



EDC effects in bivalves: Are our oysters at risk?

Patricia D. McClellan-Green
North Carolina State University
Department of Environmental & Molecular
Toxicology
Center for Marine Sciences and Technology

Thanks to those who have contributed to this work

Dr. Eva Oberdörster

Dr. Jocelyn Romano

Robin Sewiers

Joshua Osterberg

Mari Hawkins

US EPA Star Grant

Megan Phifer

Oak Foundation

Weston Smith

Florida Fish and Wildlife

North Carolina Sea Grant

Invertebrates

- 95% of all known species are invertebrates (30+ phyla)
- Molluscs are the second most abundant invertebrate group (>130,000 species)
 - 5 major classes (bivalves, cephalopods, polyplacophorans (chitons), scaphopods (tusk shells) and gastropods)
- Bivalves are very diverse (>15,000 species)



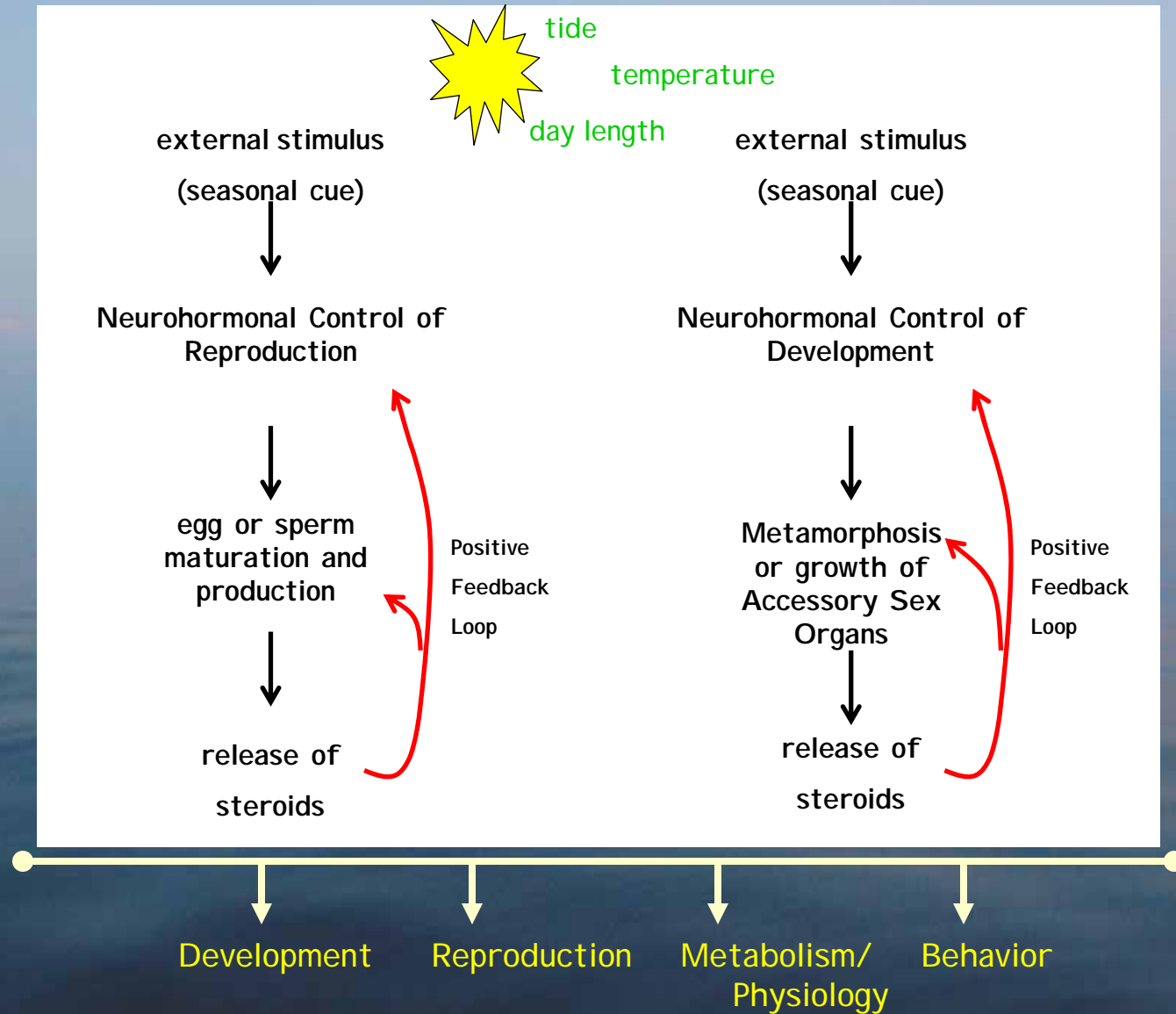
What are Endocrine Disruptors

- Exogenous agents that interfere with
 - Synthesis
 - Secretion
 - Transport
 - Binding
 - Action
 - Elimination

of hormones in the body

Types of Hormones

- Glycoproteins ?
- Polypeptides
- Peptides
- Steroids
- Modified amino acids ?
- Catecholamines ?
- Prostaglandins
- Retinoic acid



Role of environmental cues on development and reproduction in mollusks



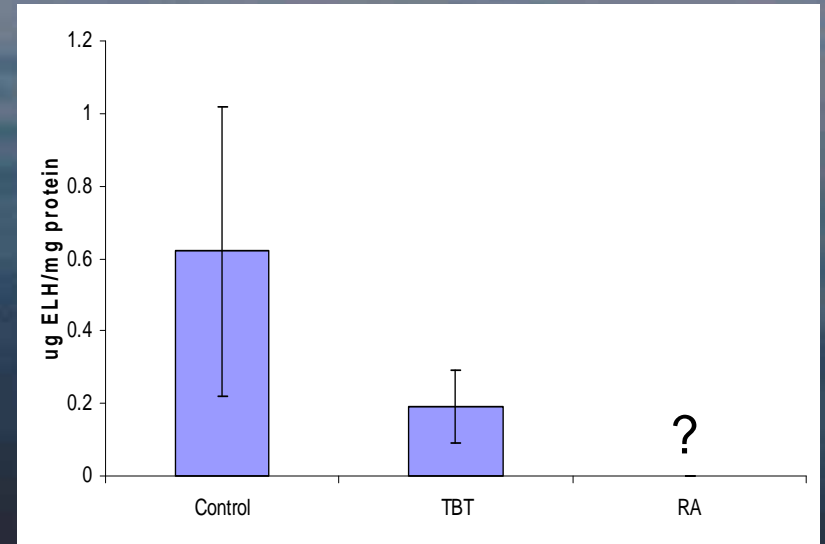
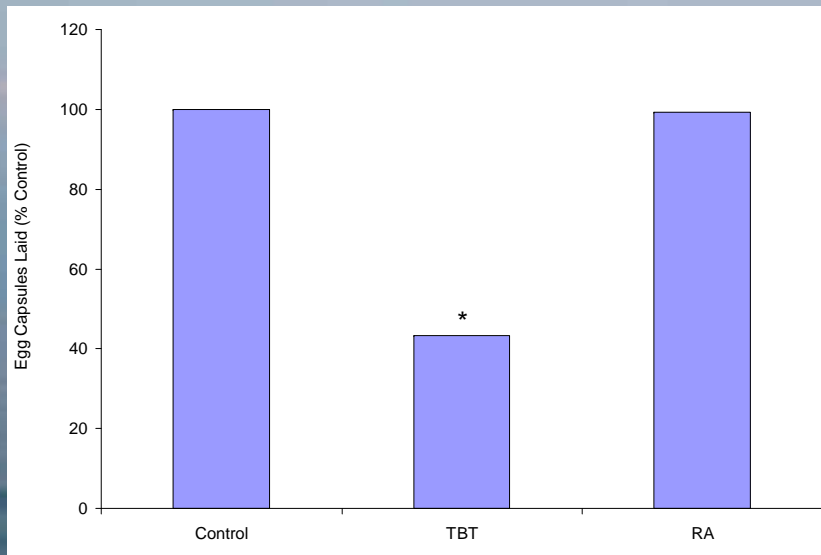
Historical Reports of Steroid Function in Molluscs

- 1969—E₂ injection in oysters (*Crassostrea gigas*) causes reversal of males to females
- 1996—T induces penis growth in female gastropods
- 1999—E₂ injections induces vitellin-like protein in *Mya arenaria*
- 2003—E₂ induces vitellin in scallops (*Patinopecten yessoensis*)
- 2003—E₂ reduces serotonin and increases monoamine oxidase activities (involved in sexual differentiation) in *Elliptio complanata* (freshwater mussel)
- 2004—EE₂ increases embryo production in freshwater mudsnail *Potamopyrgus antipodarum*
- 2007—Mixture (E₂, EE₂, NP, OP) induces ovotestis in male *Scrobicularia plana* and increases oocyte diameter in females

