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TECHNIQUES FOR APPRAISING ADULT SALMON AND TROUT POPULATIONS IN THE COLUMBIA RIVER BASIN

TECHNIQUES D'EVALUATION DES POPULATIONS ADULTES DE SAUMON ET DE TRUITE DU BASSIN DU FLEUVE COLUMBIA

by/par

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ABSTRACT

Appraisal of adult Pacific salmon, Oncorhynchus spp., and steelhead trout, Salmo gairdneri, populations in the Columbia River Basin is made at dams and supplemented by spawning ground surveys. Trained observers enumerate individual species of anadromous fish as they pass through fishways installed at most dams on the Columbia and Snake Rivers. A promising technique being field-tested involves closed-circuit television; migrating fish can be viewed on a television receiver and can be recorded for later review. Aerial surveys in larger rivers and ground surveys in smaller tributaries provide data on spawning populations.

Estimates of some specially treated populations of salmon and trout are made by mark and recovery techniques to determine their survival to maturity. Young fish are tagged during their seaward migration with magnetic colour-coded wire tags and marked with cold brands; when they return as adults the tagged fish are obtained from a fishway by an automatic recovery system. The brands identify test and control lots of fish released in previous years.

RESUME

L'évaluation de populations d'adultes de saumon du Pacifique, Oncorhynchus spp., et de truite aro-en-ciel, Salmo gairdneri, du Bassin du fleuve Columbia est effectuée aux barrages et complétée par des enquêtes aux frayères. Des observateurs spécialisés dénombrent chaque espèce de poisson anadrome lors de leur passage des échelles à poissons installées aux barrages des fleuves Columbia et Snake. Une technique prometteuse, à l'essai sur le terrain, comprend un circuit fermé de télévision; les poissons migrateurs peuvent être aperçus sur un récepteur de télévision et enregistrés pour un examen ultérieur. Des enquêtes aériennes pour les grands fleuves et sur le terrain pour les plus petits affluents, fournissent les données sur les populations de reproducteurs.

Des estimations de certaines populations de saumon et de truite particulièrement traitées sont faites par la technique du marquage et recapture, afin de déterminer leur survie à la maturité. Les jeunes poissons sont marqués au cours de leur migration vers la mer à l'aide de marques de fil magnétique de couleur codifiée, ainsi que par une brûlure à froid; lorsqu'ils remontent adultes, les poissons marqués sont repris par une échelle à poissons au moyen d'un système de recapture automatique. Les marques identifient les lots d'essai et de contrôle de poisson relâché les années précédentes.

CONTENTS

1. INTRODUCTION

Over a million and a half Pacific salmon, Oncorhynchus spp., and steelhead trout, Salmo gairdneri, return each year to the Columbia River on the northwest coast of the United States. Accurate information on the numbers of these fish migrating up the Columbia River to spawn is required to provide a management basis for regulating: (a) harvests by commercial, sport, and Indian fishermen; and (b) spawning escapements for a variety of runs. The Columbia River, second largest river in the United States (average annual flow, 5 700 m^3/s), has been transformed in the past four decades from a swift, free-flowing stream to a series of large lakes by dams constructed for hydro-electric power, irrigation, navigation, and flood control. These developments have dramatically altered ecological conditions in the river, making the need for precise information on the magnitude, timing, and duration of upstream migrations even more critical.

2. POPULATION ESTIMATES AT DAMS

Dams in the lower reaches of the Columbia and its major tributary, the Snake River, have elaborate fishways (Figure 1) to accommodate the upstream passage of anadromous fish. Each fishway has a carefully designed counting station for the purposes of enumerating migrants. At present, there are 12 major dams (Figure 2) on the Columbia and Snake Rivers with counting stations in operation from early spring to late autumn. Trained observers visually identify and record each fish as it passes the station. Although chinook, O. tshawytscha, and coho, O. kisutch, salmon and steelhead trout are the most valuable species to the fisheries, there are significant numbers of more than 16 other species of fish passing through the fishways - e.g., sockeye, O. nerka, and chum salmon, O. keta; American shad, Alosa sapidissima; sturgeons, Acipenser spp.; carp, Cyprinus carpio; suckers, Catostomus spp.; chubs, Hybopis spp.; catfishes, Ictaluridae; shiners, Notropis spp., northern squawfish, Ptychocheilus oregonensis; and Pacific lamprey, Entrosphenus tridentatus. At some dams, migrating fish are directed by picketed leads over a white counting board (Figure 3) where they can be easily seen by observers in a cubicle (Figure 4) near the water surface; the depth of the board and the cubicle are adjustable for varying water levels, and various techniques are used to control light intensity and turbulence to prevent delays in the counting area. At some of the more recently constructed dams, fish counts are made through large viewing windows (Figure 5) set in the side of a fishway. Here fish are directed near the window where observers identify each species; this method reduces delay in passage of fish at the counting station and improves visibility for the identification of special marks or tags which may have been applied previously to the fish.

