2025 Delta Invasive Species Symposium: Modeling and Managing Invasive Species for Tomorrow's Delta

Hosted by the Delta Interagency Invasive Species Coordination Team

California Natural Resources Agency, 715 P St., Room 221, Sacramento
December 4, 2025, 8:30 a.m. – 4:30 p.m.

Presentations will broadly address management of the future Delta through highlighting modeling, new invaders, using innovative tools and approaches, and methods for dealing with uncertainties. The symposium is sponsored by the Delta Interagency Invasive Species Coordination (DIISC) Team.

Agenda

Check-in

8:00 a.m. Light breakfast will be provided

Opening

8:30 a.m. Welcome
Campbell Ingram, Executive Officer, Sacramento-San Joaquin Delta Conservancy

8:40 a.m. CNRA Opening Remarks
Madeline Drake, Assistant Secretary, Biodiversity and Habitat, California Natural Resources Agency

8:50 a.m. Symposium Introduction
Anji Shakya, Environmental Scientist and DIISC Team co-lead, Sacramento-San Joaquin Delta Conservancy

8:55 a.m. Opening Remarks
Lisamarie Windham-Myers, Delta Lead Scientist, Delta Stewardship Council

Session One: Management Paradigms

9:10 a.m. The Transition from Resistance to Acceptance: Managing a Marine Invasive Species in a Changing World
Abby Keller, Department of Environmental Science, Policy, and Management, University of California Berkeley

9:30 a.m. Just Transitions in the Delta: Exploring Ecological Change in Future Salinity and Climate Adaptation Scenarios
Brett Milligan, Professor of Landscape Architecture and Environmental Design and Vice Chair of the Department of Human Ecology, University of California Davis
Elsie Platzer, PhD Candidate in Ecology, Center for Watershed Sciences, University of California Davis

9:50 a.m. Cooperative Natural Resource Management in a Mixed Private-Public Wetland
Richelle L. Tanner, Assistant Professor & Director, Environmental Science & Policy Program, Chapman University

10:10 a.m. Panel Discussion
Facilitator: Elizabeth Brusati, Adaptive Management Liaison and DIISC Team co-lead, Delta Stewardship Council

10:30 a.m. Break

Session Two: Invasive Mussels in the Delta

10:45 a.m. Introduction
Thomas Jabusch, Senior Environmental Scientist (Supervisor) and DIISC Team co-lead, California Department of Fish and Wildlife

11:00 a.m. Knowns, Unknowns, and Assumptions About the Role of Ballast Water in the Introduction of Golden Mussels to California and Potential Secondary Spread
Lina Ceballos Osuna, Senior Environmental Scientist, California State Lands Commission, Marine Invasive Species Program

11:15 a.m. Hull Fouling as a Mechanism for the Introduction and Spread of the Invasive Golden Mussel, *Limnoperna fortunei*, in North America
Tessa Beaver, Biological Technician, Smithsonian Environmental Research Center

11:30 a.m. Modeling Boater Travel Pathways for Invasive Mussels Using Anonymized Cellular Location Data
Jonas Grundman, National Aquatic Plant Control Program Technical Lead, United States Army Corps of Engineers

11:45 a.m. Golden Mussel Mitigation in the State Water Project
Tanya Veldhuizen, Environmental Program Manager, California Department of Water Resources

12:00 p.m. Question and Answer

12:15 p.m. Lunch Break (on your own)

Session Three: Lightning Talks

1:30 p.m. Introduction
Facilitator: Hollis Jones, Senior Environmental Scientist, Delta Stewardship Council

1:35 p.m. First Observation and Spread of the Oriental River Prawn (*Macrobrachium nipponense*), a New Invasive Shrimp in the Sacramento-San Joaquin Delta
Sky Jung, Graduate Student, University of California Davis

1:40 p.m. *Neoeriocheir leptognathus*: A New Invasion?
Kenji Soto, Environmental Scientist, California Department of Fish and Wildlife

1:45 p.m. U.S. Army Corps of Engineers AIS Research and Cost-Share Programs – Authorities and Opportunities
Jeremy Crossland, National Aquatic Plant Control Program Manager, United States Army Corps of Engineers

