2023 Delta Invasive Species Symposium: Making Connections: Understanding Connectivity in an Invaded Estuary

Hosted by the Delta Interagency Invasive Species Coordination Team

California Natural Resources Agency, 715 P St., 2nd Floor, Sacramento
November 30, 2023, 8:30 a.m. – 4:15 p.m.

Presentations will focus on how connections within and among estuaries impact invasive species movement, how connectivity of different types can both help and hinder invasive species control, and how making connections among disciplines, policies, and actors is critical to effective invasive species management. The symposium is co-sponsored by the Delta Interagency Invasive Species Coordination (DIISC) Team, the Sacramento-San Joaquin Delta Conservancy, and the Delta Stewardship Council's Delta Science Program. Food and beverages have been provided through generous support from The Alexander and Elizabeth Swantz Endowment.

Agenda

Opening

8:30 a.m. Welcome
Campbell Ingram, Executive Officer, Sacramento-San Joaquin Delta Conservancy
Henry Debey, Deputy Executive Officer for Science, Delta Stewardship Council

8:45 a.m. Video Legislative Welcome
Assemblymember Tim Grayson

8:50 a.m. Symposium Introduction
Rachel D. Wigginton, Senior Environmental Scientist, Sacramento-San Joaquin Delta Conservancy, DIISC Team Facilitator

8:55 a.m. Opening Remarks
Laurel Larsen, Delta Lead Scientist, Delta Stewardship Council

9:10 a.m. Break

Session One: Connectivity within and among Estuaries

9:15 a.m. Eradicating the Invasive Nutria (*Myocastor coypus*) from California
Talmadge (Tal) Robinson, Nutria Eradication Operations Supervisor, CA Department of Fish and Wildlife

9:35 a.m. Fostering Stewardship of San Francisco Bay Tidal Wetlands through Regional Partnerships
Drew Kerr, Treatment Program Manager, San Francisco Estuary Invasive Spartina Project

9:55 a.m. Does Control of *Phragmites australis* Change the Potential for Spread within Suisun Marsh? An Examination of Propagule Pressure and Herbicide Resistance
Virginia Matzek, Professor, Santa Clara University

10:15 a.m. Genomic Tools Illuminate Connectivity and Spread of Marine Invaders in the Delta and Beyond
Carolyn Tepolt, Associate Scientist, Biology Department, Woods Hole Oceanographic Institution

10:35 a.m. Break

Session Two: Connecting Research, Management, and Policy

10:50 a.m. Improving the Integration of Invasion Science with the Goals of Multiple Agencies to More Effectively Manage High Priority Invasions and Prevent Future Introductions
Edwin (Ted) Grosholz, Distinguished Professor and Alexander and Elizabeth Swantz Specialist in Cooperative Extension, University of California, Davis

11:10 a.m. Cutting Green Tape for Invasive Species Control Projects in the Delta and Beyond
Brad Henderson, Cutting the Green Tape Environmental Program Manager, CA Department of Fish and Wildlife

11:30 a.m. Strategic Communication for Collective Action in Wetland Management and Restoration: Engaging with the Public, Landowners, and Agencies
Richelle L. Tanner, Assistant Professor of Environmental Science & Policy, Chapman University

11:50 a.m. Using Economic Analysis to Connect Public and Institutional Values to Invasive Species Management
Lisa Wainger, Research Professor, University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory and Chair, Delta Independent Science Board

12:10 p.m. Panel Discussion

12:30 p.m. Lunch

Session Three: Lightning Talks

1:30 p.m. Drones and High-resolution Imagery Used as a Tool to Monitor Ribbonweed (*Vallisneria australis*), a Recently Detected Non-Native Submerged Aquatic Plant in the Sacramento-San Joaquin Delta
JT Casby, Environmental Scientist, CA Department of Water Resources

1:35 p.m. Preventing the Spread: An eDNA Guided Removal Effort
Jennie J. Wiggins, Fish Biologist, US Fish and Wildlife Service

1:40 p.m. Pollination of *Iris pseudacorus* in a Southern California Estuary
Anita Arenas, Graduate Student, California State University, Long Beach

1:45 p.m. Analytical Tools for Protecting California's Biodiversity from Invasive Plants
Doug Johnson, Executive Director, California Invasive Plant Council

