MEMORANDUM

TO: California Ocean Protection Council

FROM: Sam Schuchat, Executive Officer, Coastal Conservancy
Sheila Semans, Project Manager, Coastal Conservancy

DATE: April 20, 2006

RE: Consideration of adoption of the California Ocean Observing Program: A Recommendation for Supporting State Ocean Observing Efforts (Agenda Item #8)

Requested Action

Staff recommends that the council adopt the following resolution:

"The California Ocean Protection Council adopts recommendations contained in the *California Ocean Observing Program: A Recommendation for Supporting State Ocean Observing Efforts*." (Exhibit 1).

Background

California's ocean action plan, *Protecting our Ocean: California's Action Strategy*, calls on the California Ocean Protection Council (Council) to develop a statewide ocean observing strategy to help guide the state's $21 million investment in the Coastal Ocean Currents Monitoring Program provide for the integration of this data with existing and future observing systems (Action 8). In addition, California's Ocean and Coastal Information, Research and Outreach Strategy (adopted by the Council at it September, 2005 meeting) calls for "mak[ing] California's ocean observing system a national model." (Recommendation 2). These documents encourage state government to play a lead role in supporting the maintenance of ocean observations and coordinate the integration of data to ensure that State goals and priorities are adequately addressed, that funding is secured and well spent, and that government agencies managing ocean resources have access to appropriate data products and tools in a sustained manner.

The California Ocean Observing Program: A Recommendation for Supporting State Ocean Observing Efforts (the *Recommendation*) lays out an approach for moving the state towards an integrated ocean observing system in California. The key recommendation of the report calls for a state-sponsored entity to be created within the State Coastal Conservancy to identify observing system needs and markets within state agencies, communicate needs to the observing system developers, facilitate the flow of communication and encourage use of new decision making tools by state and federal managers, and establish statewide priorities for new and existing ocean information. This entity, Ocean Science Applications, would ensure that existing and new observing systems: (1) address the State's management priorities; (2) are sustained over time; and (3) meet the needs of a broad suite of users, from scientists to resource managers to the general public. The proposed *Recommendation* will help the Council fulfill the finding of the California Ocean Protection Act (COPA) that the state needs to coordinate governance and stewardship of the state's ocean, to identify priorities, bridge existing gaps, and ensure effective and scientifically sound approaches to protecting and conserving important ocean resources.

The Recommendation was developed by the following process:

- Council staff working on the Coastal Ocean Currents Monitoring Program drafted the proposed *Recommendation*, presented it to the Ocean Protection Council at its September 23, 2005 meeting, and solicited public comments both at the meeting and at the Council website through November 2005.
- The *Recommendation* was revised based on Council discussion, public comment and expert advice and the revised *Recommendation* is now being presented to the Council for its adoption.

Adoption of the *Recommendation* will allow your staff to move ahead with development of a statewide ocean observing program and provide a basis for further proposals for Council action to implement these recommendations.

CALIFORNIA OCEAN OBSERVING PROGRAM: A RECOMMENDATION FOR SUPPORTING STATE OCEAN OBSERVING EFFORTS

Executive Summary

Our Connection to the Sea

The ocean is an integral part of life in California, intimately affecting the lives of California's citizens and communities, even if they are unaware of their connection to the sea and its resources. The oceans are drivers of weather systems and of climate; how many Californians remember a time without constantly updated weather forecasts? For a state largely dependant on international trade, the oceans are highways for marine commerce and a buffer for national security. Eighty percent of Californians live within thirty miles of the coastal ocean, making it a haven for recreation, a major reservoir of natural resources, and a schoolroom for educators.

Unfortunately, the burgeoning number of people living near the coast is placing conflicting demands on the coastal ocean ecosystem. Despite the growing threats to our oceans, there is no single, coherent monitoring network in place to assess their status, track changes over time, or determine the success of our management efforts.

Now is the time to expand our observation and forecasting systems in our coastal ocean. A sustained and integrated ocean observing system in California will provide invaluable economic, societal, and environmental benefits, including improved warnings of coastal and health hazards, more efficient use of living and nonliving resources, safer marine operations, and a better understanding of climate change. From coastal watersheds out to the depths of the ocean, extending our understanding the coastal ocean environment is critical to conserving and protecting our living marine resources and improving our quality of life. This understanding will only come through the creation of an integrated and lasting system for observing the ocean.

California's Ocean Observing Systems

Ocean observing systems have three general characteristics:

1. They monitor selected physical, biological, or chemical attributes;
2. They are ongoing, long-term programs; and
3. They meet the information needs of management agencies, industries, scientists, educators, non-governmental organizations, and the public.

California already has many ocean observing systems in place, including two of the oldest and simplest systems in the nation, the San Francisco Bay tide station, which began collecting data in 1854, and the Scripps pier in La Jolla, which began collecting data in 1917. California also operates more complex systems, using advanced technologies to collect data across large expanses of the coast and ocean. For example, the California Cooperative Oceanic Fisheries Investigations (CalCOFI) is the longest continuous time series for fisheries and climate data in the U.S. and was established in 1949.

Observing the Ocean is Important to California

In the past several years, California has adopted progressive policies and embarked on ambitious initiatives to address ocean management concerns. Implementation of ocean management and observing programs is in the early stages, with a few exceptions, but some of California's ecosystem-based efforts are already models emulated by other states and at the national level. Continued success in these endeavors is dependent on the ongoing collection of sound scientific information. This need can be filled as never before by new ocean observing technologies.

California's ocean action plan, "Protecting Our Ocean: California's Action Strategy," calls for the development of a strategic plan for ocean observations. In addition, the Secretary of Resources has tasked the State Coastal Conservancy (Conservancy) with planning the State's coastal ocean observing systems, incorporating the newly funded Coastal Ocean Currents Monitoring Program (COCMP, *see Section III*). These decisions reflect the importance of examining the State's interests in ocean observing and recommending ways to ensure that fair value is received by the public for the substantial investments the State continues to make in ocean observing systems. Meeting these challenges will require a concerted effort to modernize the current data management system and will require greatly improved interagency planning and coordination.

<u>This report recommends a practical approach for California to organize its statewide interests in ocean observing systems.</u>

Observations of the Ocean are Useful

A robust and integrated system for observing the coastal ocean is vital to the sustained recovery of our marine ecosystems. Continuous collection of basic ocean data provides information useful in helping our marine ecosystems face the present deluge of threats to their health and sustainability. Beyond basic data collection, information is frequently required to understand specific events operating on different time and space scales. Short time scale events such as El Ninos have well documented effects on marine ecosystems. Phenomena operating over longer time scales (such as the Pacific Decadal Oscillations or sea level rise) can have major impacts on marine ecosystems and weather. Ocean observations can help us understand the major drivers creating change at various scales of time and space.

This combination of basic and applied information can support policy decisions that may prevent further ecosystem decline from continuing into the future. Some of the central issues facing California's coast and ocean are described in Appendix 2.

Ocean observations provide information useful for management decisions as well as tools practical for real-world applications. To mention just a few applications, ocean observing systems in California monitor rockfish productivity, wave height, period and frequency, seabird breeding success, coastal and Central Valley salmon recovery, and pollutants in coastal waters.

This report includes three case studies (*see Section II*) that illustrate how observing system information initially served California's ocean and coastal resource management needs. The first case study highlights a 56-year-old, internationally-respected system that continues to benefit management of fisheries and marine life along the entire West Coast. The second concerns beach water quality and human health in the most populous region of California. The last case study is a promising new experiment on addressing the persistent problem of beach erosion in San Francisco.

California's Missing Element

As the challenges we face along our coasts and in our oceans escalate, our information needs continue to grow. Although California began monitoring the ocean many decades ago, many of those systems were developed for very specific uses, with little consideration of the potential efficiencies if the observing system information were to reach a broader audience. Only now have integrated efforts begun, with great challenges and opportunities remaining to make the growing collection of ocean information available and useful in the coming decades. These integration efforts are ongoing at the global, national, regional, and state levels.

As called for by the national framework for integrating ocean observing systems, Regional Associations (RA) and their Regional Coastal Ocean Observing Systems (RCOOS) composed of operators and beneficiaries of observing systems are forming on U.S. coasts and the Great Lakes. California is fortunate to have two emerging RAs whose members operate many of the key ocean observing systems in the State: the Central and Northern California Ocean Observing System, CeNCOOS, and the Southern California Coastal Ocean Observing System, SCCOOS (*see Section III and Appendix 3*). These two RAs already involve most of the State's leading agencies and research institutions, and academic organizations that operate ocean observing systems.

A long and diverse coastline, a large and rapidly growing population, two RAs, and a complicated ocean management structure, means that California faces a difficult challenge creating a statewide, integrated ocean observing system. State government must play a lead role in supporting the maintenance of ocean observations and coordinate the integration of data to ensure that State goals and priorities are adequately addressed, that funding is secured and well spent, and that government agencies managing ocean resources have access to appropriate data products and tools in a sustained manner.

The missing piece for ocean observing in California is an overarching, coordinating entity that has a statewide perspective. This entity would focus on linking the users (those who benefit from information collected by observing systems) to the operators (those who run the systems). Meeting these challenges will require a concerted effort and will require greatly improved interagency planning and coordination. The main goals would be to ensure that existing and new observing systems: (1) address the State's management priorities; (2) are sustained over time; and (3) meet the needs of a broad suite of users, from scientists to resource managers to the general public.

This report recommends the creation of such an entity, to work in close cooperation with CeNCOOS and SCCOOS, called the Ocean Science Applications program, or OSA. This new entity could identify observing system needs and markets within state agencies, communicate needs to the observing system developers, facilitate the flow of communication and encourage use of new decision making tools by state and federal managers, and establish statewide priorities for new and existing ocean information.

Organization of This Report

The report is organized into six sections with three appendices. The first three sections introduce the reader to ocean observing systems, their usefulness, and how they are beginning to be integrated in California. The last three sections include the Conservancy's recommendations for strengthening ocean observing in California and organizing the State's interests in ocean observing.

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ACRONYMS

ADCP	Acoustic Doppler Current Profilers
AOOS	Alaska Ocean Observing System
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CDIP	Coastal Data Information Program
CICORE	Center for Integrative Coastal Observation, Research, and Education
COCMP	Coastal Ocean Currents Monitoring Program
CRANE	Cooperative Research and Assessment of Nearshore Ecosystems
CeNCOOS	Central and Northern California Ocean Observing System
DFG	California Department of Fish and Game
GOOS	Global Ocean Observing System
GPS	Global Positioning System
HF Radar	High frequency radar
IOOS	Integrated Ocean Observing System
MPA	Marine Protected Areas
NANOOS	Northwest Association of Networked Ocean Observing Systems
NOAA	National Oceanic and Atmospheric Administration
OPC	California Ocean Protection Council
OSA	Ocean Science Applications
PacIOOS	Pacific Islands Integrated Ocean Observing System
PaCOOS	Pacific Coastal Ocean Observing System
PISCO	Partnership for Interdisciplinary Studies of Coastal Oceans
PORTS	Physical Oceanographic Real-Time System
RWQCB	Regional Water Quality Control Board
RA	Regional Associations
RCOOS	Regional Coastal Ocean Observing Systems
ROV	Remotely Operated Vehicles
SDCOOS	San Diego Coastal Ocean Observing System
SCCOOS	Southern California Coastal Ocean Observing System
SWRCB	State Water Resources Control Board
SCCWRP	Southern California Coastal Water Research Project
Scripps	Scripps Institution of Oceanography
SWAMP	Surface Water Ambient Monitoring Program
USGS	United State Geological Survey

I. What are Ocean Observing Systems?

Coastal ocean observing systems monitor physical, biological, and/or chemical data relating to the coastal ocean. California already supports an assortment of observing systems for uses ranging from water quality monitoring at the mouth of the Los Angeles River to tidal measurements inside the Golden Gate (*see side bar for examples*). The operators of these observing systems are most commonly state and federal agencies with regulatory requirements or universities interested in understanding long-term oceanographic phenomena.

Ocean Observing Data

Physical: salinity, temperature, bathymetry, sediments, sea level, surface waves, ocean currents, marine meteorology
Biological: fish species and abundance, phytoplankton or zooplankton species and abundance
Chemical: water column contaminants, dissolved inorganic nutrients, dissolved oxygen

A number of the older marine laboratories, primarily Hopkins Marine Station and the Scripps Institution of Oceanography, have maintained long-term records on localized sea surface temperature. More recent but equally valuable high-quality, long-term data sets spanning many decades have been developed by California's other marine institutions. However, until recently, California coastal observations were in general temporary and site specific, were typically not coordinated or integrated with other observations, often lacked sustained funding, and commonly were not used to provide information applicable to the wide spectrum of resource management needs. The first attempt at an interagency long-term coastal ocean assessment was the California Cooperative Oceanic Fisheries Investigations (CalCOFI) initiated in 1949 in response to the collapse of the sardine fishery (*see Section II for Sardine story*). CalCOFI includes biological, chemical, and physical sampling from ships and, and as one of the longest marine data sets in history, has provided much of our insight into the California Current System.

The Southern California Coastal Water Research Project (SCCWRP) Authority brings together a regional monitoring network of more than 60 organizations, including State and local government, industrial dischargers, public health agencies, volunteer organizations, and academic institutions to better describe ecosystems conditions in the Southern California Bight. "These regional surveys provide tremendous management benefit," says SCCWRP executive director Steve Weisberg. "Not only do they meet managers' needs for a regional assessment, but they also help develop tools, data management systems, and quality assurance standards for everyday management decisions."

