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THEMED ISSUE:
SACRAMENTO – SAN JOAQUIN RIVER DELTA

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THE SACRAMENTO-SAN JOAQUIN RIVER DELTA AT THE CENTER OF CALIFORNIA'S WATER SUPPLY AND ENVIRONMENTAL CHALLENGES

EDITORIAL BY PETER GOODWIN & ANGELOS FINDIKAKIS

Peter Goodwin *Angelos Findikakis*

The Sacramento-San Joaquin watershed covers almost 200,000 square kilometers and extends 800 kilometers from the Cascade Mountains in the north to the Tehachapi Mountains in the South and is bounded on the West and East sides by the Coast Range and Sierra Mountains respectively. As shown in Figure 1, approximately 50 percent of the total surface water of California (an average 70 cu km) flows through the Sacramento and the San Joaquin rivers to the Pacific Ocean through San Francisco Bay and its Delta[1]. San Francisco Bay is the largest estuary on the west coast of the Americas and the Delta is one of the few large deltas on an inland edge of an estuary in the world. Most of California's climate is Mediterranean resulting in significant inter-annual variability as is evidenced by the severity of the current drought and the extreme and damaging floods of the 1982, 1986 and 1997. These unique physical characteristics of the San Francisco Bay-Delta have combined to create a rich ecosystem of very high biodiversity. It is one of the nation's six most important biodiversity hotspots providing critical habitat for shorebirds, waterfowl, and marsh birds, as well as over 500 species of fish, mammals and plants – many of which are threatened or endangered.

This system has been significantly altered by human actions since the mid-1800s with more than 95% of the original 3,000 square kilometers of tidal wetlands being converted to agriculture within leveed islands. Two large water transfer projects, the State Water Project and the Central Valley Project withdraw water from the Delta and convey it through long aqueducts to Central and Southern California, as well as to parts of the San Francisco Bay Area. More than two-thirds of California's population relies on water diverted from the Delta. Diverted water is also used for irrigation supporting agricultural production that supplies more than 45% of the fruits and vegetables consumed in the US at certain times of the year. The quantity and the location of water withdrawal from the Delta has been the subject of ongoing debates between water users, farmers and cities, who need the water and environmentalists concerned about the ecological health of the Delta. In addition, the water infrastructure in the Delta is at risk due to earthquakes. Multiple levee failures along the almost 1800km of levees protecting the low-lying areas (some as much as 8m below sea level) could flood the critical water diversion structures with salt water from San Francisco Bay.

The current drought is now entering its fourth year. Farmers reliant on the Central Valley Project will receive zero water deliveries for the second successive year and are forced to find water from other sources or fallow land with the consequences to the state economy measured in billions of dollars. Several recent studies have documented that this is not exceptional for California's climate and historic droughts have persisted for much longer periods[2].

These findings are being heeded by agencies responsible for managing dwindling supplies. Recent findings by NASA and others show the severity of the problem. For example, the 2014 snow pack, the primary source of water for reservoir storage was the worst in recorded history. NASA also used the Gravity Recovery and Climate Experiment (Grace) satellites to show that more than 40 cubic km is required to bring California's groundwater supplies back to normal[3]. These extreme conditions were recognized early by Governor Jerry Brown who declared a drought emergency in January 2014 that resulted in the creation of the Central Valley Project and State Water Project Drought Operations Plan (DOP). Implementation of the Plan has resulted in unprecedented collaboration between state and federal agencies in an attempt to balance environmental needs with water supply (the co-equal goals described in later sections).

This special issue describes the challenges of managing a scarce and over-committed water resource and how science is being used to guide management decisions to serve the needs of the State in view of continuing economic growth, increasing population and the uncertainty about available water resources due to climate change and the potential recurrence of long dry periods, such as those experienced in the past. There is an increasing recognition that these major challenges can only be addressed with a sustained commitment to science and engineering on a scale commensurate with the magnitude of the problem.

Sources

1 http://www2.epa.gov/sfbay-delta/about-watershed

2 Jay Famiglietti and Tom Painter, NASA Jet Propulsion Laboratory, American Geophysical Union, December 2014

3 Cook, B.I., T.R. Ault and J.E. Smerdon, 2015. Unprecedented 21st century drought risk in the American Southwest and Central Plains. Sci. Adv. 1, e1400082. 1-7.

The Sacramento and San Joaquin River basins draining in the Delta and the major water transfer projects withdrawing water from the Delta

* The Tulare Basin is a closed basin; surface water drains north into the San Joaquin River only in years of extreme rainfall

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Cover picture: Potato Slough meanders through the Central Delta between Venice Island and Bouldin Island. *Credit: Courtesy of the California Department of Water Resources*

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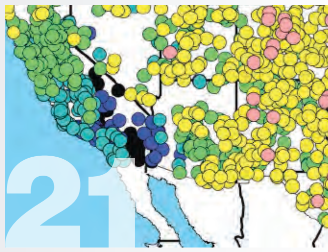


CALIFORNIA'S WATER FUTURE:

HIGH DEMAND, LIMITED SUPPLY, CLIMATE CHANGE AND MORE VOLATILE WEATHER; PROPOSED NEW TUNNELS TO SHIP WATER LEAD TO ENDLESS CONTROVERSY

BY PHILIP L. ISENBERG

For more than 50 years, Californians has been arguing about plans to build new canals or tunnels to move water from the Sacramento-San Joaquin Delta (just west of San Francisco) to farmers in the Central Valley, parts of the San Francisco Bay Area, and urban Southern California. An existing water conveyance system, built mostly in the 1960s and 1970s is operating but getting older and it causes serious environmental damage to fish. At the same time, climate change is causing a far more volatile water supply.

To complicate things, California has just gone through a three-year drought, and it appears 2015 will also be dry. We all know that dry water years mean less water is available, but how can we meet legitimate demand with a reduced supply[1]?

Equally important, what to do about legal rights (real or imagined) to use water that in sum total far exceed the average annual supply - and also exceed the supply in very wet water years?

First, some good news:

1. California Governor Jerry Brown issued his Water Action Plan in 2014[2]. It joins a reliable water supply to an improved and restored Delta ecosystem reflecting state law. Signs are that a finished tunnel plan may be present in 2015[3].

2. California finally adopted major legislation to regulate the use of underground water giving increased authority to local water districts to regulate underground water use[4]. Are local agricultural and rural water districts politically willing to impose limits on their customers? If not, the state is authorized to step in and dictate a solution - although you can be sure that decades of litigation will try and stop that from happening.

3. Voters in California approved a $7.1 billion water bond in 2014[5]. That's not much money in a state where federal, state and local governments spend $30-$40 billion annually for water supply, wastewater treatment and flood control - but it is useful in pushing the Governor's Water Action Plan.

Second, some not-so-good news:

1. The Governor's call for a 20 percent reduction in urban water use has not been met. To be sure, some communities are serious about conservation, but others are not. And there is no way to tell yet if reductions in use are permanent, or just reflect temporary changes[6].

2. The Bay Delta Conservation Plan (BDCP). The tunnel plan, has been seven years in the making, and a number of major questions remain hopefully to be answered later this year:

a. Does building a more efficient system with tunnels automatically mean more water is available to move? The obvious answer is 'no', but that answer is unacceptable to some powerful water users.
b. Will the role of science in operating any new tunnel project and Delta ecosystem improvements be increased? The Governor and federal officials pledged to so in 2012[7], but the details remain unclear.
c. Will California deliver on the promise to restore or enhance habitat on over 100,000 acres of land in the Delta? And equally important, is the money for this a reality, or just a hope?
d. Will federal and state officials finally adopt a coherent governance structure for BDCP, including an expedited dispute resolution process? The jury is out on this, but the slow pace of implementing 2007 - 2008 federal environmental standards for Delta smelt and Salmon - even with court supervision - is not encouraging[8].

To get past all the roadblocks, multiple policies have to be achieved, not just some. It has been have suggested that California does public policy backwards - as explained by The Rolling Stone's famous song by Mick Jagger and Keith Richards said it best: *"You can't always get what you want… But if you try sometimes you just might find you get what you need, baby"* Time will tell.

Phil Isenberg **was the founding Chair of the Delta Stewardship Council for its first four years and currently is Vice-Chair of the Delta Stewardship Council. He has served in numerous government roles including as a member of the California State Assembly, chair of the California Marine Life Protection Act Blue Ribbon Task Force and chair of the Delta Vision Blue Ribbon Task Force. As an elected official he focused on land use planning, water and resource issues, state budget and fiscal matters, redevelopment reform, healthcare and has a particular interest on how science can inform policy effectively. Phil Isenberg holds a Doctor of Jurisprudence from the University of California, Berkeley Boalt Hall School of Law.**

Notes

1) In 1962 prominent water attorney James H. Krieger and Harvey O. Banks – the famous California Water Director for Governor Pat Brown when voters approved the State Water Project – made a very similar point. Although focused on groundwater overuse, the article followed an 18-year dry period in southern California and sounds similar to today's water debate.
The problem of water supplies not meeting human demands *"…can be met in two ways: increase the supply or limit the demand. Both are necessary… …In limiting the demand for water California has been less imaginative. Americans are less prone to curb their appetites than they are to invent new ways to satisfy them; hence, there have been few attempts to stretch the available water supply. Conservation and reclamation are viewed as a last resort. While this philosophy is responsible in part for the people of California voting a multi-billion dollar project to import water into thirsty areas, it is equally accountable for squandering the local supply."*
Krieger JH, Banks HO. 1962. Ground water basin management. 50 Cal.L. Rev. 56; http://scholarship.law.berkeley.edu/.
2) Governor's Water Action Plan
http://resources.ca.gov/docs/california_water_action_plan/Final_California_Water_Action_Plan.pdf
3) BDCP (Bay Delta Conservation Plan) summary and environmental documents, http://baydeltaconservationplan.com/Home.aspx .
4) The Sustainable Groundwater Management Act is found in the following three bill:
AB 1739 (Dickinson): http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB1739
SB 1168 (Pavley): http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140SB1168
SB 1319 (Pavley): http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140SB1319
5) For election results on Proposition 1, see http://www.sos.ca.gov/elections/prior-elections/statewide-election-results/general-election-november-4-2014/. Proposition 1 text, plus arguments pro and con are at http://vig.cdn.sos.ca.gov/2014/general/en/pdf/proposition-1-title-summary-analysis-v2.pdf, and http://vig.cdn.sos.ca.gov/2014/general/en/pdf/proposition-1-arguments-rebuttals.pdf.
6) Be prepared for a mind boggling array of limited information, covering only 'household' use of water. This is a courageous effort, but much more information is needed. California Water Resources Control Board, http://www.swrcb.ca.gov/waterrights/water_issues/programs/drought/conservation_reporting_info.shtml.
7) Statement of Governor Jerry Brown, US Secretary of Interior Ken Salazar, and NOAA Deputy Administrator Eric Schwaab, July 25, 2012, http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library/Joint_Announcement_Press_Release-7-25-12.sflb.ashx
8) Report to Delta Stewardship Council (April 2014) on status of CAMT, http://mavensnotebook.com/2014/04/15/the-delta-stewardship-council-hears-an-update-on-the-collaborative-science-and-adaptive-management-program-csamp/.

REFERENCES

Hanak E., et al. 2011. Managing California's Water: From Conflict to Reconciliation. Public Policy Institute of California, http://www.ppic.org/main/publication.asp?i=944.
Hanak, et al. 2014. Paying for Water in California. Public Policy Institute of California, http://www.ppic.org/content/pubs/report/R_314EHR.pdf.
Grantham T. E. and Viers J. H. 2014. 100 years of California's water rights system: patterns, trends and uncertainty http://iopscience.iop.org/1748-9326/9/8/084012/article.

SAN FRANCISCO BAY-DELTA:
GROUND ZERO FOR CALIFORNIA WATER CHALLENGES - RISKS AND WATER RESOURCES

BY JAY LUND

Coastal deltas are frequently changing and shifting landscapes subject to varying fresh-water and sediment flows, sea level changes and tides, as well as many forms of human land and water management. California's Sacramento-San Joaquin Delta shares the inherent instability of delta landscapes, and also serves a central role in the water supply for one of the world's largest economies. It is a substantial agricultural area, and has the greatest potential for restored aquatic habitat of any region in California.

However, as summarized in Table 1, this California Delta, part of the largest estuary on the Americas' Pacific coast, is particularly unstable in serving these purposes due to California's highly variable hydrology, intense and changing human management of water and land, invasive species, climate change, and the threat of major earthquakes.

Many of these changes are inevitable, and threaten several current functions of California's Delta, with implications for management and for hydrologists and water managers in similar situations worldwide.

Risks to Landforms in the Delta

A fundamental risk to the Sacramento-San Joaquin Delta is to its current landforms. Land subsidence is a common problem for the stability of developed delta lands worldwide, from the Netherlands to Louisiana. Since having been largely diked and drained, starting in the 1860s, the California Delta's western and central peat lands have been exposed to air, oxidized, and subsided, often at the rate of several centimeters per year. Many of the most subsided islands are now 3-9 meters below sea level, as seen in Figure 1.

This raises flooding and drainage issues in the most subsided lands. This fundamental insta-bility in the landscape from land subsidence is exacerbated with rising sea levels, threat of earthquakes, floods, climate change, and low agricultural land values for most deeply subsided lands. In the last 4 decades, 5 of 40 subsided Delta islands have been flooded, with four of these flooded islands having been abandoned.

Newly flooded islands and other drivers of change often have fundamental implications for California's water supply system, the region's native and recreational ecosystems, and the Delta's local society and economy.

Risks to Local Society and Economy

The flooding of Delta islands will affect human uses of the Delta. Up to about 31,000 hectares of subsided, mostly agricultural land are at risk of abandonment following levee failure. This would result in the loss of about 1,000 direct and indirect jobs, gross crop revenue losses of about $150 million annually, and lost economic value added of about $83 million/year. This economic harm would be partially mitigated by the expected expansion of some recreational fishing and boating activities. Internal seepage is another growing problem for some of the most subsided islands, as waterlogging slowly displaces productive agricultural acreage with subsided and disconnected wetlands.

Table 1 - Major drivers of change and their impacts for California's Sacramento-San Joaquin Delta

Change → / Driver	Landforms	Island flooding	Salinity intrusion	Water supplies	Native fish species	Recreational fishing	Local economy & society
Sea level rise	●	●	●	●		●	●
Land subsidence	●	●					●
Floods	●	●					●
Earthquakes	●	●	●	●			●
Upstream sediment & quality	●			●	●	●	
Tightening treatment standards				●			●
Water exports			●	●	●		●
Endangered & invasive species				●	●	●	●

Risks to water supplies from the Delta

The Delta directly or indirectly supplies water to most of California's population and much of its irrigated agriculture. Landform, water quality, water management, and ecological changes can affect both the ability to pump water directly from the Delta and the ability to divert water from upstream tributaries.

Major flooding of one or more Delta islands during California's long dry season, due to a major earthquake for example, could lead to severe sea water intrusions, and so jeopardize water quality for users of Delta. Lack of large freshwater inflows into the southern Delta, where most water export pumps are located, could prolong this salinity intrusion for many months.

However, permanent flooding of islands often tends to dampen local tidal ranges and mixing, which reduces seawater intrusion into the Delta at high tides. However, Delta island levee failures also would expose more Delta water to contami-nants from peat soils, adding treatment costs for urban water users.

Continued tightening of drinking water quality standards is making treatment of Delta water more expensive, due to its high organic carbon content, along with salts and bromides from seawater and agricultural drainage. Rising salt concentrations in Delta water also affect local agriculture and larger agricultural areas depending on water exports pumped from the Delta.