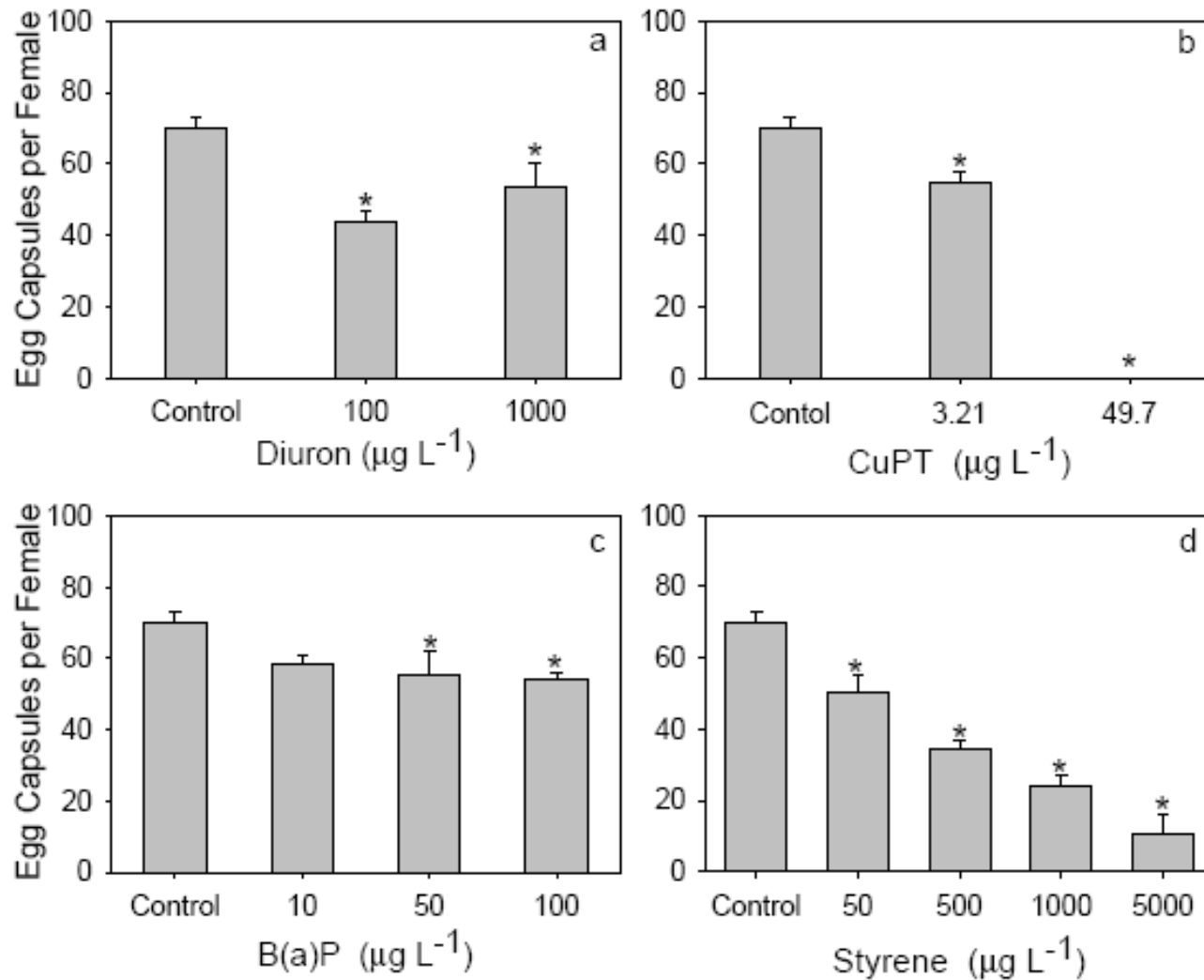
Endocrine disruptor effects in molluscs

- 1970—TBT causes developmental abnormalities and shell thickening of oysters and induces imposex in *N. lapillus* (since has been shown to have similar effect in at least 150 species of mollusk)
- 1986—TBT causes masculinization and larval reduction in *O. edulis*, *M. edulis*, *S. plana* and *M. mercenaria*
- 1999—Nonylphenol and octylphenol induce vitellin-like protein in *Mya arenaria*
- 2000—Bisphenol A or octylphenol increases egg production in *M. cornuarietis* and creates "superfemales" in *N. lapillus*
- 2000—Bisphenol A increases embryo production in female and reduction of sperm in male *N. lapillus*
- 2001—pp'DDT induces premature spawning and oocyte degeneration in *D. polymorpha*
- 2003—Nonylphenol exposure of *C. gigas* D-larvae between days 7-8 pf produced significant number of hermaphrodites and skewed sex ratio towards females

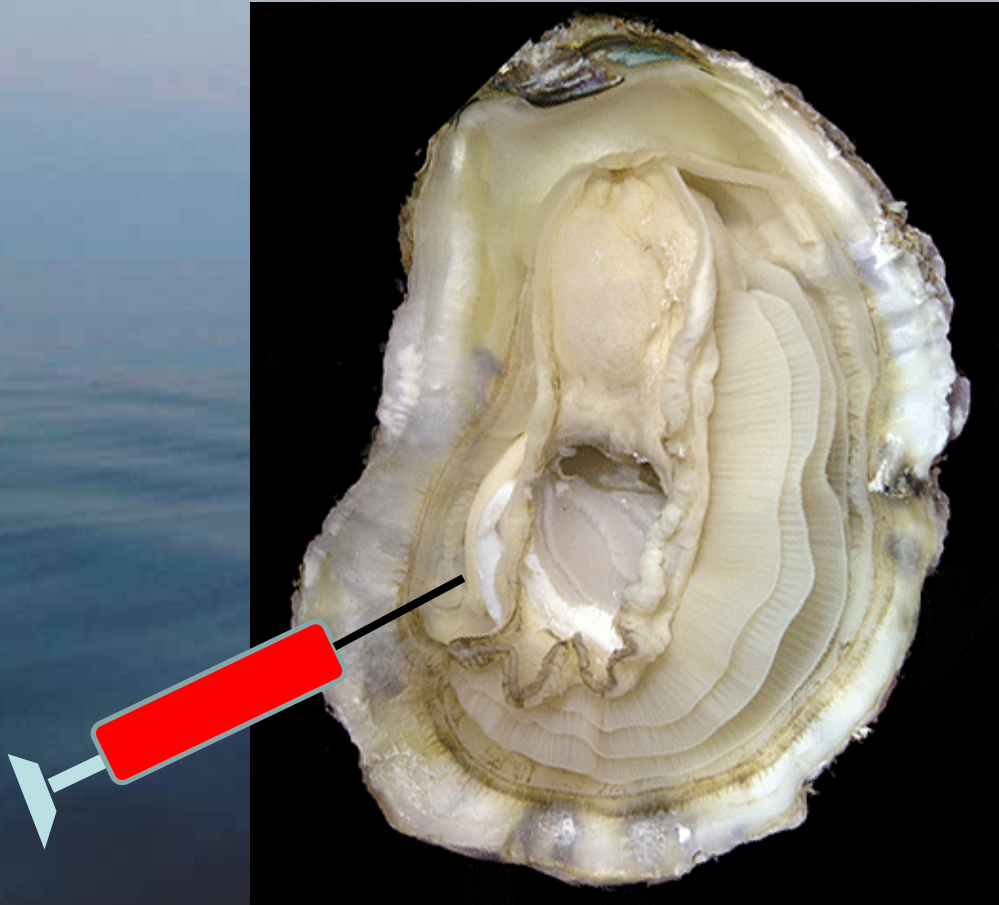
Affect of EDCs on Reproduction in Gastropods



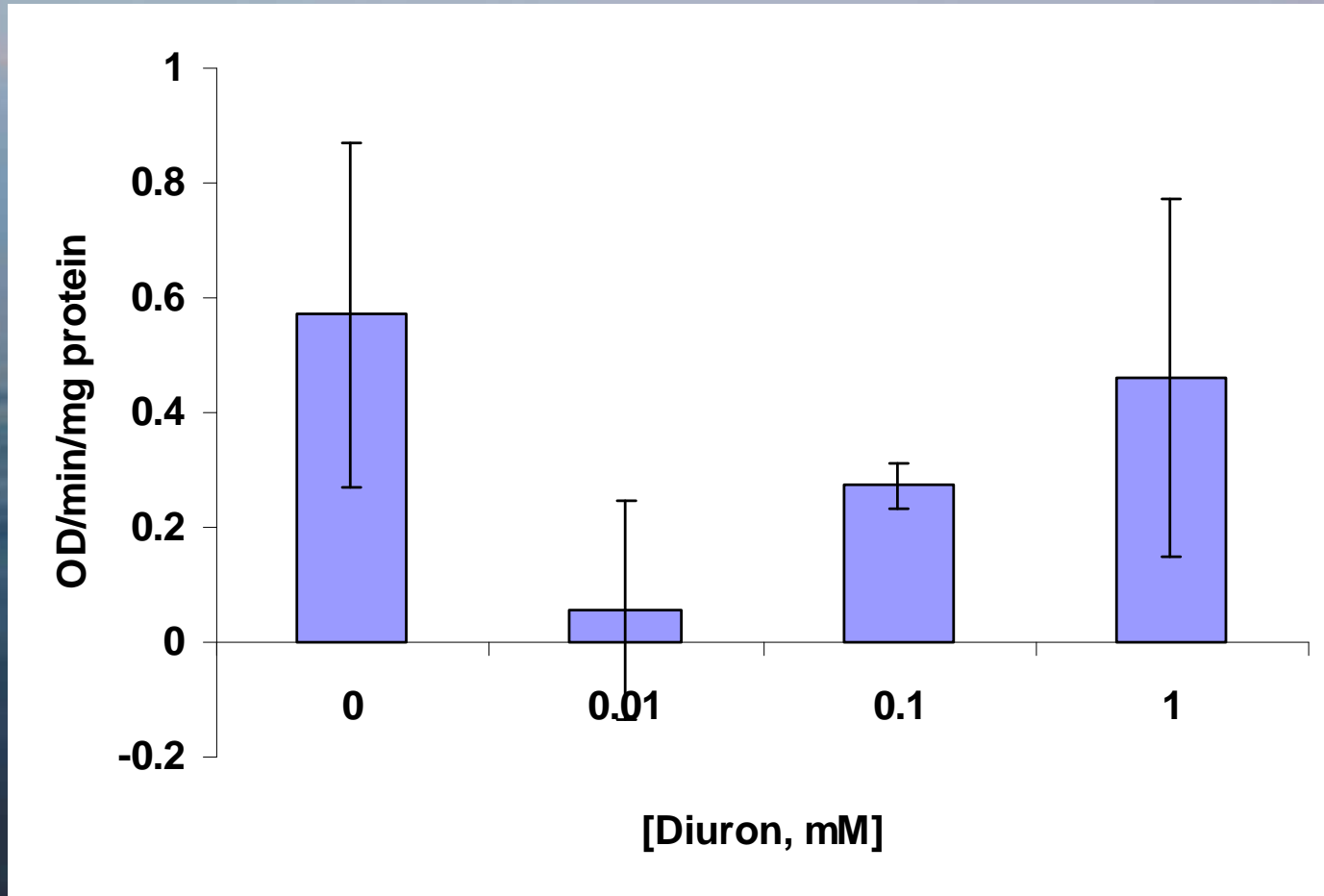
Influence of different environmental chemicals on reproductive capacity (gastropods)



