ELKHORN SLOUGH SCIENCE SYMPOSIUM

Moss Landing Marine Laboratories
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ABSTRACTS (alphabetical by first author's last name; if multiple authors, presenter(s) denoted by *; first author's email contact)

AN ECO-ARCHAEOLOGICAL STUDY OF ELKHORN SLOUGH

Alec Apodaca

People have interacted with natural resources in Elkhorn Slough for millennia. In recent years, archaeologists on the Central California Coast have been rethinking the extent and scale of indigenous resource management among hunter-gatherer societies during the Late Holocene. This research has shown that people practiced prescribed burning for centuries to expand ecological niches for economically important plants used for food, raw materials, and medicine. This presentation reviews prior archaeological research in Elkhorn Slough, introduces a current eco-archaeological research program that attempts to model indigenous management, and covers preliminary findings from June 2019 survey work. This research is especially relevant for the possibility of restoring traditional resource management and indigenous stewardship practices in Elkhorn Slough.

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CARBON SEQUESTRATION IN WETLANDS: AN INTERPLAY BETWEEN BURIAL AND EXPORT

Ariane Arias Ortiz[1,2]*, Dennis Baldocchi[1,] Adina Paytan[2]

The role of wetlands in mitigating the effects of climate change depends on the efficiency with which organic carbon (C) is incorporated into soils, versus exported to coastal waters and/or offset by methane (CH_4) emissions. The net rate of C accumulation or loss from an ecosystem conforms the net ecosystem carbon balance (NECB), which depends on a wide range of wetland parameters such as elevation, vegetation, inundation, salinity, tidal influence, soil accretion and/or wetland age. We plan to build the NECB for diked and non-diked wetlands in Elkhorn Slough to assess which wetland type maximizes C sequestration and minimizes greenhouse gas emissions (GHG). Soil cores will be collected along with surface water samples to measure century-scale C burial rates and dissolved C fluxes, respectively. Chambers will be installed to measure CH_4 and CO_2 emissions. These results will allow to compare C sequestration in soils to the aquatic C flux and GHG emissions.

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THE EFFECT OF AN ECOSYSTEM ENGINEER ON ELKHORN SLOUGH SALT MARSHES

Kathryn M. Beheshti[1]*, Kerstin Wasson[1,2], Christine Angelini[3], Brian R. Silliman[4], Brent B. Hughes[5]

Our long-term field experiment explored the effect of native shore crab, *Pachygrapsus crassipes* on salt marsh health and resilience. This ecosystem engineer constructs extensive burrow networks that blanket the marsh plain. The consequences of this bioturbation are a significant negative effect on belowground marsh biomass due to the loss of sediment attributed to burrowing. We also detected a significant negative effect of crab biomass on aboveground marsh biomass suggesting that present crab activity, be it grazing or burrow maintenance has a negative effect on aboveground production.

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ECOSYSTEM MULTIFUNCTIONALITY ENHANCED WITH SEAGRASS RESTORATION SUCCESS

Kathryn M. Beheshti[1]*, Kerstin Wasson[1,2], Kathy Boyer[3], Annakate Clemons[1], Brent Hughes[4]

In the mid 1900s, Elkhorn Slough suffered massive seagrass loss followed by a period of recovery beginning in 1980. In 2015, seagrass cover was at a 10-hectare deficit of its historical extent. We conducted three small-scale experimental restorations in 2015, 2016 and 2018 that explored how various ecosystem functions are affected by restoration and under what conditions is restoration success most likely. Our results show that restoration can

significantly enhance local biodiversity and improve water quality relative to adjacent mudflat and community composition of critical mesograzers in restored plots mirror that of existing natural beds within one year post-transplanting. We also show that algal cover, timing of transplanting, and initial plot size influence the likelihood of plot survival over time.

