Project Summary

NGOMEX 2006: Reproductive And Population Effects Of Moderate Hypoxia

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Problem: There is mounting concern over the recent dramatic increase in the incidence of seasonal hypoxia in the northern Gulf of Mexico (GOM) and other coastal regions of the world due to increased nutrient loading. Most marine species do not survive prolonged exposure to severely hypoxic conditions (dissolved oxygen, DO, <2 ppm), but many appear to tolerate moderately hypoxic conditions (DO: 2 - 3.5ppm) and remain in the margins of the 'dead zones' if food organisms are available. Even for these tolerant species, the long term effects of frequent and persistent exposure to sublethal low DO conditions are poorly understood.

Rationale: Reproduction is one of the most sensitive stages of the life cycle to stressors, and reproductive impairment (e.g., a decrease in fecundity) can have serious consequences at higher levels of biological organization such as population sustainability. Recently, marked suppression of gamete development was observed in Atlantic Croaker chronically exposed to moderate hypoxia in several estuaries in the northern GOM, suggesting that reproductive output is particularly sensitive to this environmental stressor. However, practically no information is currently available on the effects of moderate hypoxia on reproduction in marine organisms inhabiting the margins of the dead zone offshore. Therefore, the overall aims of this collaborative, multidisciplinary proposal are to determine the effects of low DO in the northern GOM on the reproductive output of two indicator species, a benthic copepod, and Atlantic Croaker, representing benthic and higher trophic level (fishery) components of the marine ecosystem, respectively, and to predict the long-term population consequences. The effects of different environmental levels of DO in the margins of dead zones (range of 2.0 to 3.5 ppm) on several molecular and morphometric biomarkers of the reproductive output of these two species will be determined. In addition, hypoxia inducible factor (HIF) 1*a* and 2*a* mRNA levels in croaker will be evaluated as molecular indicators of chronic exposure to low DO. This information will be used to predict the long term population consequences of reproductive impairment using individual-based and matrix projection population models.

Hypothesis and objectives: The hypothesis that moderate hypoxia in the northern Gulf of Mexico significantly decreases the reproductive output and predicted population abundance of two indicator species, representing different components of the marine food web, will be tested. Specific objectives are to: (1) compare reproductive output in benthic copepods and Atlantic Croaker collected from normoxic, moderately hypoxic and hypoxic sites in the northern GOM; (2) determine the correlation between endocrine function biomarkers and reproductive output indicators in Atlantic Croaker and assess HIF 1*a* and 2*a* mRNA expression in croaker as molecular indicators of environmental exposure to hypoxia; and (3) refine and test predictive models for scaling individual-level effects of low DO on fish and copepod reproduction to the population level.

Approach: Benthic copepod and croaker samples will be collected from two normoxic, six moderately hypoxic and two hypoxic sites along an isobath (15 – 20 m) transect between Texas and Louisiana that traverses the western boundary of the dead zone in the northern GOM. Samples will be collected in the summer (July), when the hypoxic zone is extensive, and in the early fall (October) when the hypoxic zone is shrinking and Atlantic Croaker are completing their reproductive cycle. The number of viable gametes (fecundity) will be estimated from measurement of a suite of molecular, endocrine and functional reproductive biomarkers in these samples and used in simulation models to predict population consequences.

Benefits and relevance: The research will provide critical information needed by resource managers for an overall assessment of the ecological and economic benefits of a reduction in the size of the hypoxic zone and its margins in the northern GOM. This research will address two priorities of the NGOMEX program for ecologically important species in the northern GOM : (1) the potential impact of the hypoxic zone (Priority C, Gulf Monitoring and Reporting); and (2) use of quantitative models to determine the individual- and population- level effects of different extents of hypoxia (Priority B, Gulf Modeling and Research).