CALIFORNIA OCEAN PROTECTION COUNCIL

Staff Recommendation
September 10 - 11, 2008

CLIMATE CHANGE ADAPTATION MODEL PILOT STUDY

File No.: 08-106
Project Manager: Neal Fishman

RECOMMENDED ACTION: Authorization to grant up to $200,000 to Stanford University to develop a climate change adaptation model pilot study. The model, which will focus on two coastal counties, will be designed for coastal managers and land-use planners to test outcomes of different policy decisions in relation to climate change scenarios.

LOCATION: Two coastal counties to be selected in consultation with the Ocean Protection Council staff

STRATEGIC PLAN OBJECTIVE: Physical Processes and Habitat Structure

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EXHIBITS

Exhibit 1: Graphical representations from the model

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 approves the disbursement of an amount not to exceed $200,000 to the Board of Trustees of Leland Stanford Junior University to develop a climate change adaptation model pilot study. The model, which will focus on two coastal counties, will be designed for coastal managers and land-use planners to test outcomes of different policy decisions in relation to climate change scenarios."

Staff further recommends that the Council adopt the following findings:

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

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

2. The proposed is consistent with the Ocean Protection Council's project funding guidelines."

PROJECT SUMMARY

Staff recommends that the Council provide $200,000 to Stanford University, in coordination with Monterey Bay Aquarium Research Institute (MBARI), to develop a climate change adaptation model as a pilot project for two coastal counties in California and to provide a legal and policy analysis of impediments to adaptation to climate change in the two selected counties. The ultimate goal of the proposed project is to provide a user-friendly, interactive model that can (1) reveal vulnerabilities to climate change impacts at a level of resolution useful to make informed policy and management choices and (2) inform and test policies to better adapt to climate change.

Climate change is predicted to have significant physical impacts on coastal communities in California, including inundation from sea level rise and storm surges, and increased impacts from landslides, drought, and wildfires. These physical changes will result in significant economic and social changes to coastal communities in California. The proposed model could provide support for both state and local coastal planners to understand the likely impacts to coastal communities and evaluate possible policy options for how to adapt to climate change in a manner that is protective of coastal resources and economies. The project will also analyze legal and policy constraints or gaps that may hinder managers' ability to implement adaptation strategies to climate change.

PROJECT DESCRIPTION

Project Background

As of 2005, California's coastal counties accounted for 83% of the state economy, 79% of its jobs, and 75% of the population on only 25% of its land area.[1] However, California's coastal region is vulnerable to numerous future climate change impacts such as sea level rise, ocean acidification, loss of near-shore habitat and wetlands, changes in species composition and distribution, wildfires, flooding and erosion, water and food supply shortages, air quality and public health problems, continued increases in air and water temperatures and precipitation, and storm changes causing changes in river and stream flow inputs.

To plan for a sustainable future, managers in charge of key natural resources and built infrastructure must be able to develop and implement adaptation strategies to deal with these potential impacts. Yet, a recent survey of 135 coastal managers in California, representing 89% of coastal cities and counties in the state, concluded that *coastal managers in California are inadequately prepared for planning for climate change impacts*.[2] In that survey, managers

[1] See www.oceaneconomics.org.

[2] Moser and Tribbia, Vulnerability to Inundation and Climate Change Impacts in California: Coastal Managers' Attitudes and Perceptions, Marine Sci. Tech. Soc. J. vol 40, pp 35-44 (2006).

stressed the need for additional information about potential future scenarios and guidance on how to incorporate these data into everyday decisions.

The proposed model will be designed to provide current information about potential climate impacts and how these impacts might "interact" with the usual considerations facing these managers, such as land use, population growth, and economic growth along the coast and coastal adjacent areas. Building all these data into an interactive tool will not only allow mangers easy visual access to new climate data, but will also allow them to test possible outcomes of different decisions.

Local and regional planners will be able to use the tool in a variety of contexts. For example, the decision tool could be used by state, city, and county governments to assess the climate vulnerability of individual parcels and critical infrastructure during CEQA or local design review. Such analysis would provide support for evaluation of alternative development and design standards (such as setbacks, hazard-resistant design, etc.) and alternative policies (such as realignment or managed retreat). The model could also help local planners visualize the consequence of different land use decisions. For example, if development is restricted in a certain area due to inundation concerns, the model could show the areas in the region where "displaced" development and economic opportunities might move.

