


UC San Diego

SCRIPPS INSTITUTION OF OCEANOGRAPHY



FUTURE OCEANS RESEARCH AQUARIUM

AT THE TED AND JEAN SCRIPPS
MARINE CONSERVATION TECHNOLOGY FACILITY

SIMULATING TOMORROW'S OCEANS TO ADDRESS CLIMATE CHANGE TODAY



As climate change advances, Scripps Institution of Oceanography is leveling up. The effects of climate change are felt acutely around the world, with ocean health and vitality critical for ecological and economic stability. Recognizing that the ocean is rapidly changing, we must prioritize the development and application of premier ocean-based research and technology. Preserving livelihoods and habitability depends on understanding on a small scale what certain changes might do at a large scale.



Scripps Institution of Oceanography at UC San Diego has long been at the forefront of ocean and climate research. Accordingly, we are constructing a **Future Oceans Research Aquarium** in the new **Ted and Jean Scripps Marine Conservation Technology Facility** – improving our capacity for ocean climate research for decades to come. The institution is uniquely positioned to direct operations, assemble research teams, and disseminate the insights generated in the aquarium facility. Our site is ideal for bringing together a critical mass of government, industry, institutional and nonprofit agencies – all within a few-mile radius.

The Future Oceans Research Aquarium will allow researchers to investigate how climate change, ocean acidification and hypoxia will impact marine species, which will help to inform future management and conservation efforts.

While many coastal University of California campuses have some form of a marine laboratory with running seawater and aquarium space, our facility's large footprint of more than 5,000 square feet, versatile tank sizes and shapes, and user control of pertinent conditions are key distinctions. We anticipate it will be in high demand.

The aquarium will be a dedicated resource for studying our changing oceans. Experts from across San Diego and beyond will perform experiments to evaluate the vulnerability of marine species to climate change and associated impacts, as the facility accommodates a variety of species, including finfish, shellfish and seaweeds. Systems can be optimized for given research needs, including manipulating critical physical and chemical environmental conditions, especially those linked to a changing climate – temperature, carbonate chemistry (including pH), and oxygen levels.

Across the road from the facility, NOAA Southwest Fisheries Science Center houses an Experimental Aquarium and an Ocean Technology Development Tank, respectively geared primarily towards rearing species for aquaculture and the testing of new ocean technology. Our facility's design is complementary, focused as it is on experiments related to climate change. Together, they are a powerful combination.

TED AND JEAN SCRIPPS MARINE CONSERVATION FACILITY

The aquarium will be situated in the new Ted and Jean Scripps Marine Conservation Facility (Scripps MCTF), a context that will optimize the important educational, coalitional and public engagement functions of climate change research. The aquarium will be available for scientific research spanning from undergraduate independent research to master's and PhD student thesis work, as well as postdoctoral studies. The Scripps MCTF boasts a 100-person classroom, teaching labs, working labs and conference rooms. Near-term additions include a state-of-the-art data visualization lab, a sustainable seafood demonstration kitchen and classroom, and a public café.

Coordination of aquarium activities will be managed by Scripps Oceanography's Center for Marine Biodiversity and Conservation (CMBC), directed by Stuart Sandin, Oliver Chair for Marine Biodiversity and Conservation. CMBC is a hub for interdisciplinary approaches to understanding and protecting our planet. CMBC will continue coordinating collaborators across a multitude of communities, ranging from government to fishermen to early professionals to young students, providing tours of the facilities and partnering with the Scripps Oceanography communications team to broadcast activities to a variety of audiences.

ADVANCING CLIMATE INNOVATION

The Future Oceans Research Aquarium will be like no other facility in the United States. A place where scientists will be able to explore the current and future impacts of global change on important marine species. A place where current and future professionals in fisheries management and conservation will obtain data on factors affecting their planning. A place where students at all stages of scientific development will get hands-on experience designing studies that actively vary conditions of monumental significance in the future life of our planet.

Your support of Scripps Institution of Oceanography's Future Oceans Research Aquarium will ensure the final stages of construction and near-term operation wrap-up expeditiously and will provide leverage for the greatest use and applicability of this critical resource as we move from planning research to actively conducting it.



