THE UNIVERSITY OF SOUTHERN MISSISSIPPI

GULF COAST RESEARCH LABORATORY
DEPARTMENT OF COASTAL SCIENCES

Linking Hypoxia and Organic Enrichment to Macrobenthic Process Indicators Using the Peters Mass Balance Model: Calibration Via Laboratory Experiments

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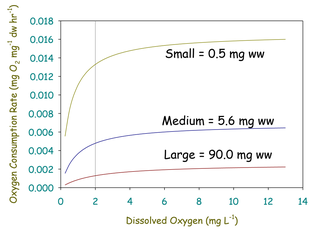
BACKGROUND

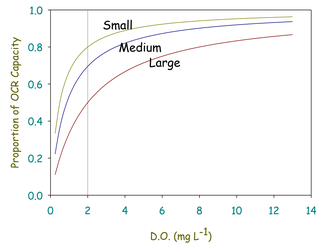
Body size is a fundamental ecological trait that underpins critical vital rates, including oxygen consumption and feeding rates. Body-size dependent processes provide one means to link environmental stress to changes in metabolic activity on the individual level, which in turn scale up to changes in the distribution of biomass among discrete size classes. Thus, size-based macrobenthic indicators can be linked to ecosystem function and health.

Rakocinski (2009) adapted the Peterson Mass Balance Model (PMBM) (Peters 1983) to simulate effects of oxygen limitation on macrobenthic biomass-size distributions through inferred effects on ingestion rates. However, this adaptation of the PMBM was predicated on several provisional premises and assumptions gleaned from the literature or derived from apparent mechanistic links, that still require experimental confirmation:

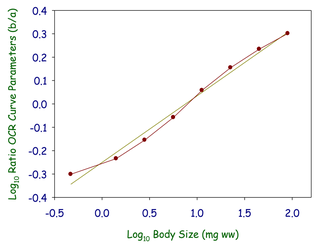
1. Oxygen consumption rate (OCR) increases hyperbolically with ambient DO concentration as OCR = $(a+b/DO)^{-1}$, where $OCR_{max} = 1/a$.



2. Given unlimited food availability, the ingestion rate will be constrained by oxygen limitation through a direct proportional relationship between OCR and metabolic capacity, wherein realized ingestion rate ~ OCR/OCR_{max}.
3. Given that small organisms attain higher mass-specific rates of oxygen consumption than large organisms, large organisms should regulate oxygen intake better than small individuals as ambient DO declines.



4. Given that the ratio of the OCR curve parameters, b/a, conveys the capacity for metabolic regulation, an allometric scaling rule was adopted wherein the slope of the log body mass vs. b/a relationship was -0.285 (i.e., intermediate between 3/4 and 2/3 scaling rules).



The need to confirm or revise the nature of these relationships, as well as to parameterize and extend them, provides much of the justification for this study.

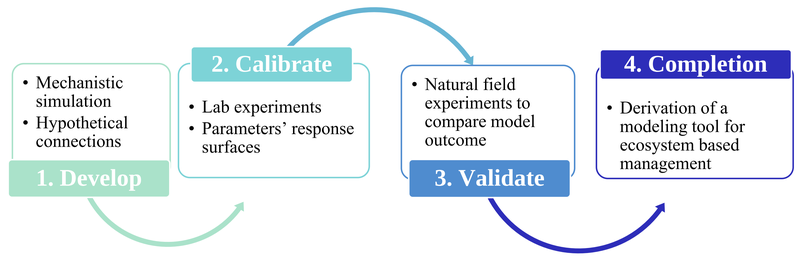
LITERATURE CITED:

Rakocinski, C. (2009). Linking allometric macrobenthic processes to hypoxia using the Peters mass balance model. *Journal of Experimental Marine Biology and Ecology 381: 513-520.*

Peters, R.H. (1983). *The Ecological Implications of Body Size.* Cambridge Univ. Press.

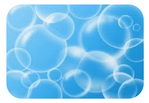
PROGRAM OBJECTIVES

Development of the HMBM initiated by Rakocinski (2009) is guided by four overarching programmatic objectives:



PHASE TWO: CALIBRATION

An important next step in development of a Hypoxia Mass Balance Model (HMBM) is calibration of the model through experimentation. Although the effects of organic enrichment upon macrobenthic communities are fairly well known, underlying mechanistic responses by individual organisms are not nearly as well understood. Experimental results will contribute to response surfaces for generating estimates of model parameters while also advancing knowledge about the expression of individual responses to hypoxia.
This research will examine five subsidiary objectives:

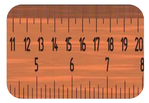


1. Oxygen Consumption

2. Tolerance

3. Weight Loss

4. Feeding Performance



5. Growth

OVERARCHING HYPOTHESIS

- **Macrobenthic community structure and function are influenced through opposing effects of oxygen versus food limitation and mediated by body-size related constraints**

Objectives	OXYGEN CONSUMPTION	TOLERANCE	WEIGHT LOSS	FEEDING PERFORMANCE	GROWTH RATES
Proposed Procedure	-Closed, intermittent respirometry	-LC_{50}	-Change of mass -Image analysis -Stoichiometry -C:N -ammonium equivalents -pH for CO_2 proxy	-Food tracer (fluro powder) in glass bead habitats -Ingestion rate/ assimilation efficiency	-Change in mass -Image Analysis
Independent Variables	-DO -Temperature	-DO -Temperature	-DO -Temperature	-DO -Temperature -Food Quality -Food Quantity	-DO -Temperature -Food Quality -Food Quantity

CURRENT FOCUS

Current efforts are focusing on measuring oxygen consumption rates (OCR) under oxygen limitation in relation to body size and temperature, for selected macrobenthic taxa. Oxygen consumption will be measured using intermittent closed respirometry in a specialized 36 ml respirometer system with a 7ml sampling chamber (QUBIT Systems). This apparatus will enable for the examination of small size classes under conditions which do not involve concurrent depletion due to respiration.

Subsequent efforts will involve longer term experiments designed to measure feeding and growth for various body sizes of selected taxa under different conditions representing combinations of ambient DO, food quantity, and food quality.