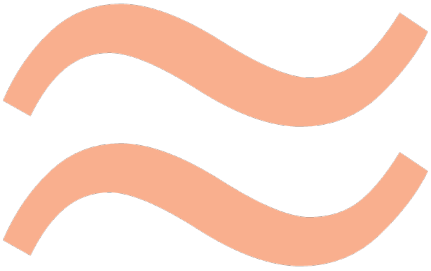
October 7-8, 2022

The First California State University Seaweed Symposium



Tiburon, CA

The First California State University Seaweed Symposium: Highlighting Seaweed Research and Artistic Expertise in the CSU System

Sponsored by the
CSU Council on Ocean Affairs, Science & Technology

Meeting convened at Estuary & Ocean Science Center,
a facility of San Francisco State University

Tiburon, California
October 7-8, 2022

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The First California State University Seaweed Symposium

October 7, 2022

Day One

4-5:30 pm	Kathy Ann Miller, PhD	Oceanside Seaweed Chat & Walk
6-7:00 pm	CSU Students and Faculty	Seaweed Research and Poster Presentations
7:00 pm	Janet Kübler, PhD	Welcome to the CSU: Seaweed Symposium
7:05 pm	Katharyn Boyer, PhD	Director of EOS Center, San Francisco State University
7:10 pm	Kimberly Jassowski, MS	CSU COAST
7:20 pm	Shauna Oh, PhD	California Sea Grant
7:30 pm	Simona Augyte, PhD	Plenary Speaker
8:00 pm	Josie Iselin, MFA	Plenary Speaker
9:00 pm	Networking Session	Seaweed Speakeasy

The First California State University Seaweed Symposium

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Day One

Poster Session

Bennett Bugbee	Aquaculture techniques enhance potential for prolonged success in the restoration of bill kelp, *Nereocystis luetkeana*
Elizabeth H Burns	Sounds of the kelp forest kings: Verification of Giant Sea Bass (*Stereolepis gigas*) spawning
Abbey Dias	Examining the role of interaction webs in dictating bull kelp forest resilience along the northern California coast
Julieta Gomez	Does climate change enhance purple sea urchin (*Strongylocentrotus purpuratus*) herbivory rates on bull kelp (*Nereocystis luetkeana*) across all of its life history stages?
John Gonzales	A survey examining peroxisome in California coastal seaweed through histochemical staining
Rachael Karm	Population-level resistance of bull kelp (*Nereocystis luetkeana*) to ocean warming: Informing restoration following a climate catastrophe
María Velázquez	Transition zones: Does community assemblage determine restoration success of a lost kelp forest?

The First California State University Seaweed Symposium

October 8, 2022

Day Two: Seaweed Science Lectures

Session One: Moderator – Rafael Cuevas Uribe, PhD

11:00 am	David Stentiford	War, peace, and Giant kelp: why two Californian Cold War missile engineers tried to farm kelp offshore in 1970s
11:15 am	Jeremiah Ets-Hokin	Flow and pH influence physiology and grazing susceptibility of coralline algae
11:30 am	Marzia Fattori	The effect of temperatures on *Nereocystis luetkeana* developmental stages
11:45 am	Hannah Joss	Monitoring bull kelp in farmed and wild systems using drones
12:00 pm	Kalani Oritz	Preliminary trials of Bull kelp (*Nereocystis luetkeana*) in Humboldt Bay, CA
12:15 pm	Vinicius Souza	Drivers of population and community assembly patterns related to remnant bull kelp (*Nereocystis luetkeana*) forests following a catastrophic decline
12:30 pm	Ava Salmi	Seafeeds: native California seaweeds could reduce methane in livestock ruminants
12:45 pm	Jessica Metter	Seaweed aquaculture for the cattle industry: A methane fix at the expense of ozone?

