The National Academies of SCIENCES ENGINEERING MEDICINE
GULF RESEARCH PROGRAM

Healthy Ecosystems Grants 2 Final Report

Project Title: Improved Understanding of the Northern Gulf of Mexico Pelagic Ecosystem: Integration, Synthesis, and Modeling of High-Resolution Zooplankton and Fish Data
Award Amount: $504,471
Awardee: University of Maryland
Award Start Date: 12/04/15
Award End Date: 12/03/17
NAS Grant ID: 2000006418

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I. PROJECT SUMMARY (from proposal)

Pelagic zooplankton and small fish provide the foundation for commercially and recreationally important fish species in the Gulf of Mexico and serve as the critical link between primary production and higher trophic levels. In order to establish "reference" ecological conditions to compare to possible oil spill effects in the northern Gulf of Mexico (NGOMEX) it is essential to characterize the standing stock, species composition and natural variability of zooplankton and fish over relevant time and space scales. However, complicating the assessment of oil impacts on the ecosystem is the fact that the NGOMEX region is dominated by various amounts and durations of seasonal hypoxia (i.e. "dead zone") that can drive dynamic changes in all trophic levels. Thus any synthesis of zooplankton and fish data in the NGOMEX must include tools to assess how hypoxia influences these pelagic communities so that managers can differentiate the potential effects of oil from hypoxia in perturbing these communities. We propose to develop predictive models of habitat suitability for zooplankton and fish, based on a critical limiting dissolved oxygen supply and demand, and using statistical coupling of physical and biological factors and bioenergetic requirements.

With NOAA and NSF funding, our research team conducted 7 summer mapping and process cruises across the NGOMEX (> 15 inshore-offshore [100km] transects between the Texas border and the Bird's Foot Delta) to gather high-resolution data to define the spatially-explicit relationships between environmental conditions and pelagic zooplankton and fish distributions. We have one of the most comprehensive, synoptic data sets on temperature, salinity, oxygen, phytoplankton, zooplankton and fish in the NGOMEX under a range of environmental conditions including differing hypoxic volume/area, freshwater input from the Mississippi River, and climatological forcing. Our data products, many of which have been published in peer-reviewed papers and are publicly available at BCO-DMO.org, include

hydrological conditions; species composition and biomass of phytoplankton, zooplankton and fish; biomass size distribution of zooplankton and fish; comprehensive measures of pelagic fish densities, fish diet data (over 3,000); and fish growth potential models to quantitatively assess fish habitat requirements. These data are comprehensive from physics to fish, are spatially explicit throughout the water column and span the coastal area of NGOMEX across 7 years. Thus we have an extremely valuable dataset to integrate with other ongoing and historical oceanographic, plankton, and fish collections in the NGOMEX region to produce integrated and synthetic metrics that can be used in a variety of models to improve our understanding of the NGOMEX pelagic food-web and assess potential responses to stressors.

We used a mix of novel and traditional methodologies. Traditional zooplankton collections (nets, pumps, Niskin bottles) were coupled with continuous optical plankton counter (OPC) measurements and high-frequency acoustic zooplankton profiles. Fish densities and sizes were measured throughout the water column using dual frequency split-beam acoustics supplemented with both mid-water and bottom trawls. Comprehensive comparisons of these traditional and advanced technology data sets comprising over 1M measurements will yield important recommendations for more cost-effective methods (acoustics and optics) for future monitoring programs in the NGOMEX.

II. PROJECT SUMMARY (from final report)

Zooplankton provide the base of the pelagic food web in the Gulf of Mexico. The are the food for both commercial and recreational fisheries. We had collected zoolankton and fish data from the northern Gulf of Mexico in/out of the large low oxygen zone on 6 cruises with variable weather and ocean conditions as well as before and after the recent BP oil spill. Our objective was to combine this data with similar information collected by other scientists to develop synthesized data products that would be useful to the research community to assess the ecosystem impacts of oil spills not only int the Gulf of Mexico but other areas in the world's ocean where oil extraction occurs. Besides combining the data we developed tools to analyse and visualize the data for easier interpretation. We have and will make these data products available to the research community.