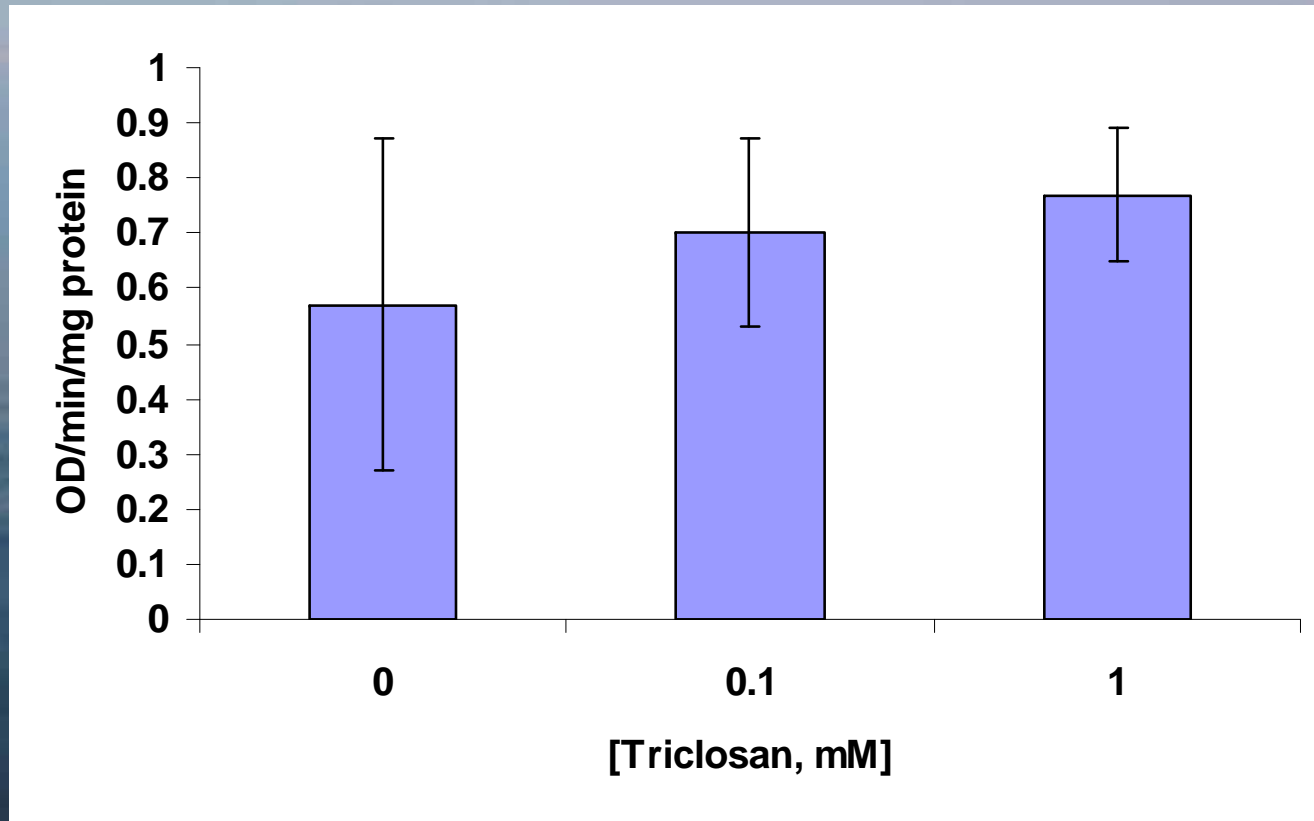
Collecting Oyster Hemolymph



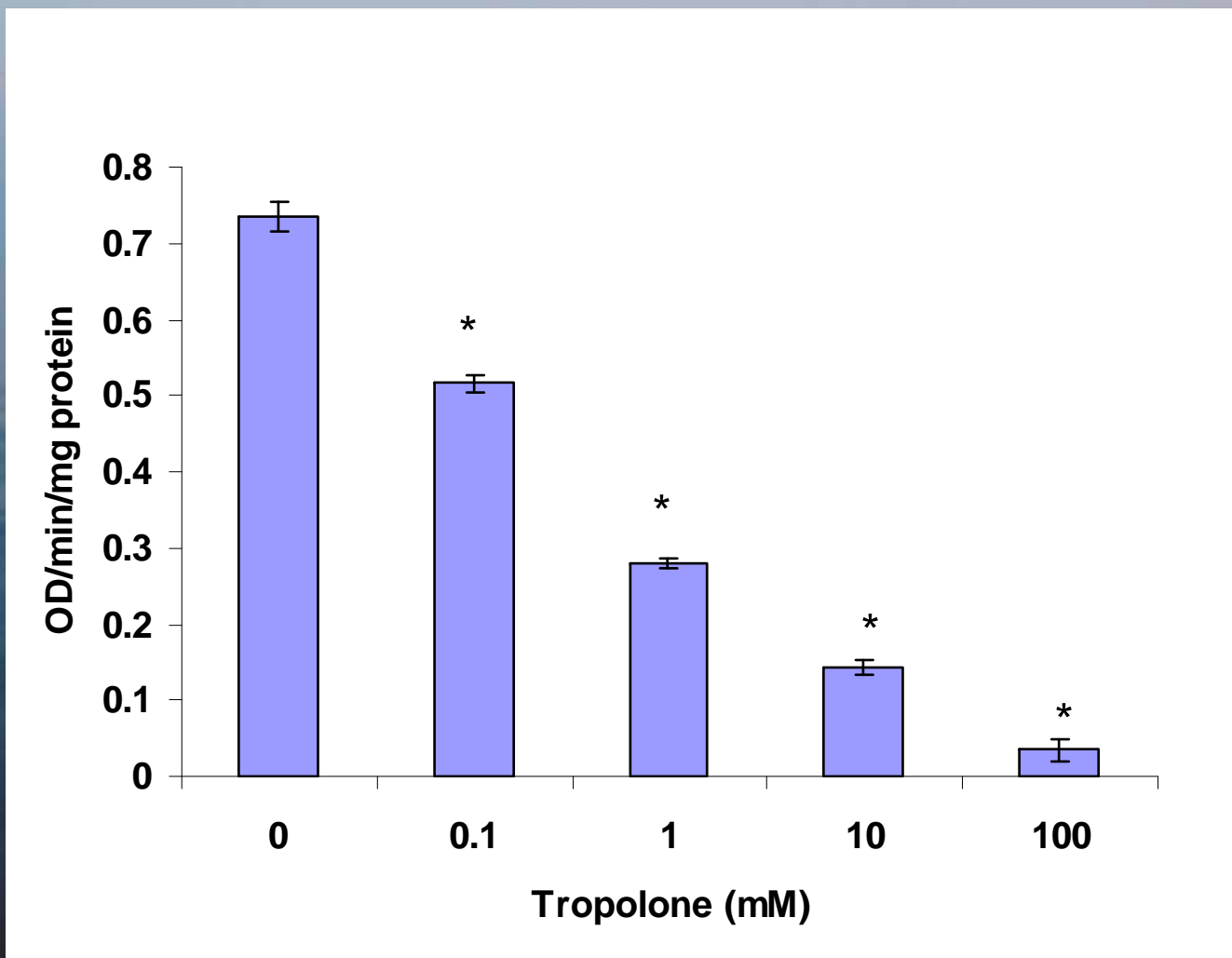
Diuron effects on PO activity *(in vitro)*



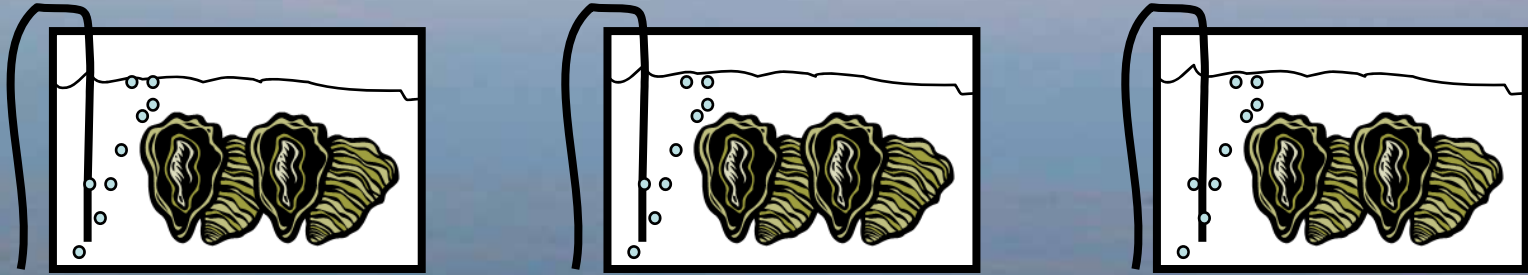
Triclosan effects on PO activity (*in vitro*)



