Informational Leaflet 3

SUMMARY OF RECENT KNOWLEDGE OF CERTAIN FACTORS INFLUENCING SURVIVAL OF SALMON IN FRESHWATER

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Summary of Recent Knowledge of Certain Factors Influencing Survival of Salmon in Freshwater

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INTRODUCTION

In the past five years, additions have been made to our detailed knowledge of factors influencing survival of salmon in fresh water. In this report results of various investigations are briefly summarized.

RESULTS OF INVESTIGATIONS AND TECHNIQUES DEVELOPED

Two of the most important needs of salmon eggs in a natural stream are adequate seepage velocity and high dissolved oxygen levels. This has been shown by Wickett, (1954, 1958), Allerdice et al. (1958), and Warren (1958), and others. Highest survival and most robust fry are attained at high seepage velocities and high dissolved oxygen levels.

Knowing this, these questions are posed: (1) what governs water velocities and oxygen levels in natural streams? (2) how can we quantitatively measure these variables, and (3) can we improve what we might find deficient.

A number of more recent papers on intragravel flow are an extension and expansion of Bjornerud's work (1949). Bjornerud discussed a mathematical approach to the solution of boundary condition and to the description of underflow in rivers. Vaux (in press) investigated the effect of stream profile curvature on direction of interchange between surface streamwater and intragravel water. Vaux later (1961) presented solutions of the boundary value problem (the boundary is that between the free flowing stream and gravel bed). Sheridan (in press) demonstrated that dissolved oxygen levels decrease with depth in a streambed and that probably in most southeast Alaska streams groundwater does not contribute to high dissolved oxygen levels. McNeil (in press) presents variation in dissolved oxygen levels from stream to stream and from place to place within one stream.

As a result of these works and those by Wickett, Pollard, and Cooper, we may conclude:

(1) High dissolved oxygen levels and high seepage velocities are necessary for high survival of salmon eggs.

(2) Major source of water containing high dissolved oxygen content is the surface of the stream. The water is aerated at the surface, goes down into the gravel, is relieved of oxygen by streambed organisms and organic matter and reappears in the surface to be reaerated. Magnitude and frequency of interchange depends on stream gradient, irregularities in streambed and permeability of streambed materials.

(3) Since one of the limiting factors to a high rate of interchange is permeability of the streambed, it follows that addition of fine sand and silt will be detrimental to survival and, conversely removal will be beneficial. Artificial lateral flow spawning channels (Jones

Creek, Mill Creek, Robertson Creek, Indian Creek, etc.) are constructed on this principle.

Now that we know the reasons for interchange, how may we measure these variables? For this, techniques have been developed and are ready to be used as management tools.

Dissolved oxygen levels. Wickett pioneered the use of perforated metal pipes driven into the streambed to obtain water samples. These were also used by other agencies until the Fisheries Research Institute (FRI) devdloped plastic standpipes for use in a study of the effects of logging at Hollis, Alaska. Plastic standpipes are light, cheap, portable, and easily handled (McNeil, in press). Intragravel dissolved oxygen values of any stream or number of streams may be determined in a short time using this technique.

Seepage velocities. Four or more west coast fisheries agencies have developed techniques for determining seepage velocities through the gravel. The FRI used the Shichter salt well electrode method. The Fisheries Research Board of Canada developed a dye extinction method and the U.S. Fish and Wildlife Service and the International Pacific Salmon Fisheries Commission have both used an electrolyte extinction method.

None of these methods completely satisfy the criteria of accuracy, portability, and ability to obtain a large number of measurements in a short time.

Some workers have tried to substitute permeability measurements, made by lowering the head in a standpipe and timing accretion of water to original level, for seepage velocity measurements, but these methods too need refinement.

Permeability and gravel composition. Although it is difficult to measure permeability in situ, it is easy to determine permeability of streambed gravels by placing a sample of gravel in a permeameter. The main objection to this method is that the gravel sample is disturbed; compaction and arrangement of particles and voids is no longer the same upon removal.

Actually, engineers have, for some years, demonstrated the relationship between permeability of gravel and amount of fine particles in the sample. Since this is a well known relationship it is apparent that sand and silt free gravel will usually be more permeable.

The FRI has developed a method of sampling and a sampler which enable us to assess the amount of fines in spawning gravels and to make comparisons of spawning gravels on this basis from stream to stream and within one stream (FRI Circular #120, 1960, McNeil and Ahnell).

Survival and abundance of embryos in the gravel. A modification of the hydraulic egg digging apparatus first used by Mathisen in 1955 (discussed in FRI Circular #126, McNeil 1960) is used by a number of agencies on the coast to estimate the survival and abundance of salmon embryos at different stages of development. The equipment and method are past the developmental stage and are a useful management tool.

