EDC effects in bivalves: Are our oysters at risk?

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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)

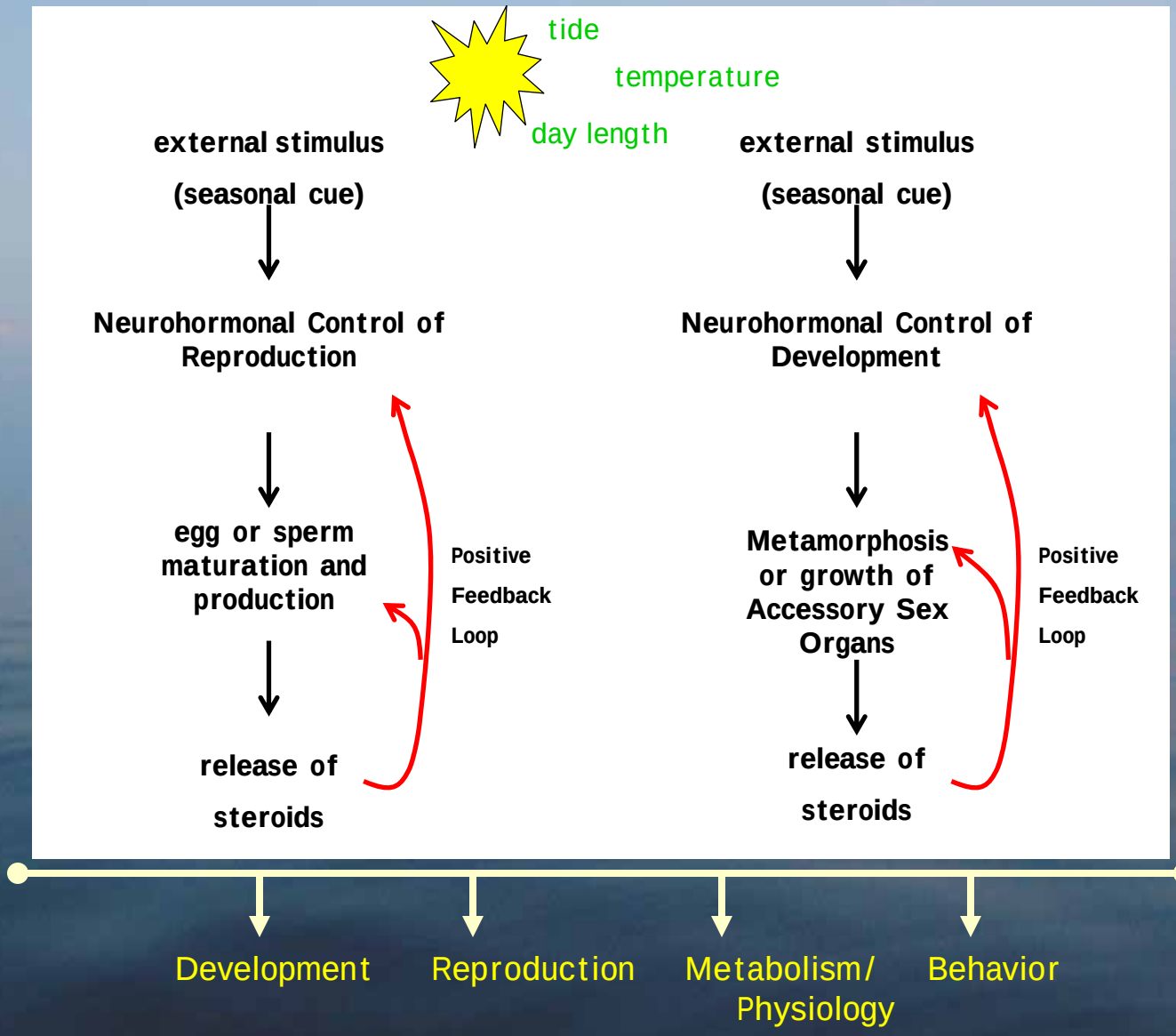
What are Endocrine Disruptors

- 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

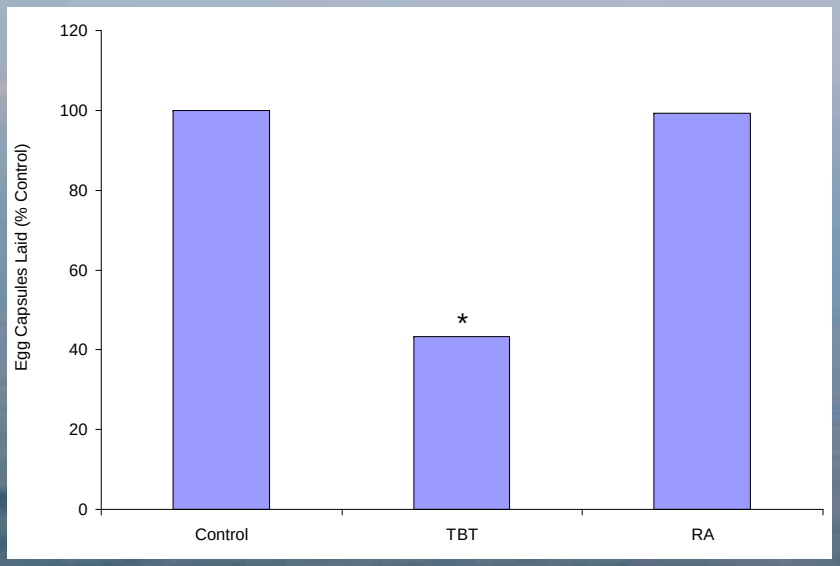
Historical Reports of Steroid Function in Molluscs

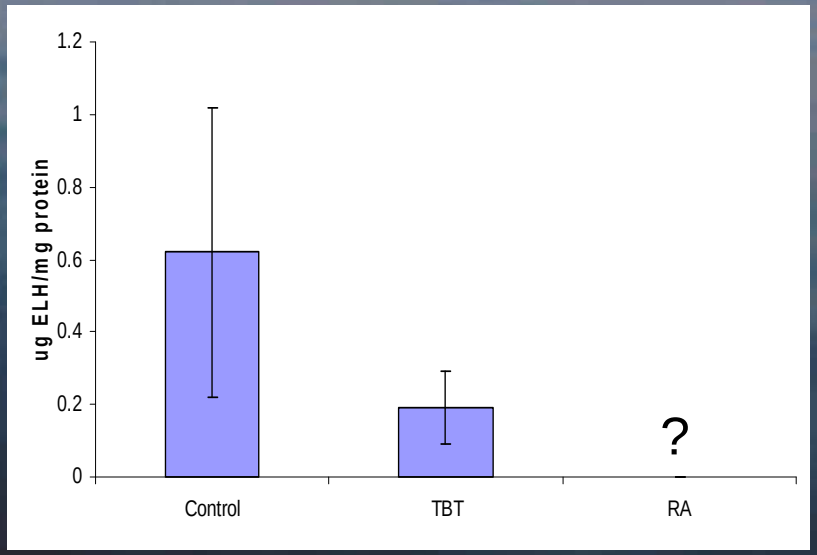
- 1969—E_2 injection in oysters (*Crassostrea gigas*) causes reversal of males to females
- 1996—T induces penis growth in female gastropods
- 1999—E2 injections induces vitellin-like protein in *Mya arenaria*
- 2003—E_2 induces vitellin in scallops (*Patinopecten yessoensis*)
- 2003—E_2 reduces serotonin and increases monoamine oxidase activities (involved in sexual differentiation) in *Elliptio complanata* (freshwater mussel)
- 2004—EE_2 increases embryo production in freshwater mudsnail *Potamopyrgus antipodarum*
- 2007—Mixture (E_2, EE_2, NP, OP) induces ovotestis in male *Scrobicularia plana* and increases oocyte diameter in females