III. PROJECT RESULTS

Accomplishments

In order to better assess the impacts of oil spills in the Gulf of Mexico is is necessary to have essential background information on the pelagic ecosystem. The focus of our project was to bring together existing data from our past projects on zooplankton and fish in the northern Gulf of Mexico with similar data from other investigators and synthesize the data products for the research community. We integrated these data products and created a number of tools to assess the pelagic ecosystem in relation to the physical

environment (water temperature, salinity and oxygen). Our data products also include integration, mapping and statistical tools to assess the ecosystem information.

Implications

Our data products will be useful to other researchers studying the Gulf of Mexico and other areas with similar oil and gas extraction, Our results will be an important component of ecosystem monitoring of the Gulf of Mexico for both scientists and society in general as the assess the ecosystem impacts of oil spills in the ocean.

Unexpected Results

N/A

Project Relevance

The following audiences would be most interested in the results of this project:

- Researchers

Researchers will use our data products to compare their own results as well as to incorporate the data into ecosystem models in the Gulf of Mexico.

Education and Training

Number of students, postdoctoral scholars, or educational components involved in the project:

- Undergraduate students: 0
- Graduate students: 0
- Postdoctoral scholars: 2
- Other educational components: 1

We worked with a volunteer who was a former science teacher.

IV. DATA AND INFORMATION PRODUCTS

This project produced data and information products of the following types:

- Data
- Scholarly publications, reports or monographs, workshop summaries or conference proceedings
- Websites or data portals
- GIS applications

DATA

See attached Data Report.

Relationships Between Data Sets:
Zooplankton and fish data are listed separately as well as hydrographic data.

Other Activities to Make Data Discoverable:
Data and graphic products will be maintained on a server at our institution. We have recently ordered the server and will list the server address with NAS when completed.
Most of our data is also available at https://www.bco-dmo.org/

INFORMATION PRODUCTS
See attached Information Products Report.

Citations for Project Publications, Reports and Monographs, and Workshop and Conference Proceedings:
Manuscripts:

- Glaspie, C. N., Clouse, M., Elliot, D. T., Kimmel, D. G., Ludsin, S. A., Mason, D. M., Pierson, J. J., Roman, M. R., and Brandt, S. B. In review – Impacts of hypoxia on the pelagic food web of the northern Gulf of Mexico. Submitted to Estuaries and Coasts.
- Roman, M.R., S.B. Brandt, E.D. Houde and J. J. Pierson. In review – Impacts of seasonal hypoxia on pelagic zooplankton and fish: Unifying Theory. Submitted to Frontiers in Marine Science.
- Glaspie, C. N., Clouse, M., Adamack, A. T., Cha, Y., Ludsin, S. A., Mason, D. M., Roman, M. R., Stow, C. A., and Brandt, S. B. In review – b. Effect of hypoxia on diet of Atlantic bumper Chloroscombrus chrysurus in the northern Gulf of Mexico. Submitted to Transactions of the American Fisheries Society.
- Brandt, S. B., Sellinger, C. E., and Glaspie, C. N. Drafted. Growth rate potential as a causal mechanism for North Pacific salmon returns in a changing climate. For submission to PLOS One.
- Huebert KB, Roman M, and Pierson, JA. Drafted Baseline for summer mesozooplankton communities in the Northern Gulf of Mexico and effects of hypoxia. For submission to be determined
- Glaspie, C. N., and Brandt, S. B. In prep. Hypoxia and temperature compress habitat for forage fishes in the Northern Gulf of Mexico. For submission to Marine Ecology Progress Series.
- Huebert KB, Pierson JA, Luo JY, Di Mauro R, Lavrentyev PJ, Benfield MC, Cowen RK, and Roman M In prep. Comparisons of zooplankton size spectra in the Northern Gulf of Mexico.