Tropolone effects on PO activity (*in vitro*)

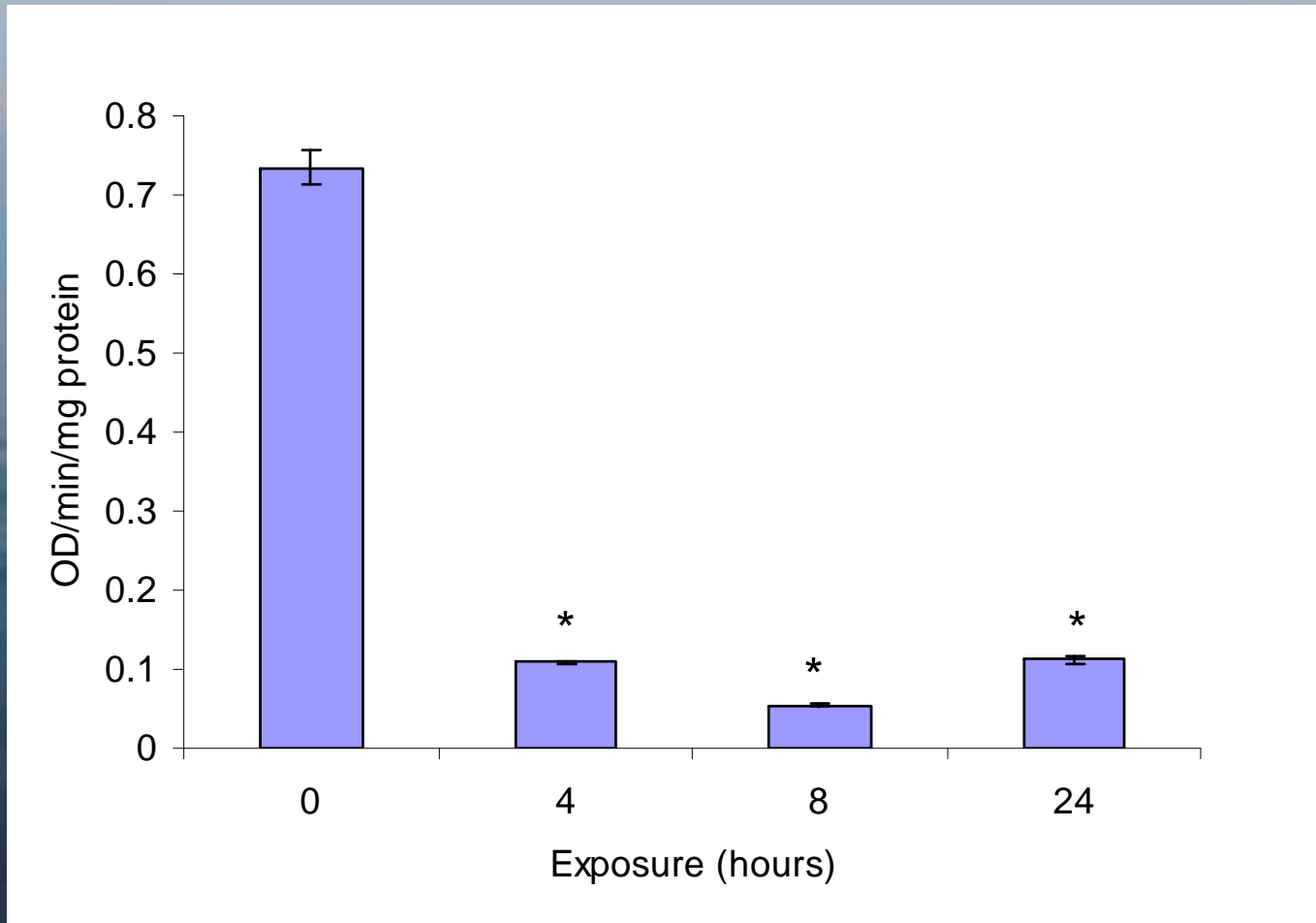


What happens if you expose whole organism?

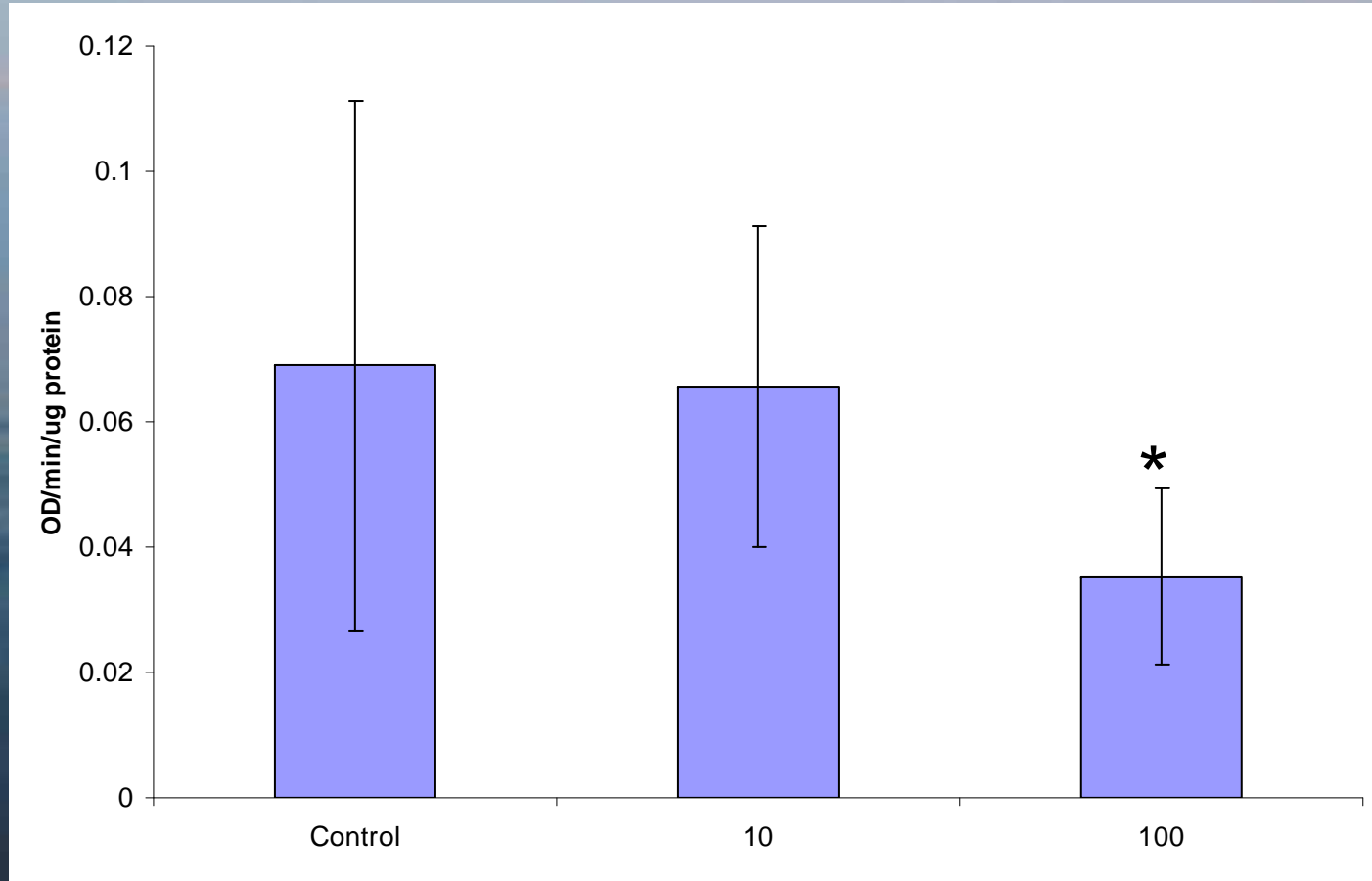


Contaminate effects on oysters in vivo ?

