Predicted population decline in fish due to bifenthrin exposure: Implications for aquatic ecosystems in the Bay-Delta

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pyrethroids

- Used for general insect control, in flea shampoos, as a mosquito spray and coating, also in agriculture.

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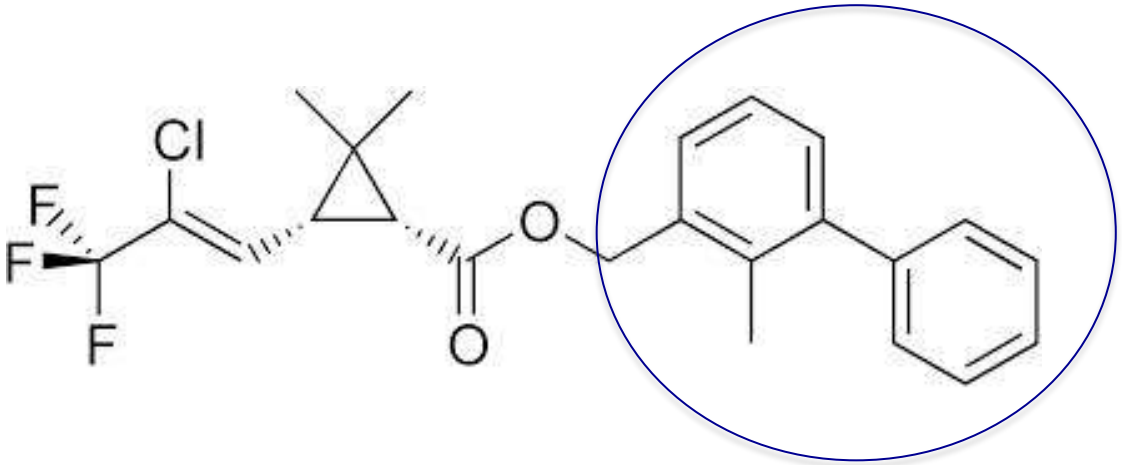
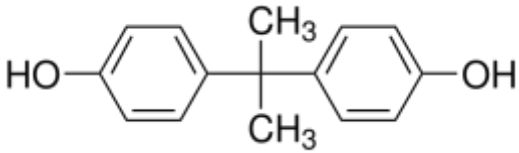
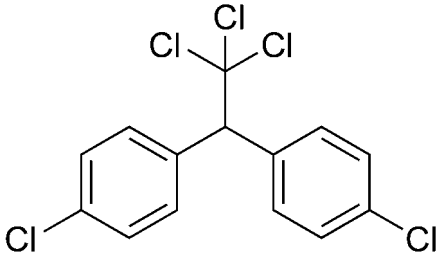


bifenthrin

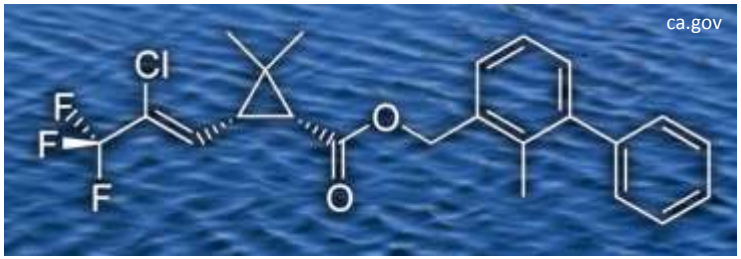
bisphenol A





DDT

bifenthrin



- Endocrine disruptor (Brander et al. 2012, Riar et al. 2013)
- Increasing usage nationally (Kuivila et al. 2012)
- Persistent, toxic at low concentrations
- High levels in stormwater, wastewater (Weston et al. '09, 10, 13)

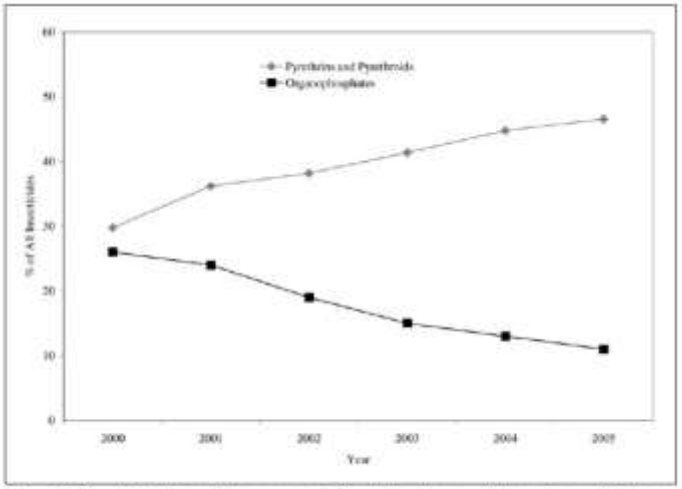
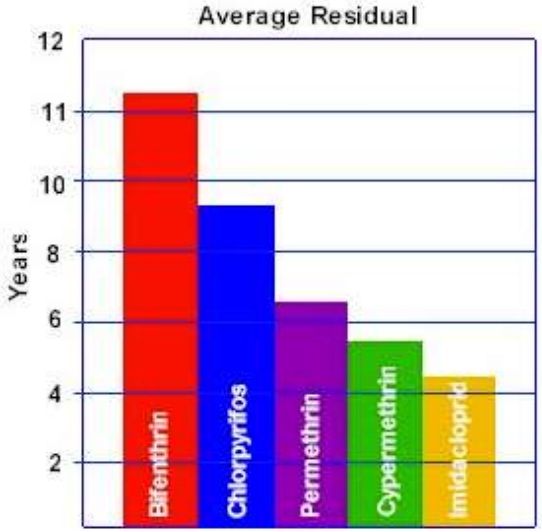


Figure 1: Percent of all insecticide exposure incidents involving pyrethrins and pyrethroids, and organophosphates by year.*
**Organophosphate data taken from [3,17].*