The counts at each dam are usually recorded on an hourly basis and later consolidated in daily, monthly and annual summaries (published by U.S. Department of Army) for management agencies. The data are used in estimating total populations, assessing spawning escapement and determining effects of changing ecological conditions on salmon and trout migrations. For example, decreasing numbers of adults arriving at successive dams upstream give indication of potential hazardous conditions affecting survival of fish such as supersaturation of water with dissolved atmospheric gases, rising temperatures, disease and "fall back" of fish over spillways.

Visual counts have provided much valuable data for many years; however, the method is expensive in manpower and susceptible to two types of error. Counts are usually made during daylight (12-16 hours, depending on the time of year) and for 50 minutes each hour; the number and species of fish passing during periods of darkness and the 10-minute break period each hour must be extrapolated from sample counts and added to actual observations. In addition to possible error in extrapolation, the possibility for substantial error due to misidentification is always present. There have been several occasions where counts of some anadromous species at upriver dams exceeded counts at lower river dams. In an effort to minimize errors and to provide more economical means for counting fish, automated counting systems are being investigated.

A promising technique for automation of fish counting now being field-tested (U.S. Department of Army, 1972) involves the use of closed-circuit television. In this operation a television camera is set up to view fish as they pass a viewing window in the side of a fishway. The camera is activated by a fish passing through an impedance tunnel (Figure 6) downstream from the window; as the fish proceeds past the window and through a second tunnel, the camera is automatically shut off.

With this system adult migrants can be visually observed on a television receiver as they pass the camera and can be recorded on video tape for later review; by proper storage the tape can provide a permanent visual record of fish passage. The tape is particularly valuable where many species of fish are passing; during review, the tape can be run slowly or stopped or replayed to obtain positive identification. In areas where only one species of fish occurs, a digital counter could be substituted for the television system.

Past experience has shown that adult fish passage varies throughout their migration period; counts at night are 2 to 8 percent of the day counts. By recording passing fish on video tape, a day's fish passage can be compressed onto one reel of tape, and in about an hour a person could count fish recorded in a 24-hour period with a minimum of error.

Estimates of adult salmon populations at each dam will probably be discontinued in the future. When the dam construction phase in the Columbia Basin has been completed and river flows have stabilized, fish may be counted only at index dams. These dams might be the lowermost on the Columbia River and its major tributaries and certain upstream dams. These index counts along with estimates of numbers of fish attaining spawning areas should provide sufficient information for fishery agencies managing the resource.

3. ESTIMATES OF SPAWNING POPULATIONS

Information on spawning populations is obtained from survey of spawning grounds. Aerial surveys are made in larger rivers when water is clear and areas used by spawning adult salmonids can be identified (Figure 7). In smaller tributaries ground surveys are made by observers wading in shallow water or drifting downstream in small boats in deeper water. In some cases SCUBA (self-contained-underwater-breathing-apparatus) diving is employed to deep pools where spawned-out fish might accumulate and remain undetected.

During ground surveys redds constructed by the spawning fish are counted, carcasses are examined for tags and marks, and percentage of completely spawned fish is determined by inspection of gonads to determine the number of eggs retained after spawning.

Data obtained from these surveys provide information on the effect of changing ecological conditions on ability of adult fish to attain usual spawning areas and spawn successfully.

4. ESTIMATES OF SPECIALLY TREATED POPULATIONS

In the development of a method to protect juvenile migrants during their seaward migration, it is frequently necessary to evaluate the success of the method by examination of marks on adult fish that had been marked as juveniles during their downstream migration and comparing survival to adults of test and control lots of experimental fish. These specially treated, returning adults must then be separated from untreated fish without disturbance or delay in a fishway, identified, and released without injury. To accomplish this, a system employing cold-branding, magnetic wire tags, and automatic recovery is used.