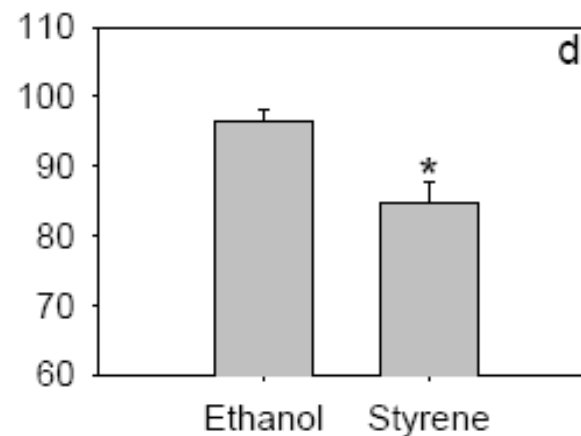
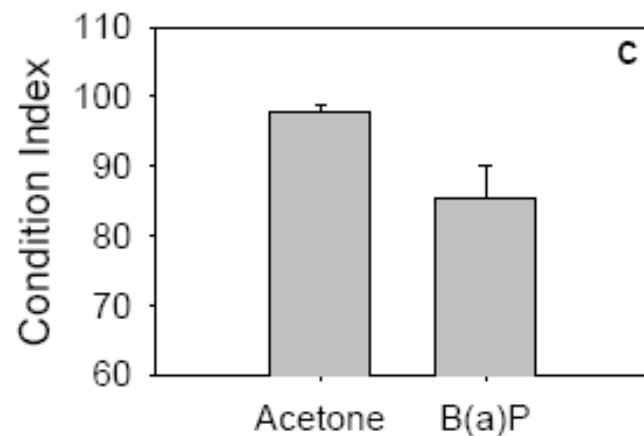
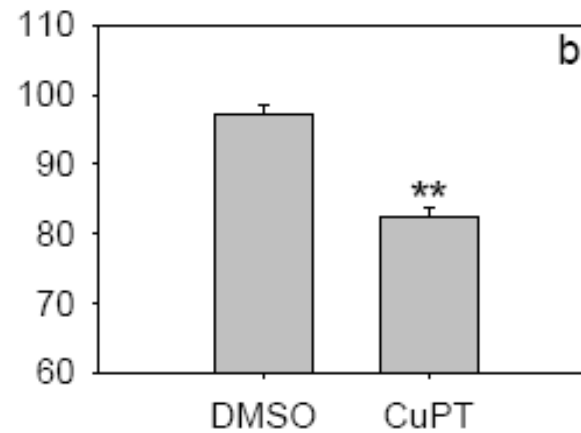
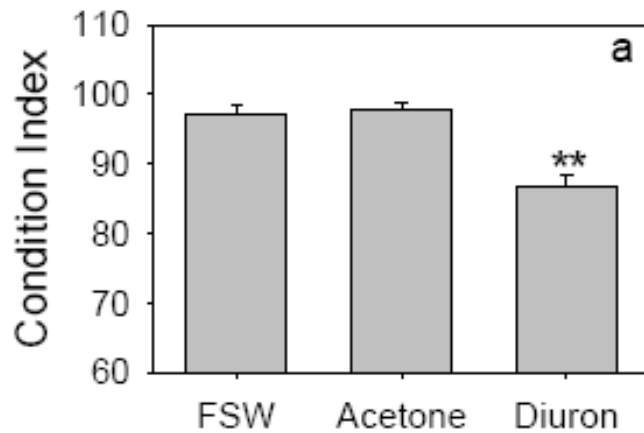
Hypoxia effects on PO activity (*in vivo*)



Triclosan effects on PO activity (*in vivo*)



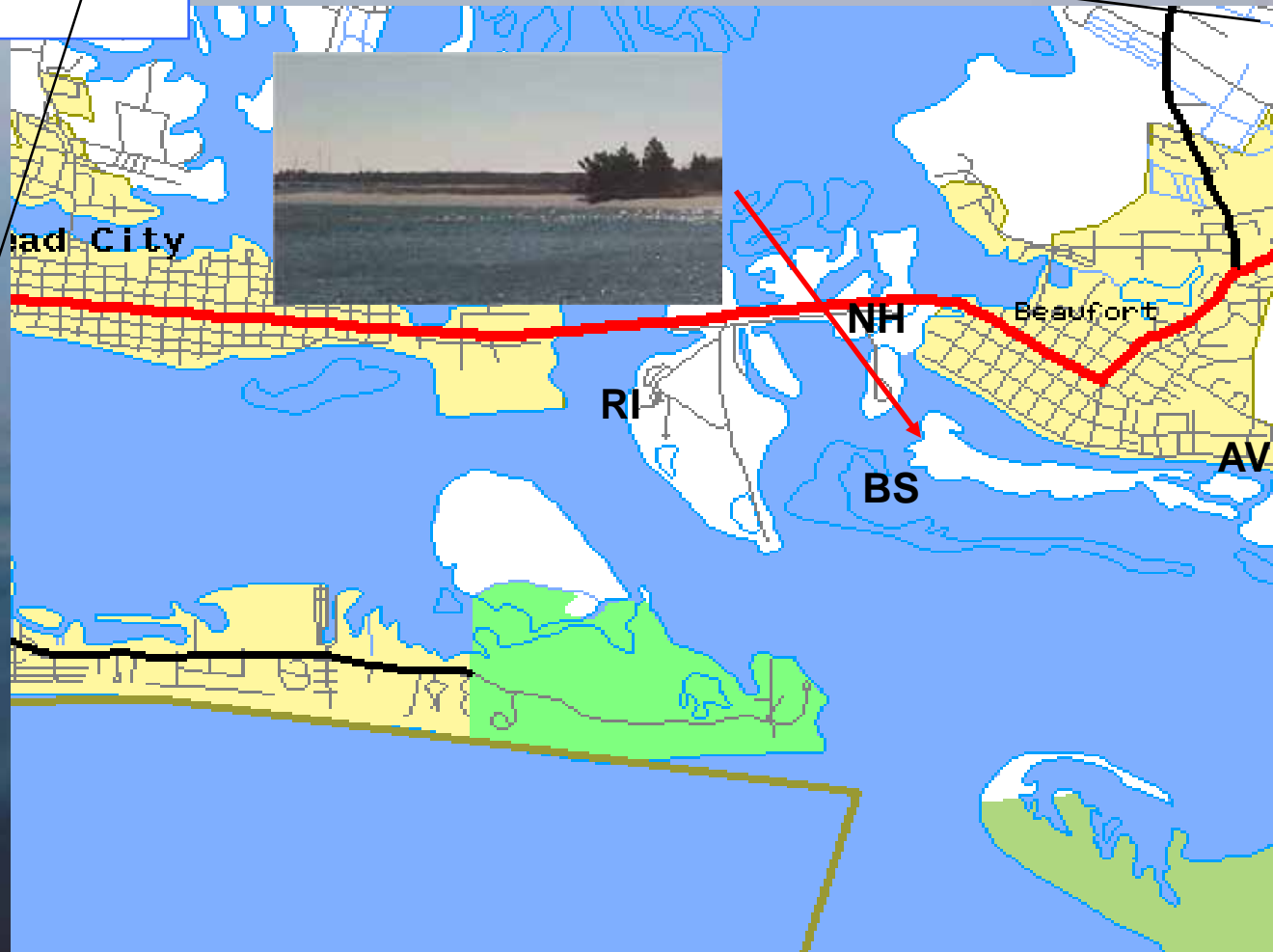
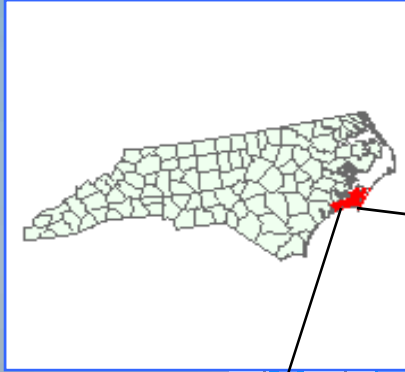
What about other contaminants?



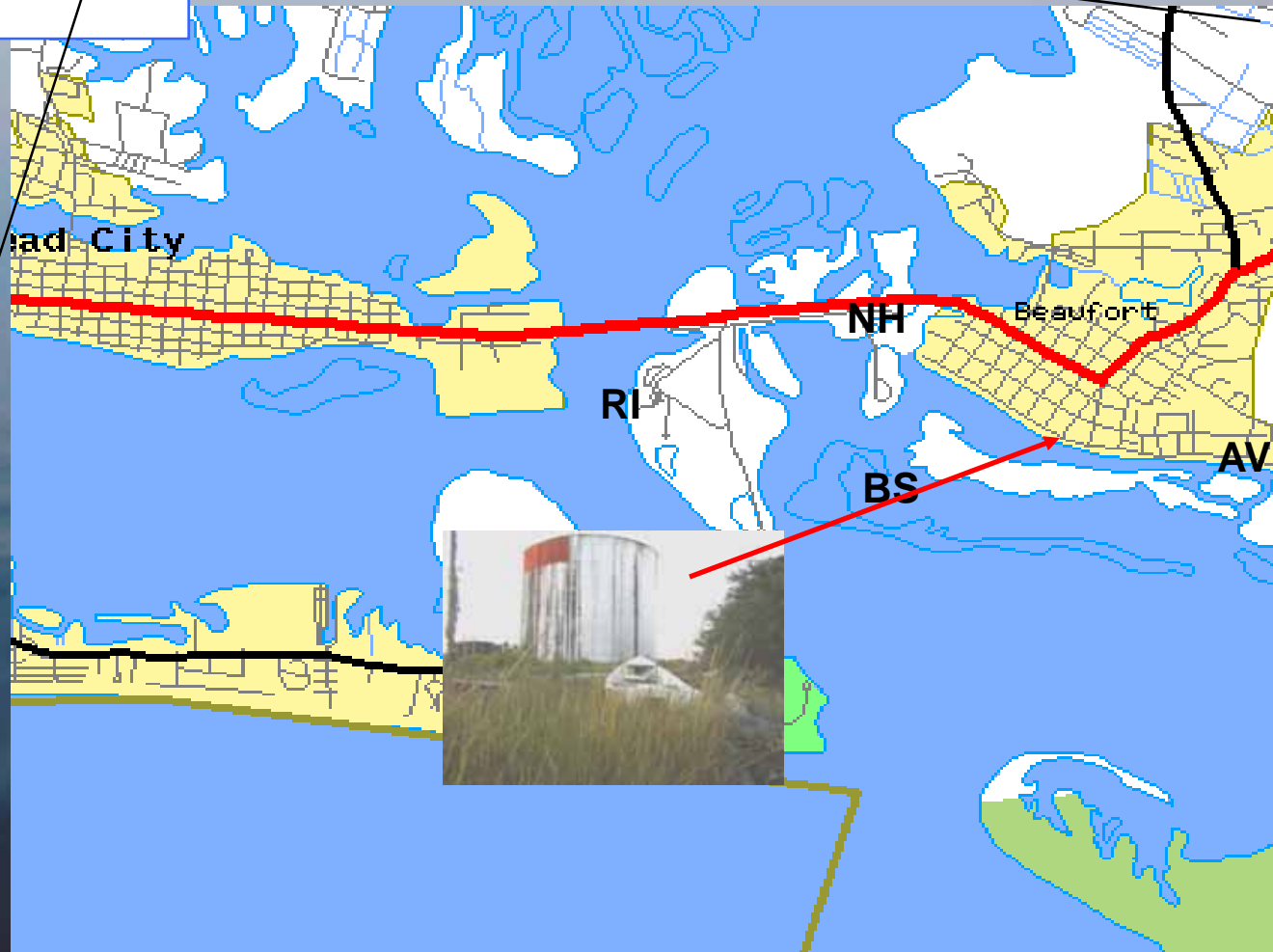
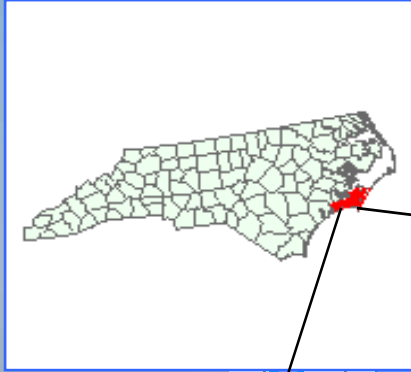
What about other contaminants?

