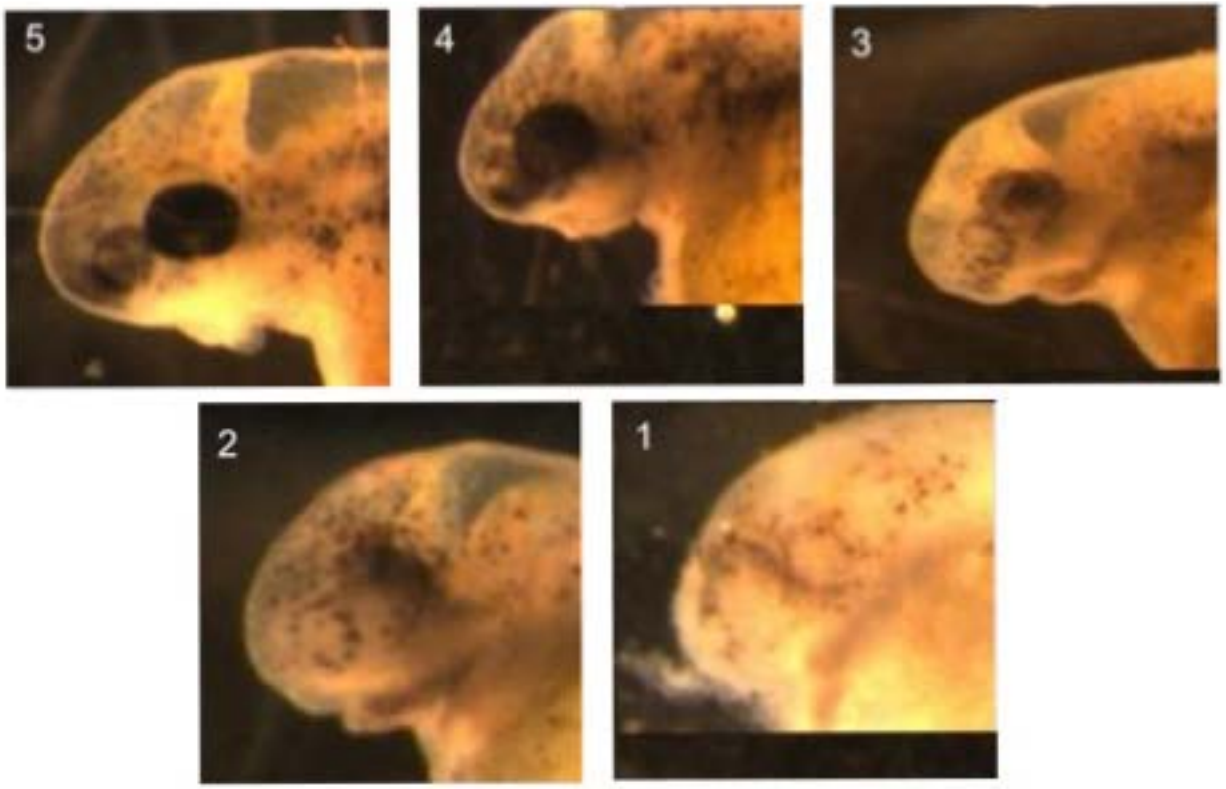


Atlantic Sturgeon