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COMBINING A NEW MARINE EDUCATION PROGRAM WITH ONGOING RESEARCH IN ELKHORN SLOUGH

Caroline Casey

Offered through the California Ocean Alliance, the Marine Mammal Scientist in Training Program (MMST) is an intensive and engaging one-week hands-on course offered throughout the summer to high school students. Taught by scientists, the goal of this class is to provide individuals with the opportunity to learn about marine mammal natural history and scientific field techniques through multisensory learning methods. The Elkhorn slough has been central to this course, as students are trained to collect sightings and spatial information on marine mammals throughout this environment to determine which habitat features influence animal distribution. While our goal is to give students skills that have real-world applications for careers in natural sciences, we are excited to use this course to aid local researchers currently working the Elkhorn Slough ecosystem. We hope to establish partnerships that support existing research programs, which in turn may aid in the continued conservation of this critical habitat.

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TESTING FOR WATER AND SEDIMENT CONTAMINATION IN THE MONTEREY PENINSULA AND SALINAS WATERSHEDS FOR SELECT PERSISTENT ORGANIC POLLUTANTS

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Triclosan, a broad spectrum antibacterial, and pyrethrin insecticides are both known to be highly toxic to freshwater aquatic life. These chemicals enter the environment through wastewater and agricultural runoff from the highly productive Salinas Valley. The goal of this study was to determine if there were detectable amounts of triclosan and bifenthrin at various points along the Salinas River, in Elkhorn Slough Marine Estuary and in samples of influent and effluent wastewater. It was anticipated there would be higher pyrethroid levels found in the environmental samples compared to wastewater samples. The results showed that a Salinas River site and an Elkhorn Slough site, had one ppb pyrethroids present. While this is a very low amount it could potentially be enough to harm certain aquatic species. It was concluded that these locations may have had detectable pyrethroid levels due to the physical characteristics of the locations.

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DIEL AND SEASONAL CYCLES OF COASTAL ACIDIFICATION AND CARBONATE CHEMISTRY AT ELKHORN SLOUGH

Lena Champlin*, Elizabeth Watson

Many coastal zones are experiencing enhanced rates of ocean acidification. In these areas, increasing anthropogenic carbon dioxide drives acidification, but also terrestrial runoff exacerbates pH dynamics through eutrophication. Also, coastal upwelling of ocean currents can create zones of intensified acidification. At Elkhorn Slough, pH variability is likely impacted by both eutrophication and upwelling. Acidification is especially harmful to mollusks with calcium carbonate shells. At Elkhorn, the shells of gastropod *Batillaria attramentaria* are eroding and perhaps low pH is trigging dissolution. This study examined temporal and spatial variability of water chemistry and its impacts on *Batillaria*. Six sites were studied along a gradient of marine to terrestrial influence. Water parameters were measured daily and seasonally to model carbonate chemistry. Results indicate that acidification depends on diel, seasonal, and tidal cycles. It is hypothesized that partially restricted areas have the greatest acidification threat because both eutrophication and marine currents influence pH variability.

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QUANTIFYING DISCHARGE OF NUTRIENT-CONTAINING GROUNDWATER INTO MORO COJO SLOUGH

Jacquie Chisholm[1]*, Kimberly A. Null[1], Ross Clark[2], Thomas Connolly[1]

Moro Cojo Slough is a water-quality impaired estuary within an agriculturally-dominated watershed of Moss Landing, California. In this region, shallow groundwater and irrigation water mix in agricultural field drains that flow directly to the estuary channel. This study aimed to quantify groundwater influence from agricultural drainage systems, identify groundwater as a source of nutrients, and highlight seasonal variability of groundwater discharge. Over a 15-month period, Radon-222 activity and stable isotopes in nitrate were used to quantify groundwater flux and nitrate sources in drainage systems, respectively. Groundwater-derived nitrate was determined as a dominant nitrate source based on a multivariate statistical mixing model. Nitrogen and oxygen isotope signatures suggest heterogeneity of groundwater discharge across the watershed and confirm that groundwater nutrients influence drainage systems. This study identifies groundwater as a nonpoint source of nutrients to coastal water bodies and further implies the importance of considering groundwater quality in environmental mitigation strategies.