Each of California's academic marine biological laboratories maintains various shore-based or near-shore ocean and meteorological measurements. In addition, several major nearshore physical and biological oceanographic investigations have been initiated in the last twenty years (e.g. the Coastal Data Information Program (CDIP) http://cdip.ucsd.edu/; the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) http://www.piscoweb.org/; Center for Integrative Coastal Observation, Research, and Education (CICORE) http://online.sfsu.edu/~dhr/cicore/about.htm). An *integrated* ocean observing system in California will combine existing local, regional and national observing systems, as well as newly developed ones, into a comprehensive network that will fill data gaps, integrate data, and provide new data products to a wide range of clients (e.g. policy makers, resources managers, maritime industry, educators and the public). Coordinating observing efforts will result in less duplicated work, easier ways to share data, and an improved ability to detect trends and patterns. Greater accessibility to this information will also help the resource managers make decisions more efficiently and effectively.

The primary objective of an integrated ocean observing system is to successfully translate science into useful and timely applications for management. This will require the creation of institutional partnerships not common in ocean management. An interactive dialogue must develop between system operators and their clients to continually refine the system and produce the types of products needed to support better decisions. This two-way feedback will also guide new research directions and new technology. Potential clients include:

- **Coastal Resource Managers** seeking to maintain economically and environmentally vital resources
- **Maritime Industry** making everyday decisions that impact safety and livelihood
- **Port and Harbor Districts** looking for ways to improve maritime safety
- **Scientists** trying to understand complex ecosystems and predict change
- **Educators** conveying the complexity and urgency of ocean science
- **Search and Rescue Teams** trying to save lives
- **Emergency Response Teams** mitigating damage from disasters
- **Public Health Officials** concerned about beach closures and human exposure to contaminants
- **Water and sanitation agencies** addressing critical human and wildlife health issues

II. How are Ocean Observing Systems Useful?

The main purpose for the State to invest in these ocean observing systems is to obtain useful and useable products and applications. This section, primarily for those new to learning about ocean observing systems, includes three brief case studies that illustrate how observing system information came to serve coast and ocean resource management needs. The first is a 56-year-old internationally respected system that is continuing to pay benefits to marine life and fisheries management on the entire West Coast. The second concerns beach water quality and protecting human health in the most populous region of California. The last example is a promising experiment that began this year to manage beach erosion in San Francisco.

Pacific Sardines: Initiating the State's first ocean observing system

In 1937, fishermen along the coast from British Columbia to Mexico caught 1.5 billion pounds of sardines, the year the fishery peaked. Pacific sardines supported one of the largest fisheries in the world in the 1930s and early 1940s. By the mid-1940s, the fishery was beginning to disappear. Catches dropped to 1/500th of what they were at the fishery's height. The fishery limped along in southern California until the State officially closed it down in 1974. Long before then, the canneries along Monterey's famous Cannery Row and elsewhere from Puget Sound south had boarded up. The cause of the sardines' disappearance was a mystery. The question, obvious even at the time, was whether the cause was overfishing or unknown natural factors.

The California Cooperative Oceanic Fisheries Investigations (CalCOFI) was formed in 1949 to solve the puzzle of the sardines' radical decline. Originally including the fishing industry as a partner, CalCOFI monitored the physics, chemistry, biology, and meteorology of the California Current ecosystem. To understand how the organisms interact with the environment, CalCOFI scientists initially measured physical factors such as currents, temperature, and salinity as well as sardines. The focus quickly broadened from sardines using nets towed from CalCOFI ships to include all fish eggs and larvae that put the sardine data into an ecosystem context (Figure 1). Through the years they continued to add a wider variety of data, such as nutrients in the water required by plants, amounts of plant plankton present (the basic food on which everything else in the ocean depends), and the presence of predators like seabirds and whales. Today, CalCOFI continues as a collaborative effort between Scripps Institution of Oceanography, the California Department of Fish and Game (DFG), and the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service.

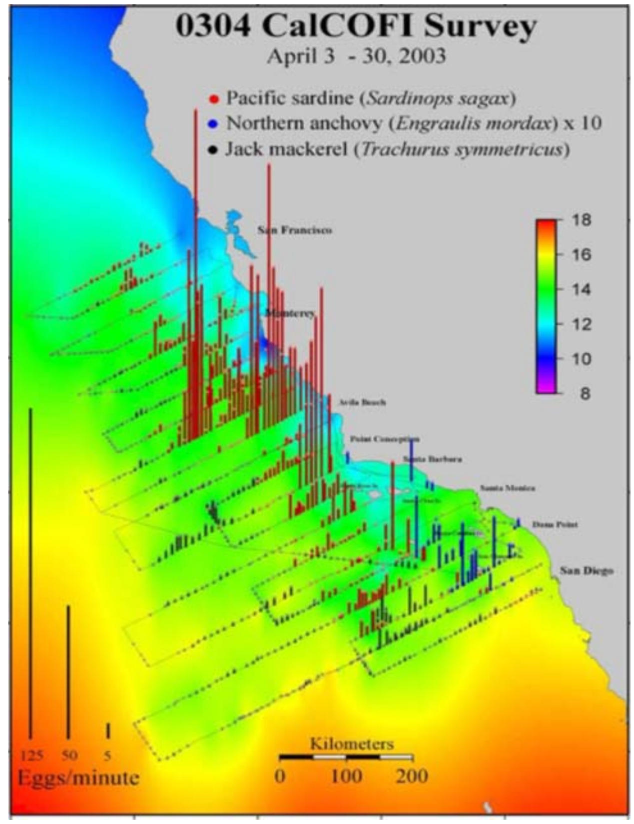

Figure 1. Example of CalCOFI cruise survey results for sardine, anchovy, and jack mackerel, April, 2003. The vertical bars represent sampling at specific locations that have been sampled monthly or quarterly since 1949.

Beginning in 1957, the Pacific Ocean experienced a powerful El Niño. For the first time, an El Niño event was closely studied, largely because it coincided with International Geophysical Year, a time when oceanographers in California and throughout the Pacific intensified observations of ocean and weather connections. CalCOFI observations provided the first evidence that the El Niño phenomenon affected California and not just the Pacific coast of South America. From then on, CalCOFI studies were consciously connected to Pacific Ocean-scale climate and weather studies.

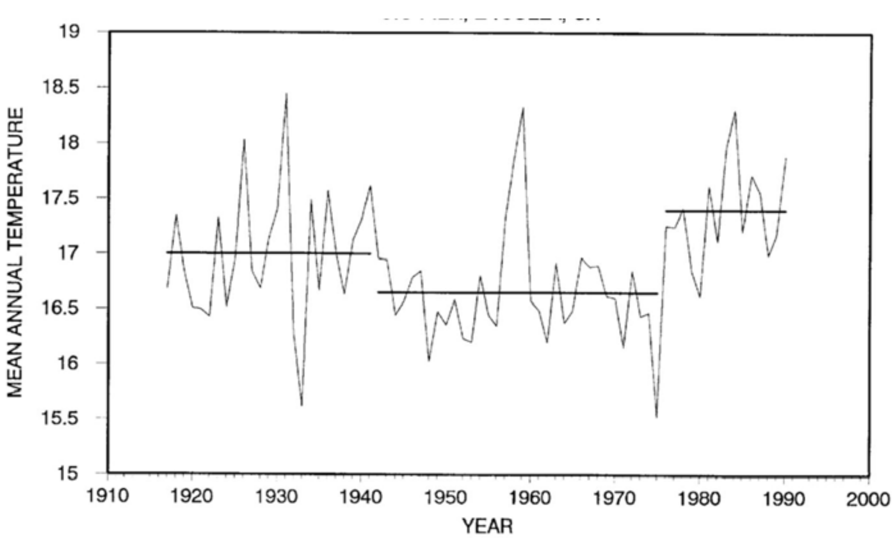

Figure 2. Average annual sea surface temperatures (SST) observed at Scripps Pier in La Jolla, California. Long-term averages are shown for three qualitatively different periods: warmer prior to 1944 and after 1977. Average SST was cooler in the intervening years in spite of the strong El Niño spike in 1957 to 1959.

The sardine detective story took another twist in the late 1960s when CalCOFI scientists found sardine scales in the layers of sediment extracted from core samples of the seafloor off Santa Barbara. Here was an "instant" 1,500-year ocean observing time series. It showed that sardine populations hit strong peaks and valleys in cycles that were several decades long. The longest series of sea surface temperature records, recorded at the Scripps Pier since 1917, also offered evidence of significant, decades-long shifts in ocean conditions (Figure 2).

Based on the picture created by 49 years of CalCOFI observations combined with these other data sources, in the 1990s California adopted a pioneering formula to manage the sardine fishery. The formula, which links the amount of catch allowed to ocean conditions, was a revolutionary step in the history of fishery management. CalCOFI data are now routinely used by fishery managers in population assessments of many species besides sardines.

Because of CalCOFI and studies that grew out of it, the California Current is one of the best ecologically understood marine regions in the world. The growing awareness of large-scale environmental change driven by Pacific basin-scale forces has made the program an ecosystem model that other observing systems seek to emulate.

What are some of the most important things we have we learned from CalCOFI?

- The California Current System, the southward-flowing river of water off our coast, determines much about California's weather and, as a result, its supply of freshwater from Sierra streams.
- Warm, wet El Niños and cool, dry La Niñas are not just a South American phenomenon.
- In addition to El Niño events every few years, the temperature and productivity of the California Current also fluctuates in 50-to-70-year cycles.
- Variations in ocean conditions have enormous influence on the fortunes of most of our fisheries – for salmon, sea urchins, squid, rockfish, and sardines, to mention a few examples.
- As with other long-term studies, the longer the time series of information, the more valuable it has become.
- Sardine populations fluctuate with sea surface temperatures and the decline in the 1940's coincided with a cold water regime.

Tracking Water Quality at Imperial Beach

Beach closures have a serious impact on the economies of communities that benefit from coastal recreation and tourism. Imperial Beach in San Diego County closed its beaches 70 times in 2001 due to high levels of bacterial contamination, mostly during the peak tourist months. The city was hard pressed to pinpoint a cause due to the variety of possible sources, including the Tijuana River, the International Wastewater Treatment Plant, Mexico's San Antonio de los Buenos treatment plant, and nonpoint source urban runoff.

Health officials were also unable to predict when a pollution event was likely to occur. Like other jurisdictions, they regularly collect water samples for bacterial analysis, testing that takes a day or more to get results. Until reliable, fast testing methods are routinely available, the lag time between collecting a sample and getting test results means that beaches are likely to remain open during pollution events and closed after an event has ended.

Responding to the city's request for information, Scripps recommended employing a new, cost-effective, land-based technology. High-frequency radar can continuously monitor surface currents and the flow of pollution in the waters off the coast of southern California. Imperial Beach and Scripps received funding from the State Water Resources Control Board (SWRCB) through the California Clean Beaches Initiative to build a system that would identify sources of pollution and track its movement. The partnership grew to include the San Diego County Department of Environmental Health and the California Regional Water Quality Control Board Region 9.

The San Diego Coastal Ocean Observing System (SDCOOS) went on line in 2002 (www.sdcoos.ucsd.edu) and now serves as a gateway for up-to-date oceanographic, weather, and water quality information for the San Diego coastal region. SDCOOS integrates water quality data (such as shoreline bacteria) and surface current mapping with other observing system information, including satellite images, bathymetry, and weather data.

San Diego public health officials now routinely use SDCOOS data to make timely decisions related to local water quality and beach closures. Surface current data is now being used to develop indicators based upon the physical environment that will provide early warning of likely contamination events; when the onshore flow pattern recurs, it can be detected immediately and health officials are able to decide whether to close a beach and when to reopen when the onshore flow pattern changes. SDCOOS has also become a great resource for lifeguards by providing real- time information not only for water quality issues, but also on daily weather and ocean conditions. This system also serves as a testbed for trying out new technologies for the region-wide observing systems now in development.

Acoustic Doppler Current Profilers (ADCP) serve as fixed platforms for the measurement of surface and internal ocean conditions. Parameters include water temperature, salinity, turbidity, chlorophyll, nutrients, speed and direction of currents, as well as surface meteorological variables such as wind speed and direction, air temperature, and barometric pressure. Data is transferred to shore via frequent electronic transmissions from the surface of the mooring. Mooring data is useful for making model forecasts and in analysis of long-term ocean trends.

Multibeam sonar sensors, also referred to as multibeam acoustic sensors, use sound to collect information about depth and other characteristics of the sea floor. As the ship travels forward, sensors pulse beams of sound waves toward the seafloor and record the signal that is reflected back. Data is collected in swaths along the vessel's path, typically in a series of overlapping tracks. Because it can provide very accurate measurements of depth, multibeam sonar is typically used for mapping bathymetry. The data collected from the returned signal has also been used to obtain other bottom characteristics, such as hardness and texture (rocky bottom, mud, sand, etc.) that can be used for habitat mapping.

Erosion at San Francisco's Ocean Beach

San Francisco has battled severe erosion at the south end of Ocean Beach for several years. One of San Francisco's largest combined sewer and stormwater pipes runs below the land west of the Great Highway, the Oceanside Water Pollution Control Plant is just across from the worst erosion area, and rocks placed over the plant's ocean outfall pipe are now partially exposed at times when the beach is most eroded.