The First California State University Seaweed Symposium

October 8, 2022

Day Two: Seaweed Science Lectures

Session Two: Moderator – Steve Dudgeon, PhD

3:00 pm	Matt Edwards	Using Ulva lactuca for nutrient remediation of polluted waterways
3:15 pm	Diana L. Steller	Reefs that rock and roll; the importance and nursery role of Pacific coralline rhodolith beds
3:30 pm	Shelby Penn	Enjoying the little things: the role of bacteria in seaweed functionality
3:45 pm	Steve Dudgeon	Selfing, sex and parthenogenesis in red algae

Josie Iselin, MFA

Biography

Josie Iselin is the photographer, author, and designer of many books, with new projects always in development in her San Francisco studio, Loving Blind Productions. Her books focus on those forms in nature we find at hand and in particular, at the beach. Her newest book, The Curious World of Seaweed features sixteen visually rich narratives of our iconic West Coast seaweeds and kelps. It was released by Heyday Books in August 2019 and has been shortlisted for the Northern California Book Award and the Alice Award, recognizing illustrated books. It was awarded The Tiffany Award for science communication by the Phycological Society of America.

Josie's mission is to produce enticing, well-researched and well-designed books that combine art and science, leaving the reader with new information about, and an appreciation for, the world around them. Her writing and art focusing on seaweed, kelp, and sea otter puts her at the forefront of ocean activism, presenting and working with scientists and environmental groups working to preserve the kelp forests of our Pacific Coast.

Josie holds a BA in Visual and Environmental Studies from Harvard and an MFA from San Francisco State University. She currently teaches in the School of Design at SFSU. For over twenty years Josie has used her flatbed scanner and computer exclusively for generating imagery. She is still captivated by the fluidity with which this technique allows her to render and design with three-dimensional objects. As a fine artist, Josie exhibits large-scale prints at select galleries, museums, hospitals, and other public spaces. Synthesizing the scientific stories of our coast is her overriding passion, bringing thoughtfulness and stewardship to this extraordinary place of discovery.

Simona Augyte, PhD

Biography

Simona grew up on the Baltic coast and moved to the Pacific coast for college. She received her Bachelor's in Botany with a minor in Art and then a Master's in Biology from Humboldt State University. She later moved to the Atlantic coast to complete a Ph.D. at the University of Connecticut. Simona has worked with macroalgal biology, cultivation, and genetics in both academia as well as in the industry sector. Her applied research includes the ecophysiology and breeding of brown, green and red seaweeds in temperate and tropical ecosystems. Currently at Ocean Era on Hawai'i Island, Simona oversees the pioneering tropical offshore macroalgae culture program, and the macroalgae utilization research using the microbiome of herbivorous reef fish as the model. She enjoys bringing together both interdisciplinary teams and the public for marine conservation and education over all things seaweed for food, feed, and bioenergy production.

Abstracts

Bennett Bugbee: Aquaculture techniques enhance potential for prolonged success in the restoration of bill kelp, *Nereocystis luetkeana*

Co-authors: Daniel J. Gossard, A. Kim, Scott L. Hamilton, and Michael H. Graham
San Jose State University

Along the northern California coast, marine heatwaves and urchin overgrazing have resulted in 95% loss of the bull kelp, *Nereocystis luetkeana*. Interannual absence of fertile adult individuals poses a direct risk to regional persistence of the once prevalent annual foundation species, especially with nearshore ecosystems shifting to an urchin barren state. Aquacultural methods have been shown to be an effective tool for restoration purposes and may likewise prove effective for restoring northern California bull kelp forests. Aquaculture mediated methodology, with the goal of shifting urchin barrens to dense kelp forest ecosystems, may enhance managerial strategies for current and future bull kelp restoration efforts.

Elizabeth H Burns: Sounds of the kelp forest kings: Verification of Giant Sea Bass (*Stereolepis gigas*) spawning

Co-authors: Larry G Allen, and Michael P Franklin. California State University, Northridge

Giant Sea Bass (GSB), Stereolepis gigas, is the largest marine bony fish off the coast of California, an apex predator, and is currently classified as critically endangered by IUCN Red List. Despite recent studies on GSB, there is no documentation of their spawning and related reproductive behaviors in their natural environment due to their depressed population size. Previous studies have shown GSB capable of producing a variety of sounds (many sounding like a "boom"). Past studies have observed that the closer in proximity you are to a GSB spawning aggregation the louder and more numerous GSB sounds are heard. In these spawning aggregations "booms" have been observed to be linked with antagonistic behaviors towards GSB males by other GSB males. Indicating that sound production is most likely apart of spawning. In the summer of 2019 novel reproductive sounds labeled "snares" were recorded during successful spawning events of captive GSB. These "snares" have only been recorded during spawning. Using the 'R' package 'warbleR' we examined audio samples gathered in the summers of 2014, 2015, and 2019 to identify "snare" sounds recorded at GSB spawning aggregations. We hypothesize that

GSB vocalization occurs frequently during spawning and is used in combination with courtship behaviors to signal reproduction readiness. This talk explores the in-progress investigation and identification of these hypothesized acoustical behaviors exhibited by GSB during spawning. I argue that by identifying these behaviors, we will be able to verify GSB spawning when these auditory behaviors are observed during their period of spawning.

