HSWRI Aquaculture Program Research Newsletter
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HSWRI partners with Scripps Institution of Oceanography for Climate Change Research

Did you know that HSWRI has been working with researchers at the Scripps Institution of Oceanography (SIO) since 2007 to support climate change research? Dr. David Checkley and Dr. Sara Shen have been investigating the effects of ocean acidification on the early life history stages of fish, including white seabass (*Atractoscion nobilis*). Ocean acidification describes the increase in carbon dioxide (CO_2) and decrease in pH of the world's oceans due to the addition of CO_2 to the atmosphere from fossil fuel burning, deforestation, and other consumptive activities.

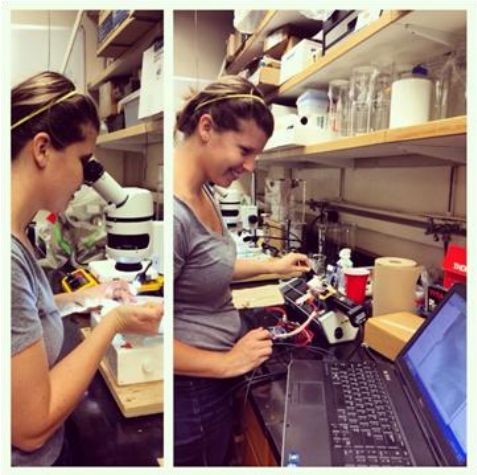

Figure 1. Dr. Shen looking at white seabass larvae under a dissecting microscope (left) before fixing the larvae on a rotating platform (right) for VOR experiments.

HSWRI has provided fertilized white seabass eggs to Drs. Checkley and Shen for experiments on the physiology, growth and behavior of these early life history stages under high CO_2 conditions. In 2009, Dr. Checkley was the first to report that the calcium carbonate ear bones of fish, called otoliths, grow faster under high CO_2. Otoliths play a role in the auditory and vestibular (orientation, balance, and accelerations) systems of fish. Dr. Checkley's findings for white seabass are published in the prestigious scientific journal *Science*.

As part of her PhD research, Dr. Shen explored the functional consequence of larger otoliths on the vestibular system of white seabass larvae by testing an otolith-dependent response called the vestibulo-ocular reflex (VOR). The VOR is an eye movement that counter-acts head or body movement so a fish or person can see clearly when moving. The VOR is important for fish larvae looking for food or avoiding predators. Dr. Shen tested the VOR of white seabass by first rearing the eggs to become 4-day old larvae at either present-day CO_2 concentrations (control, 400 parts per million; ppm) or future CO_2 concentrations (treatment, 2,500 ppm). She then embedded the larvae in a sticky substance called agarose inside of a pipette and rotated the fish up and down on a platform in the dark. During the rotation, Dr. Shen recorded the eye movement of the larvae and later analyzed the data to determine how the VOR of control and treatment fish differed. Dr. Shen found that high CO_2 did not greatly affect this behavior. Her findings are published in the journal Marine Ecology Progress Series.

Figure 2. Experimental system with beakers bubbled with control (400 ppm) or treatment (2,500 ppm) CO_2.

Dr. Shen also investigated the effects of ocean acidification on the physiology and metabolism of white seabass in partnership with other SIO scientists, Dr. Martin Tresguerres and graduate student, Garfield Kwan. Dr. Shen raised larvae under control (400 ppm) and treatment (2,000 ppm) CO_2 conditions and measured the oxygen consumption rate (OCR) of 5-day-old larvae to obtain an estimate of their metabolic rate. She did so by placing groups of larvae into a small glass vial and measuring the decline in oxygen over time with an oxygen microelectrode. The researchers then used techniques called Western blotting and immunohistochemistry to locate and measure the abundance of a protein called sodium potassium ATPase (NKA) in larvae. By staining larvae with an antibody that detects NKA cells, Dr. Shen and colleagues were able to take images of the larvae and count the number of NKA cells.

Figure 3. Image of white seabass larvae showing NKA cells (brown dots) using immunohistochemistry.

While maintaining the normal functioning of physiological processes can be more difficult for fish in stressful environmental conditions, resulting in changes to OCR or NKA protein abundance, Dr. Shen found no effect of high CO_2 on these variables for larval white seabass. The team is in the process of publishing these results.

Dr. Shen said "Simply put, most of my research would not have been possible without the collaborative partnership between HSWRI and SIO. I couldn't be more grateful that HSWRI is supportive of and invested in research outside the confines of aquaculture."

