A LABORATORY FOR FISH BEHAVIOR STUDIES

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A LABORATORY FOR FISH BEHAVIOR STUDIES

by

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ABSTRACT

A specialized laboratory has been built in Seattle, Washington, for obtaining information about fish behavior. The laboratory includes a concrete experimental tank, 60 feet long, 20 feet wide, and 5 feet deep, in which water can be recirculated at flows up to 40 cfs, and several smaller tanks for a variety of studies. Features of the laboratory include facilities for holding and acclimatizing fish, electronic control units for electrical studies, a heat-exchange system for temperature control in small tanks, means for controlling light conditions, and provisions for making chemical analyses.

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INTRODUCTION

Intelligent approaches to problems of fish passage over dams or other obstructions to migration require interpretation of fish behavior observed in the field, and the ability to predict future behavior under specified conditions. The investigation of fish behavior in relation to fish passage problems necessitates that some studies be in more detail than is sometimes possible in the field. Laboratory research is needed in which environmental factors can be isolated to determine how they affect the migratory behavior of Pacific salmon and how they can be related to the design and operation of fishways, bypasses, counting mechanisms, and guiding devices.

A laboratory for studying fish behavior has been constructed as a basic unit of the fish behavior studies initiated by Pacific Salmon Investigations with headquarters at Seattle, Washington. This paper describes these laboratory facilities, demonstrates how they can be used, and reviews briefly their use.

PHYSICAL FACILITIES

Main experimental tank

The principal experimental area is a covered concrete tank (fig. 1) which has at one end a headbox and at the other end a sump from which water can be recirculated through the headbox and tank (fig. 2, page 2). Four vertical axial-flow pumps mounted over the sump, 15 by 30 by 9 feet deep, can discharge up to 40 cubic feet of water per second into the headbox, 10 by

