Policy, Regulatory, and Management Challenges to Science in the Anthropocene

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This 5-minute Session introduction will highlight chapter topics from *The State of Bay-Delta Science* report integrated with relevant key themes from the chapter on "Delta Challenges."

Keywords: Session introduction, The State of Bay-Delta Science report, Delta Challenges

Session Title: A Preview of the State of Bay-Delta Science, 2015

Speaker Biography: Dr. Peter Goodwin is the DeVlieg Presidential Professor in Ecohydraulics and Professor of Civil Engineering at the University of Idaho. He also is the founding and current director of the Center for Ecohydraulics Research. He is recognized internationally for his research with important contributions in the field of modeling flows, sediment transport, and river channel evolution. Dr. Goodwin is also the director of Idaho's Experimental Program to Stimulate Competitive Research (EPSCoR), a federal-state partnership to enhance the science and engineering research, education, and technology capabilities of states that traditionally have received smaller amounts of federal R&D funds. He earned his B.Sc. in civil engineering from Southampton University, England, his M.S.C.E in Hydraulic and Coastal Engineering and Ph.D. in Hydraulic Engineering from UC Berkeley.

Challenges of Building the "One Delta-One Science" Approach

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How science and policy come together in the Delta is undergoing a cultural change. Competing demands on California's scarce water and environmental resources and the socio-political calls for science to guide decision-making about California's water and environmental resources have forged new opportunities for improving science-policy interactions. These cultural changes follow fatigue over tiresome litigation and new requirements for the use of science in Delta decision-making. The culture is being defined by policy-makers, managers, and scientists who have worked together to develop and begin implementing a Delta Science Plan that envisions 'One Delta, One Science' – an open science community that works collaboratively to build a shared body of scientific knowledge with the capacity to adapt and inform future water and environmental decisions. This chapter summarizes what we have learned about the need for 'One Delta, One Science', progress made to transform the Delta's science-policy interface, and recommendations for overcoming the remaining challenges to achieving the Delta Science Plan's vision.

Keywords: One Delta-One Science, decision-making, management, science communication, science-policy interface

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Climate Change and the Bay-Delta: Bounding the Uncertainties of Sea-level Rise and Changes in Precipitation

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In response to increasing atmospheric greenhouse-gas (GHG), California is warming and is projected with a high degree of certainty to continue warming this century. Our ability to predict future climate is limited by several sources of uncertainty that will be discussed as applied to sea-level rise (SLR) and precipitation projections: 1) uncertain future rates of GHG emission; 2) uncertain climate responses to changing GHG concentrations (essentially, climate-model differences); and 3) natural climate variability. Twentieth century SLR was ~0.5 foot. SLR projections are for >3 times as much this century in response to increasing ocean warming and melting land ice. However, some projections reach as much as 5 feet, leaving a wide range of possible outcomes. SLR, along with subsidence of Delta islands, will combine to make many Delta landscapes more vulnerable to inundation. Extreme sea levels from El Niños, storms, and wind waves, together with floods, will be primary occasions when SLR impacts will be felt. However, gradual SLR may drive more ocean salinity into the Bay-Delta, affecting brackish and freshwater habitats and potentially threatening water supplies.

For some time, projections of future precipitation have included nearly equal numbers of projections of wetter conditions as drier for northern California. Although most projections are within 10-15% of historical norms, we remain unable to determine whether the future will provide that much more precipitation or that much less. Despite this we know that California's precipitation will continue to vary widely from year to year and longer, and because a warmer atmosphere holds more moisture, when rain does fall, it will produce more intense downpours. Simultaneously, more dry days are projected over California, and warmer temperatures will likely enhance evaporative demands, reducing runoff per unit of precipitation. Consequently, climate change is expected to yield more extreme flood risks and more extreme drought risks.