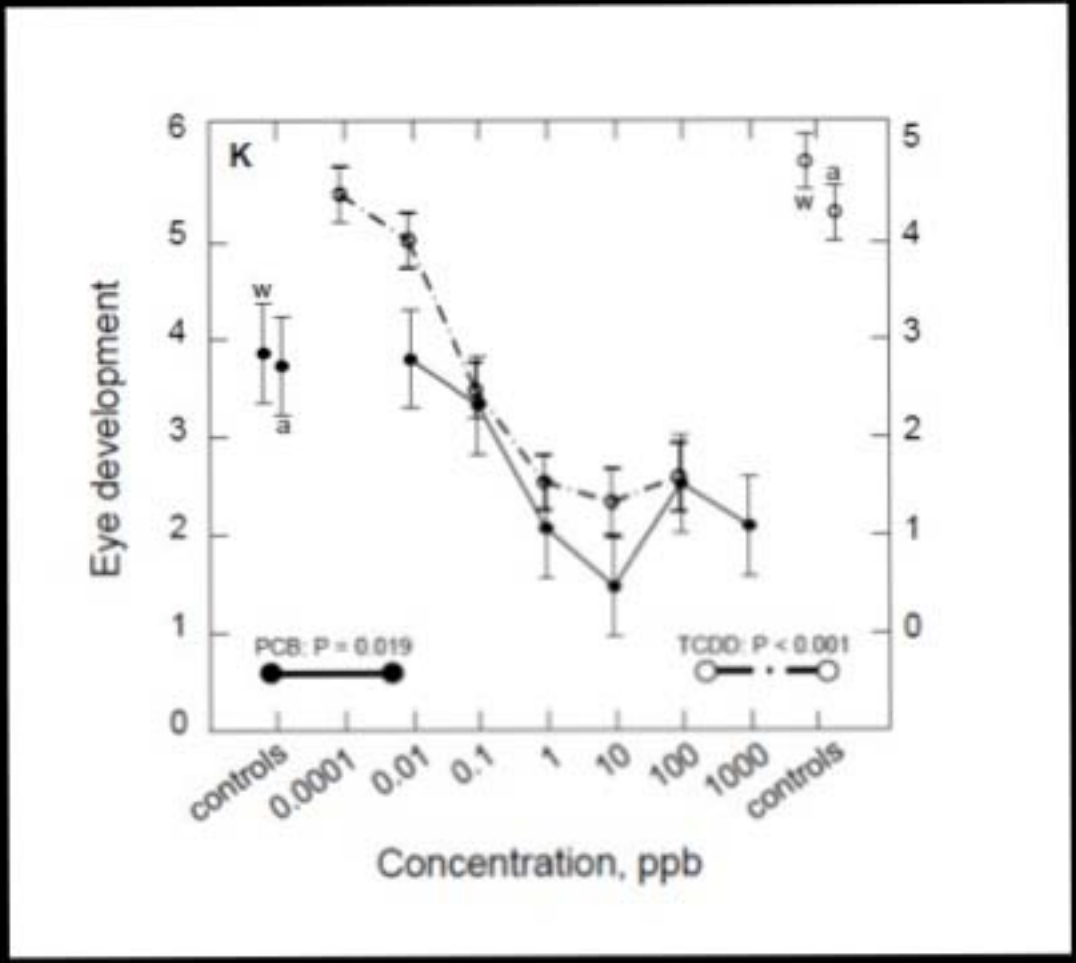


Shortnose Sturgeon

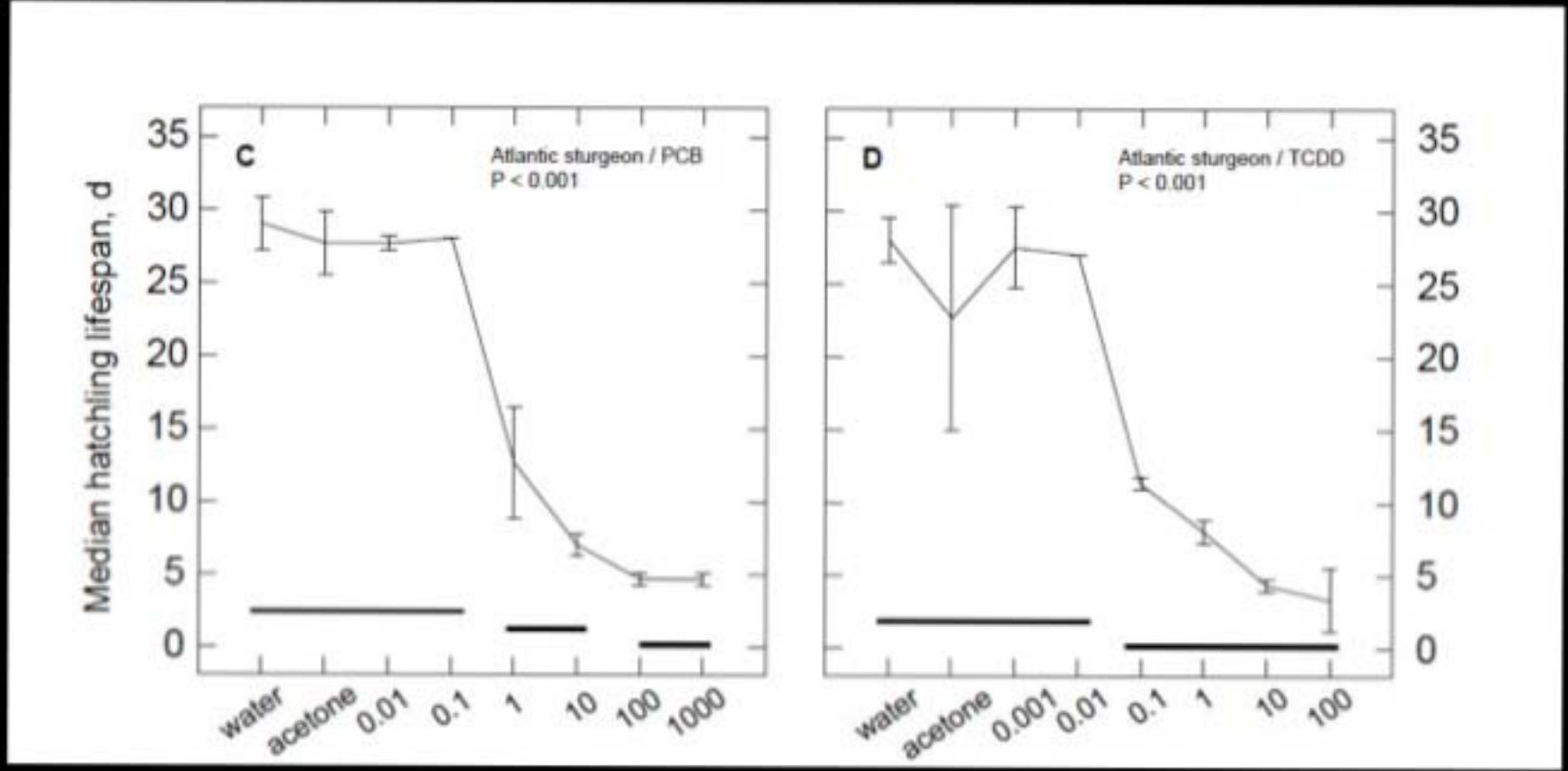
Eye Development Index
(5=normal, 1=highly abnormal)