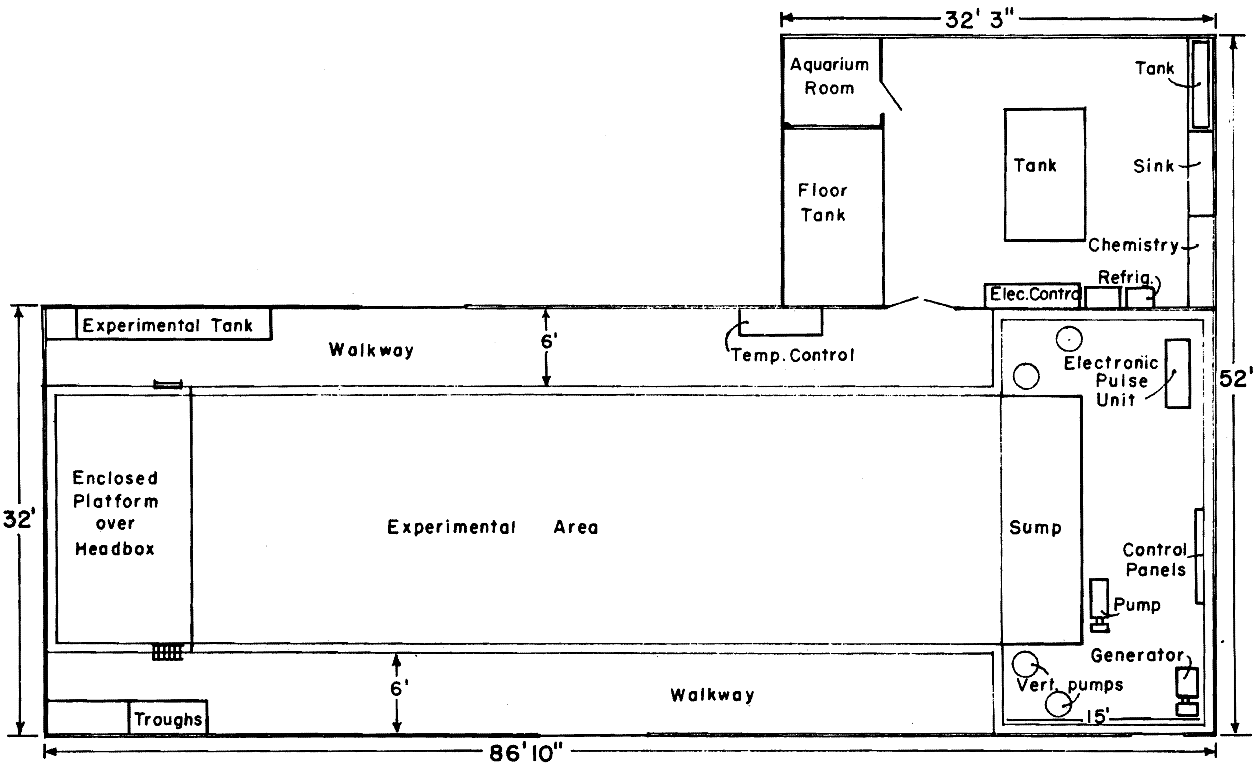

Figure 1.--Plan of laboratory building showing relation of machinery deck, wing and enclosed platform to the main experimental tank.

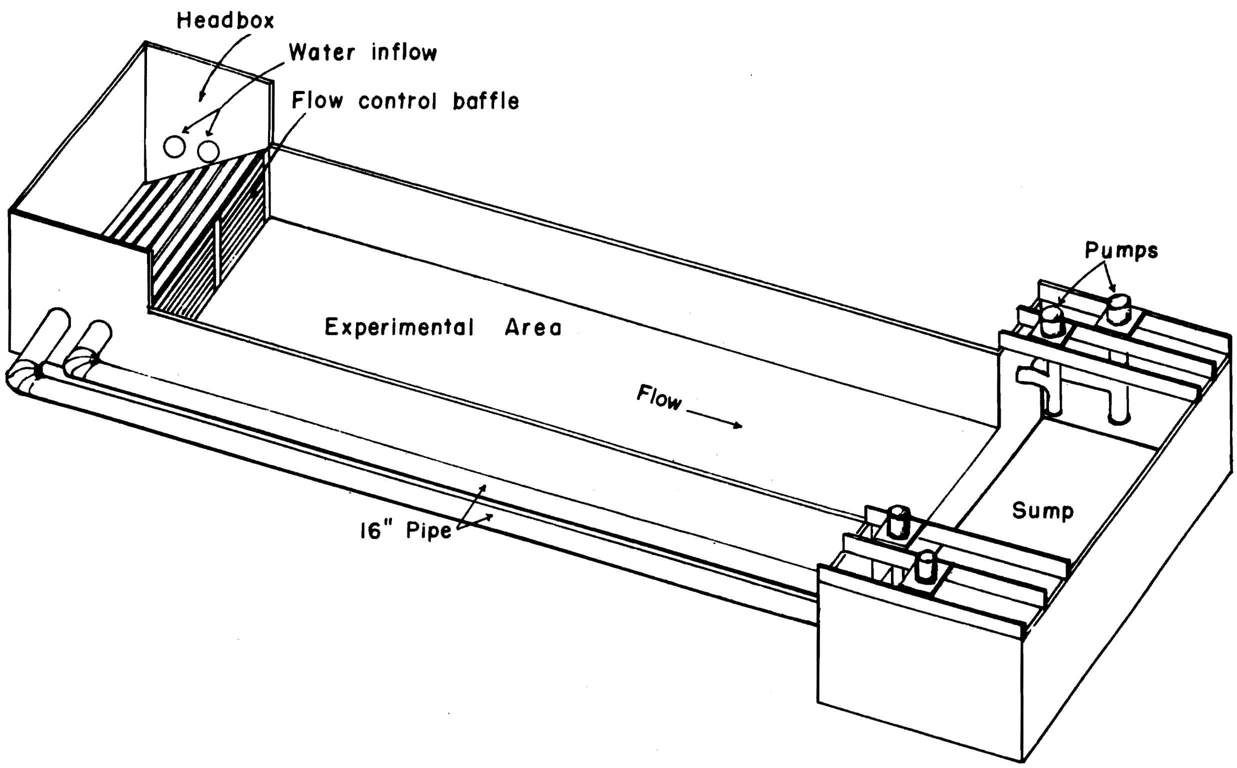

Figure 2.--Main tank showing relation of sump, 40 cfs pumping system and headbox to the experimental area.

