Species Composition and Contribution of Marine Invasive Species to Fouling Communities of San Francisco Bay

Lina Ceballos-Osuna, Smithsonian Environmental Research Center, ceballosl@si.edu
Michelle Marraffini, Smithsonian Environmental Research Center, marraffinim@si.edu
Linda McCann, Smithsonian Environmental Research Center, mccannl@si.edu
Andrew L. Chang, Smithsonian Environmental Research Center, changal@si.edu
Gregory M. Ruiz, Smithsonian Environmental Research Center, ruizg@si.edu

The overall objective of this project is to determine the extent, patterns and effects of marine species invasions on the California Coast. Estimating the relative contribution of non-indigenous species (NIS) to site- and bay-level diversity will help us to understand NIS effects on communities. To assess diversity in fouling communities, we conducted standardized field surveys to measure patterns of invasion across sites and bays. After ~15 years of repeated surveys of sites throughout San Francisco Bay, we have compiled a comprehensive list of fouling species in the bay and their distribution in relation to environmental parameters. Here, we present a subset of data from 2012 showing the diversity patterns of mobile organisms associated with the sessile community. The species composition of the sites varies based on distance from the mouth of the bay, with less diversity and richness at lower salinities far from the Golden Gate. The importance of NIS to overall diversity levels is clearly demonstrated by the mobile organisms associated with the sessile species.

Keywords: Invasive species, *Peracarida*, fouling communities, NIS, San Francisco Bay

Poster Topic: Invasive Species

Predation of Juvenile Salmon in the Tuolumne River

Jason Guignard, FISHBIO, jasonguignard@fishbio.com
Matt Peterson, FISHBIO, mattpeterson@fishbio.com

The presence of several non-native species in the Tuolumne River known to prey on juvenile salmonids has long been of concern. Repeated, intentional introductions of striped bass, smallmouth bass, and largemouth bass to the Sacramento-San Joaquin drainage occurred during the past century. Despite mounting evidence that predation by non-native species appears to be a significant source of mortality of juvenile Chinook salmon in the San Joaquin Basin and Delta, and that reduced juvenile survival due to predation is a key factor restricting the success of efforts to increase salmon survival, few studies have been conducted to directly quantify predation risk.

During 2012, a drier water year, a study was conducted on the Tuolumne River to estimate predator abundance and predation rates. In a 25-mile reach between two rotary screw trap monitoring locations where juvenile salmon abundance was estimated, the lower 95 percent confidence bounds for species abundance determined by depletion electrofishing expanded for shoreline length were 2,406 largemouth bass, 2,476 smallmouth bass, 99 striped bass, and 50 Sacramento pikeminnow during summer. Species-specific predation rates averaged for all run-pools and special run pools sampled during March and May were 0.07 juvenile salmon per predator per day for largemouth bass, 0.09 for smallmouth bass, 0.68 for striped bass, and 0.0 for Sacramento pikeminnow.

Total potential consumption of juvenile salmon was estimated to be about 42,000 individuals during March 1-May 31, 2012, with about 15% of potential consumption attributed to striped bass, 49% to smallmouth bass, and 37% to largemouth bass. This study provides the first direct assessment of potential predation impacts to juvenile salmon in the Tuolumne River and findings indicate that predation by introduced predators appears to be a significant source of mortality in at least some years.

Keywords: Predation, Chinook salmon, Tuolumne River

Poster Topic: Invasive Species

Mapping the Marsh with Unmanned Aerial Systems

Jared Lewis, Solano Land Trust and SF NERR, Jared@solanolandtrust.org
Steve Kohlmann, Solano Land Trust, steve@solanolandtrust.org

Change detection in estuarine systems is notoriously difficult to assess. Complex vegetation assemblages, unique geomorphic features, and hydrologic processes confound monitoring activities. Further difficulties arise in sites with sensitive biological resources and where regulatory constraints and narrow monitoring windows create additional challenges for land managers, researchers, and others who rely on timely and accurate data. Recent innovations in remote sensing, UAV, and GIS, technologies provide tremendous opportunities to overcome the limitations of traditional monitoring approaches, and more importantly opportunities to maximize the efficiency and effectiveness of monitoring at the landscape scale.

The Solano Land Trust in partnership with the SF Bay National Estuarine Research Reserve (SF NERR) has recently began work on a remote sensing methodology intended to support the long term vegetation monitoring requirements on more than 12,000 acres including one of the largest intact tidal brackish marsh systems in the U.S., Rush Ranch. This program seeks to develop a standardized, repeatable methodology for annual and long term vegetation monitoring that is broadly applicable across ecological gradients, including the estuarine component of the lands managed by each respective organization. The methodology adapts current GIS and remote sensing methodologies and integrates innovative research and technologies developed within the past decade.

We are reporting on our first experiences using an unmanned aerial system (aka “drone”) equipped with near-infrared and color imagery sensors to map invasive weed species and impacts of feral swine in a remnant tidal marsh and adjacent uplands at Rush Ranch in Suisun Bay. We evaluated the system’s ability to detect and map various weed species and swine rootings using high resolution imagery (2-3 cm); we also report on our successes in developing an image classification for several common invasive species. We discuss the use of low-cost unmanned aerial systems for landscape-scale mapping and monitoring.

