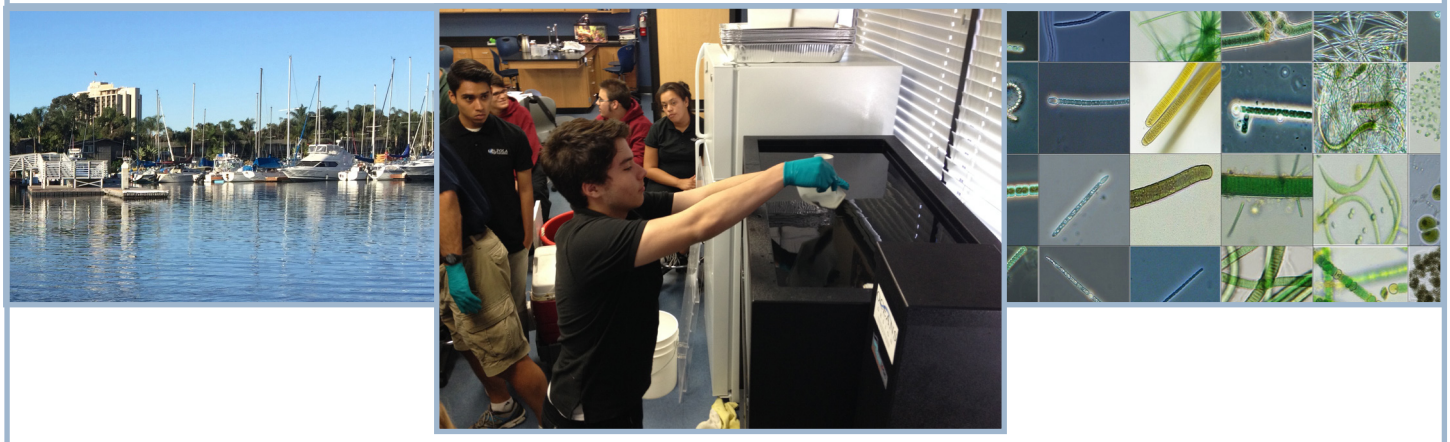
Research Highlights from USC Sea Grant

September 2017



Sea Grant
University of Southern California

1 New model that predicts the flow of sediment around headlands can help maximize the efficiency of beach nourishment projects

Key outcomes:

1) Researchers developed a model to estimate circulation and sediment movement around headlands of different sizes.

2) Researchers created a classification system of rocky headlands in California, with a focus on identifying the boundaries of littoral cells.

3) Results are useful for coastal managers as they consider beach nourishment projects and prepare for the impacts of climate change.

Project Overview:
USC Sea Grant funded research to model waves, currents, and sediment patterns around Point Dume in Malibu, California, to better understand the movement of sand and other material around headlands. Research questions included: What is the impact of headlands on the erosion and accretion of sand? What are the water and sediment transport rates around Point Dume? Do headlands act as barriers of sediment transport? Is the effect of headlands local or regional?

Relevance:
With the impacts of sea level rise becoming clearer for coastal communities, one of the most basic approaches to protecting infrastructure and property is beach nourishment. But coastal environments are connected by alongshore flow and the presence of sand on any particular beach depends on the transport of sand within its littoral cell. Littoral cells are natural compartments along the coast that contain a complete cycle of sedimentation, including transport paths, sources, and sinks. Headlands that protrude from an otherwise smooth shoreline can influence both the boundaries of littoral cells and the transport of sediment. Understanding how headlands impact the flow of sediment will help managers determine where sand should be placed to maximize the efficiency of beach nourishment as an adaptation strategy.

Results:
Results show that the size and shape of the headland, together with incident wave angle, emerged as the dominant factors influencing the pathway of sediment. Sediment pathways around headlands varied by sediment grain size, and sediment grain size determined the volume of sediment flux. Another conclusion of this research is that a new set of parameters should be utilized to define littoral cell boundaries at headlands that take into account size, shape, and sediment.

