**Hypoxia Effects on Fish and Fisheries**

**Second Advisory Panel Workshop: Tools Introductions and Training**

**NGOMEX-Hypoxia Workshop**

**University of Miami - Rosenstiel School of Marine and Atmospheric Science**

**Miami, FL**

**24 and 25 June 2019**

***Meeting Notes***

*Attendees:*

Kim de Mutsert (George Mason University, Project Lead)

Matthew Campbell (SEFSC Mississippi Labs, Application PI)

Stephen Brandt (Oregon State University, Project co-PI)

Cynthia Selinger (Oregon State University, Project co-PI)

Kristy Lewis (University of Central Florida, Project co-PI)

Cassie Glaspie (Louisiana State University)

Skyler Sagarese (SEFSC Miami, Sustainable Fisheries)

David Hilmer (NOAA-NCCOS, Program Officer)

Steve Ashby (Northern Gulf Institute, Co-Director)

Jeff Rester (Gulf States Marine Fisheries Commission)

Sara Marriott (George Mason University, PhD Student)

Joe Buzsowski (EwE Consortium)

Arnaud Laurent (Department of Oceanography - Dalhousie University)

Robert Twilley (LSU, Director of Louisiana Sea Grant)

John Walter (SEFSC Miami, Sustainable Fisheries)

Michelle Masi (SEFSC Galveston, Assessment Scientist - Shrimp)

Jiangang Luo (RSMAS Faculty)

Matt Lauretta (SEFSC Sustainable Fisheries)

***Day 1 - Morning***

***Survey Results - Sara Marriott***

We requested the advisory panel’s participation in a survey during spring of 2019 to help us focus the workshop as well as our modeling efforts on the project with the following intent:

‘The purpose of the survey is to gather more information about how to best serve managers and make sure that the outcomes/outputs of the model have the best chance of adoption or use.’

*Primary responses to the survey questions:*

* Time scales – monthly/annually selected.
	+ Shrimp assessment models operate monthly
* Spatial scales – Multiple answers provided. Need to isolate what is wanted.
	+ Management unit was the most selected
		- Fisheries managers seem to be interested in unit stock which will differ by species.
		- We can handle this by output by region
		- We would like to get a map layers of management unit boundaries.
* Uncertainty – 10% most selected. Suggest sensitivity analysis.
* Species inclusion – Only taking those that were at 50% or higher relative to respondents.
	+ Mackerel
	+ Sea Trout
	+ Red Snapper
	+ Red Drum
	+ Gulf Menhaden
	+ Blue Crab
	+ Brown Shrimp
	+ White Shrimp
	+ Zooplankton
	+ Phytoplankton
	+ Atlantic croaker (added during the meeting)
	+ Sharks (added during meeting)
* Output requests – Either in Biomass per unit area (t/km2) or one of two different versions of a difference maps based on model questions.
	+ Biomass change from the start of the model to the end of the 50 yr run under a given nutrient reduction scenario
	+ Biomass change from a current status model relative to a 50 year model run under a given nutrient reduction scenario
* Data visualization – Biomass, Relative production, Weight per individual (growth can be generated, weight at age). Spatial plots, Line plots, Box plots etc

*Open questions:*

Less easy to synthesize this section of the report due to the open form of the questions. These might be useful in regards to deciphering between what we’re doing versus what people think we’re doing. Perhaps this will lend to some clarifications on potential outcomes.

Uncertainty was a common question in this section:

* It would be good to understand the major assumptions in the model and the major sources of uncertainty.
* Also, sources of uncertainty that may not be propagated through the model estimates of uncertainty.
* What happens with poor spatio-temporal estimation of diet matrices
* How are species responses to hypoxia are parameterized. Do we really know the behavioral response? Do we really know the response curves being used in EwE well.

Calibration/comparison of model output:

* How do EWE biomass outputs compare with single species assessments in stock status, absolute biomass and carrying capacity and management implications?
* Does multispecies inference change our single species advice, either tactically or strategically.

*Summarization*

Decision support tool seems to be the direction we need to head.

* We will facilitate a training and use of the decision support tool once it is further developed (more later in the report).
* Most common responses were focused on determining how different nutrient loadings scenarios would affect Gulf productivity to inform strategic fisheries management decisions.
* Inform broad-scale management decisions by providing linkages from inshore to offshore provide guidance to fishermen as coastal conditions change (might be best driven by/through members of the advisory panel and this is a longer term goal, single message from the three models is necessary).
* Does long-term nutrient reduction create ecosystem winners and losers that would likely need to be addressed by allowing for time-varying carrying capacity estimates in our single species assessments?