- Reproduction (in progress)
- Immune responses (in progress)

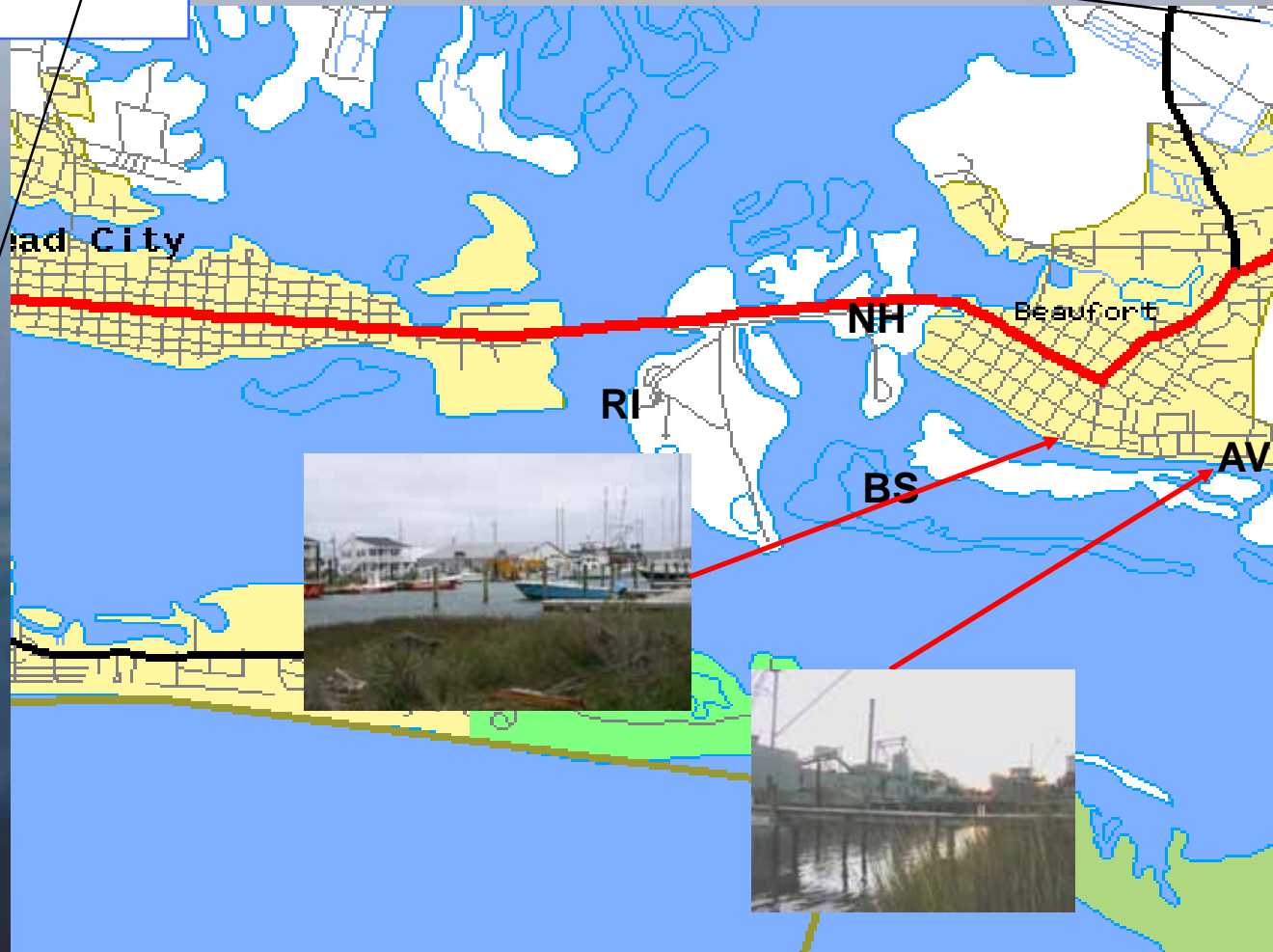
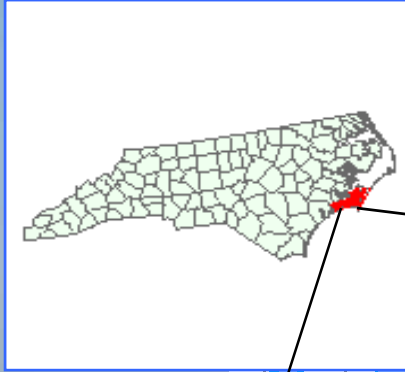
Field Sites