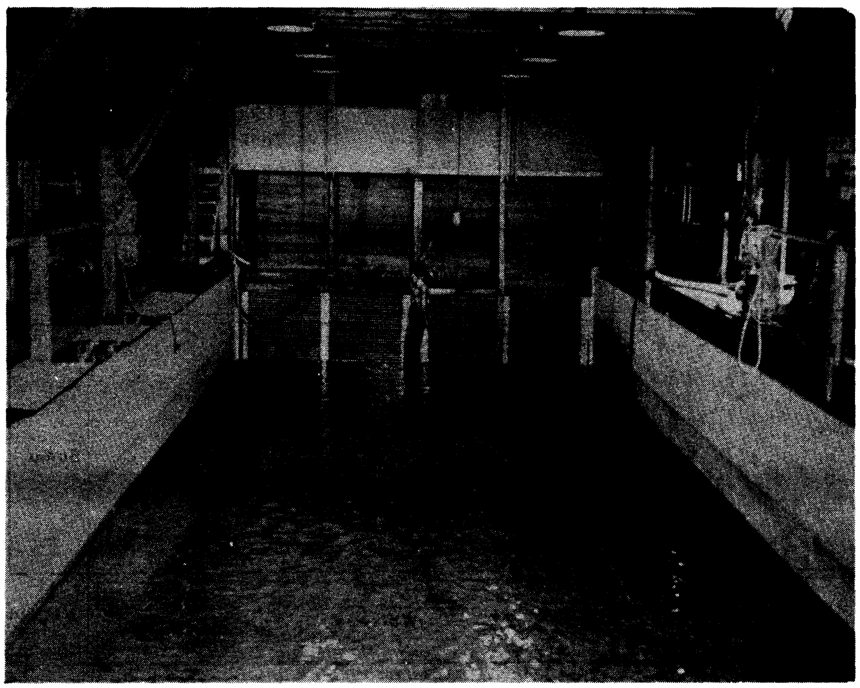

Figure 3.--Main experimental tank and headbox showing flow-control system and the enclosed platform above the headbox. Openings of 2-inch inflow pipes can be seen on right wall of headbox.

20 by 10 feet high (fig. 3), where a flow-control system designed to minimize turbulence produces a relatively uniform flow at any depth up to 4 feet in the tank.

Designed for a variety of large-scale hydraulic conditions, channel width can be varied by the installation of false walls (fig. 4). This permits channel widths up to 20 feet, depths to 4 feet, velocities to 4 feet per second (faster when channel width is reduced), and discharge rates of 10, 20, 30, and 40 cubic feet per second using 1 to 4 pumps in combination. The tank is also used as a pool (fig. 5). A coating of asphalt on the walls and floor insulates against electrical grounding and permits tests using electrical fields in water (fig. 5).

To maintain flexibility there are no permanent installations in the tank proper--only the flow-control system in the headbox and stop-log guides between the tank and sump (fig. 6, page 4).

Six-foot areas on each side of the tank allow passage space for personnel, limited storage, additional small experimental tanks, and troughs for temporary fish-holding. A large deck over the sump, continuous with the walkways, provides space for heavy machinery of a more permanent nature, such as the 4 large pumps.

Other experimental areas

Two separate laboratory areas provide space for other types of studies. The larger of these is a wing on the main structure (fig. 1) which includes several general-purpose tanks, provisions for chemical analyses, sink and refrigerator,

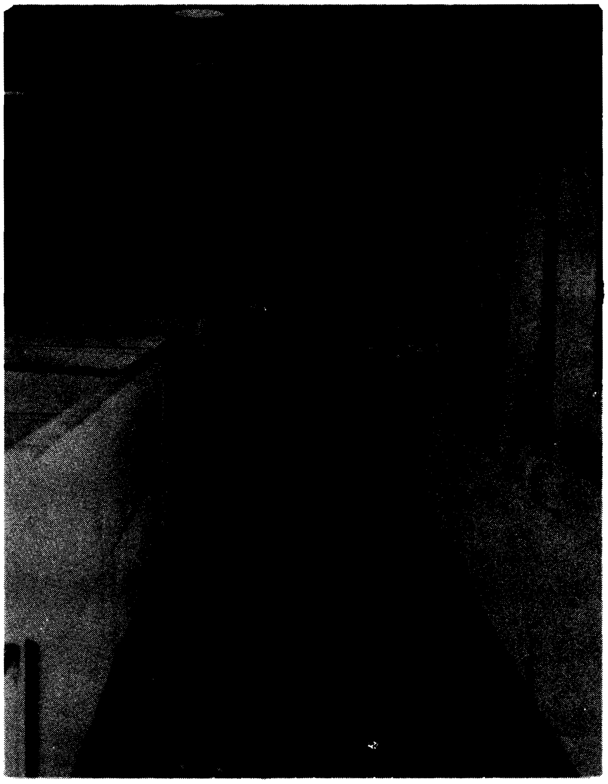

Figure 4.--Main tank with a 5-foot channel used in a study of the effect of sonic tags on swimming ability and behavior of adult salmonoids.