Keywords: climate change, uncertainty, sea-level rise, precipitation, Bay-Delta

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Speaker Biography: Dr. Michael Dettinger is a research hydrologist for the U.S. Geological Survey, Branch of Western Regional Research, and a research associate at Scripps Institution of Oceanography, La Jolla, California. Dr. Dettinger has researched the hydrology, climate, and water resources of the West for over 30 years, focusing on regional surface water and groundwater resources and modeling, hydroclimatic variability, and climate-change impacts. He was physical sciences team leader for DOI-DOD ecosystem planning in the Mojave Desert, founding member of the CIRMONT Western Mountain Climate Sciences Consortium, climate advisor to the CALFED Bay-Delta Restoration Program, research advisor for USGS Surface-Water Discipline, member of the USGS Global Change Science Strategic Planning Team, and lead author of the Water Resources chapter of the 2013 National Climate Assessment. Dettinger earned his B.A. in Physics from UC San Diego, M.S.C.E from Massachusetts Institute of Technology, M.S. in Atmospheric Sciences and Ph.D. in Atmospheric Sciences from UCLA.

Science for Water Management: Advances, Challenges, and Implications for California's Future

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Much of California relies on the Sacramento-San Joaquin Delta directly or indirectly, for some or all of its water supply. The reliability of Delta water supplies is threatened by drought, climate change, earthquakes, endangered species, and changing ecosystems. Recent years have brought a fuller understanding of how management of the Delta ties together the quantity and quality of water available statewide in California. These ties run from the Sierra mountains and coastal streams, through the Central Valley, to the Bay Areas, and then over the Tehachapi Mountains to southern California. This chapter reviews issues in water supply reliability, and the costs of unreliability in quantity and quality.

Keywords: water supply reliability, water management

Session Title: A Preview of the State of Bay-Delta Science, 2015

Speaker Biography: Dr. Jay Lund is Director of the Center for Watershed Sciences and Professor of Civil and Environmental Engineering at University of California, Davis. His research and teaching interests focus on applying systems analysis and economic methods to infrastructure and environmental problems, including policy, planning, and management studies. His work is primarily in water resources and environmental system engineering, but with substantial past work in solid and hazardous waste management, dredging and coastal zone management, and urban, regional, and transportation planning. He received his B.Sc. in Civil Engineering, M.A. in Geography, and Ph.D. in Civil Engineering from the University of Washington. Dr. Lund has been honored with the following awards: Julian Hinds Award, American Society of Civil Engineers/Environment and Water Resources Institute, Hugo B. Fischer Award, California Water and Environmental Modeling Forum, ASCE/EWRI Planning and Management Council Service to the Profession Award, Boggess Award for best paper in the Journal of the American Water Resources Association, and California Water and Environment Modeling Forum Service Award.

Beyond Fishable and Swimmable: Water Quality and Contaminant Effects on Species and Water Supply

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Contaminants in the Delta affect water quality, impact associated species, and potentially impact drinking water supply. They originate from agricultural and urban runoff, wastewater treatment effluent discharge, industrial waste, and atmospheric deposition, as well as being applied directly to surface waters. There is also a legacy of contaminants such as persistent organic compounds, mercury, and selenium, which can accumulate through the food chain leading to health risks for humans and wildlife.

Although the Bay-Delta is one of the most studied surface water systems in the world, the ecological impacts of contaminants remain unquantified, and their effects poorly understood. Fish kills that were a common occurrence in past decades are now confined to spills or first flush events, however, sublethal effects of significant concern have been reported. In fish for example, contaminants can negatively affect the immune system, impact growth and development, directly alter behavior, and have detrimental impacts on sensory systems that affect the ability to avoid predators, recognize kin, find spawning grounds, and reproduce successfully. These sublethal impairments are often difficult to measure and to attribute to specific contaminant classes, because contaminants co-occur in space and time and can interact additively, synergistically, and antagonistically.

Standard bioassay methods that are based on acute toxicity of select species are not sufficient to adequately address the impact of contaminants on aquatic life. Bioassay endpoints that are currently used to evaluate contaminant impacts for regulatory purposes thus need to be enhanced. Contaminants are also a concern in regard to the Delta as a source for drinking water. Drinking water agencies that rely on the Delta have invested in upgrades to water treatment processes over the last decade, and have also implemented an integrated system of monitoring and forecasting tools to inform water treatment operations.