1:50 p.m. Tracking Management of Delta Weeds Using Calflora
Cynthia Powell, Executive Director, Calflora

1:55 p.m. Operationalizing Sentinel-2 for Sub-Annual Mapping and Management of Invasive Aquatic Vegetation in the Delta
Bailey D. Morrison, Assistant Project Scientist, University of California Merced

2:00 p.m. Nutria Eradication Progress in California, From 2017 to the Present
Jessica Vollmer, Senior Environmental Scientist, California Department of Fish and Wildlife Nutria Eradication Program

2:05 p.m. Protecting Infrastructure from Golden Mussel
David Hammond, Senior Scientist, Earth Sciences Labs, Inc.

2:10 p.m. USFWS Pacific Southwest Aquatic Invasive Species Horizon Scan
Jenny Ketterlin, Invasive Species Coordinator, United States Fish and Wildlife Service

2:15 p.m. Question and Answer

2:40 p.m. Break

Session Four: New Tools and New Conditions

2:55 p.m. Introduction
Rachel D. Wigginton, Senior Environmental Scientist (Specialist) and DIISC Team co-lead, Sacramento-San Joaquin Delta Conservancy

3:00 pm Rapid Spread of Invasive Alligator Weed in Changing Delta-Suisun Wetlands: Functional Traits Support Multiple Strategies to Persist Under Increasing Salinity Stress
Brenda J. Grewell, Research Associate, Department of Plant Sciences and Center for Plant Diversity, University of California Davis

3:20 p.m. Drought and Aquatic Vegetation Alter Water Clarity and Fish Assemblages in Freshwater Tidal Sloughs of the North Delta
Adrianne Smits, Research Scientist, Department of Environmental Science & Policy, University of California Davis

3:40 p.m. Using eDNA/eRNA as Complementary Tools for Invasive Species Monitoring
Sarah Brown, Unit Manager for Collaborative Ecological Studies, California Department of Water Resources
Aviva Fiske, Environmental Scientist, California Department of Water Resources
Emily Funk, Lab Manager, Genomic Variation Lab, University of California Davis

4:15 p.m. Closing Remarks

Abstracts

Session One: Connectivity Within and Among Estuaries

The Transition from Resistance to Acceptance: Managing a Marine Invasive Species in a Changing World

Abby Keller, Department of Environment Science, Policy, and Management; UC Berkeley

Co-authors: Tim Counihan, US Geological Survey; Ted Grosholz, UC Davis; Carl Boettiger, UC Berkeley

Invasive species can transform ecosystems, yet mitigating their effects can be difficult, and even impractical. Often, invasive species are managed at poorly matched spatial scales, yet at the same time, rates of spread and establishment are increasing under climate change and can outpace resources available for population suppression. These circumstances challenge traditional conservation goals of maintaining a historic environmental state, especially for a species like the European green crab (*Carcinus maenas*), a formidable invader with few examples of successful long-term removal programs. For invasive species that can disperse across long distances and recolonize rapidly after removal, a management paradigm where decision alternatives include resisting or accepting a new ecological trajectory may be needed. We apply mathematical concepts from decision theory to develop a quantitative framework for navigating management decisions in this new resist-accept paradigm. We develop a model of European green crab growth, removal and colonization, and we find optimal levels of removal effort that minimize both ecological change and removal cost. We establish a benchmark of colonization pressure at which green crab density becomes decoupled from a decision maker's actions, such that population control can no longer shape the invasion trajectory. For natural resource managers facing possible ecosystem transformation, this decision framework can enable proactive and strategic decisions made under uncertainty in a changing world.

Just Transitions in the Delta: Exploring Ecological Change in Future Salinity and Climate Adaptation Scenarios

Brett Milligan, Professor of Landscape Architecture and Environmental Design, Vice Chair of the Department of Human Ecology, UC Davis

Elsie Platzer, PhD Candidate in Ecology, Center for Watershed Sciences, UC Davis

In the California Delta, salinity, and how salinity varies over time, has a strong influence on aquatic ecosystems and the assemblage of species that thrive within them. Since the state and federal water projects were operational, the Delta has been intentionally managed and maintained as freshwater (primarily for freshwater distribution and uses). But with the increasing and accelerating impacts of climate change, it is predicted that a freshwater Delta will become increasingly difficult, and eventually untenable, to maintain. A saltier future Delta is likely.