The tool would also provide useful information for local and statewide infrastructure siting decisions. For example, a dynamic model of urban growth combined with spatial information on climate change vulnerability would allow for assessment of both direct and indirect (e.g., induced growth) effects of proposed highway construction. Similarly, managers could consider inundation scenarios under different armoring strategies, examining how these strategies could be used to protect critical infrastructure such as roads, airports, and sewage treatment facilities as well as testing the secondary impacts of hardened protection on nearby resources. These data can then be combined with future economic activity and residential development, allowing for benefit/cost analysis of proposed armoring and adaptation systems.

Project Details

The pilot project will focus on two coastal counties and will:

- synthesize and augment the data and analyses produced by existing projects on climate change scenarios and sea level rise impacts and integrate this information with key land use, economic, demographic and ecological indicators
- create a model that will test implications of a range of current and potential management and policy decisions under a range of climate change scenarios
- produce a report that identifies conflicts and gaps in legal, policy, and institutional systems that hamper the implementation of adaptation strategies in a coastal areas

The model will be built as a proof-of-concept to show how climate scenario data can be presented to help decision makers:

- understand the consequences of their own land use, coastal management, and investment decisions under various climate change scenarios
- identify what information is available and useful to them, what information is not available but would be useful to them and should therefore be compiled in the future, and how crucial information can be organized and archived for use over time

- explore options, within their jurisdiction, for reducing the projected risks from climate change on natural and built resources

The ultimate goal is to create a statewide model that is useful for mangers at state, regional, and local levels. However, to test how best to create such as model, the pilot project will focus exclusively on two coastal counties and will limit the "clients" or "users" to two partner agencies.

Tasks:

I. Collaborate with agency staff to design and test project.

Stanford University and MBARI will work with OPC staff to identify two partner agencies who will serve as the clients for the pilot study. These partners will help identify the management questions and coastal data as inputs to the model, test the utility of the model outputs, and provide feedback for potential future iterations.

The grantees will engage the OPC and the partner agencies to identify each partner agency's specific needs and constraints pertaining to development and use of the model, establish common expectations and vision for the pilot project outputs, collect data from the agencies, and provide introductory training in the model's use. Early and ongoing collaboration between the researchers and the partner agencies is essential to the success of the pilot project.

II. Develop a multi-criteria, decision-making model using historical and projected land-use information, demographic and economic indicators, current policies and legal frameworks, and climate change scenarios to develop projections for future growth patterns and evaluate policy choices.

The grantees will develop a multi-criteria model to evaluate future scenarios, with the following three components: (1) trend projections for demography, spatial economy, and land cover change, (2) regional climate change projections, and (3) representations of specific policy and land use options.

(1) The grantees will compile data on land development, economic, and population changes within the target geography as far back as data allows. Once the grantees have assembled a historical time-series of economic, socio-demographic, and land use data, they will build statistical and rule-based models to predict potential urban expansion for the coastal region. Existing efforts have demonstrated the feasibility of this approach for California, but have lacked the time span, geographic specificity, and climate-change focus of the proposed project. The project team will devise multiple scenarios for the coast's future by varying growth rates, spatial interrelationships, and land consumption demands. The first scenario represents a baseline where the rates and spatial logic of growth is assumed to remain very similar to observed historical patterns of change. Other scenarios will examine policy modifications or economic changes.

(2) Climate scientists have developed a range of potential climate change scenarios based on global climate model runs using different future greenhouse gas emissions and different assumptions about how the climate will respond to rising concentrations of greenhouse gases in the atmosphere. California scientists have further analyzed these projections to produce more detailed climate impacts information for the state. This suite of climate change scenarios will

encompass impacts such as future sea level rise, and will, to the extent possible, capture extreme events (heat waves, storm surges, heavy precipitation, wildfires, etc.).