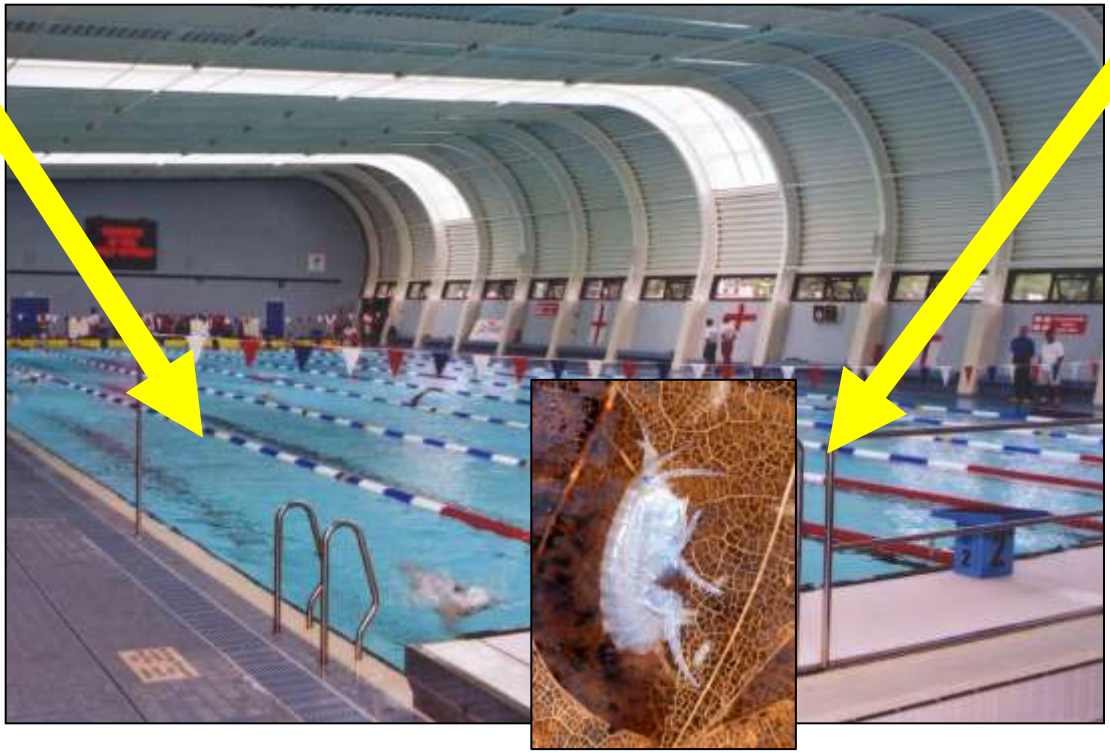
From Power et al. 2007



http://envirosafepc.com/termite_control.php

environmental relevance

parts per billion



parts per trillion

bifenthrin

slide courtesy of N. McGinn

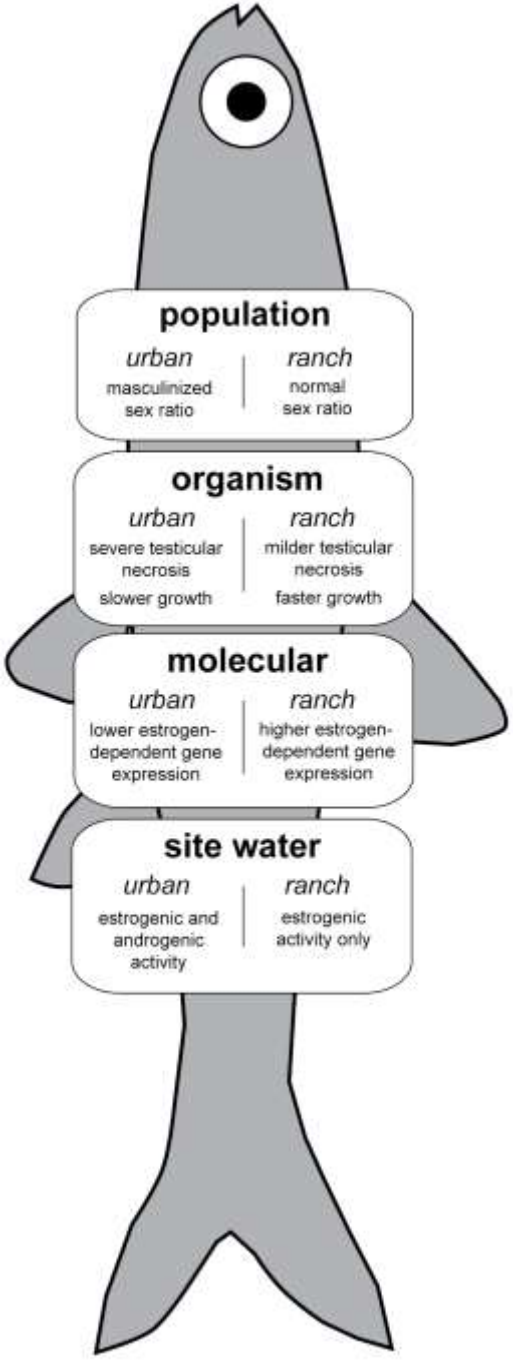
study species

Menidia beryllina (inland silverside)

- Life history / biology well-known
- Ubiquitous in N. American estuaries
- Commercially available (EPA WET)
- Small home range, high site fidelity
- Sensitive to toxicants