Abbey Dias: Examining the role of interaction webs in dictating bull kelp forest resilience along the northern California coast

Co-author: Brent Hughes. Sonoma State University

Northern California bull kelp forests are at risk of permanent loss after warm water anomalies and overgrazing of purple urchins destroyed >95%. Identification of key interaction networks within bull kelp forests can help guide targeted restoration efforts and promote resilience of the species. The extent to which *Desmarestia* spp. aka "acid algae" interacts with bull kelp forests is largely unknown. This study aims to characterize this interaction web between a foundational species (bull kelp, *N. luetkeana*), a voracious herbivore (purple urchins, *Strongylocentrotus purpuratus*), and abundant understory algal competitor (*Desmarestia* spp.). Potential benefits and consequences of such interactions expand our understanding of future kelp forest restoration.

Matthew Edwards: Using *Ulva lactuca* for nutrient remediation of polluted waterways

Co-authors: Emily Bews, Leslie Booher, Torre Polizzi, Ju-Hyoung Kim, Chris Long. San Diego State University

Excess nutrient input into the marine environment has caused health concerns for many bays and estuaries. In particular, excessive use of fertilizers in urban and agriculture setting results in nitrogen and phosphorus being transported to the ocean, especially after heavy rain when runoff carries them to the sea. Seaweed farms may prove a promising way to remove these nutrients from the water but it is unclear how the seaweeds will perform when salinities decrease following freshwater input. We studied the feasibility of using *Ulva lactuca* to remove N and P from San Diego Bay during periods of reduced salinity. To do this, we grew *U. lactuca* under two salinities and three nutrient concentrations for six weeks. We measured *U. lactuca* growth, photosynthetic performance, nitrogen and phosphorus uptake, and the resulting tissue nitrogen, phosphorus and carbon contents. Our results show that while *U. lactuca* survived and grew in all salinity and nutrient combinations, its growth, steady-state photosynthesis,

light harvesting, and tissue N and P contents were all affected by differences in salinity and nutrient availability. Specifically, low salinity and low nutrient availability negatively affected these parameters, while high salinity and medium-to-high levels of nutrients generally led increases in these parameters. Our study suggests that although its physiology may be negatively affected, growing *U. lactuca* on seaweed farms may be a feasible way to clean the water of organic pollutants, especially following rain events that increase nutrient input and lower salinity.

Jeremiah Ets-Hokin: Flow and pH influence physiology and grazing susceptibility of coralline algae

San Francisco State University

Coralline algae create reef, induce larvae settlement, and are primary producers in ecosystems worldwide. Ocean acidification (OA) and changes in grazing behavior of purple urchin are threatening coralline algae. The susceptibility of coralline algae to grazing could be worsened by a weakening of the skeletal under OA conditions. Coralline algae are photosynthesizing and calcium carbonate forming organisms, allowing them to create a diffusion boundary layer (DBL) that could influence their biomineralization. It has been hypothesized that the DBL could ameliorate the effects of OA, but the extent to which this is true is largely unknown, as is the importance of water flow on the physiology of coralline algae. Coralline algae were grown for one month under two levels of pH, and flow, then exposed to urchins for 24-48 hours. The two articulated coralline algae species had lowered growth metrics under low pH and flow treatments. Most notably, C. tuberculosum had a 40.6% decrease in proportional buoyant weight under low pH treatments and a 13.5% decrease in proportional buoyant weight under low flow treatments. The crustose coralline algae had a 67.11% decrease in surface area under low flow treatments, and a 271% increase in grazed surface area under low pH treatments. With no interactions between flow and pH, it does not appear that a DBL ameliorates the effects of OA; however, these results indicate that low pH and flow negatively impact coralline algae physiology and those impacts translate to the ecological consequence of increased grazing susceptibility.