(3) Policy decisions – which will be defined in coordination with the partner agencies – will be represented in a variety of ways within the model. For example, land acquisition or strict development prohibitions can be represented by removing particular parcels of land from consideration for future urban growth. Zoning or general plan changes can be realized by rearranging the pattern of allowed land uses or by limiting the intensity of development within an area. Armoring of the shoreline can be represented by modifying the zone of expected coastal impacts and recalculating the amount of development or economic activity likely to be affected by sea level rise. The growth-inducing impacts of certain infrastructure projects (such as highway construction) can be represented by modifying the spatial predictions within the model of land use change. A vulnerability assessment of proposed coastal improvements, such as the siting of the California Coastal Trail, can be performed by overlaying potential investment locations with likely climate change impact zones.

III. Analyze the current legal and policy frameworks' readiness, capacity and direction for managing natural and human land use changes.

The grantees will produce a legal and policy analysis report that examines the relative efficacy of existing laws and policies for implementing adaptation strategies and potentially changing existing land use patterns.

Project Outcomes

The primary deliverable from this project will be the beta version of an open source, geographic information system (GIS)-based model available for governmental use. All components of the model will be created using Python scripts along with the popular commercial GIS package ArcGIS™ (www.esri.com). The scripts can be shared freely but will require ArcGIS to run. However, ArcGIS™ is the industry standard and is already widely used in the state agencies and local governments that are the expected audience for the proposed tool. This strategy greatly facilitates the integration of the decision tool with existing data and programs that are most likely already in that format. Additionally, the scripts generated for this initial pilot effort will be written with future model expansion and broader distribution in mind. Specifically, the proposed model can be recast in the future as a free stand-alone program or a web site depending on the expressed needs of the audience.

The proposed model will be easy to use and update. Users will be able to build their own scenarios and perform particular analyses of interest by working through a series of scenario development screens. Text within the window will prompt user inputs, and an accompanying manual will detail the inputs, decisions, and model computations at each step allowing full use of the model by anyone who has read the instructions. A demo scenario run will also be included and documented to help users become acquainted with the tool. The use of the common ArcGIS™ framework will facilitate the addition or modification of information layers by individual users as new climate scenarios become available. The included manual will detail the steps necessary to format new datasets and incorporate them into the model through a series of steps requiring only basic GIS skills. Additionally, the selection of Python, a popular and easy-

to-learn high-level scripting language, will encourage advanced users to modify the tool in more substantial ways, increasing its flexibility as conditions and needs change.

Beyond the model itself, the project will generate a number of static baseline maps useful to local, regional, and state coastal decision-makers. The downscaled climate change prediction maps (e.g., temperature, precipitation for a given future year) will aid governments and agencies in a broad assessment of their likely climate change-induced vulnerabilities. A series of maps representing the probability of various extreme events (e.g., inundation, fire) for particular years will be a useful input into local General Plan and Local Coastal Program revisions. A baseline development probability map will help planners envision the midterm future and provide a warning for locales likely to see urban growth in the near term.

Coordination

A key component of this project is coordination with the partner agencies, additional coastal managers, scientists conducting new climate change research, and other modeling projects. The grantees and OPC staff will continue to research other ongoing efforts and coordinate as necessary and learn from other modeling efforts as much as possible. One of the project investigators (Mastrandrea) is one of several scientists producing new research for the 2008 Public Interest Energy Research (PIER) Scenarios Report, and the grantees are familiar with and have access to the latest climate change and climate impact projections available for California. They are also aware of upcoming products (e.g., regional climate model projections) that will be available in the future and can be added to the model. Another member of the project team (Reilly) is coordinating with spatial economic modeling research efforts at metropolitan (Bay Area, Southern California, and Sacramento) and statewide levels (CalTrans and UC Davis). The grantees have tailored their proposal to complement and build on existing and planned efforts and will continue to communicate with other research groups to sustain this process.

PROJECT GRANTEES

Stanford University is a nonprofit research institution with a worldwide reputation. Stanford researchers who are a part of this project are also members of the California Energy Commission (CEC) PIER 2008 Scenarios Report research group, which is conducting research on projected climate change impacts for all sectors statewide. Tasking Stanford to complete this pilot study will ensure that their results benefit not only the work of the OPC, but also continue to inform other statewide projects related to climate change and adaptation.