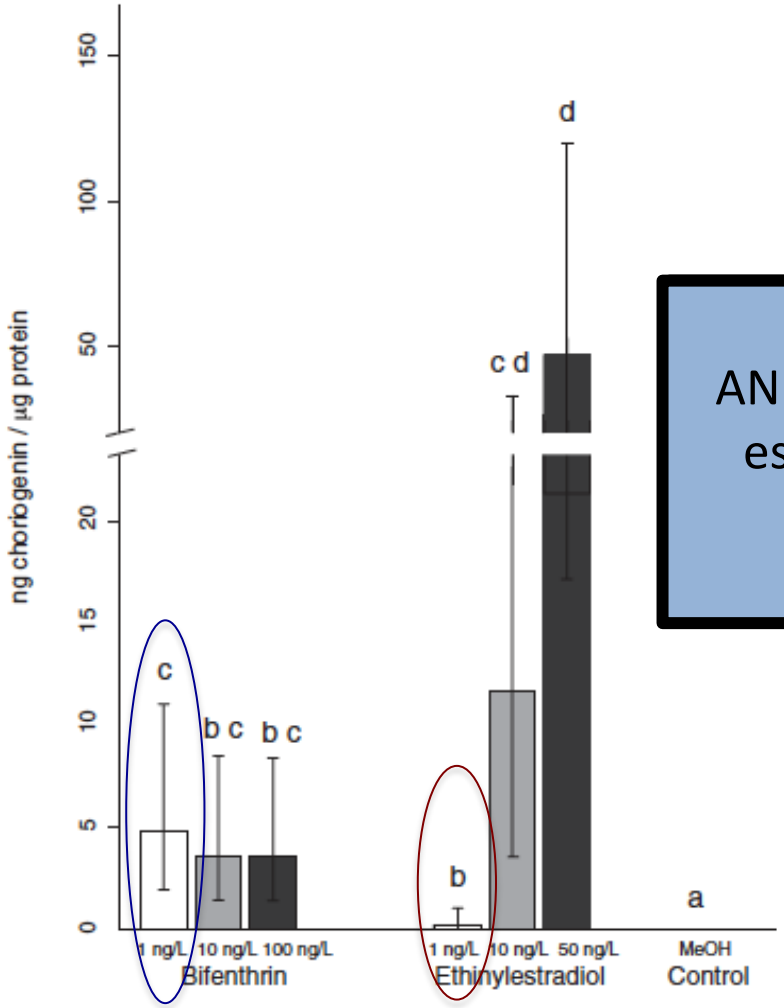
  (Brander et al. 2012a *Ecotoxicology*, 2012b *Env. Tox & Chemistry*, 2013 *PLoS ONE,* Duffy et al. 2009)
- Temperature sensitive sex determination

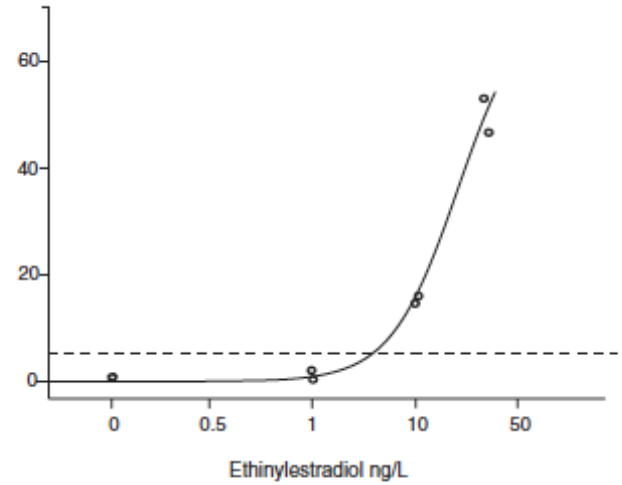
  (Duffy et al. 2009)



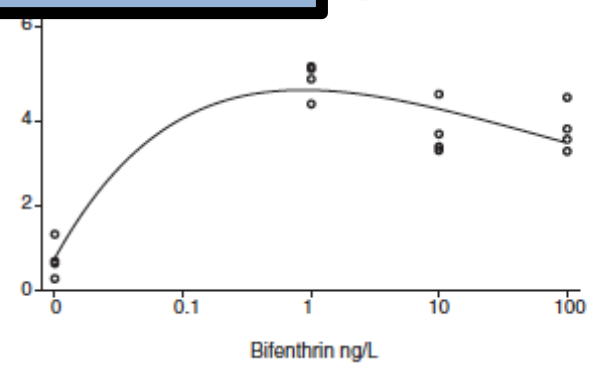
Brander et al. 2013, *PLoS ONE*

previous findings





AND … if bifenthrin is acting as an estrogen at 1 ng/L, how does it affect reproduction??



Brander et al. 2012, *ET&C*

reproduction

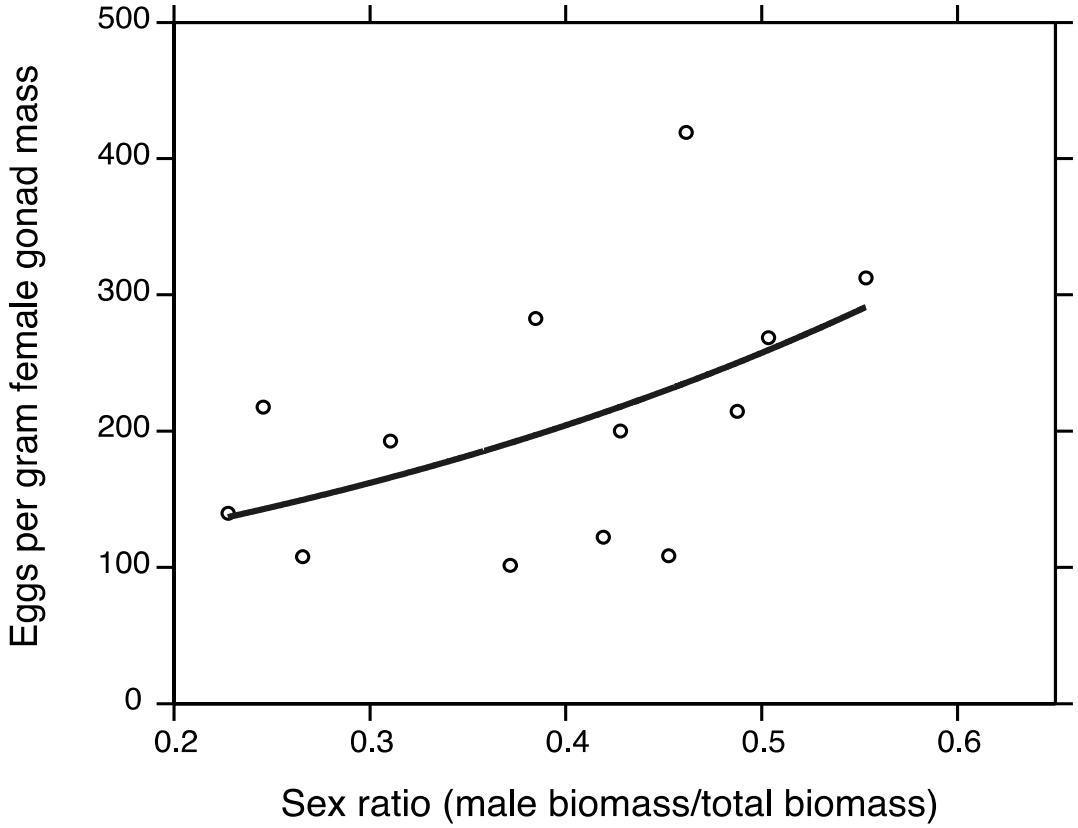
- Silversides are group spawners, not sexually dimorphic