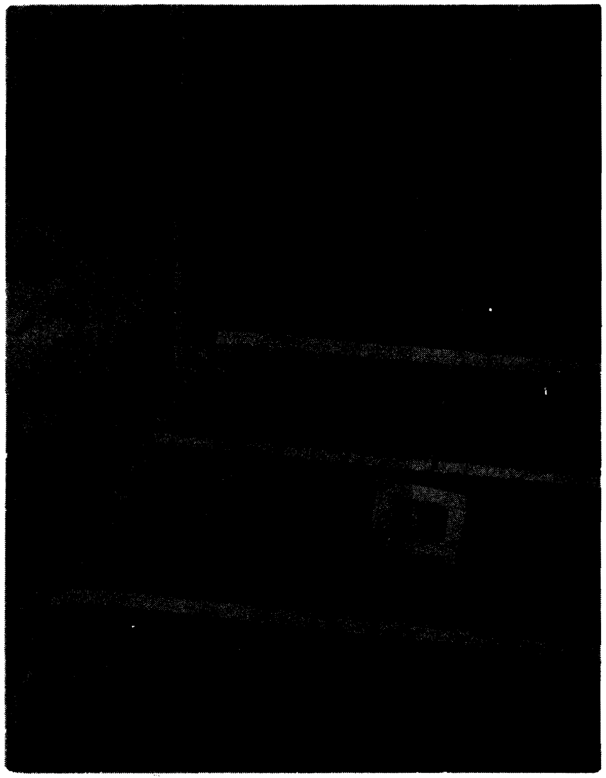

Figure 5.--The main tank as used in studies of electrotactic response of adult squawfish. An electrode array was enclosed within the tank and was energized by the generator and electronic pulse unit on the deck.

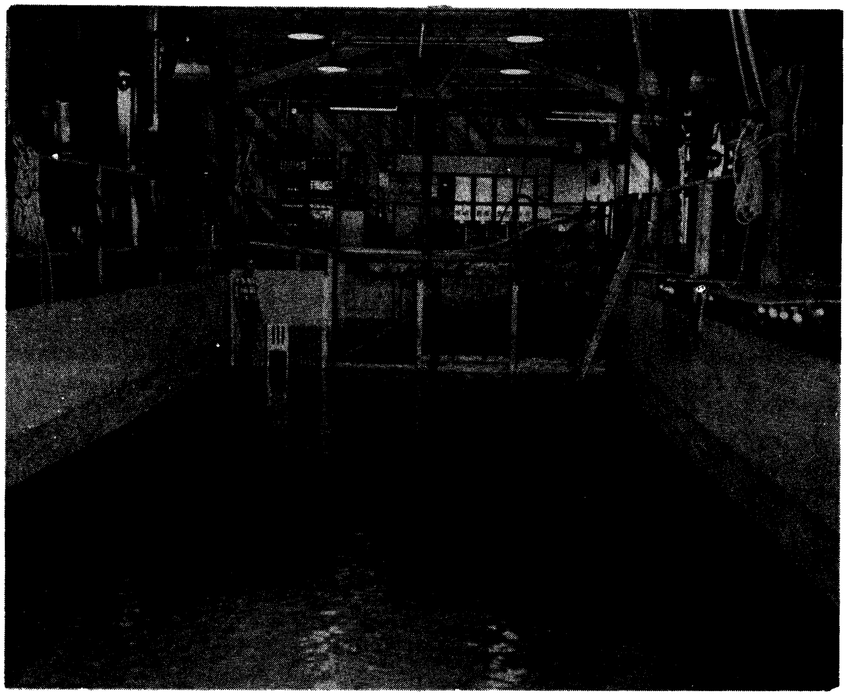

Figure 6.--View of the main experimental tank from the enclosed platform. Visible at the end of the tank, just ahead of the sump, are stop-log guides, stop-logs in place, and a picket gate beside the standing figure. On the deck above the sump (left center) are three racks of electronic controls. On the rear wall (right center) are control switches for the various pieces of electrical equipment.