Just Transitions in the Sacramento-San Joaquin Delta: Drought, Salinity and Sea Level Rise a research project that is exploring salinity management and climate change adaptation in the Delta through a scenario planning process. With public input, we have developed five scenarios for future Delta adaptation, which include a wide range of physical changes to the Delta, such as habitat restoration and expanded infrastructure, and changes to inflows and reservoir operations. Using multiple forms of modeling to inform detailed evaluation criteria, the project will compare how each scenario would provide potential benefits and impacts, and how it might perform over time.

This presentation will focus specifically on the predicted ecological effects of the Just Transitions adaptation scenarios, and of future salinity intrusion into the Delta generally. Based on extensive literature review alongside hydrodynamic modeling, we will present conceptual models elaborating changes in species abundance and distribution under different scenario conditions, based on biotic, abiotic and landscape-scale drivers of change. Predictions of both near term and longer-term time horizons will be discussed, in order to address how increasing pressures from climate change impacts may affect Delta ecosystems.

This research effort is in process and participant review and comments on methods and approach will be welcomed.

Cooperative Natural Resource Management in a Mixed Private-Public Wetland

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

Natural resource governance, especially in the case of issues that transcend the physical boundaries of land ownership, is challenging to coordinate among groups with varied interests. Suisun Marsh within the CA Delta faces substantial barriers to cooperative natural resource management because of its unique composition of landowners, which include state and federal entities, but also over 120 private duck clubs that have occupied the space since the early 1900s. We set out to characterize – and attempt to mend or strengthen – inter-individual relationships and communications among private and public landowners to facilitate the management of a rampant invasive species, *Phragmites australis*, which threatens wetland functions that matter to all parties, but in different ways. We observed a gap in literacy about *Phragmites*, leading to limited trust in only one perceived "governmental" body and few opportunities for community-led management. We went on to address how strategic language, use of trusted sources, and specific media types can improve management outcomes. This project was the first commissioned by the state to address the social aspects of natural resource management in a holistic manner alongside ecological outcomes: our findings provide valuable insight for future socioecological work in areas where political stakes are high and potential negative ecological outcomes are even more dire.

Session Two: Connecting Research, Management, and Policy

Knowns, Unknowns, and Assumptions About the Role of Ballast Water in the Introduction of Golden Mussels to California and Potential Secondary Spread

Lina Ceballos Osuna, Senior Environmental Scientist, California State Lands commission, Marine Invasive Species Program

This presentation synthesizes the current state of knowledge, assumptions, and uncertainties regarding the introduction of golden mussel (*Limnoperna fortunei*) into California. We will evaluate the likely role of ballast water from commercial shipping as a primary vector. Additionally, the presentation will include key components of commercial shipping analyses, including : 1) An overview of historical shipping activities into California's low-salinity ports from regions with known golden mussel populations, with consideration of both ballast water and biofouling risks, and 2) an evaluation of the potential for secondary spread along the U.S. Pacific coastline, and other U.S locations like the Gulf and East Coast.

Hull Fouling as a Mechanism for the Introduction and Spread of the Invasive Golden Mussel, Limnoperna fortunei, in North America Cutting Green Tape for Invasive Species Control Projects in the Delta and Beyond