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SEA OTTER FORAGING IN PROXIMITY TO SEAGRASS RESTORATION SITES

Annakate Clemons*, Kathryn Beheshti

As keystone predators, sea otters have the potential to regulate the communities in which they live. To explore correlations between sea otter activity and seagrass restoration success, plot expansion, or community complexity, we observed sea otters on kayak and tracked their activity and proximity to restoration plots. If otters are using our restored plots to forage, there could be cascading effects on the plots themselves. We standardized observation times by location to ensure equal sampling efforts across space and time. We found that sea otter use changes with increasing distance from the mouth of the estuary. Fewer individuals were present with increasing distance from the mouth. There is a correlation between sea otter density and seagrass restoration success. Therefore, sea otters may influence the success and expansion of newly transplanted seagrass restoration plots.

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NATIVE CRAB PREDATION MAY BE CONTRIBUTING TO DECLINING INVASIVE SNAIL POPULATION

Mason Emery[1]*, Kathryn Beheshti[2], Kerstin Wasson[2,3]

The rise and fall of invasive species, referred to as "Boom-bust dynamics" have been relatively understudied in their causes. In Elkhorn Slough a long-established invasive snail species, *Batillaria attramentaria*, had grown to be the most abundant epibenthic macrofaunal species potentially caused by the lack of predation from native species. However, in recent years these snails have been observed to be declining dramatically. Crab feeding trials were conducted in order to determine whether predation by native crab species, *Pachygrapsus crassipes* may have contributed toward this marked decline. Feeding trials were conducted in May and October of 2018 where we tested the effect of crab and snail size, snail shell condition and the presence of alternative food sources on crab predation. Predation rates varied across trials, showing greater predation by larger crabs, higher preference for alternatives, and no difference despite shell condition. Overall both trials provided evidence of crab predation on *Batillaria*.

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UNMANNED AERIAL SYSTEMS (UAS) AS A TOOL FOR WETLAND RESTORATION: PLANNING, MONITORING, AND DECISION-MAKING

Charlie Endris[1]*, John Haskins[2], Alex Lapides[2], Ivano Aiello[1]

In recent years, unmanned aerial systems (also referred to as "UAVs" or "drones") have become increasingly popular for scientific research due to their low cost, ease of use, and high resolution and accuracy. At Elkhorn Slough National Estuarine Research Reserve, researchers have been using UAS to document landscape change at a newly restored salt marsh. The Hester Marsh Restoration site has become an ideal testing ground for exploring the capabilities of UAS products, including high-resolution orthomosaics and Structure from Motion

photogrammetry. Here we focus on UAS data products that help to inform our restoration targets, including digital surface models that are accurate to 3 cm, and semi-automated classification results of newly colonized marsh.

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SUCCESSFUL ESTABLISHMENT OF AN EXTENSIVE BREEDING POPULATION OF A MARINE PULMONATE SNAIL FAR POLEWARD OF ITS PREVIOUSLY DOCUMENTED RANGE

Susanne Fork[1]*, Bruno Pernet[2], Kerstin Wasson[1,3]

The salt marsh snail, *Melampus olivaceus* (Carpenter, 1857) found from southern California to Mazatlan, Mexico, was observed in Elkhorn Slough for the first time in 2013, over 500 km north of its known published range. This marine pulmonate species has an established, reproducing population in the estuary that is abundant and widespread. The northward range extension of this species may be the result of larval transport beyond its range during El Niño events, as is seen for an increasing number of marine species with pelagic larvae.

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SCIENCE-BASED TIDAL WETLAND RESTORATION IN ELKHORN SLOUGH

Monique Fountain[1]*, Dave Feliz[2], Rikke Jeppesen[1], Mark Silberstein[3], Kerstin Wasson[1], Andrea Woolfolk[1]

Over the past 150 years, human actions have altered the tidal, freshwater, and sediment processes that are essential to support healthy ecosystems at Elkhorn Slough. Large areas of tidal marshes were diked and drained in the 20th century. This caused subsidence and when dikes failed, the areas were too low to support healthy marsh. In these previously diked areas the salt marsh habitat is almost entirely gone. In addition to this habitat degradation, modeling suggests most of Elkhorn Slough's remaining marshes will be lost within 50 years due to sea-level rise. The 65-acre Hester marsh restoration project is the first large scale restoration, of its type, in this estuary. Over 200,000 cubic yards of soil used to bring the marsh up to a sustainable elevation, high in the tidal frame. Restoring this degraded habitat highlights the importance of a collaborative, interdisciplinary approach to restoring sustainable habitat for the future.

