CALIFORNIA OCEAN PROTECTION COUNCIL

Staff Recommendation
June 28, 2013

INTEGRATED MODELING TO ANSWER KEY MANAGEMENT QUESTIONS REGARDING OCEAN ACIDIFICATION AND HYPOXIA

File No.: 13-06-28-02
Project Manager: *Clare O'Reilly*

RECOMMENDED ACTION: Authorization to disburse up to $375,000 to perform integrated modeling of California's coastal ocean to inform ocean acidification and hypoxia related policy.

LOCATION: California Current

STRATEGIC PLAN FOCAL AREA: Science-Based Decision Making, Climate Change, Coastal and Ocean Impacts from Land-based Sources

---

EXHIBITS

Exhibit 1: State of Washington Blue Ribbon Panel Report
Exhibit 2: Letters of Support

RESOLUTION AND FINDINGS:
Staff recommends that the Ocean Protection Council adopt the following resolution pursuant to Sections 35500 *et seq.* of the Public Resources Code:

"The Ocean Protection Council hereby authorizes disbursement of an amount not to exceed three hundred and seventy-five thousand dollars ($375,000) to the Southern California Coastal Water Research Project (SCCWRP) and University of California, Los Angeles (UCLA) to develop a computer-based model of biogeochemical ocean conditions to inform ocean acidification and hypoxia related policy for the U.S. West Coast, with a focus on the Southern California Bight and potentially other areas.

This authorization is subject to:

1. Assurances acceptable to the Executive Director of the Ocean Protection Council that SCCWRP and UCLA have sufficient funds to complete the project.
2. Prior to disbursement of funds, SCCWRP and UCLA shall submit for the review and approval of the Executive Director:

   a. A work plan, including schedule and budget.

   b. The names and qualifications of any contractors that SCCWRP and UCLA intend to employ to carry out the project.

3. Certification by the Executive Director that adequate funds in fiscal year 13/14 appropriation from the Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Bond Act of 2006 (Proposition 84) are available to the California Ocean Protection Trust Fund.

Staff further recommends that the Ocean Protection Council adopt the following findings:

"Based on the accompanying staff report and attached exhibits, the Ocean Protection Council hereby finds that:

The proposed project is consistent with the purposes of Division 26.5 of the Public Resources Code, the California Ocean Protection Act.

The proposed project is consistent with the Ocean Protection Council's current strategic plan and grant program funding guidelines."

PROJECT SUMMARY:

Staff recommends that the Ocean Protection Council (OPC) disburse up to $375,000 to the Southern California Coastal Water Research Project (SCCWRP) and the University of California, Los Angeles Institute of the Environment and Sustainability (UCLA IoES) Coastal Center to enhance the current regional oceanographic modeling system. Enhancements will enable a more comprehensive and consistent evaluation of both anthropogenic and climatic perturbations on near-shore physical, chemical, and biological conditions.

SCCWRP is a joint powers agency, formed in 1969 as a research institute focusing on the coastal ecosystems of Southern California. The proposed project directly relates to SCCWRP's research on the effects of anthropogenic nutrient inputs on nearshore hypoxia, harmful algal blooms and acidification. UCLA IoES oversees several research programs which generate knowledge and provide solutions for regional and global environmental problems. The IoES Coastal Center conducts research and provides recommendations on critical coastal water quality and natural resource management issues.

The proposed grant would fund work by SCCWRP and UCLA scientists to answer two key questions: (1) To what extent do local nutrient inputs exacerbate acidified and hypoxic ocean conditions by promoting algal growth? and (2) Which areas of the coast are more susceptible than others to acidification and hypoxia? By coupling biogeochemical models with ocean circulation models, SCCWRP and UCLA scientists will produce three key products:

1. A modeling output that identifies the spatial and temporal scales at which current and future (projected) anthropogenic inputs have a significant effect on productivity, hypoxia and acidification,

2. Analyses quantifying the net change in hypoxia and acidification versus cost associated with different scenarios of controls on anthropogenic inputs, and

3. Executive summaries of results for a policy and management audience, including maps of susceptibility of regional coast zones to hypoxia and acidification due to oceanographic properties and anthropogenic inputs. Data layers developed as part of the project will be made available through the California Coastal Geoportal.

