California Bay-Delta – Photo Credit: Paul Hames, Courtesy of the California Department of Water Resources

The Science Enterprise Workshop: Supporting and Implementing Collaborative Science

Advance Briefing Paper

Scientists, science-policy experts, and stakeholders gather for a two-day workshop to better understand how collaborative science is being managed, funded, and communicated in several high-profile ecosystems around the country. The program is designed to identify common themes and differences in the approaches being used across this group of systems. Experts will discuss how they are working to provide science support to managers who are working on improving the long-term health and viability of the nation's ecosystems.

November 1-2, 2016
Davis, California

Co-hosted by U.S. Geological Survey and the Delta Stewardship Council

USGS science for a changing world

Delta Stewardship Council

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INTRODUCTION

The Science Enterprise Workshop, **November 1- 2, 2016, Davis, California**, will bring together scientists and science-policy experts from across the country to share information about how collaborative science is funded, managed, and communicated in several high-profile and complex ecosystems – the California Bay-Delta, Chesapeake Bay and Watershed, Coastal Louisiana, Great Lakes, Greater Everglades Ecosystem, and Puget Sound.

The workshop is being conducted at a critical time for the California Bay-Delta. In the Delta, "every decision becomes unimaginably complex," because virtually any change intended to improve a public value is perceived to degrade some other value.[1] The Delta is not unique in this regard. At the Science Enterprise Workshop, participants will have the opportunity to hear from a wide-range of experts highlighting how different regions have developed science management mechanisms to support managers who are working on improving long-term health and viability of the nation's high-profile ecosystems.

The Delta management and policy community is looking for a path forward marked by better coordination, collaboration, and innovation – guided by the vision of **"One Delta, One Science."**[2] This workshop will provide a way for California's Bay-Delta to identify possible ways to improve science management and funding. Feedback and lessons learned from the workshop will be given to the Delta Stewardship Council's (Council) Delta Plan Interagency Implementation Committee (DPIIC) within two weeks of the workshop. This will directly inform the ongoing discussion of how to best improve funding, management, and communication for science enterprise in the Delta.

Purpose and Expected Outcomes

The Science Enterprise Workshop is designed to orient participants to how science is being conducted in several high-profile ecosystems and identify common themes and variations in the approaches across key points of comparison. This workshop offers an opportunity to draw lessons from other systems, including a few with more highly-integrated science programs than the California Bay-Delta's. As a first step, this workshop is designed as a comparative review that may reveal important lessons from other systems, helping managers and policymakers to:

- Avoid mistakes or "reinventing the wheel" in efforts to better coordinate and integrate science, including integrative approaches to deal with social, biological, chemical, and physical aspects of complexity;
- Better understand governance and management systems that have been set up in other high-profile systems to jointly manage resources and conduct science;
- Identify practical means by which science programs manage financial and intellectual resources and ensure the relevance of ongoing lines of research and monitoring;
- Hear expert's perspectives on what makes science "legitimate" to stakeholders and the public, and on the limitations of traditional approaches to applied science; and
- Enhance networking among programs and experts, and contribute to the body of knowledge on natural resource management of major regional systems.

[1] Luoma SN, Dahm CN, Healey M, and Moore JN. 2015. Challenges Facing the Sacramento-San Joaquin Delta: Complex, Chaotic or Simply Cantankerous? San Francisco Estuary and Watershed Science, Volume 13, Issue 3. http://dx.doi.org/10.15447/sfews.2015v13iss3art7

[2] "One Delta, One Science" 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 and environmental decisions. Delta Science Plan. 2013. Delta Stewardship Council. http://deltacouncil.ca.gov/science-program/delta-science-plan-0

Working Definitions

Science refers to information gathered in a rational, systematic, testable, and reproducible manner (Lackey 2009).[3] Although there is no definition specific to the California Bay-Delta, the 2013 Delta Science Plan encompasses all of the following activities:

- Research
- Data collection and monitoring
- Data management and accessibility
- Modeling
- Analysis and synthesis
- Independent scientific peer review and advice
- Science communication

Science Enterprise is not interchangeable with "science program." Instead, it refers to the collection of science programs and activities that exist to serve managers and stakeholders in a regional system. The elements of an enterprise range from in-house programs within individual agencies or other organizations to large-scale collaborative science programs funded by governments. Included in this definition is academic research, recognizing that academic researchers often operate independently of management and stakeholder entities. Science enterprises can vary greatly in the degree to which resources are concentrated in collaborative programs and produce publicly-available results. The differences among regional systems can reflect historical factors, depth and persistence of conflict regarding resource issues, governmental guidance and engagement, the range of agencies and interests involved, and other factors.

Science-Policy Interface is the methods by which scientists and policymakers communicate with one another. A science-policy interface (SPI) may be entirely informal, somewhat formal, or highly formalized, depending on the circumstances. The Intergovernmental Panel on Climate Change (IPCC) is an example of a highly formalized SPI. Building and maintaining an effective SPI is an important aspect of science program management.

Cooperation, Coordination, Collaboration are often used interchangeably, but with recognizable differences, in order of increasing joint commitment:

- Cooperation –involves sharing information and sometimes resources while each party pursues its own goals;
- Coordination –involves sharing information and resources, with the parties pursuing a common interest or objective. The interest or objective, however, is defined independently by each party; and
- Collaboration –involves sharing information and resources with the parties pursuing a common interest or objective that they jointly define.

Co-production denotes the participation of managers or stakeholders in the design, execution, and interpretation of scientific studies. The term has come into use as the practice of integrating science consumers into the process of science production. Co-production may be implemented as a transparency measure or as a form of actual collaboration (see above).

Useful versus Useable Science distinguishes between the perceptions of scientists who conduct research to answer questions important to resource managers and the perceptions of the managers. While all useable science is useful, the converse is not true. Useable science "directly reflects expressed constituent needs, should be understandable to users, should be available at the times and places it is needed, and should be accessible through the media available to the user community" (Lemos and Morehouse 2005).[4] One purpose of an effective science-

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[3] Lackey, R. 2009. Is Science Biased Toward Natural? Northwest Science 83(3):291-293. 2009 doi: http://dx.doi.org/10.3955/046.083.0312
[4] M.C. Lemos, B. Morehouse. The co-production of science and policy in integrated climate assessments Global Environ. Change, 15 (2005), pp. 57–68. http://www.sip.ucar.edu/thorpex/pdf/Lankao.pdf

policy interface is to increase useable science as a fraction of all science produced within a science enterprise. Of course, management and policy processes sometimes have difficulty assimilating science to make it used.

Enabling Guidance is the combined set of laws, treaties, executive orders, agency policies, regulations, court rulings, and other authorities that provide a framework under which science programs are developed and implemented.

Relevance, credibility, and legitimacy are three features commonly thought to be essential for science to play a role in policy and management decisions (Sarkki et al 2013;[5] Heink et al 2015[6]). Legitimacy is the belief that the scientific process is being applied impartially and without partisan bias or prejudice and can be the most difficult, and important, of the three factors to foster in situations where science is being used to inform contentious resource management decisions. An effective science-policy interface generally acts in part to increase legitimacy (Posner et al 2016).[7]

[5] Sarkki,S., et al. (2013)Balancing credibility, relevance and legitimacy: A critical assessment of trade-offs in science–policy interfaces. Science and Public Policy first published online August 28, 2013 doi:10.1093/scipol/sct046. http://spp.oxfordjournals.org/content/early/2013/08/28/scipol.sct046.short

[6] Heink, U., et al. (2015). Conceptualizing credibility, relevance and legitimacy for evaluating the effectiveness of science–policy interfaces: Challenges and opportunities. Science and Public Policy 2015 42: 676-689. http://spp.oxfordjournals.org/content/42/5/676.abstract

[7] Posner, S. M., et al. (2016). "Policy impacts of ecosystem services knowledge." Proceedings of the National Academy of Sciences 113(7): 1760-1765. http://www.pnas.org/content/113/7/1760.abstract

WORKSHOP ORIENTATION

Advance Briefing Paper

This Advance Briefing Paper serves as a basis for initial comparisons of the systems. Its purpose is to provide a foundation of relevant facts and potential points of similarity and differences. Due to the short time for the conference, attendees are strongly encouraged to familiarize themselves by reviewing this document before attending the talks.

Workshop Location and Logistics

The workshop will be held at University of California, Davis, in the Activities and Recreation Center (ARC) Ballroom A, on November 1-2, 2016, from 8:30 am to 5:30 pm. The UC Davis campus is easily accessible from Sacramento and the San Francisco Bay Area. Both days of the workshop will be video-recorded and available for viewing after the event.