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DO FISH LIKE RESTORED WETLANDS?

Monique Fountain*, Rikke Jeppesen

Part of understanding if a restoration project is successful is knowing if and how wildlife are using restored areas. We did pre- and post-restoration surveys of fish in tidal channels using a 30 ft beach seine. Early results suggest impaired habitat had a less diverse assemblage of small, highly mobile fish while post restoration we are already seeing a more diverse assemblage and some larger fishes.

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COUPLED HIGH-FREQUENCY SENSOR NETWORK AND ENVIRONMENTAL TRACERS TO QUANTIFY SUBSURFACE NITRATE TRANSPORT TO A COASTAL ESTUARY

Emilio Grande

Estuarine salt marshes play a fundamental role in transporting and transforming terrestrially sourced pollutants en route to marine environments. While substantial research has focused on understanding the role of rivers as terrestrial point sources of nutrients, the fate of pollutants from groundwater remains less understood. Here, we present initial results from our field-based study that seeks to characterize the role of groundwater on coastal nutrient dynamics at the Elkhorn Slough National Estuarine Research Reserve. We instrumented an upland-salt marsh transect with a network of shallow groundwater wells, piezometers and variable depth redox sensors. We used a field-based spectrophotometer in combination with a multisource pump manifold to monitor surface and pore water nitrate concentrations at sub-daily time scales at low, mid, and high marsh positions across the transect. We characterized nitrogen-argon ratio in groundwater to calculate denitrification rates across the study

transect. In addition, we used tritium-helium dating to determine residence time and subsurface water flow paths. Our high-frequency sensor network, coupled with the study of dissolved gases in water, provides insight into subsurface transport of terrestrially-derived nitrate into marsh ecosystems, and its potential removal mechanisms along shallow flow paths. Specially, these results will highlight the central role of diffuse groundwater nutrient loads in coastal settings.

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ANAEROBIC FERMENTATION OF THE MACROALGAE *ULVA* SPP. TO PRODUCE BIOHYDROGEN AND MITIGATE COASTAL EUTROPHICATION

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The consequences of climate change are being felt across all sectors of society and the environment. The need to produce carbon-neutral energy and protect sensitive habitat is at an all-time high. This study investigates the value of using *Ulva*, a green macroalga found worldwide, as biomass for anaerobic fermentation. The production of biohydrogen via anaerobic fermentation is an appealing approach to producing clean energy and producing biofertilizer which can be used as powerful mitigation tool to monitor the impacts of coastal eutrophication. Preliminary results reveal ~75g (WW) of Ulva can yield 10-22L of biohydrogen in 48 hours and produces ~3L of nutrient-rich biofertilizer. To date, yields are variable and current experiments seek to increase the efficiency of this technique and maximize hydrogen production. Biomass treatment, production rate, gas composition, and nutrient concentrations are being optimized and will be considered when determining the feasibility of this approach as a mitigation strategy.

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QUANTIFICATION OF SALT MARSH DENITRIFICATION ALONG A TIDAL INUNDATION GRADIENT

Andria Greene[1]*, Margaret Zimmer[1], Erin Seybold[2], Anna Braswell[3], Corianne Tatariw[4]

Humans are becoming increasingly reliant on ecosystem services provided by tidal marshes, which can buffer terrestrial pollutants from entering open oceans. Excess nitrogen from agricultural and urban runoff is attenuated in marsh soils through anaerobic denitrification. This study quantifies denitrification rates along a transect of tidal inundation at two field sites in the Elkhorn Slough, CA: tidally influenced and tidally restricted (i.e. anthropogenically altered). Laboratory incubations of marsh soils along each transect were measured for denitrification byproducts (N_2:Ar gas ratio method) and solutes. Marsh soils were then analyzed for parameters that we hypothesize may control rates of denitrification, specifically microbial qPCR, C:N, pH, and sulphur-sulphate.

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THE POWER OF A K-12 EDUCATION AND RESEARCH SCIENCE PARTNERSHIP

Virginia Guhin*, Peggy Foletta*

Elkhorn Slough Reserve K-12 programs are more engaging and richer in design because of the unique partnership between the Reserve Education and Research programs. An introduction to the Reserve Education programs highlights the value of collaboration for enriching environmental education for both teachers and students. The talk will present two examples that illustrate how collaboration occurs and the incredible results; WATCH and TOTE.