Tessa Beaver, Biological Technician, Smithsonian Environmental Research Center

Co-author: Gregory Ziegler PhD, Smithsonian Environmental Research Center

The golden mussel, *Limnoperna fortunei*, is a freshwater bivalve native to China that has had negative and costly impacts as an invasive species throughout Southeast Asia and South America. *Limnoperna* was identified for the first time in North America in 2024 in the Port of Stockton, CA. The mussels have since been found in many other locations within the Sacramento-San Joaquin Delta and further south as far as Lake Palmdale in LA County. The source of initial introduction into California is unknown but is likely associated with commercial shipping with introductions related to either ballast water discharge or hull fouling. We explored the potential of hull fouling as the vector of initial California introduction as well as the possibility of further coastwise spread through this mechanism. The closest ports to Stockton with established *Limnoperna* populations are in central Japan. Queries of National Ballast Information Clearinghouse (NBIC) data show a minimum transport time of 255-h for ships making this journey. The closest freshwater port for ship mediated coastwise spread from Stockton is Portland, OR with a minimum 36-h ship transit time. We first established culture procedures for adult *Limnoperna* including optimal water parameters and food resources. Simulated voyage experiments using Pacific Ocean water parameters (i.e. 10 °C, 32 psu) were then conducted with adult *Limnoperna* (avg. length 17.3 mm) sourced from California to determine survival rates for these transit times. No mussels survived the 255-h transit, suggesting that ballast water discharge may be the more likely initial vector. 70 % of the mussels survived the 36-h transit, however, demonstrating potential for coastwise spread via biofouling. The establishment of culture techniques and initial testing of *Limnoperna* serve as a starting point for experiments that will lead to a better understanding of *Limnoperna*, its potential for further spread, and possible management strategies.

Modeling Boater Travel Pathways for Invasive Mussels Using Anonymized Cellular Location Data

Jonas Grundman, National Aquatic Plant Control Program Technical Lead, US Army Corps of Engineers

Recreational boating is a primary pathway for spreading invasive mussels such as quagga, zebra, and golden mussels. Identifying boater travel patterns between infested and uninfested waters is critical for siting watercraft inspection and decontamination stations and for prioritizing prevention resources.

The U.S. Army Corps of Engineers (USACE) is developing models that use anonymized cellular location data to analyze boating-related travel. This information complements traditional survey data while providing the ability to update underlying datasets far more rapidly. As a result, managers could gain timelier insights that could support rapid response actions and help target monitoring for potential new infestations.

In the Sacramento-San Joaquin Delta region, this approach may help anticipate introduction risks from multiple infested sources and inform more efficient allocation of limited prevention and response resources. This talk will outline the modeling methodology, initial findings, and opportunities for California agencies and water managers to engage in refining and applying these tools.

Golden Mussel Mitigation in the State Water Project

Tanya Veldhuizen, Environmental Program Manager, California Department of Water Resources

The golden mussel (*Limnoperna fortunei*) was discovered in the Sacramento-San Joaquin Delta and in O'Neill Forebay, a CVP-SWP joint use facility, in October 2024. By Fall 2025, golden mussels had invaded most of the California Aqueduct distribution system. This invasive species presents a suite of challenges to DWR due to its ability to rapidly reproduce and colonize State Water Project water conveyance infrastructure that delivers water to over 27 million California residents. In response, DWR is developing mitigation plans for SWP pumping and hydropower plants and fish protection facilities. The initial mitigation efforts are focused on protecting critical systems within facilities, specifically cooling water, fire protection water and service water systems, all with small diameter piping that are at risk of occlusion from mussel biofouling. Mitigation measures include increased inspections, physical removal, installation of medium pressure UV disinfection units on critical small diameter piping, and use of limited-scale chemical treatments. Given this is the first occurrence of this species in North America, there is limited knowledge on the effectiveness of known quagga and zebra mussel control methods on golden mussels and in SWP water matrix settings; thus, DWR is researching the efficacy of chlorine, copper and other potential molluscicides, hot water exposure, and other control methods using an on-site laboratory equipped with a raw water flow-through system. The preliminary results indicate that current high-temperature watercraft decontamination guidance is applicable to golden mussel, and continuous low-dose chlorine injection is effective in preventing veliger settlement. Compared to quagga and zebra mussels, higher concentration and exposure duration of copper-based molluscicide are required to achieve mortality, but this may be partially mediated by conducting copper treatments on mussels during post-spawn body condition.