Workshop Agenda

The format for each panel will include presentations from experts representing each region organized by common points of comparison or specific topics and will conclude with an open question and answer session.

Tuesday, November 1, 2016: Comparison of Science Enterprises - Regional Programs

The workshop will start with presentations by science leaders on the structure and organization of the science programs in several major systems: California Bay-Delta, Chesapeake Bay and Watershed, Coastal Louisiana, Great Lakes, Greater Everglades Ecosystem, and Puget Sound. Common points of comparison will include:

- History of regional program development;
- Major resource management issues;
- Current science enterprise structure;
- Funding for science;
- Important tools for implementing science; and
- Communications and co-production.

Following presentations from experts representing each system, outcomes from the 2013 Puget Sound Science Enterprise Workshop will be presented. Lastly, a panel discussion will present additional data and allow questions from the audience. Panelists will also discuss practical and field-tested examples of how to achieve greater science integration, and how networking among programs and experts can contribute to the body of knowledge on natural resource management of major regional systems.

Wednesday, November 2, 2016: Collaborative Science Management, Governance, and Funding

The second day will feature comparative discussions on common challenges and opportunities that often arise in the management of science enterprises. Regional experts will be joined by social scientists, legal experts, and economists on panel presentations to discuss decision-making and key topics related to:

- Science strategies in large programs;
- Governance and adaptive management;
- Funding and resource allocation; and
- Legitimacy, co-production, and communication.

Workshop Report

The workshop proceedings will be published in long- and short-formats. The short-format will be structured as a briefing paper for decision-makers that summarizes key points of comparison across systems, building on the information presented here in the regional profiles and further discussed at the workshop. The final report, including recommendations presented to DPIIC (November 14, 2016) will be issued shortly after the event.

INITIAL REGIONAL COMPARISONS

Science enterprises in major systems are large and complex. The following pages include short descriptions of each of the six systems represented at the workshop and should provide workshop attendees a basic understanding of system characteristics, major challenges, and how restoration and scientific research is organized and funded.

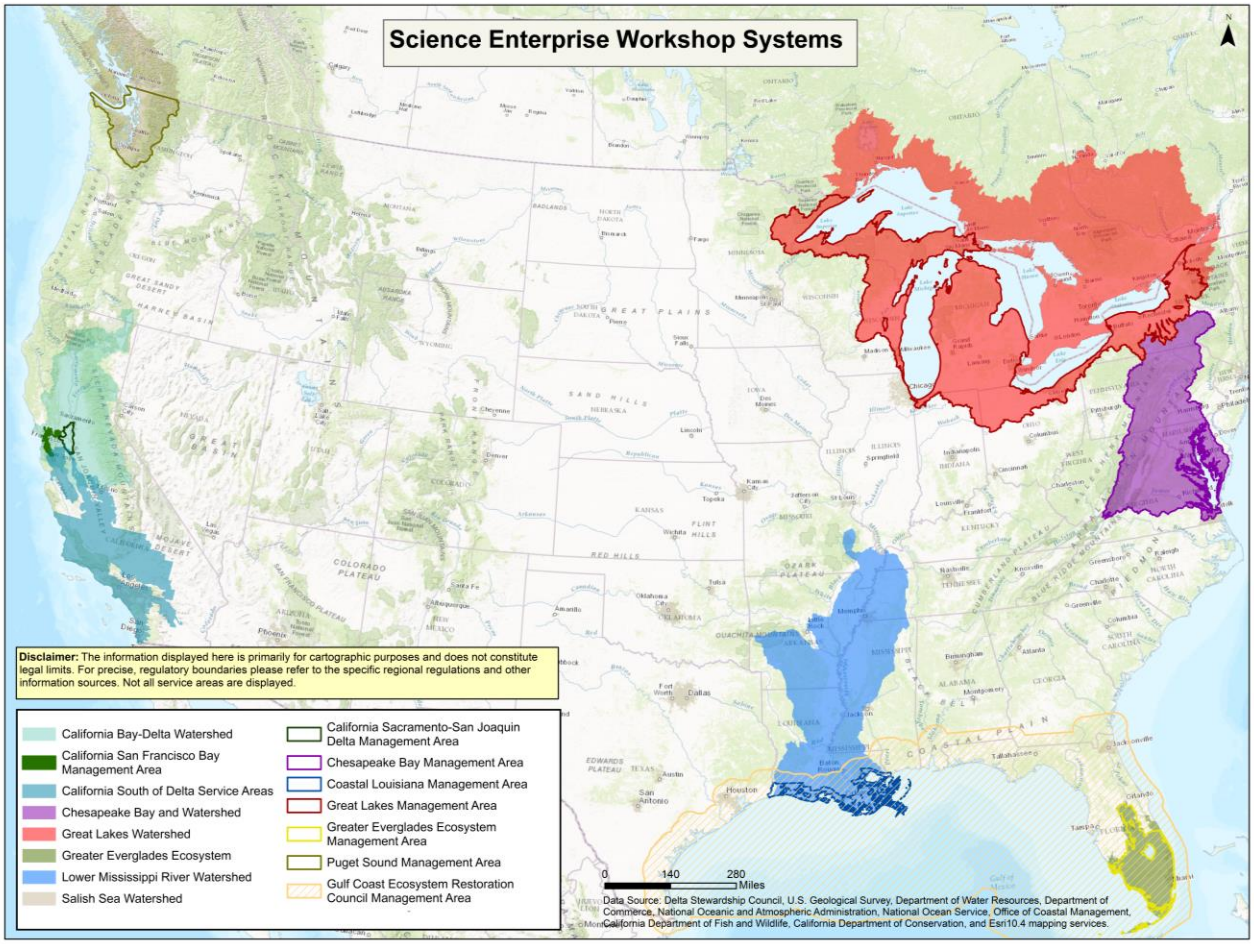
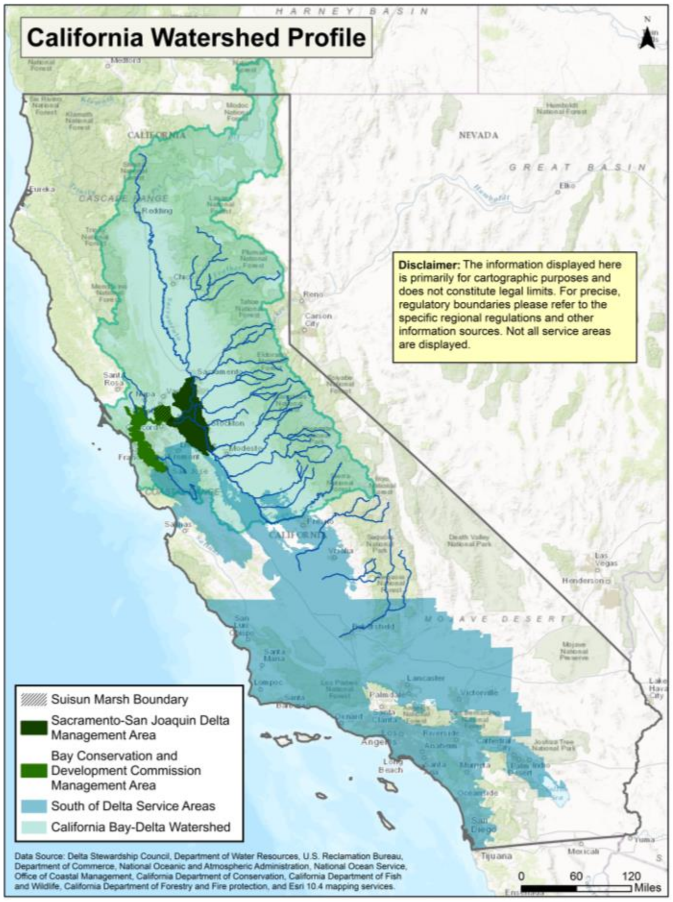


Table 1, Regional Informational Highlights: Sources for all data below provided in respective regional profiles

Watershed	Size (mi^2)	States & Provinces	Human Population Reliant on Water System (million)	Dependent Economic Output ($B) (please note that reported figures may employ different methods and may not capture economic output in the same fashion)
California Bay-Delta	45,600	CA	27	$2,200
Chesapeake Bay & Watershed	64,000	DE, MD, NY, PA, VA, WV, DC	18	$107
Coastal Louisiana	8,277	LA	2	$36
Great Lakes	295,000	IL, IN, MI, MN, NY, OH, PA, WI, ON, QC	30	$4,600
Greater Everglades Ecosystem	18,000	FL	8	$394
Puget Sound	13,700	WA, BC	4.8 (U.S. only)	$194

California Bay-Delta



Background

The California Bay-Delta is where the Sacramento and San Joaquin rivers meet as they flow out of the Sierra and Cascade mountains– spreading out into 1,160 square miles of islands, canals, and shallow waterways before flowing into the San Francisco Bay. Before it was diked, drained, and developed, the Delta was a vast wetland complex of low islands, shifting channels, woody debris accumulations, and tule marshes. Today, the Delta is a patchwork of largely agricultural islands separated by deep channels and protected by 1,100 miles of levees. It hosts farms, fisheries, water projects, recreational areas, and neighbors the State capitol of Sacramento. Geographically, it is the largest delta on the Pacific coast.