An identification system (which uses magnetic wire tags that are colour-coded), developed by Jefferts, Bergman and Fiscus (1963) and further evaluated by Bergman et al. (1968) and by Hager and Jewell (1968), was incorporated into a device designed by Durkin, Ebel and Smith (1969) that automatically separates tagged fish from untagged fish in fishways. The system requires that fish pass over a false weir and slide down a chute through a hollow cylindrical detection coil. The magnetized wire in the snout of the tagged fish generates sufficient current for detection in the coil, and a signal is relayed to operate a gate that diverts the tagged fish from the lower end of the chute into a holding area. These fish, which had

also been marked with cold brands (Groves and Jones, 1969) as juveniles are identified by the brand (Figure 8) under a mild anesthetic and then returned unharmed to the fishway to continue its upstream migration. If the brand is illegible, the fish is held for spawning in a hatchery. After spawning the coded wire tag can be removed from the head for identification.

Ebel, Park and Johnsen (1973) discuss the initial operational use of the system in a fishway at Ice Harbor Dam during 1970 and 1971. An improved design described by Ebel (1973) was installed at Little Goose Dam (Figure 9) in 1972.

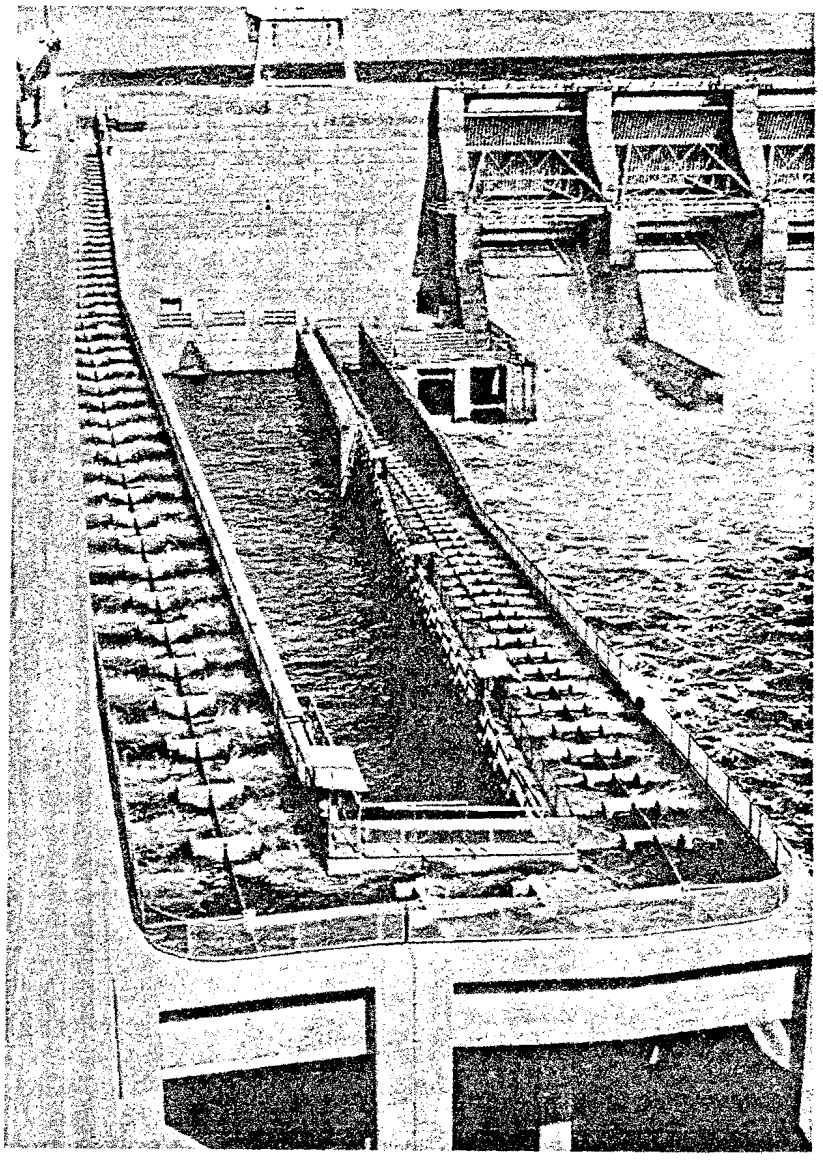

Figure 1 Fishways such as shown (Ice Harbor Dam on Snake River) provide for upstream passage of anadromous fish and enable the enumeration of adult migrants