The City and County of San Francisco and the Golden Gate National Recreation Area (GGNRA) share jurisdiction over the area, and have grappled with the problem along with several other State and federal agencies, Friends of Ocean Beach, Surfrider Foundation, and others. San Francisco has made attempts to protect the Great Highway during severe winter storms as recently as 1998 by placing rip-rap along the shoreline, but "hardening" beaches can sometimes exacerbate beach erosion. The City also spends roughly $100,000 using sand to rebuild its bluff for shoreline erosion protection, a partial and temporary solution.

With the city's agreement, the United State Geological Survey (USGS) and the Army Corps of Engineers have stepped in to assist, using new technologies to improve their computer models of the highly dynamic movement of sand along Ocean Beach. Their sand transport model requires a) the amount, speed, and direction of water moving thorough the area, and b) the depth and topography of the bottom, which provides the size and shape of the space the water is moving through.

Five recently installed Acoustic Doppler Current Profiler (ADCP) buoys (*see description in side bar*) will give USGS precise current direction and speed information at different depths from those five locations in the study area. For the second data requirement, the USGS enlisted the Seafloor Mapping Lab at California State University at Monterey Bay (Mapping Lab) to create a detailed map of the seafloor from the mouth of the Golden Gate south along Ocean Beach, a difficult challenge in an area characterized by fast currents and big waves. To accomplish this, the team used multibeam and sidescan sonar attached to a 34-foot vessel to map the area deeper than five meters. Meanwhile, USGS staff on personal water craft equipped with depth sounders and Global Positioning System (GPS) units mapped the bottom from the beach out through the surf zone.

The mapping revealed that significant changes had occurred in the last 50 years and that the bottom topography was much more complex than anyone had known. The tidal migration of massive dune fields at the bay mouth was observed and quantified for the first time (Figure 3).

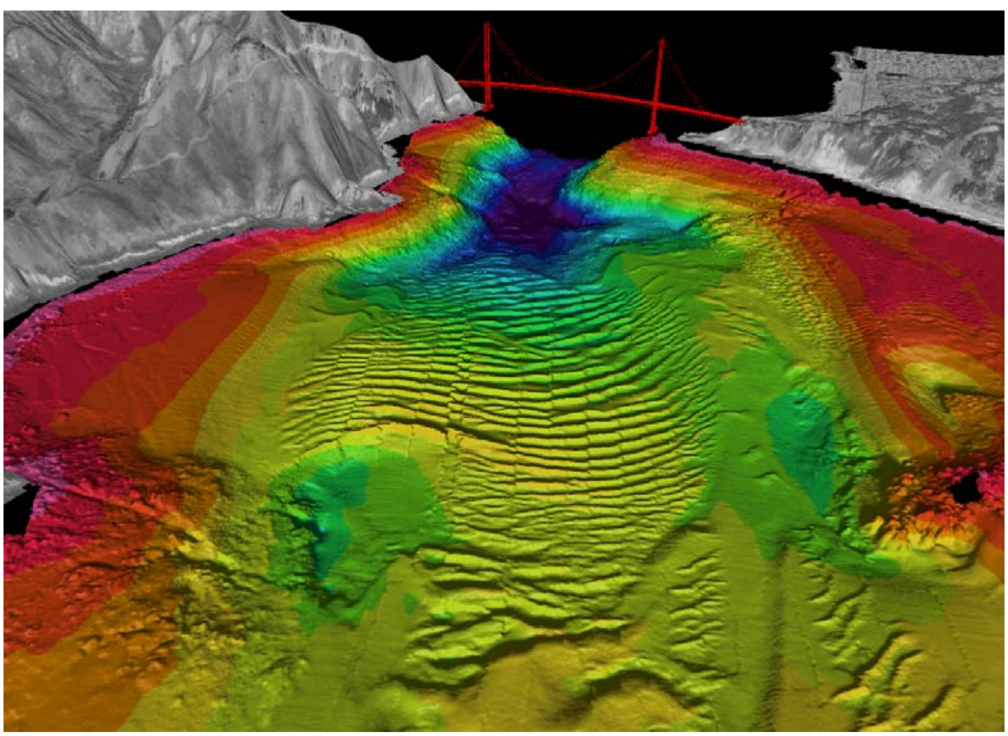

Figure 3. Bedforms at the mouth of San Francisco Bay. View is from the west toward the Golden Gate. The city of San Francisco is pictured in the upper right corner.

Armed with greatly improved seafloor mapping and coastal current data, USGS is developing a much more refined sand transport model. Based on their new understanding, USGS and the Army Corps of Engineers have already begun to experiment with a new approach to the Ocean Beach erosion problem.

The Corps maintains the main ship channel outside the Golden Gate with routine dredging of the channel through the San Francisco Bay bar, placing the sand nearby, just south of the channel. It was previously thought that the sand would migrate to the beaches and sand bars south of the Golden Gate. However, the new mapping revealed that this sand source was not feeding the beach and might instead be moving offshore and out of the system.

The outer sand bar off Ocean Beach historically protected the beach from heavy wave action. Over time, this sand bar has shrunk, exposing Ocean Beach to more wave energy and possibly contributing to the erosion problem. So in June 2005, the USGS and the Army Corps moved the deposit site of dredged sand from channel maintenance to a location a few hundred yards west of the Ocean Beach erosion site. The Mapping Lab is monitoring selected areas routinely to evaluate where the sand is moving. The monitoring results will allow USGS and the Army Corps to refine future placement of dredge spoils and hopefully successfully deliver much needed sand to Ocean Beach.

III. THE CALIFORNIA CONTEXT: OCEAN AND COASTAL POLICIES AND INITIATIVES

> "The Preliminary Report [of the U.S. Commission on Ocean Policy] makes a compelling case for supporting and strengthening the United States' commitment to ocean and coastal research, education programs, and technology development. I concur that we must renew our commitment and double the federal ocean and coastal research budget. … I also strongly support the recommendation to develop a national Integrated Ocean Observation System and believe that California will serve as a leader in this effort, having already invested $21million to develop one component of such a system."
>
> Governor Arnold Schwarzenegger
> June 3, 2004

Understanding recent efforts to begin integrating ocean observing systems in California requires some familiarity with what's developing at the global and national levels (*see Appendix 1 for a full discussion*). Efforts to create a unified system of common technologies and shared information began both nationally and internationally in the 1990's. The Global Ocean Observing System (GOOS; http://ioc.unesco.org/goos/) was established in 1992 to provide descriptions of the present state of the world's oceans, including living resources; continuous forecasts of future ocean conditions; and the basis for predictions of climate change.

> The **objectives of IOOS** are to provide information to help with the broadest range of ocean management concerns:
> - Detect and forecast oceanic components of climate variability
> - Facilitate safe and efficient marine operations
> - Ensure national security
> - Manage resources for sustainable use
> - Preserve and restore healthy marine ecosystems
> - Mitigate natural hazards

Nationally, the U.S. is organizing its ocean observing efforts under the name Integrated Ocean Observing System (IOOS; www.ocean.us), which is intended to be collaboration among State and federal agencies, industry, non-governmental organizations, and academia. IOOS is primarily concerned with the effects of weather, climate, and human activities on coastal environments, living resources, and people who live, work, and play in the coastal zone.

The coastal component of IOOS is planned as a federation of regional observing systems nested in a federally supported "national backbone" of observations. Eleven Regional Associations are forming around the country, including two in California (*see Appendices 1 and 3*). Currently the state's RAs are meeting IOOS certification criteria that include engaging management, industry and NGO stakeholders.

Recognizing that the mounting complexity of ocean resource management required immediate action, California recently established the California Ocean Protection Council (OPC) to help coordinate and improve management efforts. Consisting of the Secretary for Resources, Secretary for Environmental Protection, and the Chair of the State Lands Commission as voting members, the OPC now has an opportunity to provide the leadership and vision for California's future in ocean observations. The OPC is currently undergoing strategic planning for California, and has identified a strong and sustained ocean observing system as a primary objective.

There are many ocean management concerns that will benefit from an integrated ocean observing system in California (*see Appendix 2 for highlighted issues*). California has adopted progressive polices and begun important initiatives for improving ocean and coastal management mandates. Some of these efforts include:

- The Clean Beaches Initiative (AB411, Wayne, 1997, and related legislation; www.waterboards.ca.gov/cwphome/beaches)
- Polluted runoff control under the Porter-Cologne Water Quality Control Act (http://ceres.ca.gov/wetlands/permitting/tbl_cntnts_porter.html)
- Stormwater management under the federal Clean Water Act (www.epa.gov/region5/water/cwa.htm)
- Nonpoint source pollution management as provided for in the California Coastal Nonpoint Source Pollution Control Program (www.coastal.ca.gov/nps/npsndx.html)
- Fisheries management under the California Marine Life Management Act of 1998 and related legislation (www.fgc.ca.gov/mlma/index.html)
- Design and evaluation of marine protected areas under the California Marine Life Protection Act of 1999 (www.dfg.ca.gov/mrd/mlpa)
- Oil spill response under the Lempert-Keene-Seastrand Oil Spill Prevention and Response Act of 1990 and related legislation (http://resources.ca.gov/ocean/copc/6-10-05_meeting/ospr_overview.pdf)
- Coastal erosion and sediment transport under the Public Beach Restoration Act of 1999 (www.dbw.ca.gov/beach.asp)
- Salmon recovery under the California Endangered Species Act of 1997 (http://www.dfg.ca.gov/hcpb/species/t_e_spp/t_efish.pdf)

Without question, California has made great strides in coastal zone management in recent years, but further improvements are urgently needed, with an emphasis on ecosystem-based, watershed approaches that consider environmental, economic, and social concerns. By law, California now mandates an ecosystem approach to ocean management, but in practice, neither the funding or the ocean governance structure exists to make this legal mandate a reality. However, there are both regional and statewide examples of observing systems that have the potential to help move us towards an ecosystem approach. Below are examples of some of these systems.

Southern California Coastal Water Research Project

The Southern California Coastal Water Research Project (SCCWRP) is a joint-powers public agency whose mission is to conduct research that enhances the scientific understanding of how natural processes and anthropogenic factors interact to determine the health of the Southern California coastal environment. SCCWRP was formed in 1969 and is governed by a twelve-member Commission that represents a unique partnership of municipalities that discharge to the ocean and government organizations that regulate the discharge, working together through SCCWRP to develop a solid scientific foundation for coastal environment management in southern California.

SCCWRP's unique mix of member organizations allows it to bring disparate groups together to accomplish regional studies beyond the resources or technical capabilities of an individual organization. SCCWRP's periodic regional monitoring surveys, which cover more than 700 km of coastline, involve more than 50 organizations cooperatively sampling fish, benthos, microbiology and water quality at more than 300 sites throughout southern California. Not only do these surveys yield new information, but they serve as a catalyst for dialogue among these numerous parties about the ways that scientific information should affect management actions.

Coastal Ocean Currents Monitoring Program

Reflecting an understanding that ocean managers need better scientific information to make informed decisions about coastal resources, California recently committed $21 million towards the creation of a statewide ocean observing system, the Coastal Ocean Currents Monitoring Program (COCMP). COCMP is deploying instrumentation to monitor surface and subsurface currents, sea surface temperature, salinity, and chlorophyll, and will integrate information from data acquisition equipment deployed in

High frequency radar (HF Radar) is used to measure the direction and speed of surface currents near the coast, independent of fog or cloud cover. With instrumentation placed onshore, HF Radar allows one to get a complete map of surface currents without stepping foot aboard a boat or deploying an expensive array of current meters in the water.

A HF Radar system is based on the analysis of a reflected radio wave. A HF Radar site transmits a radio signal at a specific frequency over the surface of the ocean. Relying on the Doppler Shift, the signal reflected back is processed and used to measure the moving ocean surface. The Doppler shift explains the change in frequency of a signal scattered off a moving object, and can be used to determine if a scattering object is moving toward or away from an observer as well as the speed at which it is moving.

By measuring the reflected radio wave, the HF Radar system can determine the speed of the ocean waves that scatter the signal. From this wave speed a surface current can be calculated. To determine both speed and direction of surface currents in a region, at least two individual HF Radar are needed.

the ocean, onshore, and from satellites. Information generated by this system will help state, regional, and local agencies determine areas of contamination and pollutant transport in coastal waters, mitigate hazards, and manage California's living marine resources.

The State Coastal Conservancy, together with the State Water Resources Control Board, has developed a partnership of academic and government institutions working with industry and non-government organizations to design a real time monitoring system of surface currents along the State's 1100 miles of coastline.

COCMP will focus primarily on mapping currents in the upper one meter of ocean surface waters with high frequency radar (HF radar). HF radar is widely regarded as the most economical technology available to assess in near real time the physical and biological changes in the coastal ocean. Surface current maps of coastal waters in the U.S. exclusive economic zone (EEZ) and oceanic waters are a high priority for the national IOOS. Ocean.US has begun a surface current mapping initiative focusing specifically on HF radar technology for measuring surface currents in coastal waters. COCMP, the largest investment in coastal surface current mapping in the world, will advance this work of national importance.

The Conservancy selected the State's two regional observing systems (described later in this Section and *Appendix 3*) to operate COCMP. By 2008, an array of long range and standard range HF radar will be deployed along the entire California coastline. Higher resolution surface current mapping will be developed in San Francisco Bay. However, in order to better understand the movement of water throughout the water column, COCMP has been designed to provide ocean current monitoring infrastructure on a variety of space and time scales in a manner that is best suited for the broad range of regional and statewide needs. Data and information products will be made available in real-time where possible, and integrated with other data to enhance product development. This critical baseline information will also be incorporated into ocean circulation models to enhance our understanding of both large and small-scale ocean processes, and will serve as an incremental step towards the development of more accurate weather forecasting.