The Monterey Bay Aquarium Research Institute (MBARI) is a private, non-profit center for advanced research and education in ocean science and technology. MBARI's National Ocean Economics Program (NOEP) team has extensive capacity to provide comprehensive and accurate economic and social indicator data for developing past economic trends and future projections for the proposed project. NOEP produced the California Coastal and Ocean Economics Study for the California Resources Agency and is just completing a study of California's government expenditures on its coasts and ocean for the OPC. MBARI also completed two major studies for the State of Florida on its coastal and ocean economies and potential vulnerabilities to climate change impacts. With this experience and the extensive data base compiled over the past ten years, MBARI is well positioned to contribute to the proposed project.

SITE DESCRIPTION

The pilot study will focus on two coastal counties in California. These counties will be selected in consultation with the staff of the Ocean Protection Council, taking into consideration the following geographic selection criteria: 1) data availability; 2) planning opportunity (e.g., Local Coastal Program review, or other imminent significant coastal planning decisions that can benefit from the model); 3) population; 4) economic activity; 5) development pressure potential; 6) rural versus urban representation (the pilot study will strive to address both); 7) vulnerability to climate change impacts; 8) ecological importance and vulnerability; 9) significant non-port infrastructure at risk (another project underway at Stanford specifically examines climate change impacts on ports); and 10) potential replicability or transferability of testing the model in this geography to other coastal regions of the state.

PROJECT HISTORY

On June 14, 2007, the OPC approved $100,000 in funding to the Scripps Institution of Oceanography to derive future sea level rise scenarios for California directly from climate model simulations. The Scripps research group is completing hourly sea level projections from the present day to 2100 for key index stations along the California coast, along with wave predictions and run up. On May 15, 2008, OPC approved $350,000 of funding to the Pacific Institute to conduct a study of potential future infrastructure and resource impacts in the coastal region of the state due to sea level rise impacts. Data from both of these studies will be incorporated with other projects currently being funded by the CEC, through their PIER program. These data will be synthesized in scientific papers, as well as in an update to the 2006 statewide *Our Changing Climate* report, published by the CEC. This information will also be used by the proposed project to analyze adaptation to climate change in two counties.

OPC staff has been working with coastal management agencies and the Resources Agency to coordinate potential future policy actions and to draft a statewide adaptation plan focused on coastal impacts. The development of a model that both integrates the data and analysis from the existing CEC and PIER projects and tests the efficacy of alternative management and policy decisions will be critical for outlining the potential impacts of climate change to infrastructure, resources, and people and will inform proposed adaptation strategies as well as on-the-ground decisions. Staff anticipates bringing potential adaptation strategies to the OPC for discussion at the November 2008 meeting. The statewide adaptation plan, which will include several other sectors in addition to the coastal impacts, is scheduled to be completed by spring 2009.

PROJECT FINANCING

Ocean Protection Council	$200,000
Stanford (in kind)	$23,000
MBARI (in kind)	$5,000
Total Project Cost	**$228,000**

The anticipated source of funds will be the fiscal year 07/08 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 Division 26.5 of the Public Resources Code, the California Ocean Protection Trust Fund (Pub. Res. Code § 75060(g)). Under Section 35650(b), Ocean Protection Trust Fund monies may be expended for projects authorized by the OPC that are identified as appropriate Trust Fund purposes. The project is consistent with the Trust Fund purposes as discussed in the following section.

CONSISTENCY WITH CALIFORNIA OCEAN PROTECTION ACT

Chapter 3 of the Ocean Protection Act Division 26.5 of the Public Resources Code identifies the duties of the Council, which include coordinating activities of state agencies related to the protection and conservation of coastal waters and ocean ecosystems and improve the effectiveness of state efforts to protect ocean resources within existing fiscal limitations, (Pub. Res. Code Section 35615). The Ocean Protection Trust Fund authorizes the Council to fund projects and activities in aid of these responsibilities (Pub. Res. Code Section 35650(b)(1)).

The proposed project will support the Council in its coordination of ocean policies and scientific data gathering activities related to evaluating and adapting to projected impacts of climate change. The project also will directly inform the work of the team of state personnel and academic advisors who are drafting the coastal impacts section of the statewide climate change adaptation plan with the goal of improving state efforts to protect ocean resources.

Section 35650(b)(2) authorizes expenditure of Ocean Protection Trust Fund monies for projects that:

> (E) Improve management, conservation, and protection of coastal waters and ocean ecosystems.
> (F) Provide monitoring and scientific data to improve state efforts to protect and conserve ocean resources.