Session Three: Lightning Talks

First Observation and Spread of the Oriental River Prawn (Macrobrachium nipponense), a New Invasive Shrimp in the Sacramento-San Joaquin Delta

Sky Jung, Graduate Student, UC Davis

Co-author: Kathy Hieb, California Department of Fish and Wildlife

Introduced crustaceans both alter and form the basis of food webs in the Delta. While most research has focused on planktonic invaders, relatively little research has been done on the introduction, spread, and impacts of larger taxa, especially the highly visible and ecologically and commercially important decapods. We report the novel occurrence of Oriental River Prawn (*Macrobrachium nipponense*) in the San Francisco Estuary and provide an updated field guide for the common palaemonid shrimps in the upper estuary. First documented in 2020 by the US Bureau of Reclamation in the Clifton Court Forebay*, M. nipponense* has spread largely undetected through the Delta and water conveyance systems until recent years. A combination of public data and citizen science has documented its spread through the Central Valley down to Southern California. Despite its large size, *M. nipponense* has gone largely unnoticed by long-term monitoring projects due to several factors—similarity to other nonnative shrimp, gear selectivity, and lack of monitoring attention on shrimp and large crustaceans in general. *M. nipponense* is readily distinguishable from other palaemonid shrimps in the estuary by the presence of a hepatic spine and absence of a branchiostegal spine. Field identification using gross features such as limb size is unreliable in palaemonid shrimps, particularly between *M. nipponense* and *Palaemon* macrodactylus. The introduction of such a large and rapidly spreading invader poses a significant threat to Delta food webs, as *M. nipponense* is an aggressive predator that consumes both macroinvertebrates and small fish. However, any impacts are scarcely

understood due to the lack of knowledge on the habits and interactions of both *M. nipponense* and palaemonid shrimp generally in the estuary.

Neoeriocheir leptognathus: A New Invasion?

Kenji Soto, Environmental Scientist, California Department of Fish and Wildlife

Co-authors: Sky Jung, UC Davis; Kathy Hieb, California Department of Fish and Wildlife

The history of species introductions into the San Francisco Estuary (SFE) has been extensive and well documented; Cohen and Carlton (1995) reported that a new species invaded the estuary at a rate of one every 36 weeks since 1850. One such invader is the Chinese mitten crab, *Eriocheir sinensis*, which has been seen globally and became established in the SFE in the 1990s (SERC). Two other Western Pacific mitten crabs have been observed in the Eastern Pacific - the E. japonica, reported from one specimen collected in the Columbia River in 1997 (Jensen and Armstrong 2004) and the newly documented *Neoeriocheir leptognathus*, native to the Yellow Sea and collected in San Pablo Bay on February 6, 2025.

Neoeriocheir leptognathus differs from other mitten crabs morphologically and genetically enough to place it in its own genus, however there is some taxonomic controversy (Chu 2003, Guo 1997, Rathburn 1913). Additionally, unlike *E. sinensis* and *E. japonica, N. leptognathus* is not catadromous, so if it were to establish itself in the SFE, it would be restricted to higher salinity regions.
Like many other non-native invertebrates to the SFE, *N. leptognathus* was most likely introduced via ballast water, but there have been attempts to introduce live adult mitten crabs (Cohen 1997). It is unknown if *N. leptognathus* could negatively impact the environment, but *E. sinensis* has been shown to reduce native biodiversity via predation, compete with other native crustaceans, be a vector for parasites, and dig enough burrows to destroy levees (IUCN Global Invasive Species DB). Continued monitoring of the SFE will determine if *N. leptognathus* establishes itself and if its presence will be considered an invasion.

U.S. Army Corps of Engineers AIS Research and Cost-share Programs – Authorities and Opportunities

Jeremy Crossland, National Aquatic Plant Control Program Manager, US Army Corps of Engineers

The U.S. Army Corps of Engineers (USACE) Aquatic Plant Control (APC) Program, established under Section 104(a) of the Rivers and Harbors Act of 1958, was the nation's first federal program addressing aquatic invasive species. The authority provides for "a comprehensive program to provide for prevention, control, and progressive eradication of noxious aquatic plant growths and aquatic invasive species from the navigable waters, tributary streams, connecting channels, and other allied waters of the United States…including continued research for development of the most effective and economic control measures."

The program commonly operates on a cost-shared basis with non-federal sponsors, enabling field management projects, applied research, and technical support. At the same time, certain research and planning activities may be carried out at full federal expense. This structure allows USACE to partner with states, local agencies, and others to address aquatic invasive species challenges through both management and research activities.