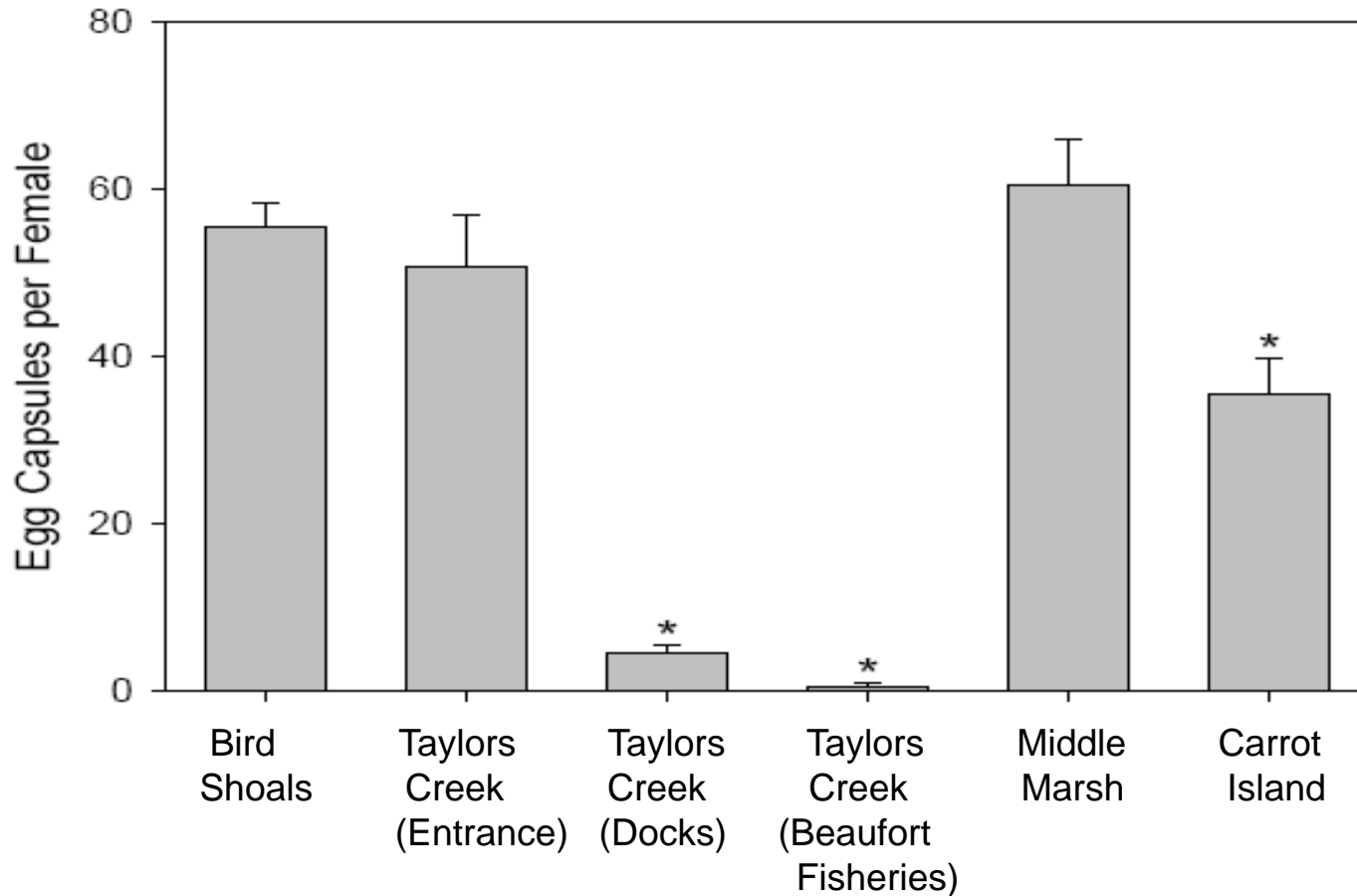
Field Sites



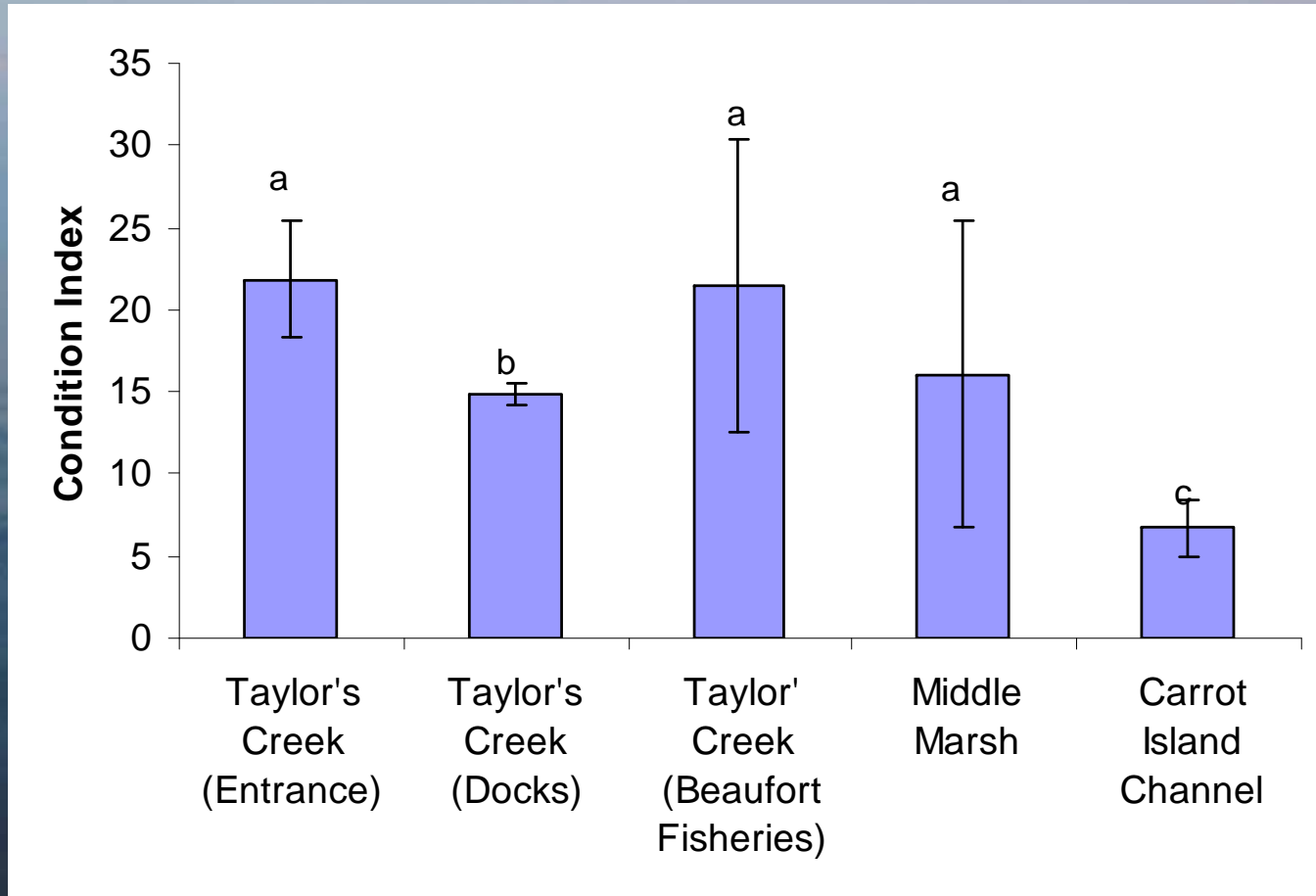
Field Sites



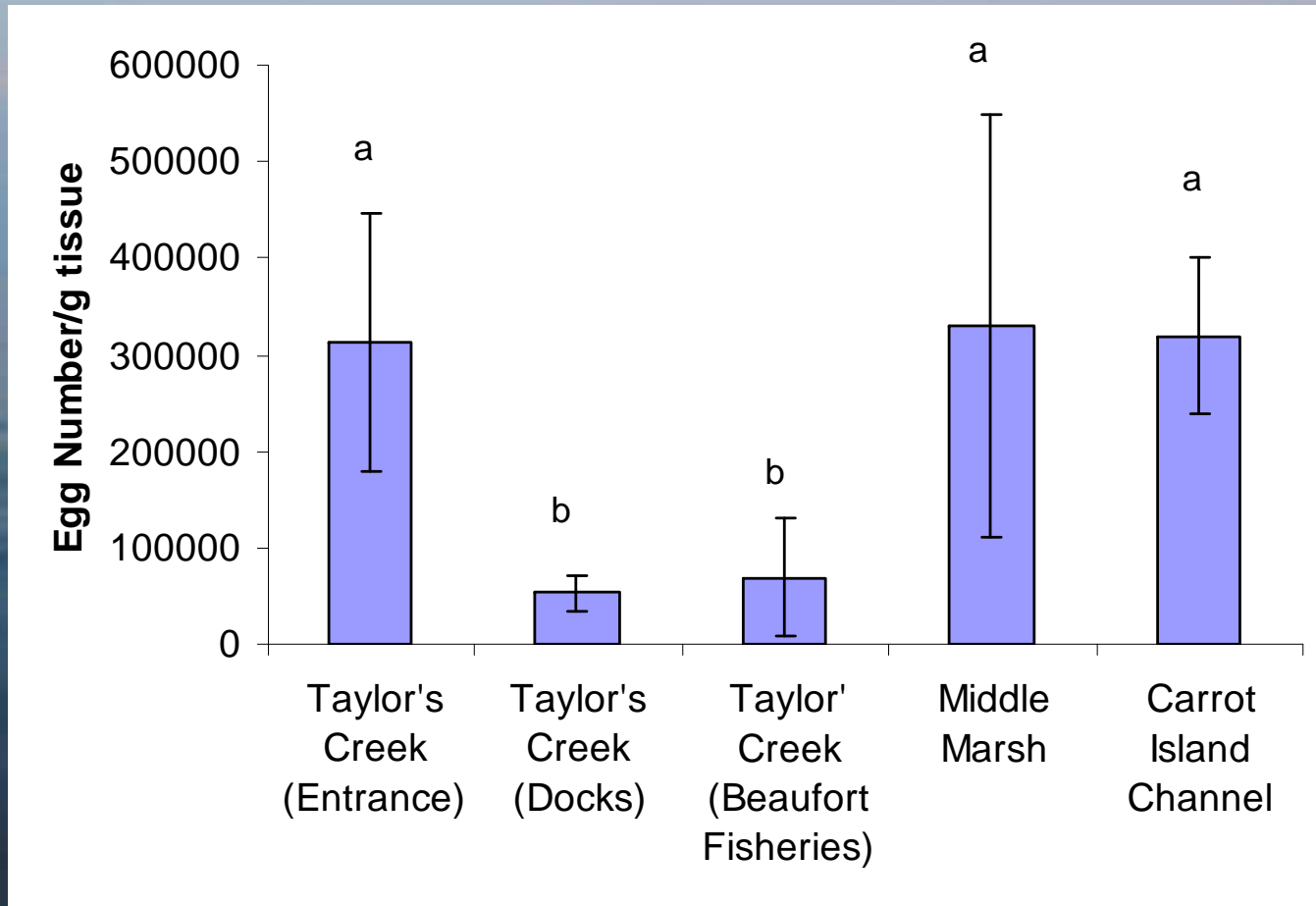
Reproductive capacity of gastropods in field exposures



Do Environmental Pollutants Affect Oysters?



Do Environmental Pollutants Affect Oysters?



Primary Controls

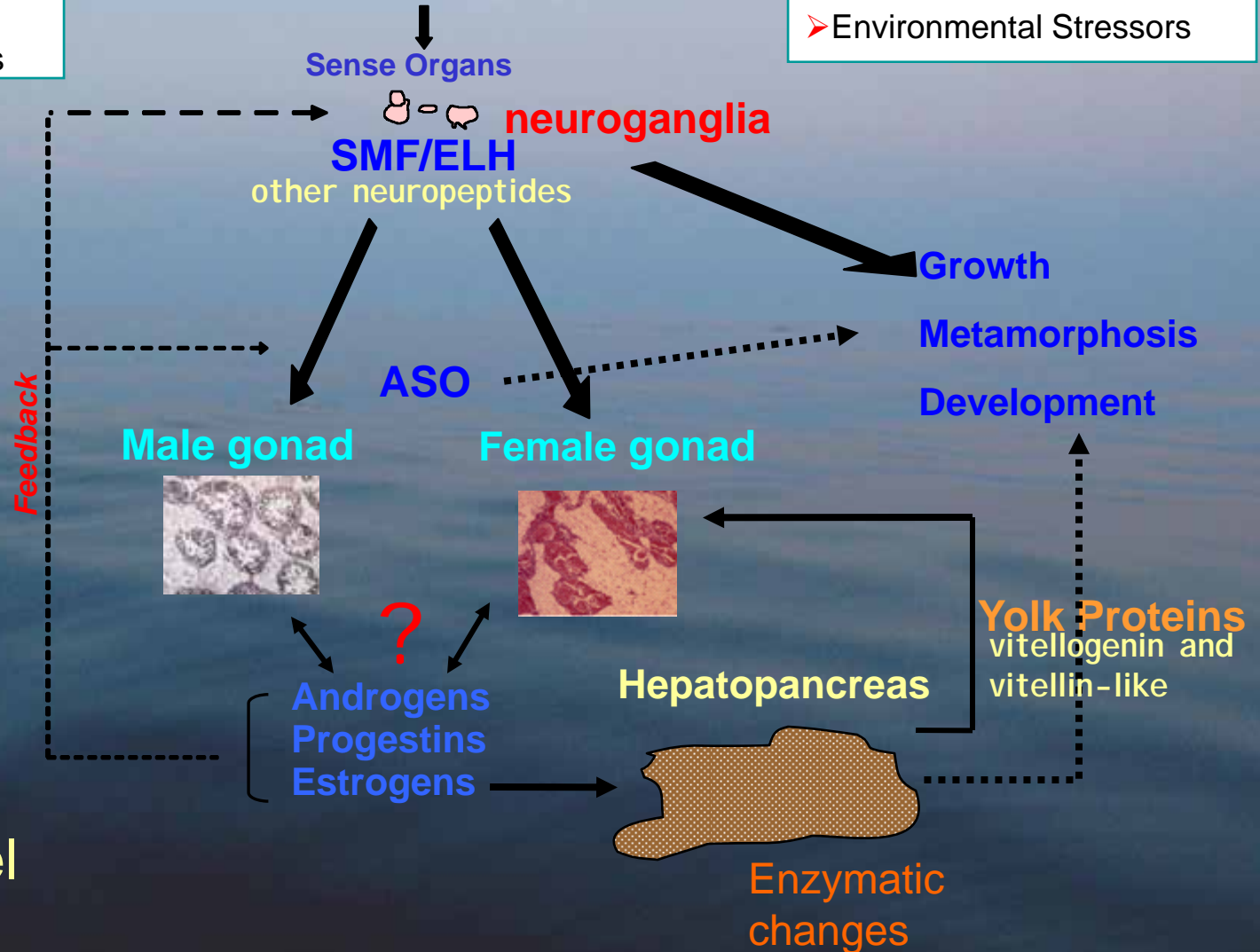
- Temperature
- Day Length
- Water Chemistry
- Organism Interactions

