CHEHALIS BASIN STRATEGY

SATSOP PONDS

Study Goals and Objectives

Encompassing a cumulative ~ 13.6 acres, the Satsop Ponds are located just east of the Satsop River, 1.0 mi upstream of the confluence with the Chehalis River. The Lower Satsop River Habitat Restoration Project included habitat restoration of three off-channel ponds (**Figure 1**) in a phased experimental approach. Our goal with this experiment was to study amphibian and fish responses to restoration treatments (shallow water creation, spoil piles/dike removal, and increased floodplain connectivity). The project aimed to improve riverine connectivity and habitat in the floodplain and reduce riverbank erosion by absorbing higher flows into the ponded area.

To support this effort, we began monitoring this site including its seasonal ponds in March 2015. Monitoring from 2015-2019 documented baseline conditions at the ponds prior to restoration. In 2019 & 2020, post-restoration monitoring began and will be completed in 2023.

Figure 1. *Satsop Ponds Pre-Restoration Footprint (left). Lines approximate positions of ponds, dikes, and spoils areas. Temporary (Auxiliary) Ponds (right) associated with permanent Pond C at the Satsop Restoration Sites*

With increased connectivity, we anticipated a shift toward a greater range in stage, a reduced seasonal water temperature profile, and potentially a higher seasonal dissolved oxygen profile. We expected that these physical shifts will promote greater native species composition and abundance, and a shift toward fewer exotic species or numbers. Our pre- and post-monitoring on a suite of aquatic or aquatic-associated vertebrates should enable us to determine whether these restoration efforts favor native over exotic species.

Methods / Study Design

Phase 1: We commenced restoration actions on Pond C during summer 2019. These actions included excavating approximately half of the spoils pile and placing material into Pond C to shallow the margins on the North and West sides. All large trees removed from the spoils pile were placed in the ponds to provide shallow water habitat cover. The remaining small trees were placed in discrete piles in the floodplain for wildlife habitat. Care was taken to recreate lost auxiliary ponds

used by Long-toed Salamanders and Pacific treefrogs, by creating compacted swales that would hold temporary water in winter.

Phase 2: In June 2020 the restoration to improve the hydrological connection for Ponds B by removing all remaining spoils and dikes began. We used the removed spoil materials to shallow Pond B and create shallow water habitat ideal for amphibian breeding and dabbling/wading birds. In addition, we also removed rock toe and rip rap located north of Pond A and B along the river to allow increased bank erosion and engage historic channels that run into the ponds. This increased overall reconnection and flood storage into the general pond areas. Active flooding in winter continues to expose more rip rap for ongoing removals.

In 2018 prior to restoration actions, an active channel scour on the north end of Pond C developed due to high flooding causing erosion around the rip rap on an upstream bend of the river. This allowed waters to re-engage an old channel during extreme events, scouring into Pond C (**Figure 2**). This was the same year there was an avulsion event just downstream of our project site that disconnected an entire oxbow from the rest of the river.

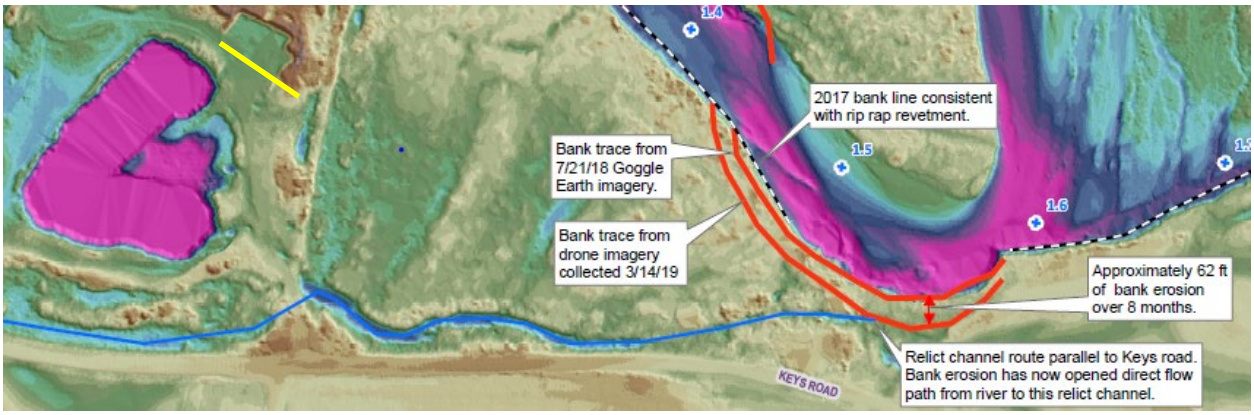

Figure 2. *Pond C (in pink, left side) natural re-engagement with Satsop River due to rip rap erosion. High waters flowed around rip rap, engaged the relict channel, and moved out of channel to scour across an access road (area in yellow) into Pond C.*

