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Shad Removal Strategies for Columbia and Snake Rivers

Over the last 20 years, numbers of American shad *Alosa sapidissima* returning to the Columbia River have ranged widely, from 0.9 million in 2011 to the current record of 7.4 million so far this year (Figure 1). Based on 10-year averages, the adult shad spawning run has the greatest overlap with summer Chinook and sockeye salmon (Figure 2). Any potential actions to remove or decrease the numbers of shad in the system will require consideration on how they might impact Chinook and sockeye salmon passage.

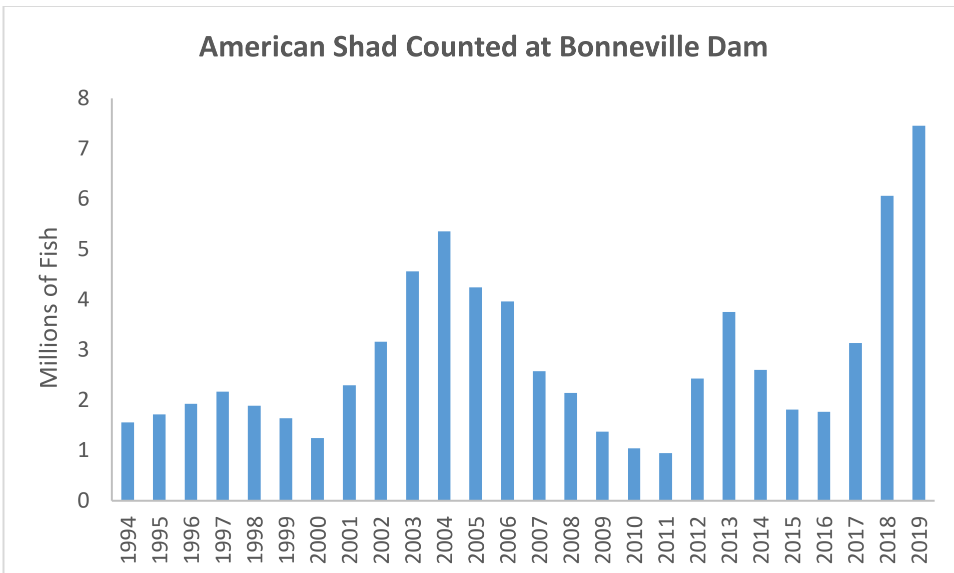

Figure 1. Numbers of American shad counted at Bonneville Dam 1994-2019.

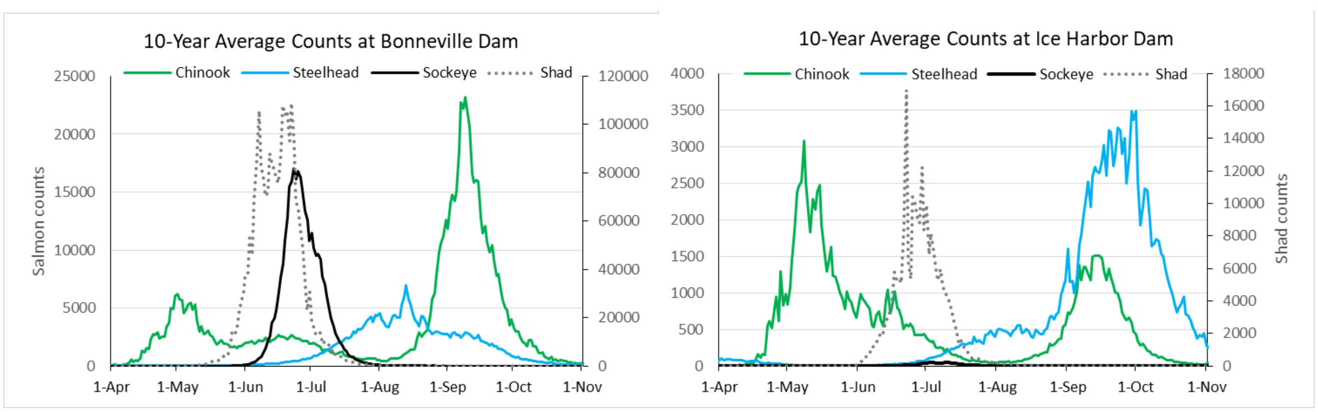

Figure 2. Ten year average counts for American shad, steelhead and Chinook and sockeye salmon at Bonneville and Ice Harbor dams.