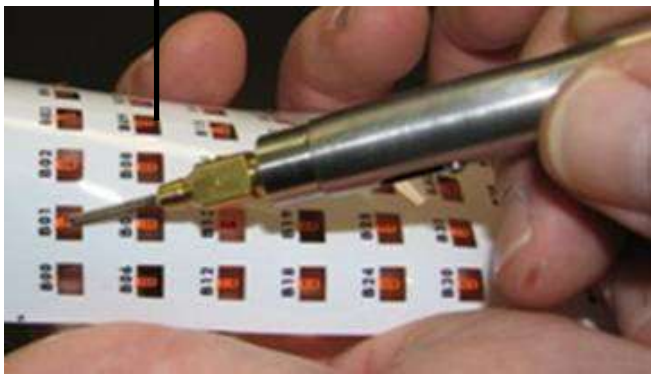
- Will spawn daily in field during reproductive season

- Spawn regularly in the lab if kept at spring-summer temps (25 deg C)

http://emilykinskey.com/work/bbc-magazine-tales-from-the-bush/

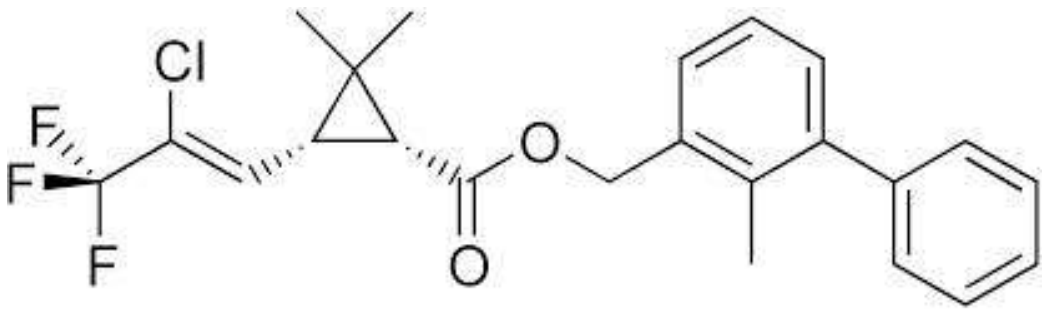
reproduction





Sigmoidal-shaped spawning functional response, similar to that of pair spawners.

reproduction

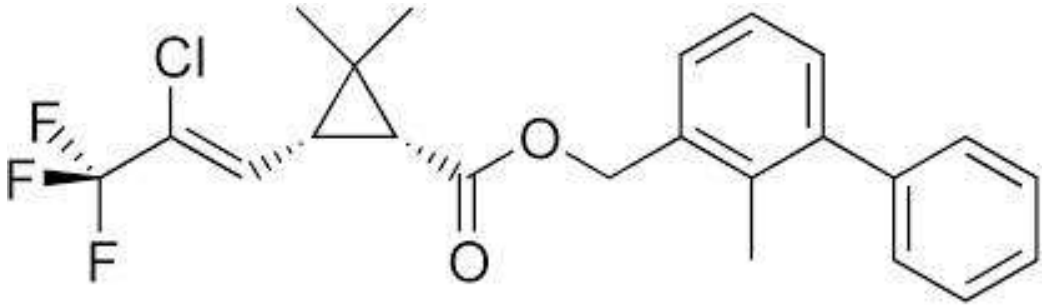


Exposed adults (8 months old) for 7 days to 0.5 ng/L bifenthrin at 25 ppt salinity

Returned to recirculating tanks to spawn for 48 hours

30% reduction in fertilized egg output overall

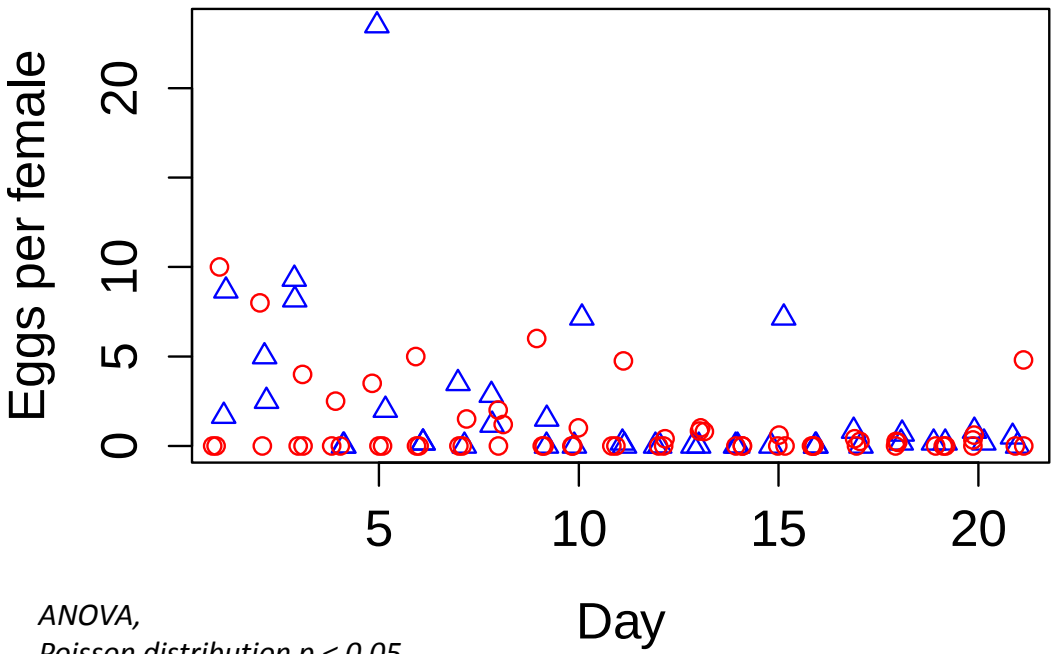
reproduction



Exposed adults (8 months old) for **21 days** to 0.5 ng/L bifenthrin at 25 ppt salinity

Collected eggs each morning for 21 day period

reproduction



ANOVA,
Poisson distribution p < 0.05

Exposed adults (8 months old) for **21 days** to 0.5 ng/L bifenthrin at 25 ppt salinity