Funding for COCMP came from propositions 40 and 50 bond funds, which can only be used for the development of capital projects. The Conservancy is currently working with the regional associations to identify possible funding sources for the ongoing maintenance and operation of the system.

Cooperative Research and Assessment of Nearshore Ecosystems

Led by the Department of Fish and Game (DFG), the Cooperative Research and Assessment of Nearshore Ecosystems (CRANE) is collaboration to provide information needed to manage fisheries and evaluate marine protected areas (MPAs) in California's nearshore waters. In addition to DFG, participants include PISCO and other academic scientists, NOAA's National Marine Sanctuary Program, and the National Park Service. The program is designed to include both visual surveys by SCUBA divers and remotely operated vehicles (ROV), and surveys that use fishing gear for sampling. CRANE compares areas subject to different levels of fishing effort, including MPAs, to evaluate management and assess the long-term health of the nearshore environment. It is intended to provide much of the information needed to monitor marine reserves and other MPAs, evaluate fishery management, and distinguish between naturally occurring and human-caused changes in the nearshore environment.

The development of CRANE coincided with the formation of Channel Islands MPAs, and a large part of CRANE's initial effort has contributed to monitoring the effectiveness of these MPAs. CRANE scuba divers monitor additional sites along the mainland coast from Santa Cruz to San Diego.

To date, CRANE funding has only allowed scuba and ROV surveys at the Channel Islands MPAs and scuba surveys at several mainland sites. Surveys conducted by fishermen using fishing gear, essential for CRANE's success, have not been funded. However, two pilot studies to develop fishing gear survey protocols have been conducted by Sea Grant supported by Sea Grant, PISCO, and private funding. Additionally, for CRANE's information to be useful for fisheries management, Channel Islands MPA evaluation, and MPA design and evaluation under the Marine Life Protection Act process, DFG will need substantial assistance in converting the data already collected into information useful for management decisions.

Physical Oceanographic Real-Time System

The Physical Oceanographic Real-Time System (PORTS®) is a program of the NOAA National Ocean Service to support safe and cost-efficient navigation by providing real-time information required to avoid groundings and collisions. There are two existing PORTS in the California providing information in the San Francisco Bay area and around the Ports of Los Angeles and Long Beach. PORTS is a partnership between NOAA and the local maritime users: the locals ensure regular operations and maintenance, and NOAA brings the data into its system and produces real-time, quality-assured information on water levels, currents, and other oceanographic and meteorological data to the maritime user community. The information is relayed in a variety of formats, including telephone voice response and the Internet. In addition to real-time nowcasts, PORTS provides predictions with the use of circulation models.

PORTS is critical to environmental protection, since marine accidents can lead to hazardous material spills that can destroy a bay's ecosystem and the tourism, fishing, and other industries that depend on it. The system also provides critical information to the shippers in making sound decisions on passage timing and loading of ships that doesn't compromise passage safety. There are also many additional users of the system's data including recreational boaters, winder surfers and modelers. Information on the system and links to the San Francisco and Los Angeles/Long Beach PORTS can be found at: http://tidesandcurrents.noaa.gov/d_ports.html.

Mussel Watch

The California State Mussel Watch program was a surface water monitoring program conducted from 1977 to 2003 as a joint effort of the SWRCB and the DFG. Under the program, transplanted and resident mussels and clams were collected from the State's bays, harbors, and estuaries to be analyzed for trace elements, pesticides, and PCBs. In some areas, sediment quality and bioaccumulation in freshwater mollusks were also monitored. Sampling sites were selected by the coastal Regional Water Quality Control Boards (RWQCBs), targeting areas with known or suspected impaired water quality.

Mussel Watch fulfilled the goal of providing the State with long-term trends in the quality of coastal marine and estuarine waters. Because mussels are an indicator organism for trace metals and synthetic organic compounds in coastal and estuarine waters, they provide a glimpse of toxic pollutant levels present along the coast. The mussel populations of bays and estuaries that were monitored by Mussel Watch are different species than those found along the open coast, but were suitable as indicators because of their ubiquity along the State's coast, their ability to concentrate pollutants and provide a time-averaged sample, and their non-motile nature allowing a localized measurement of water quality.

Mussel Watch was a cost effective monitoring program compared to alternative sampling methods, such as seawater and sediment sampling. The program provided the SWRCB with a standardized statewide approach to monitoring for and evaluating incidences of toxic substances in marine waters. Due to a loss of funding, the Mussel Watch Program has been greatly reduced and is now incorporated in the Surface Water Ambient Monitoring Program (SWAMP; www.swrcb.ca.gov/swamp/programs.html), an ongoing statewide monitoring effort tasked to integrate existing water quality monitoring activities of the SWRCB and the RWQCBs, and to coordinate with other monitoring programs.

Coastal Sediment Management Workgroup

The Coastal Sediment Management Workgroup (CSMW, www.dbw.ca.gov/cswm/csmwhome.htm) is a taskforce of State and Federal agencies focused on regional solutions to coastal sediment issues that will protect California's natural resources. Co-chaired by the California Resources Agency and the US Army Corps of Engineers, CSMW is working to develop and implement a Sediment Master Plan (SMP), which addresses important concerns such as coastal erosion, excess sedimentation, littoral cell approaches to beach nourishment and other coastal projects, identification and protection of coastal (on-land and nearshore) biota and/or habitat, prioritization schemes for coastal projects, outreach and public education. Web-based mapping utilizing GIS will promote widespread dissemination of data gathered to characterize this critical portion of the oceanic environment. This information will provide valuable assistance to coastal planners, managers and other interested stakeholders in their decision-making process, and essential linkage between upland and offshore considerations.

California's Regional Associations

As discussed in Section III, the federal Integrated Ocean Observing System (IOOS) will consist of 11 Regional Associations (RAs) across the country (*see Appendix 1, Figure A1*). Due to two very different oceanographic regimes off the California coast and variation in regional priorities, it became evident that two distinct regional systems were needed in order to effectively address local concerns (e.g. water quality at our Southern California beaches, oil spill response in Northern California). These RAs were formed to coordinate and enhance the numerous, existing observing activities in their regions, and translate these observations into products that will provide a scientific basis for evaluating and improving management of our coastal resources. Working with state and federal partners, the two RAs are working together to assure that their systems compliment each other, and to create corresponding data products at various scales, covering the whole state as well as local bays and estuaries. As well as working together within the state, the two consortia are also collaborating with partners in Mexico and the Pacific Northwest (Northwest Association of Networked Ocean Observing Systems (NANOOS) and the Alaska Ocean Observing System (AOOS), and Pacific Islands Integrated Ocean Observing System (PacIOOS)) to ensure a unified west coast system that will allow for regional, ecosystem-based analysis.

SCCOOS

SCCOOS was formed by a consortium of 11 Southern California universities and laboratories that extends from Northern Baja California in Mexico to Morro Bay at the southern edge of central California (http://www.sccoos.org/). Its organizational structure includes an outside Senior Advisory Committee with over 20 key stakeholders from regional, State, and federal agencies as well as representation from multi-agency working groups. Water quality problems are especially acute in Southern California where 20 million people live within 50 miles of the coast. Beach usage is higher in Southern California than in the other 49 states combined and these popular beaches continue to experience more closures than any other area along the western coastline of North America. Consequently, SCCOOS is designing an observing system that will, among other things, lead to a better understanding of the transport processes that carry bacteria or other pathogens to the beach and provide for more timely warning of the start of beach contamination events. SCCOOS is also actively involved in observing the offshore climate and its relationship to fisheries for purposes of understanding natural and manmade variability of the State's biological resources.

CeNCOOS

CeNCOOS is a consortium of universities, state, local, and federal governments, industry, and nonprofit organizations, and covering the area from Point Conception northward to the Oregon border (http://www.cencoos.org/). The challenge faced by the northern consortium is how to cover such a large and geographically diverse region effectively, meeting the needs of highly populated areas and well used bays, as well as cover the most remote stretches of California that contain some of the state's most valuable marine resources.

By leveraging existing infrastructure, partnerships, and private, local, state, and federal resources, the RAs plan to develop a fully operational coastal observation system to address issues related to coastal water quality, marine life resources, and coastal hazards for end user communities in their regions. The RAs will make observations, collect real-time data, and develop models; convert these into products that are useful to the public, federal, state and local agencies, and organizations interested in the ocean; and solicit feedback from these users on how these products can be improved.

IV. STRENGTHENING CALIFORNIA'S COASTAL OCEAN OBSERVING SYSTEMS

California is facing three pressing questions in regard to integrated ocean observing systems:

- Does California have the ocean observing systems it needs?
- How can the State ensure that existing and future ocean observing systems truly benefit the people of California?
- How will the State identify and fund essential future ocean observing efforts that are not funded from federal sources?

Answers to those questions are not available, and answering them will be an ongoing process. But it is timely for the State to begin to address them. This section and the two that follow recommend a path toward that end.

California's coastal ocean observing system capabilities are ahead of, or competitive with, other states and regions, due in part to proactive State involvement and the resident expertise contained within the UC, CSU, and private university systems. As indicated in the previous section, we have many useful coastal ocean observing systems operated by a wealth of first-rate marine science institutions and regional, State, and federal agencies. California's two regional associations – SCCOOS and CeNCOOS – together cover the entire California coast and will be part of the national network of such associations. Also, the Pacific Coastal Ocean Observing System (PaCOOS) promises to play a significant role in monitoring fisheries and other biological resources within the California Current Large Marine Ecosystem (with a geographic focus spanning the U.S. Exclusive Economic Zone off the coasts of California, Oregon and Washington with international links to the portion of the California Current Ecosystem occurring in Canadian and Mexican waters).

The Missing Element

A strong, integrated ocean observing system is vital to ensuring the sustained recovery of our marine ecosystems. While examples of successful observing systems exist today, the missing piece for ocean observing in California is an entity that has a statewide perspective, is oriented toward those who can benefit from the information rather than those who operate the system, and is a funding source for the integrated whole. That is, <u>California requires an entity whose main purpose is to ensure that existing and new observing systems address the State's management priorities, benefit the greatest number of users, and are sustained over time</u>.

The State should take a lead role collaborating closely with the observing system operators in deciding what information is most vital to the long-term health of its coastal ocean. It has the greatest interest in the welfare of the people of California and faces a wide variety of ocean resource management concerns. Many of these concerns vary from one part of the coast to another, and some are statewide. Moreover, the State continues to make a large investment in ocean observing, from basic support for the university systems to direct support for coastal water quality monitoring, CalCOFI, COCMP, CRANE, and other efforts. The State's role would provide the lead in integrating existing efforts to meet the statewide needs not addressed by regional efforts.

Among coastal states, California has a unique challenge in integrating observing systems. Its long and diverse shoreline and its large, diverse and growing population necessitate regional foci to ensure that resources are appropriately distributed and that observing system efforts are coordinated at the appropriate scale. Having two RAs means that the State must work with the RAs to promote coordination across the various systems and regions. This is necessary to ensure that all agencies managing coastal and ocean resources have access to integrated data, products, and tools. In addition, to plan for future State investments, an entity should exist to aid in determining statewide priorities with goals and objectives that encompass the entire State. This entity would facilitate statewide two-way communications between the RAs, state agencies and the OPC.

There is a critical need for a unifying governance structure for the various ocean observing activities. With this understanding, the State Coastal Conservancy recommends the creation of a State-sponsored entity to work in close cooperation with the CeNCOOS and SCCOOS, with the primary purpose of systematically making linkages between observing system operators and those who apply the information from those systems. This State-sponsored entity should also be charged with assisting in State priority-setting, determining what observing system elements to fund and when, and securing federal or other funding.

V. Linking the Land and Sea through an Integrated California Ocean Observing System

From the beginning of the Conservancy involvement with COCMP and the IOOS process, advisors from management agencies and marine science institutions both in California and Washington DC have stressed the desirability of creating or designating some entity to organize statewide interests in ocean observing programs. Moreover, because ecosystem-based management is multi-disciplinary and involves a broad range of potential information customers, a similarly broad-based entity is critical to insuring that ocean observing systems are integrated and that information is presented in ways that can enhance management and increase public understanding. This falls beyond the scope of any single agency currently involved in coastal ocean management. Instead, a viable approach is to create an entrepreneurial entity that effectively assesses observing systems and mobilizes quickly to maximize collaboration, funding, and technological opportunities as they arise.

The previous section summarizes the Conservancy's analysis of the need for a State-sponsored entity. For discussion and planning purposes, the Conservancy has been calling this entity Ocean Science Applications (OSA).

The Conservancy recommends that the primary purposes of OSA be to help ensure that:

1. California has a strong, integrated ocean observing system;
2. Existing and new observing systems benefit the people of California; and
3. Adequate funding is secured for important ocean observing programs from both state and federal sources.

It is important to stress two things that OSA would *not* do: it would <u>not</u> operate observing systems; and it would <u>not</u> compete with observing system operators or the RAs for federal funding.

1. To help ensure that California has a strong, integrated ocean observing system, OSA would:

- Identify important management information needs that can be met through coastal and ocean observation systems.