Marzia Fattori: The effect of temperatures on *Nereocystis luetkeana* developmental stages

Co-authors: Rafael Cuevas Uribe, Rick Zechman, Sean Craig. Cal Poly Humboldt

Bull kelp (*Nereocystis luetkeana*) is a predominant canopy forming macroalga along the California coast, creating one of the most diverse ecosystems. Unfortunately, due to a series of marine heat wave events and other environmental factors, there has been a 95% decline in these kelp forests along the California coastlines that have yet to recover. Due to its sensitivity to thermal stress, our goal is to evaluate the temperature tolerance among *N. luetkeana* found at different locations (Humboldt, Monterey and Mendocino) and how the early stages in their life cycle respond to such extreme temperature variations.

An 8-week temperature trial was conducted to evaluate the growth of *N. luetkeana* at three temperatures: 10°C, 18°C and 19 °C. Each temperature treatment had four 5 L tanks containing five glass slides that were seeded with a spore suspension obtained from sori tissues from Humboldt, CA. Tanks were exposed to a 12:12 photoperiod and a light intensity of 15 µE/m2/s. Growth was measured every 10 days by counting the number of attached spores and gametophytes, as well as the presence/absence of sporophytes.

After 8 weeks, germination occurred at all temperatures; however, sporophytes only developed at 10°C and 18°C. Previous publications showed no germination at 18°C, indicating that the upper temperature limit could vary across regions. In future trials, the same experiment will be repeated with sori collected from Monterey and Mendocino. Findings from this study could be beneficial for restorative approaches, such as green gravel, that are currently being implemented to enhance kelp beds.

Julieta Gomez: Does climate change enhance purple sea urchin (*Strongylocentrotus purpuratus*) herbivory rates on bull kelp (*Nereocystis luetkeana*) across all of its life history stages?

Co-authors: Aurora M. Ricart, and Brent Hughes. Sonoma State University.

Herbivory can impact community structure and dynamics. When left unchecked by predators, runaway herbivory occurs: primary producers are overgrazed before they can recover. Bull kelp (*Nereocystis luetkeana*) is a canopy forming foundation species found in Northern California eaten by the purple urchin (*Strongylocentrotus purpuratus*). Bull kelp exhibits an alternation of generations life history: microscopic and macroscopic stages, but little is known about purple urchin feeding rates on the different life stages. Bull kelp and

purple urchin abundance relationships and herbivory on life stages were studied through field surveys and lab experiments. Preliminary results showed a negative relationship between bull kelp and purple urchin abundance. Results from this study provides insight on the status of remnant bull kelp patches in Northern California and determines kelp life history stages vulnerable to purple urchin herbivory, informing restoration efforts.

John Gonzales: A survey examining peroxisome in California coastal seaweed through histochemical staining

Co-authors: Ramon Rodriguez, Patra Holmes, Matthew Dominguez, Keiko Hokeness, Joe Ramahi, Clara Nungaray, Michelle Chong, Jadi Allen, Karen Yang, John Gonzales, Sergey Ingram, Zheng-Hui He, and Brian von Herzen.
San Francisco State University

The impacts of climate change are closely related with man-made increases in greenhouse gases such as Methane and CO2. Prior research has shown that bromoform, a metabolic product of several seaweed peroxisomes, is an inhibitor of methane fermentation in the ruminant gut of cattle and similar agricultural animals. In an approach to utilize local California seaweeds to decrease agricultural greenhouse gas emissions, the 2022 Center for Cellular Construction Seaweed Peroxisome group performed field collections in Pebble Beach, California and analyzed peroxisomes by DAB (diaminobenzidine) staining. Samples were collected at Pebble Beach, CA and processed at the CCC teaching lab at SFSU. Peroxisomes of live samples were detected histochemically by DAB staining. Several iterations of DAB staining were performed with optimization steps around incubation time and temperature. Results show that longer DAB incubations followed by various clearing give striking peroxisome detection. Our study also showed that some seaweed species proved to be technically difficult to stain due to tissue thickness. Future directions include improving histochemical detection of peroxisome at the sub-cellular level and expanding our survey.