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ELKHORN SLOUGH WATER QUALITY UPDATE, TRENDS AND WEBSITE

John Haskins

For the past 30 yrs we have been monitoring water quality in Elkhorn Slough region. Recently a student Kathleen Hicks analyzed these data to determine what are the trends. High variation was determined among years and trends were not generally correlated with weather or oceanography suggesting local factors, such as land use activities and tide gate management, have strong and rapid effects on wetland water quality. Overall water

quality is improving with more sites decreasing in concentrations outnumbering those increasing in nutrient concentrations. All these data can now be investigated with our new updated online interactive report card.

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RECOVERING POPULATION OF THE SOUTHERN SEA OTTER COINCIDES WITH DECLING POPULATION OF INVASIVE GREEN CRABS AT ELKHORN SLOUGH

Rikke Jeppesen[1]*, Kerstin Wasson[1], Catherine de Rivera[2], M. Tim Tinker[3], Edwin Grosholz[4], Ron Eby[1], Brent B. Hughes[5]

Could an endangered native species keep a non-native invader in check? Elkhorn Slough Estuary is habitat for keystone species, such as the Southern sea otter, but also harbors a number of non-native invertebrates, including the European green crab. Monitoring programs at the slough have tracked both otter and green crab abundances and distributions since the early 2000s. While the otter population has been steadily increasing over the past decade, the green crab population has declined. Otters consume a variety of prey items including crabs, frequently observed and documented by researchers and volunteer scientists at the slough. We explored relationships between otter density and relative crab abundance and carapace width, at sites throughout the estuary, over time. We also evaluated green crab population trends in nearby bays and estuaries. Our preliminary analysis suggests that sea otters could be keeping the green crab population at Elkhorn Slough at a low abundance.

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SETTING THE RECORD STRAIGHT: TESTING WHETHER P. CRASSIPES BURROWS IN A LAB SETTING

Hannah Levy[1]*, Mayah Levy[1]*, Kathryn Beheshti[2]

The literature states that *Pachygrapsus crassipes*, the lined shore crab is not a burrowing crab. Our natural history observations over the past two summers as field interns provided evidence that *P. crassipes* likely burrows. At the Hester Restoration Site, we have been monitoring crab colonization and burrowing into the newly restored system. We decided to conduct a lab study in order to confirm that if burrowing was observed, it was due to activity by *P. crassipes* as no other species were present. Our lab trials tested whether artificial starter holes (small and large) encouraged burrowing versus sediment without starter holes. Our results showed evidence of burrowing and burrow maintenance only when the "starter hole" was made in proportion to the carapace length of the trialed individuals. One of the seven individuals of the "no hole" treatment from the most recent trial created a burrow within one week.

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SURROGATE-REARING A KEYSTONE SPECIES FOR POPULATION AND ECOSYSTEM RESTORATION

Karl A Mayer[1]*, M. Tim Tinker[2,3] Teri E Nicholson[1], Michael J Murray[1], Andrew B Johnson[1], Michelle M Staedler[1], Jessica A Fujii[1], Kyle Van Houtan[1,4]

From 2002-2016, we reared 37 orphaned sea otter *Enhydra lutris* pups using captive otters as surrogate mothers, and released them into Elkhorn Slough. Observed increases in the local sea otter population during this period brought ecosystem benefits; however, the relative contributions of surrogate-reared otters remained uncertain. To resolve this, we developed an individual based model (IBM) of the local population using surveyed individual fates of surrogate-reared and wild-captured otters, and modeled estimates of immigration. The IBM simulations indicate that reconstructed counts of the wild population were best explained when including surrogate-reared otters combined with low levels of unassisted immigration; and that 55% of the observed population growth over this period was attributable to surrogate-reared otters and their wild progeny. These results indicate that the integration of surrogacy methods and reintroduction of juvenile sea otters helped establish a biologically successful population and restore a once-impaired ecosystem.