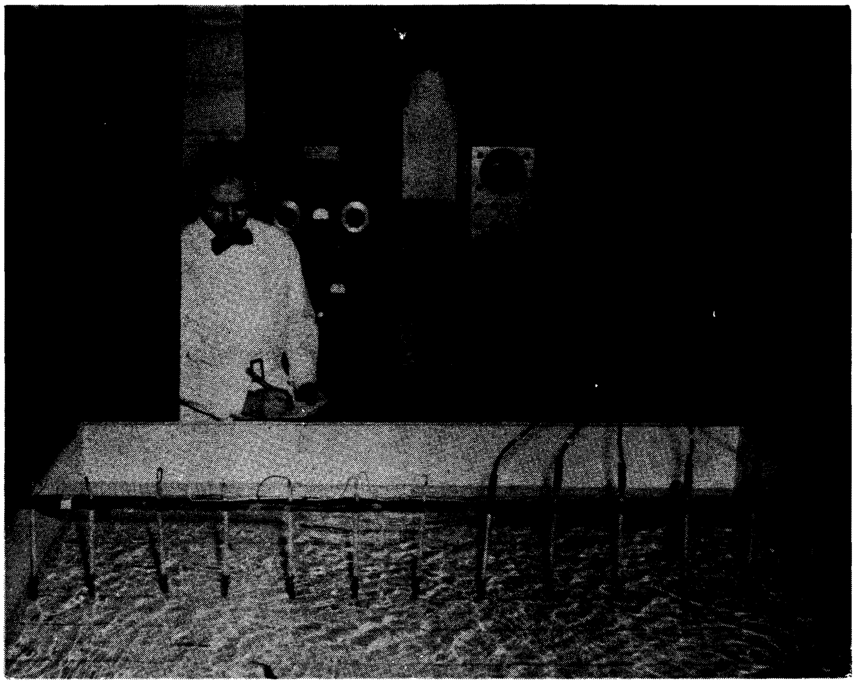

Figure 7.--An experimental tank with electrodes installed for studies of behavior of fish in an electrical field. Black curtains, as shown here, are used around many tanks to prevent visual disturbances while tests are in progress. Electronic pulse-control units in background.

electrical control equipment, and storage cabinets.

A smaller area in an enclosed platform over the headbox (fig. 3) provides for tanks and experimental apparatus to be set up for work in convenient isolation. Electrical outlets and water taps are located along the rear wall. The enclosed platform was also designed to serve as an observation platform with an overall view of the main tank (fig. 6), and for that reason the side facing the tank has a 36-inch high wall and has curtains handing from above.

Flexibility is maintained in the same manner as in the main tank; the wing room and enclosed platform have no permanently installed equipment, but each piece is set in position when needed. Small pieces of apparatus which require a catch basin for splash or a temperature-maintaining bath can be set up in the large tank or one of the smaller ones.

Special equipment

The varied nature of the research in this laboratory requires special constructed equipment as well as converted military surplus and standard commercial apparatus.

Tests investigating the responses of fish to an electrical field (fig. 7) require an electric generator and electronic pulse-control units. The generator and one set of controls are located on the machinery deck over the sump. A second control unit is located in the wing room.

Studies of fish behavior in the dark or in very low light intensities are aided by military-type infrared viewers and lamps. Infrared illumination (figs. 8 and 9) permits observations without disturbing the behavior of the fish (Duncan 1956).

Experiments which require close control of water temperature are conducted in the wing room where heat-exchange coils can be set in the tanks. These coils are a part of a custom-built heat-exchange unit that provides heating or cooling as desired with a regulation of ± 0.1° C. The unit will maintain any preselected temperature from 0° to 25° C., and it has a heating rate of 2.1° C. per hour, a cooling rate of 1.5° C. per hour as currently used with the 300-gallon experimental system shown in figure 10 (page 6).