Just for the Halibut – HSWRI and CCA California Collect Broodstock for the Dick Laub Fisheries Replenishment Program

Thanks to the generosity of several visionary philanthropists, HSWRI established the Dick Laub Fisheries Replenishment Program (DLFRP) in 2014 to expand its efforts on white seabass to other native depleted marine species. Working closely with the recreational fishing community and State regulators, California halibut have recently been prioritized as a species-of-interest for future replenishment. However, one of the key challenges that must be addressed going forward relates to the potential that halibut stocks may exhibit a more complex genetic make-up than other pelagic species like white seabass. Specifically, some scientists believe that halibut occur in multiple sub-populations along the coast, in contrast to a single, well-mixed population of white seabass. Until this issue is resolved with more certainty, we intend to ensure that breeding practices in the hatchery meet strict genetic guidelines, whereby halibut offspring are produced

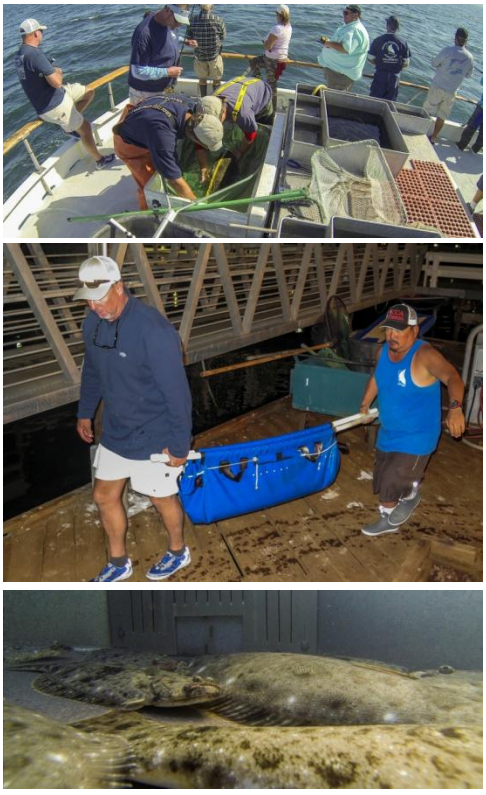

Figure 4. Newly caught halibut is measured and tagged (top); halibut resting in the holding tank (middle); halibut being carried to the transport truck for delivery to the laboratory (bottom).

from breeders originating from a constrained geographic range. At our research facility in Mission Bay, the halibut broodstock inventory consists primarily of individuals from Santa Monica Bay. As the DLFRP has gained traction, the desire for an additional San Diego halibut broodstock has become apparent, especially to facilitate future pilot release studies. This was a perfect opportunity to build on the existing HSWRI–Coastal Conservation Association of California (CCA Cal) partnership, and members are more than willing to help us collect brood fish!

In early November, a team of fifteen CCA Cal anglers and three HSWRI scientists set out from Point Loma on the *Mission Belle*. Local sportfishing captain Ron Baker was also aboard to help guide us to some halibut fishing hotspots. Despite the rough conditions, the trip proved to be a great success – operating under a CDFW Scientific Collection Permit we caught twelve halibut. All fish were carefully brought aboard, unhooked, measured and individually tagged, before being placed in the boat's holding tank until the end of the day. Back at the dock, the anglers assisted HSWRI with loading of the fish onto an oxygenated transport trailer for the short drive to Mission Bay. The halibut were assessed by HSWRI's veterinarian before being given the all-clear and transferred to a quarantine tank.

The CCA Cal anglers and their families followed up the collection trip with a tour of the Mission Bay facility in mid-December, to see the ongoing research being conducted as part of HSWRI's Aquaculture program. Participants heard from several HSWRI scientists on topics ranging from California yellowtail broodstock nutrition to culture of tropical angelfish, and of course the DLFRP. Unsurprisingly, the group was very excited to see the fruits of their labor in the halibut holding tank! Thanks to the careful handling by all involved in the collection trip, the San Diego broodstock have acclimatized well to their new environment and will hopefully produce offspring in the near future. Over lunch, HSWRI staff and CCA Cal participants discussed the next steps in the DLFRP, including future collection trips

Figure 5. Group photo during the facility tour (top); participants get to see their fish in the holding tank (bottom).

to ensure we maintain a healthy San Diego broodstock that will position us well for local experimental releases.

Acknowledgements

This document reports on aquaculture research projects supported by numerous grants, contracts and private contributions. It also represents the hard work of many dedicated staff and volunteers throughout southern California, as well as collaborators around the country. This information was contributed by HSWRI staff and compiled by Senior Research Scientist and HSWRI Aquaculture Program Director Mark Drawbridge.

The aquaculture research program has been active for more than 35 years at HSWRI. The primary objective of this program is to evaluate the feasibility of culturing marine organisms to replenish ocean resources through stocking, and to supply consumers with a direct source of high quality seafood through aquatic farming. Please direct any questions to Mark Drawbridge at mdrawbridge@hswri.org.

Aquaculture research at HSWRI is currently supported by these major contributors:

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- H & M Landing
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- NOAA's Saltonstall-Kennedy Program
- Point Loma Sportfishing
- San Diego County Fish and Wildlife Advisory Commission
- Santa Monica Seafood
- SDG&E Environmental Champions

- Seaforth Sportfishing
- SeaWorld & Busch Gardens Conservation Fund
- SeaWorld Parks and Entertainment
- SeaWorld San Diego
- Sempra Energy Foundation
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- The California Department of Fish and Wildlife's Ocean Resources Enhancement and Hatchery Program
- The Catalina Seabass Fund
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- The Shedd Family
- The U.S. Fish and Wildlife Service's Sport Fish Restoration Account
- United Soybean Board
- USC Sea Grant
- USDA National Institute of Food and Agriculture
- Western Regional Aquaculture Center (WRAC)

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