1:50 p.m. Connect to New Rapid Response Funding!
Martha Volkoff, Invasive Species Environmental Program Manager, CA Department of Fish and Wildlife

1:55 p.m. Using Calflora to Track Your Weeds and Treatment
Cynthia Powell, Executive Director and Pete Frye, Weed Manager Trainer, Calflora

2:00 p.m. Water Lettuce (*Pistia stratiotes*): Not in the Delta but a Little Too Close for Comfort
Nick Rasmussen, Senior Environmental Scientist, CA Department of Water Resources

2:05 p.m. CDFW Invasive Watersnake Eradication Project
Thomas Jensen, Environmental Scientist, CA Department of Fish and Wildlife

2:10 p.m. Question and Answer

2:30 p.m. Break

Session Four: Challenges and Advantages of Connectivity

2:45 p.m. Impacts of a Cyanobacteria Harmful Algal Bloom (CHAB) Hotspots in the Sacramento San Joaquin Delta
Ellen Preece, Senior Environmental Scientist, CA Department of Water Resources

3:05 p.m. Amazing Graze: Shifts in Jellyfish and Clam Distributions During Dry Years in the San Francisco Estuary
Elizabeth Wells, Benthic Lead, Environmental Monitoring Program, CA Department of Water Resources

3:25 p.m. How Vulnerable is Delta Smelt to Hybridization with Wakasagi?
Evan Carson, Population Geneticist, US Fish and Wildlife Service, San Francisco Bay-Delta Fish and Wildlife Office

3:45 p.m. Integration of Restored Hydrological Connectivity and Herbicide Use Suppresses Dominance of a Floodplain Invasive Species
Rachel Hutchinson, District Ranger, Tahoe National Forest, US Forest Service

4:15 p.m. Closing Remarks

Abstracts

Session One: Connectivity Within and Among Estuaries

Eradicating the Invasive Nutria (*Myocastor coypus*) from California

Talmadge (Tal) Robinson, Nutria Eradication Operations Supervisor, CA Department of Fish and Wildlife

California's Department of Fish and Wildlife (CDFW) Nutria Eradication Program collaborates with California's Department of Food and Agriculture (CDFA) and Department of Water Resources (DWR), US Department of Agriculture's Wildlife Services (WS), US Fish and Wildlife (USFWS), Delta Conservancy and a multitude of landowners. To date, 4,001 nutria have been removed from California, and trapping efforts are ongoing year-round. WS detector dogs have recently helped confirm presence/absence of nutria in key locations, both where trapping has occurred as well as where it has not. Detector dog site visits over a wide geographic extent have confirmed low densities of nutria relative to available habitat. Populations typically detected in the Delta are comprised of single animals to a few family groups and are spread with large gaps of good habitat present between known populations.

Fostering Stewardship of San Francisco Bay Tidal Wetlands through Regional Partnerships

Drew Kerr, Treatment Program Manager, San Francisco Estuary Invasive Spartina Project

The San Francisco Estuary Invasive *Spartina* Project (ISP) was formed as a partnership between the California Coastal Conservancy and USFWS to manage the invasion of aggressive non-native cordgrass, primarily the hybrid formed between our native *Spartina foliosa* and the *Spartina alterniflora* introduced from the eastern U.S. in the 1970s. This conservation work, spanning nine counties and 70,000 acres of tidelands, guards against the degradation of our remaining tidal marshes while protecting our naturally unvegetated mudflats (essential for shorebird foraging) from type conversion by the invasive cordgrass. The ISP's stewardship is also fundamental to landscape-scale tidal marsh restoration around the Estuary, such as the South Bay Salt Pond Restoration Project, the largest such effort on the West Coast at 15,100 acres. Protecting vulnerable new sites from invasion allows newly breached marshes to develop a diverse native plant assemblage without domination by the invasive *Spartina*, contributing to higher biodiversity and greater resilience. Thousands of acres of former salt evaporator ponds and diked areas have been returned to tidal exchange under the watchful plant stewardship of the ISP, including large tracts in the Napa Sonoma Marsh such as Sonoma Baylands, Sears Point, and Cullinan Ranch.