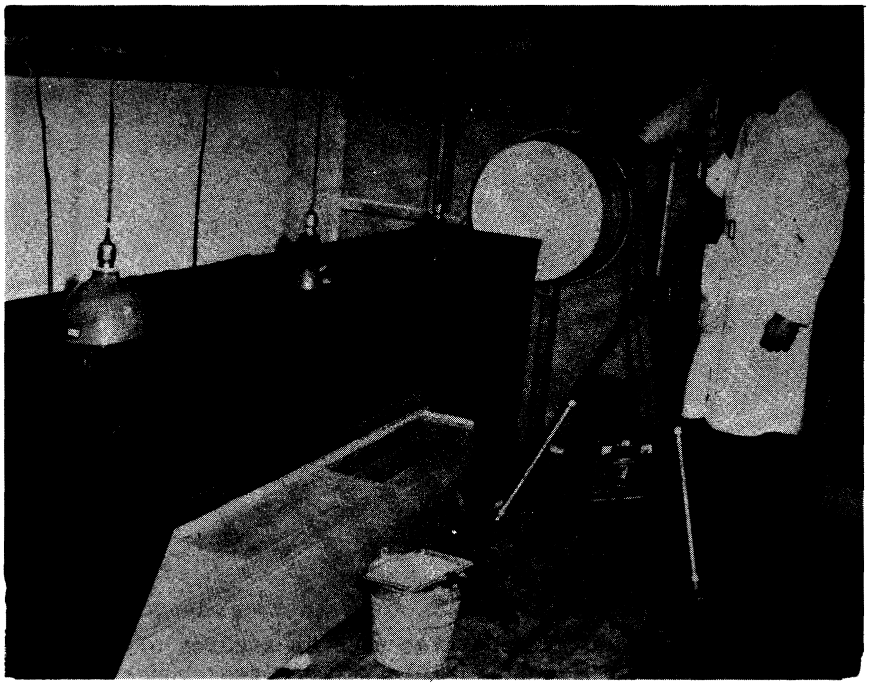

Figure 8.--Interior view of the enclosed platform over headbox. Mounted on tripod are infrared lamp and viewer used for observing fish in darkened tanks.

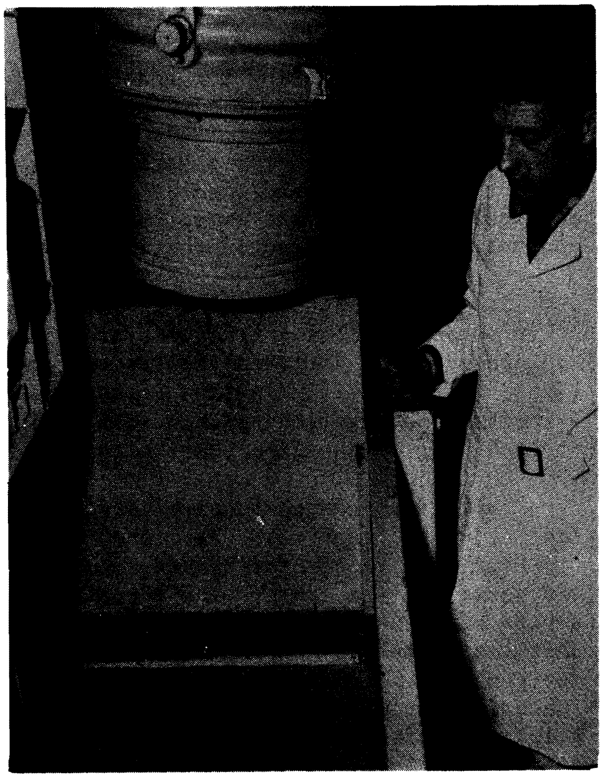

Figure 9.--An experimental tank, located along one of the walkways, equipped to evaluate small tunnels to be used in passing downstream migrating fingerlings. Infrared lamp hanging above tank.

Studies of underwater sound and fish behavior use underwater sound transducers and hydrophones developed for this purpose. A more detailed description of this equipment and its past use are given by Moore and Newman (1956).

Studies in small tanks requiring regulated water flows can be supplied by 2-inch hose from a high-velocity pump discharging up to 400 gallons per minute. This pump is on the machinery deck and pumps from the sump below.

Most of these studies demand precise measurements of environmental conditions such as water velocities, light intensities, and electric potentials. These are measured by appropriate standard instruments such as water current meters, light meters, oscilloscopes, and vacuum-tube voltmeters.