Endocrine disruptor effects in molluscs

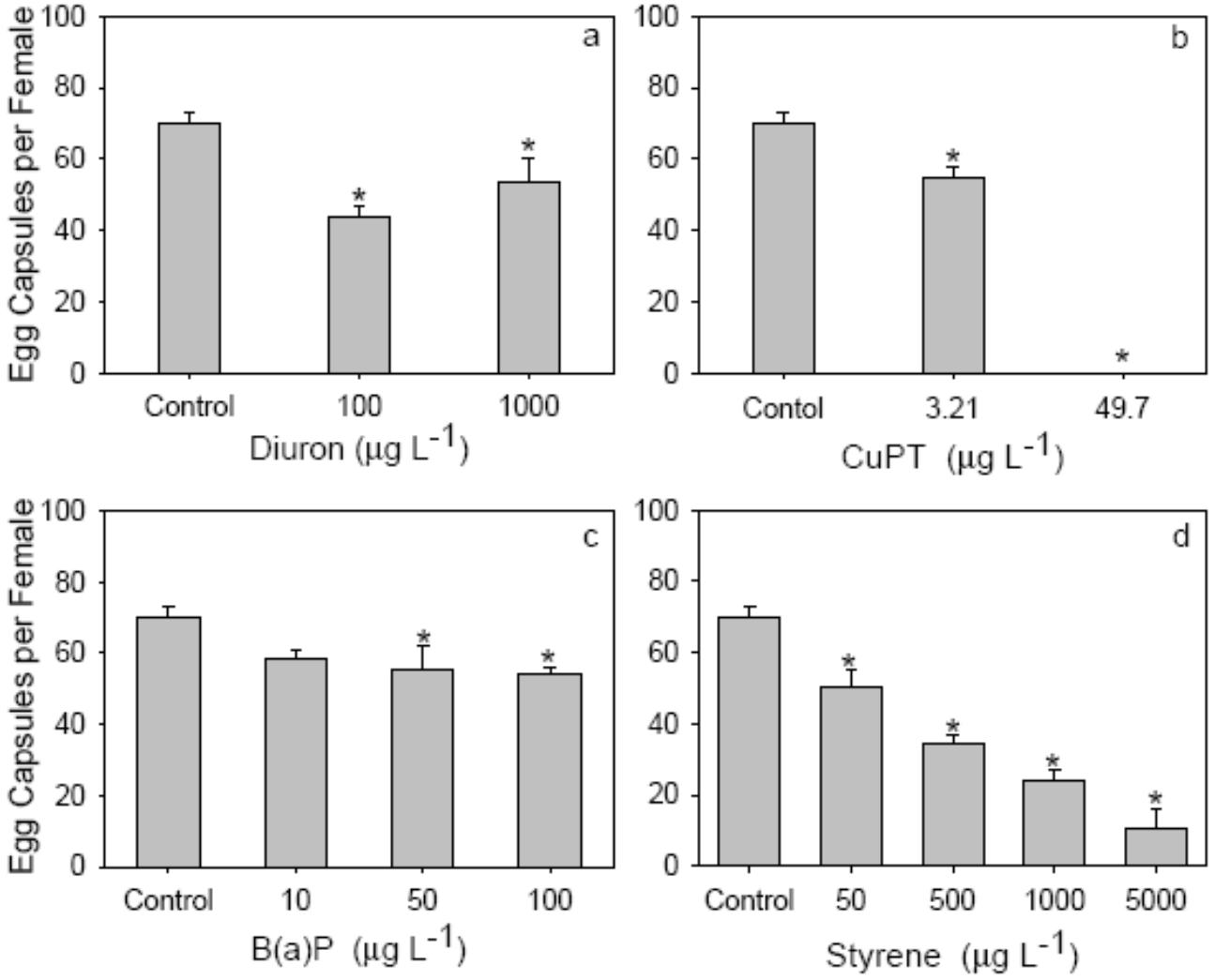
- 1970—TBT causes developmental abnormalities and shell thickening of oysters and induces imposex in *N. lapillus* (since has been shown to have similar effect in at least 150 species of mollusk)
- 1986—TBT causes masculinization and larval reduction in *O. edulis, M. edulis, S. plana* and *M. mercenaria*
- 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

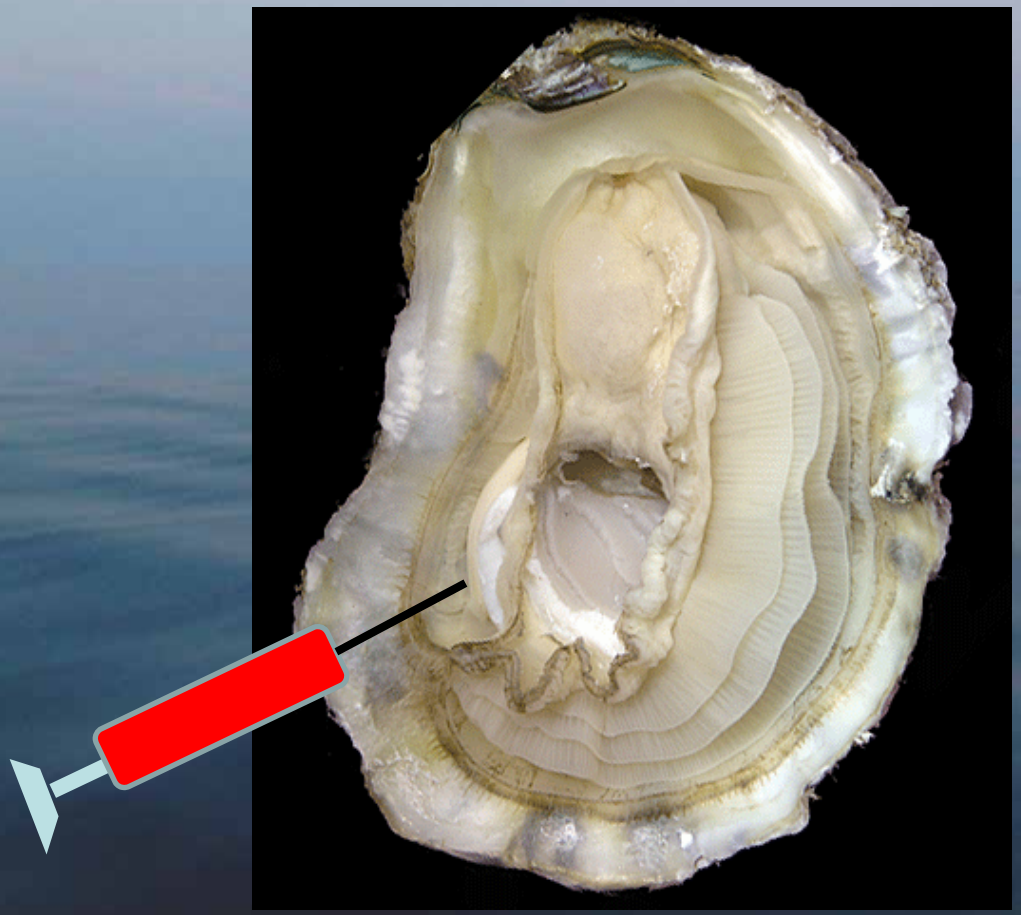




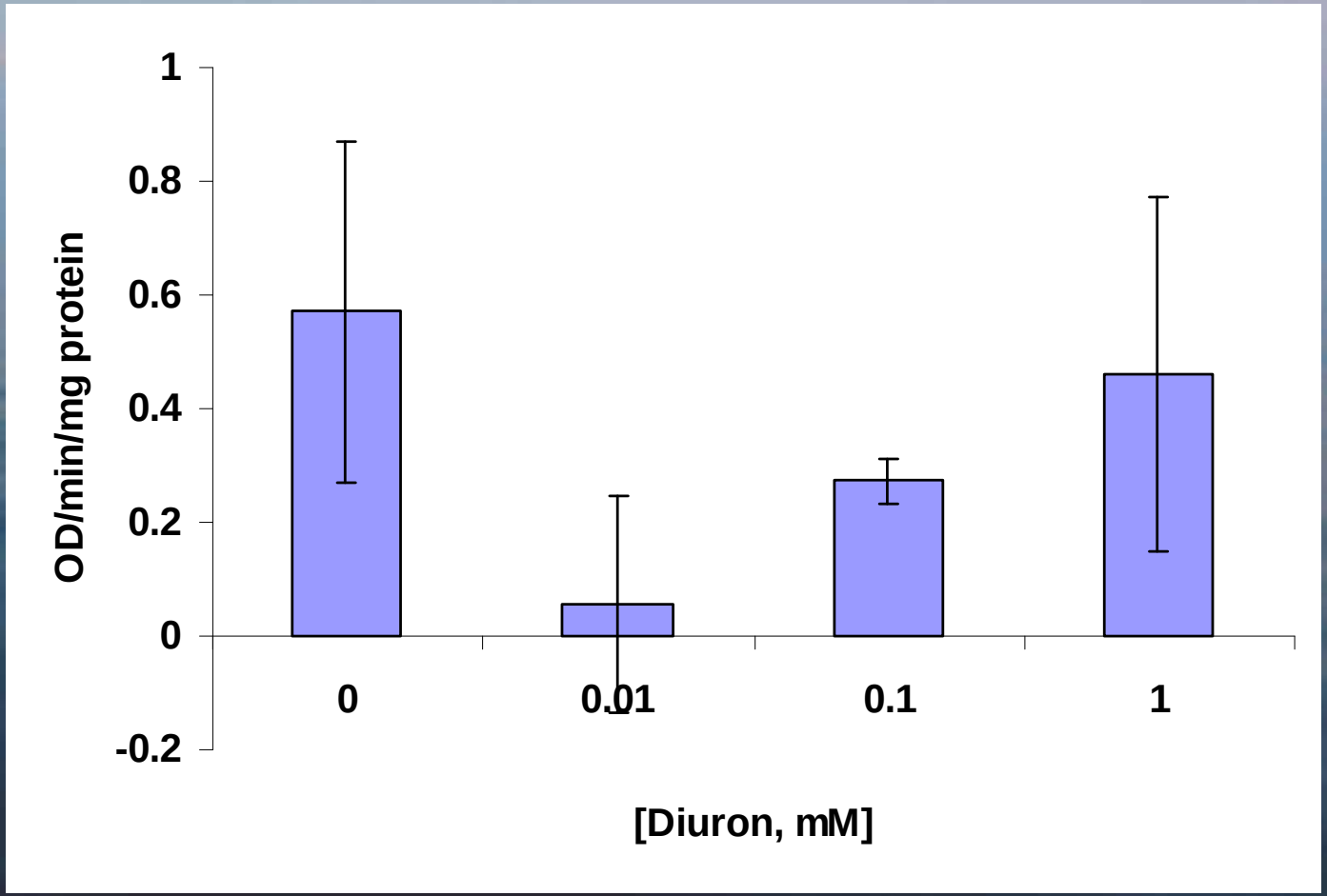
Influence of different environmental chemicals on reproductive capacity (gastropods)