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LOCAL PUBLIC OUTREACH SCIENCE PROGRAM CATAPULTS THE PRODUCTION OF A VIRTUAL MINISERIES FEATURING SLOUGH ANIMALS

Jezebel Powers*, Annabelle Pavlak*, Kathryn M. Beheshti

One of the challenges for the scientific community is relaying results to the general public in a colloquial way. We used public outreach programs and a video miniseries to translate scientific research in Elkhorn Slough. The "Science is F.U.N (For Understanding Nature)" program and the "Just Slough It Miniseries" aims to reach a wide audience that may not otherwise become involved in or excited about science. "Science is F.U.N" is an interactive classroom program with science activities that parallels current research. Using interactive vlogs, the "Just Slough It Miniseries" has the capability of reaching a broader audience. These innovative outreach methods have made a direct impact. "Science is F.U.N" has reached over 100 local 6th/7th graders and our vlogs have earned over 420 views to date. We expect to further increase public interest through continued outreach, using both on-the-ground and virtual methods.

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THE NATIVE OLYMPIA OYSTER COLLABORATIVE (NOOC): SYNTHESIZING LESSONS LEARNED AND CATALYZING FUTURE NATIVE OYSTER CONSERVATION EFFORTS.

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The Olympia oyster (*Ostrea lurida*) is a foundation species that creates habitat for a host of estuarine species, and has provided humans with food and cultural value for millennia. Yet, populations of this native oyster have declined precipitously across most of its range from British Columbia to Baja California, Mexico. The Native Olympia Oyster Collaboration (NOOC) is a network of collaborators engaged in research and science-based restoration that aims to conserve and rebuild populations of native oysters. In the past year, we have established the first database of all historic and current Olympia oyster restoration projects on the West Coast, from which we will produce a synthesis of lessons learned. In addition, we've created a website, an interactive Story Map, and educational and outreach resources to increase engagement and collaboration among scientists, practitioners, agencies, and community groups that are restoring and conserving populations of this native oyster.

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TRACKING EFFECTS OF CRAB COLONIZATION INTO THE HESTER MARSH RESTORATION SITE

Natalie Rossi[1]*, Kathryn M. Beheshti[1], Anya Morrill[1], Kerstin Wasson[1,2], Brian Silliman[3]

The Hester Marsh Restoration at Elkhorn Slough has created a unique opportunity to track the colonization of crabs in virgin marsh. *Pachygrapsus crassipes* is a native grapsid shore crab that burrows along tidal creek banks. The destabilization attributed to crab burrowing increases vulnerability to erosion and loss of marsh; however, a recent study shows that sea level rise may pose a greater threat to the vulnerable banks than crabs. This "clean slate" of new sediment at Hester will allow us to better characterize how colonizing crabs affect marsh vegetation and the stability of vulnerable bank edges. The experiment is designed to understand how the crabs affect newly colonizing marsh plants. This will allow us to see how crabs interact with artificially constructed high marsh that was built with the goal of creating marsh habitat more resilient to projected sea level rise. Our results so far show rapid colonization of both crabs and pickleweed plants, but the rate of colonization varies by elevation and channel sediment type.

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TESTING CLUSTERED PLANTINGS TO INFORM SALT MARSH RESTORATION

Karen E. Tanner*, Kerstin Wasson, Ingrid M. Parker

The Stress Gradient Hypothesis is a conceptual model that predicts interactions between plants will shift from competitive under benign conditions to facilitative under stressful conditions – and there is a call to apply these predictions to restoration practice, because site preparation tends to create harsh growing conditions. Research in other systems has shown that clustering plants together can reduce the effects of physical stress; however, the benefits of clustering might come at a cost, especially as plants grow. We are testing whether clustering can improve performance of five species at the Hester Marsh restoration site, where the relative influence of positive and negative plant interactions is likely to vary with tidal inundation as well as rainfall. We track survival, physiology, and cover in uniform and clustered plantings, allowing us to test whether facilitation can bolster plant performance and improve restoration outcomes in the high marsh.

