SOUTHERN CALIFORNIA COASTAL OCEAN OBSERVING SYSTEM: A Science-Based Decision Support System

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July 27, 2018

Dr. William Cochlan
Senior Research Scientist
Estuary & Ocean Science Center | Romberg Tiburon Campus
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3150 Paradise Drive
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Dear Dr. Cochlan,

This letter is written in full support of your Sea Grant/Ocean Protection Council proposal titled "Present and Future Climatic Drivers of Domoic Acid Toxicity in Coastal Ecosystems of California." This project to examine how temperature and pH affect domoic acid production in the most toxigenic *Pseudo-nitzschia* species is extremely important, not only because we need these data for better model parameterizations, but because (shockingly) very few studies like this have been done! The role of temperature and pH in phytoplankton physiological responses is a fundamental part of harmful algal bloom science, and yet those relationships have not been methodically worked out in the laboratory for the most relevant species and done in the forward-thinking way that you propose here.

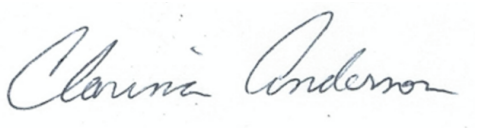
While much of the focus in HAB research has traditionally been on dinoflagellates and the role of nutrient run-off, *Pseudo-nitzschia* blooms are rare in that they are caused by a toxic diatom and they are associated with a complex combination of environmental factors that are unique to the interplay of oceanic and coastal waters. Our ability, so far, to predict toxic *Pseudo-nitzschia* blooms in the coastal environment relies on statistical models trained with *in situ* field data that will no doubt change with time and move beyond the statistical envelope with which they were parameterized. These models, known collectively as the California Harmful Algae Risk Mapping system (C-HARM), include temperature as an important predictive term, but they were built off of statistical relationships that are not static in space and time. We appreciate that climate is changing, and with it, so are these relationships. The funding does not exist to continually assimilate new data into these models since the expense of collecting the full suite of offshore samples necessarily on a monthly basis exceeds what current federal and state programs will support. Our best alternative is to look forward to mechanistic modeling efforts and to find ways to better "tune" and "calibrate" C-HARM. It is crucial to understand the connection with temperature in a physiological context, not only to explain why the C-HARM system is valid (or invalid), but to expand our ability to include realistic formulations in our predictive tools.

As the Executive Director of the Southern California Coastal Ocean Observing System (SCCOOS) and as a HAB researcher, my interest in this project is two-fold. A physiologically based approach to predicting domoic acid events will certainly improve the modeling and give us a better understanding of climate connections to HABs. It will also allow SCCOOS to help the HAB community seek out better funding opportunities for HAB monitoring given that the HABMAP program co-funded by SCCOOS and CeNCOOS has put a lot of investment in creating paired records of HAB species, toxins, temperature, salinity, and (in some places) pH. If we think about this in terms of climate thresholds and tipping points, the work proposed here will give us the

ability to set dynamic thresholds that can be monitored in real-time in relation to changing temperatures and pH levels. SCCOOS would then be able to create management tools that are adaptive instead of reactive. This will feedback on the CA HAB Bulletin that SCCOOS is creating to give managers (and the public) near real-time snapshots of HAB risk along the CA coast and could become a critical component of seasonal forecasts as they relate to basin scale changes, such as the El Niño-Southern Oscillation (ENSO) and the Northern Pacific Gyre Oscillation (NPGO), both of which seem to have low frequency effects on the likelihood of HABs in our region and are known to drive OA and hypoxia patterns.

I wholeheartedly support your work, and will do what I can to see that the results are used, useful, and have a lasting impact.

Sincerely,



Dr. Clarissa Anderson
Executive Director - SCCOOS

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23 July 2018

Dr. Bill Cochlan
Estuary and Ocean Science Center
Romberg Tiburon Campus
San Francisco State University

Dear Bill,

I am pleased to provide a letter of support for your proposal to the OPC/Sea Grant Proposition 84 competition for your project "Present and Future Climatic Drivers of Domoic Acid Toxicity in Coastal Ecosystems of California". I would be particularly interested in leveraging your results for our own efforts focusing on monitoring and prediction of *Pseudo-nitzschia* toxicity through the Central and Northern California Ocean Observing System (CeNCOOS) and related efforts.

