Determining the influence of high flows of the spawning behavior of chum salmon at Ives Island

Project 1999003 (Task 4.4)

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This document is a detailed study plan for work proposed on BPA project 1999003 by the U.S. Geological Survey for the period from October 1, 2004 through September 30, 2005. This plan is an adaptive response to new information acquired on chum salmon behavior in 2003 and current management practices to protect spawning chum salmon below Bonneville Dam. This work was proposed in the project's FY05 statement of work to the BPA, but more detail is provided here to solicit the input of the FPAC, TMT, and BPA to keep this study relevant to the needs of the fishery managers.

<u>Background</u>

The current management strategy to protect spawning chum salmon at Ives Island is to maintain a stable Bonneville Dam tailwater elevation of 11.5 feet. From November 1 through December 15, 2003, tailwater elevations exceeded 13 feet on 17 occasions and they exceeded 14 feet on 14 occasions, with most of these events occurring at night in December due to reverse load following. These tailwater elevations corresponded to flows in excess of 150 kcfs. Our previous habitat assessment work showed a significant reduction in the amount of suitable chum spawning habitat at flows >150 kcfs in the area below the mouth of Hamilton Creek (Garland et al. 2003) likely due to increased water velocities.

<u>Working hypothesis</u>

As flows increase, chum salmon spawning habitat suitability will decrease to a point at which fish behavior will be altered.

<u>Expected responses</u>

1. **None –** fish maintain position over their redds (no change in behavior).
2. **Temporary displacement, but return to spawn –** fish temporarily move into slower water velocities near shore and subsequently return to their redds and spawn when conditions become suitable.
3. **Displacement with spawning elsewhere –** fish are displaced from their original locations and seek new areas for spawning.
4. **Displacement without spawning elsewhere –** fish are displaced from their redds and do not complete spawning.

<u>Objectives</u>

1. Determine the flow and tailwater elevation at which chum salmon spawning behavior is altered.
2. Determine where fish go in response to high flows and when they return to their redds.

3. Determine if normal spawning behavior resumes after a flow-induced change in behavior.
4. Determine if fish will spawn at higher riverbed elevations as higher flows inundate these areas.

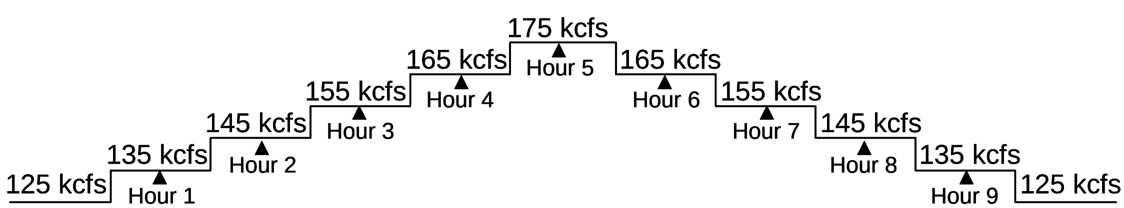
Approach

We will capture, tag, and release chum salmon with acoustic tags and determine their 2-D locations during tests using fixed hydrophones and an acoustic receiver. Spawning behavior (e.g., digging, tail crossing, chasing) before and after tests will be documented using an acoustic camera. During and after high-flow tests, higher riverbed elevations will be searched for evidence of chum salmon redd construction. At higher flows, hyporheic temperatures will be measured to determine the suitability of higher riverbed elevations for chum salmon spawning.

Methods

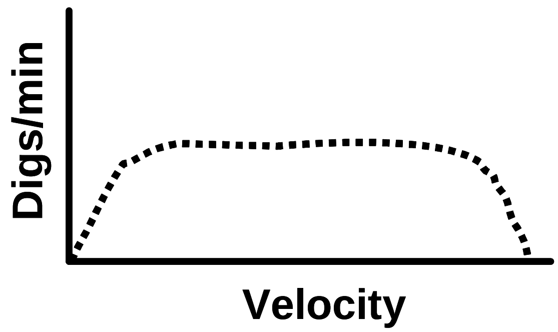
A total of 30 female chum salmon will be collected in conjunction with WDFW seining activities. Six fish will be gastrically tagged with an acoustic transmitter each week from November 9^{th} through December 9^{th}. Fish will also be floy tagged to allow for visual identification in the study area. The location of tagged fish will be determined with an acoustic receiver and hydrophones placed throughout the area from the mouth of Hamilton Creek to the fish wheel pilings. The study will be limited to this area in 2004 due to logistical and equipment constraints. The acoustic receiver will log the two-dimensional fish locations continuously. An acoustic camera will be set up to observe at least one fish per test.

On ten separate occasions, or trials, we will request experimental increases in flow from Bonneville Dam to measure fish responses. Five of these will be at night and five will be during the day. We will coordinate flow requests so as not to interfere with the work of other study cooperators. We request that flows be increased from 125 kcfs to 175 kcfs over a period of 5 h in 1-h increments and ramped back down in a similar manner as shown below.