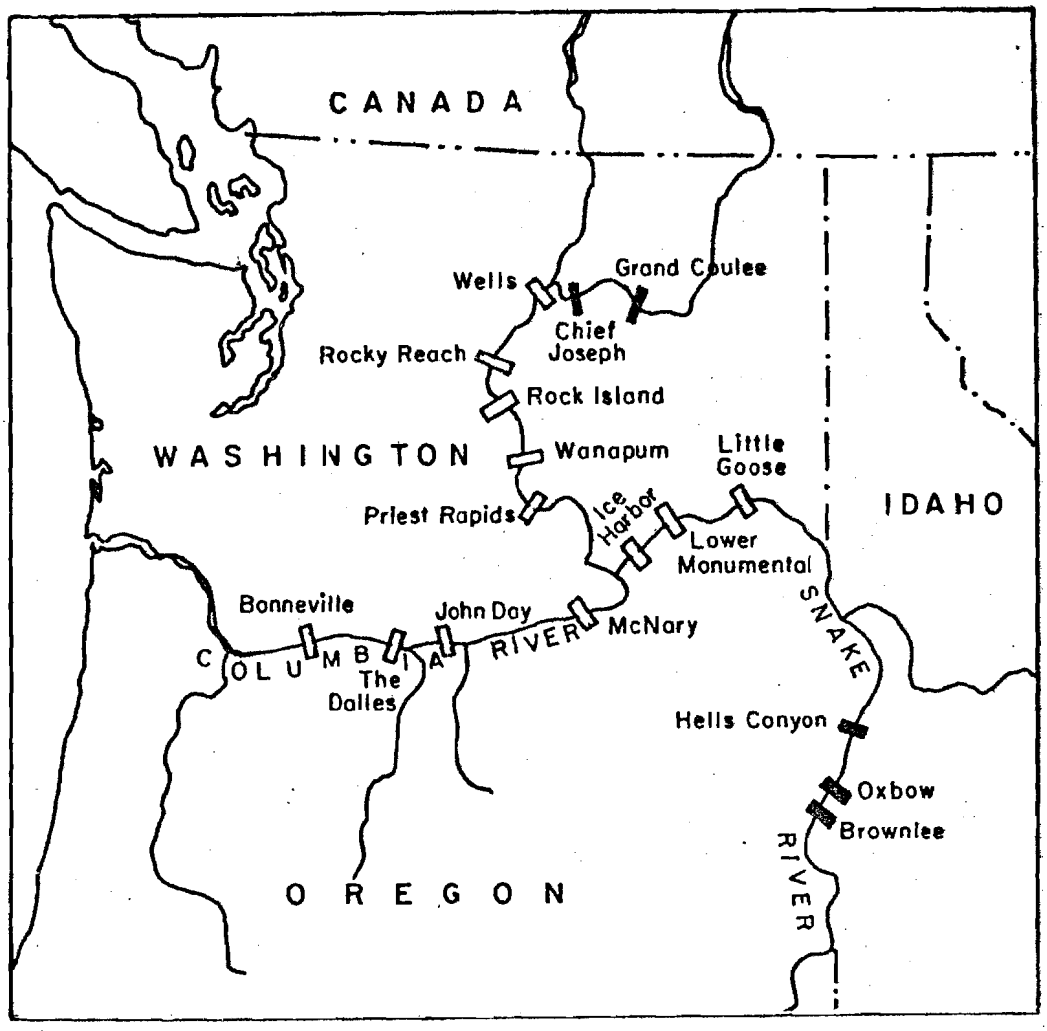

Figure 2 Major dams with fishways (▯) on Columbia and Snake Rivers where migrating adult fish are enumerated

