Salmon Passages and Other Wildlife Activities in Washington State

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SALMON PASSAGE PROGRAM

Salmon are an important cultural, ecological, and economic value to the people of Washington State. There are five salmon species (chinook, coho, chum, pink and sockeye) plus three trout species (steelhead, cutthroat and Dolly Varden) that are strongly anadromous, meaning that they spawn in freshwater and migrate to and from marine waters (Williams et al 1975). Dams, urbanization and land uses have lead to degradation of habitat and loss of access to habitat due to migration barriers. While there are both natural and unnatural barriers to fish passage, roads and impassable culverts are responsible for the loss of many miles of stream habitat. The latest estimate from the Washington Department of Fish and Wildlife (WDFW) is that there are 24,000 culverts blocking off 3,000 miles of habitat at a time when 57% of our salmon and steelhead stocks are in trouble (WDFW 1995b).

There are over 79, 802 miles of roadway in Washington State, each of which could potentially be a harboring a migration barrier for salmon or trout. Of all of these roadways, Washington State Department of Transportation (WSDOT) is responsible for 7,036 miles of state highways (WSDOT 1996).

In 1991, knowing that culverts can cause major migration barriers to salmon, and faced with plummeting salmon runs, the Washington State legislature directed the former Washington Department of Fisheries - WDF (now the Washington Department of Fish and Wildlife) and the Washington State Department of Transportation (WSDOT) to cooperate in the inventory and correction of salmon and trout migration barriers at state highways road culverts in the 1991-1993 and 1993 -1995 biennium's. In addition to the inventory, the legislature directed WSDOT to correct 6 fish barriers during the 1991 -1993 biennium. This was subsequently modified to correct 5 barriers and to began the initial planning on 2 others.

In order to fully understand what constitutes a migration barrier to salmon, it is necessary to understand the biology of these fish. All five of the salmon species need clean, stable, well oxygenated gravel habitats to spawn in. After the eggs are laid in the gravel, well oxygenated water must pass over the eggs. The amount of time it takes for the eggs to develop and the alevins to hatch depends upon the water temperature and species (Wydoski and Whitney 1979). Hatching can take from 2 weeks to 5 months. Upon hatching, the young remain in the gravel, absorbing their egg yolks for 3 to 5 weeks.

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Depending upon the species, the young fry may remain in the river system for 12 to 15 months or they may only spend several days in the system, before migrating out to sea.

It is normal to have more than one species of anadromous fish in each river system (Williams et al 1975). Salmon have evolved to the point that they follow different life strategies to allow for the greatest utilization of each river system.

Pink salmon have a fixed two-year life cycle (Groot and Margolis 1991). In Washington, they primarily spawn only in odd years. Spawning areas are usually within the lower reaches of the river system, within a few kilometers of saltwater. Pink salmon fry migrate out to saltwater shortly after hatching where they spend 3 to 4 months rearing in the estuaries before moving out to sea (Williams et al 1975).

Chum salmon also move directly out toward saltwater shortly after hatching and spend 3 to 4 months rearing in the estuaries before entering the ocean. Unlike pinks who return to spawn as 2 year olds, chum salmon may spend 3 to 5 years in the ocean before returning to spawn (Groot and Margolis 1991).

Sockeye salmon spawn in lake tributaries and along lakeshores. Most populations spend one to three years rearing in lakes before migrating out to sea (Groot and Margolis 1991). A few populations will rear in rivers rather than lakes.

Chinook salmon have the most varied life cycle strategies, with several runs occurring in the same year. Usually runs are divided into spring or fall runs, named for the time of year they begin their upstream journey to spawn. Spawning areas can be many miles up river, in the smaller tributaries, areas which can potentially be blocked by culverts. Juveniles produced from the spring run will spend up to one year rearing in the river, while the fall run juveniles migrate out after only spending 3 to 4 months in freshwater.

Coho, like the chinook salmon spawn in the upper reaches of the rivers, where culvert blockages may be encountered more frequently. They spend at least one year, if not two years rearing in freshwater (Williams et al 1979). Juvenile coho will redistribute themselves up and down stream, rearing throughout the system. During the winter, when streams and rivers are running at flood stage, juvenile salmonids which are overwintering, are forced to move into small tributaries, ponds and wetlands to avoid being carried out of the system(Groot and Margolis 1991).

