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FISHWAYS FOR SMALL STREAMS

By George A. Rounsefell, Ph.D., Aquatic Biologist,
Division of Fishery Biology.

The question of providing a fishway arises wherever a stream is obstructed by either a dam or a natural barrier that prevents or hinders the free passage of fish. A fishway is a water-filled passageway, lock, or series of connected pools by means of which fish may swim upstream or downstream past an obstruction. Before incurring the expense of constructing a fishway and providing for its proper annual operation and maintenance, its cost should be considered in relation to the expected benefits.

Anadromous fishes, such as salmon, shad, sturgeon, alewives, smelt, striped bass, and sea-run trout or steelheads, must be able to ascend streams far enough to reach spawning grounds suitable for the particular species involved and sufficiently extensive to accommodate the populations. For species in which the young must spend some time in fresh-water before migrating to sea, suitable nursery areas of a stream or lake as the case may be must be available for them. Many fine runs of all of these anadromous species have been totally destroyed in the past because of failure to provide passage over dams.

For fresh-water fishes the necessity for fishways is not always so clear-cut. Certain species, especially the salmonoids, have rather strict requirements so far as spawning conditions are concerned. They need gravel beds in moving water that will keep the eggs aerated during the long period of incubation. Many lakes, otherwise suitable for land-locked salmon and trouts, have spawning grounds insufficient for the fish to maintain themselves in abundance owing to obstructions on tributary streams that contain the needed spawning beds.

For many warm-water species which can reproduce and make proper growth without extensive migration, fishways often are entirely unnecessary. In streams inhabited principally by resident fishes, the situation should be carefully appraised before a fishway is installed.

The basic requirement of a successful fishway is that it shall provide a passageway over the dam for the various types of migratory fishes in the particular stream at any water level or volume of stream flow. Furthermore, they must be able to make the ascent without injury or the exertion of extreme effort and must not be unduly delayed at the barrier while searching for the entrance. To meet these requirements particular attention must be paid to certain features of location and design.

Fishways have been in use for a great number of years and a multiplicit of types, sizes, and designs have been tried in various streams. A few types have met with success; some have been partially successful; and a greater number can be counted as failures.

The simplest type of fishway is merely an inclined chute, with or without some modification to decrease the velocity of the water, and with or without resting pools. The more usual fish ladder is a succession of pools, one above the other, connected by low falls or short rapids. These pools may be connected also by a submerged opening. A third type of fishway is the fish lock or elevator which requires mechanical gates and either an automatic or an attended device to regulate the flow of water into the lock.

Certain basic factors must be considered in selecting the proper type of fishway, such as: the size and activity of the fish using it, the total height of the dam, and the general configuration of the terrain. In streams wherein large numbers of small fish such as alewives migrate within a short season, the fishway needs to be of fair size to accommodate the large number of fish that must pass through in a short space of time. The total height of the dam that must be surmounted determines the need for resting pools. Some types of fishways are built without resting pools but these are suitabl only for low dams, perhaps up to six or eight feet in height.

It may be possible to surmount a low dam in a very small stream which forms an important path of migration (as in the case of many large alewife runs ascending a small stream to a large pond or lake) by making the entire streambed into a succession of pools with a low fall or short rapid between them.

The entrance of a fishway, if located too far downstream from the barri will be passed unnoticed by the fish, which tend to follow the main channel until barred by the dam. If they find such an entrance at all it is often encountered only when drifting downstream, exhausted or injured, after fight ing in vain to pass the obstruction. Therefore, the entrance should be placed very close to the foot of the dam. If the dam is built obliquely across the stream, the entrance to the fishway is usually best located at the upstream end. One of the primary requirements for attracting fish into the ladder is that the entrance shall be sufficiently close to the main current from the spillway or the tail race so that fish following this current will find themselves at the entrance. If it is so favorably located that the fish find it, then inducing them to enter is largely a matter of providing a sufficient flow of water. The volume necessary depends to a great extent on that of the main stream.

The permissible velocity of the water in a fishway is governed by several factors, but chiefly by the species and size of the fish, the total height of the dam, the distance between resting pools, and the size and type of the fishway. Most observations on the speed of fish are maximum speeds under ideal conditions over a comparatively short distance. Swimming against a current with its surges and eddies is quite different from swimming in quiet water.

A table of maximum velocities against which fish can swim is given by Dr. Frischholz, in the Construction and Operation of Fishpasses. His velocities in meters have been translated into feet. In a straight flume or sluiceway, in which the water flows without any baffles or obstruction, he found for distances over 33 feet that poor-swimming species could swim only 1.7 to 3.3 feet per second and good swimmers 3.3 to 5.0 feet. When the distance was reduced to less than 33 feet the poor swimmers could swim 1.7 to 3.3 feet per second and the good swimmers 6.6 to 8.3 feet.