Why is this system important?

The Bay-Delta is a complex ecosystem made up of interconnected tributaries, rivers, bays, wetlands, marshes, floodplains, and islands. It contains areas of rich biodiversity, supporting hundreds of species of birds (migratory and resident), fish, and other plant and animal species. Endangered and threatened species include the delta smelt,[8] Chinook salmon, and ridgway's rail. The Delta and Suisun Bay/Marsh together cover about 1,300 square miles (land and water) spanning 6 counties, hold 400,600 acres of high quality farmland,[9] and are home to more than 550,000 people. The Bay's watershed covers over 45,600 square miles and drains 40 percent of California.[10] The Bay's surrounding lands are home to over 7.5 million residents.[11] The Bay-Delta is the hub of the nation's largest water delivery system. Two-thirds of the state's population, about 27 million people, depends on the Delta watershed for some portion of their water supply, as do more than 3 million acres of irrigated farmland.[12] Water from the California Bay-Delta provides a critical base for most of the State's economic output of $2.2 trillion in 2015.[13] In addition to water supply and agriculture, the Bay-Delta supports other industries including tourism and recreation, technology, entertainment, and fisheries.

What are major challenges?

The Bay-Delta is confronted with many challenges due to extreme habitat alterations and its central role in California's water supply. Water diversions impair natural flow regimes, migratory cues, and water quality, and entrain fish into water delivery systems. More than a century ago, Delta residents began to build an intricate levee system to channel water and dry out land, which converted hundreds of thousands of acres of seasonally and tidally flooded wetlands into fertile agricultural fields. As a result of continued land use change and urbanization, 95 percent of the historical tidal marsh in the Delta has been lost and has led to major declines in native species.

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[8] Please note for consistency purposes, all species names throughout the report are lower case

[9] The Delta Plan: Chapter 5. http://deltacouncil.ca.gov/sites/default/files/documents/files/CH_05_2013.pdf

[10] The Delta Plan: Chapter 1. The Delta Plan. http://deltacouncil.ca.gov/delta-plan-0

[11] The San Francisco Bay Estuary. San Francisco Estuary Partnership. http://www.sfestuary.org/about-the-estuary/

[12] *Id*

[13] Luoma SN, Dahm CN, Healey M, and Moore JN. 2015. Challenges Facing the Sacramento-San Joaquin Delta: Complex, Chaotic or Simply Cantankerous? San Francisco Estuary and Watershed Science, Volume 13, Issue 3. http://dx.doi.org/10.15447/sfews.2015v13iss3art7

Other Delta challenges include land subsidence, nutrients (which affect plankton communities and aquatic plants), toxins/pollutants (which affect species survival and human food safety), invasive and introduced species (which lead to competition with native species, predation, and habitat alteration), and a boom and bust hydrologic cycle of floods and prolonged droughts. The Delta and Bay are interconnected, and stressors affect the health of both. Water management decisions have significant financial implications for the economic interests of the State, and by extension, represents one of the most politically charged subjects in California. Additional complications arise from the differences in governance and science organization between the Delta and the Bay, which have their own unique, but interrelated management needs. Each of these challenges will be compounded by climate change.

How is restoration and scientific research organized?

Hundreds of government, non-government, academic, and private institutions are involved with Bay-Delta research, restoration, and science management. Several interagency science groups organize new studies, review study plans and proposals, write scientific papers and reports, and promote collaboration, including the Interagency Ecological Program, San Francisco Estuary Partnership, San Francisco Estuary Institute, Collaborative Adaptive Management Team, Delta and Bay Regional Monitoring Programs, and the California Department of Fish and Wildlife's (DFW) Watershed Restoration Grants Branch. A host of State and federal government agencies play roles in Delta science or management, including the U.S. Geological Survey (USGS), U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service (USFWS), DFW, California Department of Water Resources (DWR), and the State Water Resources Control Board. The Council, created as part of the 2009 Delta Reform Act, is the State agency charged with creating the Delta Plan, a blueprint for how to connect the many stakeholders to further achieve the coequal goals of a reliable water supply and a healthy ecosystem. The Delta Plan includes a recommendation for better organizing science, which led to the creation of the Delta Science Plan in 2013. The Council's Delta Science Program is charged with developing scientific information and synthesizing the state of scientific knowledge on issues critical for managing the Bay-Delta system. That body of knowledge must be unbiased, relevant, authoritative, integrated across State and federal agencies, and communicated to Bay-Delta decision-makers, agency managers, stakeholders, the scientific community, and the public.[14] Numerous academic institutes also play major roles in Bay-Delta research, including the UC Davis Center for Watershed Sciences and the UC Davis Coastal Marine Sciences Institute.

How is scientific research funded?

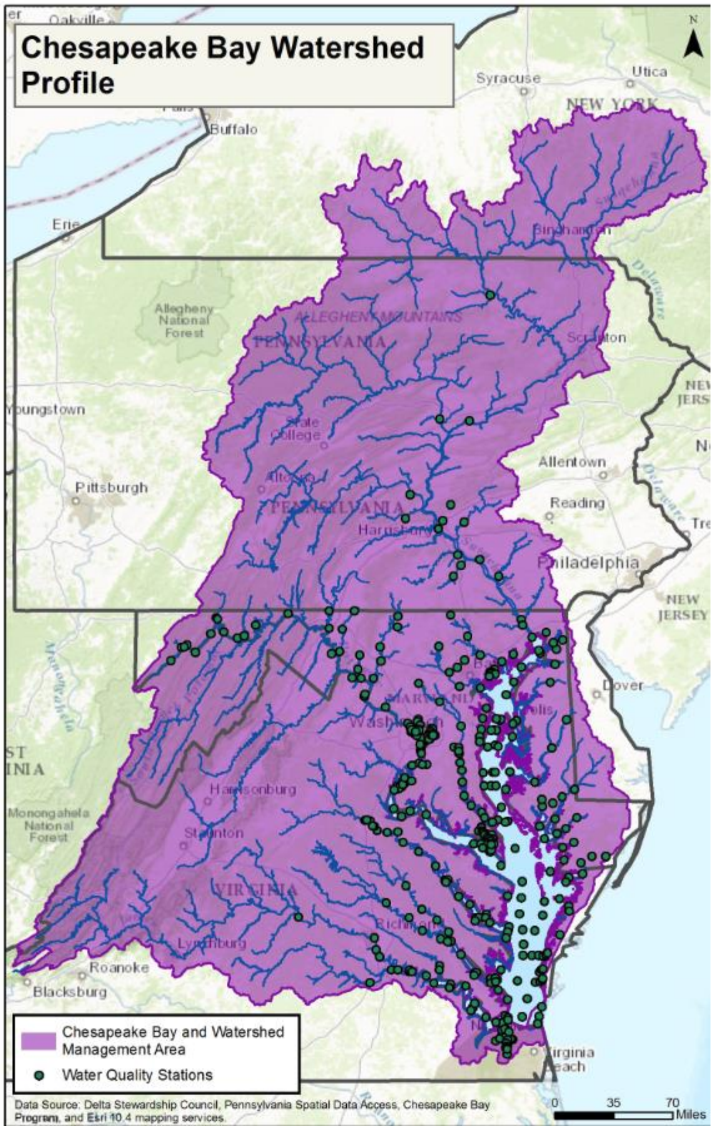
Funding for scientific research in the Delta comes from numerous sources, including government (federal, State, and local), non-government organizations, and private interests. In general, it is difficult to obtain funding information on all scientific research as it is rarely separated out as a budget line item. It is also challenging to find funding information on restoration and other system-wide investments. For example, public sources like the Federal Crosscut Budget are not revised over time to reflect actual spending; however, it is useful in providing an estimate that can be compared with other Federal Crosscut budgets in other systems.

