Global Warming: Is the Science Settled Enough for Policy?

Stephen Schneider, Stanford University

In the Fourth Assessment Report of the UN-sponsored Intergovernmental Panel on Climate Change (which shared the 2007 Nobel Peace Prize), Working Group I states that warming is "unequivocal" and it is "very likely" that human activities are responsible for most of the warming of recent decades. The same report says warming to 2100 is "likely" to be 1.1 -6.4 degrees C. Working Group II says 1.5 – 2.5 degrees C warming could commit 20-30% of known species to extinction (but only assigns this about a 50% chance). So, what is settled? Some projections are well established, some have competing explanations, yet others are speculative. Thus policy is a risk management judgment, just like most other complex socio-technical systems problems.

There is strong consensus that the increasing numbers of people in the world, demanding higher standards of living, and using cheap, available technologies (e.g. burning coal, and driving gas-consuming large automobiles) will double or triple the carbon dioxide content in the atmosphere by 2100. This implies many potentially serious impacts, although not all are negative. However, the distribution of these impacts is uneven, with most severe effects being experienced in poorer, warmer places, coastal regions, high mountains, polar regions, or in "hurricane alley." Local, regional, and international actions are already beginning and much more could be done if there were political will to substantially reduce the magnitude of the risks by putting in place adaptation strategies to reduce vulnerability to impacts already in the pipeline which can't be avoided and to enact mitigation legislation to lessen the risks of more severe climate impacts that we can't adapt to.

Session: The Heat is On

Sea-Level Rise and the San Francisco Bay

Heather Cooley, Pacific Institute, hcooley@pacinst.org

Over the past century, sea level has risen nearly eight inches along the California coast, and general circulation model scenarios suggest very substantial increases in sea level as a significant impact of climate change over the coming century. Recent research by the Scripps Institution of Oceanography suggests that sea levels along the California coast will rise by 1.4 meters (55 inches) by 2100 under a medium-high greenhouse gas emissions scenario. We estimate that a 1.4 meter sea-level rise will put 270,000 people at risk of a 100-year flood event along the San Francisco Bay, given today's population. Among those affected are large numbers of low-income people and communities of color, which are especially vulnerable. Critical infrastructure, such as roads, hospitals, schools, emergency facilities, wastewater treatment plants, power plants, and more will also be at increased risk of inundation, as are vast areas of wetlands and other natural ecosystems. In addition, the cost of replacing property at risk of flooding along the San Francisco Bay under this sea-level rise scenario is estimated to be $62 billion (in year 2000 dollars). Continued development in vulnerable areas will put additional areas at risk and raise protection costs. A number of structural and non-structural policies and actions could be implemented to reduce these risks.

Key Words - *climate change, sea level rise, San Francisco Bay*

Session: The Heat is On

Ocean Processes Influencing Seabirds and Their Prey in the Gulf of the Farallones

Jennifer Roth, PRBO Conservation Science, jroth@prbo.org
Jaime Jahncke, PRBO Conservation Science, jjahncke@prbo.org
Russell Bradley, PRBO Conservation Science, rbradley@prbo.org
Pete Warzybok, PRBO Conservation Science, pwarzybok@prbo.org
Meredith Elliott, PRBO Conservation Science, melliott@prbo.org

The California Current System is one of the most productive regions in the world's oceans and may be drastically impacted by climate change. Impacts may include changes in the timing and strength of wind-driven upwelling, increased sea surface temperature, increased stratification of the water column, and more frequent El Niño events. The effects of these changes are difficult to predict, but will likely lead to an overall reduction in biological production that will affect species at all levels of the marine food web. We assessed effects of ocean conditions on seabirds by (1) evaluating trends in ocean conditions and seabird breeding parameters and (2) examining underlying seabird – ocean climate relationships using 35 years of data from a breeding colony in central California. In addition, we examined relationships between ocean conditions and marine bird prey availability during the breeding season. We assessed the effects of ocean conditions on zooplankton and fish abundance by relating prey abundance in the diet to ocean conditions at the time of prey harvest from the ocean. We compared these results with previous analyses that examine relationships between ocean climate and timing of nesting and reproductive success of marine birds in Central California. This work enhances our understanding of how ocean climate affects seabirds and their prey in the Gulf of the Farallones, improving our ability to make predictions about how climate change may affect prey and predators in the California Current.