In a fishway in which the flow is checked at intervals by baffles or partitions so that the points of maximum velocity are spaced at intervals, a much greater velocity can be tolerated at these particular points. Thus Frischholz gives a maximum velocity of 3.3 to 6.6 feet per second for poor swimmers passing over five of these swift points and 6.6 to 9.8 for good swimmers. When less than five openings were to be negotiated the poor swimmers could face currents of from 5.0 to 8.3 feet per second and good swimmers those of from 13.1 to 16.4 feet per second. Of course these last-named swimming velocities are attained only with extreme exertion and for a very short distance. They are much too fast to consider in fishway construction.

The 6.6 to 8.3 feet per second for good swimmers in a straight flume less than 33 feet in length roughly coincides with the findings of McLeod and Nemenyi. The best speed that trout (a good swimmer) could attain was 7 feet per second in flumes not over 10 feet in length.

In general, the velocities should be held to a maximum of less than 5 feet per second at any point in the fishway, and if poor swimmers, such as perch, carp, whitefish, or catfish, are to make use of the passage the velocities should be somewhat less.

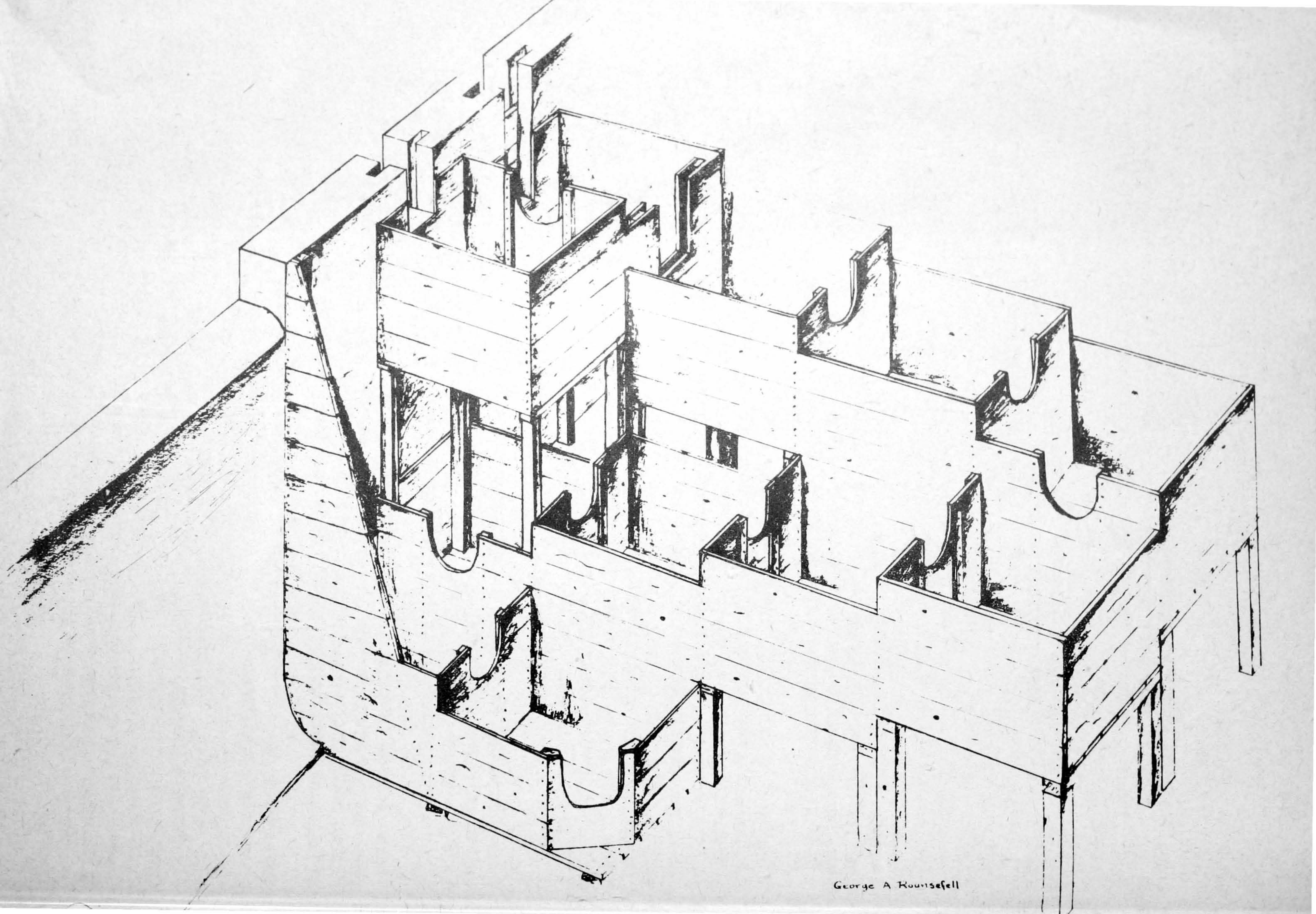
Fishways for the smaller species are sometimes merely inclined sluiceways, in which the water is somewhat retarded by a series of baffles extending from each side of the flume. This type is entirely unsuited for a dam of any height, for, unless the slope is very gradual, the water rushes through at high speed. Furthermore, unless the dam is very low, the entrance is too far downstream. For dams up to six or perhaps eight feet or more in height this type can be used but the slope must be moderate, preferably not over one foot rise in five. The flume should be at least four or five feet in width, with the sides at least four feet in height. The baffles should be spaced about four feet apart and extend to within about eighteen inches of the opposite side. Two problems then present themselves: the entrance must be near the foot of the dam which may necessitate a complete turn in the flume; and a large flow of water must be available for efficient functioning. This type of installation may be found excellent for passing natural barriers of moderate height if the terrain permits a moderate rise. In such a situation plenty of water is usually available; and the lack of complete partitions will aid in keeping the pass clear of gravel and debris. Such a bypass if built with considerable depth will provide adequate passage through a large range in water levels.