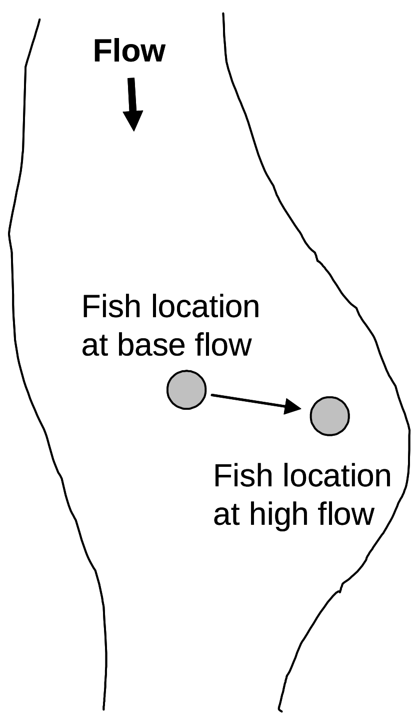


The basis for our upper flow limit of 175 kcfs is that hourly flows of this magnitude occurred an average of 13 out of the 60 days in the November 1-December 30 spawning period for the last six years. In addition, in all years except the high-flow year of 1999, an average of 92% of hourly flows were less than 175 kcfs.

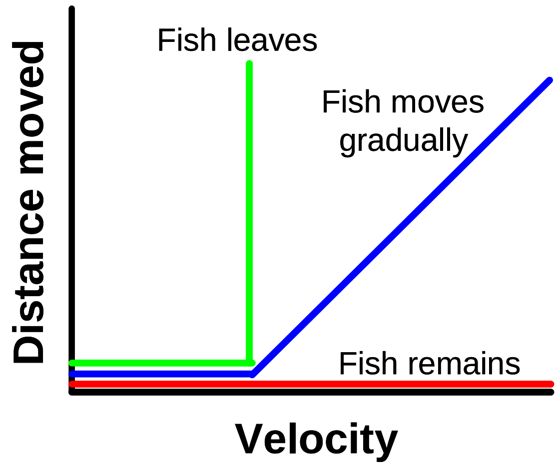
As discussed above, we expect that at some flow and velocity threshold, fish spawning behavior will be altered or will cease altogether. The figure below shows one possible response in female chum salmon digging activity to increasing water velocity.



This particular behavioral response can be quantified by using an acoustic camera before and during increased-flow events. Acoustically-tagged fish will also allow us to determine if chum salmon are removed from their base-flow spawning location to some other location when flows increase as illustrated below.

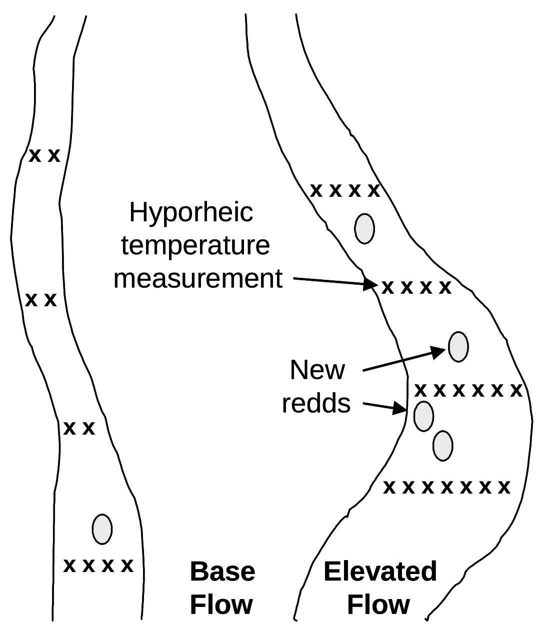


We anticipate that there are three possible movement responses that fish might exhibit to increased flow and velocity as shown below.



First, fish behavior and location may not be altered by increased flow and will remain in their current position regardless of flow (red line). Second, as flow and velocity increase, fish may gradually move away as they remain in suitable velocities (blue line). Third, a velocity threshold may exist above which fish seek refuge elsewhere. We will measure water velocities at original fish locations before flow increases and then hourly at these locations with each flow/time step using a current meter or an acoustic Doppler current profiler (ADCP) so that velocity can be related to behavioral responses. When flows return to base levels, we will use the acoustic camera to determine if normal spawning behavior continues at original redd locations.

It is possible that as shoreline areas become inundated at higher flows, fish may move into these areas and spawn at these higher elevations as illustrated below. During periods of elevated flow, we will search for fish presence in these areas, and we will determine if fish begin constructing redds at these higher elevations through direct observation or by searching for redds the following day after flows return to base levels. In addition, we



will establish transects in the inundated areas, as shown above, and collect riverbed temperatures (15 cm deep) to determine if warmer hyporheic temperatures exist that would be conducive to chum salmon redd construction.

Expected Products

1. Identification of flow and velocities at which chum salmon spawning behavior is altered.
2. Determination of behavioral response of chum salmon to elevated flows.
3. Determination if chum salmon complete spawning if behavior is disrupted by elevated flows.
4. Determination of whether chum salmon will spawn at higher elevations when flows are elevated.

Coordination

These activities have been coordinated so as not to interfere with WDFW seining activities. Fish for tagging will be collected during WDFW seining. USFWS has permitted take for the proposed tagging under their ESA Section 10 permit.

Critical Uncertainty

The proposed activities will require support by FPAC, TMT, and BPA to ensure experimental flows are provided.