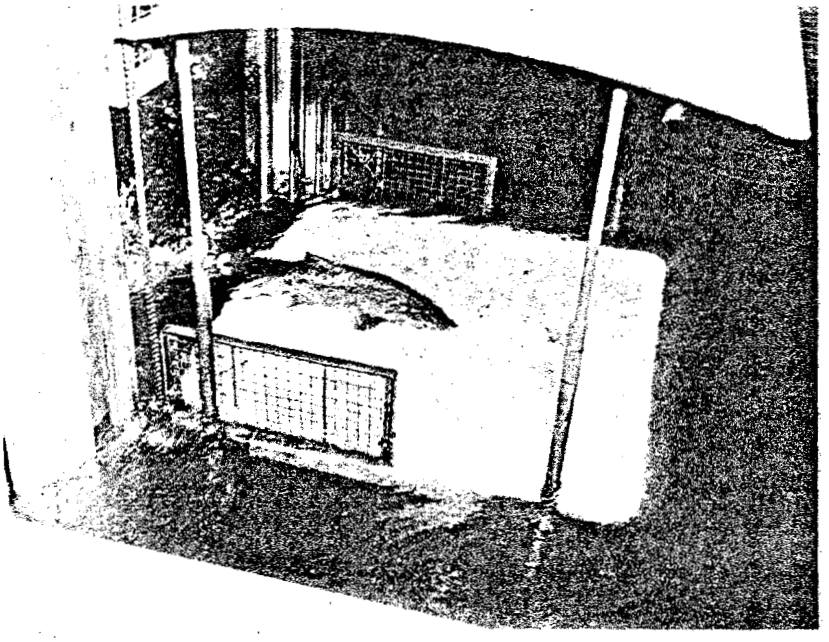

Figure 3 Adult salmon passing over white counting board which aids trained observer in identifying species

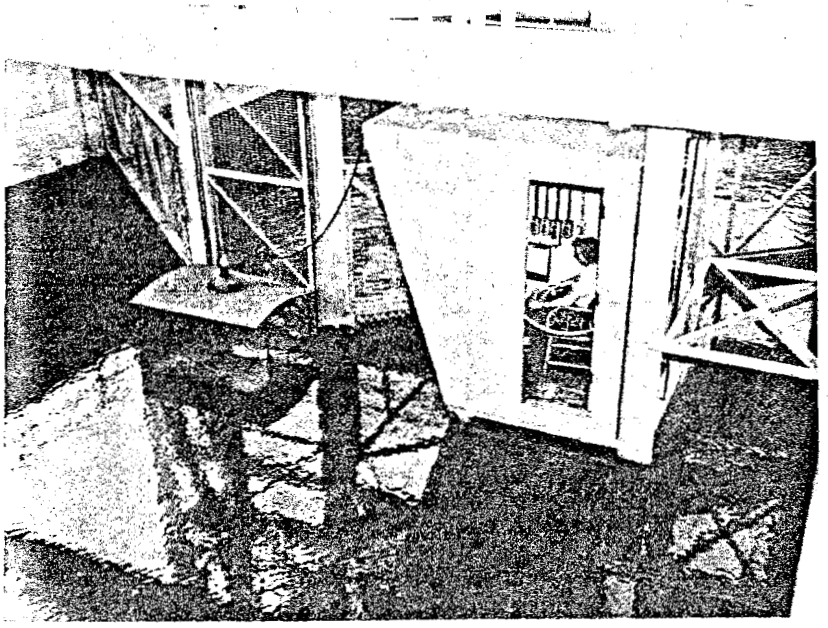

Figure 4 Fish counter in cubicle tallies fish by species as they pass over counting board (left centre)

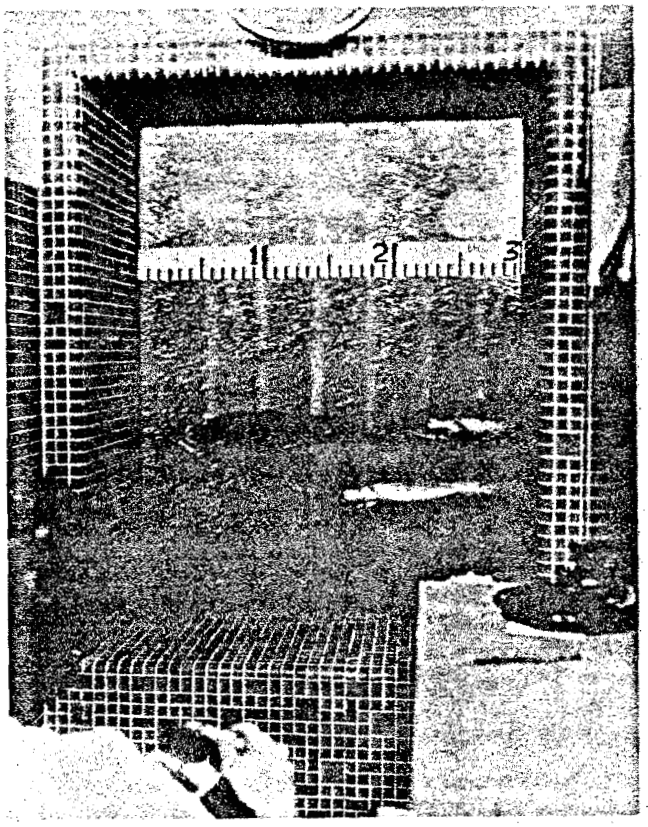

Figure 5 Adult fish are counted as they pass viewing window set in side of fishway