Most fish have little difficulty ascending through a series of pools connected by low falls or short rapids. Where it is impractical to construct pools of natural rock or masonry, a series of wooden or concrete boxes may be substituted. Such a ladder for small species is illustrated in figure 1. The fall between successive boxes should not exceed 12 to 16 inches. The size of the pools can vary somewhat in accordance with that of the stream and of the run of fish that must be accommodated. In streams with a good run, the boxes should be not less than six feet long, four feet wide, and four feet deep. If the ladder is also to accommodate salmon or other large species, it is desirable to increase the size somewhat, thus a box eight feet long, six feet wide, and six feet deep provides a ladder of ample proportions. The overfall pool type of ladder is especially desirable for streams with a very small summer flow as it can be run effectively with less water than other types.

Pool type ladders are sometimes built in which an opening is cut through the partition between the pools, instead of allowing all of the water to flow over the top. This latter type requires a larger volume of water and the lowest orifice must be submerged at all times. It is more difficult to obtain a proper flow as the amount of water must be maintained within narrow limits. The fish must overcome a considerable "threshold resistence" in passing from one pool to the next. The underwater current from the submerged orifice is not as attractive to most fish as is the noise and splash of the overfall entrance.

The chief advantage of using the submerged orifice in the pool type of fishway is that it provides an easier passage for species of fishes that do not like to jump or expose themselves. Fish can ascend the overfall pool type, however, without leaving the water if the difference between pools is held to one foot or less, and the gap in the partitions is rounded so as to present a solid flow. Do not use a V-shaped notch as it breaks up the stream of water. The overfall type of fish ladder makes each pool a "resting pool," whereas the submerged orifice type has strong currents on the bottom.

It will be noted in the sketch of the fishladder (figure 1) that provision has been made for differences in the level of the water in the forebay, by building two pools parallel with the face of the dam. If the dam is very high or subject to great fluctuations in water level, this number may have to be increased. The exists are provided with stop logs, so that the flow can be readily adjusted. Many dams, instead of having stop logs, have a gate setting on the bottom of the opening that can be raised to allow water to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pass into the fishway by flowing under the gate. This method of regulating the flow, however, has certain definite disadvantages. If the gate extends deep enough to provide water for the fishway when the level in the forebay is low, the opening is so deeply submerged at high water levels that the fish must force their way through the opening under the gate against a considerable head of water. Furthermore, because of the increased pressure at high levels the opening must be made so small to compensate for increased velocity of current that the space is usually too small and the current through the opening too swift. We have seen several ladders otherwise well designed that were difficult for fish to pass because of this feature.

The upper end of the fishway, or exit, may need protection to keep it from becomming clogged or damaged by floating logs or large debris. This may be accomplished by installing a trash rack of widely spaced beams or iron bars well in front of the exit.

If a fishway is constructed of wood, be sure to bore a small hole close to the floor of each pool so that it will drain into the next one, to prevent freezing in the pools when the ladder is not in use. The floors of the pools can be given a slight slope to aid the drainage.

In some localities ice is a major problem. It may be met by covering the whole structure with heavy wooden beams, about six by six inches or larger, placed longitudinally and leaving spaces about four inches wide between the beams to admit light. Ice coming over the top of the dam will slide down the beams into the streambed below.

In conclusion, there are a few seemingly minor "dont's" that lack of attention to which may spell success or failure. Don't place the fishway so that water from the spillway can fall into it, breaking up the flow and super-aerating the water. Don't allow any contaminated water to enter the fishway, as many fish shun such water.

Before building a fishway it is advisable to consult a fishery biologist and an engineer on the design and location. The operation, maintenance, and repair must be definitely assigned to responsible persons to insure success.

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