By 2022, over 97% of the invasive *Spartina* has been removed from the Estuary. As a result, invasion pressure throughout the North Bay and up into Suisun is very low, due to continued progress that has either eliminated historic invasive *Spartina* infestations or reduced them down to trace levels. Nearly 600,000 native plants have been installed at over 40 marshes to jump start the biodiversity stymied by the hybrid *Spartina* monocultures and to benefit the endangered Ridgway's rail (*Rallus obsoletus obsoletus*). ISP native plant restoration plans, in combination with the construction of 82 high tide refuge islands, are designed to enhance habitat for rail nesting, foraging, and roosting.

Does Control of *Phragmites australis* Change the Potential for Spread within Suisun Marsh? An Examination of Propagule Pressure and Herbicide Resistance

Virginia Matzek, Professor, Santa Clara University

Michael Weatherford, Santa Clara University

Gabriel Rodkey, Santa Clara University

Brackish wetland ecosystems around San Francisco Bay have been increasingly invaded by the species known as common reed or phragmites (*Phragmites australis*). In Suisun Marsh, long-term management has consisted of herbicide spraying, mowing, discing, and occasional burns, but treatments have been unsuccessful at halting the spread of phragmites. We sought to determine if intensive management had diminished the propagule pressure of existing phragmites stands by decreasing seed number or seed viability, or, conversely, if the long history of herbicide use had resulted in herbicide resistance in the invader. We collected inflorescences of phragmites from areas with a long history of intensive control (>10 years of spraying) and from sites where little or no spraying (0-3 years) had occurred. We stripped inflorescences of florets, measured seedset, and did germination trials to test seed viability. We also subjected seedlings to glyphosate as a test of acquired herbicide resistance. We found that inflorescences from the high-intensity treatment were less numerous and had fewer seeds on average than those from low-intensity sites, although high-intensity inflorescences tended to be slightly larger and have heavier seeds. Coupled with decreased patch area and decreased inflorescence density of *P. australis* within patches in heavily treated areas, the propagule pressure of the invader diminished by 73%, from 4486 seeds per m2 of marsh to 1214 seeds per m2 of marsh. We found no significant differences in germination rate between the low-intensity and high-intensity treatment areas. Results from the herbicide trials showed no difference in herbicide damage levels in long-sprayed populations, suggesting that herbicide resistance is unlikely to be a factor in the continued persistence of phragmites in Suisun Marsh. We conclude that current methods of control reduce the potential proliferation of new invasion fronts within Suisun Marsh but are not sufficiently widespread to halt marshwide spread.

Genomic Tools Illuminate Connectivity and Spread of Marine Invaders in the Delta and Beyond

Carolyn Tepolt, Associate Scientist, Biology Department, Woods Hole Oceanographic Institution

Zachary JC Tobias, PhD candidate, MIT-WHOI Joint Program in Oceanography/Applied Ocean Science and Engineering, Cambridge and Woods Hole

The San Francisco Bay Delta is often the first “port of call” for marine invasive species before they disperse more broadly in the northeast Pacific. Understanding how these species spread among estuaries, and how these estuaries are connected via dispersal, can help to design management strategies at an appropriate spatial scale. The emergence of cost-effective high-throughput genetic sequencing permits us to examine dispersal and connectivity directly using a much higher-resolution, genome-wide perspective than traditional population genetics approaches. I will discuss the utility of genomic tools for better understanding and managing marine invasions, contrasting two species that were initially introduced to San Francisco Bay and have since spread extensively to other northeast Pacific embayments. These species exemplify two different dispersal mechanisms: one is a crab with a two-month larval duration that disperses via currents, while the other is a tunicate that travels primarily via biofouling on ships and other marine infrastructure. European green crabs have spread rapidly on the west coast since their first detection in San Francisco Bay in 1989; genomic data have uncovered ongoing connectivity between the Bay and populations as far away as British Columbia. The

golden star tunicate is a cosmopolitan fouling species found from Mexico to Canada and still spreading; whole-genome sequencing has identified at least two distinct introductions to the west coast and can clearly distinguish between populations as close as 15 km apart in San Francisco Bay. We will present these examples in the context of ongoing management efforts, and we will more broadly discuss different patterns of dispersal and coastal connectivity in marine invasive species.