The most notable outcome of the project is a new model that estimates circulation and sediment transport around differently sized headlands on the coast of California. The results are useful for coastal managers, including state and federal agencies, regional bodies, and local municipalities, as they consider beach nourishment projects and prepare for the impacts of climate change.

Project Title:
Transport of sediment and water around headlands: Observations and modeling at Point Dume, with implications for Santa Monica Bay beaches and littoral cell

Principal Investigators:
Doug George, Bodega Marine Laboratory, UC Davis; John Largier, Bodega Marine Laboratory, UC Davis

Additional details: http://dornsife.usc.edu/uscseagrant/largier-and-george/

2 A new method for citizen science-based monitoring of sandy beach ecosystems

Key outcomes:

1) A citizen science-based ecological monitoring protocol for sandy beach ecosystems has been developed and proven successful.

2) Preliminary data analysis indicates the species richness, abundance, and biomass of the intertidal community are significantly lower on urban beaches, compared to natural beaches.

Project Overview:
USC Sea Grant funded the project, All Ashore: Monitoring Sandy Beach Ecosystems, to develop and test an ecological monitoring approach suitable for use by citizen scientists on urban beaches in California. The project set out to determine if citizen scientists, with proper training, can collect high quality, repeatable data on ecosystem components of urban beaches over appropriate time scales and across geographically diverse sites. This approach has the potential to generate critically needed information on the ecological condition of sandy beaches, allowing scientists and managers comparisons of ecosystem status and trends among beaches over time, and evaluation of effects of environmental impacts and restoration projects.

Relevance:
Despite being iconic and universally loved, the white, sandy beaches of urban Southern California suffer from a critical lack of ecosystem information, making it difficult to manage them sustainably. This lack of information is partly due to the vast geographic expanse of the beaches and lack of time series data, so it makes sense to design a monitoring protocol for citizen scientists. The idea is simple: more people observing means more information. For example, if someone walks a beach at dawn, another person midday, another at sunset and even another in the moonlight, those are 4 time points of data covering almost two tidal cycles. Having these data points from many beaches in a region may reveal patterns one would not be able to see from just two researchers checking a few beaches once a day.

Results:
The project developed and tested a protocol for successful sandy beach monitoring by trained, volunteer citizen scientists. Thus far, researchers have produced a detailed draft field guide, created a project web site for outreach, www.AllAshore.org, a web portal for data acquisition and database management, and secured a number of non-financial partners and collaborators, including Los Angeles County Beaches and Harbors, to continue the project so that it can be used by educators and students.

Preliminary data analysis indicates the species richness, abundance, and biomass of the intertidal community are significantly lower on urban compared to natural beaches. The composition of the intertidal community also differs significantly, with extensive loss of endemic beach taxa and only a small subset of what appear to be resilient species remaining on urban beaches.

Project Title:
A new method for monitoring urban beach ecosystems

Principal Investigators:
Karen Martin, Pepperdine University; Jenny Dugan, UC Santa Barbara

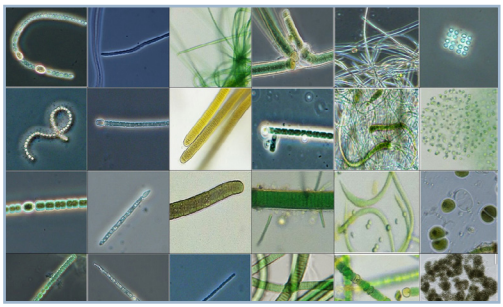
Additional details: http://dornsife.usc.edu/uscseagrant/martin-and-dugan/

3 Previously undocumented phycotoxins found along the Southern California coast

Key outcomes:

1) Results show a large number of potentially toxic species of cyanobacteria from over 50 locations along the coast of Southern California.

2) A collection of species is being established for future public monitoring use and research.



Project Overview:
USC Sea Grant funded research designed to: (1) determine the extent of known or presently-undocumented phycotoxins in Southern Californian coastal waters and estuarine ecosystems; (2) isolate, culture and identify the cyanobacteria/algae that are the origin of the toxins; (3) obtain greater understanding of the phycotoxins at 'hot spots' identified within the region; (4) establish the basic physiological tolerances (temperature, salinity) of these species and their effects on toxin production; and (5) provide information for the development of future monitoring practices.