Shad are non-native anadromous species and, studies from their home range, indicate they predominately home to natal spawning streams. Analysis of otolith micro-chemistry of adult shad in the York River, PA, indicated that 94% originated from the drainage, 6% were strays from outside drainages (Walther 2007[1]). This suggests blocking access to spawning areas could reduce, but not necessarily eliminate, numbers of adult spawners returning to those areas in the future.

Given the choice to use surface routes or submerged orifices to ascend fishways, American shad exclusively used surface routes in one study (Haro and Kynard 1997[2]). In addition, the authors noted;

> "Turbulence, air entrainment, and upwelling flow within the area downstream of the surface weir all appeared to confound appropriate orientation and upstream movement of American shad. American shad generally occupied areas in pools where water velocity and turbulence were minimal, and they appeared to select lower water velocities when ascending the surface weir (i.e., searching and approaching from beneath the high velocity surface flow)."

American shad most sensitive to sound from 0.2 to 0.8 kHz in the sonic range and from 25 to 130 kHz in the ultrasonic range (Plachta and Popper 2003)[3]and in behavioral studies they will exhibit evasive behavior under certain conditions;

> "Between 175 and 184 dB re 1 µPa at stimulus frequencies between 70 and 110 kHz, the fish showed a very rapid and directional response directly away from the sound source, whereas above 185 dB re 1 µPa, the fish would show a very rapid and random pattern of behaviours that resulted in some animals attempting to jump out of the test tank."

In contrast, salmonids appear limited to detecting sounds in the range below 0.5 kHz (Figure 3).

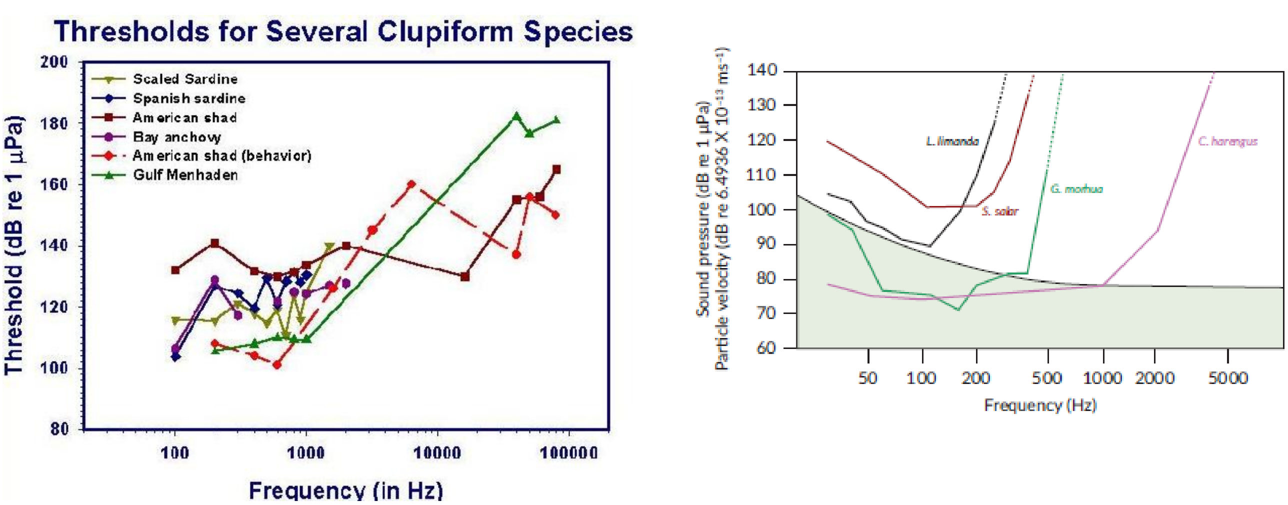

Figure 3. Relative sensitivity of American shad and other clupiforms (left) and Atlantic salmon (right) to sound.

