**Modeling the Effect of Anthropogenic Inputs on Ocean Acidification**

**and Hypoxia in the Southern California Bight**

**Special CTAG Intersessional Meeting on OAH Modeling**

**June 26, 2018, 9:30 am – 3:30 pm**

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**Meeting Location:** Southern California Coastal Water Research Project Authority, 3535 Harbor Blvd., Suite 110, Costa Mesa CA 92626

**Meeting Goals:**

* Update on ROMs-BEC modeling progress;
* Discuss proposed approach to conduct a focused validation of the ROMs-BEC for application to local pollution impact assessment
* Discuss proposed approach to conduct a pollution impact assessment based on acidification and hypoxia impacts.

Meeting Attendees

Katherine Faick State Water Board

Andy Leising SWFSC

Eric Wilkins CDFW

George Robertson OCSD

Naoko Munakata LACSD

JoAnn Linnenbrink City of LA

Kristen Davis UCI/SCOOS

Ryan Searcy Heal the Bay

Beth Turner NOAA

Erica Ombres NOAA

Holly Wyers OPC

Megan Hepner UCSD/SCOOS

Mark Gold UCLA

Daniele Bianchi UCLA

Rich Ambrose UCLA

Faycal Kessouri UCLA/SCCWRP

Dick Feely NOAA PMEL

Nina Bednarsek SCCWRP

Martha Sutula SCCWRP

Steve Weisberg SCCWRP

Shelly Walther LACSD

Alex Steele LACSD

Evan Howard Univ. of Washington

Karen McLaughlin SCCWRP

**Meeting Summary and Action Items**

The meeting was open with introductions and a brief background on the modeling project. A key conceptual slide was presented to show the project work flow, which also serves a road map for the day’s presentations and discussion (see below and attached slides on Meeting Intro Presentation).

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Martha Sutula also discussed a key concept that frames the discussions during the day: focused validation and pollution impact assessment will be conducted in stages, with the first stage of pollution impact assessment helping to clarify the temporal and spatial scales in which the model needs to perform (focused validation). During that first stage, the team would identify by sub region where pollution effect > model uncertainty. In the second stage, the team would conduct a refined validation on those subregions, with a clearer picture of quantitative performance criteria. At that stage, if pollution effect > model uncertainty, then the team would proceed to subsequent iterations of the pollution impact assessment, source attribution, pollution management scenario analyses, without and without climate change.



**Summary of modeling progress**

* Faycal Kessouri, on behalf of the UCLA and UW modeling team, presented the background and context for the ROMS-BEC modeling project, the component steps to develop, refine and validate the model, before applying the model to its intended management applications (slide 21 of AM presentations).
* One core message is that the team is approximately 80% through the initial NOAA work plan, with the completion of coastwide validation, downscaling of the model to 1 km and inclusion of compiled terrestrial and atmospheric forcing to the model. Subsequent investigations of model resolution (4 km-versus 1 km) on the representation of submesoscale processes (e.g. eddies) and its implications for nutrient transport led the group to decide that pollution impact assessments should be conducted on simulations run with a 300-m resolution (See presentation on modeling progress for explanation). Model grids have been developed for SCB and the San Francisco and Monterey Coasts. Terrestrial and atmospheric forcing, which includes anthropogenic nutrient inputs, have been added to the model. After an initial set of tests to optimize time step, the group has started to run the initial set of model scenarios (1997-2007, with and without terrestrial and atmospheric forcing). These runs will take ~4 months to complete (end of September 2018).
* The group is working to get the atmospheric forcing complete before preparing second set of runs that will extend the hindcast from 2007-2015. A comparable set of model runs will be conducted for the SF and Monterey Coasts (300-m resolution) beginning in the springtime.
* In the next 6-9 months, the team will be focused on 1) SCB focused validation and pollution impact assessment, 2) updating 300-m runs simulations through 2015 in the SCB and SF/Monterey Coasts, 3) alternative future scenarios, 4) adding a rudimentary food web model and ecosystem model of rocky subtidal. Faycal noted that in real practice, this is an iterative cycle of model refinement, ongoing validation and application.
* Question and answers ensued, focusing
	1. Discussion of the fact that this is the first 300-m resolution ocean modeling simulation of physics and biogeochemistry—the group was enthusiastic! These modeling runs will be an enormous research asset to the scientific community for the next decade.
	2. How did the modeling team decide what was the appropriate resolution for pollution impact runs? Discussion ensued about the sensitivity analyses of model resolution versus what coastal transport process are captured. Meeting participants requested that the modeling team (McWilliams et al.) provide a rationale for how they would approach subsequent model runs for focused pollution impact assessment (what scale would be considered? How would they decide that? Does it make sense to include a 1 km with atmospheric and terrestrial forcing, even for one year, to make the scale comparison). Martha Sutula agreed that Faycal and Daniele would bring the conversation back to the modeling team, and would report back with the team’s perspective on the approach.
	3. How will future model simulations capture the potential impact of water recycling on plume dispersion and pollution impact? Discussion ensued—the short answer is that 1) OCSD is actively pursuing this course of action, so to some degree their effluent record reflects this progressive change in nutrient concentration and effluent volume over tie (since the 2000s) and 2) OCSD has proposed to have the modeling team do an intensive validation of modeled plume dispersion and pollution impact assessment, so if this proposed project is funded, we will have an opportunity to evaluate this more in detail.
	4. The question of whether DIC in wastewater effluent was measured. The answer is no—it is being backed out from alkalinity and pH. Feely said that the conversion may not hold with wastewater the way it does with seawater. Sutula said that we can look at the sensitivity of this data gap in short modeling experiments and decide if we need to prioritize this gap for stage 2 work.