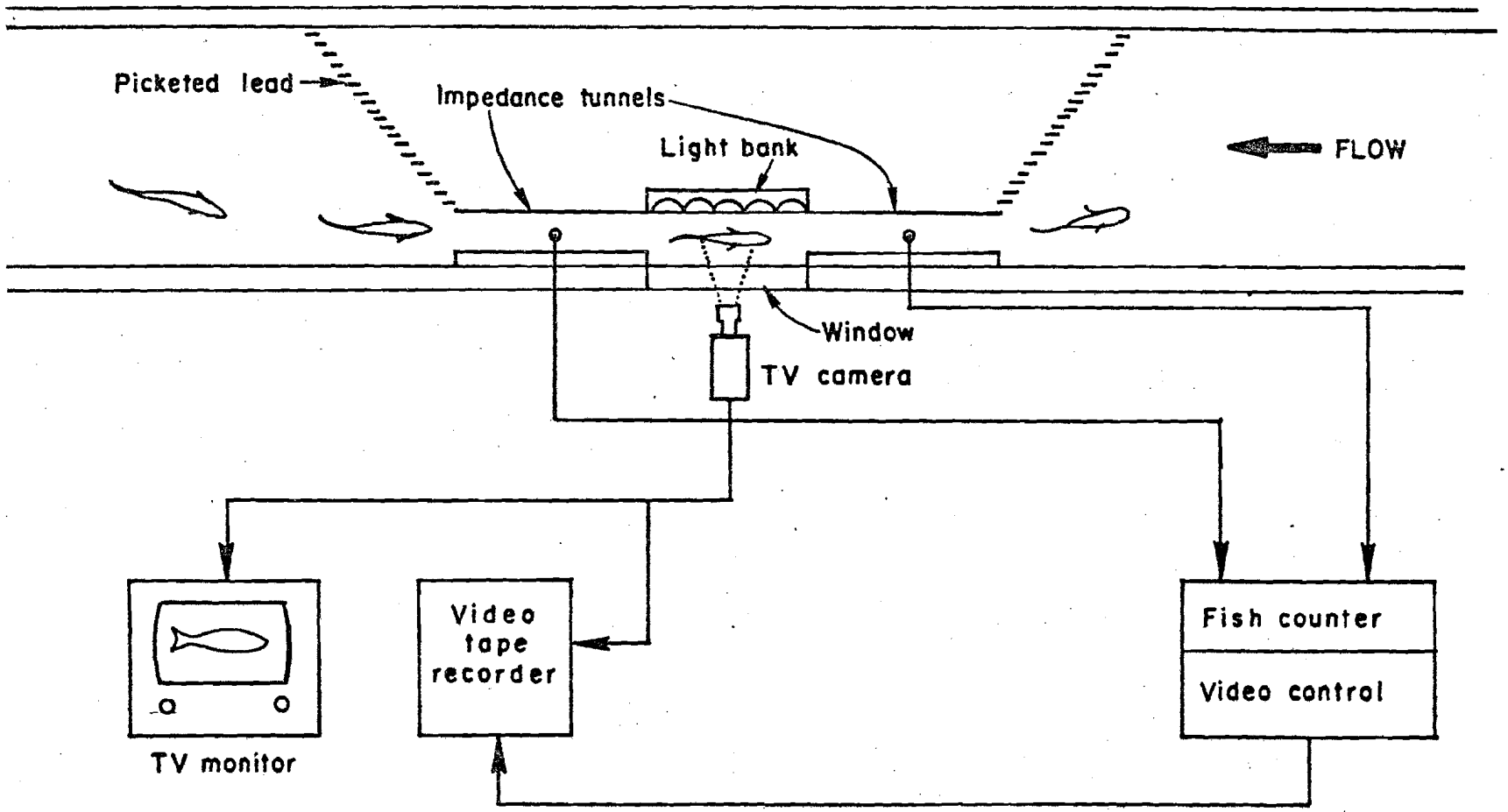

Figure 6 Diagram of automatic counting system

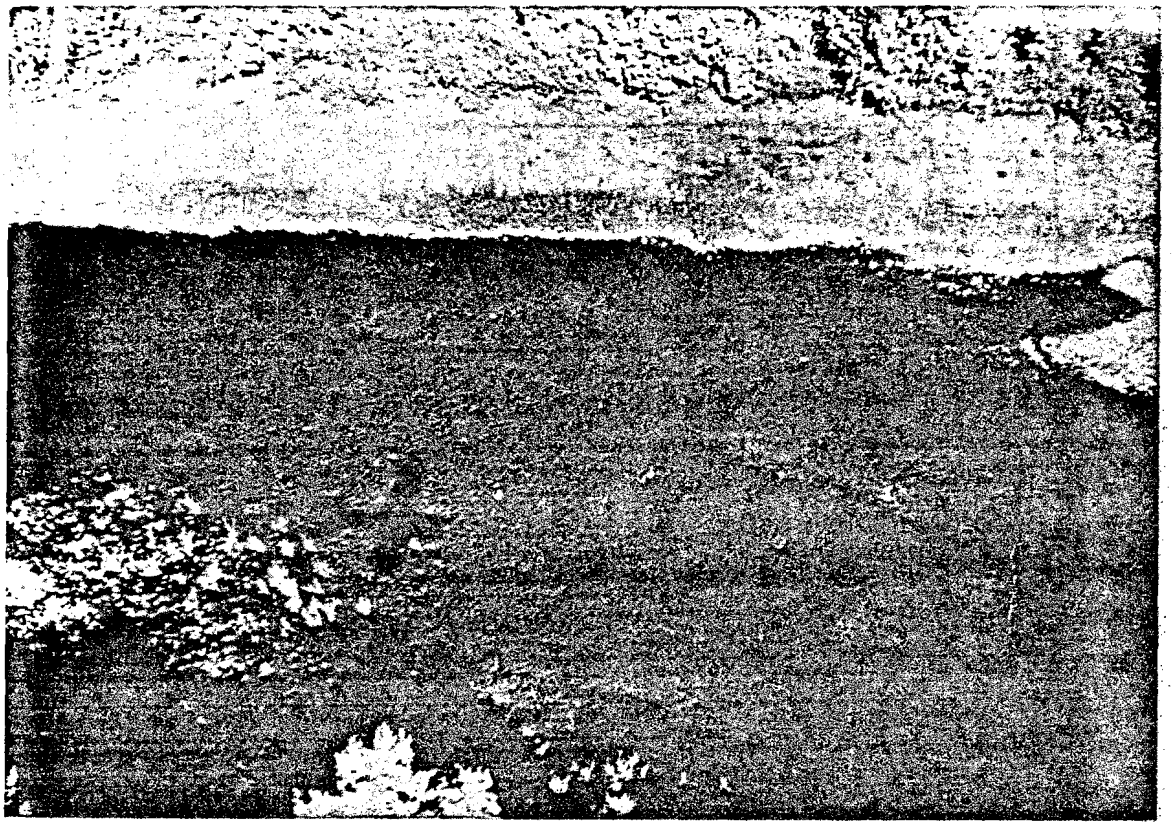

Figure 7 Aerial photograph of salmon redds (light coloured patches in stream bed above