Hypoxia effects on fish and fisheries

kick-off meeting of decision support tool development

Summary workshop 1, February 6, 2017, New Orleans

This was the first of three workshops organized as part of the project: "NGOMEX 2016: User-driven tools to predict and assess effects of reduced nutrients and hypoxia on living resources in the Gulf of Mexico" funded by NOAA's Center for Sponsored Coastal Ocean Research (CSCOR) under grant no. NA16NOS4780202. The morning of the workshop was open to all interested parties, while the afternoon served as an advisory panel meeting. All presentations given at the workshop are uploaded at this location: https://demutsertlab.com/ngomex/workshop1/

Morning presentations

Matt Campbell, the application PI of the project, opened the meeting. Kim de Mutsert, lead PI of the project, introduced the workshop goals, which were to introduce the project to the advisory panel and other stakeholders, solicit input on various components of project development, align the project with NOAA goals, and evaluate collaboration potential with synergistic projects. This introductory presentation is uploaded to the website (see above for web address). After that the three models used in this project were presented, all uploaded to the website: Ecospace (Kim de Mutsert), Production Potential models (Stephen Brandt), and the ROMS hypoxia model (Arnaud Laurent). The main goal of our project is to integrate these three models to address how changes in nutrients affect fish and fisheries, develop practical management tools based on these linked models, and deliver those to managers and stakeholders. Matt Campbell presented the science application of the project (posted on the website). The lead PI's of the two other projects that were funded under NGOMEX 2016, Daniel Obenour and Kenny Rose, were invited to the workshop, and they presented a summary of their projects (uploaded to the website). The intent of an early connection with the other projects is to learn how the goals of these synergistic projects align and find areas to collaborate. The presentations showed we have very similar goals with different approaches, and the discussion that followed made clear that all teams are interested in collaborating.

Break-out groups

The breakout sessions were meant to receive input in the modeling process from the workshop participants. While we have developed models, they will be improved as part of the project, new production potential models will be developed to represent more species, and decisions need to be made which nutrient reduction scenarios to simulate. First the topics on which we can use participant input were presented. The decision options for Ecospace (presented by Kim de Mutsert), the PP models (presented by Steve Brandt), and the ROMS model (presented by Arnaud Laurent) are uploaded to the website. Participants were rotated and provided input on each of the three subjects (Ecospace, ROMS, PP models) for 15 minutes,

resulting in three lists of inputs per subject. After merging the advice from the different groups, our take-home messages of these breakout session per subject were as follows:

Ecospace

Model domain

- Stick to 5 km^2 grid
- Extend model area to the east to encompass ROMS domain
- Model domain will have coverage of the estuaries; we will not receive ROMS output there, but the model is then set-up for potential other model linkages that do provide output in some estuaries (e.g. FVCOM)

Species

- List of important species mentioned by participants already covered include menhaden brown shrimp, white shrimp, red snapper, Atlantic croaker, spot, blue crab, mullets, Atlantic bumper, red drum (total list of 60 groups is uploaded; second slide of decision options in Ecopace)
- Additional species to consider: sea robins, butterfish (or perhaps leave them in the group 'small forage fish')
- While the model runs on a monthly timestep, a recent development to include effects of environmental drivers on a daily timestep should be used for some 'slow' species (benthic crabs) and target species (red snapper, Atlantic croaker, shrimps, red drum).
- Be aware that red snapper is contentious
- Aggregation of species groups can be done after the fact (so don't run the model with functional groups instead of species, but output can be presented in terms of functional groups when appropriate)
- Habitat niche consideration would also be helpful when aggregating species groups. For example, benthic vs. pelagic feeders may help better understand how hypoxia can eliminate habitat for benthic feeders and displace them to the pelagos as they move up and out of the low oxygen. This can also produce new interactions and competition among benthic and pelagic fish. Therefore, consideration of benthic vs. pelagic could be insightful.

Connection to other models and environmental drivers

- Connection to another model than the ROMS model could provide inshore information
- Including salinity as driver may or may not be useful depending on which model is used to provide the environmental drivers (e.g. yes when the inshore areas are covered, not when we only model offshore)
- In response to a question related to how much the model aligns with the Atlantis model: this model was developed in tandem with the Atlantis model section of this area (coastal Louisiana), but then diverged. The Ecospace model evolved through further development, and development on Atlantis had stopped before it was functional. A new proposal currently under review may result in Atlantis being picked up again and comparative runs will be completed with this Atlantis and the Ecospace model, depending on whether that proposal will be funded.