Presentations:

- Huebert K. B., Pierson J. J., Roman M. R. "Northern Gulf of Mexico plankton size spectra." ICES Annual Science Conference, Ft. Lauderdale, FL, Sep. 2017
- Huebert K. B., Roman M.R., Pierson J. J. "Gulf of Mexico zooplankton synthesis and data portal." Gulf of Mexico Oil Spill and Ecosystem Science Conference, New Orleans, LA, Feb. 2017

- Brandt, S., Laurent, A., Glaspie, C., Sellinger, C., and de Mutsert, K. “Assessing and predicting the effects of reduced nutrients and hypoxia on fishes in the Gulf of Mexico.” Ocean Sciences Meeting, Portland, OR, February 2018.
- Glaspie, C. N., Brandt, S. B. and Sellinger, C. E. “Hypoxia impacts on marine fish trophic dynamics in the Northern Gulf of Mexico.” Hatfield Marine Science Center Seminar Series, Newport, OR, December 2017.
- Glaspie, C. N., Brandt, S. B. and Sellinger, C. E. “Defining energy seascapes to predict future distribution and production of fish.” Ecological Society of America, Portland, OR, August 2017.
- Glaspie, C. N., Brandt, S. B. and Sellinger, C. E. “Hypoxia impacts on small pelagic fishes: Insights from high-frequency acoustic sensing.” American Fisheries Society Meeting, Tampa, FL, August 2017.
- Brandt, S. B. “Ecosystem Forecasting: Bridging Science to Management”. Invited Plenary Speaker, Greater Everglades Ecosystem Restoration (GEER) Conference, Coral Springs, Florida, April 2017.
- Brandt, S. B. “Use of Models: Production Potential Models”. Workshop: Hypoxia effects on fish and fisheries. Gulf of Mexico Oil Spill & Ecosystem Science Conference 2017 Workshop, New Orleans, Louisiana, February 2017.
- Brandt, S.B. 2017. “Spatial Ecology of Pelagic Fishes”. Invited Seminar to Fisheries and Wildlife Department Stream Team, Oregon State University, 13 March, Corvallis, Oregon.
- Brandt, S. B. and Sellinger, C. “Assessing essential fish habitat for a marine pelagic fish.” American Fisheries Society (AFS) Annual Meeting, Kansas City, Missouri, August 2016.
- Brandt, S. B. and Sellinger, C. “Variability in North Pacific Ocean conditions: Assessing habitat-specific vital rates and thresholds for fishes.” North Pacific Marine Science Organization (PICES) Annual Meeting, San Diego, California, November 2016.

Workshops:

- Huebert KB. Gulf of Mexico Tools Café, Gulf of Mexico Oil Spill and Ecosystem Science Conference, New Orleans, LA, Feb. 2017
- Brandt, SB & Mason D. Pelagic fish seascapes: Integration of new technology and modeling, American Fisheries Society Annual Meeting 2017 Symposium, Tampa, Florida, August 2017
- Glaspie C & Brandt S. Response of fishes to extreme climate events. American Fisheries Society Annual Meeting 2017 Symposium, Tampa, Florida, August 2017

Websites and Data Portals:

This will be completed within 3 months.

We will maintain the data on the local server for 10 years. Data maintained on https://www.bco-dmo.org/ will be archived.

Additional Documentation About Information Products:
N/A

Other Activities to Ensure Access to Information Products:
N/A

V. PUBLIC INTEREST AND COMMUNICATIONS

Most Unique or Innovative Aspect of the Project
One aspect which is innovative about our data products in the high resolution spatial sampling of zooplankton and fish in relation to hypoxia in the northern Gulf of Mexico. Our data and data products can be used to assess the impacts of low oxygen zones on the pelagic ecosystem.

Most Exciting or Surprising Thing Learned During the Project
Our data synthesis products show how low oxygen zones in the northern Gulf of Mexico can have detrimental effects on essential fish habitats.

Most Important Outcome or Benefit of Project
Our project results provide a better understanding of the Gulf of Mexico ecosystem for improved management and sustainability.

Communications, Outreach, and Dissemination Activities of Project
N/A