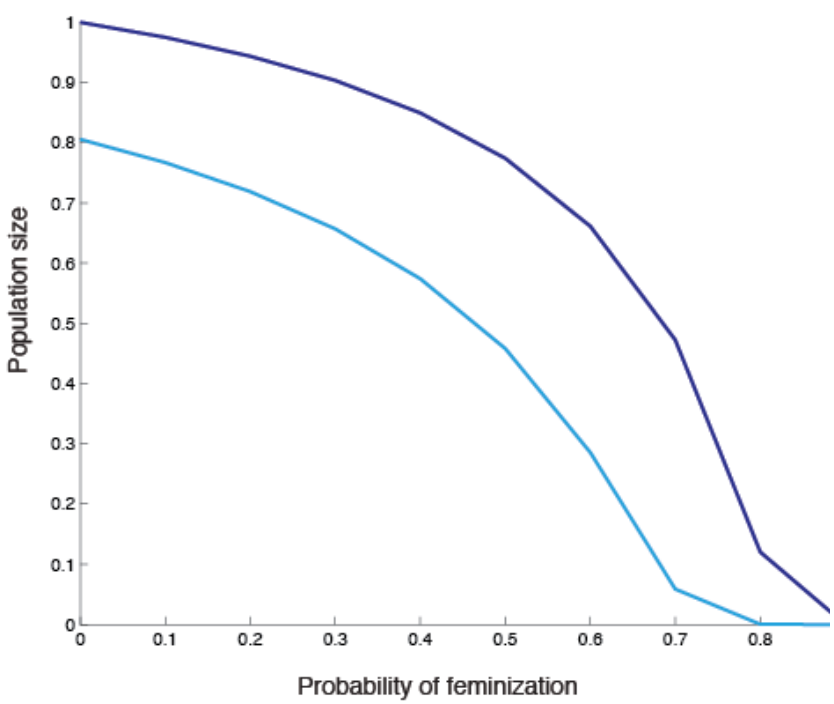
Collected eggs each morning for 21 day period

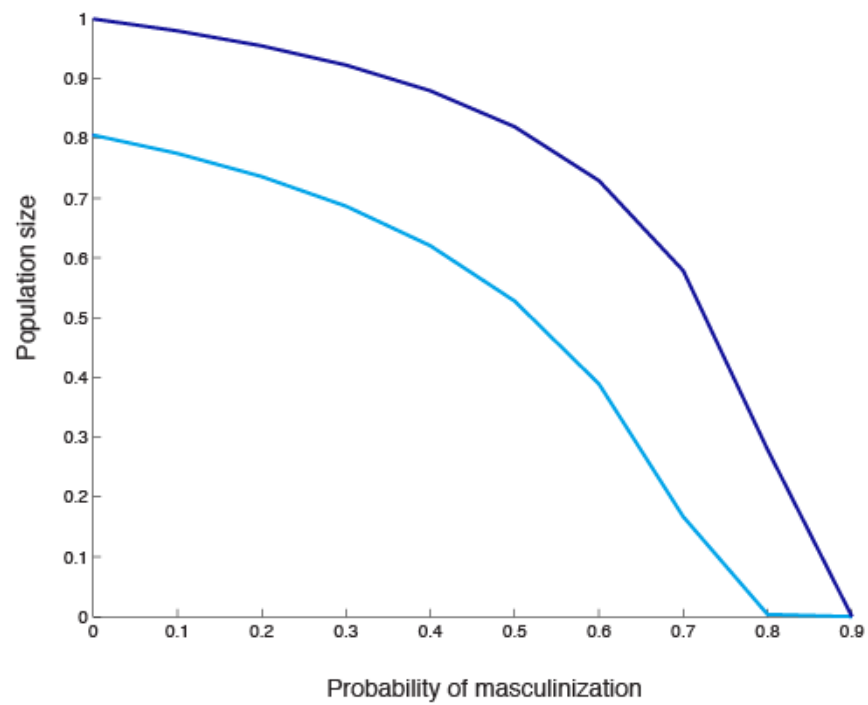
35% reduction in fertilized egg output overall

modeling

What effect would bifenthrin have on population size and persistence, in combination with changes in sex ratio?

Age-structured population model, parameterized using silverside functional spawning response