How do we lead this towards the Management Application outcomes from the project (Manuscript)? Might have to wait until we have more outcomes. Matt and Sara will work on this.

***Hypoxia model – Arnaud Laurent***

Conducting annual retrospective analysis to continue to improve model and predictions

Survey results asked about validation and uncertainty.

The model is used retrospectively to generate hindcasts but is also used to generate annual hypoxia forecasts (daily size and location). The model has been validated against several types of observations (Hetland and DiMarco 2012, Laurent et al 2012, Yu et al 2015, Mattern et al 2013, Marta-Almeida et al 2013)

Nutrient load, combined with wind and river discharge, driving much of the hypoxia variability.

Broad scale (10km) average features are predicted well. Fine scale (km) is far more difficult to produce due to mesoscale variability associated with hydrodynamic instabilities along the river plume fronts.

Mixing depth? Does wind speed affect nearshore more strongly?

Can you calculate the time it takes to reestablish hypoxia after a storm event?

What spatial scale are we looking at hypoxia in regards to volume or area?

***Bioenergetic models – Stephen Brandt***

Wisconsin Bioenergetics models. Parameters change for each species. Energetics models simulated in each of the ROMS cells (3d). Using the daily output. Tested 0, 20, and 40% reduction scenarios.

System is inherently complex in both space and time.

What scale do we need to look at? Northern Gulf, Louisiana, Atchafalaya? Very critical depending on which stakeholder you are speaking with.

Spatial resolution might not matter when you start talking about creating output scaled to stock-unit (i.e. management of snapper).

Working on understanding the spatio-temporal scale. Turns out to be difficult to sort out. What scale to model this to end up with correctly scaled (meaningful output to managers). Recruitment will be challenging.

What about the benthic community. Currently simulates only the water column (or fishes that perhaps are using the benthos).

How to balance the drivers of oxygen or food limitation etc.?

***Ecospace model – Kim de Mutsert***

Model parameterized with SEAMAP trawl data 2000-5 averaged data.

Moved to stock assessment data. Estimated biomass from single species assessments.

Stock assessment data used when available, if not, biomass estimates come from the SEAMAP survey.

Most of the other parameterization is coming from literature, GOMEXSI, fishbase

Exact diet proportion data are rare and a snapshot even when available. So these are estimated based on the available information scaled to 0-1 based on how much of the used resources are available, or known prey selectivity.

Model parametrization and calibration (2000-16).

Catches - Biomass - Mortality. All of this is coming from stock assessments and SEAMAP time-series. Landings data from NOAA landings query and MRIP. The model is calibrated to the landings data, commercial as well as recreational.

Environmental drivers

Can be done in various ways but for this model spatial averages coming out of the ROMS model.

Response curves are modeled differently depending on the variable of interest and species specific physiological conditions. These range from sigmoidal to trapezoidal (thresholds).

Temporal scales. ROMS is daily so the translation to Monthly is required. Turns out the median is best choice.

New developments:

New reduction scenarios (based on the recommendations of the Hypoxia Task Force)

Different treatment of nutrients in the model. Treating them as an environmental driver with a functional form (response curves).

Change in model parameterization (e.g. use of Biomass derived from assessment models) which required re-balancing of the model and re-calibration as well.

Some species appear to be affected differentially (winners/losers).

Focus for the next year

Model improvement through further calibration, validation and uncertainty analysis

Potential data available for validation: Spatial density of trawls (Robert Twilley). Commercial shrimp trawls? VMS data (electronic logbooks).

Development of the decision support tool (concept presented at workshop).

Include production potential as habitat capacity maps (from Stephen)

Transfer of models and tools to ‘managers’ (more likely Assessment Scientists and SSC, but also Hypoxia Task Force and Louisiana Sea Grant).

Changes to the model (specifically inclusion of response curves) suggest different outcomes than we had before in terms of negative impacts of nutrient reduction on fish biomass in response to the nutrient reduction scenarios (less negative impact from nutrient reduction).

Single message will be needed when coming back to stakeholders

Other comments:

Thoughts on prioritizing hypoxia growth rate and value of fishes (anchovy vs snapper)

Important to know the stratification and redistribution of fish.

Need to consider how we deal with uncertainty.