Risks to Ecosystems

The Delta is the permanent or seasonal home to several endangered species of fish and other

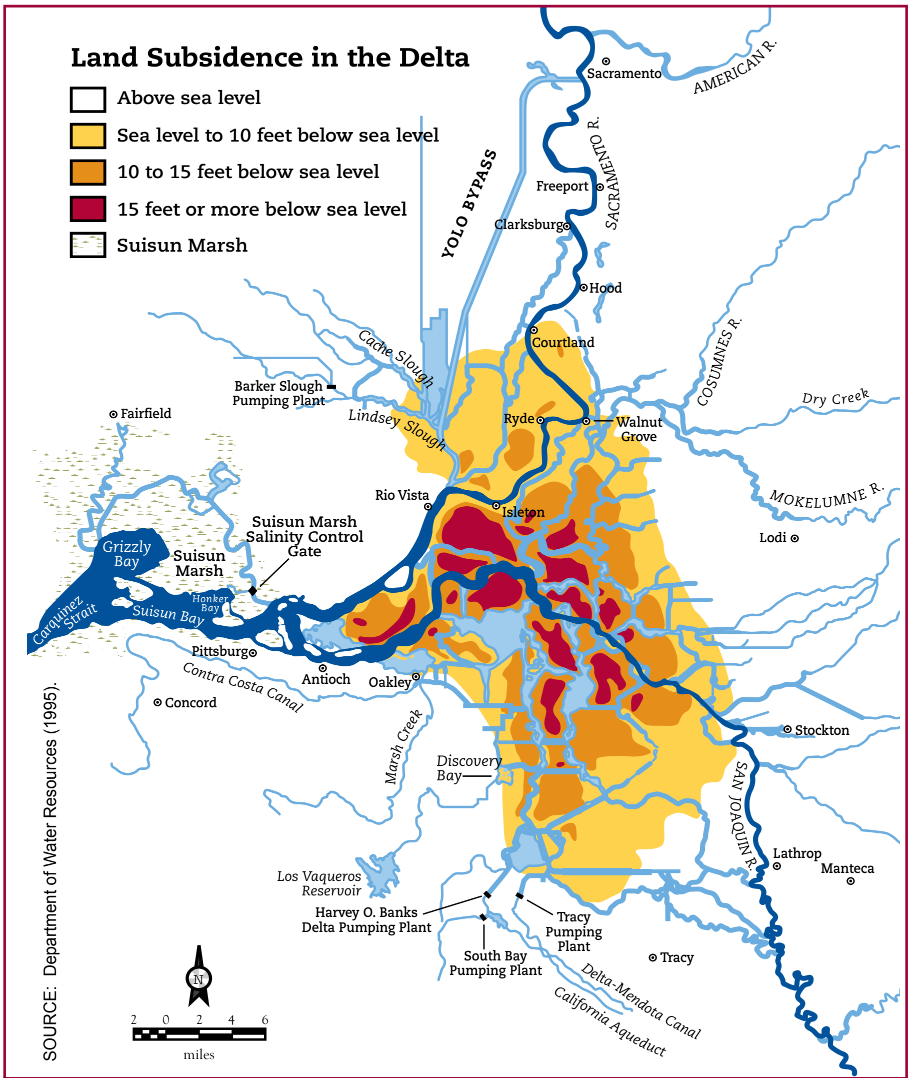


Figure 1 - Land subsidence in California's Sacramento-San Joaquin Delta

animals and has become home to an increasing number of invasive and introduced species. In much of the Delta, native fish species are only 10-20% of total fish biomass. Invasive clams, zooplankton, and plants have fundamentally altered most of the Delta's ecosystem. The Delta's landscape has changed from predominantly tidal freshwater wetlands to often-subsided agricultural land ringed by riprapped levees. Stream and channel flows have been greatly altered in their flow patterns and direction due to upstream water management and in-Delta pumping.

Flooding of Delta islands would return some areas to open water, enlarging aquatic habitat area, but at much greater depths, quite different from the vast freshwater tidal marshes of pre-development times.

Uncertain solutions

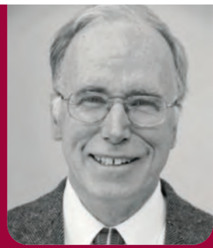
These changes, and tightening restrictions on water diversions due to endangered species concerns, have led to great, but highly controversial, interest in the construction of tunnels to divert fresh water from the Sacramento River under the Delta to the major water diversion locations for cities and farms south and west of the Delta.

For ecosystems, there is great interest in restoring the Delta's tidal wetlands, which are limited by the scarcity of suitable land elevations after subsidence, changing and reducing water diversions, and controlling the introduction of new invasive species. These actions would affect local and regional economic activity, displace some agriculture, and would usually reduce water diversions from the Delta. This reduction in Delta water exports would result in several hundred million dollars per year of lost economic value, especially during drier years.

Much of the Delta's local economy and society will be unaffected by these changes because it lies far from areas of the Delta likely to be most affected. However, these changes will fundamentally affect much of the western and central subsided areas of the Delta, and there is great interest in further strengthening Delta levees and increasing freshwater flushing flows from the Delta.

Several State and federal agencies and major Delta export water users are currently proposing a Bay Delta Conservation Plan that would restore extensive habitat areas, build tunnels to improve Delta water export quality and reliability, and provide a different long-term basis for managing water in the Delta. This plan is unsurprisingly controversial.

As with many deltas around the world, some changes are physically and economically inevitable for California's Sacramento-San Joaquin Delta. Changes are always difficult with so many diverse interests in the outcomes and management of change. California faces a strategic challenge in how to best manage the Delta, this central feature of local and statewide water supply and ecosystem importance. Time will tell how successful California will be in this effort, given the highly decentralized, and locally effective, system of water governance in California.



Jay Lund **is the Director, Center for Watershed Sciences, and Ray B. Krone Professor of Environmental Engineering, University of California, Davis, California. Dr. Lund's 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. He is the chair-elect of the Independent Science Board of the Delta Stewardship Council, California.**

References

Healey, M. (ed.), The State of Bay-Delta Science 2008, Delta Science Program, Delta Stewardship Council, Sacramento, CA, 2008.
Lund, J., E. Hanak, W. Fleenor, W. Bennett, R. Howitt, J. Mount, and P. Moyle, Comparing Futures for the Sacramento-San Joaquin Delta, University of California Press, Berkeley, CA, February 2010.
Medellín-Azuara, J., E. Hanak, R. Howitt, and J. Lund, Transitions for the Delta Economy, Public Policy Institute of California, San Francisco, CA, 62 pp., 2012.

SCIENCE AND TECHNOLOGY AS A GUIDE: MOVING FROM COMBAT TO COLLABORATION

BY LINDSAY CORREA, PETER GOODWIN, VALERIE CONNOR & LEO WINTERNITZ

The decision-making environment in the United States differs extensively from many other parts of the world where a single agency, program or science team develops the understanding of the problem and projections of alternative futures as a single scientific basis for community feedback and decision-makers to act upon. In the California Delta, major contributions to the scientific knowledge to guide decisions and policies are derived from agency programs, special studies initiated by environmental groups, local agencies (including water contractors), as well as through university research projects, single agency or collaborative programs. The federal government, State of California, local governments, water agencies, and Non-Governmental Organizations (NGOs) all recognize that science-based decisions are likely to result in more enduring strategies, reduced uncertainty in water supply reliability and more sustainable and desired ecosystem outcomes. This commitment results in diverse data sets, modeling approaches, and analyses focusing on a specific problem or issue. This approach results in innovation and a dynamic scientific community, but also has inherent challenges when synthesis is required across issues to understand cumulative system-wide response to multiple management actions.

Science and Technology in the California Delta

High stakes and tall expectations for science and technology exist in the California Delta. Beyond legal obligations, a commitment exists to actively use science to guide how to make challenging decisions about the management of California's water resources, building even greater hopes for the role of science in the future. These expectations have evolved over time, are riddled with challenges, and will only be met if champions arise from all interested parties who can lead California into a new era of collaborative science-based water policy.


They shall beat their swords into ploughshares – from Combat Science to Collaborative Science.

Dueling Science

The history of science-based decision-making in the Delta includes mistrust, frustration, and legal disputes. This history includes the advent of "combat science", defined as the selective development and presentation of facts and analysis primarily for regulatory advantage (or disadvantage) of one stakeholder group or another (Hanak 2011). This advocacy science has clouded the use of science in Delta decision-making and has been the source of court-based interpretations and decisions on science (Cloern and Hanak 2013). It has been destructive to collaboration between scientists, resulting in dueling scientific presentations between scientists from different backgrounds and differing levels of financial support, and has exacerbated struggles for managers, policy makers, scientists, judges, and the public to find consensus on critical decisions based on science (NRC 2012).

Further complicating the science-scape in the Delta are the numerous science efforts conducted by multiple entities with multiple agendas. All levels of governments with jurisdiction in the Delta engage in scientific research and monitoring to meet individual agency mandates. This institutional fragmentation adds a layer of complexity to an already complex physical and biological system and has been identified as a major obstacle to achieving ecosystem management goals (NRC 2012; Hanak et al.2013).

In a system that is both complex and rich in scientific knowledge, there is a growing recognition that continuing to hold an open door to combat science and endless litigation is neither sustainable nor productive. There is general acknowledgement that forthcoming challenges will be greater than today's troubles and that a new way of using science to guide decision-making is needed (Luoma 2013). Here we discuss the paradigm shift underway that is moving California beyond the status quo and into a new era for science under the vision of 'One Delta, One Science' – which means an open Delta science community that works collaboratively to build a shared body of scientific knowledge with the capacity to adapt and inform future water an environmental decisions.

A Change of Course for Delta Science

In 2009, California passed legislation (Delta Reform Act) that set new requirements for how science would be used in decision-making about water policy and environmental management of the Delta. This same legislation established the Delta Stewardship Council, Delta Science Program, and Delta Independent Science Board; each with specific roles for supporting, coordinating, and overseeing best available science and adaptive management in the Delta. With regulatory requirements for the use of best available science and adaptive management set by the Delta Stewardship Council's Delta Plan, a Delta Science Program with a mission to provide the best possible science to inform water and environmental decision-making, and a Delta Independent Science Board (Delta ISB) tasked with overseeing science and adaptive management programs in the Delta – a higher standard and accountability for the use of science was established. In 2012, California Governor Brown and U.S. Department of the Interior Secretary Salazar further elevated expectations for science-based decision-making in their joint statement about direction for the draft Bay Delta Conservation Plan and California's water future, *"with science as our guide, we are taking a comprehensive approach to tackling California's water problems…"*. With this momentum for moving beyond the status quo, a cultural change was set in motion to build science collaboration and bridge the cultural divides of science and policy.

Building a New Culture for Delta Science and Technology

As recommended by the Delta Plan (www.deltacouncil.ca.gov) and encouraged by the Delta ISB, the Delta Science Program completed a Delta Science Plan (2013) to address the challenges of combat science, institutional fragmentation of science, and the need for new mechanisms that bring scientists and decision-makers together.

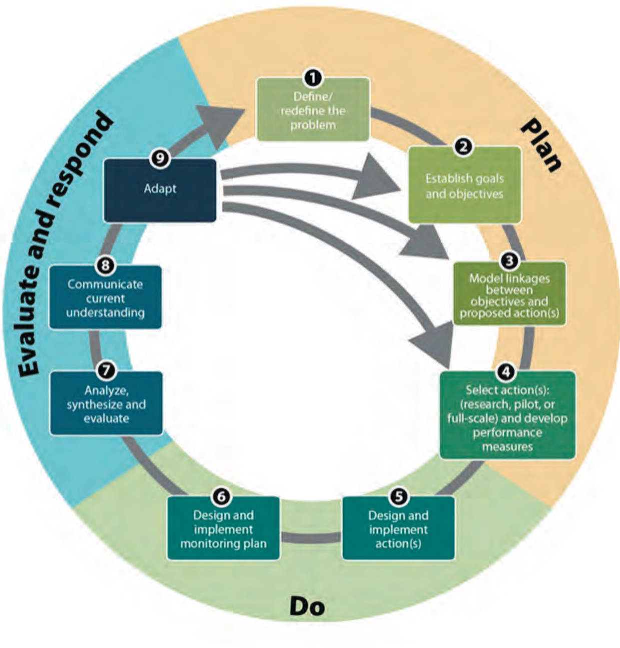
The Delta Science Plan aims to achieve a vision of 'One Delta, One Science' – an open science community that works collaboratively to build a shared body of scientific knowledge with the capacity to adapt and inform future water and environmental decisions. The objectives of the Plan include enabling and promoting science synthesis across agency programs and mandates that result in actions that can be taken, managing scientific conflict, building effective policy-science interactions to ensure decision-makers are receiving information that is useful and defensible, provide support to the adaptive management of this complex socio-environmental system, and supports fundamental research that continually advances the understanding of this dynamic ecosystem. Hundreds of scientists contributed to the development of the plan with well over 1000 individual suggestions and comments incorporated into the final version. The actions in the plan reflect the principles of relevancy (science is developed to guide actions to address the problem being considered), legitimacy (scientists from different perspectives and organizations are engaged in the science activity, and credibility (hypotheses have been tested and the findings have been peer-reviewed) (Scarlett

Lindsay Correa **is a Senior Environmental Scientist with the Delta Science Program at the Delta Stewardship Council (a State of California Agency) in Sacramento, California, USA. Her work focuses on the integration of science, policy, and management in the California Delta. She is specifically interested in interdisciplinary approaches to organizing, synthesizing, and communicating science to inform policy and management decision-making.**

Leo Winternitz **has over 30 years of water resource experience in California. He is currently working for GEI consultants engaged in flood and other water resource management work. He most recently was a senior advisor for The Nature Conservancy's water program, focusing on San Francisco Bay-Delta water and restoration issues. Leo also worked for the CALFED Program, Sacramento Water Forum, Department of Water Resources and Water Resources Control Board.**

Peter Goodwin **currently serves as Lead Scientist for the Science Program of the Delta Stewardship Council in California. He is the DeVlieg Presidential Professor of Civil Engineering and founding Director of the Center for Ecohydraulics Research at the University of Idaho. Peter Goodwin also serves as Director of the Idaho EPSCoR program for the National Science Foundation. His research interests include systems approaches to ecological restoration of river, wetland and estuarine systems.**

Val Connor **has over 20 years experience with the State of California on research and management of water quality problems, and her professional interests include emerging contaminants. She currently serves as the Science Manager for the State and Federal Contractors Water Agency (www.sfcwa.org).**



The Adaptive Management Process being used for Delta restoration and water management

2013). The Plan is part of a three-part Delta Science Strategy that has two other key elements: the Science Action Agenda (SAA), a detailed workplan for a four-year period, and the State of Bay Delta Science which summarizes the new insights, discoveries and innovations generated from the SAA and other sources. This latter document summarizes the progress made in the preceding period and helps guide the next iteration of the SAA.

The Delta Science Program functions as a facilitator of collaborative science, a funding source for research, a convenor of independent scientific peer review and communication of science through workshops and conferences and an online peer-reviewed journal that is freely available (https://escholarship/.org/uc/ jmie_sfews). In support of the Delta Science Plan, the Science Program hosted a summit on sharing and accessing data in the era of Big Data in June 2014. In May 2015, the Delta Science Program in collaboration with IAHR, the California Water and Environmental Modeling Forum and the USGS will be convening a workshop on integrated modeling to simulate complex socio-environmental systems that will chart future directions for community modeling of the San Francisco Bay Delta. Details of these activities and resulting white papers are available at www.deltacouncil.ca.gov/science-program.

The Era of 'One Delta, One Science'
While establishing a Delta Science Plan initiated a new paradigm for Delta science, achieving its vision takes leadership, dedication, and commitment to change. Here we highlight two efforts that are evidence that change is underway and that we are entering a new era of Delta science.

Collaborative Science and Adaptive Management
The Collaborative Science and Adaptive Management Program (CSAMP) and the Collaborative Adaptive Management Team (CAMT) efforts are evidence of a recent positive step forward in achieving the vision of the Delta Science Plan (Connor 2013). The CSAMP and CAMT were formed to modify court-ordered schedules for remanding environmental permits to protect native Delta fish species. Important to achieving the vision of *One Delta, One Science*, the CSAMP represents an opportunity to test, in part, the types of collaborative, integrated science approaches described in the Science Plan.
The CSAMP has tested the Delta Science Plan's methodologies for adaptive management,


(Photo credit: U.S. Geological Survey photo by Michelle Shouse)
Scientists deploying sampling equipment in the Delta

conflict resolution, engagement of decision-makers in setting research and monitoring priorities, and new ways for organ- izing policy, science and management (Connor 2013). The CSAMP effort has successfully moved from talking about collaborative science to imple- menting collaborative science efforts (http://www.sfcwa.org/2014/04/01/csamp-monthly-progress-reports/). Even with a recent lifting of court-ordered requirements for the CSAMP, a commitment to proceed with collaborative science remains, evidence that "collaborative" has taken precedence over "combat" science.

Interagency Action
As an initial step to implement the Delta Science Plan's call for a Science Action Agenda that prioritizes science activities to address decision-makers policy and management challenges, an Interim Science Action Agenda (2014) was developed. This initial effort was enabled through the engagement of scientists and managers from all levels of government, non-governmental organizations, and the private sector, who participated in a public workshop and focused interviews to summarize proposed and ongoing science activities in the Delta. The development and completion of the Interim Science Action Agenda demonstrated the Delta science community's interest and ability to make progress on the vision of *One Delta, One Science*.