Relevance:
The confluence of freshwater and marine ecosystems along the coast of Southern California can be affected by multiple toxins of either freshwater or marine origin. The geographic distribution and types of these chemical threats is presently unknown, making it difficult to understand or predict the threats posed to animal health in estuaries and lagoons as well as threats to human health through the contamination of seafood.

Results:
Although only half way done with the project, the key findings to date have already been summarized in a recent publication in the journal "Toxins." Results show a large number of potentially toxic species of cyanobacteria from over 50 locations along the coast of Southern California. Most sampling sites have multiple species of potentially toxic genera of cyanobacteria present, and multiple cyanobacterial toxins were documented at 23% of the sites examined. The establishment of a culture collection of cyanobacterial species has provided a community resource for further research. The culture collection will be made publicly available as it is established and curated.

Project Title:
Documenting multiple phycotoxins in coastal ecosystems of the California coast

Principal Investigators:
David A. Caron, University of Southern California; Eric A. Webb, University of Southern California; Avery O. Tatters, University of Southern California

Additional details: http://dornsife.usc.edu/uscseagrant/caron-2016/

4 Study determines multi-billion dollar economic value of west coast moorage marinas

Key outcomes:

1) Research determined that the economic value of moorage marinas, and marina-related activities, is $4.6 billion annually in Southern California and $8.1 billion annually in Washington State.

2) Analysis of economic and environmental impacts of West Coast marinas are providing insight and tools for sustainable development.

Project Overview:
USC Sea Grant and Washington Sea Grant jointly funded a project to investigate the previously undocumented, net impacts of the economic benefits and the environmental consequences of marinas in Southern California and Washington State. Using newly developed models, the project should provide new insight to environmental management and policy decisions to the related industries and managers involved.

Relevance:
Marina development is increasing in almost all coastal areas, but especially on the West Coast. Local governments are interested in increasing revenues from mooring fees, and the local population supports marinas for the public enjoyment. However, there is lack of research on how mooring facilities harm the marine environment and shoreline health as a result of oil spills, soap and waste discharges, and other environmental consequences. There is also very little research into how these environmental impacts are offset by regional economic benefits.

Results:
Researchers developed a model to look at economic input and output for marinas in both states. Results thus far: (1) For Southern California, the annual direct economic impact (gains) of marina activities is $3.0 billion, and the annual total economic impact (including marina-related industries) is $4.6 billion; and (2) For Washington State, the annual direct economic impact of marina activities is $5.0 billion, and the annual total economic impact is $8.1 billion.

Additionally, sectors (i.e., retail trade, manufacturing, accommodation and food service, information, and professional, scientific and technical services) have been identified in each state that provide the biggest economic gains. These findings set up the next phase of the project to ground-truth model results and determine the economic costs of marinas and the net value of marinas to the economy in each state.

The study has also completed an interactive map of land uses near marinas in the Puget Sound, WA area; a map of oil spill occurrences and quantities from 2011 to 2015; a compilation of tax information from the Department of Licensing, WA; a database of costs of Clean Marinas BMP; and a compilation of the costs of pump out. An interactive online map has been created to share the data collected thus far.

Project Title:
The environmental and economic impacts of moorage marinas on the West Coast

Principal Investigators:
Christine Bae, University of Washington; Nathaniel Trumbull, University of Connecticut;
Jiyoung Park, State University of New York; James E. Moore, University of Southern California

Additional details: http://dornsife.usc.edu/uscseagrant/bae-and-trumbull/

5 Movement patterns of fish through culvert inform restoration plans for 18-acre urban lagoon

Key outcomes:

1) This research has determined the factors influencing fish movement within an urban lagoon with a large culvert in Long Beach, California.

2) Results are being used in the municipal process to determine appropriate mitigation and restoration plans for the 18-acre lagoon.