- Work with CeNCOOS and SCCOOS to identify existing coast and ocean observation systems (*see Appendix 3*), the information they provide, and the existing or potential linkages between the available information and management needs.
- Identify unmet ocean observing system needs and potential duplication of observing systems and recommend ways to prioritize and fill unmet needs.
- Build on work already done by the RAs to complete a needs assessment for future ocean observing systems that responds to the State priorities.
- Periodically review and update the products of the previous four activities.
- Encourage collaborations among the public and private entities that conduct coast and ocean science programs.
- Represent State interests in integration of information across observing systems, between regions, and between California systems and the national IOOS program.
- Represent State interests in the development and maintenance of national data management and accessibility standards.
- Evaluate the implementation of State-funded ocean observing systems at the request of the funding agency, for example the COCMP.
- Work with appropriate advocacy groups to maximize sustained funding opportunities with coordinated strategies.

The first five activities above constitute much of what is needed for a California ocean observing strategic plan, as called for in "Protecting Our Ocean: California's Action Strategy." In a rapidly evolving field such as ocean observing, prioritization and needs assessments will be needed for many observing systems and technologies. These assessments will need to be revisited frequently as technologies improve and management policies evolve. The last four activities listed above are related to ongoing representation of State and statewide interests in prerequisites for effective and useful ocean observing.

Ocean current mapping illustrates the type of analysis needed. Ocean current data is useful for addressing many management concerns (*see Appendix 2*). Both surface and subsurface current information is needed to develop accurate ocean circulation and weather forecast models. The speed and direction of surface currents can vary significantly from subsurface currents, which also vary depending on depth. The State has invested in COCMP, an ambitious statewide ocean current monitoring program. While focusing heavily on surface currents, COCMP only includes subsurface current monitoring components in locations where outside observing assets are already concentrated or are being added to benefit COCMP. However, in the future, to build stronger models, more subsurface current monitoring will be needed. OSA, working closely with CeNCOOS, SCCOOS, and any potential beneficiaries of improved coastal ocean current models, would identify those gaps and recommend priorities for filling them.

Developing the initial analysis and maintaining it will require dedicated personnel with adequate knowledge of both ocean management needs and the potential of observing systems to affect the complex planning process. The ocean observing strategic plan would be drafted by OSA and would be submitted to the Ocean Protection Council for its review and approval.

2. To help ensure that existing and future ocean observing systems benefit the people of California, OSA would:

- Identify high-priority potential beneficiaries of observing system information and proactively encourage linkages between observing system operators and these beneficiaries.
- Promote integration of information from coastal and ocean science systems.
- Identify high-priority potential applications and assist with development of those applications.

As we enter an era of increasingly more data, and as we build useful systems to help observe our oceans, no agency, institution, or organization has focused on making information from this expanding field more useful throughout the state. While the RAs are charged with integrating data within their regions, there is no entity whose dominant perspective is that of ocean observing system information clients. There is no entity concerned with ensuring that information from disparate observing systems is being integrated and translated into applications that meet the State's highest priority needs, both public and private. OSA is proposed to fill that role.

Connections between observing system operators and users do occur now; this report described three of many possible examples in Section II. However, many more connections are possible. The Conservancy believes that the possibility of making observing system information useful would be greatly enhanced with systematic prospecting and development of linkages between system operators and information users. The greatest emphasis in that effort should be on identifying high-priority needs in ocean management that could likely benefit from ocean observing system information but currently are not. OSA could achieve economies of scale in coordinating users, ensure that overarching needs are given priority, and ease some of the problems faced by the RAs in trying to devise a user-responsive governance system while working on the technical problems of implementing effective and efficient observing systems.

These activities will require the closest possible collaboration between OSA, SCCOOS, and CeNCOOS. The focus of each of these entities is different. Whereas the two RAs and their member institutions should continue to make outreach efforts themselves (especially regarding regional analysis), their primary focus should be on the coordination of observing system operations. The primary emphasis for OSA would be outreach to those who can benefit from observing systems.

3. To ensure that there is adequate funding for important ocean observing programs that are not funded from federal sources, OSA would:

- Broaden support for useful ocean observing systems by carrying out the functions specified in Statement 2, and helping increase essential applications of observing system information.
- Inform and educate a wide array of the public, including State and federal decision-makers, educators, journalists, and others of the value of California's integrated ocean observing systems.
- Identify and secure sources of funding.
- Encourage increased funding for high priority observing system needs.

Here, again, it will be essential for OSA to collaborate with SCCOOS and CeNCOOS in providing its statewide perspective. One of the highest priorities will be to craft and deliver a united California viewpoint on ocean observing in a highly competitive federal process. Existing federal funding supporting California ocean observing efforts have not been developed as an integrated statewide process, resulting in ad-hoc regional successes and failures.

While the creation of an ocean observing strategic plan is a necessary first step for OSA and the State, the need for progress on some of the OSA functions listed above has become urgent and should not wait for completion of the plan. Examples of pressing, high priority activities include data management/integration and development of applications for CRANE and COCMP. Taking a lead role in these activities will ensure that the investment the State has made in these programs will result in useful products that reach a wide range of customers. The State should also participate at the federal level on issues related to funding strategies, data management, integration, and information dissemination. These activities could happen concurrently with creation of the strategic plan. Identifying funding sources and encouraging funding for high priority observing system would come out of the strategic plan process.

OSA and Marine Protected Areas: A Practical Example

The creation of a network of marine protected areas (MPAs) is currently one of the states best tools available for ecosystem-based management and assuring the success of MPAs will be critical to moving our ocean resources towards sustainability. OSA could play a significant role in ensuring the long-term success of its MPA network.

The Master Plan Framework recently prepared under the Marine Life Protection Act (MLPA) establishes requirements for monitoring the State's MPAs and for using the resulting data to adaptively manage some of California's most valued marine ecosystems and habitats. MLPA monitoring will evaluate performance of each particular MPA or MPA network relative to established management goals and objectives.

Operationally, monitoring and adaptive management of California's MPA system will require a distributed information system that provides for local and statewide data development, management, synthesis and communication. Management goals and objectives will determine what information it contains. Maintaining this focus on ecosystem-based management will require more than a "business as usual" approach to science – and is likely to involve new kinds of institutional arrangements among government agencies, planning bodies, and academic institutions.

As implementation of the MLPA brings new clarity to California's policy objectives for MPAs, a clear need has emerged for a State entity that can:

- Develop required monitoring data at individual MPAs and MPA networks.
- Conduct syntheses across multiple data resources and provide ongoing communication of results to local communities in order to ensure sound adaptive management of individual MPAs and MPA networks.

- Conduct statewide data syntheses and provide ongoing communication of results to policymakers, managers, and the public in order to ensure sound adaptive management of California's statewide MPA system.
- Coordinate and share data with other living marine resource management programs.
- Educate/train management personnel on the potential uses of these integrated data sets.

VI. Ocean Science Applications: How Should It be Organized?

Primary mission

As stated previously, the Conservancy recommends that the primary mission of OSA is to ensure that State investment into existing and new observing systems address the State's management priorities, benefit the greatest number of users, and are sustained over time.

Program

OSA would have three simultaneous initial program priorities:

- Complete an ocean observing strategic plan process within nine months.
- Advise the Conservancy and Ocean Protection Council on ocean observing issues and priorities.
- Assist COCMP and CRANE, two clear ocean observing priorities because of existing mandates with data management needs, the development of application and products, and the identification and development of sustained operational funding.

Governance

Alternatives for governance models include, in order of preference:

1. A program within the Coastal Conservancy. The Coastal Conservancy makes a logical choice to house this program primarily because of its ongoing involvement with COCMP and the federal IOOS process. Other benefits of initiating OSA within the Conservancy include: its non-regulatory mandate; its exclusive focus on coast and ocean issues; its broad range of program responsibilities; and its flexible granting procedures. Other state agencies that could house OSA include the Department of Fish and Game, Department of Parks and Recreation, State Lands and the State Water Resources Control Board.
2. Joint powers agreement. This should involve representation from State agencies as well as non-profits in order to combine public sector accountability with private sector flexibility. Federal agencies, particularly NOAA, should be included.
3. Independent non-profit organization. This option is not recommended because the Conservancy believes OSA needs strong State leadership to succeed.
4. Academic institution. This recommendation is not recommended because OSA activities should focus on user needs and academic institutions are traditionally observing system developers not operators.

Advisory committees and working groups

OSA could have an executive committee to advise on its programmatic agenda. This committee could include:

- Both observing system operators and those who use observing system information. Because OSA's focus is on applications, the emphasis should be on ocean resource management agencies and industries that benefit from observing systems.
- At least one statewide agency with broad interests in ocean observing science and its applications.
- A small number of other local, regional, or State agencies and private sector representatives that fund ocean observing systems.
- A non-profit partner.
- One representative each from SCCOOS and CeNCOOS.
- One representative each from the University of California and California State University systems.

It will be important for OSA to have broad involvement through the use of advisory committees and working groups. Advisory committees should be largely self-selecting, based primarily on interest in ocean observing system operations and benefits. Advisory group roles should include reviewing and commenting on plans and regular plan updates, advising on annual OSA work programs, and advising on selection of working groups. Examples could include legislative, scientific or outreach and education advisory committees.

Individual working groups should be *ad hoc*, formed to address a specific short-term need. An example might be linking observing system operators with potential users to explore development of a particular application (e.g. pollution tracking products from ocean currents and water quality data).

Personnel

The Conservancy envisions OSA as a small and flexible entity. OSA should have at least three highly competent staff to get it off the ground and to build it over the first one to three years:

- An executive director with strong experience integrating science and policy; scientific and policy literacy (specifically related to ocean observing); organizational-entrepreneurial abilities; excellent communication skills; and broad experience in State issues and agencies.
- A program manager to work directly with agency or industry staff, the RAs, and other observing system personnel on data management and application development issues; to develop business plan and plan updates; and to ensure the development of outreach materials oversee independent contractors.
- Administrative staff experienced in dealing with State agencies and contracts.

Budget

The Conservancy believes that initial OSA funding should cover staffing for a minimum of three years (in order to attract strong applicants), plus allow for consultant services for a variety of project needs: print and web-based outreach materials; data management questions; application development; and assistance with developing a strategic plan.

	2006	2007	2008	Capital	Operational
OSA infrastructure					
A. OSA staffing and organization	$75K	$100K	$150K		$350K
B. Ocean Observing Strategic Plan	$100K				$100K
C. Data mgt. & accessibility					
1. CRANE data mgt. & access	$50K	$100K	$100K	$100K	$200K
2. COCMP data mgt. & access	$50K	$50K	$50K		$150K
D. Applications development					
1. CRANE application development	$50K	$75K	$75K		$200K
2. COCMP application development	$50K	$100K	$150K		$350K
Total	$375K	$425K	$525K	$100K	$1,350 K

A strong, integrated ocean observing system is vital to ensure the sustained recovery of our marine ecosystems. California has substantially invested in ocean observing programs and has the responsibility to ensure that these investments result in better management of our living marine resources, and that the information is communicated to the largest audience possible. The State is positioned to be both a leader in the development of a useful ocean observing system and a prime beneficiary of an integrated system. The Conservancy is therefore recommending that California create the California Coastal Ocean Observing System (OSA), an entity whose primary mission would be to ensure that existing and new observing systems address the State's management priorities, benefit the greatest number of users, and are sustained over time.

APPENDIX 1:
THE GLOBAL AND NATIONAL CONTEXTS

Understanding recent initiatives to begin integrating ocean observing systems in California requires some familiarity with the related global and national contexts. Efforts at all three levels share a common vision: a world where the information needed by governments, industry, scientists, and the public to deal with ocean issues is provided by a network that integrates and distributes ocean observations and generates useful products.

Global Ocean Observing Programs: GOOS

The Intergovernmental Oceanographic Commission (IOC), a United Nations agency, started the Global Ocean Observing System (GOOS; http://ioc.unesco.org/goos/) in 1992. GOOS is providing descriptions of the present state of the oceans, including living resources; continuous forecasts of the future ocean conditions; and the basis for predictions of climate change.

GOOS information comes from large-scale ocean observing systems that are operated by participating nations, particularly the U.S., the European Union, and Japan.

GOOS operates under an international governing body whose primary purposes are to:

- Decide what global or ocean basin-scale data are the highest priority to acquire;
- Develop the strategy for the acquisition and exchange of data;
- Facilitate the development of data applications for the use and protection of the marine environment; and
- Ensure the integration of GOOS operations with wider global observation programs.

As the State Coastal Conservancy recommends in this report, California's interests in ocean observing would benefit greatly from an entity whose function is similar to that of the GOOS governing body.

United States Ocean Observing Programs: IOOS

The U.S. is organizing its national ocean observing efforts under the name Integrated Ocean Observing System (IOOS), an initiative of the National Oceanographic Partnership Program (NOPP). NOPP is a coordinating body of federal agencies with ocean observing interests. The member agencies most actively engaged in ocean observations are the National Oceanic and

> "The IOOS [Integrated Ocean Observing System] will substantially advance our ability to observe, monitor, and forecast ocean conditions and will contribute significantly to global Earth observing capabilities. The information generated by the IOOS will have invaluable economic, societal, and environmental benefits, including improved warnings of coastal and health hazards, more efficient use of living and nonliving resources, safer marine operations, and a better understanding of climate change."
> - U.S. Commission on Ocean Policy
> April 20 2004

Atmospheric Administration (NOAA), the National Aeronautic and Space Administration (NASA), the National Science Foundation (NSF), the Navy, and the Coast Guard.