Data collection: Monitoring for focal amphibians was conducted using a combination of egg mass (EM) and off-channel extensive surveys (OE). We used visual encounter surveys for EM as these are the most common and effective way to monitor amphibian presence and breeding abundance. We conducted EM surveys at water depths of up to 1m supplemented with dip net sampling in both permanent and temporary ponds. Because dipnet sampling efficiency can be limited for some fishes, we added one electrofishing survey to the EM effort starting in 2016. For all aquatic vertebrates encountered, we recorded the identity and life stage of all species.

OE surveys were conducted over two-days exclusively in the permanent ponds and were designed primarily for fishes and turtles, but also could detect invasive American Bullfrog. These surveys involved 10 evenly spaced vegetation transects where vegetation composition, percent cover, water temperature, deepest depth, visibility, wetted widths, and distance between transects were recorded. Animal sampling involve dip net surveys, minnow traps, and fyke nets. All traps were left overnight and retrieved the next day and captured animals were processed and released. One electrofishing survey identical to that performed for the EM surveys was added to each extensive survey beginning in June 2016.

We recorded incidental observations on other highly aquatic species like American Beaver or predatory mammals like River Otter. Observations of these species include direct observations of

animals or various observations of sign such as lodges, dams, dens, scent mounds, chews, or middens. We also established permanent photopoint stations around each pond to photo archive gross water level, vegetation, and habitat changes. At each photopoint photographs were taken at 30° increments covering the full 360° in late winter/early spring, summer and fall.

Summary of Results

Winter 2020-2021 was the first high flow season after all completed restoration actions across the pond complex. The restoration site is fully functioning to absorb flood waters from the Satsop River for storage after our rip rap, dike, and spoils pile removals and active channel reengagement (**Figure 3, Figure 4**). Enhancing a connection from the upper end of Pond C was not part of our restoration plans but, because the river independently re-engaged, we decided to actively contribute to this ongoing process.

Figure 3. *Drone flight of January 2021 high water event (DFW, Jane Atha). All ponds are connected to the river.*

Figure 4. *January 2021 drone flight showing Phase 2 restoration activities to enhance hydraulic connection and overflow channel into Pond C fully engaged.*

***OFF-CHANNEL HABITAT MONITORING*:**

The Pre-restoration monitoring phase occurred from 2015-2019 for Pond C and 2015-2020 for Pond B. Of the seven amphibian species found during this phase, six were native: Northwestern Salamander, Long-Toed salamander, Pacific Treefrog, Northern Red-Legged Frog, Roughskin Newt, and Western Toad. The seventh amphibian species was the non-native American Bullfrog.

Twelve total native fish were recorded across the pond complex. Seven species (Largescale sucker, Northern pikeminnow, Pacific Lamprey, Prickly sculpin, Speckled Dace, Redside shiner, and Three-spined stickleback) were recorded in all three ponds. Lampreys were the only native fish taxon recorded exclusively with electrofishing. The other species of native fish (Chum, Rainbow Trout/Steelhead, Olympic Mudminnow, Torrent and Riffle/Reticulate Sculpin) were captured in at least one pond. Five taxa (Northern Pikeminnow, Olympic Mudminnow, Redside Shiner, Speckled Dace, and sculpins) comprised most observations of native fish, with sculpins representing over half of our observations. Juvenile Chum were represented by relatively small fry and found in the pond closest to the river (without a levee around it) that still receives flows during high flow events; we speculate that these were deposited during high flow events. Of the eight non-native fishes, three centrarchids (Bluegill, Pumpkinseed, and Rock Bass) dominated and all three were found in each permanent ponds. The remaining five species were each found in one pond (Brown Bullhead in Pond A, Yellow Perch and Common Carp in Pond B, and Black Crappie and Largemouth Bass in Pond C). Prior to restoration, we also recorded American Beaver, River Otter and the exotic Red-eared Slider Turtle. We found both the non-native Asian Clam (*Corbicula fluminea*), at least one species of native freshwater mussel (Floater Mussel; *Anodonta spp.*), and large jelly-disc colonies of bryozoan.