For FY2016, federal agencies budgeted $372 million for the Bay-Delta Program. For reported years 1998-2017, average annual budgeted funding has been $314.7 million and totaled $6.294 billion.[15] For FY2000-2012, State agencies provided, in total $3.258 billion and on average $250 million in funding for the Bay-Delta Program.[16] Public water agencies and the State and Federal Water Contractors Agency also play major roles in funding and implementing restoration and scientific research, as well as quasi-private organizations like water districts.

The Council has recently launched DeltaView (http://deltaview.deltacouncil.ca.gov/), a new database that will capture and track State and federal spending on programs, plans and projects in the Delta, as well as project goals and project descriptions, cost and funding sources, key dates, responsible agency, and relevant performance measures. DeltaView will provide implementing agency users the opportunity to update their records on an ongoing basis, and allow the broader public the ability to track progress toward Delta Plan implementation.

[14] About the Science Program. Delta Stewardship Council. http://deltacouncil.ca.gov/science-program/about-science-program
[15] California Bay-Delta Federal Budget Crosscut. Fiscal Year 2017. Released March 2016. Executive Office of the President. https://www.whitehouse.gov/sites/default/files/omb/assets/legislative_reports/bay-delta_fy17_budget_crosscut_-_alexander.pdf
[16] CALFED Projects by Agency. CPPIS. http://cppis.deltacouncil.ca.gov/drilldown.aspx?view=agency&obj=1&year=8&element=8

Chesapeake Bay and Watershed



Background

The Chesapeake Bay (Bay) is the largest estuary in the United States and connects the Atlantic Ocean with the over 150 major rivers in the surrounding watershed. The Bay is within Virginia and Maryland, while the watershed extends to New York, Pennsylvania, Delaware, Maryland, Virginia, West Virginia, and the District of Columbia. The extremely productive Bay and surrounding lands encouraged numerous early settlements in the area along with rapid growth in agriculture, industry, and population starting in the 1700s, leading to the first signs of environmental degradation. Extensive urban development accelerated in the 1800s, causing the region's forest cover to rapidly decline, leading to degraded water quality.

Why is this system important?

The Bay and watershed covers about 64,000 square miles.[17] The ecosystem is complex and supports over 3,600 species of plants and animals. Threatened and endangered species that rely on the Bay ecosystem include the atlantic sturgeon, the puritan tiger beetle, and the loggerhead sea turtle. Almost 18 million people live within the Chesapeake Bay watershed, most of which rely on the system for drinking water.[18] The Chesapeake Bay system heavily bolsters the region's economy by supporting commercial fishing. Each year, 500 million pounds of seafood are harvested, yet productivity used to be much greater. Oyster harvests have fallen to less than 1 percent of historic levels.[19] Other industries reliant on the Bay include tourism and recreation, agriculture, real estate, and shipping. In 2009, the lands and water of the Bay region provided an estimated $107.2 billion[20] annually in general economic benefits. It is projected that by restoring the Bay, rivers, and streams, the economic activity driven by the Bay will increase by $22.5 billion a year.[21]

What are major challenges?

The major threats to the Chesapeake Bay are land use and pollution. Forests and wetlands provide critical wildlife habitat, protect clean water and air, and support recreation and the economy. By the late 1800s, 40-50 percent of the watershed's forest had been harvested for timber and to make space for agriculture and urban development.

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[17] Facts & Figures. Chesapeake Bay Program. http://www.chesapeakebay.net/discover/bay101/facts

[18] Chesapeake Bay. National Wildlife Federation. https://www.nwf.org/Wildlife/Wild-Places/Chesapeake-Bay.aspx

[19] The Economic Importance of the Bay. Chesapeake Bay Foundation. http://www.cbf.org/about-the-bay/issues/cost-of-clean-water/economic-importance-of-the-bay

[20] The Economic Benefits of Cleaning up the Chesapeake. Chesapeake Bay Foundation. http://www.cbf.org/news-media/features-publications/reports/economic-benefits-of-cleaning-up-the-chesapeake-bay

[21] *Id*

Between 1990 and 2005, about 100 acres of forest habitat were lost each day to urban and agricultural development. The major pollution input to the Bay is excess nutrients, which come from agriculture and urban runoff, wastewater treatment plants, and air pollution. Excess nutrients fuel harmful algal blooms, which deplete the water of oxygen and suffocate aquatic life. Other major challenges include chemical contaminants (including pesticides), sediment, groundwater pollution, invasive species (like the blue catfish and zebra mussel), health of rivers and streams (affected by pollution and dams), native species decline, and many impervious surfaces (increased runoff and prevention of groundwater recharge). These challenges are compounded by climate change, which causes warming temperatures and more frequent occurrences of extreme weather.

How is restoration and scientific research organized?

The Chesapeake Bay Program was formed in 1983 to guide restoration efforts. The program is a regional partnership that includes dozens of federal and State agencies, local governments, non-profit organizations, and academic institutions. The partners work together through the Bay Program's goal teams, workgroups, and committees to collaborate, share information, and set goals. In 2009, President Obama issued Executive Order 13508 for Chesapeake Bay Protection and Restoration, directing the U.S. Department of the Interior (USDOI) represented by the National Park Service (NPS), the USFWS, and the USGS to increase efforts and leadership in research and restoration of the Bay and its watershed. In 2014, the Chesapeake Bay Watershed Agreement was signed by representatives from each of the watershed's six states, containing ten goals aimed at advancing restoration and protection. Data and information related to restoration and pollution prevention efforts are communicated, tracked, and shared via ChesapeakeStat and the Chesapeake Bay Program Data Hub.

How is scientific research funded?

Broadly, a range of agencies and organizations support the Chesapeake Bay Program's work. Funding comes from numerous federal agencies, State and local governments, non-governmental organizations, and private interests. Currently, there is only a rough estimate of total funding that is directed toward the Chesapeake Bay Watershed Agreement. Like the other systems, science research funding is rarely separated out as a budget line item. Of note, the recently passed Chesapeake Bay Accountability and Recovery Act will require an annual Federal Cross-Cut Budget starting in fall of 2016.[22]

For FY2016, federal agencies provided an estimated $487 million in funding for the Chesapeake Bay Program. For reported years 2011-2016, average annual funding was $473.3 million and totaled $2.8 billion.[23]

For FY2008-2011, State agencies provided in total, $2.400 billion and on average, $600 million in funding for the Chesapeake Bay Program.[24]

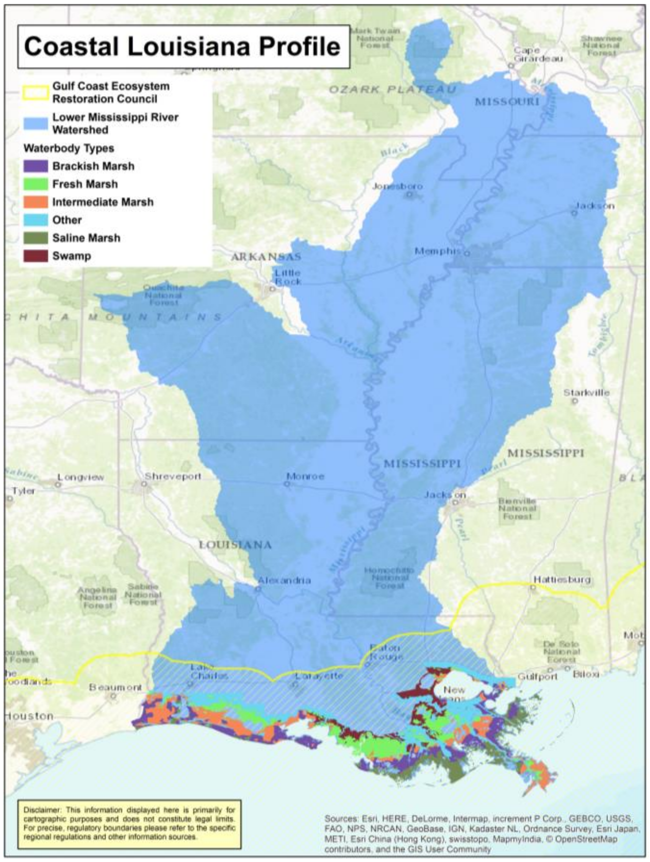
Aerial view near Aberdeen Proving Ground
Credit: Leo Miranda/USFWS

[22] Chesapeake Bay Accountability and Recovery Act Implementation (CBARA). Chesapeake Bay Program. http://www.chesapeakebay.net/channel_files/23868/cbara.pdf

[23] Funding. Chesapeake Progress. http://www.chesapeakeprogress.com/funding

[24] Facts & Figures. Chesapeake Bay Program. http://www.chesapeakebay.net/discover/bay101/facts

Coastal Louisiana



Background

Coastal Louisiana is the drainage gateway to the Gulf of Mexico for the Lower Mississippi River Watershed. Southern Louisiana contains approximately 40 percent of the coastal wetlands found in the contiguous 48 states. The coastal system is comprised of the Mississippi Deltaic Plain in the east and the Chenier Plain in the west.