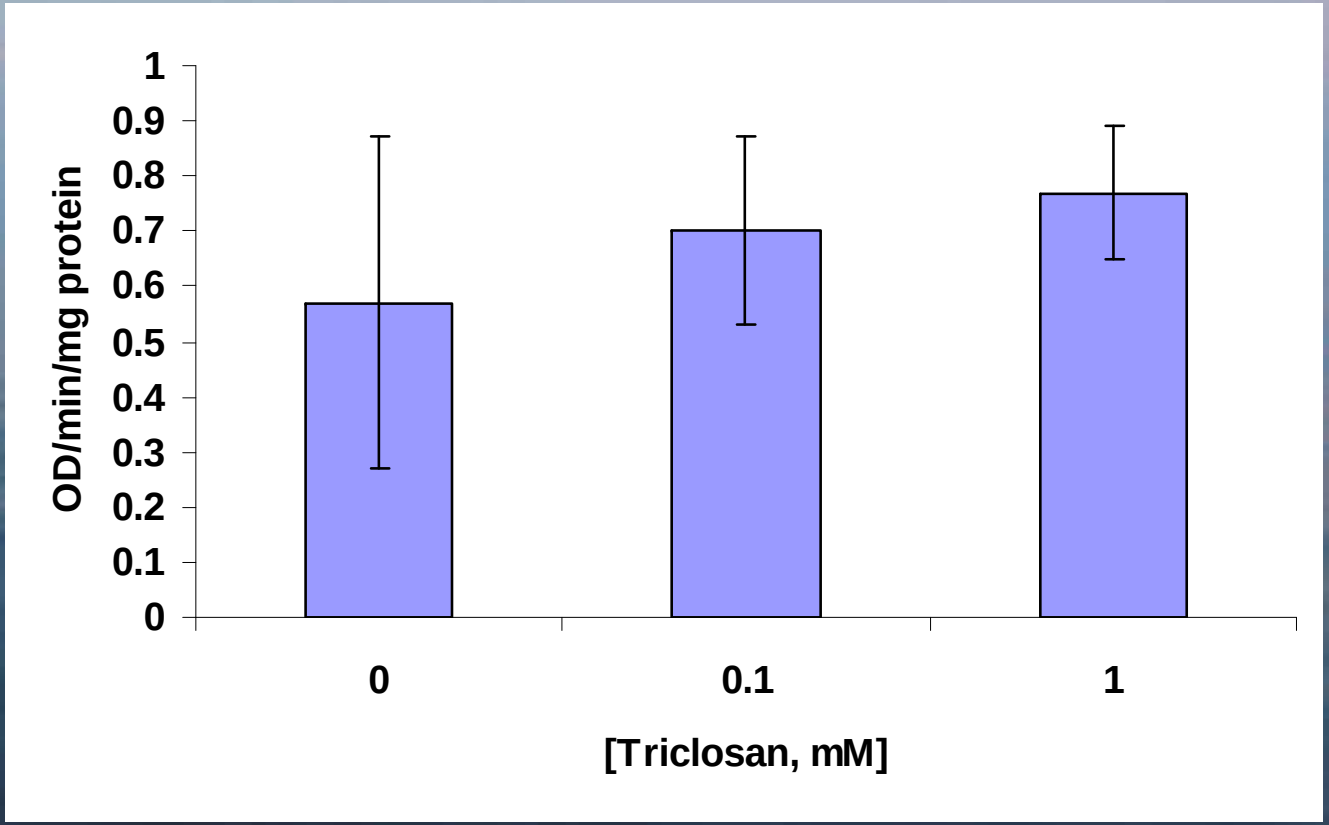
Collecting Oyster Hemolymph



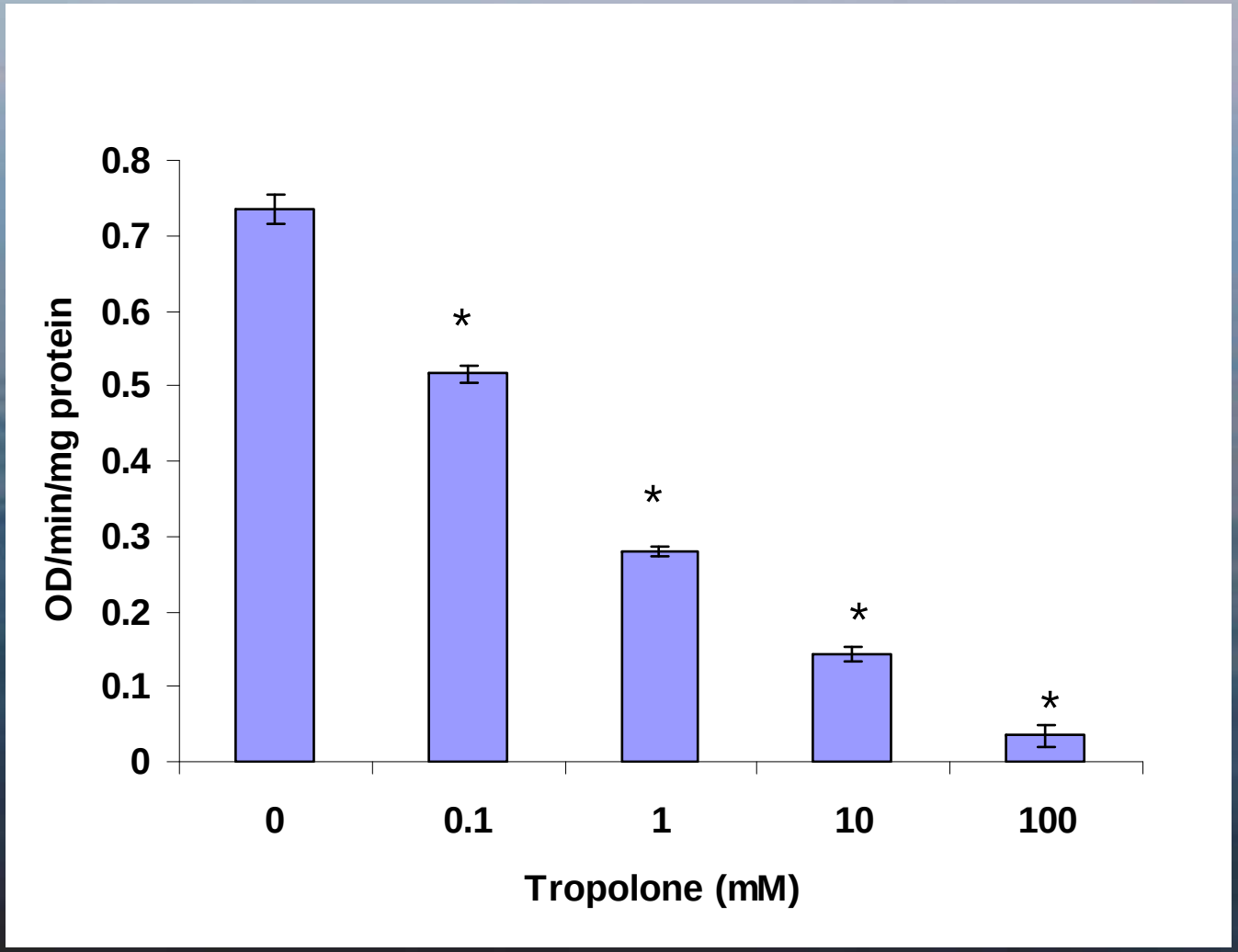
Diuron effects on PO activity (*in vitro*)



Triclosan effects on PO activity (*in vitro*)