During Post-restoration surveys through 2022 we have observed at least 20 species of amphibians and fishes; fourteen were native, six were non-native, seven were amphibians, and thirteen were fishes. There has been no difference on the suite of amphibian species found. Of the thirteen fish species, eight were native: Coho Salmon, Largescale Sucker, Northern Pikeminnow, lamprey sp., sculpin sp., Redsided Shiner, Speckled Dace, and Three-spined Stickleback. Juvenile Coho have been captured in the center pond which had been completely isolated for a long period prior to restoration. We have yet to capture Olympic Mudminnow during post-restoration surveys, however observations of Mudminnow were relatively small and sparse during pre-surveys. The remaining five fish species were non-native: Black Crappie, Bluegill, Brown Bullhead, Pumpkinseed, Rock Bass. There are three species of non-native fish that have not been encountered post-restoration: Yellow Perch, Largemouth Bass and Common Carp.

Statistical analysis of species assemblage change is pending our final year of data collection in 2023.

Discussion

The pond complex contains all five native stillwater-breeding amphibian species that are known to reproduce in off-channel wetlands elsewhere within the Chehalis River floodplain. Besides these five species, we also found juvenile Western Toads in the riparian area adjacent to the Ponds. This pattern agrees with what we have found elsewhere in the Chehalis floodplain, where Toads appear to only be riverine breeders and Toad breeding does occur in the nearby Satsop River. Although breeding does not occur in these habitats, offchannel areas act as rearing grounds for metamorphosed and juvenile toads.

Overall breeding abundance of native amphibians in the permanent ponds is low in comparison to many sites within the Chehalis floodplain, where dozens to hundreds of egg masses of amphibians have been found. Low native amphibian production may reflect the influence of either biotic or abiotic factors. In the permanent ponds of the Satsop complex, these factors are most likely to originate from exotic warm water species of fish and bullfrogs that are predators or competitors and habitat suitability that relates to pond structure (e.g., too deep, limited oviposition habitat).

The shallowing of the deeper, permanent ponds may provide ideal water depths and newly planted low emergent vegetation habitat may provide the structure that is important for the breeding and rearing of native amphibians and is important habitat for the Olympic Mudminnow, a Washington State sensitive fish species. Our restoration actions were tailored to create shallow shelves as potential habitat for native amphibian breeding and larval development. In addition, we planted emergent vegetation to add structure for egg braces. Whether these habitat alterations offset any impact of exotic fish is still to be seen and may require some adult immigration from outside the area.

The temporary ponds currently provide a unique seasonal breeding and rearing habitat currently not available elsewhere within the pond complex. Long-Toed Salamanders and Pacific Treefrogs used these seasonally short-lived ponds heavily; both species are capable of developing through metamorphosis relatively rapidly. Both species can also breed in the permanent ponds, but the temporary ponds are both typically aquatic predator free (especially of warmwater exotics) and likely have thermal regimes, especially during the day, that favor accelerated development. Hence, though opportunity exists for these two species to breed in the permanent ponds, their vulnerability to predation likely results in their higher densities in the temporary ponds.

A final analysis of physical habitat changes pre- and post-restoration is pending the final year of data collection in 2023. We anticipate that the improved connections between the ponds and the Satsop River mainstem will shift physical conditions such that 1) the seasonal variation in stage will increase, 2) the seasonal thermal profile of the pond will decrease, and 3) seasonal dissolved oxygen variation in the pond will probably increase.

Adaptive Management

This work represents a case study that can inform Steering Committee decisions around projects that connect or reconnect offchannel habitats to streams. The goal of this work was to improve habitat conditions for native species and reduce conditions that support exotic species. Although habitat conditions have qualitatively improved, restoration actions have not clearly resulted in improvements to native species populations or communities but neither have they been detrimental. However, exotic species also do not seem to have been influenced yet by the restoration actions. Noteworthy here is that these focal ponds are very deep historical borrow pits and do not reflect most offchannel habitats in the Chehalis Basin. As such, other offchannel reconnection projects targeting relatively natural offchannel habitats will provide different insights. Regarding connecting such deep, atypical habitats to streams, it remains unclear as to whether restoration is capable of providing sufficient habitat for native aquatic species while negating the impacts of exotics. Accordingly, such an action may not be the most prudent project type for the ASRP unless the ponds' depths and hydroperiods are greatly reduced.