Not only do the different species vary with the amount of time the juveniles spend rearing in freshwater, they also vary in what types of water they prefer to spawn in (Williams et al 1975). All of these adaptations are designed to allow for the greatest utilization of each river system.

To meet the Legislative requirements, the WDF divided its inventory into four phases. Phase I involved searching on the state highways for stream culverts that prevent or restrict the upstream migration of salmonids. Phase II involves further investigation of stream areas where these culverts are located to verify salmonid presence in the streams and their access up to the culvert. Phase III involves measurement of habitat quantity and quality located above the barrier culverts (physical surveys). Phase IV is a engineering evaluation of improvements needed to restore fish passage, project prioritization, and correction of barriers (WDFW 1995b).

To complete the Phase I portion of the inventory, it was necessary to determine what factors make a culvert a migration barrier. There are three factors which can play a role in determining if a culvert is a barrier. The culvert, the stream, and the fish species inhabiting the stream. Culvert factors include size, length, material, slope, inlet and outlet inverts, interior slope changes, drop at outlet, wingwall placement, and aprons (Adams and Whyte 1990; Meehan 1991; WDFW 1995a). Stream factors include hydroperiod, bedload, flood stages, velocity, minimum flow depth, and high flow depth (Adams and Whyte 1990; Meehan 1991; WDFW 1995a). Fish species plays a key role, pinks and chums in particular, are poor jumpers and may be effectively excluded by a 1/2 foot drop (WDFW 1995a). Other species related factors include timing: both seasonal and diurnal behavior of the fish, range of flows through culvert, age of fish, size of fish as that relates to swimming capabilities (design for smallest size), run size, and general condition of the fish (Adams and Whyte 1990; Meehan 1991; WDFW 1995a).

Currently most of the culvert work has been focused on adult fish returning to spawn. But life history studies have pointed out the importance of providing both up and down stream passages for juveniles who need access to all available rearing habitat (WDFW 1995a).

There are several common conditions at culverts that create migration barriers (see Figures 1, 2, & 3). These include: excess drop at culvert outlet, high velocity within culvert barrel, inadequate depth within culvert barrels, high velocity and or turbulence at culvert inlet, debris accumulation at culvert inlet (WDFW 1995b).

These common conditions that create migration barriers are caused by improper culvert design, improper installation, inadequate maintenance, and subsequent channel changes. Culverts in urbanizing areas are often degraded due to changes in hydrology.

The 6 WSDOT districts were inventoried to coincide with adult salmonid presence. Phase I of the inventory was competed in May of 1994. Since then the work has concentrated on Phase II and III, with most of the emphasis placed on streams in Western Washington, due to the fact that most of the streams in Eastern Washington are upstream of the hydropower development on the Columbia River (WDFW 1995b).

As of 1995, 1,333 culverts had been evaluated for a total cost of $ 380,000. Of the 1,333 inventoried culverts; 763 were found to be totally passable, 185 were found to be total barriers, 155, were found to be partial barriers, and 230 were classified as other. Culverts were classified as other if there was no access to the culvert due to impassable barriers down stream or due to a high gradient, or if there was no habitat upstream of the culvert, of if there was no salmon utilization (WDFW 1995b).

Of the 340 full and partial barriers located in Phase I and II, 91 physical habitat surveys (Phase III Studies) have been completed on approximately 105 miles of stream. Removing barriers on these 91 streams would result in a gain of 176,982.4 square meters (44 acres) of spawning habitat and 318,465.3 square meters (79 acres) of rearing habitat, which relates to an additional 29,000 wild salmon (WDFW 1995b).

An important component of this process is to prioritize the removal of the barriers. Prioritization involves determining the benefits of the project in terms of habitat gain, fish production potential, increase stocks, value of the fisheries resource and the cost of the project. The priority is set by calculating a priority index.

The priority index was then used to select the projects which were completed in the 1991-1993 and 1993-1995 biennium, and to set the projects for the 1995-1997 biennium.