The Delta science community's efforts resulted in an Interim Science Action Agenda that includes 17 science action areas representing broad policy-relevant science needs. These 17 science action areas include science to reduce knowledge gaps critical to decisions about water management, habitat restoration, flood risks, water quality concerns, and the Delta economy. The science action areas also identify topics in need of investment to build the Delta's science and technology infrastructure related to advancing collaborative modeling approaches, improved data management, and integrative system-wide monitoring and modeling. Encouraged by the Delta ISB's support for the Interim Science Action Agenda as a "credible, balanced, and technically sound as a near-term basis for guiding regional science activities in support of policy and management decisions in the Delta", an interagency committee of Federal and State agencies with responsibilities in the Delta (Delta Plan Interagency Implementation Committee), unanimously accepted the Interim Science Action Agenda as a step toward shared, collaborative science in the Delta. This action illustrates the forward momentum toward community and collaborative approaches to science that span institutional divides.

Conclusion
Changing the way we do science in the California Delta is challenging. Writing about this challenge Dr. Valerie Connor (2013) stated, "Conducting the monitoring, research, and modeling to inform policy isn't easy, but it isn't the most difficult part: The hard part is creating the new, supportive, and sufficiently strong organizational cultures necessary to succeed over the long run." The good news is that there is evidence that the organizational cultural changes needed are underway. Policymakers, managers, scientists, and engineers are actively engaging in a new culture of collaboration. We have a long way to go, but the vision of *One Delta, One Science* and collaborative science are in sight.

References
Cloern, James; & Hanak, Ellen. (2013). It's Time for Bold New Approaches to Link Delta Science and Policymaking. San Francisco Estuary and Watershed Science, 11(3). jmie_sfews_18652. Retrieved from: http://www.escholarship.org/uc/item/4px547r2.
Connor, Valerie. (2013). Leading Change: The Collaborative Science and Adaptive Management Program. San Francisco Estuary and Watershed Science, 11(3). jmie_sfews_19013. Retrieved from: https://escholarship.org/uc/item/0b90d3p8
Delta Science Plan. 2013. [Cited 17 December 2014]. Available from: http://deltacouncil.ca.gov/sites/default/files/documents/files/Delta-Science-Plan-12-30-2013.pdf.
Hanak, E., J. Lund, A. Dinar, B. Gray, R. Howitt, J. Mount, P. Moyle and B. Thompson, Managing California's Water: From Conflict to Reconciliation, Public Policy Institute of California, San Francisco, CA, 500 pp., February 2011
Hanak, E., J. Lund, J. Durand, W. Fleanor, B. Gray, J. Medellin-Azuara, J. Mount, P. Moyle, C. Phillips, B. Thompson, Stress Relief: Prescriptions for a Healthier Delta Ecosystem, Public Policy Institute of California, San Francisco, CA, 30 pp., April 2013
Luoma, Samuel N.(2013). Essays on Science and Policy in the Bay-Delta. San Francisco Estuary and Watershed Science, 11(3). jmie_sfews_20025. Retrieved from: https://escholarship.org/uc/item/1p05h0x4.
[NRC] National Research Council. 2012. Sustainable Water and Environmental Management in the California Bay-Delta, Washington, D.C.: Committee on Sustainable Water Environmental Management in the California Bay-Delta; Water Science Technology Board; Ocean Studies Board; Division on Earth Life Studies. 220 pp.
Scarlett, Lynn, (2013). Collaborative Adaptive Management: Challenges and Opportunities. Ecology and Society. 18(3):26.

Prince Sultan Bin Abdulaziz International Prize for Water

Recognizing Innovation

Winners for the 6th Award (2014)

Creativity Prize: The prize is awarded to the team of Dr. Eric F. Wood and Dr. Justin Sheffield (Princeton University, USA) for their development of a state-of-the-art system for accurately monitoring, modeling, and forecasting drought on regional, continental and global scales.

Creativity Prize: The prize is awarded to the GPS Reflections Group led by Dr. Kristine M. Larson (University of Colorado, Boulder), and including Dr. Eric E. Small (University of Colorado), Dr. Valery U. Zavorotny (NOAA) and Dr. John J. Braun (UCAR), for their discovery that standard geodetic GPS instruments are sensitive to hydrological influences and their subsequent development of a new, unexpected, and cost-effective technique, GPS Interferometric Reflectometry (GPS-IR), to measure soil moisture, snow depth, and vegetation water content.

Surface Water Prize: The prize is awarded to Dr. Larry W. Mays (Arizona State University, USA) for his comprehensive work in surface water hydrology and water resources engineering, culminating in three leading and innovative textbooks in the field, and for his applying this extensive knowledge base to develop optimization models in practical hydrology for current problems, including real-time optimal dam release during flood conditions and watershed development in urban areas.

Groundwater Prize: The prize is awarded to Dr. Jesús Carrera Ramirez (Institute for Environmental Assessment and Water Research (IDAEA), CSIC, Barcelona, Spain) for contributing decisively to the development of mathematical hydrogeology and transport modelling in groundwater systems. As a result, he has helped in the quantitative identification of the mechanisms and possible solutions for the globally critical problem of seawater intrusion and water salinisation in arid regions, as well as making advancements in the reliable prediction of the long-term fate of pollutants in environmental systems.

Alternative Water Resources Prize: The prize is awarded to Dr. Polycarpos Falaras (National Center for Scientific Research "Demokritos", Athens, Greece), coordinator of the European Union's CLEANWATER Project, for developing a novel water detoxification technology by taking advantage of solar light and advanced titania photocatalysts combined with ceramic and composite membranes.

Water Management and Protection Prize: The prize is awarded to Dr. William W-G. Yeh (University of California, Los Angeles, USA) for pioneering the development of optimization models to plan, manage and operate large-scale water resources systems throughout the world. His methodology, and the algorithms he developed for the real-time operation of complex, multiple-purpose, multiple-reservoir systems, have been adopted in a large number of countries, including the United States, Brazil, Korea, Taiwan and the People's Republic of China.

Nominations are open for the 7th Award. Nominations can be made online until 31 December 2015.

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HISTORICAL ECOLOGY AND LANDSCAPE CHANGE IN THE SACRAMENTO-SAN JOAQUIN DELTA

BY JULIE BEAGLE, ALISON WHIPPLE & APRIL ROBINSON

Before modern development, almost half of California's estuarine wetlands were found in the Sacramento-San Joaquin Delta. The Delta supported the state's most important salmon runs, the Pacific Flyway, and endemic species ranging from the delta smelt to the Delta tule pea. Within the Mediterranean climate region, the Delta's year round freshwater marshes were an oasis of productivity during the long dry season. Until reclamation beginning in the 1850s, the Delta stored vast amounts of carbon in its peat soils. Today the Delta functions very differently, having undergone a massive and continuing transformation. Despite the dramatic changes, however, many native species are still found in the Delta, albeit in greatly reduced numbers. Some are threatened by extinction, and others may be soon (Moyle et al. 2012). The Delta no longer functions as a delta, spreading river and bay water and sediment across wetlands, floodplains, and riparian forests. Recovery of some of these lost ecological functions is considered crucial to ecosystem restoration in the Delta (Delta Independent Science Board 2013).

Because of biological declines and regulatory challenges, Delta planning efforts often emphasize a few target species in habitat restoration and management. Yet, recent state policy sets ambitious goals for ecosystem restoration in the Sacramento-San Joaquin Delta. The Delta Plan and California Water Code, as well as other regional documents, identify the need to go beyond small-scale habitat restoration to create larger functional landscapes of interconnected habitats (California Water Code Section 85302, Teal et al. 2009, The Delta Plan 2013 and others). Yet there is little quantitative guidance available to help design the complex spatial systems that are likely to achieve these goals.

Figure 1 - **Study area and regional geographic context.** The project area (green) is about 800,000 acres, including parts of Sacramento, Yolo, Solano, Contra Costa, and San Joaquin counties. The legal Delta boundary is shown in red. Historical water bodies are shown within the study area and modern waterbodies are shown outside the study area Adapted from Whipple et al. 2012

The San Francisco Estuary Institute's Delta Landscapes project provides the first analysis of landscape ecology metrics in the pre-disturbance and contemporary Delta to help define, design, and evaluate functional, resilient landscapes for the future. The Delta Landscapes project attempts to provide a "big picture" ecosystem perspective on how to reestablish ecosystem functionality for multiple suites of taxa. Our approach is to evaluate the landscape patterns and processes that supported native species in the historical Delta, measure how they have changed, and assess the potential for reestablishing smaller, modified, but ecologically functional deltaic landscapes in the future. The project contributes a missing dimension to Delta planning by providing a landscape-scale perspective on restoration opportunities that is founded in a sound understanding of how the Delta historically supported native species. This approach gives us the best chance at creating the new, reconciled landscapes of the future that integrate natural and cultural processes, maximizing resilience to climate change, invasive species, and other challenges (Moyle et al. 2012, Cannon and Jennings 2014).

In order to imagine and plan for a functioning Delta ecosystem in the future, we must first understand how a healthy ecosystem works (Montgomery 2008, Jackson and Hobbs 2009). Currently, we have no first-hand knowledge of how Delta landscapes functioned because there are no large areas typical of the historical Delta left. Such understanding is essential to evaluating the settings in which native wildlife (defined as plants and animals) evolved and designing future habitats that preferentially benefit these species.

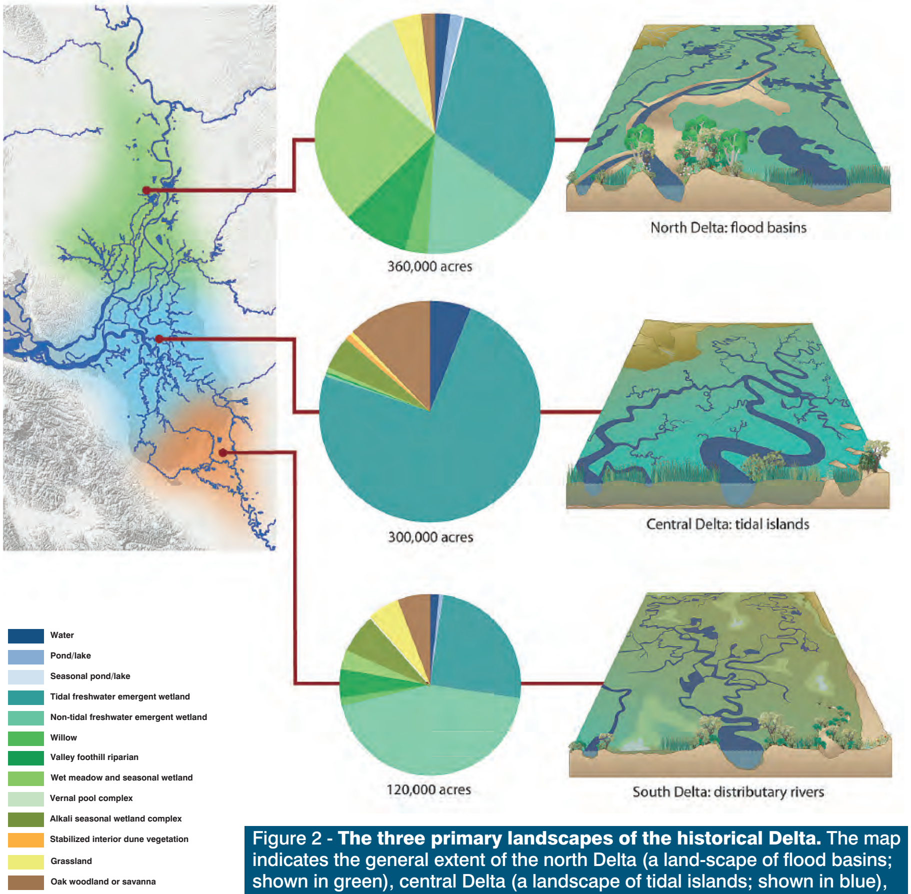


Figure 2 - **The three primary landscapes of the historical Delta.** The map indicates the general extent of the north Delta (a land-scape of flood basins; shown in green), central Delta (a landscape of tidal islands; shown in blue), and South Delta (a landscape of distributary rivers; shown in brown). These landscapes were characterized by different assemblages and relative proportions of habitat types (as seen in the pie charts). (Whipple et al. 2012)

Julie Beagle's **work with the Resilient Landscapes Program of SFEI focuses on fluvial and tidal geomorphic processes in Bay Area rivers and streams. She leads the Delta Landscapes project which has created spatially explicit landscape metrics to provide a basis for restoration targets, and conceptual models to guide more effective subregional restoration and acquisition priorities. She received a master's degree from University of California, Berkeley in environmental planning focusing on geomorphology and watershed management.**

Alison Whipple's **interests center on hydrologic regimes and spatiotemporal inundation patterns within floodplains, related ecological functions, and impacts of land and water management and climate change. She is a Research Associate with the San Francisco Estuary Institute, where she previously led the Delta Historical Ecology Investigation. She is currently a PhD candidate in the Hydrologic Sciences Graduate Group and based in the Center for Watershed Sciences at the University of California, Davis, and is part of the NSF IGERT on Climate Change, Water, and Society.**

April Robinson **is an associate environmental scientist at SFEI. Her work focuses on wetland ecology and mercury biosentinels. She is lead contributor to the Delta Landscapes project and is the lead author of A Delta Transformed. She has more than 10 years of experience working as a biologist in the San Francisco Estuary, and is completing her master's degree at San Francisco State University in ecology and systematic biology.**

A short primer on the historical Delta landscape (summarized from Whipple et al. 2012)

The Sacramento-San Joaquin Delta historically served multiple physical and ecological functions. It was a perennial freshwater source in a Mediterranean climate, collecting, draining, and mixing water from the interior of the state (40% of the state's freshwater flows) to the ocean. It likewise served as an extended fluvial-tidal interface, with tidal influence extending past Sacramento. Saltwater influence was historically limited to the brackish Suisun marshes, and diminished towards Sherman Island, though the boundary was variable depending on season and year. Unlike coastal plain river deltas, the Sacramento-San Joaquin Delta is an inverted estuary that narrows at its outlet before opening to the San Francisco Bay (Atwater and Belknap 1980) (Figure 1). It functioned as a sediment sink, slowing and settling materials from the Sierras, and during high flows sediment was carried downstream to San Francisco Bay and its marshes. It was also the lungs of the region, sequestering carbon and releasing oxygen. The Delta was a highly productive system that provided abundant and diverse food resources to support robust food webs, as well as indigenous tribes. Many native wildlife species were able to exploit the complex and resource-rich landscape of the Delta, some thriving in astonishing numbers.

The historical reconstruction of the Delta reveals the large-scale patterns and heterogeneity that existed before major anthropogenic influences. The central, northern, and southern parts of the Delta were diverse in their geomorphic and hydrologic settings, and in the ecological functions they provided (Figure 2). The central Delta consisted predominately of islands of tidal freshwater emergent wetland (marsh), which supported a matrix of tule, willows, and other species. These wetlands – topographically almost flat – were wetted by twice daily tides, and inundated monthly (if not more frequently) by spring tides. During high river stages in the wet season, entire islands were often submerged with several feet of water. The large tidal sloughs had low banks and, like capillaries, bisected into numerous, progressively smaller branching tidal channels which wove through the wetlands, bringing the tides onto and off of the wetland plain, promoting an exchange of nutrients and organic materials. Channel density in the central Delta was greater than in the less tidally dominated northern and southern parts of the Delta (but lower than the brackish and saline marshes of the estuary downstream). The edges or transition zones around the central Delta were composed of alkali seasonal wetlands, grassland, oak savannas, and oak woodlands. On the western edge of the central Delta, sand mounds (remnant Pleistocene dunes) rose above the marsh, providing gently sloping dry land in an otherwise wet landscape that served as a high tide refuge for terrestrial species.

The ecological functions provided by the north Delta were driven primarily by the great Sacramento River, which created large natural levees and flood basins. These flood basins, running parallel to the river, accommodated large-magnitude floods, which occurred regularly, with inundation often persisting for several months. They consisted of broad zones of non-tidal marsh that had very few channels and transitioned to tidal wetland towards the central Delta. Dense stands of tules over three meters (m) (~10 ft) tall grew in these basins and large lakes and ponds occupied the lowest points.