Production Potential models

Drivers

- The primary model drivers are field observations and 3-D hydrodynamic/biogeochemical models
- It was suggested that salinity be included in the Growth Rate potential maps of fish habitat quality, particularly for white and brown shrimp given its importance in shrimp habitat selection
- It was suggested that we explore uncertainty
- Future model applications as a tool will require observational input and the region needs to have dedicated continuous oxygen sensors
- The steps getting to GRP matter- address the primary drivers
- A number of ways to validate the model output were suggested including Acoustic tag data, lipids, SEAMAP FWRI

Species being modeled

Various species were suggested to add to the modeling products. Red snapper, croaker and red drum. Spotted Seatrout were also suggested since a bioenergetics model was already developed (NOAA). Spanish and king mackerel were suggested by some. The lady fish was suggested because of its abundance. There was also a discussion of looking at an invading species such as lionfish in the context of climate change.

Products

- A number of ways to validate the model output were suggested including Acoustic tag data, lipids, SEAMAP FWRI
- Habitat quality maps are a desired product
- Interfacing with observation systems would be useful
- Recommend bottom oxygen is measured on a continuous basis
- There are only 2 buoys collecting continuous oxygen (DiMarco and Rabalais). These are 2 platforms that are currently functioning in the hypoxic zone area west of the Delta, CSI-6 and CSI-9. There are other locations where buoys were deployed but stopped due to funding issues. A proceedings report from the Sept 2016 Cooperative Hypoxia Monitoring Program workshop will be available soon that describes these and lays out costs for implementing, etc.
- Bioenergetics (Wisconsin) model available on a laptop might be of interest to managers
- Relate juvenile GRP correlate to recruitment indices?

<u>ROMS model</u>

Nutrient reduction scenarios

- Reclassify existing scenarios according to goals or management actions. Scenarios for short-term and long-term hypoxia reduction should be explored. The short-term goal is a 20% reduction in N and P load by 2025, whereas the long-term goal is to reduce the hypoxic area to 5000 km^2. Currently, a 45% reduction in N and P seems to be needed to reach the long-term goal. Additional scenarios based on specific management actions could also be included later if needed.

- Diversions are not included in the ROMS experiments but were mentioned during the discussion because they are included in Dubravko's model. Outputs from FVCOM could be used to test the effect of diversions. These outputs could also be used to simulate diversions with ROMS.
- The covariance of N and P loads raised a question about the necessity of scenarios with different N and P load reduction. N and P have different sources, they are not really coupled and have a different annual cycle; hence, different management measures are necessary to reduce N and P, and it is important to explore the effect of different N and P load reduction.
- A scenario with increased nutrient load was suggested but is not currently included in the set of ROMS scenarios.
- It was mentioned that climate-related changes in the watershed in the next 100 years might offset the nutrient load reduction of the scenarios. The effects of climate-related changes in the watershed could be explored by looking at individual years. For example, the earlier discharge pulse from spring melt.

Model output

- It would be nice to include bays, and inshore areas. However, they are not included in the ROMS grid and some extrapolation will be necessary to expand ROMS results to these areas.
- Temporal averaging (i.e. monthly averages) of model output for Kim's model loses a lot of information. ROMS provide daily output and information at this frequency could be used. Including minimum and maximum values (in addition to average) is recommended. Other indices, such as the number of low-DO days could be used.

Model comparison and validation

- Simulations with ROMS and FVCOM provide an excellent opportunity to do some comparison exercises with the different models, such as the effect of different wind forcing or the effect of diversions.
- Within the ROMS experiments, the relationship between phytoplankton and hypoxia should be examined further, as done during the opening presentation. Zooplankton is poorly validated due to the lack of suitable data. Datasets for validation were mentioned by participants.

Afternoon Discussion

The afternoon was used to first discuss the outcome of the break-out groups, and to evaluate the collaboration potential with the other two funded projects. The remainder of the afternoon was used as a closed meeting with the project team and the advisory panel, which consists of a selection of managers and other stakeholders that are going to be intimately involved throughout the course of the project in an advisory role.

Collaboration with synergistic projects

It would be useful to know all of the outputs the models produce in this project and the synergistic projects, where they overlap, and which ones can be compared and how. There was a general consensus that a collaboration between the synergistic projects would be fruitful, and that opportunities should be pursued to promote these collaborations in the future. Some early ideas include running the same nutrient reduction scenario in all 3 projects and compare outputs, using bioenergetics parameters from Rose's croaker model to develop a new Atlantic Croaker production potential model, using dissolved oxygen and possibly Chl *a* output from Obenour's statistical model and Dubravko's FVCOM model as drivers in the Ecospace model (as an additional alternative to the ROMS model from our project), agree to base years (2000 – 2016) and providing the cruise data from earlier Brandt et al. projects to the other PIs. After that, Alan Lewitus, Branch Chief at NOAA's Center for Sponsored Coastal Ocean Research, presented what the science needs were as viewed by the program office (presentation uploaded in the website). He expressed his enthusiasm about the potential and willingness of the different teams to collaborate, which may result in a bigger return than the sum of the parts. Additional ideas to the ones mentioned above were to use the fleet information from Kevin Craig (application PI of the other two projects) to validate the fleet distribution map output of the Ecospace model. Where possible, the same assumptions and input parameters will be used to maximize comparability. Multi model comparison will help clear up some of the major issues relating to noise in the models and identify drivers.