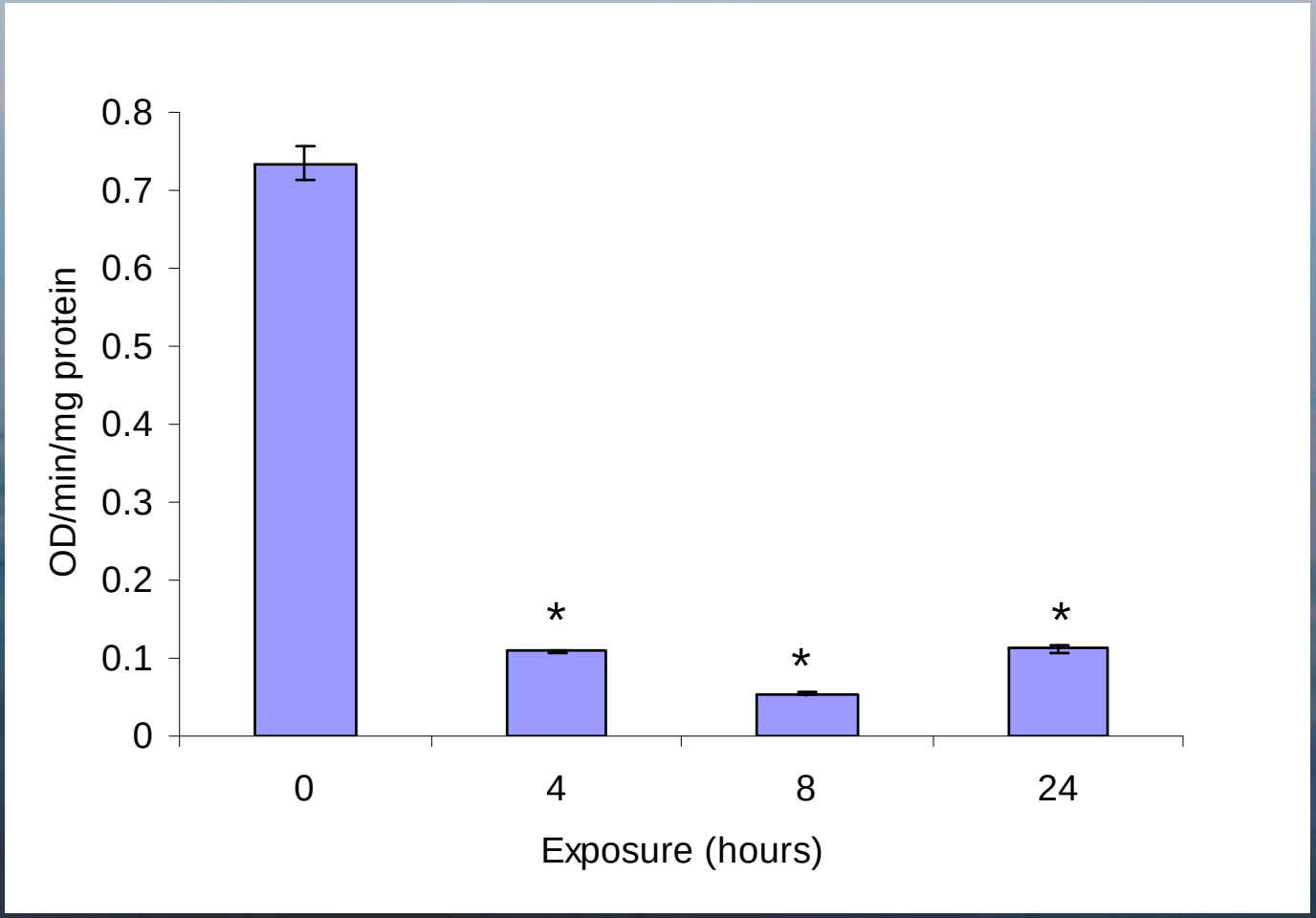
Tropolone effects on PO activity (*in vitro*)



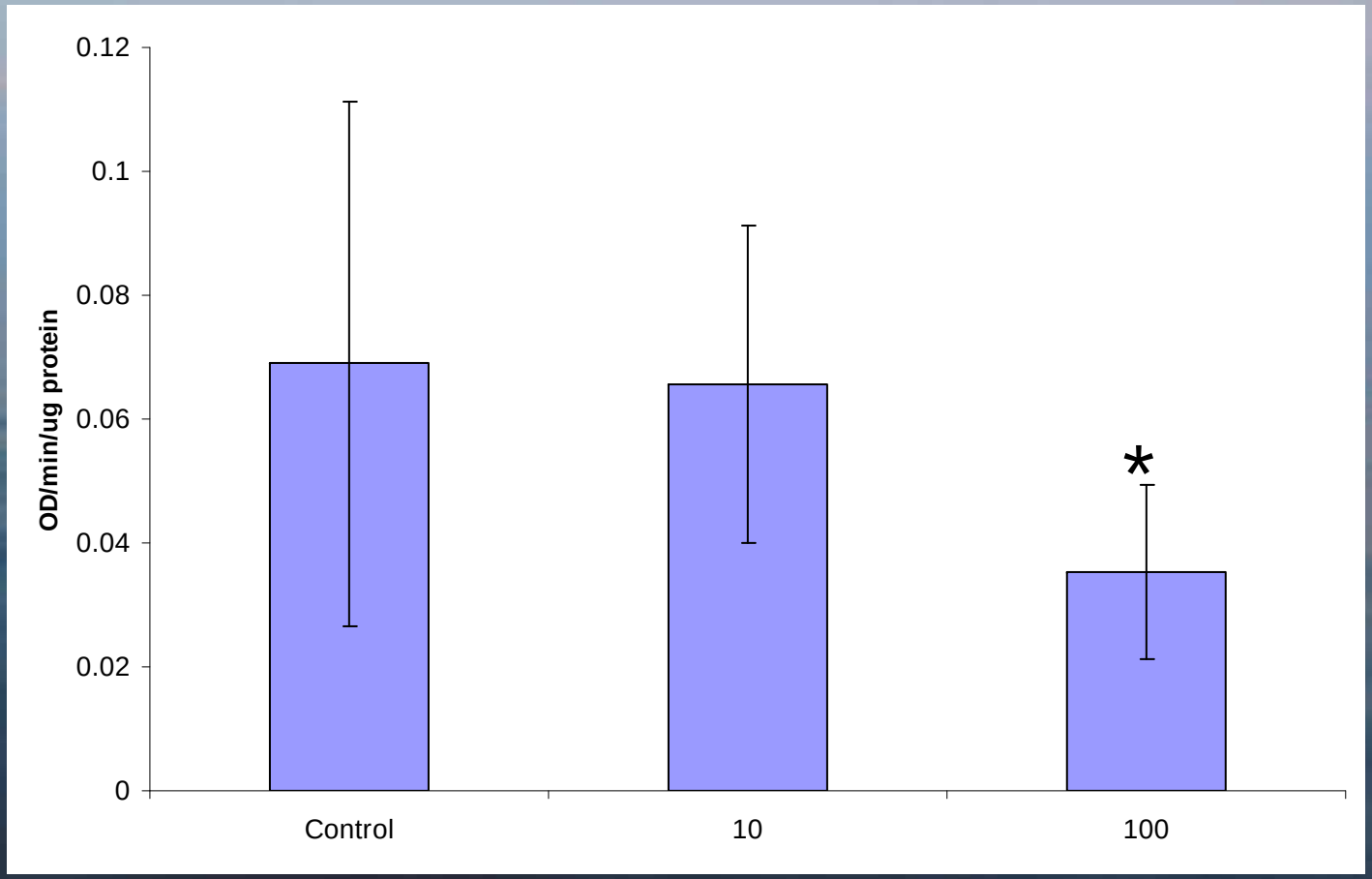
What happens if you expose whole organism?

Contaminate effects on oysters in vivo ?

