FISH PASSAGE RESTORATION

1 DESCRIPTION OF TECHNIQUE

This technique focuses on restoring safe upstream and downstream fish passage to streams and stream reaches that have become isolated by culverts, dams, and other artificial obstructions. It also addresses ways to prevent or minimize harm to fish at stream diversions and water intakes. For migratory species of fish and aquatic wildlife, successful completion of their life cycle hinges on having access to and safe effective passage between reproduction, feeding, and refuge habitats. For fish, such habitats may lie longitudinally (upstream/downstream) within the stream system, estuary, and ocean or laterally within floodplain habitats such as side channels, ponds, wetlands, and periodically flooded grasslands and forests.

Man-made in-stream structures (e.g., culverts, dams, levees, or tide gates) can become physical barriers that impede fish passage and reduce connectivity through habitat fragmentation. Passage may also be impeded by stream diversions, water intakes, or other structures that injure fish or cause stranding. Even un-maintained fishways can impede or prevent fish access to critical habitat. Where fish passage is obstructed longitudinally within the stream, the downstream transport of habitat elements (sediment, water, wood and other material) is often obstructed as well, along with the upstream and downstream passage of many species of amphibians, reptiles, and mammals that use stream corridors for migration and as daily movement corridors.

This technique focuses on restoring fish passage longitudinally within the stream. For a list of techniques to consider when restoring fish passage to floodplains, refer to Chapter 4.3.2 *Restoring Habitat Connectivity*.

While salmonids are typically emphasized in fish passage projects in Washington, other species also require effective passage. The following migratory fish species rely on unimpeded access to and from upstream and downstream habitats.

Fish Passage Table 1. Migratory fish species in Washington[1]

Anadromous

Steelhead
Coho, Chinook, Pink, Chum, and Sockeye Salmon
Cutthroat Trout
Pacific and River Lamprey
Green Sturgeon
White Sturgeon
American Shad
Dolly Varden/Bull Trout
Longfin Smelt
Eulachon

Freshwater

juvenile Coho, Chinook, and Steelhead
Kokanee
Rainbow and Cutthroat Trout
Brown and Brook Trout
Bull Trout / Dolly Varden
Olympic Mudminnow
Stickleback
Sculpin (Cottids)
Pygmy and Mountain Whitefish
Cyprinids (Minnow family)
Catostomids (Suckers)
Sturgeon (adult and juvenile)
Western Brook Lamprey

The necessary timing, frequency, and duration for unimpeded access to required habitats varies with the fish species and life stage, as does the direction and length of migration. For example, juvenile salmonids need to freely disperse to find optimal rearing conditions (e.g. areas with reduced competition, good quality low velocity refuge habitat, food, and fewer predators) to ensure their survival. Required access is not limited to solely the mainstem environment, especially for fry, as they often move laterally out of rivers and into tributaries and side channels. During smoltification, the downstream migration of anadromous salmonids must occur without delay. Similarly, adults migrating upstream must be allowed to freely distribute within suitable habitat and have unconstrained access to spawning areas. Again, timing is important during adult spawning migrations.

In Washington State several laws pertain to fish passage. These include WAC 220-110-070, RCW 77.55.060 and RCW 77.55.070. Most fish passage barriers within the stream network occur at road crossings and flow control structures such as dams and weirs. Washington Department of Fish and Wildlife (WDFW[2]) reports that, as of September 2003, a total of 2,256 Washington State Department of Transportation (WSDOT) road crossings of fish bearing streams have been documented. Of these, 1036 have been identified as barriers. WSDOT road crossings represent only a small fraction of fish passage barriers in the state. It is estimated that there is a potential for 33,000 salmonid passage blockages in the state of Washington at this time[3]. The number of blockages is likely to be higher if other migratory fish and wildlife species are considered. Barriers to fish passage are typically classified as complete, temporal, or partial. Complete barriers block the movement of the entire population of an organism all of the time; temporal barriers block the movement of the entire population of an organism some of the time; partial barriers block some individuals of a population some of the time, limiting the genetic diversity that is essential to support a robust population. Refer to WDFW[4] for guidance on the assessment and repair prioritization of fish passage barriers and surface water diversion screens.

Fish passage restoration complements virtually all other habitat restoration techniques, because safe and effective passage is fundamental to the life history of salmonids.