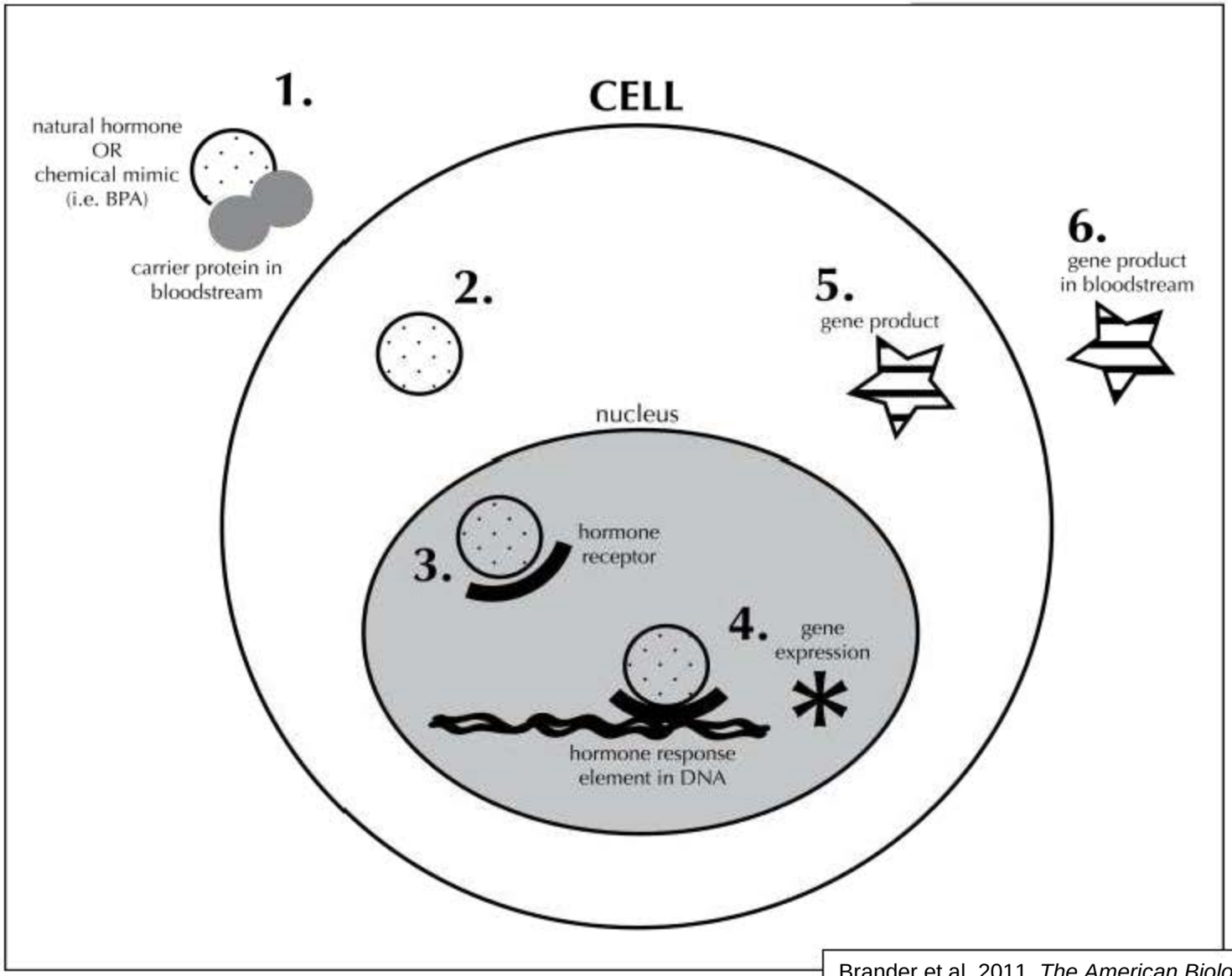


Without bifenthrin

With bifenthrin

Brander, White, Connon *(in prep)*

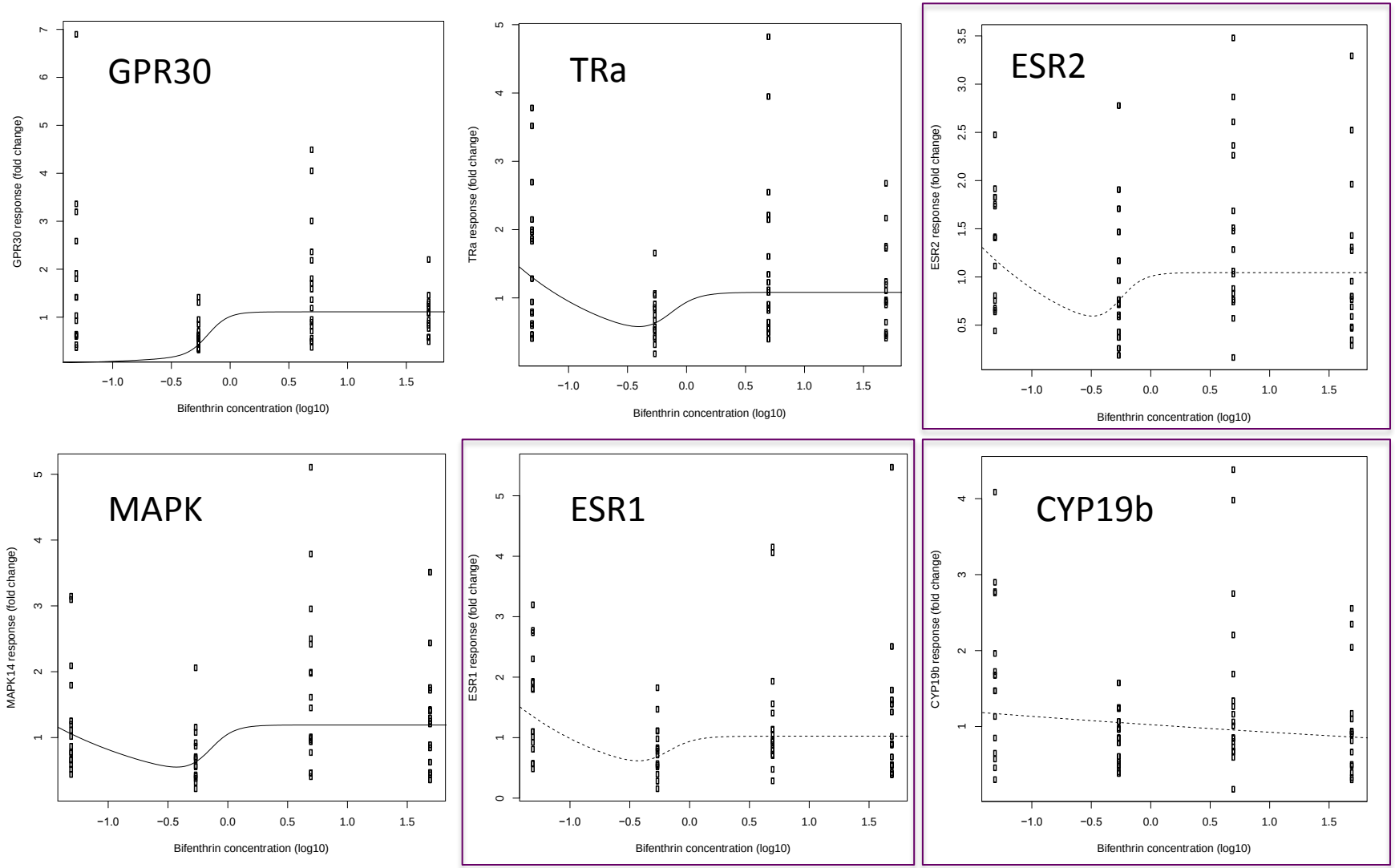
mechanism



Brander et al. 2011 *The American Biology Teacher*

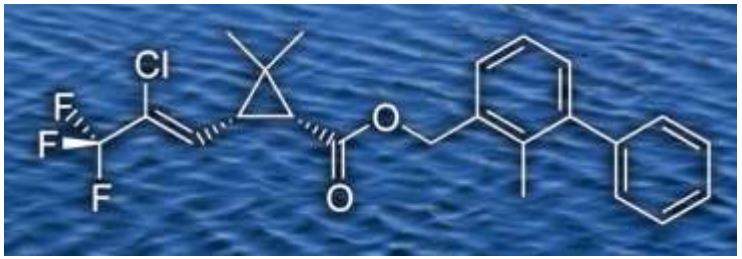
gene expression (qPCR)

PCA

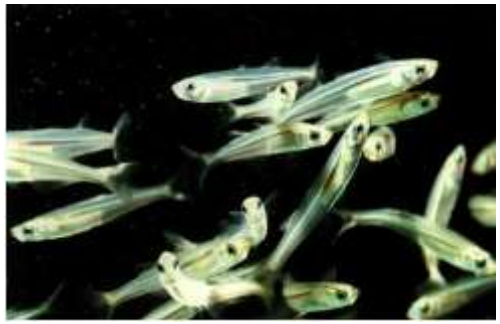


Fit both logistic and non-monotonic curves using maximum likelihood (solid lines $p < 0.05$).