In 2000, nine of the federal agencies involved in NOPP jointly formed the National Office for Integrated and Sustained Ocean Observations, commonly known as Ocean.US (www.ocean.us). The mission of Ocean.US is to coordinate the design and implementation of the national IOOS. The objectives of the IOOS are to provide information to help with the broadest range of ocean management concerns:

- Detect and forecast oceanic components of climate variability
- Facilitate safe and efficient marine operations
- Ensure national security
- Manage resources for sustainable use
- Preserve and restore healthy marine ecosystems
- Mitigate natural hazards
- Ensure public health

IOOS is being developed as two related and linked components: a global oceanic component, and a national coastal component.

> Although issues relevant to atmospheric observations and prediction are less complex than those required for integrating ocean observation systems, NOAA's National Weather Service provides a model for the development of the IOOS. NOAA Weather Service maintains a system of observations, data management and analysis designed to provide weather forecasts and warnings to the public. NOAA Weather Service also supplies meteorological data, in accordance with national standards, to private enterprise, scientists, and educators who generate value-added applications to meet specific needs.
>
> Unlike the history of weather observations that have always been centralized in one federal agency, ocean observing systems have been initiated and maintained by many different agencies, universities, private marine science institutes, and industries. Consequently, as Ocean.US documents describe the IOOS, "the process for establishing an integrated ocean observing system can be compared to assembling a patchwork quilt. Some pieces of the quilt already are in place, others are ready to be installed, and others have yet to be designed or imagined."

Global component of IOOS
The global component includes the U.S.-operated programs that are part of the GOOS international effort to improve our ability to detect and predict changes in the state of the global ocean for a wide variety of applications, to increase our understanding of the role of the ocean in global climate variability, and to improve forecasts of future climate. These observing systems are primarily of interest to agencies and industries concerned with the climate, defense, maritime commerce, research, and education sectors. Implementation is underway, but not complete.

Coastal component of IOOS
The coastal component of the IOOS will encompass the U.S. Exclusive Economic Zone (EEZ),

estuaries, and the Great Lakes. It is intended to be collaboration among state and federal agencies, industry, non-governmental organizations, and academia. IOOS is primarily concerned with the effects of weather, climate, and human activities on coastal environments, living resources, and people who live, work, and play in the coastal zone.

The coastal component is planned as a federation of regional observing systems nested in a federally supported "national backbone" of observations. Regional observing systems will contribute to and benefit from the national backbone. This approach reflects two important realities: environmental priorities vary among regions and states, but there are common requirements for data and data processing that transcend state and regional boundaries and provide a basis for achieving economies of scale.

Specifically, the national backbone will measure and manage a set of core variables required to detect and predict most of the phenomena of interest associated with the seven goals (listed above). However, it is important to emphasize that measurement of the core variables will not, by themselves, provide all of the data required for detecting or predicting all phenomena of interest. For instance, in the areas of public health, ecosystem health, and living marine resources, it is likely that more variables will have to be measured with greater resolution on regional scales.

Regional Associations

In the past few years, observing systems operators and data users have been organizing themselves into Regional Associations, an essential element in the national/regional partnership of the coastal IOOS. Under the Ocean.US plan, 11 Regional Associations will be responsible for the design and operation of their regional contributions to the national observing system (*see Figure A1*). A National Federation of Regional Associations will represent the regions at the federal level and coordinate their development according to the IOOS standards.

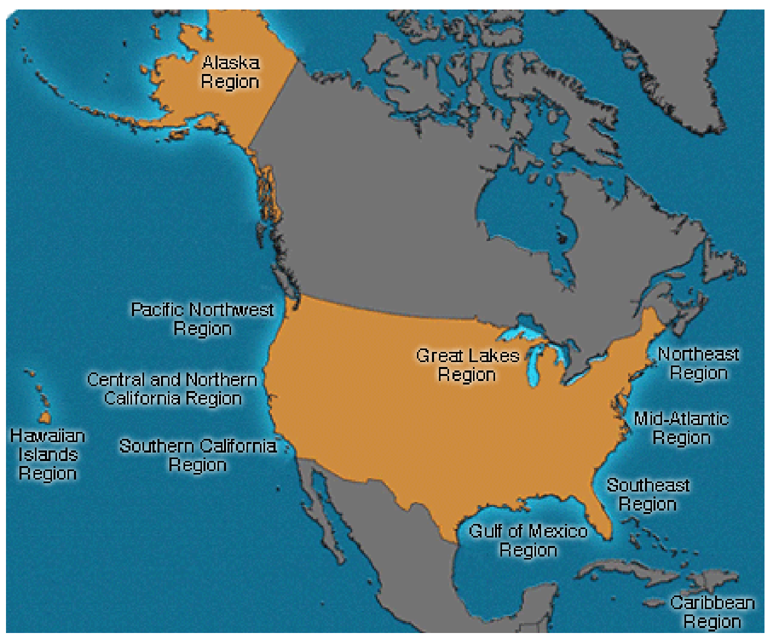

Figure A1. Eleven Regional Associations forming under IOOS

California has two emerging Regional Associations: the Southern California Coastal Ocean Observing System (SCCOOS; www.sccoos.org) covers the coast from Point Conception to the Mexican border, and the Central and Northern California Coastal Ocean Observing System (CeNCOOS; www.cencoos.org) encompasses the coast from Point Conception to the Oregon border. California's RAs are working together and with their partners to the north and south to expand their observations whenever possible.

SCCOOS and CeNCOOS are described in further detail in Section III and Appendix 3 because they are critical pieces in the California context of ocean observing.

One additional integrating initiative on the Pacific Coast important to note is the Pacific Coast Ocean Observing System (PaCOOS; www.pacoos.org), organized by NOAA, marine science institutions, and state fisheries agencies. PaCOOS extends along the entire California Current System, with international links to Canada and Mexico. Although this geographic scope is larger than that of SCCOOS or CeNCOOS, its observing focus is narrower. The PaCOOS mission is to provide the information needed for management of fishery resources, protected marine mammals, marine birds, and turtles, and to forecast the ecosystem consequences of fishing, environmental variability, and climate change. PaCOOS will also serve as the ecosystem observing backbone of the IOOS for the California Current Large Marine Ecosystem. This information and data will also be integrated in the regional associations work.

An integral part of the IOOS are those observations either supported or conducted by federal agencies. These programs help provide the nationwide backbone of common and comparable monitoring information for the benefit of the entire nation as well as provide resources to regional or local groups to enhance important monitoring efforts in those areas. Almost every federal agency that works in coastal and ocean areas has some involvement in providing data to these efforts, including (but not limited to) NOAA, NSF, the Office of Naval Research (ONR) and the Naval Research Laboratory (NRL), the Environmental Protection Agency, the Army Corps of Engineers, the Minerals Management Service, the U.S Coast Guard, U.S. Geological Survey, and the National Aeronautics and Space Administration (NASA). A few examples of the types of observations follow:

- NOAA maintains the National Water Level Network, which provide tides, currents, and water level information; the moored buoys and C-MAN stations, which measure meteorological and oceanographic information to support weather forecasting; and a variety of physical, chemical, and biological information around the country for managing our marine resources. NOAA also supports a number of regional coastal ocean observing systems in California, including the Center for Coastal Observation, Research, and Education (CI-CORE), the Center for Integrated Marine Technologies (CIMT), SCCOOS, and in through the National Estuarine Research Reserves, the System Wide Monitoring Program. NOAA also supports the two emerging RAs in California and the other nine around the country.

- NSF supports the Long-Term Ecological Research (LTER) program, fundamental ecological research that requires long time periods and large spatial scales, and has two programs in California: the Santa Barbara Coastal and the California Current Ecosystem. The NSF Ocean Observing Initiative also funds the Ocean Research Interactive Observatory Networks (ORION), which aims to improve ocean observatories, including a cabled sea floor network, deep sea buoys, and enhancements to existing observations. NSF is also the federal agency leading the development of the land side equivalent to IOOS, the National Ecological Observatory Network (NEON).

- Other agency activities in California include the stream gauge network operated by USGS and the wave measurements supported by the Army Corps of Engineers.

All told, federal agency support for integrated ocean observing systems across the country and the globe total in the hundreds of millions of dollars. Additionally, increasing amounts of resources are being provided to regional efforts; NOAA awarded approximately $5 million this year alone to California institutions in support of ocean observing efforts. If passed, congressional bills will authorize additional funding for IOOS efforts across the country at both the national and regional levels.

APPENDIX 2: COASTAL RESOURCE ISSUES FACING CALIFORNIA

Our understanding of coastal waters has not kept pace with the economic needs associated with this resource. As millions of Californians and visitors enjoy the benefits of the ocean – each deriving benefit in multiple ways – our ability to manage these resources is compromised. Without better information on how natural processes interact with anthropogenic factors, the health of our oceans will continue to deteriorate. Ocean resource management must evolve with the changing needs of society, respond to new developments in technology, and prioritize better scientific information. This evolution towards ecosystem-based management of our living marine resource cannot happen without an integrated ocean observing system.

The following selection of ocean management concerns that will benefit from an integrated ocean observing system is not exhaustive, but provides a range of issues confronting California today.

Coastal Water Quality

Coastal waters are one of California's greatest assets, yet they are being bombarded with pollutants from a variety of sources. Clean oceans are central to our quality of life for recreation, consumption, and other marine resource uses, and therefore water quality problems create some of the most complex management challenges today. Sources of pollution into the marine environment are many and diverse. For example, beach closures due to sewage release have become a common problem in Southern California, affecting human health and impacting the regional economy. An innovative surface current monitoring program in Imperial Beach was put in place to increase warning times and consequently reduced risk of human exposure (*see page 6*). Once the system is fully operational and patterns have been detected, the timing of effluent releases could also be synchronized to the appropriate oceanographic conditions.

While progress has been made in reducing point sources of pollution, nonpoint source pollution has increased and is the primary cause of nutrient enrichment, hypoxia, harmful algal blooms, toxic contamination, and other problems that plague coastal waters. Nearly all California cities or counties now have stormwater monitoring programs to address urban nonpoint source runoff. And in the central coast, the Monterey Bay National Marine Sanctuary and the Central Coast Regional Water Quality Control Board are working with the Farm Bureau, local jurisdictions and landowners to reduce nonpoint source runoff from agricultural lands through the use of best management practices. However, a better understanding of the fate of urban and rural surface pollution is essential to managing how these events impact coastal water quality.

A more subtle form of coastal pollution, but one of great concern, is the emergence of marine diseases affecting both humans and marine wildlife. Examples of diseases showing up in coastal waters are toxoplasmosis, which is proving lethal to sea otters; and Norwalk virus that can bio-accumulate in oysters. Both these diseases have significant implications for human health and can be traced to feral or domestic cats or other terrestrial mammals living along the coast.

Naturally occurring harmful algal blooms (HABs), which concentrate biotoxins in shellfish, are potentially fatal when ingested by humans and other organisms, and require intensive annual monitoring by state and county health agencies. Better monitoring will, over time, create an understanding of the physical and biological processes that give rise to harmful algal blooms, and allow for their prediction.

Sustainable Fisheries

More than 70% of U.S. commercial fishery stocks are considered fully exploited, overfished or collapsed. In the past decade, scientists have gained a new understanding of the critical linkages between physical and biological processes in coastal oceans (*see Sardine story in Section II*). These linked processes underlie ocean productivity that drives marine food chains – necessary for salmon recovery and the management of other near shore commercially important fisheries. Addressing the basis of ocean carrying capacity is an essential approach to a multi–species integrated ecosystem management goal. This type of management requires better information about ocean conditions and annual variability. California already has the laws and regulations in place to move fishery management away from the more traditional single species management and towards ecosystem management, but what it lacks is the kind of knowledge base an integrated ocean observing system can provide. The goal is to reduce uncertainty and risk to precious resources, and to provide sound information to support sustainable management.

Marine Protected Areas

California initiated a new era in ecosystem management with the passage of the Marine Life Management Act (MLMA) in 1998 and the Marine Life Protection Act (MLPA) in 1999. Rather than focusing on single-species management, the MLMA mandates an ecosystem-based approach. The MLPA requires explicit consideration of marine protected areas (MPAs) as one of several complementary management approaches for conserving nearshore marine ecosystems. When designed effectively and managed adaptively, MPAs will help the state's most important marine ecosystems to thrive, while potentially enhancing fisheries and other uses beyond their boundaries. Moreover, the protected status of MPAs will, in time, make it possible to understand whether changes outside MPAs are due to human impacts or natural causes. Thus the state's MPAs will become crucial scientific reference sites for understanding coastal ecosystems and for managing human uses.

The MLPA requires the adoption of a comprehensive plan for installing a network of MPAs in State waters, using a scientifically sound process for siting and designing marine reserves and other types of MPAs. High resolution sea floor mapping is critical in determining habitats most suitable for MPAs and these maps are still needed along a majority of California's coastline. Sustained monitoring within and around an MPA is a crucial element to determining if the ecosystem objectives for which the MPA was established are being met. However, funding for sustained long-term monitoring is often difficult to secure.

In 2003, 12 MPAs were established around the Channel Islands. Determining the effectiveness of this design will help with future placement of MPAs along the coast. The Cooperative Research and

Assessment of Nearshore Ecosystems (CRANE), a program lead by the Department of Fish and Game, was created to design and develop a statewide nearshore rocky-reef monitoring network, focusing initially on the Channel Islands MPAs. However, CRANE has never been fully funded and has struggled to accomplish its objectives.