Session Two: Connecting Research, Management, and Policy

Improving the Integration of Invasion Science with the Goals of Multiple Agencies to More Effectively Manage High Priority Invasions and Prevent Future Introductions

Edwin (Ted) Grosholz, Distinguished Professor and Alexander and Elizabeth Swantz Specialist in Cooperative Extension, University of California, Davis

We can look back on the "Invasive Species Challenge" discussed in 2008 (Williams and Grosholz 2008) and see how far the world of science and management has progressed in addressing the causes and consequences of non-native species invasions in estuarine systems. The linkages between the science of biological invasions and the management approaches used for prevention of new introductions and mitigating the impacts of high-priority invasions have increased. However, despite clear progress, many obstacles still exist that disable effective prevention of new invasions and delay responses to invasions in need of rapid action continue. I discuss some examples that illustrate several important issues that have contributed to these results and suggest some ways in which more collaborative approaches to science and management and better integration of multi-agency objectives would facilitate more successful outcomes. I will also compare successes and failures of managing invasive species invasions in the Bay/Delta with similar situations in other estuaries where different approaches have been used and discuss the lessons that can be distilled from these other systems.

Cutting Green Tape for Invasive Species Control Projects in the Delta and Beyond

Brad Henderson, Cutting the Green Tape Environmental Program Manager, CA Department of Fish and Wildlife

The California Department of Fish and Wildlife's Cutting the Green Tape (CGT) program focuses on developing procedures and tools designed to improve processes for restoration and invasive species control projects in the Delta and beyond. The State of California has identified "Cutting Green Tape" as a priority initiative to increase the pace and scale of ecological restoration, conservation, climate adaptation, and stewardship. The CGT program supports and complements California's 30x30 initiative, a commitment to achieving the goal of conserving 30 percent of California's lands and coastal waters by 2030. CDFW's CGT Strike Team is hard at work across California, matching invasive species control and restoration projects with the most efficient restoration permitting tools. During the past two fiscal years, CDFW funded, permitted, or assisted with environmental review exemptions for nearly 250 restoration projects covering over 150,000 acres and 580 stream miles with an average permit processing time of approximately 58 days. At the same time, the CGT Program has continued to develop and support new initiatives, including the California Environmental Quality Act (CEQA) statutory exemption for restoration projects (SERP). This presentation will provide an overview of the CGT program's organization and structure followed by a review of its restoration permitting tools, the CEQA statutory exemption, and a brief overview of how other regulatory agencies are also cutting green tape. We are here to help you save time and money while controlling invasives and restoring California. Restoration practitioners will learn who we are, what we do, and how to connect with us and our partners.

Strategic Communication for Collective Action in Wetland Management and Restoration: Engaging with the Public, Landowners, and Agencies

Richelle L. Tanner, Assistant Professor of Environmental Science & Policy, Chapman University

The California Delta has vast diversity in ecological, social, and political management needs and ideologies. Our field has spent decades investigating how each of these individually are contributing to the preservation and careful allocation of our natural resources for ecological and human uses. However, we still fall short when trying to implement solutions presented by scientific research, largely because of diverse viewpoints on best practices (ecological, financial, social). Invasive species management is an area that suffers disproportionately from stalled action on potential solutions because problems are time-sensitive and span property lines. We have been investigating the role that communication, including the assumption of shared literacy among stakeholders, has been playing in these management shortcomings. Using approaches in environmental psychology and strategic communication, we developed a comprehensive plan to motivate collective action among diverse stakeholders tackling *Phragmites australis* management. We began with surveys and interviews that produced language to discuss eleven wetland restoration topics with the public, including cultural values that build trust between communicator and audience. We next developed a survey for >170 landowners (public agencies and duck clubs) in Suisun Marsh that produced attitudes and behaviors on *Phragmites* management and cooperation among landowners. Then, we deployed interviews among landowners and water managers to produce language that motivates each stakeholder group to engage in collective action for invasive species management. Our next step is to test variations of these strategic communication plans to link attitudes to behaviors (i.e., whether they request resources to take action). Attitudes, behaviors, and actions operate from non-rational thought grounded in cultural values and social conditioning, so it is important to take a psychology evidence-based approach when designing strategic communication plans. While we must ground our management solutions in scientific discourse, scientific expertise alone is largely ineffective in motivating collective action in the social behavioral context.