These products will address the need for a better understanding of ocean acidification and hypoxia in coastal systems in order to identify potential management actions. The project was identified as a critical information need during an agency science needs assessment undertaken in preparation for convening the California Ocean Acidification & Hypoxia Panel, called for by the OPC on September 13, 2012. Staff of the State Water Resources Control Board, as the primary agency in California charged with regulating discharges from land based pollution, has expressed to OPC staff that this project is a vital component to underpin future regulatory decisions.

The proposed project represents a unique partnership among research organizations to generate new knowledge on the relationship between ocean acidification, hypoxia and coastal nutrient loading. The proposed project was conceived by the UCLA Department of Atmospheric and Oceanic Science and developed in partnership with SCCWRP. These organizations represent the best in integration of research and application of scientific findings. By committing up to $375,000, the OPC would leverage the investment of in-kind services from SCCWRP and matching funds from federal agencies and private foundations in this critical modeling effort. OPC staff are actively working with USEPA, NOAA and several key private partners to finalize funding.

PROJECT DESCRIPTION:

Project Background:

Relationships between Ocean Acidification, Hypoxia and Nutrient Inputs in the California Current

The US West Coast lies along one of the most biologically productive regions of the world ocean. Seasonal upwelling of deep nutrient-rich water maintains high rates of biological productivity over broad scales. The natural nutrient fluxes are enhanced in nearshore waters by a variety of anthropogenic sources. In the Southern California Bight – the most densely populated stretch of the Pacific coastline - these are dominated by nutrient discharges from wastewater treatment and episodic pulses of terrestrial runoff and associated pollutants. These inputs have been hypothesized to contribute to the increasing frequency and toxicity of harmful algal blooms along California's coast.[1] In the Northern California Current, the Columbia River provides a major source of nutrients as well as buoyancy that can alter near-shore productivity and circulation.

In addition to the direct human influences at local scales, the entire coastal ocean is subject to the

[1] Anderson, D. M., J. M. Burkholder, W. P. Cochlan, P. M. Glibert, C. J. Gobler, C. A. Heil, R. M. Kudela, M. L. Parsons, J. E. J. Rensel, D. W. Townsend, V. L. Trainer, and G. A. Vargo (2008), Harmful algal blooms and eutrophication: Examining linkages from selected coastal regions of the United States, *Harmful Algae*, *8*(1), 39-53.

large-scale climate changes occurring in the Pacific basin.[2] Acidification due to the absorption of anthropogenic CO_2 has been observed in coastal waters of Northern California[3] and may be exacerbated by pollutants deposited from the atmosphere (e.g. nitric and sulfuric acid).[4] Multi-decade declines in oxygen have also been observed in the coastal water off Southern California[5] and have altered the proportions of biologically important nutrients.[6] In the Northern California Current, massive benthic die-offs have been attributed to episodes of extreme hypoxia along the Oregon shelf.[7] As species populations respond to climate change, marine protected areas are being established to protect diversity and abundance, and their efficacy is dependent on climate conditions and circulation dispersal.

Coupled Modeling to Meet Management Needs

These phenomena are coupled, and they are embedded in a complex circulation that is modulated by large inter-annual and decadal fluctuations (e.g. El Nino and the Pacific Decadal Oscillation) in combination with strong, local, intrinsic variability. To establish long-term trends and to understand their relationship to global change requires a state-of-the-art modeling effort that is systematic in its approach and carefully validated against observations. UCLA and other academic researchers have been developing such a system, by integrating ecosystem and biogeochemical modules into a regional eddy-resolving oceanic model (ROMS).[8] The model is able to capture large-scale climate forcing as well as localized near-shore and anthropogenic effects using nested grids to move across scales.

The model simulations can be used to reconstruct historical conditions throughout coastal waters, which contain varying records of spatial and temporal observations, but whose interpretations are hampered by sampling gaps and missing parameters. Model simulations can also be used to evaluate and interpret the physical/biogeochemical state of portions of the California Current System, such as the Southern California Bight and Monterey Bay, during intensive field campaigns and to help design the sampling strategies for such efforts, such as the Southern California Bight Regional Monitoring Program. However, measurement programs alone are not sufficient to establish material budgets and assess the fate and transport of biological tracers or contaminants. This requires a model with demonstrated ability to reproduce the biogeochemical measurements from such field studies. Finally, the modeling system can also be used to zoom in on the regional

[2] Di Lorenzo, E., N. Schneider, K. M. Cobb, P. J. S. Franks, K. Chhak, A. J. Miller, J. C. McWilliams, S. J. Bograd, H. Arango, E. Curchitser, T. M. Powell, and P. Riviere (2008), North Pacific Gyre Oscillation links ocean climate and ecosystem change, *Geophys Res Lett*, *35*(8), -.