Once projects had been assigned a priority index, possible solutions were examined. There are numerous possible solutions including bottomless culverts; removal and replacement of culvert using Fish Passage Requirements; steepening the downstream channel - eliminate drop; constructing fishways (fish ladder); and or installing baffles in existing culverts. It is important to note that there will be situations where culverts are not appropriate and can not be used (WDFW 1995a, WDFW 1995b). In these instances, it may be necessary to bridge the system, since bridges which span a system rarely cause barriers .

Fish passage requirements in Washington State are applied on a site by site approach based on stream flows, culvert lengths and fish species. Factors considered include: velocities - match to swimming speeds of smallest fish - usually less that 2 feet per second for salmon. Culvert shape: elliptical and arch shapes are preferred, and most culverts are counter sunk. Water depth: in the culvert should be at least 0.8 feet for resident trout, pink and chum salmon, and 1.0 foot for chinook, coho, sockeye and steelhead (WDFW 1995a, WDFW 1995b).

In the 1991-1993 biennium, seven separate projects were completed, resulting in a gain of on 611,067 square feet (14 acres) of habitat at a total cost of $208190. In the 1993 to 1995 biennium 8 projects were completed, creating 695262 square feet (16 acres) of habitat at total cost of $767,053. An additional 6 projects have been selected for the 1995- 1997 biennium.

During the 1993-1995 biennium the two departments realized that long term planning should include not only dedicated, independent funding of projects but close communication between the two agencies to accomplish barrier correction in conjunction with planned road projects such as safety and mobility improvements regularly done by WSDOT). Due to the number of barriers identified in the inventory it could take over a century with a much lower benefit to cost ratio to correct 340 barriers using only dedicated funding (correcting 3/year). Using a road project associated culvert repairs, fixes would be done quickly and costs of mobilization would be greatly reduced since equipment would be on site or in the vicinity. Road project associated fish passage improvements would require long term commitment by the legislature and would be beneficial in correcting problems affecting many depressed salmonid stocks in need of immediate attention. In the future this strategy could help avoid petitions under the Endangered Species Act.

Other components of the Fish Passage Program include interagency education and training, and additional research. Training efforts include day long workshops entitled Fish Passage Design at Road Crossings, conducted by WDFW each year for WSDOT engineers, designers, environmental coordinators and other personnel. Research activities include a three year study on juvenile fish passage through culverts work which will examine hydraulics and the biology of the fish.

OTHER WSDOT ACTIVITIES

DEERKILL DATABASE

Since 1973 WSDOT has been maintaining a computerized data base of deer and elk kills on state highways. Information is gathered by local maintenance shops who are responsible for removing road killed animals from the highways and right of ways. They are asked to keep track of the animals they dispose of on this form. The form collects information on: Date killed, Light at time of kill, State Route, Mile Post, Setting, Weather, Right of Way Fencing, Sex, Age and Species, along with a column for other wildlife species and comments. The other wildlife species is used to record elk, bear and moose information as we are not collecting information on small and medium sized mammals such as beaver, coyotes etc. The species column is used to collect information on which deer species was killed as there are 2 subspecies of mule deer and 2 subspecies of white-tailed deer in our state. The forms were used during our deer reflector studies which were conducted in the late 1980's and early 1990's. The forms are submitted to our office when full or on a quarterly bases. We use this information to track yearly deerkills in each region and locate problem areas such as SR 395 where we average 250 deer killed per year in a 70 mile stretch. This information can be used to plan for deer undercrossings and fencing needs.

There are several limitations on this information. Limitations include the fact that some animals die outside the right of way and are not picked up, some animals are removed by WDFW personnel, and some roadways are less frequently traveled by our maintenance people than others, there are no set definitions for determining when a individual is a fawn or an adult, and not all maintenance personnel may be able to identify the species of deer killed. All of these factors can influence the validity of the information we receive, but we believe that the database can serve as an index of deer mortality on state highways.

PROPOSED JOINT HABITAT CONDUCTIVITY STUDY WITH USFWS : IS I-90 A BARRIER TO WILDLIFE SPECIES?