Fish-holding facilities

The tests performed in the Behavior Laboratory, because of their number and variety, require several tanks for holding fish in small lots separately. Space must be available for holding several species of fish, sometimes in rather large numbers. The facilities to meet this need are grouped in the fish-holding area. There are 10 circular steel tanks 1 1/2 feet deep (four

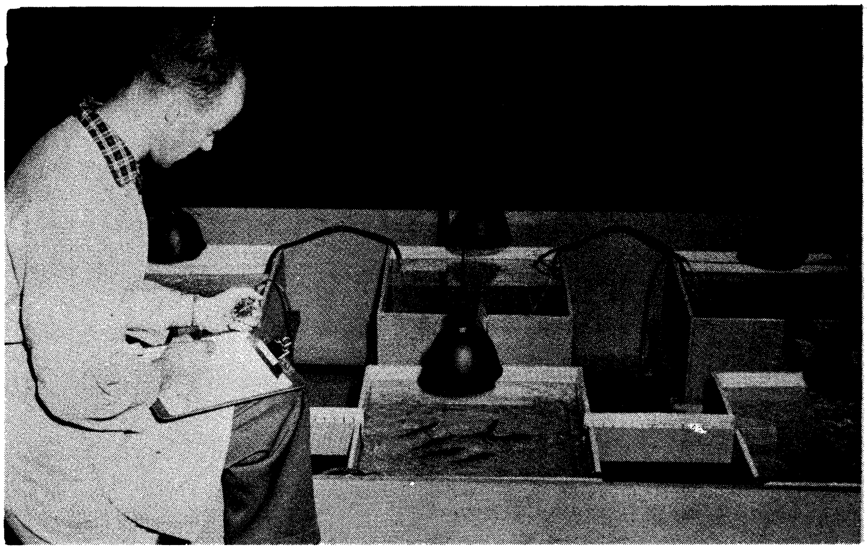

Figure 10.--An experimental apparatus used in studies of fingerling responses to water flow. Visible between rear boxes are tubes connecting heat-exchange coils in boxes to temperature control unit. The suspended lights are connected through a variable transformer for light intensity control.

6-foot diameter and six 4-foot diameter, similar to that shown in fig. 11). Two additional wooden tanks of 4-foot diameter, 2 1/2 feet deep, provide storage for separate lots, and two wooden tanks 6 feet in diameter and 3 1/2 feet deep are available to be set up as needed for extra juvenile or adult fish. The fish-holding tanks are all provided with running water from the city domestic system. Three 500-gallon charcoal filters with a discharge rate of 150 gpm dechlorinate the water.

A small bay of Lake Union into which the holding tanks discharge was dammed, and here, in a 30- by 40-foot pond 6 feet deep, special types of fish such as adult carp (for blood studies) or adult squawfish (for electrical studies) are stored until needed.

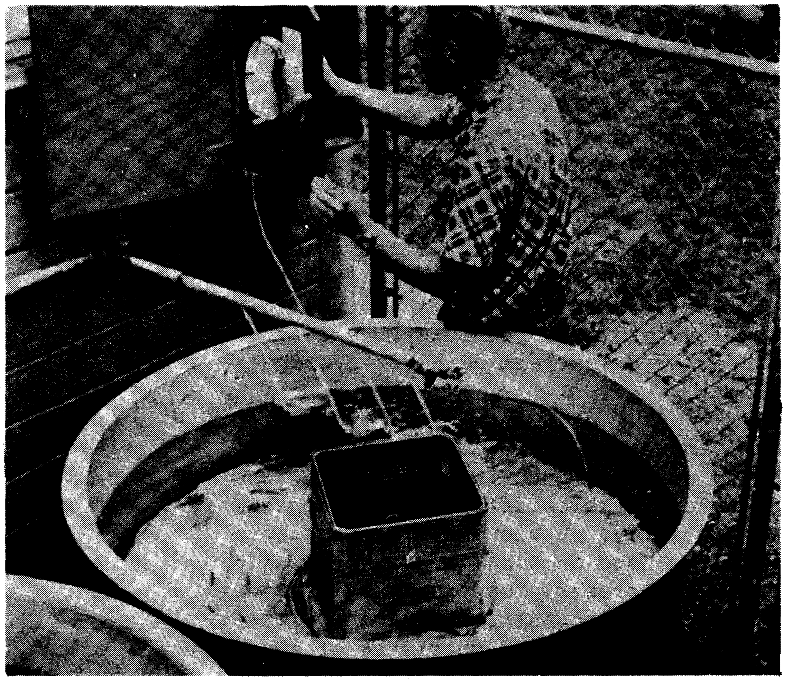

Figure 11.--A 4-foot diameter steel tank in the fish-holding area.