Keywords: contaminants, water quality, drinking water, toxicity

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Speaker Biography: Stephanie Fong is the Acting Science Program Manager of the State and Federal Contractors Water Agency (SFCWA). She earned her B.S. at UC San Diego before accepting a position at UC Davis, where she worked for 6 years. During that time, she led research studies and monitoring of surface waters across CA. She focused in particular on environmental toxicology and method development. Stephanie's desire to apply environmental toxicology to resource management and policy then led her to work for the Water Boards in 2005, and then SFCWA in 2012. Her projects mainly focus on the Delta and its tributaries, aimed at providing resource managers with the science they need to make informed decisions. Stephanie has served on various planning committees and on the Board of Directors for the Northern California Chapter of the Society of Environmental Toxicology and Chemistry, and believes in advancing science through communication, collaboration, and multidisciplinary contributions.

Communicating at the Science-Policy Interface in the Bay and Delta

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Speaker Biography: Dr. Jay Lund is Director of the Center for Watershed Sciences and Professor of Civil and Environmental Engineering at University of California, Davis. His research and teaching interests focus on applying systems analysis and economic methods to infrastructure and environmental problems, including policy, planning, and management studies. His work is primarily in water resources and environmental system engineering, but with substantial past work in solid and hazardous waste management, dredging and coastal zone management, and urban, regional, and transportation planning. He received his B.Sc. in Civil Engineering, M.A. in Geography, and Ph.D. in Civil Engineering from the University of Washington. Dr. Lund has been honored with the following awards: Julian Hinds Award, American Society of Civil Engineers/Environment and Water Resources Institute, Hugo B. Fischer Award, California Water and Environmental Modeling Forum, ASCE/EWRI Planning and Management Council Service to the Profession Award, Boggess Award for best paper in the Journal of the American Water Resources Association, and California Water and Environment Modeling Forum Service Award.

The Bay-Delta Food Web: Why We Care about the Dynamics of Sustaining Native Species

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We examine what has been learned recently about foodwebs of the upper San Francisco Estuary including the Delta, and identify key topics requiring additional research. Substantial new knowledge has been developed on lower trophic levels of various estuarine habitats, and we focus on a few key topics. The current foodweb of the open waters of the main branch of the estuary are unproductive and dependent on spatial subsidies of organic matter, phytoplankton, and zooplankton; small isolated channels and sloughs seem more productive. Zooplankton and fish species have spatial-temporal patterns of abundance that appear adapted to low productivity through shifts in spatial distribution (striped bass, anchovy, longfin smelt, delta smelt) or temporal abundance patterns (*Eurytemora affinis*), and introduced species of copepod have spatial or temporal patterns or feeding niches that minimize effects of low productivity. *Microcystis aeruginosa* forms blooms in the Delta during warm years that have detectable negative effects on zooplankton reproduction and abundance. In contrast to open waters, vegetated beds in the Delta (SAV) appear to be thriving and supporting a vibrant assemblage of invertebrates and fish that are largely non-native. The SAV beds and marshes have distinct isotopic signatures from open water, indicating alternative pathways for energy and nutrients.

Several large-scale, important questions need to be addressed. First, is it possible to increase subsidies of zooplankton through habitat restoration in the Delta? Existing information does not support this idea but cannot be used to rule it out. Second, would reducing the ammonium discharge to the estuary improve conditions, and how? Third, how do spatial connections affect the productivity of heterogeneous habitats? And fourth, will it ever be possible to use an experimental approach to management and restoration, so we can fill in the huge gaps in our knowledge?

Keywords: Bay-Delta, food web, productivity, phytoplankton, zooplankton

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Speaker Biography: Dr. Wim Kimmerer is a Research Professor of Biology at the Romberg Tiburon Center for Environmental Studies of San Francisco State University. He is an honorary Fellow of the California Academy of Sciences who studies how estuarine ecosystems function, with particular emphasis on human effects. For over 25 years he and his associates have conducted studies in the San Francisco estuary on effects of freshwater and tidal flow on habitat, abundance, and movement of plankton and fish; the influence of introduced species; and population dynamics, reproduction, growth, and mortality of fish and food web organisms. He has participated in modeling studies on topics, such as delta smelt population dynamics and hydrodynamics. Dr. Kimmerer earned a B.S. in Chemistry from Purdue University, and his Ph.D. in Biological Oceanography from University of Hawaii.