Why is this system important?

The wetlands of the Louisiana coast provide habitat for a variety of land and aquatic life and are the breeding ground and nurseries for thousands of species of wildlife including the bald eagle. The ecosystem provides migratory habitat for millions of waterfowl each year. Threatened and endangered species that rely on Coastal Louisiana include sturgeon, sea turtles, the West Indian manatee, and the piping plover. The coastal zone is over 8,277 square miles[25] and inhabited by roughly half of Louisiana's population – over 2 million people.[26] The coast is home to unique cultures made up of people whose way of life is directly connected to the bayous and wetlands. Louisiana's economy is dependent on the industries that rely on the coast, including oil and gas production, shipping, seafood, hunting, fur harvesting, and tourism; accounting for up to 1.7 million jobs and approximately $35.7 billion in economic output.[27] For example, Louisiana accounts for roughly 75 percent of fish and shellfish from the Gulf of Mexico and 28 percent of total volume of United States fisheries with a value of about $1 billion annually.[28] Louisiana ranks among the top in the United States in crude oil and natural gas production and the Port of South Louisiana is one of the ten busiest ports in the world by cargo volume.

What are major challenges?

Coastal Louisiana has experienced dramatic land loss since at least the 1930's. A combination of natural processes and human activities has resulted in loss of over 1,880 square miles since the 1930's, and a current land loss rate of 16.6 square miles per year. Not only has this land loss resulted in increased environmental, economic, and social vulnerability, but these vulnerabilities have been compounded by multiple disasters, including hurricanes, river floods, and the 2010 Deepwater Horizon oil spill, all of which have had a significant impact on the coastal communities in Louisiana and other Gulf coast states. Another challenge includes excess nutrients from the upper Mississippi River watershed that contribute to the "dead zone", or a low-oxygen hypoxic area along the coast that is toxic to marine life. In 2016, the area reached about 5,898 square miles, an area about the size of Connecticut.[29] Global warming will also bring more extreme weather events, and exacerbate land loss from sea level rise.

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[25] Louisiana Watershed Management. Southern Region Water Quality Planning Committee (SRWQPC). http://srwqis.tamu.edu/louisiana/program-information/louisiana-target-themes/watershed-management/

[26] Louisiana Coastal Facts. Coastal Protection and Restoration Authority of Louisiana. http://www.americaswetland.com/photos/article/Coastal_facts_sheet_03_27_2012.pdf

[27] Answering 10 Fundamental Questions About the Mississippi River Delta. 2012. http://www.mississippiriverdelta.org/files/2012/04/MississippiRiverDeltaReport.pdf

[28] Coastal Wetland Planning, Protection and Restoration Act. NOAA. http://www.habitat.noaa.gov/restoration/programs/cwppra.html

[29] NOAA and partners cancel Gulf Dead Zone summer cruise. NOAA. 2016. http://www.noaa.gov/media-release/noaa-and-partners-cancel-gulf-dead-zone-summer-cruise

How is restoration and scientific research organized?

Several State and federal restoration programs are currently in place. The Coastal Wetlands Planning, Protection, and Restoration Act[31] of 1990 is federal legislation designed to identify, plan, and fund coastal wetlands restoration projects to provide for long-term conservation. The U.S. Army Corps of Engineers (USACE) and the State of Louisiana initiated the Louisiana Coastal Area (LCA) Comprehensive Coastwide Ecosystem Restoration Study in 2003. Following hurricanes Katrina and Rita in 2005, the Louisiana Legislature created the Coastal Protection and Restoration Authority (CPRA) and tasked it with coordinating the local, State, and federal efforts to achieve comprehensive coastal protection and restoration. To accomplish these goals, the CPRA was charged with developing a Coastal Master Plan to guide work toward a sustainable coast. Scientific research on coastal Louisiana has been funded by Louisiana Sea Grant and others. The Mississippi River Hydrodynamic and Delta Management Study under the LCA program included research and model development to better understand the dynamics of the lower Mississippi River and the estuarine basins. The CPRA Applied Research Program ran for several years and funded research projects in support of implementation of the Coastal Master Plan. CPRA also sponsors a Coastal Science Assistantship Program (CSAP) which funds graduate student research. Many other government, non-government, academic, and private institutions participate in research and restoration efforts. The Water Institute of the Gulf, named the Louisiana Center of Excellence under the RESTORE Act, is a nonprofit institute that conducts research and links academic, public, and private research to increase the understanding of human influences to the coastal water systems and develops tools to assist in ecosystem restoration planning.

RESTORE THE GULF

Following the Deepwater Horizon spill in 2010, many investigation and restoration efforts took place, including the establishment of the Gulf Coast Ecosystem Restoration Council (GCERC[30]) in 2012 by the RESTORE Act (Act). The Act dedicates 80 percent of civil and administrative penalties paid under the Clean Water Act, to the Gulf Coast Restoration Trust Fund (Trust Fund) for ecosystem restoration, economic recovery, tourism promotion, and science to benefit the Gulf Coast Region—defined as land within the coastal zones (CZMA 1972), adjacent land, water, and watersheds within 25 miles of the coastal zone, and all federal waters in the Gulf of Mexico. The GCERC will oversee approximately $3.2 billion over the next 15 years, which is 60 percent of the Trust Fund. The Act requires the GCERC to "undertake projects and programs, using the best available science that would restore and protect the natural resources, ecosystems, fisheries, marine and wildlife habitats, beaches, coastal wetlands, and economy of the Gulf Coast." In addition, the GCERC is committed to science-based decision-making, delivering results, and measuring impacts.

How is scientific research funded?

Broadly, a range of agencies and organizations provide funding for scientific research in Coastal Louisiana and, like the other systems, it is very difficult to find funding information in general for total research, restoration, and protection efforts. A legislative audit found for FY2008 – 2015, federal agencies provided $10.276 billion in funding for protection and restoration projects to CPRA; average annual funding has been $1.285 billion.[32] State agencies for FY2008 – 2015 provided in total $1.615 billion for CPRA protection and restoration projects, and on average $202 million.[33] Of note, these figures do not include funds from the oil spill settlement, which were reported separately. Scientific research is often leveraged as part of restoration project development and refinement. CPRA's three-year protected budget through FY2019 is $1.5 billion, with over $96 million identified as part of adaptive management. This includes, for example, $325,000 per year for the CSAP and $6.4 million for Data Management. Under the RESTORE Act, Centers of Excellence across the Gulf coast will receive 2.5 percent of Trust Fund principal; 0.5 percent goes to Louisiana or about $4 million from the Transocean and about $0.6 million from the Anadarko settlements. It is expected that the gross allocation to Louisiana for the Center of Excellence will amount to $26.6 million through 2031. Scientific research will be funded across several different organizations including the Gulf Coast Ecosystem Restoration Council, the National Academy of Sciences, and the National Oceanic and Atmospheric Administration (NOAA) RESTORE Science Program.[34]

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[30] GCERC's effort is in addition to the restoration of natural resources injured by the spill that is being accomplished through a separate Natural Resource Damage Assessment under the Oil Pollution Act. A third and related Gulf restoration effort is administered by the National Fish and Wildlife Foundation using settlement funds from criminal charges against BP and Transocean Deepwater, Inc.