Hannah Joss: Monitoring bull kelp in farmed and wild systems using drones

Cal Poly Humboldt

As farming kelp grows in popularity on the West Coast, the need for efficient monitoring solutions is also growing. In this study, I am using drones to survey the growth of bull kelp on farm systems in Humboldt Bay. With the imagery, I am classifying and measuring the area of observed kelp from the drone imagery and correlating it with harvested biomass from each line. Ultimately, I hope to

develop a model to predict harvestable biomass of kelp on farmed systems while also building a toolbox to survey and classify kelp in natural, coastal environments.

Rachael Karm: Population-level resistance of bull kelp (*Nereocystis luetkeana*) to ocean warming: Informing restoration following a climate catastrophe

Co-authors: Brent Hughes, Julieta Gómez, and Aurora Ricart. Sonoma State University

Anthropogenic climate change is threatening earth's ecosystems. Both ecological resistance and ecological resilience serve as proxies for ecosystem stability and are important for informing recovery and restoration of threatened habitats. The earth's oceans are facing increased sea surface temperatures attributed to climate change which is pushing some ecosystems, such as California bull kelp forests, past the thresholds for disturbance where natural resistance or resilience cannot function. These ecosystems could be dependent on human intervention to persist. Bull kelp is an important foundation building species that forms near shore marine habitats which enhances biodiversity. Recently about 90% of historical Northern California bull kelp coverage has been lost due to a variety of factors, including increased temperature, but this compares to relatively stable bull kelp forests in central California. This study aims to understand population level resistance of kelp throughout its early life history stages from different sites throughout central and northern California. It is hypothesized that the bull kelp will have more growth and abundance from central California as there may be a higher level of thermal tolerance. This was tested in a laboratory experiment by collecting bull kelp from these different populations and culturing them in an environmental room in two temperature treatments: ambient (13 C) and warm (17 C). Size and bull kelp percent cover were observed throughout the experiment and measured using ImageJ. Differences in growth and development between the sites and treatments would inform conservation and management efforts by highly strategizing source material for future restoration.

Jessica Metter: Seaweed aquaculture for the cattle industry: A methane fix at the expense of ozone?

Co-authors: Maxime Grand, and Luke Gardner. San Jose State University

Methane is a potent greenhouse gas and enteric fermentation (i.e, cow burps) is responsible for almost a third of all methane emissions from the United States. A promising strategy to reduce methane emissions from ruminant livestock is to

supplement their diets with seaweeds naturally rich in a chemical called bromoform (CHBr3). There is thus a strong interest in farming bromoform rich seaweeds on a large scale to meet climate targets. However, this practice may also alter the atmospheric inventory of bromine and induce catalytic ozone degradation. To ensure that any reduction in methane emissions from cattle does not result in damage to the ozone layer, the amount of bromoform that escapes to the atmosphere when bromoform rich seaweeds are farmed must be urgently quantified. In this presentation, we will present updated bromoform emissions from *Asparagopsis taxiformis*, which is currently the leading seaweed candidate for methane reduction in cattle. We show that bromoform emissions from over two dozen *Asparagopsis taxiformis* incubation experiments performed on Santa Catalina Island (California) were significantly higher than previously reported values. Furthermore, our results show that bromoform emissions from *Asparagopsis taxiformis* vary on diurnal timescales with emissions approximately four times higher at midday relative to dawn/dusk. Finally, we will discuss the impact of temperature on seaweed bromoform emissions and the scalability of our results by comparing emissions from bottles (0.5 L) to aquaculture tanks (370 L) mimicking long-line seaweed farming practices.

Kalani Ortiz: Preliminary trials of Bull kelp (*Nereocystis luetkeana*) in Humboldt Bay, CA

Co-author: Rafael Cuevas Uribe. Cal Poly Humboldt

The cultivation, restoration, and conservation of macroalgae are emerging mariculture practices in the United States. While cultivation of kelp species is one of the fastest growing industries in the northeastern of the United States, kelp aquaculture in California is at an early stage of development. We propose to evaluate the cultivation of bull kelp (*Nereocystis luetkeana*) from a hatchery at the Cal Poly Humboldt (CPH) marine laboratory in Trinidad, CA, and successfully integrate them to grow out in open water in Humboldt Bay, CA.