Using Economic Analysis to Connect Public and Institutional Values to Invasive Species Management

Lisa Wainger, Research Professor, University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory and Chair, Delta Independent Science Board

Given that resources for managing invasive species are limited, valuing economic benefits can inform socially efficient resource allocation. Engaging with interested parties is the first step to identifying the multiple pathways of invasive species harm or benefit. Next, economic values are measured by connecting cause and effect along such pathways, through coupled or integrated models. Values reflect the intensity of concern for ecosystem changes and can be used to weight tradeoffs of alternative management approaches and net benefits.

Generating appropriate empirical data for economic analysis is a challenge that is best addressed by interdisciplinary or transdisciplinary approaches. Collaborations across institutions and interested parties are typically necessary to provide the best available information and fill data gaps. I will demonstrate these techniques using a case study of *Hydrilla verticillata* (dioecious) in hydrologically connected Florida lakes, where the species reduces the value of lake recreation and other ecosystem services. We applied a retrospective benefit-cost analysis to quantify the net benefits of invasive species control, as informed by government-supported research. The research examined alternative treatment protocols in response to the development of Fluridone tolerance in hydrilla. A key management tradeoff identified was that the optimal level of hydrilla cover differed across interested parties.

In addition to describing the case study, I will synthesize findings from multiple case studies, including a study that optimized invasive species management under uncertainty, to provide some broad lessons learned. This talk will emphasize the systems-level understanding that can be gained from integrating economic perspectives into the assessment and management of invasive species to promote efficient use of limited resources.

Session Three: Lightning Talks

Drones and High-resolution Imagery Used as a Tool to Monitor Ribbonweed (*Vallisneria australis*), a Recently Detected Non-Native Submerged Aquatic Plant in the Sacramento-San Joaquin Delta

JT Casby, Environmental Scientist, CA Department of Water Resources

In 2017, an unknown submersed aquatic plant was found by Long Island in the Sacramento-San Joaquin Delta. It was later identified as ribbonweed (*Vallisneria australis*), a popular aquarium plant native to Australia. Patches of this species have now been found at eight sites across an arc of the Delta stretching more than 70 km. These patches are dense monocultures with foliage filling the water column from substrate to surface, and some are already impacting marinas and boat ramps. This growth pattern resembles that observed in New Zealand, Japan, Hungary, Belgium, and Germany, where this non-native species clogs waterways and displaces native vegetation. An important step in controlling a new non-native plant is quantifying the spatial extent of the infestation. Submersed aquatic plants are notoriously difficult to monitor, but the structure of ribbonweed patches appeared amenable to monitoring via drones. During June 2022 to February 2023, we conducted drone surveys of all known patches of ribbonweed and concluded drones were an effective monitoring tool if surveys were timed with appropriate field conditions (e.g., low tide, low wind, strong sunlight). We found the size of infestations varied widely among sites from 57 m2 to 12,748 m2 and that the total known area of ribbonweed across the Delta was 28,564 m2 or 2.85 ha, which is the area of 5.5 football fields. These data provide a baseline for evaluating future rates of expansion of this species and efficacy of potential control measures.

Preventing the Spread: An eDNA Guided Removal Effort

Jennie J. Wiggins, Fish Biologist, US Fish and Wildlife Service

The San Francisco Estuary (SFE) is one of the most heavily invaded estuaries in the world. The non-native Large-Scale Loach (*Paramisgurnus dabryanus*; family Cobitidae) was first detected in the SFE watershed (San Joaquin River) in 2014. Since then, loaches have been located elsewhere in the San Joaquin system including the San Luis National Wildlife Refuge (SLNWR; Merced County). Cobitids have great invasive potential. In particular, their high fecundity and opportunistic omnivory may allow them to increase their numbers and range rapidly. An expanding loach population could negatively impact native fishes, including species of special concern. Rapid detection and targeted removal of loaches is needed to limit loach population expansion in the San Francisco Estuary. We developed a protocol using eDNA data to inform focused trapping efforts. In a 2022 pilot study, we developed a qPCR assay to detect loach eDNA and then deployed a paired sampling design to compare eDNA detections with minnow trapped loach at the SLNWR. The pilot data informed a follow-up study comprising (1) a live car experiment to calibrate the probability of detecting loach eDNA, and (2) loach removal. In the removal phase, we mapped eDNA concentration as heat maps to guide the selection of trapping locations. Overall, we observed (1) strong agreement between eDNA detections and trapped loach and (2) considerable improvements in removal efficiency when eDNA data guided trapping efforts.