and to right of plane shadow) provide data on spawning activity

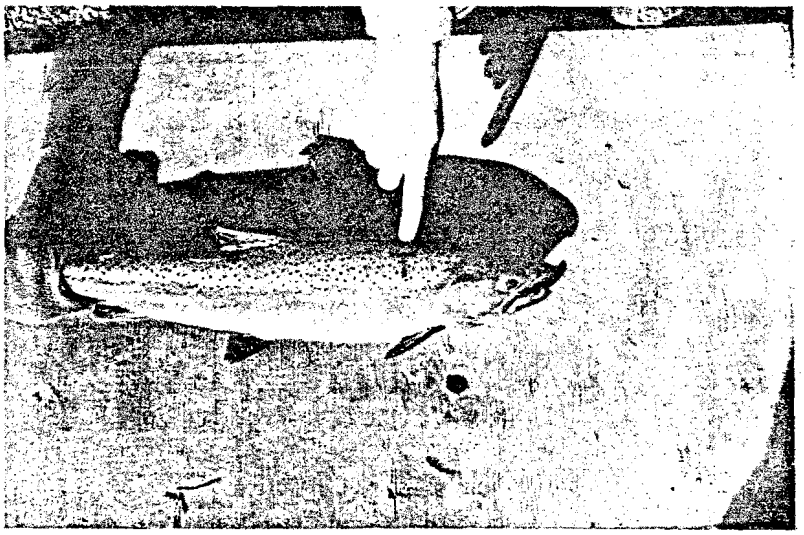

Figure 8 Adult steelhead trout showing brand (T) applied to fish as a juvenile during its downstream migration