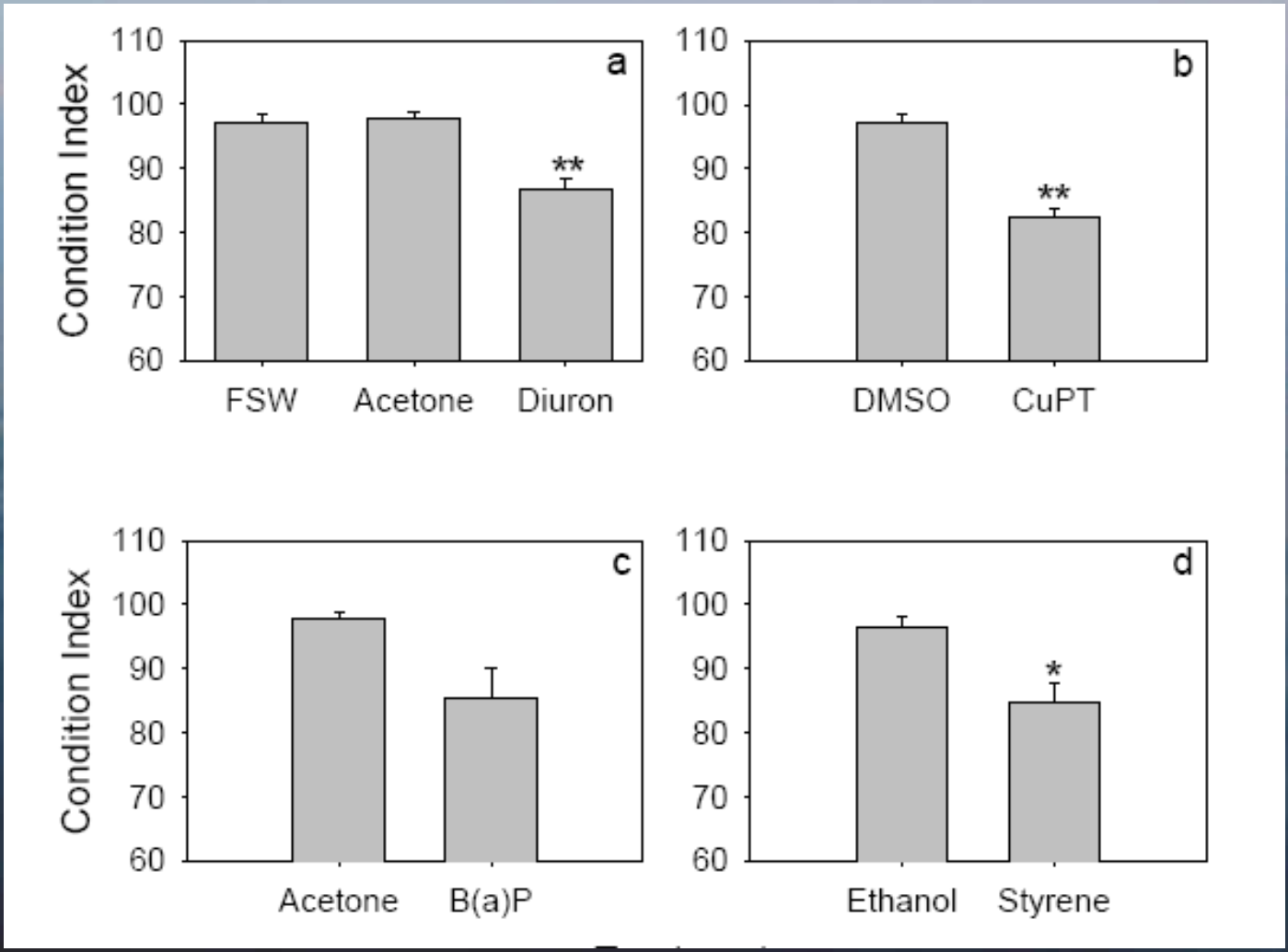
Hypoxia effects on PO activity (*in vivo*)



Triclosan effects on PO activity (*in vivo*)



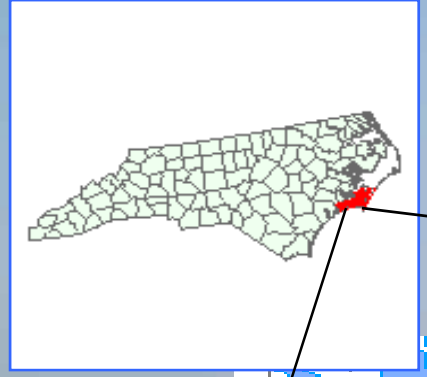
What about other contaminants?

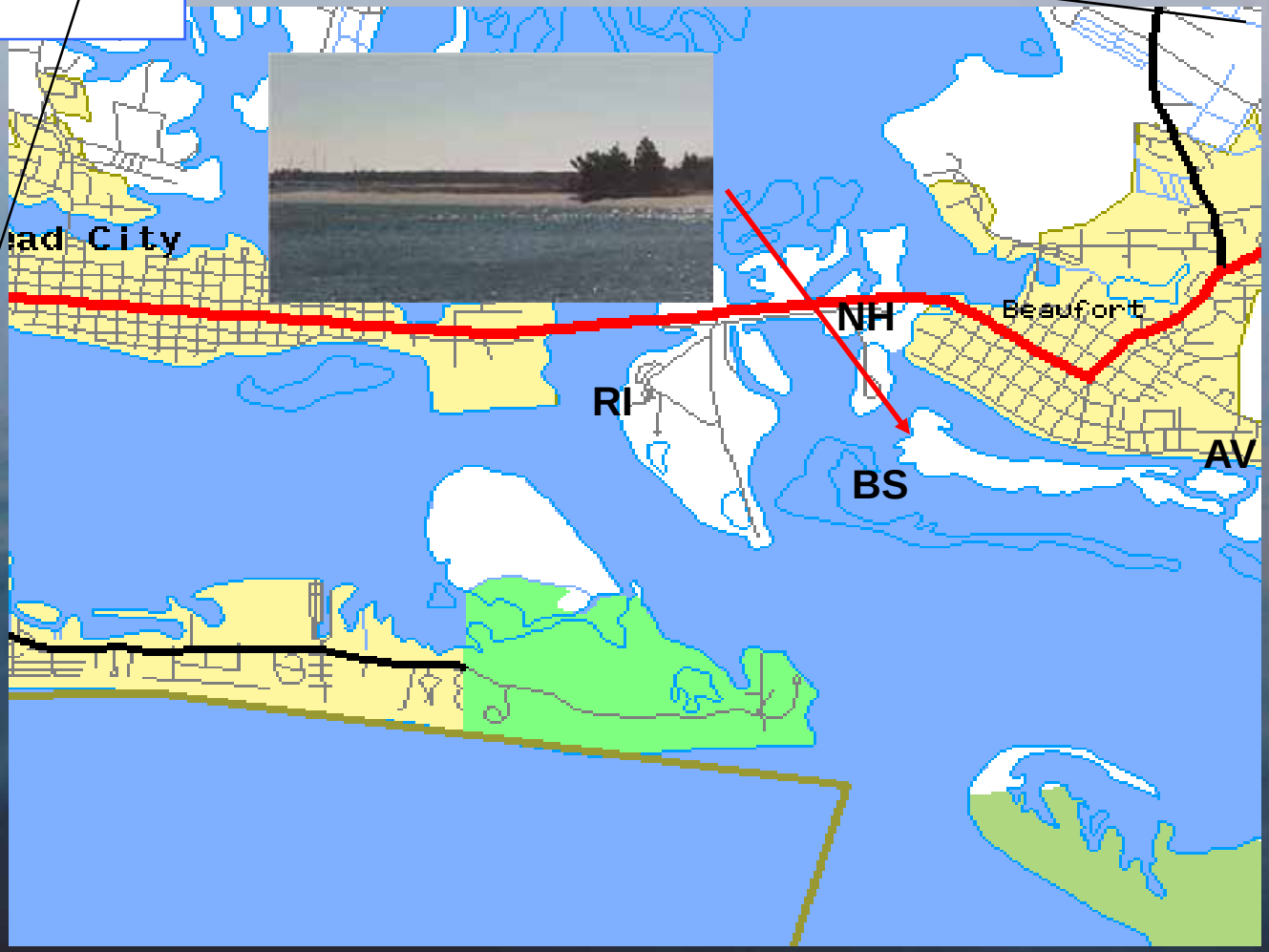


What about other contaminants?

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

Field Sites





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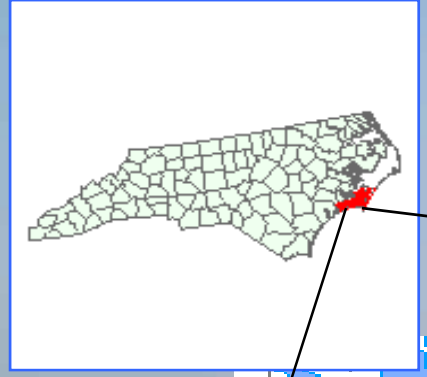