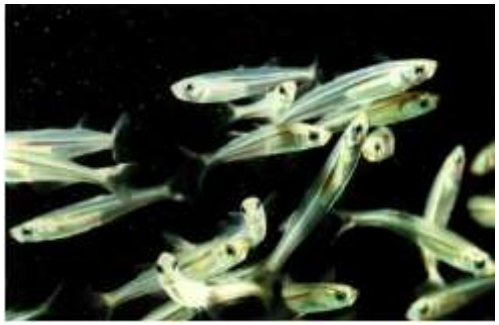
conclusions



- Environmentally relevant concentrations cause a significant reduction in reproductive output.
  - Population models predict that such a reduction would result in population decline.
- Small fold-changes in gene expression correspond to impacts at reproductive level.
- At molecular level, low concentrations appear to be more endocrine active.



future directions



Further optimize repro assay

- vary salinities and temperatures
- creating an ethogram using videos of trials

Multiple stressors and bifenthrin response

- current multi-generational assessment is underway
- evaluating response at low and high salinity

Collaborations …

Effects of EDCs on sex determination, adult sex ratio

- Summer – Fall 2014 (Denslow, Mehinto et al.)

funding sources

CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

UNCW

Delta Stewardship Council

ECOSYSTEM RESTORATION PROGRAM

SFCWA State and Federal Contractors Water Agency

UNCW UNIVERSITY of NORTH CAROLINA WILMINGTON

Sea Grant North Carolina
www.ncseagrant.org

Friends of UNCW

eTEAL

acknowledgments

Members of the Connon, Fangue labs

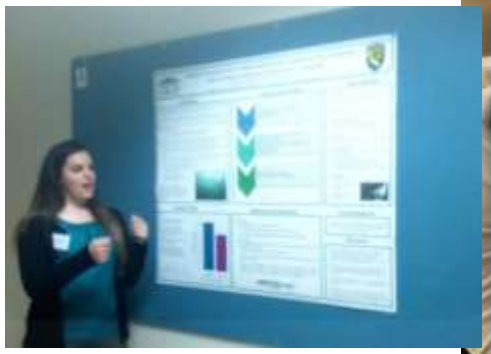
B Decourten (PhD student)

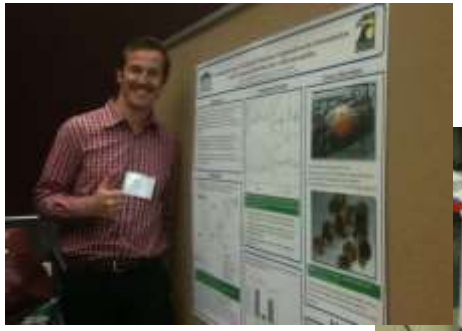
A Goff (Masters student)

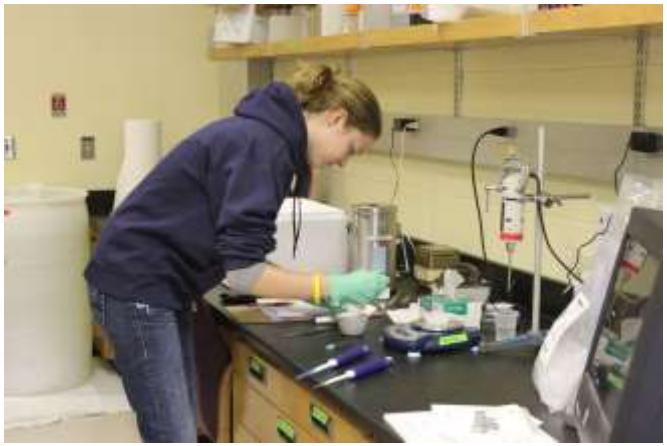
MANY undergraduate researchers!

UNCW Center for Marine Science,
UNCW Dept. Biology and Marine Biology,
UC Davis Genome Center, UCD Aquatic Tox Lab

collaborations:
G Cherr, M Denison, N Denslow, A Mehinto, K Maruya, S Bay, M Hladik, MB Hawkins, C Rochman, L Komoroske

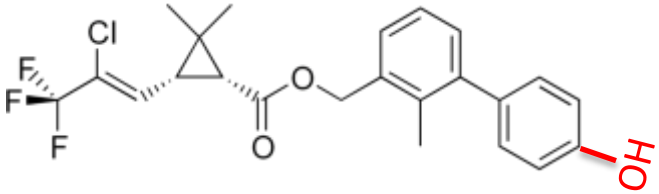






questions?