**Approach to Focused Validation**

* Karen McLaughlin and Faycal Kessouri presented the approach to focused validation of the ROMs-BEC for the purposes of application to investigate the impact of local pollution sources (see presentation starting slide 53 -104 of AM presentations).
* McLaughlin talked about what data sets and parameters are available for use in validation in Stage 1 and 2 of focused validation. Her main message was that 1) there are a lot of data available in SCB (one of the best and long-standing ocean observing programs in the world); 2) but data are patchy in space and time (so validation will require a mosaic of data sources), 3) observations get better with time (i.e. most data on chemistry and process rates are available after 2007, so the first stage of validation will focus on remote sensing, ship-based data and POTW thermistor/ADCP data, largely focused on broad scale patterns within the Bight, while the second stage of validation will allow more focused on the biogeochemistry and validation along the coast. She showed several examples of the types of patterns that the model should be able to reproduce.
* Kessouri discussed the types of key graphic and metrics that would be assessed in the focused validation. He talked about: 1) visual comparisons, 2) statistical metrics of model performance, 3) reproducing events, and 4) assessing performance vis-à-vis management endpoints, giving examples of the types of comparison by data type and for physics versus biogeochemical state and process rates. He finished with a summary of which types of comparisons were of high, medium and low priority for the team, by parameter and data type. He solicited feedback from the group on this.
* Discussion ensued. There were several suggestions:
	1. There was a suggestion to add plume dispersal to the table and make that high priority, so there was a suggestion to also prioritize salinity at all scales.
	2. There was a suggestion and/or clarification that the acidification outcome parameters should include not only omega saturation state but also pH and pC02.
	3. The group wanted to know why the alongshore validation was only of medium priority; FK responded that the modeling group thought that the Region may not be showing strong gradients among subregions (see Karen’s talk), but the if we are considering the entire Bight, or the entire California coast, then that scale becomes important.



**Afternoon—Pollution Impact Assessment Methodology**

Martha Sutula, Nina Bednarsek, and Evan Howard provided a coordinated presentation on the overarching approach to assessing the impact of local pollution sources.

Sutula started out with an overarching approach, noting: 1) near-term plans are to focus on OA and hypoxia, but long-term plan includes extending ROMS-BEC to HABs, 2) ocean plan standards are inadequate to assess the effects of local pollution sources on OAH, 3) the team has made significant progress on an approach to develop OAH endpoints based on biological impacts to marine organisms, and 4) the basis for this assessment is “habitat compression”. She presented selection criteria for organisms, presented what organisms the team currently has or will have by the fall 2018 as the basis for impact assessment. For the fall, these include pteropods (pelagic) and echinoderms (benthic and pelagic life stages) for OA and anchovy and an average fish case (pelagic) for and a crustacean and/or demersal fish for DO. She described that for both OA and hypoxia, the scientific approaches could include 1) consideration of single stressor thresholds, assembled in a key graphic and 2) multivariate statistical response models, that can be applied to model output, that can predict the impact of acidity and DO, in combination with temperature, on population measures such as abundance.

Bednarsek proceeded to provide the synthesis of OA—focusing her example on recent work with pteropods, but noting that work has advanced significantly for echinoderms (see presentations). The take home message from her talk was that the team has a key graphic of synthesized omega saturation state thresholds for pteropods, developed with expert consensus in a 4-step process, the team has developed a habitat suitability index model that can predict 70% of the variation in observed abundances. Both the expert synthesis of pteropod OA thresholds and the HSI manuscripts are in prep. The team is proposing to demonstrate the applicability of the tools in the Stage 1 impact assessment.

Evan Howard presented on behalf of the UW team. He began by noting that although a synthesis of DO concentration thresholds exist, use of these thresholds posed several problems (see start at slide 52) that could result in false negative or false positives. Instead, the team is proposing to use the metabolic index approach, which accounts for both organismal demand and environmental supply that is temperature dependent. The metabolic index can be experimentally determined or empirically derived. He presented an extended example for anchovy, demonstrating that the model predicts up to 90% of the variability in observed biogeographic data for anchovies and that the MI has be validated on several special and temporal scales. A manuscript is in prep on Anchovies—and two other taxa (benthic invertebrate and demersal fish) are expected to be completed this fall, in time for use in the pollution impact assessment.

Sutula wrapped up the proposal by summarizing the proposal as follows in two slides. She noted that the HSI and metabolic indices could be used to assess realistic habitat to assess net change in habitat. Change would be evaluated on both spatial (net change in volume) and temporal scales (duration, intensity, and severity) of departure from thresholds. The thresholds proposed below are nominally used to bracket a range from severe (lethal) effects to sublethal effects.





**Discussion ensued, including:**

1. With echinoderms, how would team deal with lumping/splitting of species? Answer was that experts would assist in decisions in whether or how to combine.
2. Comment from Wyer (OPC staff) that the response models (HSI and metabolic indices) seem particularly important to have for interpretation of model output. Wilkens (CDFW) noted that it would be helpful to have a briefing for the Pacific Fisheries Management Council or its science teams on this work.

**Next Steps and Action Items**

* Group discussed the timing and need for additional meetings before the SAG reconvenes in the November -December 2018 timeframe. The group was very interested in having that meeting. Sutula agreed to follow up with CTAG and the SAG to decide on next steps.
* Modeling team will provide copies of validation, biological assessment endpoints or index manuscripts for review as soon as they are available.
* Modeling team will provide a rationale for selection of model resolution and how they view that with future downscaling of ROMs-BEC for sub-regional pollution impact assessment.