Thus, it is apparent that the tools are now at hand with which to measure the two most important environmental variables in the production of salmon in freshwater. It seems that the next step is to obtain extensive measures of the environment, and the survival of salmon eggs in relation to spawning escapements. Then the potential for environmental improvement will be understood and can be undertaken if necessary.

BIBLIOGRAPHY

Alderdice, D.F., W.F. Wickett, and J.R. Brett. 1958. Some effects of temporary exposure to low dissolved oxygen levels on Pacific salmon eggs. Jour. Fish. Res. Bd. of Canada, Vol. 15, No. 2, 229-248.

Benson, Norman G. 1953. The importance of ground water to trout populations in the Pigeon River, Michigan. Trans. 18th No. Amer. Wildl. Conf., pp. 269-281.

Bjorenrud, E.K. 1949. Preliminary report on underflow of rivers. Unpublished manuscript, Fisheries Research Institute, University of Washington.

Burgner, Robert L. 1958. A study of fluctuations in abundance, growth, and survival in the early life stages of the red salmon *Oncorhynchus nerka* (Walbaum), of the Wood River Lakes, Bristol Bay, Alaska. PhD thesis, University of Washington, Seattle. 200 pp.

Chambers, J.S., G.H. Allen, and R.T. Pressy. 1955. Annual report for 1955. Submitted to U.S. Corps of Engineers by Washington State Department of Fisheries, Contract No. DA-35026-Eng. 20572.

Cooper, A.C. 1959. Discussion on the effects of silt on survival of salmon eggs and larvae. Proceedings of the Fifth Symposium Pacific Northwest, on Siltation, its Sources and Effects on the Aquatic Environment. Dept. of Health, Education, and Welfare, U.S. Public Health Service, Water Supply and Pollution Control Program, Portland, Oregon, pp. 18-22.

Hunter, J.G. 1959. Survival and production of pink and chum salmon in a coastal stream. Jour. Fish. Res. Brd. Canada, Vol. 16, No. 6, pp. 835-886.

James, George A. 1956. The physical effect of logging on salmon streams in southeast Alaska. Alaska Forest Research Center, U.S. Forest Service, Station Paper No. 5, 49 pp.

Mathisen, O.A. 1955. Studies on the spawning biology of the red salmon, *Oncorhynchus nerka* (Walbaum), in Bristol Bay, Alaska with special reference to the effect of altered sex ratios. PhD thesis, University of Washington, Seattle, 285 pp.

McNeil, W.J. Variations in the dissolved oxygen content of intragravel water in four spawning streams of southeast Alaska. Fish and Wildlife Service, Special Scientific Report, in press.

Muskat, Morris. 1937. The flow of homogenous fluids through porous media. McGraw-Hill Book Co., New York.

O'Conner, D.G., Dobbins, W.E. Mechanism of reaeration in natural streams. Am. Soc. of Civ. Eng. 82, part 6, No. 1115.

Pollard, R.A. 1955. Measuring seepage through salmon spawning gravels. Jour. Fish. Res. Brd. Canada, 12, 9, pp. 706-741.

BIBLIOGRAPHY (Continued)

Royce, W.F. 1959. Breeding habits of lake trout in New York. U.S. Fish and Wildlife Service, Fish. Bull., Vol. 52, No. 59, pp. 59-76. On the possibilities of improving salmon spawning areas. Trans. 24th No. Amer. Wildl. Conf., pp. 356-366.

Scheidegger, A.E. 1957. The physics of flow through porous media. University of Toronto Press, London.

Schlitching, H. 1955. Boundary layer theory. Pergamon Press, New York.

Sheridan, W. L. Water flow through a salmon spawning riffle in Indian Creek, southeastern Alaska. United States Department of the Interior. Special Scientific Report - Fisheries. In press.

Slichter, C.S. 1899. Theoretical investigations of the motion of groundwaters. U.S. Geological Survy, 19th Annual Report.

Vaux, W.G. Interchange of stream and intragravel water in a salmon spawning riffle. U.S. Fish and Wildlife Service, Special Scientific Report. In press.

Warren, C.E. 1959. The influence of dissolved oxygen upon the survival, development, growth, activity, and movements of freshwater fishes. U.S. Publ. Health Service - NIHR, Grant RG-4352-Progress Report Sept. 1, 1955 to Aug. 31, 1959.

Wickett, W.P. 1954. The oxygen supply to salmon eggs in spawning beds. Jour. Fish. Res. Bd. Canada, Vol. 11, No. 6, pp. 933-953. Review of certain environmental factors affecting the production of pink and chum salmon. Jour. Fish. Res. Bd. Canada, Vol. 15, No. 5, pp. 1103-1126.

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