Current priorities include advancing early detection and rapid response capabilities, supporting innovative management methods, and integrating aquatic plant control into broader invasive species strategies. In the Sacramento–San Joaquin Delta, the APC Program may provide a potential mechanism

for cost-shared projects, coordinated research, and collaborative management approaches with California partners.

This talk will highlight the APC Program's authorities, partnership framework, and opportunities for collaboration.

Tracking Management of Delta Weeds Using Calflora

Cynthia Powell, Executive Director, Calflora

Calflora aggregates data from thousands of sources; other words for this work are Compile, Assemble, Collate, and Gather. From this aggregated dataset called Calflora, 350 non-native species are currently in Calflora and grow in the Sac River Delta. Of those, 120 are Cal-IPC listed. Alligator weed is of course among them. Using Calflora, we can better track progress (or lack thereof) we are making in managing invasive plants. All data in Calflora also feeds into Cal-IPC's CalWeedMapper.

Operationalizing Sentinel-2 for Sub-Annual Mapping and Management of Invasive Aquatic Vegetation in the Delta

Bailey D. Morrison, Assistant Project Scientist, UC Merced

Co-authors: Shruti Khanna, California Department of Fish and Wildlife; Erin L. Hestir, UC Merced

Since 2004, high resolution (3 m) airborne imaging spectroscopy has been collected near annually over the Sacramento–San Joaquin Delta to map invasive aquatic vegetation (IAV) at the genus and species level, supporting critical management and research needs. While these annual IAV maps are an invaluable resource, routine high resolution imaging spectroscopy is not currently available from space, resulting in temporal gaps that prevent consistent, long term IAV monitoring in the Delta. In collaboration with the Delta Stewardship Council, CA Department of Water Resources, CA Department of Fish and Wildlife, and the CA Interagency Ecological Program, we are working to fill this critical data gap in monitoring by implementing the first sustainable mapping effort for IAV using orbital remote sensing. Using Sentinel2 (S2) satellite imagery, we are operationalizing sub-annual community level IAV maps at 10 m resolution, with preliminary classification models achieving accuracies comparable to the airborne products and offering new opportunities to inform modeling and management of vegetation dynamics. To ensure the maps serve as an effective management tool, we have begun developing an interactive mapper and will work with project end users and stakeholders to codesign features that enhance multiagency decision making and support progress toward the Delta's coequal goals. Alongside the S2 mapping effort, we will develop species distribution models, forecasting tools, and performance metrics to evaluate management actions, anticipate future spread, and guide adaptive strategies. This effort will strengthen our ability to anticipate and respond to changing IAV infestations, enabling more proactive and informed management in the Delta's dynamic environment.

Nutria Eradication Progress in California, from 2017 to the present

Jessica Vollmer, Senior Environmental Scientist, California Department of Fish and Wildlife Nutria Eradication Program

Following the 2017 discovery of a pregnant female nutria (*Myocastor coypus*) in Merced County, the California Department of Fish and Wildlife (CDFW) established the Nutria Eradication Program (NEP) to eradicate nutria from the state for the prevention of significant environmental, agricultural, and economic impacts in the Sacramento-San Joaquin River Delta and San Joaquin Valley. This talk will focus on the efforts of the NEP, reviewing the progress toward eradication in the eight years since the

initial detection, specifically focusing on the years 2023-present. As of August 2025, CDFW has conducted surveys on over a half a million acres throughout the two-million-acre project area, which spans the San Joaquin Valley and Delta regions of California, stretching from Suisun Marsh to Kings County. To date, the NEP has removed 6,582 nutria from the landscape, with 2024 having the highest number of captured nutria to date and 2025 on track to capture even more. We will describe recent changes in distribution as nutria have recently been detected in multiple locations in the Delta, and farther south than previously known. Methods critical for the early detection of nutria include dedicated field staff to conduct surveys, a robust network of monitoring stations, and targeted means of detecting small and/or localized metapopulations. We will explore the progress of the nutria eradication effort in California, including the recent deployment of Judas nutria and scat-detector dogs. To help tell that story, we will review trends across years for survey and trapping efforts, numbers taken and average densities among infested sites, land access, and progression of infested sites through the 5-phases of the eradication strategy.