[3] Feely, R. A., C. L. Sabine, J. M. Hernandez-Ayon, D. Ianson, and B. Hales (2008), Evidence for upwelling of corrosive "acidified" water onto the continental shelf, *Science*, *320*(5882), 1490-1492.

[4] Doney, S. C., N. Mahowald, I. Lima, R. A. Feely, F. T. Mackenzie, J. F. Lamarque, and P. J. Rasch (2007), Impact of anthropogenic atmospheric nitrogen and sulfur deposition on ocean acidification and the inorganic carbon system, *Proceedings of the National Academy of Sciences of the United States of America*, *104*(37), 14580-14585.

[5] Bograd, S. J., C. G. Castro, E. Di Lorenzo, D. M. Palacios, H. Bailey, W. Gilly, and F. P. Chavez (2008), Oxygen declines and the shoaling of the hypoxic boundary in the California Current, *Geophys Res Lett*, *35*(12), -.

[6] Deutsch, C., H. Brix, T. Ito, H. Frenzel, and L. Thompson (2011), Climate forcing of ocean hypoxia, *Science*, *333*, 336-339.

[7] Chan, F., J. A. Barth, J. Lubchenco, A. Kirincich, H. Weeks, W. T. Peterson, and B. A. Menge (2008), Emergence of Anoxia in the California Current Large Marine Ecosystem, *Science*, *319*.

[8] Shchepetkin, A. F., and J. C. McWilliams (2005), The regional oceanic modeling system (ROMS): a split-explicit, free-surface, topography-following-coordinate oceanic model, *Ocean Modelling*, *9*(4), 347-404.

implications of future climate scenarios. This allows the large-scale projections from global climate models to be scaled down to capture the important dynamics of the coastal zone that are not resolved by global models.

The development of this modeling system to date has been largely motivated and funded by basic science questions. This grant, and the project's partnership between research and management agencies, represents the opportunity to leverage partner investments for accelerated application of the model to more practical questions. Funding from the OPC and additional partners will provide the support needed to make this modeling system useful for addressing policy-related questions and environmental management goals.

The changing chemistry of the ocean has been a concern for several years, and this project responds to many issues cited by agency decision makers and scientists. Last year the State of Washington completed a Blue Ribbon Panel report (see Exhibit 1) documenting concerns and making recommendations for action in response to ocean acidification. On September 13, 2012, the OPC directed its Science Advisor (Executive Director of the California Ocean Science Trust (OST)), through the OPC's Science Advisory Team, to empanel a group of scientists to evaluate the Washington Report for its applicability to California, and determine how California should proceed. OST staff interviewed state agency managers and scientists from NOAA and USEPA to determine their issues and needs and frame the charge of the California panel. That process brought forward the urgency to begin filling critical science gaps, and creating models that can be used to answer pressing management questions. While the additional effort and funding needed to make this modeling system useful for addressing policy-related questions and environmental management goals is considerable, the economic issues associated with increasing acidification and the pressing need to understand if land based discharges contribute to acidification are paramount.

Project Details and Scope of Work:

The proposed project will expand the capability of the current regional modeling system to enable a more comprehensive and consistent evaluation of both anthropogenic and climatic perturbations on near-shore physical, chemical, and biological conditions. The model will be used to investigate climate-scale variability for the US West Coast, focused on the California Coast, with nested fine scale grids centered on regions of high human impact – the Southern California Bight, and potentially others (e.g. Monterey Bay). Model development and integration will focus on:

1. Land-sea exchange: Model simulations will attempt to quantify the relative importance of natural and anthropogenic nutrient sources to the productivity, hypoxia, and acidification of the coastal ocean.

2. Ecosystem-complexity: Biogeochemical models will be improved to account for impacts of hypoxia and acidification to a wider diversity of species and interactions across the food web.

3. Physical scale: Model scaling will be adjusted to enable assessments of biogeochemical processes at finer scales, especially at the land-sea interface.