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[1] Walther, B. 2007. Migratory patterns of American shad revealed by natural geochemical tags in otoliths. Massachusetts Institute of Technology and Woods Hole Oceanographic Institution. Doctoral Dissertation.

[2] Haro, A., and B. Kynard. 1997. Video evaluation of passage efficiency of American shad and sea lamprey in a modified Ice Harbor Fishway. NAJFM 17:981-987.

[3] Plachta, D., and A. Popper 2003. Evasive response of American shad to ultrasonic stimuli. Acoustics Research Letters Online 4, 25 (2003).

Options

1. Use sound to repel shad from fishway entrances.

   High frequency emitters downstream from dams may deter shad from approaching and using fishways. Testing would be needed to verify that sounds do no interfere with salmonids and lamprey and to determine optimal deployment locations. It would also need to be determined if shad would habituate to continuous exposure to frequencies that illicit an escape response in lab studies.

   Pros: Inexpensive and relatively easy to install and operate. Has the potential to be used at locations to deter fish prior to reaching and entering fishways.

   Cons: Blocking large numbers of shad in or near fishways could interfere with salmonid passage.

2. Block or discourage from passage at dams using non-overflow weirs or other design features.

   Intent if this option is to use downstream dams to block or discourage shad from reaching upstream areas. A series of weirs with submerged orifice flow only would likely block a significant portion of the adult shad migrants. Use of design features that create adverse condition such as turbulence and higher surface velocities (see Monk et al. 1986[4]) could also be used to discourage passage at a dam, reducing the number that convert to upstream projects.

   Pros: Quick response during first year of implementation. Since shad appear to exhibit homing behavior in their native range, the number of upstream migrants may be significantly reduced within a few generations of implantation. However, homing behavior for Columbia River shad has not been investigated.

   Cons: Blocking significant numbers of shad within a fishway could potentially (likely?) interfere with salmonid passage. Operational and structural changes to interfere with shad passage could also affect salmonid passage. Sockeye salmon in particular appear more likely to use overflow over submerge orifices to pass fishway weirs. A query of data from 2016-18 for Lower Granite Dam, weir 648 interrogators, of 191 unique PIT-tagged sockeye salmon detected, 99% were detected on the overflow antennas and 1% were detected at the orifice antenna. Similarly, at John Day Dam during 2018, 1,700 unique sockeye salmon had 93% of their detections at the overflow weir antennas versus 7% on orifice antennas (total of 3,693 detections at 2 weirs in each fishway). However, elimination of the overflow at several weirs at Priest Rapids Dam has not appeared to have a negative effect on sockeye passage. This suggests that, given a preference, sockeye salmon will use overflow sections at weirs but when not present they will readily pass through submerged orifices.

3. Remove/harvest shad from fishways.

   This option could be implemented along with, or separately from, Options 1 and 2. The intent is to minimized numbers of shad in the system through systematically trapping and removing them from one or more projects using the bottlenecks created at fishways. For example, Monk et al. (1986) recommended using a series of weirs whereby all fish using overflows were diverted away from the fishway but fish using submerged orifices would be directed back to the fishway. Using this method they estimated most (96%) salmonids would have been returned to the fishway by the fourth weir to continue their passage at the dam

[4] Monk, B., D. Weaver, C. Thompson, and F. Ossiander. 1986. Effects of flow and weir design on the behavior of American shad and salmonids in an experimental fish ladder. Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, Seattle, WA 98112.

while most shad could be removed. The authors did not suggest a method to deal with the remaining 4% of salmonids retained with shad.

Pros: Same as Option 2 plus reducing potential interference with salmonid passage from large numbers of shad being held up in a fishway. Free cat food.

Cons: Equipment and operations to collect shad could interfere with passage and cause by-catch of salmonids.

4. Harvest in the ocean prior to adult spawning migration.

5. Selective harvest adult shad in river downstream of Snake River.

   Both Options 4 and 5 have the advantage that they would occur away from dams and would be largely implemented by other entities. These actions would act to reduce numbers of shad reaching the dams but would not eliminate all shad passage.

6. Use operation changes to discourage spawning in reservoirs.

   Still working on this one…

7. Collection/removal of juvenile shad at bypass systems.

   Similar to protocols to remove Siberian prawns from sample collections at juvenile fish facilities.