This project will consist of 8 aquaria replicates containing spools. We will evaluate the growth and morphology of bull kelp using a variety of seeding strings commonly used in different regions for open water cultivation of macroalgae. At an optimal development stage and length (juvenile sporophyte at 3 mm in length), they will be transported to CPH ProvidenSea seaweed farm, where they will be out planted in the selected farm array systems for further assessment of growth. Nutrients in the seaweed's tissues and surrounding water will be analyzed to determine the extractive properties of macroalgae grown in the bay. Between the months of December 2021-July 2022 a preliminary study was conducted to see the viability of growing and harvesting bull kelp in a multiline cultivation in Humboldt Bay.

Results from this study will help expand the under-developed research in bull kelp cultivation practices and provide a foundation for future farmers in regenerative seaweed farming practices within the California northern pacific coast.

Shelby Penn: Enjoying the little things: the role of bacteria in seaweed functionality

San Diego State University

It is easy to forget that ecological interactions take place at the microscopic level and not only at macroscopic scales. In marine environments, bacteria and other microorganisms colonize every surface, both biotic and abiotic, and provide important benefits to their biotic hosts. Just like in the human gut, these communities called microbiomes, not only interact within the microbiome itself, but also transfer metabolites and information to the host. In function, they are considered to behave similarly to multicellular organisms, and the host and associated microbiome are referred to as the holobiont. So how might these bacteria and other microorganisms help the seaweed? Though the seaweed-microbiome relationship is still poorly understood, researching these interactions have already given us insights on how microbes can enhance seaweed farming production and bioremediation. Come find out how the algal microbiomes can literally shape the seaweed, provide antibiotic resistance to diseases, and adaptations to the stressors of life in the ocean.

Ava Salmi: Seafeeds: Native California seaweeds could reduce methane production in livestock ruminants

Co-authors: Luke Gardner, Steven Cunningham, and Evan Simpson. San Jose State University

California's largest contributor to methane production is cattle, housing around 1.4 million dairy cows and 1 million beef cattle. The methods for reduction in cattle are still relatively unexplored. Recent research in Australia has shown that some species of stub-tropical seaweed can reduce methane production from cattle by up to 99% when used as a feed additive at 2% inclusion rates of organic matter. However, temperate species have not yet been assessed for methane-reducing properties, but many are related to these sub-tropical species and present in the California Current Ecosystem. For this study, we initially measured the in vitro effects of 20 different species of local seaweed on total gas production and digestibility when added to cattle diets. The best

performing species, *Gracilaria parvispora*, was chosen for further studies and culturing at Moss Landing Marine Laboratories (MLML). We addressed the relationship between culture conditions (shading, light intensity, water temperature, and desiccation), growth, and bromoform content in *G. parvispora*. Preliminary results have shown that the growth of *G. parvispora* can be optimized in 30% shade from natural light. In comparison, bromoform concentrations are highest in 0% shade and warmer waters and depend on light intensity. Trials will conclude with an in vivo examination of *G. parvispora* grown at MLML on whole-animal digestion and methane emissions of dairy cattle in Wisconsin, carried out by collaborators at the USDA. This project offers an excellent opportunity to address the great potential of seaweed aquaculture in California and the vital role it can play in mitigating climate change impacts from ruminant livestock.

Vinicius (Vini) Souza: Drivers of population and community assembly patterns related to remnant bull kelp (*Nereocystis luetkeana*) forests following a catastrophic decline

Sonoma State University

As the number of climate driven events increase, the persistence of many marine ecosystems become progressively more vulnerable. Additionally, population dynamics, larval production and demographic connectivity are likely to become more variable as the climate changes. Temperate kelp forests are known to be some of the most productive ecosystems in the world and provide a wide range of ecosystem services yet are susceptible to collapse when temperatures and physiological demands increase. In Northern California, a series of perturbations, including a record breaking Marine Heatwave (MHW) has led to a catastrophic decline of these iconic and historically stable forests. Although many kelp forests have shifted to sea urchin barrens, observational and survey data shows there were certain locations where kelp and macro-invertebrate populations persisted. However, the habitat aspects that influence the persistence within these patches following an ecological catastrophe are not well understood. In this study, I will examine the drivers of population and community assembly patterns related to remnant kelp patches following the drastic decline of northern California kelp forests. To test these drivers, I will quantify the abundance and composition of canopy and subcanopy kelp, and macro-invertebrates at 9 sites that represent a gradient of bull kelp persistence and density. Furthermore, I will assess if the presence of canopy and subcanopy kelp influences the recruitment of macro-invertebrates at two spatial scales: county and site. This study aims to shed light on the importance of assessing how biotic and abiotic factors effect the structure of meta-communities and meta-ecosystems.