[31] About CWPPRA. Coastal Wetlands Planning, Protection and Restoration Act. http://lacoast.gov/new/About/

[32] Oversight of Project Funding and Outcomes Coastal Protection and Restoration Authority. Louisiana Legislative Auditor. 2016. http://app.lla.state.la.us/PublicReports.nsf/0/EAF432D2895F6F4A86257F40007DE11E/$FILE/0000C38F.pdf

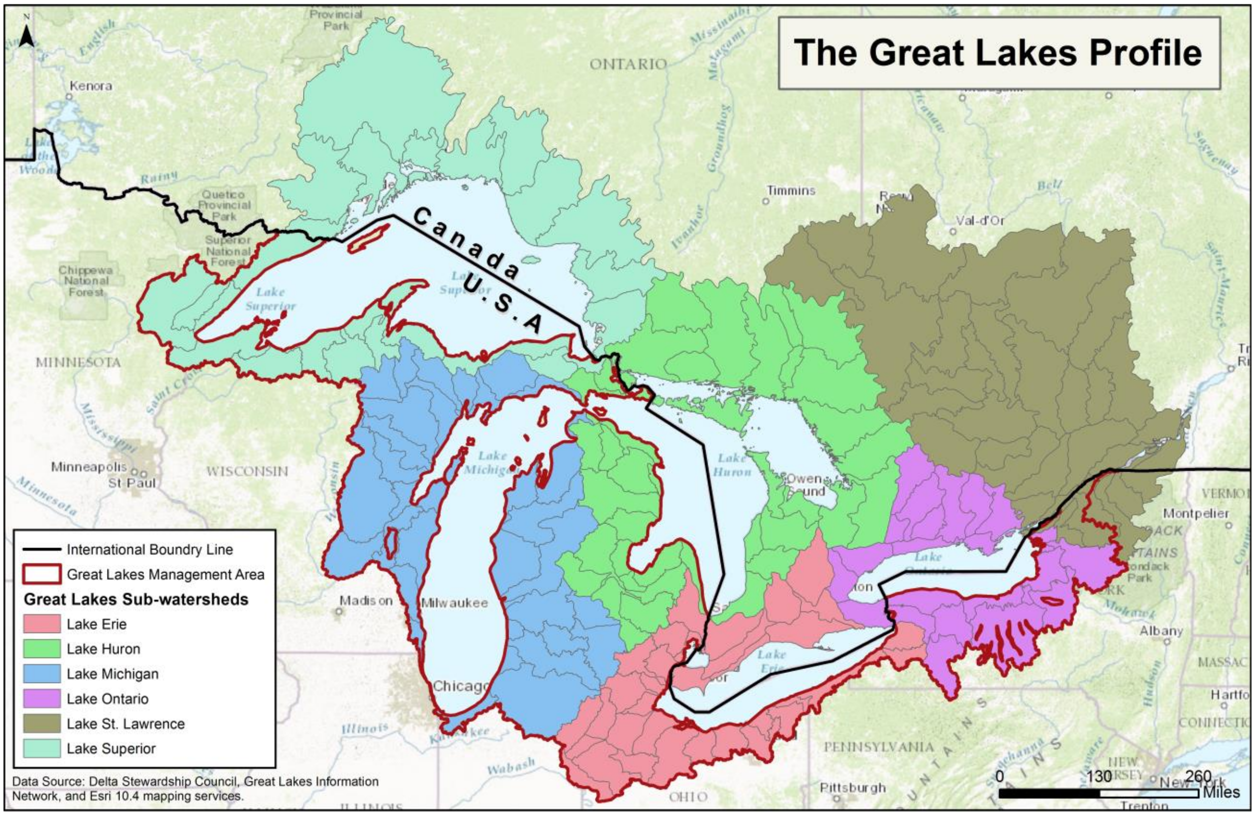
[33] *Id*

[34] About the DWH Funding Programs. DWH Project Tracker. http://www.dwhprojecttracker.org/about/about-the-funders/

Great Lakes

Background

The Great Lakes consist of lakes Superior, Michigan, Huron, Erie, and Ontario. Some water enters Lake Superior from the Hudson Bay drainage system. Between 65-85 percent of the precipitation evaporates, while some water drains out of Lake Michigan. The Great Lakes and surrounding lands, once covered by forests, grasslands, and interspersed wetlands, are heavily impacted by urbanization, agriculture, and industry.



Why is this system important?

The Great Lakes cover a surface area of over 94,294 square miles, and drain about 201,460 square miles of land.[35] They contain 84 percent of the surface fresh water in the United States, and about 21 percent of the world's supply of fresh water.[36] The Great Lakes contain over 150 species of fish, including lake sturgeon, which are endangered due to extensive commercial fishing. Hundreds of other diverse plants and animals are dependent on the Great Lakes ecosystem, including many threatened or endangered species like the gray wolf and piping plover. Over 30 million people live in the Great Lakes basin – in 8 states and 2 Canadian provinces.[37] The land surrounding the Great Lakes supports nearly 25 percent of Canadian agricultural production, and 7 percent of American farm production.[38] The Great Lakes support over 1.5 million United States jobs in numerous sectors including shipping, manufacturing, agriculture, science and engineering, utilities, commercial fishing, mining, recreation, and tourism - and in 2008, the region generated more than $4.6 trillion in economic output.[39]

[35] Physical Features of the Great Lakes. EPA. https://www.epa.gov/greatlakes/physical-features-great-lakes
[36] Great Lakes. US Environmental Protection Agency. https://www.epa.gov/nutrient-policy-data/great-lakes
[37] Great Lakes Facts and Figures. US Environmental Protection Agency.https://www.epa.gov/greatlakes/great-lakes-facts-and-figures
[38] *Id*
[39] Annual Report of the Great Lakes Regional Water Use Database Representing 2012 Water Use Data. 2012. http://projects.glc.org/waterusedata/pdf/wateruserpt2012.pdf

What are major challenges?

Invasion of non-native species is a major challenge in the Great Lakes system. The introduction of zebra mussels has decimated the amount of *diporeia* (zooplankton), an important food source for fish in Lake Michigan. Other major challenges include legacy pollution from historical point-source waste (including mercury) and nonpoint-source discharges from urban and agricultural runoff, affecting water quality and the food web. Nonpoint-source pollution is difficult to regulate and a major cause of harmful algal blooms, which continue to plague the Great Lakes despite initial successes following upgrades to wastewater treatment plants since the 1970s. Mining, extensive logging, and atmospheric pollution are other major contributors of ecosystem degradation. Global warming is increasing air and water temperatures, affecting water quality, and compounding the challenges that affect the ecosystem.

How is restoration and scientific research organized?

Restoration and research efforts are coordinated and executed by government agencies, academic institutions, non-governmental organizations, and private industries. The U.S. Environmental Protection Agency's (USEPA) Great Lakes National Program Office coordinates United States efforts with Canada to restore and maintain the chemical, physical, and biological integrity of the Great Lakes basin ecosystem. The USGS Great Lakes Science Center was established in 1927 with the mission of providing scientific information for restoring, enhancing, managing, and protecting living resources and their habitats in the Great Lakes basin ecosystem. Because of the many stakeholders, many multi-party agreements have been implemented. Examples include the 1972 Great Lakes Water Quality Agreement between the United States and Canada (focusing on nutrients and eutrophication), the 2008 Great Lakes Compact (focusing on water rights and supply), and the 2009 Great Lakes Restoration Initiative (GLRI) (an inter-agency effort to clean up contaminated harbors). Data management has greatly improved how science is used in the Great Lakes. Data are organized using the Great Lakes Observing System (GLOS), a binational nonprofit organization funded by dues that are scaled based on type and size of organization.

How is scientific research funded?

Like the other systems, funding for scientific research in the Great Lakes comes from numerous sources, including government (federal, State, and local), non-government organizations, and private interests. Like the other systems, it is difficult to obtain funding information for scientific research specifically. The publically available funding estimates from the Federal Crosscut Budget for the Great Lakes are provisional and final allocations may differ. It is useful, however, in providing a "directional" estimate in general terms that can be compared with other Federal Crosscut budgets in other systems.

For FY2016, federal agencies budgeted $785 million for Great Lakes restoration activities. For reported years 2011-2016, average annual funding has been $932 million and totaled $5.6 billion.[40] Of note, the USEPA administers the GLRI, which funds a variety of activities including grants and implementation of the Great Lakes Legacy Act projects.[41]

For FY2010-2014 (the last reported figures for state funding), State agencies provided in total, $140.6 million and on average, $28.1 million in funding for Great Lakes restoration.[42]

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[40] Great Lakes Restoration Crosscut: Report to Congress. Office of Management and Budget. Jan 2016. https://www.whitehouse.gov/sites/default/files/omb/assets/legislative_reports/great_lakes_crosscut_2016_final_a.pdf
[41] Great Lakes Funding. EPA. https://www.epa.gov/great-lakes-funding
[42] *Id*

Greater Everglades Ecosystem

Background

The Greater Everglades Ecosystem is a region of tropical wetlands beginning at the headwaters of the Kissimmee River. The Kissimmee drains into Lake Okeechobee, which would historically spill over its southern banks during the wet season and replenish the Everglades with fresh water. The Everglades was once a free-flowing, vast, and shallow river of grass. Watershed alteration began on a small scale in the late 1800s, and reached a peak with the Central and Southern Florida Flood Control Project authorized in 1948. Hundreds of water control structures and thousands of miles of canals and levees were constructed over the ensuing five decades to provide flood protection and water supply. This large civil works project and the millions of residents reliant on the water it supplies have resulted in significant environmental damage.