The north Delta's natural levees, created pre-Holocene by the large sediment supply of the Sacramento River, were broad, sloping features that graded into the marsh. These supra-tidal levees supported dense, diverse, multi-layered riparian forests up to a mile in width. They ran parallel to the Sacramento River and along other large tidal sloughs that conveyed enough sediment to build them over time during high flow events. The levees provided migration corridors for birds and mammals, and allochthonous input (organic debris) and shade to the river systems for aquatic species. Some areas within tidal elevations were seasonally isolated from the tides due to the presence of these levees and complex fluvial and tidal interactions. The edge of the north Delta was lined by seasonal wetlands and willow thickets, or "sinks," at the distal end of tributaries as they entered the flood basins.

The south Delta, like the north, was shaped by a large river system. Here, the three main distributary branches of the San Joaquin River created a complex network of smaller distributary channels, oxbow lakes, tidal sloughs, and natural levees of varying heights which graded across the long fluvial-tidal transition zone. In contrast with the broad main channel of the Sacramento and the parallel flood basins, the San Joaquin River had lower flood peaks and less power and sediment supply to build high natural levees, and thus had many channels branching from the mainstem and coursing through the marsh islands; these channels likely vacillated between being fluvially or tidally dominated, depending on the time of the year. Small lakes and ponds were scattered in the south Delta, and the marsh was intersected with willow thickets, seasonal wetlands, and grasslands, making it a very diverse place for wildlife. The edge of the south Delta was dominated by alkali seasonal wetland complex, grassland, and oak woodland. The eastern edge of the Delta was shaped by the alluvial fans of the Mokelumne and Calaveras rivers that spread into the marsh.

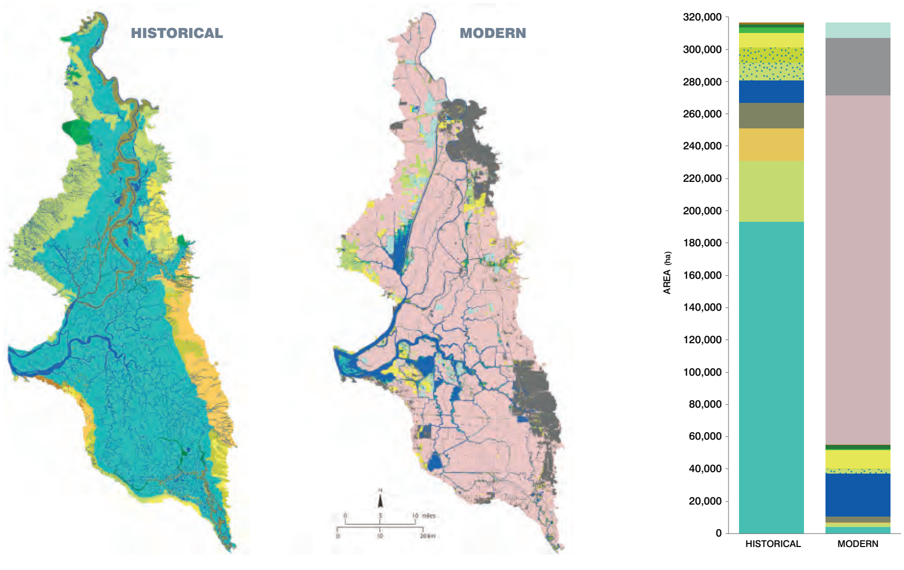


Figure 3 - **Habitat change in the Sacramento-San Joaquin Delta.** The extent of wetland habitats has decreased in the modern Delta while the extent of open water and grasslands has increased. Agriculture and managed wetlands take up a large portion of the modern Delta and provide some important wildlife support but are not equivalent to historical habitats. Oak woodlands and interior dune scrub have mostly been eliminated. For legend, see Figure 2

The Delta was not a static place. Though the positions of large tidal channels, natural levees, and lakes were relatively stable, the Delta would have looked very different depending on the year and season. Areas of marsh that were flooded with several feet of water by late winter could be dry at the surface by late fall. The Delta was a place of significant spatial and temporal complexity at multiple scales.

Delta landscapes approach

To assess ecological changes in the Delta, we analyzed early 1800s habitat mapping and other information from the Delta Historical Ecology Investigation (Whipple et al. 2012), through a lens of key ecological functions that supported Delta wildlife. With a team of local and national experts in ecological and physical processes, we developed quantifiable metrics that represent different suites of functions provided by different Delta settings. In order to evaluate change over time, the selected landscape metrics were also applied to the current Delta. Key findings are summarized below:

The historical Delta is gone. The defining characteristic of the historical Delta was its extensive wetland landscape, formed over time as floodwaters met the tides. Modern land management has increasingly disconnected floodwaters from the wetlands by widening and deepening channels, diking and draining wetlands for agriculture, and building levees for flood protection. The consequences of this disconnection include a nearly complete loss of Delta wetlands, along with the processes that sustain them, and a dramatic altering of the remaining aquatic habitats.

The habitats that dominated when the Delta was a functionally intact ecosystem have been reduced to small fractions of their former extent (Figure 3). For example, almost 200,000 hectares of freshwater emergent marsh has been reduced to approximately 4000 hectares: a reduction of 98%. Furthermore, more than 15,000 hectares of Valley foothill riparian forest throughout the historical Delta have been reduced to 4,000 hectares: a reduction of 74%. There were at least 3,200 km of small channels (<15 m wide) in the Delta historically, but only 144 km of small channels exist in the modern Delta: a 96-97% loss of channels in this size class. This decrease has most likely reduced the population viability of native wildlife in these habitats by eliminating the large, widely distributed, and connected populations. The

Habitat type	Total area (ha) Historical	Modern
Marsh	193,224	4,296
Open water	16,344	26,554

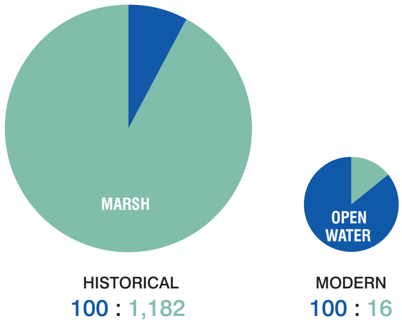


Figure 4 - **The reversal in marsh to open water area ratio over time** is the result of a 98.7% decrease in the area of marsh and a 62.5% increase in the area of open water. Where historically the Delta was characterized by narrow channels embedded within large areas of marsh, today we find tiny marshes embedded within large areas of open water

reduced extent of high-endemism habitats, such as willow-fern swamps, vernal pools and alkali wetlands, may have significant consequences for biodiversity in the region. As a result of the diking of marshes, dendritic channel networks have been lost, with ecological consequences for native fish. Furthermore, there has been a complete reversal in the ratio of marsh to open water area in the Delta. Where historically the Delta was characterized by narrower open water channels embedded within larger areas of marsh, today we find small marshes embedded within larger areas of open water (Figure 4).

The quality of remaining habitats within the Delta has been degraded by a loss of complexity and the addition of anthropogenic stressors. The channels that now characterize the Delta are wider, straighter, deeper, and simpler than historical channels, and generally lack the fine-scale structure and micro-topography (e.g., from pools, vegetated banks, channel cut-offs, and backwaters) that once increased habitat value for aquatic wildlife. Invasive species have altered food-web dynamics, particularly the Asian clam, which reduces phytoplankton availability (Greene et al. 2011). Introduced predatory fish, like bass and sunfish, directly compete with and prey upon native fish. Wetland and upland habitats have also suffered the effects of introduced species such as Arundo and Himalayan blackberry, both of which can dramatically alter habitat structure and diversity. Grasslands along the edge of the Delta have been almost entirely converted from perennial grasses and forbs to non-native annual grasses.

Habitat types are now disconnected from the processes that created and sustained them. The rivers that feed the Delta have been almost uniformly dammed and their channels armored and leveed, simultaneously cutting off peak flows, reducing sediment supply, altering seasonal hydrology, and disconnecting rivers from their floodplains. The historical Delta exhibited dramatic seasonal variation in flooding, but although seasonally flooded non-tidal habitat once totalled more than 117,000 ha in the Delta, it is now largely restricted to parts of the Yolo Bypass and Cosumnes River floodplain and totals less than 19,000 ha (a decrease of approximately 84%). Today, the decrease in the extent of inundation across the Delta has been accompanied by a decrease in the spatial-temporal variability of inundation. Rivers and sloughs are separated from their floodplains by approximately 1.770 km of artificial levees, so flood waters do not deliver the sediment and nutrients to adjacent lands during seasonal floods. Similarly, riparian forests are no longer inundated by the floods that maintained the natural levees they grow upon. Lakes, ponds and basins are now often disconnected from the larger channel network, and no longer fill with floodwaters during the winter and then drain over the summer. Instead, they have become perennial warm-water habitat that favor invasive fish. These and other interruptions or constrictions of physical processes have contributed to the development of a brittle skeleton of the former Delta, pinned in place by roads and levees, and unable to benefit from the processes that created it.

Given the multiple uses of the Delta, a wide range of ecosystem stressors, and future challenges such as sea level rise and flooding, the future Delta will be a novel ecosystem, likely to look very different from either the historical or the contemporary system (Hobbs et al. 2006, Bridgewater et al. 2011). Today's Delta experiences multiple layers of impact, including freshwater flow diversions and alterations, contaminants, reduction in sediment supply, and non-native invasive species (Hanak et al. 2013). But while habitat mosaics cannot necessarily be reestablished in the same places or at the same scale at which they existed historically, there exist opportunities to provide many of the same target functions at suitable scales within the contemporary landscape. The challenge is to recognize the potential resilience of disturbed physical and ecological systems, working in concert with underlying topographic and hydrological attributes to recover desired ecological functions (Balaguer 2014). By understanding how the landscape works and has changed, we can recognize the opportunities to strategically reconnect landscape components in ways that support ecosystem resilience to both present and future stressors.

To improve the health and resilience of native wildlife populations in the Delta, another transformation will be required—one that restores greater habitat extent, connectivity, and diversity, as well as the physical processes that increase resilience and drive ecosystem function. This restoration must occur in the context of invasive species, changes in freshwater flow, and human uses of the landscape necessitating a vision of the future that incorporates knowledge of the past and present but is completely new. This will require a landscape-scale framework for restoration that joins individual project "pieces" into a functional landscape "puzzle." The metrics presented in "A Delta Transformed," as well as the landscape restoration conceptual models to be produced in the next phase of this project, can be useful tools to meet this challenge.

For more information, please see "A Delta Transformed" http://tinyurl.com/p9yo4y6

References

Atwater BF, Belknap DF. 1980. Tidal-wetland deposits of the Sacramento-San Joaquin Delta, California. In Quaternary depositional environments of the Pacific Coast: Pacific Coast Paleogeography Symposium 4, ed. M.E. Field, A.H. Bouma, I.P. Colburn, R.G. Douglas, and J.C. Ingle. Los Angeles, California: The Pacific Section Society of Economic Paleontologists and Mineralogists.
Balaguer L, Escudero A, Martín-Duque JF, Mola I, Aronson J. 2014. The historical reference in restoration ecology: re-defining a cornerstone concept. Biological Conservation 176:12-20.
Bridgewater P, Higgs E, Hobbs R, Jackson S. 2011. Engaging with novel ecosystems. Frontiers in Ecology and the Environment 9.
California Water Code 85302 (e)(1). Available: http://www.leginfo.ca.gov/.html/wat_table_of_contents.html
Cannon T, Jennings B. 2014. An overview of habitat restoration successes and failures in the Sacramento-San Joaquin Delta. California Sportfishing Protection Alliance.
Delta Independent Science Board. (2013). Habitat Restoration in the Sacramento –San Joaquin Delta and Suisun Marsh: A review of Science Programs. Delta Stewardship Council.
Delta Stewardship Council. (2013). The Delta Plan: Ensuring a reliable water supply for California, a healthy Delta ecosystem, and a place of enduring value.
Greene VE, Sullivan LJ, Thompson JK, Kimmerer WJ. 2011. Grazing impact of the invasive clam Corbula amurensis on the microplankton assemblage of the northern San Francisco Estuary. Marine Ecology Progress Series 431:183-193.
Hanak E, Phillips C, Lund J, Durand J, Mount J, Moyle P. 2013. Scientist and Stakeholder Views on the Delta Ecosystem. San Francisco, CA: Public Policy Institute of California.
Hobbs RJ, Arico S, Aronson J, Baron JS, Bridgewater P, Cramer VA, Epstein PR, Ewel JJ, Klink CA, Lugo AE, Norton D, Ojima D, Richardson DM, Sanderson EW, Valladares F, Vilà M, Zamora R, Zobel M. 2006. Novel ecosystems: theoretical and management aspects of the new ecological world order. Global Ecology and Biogeography 15:1-7.
Jackson S, Hobbs R. 2009. Ecological restoration in the light of ecological history. Science 325:567-569.
Montgomery DR. 2008. Dreams of natural streams. Science 319(5861):291-292.
Moyle P, Bennett W, Durand J, Fleenor W, Bray B, Hanak E, Lund J, Mount J. 2012. Where the wild things aren't: Reconciling the Sacramento-San Joaquin Delta Ecosystem. Public Policy Institute of California.
Teal JM, Aumen NG, Cloern JE, Rodriguez K, Wiens JA. 2009. Ecosystem Restoration Workshop Panel Report. CALFED Science Program.
Whipple A, Grossinger RM, Rankin D, Stanford B, R A. 2012. Sacramento-San Joaquin Delta Historical Ecology Investigation: Exploring Pattern and Process. San Francisco Estuary Institute-Aquatic Science Center, Richmond, CA.

SAN FRANCISCO ESTUARY:
TIME FOR A RECONCILIATION APPROACH TO SPECIES CONSERVATION

BYJOHN DURAND & PETER B. MOYLE

California is a hotspot of physical and biological diversity. At its center lies the Sacramento-San Joaquin watershed, a network of rivers that converge in the Sacramento-San Joaquin Delta. The rivers course through an ever-changing landscape, from Sierra Nevada canyons to Central Valley floodplains and marshes. From there, water flows through the Coast Range and mixes with seawater in a gradient of freshwater to marine habitats within 100 kilometers. This transitional region is the Bay-Delta estuary, home to a variety of habitats and native and alien (often naturalized) species that manage to coexist in a constantly changing ecosystem.

Managing the estuary for endangered and valuable species has become increasingly important, difficult and controversial. The estuary hosts four overlapping runs of salmon, each timed to capitalize on seasonal resources. These runs once were among the most productive on the west coast of North America; today two runs are endangered and others are in serious decline. The estuary is also a refuge for many rare and threatened species, such as the endemic delta smelt and Suisun song sparrow, and is the wintering grounds for one of the highest concentrations of migratory birds in North America.

The native species in the estuary have declined from the combined effects of development, especially water exports, but also levee construction, deposition of mining sediment, reclamation of intertidal regions and land subsidence. As changing conditions have led to the decline in natives, alien species have flourished. Some non-natives such as the invasive Brazilian waterweed have altered physical habitat to the benefit of other non-natives. Still other alien species, such as two species of small clams, have changed the food web to favor alien fishes and invertebrates.

Conflicting environmental and economic goals, combined with irreversible physical changes and species invasions, have ruled out traditional restoration approaches in the estuary, especially the Delta. A reconciliation approach, however, offers promise. It seeks to improve conditions for desirable species (native species are usually deemed preferable by resource agencies and environmental NGOs to invasive species whose influence on the ecosystem is difficult to predict in the short term) while acknowledging that many of the human-caused alterations to estuary are impossible to surmount. Thus, improving ecosystem performance must occur as humans continue using the land and water and as the estuary continues to change biologically and physically.

Example of juvenile chinook salmon raised in rice ponds on the Yolo Bypass (upper) compared to a salmon reared in the Sacramento River (lower). Photo credit: Carson Jeffres

John Durand **is a researcher at the Center for Watershed Sciences, U.C. Davis. He specializes in the ecology and conservation of estuaries, and has actively been involved in Delta research for over ten years.**

Peter Moyle **is Professor and former Chair of the Department of Wildlife, Fish and Conservation Biology. His research interests include conservation of aquatic species, habitats, and ecosystems, including salmon; ecology of fishes of the San Francisco Estuary; ecology of California stream fishes; impact of introduced aquatic organisms; use of flood plains by fish.**

For example, much of the Delta is too deeply subsided to restore the estimated 95 percent loss of tidal wetland. These sunken areas are vulnerable to flooding and permanent inundation. Once flooded, they will slow tidal action, burdening the restoration effort.