Eye Development Index Results in PCB126 and TCDD Treated Atlantic Sturgeon



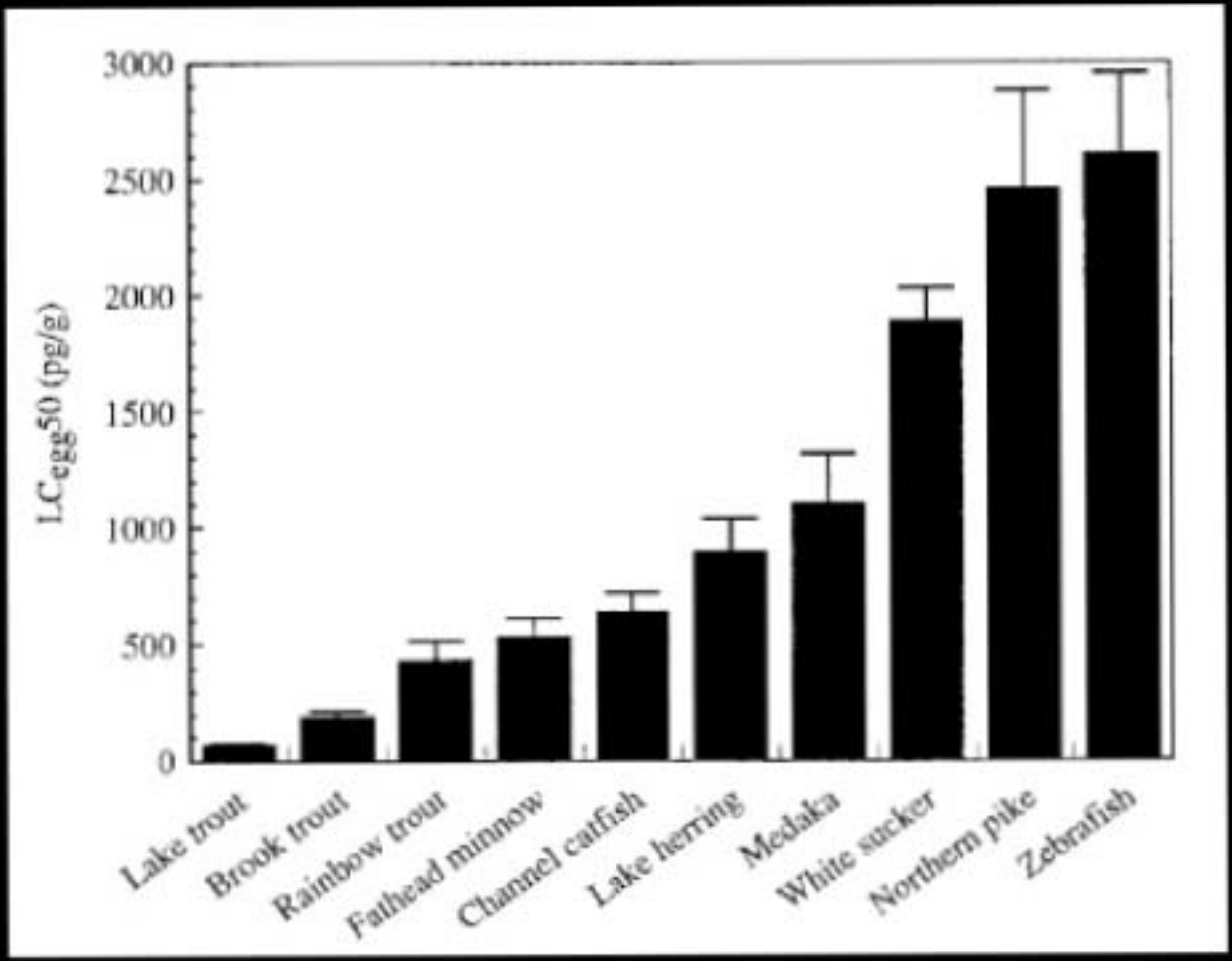
Mean Lifespan of Starved Atlantic sturgeon Larvae Treated as Embryos with PCB126 or TCDD



Result Highlights

- CYP1A mRNA expression significantly induced by TCDD and PCB126 in both sturgeons at lowest doses used, 0.001 ppb and 0.01 ppb, respectively
- Survivorship to hatch significantly decreased in Atlantic sturgeon by TCDD and PCB126 exposure
- Morphometric characters reflective of fish length and eye size decreased in both sturgeons with increasing doses of TCDD and PCB126
- Eye development index significantly decreased in both species by TCDD and PCB126
- Survivorship duration of unfed larvae significantly decreased in both species by embyronic exposure to TCDD or PCB126

How does sensitivity to TCDD and PCB126 in sturgeons compare to TCDD LC_{50} in other fishes?



Initial Significant Response

I. Eye Development
2. Larval Lifespan

Atlantic S- 100 pg/g

Shortnose S-100 pg/g

from Elonen et al. 1998

How does sensitivity to TCDD and PCB126 in sturgeons (100 pg/g) compare to TCDD TEQ tissue burdens in HR fishes?

Location and gender	Total dioxins and furans (TCDD TEQs) Wet (ng/kg)	Total dioxins and furans (TCDD TEQs) Lipid (ng/kg)
Hudson males	99	270
Hudson females	32	476
Hackensack males	673	1867
Hackensack females	256	1878

Atlantic tomcod

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