Session: Aquatic Resources: Linking the Ocean, Estuary, and Watershed

Ocean-Driven Interannual Variability in San Francisco Bay Ecology

James Cloern, US Geological Survey, jecloern@usgs.gov

Sustained observations are necessary to detect and understand ecosystem processes that fluctuate over periods longer than a decade. The California Department of Fish and Game Bay Studies Program measured record high abundances of demersal marine fish (e.g. juvenile English sole), crabs (e.g. juvenile Dungeness crab) and shrimp beginning in 1999 and continuing through 2008. The timing and persistence of this biological shift inside San Francisco Bay coincided with a climate-driven oceanic shift that occurred in 1999 when the North Pacific Gyre Oscillation (NPGO) flipped from its negative to positive phase, signaling a strengthening of the California Current and intensification of coastal upwelling. Concurrent sampling by the U.S. Geological Survey documented a trend of increasing phytoplankton biomass in San Francisco Bay that also began in 1999 and persists during the positive phase of the NPGO. Strong coherence of these shifts suggests that decadal oscillations of atmospheric forcing across the Pacific Ocean can generate large changes in the biological communities of San Francisco Bay, but the mechanisms of this linkage are not yet understood. Our discovery of synchronous physical and biological changes after 1998 motivates a new research challenge to discover the processes through which atmosphere-ocean regime shifts propagate into San Francisco Bay to modify its biological communities.

Key Words - *San Francisco Bay; estuary-ocean connectivity; climate variability*

Session: Aquatic Resources: Linking the Ocean, Estuary, and Watershed

The Once and Future Kings? Status and Prospects for California's Chinook Salmon.

Steve Lindley, NOAA Fisheries Service, steve.lindley@noaa.gov

As recently as 2002, nearly 1.5 million Sacrament River fall Chinook (SRFC) were caught in fisheries or returned to the Sacramento River basin to spawn. Only 66,000 spawners returned to natural areas and hatcheries in 2008. As a result of this dramatic decline, fisheries for Chinook salmon off California and Oregon were closed to protect SRFC in 2008 and 2009. In this paper, I will show that the proximate cause of this unprecedented collapse was poor feeding conditions for juvenile salmon in the coastal ocean, and argue that the ultimate cause of the collapse is the declining resilience of the Central Valley chinook complex that has been driven by a century and a half of land and water development. A simple conceptual model illustrates how the dynamics of a salmon population supplemented by hatchery production are influenced by trends in freshwater environmental quality, hatchery production, fitness, and climate. The model predicts that SRFC will recover to higher levels of abundance when ocean conditions improve (which may already be happening), only to decline sharply when ocean conditions again turn poor. Improving the sustainability of the Chinook salmon fishery depends on reversing trends in freshwater and estuarine habitat quality and quantity, which should also benefit listed runs of Chinook. Ecosystem-based management and ecological risk assessment will be required to make progress on these challenging problems.

Key Words - *chinook salmon; fisheries; resilience; biocomplexity; ocean climate*

Session: Aquatic Resources: Linking the Ocean, Estuary, and Watershed

Changing Habitats, Changing Communities: An Update on the Upper Estuary Pelagic Organism Decline

Larry Brown, U.S. Geological Survey, lrbrown@usgs.gov
Randall Baxter, California Department of Fish and Game, rbaxter@dfg.ca.gov
Richard Breuer, California Department of Water Resources, rich@water.ca.gov
Frederick Feyrer, U.S. Bureau of Reclamation, FFeyrer@usbr.gov
Stephanie Fong, Central Valley Regional Water Quality Control Board, SWFong@waterboards.ca.gov
Bruce Herbold, U.S. Environmental Protection Agency, herbold.bruce@epa.gov
Peter Hrodey, U.S. Fish and Wildlife Service, Pete_Hrodey@fws.gov
Anke Mueller-Solger, CALFED Bay-Delta Program, amueller@calwater.ca.gov
Ted Sommer, California Department of Water Resources, tsommer@water.ca.gov
Kelly Souza, California Department of Fish and Game, KSouza@dfg.ca.gov
Curtis Yip, State Water Resources Control Board, CYip@waterboards.ca.gov

Populations of several important pelagic fishes of the upper San Francisco Estuary declined to historically low levels in the early 2000s and have shown little sign of recovery. This collective decline has become known as the Pelagic Organism Decline (POD). These declines are of intense interest to resource managers, scientists, legislators, and the general public because several of the species are protected under state and federal threatened and endangered species legislation. Since 2005, the Interagency Ecological Program has conducted a comprehensive study of the POD with the goal of evaluating potential causes of the decline. Results to date suggest that the declines are multi-causal and that there has been a relatively rapid shift in conditions superimposed on a long term trend of decline. The shift is likely related to multiple factors including water quality, food webs, and water management.