Why is this system important?

The Florida Everglades is currently the largest wetland ecosystem in the United States covering over 18,000 square miles.[43] The Everglades supports an extraordinarily rich and unique wildlife population consisting of nearly 70 threatened and endangered species, including the manatee, American alligator, sea turtle, Florida panther, and a variety of birds. About one third of the state's population (8 million people) rely on the Everglades for their water supply.[44] The Everglades National Park is a World Heritage Site, an International Biosphere Reserve, and a Wetland of International Importance. The economic influence of a healthy Everglades ecosystem is substantial. Recreational fishing alone generates approximately $1.2 billion a year in economic activity in the 13-county Everglades Region.[45] It is projected that investing $11.5 billion in Everglades restoration will result in $46.5 billion in gains to the economy, and create more than 440,000 jobs over 50 years.[46] Major industries impacted by the Everglades include freshwater supply, fishing, hunting, real estate, and tourism/visitation - all contributing to up to $394.1 billion in dependent economic output in 2008.[47]

What are major challenges?

Meeting the water supply and flood protection needs of population growth, urbanization, and the agricultural sector required severe land-use alterations and water flow control. This effort has reduced the area of the

[43] What is Everglades Restoration? Everglades Restoration. http://www.evergladesrestoration.gov/
[44] Quick Facts. The Everglades Foundation. http://www.evergladesfoundation.org/the-everglades/facts/
[45] Reports. The Everglades Foundation. http://www.evergladesfoundation.org/what-we-do/reports/
[46] Economic Benefit of Restoring America's Everglades. Clean Water Fund. http://www.cleanwateraction.org/files/publications/fl/Economic_Benefits_of_Restoration.pdf
[47] The Economics of the Everglades Watershed and Estuaries. Center for Urban and Environmental Solutions at Florida Atlantic University. 2009. http://www.drivecms.com/uploads/riverofgrasscoalition.com/1022369245The%20Economics%20of%20the%20Everglades%20FINAL%20REPORT.pdf

Everglades to about half of its original area. Decreases in habitat, combined with a widespread invasion of non-native plants and animals such as the brazilian peppertree and the burmese python, have resulted in severe ecosystem degradation. Water quality within the Everglades suffers from extreme variations in salinity, pollutants from agricultural/urban runoff and other sources (especially excess phosphorus), harmful algal blooms, and high levels of dissolved organic matter and methyl mercury. Water quality challenges have led to deteriorated habitat and stressed native wildlife. Another challenge includes water management and the complications that go with it, including groundwater overdraft and saltwater intrusion. Development pressure is threatening the remaining Everglades landscape on many of the urban/agriculture and Everglades borders. Climate change, especially more variable precipitation events, temperature increases, and sea-level rise are additional challenges to the Everglades and restoration efforts.

How is restoration and scientific research organized?

In 2000, the United States Congress enacted the Comprehensive Everglades Restoration Plan, the most substantial ecosystem restoration ever attempted. In support, the USGS initiated the Greater Everglades Priority Ecosystem Science program to inform and monitor the results of restoration decision-making. To assist ongoing South Florida restoration efforts, the USDOI and its bureaus, the USFWS, the NPS, and the USGS, developed a science plan to identify the science needed to support natural resources in South Florida. In addition, many agencies, consortia, academic institutions, non-profit organizations, and water districts (including the South Florida Water Management District) are involved in research and restoration efforts. The South Florida Ecosystem Restoration Task Force[48] brings together and coordinates federal, State, tribal, and local agencies involved in restoring and protecting the Everglades.

How is scientific research funded?

While the South Florida Ecosystem Restoration Program Federal Crosscut budget is perhaps one of the more detailed fiscal reports, and funding for scientific research is identified throughout the budget narrative, it is generally integrated within projects or programs and not separated as a budget line item. Like the other system reports, given the nature of estimated budgets, it should be considered as providing a "directional" estimate that can be compared with other Federal Crosscut budgets in other systems.

Northern Everglades. Photo credit: USDA

For FY2017, federal agencies requested $174.6 million in funding for Everglades restoration. For reported years 1993-2017, average annual enacted and requested funding has been $231 million and totaled $5.8 billion.[49]

For FY1993 – 2017, State agencies enacted and requested in total, $17.095 billion and on average, $712 million in annual funding for Everglades wetland restoration.[50]

[48] South Florida Ecosystem Restoration Program: Cross-Cut Budget 2017. Everglades Restoration. http://www.evergladesrestoration.gov/content/cross-cut_budget.html
[49] *Id*
[50] *Id*

Puget Sound

Background

Puget Sound is the second largest estuary in the United States, and largest by volume. It is a complex system of connected waterways and deep basins, fed by thousands of seasonal rivers and streams from the Olympic and Cascade mountains. Puget Sound is part of a larger marine ecosystem called the Salish Sea, which also includes the Georgia Basin in Canada and the Strait of Juan de Fuca, which is the major connection to the Pacific Ocean. Puget Sound generally refers to the marine areas south of the United States-Canada border and east of the Strait of Juan de Fuca. Settlement in the area began in 1833, as a fur trading post. Population soon expanded due to hunting, logging, trading, shipbuilding, and seafood industries.

Why is this system important?

The Puget Sound Estuary and surrounding lands are made up of wetlands, salt marshes, bays, beaches, and rivers. Thousands of species of invertebrates, fish, birds, mammals, and vegetation rely on the system. Endangered and threatened species impacted by the health of the Puget Sound area include orcas, the gray wolf, Chinook salmon, and the marbled murrelet. Aquatic vegetation is a key component of the ecosystem, including 26 species of kelp,[51] which make Puget Sound one of the highest sites of kelp diversity in the world. The Puget Sound water area covers over 1,016 square miles, and the watershed covers over 13,700 square miles.[52] About 4.8 million people live in the 12 counties around Puget Sound, many of which depend on the watershed for drinking water.[53] Puget Sound's natural resources are directly tied to the area's economy through industries including seafood, lumber, recreation, shipping, aerospace, and recreation, which generate up to 194.2 billion[54] of annual dependent economic activity and hundreds of thousands of jobs for the State of Washington.

What are major challenges?

Urbanization and industrial development have led to numerous environmental challenges in and around Puget Sound. Historical poor management of dangerous chemicals, as well as numerous oil spills and stormwater and wastewater discharges have led to contamination. Another challenge is hypoxia (low-oxygen) in some marine waters, caused by natural and human-made sources, which can lead to wildlife "kills" either locally or over a wide area. Excess nutrients, which originate from wastewater discharge, storm water runoff, agriculture, and other sources, lead to algal blooms that consume oxygen and exacerbate hypoxia. Combined sewage overflow (CSO) occurs when runoff in combination with raw sewage overflows the pipes. CSO carries pollutants, pathogens, and excess nutrients into Puget Sound, threatening wildlife. Other challenges include sharp declines in aquatic vegetation, including eelgrass, a keystone species; shoreline modifications that contribute to degradation and loss of important habitat; invasive species that threaten biodiversity, natural habitats, and irrigation systems; and sea-

[51] Puget Sound. National Wildlife Federation. https://www.nwf.org/Wildlife/Wild-Places/Puget-Sound.aspx
[52] 2015 Puget Sound Fact Book. Encyclopedia of Puget Sound. https://www.eopugetsound.org/articles/2015-puget-sound-fact-book
[53] *Id*
[54] *Id*

level rise, which is predicted to threaten critical wildlife habitats and make habitats and infrastructure more susceptible to damage from storms.

How is restoration and scientific research organized?

Multiple overlapping efforts to advance Puget Sound recovery and long-term protection are managed by federal and State agencies. The Puget Sound Partnership, a State agency formed in 2007, leads a broad restoration and protection effort, responding to assignments from Washington State statute for Puget Sound ecosystem recovery and recovery of threatened and endangered salmon and related species in the Puget Sound region. The state's approach to Puget Sound ecosystem recovery dovetails with the designation of Puget Sound as an estuary of national significance and its inclusion in the USEPA's National Estuary Program (NEP). The Puget Sound Partnership (and other regional entities elsewhere in the State) implements Washington State's innovative, watershed-based approach to recovery of threatened and endangered salmonid stocks, which is overseen by NOAA Fisheries.