The California Resources Agency and California Department of Fish and Game are currently partnering with the Resources Legacy Fund Foundation and others in a new initiative to create MPAs along the central coast. This public-private partnership will result in recommendations for MPA designations to the Fish and Game Commission by the end of 2005. Improved ocean observations in support of these efforts will aid in the future siting, design, and evaluation of MPAs.

Sediment Management

Sediment management is of increasing concern in coastal oceans and estuaries, combining issues related to economic development, living marine resources, and human and marine wildlife health. The California Sediment Management Workgroup was formed by the Resources Agency and the U.S. Army Corps of Engineers to facilitate regional approaches to protecting, enhancing and restoring California's coastal beaches and watersheds through federal, state and local cooperative efforts. This workgroup will soon release the California Coastal Sediment Management Master Plan, a strategic plan to address the State coastal sediment management needs.

Some of the key issues related to sediment management include beach nourishment, coastal erosion, dam removal, and dredging. Beach nourishment and depletion is a major issue for California, particularly along the southern coast. The California Beach Restoration Study, produced by Department of Boating and Waterways in 2002 found that California's beaches generate over $15 billion annually in tax revenue, but to protect and restore these beaches, California needs to invest $120 million in one-time beach nourishment costs and $27 million in annual beach maintenance costs.

Bulkheads, seawalls and other structures created to prevent coastal erosion can sometimes result in surprising consequences, including accelerated beach erosion (*see Ocean Beach story, Section II*). These structures are often placed in areas where there is significant wave action. In many cases, the placement of sand on these beaches will only be a temporary solution.

Other sediment issues concern the movement and dispersal of sediment "plugs" locked behind dams. Coastal dams prevent over one quarter of the average annual volume of sand supplied by streams from reaching the beaches. As dams are selectively removed via stream restoration activities, it is critical to understand the fate of this material once it reaches the coast. For example, the Matilija Dam on the Ventura River, due to be decommissioned by 2012, currently traps 5.9 million cubic yards of sediment. Baseline monitoring now, as well as after the decommissioning, will be a vital determinant to understanding the impact to the nearshore environment.

Levee Maintenance

Hurricane Katrina has created new and heightened awareness concerning California's vulnerable levee system. The State's 1600 mile inland levee system contains 700 miles of structural questionable levees. Governor Schwarzenegger, Senator Feistein and Congressman Pombo are collaboratively addressing options to address the State's vulnerable levee system, which deliver two-third's of California's water supply and protectes billions of dollars of developed Central Valley land from flooding.

As the State attempts to mobilize resources for levee repair and maintenance, it is important that it examine how existing and proposed programs can assist in assessing risk and increasing predictive capability. This is particularly important as we enter an era of uncertainty arising from global change.

Indeed, California requires better information tools to address the potential threats of early Sierra snow melt and runoff, increased tide levels, and storm events. If such events occurred simultaneously, serious disaster could result. Further, during the 1997-98 El Nino, the Bay Area experienced significantly higher tides than were predicted with existing equipment as a result of ocean thermal expansion in the Eastern Pacific.

El Nino events typically focus attention on possible and realized coastal impacts. However, the accompanying extreme tides and wind driven waves that severe weather events deliver can have devastating effects on the state's levee system. This is especially true when combined with the Sierra and Central Valley flood pulses that scientists predict will increase with global warming. Ocean observing information products could help managers deal with these potential disasters by providing more precise tide, weather, and climate prediction while also supporting routine port and maritime operations.

The synergistic tasks necessary to maximize the application and benefit of this information will flow from the State's investment in ocean observing systems. Developing appropriate information products useful to the broadest range of applications and users is the central feature of California's ocean observing strategic plan.

APPENDIX 3:
CENCOOS AND SCCOOS: WHAT'S INCLUDED

CENTRAL AND NORTHERN COASTAL OCEAN OBSERVING SYSTEM
(www.cencoos.org)

Example Ocean Observing Activities in the CeNCOOS Region

Coastal Ocean Currents Monitoring Program – Northern California: Real-time data on coastal currents provided by CeNCOOS partners throughout the entire CeNCOOS region by high frequency radar. The real-time data will also be used in models to estimate surf zone and three-dimensional circulation. The data will also be combined with other data sources, such as satellite imagery and in-situ data. *www.cocmp.org*

NOAA West Coast CoastWatch (WCCW): Provides near real-time ocean satellite remote sensing data and satellite-derived data products for the Pacific west coast. Relocated from southern California in 2002 to the NOAA Fisheries Environmental Laboratory in Pacific Grove, CA, and funded by NOAA NESDIS. Suite of ocean satellite-based data expanded in 2002 to include information from satellite sensors measuring ocean color, ocean winds and ocean height, in addition to SST data products that have been distributed since 1992. *http://coastwatch.pfel.noaa.gov/*

Historical time series data, 1929-present: Hydrographic data from historical Monterey Bay stations provide climatologies and decade-scale trends. The time series is maintained and extended through the efforts of Hopkins Marine Station (HMS), California Cooperative Fisheries Investigations (CalCOFI), Moss Landing Marine Labs (MLML), Naval Postgraduate School (NPS), Monterey Bay Aquarium Research Institute (MBARI), University of California at Santa Cruz (UCSC).

Mooring and shipboard Monterey Bay time series, 1989-present: Annual and ENSO variability is being documented with bio-optical, physical, and meteorological, chemical and biological time series data from both mooring and shipboard programs ("M" stations). MBARI maintains the time series, with funding from the David and Lucile Packard Foundation. *http://www.mbari.org/moos/*

Line 67 time series cruises, 1997-present: Annual and ENSO variability of the California Current system is examined with biological, chemical and physical measurements along CalCOFI Line 67 to 275 km offshore through a joint effort between the NPS and MBARI.

Juvenile rockfish surveys, 1985-present: The National Marine Fisheries Service (NMFS) examines larval and juvenile rockfish distributions with springtime CTD and trawl surveys from Bodega Bay to Point Sur. *http://swfsc.nmfs.noaa.gov/*

Acoustic array, late 1980's-2000: The U.S. Navy monitored low frequency ocean acoustic signals off Point Sur, with initial plans for future acoustic and oceanographic measurements.

HF Radar, 1994-present: Improvements to HF radar hardware and software allow examination of circulation in Monterey Bay and the adjacent coastal ocean. This effort is led by NPS, California State University at Monterey Bay (CSUMB) and Oregon State University. *http://newark.cms.udel.edu/~brucel/realtimemaps/*

Monterey Accelerated Research System (MARS), 2002-present: NSF has funded MBARI to install a fiber-optic underwater observatory to serve as a national facility for testing new instruments, deployment protocols, and experimental procedures for using cabled underwater observatories. MARS will provide high power and high bandwidth for research in deep Monterey Bay waters. Installation is expected in 2005. *http://www.mbari.org/mars/*

Autonomous Ocean Sampling Network (AOSN), 2002-present: This Navy-funded effort is developing a real-time adaptive and predictive observational/modeling system using autonomous mobile assets in Monterey Bay and contiguous water of the California Current. MBARI leads 10 institutions in this project. *http://www.mbari.org/aosn/*

Wind-to-Whales/Center for Integrated Marine Technology (CIMT), 1997/2002-present: This NOAA-Coastal Observation Technology (COTS) project combines emerging technologies to analyze the processes underlying coastal upwelling dynamics along the California coast and develop protocols for integrating and visualizing data by managers. UCSC leads the effort, which includes NPS, MBARI, MLML, NMFS, JPL, Cornell, and MBNMS. *http://cimt.ucsc.edu/siteNew/*

Innovative Coastal-Ocean Observing Network (ICON), 1998-2000: This NOPP-funded project supported a partnership to observe coastal oceanographic data, retrieve the data in near-real time, assimilate the data into coastal models, and predict future states of the system. The acquisition network included moorings, acoustic tomography, satellite temperature and color, HF radar, and shipboard surveys. NPS, MBARI, CSUMB, Hobi Labs, and 4 other partners. *http://www.oc.nps.navy.mil/~icon/*

Simulations of Coastal Ocean Physics and Ecosystems (SCOPE), 2000-present: The goal of this ICON-follow-up, also funded by NOPP, is to provide high spatial and temporal resolution modeling of the coastal upwelling ecosystem within the MBNMS. The model incorporates interconnected physical, chemical, and biological processes and assimilates data from real time sensors. This MBARI-led effort includes the MBNMS, NPS, JPL, UCLA, UCSC, NRL, Hobi Labs, and several other partners. *http://www.mbari.org/bog/nopp*

Regional Monitoring Program for Trace Substances in the San Francisco Estuary (RMP), 1993 - present: The RMP is the primary source of information used to evaluate chemical contamination in the Bay. The RMP focuses on determining spatial patterns and long term trends through sampling of water, sediment, bivalves, and fish, effects on sensitive organisms, and chemical loading to the Bay, and seeks to synthesize RMP data with data from other sources to provide the most complete assessment possible of chemical contamination in the Bay. The RMP is a cooperative effort of the San Francisco Estuary Institute, the Region 2 Water Quality Control Board and the regulated discharger community.

Center for Integrative Coastal Observation, Research and Education (CICORE), 2002-present: With funding from NOAA-COTS, a consortium of California State Universities is establishing a nearshore observatory (working within the 100 m isobath) distributed along the entire 1760 km of California coastline. This observatory will help address a variety of challenges to coastal environmental quality, including watershed alteration, erosion, chemical contamination, depletion of fish stocks, toxic plankton blooms, marine-borne pathogens, and non-indigenous species. The three technologies being used are hyperspectral imagery, multibeam bathymetry, and pier-based in situ sampling. *http://www.mlml.calstate.edu/cicore/index.html*

Alliance for Coastal Technologies (ACT): This program, sponsored by NOAA-COTS, is developing and applying sensor technologies for monitoring coastal environments. MLML and MBARI together are one of the 5 partner institutions, and the only ones on the West Coast. *http://www.actonline.ws/*

Sanctuary Integrated Monitoring Network (SIMoN), 1999-present: The specific goals of SIMoN are to integrate existing monitoring conducted in the MBNMS, initiate basic surveys of habitats of the MBNMS, establish long-term or targeted monitoring efforts to fill in critical gaps, and provide timely and pertinent information to managers and decision makers, the research community, and the general public. The SIMoN web site is intended to serve as a portal for many end users of results from many ocean observing activities in the central California region. Funding for SIMoN is supplied by NOAA, the Packard Foundation, and Duke Energy. *http://www.mbnms-simon.org*

Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO), 2000-present: With funding from the David and Lucile Packard Foundation and the Gordon and Betty Moore Foundation, this project integrates long-term monitoring of ecological and oceanographic processes at dozens of coastal sites with experimental work in the lab and field. PISCO's results are applied to issues of ocean conservation and management, and are shared through public outreach and student training programs. Led by Oregon State University, UCSC, UCSB and HMS are partners. *http://piscoweb.org/index.html*

Tagging of Pacific Pelagics (ToPP): Marine biologists from HMS are using archiving tags attached to fish, marine mammals and birds in the North Pacific to learn how they use the ocean environment. The project is funded by the Census of Marine Life. http://las.pfeg.noaa.gov:8081/las_TOPP1/servlets/dataset

Rapid Environmental Assessment Laboratory (REAL), 1999-present: NPS is developing a research and teaching laboratory focused on long-term, cross-shelf wave observations, bottom boundary/bedform measurements, and inner shelf current measurements. *http://www.oc.nps.navy.mil/~stanton/miso/*

San Francisco Physical Oceanographic Real-Time System, 1997 - present: This system, installed by NOAA, provides real-time data on winds, currents, tides, water temperature, air temperature, and air pressure in San Francisco Bay. SFPORTS is now a partnership of NOAA, USGS, the Office of Spill Prevention and Response, and the San Francisco Marine Exchange. *http://co-ops.nos.noaa.gov/d_ports.html*

Bodega Marine Lab's Coastal Observing System, 1967-present: continuously monitors meteorological and oceanographic conditions on the Bodega Marine Reserve and currents in the coastal waters of Marin and Sonoma Counties. The data acquisition system was automated in 1988 and expanded several times to measure additional parameters and apply new technologies such as coastal radar. Data archives are queriable over the internet. The resulting data sets describe the climatological context for all field studies at the site and are a central element of many research and resource management programs. *http://www.bml.ucdavis.edu/envdata/*

Education and Research Testing Hypothesis (EARTH), 2002-present – EARTH is a collaboration of the Monterey Bay Aquarium and MBARI. It provides teachers with means for integrating real-time data with existing educational standards and tested curriculum in an interactive and engaging way. EARTH will use near-real-time data from the ocean observatory to design and test outreach with the Internet as an interface to scientists, teachers, students, and the public. *http://www.mbari.org/education/earth/*

SOUTHERN CALIFORNIA OCEAN OBSERVING SYSTEM (SCCOOS)

www.sccoos.org

This document describes a) the implementation of observing system components and b) existing/ planned data integration activities and/or other observing system programs in Southern California.