2 PHYSICAL AND BIOLOGICAL EFFECTS

Restoring fish passage increases the amount of available habitat within a stream system. If habitat abundance is the limiting factor for the migratory fish species, its population may rise in response to access to additional habitat. However, the population response to habitat gain is also dependent on numerous other factors, such as the quality and quantity of newly available habitat, and the abundance and nature of the predators, competitors, and prey that reside there.

Where obstructions are modified (for example removing a dam or replacing a culvert), restoring fish passage may change the transport of sediment, wood, and other material to downstream reaches as well as the upstream and downstream passage of aquatic wildlife. The slope and/or elevation of upstream and downstream channel reaches and, hence, the degree of hydrologic and biologic connectivity between the stream channel and the floodplain may also change in order to reconcile elevation differences between the upstream and downstream reach. The extent of such changes may be localized or extend far upstream and downstream. These physical changes directly impact the aquatic environment by altering habitat characteristics that effect fish use and behavior. In WDFW's Fish Passage Design at Road Culverts[5] Chapter 7 on channel profile describes habitat issues related to regrade and channel incision. Castro[6] describes a geomorphological evaluation process to determine potential impacts.

The longevity of effects and benefits of fish passage restoration depends on the longevity of the passage structure, i.e., fishways, or method that has been applied. These may be very susceptible to unpredictable natural hydrologic and sediment transport events, though such events can typically be accounted for in the design of passage structures. Implemented passage projects are typically effective as soon as complete and at the next migratory season. The scale of benefits is entirely dependent upon the scale of habitat that becomes accessible as a result of restored passage. If a fishway is selected as an option for passage correction, routine inspections and maintenance must be recognized as part of the project in order for it to succeed in passing fish.

As with all instream projects, installation of passage features may result in temporary construction impacts such as increased turbidity, disturbance of substrate, and dewatering impacts. Typical construction impacts of in-stream projects are discussed in the *Construction Considerations Appendix*.

3 APPLICATION

In many watersheds, fish passage restoration projects may be the most effective use of resources to generate the greatest return on value relative to other habitat restoration techniques. In many instances, a relatively simple low-cost alternative such as retrofitting of a culvert can provide access to miles of valuable habitat that may be otherwise isolated from migratory species.

Passage projects are more likely to provide long-term benefits in channels that are vertically and laterally stable. In less stable channels, passage structures or features may become buried (in aggrading channels), undermined (in degrading channels) or abandoned (in laterally migrating channels).

4 RISK AND UNCERTAINTY

4.1 Risk To Fish And Wildlife

The primary risks to fish and wildlife associated with passage restoration are short-term construction impacts, potential long term maintenance impacts, and the risks associated with introducing or reintroducing species that compete with or prey on species already present in upstream waters. Introduction of new species may occur where native species did not historically have access to upstream waters, or where non-native species have been introduced (e.g., into lakes). In such instances, providing passage may prove detrimental to resident fish. Whether species are introduced or reintroduced, providing fish passage to habitat previously unavailable will likely cause a redistribution of competitor, predator, and prey species in the watershed.

Long-term risks may be associated with maintenance that is required to ensure design criteria are met. For example, pool and weir fishways often fill in with sediment. To maintain pool volume this sediment is excavated out of the fishway. On small streams this removal of sediment (which would have been transported downstream without the fishway) can result in a degradation of downstream spawning habitat. Concerns such as this have led designers recently to consider more natural types of fishways where sediment transport is part of the design, or operation and maintenance plans are developed to maintain the sediment budget of the stream.

4.2 Risk To Infrastructure And Property

Risk to infrastructure or property associated with passage increases with the extent and size of the structures which crosses the channel and the amount of channel and floodplain which is constricted by the structure. Examples would be when weirs, dams, and culverts are constructed in the stream channel. There have been cases where road culverts plugged with debris under a high road fill during a flood event. This causes a pooling of the water upstream that saturates the road fill and surrounding ground resulting in catastrophic failure of the road fill and stream channel side slopes, with extreme disturbances to fish life and habitat downstream. Structures also collect debris, and as debris builds up the potential for the stream scouring a new channel around the structure increases.