RESEARCH SPOTLIGHTS

SOUTHERN CALIFORNIA SEaweEDS IN A CHANGING OCEAN

Kelp forests are among California's most iconic marine ecosystems and are immensely important for supporting biodiversity, fisheries and tourism. A recent study estimates that kelp forests globally generate more than \$500 billion through their impact on fisheries, and are promising targets for nitrogen removal and carbon sequestration. The abundance and distribution of kelp forests and associated plants are linked to a number of environmental and biological factors. However, increases in greenhouse gas emissions and associated increases in seawater temperature mean some of these species have seen widespread declines.

Faculty plan to use the Future Oceans Research Aquarium in a project studying the effects of climate change-induced stressors on California's coastal habitat-forming species. The research will involve a series of laboratory experiments where temperature will be manipulated across the naturally existing thermal range in San Diego, including during marine heat waves. If research identifies more thermally tolerant strains here, it may surface opportunities to sustain and restore populations further north.

Beneficiaries of this research include a broad cross-section of stakeholders, ranging from state management agencies interested in better understanding the vulnerability of California's kelp forests to governmental and nongovernmental organizations interested in exploring restoration

research aimed at increasing resistance of these systems to future warming. Supporting efforts to restore populations to our north, our seedbank will be available for future collaborative efforts.

SPOT PRAWN SENSITIVITY TO OCEAN ACIDIFICATION AND WARMING

Ocean warming and ocean acidification are compounding concerns for marine species, especially those supporting California fisheries. Projected increases in surface water temperature and CO₂ by the end of the century will impact a variety of fish and invertebrate species. Of note, in coastal Southern California, several crustacean species — such as spiny lobster, rock crab and spot prawn — contribute to productive ecosystems and support valuable commercial fisheries. Deeper water species like spot prawn are more vulnerable to ocean acidification and warming because of the narrow range of environmental conditions that typically occur in these habitats. Unsuitable habitats could spur migration to greater depths or higher latitudes, disrupting local fisheries and the communities they support.

With the Future Oceans Research Aquarium, faculty will design experiments to study the effects of ocean acidification and warming on spot prawn. This research will explore whether ocean acidification and ocean warming conditions affect the health of spot prawn by experimenting on adult prawn collected from local commercial fishermen. These insights are essential for



fisheries management — requiring an adaptive approach to changing ocean conditions — which may, for example, prompt migration away from current habitat to depths beyond the range for current methods. While prior studies have revealed potential impacts to other valuable fisheries resources, this would be the first to explore impacts on a highly valuable deep-water species.




CLIMATE CHANGE AND CARBON SEQUESTRATION ALONG THE CALIFORNIA COAST

The ocean absorbs millions of tons of CO₂ every day, affecting all marine life, particularly carbonate-containing organisms like corals and shellfish. Climate change impacts on the ocean include overall warmer temperatures, shifts in circulation patterns, and acidification of ocean water. Together, these impacts affect the biogeochemistry of ocean water.

A project in the Future Oceans Research Aquarium is envisioned to examine a novel marine carbon dioxide removal (CDR) approach to remove CO₂ from the marine environment and sequester it. To test effective balances, the project will develop the Floaters-Coupled-to-Sinkers Carbon Sequestration System (FloCS) to drive the system towards net sequestration. Floating fleshy seaweeds will be coupled with calcified versions, creating "FloCS." These affiliated organisms will be grown under a variety of climate change scenarios to explore the potential of these FloCS to achieve carbon dioxide removal. If effective, these FloCS could act as a form of permanently sequestered carbon if they were to sink to the ocean floor, where they could remain for hundreds to thousands of years.

FloCS are small, easy to manufacture and deploy, and customizable to local needs. They can provide a solution to end-users that can help mitigate the CO₂ levels produced from California businesses and residents, as well as global emissions.



At UC San Diego, we believe that what we don't know today will forever change our tomorrows. Empowered by generosity and fueled by curiosity, we are unafraid to chase the unknown — to ask the questions no one has asked before and to push the boundaries of possibility.

Together with your support for Scripps Institution of Oceanography, we will unite diverse people and unconventional perspectives to propel limitless impact. Because we know that when we come together, nothing is beyond us.

To learn more about supporting the Future Oceans Research Aquarium and the research it will enable, please contact:

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