To develop a restoration program for nearshore habitats, federal, State, tribal, and local governments, non-governmental organizations, universities, and private industry created the Puget Sound Nearshore Ecosystem Restoration Project in 2001. This effort generated a State-funded restoration program – the Estuary and Salmon Restoration Program – and may lead to authorization of a Puget Sound nearshore restoration program by the USACE.

In its work to connect the hundreds of partners to further the collective effort to restore and protect Puget Sound, the Puget Sound Partnership has described (but not fully developed) a strategic science program and prepares (but is not able to fully implement) biennial science work plans.

In 2011, a Puget Sound ecosystem monitoring program was launched to coordinate monitoring and assessment activities in the region. This program is managed independently of the Puget Sound Partnership but is supported by staff and other resources provided by the Partnership.

The USGS Coastal Habitats in Puget Sound project provides scientific support for ecosystem recovery activities. Other important contributions to scientific research that supports Puget Sound recovery and protection include programs and studies at a variety of federal, State, and local organizations.

How is scientific research funded?

The overall spending on Puget Sound recovery and long-term protection, and on scientific research, has not been calculated. One available data source, which emphasizes capital investments in restoration and acquisition projects, demonstrates a majority of project funding from State sources (55 percent) with significant contributions from local (34 percent) and federal (11 percent) sources. As there is no Federal Crosscut Budget for Puget Sound, it is somewhat more difficult to obtain funding information in general for Puget Sound program activities, and like the other systems, scientific-specific funding information is not available.

- For reported years 2003-2018, average annual federal funding for the Puget Sound Partnership recovery projects has been $6.4 million and federal project funding totaled $102.5 million.[55]
- For reported years 2003-2018, total State project funding for the Puget Sound Partnership has been $508 million, with an annual average of $31.7 million in funding for Puget Sound restoration and protection projects.[56]

Over 11 years (2006-2016), a total of $198 million of Puget Sound NEP funds has been invested in projects; $50 million of this total supported research and monitoring projects.[57] This is the primary Puget Sound-identified source of federal funding to support scientific investigation. Investments in Puget Sound-relevant studies through other federal programs (i.e., those identified above) have not been summarized.

[55] Puget Sound Partnership. http://gismanager.rco.wa.gov/projectatlas/?summaryArea[areaName]=Puget+Sound&summaryArea[areaType]=PSP+Boundary&summaryArea[areaShapeId]=NA
[56] *Id*
[57] Puget Sound Partnership. http://psp.wa.gov/gis/NEPAtlas/NEPActivities

PANELISTS

In alphabetical order:

Nick Aumen, USGS. Regional Science Advisor, SE Region. Research interests include nutrient biogeochemistry, microbial ecology, wetland restoration, linking science and policy.

Joel Baker, University of Washington. Chair in Environmental Science. Director of the Center for Urban Waters. Research interests include contaminants, aerosol chemistry, contaminant transport in estuaries, modeling, food webs, and water quality.

Steve Brandt, Oregon State University, Professor. Delta ISB. Research interests include fish ecology, management of marine and freshwater ecosystems, food webs, fish bioenergetics, underwater acoustics, and coastal hypoxia.

Mike Chotkowski, USGS, Bay-Delta Science Coordinator, Pacific Region. Research interests include marine and estuarine fish ecology, ichthyology, science planning, and policy.

Tracy Collier, NOAA Fisheries, Division Director for NW Fisheries Science Center. Delta ISB. Research interests include environmental toxicology and chemistry, assessing oil spill impacts, and harmful algal blooms.

Josh Collins, San Francisco Estuary Institute, Chief Scientist. Research interests include landscape ecology, regional ecological planning, mapping/assessing stream and wetland ecosystems, restoration, and monitoring.

Ken Currens, NW Indian Fisheries Commission, Manager of Conservation Planning Program. Research interests include conservation strategy and planning, population genetics, risk assessment, science communication, and policy.

Cliff Dahm, Delta Stewardship Council, Lead Scientist. Research interests include aquatic ecology, nutrients, climatology, and restoration

Alyssa Dausman, Restore the Gulf, Science Director. Research interests include restoration, groundwater, water quality, saltwater intrusion, modeling, and monitoring.

Randy Fiorini, Delta Stewardship Council, Chair. Research interests include water resources policy, agriculture, and local and state governance.

Erin Foresman, USEPA, Environmental Scientist. Research interests include environmental policy and science, ecology, wetlands, NEPA, CWA, water quality, and permitting.

Peter Goodwin, University of Idaho, Director-Center for Ecohydraulics Research. Former Delta Lead Scientist. Research interests include ecohydraulics, sustainability, modeling river and estuarine flows, sediment transport, and geomorphic evolution.

Rainer Hoenicke, Delta Stewardship Council, Deputy Executive Officer of Delta Science Program. Research interests include ecology, limnology, water quality, landscape restoration planning, decision-support tools, and policy.

Jon Hortness, USGS Liaison to the USEPA Great Lakes National Program Office, USGS Coordinator for the Great Lakes Restoration Initiative. Research interests include river and watershed modeling, surface/ground-water interactions, flood and drought analyses, and in-stream flow criteria.

Stephanie Johnson, National Academy of Sciences, Senior Staff Officer. Research interests include contaminant hydrogeology, water quality, science and practice of restoration, science communication, and policy.

Bill Labiosa, USGS, Regional Science Coordinator, Northwest Region. Research interests include modeling, ecosystem recovery, and decision support.

Denise Lach, Oregon State University, Professor, Director of School of Public Policy. Research interests include environmental natural resource sociology, applied sociology, program evaluation, organizational sociology, and water conflict resolution.

Jessica Law, Delta Stewardship Council, Delta Plan Interagency Implementation Committee (DPIIC) Coordinator. Research interests include land use planning, facilitation, communications, ecology, and water resources policy.

Steven Lindley, NOAA Fisheries, Southwest Fisheries Science Center. Director, Fisheries Ecology Division. Research interests include ecosystem manipulations, capture-recapture, telemetry, trophic dynamics in tidal environments, and modeling.

Jeff Loux, UC Davis Extension. Chair of Science, Agriculture and Natural Resources. Research interests include sustainable urban planning and design, water resources policy, community engagement and collaboration, sustainable transportation, water resources, GIS, and environmental law.

Mark Lubell, UC Davis, Professor. Director, Center for Environmental Policy and Behavior. Research interest include water management, sustainable agriculture, adaptive decision-making, climate change policy, and policy/social network analysis.

Jay Lund, UC Davis, Director of the Center for Watershed Sciences. Delta ISB. Research interests include system analysis, economics, water management, and policy.

Jayantha Obeysekera, South Florida Water Management District, Chief Modeler. Research interests include modeling, restoration, hydrology, hydrodynamics, and water quality.

Scott Phillips, USGS, Environmental Scientist, Coordinator of the USGS Priority Ecosystems Science (PES) program for Chesapeake Bay. Research interests include hydrogeology, modeling, and nutrient loading.

Scott Redman, Puget Sound Action Team (Partnership), Program Manager. Research interests include toxic contaminants, marine shoreline habitats, and collaborative approaches to science and management.

Denise Reed, Water Institute of the Gulf, Chief Scientist. Research interests include coastal restoration and planning, role of human activities in coastal systems, sea-level rise, adaptive management, and modeling.

Richard Roos-Collins, Water and Power Law Group PC, Principal. Research interests include law and complex cases involving multiple parties.

Ted Sommer, DWR, Lead Scientist. Research interests include aquatic ecology, floodplain ecology, native fish restoration, and salmonid biology.

Paul Souza, USFWS, Pacific Southwest Regional Director. Research interests include conservation, planning, landscape-scale adaptive management, and endangered species.

Lisa Wainger, University of Maryland, Professor. Research interests include regional-scale ecological and economic modeling, invasive species, environmental economic indicators, and GIS-based landscape analysis.

Dave Wegner, Water, Energy and Transportation committee at U.S. House of Representatives, former Senior Staff. Research interests include fluvial geomorphology, GIS, pacific salmon dynamics, aquatic ecology, vegetation dynamics, and science policy.

Carl Wilcox, DFW, Policy Advisor to the Director for the Delta, Bay-Delta Regional Manager. Research interests include ecology, conservation, fisheries, natural resources, and policy.

Workshop Planning Committee:

The workshop would not have been possible without the hard work of the workshop planning committee:

Co-chair: **Jessica Law**, Delta Stewardship Council

Co-chair: **Mike Chotkowski**, USGS

Cliff Dahm, Delta Lead Scientist

Jay Lund, Delta Independent Science Board

Tracy Collier, Delta Independent Science Board

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