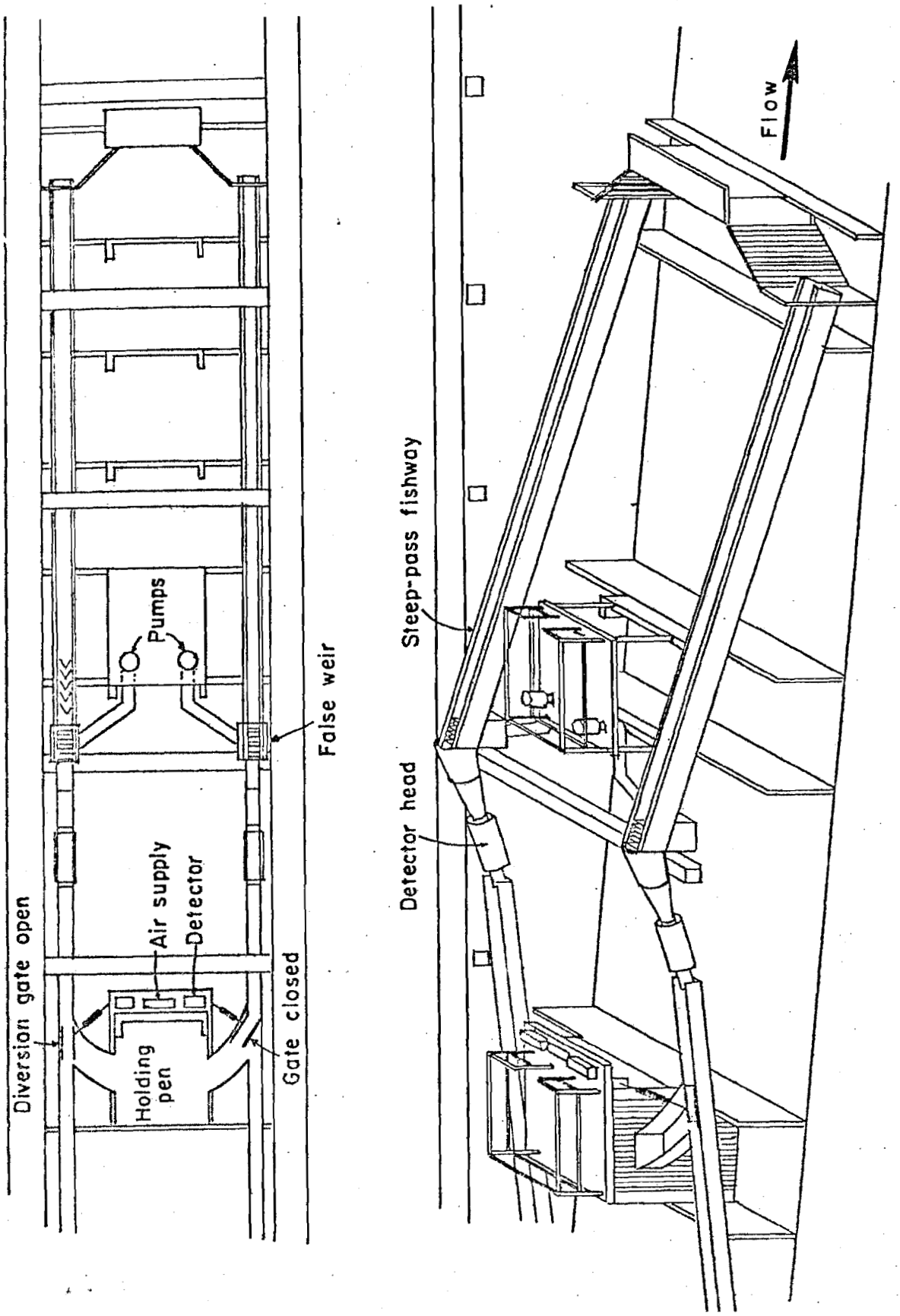

Figure 9 Plan and isometric views of wire tag detector and fish separator systems used at Little Goose Dam