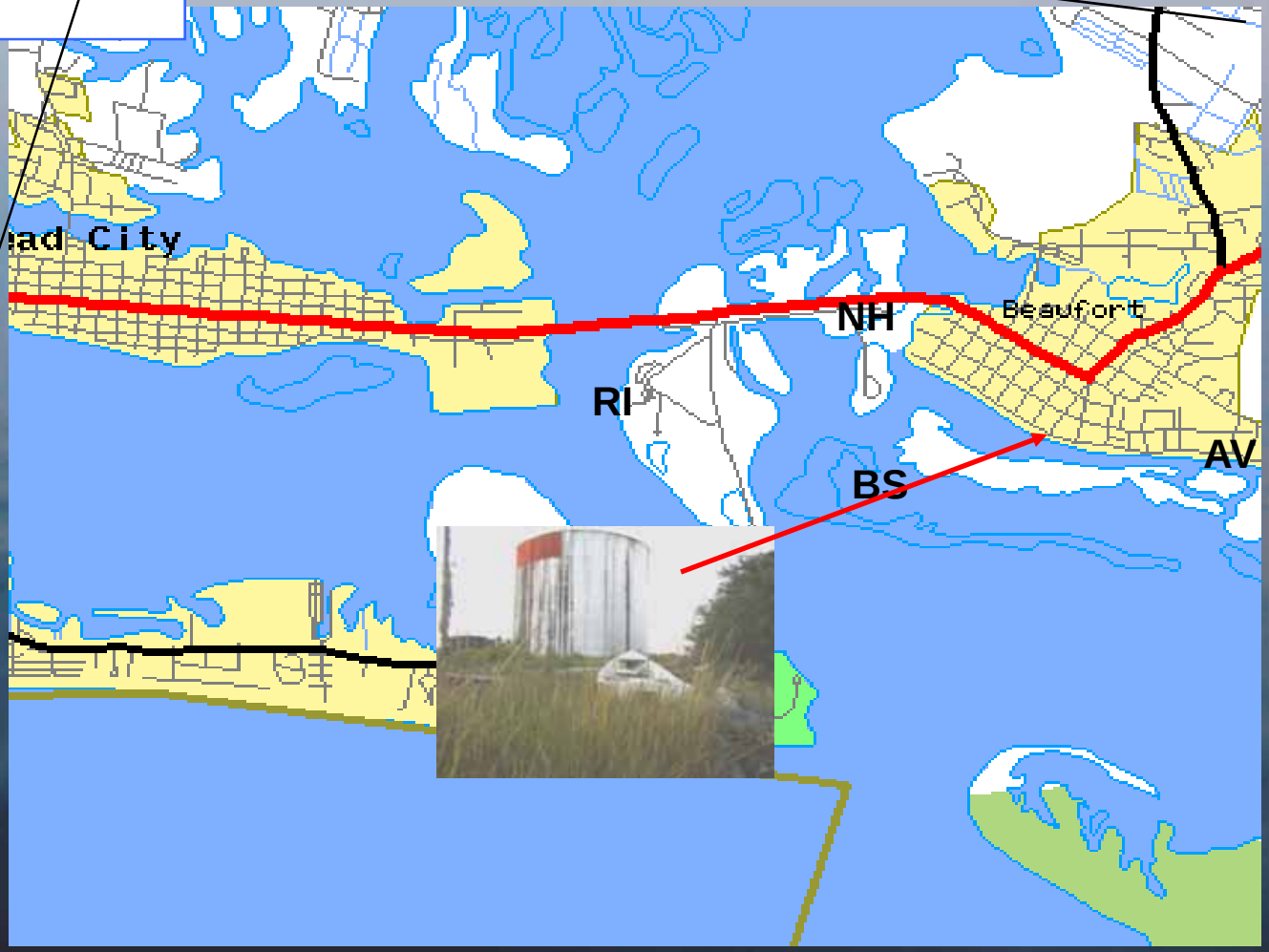

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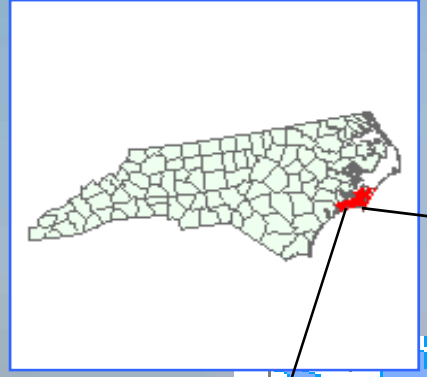
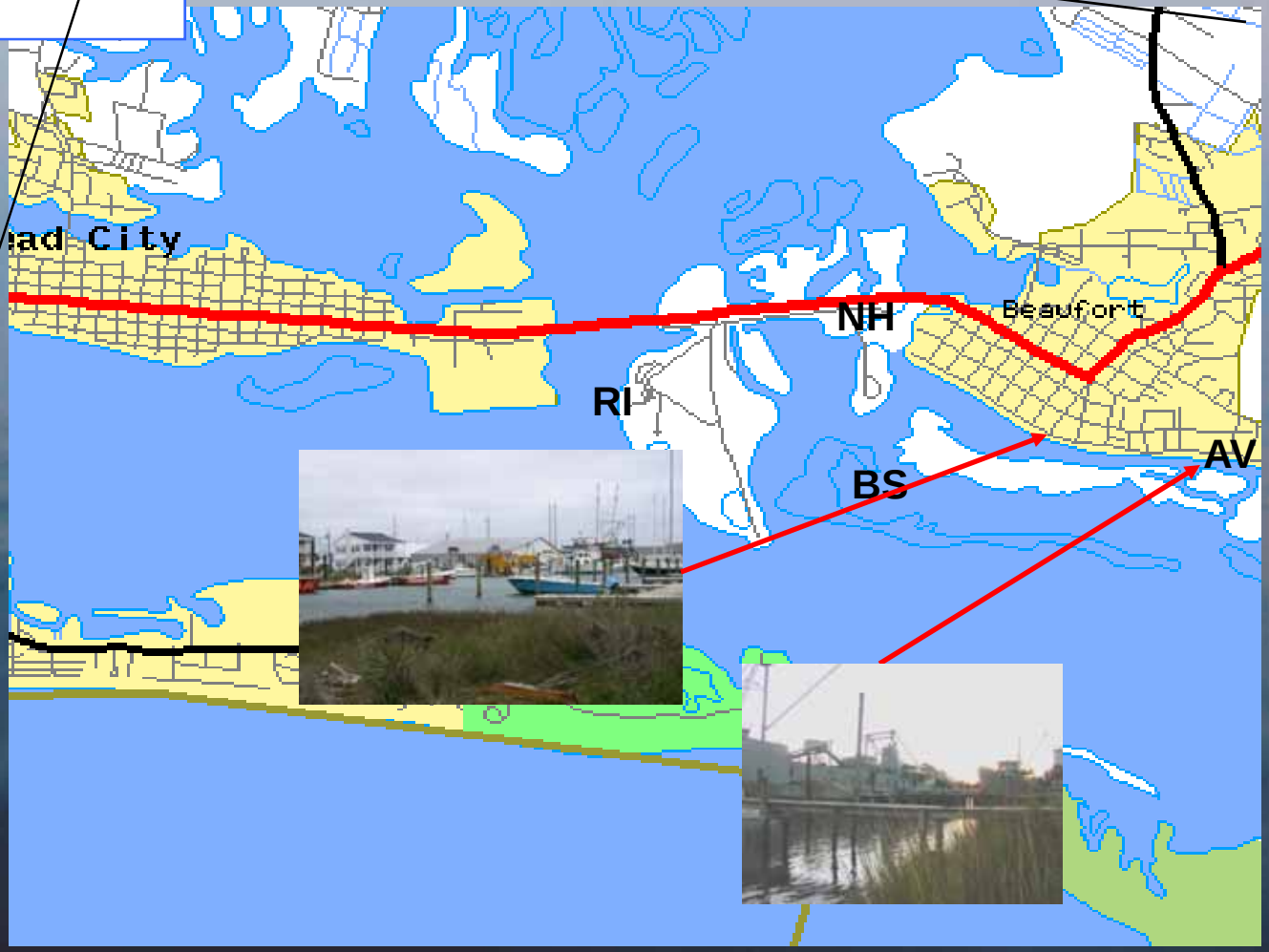
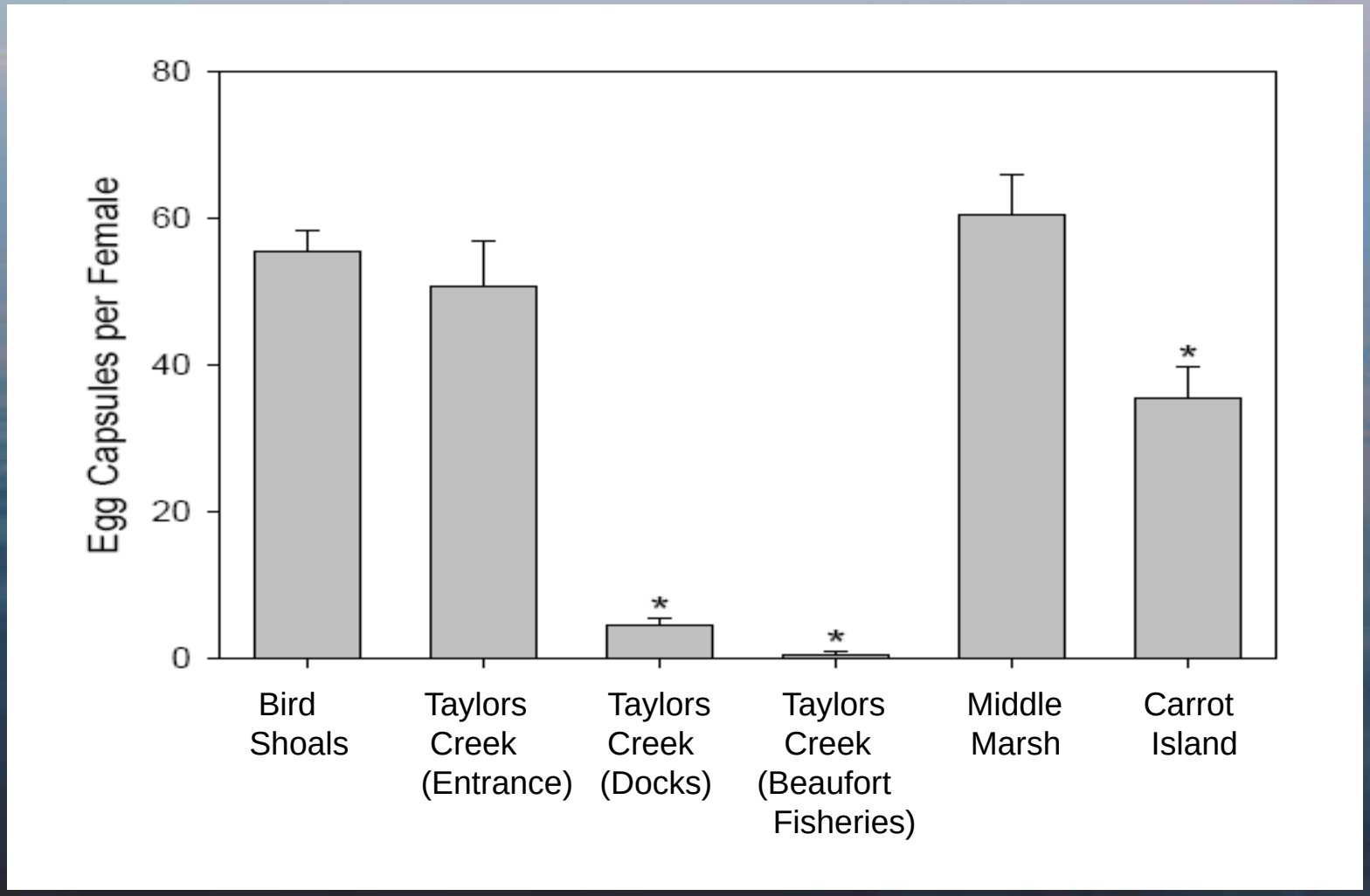
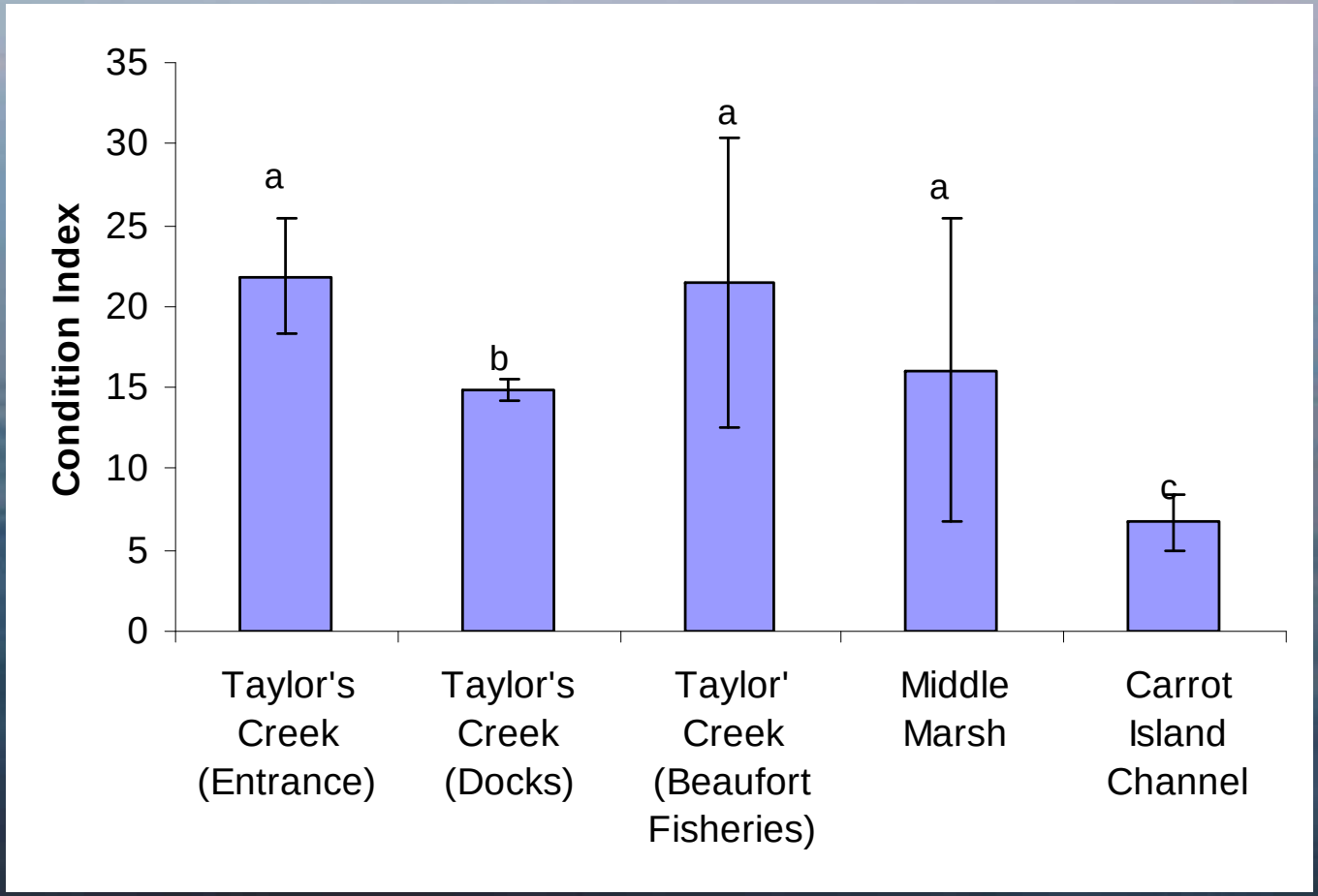