4.3 Risk To Public Safety

As fish passage projects often result in the installation of structures across or within a stream, there may be some risk to recreational users of the stream. Fish passage structures often attract visitors, and there is risk to people falling in the deep pools. Fences are often constructed around high risk facilities, but even these won't keep people out.

4.4 Uncertainty Of Technique

Passage restoration can be conducted with minimal uncertainty, assuming relevant data are available to conduct analyses. Accurate hydrologic statistics, hydraulic models, and biological statistics allow for a great deal of certainty in application. Uncertainty arises from changing channel conditions, or inaccurate or unavailable data for design. Underestimating the potential of the stream to transport sediment and woody debris is often the leading cause of failure.

5 Methods and Design

Methods of restoring upstream and downstream fish passage vary with the type of obstruction. They may include removal or replacement of culverts, construction or modification of fishways, removal or modification of dams and other obstructions, or installation of fish guards or screens at stream diversions and water intakes. The WDFW has published several documents directly related to this topic. As such, the reader is encouraged to refer to these documents for a comprehensive presentation of design and implementation guidelines relative to fish passage and fish screening. These documents are:

Fish Passage Design at Road Culverts[5]. This manual covers habitat issues at road crossings, design options, channel profile considerations, and tide gates. The appendices include details for: design flows, baffles, roughened channels, construction costs and a description of how to measure channel width which is a critical design variable. Also in the appendix is a data design form for collecting and analyzing fish passage design information and the current Washington State regulation on Water Crossing Structures.

Fishway Guidelines for Washington State[7]. This guideline contains pre-design data requirements and considerations, design considerations for fishway entrances (entrance pool and transportation channel design), auxiliary water systems (diffuser and water supply source), fish ladders (pool and weir fishways, vertical slot fishways, roughened channels, hybrid fishways), fishway exits, tributary fish passage, upstream juvenile fish passage, flap gates, and fishway flow control.

Fish Protection Screen Guidelines for Washington State[8]. This guideline contains types and applications of screen styles (drums, fixed plate, traveling, pump screens, infiltration galleries), screen design criteria, hydraulic design, fish bypass systems, and debris management.

All of the above documents are available of the Washington Department of Fish and Wildlife's web site at the Aquatic Habitat Guidelines page (http://www.wdfw.wa.gov/hab/ahg). Additional documents and references concerning fish passage issues are also available from the WDFW AHG web site. The reader is also encouraged to review the 2001 Proceedings of the International Conference on Environment and Transportation (ICOET)[9]. The ICOET's purpose is to address the broad range of ecological issues related to surface transportation development, providing the most current research information and best practices in the areas of wildlife, fisheries, wetlands, water quality, overall ecosystems management, and related policy issues. ICOET is a multi-disciplinary, inter-agency supported event, administered by the Center for Transportation and the Environment.

6 REFERENCES

[1] Wydoski, R. S. and R. R. Whitney. 1979. Inland Fishes of Washington. University of Washington Press, Seattle. Appendix 1.

[2] WDFW. 2003. 2002 Annual Report. Habitat and Passage Projects Section. Technical Applications Division. Habitat Program. Olympia, Washington. 56 pp.

[3] pers. communication. Brian Benson, Washington Department of Fish and Wildlife (November 5, 2003).

[4] Washington Department of Fish and Wildlife. 2000. Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization Manual. Olympia, Washington.

[5] Washington State Department of Fish and Wildlife. 2003. Fish Passage Design at Road Culverts. K. Bates, B. Barnard, B. Heiner, J.P. Klavas. P. Powers, and P. Smith. Olympia, Washington. 110 pp.

[6] Castro, Janine. 2003. Geomorphic Impacts of Culvert Replacement and Removal. US Fish and Wildlife Service, Pacific Region Office, Portland, Oregon.

[7] Washington State Department of Fish and Wildlife. 2000. Fishway Guidelines For Washington State – Draft Report. K. Bates. Olympia, Washington. 57 pp.

[8] Washington State Department of Fish and Wildlife. 2000. Fish Protection Screen Guidelines For Washington State – Draft Report. K. Bates. Olympia, Washington. 53 pp.

[9] ICOET. 2002. Proceedings of the International Conference on Ecology and Transportation, Keystone, Colorado, September 24-28, 2001. Center for Transportation and the Environment, North Carolina State University, Raleigh, North Carolina.