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# Predicting ecological impacts of poor water quality: a mechanistic solution

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## Background:

**Dynamic hypoxia causes ecological impacts (Fig. 1):**

1. Avoidance of hypoxia alters spatial distribution of blue crabs.
2. Direct mortality of adults occurs from exposure to hypoxia.
3. Indirect mortality of juvenile crabs occurs when cannibalistic adults move to shallow water to avoid hypoxia.

**Respiratory physiology may affect blue crab avoidance behavior and mortality during hypoxic events.**

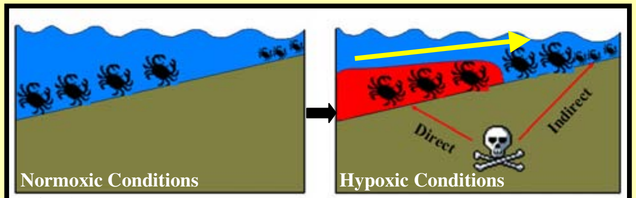


**Fig. 1.** Conceptual model showing blue crab avoidance behavior of hypoxia (in red) and its subsequent ecological impacts.

**How physiology and behavior interact with hypoxia dynamics to alter population demographics is unknown but is important to water quality managers who want to predict how nutrient loading impacts marine resources.**

## Objectives

**Develop a computer model that accurately simulates blue crab behavior and physiology during hypoxic events.**

**Test model predictions with free-ranging animals in a highly eutrophic system, the Neuse River Estuary, NC (Fig. 2).**

**Understand how the concentration and structure of a respiratory protein (hemocyanin) influences behavior and mortality during hypoxic events.**


**Fig. 2.** NC study system

## Approach

**Laboratory studies (completed) will determine relationships between declining oxygen, movement, and mortality.**

- Flume study (**Fig. 3**) simulates hypoxic events in the lab to monitor crab movement behavior.
- Mortality study quantifies survival probabilities in hypoxia.

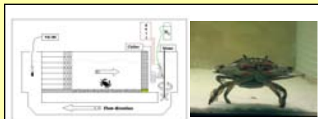

**Fig. 3.** Diagram of flume used to simulate hypoxic events and picture of crab exposed to hypoxia.

**Computer model will predict which type of hypoxic events pose the greatest threat to blue crab populations.**

- Model will be parameterized with laboratory results.
- Model simulates hypoxic events and crab behavior in a virtual landscape to predict population mortality rates.

**Field study (in progress) will examine the effects of physiology and hypoxia on free-ranging crab behavior.**

- Sonic tags (**Fig. 4**) mark the location of each crab.
- Telemetry system (**Fig. 4**) autonomously tracks crab positions
- Hydrographic instruments record real-time water quality.
- Results will test the model's predictions.

**Fig. 4.** Diagram of the VRAP telemetry system used to track crabs and pictures of a transmitter and receiver buoy.

**Molecular techniques (in progress) will be used to examine respiratory physiology of all crabs used in experiments.**

- Spectrophotometry measures hemocyanin concentration.
- Gel electrophoresis determines structure of hemocyanin molecule.

## Results & Conclusions:

**Behavior (Fig. 5):**

- As DO drops to hypoxia, crabs initially increase their movement rates before becoming quiescent.
- Crabs are more active when DO drops fast than when rate of DO change is slow.

* **Blue crabs may sense hypoxic exposure risk levels, suggesting their behavior will vary with different types of events.**

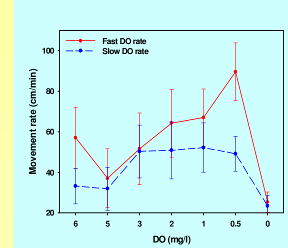


**Fig. 5.**

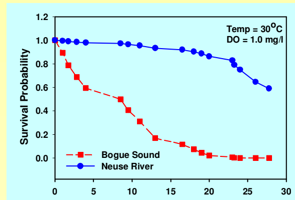


**Fig. 6.**

**Mortality (Fig. 6):**

- Crabs survive for many hours in severe hypoxia and high temperatures.
- Neuse River crab survival is greater than Bogue Sound crab survival.

* **Blue crabs are very tolerant of hypoxia**

* **Animals from hypoxia-stressed systems may develop physiological mechanisms to enhance their survival.**

**Physiology:**

- Hemocyanin concentration does not influence blue crab behavior or mortality.

* **Another molecular mechanism (hemocyanin structure; Fig. 7) may explain differences in mortality and behavior.**

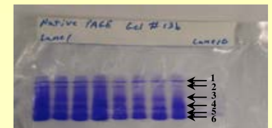

**Fig. 7. Gel banding pattern of hemocyanin structure.**

## Significance:

**My research will help understand the molecular and behavioral mechanisms that control ecological impacts of hypoxia.**

**My behavior/physiology model can be coupled to water quality models to help with nutrient loading management decisions.**

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