Reproductive capacity of gastropods in field exposures



Do Environmental Pollutants Affect Oysters?



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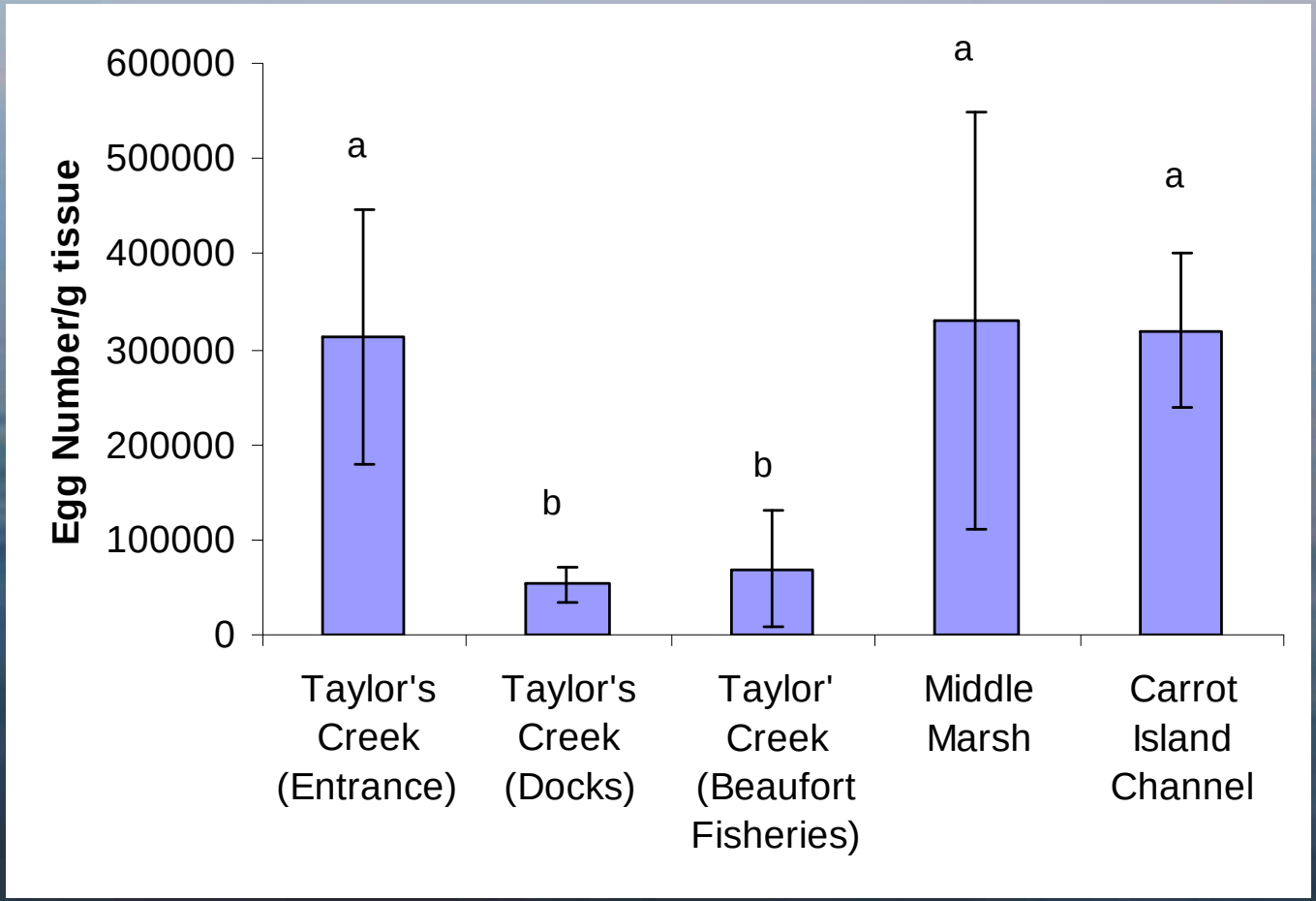


Primary Controls

- Temperature
- Day Length
- Water Chemistry
- Organism Interactions

Alternative Controls

- Toxic Chemicals
- Disease
- Environmental Stressors

Environmental Stimulation (seasonal cue)

Sense Organs

neuroganglia

SMF/ELH

other neuropeptides

Development
Reproduction
Metabolism
Behavior
Physiology

Growth

Metamorphosis

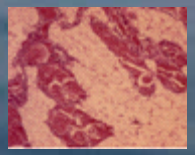
Development

Feedback

ASO

Male gonad

Female gonad



?

