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Restoration of fish habitat in the Provo River: a multispecies approach

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BACKGROUND

Historically, the Provo river, located in Utah and Wasatch Cos., Utah, was a clear-flowing stream with headwaters in the western edge of the Uinta mountains that emptied into Utah Lake near Provo, Utah. The river had a wide flood plain and a braided channel, especially in the Heber valley and Utah valley areas. Diversion of water and construction of water storage facilities began in the late 1800's and intensified in the 1900's. Deer Creek reservoir was built in the 1950's and diking and channelization continued until the construction of Jordanelle reservoir in the late 1980's. The Provo River Restoration Project, began in the early 1990's, is a federally funded project.

Originally, the Provo river contained at least 10 species of native fish. These included two salmonids, the Bonneville cutthroat trout, with large-bodied forms in the lake and lower river and probably smaller forms further upstream, and mountain whitefish. The rest of the fish fauna was made up of two species of suckers, two species of dace, leatherside chub, Utah chub, redside shiner, and mottled sculpin. June suckers, a lake sucker endemic to Utah lake, used the lower several kilometers of river to spawn every year. Brown trout, *Salmo trutta*, were introduced in the early 1900's, probably in response to declining numbers of cutthroat trout and a desire for more sport fishing opportunities.

Extreme channelization and fragmentation combined with introduction of brown trout created a large change in the fish fauna in most of the Provo River. Most segments are now dominated by large populations of brown trout and mottled sculpin. This combination of simplified habitat and large populations of an introduced predator appears to have led to the decline of native species in most segments of the river.

OBJECTIVES

The goal of the Provo River Restoration Project is to recreate a natural river channel where native species might be able to persist and to continue to provide recreational fishery opportunities. However, the presence of brown trout as an important fisheries species meant that we had to determine what type of habitat was required to allow vulnerable native species to coexist (if possible) with brown trout. Typically, habitat restoration is done in a single-species framework. Usually, for fish habitat this means trout habitat. We wanted to create habitat that would benefit native species as well, so we took a multispecies approach. We asked Awhat are habitat requirements of native nongame species? Can they coexist with the introduced brown trout? In short, if we build it will they come...back?

METHODS

We used a three-prong research approach to answer these questions. First, we did surveys of habitat use and abundance of fish in streams where brown trout coexisted with several native species. Second, we did manipulative experiments to determine the possible mechanistic relationship between vulnerability to brown trout and habitat structure. Third, we monitored and compared fish community development between segments of the river with differing characteristics and before and after habitat restoration.

To determine whether presence of brown trout affected habitat use of native species we conducted snorkel surveys of areas with and without brown trout. A total of six areas were surveyed. Three contained large numbers of brown trout, and the other three had few or no brown trout. At each location where fish were observed the following variables were recorded or measured: species, number, age class (young-of-year, juvenile, or adult), location in water column, depth of water, water velocity (measured using a handheld velocity probe), substrate particle size, cover level, and type of mesohabitat occupied (main channel pool, riffle, or run; or off-channel backwater, or cut-off pool).

Habitat use was compared at two scales. Changes in microhabitat use by species were determined by comparing mean water depth, water velocity, substrate size, and cover level for each species between study areas with an without brown trout. Mesohabitat use was measured as the percentage of total observations of a given species occurring in a given habitat type. For purposes of this analysis mesohabitats were divided into main channel and off-channel habitats. Percent occurrence for each species in each habitat type was compared between locations with and without brown trout.

To determine the vulnerability of native species to brown trout we conducted mortality experiments in enclosed stream segments. We tested for mortality of prey species with and without brown trout and to different sizes and numbers of brown trout. Enclosures were electroshocked to remove fish, and then a known number of prey fish were placed in the enclosure. Brown trout were added to the enclosure and allowed to remain for three to four days. At the end of the experiment we removed all remaining fish. We calculated mortality rate as the number of fish at the beginning of the experiment minus the number recovered at the end divided by the number at the beginning of the experiment. Two different experiments were conducted. Differences in mortality rate among treatments was determined by analysis of variance.

In addition to enclosure mortality experiments, we also conducted experiments to measure habitat choice and activity level and escape response of leatherside chub and redside shiner to the presence of brown trout. Habitat selection and activity level were evaluated in the presence and absence of brown trout in 2 m diameter, 1100 L plastic tanks. Individual tanks were arranged such that four different habitat types were equally available for the prey to inhabit. These four types were: shallow water no cover, shallow water with cover, deep water no cover, and deep water with cover. Five individuals of either leatherside chub or redside shiner were placed into the tanks and allowed to acclimate for 30 minutes (a time when behavior seemed to become consistent in pre-trials). After acclimation, position of each fish (in or out of cover and shallow or deep) was recorded at one minute intervals. In addition, 1 of the 5 fish was monitored continually and activity level (swimming or stationary) was recorded at 30 second intervals. Position and activity level were recorded for 30 minutes after which one brown trout was added to the tank. The trout was allowed to acclimate for 10 minutes (again a time determined through pre-trials) and the same observations were recorded for the prey fish. Proportion of individuals in each habitat and proportion of time active was compared between treatments with and without brown trout.

Escape response of leatherside chub and redside shiner was evaluated by measuring reaction distance, flight speed, number of turns, and angle of flight in response to simulated predator attack. Individuals of each species were tested in a circular trial arena (61 cm diameter, 10 cm water depth). Fish were placed in a 10 cm diameter transparent enclosure located in the center of the arena. After the fish had stopped moving and was facing directly toward the area where the model predator would emerge, a lever was tripped allowing the model brown trout to rapidly enter the arena. Responses to the emergence of the brown trout were recorded via a video camera located above the arena. Differences between species in the four variables were determined using analysis of covariance with total length as the covariate.

RESULTS AND DISCUSSION

Habitat surveys showed an almost complete shift of leatherside chubs, juvenile mountain suckers, and possibly other species out of the main channel and into off-channel habitats when brown trout were present. Sculpin and adult mountain sucker did not appear to shift habitats. Mortality experiments suggested that juvenile leatherside chub and redside shiner were highly vulnerable to predation, but leathersides were about 4X more likely to die than redside shiner. Leathersides and redsides employed different responses to presence of predators. Redsides increased activity in the presence of brown trout whereas, leathersides decreased activity. Redsides reacted faster and employed a more complex escape response compared to leathersides. Overall, leatherside chub seem to be the most vulnerable to brown trout. Their coexistence with brown trout seems to depend on availability of off-channel habitats that allow leathersides to avoid coming in contact with brown trout.

Based on these recommendations, the new channel was designed to increase complexity and to provide a large variety of off-channel type habitats. Did this work to increase the likelihood of coexistence? Results of the pilot project are encouraging. First of all, off-channel habitat and habitat variability was greatly increased in the pilot area. New off-channel habitats have a different fish community, dominated by native species, compared to the main channel. A reintroduced population of leatherside chubs has persisted for at least one year and reproduced. Abundance of brown trout in the main channel has increased dramatically. We believe that this increased diversity in habitat types will result in a diverse assemblage of native species that can coexist with large populations of brown trout. Preliminary results seem to indicate that by focusing on the most vulnerable species, and habitat required by them, we can have a great fishery and stable populations of native species.