Given these constraints, the optimal reconciliation approach would be to tailor the different regions of the Delta for different ecological functions. The northern Delta, for example, offers the most promise for establishing intertidal marsh and floodplain habitat to support native species; the region has a remnant arc of this habitat that extends from Suisun Marsh to the Yolo Bypass, tied together by the Sacramento River. The eastern and southern Delta may support riparian and seasonal floodplains fed by the San Joaquin, Cosumnes, and other rivers – habitat for many native migratory fish and bird species. The central Delta will continue to support ship traffic and sport fishing for bass and other alien fishes as some of its most deeply subsided islands permanently fill with water, creating lake-like habitat.

Under a reconciliation approach, conservation dollars would be invested at sites promising the biggest “bang for the buck” while investments in less promising sites would be minimal.

The tools used to manage the Delta for agriculture, water export and flood control will continue to be essential for managing fish and wildlife – though operations will need to be reconsidered to mimic historic conditions that support valued species.

Ponds, managed wetlands, flooded islands and other restoring sites can be gated and their flows controlled to imitate the flow patterns of historic long, meandering sloughs, which were nearly all straightened and shortened for farming and shipping. The longer residence times of tidal water in the historic, natural sloughs resulted in a high abundance of plankton – food for fish. Managing flows through gated ponds could restore this food supply even if the sloughs themselves remain unchanged.

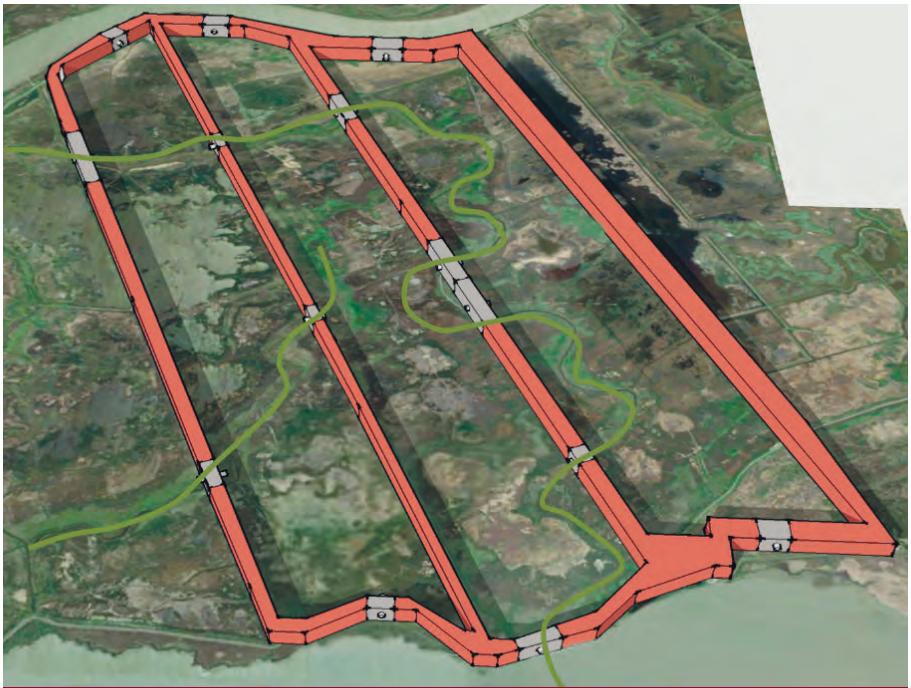
Tidal marshes and seasonal floodplains will continue to need directed flows controlled by levees, channels and barriers. Levees and gates can be operated so that Delta waterways can once again support delta smelt and other fishes. They also can work to drain and “re-set” restoration sites overrun with detrimental species such as Brazilian waterweed.

Our prescription for the estuary acknowledges a revolutionary change emerging in our relationship with the environment, from one of total domination to reconciliation. Reconciliation means accepting that the Delta is a novel ecosystem in an irreversibly changed landscape that supports an interacting mix of native and alien species. Such an ecosystem can be managed to favor species and services desired by humans. Managing novel ecosystems, especially in a changing climate, is necessarily experimental; an iterative approach will be needed to reach desired results.

Traditional water management and conservation goals have historically been at odds. A reconciled approach to water management offers the best possibility for achieving the “co-equal goals” of providing a more reliable water supply for California and protecting, restoring and enhancing the Delta ecosystem – as mandated by the state’s 2009 Delta Reform Act.

The Delta ecosystem cannot be restored to look or function as it did at some idyllic point in the past. We cannot bring back the sinuous sloughs and tule-filled marshes as they were 150 years ago. Too much has changed for that to happen. But we can change our approach to species conservation. We can create and maintain new habitats to conserve species diversity – even in an environment as unnatural at the Delta.

Subsided pasture lands on Twitchell Island, bordered by elevated Delta channel. Many levees throughout the Delta have a high probability of failure



Using a reconciliation approach to landscape restoration, shallow water habitat could be restored as experimental replicates, with configurable gates to change flows and residence time. Gates would allow restorations to mimic the hydrodynamic functions that are otherwise lost because of irreversible landscape-level changes to the estuary. Graphic: John Durand

LANDSCAPE-SCALE RESTORATION IN THE SACRAMENTO SAN JOAQUIN DELTA: RECONCILING PROPERTIES WITH PROJECTS FOR BETTER ECOLOGICAL PERFORMANCE, LESS COST, AND STAKEHOLDER ACCEPTANCE

BY CHRIS ENRIGHT, STUART SIEGEL, ROBIN GROSSINGER & LEO WINTERNITZ

Large-scale ecosystem restoration in the Sacramento San Joaquin Delta is planned for the coming decades to conserve native species. The authors believe that restoration planning should fundamentally embrace a landscape perspective using adaptive scientific assessment methods to define operational landscape units for the best chance at long-run success. Focusing restoration at landscape scales also lowers costs by reducing permitting effort, creating more land acquisition options, and encouraging broader acceptance of restoration for the future of the Delta. Despite these advantages, regulatory drivers oblige responsible public agencies to dismiss the long-term view required for landscape scaling in favor of acquiring and quickly reconnecting properties with problematic levee boundaries. We propose several advantages of restoration at the landscape scale and the institutional changes required to incentivize a landscape restoration perspective.

The Sacramento-San Joaquin Delta has been transformed over the last century as tidal marshes have been disconnected and over seven hundred thousand acres substantially subsided. The connections within the Delta and between adjacent floodplains are profoundly sensitive to geomorphic change through river and tidal energy dynamics. Restoring connections in ways that favor native species and meet flood management and water supply goals will be challenging on many fronts. We know that restoration opportunities will arise in an uncertain sequence. Reconnected land and water will cascade effects Delta-wide on hydrodynamics, geomorphology, water chemistry, and ecology. Progress will be challenging to assess because each restoration strongly affects previous restorations and, in turn, is affected by those yet to come. Incremental restoration actions will continuously shift the Delta baseline, including the ecosystem effects of Delta flows. Other ecosystem stressors like invasive species and contaminants will interfere with uncertain timing and effect. Large-scale restoration is therefore not so much about final outcomes because the Delta system state won't hold still long enough to distinguish restoration signals from powerful ecosystem effects. Rather, the adaptive management challenge is to actively steer the trajectory of landscape change toward functions that support native species over time.

It will be equally challenging to make Delta ecosystem restoration acceptable to diverse stakeholders. Though the extent and pace of proposed future Delta restoration is unprecedented, restoration actions so far have taken years to complete, hamstrung by permit requirements, Delta neighbor apprehension, and scientific and regulatory uncertainty. Nevertheless, public agencies responsible for restoration have acreage requirements that must be met on a legally demanding schedule. In parallel, the Delta community is understandably apprehensive about how restoration projects affect the Delta's future. Delta stakeholders are concerned about flood protection, the Delta agricultural and recreation economy, and the heritage value of the Delta as an evolving place.

An adaptive landscape vision: Strategic assessment tools and operational landscape units

Scientific assessments are needed about how land-water connections, natural processes, and spatial patterns improve native species persistence in the Delta. A key assessment will be to determine effective operational scales and connectivity that repair natural ecological patterns and processes. These "operational landscape units" (OLU's) help us avoid the risk of implementing many small, disconnected restoration actions that fail to restore functional ecosystems. An OLU (after Verhoeven) is a naturally-defined geomorphic unit where there is potential to reestablish higher-level ecological functions and processes through adaptive restoration, science, and management. In parallel, the Delta is also a complex social system that requires broadly-supported visions of regional restoration. Strategic assessments must encompass both social and ecological imperatives in an adaptive assessment environment. They should offer a landscape-level vision and adaptive conceptual model describing the geographic template, ecological targets, associated physical process/management requirements, and steps needed to advance the vision. The landscape vision should directly inform restoration planning through a set of explicit, geographically based landscape and ecosystem target metrics.

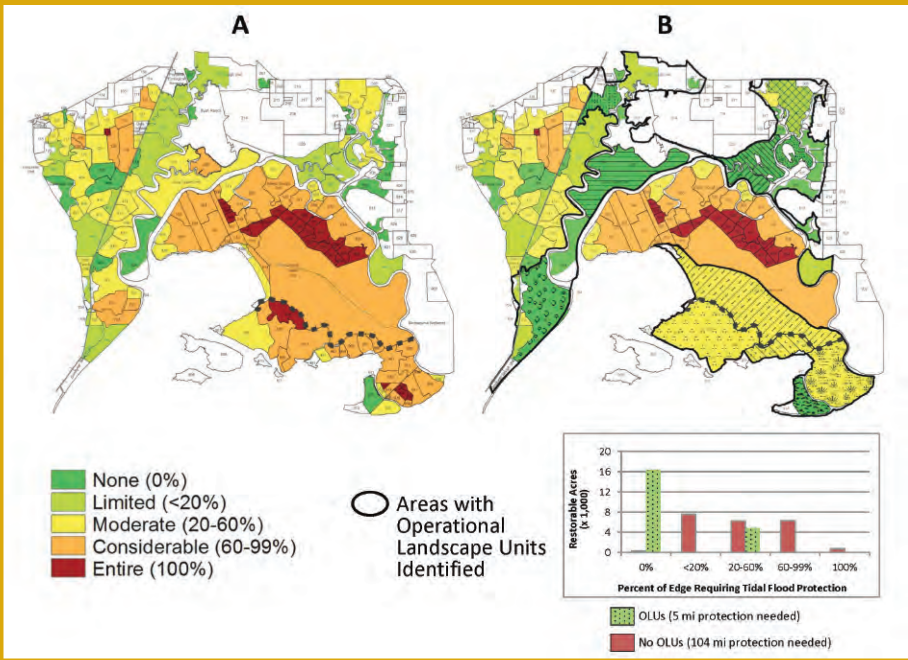


Figure 1 - One possible realization of how "operational landscape units" would reduce flood protection needs in the Suisun Marsh region of the California Delta. Colors indicate the percent of property edge requring flood protection
A - Restoration of individual properties
B - Restoration of identified operational landscape units – about half of Suisun Marsh

Figure 2 - Individual properties acquired for restoration in Suisun Marsh. Both projects require reinforced levees to protect adjacent properties while leaving historical tidal marsh features disconnected. The authors propose holding and managing properties like these for other benefits until landscape-scaled connections can be made

These metrics can help evaluate projects, the interactions between them, and trajectories of Delta ecological performance (Figure 1).

Recently there is broader understanding that landscape visions are a key to successful native species recovery. Unfortunately, the institutional relationships that enforce and implement biological opinion requirements and habitat conservation plans inadvertently encourage insular restoration of acquired properties. Public and private properties with restoration potential often have complex boundaries that comport little with ecological patterns and processes that would support competitive advantage for native species. For example, tidal marshes in the Suisun Marsh region of the San Francisco estuary have been converted to over one-hundred fifty waterfowl hunting properties, disconnecting dendritic tidal channel networks and grading out low-order channels. Property boundaries often cut directly across tidal channel networks with berms for water level control that limit ecosystem exchanges (Figure 2). Individual property restoration usually requires reinforced levees to protect neighboring properties with attendant cost and risks. Recovering tidal geomorphic patterns and processes is difficult where levees short-circuit natural marsh-building processes.

We argue that a strategic, creative, and patient approach to land acquisition, management, and restoration planning will achieve desired ecological outcomes over time at far less cost and social conflict. This will require new approaches including establishing "acquire-and-hold" as a key strategy. That is, encourage acquired properties with inadequate landscape scale to be held in productive interim land uses until an OLU can be established over time. Many advantages will accrue:

Less levee extent to protect. Operational landscape units work because they connect aquatic, intertidal, and upland habitats reminiscent of historical patterns. Most public and private properties border other properties with a levee between. When multiple properties comprise an OLU, levee boundaries can be removed along with attendant economic and ecological cost.

Fewer neighbor conflicts. Incompatible adjacent land uses can arise when restoration projects have neighbors. Depending on the land use, complaints can surface about issues like mosquito abatement, public access and liability, levee seepage, and safe harbor for endangered species. Restoration at landscape scales would connect properties into geomorphically and ecologically effective units where boundaries are more likely to be channel and bay edges.

Fewer restoration projects and required permits. Connecting properties into OLU's for restoration would reduce the number of individual restoration projects and thus the number of associated environmental permits, resulting in far less planning costs and effort.

More time for adaptive analysis and planning. An "acquire-and-hold" strategy allows adaptive analysis and decision making that considers multiple social and economic opportunities together with the complex hydrodynamic, geomorphic, and ecological cascade each restoration project will activate. Integrating restoration goals with flood management, water supply, and agricultural goals requires a dynamic whole-system view. To work, new interdisciplinary science and management competencies must be developed that emphasize system modeling, decision support tools, and advanced data analysis.

More acquisition instruments, less land speculation. Emphasizing a landscape perspective through OLU's encourages a greater diversity of acquisition instruments because time and analysis become assets rather than liabilities (as they are perceived today). Land swaps, conservation easements, rent back, options-to-buy etc., encourage landowner participation because payments can be made now for future options. This approach may also reduce restoration land speculation and spiraling land values. In the meantime, existing land uses can optionally continue for years to decades.

Improved Delta community acceptance. The more patient approach to restoration required by OLU's affords more time for the Delta community to understand and participate in restoration change. Community apprehensions are eased as neighbor conflicts diminish, acquisitions are creatively tailored to fit diverse needs, and present payments are made for future options. Large-scale restorations also lend themselves to better flood management alternatives which are desired by Delta communities. OLU's may also provide better public land experiences that would attract visitors and economic activity to the Delta.

More effective for natural process restoration. Floodplains and tidal marshes are patterned by tides, river flows, sediment, and vegetation processes. Forcing these drivers to work in constrained spaces defined by artificial property boundaries prevent natural landform recovery processes from working. Levees become necessary controls with ongoing cost and liability and often with unintended ecological consequences. A patient approach to long-term restoration affords options and time to adaptively connect properties into OLU's that leverage natural process and recover landforms and biophysical gradients that native species can use to competitive advantage.

Needed changes in the restoration management approach

Realizing the advantages of landscape-scale restoration will require new institutional approaches. First, permitting agencies must reframe their directives to allow for longer timeframes of action. Restoration planning must accommodate emerging landscape scaling opportunities that create fewer, less costly, and more ecologically effective projects over time. Second, permitting agencies should devise more programmatic mechanisms for environmental analysis and permitting and encourage performance metrics that are tied to landscape scales and dynamic long-term outcomes. Third, the mismatch of property scales and effective landscape scales can be remedied by "acquire-and-hold" strategies that allow adaptive assembly of OLU's. Fourth, acquire-and-hold will require interim land management for public benefits. Many options are available including carbon sequestration which can both prepare restorations for more effective connection and mitigate greenhouse gases. Existing land uses, flood management, recreation, and conservation of other species can be integrated in. Finally, the landscape perspective will require adaptive planning, scientific assessment and skillful social interactions as the landscape changes. This will be accomplished best by assigning restoration responsibility and authority to a trusted science and management organization with interdisciplinary skills and long-term mission to recover native species in the most effective and socially acceptable way.