Model simulations will be validated against field campaign data, such as the Southern California Bight Regional Monitoring Program, and historical time series, such as the California Cooperative Oceanic Fisheries Investigations (CalCOFI) program. Using the validated model system, scientists at SCCWRP and UCLA will diagnose the factors that govern both the time-averaged and fluctuating importance of anthropogenic and climate forcing of biogeochemical cycles along the California coast, with particular attention to the Southern California Bight and potentially other test beds (e.g. Monterey Bay). To do this, simulations will be conducted with and without anthropogenic nutrient loadings, and with constant and variable climate forcing. Outputs from model scenario runs will be synthesized to quantify the effects of anthropogenic nutrient inputs and climate change on productivity, hypoxia, and ocean acidification over time.

The project will results in the following deliverables, to be tailored to meet policy and management needs:

1. A modeling output that identifies the spatial and temporal scales at which current and future (projected) anthropogenic inputs have a significant effect on productivity, hypoxia and acidification,

2. Analyses quantifying the net change in hypoxia and acidification versus cost associated with different scenarios of controls on anthropogenic inputs, and

3. Executive summaries of results for a policy and management audience, including maps of susceptibility of regional coast zones to hypoxia and acidification due to oceanographic properties and anthropogenic inputs. Data layers developed as part of the project will be made available through the California Coastal Geoportal.

The work will be conducted as a partnership between staff at SCCWRP and scientists affiliated with the UCLA IOES Coastal Center.

Site Description:

The proposed authorization will support coupled model development for the US West Coast. Scientists at SCCWRP and UCLA will develop products that are statewide in nature, with a geographic focus on the Southern California Bight and potential other regions (e.g. Monterey Bay).

PROJECT GRANTEES:

The Southern California Coastal Water Research Project (SCCWRP) is a research institute focusing on the coastal ecosystems of Southern California, from watersheds to the ocean. SCCWRP was formed in 1969 as a joint powers agency. The common mission of its member agencies is to contribute to the scientific understanding of linkages among human activities, natural events, and the health of the Southern California coastal environment; communicate this understanding to decision makers and other stakeholders; and recommend strategies for protecting the coastal environment for this and future generations. SCCWRP organizes the Bight Regional

Monitoring Program and participates in data collection, data analyses and compilation of the results

The UCLA's Department of Atmospheric and Oceanic Science and IoES Coastal Center will provide research faculty, and computing and data storage. Since its inception in 1940, the Department of Atmospheric and Oceanic Sciences at UCLA has been at the forefront of atmospheric research and education. A strong emphasis of the oceanography program is given to the study of the coastal environment and its interaction with the open seas and the land. Much of this research is highly interdisciplinary and involves partnerships with other departments and institutes, including the IoES Coastal Center. The Coastal Center was formed in 2002 to encompass all IoES activities that involve marine resources and environmental issues, including coastal watersheds and wetlands. The Associate Director of the Coastal Center will participate in the project to advise the science team on questions of policy importance and communications.

The partnership between SCCWRP and UCLA will draw upon the strengths of the partnering organizations. This combined expertise in water quality, biogeochemical modeling, and tailoring science to inform decision making, is anticipated to result in the efficient transfer of model outputs to identify actions to mitigate the effects of nutrient loading, hypoxia and acidification.

PROJECT FINANCING:

Ocean Protection Council	$375,000
Other Funding	$550,000
Total Project Cost	$925,000

Gathering full funding for this project is still underway, and the OPC's authorization is critical to stimulate other funders. Discussions are currently ongoing with foundations, USEPA and NOAA for additional matching funds. SCCWRP will provide in-kind services from their Bight Regional Monitoring Program and ocean acidification research initiatives in support of this project.

The anticipated source of funds for this project is the FY 13/14 appropriation from the Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Bond Act of 2006 (Proposition 84).

Proposition 84 authorizes the use of these funds for purposes consistent with Section 35650 of the Public Resources Code, establishing the California Ocean Protection Trust Fund (Public Resource Code§ 75060(g)). Under Section 35650(b), Ocean Protection Trust Fund monies many be expended for projects authorized by the OPC that are indentified as appropriate Trust Fund purposes. These purposes include projects that provide funding to eliminate or reduce threats to coastal and ocean ecosystems, habitats, and species (Section 35650 (b)(A) and to provide monitoring and scientific data to improve state efforts to protect and conserve ocean resources (Section 35650 (b)(2)(G). This project will result in information to help reduce threats to the ocean environment.