protein - choriogenin



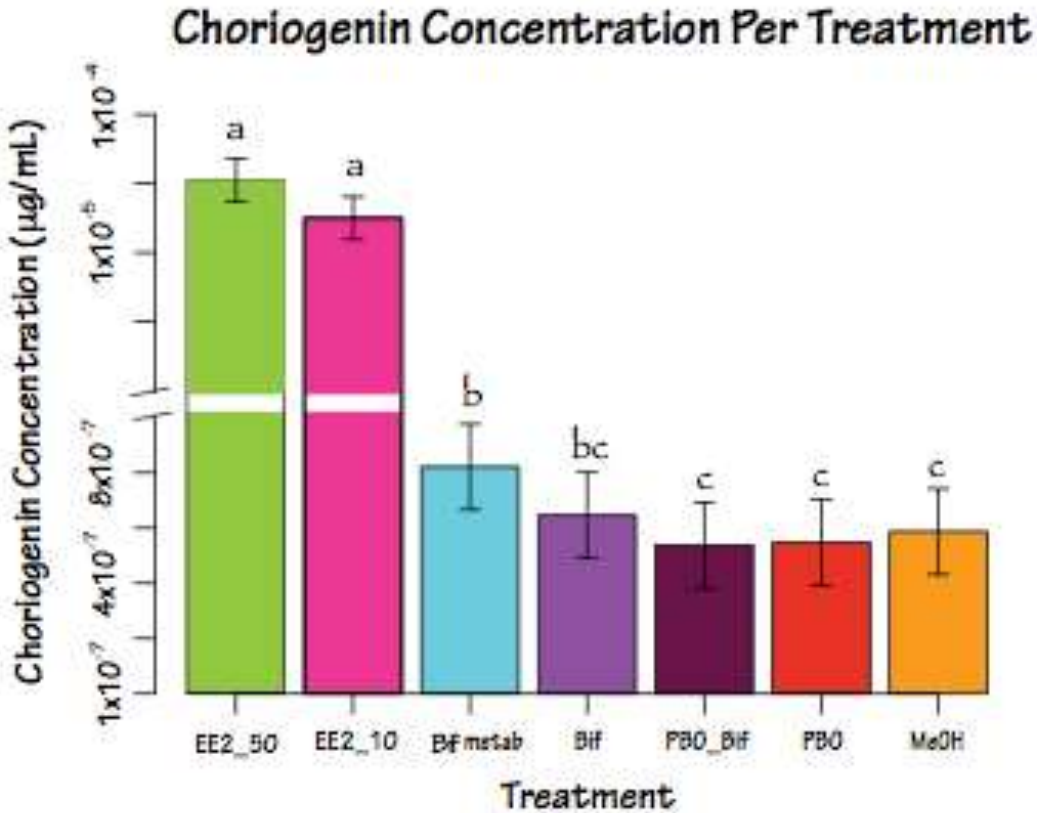
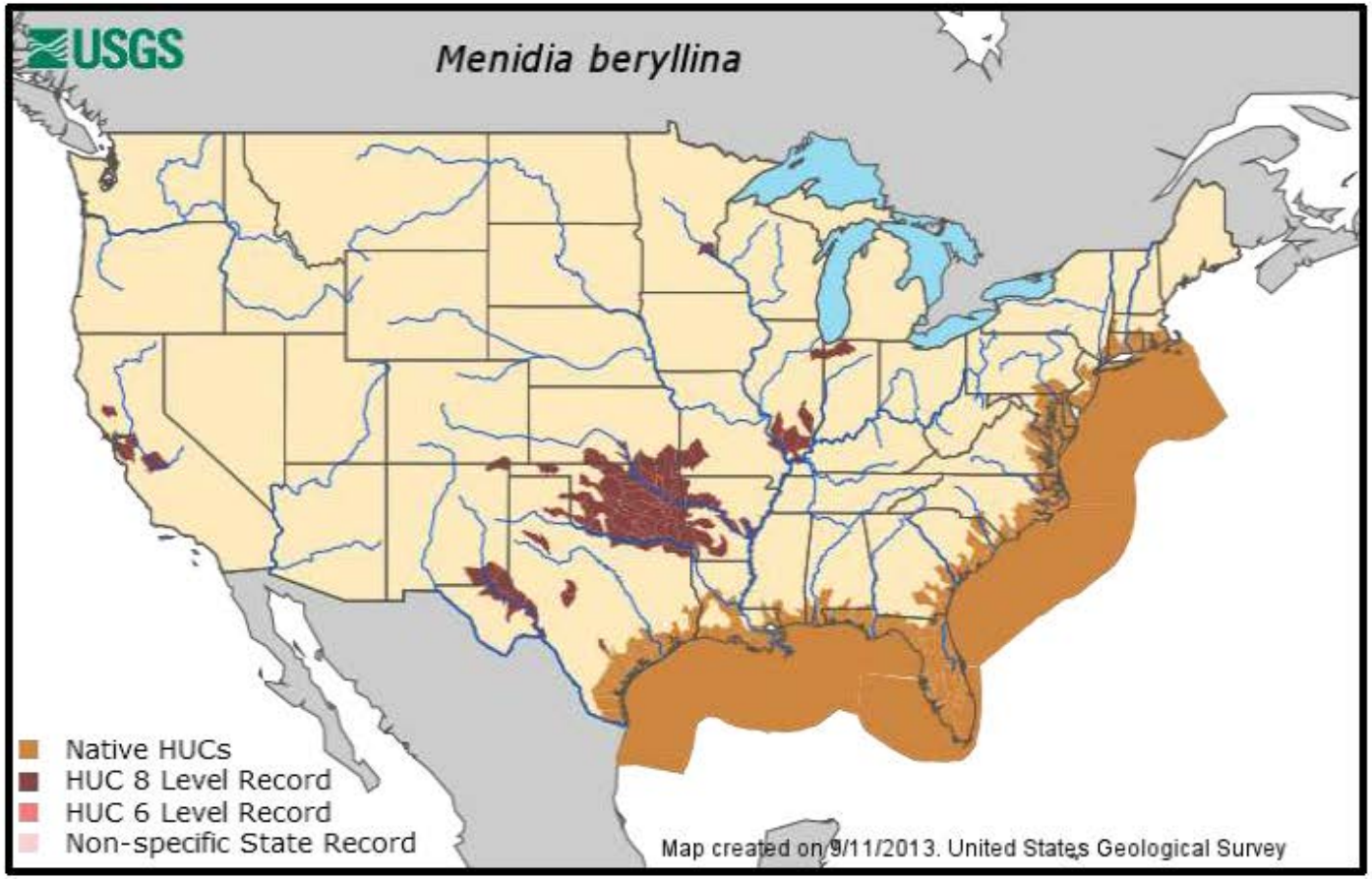


Figure 6: Effect of 10 ng/L EE2, 50 ng/L EE2, 10 ng/L 4-hydroxy bifenthrin (bifenthrin metabolite), 10 ng/L bifenthrin, and 10 ng/L bifenthrin+ 25 µg/L PBO on choriogenin expression in juvenile Menidia beryllina.

P450 metabolism may play a role in increasing bifenthrin's estrogenicity.

May explain non-monotonic responses.

DeGroot and Brander *2014, Aquatic Toxicology*

M. beryllina range