Christopher Enright **is a Senior Engineer at the California Delta Science Program. His primary research has included estuarine hydrodynamics and transport processes, estuarine landscape ecology, and wetland restoration. In various research capacities over 25 years, he developed numerical models and conducted field studies focused on estuarine heat transport and land-water exchange dynamics, and water quality. He is consulting on several restoration initiatives in the California Sacramento San Joaquin Delta that would balance water supply, ecosystem reconciliation, and legacy land uses.**

Stuart Siegel **has over the past 30 years collaboratively studied, planned, designed, permitted, constructed, and monitored tidal marsh restoration projects in the San Francisco Bay-Delta and participated actively in large-scale, long-term regional restoration science and planning efforts. His UC Berkeley PhD focused on geomorphic evolution in tidal marsh restoration. Along with active restoration projects and science, he is currently working with UC Davis to evaluate rice agriculture viability in the Sacramento Delta for water supply reliability and greenhouse gas emissions reduction. Mr. Siegel is a Professional Wetland Scientist.**

Leo Winternitz **has over 30 years of water resource experience in California. He is currently working for GEI consultants engaged in flood and other water resource management work. He most recently was a senior advisor for The Nature Conservancy's water program, focusing on San Francisco Bay-Delta water and restoration issues. Leo also worked for the CALFED Program, Sacramento Water Forum, Department of Water Resources and Water Resources Control Board.**

Robin Grossinger **is a Senior Scientist at the San Francisco Estuary Institute, where he directs SFEI's Resilient Landscapes program. For over twenty years Robin has analyzed how California landscapes have changed since European contact, using these data to guide landscape-scale restoration strategies. Robin is author of the Napa Valley Historical Ecology Atlas (University of California Press 2012) and co-author of major publications on the Delta including the Delta Historical Ecology Investigation and A Delta Transformed.**

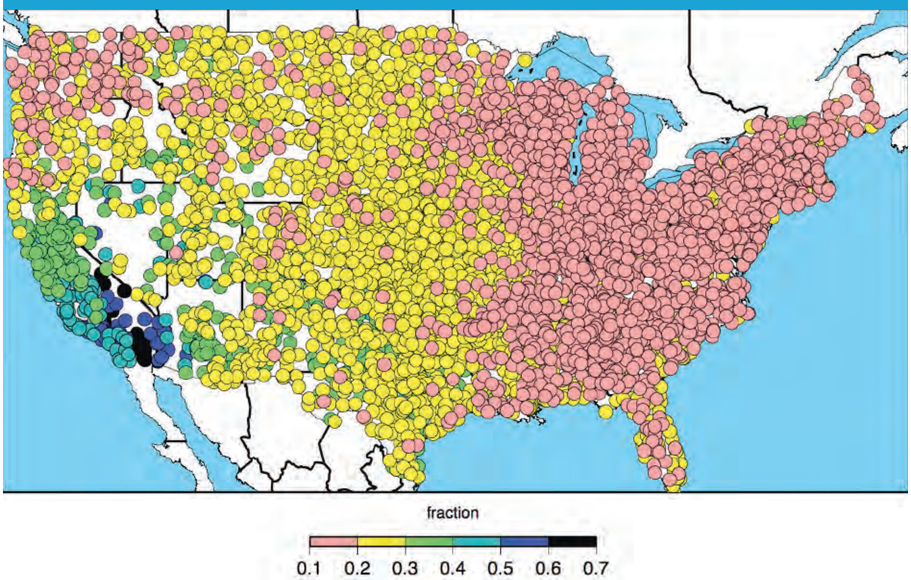
STURM UND DRANG – CALIFORNIA'S REMARKABLE STORM-DROUGHT CONNECTION

BY MICHAEL DETTINGER

Michael Dettinger **is a research hydrologist for the U.S. Geological Survey, National Research Program, Western Branch, and a research associate of the Climate, Atmospheric Sciences and Physical Oceanography Division at Scripps Institution of Oceanography, La Jolla, California. Dettinger has monitored and researched water resources of the West for over 30 years, focusing on regional surface water and groundwater resources, causes of hydroclimatic variability, and climatic influences on western water resources. He has a masters in Civil Engineering from MIT and a PhD in atmospheric sciences from UCLA.**

Storm and drought are essentially the whole story of water and life in California in ways that have always made hydro-environmental engineering a unique proposition there. To begin with, California experiences larger year-to-year variations in precipitation than elsewhere in the US, with standard deviations of annual precipitation between 30-50% of long-term averages, compared to 10-30% nearly everywhere else (Fig. 1). California's annual precipitation totals routinely vary from as little as 50% to more than 200% of long-term averages, with those dry excursions forming our droughts. This extreme variability arises because California's Mediterranean climate only provides a limited seasonal window of precipitation events, and within that period a small number of storms deliver most of the State's precipitation each year. If a few extra large storms reach California in a given winter, we can have a very wet year

Figure 1 - Coefficients of variation of water-year precipitation totals at long-term US National Weather Service COOP weather-monitoring stations, from water year 1951–2008 (from Dettinger et al. 2011)



indeed; if some are lacking, we face drought. But the storm-drought connection is deeper and more pervasive in California than anywhere else in the US.

For example, droughts in California, and nationwide, almost always begin gradually - as month-by-month precipitation deficits build up - but tend to end abruptly in a single very wet month (about 70-80% of the time in California; Dettinger 2013). In California (and northward along the West Coast), the wet, drought-busting months are typically reflections of one or two extremely large storms, with almost half of the large drought-busting storms resulting from landfalling atmospheric rivers (ARs) or "pineapple express" storms. More generally, these AR storms (Ralph and Dettinger 2011) contribute a substantial majority of the largest historical daily storm totals in California and, in turn, result in more that 80% of large floods in California and the Pacific Northwest (Dettinger and Ingram 2013; Neiman et al. 2012).

In addition to drought busting, year-to-year differences in large storms actually define California's multi-year droughts. Analyses of long-term historical records of precipitation, streamflow and lake levels reveal that past multi-year drought interludes have been due almost entirely to the absence of large storms (as opposed to normal-to-light storms). Specifically, water-year total precipitation contributions from storms that yield >95th-percentile daily-precipitation totals amount to about one-third of all California precipitation, but explain 92% of overall precipitation variability on 5-yr moving-average time scales (heavy curves, Fig. 2) and 85% of the variance of unfiltered water-year totals. In contrast, normal-to-light storms (<95th-percentile days) contribute the other two thirds of precipitation but capture a much smaller fraction (24%) of multi-year precipitation variability in California. Such a dominant role for California's largest storms may seem surprising, until you realize that a historical canvas of the very heaviest precipitation amounts across the US found that the largest storm totals along California's windward slopes have exceeded those anywhere else in the US except along the hurricane-dominated southeastern states, and California's largest storms are just as large as the largest storm totals there (Ralph and Dettinger, 2012).

Not surprisingly, ARs are at the heart of this storm-drought connection too. Historical multi-year droughts in California reflect a close relation (75% of variance) between precipitation totals and annual counts of landfalling atmospheric rivers in the State (Fig. 2b). Thus, among the year-to-year variations of AR arrivals, periods with fewer AR storms are droughts in California result in droughts; periods with more are wet. This close connection between California's largest storms and its droughts is actually quite unusual within the US. Precipitation contributions from 95th-percentile storms are important elsewhere, but contribute only 40-70% of multi-year precipitation variations (compared to 92% in California). Because the connections between California's storms and droughts are so uniquely strong, solutions to the State's hydro-environmental problems necessarily have their own peculiar flavors. In particular, design and planning for "normal" conditions in California can seem all but irrelevant sometimes, and planning for floods and droughts can never quite be completely disentangled.

> **"planning for floods and droughts can never quite be completely disentangled"**

References

Dettinger MD. 2013. Atmospheric rivers as drought busters on the US west coast. J Hydromet 14:1721-1732.
Dettinger M, Ingram, L. 2013. The coming megafloods. Scientific American 308:64-71.
Dettinger MD, Ralph FM, Das T, Neiman PJ, Cayan D. 2011. Atmospheric rivers, floods, and the water resources of California. Water 3:455-478.
Neiman PJ, Schick LJ, Ralph FM, Hughes M, Wick GA. 2011. Flooding in western Washington--The connection to atmospheric rivers. J Hydromet 12:1337–1358.
Ralph FM, Dettinger MD. 2011. Storms, floods and the science of atmospheric rivers. Eos 92:265-266.
Ralph FM, Dettinger MD. 2012. Historical and national perspectives on extreme west-coast precipitation associated with atmospheric rivers during December 2010. Bull. Amer. Meteorol. Soc. 93:783-790.

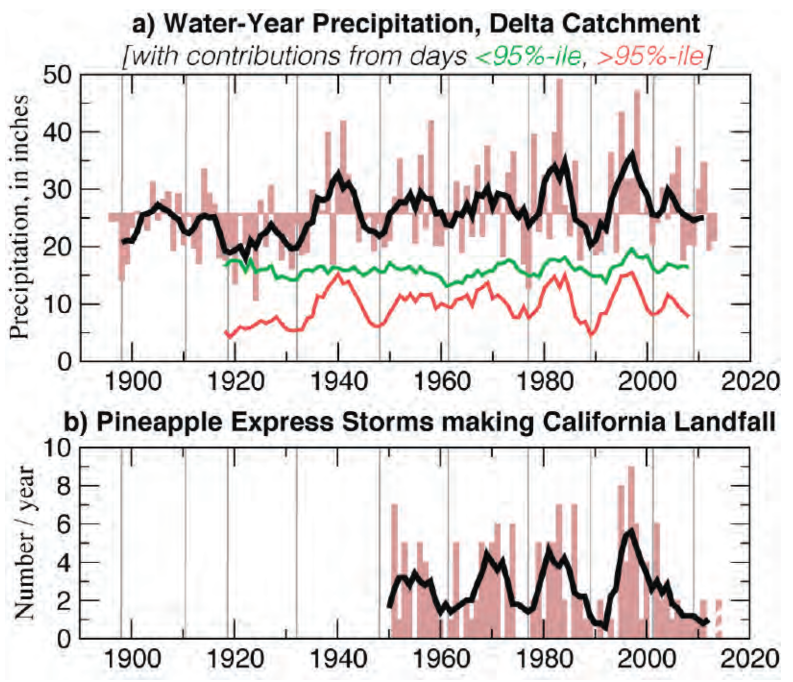
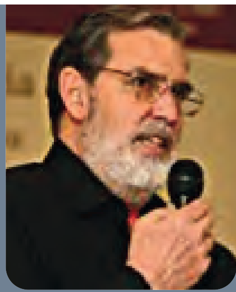


Figure 2 - (a) Water-year precipitation totals (brown bars and black curve) in Delta's catchment (Central Valley and surrounding mountain ranges, 1895-present, and 5-yr moving averages of contributions to totals from the wettest 5% of wet days (days with precipitation > 95th percentile; darker, red curve) and all other wet days (< 95th percentile; lighter, green curve), 1916-2010, and (b) numbers of pineapple-express (AR) storms making landfall between 35°N and 42.5°N per water year (using counts from Dettinger et al. 2011, updated through March 2014). Heavy curves are 5-yr moving averages in both frames; vertical grey lines are approximate centers of persistent droughts in upper panel (from Dettinger and Cayan, 2014)

AN ECONOMIST'S NIGHTMARE

BY RICHARD NORGAARD

Everything about the Delta is difficult because: 1) water is scarce in California, 2) markets do not allocate California's limited water, and 3) the Delta is the heart of California's water system where many of the feedbacks of non-market disequilibria swirl.



Richard Norgaard **is a Professor Emeritus at the University of California, Berkeley and Past Chair of the Independent Science Board.**
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.

That's an exaggeration. Indeed, perfect water markets only exist in economists' imaginations. But by looking at the Delta through an economic lens we can gain key insights into the basic difficulties of balancing human and environmental uses using strong science.

First, in the economist's ideal world, property rights are solidly defined and clearly assigned to individual economic actors so that they can make decisions as to how to use the assets they have. Rights to water, however, are inherently fluid, and the situation in California is especially sloppy.

Much of California is technically desert, land that typically only has significant economic value because land owners have access to water that has fallen as rain or snow somewhere else or has accumulated over time as groundwater beneath their land. Access to water makes land extremely productive due to good soils and favorable climate. Indeed, California has some of the most valuable agricultural land in the world. Access, however, is not the same as a clear property right. Technically, the State owns the water and allows people to use the water. There are many more claims to use water than water available and few water claims in California have been adjudicated. Access to surface water is largely provided by State and federal water development agencies and then distributed through regional water districts. Precipitation is highly variable from year to year, and how much water should be stored for the next year, or more, is constantly questioned. Environmental needs have been increasingly honored over time, and these can be especially critical during the driest of years. Thus, with the value of agricultural land tied to water access, and access always up for grabs, the defense of access to water is a constant, very high stakes, political, legal, and regulatory noisy struggle. Sound science speaks above this melee, but not without difficulty.

Second, economists are fond of how markets equilibrate supply and demand, of how prices generate efficient solutions. The California water system is far from any kind of an ideal equilibrium. Where the system is operating now is clearly not sustainable. Groundwater is a common pool resource that needs to be wisely shared between users and over time. Individual water users, however, have pumped water at whatever rates are advantageous for them. For this reason, most groundwater basins, especially in the San Joaquin Valley, are seriously overdrawn. Some wells can no longer be extended to get more water. In some areas, land has subsided from compaction after depletion. In some basins compaction is so severe that they can no longer store nearly as much water. The data are poor, but all agree that a significant portion of total water use, especially in San Joaquin Valley agriculture, over the past few decades has come from groundwater and that the historical rate of withdrawal is coming to an end. Significant groundwater regulation legislation was not passed until 2014. Total water use going forward must be lower than it has been, but a rational transition plan has not been put in place. It is difficult to make wise decisions based on science when the system fundamentals are far from where they will be at some future date. Of course, the uncertainties of how climate change will affect the supply of and demand for water only compound this problem.

Third, politics work well when actors trust each other. The levels of historic mistrust between northern and southern Californians, water users and environmentalists, and Delta residents and government generally are sufficiently high to make bargaining very difficult. Politicians keep hoping that good science will determine answers water bargainers have not been able to reach. In a state where "whiskeys for drinking and waters for fighting over", the science can never be good enough. Considerably more trust, however, could improve California water negotiations substantially.

> **"The invisible hand of the market finds ways to work, albeit beyond the imaginations of economists"**

Nearly six decades ago, Jack Hirshleifer, a professor of economics at UCLA, argued that allowing water to be traded from areas where its use value is low to where its value is high would bring rationality to California water. Markets have proven very difficult to establish because rights are so difficult to define. After three years of drought and much reduced water deliveries to San Joaquin Valley farmers compounded by very hot weather, a solution is arising. A few San Joaquin farmers are bringing their capital, drip irrigation systems, and specialty crop expertise north to the Delta and leasing farmland with firmer water rights. The invisible hand of the market finds ways to work, albeit beyond the imaginations of economists.

YOUR VOTE COUNTS!

The IAHR Council Elections are open until Wednesday July 1st. All IAHR Members have been invited to vote by electronic ballot. If you wish to vote and have not received a ballot or have lost your ballot, please contact Sally Feng at *membership@iahr.org* or visit the website at *www.iahr.org* !

All members have the option to file a nomination by petition, which deadline is April 29th. For more information on this election procedure visit www.iahr.org, under "2015 - 2017 Council Elections" or contact Maria Galanty at *office@iahr.org*

2015 COUNCIL ELECTIONS

For President

Prof. Peter Goodwin
DeVlieg Presidential Professor
Director of Center for Ecohydraulics Research
University of Idaho, USA

I am honored deeply to be selected by the Nominating Committee as candidate for President of IAHR. The greatest challenge facing society is maintaining and improving the quality of life within a healthy earth system. Population growth and climate change make balancing the reliability of a clean water supply with a sustainable but desirable ecosystem fundamental to addressing this challenge. IAHR is poised uniquely to make major contributions to the science and engineering that will inform these critical management decisions and best practices. Our community includes many of the world's leading experts and research organizations with relationships that span the globe. This is a pivotal moment in the development of IAHR as the capacity of the Secretariat has recently doubled with the opening of the second office in Beijing. If elected President, my agenda will include creating a truly global and cohesive organization, forging strategic partnerships, advancing integrated modeling, enhancing committee networking and promoting opportunities for young professionals.

Comprehensive solutions to water challenges frequently require expertise from multiple disciplines drawn from the private, academic and government sectors. IAHR will explore where strategic collaborations with international agencies and other professional learned societies could provide most impact and benefit to our membership. Examples include international professional qualifications, best practices in assessing sustainability and resilience, technical support and developing influential monographs or white papers on emerging technical areas of interest.

New monitoring technologies, modeling of complex dynamic systems, visualization and communication are increasingly important. Our committees are engaged in all aspects of the water cycle from the cryosphere to coastal waters encompassing observations, managing the ever-increasing deluge of information in the era of 'Big Data', and developing models that capture our current understanding of complex systems. IAHR will actively support these activities and as an example will cosponsor a workshop with many partner organizations in California later this year.