Key Words - *pelagic organism decline; fishes; pelagic fishes*

Session: Aquatic Resources: Linking the Ocean, Estuary, and Watershed

Elvis on Sediment Management: "A Little Less Conversation, A Little More Action Please"

Michelle Orr, Philip Williams & Associates (PWA), m.orr@pwa-ltd.com
Stephen Crooks, Philip Williams & Associates (PWA), s.crooks@pwa-ltd.com

With the recent estimates of global sea level rise (SLR) emerging from the scientific literature and permeating the planning consciousness, we are increasingly recognizing the need to implement on-the-ground adaptation measures. But what do we actually do? Holistic sediment management is a critical component of a SLR adaptation strategy to protect wetland (marsh and mudflat) habitats and infrastructure. We propose that we need to prioritize where to restore wetlands to maximize resiliency, decide where to hold the line for wetlands and infrastructure, and decide where to let the line roll back. We also need to ask and answer difficult questions about the trade-offs between removing sediments from the bay for navigation, flood protection, and water quality, and reusing them – on both marshes and mudflats – to sustain wetland habitats with accelerating SLR. It's time to reconsider the balance. The alternative is to accept a progressive loss of wetlands.

Key Words - *sea level rise; wetlands; sediment management; adaptation*

Session: Will Our Wetlands Sink or Swim with Climate Change?

Our Actions, Our Estuary
9th Biennial State of the San Francisco Estuary Conference

ORAL ABSTRACTS: Day 1 Presentations

Bay Wetland Plants and Sediments: Inseparable in the Face of Climate Change

John Callaway, University of San Francisco, callaway@usfca.edu

Increases in sea-level rise (SLR) and salinity associated with climate change will be critical factors for the future of tidal wetlands in San Francisco Bay and beyond. Tidal wetlands can compensate for increases in SLR by accumulating sediment, through both allochthonous mineral matter inputs and autochthonous organic matter accumulation. As wetlands build elevation, mineral inputs are reduced due to less frequent inundation. If wetlands can keep pace with SLR, this negative feedback leads to stable wetland elevations, typically around MHW in mature wetlands. By building wetland elevation, sediment inputs directly affect plant distributions because species have relatively narrow distributions across tidal elevations. Reciprocal effects of plants on elevation and sediment inputs also occur: plants build elevation through organic matter accumulation, leading to reductions in mineral matter inputs. These non-linear, complex interactions make it difficult to identify if sediment inputs control plant inputs or if plants control sediment inputs. Accretion rates from mature tidal wetlands across the world range from 1-2 mm/yr to over 1 cm/yr. Most San Francisco Bay wetlands currently accumulate 3-5 mm/yr, although much greater rates of accumulation are found in newly restored sites. Sediment accretion rates at the Island Ponds (part of the South Bay Salt Pond Restoration Project) during the first year post-breach averaged over 10 cm/yr across the lower half of the pond, with even greater rates at individual locations. While accretion rates have slowed over the last two years at the Island Ponds, current rates are still greater than in mature wetlands. Salinity increases associated with climate change will also affect plant distributions, thus presenting implications for elevation and sediment accumulation. Freshwater and brackish wetlands are more productive and accumulate more organic matter than salt marshes, and future salinity increases could inhibit organic matter accumulation rates.

Session: Will Our Wetlands Sink or Swim with Climate Change?

Wetlands Restoration and Flood Protection: The Essential Symbiosis

Steven Ritchie, State Coastal Conservancy

For decades, we built "hard edge" solutions to flooding, such as levees, flood walls, tide gates, and other constructed elements. At the same time, people began to believe that they were provided complete protection from flooding. We have learned that both of those conclusions are wrong. Simple constructed elements are not sufficient in and of themselves to appropriately mitigate flood risk, and flood risk cannot be eliminated. We began to combine hard edge works with natural floodways and tidal marshes to achieve better results, both for flood risk management and the environment. Now in the face of sea level rise, there seems to be a rising trend of fatalism that wetlands will be drowned and that "hard edge" solutions are society's only hope. The South Bay Salt Ponds and the South Bay Shoreline Study will be used to show that selective use of hard edges combined with natural processes continue to be superior solutions.

Session: Will Our Wetlands Sink or Swim with Climate Change?