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This document represents a summary of NSE project findings to date. Detailed information can be found in previous annual reports and in three University of Florida Master's Theses all available at this web page

(http://floridarivers.ifas.ufl.edu/NSE.htm)

Introduction- The "Nearshore Ecology" (NSE) project was designed to assess two key fundamental research questions related to our knowledge of humpback chub population ecology.

> (1) Do steadier flows during late summer and early fall increase survival, abundance, and/or growth rates of juvenile native and non-native fish?
> (2) Do juvenile humpback chub select specific habitat types and if so, does this selection change under different river flow regimes?

Background- Glen Canyon Dam is operated primarily as a load-following hydropower facility, increasing and decreasing dam discharge to match power demand. This periodic "flushing" of the river reduces the residence time of water as well as the availability of certain shoreline habitat types. In contrast, steady flows can increase the retention time of water in littoral areas such as backwaters and low-angle shorelines, and if discharge volume and ambient temperature are appropriate, can locally increase water temperatures. The NSE project evaluated experimental steady flows that occurred from 1 September- 31 October in each year 2009-2011. This study took place between river km 102-106 just downstream of the confluence of the mainstem Colorado and Little Colorado rivers, where most prior research on humpback chub in Grand Canyon has been completed. The timing and magnitude of the steady flow experiment was developed by resource managers independent of the NSE team and experimental flow regimes were about 10% of the unregulated (pre-Glen Canyon Dam) annual fluctuations.

Prior to the NSE project, our understanding of juvenile humpback chub ecology in the mainstem Colorado River was deficient compared with our knowledge of adult humpback chub primarily because of limited sampling of mainstem habitat for juvenile life stages. The NSE project developed a sampling and analytical framework to directly assess juvenile humpback chub survival, abundance, individual growth, and habitat use through spatially referenced mark-recapture experiments with multiple gear types. This direct assessment of key vital rates complements indirect approaches used to estimate survival through population modeling efforts. For example, age-structured-mark-recapture (ASMR, Coggins et al. 2006) reconstructs juvenile abundance and survival through time from adult population numbers (estimated from mark-recapture) and assumed survival relationships based on life-history characteristics and growth rates. In contrast, the NSE project directly estimates juvenile fish population metrics, in terms of abundance, survival, growth, or habitat use, which is useful for rapidly assessing how juvenile humpback chub respond to management actions such as experimental flows.

Results and Discussion- The NSE project found that annual apparent survival of juvenile humpback chub (size at tagging < 100-mm total length, "TL") did not differ significantly between the extant fluctuating flows and the experimental steady flow treatments. The NSE project also documented that juvenile humpback chub were able to survive and rear in the mainstem Colorado River even at small sizes of 40-100 mm TL. A somewhat surprising finding was that growth in juvenile humpback chub declined during these short-term steady flows versus fluctuating flows even though water temperatures were generally similar between the fluctuating and steady flow treatments (Finch 2012). Reasons for this counterintuitive growth response are not known, but Finch (2012) hypothesizes that food availability in the drift (primarily aquatic insects) may change between fluctuating and steady flows with higher food resources found in fluctuating flows.

In Grand Canyon the creation, maintenance, and persistence of specific habitat types considered critical for the persistence and recovery of native fish populations, including humpback chub. For example, backwaters are thought to be more similar to the Colorado River ecosystem prior to river modification because they are generally warmer and may be less influenced by river stage and dam operations than other mainstem habitat types. The NSE study compared abundance, density and habitat selection patterns between shoreline habitats (cliff, talus, debris fan, sand, backwater) and found that abundance of juvenile humpback chub was consistently highest in talus habitats and lowest in backwater habitats (Dodrill 2012). Juvenile humpback chub did show positive selection for backwater habitats, but in the NSE study reach, the spatial extent of backwater habitats was small compared to other habitat types, so the overall abundance in backwater habitats was low compared to other habitat types. Additionally, ultrasonic telemetry of larger juvenile humpback chub (about 180-190-mm TL) found that habitat selection and daily movements did not change between fluctuating and the steady flow experiment (Gerig 2012). This suggests that, at least in this reach of the Colorado River, management actions directed at manipulating this habitat type will affect a small proportion the habitat, and the population, of humpback chub. Because the NSE study reach is a section of Grand Canyon with steep bank angle, the available habitat in this reach is robust to changes in river stage associated with the range of flows observed from 2009-2011. Future work could assess whether juvenile humpback chub are similarly robust to changes in a river reach where available habitats are more flow sensitive.

Conclusions- The NSE project provided a sampling and analytical framework to directly assess juvenile humpback chub (and other fish species) population responses to management actions at smaller fish sizes than were previously possible. This framework is important, as the key outcome from many different types of management actions in the Colorado River is to improve survival of juvenile humpback chub, increasing overall abundance and accelerating the population to recovery. The NSE project also documented that small juvenile humpback chub can survive and rear in the mainstem Colorado River. This is important because over the past decade adult humpback chub numbers (age 4+) have increased and one possible explanation for this increase is improved survival in the mainstem Colorado River (Coggins and Walters 2009).

The results of the NSE project suggest that juvenile humpback chub survival, growth, abundance, and habitat use are robust to the fall steady flows observed during 2009-2011. It is likely that more extreme flow treatments (higher or lower discharges, longer duration) are required before changes in these metrics would be observed. This data demonstrating the apparent flexibility of juvenile humpback chub in habitat selection regardless of flows as well as the growth, survival, and persistence of juveniles in the mainstem Colorado River are invaluable additions to the body of knowledge available for managing both the Colorado River and regulated rivers globally.

Outcome products

We are currently preparing results for submission to peer reviewed journals in cooperation with agency partners. Topics of potential manuscripts include:

(1) A paper describing growth and survival of juvenile humpback chub in response to the flow experiment
(2) An assessment of movement and habitat use for large juveniles from telemetry
(3) Estimation of juvenile humpback chub density in different habitat types
(4) An evaluation of predation risk for juvenile fish in different habitats
(5) An assessment of juvenile humpback chub growth and provenance for juvenile humpback chub.

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