***Data collection metrics – Cynthia Sellinger***

Sources for environmental data:

NOAA’s world ocean database. Searchable to pull data from selected spatio-temporal scales/ranges.

SEAMAP data sets.

BCO-DMO National Science Foundation data set.

How are we using this data? Validation?

Arnaud using these for boundary conditions.

Stephen etc. This expands time horizon in which you can look.

SEAMAP collections will now have altimeters on the CTD cast, as well as data sondes located on trawl doors. Perhaps could deliver some better spatial resolution on hypoxia relative to observed catch.

***Day 1 - Afternoon***

Working with EwE - Kim de Mutsert and Joe Buszowski

***Day 2 - Morning***

***Bioenergetics in R - Cassie Glaspie***

Using the Wisconsin Bioenergetics models to evaluate energy budgets

Consumption - metabolic costs = growth

These vary by species and temperature

Carnivores and herbivores have different energy budgets and thus life history strategies

Wisconsin Bioenergetics has good examples for some species but perhaps not all of the ones that we’re interested in. 3.0 (56), 4.0 (105). Can use the examples to create a model for species of interest.

Shiny App

***Decision Support Tool – Kristy Lewis***

Preliminary version of the tool can be found at the following web address:

<http://ucfonline.maps.arcgis.com/apps/webappviewer/index.html?id=1f26f19a83294e5d83bc502980fa2178>

\*\*\*\*\*ADVISORY PANEL INPUT\*\*\*\*\*

What we need to know is what kind of outputs would be most useful to resource managers. Currently this is just a quick look at biomass distribution and so this needs to be expanded.

Red Tide example - Current assessment had 2017 as the terminal year and in 2018 we had a strong red tide event. Thus a tool that could incorporate updated information on red tide (in our case Hypoxia) then perhaps this could give managers a tool to evaluate tradeoffs. Fisheries data determining stock status + forecasted effects due to some strength of an event. Need error of some variety perhaps derived off of sensitivity runs.

Difference maps- red to green color (doesn’t have to be red and green, but two different colors with white as 0 change)

Addition of Sharks and Atlantic croaker for the decision support tool

I would suggest lumping forage fish (pinfish, small forage fish, mullet, etc) into a forage group in the decision support tool. The forage base would be important to many stakeholders. Same for brown and white shrimp. You have the raw data separate, but doubting many stakeholders will care about species distinctions (and you could always go back to the data to make the distinction- if needed).

Layer ROMS etc, be able to point and click and view data per cell.

Be able to load new data.

***Feedback - Matt Campbell***

* 2d maps (out of ecospace) of a 3d (system) response. Interpretation is difficult.
	+ Response curves are effectively being implicitly modeled so the 3d effects are incorporated.
	+ Quality factor is assumed to be uniform over the 3d cell.
	+ Foraging area in a cell is being reduced by the response curve (implicit modeling of 3d effects)
	+ Different species will have different response curves dependent on field data and different life history strategies.
	+ This is being driven by the area vs volume effect of the hypoxic layer and how individual species might be experiencing the effect.
* Convergence between biomass estimated and your production potential maps. These models need to be validated. Bioenergetics need to concur with the biomass estimation
* Really need to validate how the conversion of 3d phenomena are translated to 2d EwE models.
* 6% effect across models maybe not very surprising. The system may just be responding to the same hypoxia reduction in the ROMS model.
* Better way to look at it perhaps is to look at cell-cell level to evaluate if the bioenergetics predicts the density in a given cell. Perhaps regional and not down to the cell level.
* Perhaps the regions need to be within the hypoxic region, on the border of the feature, and outside of the feature.
* Should be validated against other data. Perhaps looking at great red snapper count data. Karnouskas et al.
* What’s next for the Hypoxia Task Force. Task force doesn’t focus on fish. Perhaps a better approach is focusing on EBFM out of this rather than specifically on Hypoxia task force.
* Find ways to reach out to fisherman groups? Ryan Bradley (Steve Ashby contact). Perhaps figure out the best way to approach and send a message. Figure out different ways of targeting different people. Perhaps through the advisory panel (Robert Twilley). This project uses the advisory panel as our liaisons to the stakeholders.
* Ideas of how to include environmental considerations in stock assessment:
* Index of mortality and how do we get some value of error about this for inclusion into an assessment. Spatial extent (or do you do it volumetrically).
* Recruitment index relative to hypoxia. Change in recruits of juvenile shrimp based upon level of hypoxia (areal vs volume).