Delta Landscapes: Translating the Findings of Historical Ecology to Inform Ecological Restoration

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The Delta is many places, with many uses, values and functions to many users, both people and wildlife. These do not occur as separate, independent entities, although they are often treated or managed as such. A landscape perspective is important for several reasons. People live in landscapes. Consequently, landscapes are where they raise crops and families and where they experience the environment and nature. Landscapes are the scale at which people and the Delta intersect. A landscape perspective also enables one to step back and take a broad view, somewhere between a single place and the Delta as a whole. Focusing conservation or management on a single place isolates the place from its surroundings, while attempting to deal with the entire Delta in all its complexity is overwhelming. The former may lead to ineffective management, the latter to inefficient and superficial management. While local or Delta-scale issues should not be ignored, a landscape perspective provides a workable scale for Delta management as well as an interface that allows the small and the large to be seen in context.

Landscape ecology has the power to integrate land with water, as well as places, habitat, species, stakeholders, policy, agencies, and scales. It draws attention to entire landscapes and considers how multiple features interact in space and time. By considering the structure and function of entire landscapes rather than their individual parts, the broad-scale patterns and processes that determine how Delta ecosystems function emerge. This integrated landscape perspective provides the foundation for managing or restoring ecological connectivity, habitat diversity, landscape adaptability, and resilience to change—all of which are critically important as the Delta is exposed to the forces of climate change and sea-level rise.

Keywords: landscape ecology, historical ecology, habitat, conservation, management

Session Title: A Preview of the State of Bay-Delta Science, 2015

Speaker Biography: Dr. John Wiens is a leader in the field of landscape ecology. An Emeritus University Distinguished Professor at Colorado State University, Winthrop Research Professor at the University of Western Australia, and Chief Scientist at PRBO Conservation Science (Point Reyes Bird Observatory), he grew up in Oklahoma as an avid birdwatcher. This led to degrees from the University of Oklahoma and the University of Wisconsin-Madison (M.S., Ph.D.). He served on the faculties of Oregon State University, the University of New Mexico, and Colorado State University, where he was a Professor of Ecology. In 2001 he left academia to join The Nature Conservancy as Lead/Chief Scientist, working to integrate scientific research into conservation practice. His research, which has emphasized landscape ecology and the ecology of birds, has led to over 200 scientific papers and seven books.

Translating Science for Management: The Art of Decision-Making Frameworks

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Providing policy-makers and managers with pertinent information for making decisions is often a struggle for scientists working on complex science in a dynamic system like the Bay-Delta. Improving our scientific communication will require a shift in our thinking and approaches to solving resource management and ecological problems, possible shifts in culture, and the ways scientists communicate to policy-makers. One way of communicating complex science in a way that is helpful for policy-makers is through decision-support tools and frameworks.

Decision-support tools and frameworks provide a way of reaching standard, reproducible, transparent approaches to making decisions. They integrate knowledge from many disciplines and provide context by incorporating broader perspectives, and non-scientific values and information. They allow users to explore the solution space, which provides a way of dealing with uncertainty and multiple and often conflicting objectives. They can highlight multiple approaches as well as tradeoffs among those approaches. Strengths of decision-support tools and frameworks include: providing transparency in decision-making; discerning key information from basic information; integrating information into a coherent structure; and identifying realistic management choices. Techniques can be document-driven, model-driven or data-driven and include cost-benefit analyses, structured decision making, adaptive management, organizational restructuring, and the use of facilitators and facilitation techniques. We explore how to organize our science tools to better inform policy-makers.

Keywords: decision-support, decision-making, science communication

Session Title: A Preview of the State of Bay-Delta Science, 2015

Speaker Biography: A pioneer in the field of ecological economics, Dr. Norgaard's recent research addresses how complex environmental problems challenge disciplinary scientific understanding and the policy process. He serves on the Fifth Assessment of the Intergovernmental Panel on Climate Change and as a member of UNEP's International Panel on Sustainable Resource Management. He was a member of the Environmental Economics Advisory Committee of the Science Advisory Board of the U.S. Environmental Protection Agency. He has served on the Board of the American Institute of Biological Sciences and as President of the International Society for Ecological Economics. Dr. Norgaard was a member of the CALFED Independent Science Board, and before that the Water Management Science Board. He earned his doctorate in economics from the University of Chicago. Currently, he works as a Professor, Energy and Resources Group, University of California, Berkeley.