We are currently working on a joint research project looking at habitat conductivity and wildlife movement across I-90 a six lane interstate which crosses the Wenatchee National Forest and Mount Baker-Snoqualmie National Forest. The purpose of this study is to determine what species I-90 is a potential barrier to movement for, where the critical crossing points are now and where they will be in the future as the landscaped changes, determine if crossings are currently made in underpasses (culverts, bridges etc), how habitat conditions adjacent to the freeway such as vegetation and fences influence wildlife crossings and collision/mortality, and how to mitigate to facilitate safe wildlife movement across a freeway.

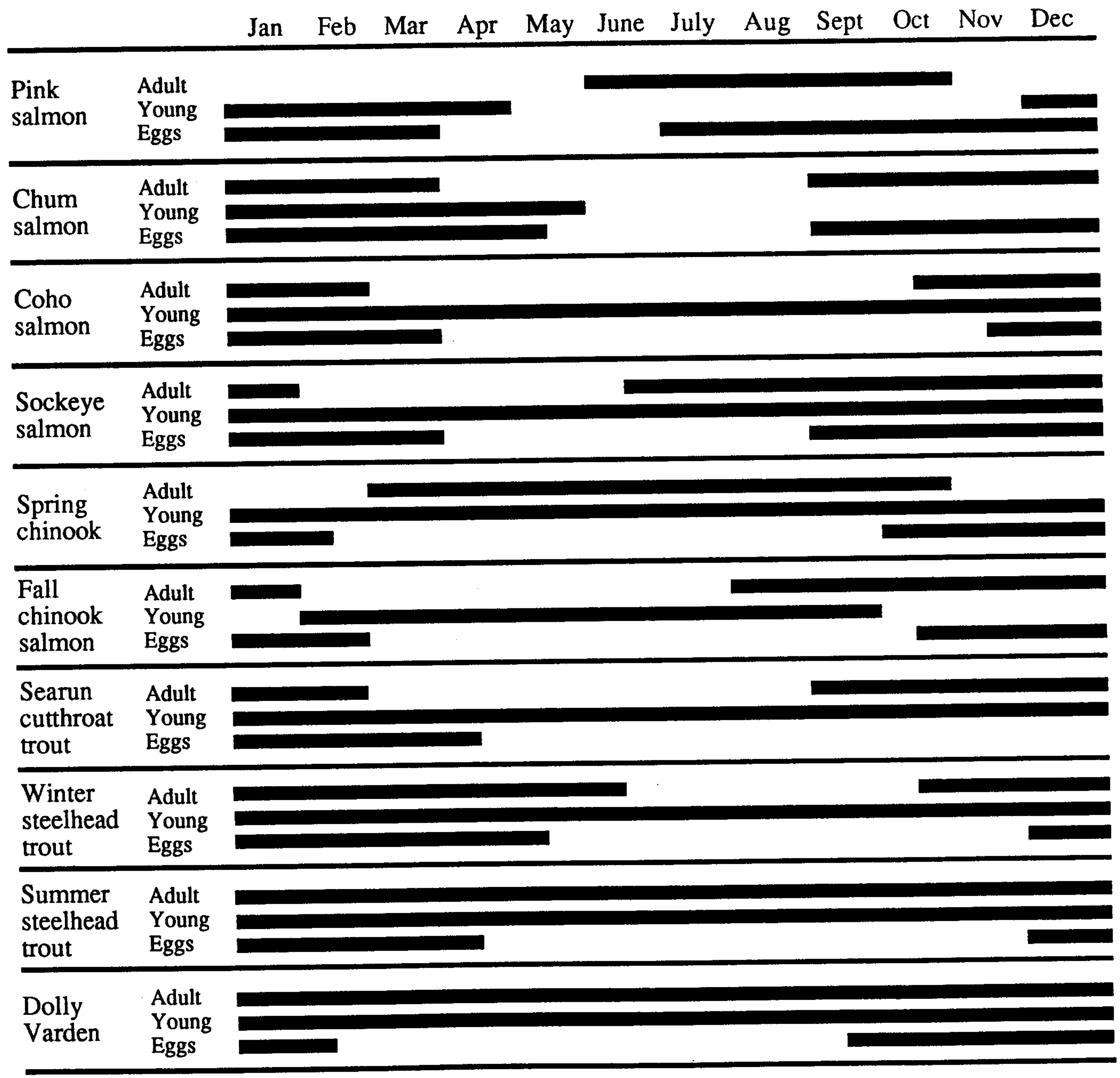

Table 1. Seasonal occurrence of adult and juvenile (eggs in gravel and young) anadromous salmonids in freshwaters of western Oregon and Washington.