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UNDERSTANDING PATTERNS OF PLANT COLONIZATION AT HESTER MARSH

Alexandra Thomsen[1]*, Karen Tanner[2], Kerstin Wasson[3], Charlie Endris[3], Alex Lapides[3], John Haskins[3], Andrea Woolfolk[3], Monique Fountain[3]

Large-scale restoration projects are increasingly necessary to maintain marsh area in the face of historic marsh loss and current and future threats, but expectations for colonization at restored sites can be uncertain. At Elkhorn Slough's Hester Marsh, sediment addition has been used to create 61 acres of high-elevation marsh resilient to sea level rise. The site was initially bare following sediment addition, with plantings limited to the ecotone transition zone. Early monitoring data confirm that pickleweed, the dominant marsh plain species, colonizes readily by seed. However, research is needed to understand the spatial patterns of colonization. Using traditional field surveys and unmanned aerial vehicles, we are examining drivers of natural colonization (including elevation and proximity to channels) and evaluating the need for active planting. Results will inform future projects by enabling realistic goal setting, identifying species differences in colonization, and identifying factors that promote or inhibit colonization.

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OLYMPIA OYSTER RESTORATION AQUACULTURE IN A RECRUITMENT-LIMITED ESTUARY

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Olympia oyster populations in Elkhorn Slough are at risk of local extinction. No successful reproduction has occurred in the estuary since 2012, leaving an aging population of about 1000 remaining oysters. In May 2018, 85 oysters were collected and brought temporarily to Moss Landing Marine Laboratory. With sufficient food and elevated temperatures, they were induced to spawn and release larvae. Spat were settled on native gaper clam shells and outplanted back into Elkhorn Slough in October 2018, in naturalistic clusters mimicking historic oyster habitat. Survival and growth of these oysters has been excellent over the past year: they are now adult-sized. These hatchery-raised oysters have tripled the population size in the estuary and provided the first new cohort since 2012. Restoration aquaculture is a powerful tool that could more broadly be applied to coastal foundation species limited by reproduction.

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MORO COJO WATERSHED WETLAND RESTORATION AND NUTRIENT REDUCTION

Jessica Williamson

During the early part of the 20th century there was little interest in protecting wetlands and other waterways. Within the Salinas Valley and throughout California, water was drained from lands for farming and cities. This statewide trend led to a loss of 90% of the states' wetlands. The priorities have changed and we (CCWG) are

focusing on restoring the area's waterways and reducing the impacts of agricultural land uses on water quality. Our research has documented that nitrate levels within the Moro Cojo Slough have dropped from common spikes of 20 mg/L to concentrations below 0.2 mg/L NO_3. These nutrient reductions correspond with wetland restoration efforts completed in the watershed over the past 15 years. The water quality improvement projects include constructed bioreactors near farmland, wetland recreation in historical wetland areas, and restoration of riparian and transitional zones. Our study shows that these practices have decreased nutrient loads and recreated 68 acres of habitat for the wildlife and flora of the area. Water quality benefits have been monitored using a strategic combination of grab samples, automatic samplers, and osmotic pumps.

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WHO ARE YOU CALLING SLUGGISH? ELKHORN SLOUGH BEFORE 1909.

Andrea Woolfolk

Many local scientists have claimed that Elkhorn Slough was a "freshwater lagoon" or "sluggish backwater with limited tidal action" before the Salinas River was diverted in 1909 and the Moss Landing Harbor was constructed in 1946. But primary historical maps and documents paint a very different picture, describing Elkhorn Slough as a dynamic tidal environment in the 1700s and 1800s. An accurate understanding of Elkhorn Slough's past can help us better understand its environment today and help us make better decisions for its future.

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SPATIOTEMPORAL NITRATE CONCENTRATION DYNAMICS IN A SALT MARSH SYSTEM

Margaret Zimmer[1]*, Emilio Grande[1], Andria Greene[1], Erin Seybold[2], Anna Braswell[3]

Nitrate transport and transformation dynamics in salt marsh systems are, in large part, controlled by a range of environmental and hydrological conditions that fluctuate across tidal cycles and seasons. Here, we seek to characterize the spatiotemporal dynamics of surface and subsurface nitrate concentrations with depth along a salt marsh transect in Elkhorn Slough, CA through high frequency in situ optical sensor systems. We pair this novel dataset with hydrologic, salinity, pH and denitrification rate measurements to develop a conceptual model of four-dimensional nitrate concentration variability in this system.

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