Project Overview:
USC Sea Grant funded a study on fish movements in a large 268-meter culvert that runs under a park between Alamitos Bay and the 18-acre Colorado Lagoon in Long Beach. Colorado Lagoon is currently undergoing restoration and the study is informing restoration plans. The study aims to understand the movement patterns of fish into and out of the lagoon through the culvert and what factors drive the movements; factors such as the culvert, water temperature, prey species, and others.

Relevance:
There are few studies that have investigated the effects of culverts—tunnel structures that allow water to flow under a road or soil—on fish movements in the marine environment. Concrete box culverts that connect ocean water to coastal wetlands and lagoons can be found in many habitats along Southern California's urban coastline. Understanding their effects on marine life is vital in maintaining or improving these sensitive wildlife habitats, which have diminished greatly in this region.

Results:
Study results show that habitat quality factors such as food availability and water temperature are not driving movements of the fish between the lagoon and the bay by way of the culvert. Rather, a fish's ability to transit the culvert, which may include their size and swimming ability, is driving their movements. Movement patterns showed that many fish were able to move quite freely between both sites and it was noted that the grates, and not the culvert itself, are likely limiting movements of larger fish. This study was shared with the City of Long Beach and helped guide decisions about ongoing restoration plans. Results have also been shared with the interagency review team charged with helping establish a mitigation bank at Colorado Lagoon. This will determine the monitoring requirements as well as acre credits for the proposed mitigation project that involves removal of the culvert. More broadly, study results help us understand the functional recovery of estuaries and improvements for fish from culvert removal.

Project Title:
Understanding fish habitat in a tidally restricted urban lagoon

Principal Investigators:
Christine Whitcraft, CSU Long Beach; Christopher Lowe, CSU Long Beach

Additional details: http://dornsife.usc.edu/uscseagrant/whitcraft-and-lowe/

6 First database of Los Angeles stormwater biofilters and their ecosystem services is generated

Key outcomes:

1) This study compiled the first database and map of Los Angeles biofilters with information about drainage mechanisms and soil microorganisms.

2) The project looks at biofilters from an ecosystem services perspective, providing the groundwork for monetary valuation of biofilter ecosystem services.

Project Overview:
USC Sea Grant funded a study to compile a database of: the locations of existing biofilters in Los Angeles; their linkage to the ocean; the configurations and construction designs; their effects on surrounding plant and animal ecology; and an analysis of the ecosystem services (e.g. water supply, flood control, contaminant removal, biodiversity, pollination, climate regulation, education, recreation, aesthetics) that are provided by the biofilters.

Relevance:
Urban areas in Southern California waste vast quantities of stormwater by letting it flow directly to the ocean. Moreover, this water carries numerous contaminants derived from residential and commercial activity, having a significant impact on coastal water quality. One emerging solution in Southern California is to employ treatment systems such as biofilters which use natural processes, e.g., plant uptake, and living materials, e.g., microorganisms in the soil, to treat urban runoff before it reaches the ocean and augment municipal water supply. However, there are no comprehensive lists of where biofilters are currently being used, quantifications of their ecological attributes, or monetary valuation of ecosystem services provided by these systems.

Results:
This project generated a lengthy list and interactive map of Los Angeles region biofilters, with information about drainage mechanisms (bioretention vs. biofiltration) and distances to the ocean that can be used as the basis of applied research by regulators, industry, or academia. The project provided a first look at biofilters from an ecosystem services perspective, providing the groundwork for monetary valuation of biofilter ecosystem services, information that could be very persuasive for the adoption and implementation of low impact development plans for jurisdictions. Faunal studies will contribute to an international database used to study the importance of soil invertebrates in biofilter function.

Project Title:
Cleaning urban stormwater on its way to the ocean: Ecosystem services from natural treatment systems

Principal Investigators:
Lisa Levin, Scripps Institution of Oceanography, UC San Diego

Additional details: http://dornsife.usc.edu/uscseagrant/levin-2015/

7 New sea level rise vulnerability assessment helps improve restoration of urban wetlands

Key outcomes:

1) This project evaluated 104 wetland systems in the Southern California Bight and created a model projecting regional sea level rise vulnerabilities of wetlands.