Species/race	Life History 1/	Reproduces in: Lakes	Reproduces in: Streams	Rears in: Lakes	Rears in: Streams	Rears in: Estuaries	Rears in: Oceans
Pink salmon	Anadromous		X		X	X	X
	Anadromous		X				X
Chum salmon	Anadromous		X		X	X	X
	Anadromous		X		X		X
	Anadromous		X				X
Coho salmon	Anadromous		X		X	X	X
	Anadromous		X		X		X
Sockeye salmon	Anadromous		X	X			X
	Anadromous	X		X			X
Sockeye salmon (kokanee)	Resident		X	X			
Chinook salmon (spring)	Anadromous		X		X	X	X
	Anadromous		X		X		X
Chinook salmon (fall)	Anadromous		X		X	X	X
	Anadromous		X		X		X
Pygmy whitefish	Resident			X			
Mountain whitefish	Resident		X		X		
Golden trout	Resident		X		X		
	Resident		X	X			
Cutthroat trout	Resident		X		X		
	Resident		X	X			
Cutthroat trout (searun)	Anadromous		X		X	X	X
	Anadromous		X		X		X
Rainbow trout	Resident		X		X		
	Resident		X	X			
Rainbow trout (steelhead)	Anadromous		X		X		X
Brown trout	Resident		X		X		
	Resident		X	X			
Bull trout	Resident		X		X		
	Resident		X	X			
Brook trout	Resident			X			
	Resident		X		X		
	Resident		X	X			
Dolly Varden	Anadromous		X		X	X	X
	Anadromous		X		X		X
	Anadromous		X	X			X
Lake trout	Resident			X			
Arctic grayling	Resident		X		X		
	Resident		X	X			

1/ Some species have several races with different life history patterns.

Table 2. Variations in life history of salmonids.