Working with data

When you are looking at models and not the actual data how do you ensure it is meaningful and doesn't diverge to far from the real data?

- The models are populated with data
- The calibration and validation processes include real data
- The SEAMAP survey data are adequate for Ecospace model development and calibration, additional data will be used in the validation process (cruise surveys, fleet location data, landings and revenue data)
- Validation suffers when data is sparse in time and space, make sure to communicate limitations when that becomes clear

Socio-Economics

There is an interest in the socio-economic effects of hypoxia, which is beyond the scope of this project. Is there some way to account for these?

- Ecospace comes close to a socio-economic aspect by including fleets and simple information to account for cost and revenue of fishing to determine how fleets disperse spatially to gain the most revenue from the catch.
- Matt will inquire with the SEFSC branch that are looking at socio-economic impacts if they are interested in helping with this.

Stock assessment

We need a product that can be incorporated into stock assessment. This is of high interest to the SSC. Workshop 2 and 3 will be hands-on and will focus on the people who will

use the tools we aim to develop. The main example of integrating ecosystem effects in stock assessment in the Gulf of Mexico is SEDAR 42-Red Grouper, where effects of red tide was incorporated in red grouper mortality. These adjusted mortality rates were based off an EwE model. One issue with this approach is there may have been overestimates of mortality rates in years where red tide was present, but did not affect the spawning grounds of red grouper. Our approach may be less affected by similar issues because of the spatial component of Ecospace in general, and because the incorporation of GRP as habitat quality could improve the EwE estimates.

We need to link in with existing meetings. The earliest one coming up is the State of the Gulf of Mexico One Gulf Summit from March 26-31. We can have our next advisory panel call follow right after this meeting, and ask for a summary and a repeat of a One Gulf Summit presentation relevant to our project during our advisory panel call. Other than that we want to make sure that our outputs are ready to be included in relevant assessment meetings. Matt is putting together the dates and species for those assessments.

We need to make sure we are linked in with all those that are doing the assessments. These may be done by different states, NOAA, etc. Ultimately all the models go back to the SSC to determine if they are suitable for management. We have representation from various portions of the process, but each species has its own assessment and the process is fairly complicated. It may be particularly challenging to incorporate anything from our approach into Red snapper assessment.

<u>Advisory panel</u>

We may need more extension and outreach representatives on the panel. We need to find opportunities to interface directly with stock assessment groups. We should strive for more state representation on the advisory panel.

<u>Workshop participants:</u>

Name	Affiliation	Role
Alan Lewitus	NOAA Center for Sponsored Coastal Ocean Research	Program office
Angelina Freeman	Coastal Protection and Restoration Authority	Advisory panel
Arnaud Laurent	Dalhousie University	Project team
Brian Cameron	BOEM	Participant
Brian Dixon	ECOGIG (Ecosystem Impacts of Oil and Gas Inputs to the Gulf)	Participant
Cassandra Glaspie	Oregon State University	Project team
Cholena Ren	BOEM	Participant
Chris Kelble	NOAA	Participant
Cynthia Sellinger	Oregon State University	Co-PI
Daniel Obenour	North Carolina State University	Synergistic project PI
Dave Lindquist	Coastal Protection and Restoration Authority of Louisiana	Participant
David Hilmer	NOAA Center for Sponsored Coastal Ocean Research	Program manager
Demetri Spyropulas	Medical University of South Carolina	Participant
Doug Daigle	Louisiana Hypoxia Working Group	Participant

Dubravko Justic	Louisiana State University	Synergistic project co-PI
Haosheng Huang	Louisiana State University	Synergistic project co-PI
Idrissa Boube	BOEM	Participant
James Tolan	Texas Parks and Wildlife Department	Advisory panel
Jeff Rester	Gulf States Marine Fisheries Commission	Advisory panel
Kenny Rose	Louisiana State University	Synergistic project PI
Kim de Mutsert	George Mason University	Lead PI
Kirsten Larsen	NOAA	Participant
Mark Belter	BOEM	Participant
Mark Schexnayder	Louisiana Department of Wildlife and Fisheries	Advisory panel
Matt Campbell	NOAA Fisheries	Application PI
Melissa Baustian	Water Institute of the Gulf	Advisory panel
Pat Makoski	Calhoun County - Public Health Dept.	Participant
Ross Del Rio	BOEM	Participant
Rusty Gaude	Louisiana Sea Grant	Participant
Shannon Martin	NOAA Fisheries	Advisory panel
Steve Ashby	Northern Gulf Institute	Advisory panel
Steve Brandt	Oregon State University	Co-PI
Steve DiMarco	Texas A&M University	Participant
Thomas DeWitt	Texas A&M University	Participant