Keywords: invasive species, aerial imagery, unmanned aerial systems

Poster Topic: Invasive Species

Identifying Emerging Invasive Plants for Early Eradication on the San Mateo County Coast

Dana Morawitz, California Invasive Plant Council, dfmorawitz@cal-ipc.org
Elizabeth Brusati, California Invasive Plant Council, edbrusati@cal-ipc.org
Doug Johnson, California Invasive Plant Council, dwjohnson@cal-ipc.org

Identifying and removing new invasive plants before they become widespread is a cost-effective strategy that prevents ecological impacts. As in most areas, invasive plant management on the San Mateo County coast has mostly focused on high-profile species, including Cape-ivy, European beach grass, pampasgrass, Hardinggrass, and Canary Island St. Johnswort. Working on less well-established invasive plants, for which eradication remains feasible, has been promoted by Cal-IPC and the Bay Area Early Detection Network (BAEDN). In previous years BAEDN had identified several isolated populations of known weeds in the region as strategic targets. As a next step, Cal-IPC and the region's land managers wanted to better understand the potential future threat from emerging weeds. With support from the US Fish & Wildlife Service's Coastal Program, Cal-IPC analyzed non-native plant species already naturalized in the region to determine which presented the highest risk of causing environmental harm in the future. The project used three complementary tools: the Calflora database to determine non-native plants that were not widespread in the region; expert interviews to check on distribution and perceived risk; and the Plant Risk Evaluation (PRE) criteria system from UC Davis to predict risk based on life history factors. Using these tools, we identified 9 species as potential early-eradication targets and 11 species as surveillance targets. Local partners, including the San Mateo County Resource Conservation District (RCD), will collect additional information on distribution of each species, and public landowners will undertake control efforts to learn about the efficacy of different approaches. This process could be adapted to other counties around the San Francisco Bay and Estuary to prioritize future efforts on invasive plants.

Keywords: invasive species, restoration, early detection, land management

Poster Topic: Invasive Species

Mapping and Prioritizing the Invasive Plant *Arundo donax* for Eradication in the Legal Delta

Bryan Sesser, Sonoma Ecology Center, bryan@sonomaecologycenter.org
Alex Young, Sonoma Ecology Center, alex@sonomaecologycenter.org
Mark Newhouser, Sonoma Ecology Center, mark@sonomaecologycenter.org

The invasive plant *Arundo donax* has become widespread in California. In Southern California some riparian habitat has been reduced to monotypic stands, devastating native species locally. Eradication has been extensive and costly. In Northern California, *Arundo* infestations are less widespread. However eradication efforts began later and primarily have been occurring piecemeal as individual organizations fight local infestations.

The Sacramento-San Joaquin Delta Conservancy and the California Department of Water Resources have begun an initiative to eradicate *Arundo* within the Legal Delta. For Phase 1 of this project, the Sonoma Ecology Center has been contracted to complete the mapping of *Arundo*, and prioritizing it for eradication. Additionally, within the Cache Slough Complex, Sonoma Ecology Center will eradicate *Arundo* and perform native plant restoration as a pilot project. A series of eradication and restoration projects will follow in coming years.

High quality mapping was achieved through the following methods: imagery analysis by trained technicians was followed by a series of ground and boat truthing sweeps throughout the Legal Delta. Innovative technology was deployed enabling restoration teams to complete validation of 52% of mapped infestations in minimal field time.

Prioritization was achieved through utilization of the Indexed Multispecies Conservation Value (IMCV) metric and other ground condition factors. A multi-organizational group of biologists contributed expertize to the selection of key species on which to base prioritization and the development of habitat suitability rankings for these species. VegCamp map of the Legal Delta was source map. The habitat suitability rankings, weighted by endangered/threatened status form the core of the IMCV metric. Numerous other ground condition factors can be combined with the IMCV to develop ranked prioritization of all *Arundo*.

Eradication and restoration will begin in the Cache Slough Complex in the summer of 2015.

Keywords: Legal Delta, Invasive *Arundo*, Mapping, Prioritization, Threatened Species

Poster Topic: Invasive Species

The USDA-ARS Areawide Pest Management Project for Integrated Management of Water Hyacinth, Brazilian Waterweed, *Arundo* and Associated Pests in the Sacramento-San Joaquin Delta

Patrick Moran, USDA-Agricultural Research Service (ARS), Exotic and Invasive Weeds Research Unit (EIWRU), Patrick.Moran@ars.usda.gov
John Madsen, USDA-ARS EIWRU, John.Madsen@ars.usda.gov
Paul Pratt, USDA-ARS EIWRU, Paul.Pratt@ars.usda.gov
David Bubenheim, NASA-Ames Research Center, David.L.Bubenheim@nasa.gov
Chris Potter, NASA-Ames Research Center, Chris.Potter@nasa.gov
Edward Hard, Div. of Boating & Waterways, CA Dept. of Parks & Recreation, Edward.Hard@parks.ca.gov
Karen Jetter, UC Davis, Agricultural Issues Center, jetter@primal.ucdavis.edu
Michael Parrella, UC Davis, Department of Entomology and Nematology, mpparrella@ucdavis.edu
Sharon Lawler, UC Davis, Department of Entomology and Nematology, splawler@ucdavis.edu
Christian Nansen, UC Davis, Department of Entomology and Nematology, chrnansen@ucdavis.edu
Joseph DiTomaso, UC Davis, Department of Plant Sciences, jmditomaso@ucdavis.edu