2) Results are helping managers across 18 agencies prioritize sites and improve the design of wetland restoration projects, and are contributing to a regional strategy to restore and preserve these valuable systems.

Project Overview:
USC Sea Grant funded a project to improve the understanding of regional sea level rise (SLR) vulnerability of wetlands. The project analyzed sea level rise, vertical land motion, marsh accretion, and estuarine mouth dynamics; and created a model that allows predictions in future wetland changes in elevation and inundation, and impacts to habitat composition. The summation of site-specific habitat change provides a high-resolution understanding of regional vulnerability.

Relevance:
Wetlands in Southern California are geographically sparse, constrained by urbanization, vary widely in size and habitat composition, and are highly susceptible to climate change impacts, such as drought, storm events, and sea level rise. It is critical for managers to evaluate the impacts of climate change at each site when planning restoration efforts and there is a need for a unified regional strategy in order to successfully restore and preserve these valuable systems. Insights into sea level rise vulnerability are needed at scales that are meaningful to both site managers and regional regulators.

Results:
The project evaluated and modeled 104 wetland systems throughout the Southern California Bight which range in size, structure and initial habitat composition. The model results show that for a 2050 SLR scenario, 35% of the systems are vulnerable; and for a 2100 SLR scenario, 68% of the systems are vulnerable. The most vulnerable systems for 2050 are the large perennially open lagoons, indicating that there is a great risk for drastic conversion of marsh habitats to subtidal and mudflat habitats. By 2100, the small creeks and small lagoons also will be among the most vulnerable systems. The highest concentration of vulnerable sites is in Santa Barbara County. This regional vulnerability model provides a platform to prioritize future work based on greatest vulnerabilities. There a number of management strategies that can be incorporated into the model, and 18 agencies across California are using the model results.

Project Title:
Developing a dialog/decision support tool for climate smart restoration in coastal wetlands of Southern California

Principal Investigators:
Cheryl Doughty, UCLA; Kyle Cavanaugh, UCLA; Rich Ambrose, UCLA; Eric Stein, SCCWRP

Additional details: http://dornsife.usc.edu/uscseagrant/stein-ambrose-2015/

8 Study reveals a rapid decline in 19th century of diverse, coastal California seafloor due to siltation from livestock

Key outcomes:

1) After thriving for millennia, the continental shelf ecosystem rapidly collapsed and shifted in the 19th century; this coincided with Mission-Era livestock grazing in coastal watersheds and was thus probably driven by siltation.

2) New scientific methods developed and refined by this study are now being picked up by scientists globally.

Project Overview:
Ten years ago, USC Sea Grant funded a study geologically age-dating young fossil records of dead brachiopod shells (mollusks) preserved in Los Angeles-Orange County open shelf seabeds. The goal was to determine any significant changes in benthic (seafloor) community composition before the start of scientific monitoring in the 20th century or other historic accounts.

Relevance:
Knowledge of the natural baseline for coastal marine ecosystems is critical to understanding the full impacts of humans and the extent of changes that have occurred over the last two centuries. Very little is known about the soft-sediment seafloor of the open continental shelf—especially prior to scientific monitoring in the 20th century—despite its high diversity and importance to fisheries and biogeochemical cycling.

Results:
This study has created one of the most detailed, long-term records of any continental shelf in the U.S. Results show that after thriving for millennia, the shelf ecosystem rapidly collapsed and shifted in the 19th century from one dominated by filter feeding epifaunal animals (scallops, barnacles, and other mollusks that attach themselves to surfaces such as rocks) to widespread muddy sediments dominated by detritus-based benthic communities (animals that feed on dead plant or animal matter). This shift coincides with the rise of Mission-Era livestock grazing in coastal watersheds (reaching carrying capacity by the 1820s-30s) and was thus probably driven by siltation.

This rapid loss of filter-feeding fauna would have altered ecosystem functioning by reducing habitat heterogeneity and seawater filtering. Results indicate that the ecosystem shift was anthropogenic, but 'pre-urban;' as siltation caused by urbanization and industrial fertilization affected shelf ecosystems in the mid to late 20th (and 21st) century. Results also indicate that the negative effects of siltation are not limited to lakes and small coastal water bodies, as previously reported in the literature, and are likely under-recognized on continental shelves elsewhere as legacies of watershed land use.