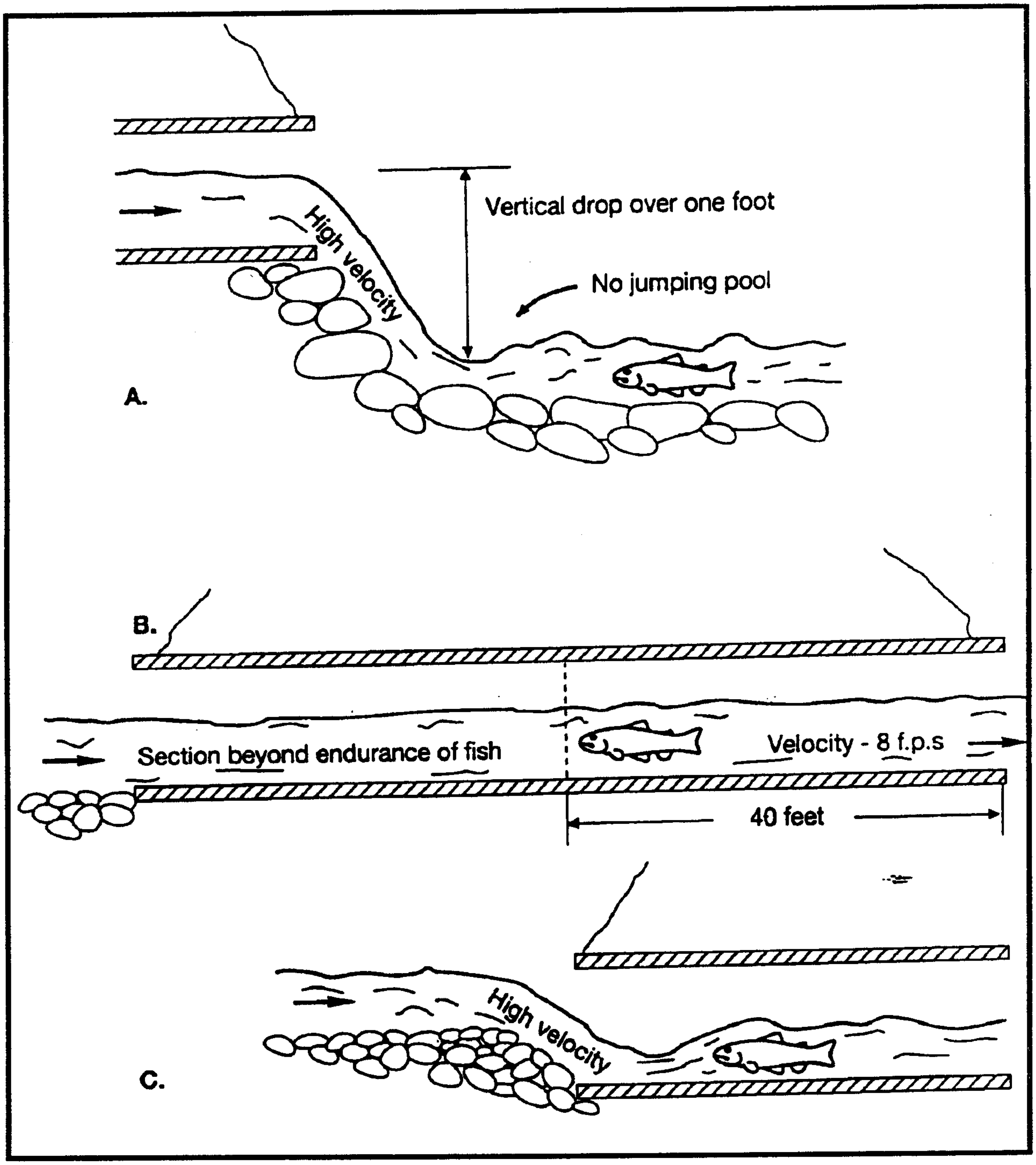

Figure 1. Undesirable conditions for passage of fish through culverts.
Gebhards & Fischer, 1972