IAHR will offer extended support to Divisions and Committees as well as grassroots efforts of groups of colleagues where the activity leads to greater impact than a single research group or single study site. It is also our collective responsibility to improve access in regions typically underserved by IAHR. We will experiment with technology to expand accessibility to IAHR services and enhance education and professional development opportunities.

Young professionals (YP) are the future and enhancing their IAHR experience is important. IAHR has always been a place for senior members to mentor rising stars and we will grow master classes, engage YPs in Committee activities and through the YPNs enhance networking opportunities for international relationships that often last a lifetime.

The foundational work in restructuring IAHR over the past 5 years, coupled with on-line communication tools, the intellectual capacity within the Association and our global yet collegial culture, places IAHR in a unique position to assist in addressing the major water challenges facing society. As President, I will use these assets to promote IAHR on the global stage. Most importantly, IAHR is your professional organization and I welcome your ideas and initiatives to improve the effectiveness of the association.

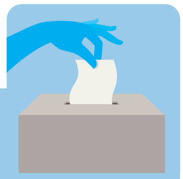
For Vice-President For the Americas

Prof. Arturo Marcano
Professor, Andres Bello Catholic University, Venezuela

Professor Rennie is currently Secretary of the IAHR Hydraulics Division and was previously Chair of the IAHR Experimental Methods and Instrumentation Committee (2009-2011).
His eight years of experience and achievements in IAHR leadership roles make him a strong candidate for IAHR Council membership. He is also a member of the American Society of Civil Engineers (ASCE) Technical Committee on Hydraulic Measurements and Experimentation. He is an Associate Editor of the Journal of Hydraulic Engineering (ASCE) and previously of the Journal of Geophysical Research – Earth Surface (AGU). He obtained his Ph.D. from the University of British Columbia (2002), where he pioneered the use of an acoustic Doppler current profiler (aDcp) for measurement of bedload. He has been a professor at the University of Ottawa since 2003, where he carries out research in the areas of river engineering, environmental hydraulics, sediment transport, turbulence, and aquatic habitat. His research focuses on flow-sediment interactions, river morphodynamics, and mixing processes, utilizing high resolution field measurements with acoustic instruments, laboratory physical models, and three-dimensional numerical modelling. He has published 45 papers in high quality journals, including a recent paper in Nature.

Research and practice in hydro-environment engineering are at a cross roads. Researchers are developing increasingly sophisticated methods to examine complex flow fields. These include fully spatiotemporally distributed measurements of important quantities such as precipitation, landscape and soil properties, water velocity, sediments, constituent concentrations, temperature, and biota. These measurements guide the development of highly resolved three-dimensional numerical models that can reproduce these distributions and predict hydro-environmental phenomena. These tools offer the possibility to design novel solutions for pressing problems facing society, such as sustainable supply of potable water, provision of sufficient renewable energy, and adaptation to climate change. In order for this to occur, these powerful tools must be adopted by design practitioners. As these tools have matured, they have become increasingly available to practitioners, but the transition to practice is slow. IAHR has successfully established itself as the global organization that mediates hydro-environment scientific exchange. IAHR Council must continue to provide mechanisms to drive the translation of advanced research to practice.

Statement
If elected to IAHR Council, I would:
- Foster further direct links between researchers and practitioners through open fora, specialized symposia, and training sessions. The goal would be to ensure that advanced tools are implemented in design practice for solution of fundamental problems.
- Encourage greater IAHR participation in the Americas through development of local Chapters that provide linkages with national organizations such as ASCE and CSCE. Ultimately, IAHR should have an active North American Division.



SLATE OF CANDIDATES

For Vice-President
For APD

Prof. James E. Ball
Associate Professor, School of Civil and Environmental Engineering
University of Technology Sydney
Australia

James Ball is a Professor in the School of Civil and Environmental Engineering at the University of Technology Sydney, in Sydney Australia. His primary research interest is in the development and application of catchment modelling systems for flood estimation in both Urban and rural catchments. This includes the determination of parameters for these systems and the use of information technology in the determination of these parameters. Through these research activities he has published a number of book chapters, over 50 journal papers and 170 referred conference papers. In 2011 he was awarded the JC Stevens Award by the ASCE for his publication in the Journal of Hydraulic Engineering. Prior to joining the University of Technology Sydney, Professor Ball obtained experience through research undertaken at universities in Australia, Canada and USA. Professor Ball also obtained experience as a Consulting Engineer and in Government Authorities.

James Ball has been appointed by Engineers Australia as the Editor responsible for the current revision to Australian Rainfall and Runoff. In this role, he is a corresponding member of Engineers Australia's National Committee on Water Engineering. In addition to his Engineers Australia activities, he is a member of the editorial boards for the Urban Water Journal, the Journal of Hydroinformatics, and is an Associate Editor for Water Science and Technology and the Journal of Applied Water Engineering and Research.

Statement
It is an honour to be considered for election as a Vice president of IAHR representing the APD. APD membership and relevance to IAHR has been growing over the past decade and this has been reflected in the new Beijing office. As a member of IAHR since 1985 I have participated in many IAHR activities; particularly in the Hydroinformatics and Urban Drainage Committees. Additionally, I was involved with organisation of the 2011 World Congress held in Brisbane.
I believe that the role of an IAHR VP is multi-faceted with prime roles being to:
- Encourage collegiality between members recognising the many diverse views, thematic areas of interest and backgrounds;
- Ensure member access to rigorous technical discussions and publications covering the spectrum of science to application;
- Encourage the exchange of knowledge where IAHR members (both individual and corporate) are active;
- Co-operate with other water related associations where the thematic activities of IAHR members overlap with those associations; and
- To assist the President in his role.

I believe that my experience in IAHR, my commitment to IAHR and my demonstrated capacity within IAHR provides an excellent background to be an effective VP of IAHR representing APD.

For Vice-President
For Europe

Prof. Arthur Mynett
Professor of Hydraulic Engineering and Head of Water Science and Engineering Department at UNESCO-IHE Institute for Water Education, Delft
The Netherlands

Arthur Mynett has long been contributing to IAHR in various capacities. He was actively involved in specialist working groups and served for over a decade as secretary and chairman of the IAHR-IWA-IAHS Joint Committee on Hydroinformatics. He stimulated cross-links within IAHR as well as with other associations outside. He served as Division Chair and has been elected on Council since 2005.

Prof. Mynett is the President of the LOC of the 36th IAHR World Congress in The Hague.

Statement
Having served on Council for 10 consecutive years, I am much looking forward to contribute to our association as Vice President for another term. Special attention remains needed to increase the membership and financial viability of our association. Our new office in Beijing deserves full support in order to play a pivoting role in extending the presence of IAHR in South-East Asia. At the same time, assuring secure footings in Europe as well as in the America's are pivoting if our association is to be recognized as a global player.
Water and environment are high on the global agenda and likely to become even higher during the coming decades due to increasing global population and effects of climate change. The various World Water For a all emphasize the need for an integrated approach in order to meet the Sustainable Development Goals. Yet, professional water associations tend to remain discipline-oriented. Hence closer links and ties are to be developed amongst the numerous water associations (IWA, IAHS, ICID, ICOLD, …). Over the past few years IAHR has already initiated this process, but further elaboration and effort is required to jointly develop a stronger future role.
As Chair of the LOC for 36th IAHR World Congress in Delft-TheHague I had the privilege to work with our future generations – I will continue to further stimulate and support our Young Professionals Networks and the IAHR Africa Division.

For Secretary General

Dr. Ramon M. Gutierrez Serret
Director of the Maritime Experimentation Laboratory of the CEDEX – Ministry of Environment
Spain

Dr. Gutiérrez graduated in Civil Engineering from the Madrid Polytechnic University in 1978, and was awarded a doctorate from the same institution in 1994, achieving an Extraordinary Award for his thesis ("air water flow in hydraulics structures"). From 1978 until 1998 he worked as an engineer in the Hydraulic Studies and Planning Department of the CEDEX "Hydrographic Studies Centre", in Spain, occupying different posts including finally Head of Department. From 1998 until now he is the Director of the Maritime Experimentation Laboratory of the CEDEX "Ports and Coastal Studies Centre". He is also Associate Professor at the Madrid Polytechnic University from 1983 to 1999 and from 2004 until the present time. He has published numerous papers related to hydraulic structures and maritime works, specially related with dams, pipelines, breakwaters and maritime physical models. In 2007, he received the Spanish decoration of the Order of Isabel La Católica, for services to foreign administration. From 2005 until now he has occupied the IAHR Secretary General post.

Statement
I plan to engage in the following activities:
- To develop the current agreements between IAHR-SPAIN WATER[1] and IAHR-IWHR CHINA[2].
- To ensure a proper execution of collaboration between IAHR and the two new sponsors: SPAIN WATER and IWHR CHINA.
- To promote the operation of the two sites of the IAHR World Secretariat -Beijing and Madrid.
- To facilitate appropriate staffing arrangements for the Madrid IAHR Secretariat operation in CEDEX.
- To improve visibility and presence of the IAHR in the water field, especially in the area of engineering.
- To improve the IAHR finances by increasing the number of members, corporate (especially) and individual.
- To increase the Association's involvement in practical issues and to encourage relations between practitioners and researchers.
- To sustain the publications quality, especially in the fields of applied hydraulics, by improving the two new Journals: Applied Water Engineering and Research (JAWER) and the Revista Iberoamericana del Agua (RIBAGUA).
- To encourage the activities of the Regional Divisions.
- To encourage the setting up of national chapters in those countries that do not have their own national hydraulics associations and, in those countries where they do exist to establish agreements and closer relationship with IAHR.
- To promote the activities of the Coastal and Maritime Hydraulics Committee.
- To boost collaboration with other similar associations: PIANC, IWA, IWRA, etc.

1) SPAIN WATER: a consortium betwen CEDEX, the General Water Directorate and the company Aqualogy
2) IWHR CHINA:Institute of Water Resources and Hydropower Research

2015 COUNCIL ELECTIONS

Council Member - For the Americas **2 candidates for 1 position**

Prof. Colin D. Rennie
Ph.D., P.Eng., Professor, Director of the Water Resources Engineering Laboratory, University of Ottawa, Canada

Colin D. Rennie has previously been Chair of the Experimental Methods and Instrumentation Committee (2009-2011), and currently Secretary of the Hydraulics Division. Eight years of experience and achievements in IAHR leadership roles make him a strong candidate for IAHR Council membership.

Statement
Research and practice in hydro-environment engineering are at a cross roads. Researchers are developing increasingly sophisticated methods to examine complex flow fields. These include fully spatiotemporally distributed measurements of important quantities such as precipitation, landscape and soil properties, water velocity, sediments, constituent concentrations, temperature, and biota. These measurements guide the development of highly resolved three-dimensional numerical models that can reproduce these distributions and predict hydro-environmental phenomena. These tools offer the possibility to design novel solutions for pressing problems facing society, such as sustainable supply of potable water, provision of sufficient renewable energy, and adaptation to climate change. In order for this to occur, these powerful tools must be adopted by design practitioners. As these tools have matured, they have become increasingly available to practitioners, but the transition to practice is slow. As a Council member I would aim to remedy this by fostering further direct links between researchers and practitioners through open fora, specialized symposia, and training sessions. IAHR has successfully established itself as the global organization that mediates hydro-environment scientific exchange. IAHR Council must continue to provide mechanisms to drive the translation of advanced research to practice.

Prof. Rafael Murillo
Adjunct professor, Civil Engineering Department, University of Costa Rica, Costa Rica

Rafael Murillo-Muñoz was appointed at the University of Costa Rica in 1994 where he currently serves as the head of graduated studies in Civil Engineering since 2010. With a civil engineering background, Rafael obtained his undergraduate degree at University of Costa Rica (1994), his M.Sc. degree at UNESCO-IHE, The Netherlands (1998) and his Ph.D. degree at University of Manitoba, Canada (2006).

Rafael is an IAHR member since 1997 and he was the chairman of the Latin-American Division from 2012 to 2014. He was also the LOC chairman of the XXV LAD Divisional Congress and of the International Conference on Fluvial Hydraulics River Flow, both held in San José, Costa Rica, in 2012. As a hydraulic engineer he has worked intensively in Central America in the areas of hydrology, small hydropower as well as highway drainage.

His main areas of interest are hydraulic structures, river engineering, highway drainage and physical modelling.

Statement
As potential member of the Council I will help to attract more Latin-American professionals to join IAHR. To achieve this I will strive to improve communication channels within our community in order to make IAHR activities more visible. On the same route to, I will encourage the formation of young professional networks as well as student chapters.

Council Member - For APD

Prof. Subhasish Dey
Professor and Head of the Department of Civil Engineering, Indian Institute of Technology Kharagpur India

Subhasish Dey is a Professor and Head of the Department of Civil Engineering at Indian Institute of Technology Kharagpur. He also holds an Adjunct Professor position in Physics & Applied Mathematics Unit at Indian Statistical Institute Kolkata. Besides he has held numerous visiting professorships in different universities of various countries, where he has taught and/or offered short courses on turbulent flow, sediment transport and scour.

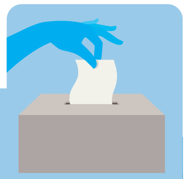
He is internationally known for his research on hydrodynamics throughout the world and acclaimed for his contributions in developing theories and solution methodologies of various problems on applied hydrodynamics, in which he has more than thirty years of experience. His general areas of research interests encompass analytical hydrodynamics, turbulence and sediment transport.

He is an associate editor of the Journal of Hydraulic Research, Journal of Hydraulic Engineering, Sedimentology, Acta Geophysica, Journal of Hydro-Environment Research, International Journal of Sediment Research etc. He has published more than 135 international journal papers. He is also an author of a book "Fluvial Hydrodynamics" published by Springer.

He is member of IAHR Fluvial Hydraulics Committee (2014–) and a past-council member of the World Association for Sedimentation and Erosion Research (WASER) (2010–2013). He is a fellow of Indian Academy of Sciences, National Academy of Sciences India and Indian National Academy of Engineering. Further details are given on http://www.facweb.iitkgp.ernet.in/~sdey/

Statement
My primary aim and motivation, as a Council member of IAHR, is to make the hydro-environmental research activities more perceptible within our world community, supporting and strengthening the global cooperation and exchange. In this issue, the young generation can play a significant role. Therefore I will encourage the young generation of hydro-environment professionals to take a prominent role within our association in strengthening their position within our existing network. However, I also boost the research students to engage themselves in fundamental research on hydro-environment issues and as well as the seniors to come up with more innovative research/professional development programs.

I also find it important to promote the regional and the international collaboration in hydro-environment research in the countries, where the activities of IAHR are being limited, by expanding the membership and facilitating cooperation and exchange.



SLATE OF CANDIDATES

Council Member - For Europe

2 candidates for 1 position

Prof. Mohamed S. Ghidaoui
Department of Civil & Environmental Engineering
The Hong Kong University of Science and Technology
Hong Kong, China

Mohamed S. Ghidaoui, born on August 24th, 1964 in Tunisia, received the BASc, MASc and Ph.D. in civil engineering from University of Toronto, Canada. Since 1993, he is with the Department of Civil & Environmental Engineering, Hong Kong University of Science & Technology (HKUST), where he is a Chair Professor. Ghidaoui is a Member of IAHR and of ASCE. He is the Chair of the IAHR Fluid Mechanics section, and a founding chair of the new IAHR section on fast transients. He served as the chairman of the IAHR-Hong Kong Chapter from 2004 to 2007 and was one of its founding members. He is the Associate Editor of the Journal of Hydraulic Research (2003-present); the Journal of Hydro-environment Research, IAHR-APD Journal (2007-present); and the Journal of Hydraulic Engineering, ASCE (2014-present). He served as an Editorial Board Member of the Journal of Hydroinformatics, IAHR (2000-2013). His awards include the Arthur Ippen Award (2007), Erskine Fellowship, University of Canterbury, NZ, and the Albert Berry Memorial Award, American Water Works Association.

Statement

If elected as council member,

- I will play an active role in consolidating the IAHR Beijing office, where I will leverage my links with the international community, the hydraulics community in China and Asia.
- I plan to revive the IAHR links with Africa, where I will build on the successful session "Challenges and Issues in Water Resources Management in Africa: past and present" which I organized at the 35th IAHR Congress in China. There is a significant number of African students studying hydraulics in Asia and strong links between hydraulicians in Asia and Africa. I will work actively with the IAHR Beijing to tap these links and bring a strong link between IAHR and Africa.
- I will build a link between the pipeline hydraulics community and IAHR. The pipeline community is large and organizes a number of conferences that often bring around 200 people. According to the data shown at the 2013 IAHR congress by Willi Hager this group is also the 2nd most papers to Journal of Hydraulic Research. Yet, this group is, by and large, not a part of the IAHR family. Since a part of my research is in the pipeline field and I know this community well, I would like to build links between this community and IAHR. They are hydraulicians and IAHR would be the natural home for them.