Protecting Infrastructure from Golden Mussel

David Hammond, Senior Scientist, Earth Sciences Labs, Inc.

Discovery of the golden mussel (*Limnoperna*) in the Sacramento River Delta in fall of 2024 forces a wide variety of water managers to consider how they will protect their infrastructure from biofouling. A wide variety of facilities will be affected, including drinking water treatment, water conveyers and sellers, power generators, irrigation districts, and agricultural end users. One of the only products currently labeled and approved for control of golden mussel in California is a liquid ionic copper formulation called EarthTec QZ. Several utilities and ag users in the Delta and Central Valley are now applying this ionic copper product into their source waters to protect against *Limnoperna* and other pests, and therefore have hands-on practical experience that will prove helpful to people still trying to evaluate their options and decide what to do. Up-to-date information will be shared about dose rates, efficacy, and expectations.

USFWS Pacific Southwest Aquatic Invasive Species Horizon Scan

Jenny Ketterlin, Invasive Species Coordinator, US Fish and Wildlife Service

Horizon scanning is a systematic approach to identifying risk of introduction and harm of potential invasive species not yet established within a region. The U.S. Fish and Wildlife Service (USFWS) recognizes horizon scanning and the resulting species watch lists as the foundation of proactive aquatic invasive species management because they help direct limited resources towards species most likely to cause harm, improving the efficiency and effectiveness of prevention and early detection activities. Horizon scanning and watch lists are also foundational to the implementation of a National Early Detection and Rapid Response Framework by the U.S. Department of the Interior. From October 2021 through November 2021, USFWS gathered 19 Federal, Regional, State, and University partners to provide input on exact geography and priority introduction pathways and taxa groups on which to focus a regional horizon scan for the Pacific Southwest Region. Based on the input of the regional expert group, the scope of this initial Pacific Southwest horizon scan focused on identifying freshwater or estuarine mollusks, fish, and plants that are likely to be transported as contaminants adhered to recreational watercraft, hitchhikers in live trade shipments, or spread through hydrologic connections. Risk screening was conducted for a prioritized subset of the species list generated in the previous phase using the USFWS' Ecological Risk Screening Summary tool. Three mollusk species, two fish species, and one species of plant were identified as posing high risk to the Pacific Southwest based on both climate match and prior history of invasiveness in other locations: silver carp (*Hypophthalmichthys molitrix*), bighead carp (*H. nobilis*), Mexican primrose-willow (*Ludwigia*

octovalvis), giant ramshorn snail (*Marisa cornuarietis*), common river snail (*Viviparus viviparus*), and the false mussel (*Mytilopsis adamsi*). These horizon scanning results can be used to inform regulatory decision-making, improve training resources, and refine detection tools and strategies on a local, regional, and national level.

Session Four: New Tools and New Conditions

Rapid spread of invasive alligator weed in changing Delta-Suisun wetlands: Functional traits support multiple strategies to persist under increasing salinity stress

Brenda J. Grewell, Research Associate, Department of Plant Sciences and Center for Plant Diversity, UC Davis

Accelerating increases in sea level rise and frequency and severity of bioclimatic drought in Mediterranean-climate watersheds drives seawater intrusion further into estuaries. Increasing stress gradients can alter the invasibility and biological diversity of tidal wetlands, depending on salinity tolerance of the invading species. Alligator weed (*Alternanthera philoxeroides*; Amaranthaceae), long recognized as one of the world's worst freshwater aquatic weeds, recently invaded tidal wetlands in the inland Delta and brackish Suisun Marsh reaches of San Francisco Estuary. Though widely considered to be freshwater-limited, observations suggested the invading haplotype may have some degree of salinity tolerance though its capacity to spread with increasing salinity were unknown. In a field study following initial detection, we monitored the weed's rapid spread and distribution in Suisun Marsh for 6 years. Overall, numbers of occupied patches in our study area increased by 99% though the increased spread was nonlinear relative to the salinity gradient. In two full-factorial greenhouse experiments, we assessed functional trait responses of two growth forms (emergent (soil-rooted); free-floating) to four salinity concentrations (freshwater to euhaline) at the whole-plant, physiological, and biochemical levels. Although sensitivity of alligator weed to increasing salinity was documented, survival of both growth forms in the full range of salinity treatments was notable and unexpected. Next, we explored the recovery potential of free-floating ramets in freshwater following extended exposure in meso- to euhaline aqueous salinity. Our results indicate alligator weed is a facultative halophyte well-adapted to oligohaline–mesohaline salinity levels. The macrophyte expressed mechanistic trait responses underlying stress tolerance, avoidance, and escape strategies to counter physiological stress with increasing seawater intrusion. Results support better understanding of potential range expansion to improve risk assessments with changing seawater intrusion, predictive models of the weed's growth relative to dynamic climate drivers, and spatial prioritization of weed management efforts.