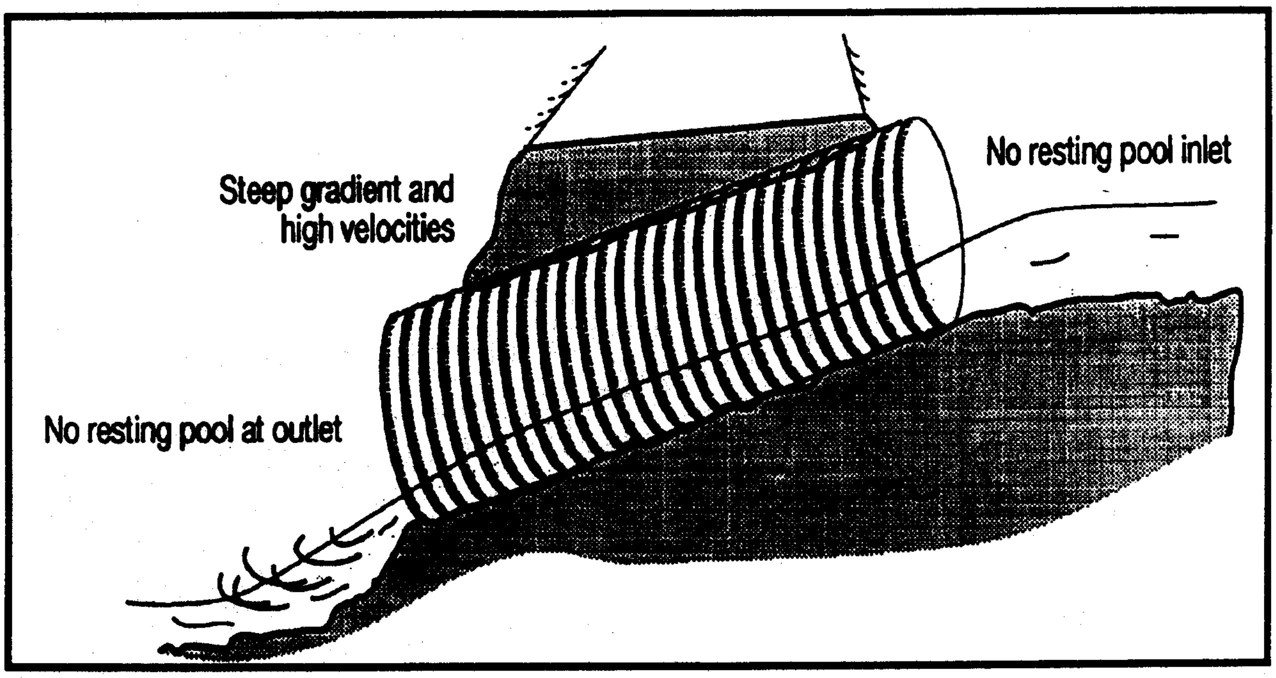

Figure 2a. Installation unsuitable for fish passage. Evans & Johnson, 1980

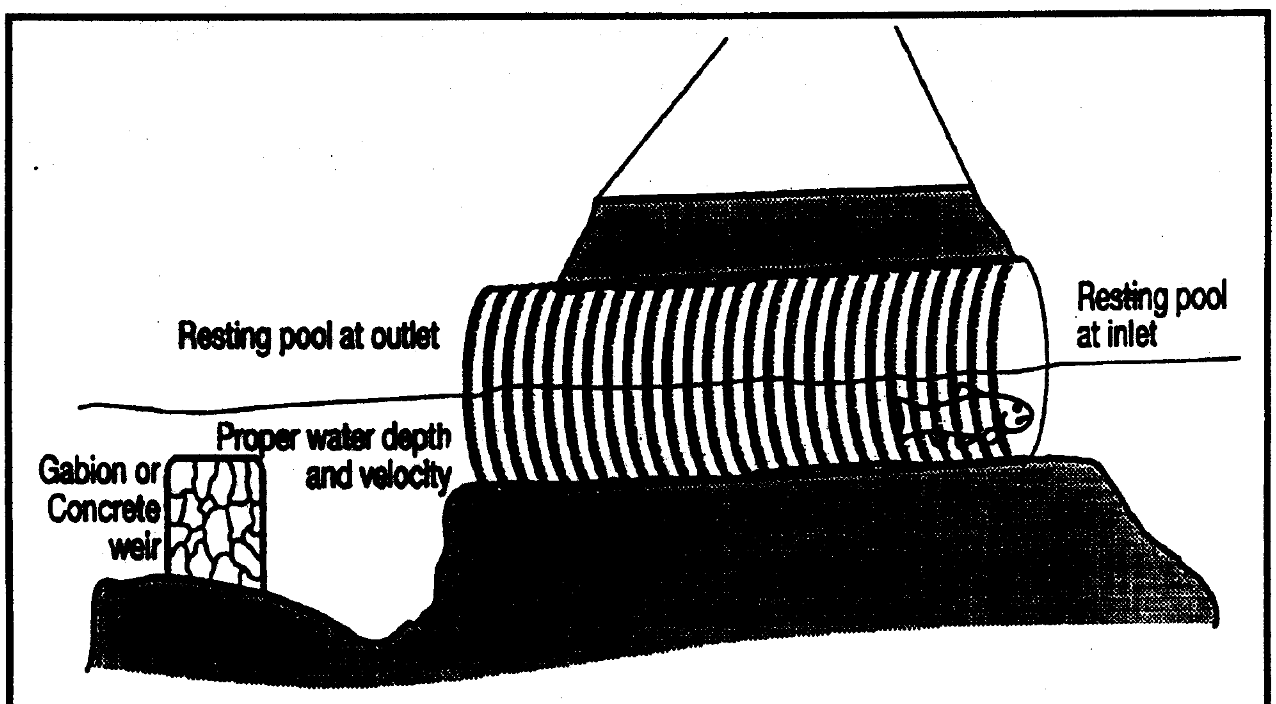

Figure 2b. Installation suitable for fish