Dr. Damien VIOLEAU
Senior Scientist
Laboratoire National d'Hydraulique et Environnement
EDF R&D
France

Damien Violeau has been working since 1997 at the Laboratoire National d'Hydraulique et Environnement of EDF R&D, where he was appointed Senior Scientist in 2013. He is also involved in the Laboratoire d'Hydraulique Saint-Venant, created in 2006. His main activities are the development of the Smoothed Particle Hydrodynamics (SPH) numerical method and the design of coastal water-works, with an additional contribution to turbulent processes in the environment. He compiled his work on Theoretical fluid mechanics, SPH and its application to waterworks in a 600+ page book published by Oxford University Press in 2012. Besides his research activities, he developed a long and fruitful teaching experience, as lecturer in several engineering colleges in France, in particular Ecole des Ponts ParisTech, where he has been teaching Fluid Mechanics since 1998. Damien was introduced to IAHR in 2003, first as a member of the Hydroinformatics Section, then as a member of the Maritime Section (now Committee on Coastal and Maritime Hydraulics) where he was secretary from 2006 to 2007. He participated to the Biennial congresses since then, as well as many other IAHR congresses, as speaker, chairman and organizer of special sessions. He is also a regular reviewer of JHR, and was appointed Associate Editor in January 2015. He was co-opted member of the Council in 2013 and participated to the Council meeting in Porto that year. Since then, he started to think about the way to improve the links between Industry and Academia in IAHR. He also built a new YPN, the Paris IAHR YPN, officially started at the end of 2014; he is the YPN advisor.

Damien has also been member of ERCOFTAC and is member of the French Hydro Society (SHF). In 2005, he created the SPH European Research Interest Community which he chaired until 2009.

Statement

If elected, Damien Violeau will work to:

- Continue to increase relations between Academia and Industry within our community.
- Develop the interest in water and hydro-environmental sciences in Universities, by extending the Paris YPN to other Paris universities / engineering schools.
- Promote IAHR and enhance exchanges with other existing scientific communities (in particular the French Hydro Society).
- Help in keeping IAHR a dynamic community in the (near) future, by attracting new young scientists and trying to foster communication between the latter and the most experienced members.
- Promote more communication between specialists of connected areas (e.g. sediment and turbulence; waves and coastal currents, coastal and river flows, etc.).
- Foster the use of recently developed numerical methods for fluids and High Performance Computing in order to extend the capabilities of CFD to a wider range of applications in hydraulic engineering.

2 candidates for 1 position

Prof. Stefano Pagliara
Professor of Hydraulic Constructions
University of Pisa
Italy

My work at the University of Pisa regards, since 1990, mainly river hydraulic structures and flood mitigation with a strong motivation on experimental hydraulic. I am the Coordinator since 2004 of the Ph.D. program on Civil and Hydraulic engineering. In the last 6 years I served the IAHR committee on Hydraulic Structure also as Chairman.

Statement

As potential member of the council my statements are:

- A main point is to improve the appealing and attractive of IAHR to practitioners, engineers and young researchers.
- Drive IAHR to promote events and cooperative projects in order to share best practices and team-working activities.
- Support the creation of new task groups on the main new, actual topics that our environmental research propose.
- Work with the IAHR team to encourage membership growth that remains a key issues for our association.
- Work in order to maintain JHR as a prestigious research journal.

HYDROWEB EXPERIENCE 2014

BY MICHAEL TRITTHART & FRANK MOLKENTHIN

HydroWeb is an educational IAHR initiative, focusing on web-based collaborative engineering in hydro-sciences. In November 2014 it was run as a pilot project with the participation of 27 students from three different IAHR Young Professionals Networks distributed globally: Beijing/China in Asia, Curitiba/Brazil in South America and Vienna/Austria in Europe.

Three student teams of nine persons composed of three students from every location worked on a river modelling task on a shared Web-project platform. The platform offered several linked Web services to share application software, model data and project reports (see http://euroaquae.tu-cottbus.de/hydroweb). Project tasks for the student teams were the flood management of a river in Denmark using a numerical simulation model. While the river modelling task was at the core of the exercise, the real challenge was the team collaboration over three different time zones and between people with different educational and cultural backgrounds as well as different mother tongues. The bottom line for many participants was that the course presented a unique experience during their studies and that they substantially improved their skills in intercultural collaboration as well as in modern ICT application for team work in the Web. The supervised "trial and error" approach led after four hard weeks for the participants to the HydroWeb "miracle": Students from different countries and continents, who never met before, who never heard something about the river region in Denmark, who never used the applied river simulation tool and who never did engineering team work in the Web with different locations and in different time zones were able to set up an efficient collaboration and team spirit to solve the given problem in only one month.

IAHR offers with HydroWeb young professionals the opportunity to develop international and interdisciplinary collaboration experiences and to prepare themselves for the ongoing globalization process in the water sector. The HydroWeb course will be assessed and broadly discussed during the forthcoming IAHR World Congress 2015, with the participation of Young Professionals in the discussions being highly appreciated. Based on the experiences gained during this year's pilot project, the course will be adapted and offered to YPNs worldwide for the next time in autumn 2015.

***Michael Tritthart* graduated in civil engineering from the University of Innsbruck, Austria, in 2000, and obtained a doctorate in technical sciences at Vienna University of Technology in 2005. He then joined the University of Natural Resources and Life Sciences, Vienna as a senior scientist, where he obtained a post-doctoral lecture qualification for hydroinformatics and river engineering in 2013. Throughout his career, he has developed various numerical models in hydrodynamics, sediment transport and ecohydraulics. He is currently Vice-Chair of the IAHR Education and Professional Development Committee.**

***Frank Molkenthin* graduated in civil engineering from TU Berlin in 1988, where he also obtained his doctorate in 1994. Afterwards he joined BTU Cottbus as scientist and went on to receive a post-doctoral lecture qualification in 2001, before being appointed apl.Professor in 2009. He established the first HydroWeb course in 1999, which was offered as IAHR student chapter activity until 2005, later continued within the international Erasmus Mundus MSc course programme EuroAquae, and he conducted the IAHR-HydroWeb pilot project for YPNs in 2014.**

IAHR-BW YPN'S EVENT

ANNUAL COLLOQUIUM "TOWARDS A SUSTAINABLE FUTURE: WATER, FOOD, ENERGY"

BY EVA FENRICH

On December 1st , 2014 more than 80 students and young professionals from nine universities in the German state of Baden-Württemberg and beyond gathered, meeting both senior and young professionals from consulting firms for the 15th Annual Colloquium "Towards a sustainable future: water, food, energy" organised by the IAHR- Baden-Württemberg YPN.

IAHR-BW YPN President Arslan Tahir at the opening

IAHR-BW YPN with the guest speakers of the colloquium

The IAHR-BW YPN was very honoured to have IAHR President Roger Falconer as a guest and speaker at the colloquium.

The Colloquium started off with the "Young Scientists' Forum" in the morning where students presented their work on topics ranging from energy related topics like hydropower and biogas to water management and hydroponic agriculture. With seven fabulous presentations the "Young Scientist's Prize" competition was a very close run.

After the lunch break the session was opened by IAHR-BW YPN President Arslan Tahir. IAHR President Professor Roger Falconer gave a welcoming speech emphasising IAHR's commitment to the young professionals within the organisation.

In his presentation on global water security he gave the audience a broad overview of the pressures on water supplies, internal and external water footprints and how the virtual water content of different products could be used to influence consumer decisions.

Professor Jörn Birkmann Head of the Institute of Regional Development Planning at the University of Stuttgart shared insights into the changing and emerging risk profiles in the Mekong Delta and their implications for the water-food nexus reminding the young water professionals that it is necessary to work with

YOUNG PROFESSIONALS NETWORK LOGO

This logo will give an identity to the YPN and will help to target the activities related to the Young Professionals Network in the next World Congress and other YPN events. It has been also created with the objective of promoting the YPN in Social Media under the IAHR umbrella. This logo looks dynamic and young but keeping the essence of IAHR!

IAHR YPN

Young Professionals Network

Supported by
Spain Water and IWHR, China

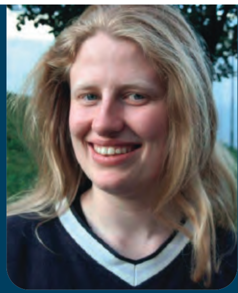
the local communities to take changes in land use into account when planning flood protection and other measures.

Next Gareth Whealan from the SWaFA project introduced an innovative approach to distribute safe water in communities in developing countries. Currently the system is designed in London. With this approach basic water needs are fulfilled before bringing excess water to the market.

Dr. Ines Dombrowsky, Head of Department Environmental Policy and Natural Resources Management at the German Development Institute described the challenges of hydropower projects in shared river basins. These projects in the WEF-Nexus are a chance as well as a challenge for all parties involved.

From a Nigerian point of view Olusola Matthew Adeoye from the Institute of African Studies, University of Ibadan, Ibadan, Nigeria gave everyone an understanding how changing water policies can have a major influence on sustainable solutions.
A broad range of research projects and opportunities within the research training group "Water - People –Agriculture" was presented by Dr. Marcus Giese from the University of Hohenheim,where the students were informed of the possible scholarships that the University of Hohenheim is offering in the subject area for PhD and research.

IAHR Council member Prof. Silke Wieprecht, Director of the Institute for Modelling Water and Environmental Systems at the University of Stuttgart, advisor of the IAHR-BW YPN summed up this varied and exciting afternoon and prizes were awarded to two of the Young Scientist's who best presented in the young professionals forum.



Eva Fenrich **- Baden-Württemberg IAHR Young Professional Advisor**

In the evening everyone had the opportunity for fruitful discussions at the Meet and Greet party and to visit the hydraulic laboratory.
This successful event was made possible by all the speakers who provided their time and expertise and team of more than 20 highly enthusiastic and efficient volunteers of the IAHR-BW-YPN.

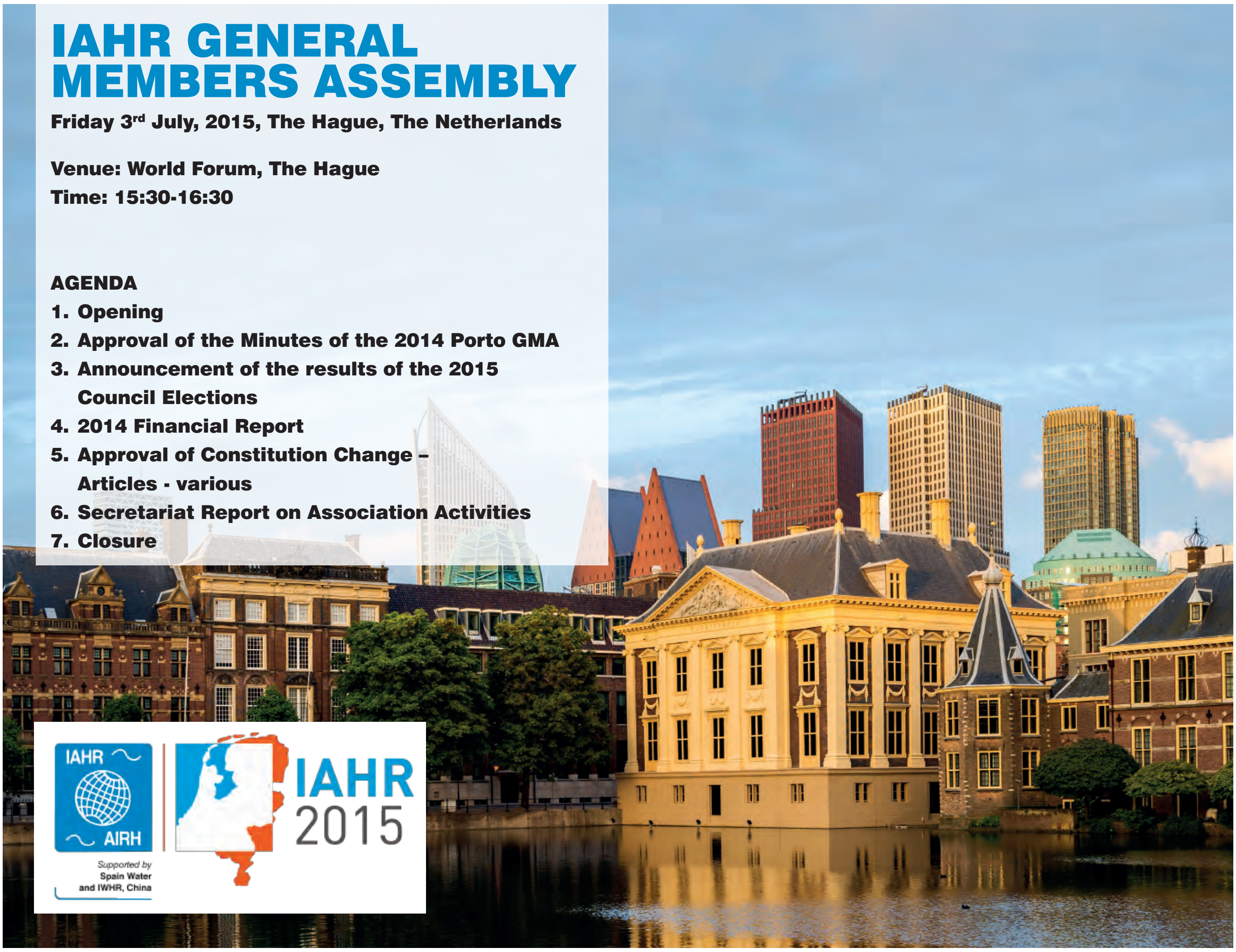
IAHR GENERAL MEMBERS ASSEMBLY

Friday 3rd July, 2015, The Hague, The Netherlands

Venue: World Forum, The Hague
Time: 15:30-16:30

AGENDA

1. **Opening**
2. **Approval of the Minutes of the 2014 Porto GMA**
3. **Announcement of the results of the 2015 Council Elections**
4. **2014 Financial Report**
5. **Approval of Constitution Change – Articles - various**
6. **Secretariat Report on Association Activities**
7. **Closure**



IAHR EVENTS CALENDAR

IAHR Specialist Events

17th IAHR International Conference on Cooling Tower and Heat Exchanger
08 September 2015 - 11 September 2015
Gold Coast, Queensland, Australia
www.geothermal.uq.edu.au/17iahr-cooling-tower

10th International Conference on Urban Drainage Modelling (10UDM)
20 September 2015 - 23 September 2015
Quebec, Canada
www.udm2015.org

11th International Symposium on Ecohydraulics
08 February 2016 - 12 February 2016
Melbourne, Australia
www.ise2016.org

International Symposium on Outfall Systems 2016 co-jointly with CoastLab 2016
10 May 2016 - 13 May 2016
Ottawa, Canada

ISHS 2016 - International Symposium on Hydraulic Structure
28 June 2016 - 30 June 2016
Portland, Oregon, USA

28th IAHR symposium on Hydraulic Machinery and Systems
04 July 2016 - 08 July 2016
Grenoble, France
www.iahrgrenoble2016.org

RiverFlow 2016 - 8th International Conference on Fluvial Hydraulics
10 July 2016 - 14 July 2016
Missouri, United States
www.iihr.uiowa.edu/riverflow2016/

12th International Conference on Hydroinformatics
21 August 2016 - 25 August 2016
Incheon, South Korea

14th ICUD - International Conference on Urban Drainage
September 2017
Prague, Czech Republic

IAHR Regional Division Congresses

4th IAHR Europe Congress
27 July 2016 - 29 July 2016
Liege, Belgium
airh2016@ulg.ac.be

IAHR 20th Congress of the Asia & Pacific Division
29 August 2016 - 31 August 2016
Colombo, Sri Lanka

XXVII Congreso Latinoamericano de Hidraulica 2016
Lima, Peru

IAHR World Congresses

SEE YOU THERE!

36th IAHR World Congress
28 June 2015 - 03 July 2015
The Hague/ Delft, the Netherlands
"Deltas of the future (and what happens upstream)"
www.iahr2015.info

37th IAHR World Congress
14 August 2017 - 18 August 2017
Kuala Lumpur, Malaysia
office@iahr.org

IAHR AIRH
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