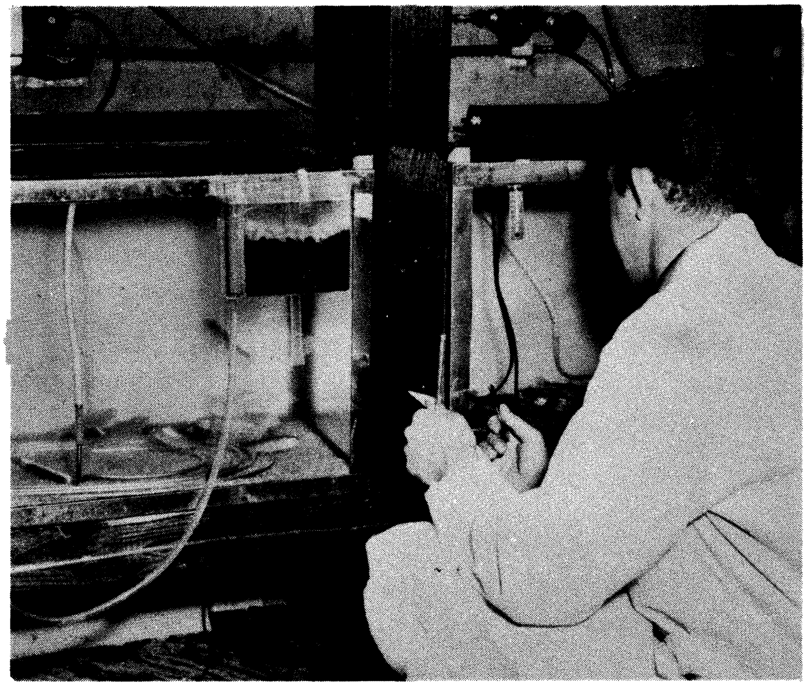

Figure 12.--Two of 9 tanks in the aquarium room. Coils in the tanks connect to the temperature-control unit. Standard aquarium heaters and thermostats are used to complete temperature regulation.

Conditioning and acclimation aquariums

Because the reactions of fish to certain stimuli may depend upon the environment to which they have been conditioned, an aquarium room has been provided to enable us to hold fish under specific temperature and light conditions. A space in a corner of the laboratory wing was partitioned off and equipped with nine 60-gallon aquariums. Each aquarium can be provided separately with air diffusion stones, air-driven charcoal filter, electrical immersion heater, lights, or a cooling coil supplied with coolant from the heat-exchange unit mentioned previously (fig. 12). Temperature can be controlled in each aquarium within the range of 0° to 33° C.

RESEARCH IN PROGRESS

A major part of our current research is a study of the reactions of salmon fingerlings to water currents. Water flow serves to guide and transport fish in the river as they migrate from the hatching area to the sea. The orientation of fingerling salmon to the water flow, their upstream or downstream movements, variables such as changes in water temperature, light intensities, and dissolved gas tensions, the age of the fish, and the season of the year are all to be studied for their possible role in the upstream or downstream movement of fingerlings.

In conjunction with the rheotaxis study we are conducting tests to determine the factors which affect fingerling swimming ability. A knowledge of physical abilities and factors that govern performance is necessary for proper evaluation of rheotactic responses. Preliminary tests have emphasized the importance of the relation of water temperature to swimming ability.

Studies of the behavior of fingerlings in an electrical field at present are concerned with minimum voltage-gradients at which fingerlings respond. Information on threshold gradients is needed to facilitate both the design of electrode array installations and the placement of nonelectrified bypasses.

Group behavior of salmon fingerlings is also being studied. Differences in behavior of sockeye salmon smolts have been found in the laboratory to be related to numbers of fish and spatial relationships. Laboratory observations indicate that silver salmon smolts have a very different behavior pattern from sockeye smolts. Group behavior in restricted spaces may be of considerable importance in the design of fingerling bypasses and traps.

These and other studies performed by the staff of this laboratory are part of a larger fish behavior research program. Its purpose is to obtain detailed information on migratory behavior of juvenile and adult fish necessary to the design of effective facilities for fish passage.

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