Pollination of *Iris pseudacorus* in a Southern California Estuary

Anita Arenas, Graduate Student, California State University, Long Beach

Christine Whitcraft, Professor, California State University, Long Beach

About 90% of wetlands have been lost in California. Of those that remain, many are degraded by invasive species, such as *Iris pseudacorus* (IRPS). IRPS has invaded freshwater, brackish, and marine tidal areas of Los Peñasquitos Lagoon in North County San Diego (CA). Our objectives were to determine the pollinator community of IRPS compared to non-IRPS vegetation in their non-native range. Vegetation was observed for flower visitors in 15-minute periods adding up to 160 hours in a one-meter quadrat space. During each 15-minute periods flower visitor pollinators were identified, and total time spent in the quadrat, behavior, and the number or flowers visited were documented. Visitor frequencies were then calculated for each site and vegetation type. Preliminary data from visual observations of pollinator visitation showed the highest visitation in the IRPS canopies at the freshwater site as compared to all other locations and plant types. Pollinator community composition varied by location, but not by plant type, with an increased percent of honeybees found at the freshwater site and an increased percent of bumblebees at the brackish water site relative to other areas. Being able to understand the impacts of IRPS on pollinator communities and seed production can help prioritize management strategies by determining the extent of impacts and most impacted locations.

Analytical Tools for Protecting California's Biodiversity from Invasive Plants

Doug Johnson, Executive Director, California Invasive Plant Council

Controlling invasive plants is critical to protecting California's biodiversity. The California Invasive Plant Council provides tools to support those working to control invasive plants in the state. These tools include our Inventory of invasive plants, the CalWeedMapper online tool for regional distribution, and the WeedCUT online tool for recommended control approaches and BMPs. Together, these tools help managers set priorities and design effective invasive plant control programs needed to protect biodiversity.

Connect to New Rapid Response Funding!

Martha Volkoff, Invasive Species Environmental Program Manager, CA Department of Fish and Wildlife

The most effective time to control an invasive species is when it is first discovered and before it has spread to cause severe impacts. However, natural resource managers often struggle to obtain funding for this initial response. New state and federal funding will facilitate rapid response to invasive species. Each fund has different requirements, but both are intended as seed money to start containment or eradication of newly detected species. State rapid response funding is pending approval by state Secretaries, so information presented here is tentative. Funds will be administered by the California Invasive Species Advisory Committee (CISAC). Eligible applicants include public and private colleges and universities, federal state, and local government entities, tribal entities, and non-profit organizations. The maximum award will be $100,000 with no minimum and funds must be used within 12 months of the award date. Projects can be anywhere in California and focus on any taxa, but applicants must show why an immediate response is needed. Application information will be posted at the Invasive Species Council of California website once final approval is granted. The U.S. Fish and Wildlife Service opened a Rapid Response Fund for Aquatic Invasive Species (AIS) in August 2023. Applicants must be state or federal agencies, interstate organizations, or Native American tribal governments. Projects must address AIS new to the U.S. or range expansions and activities must be rapid response to a

species in a defined location with a minimum award of $50,000. Applications will be reviewed quarterly, and the fund is available for one year. Find application information at Grants.gov (opportunity F24AS00018).

Using Calflora to Track Your Weeds and Treatment

Cynthia Powell, Executive Director, and Pete Frye, Weed Manager Trainer, Calflora

Do you feel three steps behind in terms of technological and tool developments? The Calflora Database provides free tools for mapping weeds, color coding those maps, and sharing this information across borders. Use Calflora's free phone app "Observer Pro" to map points and polygons of invasive plants you are tracking while in the field. Then, and this is brand new, you may color code observations on the map. For example, you may have ten different weeds shown in ten different colors on your map. Similar to other GIS software, you choose the colors. However, an advantage to using Calflora's Observer Pro over online GIS or a modified Survey123 or Collector tool is your ability to share data. Sharing easily with partners and neighbors is vital, in particular for state and federal agencies. Send these color-coded maps via URL/web links with colleagues, neighbors, and partners alike. This shared information via Calflora links is dynamic, not static. As you make revisions and changes, they will automatically be reflected in your shared (and colorful!) maps. You may create a free Calflora group to share private data only with these select people. Alternatively, if there is information that you are not ready to share with colleagues, neighbors, or anyone, you may opt to keep it private.