California Ocean Current Monitoring Program (COCMP)

SCCOOS is implementing the Southern California component of the California Ocean Current Monitoring Program (COCMP) funded by the State Conservancy. COCMP is made possible by voter approval of Proposition 40 and 50 which funds the infrastructure to establish a modeling and observation system for coastal circulation. The program is in accords with the California Ocean Protection Council plan for improving ocean observations and natural resource management along the coastline. www.cocmp.org

NOAA Coastal Ocean Technology System (COTS)

The Coastal Observation Technology System (COTS) funds SCCOOS to deploy, maintain, and evaluate new sensors and information technologies as part of a pilot program to create an integrated, multi-disciplinary coastal observatory in the Southern California Bight. NOAA funds this grant to further development of the country's Integrated Ocean Observing System (IOOS – www.ocean.us), with SCCOOS being one of two federally recognized regional associations within California.

Automated Shore Stations

Automated shore stations are attached to piers at several locations and contain sensors for automated measurement of temperature, salinity, and water level. A few limited sites have expanded sensor suites for measurement of biological parameters, nutrients and water quality. The data provides local and regional information on mixing and upwelling, land runoff, and algal blooms. One goal for the automated shore stations under SCCOOS is the expansion of both instrumentation and measurement locations.

Manual Shore Station Program

This program consists of temperature and salinity measurements at several volunteer shore stations along the coast of California, with the earliest station dating back to 1916. The continued operation of this long term record offers local and regional insights on the impact of climate change. Samples collected by the manual shore station program require laboratory analyses. At present, time series of chlorophyll, nutrients, and chemical constituents indicative of harmful algal blooms are maintained at a limited number of shore sites. This project is supported by both California Department of Boating and Waterways and NOAA.

Remote Sensing

SCCOOS acquires, processes, integrates and stores multi-parameter satellite data and imagery at the highest resolution possible. Multi-sensor satellite data provide a synoptic view of ocean-surface physical and biogeochemical properties essential to assessing and predicting important fields (e.g., sea surface temperature, ocean temperature, offshore winds, water quality, algal blooms). Available products are (1) *standard* – data products (e.g., chlorophyll-a) provided by space agencies, (2) *derived* – higher-level products that utilize existing techniques (e.g., primary productivity), and (3) *information products* – derived from standard or derived products to provide integrated indicators of ecosystem health and productivity, typically of a provisional, non-calibrated nature, but of high value to agency users (e.g., spatial and temporal tracking of storm water runoff).

High Frequency (HF) Radars
SCCOOS installs, operates and maintains a system of high frequency (HF) radars for monitoring surface currents and creating surface current maps in near real-time. The data can be used to determine the transport and fate of surface constituents, such as oil due to a spill, planktonic populations (red tide or larvae), and freshwater outflow from broken sewage lines or river outflow. The data is also of interest to the US Coast Guard, lifeguards, and the marine safety community for search and rescue applications.

Coastal Ocean Modeling
SCCOOS incorporates data into computer models to forecast coastal ocean conditions. Models can be used to forecast ocean transport pathways, such as those responsible for the circulation of coastal pollutants, small marine organisms, and nutrients. Models also aid in assessing variability induced by climate change its potential effects on coastal communities. Long term measurements, like those collected at SCCOOS moorings, shore stations, and HF radar sites, are instrumental in providing high quality input to these regional coastal models.

Coastal Wind Modeling
The measurement and forecasting of coastal winds are important for both identifying at-sea hazardous conditions, coastline conditions, and for input to drive ocean circulation and wave models. SCCOOS supports the operation of wind models for the region, receives forecasted wind models from the Naval Research Laboratory, and accesses data from a network of coastal wind sensors.

Gliders
Gliders survey specific areas of the ocean, collecting an array of data en route. They are designed to start at the surface of the ocean, glide down to the ocean floor or a predefined depth, and then return to the surface while sampling ocean properties with automated sensors. These instruments can provide SCCOOS with data about the ocean when the conditions may not be suitable forship-based or space-borne (satellite) sampling. Gliders have been funded by COCMP to monitor currents in three dimensions essential fro HF radar model validation and the NOAA MERHAB program to monitor harmful algal blooms.

Moorings
Moorings serve as a fixed platform for measurements of surface and internal ocean conditions. Parameters include water temperature, salinity, turbidity, chlorophyll, nutrients, speed and direction of currents, as well as surface meteorological variables such as wind speed and direction, air temperature, and barometric pressure. Data is transferred to shore via frequent electronic transmissions from the surface of the mooring. Mooring data is useful for making model forecasts and in analysis of long-term ocean trends. At present, moorings exist in San Diego, Santa Monica Bay, and Santa Barbara.

Underway CTD
SCCOOS will make repeated CTD tows between Point Conception and San Diego, with continuous sampling between the 100 and 30 m isobaths. Bongo-net tows are taken in addition at 8 CTD

stations.. These along-shore transects serve to (1) fill in data gaps, (2) validate other data (e.g., temperature, chlorophyll and turbidity from the remote sensing component) and (3)characterize nearshore fish habitat by monitoring populations of fish and plankton.

REMUS Autonomous Underwater Vehicles (AUVS)
A REMUS underwater vehicle is an eighty pound robot which can swim pre-programmed tracks with upward and downward looking current meters and sensors for rapidly sampling ocean properties including temperature, salinity, dissolved oxygen, bioluminescence, and multi-spectral optics. These vehicles make routine autonomous transects out to 20 km offshore but are deployed particularly to monitor special events such as heavy river outflows following heavy rain, or red tides. Equipped with side scan sonars, the vehicles can also rapidly survey benthic habitats.

Ship-based sampling
Ship-based sampling programs are supported for those oceanic variables which can not be measured easily from moorings or autonomous vehicles. At present, ship-based programs exist in both the Santa Monica Bay region, as well as extended CALCOFI stations which enables overlap with measurements made closer to shore, such as NPDES permit monitoring.

Data Management
SCCOOS is developing a state-of-the art data management system to allow storage, archiving, and online retrieval of all measurements made by SCCOOS and participating organizations.

Education and Outreach
SCCOOS is working with aquaria, the Ocean Institute, and National Science Foundation sponsored Centers for Ocean Sciences Education Excellence (COSEE) to develop E&O materials. The Beckman foundation has sponsored the generation and distribution of 5th grade science education program based upon SCCOOS that meets State curriculum standards. The program will initially be distributed to over 15,000 students in Los Angeles schools.

SCCOOS data integration activities and other pre-existing observing system programs (not complete)

NPDES Monitoring
NPDES monitoring data and shoreline water quality data. Data collection is pursuant to the Water Quality Act (WQA), which requires the state EPA to issue a National Pollutant Discharge Elimination System (NPDES) permit and to monitor all significant dischargers, including storm water runoff. At present, both ship-based sampling of the ocean (CTD) data and indicator bacteria data are being provided to the SCCOOS data management system for planned integration with other observations. Data are typically provided 60 days after collection to allow for QA/QC.

AB411 Shoreline Monitoring
The passage of Assembly Bill AB411 in 1997 now requires the monitoring of shoreline water quality data for indicator bacteria species that are representative of human health risks (enterrococus, total and fecal coliform). These data are typically obtained or provided on a regular basis by county agencies in Southern California at approximately 364 beach sites (less during winter months). SCCOOS is making arrangements with these counties' agencies to access, integrate, and display the

data alongside other observing system data streams to facilitate the development of decision making tools. Five counties in the region already provide data to the SCCOOS data management system on a weekly basis and GIS based tools are in development.

CALCOFI
California Cooperative Oceanic Fisheries Investigations (CalCOFI – www.calcofi.org) is a collaborative project between the California Department of Fish and Game, the NOAA Fisheries Service and the Scripps Institution of Oceanography and has been in existence since 1949. Originally developed in response to the collapse of the sardine populations off the coast of California, its focus has broadened to include observations and science of the marine environment to aid in the management of all living resources.

Southern California Long Term Ecological Research (LTER)
The California Current Ecosystem (CCE) LTER site (http://www.lternet.edu/sites/cce/) is a new collaborative effort for investigating ecological processes over long temporal and broad spatial scales where individual or localized interdisciplinary research teams focus on specific ecosystems. The CCE represents a pelagic coastal upwelling biome and one of the most biologically productive coastal ecosystems in the world. Research at this site will focus on mechanisms leading to transitions over time, CalCOFI observations, the effects of external factors in forcing alterations to this ecosystem, such as warming trends, the Pacific Decadal Oscillation, and the year-to-year temperature fluctuations dominated by El Niño. Sponsored by the National Science Foundation, the program is based out of Scripps.

PACOOS
The Pacific Coast Ocean Observing System (PaCOOS www.pacoos.org) is an alliance of scientists from west coast NOAA fisheries offices, academic institutions, state fisheries agencies, and other organizations on the west coast to develop a practical backbone of physical and biological marine-observation that supports fishery resources and protection of marine species within the California Current Large Marine Ecosystem.

Coastal Data Information Program (CDIP)
The Coastal Data Information Program (CDIP – http://cdip.ucsd.edu/) provides observations, model forecasts, and historical archives of wave conditions in California. Started in 1975, the CDIP is a collaborative program between Scripps, the U.S. Army Corp of Engineers, and California Dept. of Boating and Waterways.

Southern California Beach Processes (SCBPS) Study
Funded by the U.S. Army Corps of Engineers, the Southern California Beach Processes Study (SCBPS) uses state-of-the-art techniques, including airborne lidar terrain mapping, imagery, and bathymetry mapping jetskis for seasonal mapping of beach sediment volumes and cliffs in Southern California. These observations are used to develop and test regional sand management models. SCBPS seeks to improve the cost, efficiency, and efficacy of future coastal engineering, beach nourishment, and management projects by characterizing the response of the beach to waves. (http://cdip.ucsd.edu/SCBPS/)

LA County Watch the Water Program
A project which provides public access to beach conditions in the Los Angeles County region (www.watchthewater.org). Data collected include water temperature, wind speed and direction, surf, sun, air and tide conditions. The system serves as a public front end to coastal conditions and has received technical support from LA County, CDIP, SCCOOS, and USC SeaGrant.

National Estuarine Research Reserve (NERR) at Tijuana Estuary
The Tijuana NERR is part of the National Estuarine Research Reserve system, a nationwide wetland restoration program to reverse the effects of flood, erosion, sedimentation, storm, fire, and pollution on the river and estuaries. These systems are vital to maintaining a clean watershed, good water quality, and fish populations along the coast. The programs also promote global stewardship of the world's oceans and atmosphere through science and service.

The Tijuana Estuary NERR is funded by the State Conservancy, Fish and Game, and NOAA for the Tijuana Estuary Tidal Restoration Program (TETRP).
(http://nerrs.noaa.gov/TijuanaRiver/welcome.html)

NOAA National Data Buoy Center (NDBC)
The National Data Buoy Center (http://www.ndbc.noaa.gov/) provides hourly observations from a network of offshore buoys and Coastal Marine Automated Network (C-MAN) stations to observe and forecast meteorological conditions for commercial and recreational activities. All stations measure wind speed, direction, and gust, barometric pressure, and air temperature. In addition, all buoy stations, and some C-MAN stations, measure wave height, period, and sea surface temperature. Conductivity and water velocity are measured at selected stations.

NOAA NOS Tide Gauge Network
Water level stations are maintained at several locations within Southern California by the National Ocean Service. (See http://tidesonline.nos.noaa.gov/geographic.html.)

USGS Streamflow Network
The USGS Streamflow Network monitors stream water levels at a number of rivers entering the ocean. (See http://waterdata.usgs.gov/nwis/rt.)

Monitoring and Event Response for Harmful Algal Blooms (MERHAB)
The NOAA sponsored Monitoring and Event Response for Harmful Algal Blooms (MERHAB) Program is a targeted research program to develop tools, approaches and technologies that could be included as routine components of a Harmful Algal Bloom (HAB) monitoring programs. It is based out of University of Southern California.
(http://www.cop.noaa.gov/stressors/extremeevents/hab/current/fact-merhab.html)

Santa Monica Bay Restoration Commission
Originally established as part of the EPA's National Estuary Program (NEP), the Santa Monica Bay Commission (www.santamonicabay.org) is funded by the US Environmental Protection Agency, the State of California, and the Santa Monica Bay Restoration Foundation. Its mission has been to create a comprehensive plan to ensure the long-term health of Santa Monica Bay, the 266 square-mile body of water located adjacent to the heavily urbanized, second most populous region in the U.S.

PISCO

The Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO www.piscoweb.org/) is a research consortium involving marine scientists from four universities along the U.S. West Coast, with University of California, Santa Barbara the only participant in southern California. PISCO is a large-scale marine research program that focuses on understanding the nearshore ecosystems of the U.S. West Coast.

IMECOCAL

Modeled after CALCOFI, the long-term goal of IMECOCAL is to improve the capability to predict the response of the pelagic ecosystem in Baja California to regional and global climate change, as well as to the combined effects of harvesting practices by Mexico and the United States. (http://imecocal.cicese.mx/)

CEA-CREST

Funded by the National Science Foundation, the CEA-CREST program at Cal State Los Angeles employs graduates and undergraduates in integrated research teams tackling key environmental research questions related to 1. Coastal marine population dynamics 2. Monitoring changing ecosystems at multiple spatial scales 3. Molecular genetics in evolution, ecology, and conservation 4. Biogeochemical processes 5. Hydrology of regional aquifers and riparian areas in arid zones. (http://cea-crest.calstatela.edu/)

San Pedro Ocean Time Series (SPOT)

Based out of the USC Wrigley Marine Science Center, the San Pedro Ocean Time Series (http://wrigley.usc.edu/research/spot.html) is long time series program to collect a record of physical, bio-geochemical, and microbial parameters from San Pedro.