Androgens
Progestins
Estrogens

Yolk Proteins
vitellogenin and
vitellin-like

Hepatopancreas

Enzymatic changes

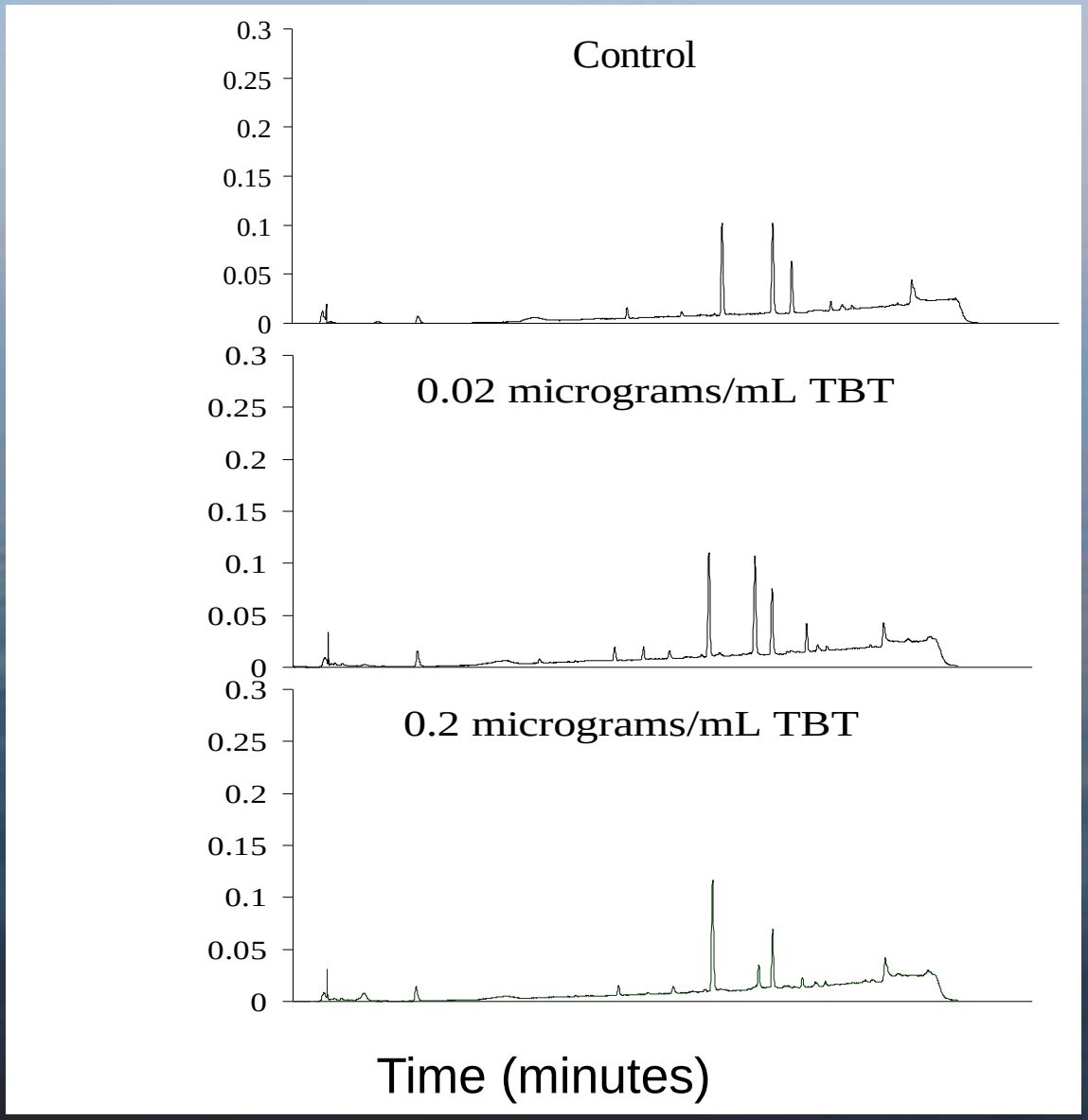
Mollusc Model

Adapted from presentation by P. Thomas

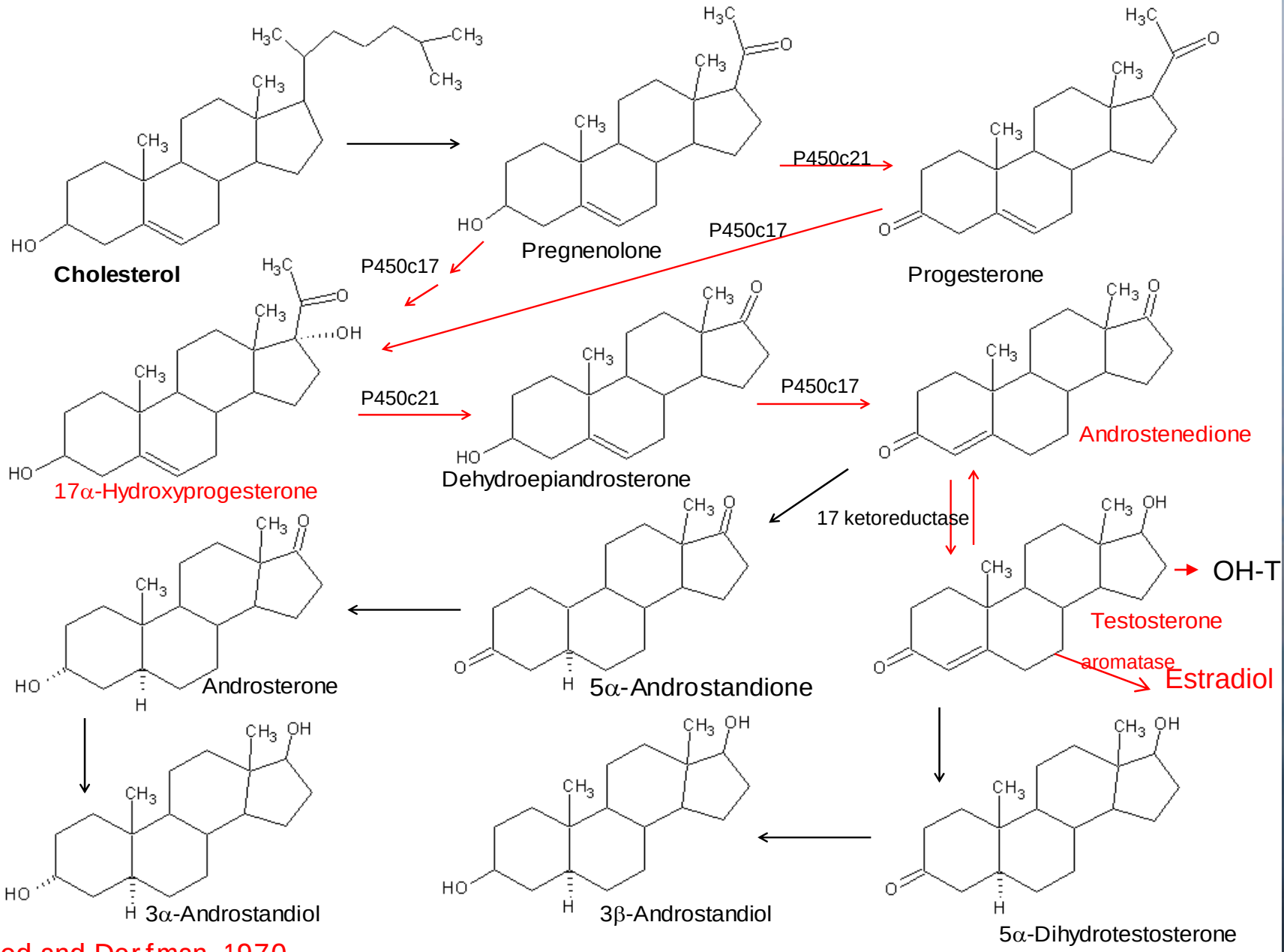
Are our oysters at risk?

- 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



Gottfried and Dorfman, 1970

Six Degrees of Contamination