Water Lettuce (*Pistia stratiotes*): Not in the Delta but a little too close for comfort

Nick Rasmussen, Senior Environmental Scientist, CA Department of Water Resources

Water Lettuce is among the worst weeds in the world. It has been present in parts of southern California for many years. Within the past ten years, a few populations have been found in or near the watershed for the Delta. This talk will cover information about how to identify this species, where it has been found, and what the impacts could be if it invades the Delta.

CDFW Invasive Watersnake Eradication Project

Thomas Jensen, Environmental Scientist, CA Department of Fish and Wildlife

Watersnakes of the genus *Nerodia* are aquatic, non-venomous snakes native to the eastern U.S. At least three species have become established at multiple sites in California, including Roseville, Folsom, Los Angeles, near the Colorado River, and possibly the Sacramento-San Joaquin Delta. All species of *Nerodia* are restricted in California, and it is speculated these populations are the result of illegal pet releases. *Nerodia* primarily prey upon amphibians and fishes, and, if allowed to spread, threaten to outcompete native garter snakes and prey upon sensitive Central Valley (California) and Sacramento-San Joaquin Delta fishes. Since 2015, CDFW has implemented an eradication project for two populations of *Nerodia*, Folsom and Roseville, and has made significant progress towards achieving eradication. The effort has led to publications of *Nerodia* research by UC Davis (Dr. Brian Todd and others). Additionally, in collaboration with CDFW's Wildlife Health Lab, *Nerodia* that are trapped and subsequently removed are sampled for snake fungal disease which is an emerging disease in California that threatens all snake species.

Session Four: Challenges and Advantages of Connectivity

Impacts of a Cyanobacteria Harmful Algal Bloom (CHAB) Hotspots in the Sacramento San Joaquin Delta

Ellen Preece, Senior Environmental Scientist, CA Department of Water Resources

Janis Cooke, Central Valley Regional Water Quality Control Board

Timothy Otten, Bend Genetics

Cyanobacteria harmful algal blooms (CHABs) constitute a major, worldwide environmental threat to aquatic resources that is expected to expand in scale and intensity with global climate change. River dominated coastal systems, such as the Sacramento-San Joaquin Delta (Delta), area particularly at risk of experiencing more CHAB events due to combined effects of nutrient over-enrichment, warming temperatures, and extreme weather events. Large estuarine systems that are prone to CHABs often have “hotspot” regions – areas where cyanobacteria blooms are most severe and most likely to occur. Hotspots cause transient problems as cyanobacteria cells travel from the point of origin to other portions of the watershed. This is exemplified in the Delta where static peripheral areas and marinas are increasingly being recognized as CHAB hotspots. We investigated one of these Delta CHAB hotspots – the Stockton Channel. We studied water quality and sediment conditions across the Stockton Channel to better understand the factors that cause severe CHABs to occur at this location. A dense, toxin forming Microcystis spp. bloom was present across the Stockton Channel in the summer of 2022. Although the bloom was most severe at the terminus of the channel, Microcystis spp. colonies were also present over five miles from the channel terminus. We used genetic tools to elucidate how CHABs in the Stockton Channel and other Delta hotspots may be spreading from the point of origin across the Delta.

Amazing Graze: Shifts in jellyfish and clam distributions during dry years in the San Francisco Estuary

Rosemary Hartman, California Department of Water Resources

Laura Twardochleb, California Department of Water Resources, California State Water Resources Control Board

Christina E. Burdi, California Department of Water Resources, California Department of Fish and Wildlife