passage. Evans & Johnson, 1980

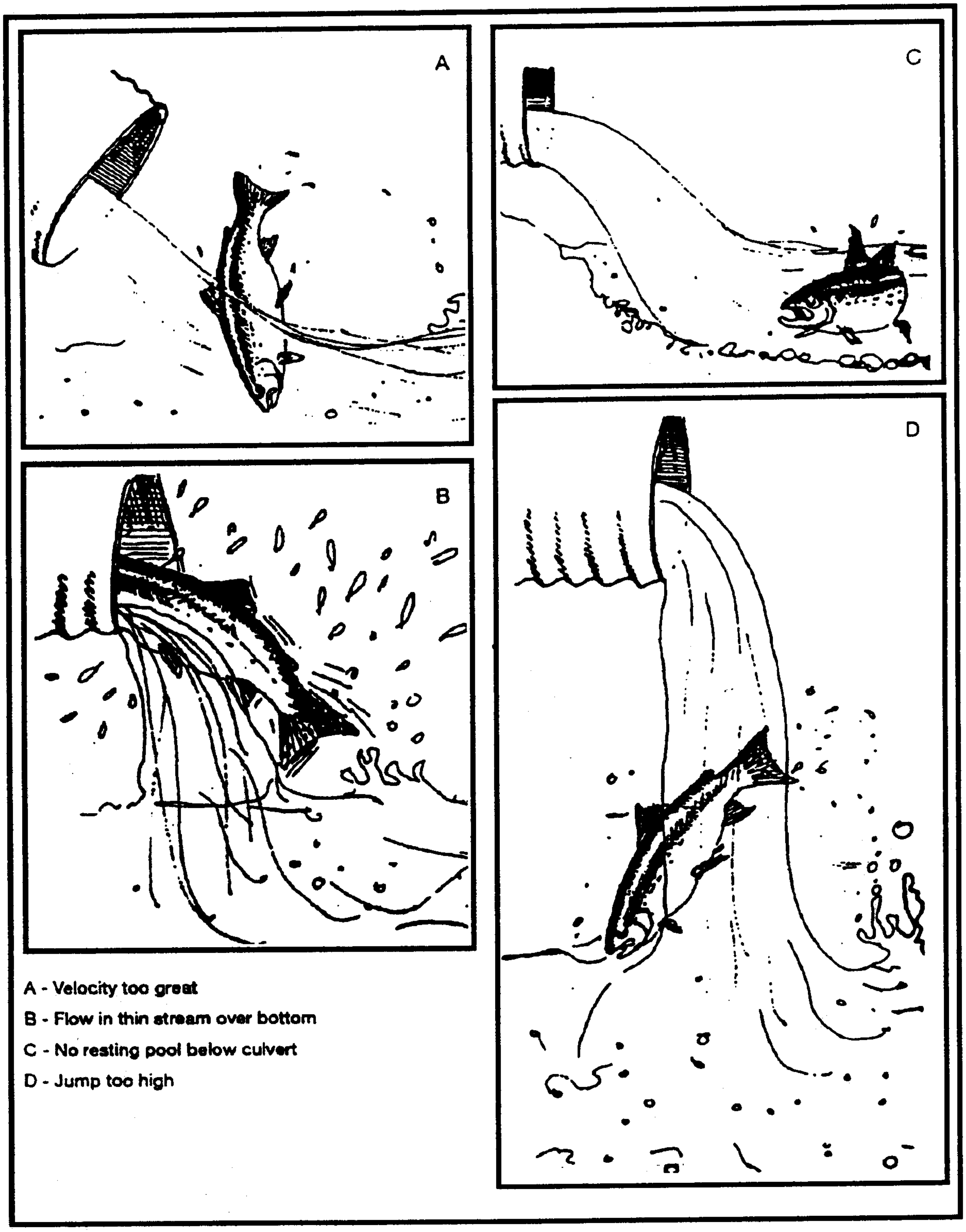

Figure 3. Common conditions that block fish passage. Evans & Johnson, 1980

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