CONSISTENCY WITH CALIFORNIA OCEAN PROTECTION ACT:
The proposed project is consistent with the Ocean Protection Act (division 26.5 of the Public Resources Code) in the following respects:

Under Public Resources Code 35620, the OPC may award grants, enter into interagency agreements, and provide assistance to public agencies and nonprofit organizations to support efforts to improve geospatial data collection, interagency data sharing and collaboration, and tools for visualizing and analyzing these data.

Public Resources Code § 35615(a)(2) directs the OPC to establish policies to coordinate the collection of scientific data related to coastal and ocean resources. In addition, PRC § 35650(b)(2) specifies allowable projects on which the California Ocean Protection Trust Fund may be spent. In particular, subsection (b)(2)(G) identifies projects that "provide monitoring and scientific data to improve state efforts to protect and conserve ocean resources" as appropriate for funding.

The proposed project is consistent with the trust fund allowable projects listed above in that the project will: (1) provide information about the cause and course of ocean acidification, nutrient loading and HABs in California's coastal ocean; (2) make recommendations for improving management and protection of coastal waters and ocean ecosystems from ocean acidification, hypoxia and nutrient loading; (3) provide monitoring and scientific data to improve the state's efforts to protect and conserve ocean resources; and (4) support the protection of coastal waters and ocean ecosystems through the recommendation of management actions to mitigate the effects of hypoxia and ocean acidification and prevent or mitigate nutrient loading and the proliferation of HABs.

CONSISTENCY WITH THE OPC'S STRATEGIC PLAN:

The project implements **Focal Area A (Science-Based Decision-Making)** by leveraging the scientific community to support management and policy direction.

This project also implements Issue 5 from the Climate Change focal area:
Focal Area B (Climate Change), Issue 5: Ecosystem Impacts of the Changing Climate:
The Strategic Plan specifically calls for OPC to provide for improved understanding of how changing climate and ocean chemistry, ocean acidification, will alter California's ocean and coastal ecosystems and the benefits they produce.

This project also implements Issue 9 from the Coastal and Ocean Impacts from Land focal area:
Focal Area D (Coastal and Ocean Impacts from Land), Issue 9: Downstream Impacts:
The Strategic Plan specifically calls for OPC to fund studies to advance management, improve understanding, and identify opportunities to improve policies to reduce land-based impacts to the ocean related to nutrient pollution, HABs, urban runoff, or other issues.

CONSISTENCY WITH THE OPC'S GRANT PROGRAM FUNDING GUIDELINES:

The proposed project is consistent with the OPC's Grant Program Funding Guidelines adopted November 20, 2008.

Required Criteria

1. **Directly relate to the ocean, coast, associated estuaries, or coastal-draining watersheds:** The proposed project will improve scientific understanding of ocean acidification, hypoxia and nutrient loading in state waters. The products resulting from this modeling effort will inform policy and management in order to maintain a healthy, resilient, and productive ocean and coast for the benefit of current and future generations.
2. **Have demonstrable support from the public:** The proposed authorization is supported by numerous governmental, academic, and NGO entities. See letters of support in Exhibit 3.
3. **Be of greater-than-local interest:** The proposed project is statewide in scope.

Additional Criteria

1. **Innovation:** Coupled models capable of achieving these products do not presently exist, and this groundbreaking work will serve California, the West Coast, and the nation.
2. **Improvements to management approaches or techniques:** The proposed project will provide critical information to address the pressing need for enhanced understanding of how land based discharges contribute to acidification and hypoxia. Improved policies and management approaches can be developed based on this improved understanding.
3. **Resolution of more than one issue:** The proposed project will provide better understanding across the land sea interface of how land based discharges exacerbate acidification due to atmospheric climate change and hypoxia.
4. **Coordination:** The proposed project is a collaboration among state and federal agencies, academic institutions, and a joint powers agency. It is anticipated that these entities will contribute funds or services, and that these contributions will attract additional partners and contributors, including private foundations.

COMPLIANCE WITH CEQA:

The projects included in the proposed authorization are categorically exempt from review under the California Environmental Quality Act ("CEQA") pursuant to 14 Cal. Code of Regulations Section 15306 because they involve only data collection, research, experimental management and resource evaluation activities that will not result in a serious or major disturbance to an environmental resource. These activities may be a part of a study leading to an action which the OPC or another public agency has not yet approved, adopted, or funded.