By synthesizing the impacts from climate change and demonstrating outcomes from various adaptation strategies, the proposed project will improve management, conservation and protection of coastal waters and ocean ecosystems. This project will provide information that will improve the state's efforts to protect and conserve ocean resources by assessing how coastal resources might change in the future due to climate change and what the effects might be of making different land use and management choices.

CONSISTENCY WITH OPC'S STRATEGIC PLAN GOALS & OBJECTIVES

The proposed project is consistent with OPC's Five Year Strategic Plan by furthering a goal and objective related to physical processes and habitat structure. Specifically, the proposed project is consistent with Goal D, Objective 3a, "work with the Climate Action Team to investigate the long-term impacts of sea level rise and develop statewide adaptive management policies that will help agencies deal with these impacts." The proposed pilot study will synthesize projections of climate change impacts to both natural and manmade resources along the State's coast. The scope of these potential impacts will directly inform the coastal managers' ability to test different adaptation strategies.

CONSISTENCY WITH OPC'S PROJECT FUNDING GUIDELINES

The proposed project is consistent with the OPC's Project Funding Guidelines adopted June 14, 2007, in the following respects:

Required Criteria

1. **Directly relate to the ocean and coast**: The project is directly focused on coastal resources, infrastructure, and communities and how those natural and built assets might be impacted by climate change.

2. **Support of the public**: The interagency coastal resources climate change workgroup, which is organized by the OPC, has indicated that these data will be very useful to their departments as they evaluate and implement adaption strategies along the coast. See also exhibit 2.

3. **Greater-than-local interest**: The project scope is focused on two coastal counties in its pilot study stage. With proof of concept, the findings of the pilot study and the policy discussion it will inform will have statewide implications for management.

Additional Criteria

4. **Timeliness**: Immediate funding for this proposal will ensure that the results and the pilot model itself will be available to inform actions in the context of the statewide adaptation plan scheduled to be completed in early 2009. In addition, a key criterion of the geographical selection process will be choosing locations for which specific opportunities exist to influence planning decisions. Funding this project now will also allow the research team to build on work currently funded by the CEC PIER program for the 2008 Scenarios Report.

5. **Innovation**: This will be the first study of its kind conducted in California. The data generated by this study will inform discussions among coastal managers, allowing them to consider a range of innovative solutions to future sea level rise impacts. In particular, this project will go beyond other work in four ways. First, it will characterize economic vulnerabilities in terms of activities and natural resources at risk, in addition to infrastructure. Previous estimates of economic impacts from climate change have focused solely on the value of infrastructure at risk and the cost of protection. Second, it will incorporate demographic, economic, and land use trends and projections. Third, it will synchronize climate impact scenarios with these societal projections, to better characterize the risks coastal regions will face. Previous studies have not done these projections, but have instead focused on projected climate change impacts assuming current socioeconomic conditions. Finally, the proposed project will develop a model to simulate policy scenarios and outcomes, providing an interactive model which planners can use to test specific policy options in the context of future socioeconomic and climate changes.

6. **Coordination**: This project is being conducted in coordination with several other ongoing studies related to climate change, either funded by the OPC or the CEC PEIR program. Collectively these studies will provide a range of scenarios and impacts that all state agencies can use to individually or collectively assess future impacts and implement strategies to adapt to potential changes.

CONSISTENCY WITH OPC'S 2007/2008 FUNDING PRIORITIES

Climate change was included as one of the priority areas for funding for 2007/2008. Specifically, one of the priorities is to fund projects that identify the types of policy changes California may need to adapt to sea level rise. Coastal managers need to understand the scope of potential coastal impacts due to sea level rise for them to develop and implement adaptation strategies. Most coastal management agencies are poised and ready to consider climate change and sea level rise in their decisions; however, understanding the magnitude and range of potential impacts as well as potential responses will help to ensure that appropriate strategies are pursued.

COMPLIANCE WITH CEQA

The proposed project is categorically exempt from review under the California Environmental Quality Act ("CEQA") pursuant to 14 Cal. Code of Regulations Section 15306 which exempts projects that involve only data collection, research and resource evaluation activities that will not result in a serious or major disturbance to an environmental resource but which may lead to a project which a public agency has not approved, adopted, or funded. Staff will file a Notice of Exemption upon approval by the Council.