Diana Steller: Reefs that rock and roll; the importance and nursery role of Pacific coralline rhodolith beds

Co-authors: Matthew Edwards, Scott Gabara, and Billie Beckley. San Jose State University.

Rhodolith beds are diverse and complex benthic ecosystems which range in the North East Pacific from Alaska to Baja California Sur, México. Globally, these beds of unattached, branching coralline algal nodules create fragile ecosystems, often acting as nursery habitat for invertebrates. Santa Catalina Island supports numerous beds, all of which are threatened by intensive boat mooring systems. Despite distribution within marine protected areas, the ecological role and overall health of California rhodolith beds is poorly understood. In this study we sought to 1) identify dominant associated marine species, 2) establish metrics to monitor bed health and to quantify spatial and temporal patterns among six rhodolith beds in Catalina Island and 3) to identify species utilizing beds as nursery habitats. Surveys of six rhodolith beds were conducted over four sampling periods. Rhodolith cover, heterogeneity and species abundances within beds were positively correlated and suggest invertebrates, seaweeds and fish associate with rhodoliths for habitat and food provisioning. Catalina Island rhodolith beds act as nursery grounds for the gastropod *Megastrea undosum* and the urchin *Lytechinus pictus*. While high in biodiversity, Catalina Island rhodolith beds are likely the most disturbed along the Pacific coast and are in need of protection.

David Stentiford: War, Peace, and Giant Kelp: Why Two Californian Cold War Missile Engineers Tried to Farm Kelp Offshore in 1970s

Stanford University

Can kelp save the planet? Two missile builders in the 1970s thought it might. Indeed, the current excitement for farming kelp in the open ocean has its roots in research done independently by two cold war weapons engineers. One built the nation's infrastructure to deliver nuclear missiles anywhere in the world. His name was Edward Hall. The other worked at Los Alamos on the atomic bomb and then oversaw the construction of the Sidewinder heat-seeking missile. His name was Howard Wilcox. Wilcox went on to establish the first multimillion dollar kelp farming project in the U.S., funded by the Navy, the National Science Foundation, and the natural gas industry. Why were these two different California missile builders so hot on kelp? Well, I'll explain how their Cold War fears, the Santa Barbara oil blow out, and worries about sea level rise—not just the energy crisis, as is often thought—spurred the first US marine biomass program in the 1970s. In my talk, I'll also tell how others at the time imagined that

ocean farms could unite the world in a common cause and bring about world governance and global peace. Some even thought ocean farming would evolve "human nature" at sea, the next big thing since the Neolithic Revolution.

María Velázquez: Transition zones: Does community assemblage determine restoration success of a lost kelp forest?

Co-author: Brent Hughes. Sonoma State University

In recent years, northern California bull kelp (*Nereocystis luetkeana*) forests have experienced a catastrophic decline (~95% loss) due to a 'perfect storm' of stressors. Recovery has been slow, variable, and patchy, as such, restoration efforts must be timely, strategic and highly collaborative. This ongoing experimental restoration study aims to better understand restoration dynamics across three alternate kelp forest ecosystem states (*Nereocystis* forest fringe, an understory *Pterygophora californica* patch, and a *Strongylocentrotus purpuratus* urchin barren) at Portuguese Beach, in Mendocino, CA. Specifically, how community assemblage and structure in these states may determine restoration success. Particularly interested in any variation of sea urchin population structure (size distribution, gonad indices) and behavior (grazing mode, diet preferences), energy dynamics (drift kelp), invertebrate larval recruitment and physical characteristics (relief, rugosity) across alternate states that may illuminate feedback mechanisms maintaining specific domains of stability across this patchy landscape.

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