Initial funding by USC Sea Grant helped transition this research into a $350,000 multi-year National Science Foundation Grant and a decade of support from municipal agencies to continue the work. This study demonstrates the power of using young fossil records to differentiate human drivers and the new scientific methods developed and refined by this study are now being picked up by scientists globally.

Project Title:
19th-Century collapse of a benthic marine ecosystem on the open continental shelf

Principal Investigators:
Susan M. Kidwell, University of Chicago; Adam Tomasovych, University of Chicago

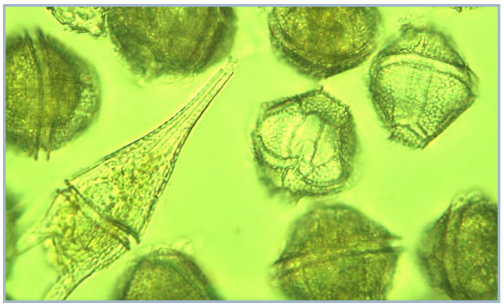
Additional details: http://dornsife.usc.edu/uscseagrant/research-highlight-kidwell-cows/

9 Global climate change may increase the prevalence, size and impacts of toxic algal blooms

Key outcomes:

1) Research shows that *Pseudo-nitzschia* is more toxic, grows faster, and outcompetes all other diatoms with increases in water temperatures and CO2 levels.

2) These results suggest that ecologically and economically devastating toxic events like the one in 2015 are likely to become more common in the future as the California coastal regime continues to warm, and CO2 concentrations continue to rise.



Project Overview:
In response to an ecologically and economically devastating toxic *Pseudo-nitzschia* bloom off the coast of California in 2015 during an unusual warm water event, USC Sea Grant funded research to examine the interactive effects of warming ocean temperatures and CO2 on local *Pseudo-nitzschia* growth and toxin (domoic acid) production.

Relevance:
The unusual warm water event off California in 2015 was accompanied by a massive toxic *Pseudo-nitzschia* bloom that closed crab fisheries and killed off wildlife all along the U.S. West Coast, resulting in multi-million dollar impacts on local marine ecosystems and fisheries resources. Research was needed to demonstrate how global climate change may affect the prevalence of toxic algal blooms off the U.S. West Coast.

Results:
Results, which are now in review for two publications, show that increases in both water temperatures and CO2 levels (similar to those seen in the 2015 warm water event off California) resulted in increased toxicity and growth rates of local *Pseudo-nitzschia* populations. The experiments also demonstrated that the relative abundance of *Pseudo-nitzschia* always increases compared to other co-occurring diatom species when temperatures are elevated, thus this diatom is more toxic, grows faster, and outcompetes all others at warmer temperatures. These experiments suggest that ecologically and economically devastating toxic events like the one in 2015 are likely to become more common in the future as the California coastal regime continues to warm, and CO2 concentrations continue to rise.

Project Title:
Trophic transfer of domoic acid in food webs of the future greenhouse coastal ocean

Principal Investigators:
Dave Hutchins, University of Southern California; Feixue Fu, University of Southern California

Additional details: http://dornsife.usc.edu/uscseagrant/hutchins-and-fu-2014-2016/

10 New mobile tool developed for beach erosion monitoring by citizen scientists

Key outcomes:

1) High quality data was collected during pilot testing of the MoBERM tool by municipal and citizen scientists.

2) Data gathered will be used to calibrate better models for sand berm design.

Project Overview:
USC Sea Grant funded a project to pilot test a mobile data collection tool (MoBERM) that can be used by municipal and citizen scientists to accurately collect data on sand and berm erosion at heavily used urban beaches. The goal is to use the data gathered by municipal and community scientists to calibrate better models for berm design and develop local survey partners along the Southern California coastline to create a monitoring network.