Water resources flowing into the 28,000 ha- Sacramento-San Joaquin Delta support $25 billion in irrigated agriculture and drinking water for 25 million people statewide, and also support ecosystem health throughout the San Francisco Estuary. Floating water hyacinth (*Eichhornia crassipes*), submersed Brazilian waterweed (*Egeria densa*), and giant reed or *Arundo* (*Arundo donax*), an emergent riparian grass, each occupy several thousand ha in the Delta, wasting water and hindering its use, obstructing recreational and commercial navigation, and reducing environmental quality by displacing native plant species, harboring disease-vectoring mosquitos, and (in the case of *Arundo*) spreading fires and increasing erosion. A USDA-ARS-funded Areawide Pest Management Program has been initiated to develop and implement integrated assessment and decision-support tools to improve Delta-wide management of aquatic invasive plants using chemical, mechanical, physical, cultural, and biological methods. Satellite- and aerial-based remote sensing tools and analyses of water quality and flow data are being used to prioritize water hyacinth infestations, leading to improved early-season control. Information on aquatic plant growth and responses to existing and new herbicides is being used to optimize the timing of chemical and mechanical control. Three new insect agents are being released for biocontrol of water hyacinth and *Arundo*. Coordinated aquatic plant-mosquito control operations are being implemented to reduce the ability of live and decaying weeds to support mosquito outbreaks in areas where human health is most at risk. Cascading effects of the control programs on aquatic food webs are being monitored. Site selection for restoration of native aquatic plants is being initiated. The economic impacts of aquatic weeds in the Delta, and the benefits of the Areawide aquatic plant control approach, are being modeled to predict and document project impact. By integrating research with aquatic plant management operations, this project is expected to help protect scarce water resources in the Delta.

Keywords: Invasive aquatic vegetation, Herbicide, Navigation, Biological control

Poster Topic: Invasive Species

Invasion Trends in San Francisco Estuary Sessile Invertebrate Communities over Fifteen Years (2000 to 2014)

Andrew Chang, Smithsonian Environmental Research Center, ChangAL@si.edu
Gail Ashton, Smithsonian Environmental Research Center, ashtong@si.edu
Lina Ceballos, Smithsonian Environmental Research Center, CeballosL@si.edu
Stephen Foss, California Department of Fish and Wildlife, Steve.Foss@wildlife.ca.gov
Stacey Havard, Smithsonian Environmental Research Center, HavardS@si.edu
Kristen Larson, Smithsonian Environmental Research Center, LarsonK@si.edu
Michelle Marraffini, Smithsonian Environmental Research Center, MarraffiniM@si.edu
Linda McCann, Smithsonian Environmental Research Center, McCannL@si.edu
Michele Repetto, Smithsonian Environmental Research Center, RepettoM@si.edu
Sharon Shiba, California Department of Fish and Wildlife, sharon.shiba@wildlife.ca.gov
Brian Steves, Smithsonian Environmental Research Center, StevesB@si.edu
Gregory Ruiz, Smithsonian Environmental Research Center, RuizG@si.edu

Invasions by non-native species are well-known drivers of significant ecological change worldwide. Despite considerable available information on marine invasions in California, and particularly the San Francisco Bay region, it remains challenging to detect new invasions and estimate actual changes in invasion patterns, such as rate and spread. These data are key to understanding invasion processes and informing management and policy aimed at prevention of new invasions and responses to existing invasions. We addressed this issue for hard substrate-dwelling sessile invertebrate communities, which make up a significant portion of invasions worldwide, by conducting repeated, standardized surveys of fouling communities throughout the San Francisco Estuary over a fifteen-year period spanning a wide range of environmental conditions.

We characterized communities using settlement panel surveys at sites throughout the estuary, from Antioch to the Golden Gate to the Dumbarton railroad bridge in the South Bay, from 2000 to 2014. These years spanned recent dry and wet extremes, including two major droughts and several wetter winters.

Non-native species were prevalent throughout the estuary, but achieved greater dominance following dry winters. Community composition at any given site during the summer period (May to October) was predicted by environmental conditions, especially the previous winter's precipitation, which is linked to salinity levels. Rarefaction analyses and richness estimators indicate that the number of species detected varied both as a function of the number of sites sampled in a given year and with environmental conditions, suggesting that standardized sampling across a broad range of conditions over time is needed. For years in which at least ten were sampled, an asymptote in estimated richness was reached, indicating statistically sufficient sampling to estimate the true richness of the community. This large set of data allows us to better understand the influence of physical characteristics on invasion patterns in the San Francisco Estuary.

Keywords: invasions, non-native species, sessile invertebrates, fouling, salinity

Poster Topic: Invasive Species