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Title

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Salinity Tolerances and Biomarkers of Salt Stress in Longfin and Delta Smelt

Brittany Kammerer, Delta Science Fellow

BACKGROUND

San Francisco Bay's estuary and delta have been rapidly changing due to freshwater diversion, changing water flows, and decreasing low-salinity habitat, which is used by smelt. As a result, Delta smelt (CA and Fed endangered species) and Longfin smelt (CA threatened, Fed proposed) have been subject to changing habitat location and conditions.

These species spawn in freshwater but may be exposed or move quickly to low salinity habitats in the dynamic estuary. When the Low Salinity Zone moves near water export facilities in the Delta, smelt are at risk of entrainment, or being carried out of their habitat by water flow into a harmful environment.

Although it appears that smelt migrate and select habitat based on salinity gradients, little is presently known about how they adapt physiologically to changing salinities. This information could provide key insights into smelt habitat requirements in the San Francisco Bay-Delta.

The critical habitat for Delta smelt, above center, has been rapidly changing. Largely influenced by freshwater diversion, decreased low-salinity habitat, and changing water flow influenced by global climate change, both the Delta smelt and Longfin smelt face uncertain conditions in the San Francisco Estuary (SFE).
 IMAGE: US Fish and Wildlife Service



PROJECT

The Fellow experimentally tested the physiological tolerance limits of Longfin and Delta smelt larvae and juveniles to increases in salinity.

The Fellow also examined the physiological mechanisms for acclimation and biomarkers of salinity responses in adult Delta smelt. Additionally, the Fellow explored the effectiveness of two salt formulations (Instant Ocean and NaCl) for salinity stress experiments.

Several pelagic fishes of the SFE have experienced a considerable decline since 2001. Even prior to 2000, the delta smelt, top right, had been listed as endangered by California and the U.S. government.
 PHOTO: US Fish and Wildlife Service

Text



Fellow Brittany Kammerer performs a necropsy of a Delta smelt to identify key physiological effects of salinity and identify biomarkers indicative of successful acclimation and unsuccessful acclimation to salinity stress.
 Photo courtesy of the Aquatic Health Program at UC Davis

“Predicted increases in regional and global climate may change the hydrology of the Estuary and Delta. It is imperative that we address the influence of salinity as an abiotic habitat factor.”

-Brittany Kammerer, Delta Science Fellow

RESULTS

Results revealed that smelt undergo many physiological changes in order to move through salinity gradients. They were able to survive 10 ppt salinity at all life stages, at increases of 1, 2, and 4 ppt. Changes as little as 2 ppt initiate a physiological response.

Following increases in salinity, adult Delta smelt exhibited increases in blood hematocrit, plasma osmolality levels, and muscle water content – all of which decreased to freshwater levels after 4 days. Likewise, chloride cells showed increased apoptosis, Na⁺/K⁺ ATPase and cell size over time in salty water, indicating that turnover to new, salinity-tolerant chloride cells occurs. These results signify that osmoregulatory changes in chloride cells regulate Delta

smelt's transition to brackish water, and can be used as biomarkers in monitoring their response to changing salinity. Responses in hematological parameters and muscle water content may also be used as biomarkers.

Rearing trials of Longfin and Delta smelt larvae revealed that mortalities increased and feeding rates decreased dramatically at low rates of salinity increase (1ppt/week) for NaCl relative to Instant Ocean (IO), suggesting IO is more effective for larval salinity tests. Subsequent tests on juvenile smelts at 2 ppt increases in salinity showed no significant differences in gut fullness or survival between IO and freshwater treatments, and both species grew over the course of the treatments.

MANAGEMENT APPLICATIONS

This research provides new information on the physiological effects of salinity on smelt, and will help predict the potential impacts of changing hydrologic regimes. Additionally, understanding salinity responses at different life stages will allow for management of suitable low salinity and potentially spawning habitat. Knowing the timing and speed at which smelt can acclimate from fresh to saline water will allow managers to monitor and control Delta flows for smelt survival.

POSTERS

Kammerer, B., R. Baxter, and S. Teh. (2014) Physiological responses of Delta smelt to low salinity acclimation. 8th Bay-Delta Science Conference. Sacramento, Calif.

Kammerer, B., G. Tigan, J. Lindberg, and S. Teh. (2013) The effects of salinity on Longfin smelt larvae in rearing trials. Inter-agency Ecological Program Workshop. Folsom, Calif.

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