Elizabeth H. Wells, California Department of Water Resources

Aquatic invasive species have drastically changed how the San Francisco Estuary functions. During the past two decades, the impacts of invasive species in the estuary may have increased in response to frequent and severe drought conditions. The invasive overbite clam (*Potamocorbula amurensis*), and the Asian Clam (*Corbicula fluminea*) have well documented consequences on the estuarine food web, but their responses to drought are not well understood. Another invasive species, the jellyfish *Maeotias marginata*, has the potential to further impact the food web, but these impacts have not been studied. We investigated the population responses of these invasive species to dry years and their potential effects on the pelagic food web using data from the Interagency Ecological Program's monitoring surveys. We found *M. marginata* rapidly moves upstream with changing salinities during dry years, though it sees its highest abundance during high-outflow years in Suisun Bay and Suisun Marsh. Grazing rates of *M. marginata* in the estuary have not been quantified but are potentially high during localized blooms. The two invasive clams overlap in distribution, but have opposite population

responses to drought conditions, with increases in *P. amurensis* densities and decreases in *C. fluminea* densities in dry years. With increasing *P. amurensis* densities, the clams' combined annual filtration rates increase during drier years in the Confluence and Suisun Marsh. Like *M. marginata*, *P. amurensis* also shifts upstream during droughts, but because adults cannot move immediately with a change in salinity, the population center of distribution shifts upstream the year following a dry year due to juvenile recruitment. If multiple dry years occur in a row, and both *P. amurensis* and *M. marginata* move upstream together, their effects on the food web could be compounded and phytoplankton and zooplankton biomass could steeply decline in the Confluence, impacting higher trophic levels in the estuary.

How Vulnerable is Delta Smelt to Hybridization with Wakasagi?

Evan Carson, Population Geneticist, US Fish and Wildlife Service, San Francisco Bay-Delta Fish and Wildlife Office

Hybridization between species is a common phenomenon that ranges from natural occurrences between native forms to interbreeding between native and non-native ones. For imperiled species, hybridization of either type can be of conservation concern, in part because interspecific mating can become more likely when conspecific mating opportunities are sparse. For the endangered delta smelt *Hypomesus transpacificus* – a San Francisco Estuary (Estuary) endemic – hybridization with other native osmerids appears to be negligible. However, consequences of its hybridization with non-native *wakasagi H. nipponensis* remain unclear. Studies of wild-collected specimens suggest that hybridization between the two is uncommon, asymmetric (WAK ♀ x DSM ♂), and rarely advances beyond production of first generation (F1) hybrids. This is consistent with severe if not strict incompatibility between the species. Other plausible explanations, however, have not been ruled out (e.g., species differences in reproductive timing and fecundity), and spawning experiments have demonstrated that, under laboratory conditions, delta smelt and wakasagi hybridize willingly in both directions (DSM ♀ x WAK ♂ and vice versa) and that both crosses yield viable offspring for up to 10 days posthatch (experiment concluded). Additional uncertainty stems from changes to their respective populations in the Estuary. Whereas wakasagi abundance has increased in recent years, delta smelt plummeted to near extirpation over the same period. The latter prompted implementation, in 2021, of annual experimental release of cultured – and perhaps naïve – delta smelt to avert its extinction in the wild. A better understanding of the propensity and outcomes for delta smelt x wakasagi hybridization would facilitate a more robust assessment of the risks posed to delta smelt by 1) genetic introgression from wakasagi to wild and cultured populations and 2) recruitment costs exacted by reproductive resources lost to interspecific mating. This talk explores that challenge in the context of guidance for management and regulatory purposes.

Integration of Restored Hydrological Connectivity and Herbicide Use Suppresses Dominance of a Floodplain Invasive Species

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Invasive species present one of the largest threats to the recruitment and persistence of native plant communities. Over nearly a decade, we tracked the establishment and population growth of *Lepidium latifolium* (perennial pepperweed) on a hydrologically restored floodplain and adjacent grassland sites, concurrently with a controlled herbicide application experiment. We found that perennial pepperweed

stem counts were lower in years with longer duration and larger magnitude flood events ($p<0.0001$) and after herbicide application ($p<0.0005$). In floodplain areas, native species increased in the years following herbicide treatments or after wet water years, while grassland sites were re-invaded by other non-native species. Our results suggest that floodplain connectivity, resulting in longer inundation periods, can be an effective management tool for perennial pepperweed over large areas. Herbicide application in drier sites or in drier years can increase management efficacy. This study emphasized the need for further integration of traditional weed control approaches with restored ecological function to effectively control perennial invasive plants and stimulate native plant recovery.