Environmental Stimulation (seasonal cue)

Alternative Controls

- Toxic Chemicals
- Disease
- Environmental Stressors

Development
Reproduction
Metabolism
Behavior
Physiology

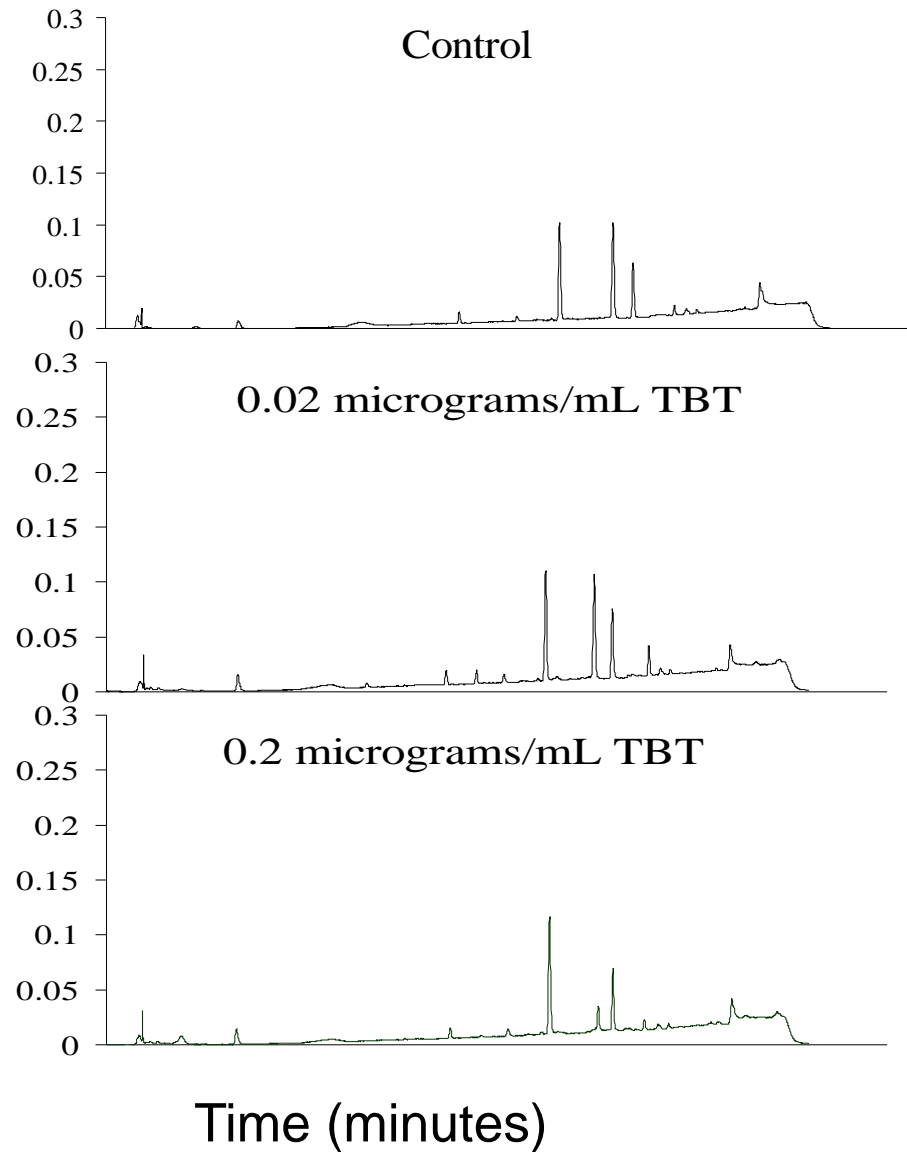


Mollusc Model

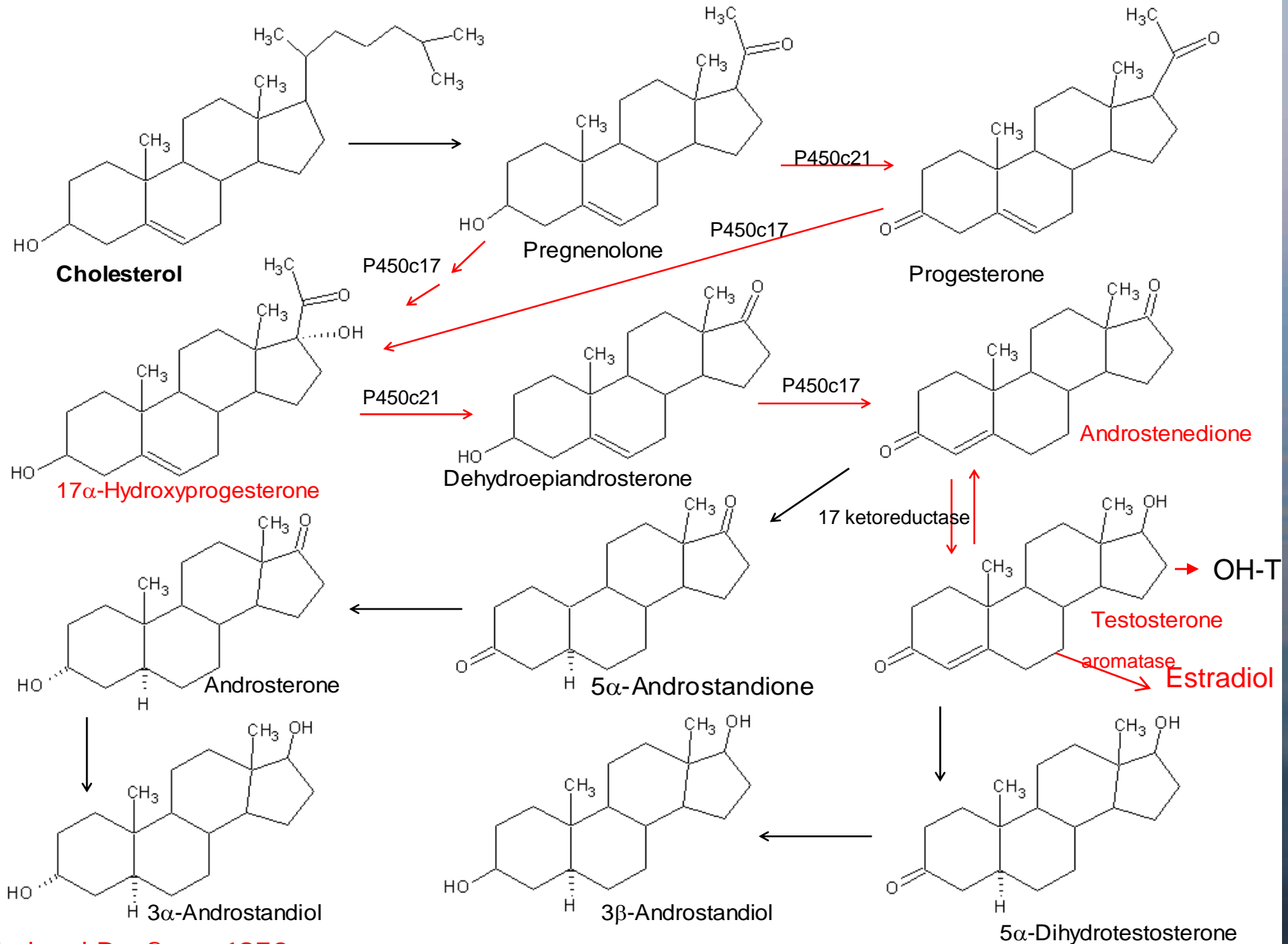
Are our oysters at risk?

- Know: Molluscan endocrine systems are extremely varied.
- Know: Mechanisms (or at least processes) are conserved across phyla
- Know: Environmental endocrine disruptors do affect oysters—but you have to do your homework on the basic mechanisms that are affected.

Oyster Testosterone Metabolites



Steroid Biosynthetic Pathway in Molluscs



Six Degrees of Contamination