Relevance:
In Southern California, it is common for management agencies to create sand berms to prevent beach erosion and flooding during storms, high tides, and rainfall. It is much less common for management agencies to track and record the performance of these berms over time. Without more time data on these berms, engineers cannot design better berm models. However, adequate data for modeling would have to be captured over large time scales and long coastlines, making it difficult for one research team to complete.

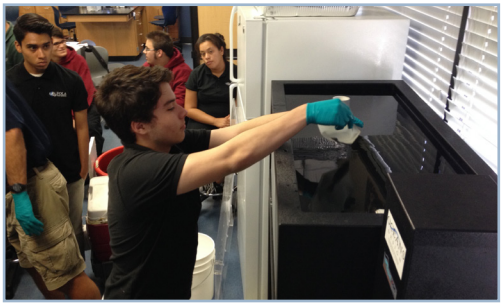
Results:
High quality data was collected during pilot testing of the MoBERM tool by municipal and citizen scientists. The data collected to date confirms that the 2016 El Niño was very energetic, resulting in substantial erosion at San Diego beaches. On the contrary, some beaches assumed to be eroding, like Seal Beach in Los Angeles, did not erode substantially during the season. The next phase of the project includes deploying MoBERM to alternate locations and processing all data to initialize, calibrate, and validate future numerical models for berms; and expanding the network of community partners using the tool.

Project Title:
Mobile Beach Erosion Monitoring (MoBERM)

Principal Investigators:
Robert Guza, Scripps Institution of Oceanography, UCSD
Timu Gallien, UCLA

Additional details: http://dornsife.usc.edu/uscseagrant/guza-and-gallien-2015/

11 New technology improves sustainable aquaculture production



Key outcomes:

1) New, self-cleaning aquaculture tank technology has been proven equal to, if not better than, traditional tank designs in improving larval rearing success.

2) The tank design reduces husbandry labor costs of aquaculture production; seven units have already been sold to businesses, demonstrating a successful and immediate industry application.

3) USC Sea Grant linked this new tank technology to aquaculture education in classrooms through the Seabass in the Classroom program. Students increased their knowledge and skills in a variety of core topics including fish biology and sustainable aquaculture practices.The successful classroom program is continuing.

Project Overview:
USC Sea Grant funded a project through Hubbs-Sea World Research Institute to: 1) improve larval finfish rearing through the enhanced microbial control of self-cleaning tanks (the first technology of its kind in the U.S); and 2) increase public awareness of aquaculture through classroom and public education.

Relevance:
Marine finfish aquaculture production in the United States has significant growth potential, yet this potential is largely unmet due to an uncertain regulatory regime, a public perception of aquaculture that is at times negative, and the need for improved husbandry protocols with reduced cost. Research is needed to advance sustainable marine aquaculture production.

Results:
The project successfully tested the new self-cleaning tank against traditional tank designs for both white seabass and California yellowtail. Larval production yield was robust, and the project even achieved record levels of yellowtail production. After presentations and prototype displays at aquaculture tradeshows, the tank designer, Ocean Design, has sold seven units thus far, demonstrating a successful industry application of this research.

USC Sea Grant also led the expansion of Hubbs-Sea World Research Institute's Seabass in the Classroom aquaculture program at the Port of Los Angeles High School – the program's first school in Los Angeles County. Students received a scaled-down version of the new self-cleaning tank and USC Sea Grant led curriculum development that incorporates the economics and environmental impacts of aquaculture, engineering and technology, biology, water quality, fish husbandry, math, and ways to evaluate human impacts on the ocean. The successful program is continuing into it's fourth cycle at the school. During each semester, students test and refine the tank, and raise white seabass in the classroom: feeding; monitoring growth; implanting an identification tag in each fish; and releasing them into local oceans. Students have increased their knowledge and skills in a variety of core topics.

Project Title:
Technology transfer of self cleaning larval rearing tanks to improve microbial control in fish hatcheries

Principal Investigators:
Paul Olin, CA Sea Grant Extension, Scripps Institution of Oceanography, UC San Diego
Mark Drawbridge, Hubbs-Sea World Research Institute

Additional details: http://dornsife.usc.edu/uscseagrant/olin-2015/