Drought and aquatic vegetation alter water clarity and fish assemblages in freshwater tidal sloughs of the north Delta

Adrianne Smits, PhD, Research Scientist, Department of Environmental Science & Policy, UC Davis

Co-authors: John Durand, PhD, Center for Watershed Sciences, UC, Davis; Brian Williamshen, PhD, Center for Watershed Sciences, UC Davis; Kim Luke, MS, Delta Stewardship Council; Teejay O'Rear, MS, Center for Watershed Sciences, UC Davis

Tidal freshwater habitats in the Sacramento-San Joaquin River Delta (Delta) face multiple environmental stressors, including declining turbidity and invasion by submersed aquatic vegetation (SAV). We used a decade of monitoring data (2013 – 2023) in two tidal slough networks in the north Delta to (1) estimate trends in SAV, water clarity (Secchi depth), and abundance of pelagic, littoral, and benthic fish species; (2) identify the role of droughts and SAV expansion on water-clarity dynamics; and (3) quantify relationships between changing habitat conditions and fish assemblages. Two multi-year

droughts, concurrent with rapid expansion of invasive SAV, triggered a regime shift from turbid to clear conditions in tidal freshwater sloughs of the north Delta. Water clarity decreased with local precipitation (e.g., sediment loading) and increased with SAV. Abundance of non-native littoral fishes increased with higher SAV, whereas SAV was negatively associated with abundance of non-native pelagic and benthic species and with a native littoral species. Relationships between water clarity and fish abundances were more complex. Abundances of some native fishes increased following a sudden decline in SAV (2021-2022) combined with a decline in water clarity during a record wet year (2023). Dynamic responses of fish assemblages to SAV and water clarity in the north Delta demonstrate the importance of hydroclimatic variation in mediating the effects of invasive SAV on tidal freshwater ecosystems.

Using eDNA/eRNA as complementary tools for invasive species monitoring

Sarah Brown, Unit Manager for Collaborative Ecological Studies, California Department of Water Resources
Aviva Fiske, Environmental Scientist, California Department of Water Resources
Emily Funk, Lab Manager, Genomic Variation Lab, UC Davis

Co-authors: Sarah Stinson, California Department of Water Resources; Andrea Schreier, UC Davis; Melinda Baerwald, California Department of Water Resources

Environmental DNA (eDNA) is DNA shed by an organism that can be captured by collecting environmental samples including water, soil and air. Though eDNA is often present at low concentrations, advances in genetic techniques (e.g. SHERLOCK, qPCR, metabarcoding, etc.) have made it possible to detect minute amounts of DNA in the environment. The ability to detect low concentration DNA is what makes eDNA tools ideal for early detection of invasive species when population numbers are still low. Early detection of invasive species is key for effective management and eradication.

Alongside eDNA, environmental RNA (eRNA) can be used to improve the spatial and temporal accuracy of eDNA detections. Because eRNA degrades faster than eDNA, it has a decreased chance of being transported away from the organism shedding its DNA. Additionally, eRNA can only be shed by living organisms, whereas eDNA can be shed by both living and dead organisms. Thus, eRNA has the ability to confirm the presence of a living organism.

Here, we discuss three projects developing and utilizing eDNA/eRNA tools for invasive species monitoring. 1) Development of a CRISPR-based SHERLOCK assay to detect nutria using eDNA and eRNA. 2) Using eDNA to determine the range/invasion front of the golden mussel in California. 3) Development of the SENTRI program, an invasive species eDNA surveillance monitoring program in the Delta.

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