Your proposal addresses a question that has been at the forefront in California recently, following the 2015 west coast-wide domoic acid event. There are conflicting views on exactly why 2015 was so toxic, and whether it is likely to happen again. While the bloom(s) were associated with elevated temperature, Ryan et al. (2018) show that in the southern California Current, temperatures during peak toxicity were essentially normal, suggesting that the warming event primarily expanded the niche for *Pseudo-nitzschia* northward. This is anecdotally supported by the lack of toxicity in Southern California in 2015, which we hypothesize was too warm. This strongly suggests that temperature is an important but poorly understood driver of these large-scale events. It perhaps also partially explains why we do not see very high toxin levels in bays and estuaries such as Humboldt Bay and San Francisco Bay, despite occurrence immediate offshore, if the bays are simply too warm.

There is even less known about the effects of pH on toxin production, with only a handful of (sometimes contradictory) papers to date. There is increasing demand for multi-factor experiments to understand how environmental changes will result in synergistic or antagonistic regulation of algal toxicity. Without the careful laboratory experiments you propose, we are left to sift through the complicated and difficult to interpret field results that fail to provide definitive answers.

Beyond improving our understanding of toxin production, your results will also provide a useful test of whether a "habitat envelope" approach would improve our existing predictive models. Right now temperature is only an indirect model parameter (primarily related to nutrients). We have considered adding thermal thresholds based on growth rate and toxicity, which would have improved our model predictions for 2015 by identifying southern California (and probably San Francisco Bay) as too warm to support toxin production. This could be easily implemented in the existing C-HARM model once we have the scientific basis for establishing the envelope, which your project would provide.

I wish you success with the proposal and very much look forward to collaborating with you to implement your results as soon as they are available.

Sincerely,

Raphael Kudela
Professor, Ocean Sciences
Director, Center for Remote Sensing
Co-Chair, GlobalHAB (an IOC/SCOR working group)

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July 22, 2018

Dear Dr. Cochlan,

This is to convey my support for the proposed project "*Present and Future Climatic Drivers of Domoic Acid Toxicity in Coastal Ecosystems of California*", being submitted to the Ocean Protection Council (OPC) Proposition 84 Competitive Grant Program.

I am an assistant professor in the AOS Department at University of California Los Angeles. As part of ongoing collaborations, my group is engaged in the development of numerical ecosystem models of the California Current ecosystem. As part of a project approved for funding by NOAA, we will develop a model component that will mechanistically represent *Pseudo-nitzschia* and domoic acid concentration in California's waters.

Current HAB models rely on statistical relationships with the environment, but have limited applicability to conditions outside the envelop of observations. Our project intends to build a model that leverages studies on the nutrient response by *Pseudo-nitzschia* populations, and embeds their representation within a state-of art hydrodynamics and biogeochemistry model. This type of mechanistic models are increasingly important to consider management response to toxic HAB events.

I understand that the goal of your proposal is to use laboratory cultures of two common *Pseudo-nitzschia* species to: (1) quantify their physiological response (growth, domoic acid production) to warming and acidification, and (2) quantify the synergistic effects of these two stressors. We are very interested in the results of your project, as they would provide the needed information to parameterize temperature and acidification effects in our model of *Pseudo-nitzschia* and domoic acid production.

If your proposal is funded, we plan to collaborate by: (1) advising your experimental approaches to ensure that the selection of experimentally tested conditions is appropriate for use in the development of HAB models; and (2) including a parameterization of warming and acidification effects on *Pseudo-nitzschia* in our model, based on the results of your experiments.

Sincerely,

Daniele Bianchi
Assistant Professor
Department of Atmospheric and Oceanic Sciences
University of California Los Angeles