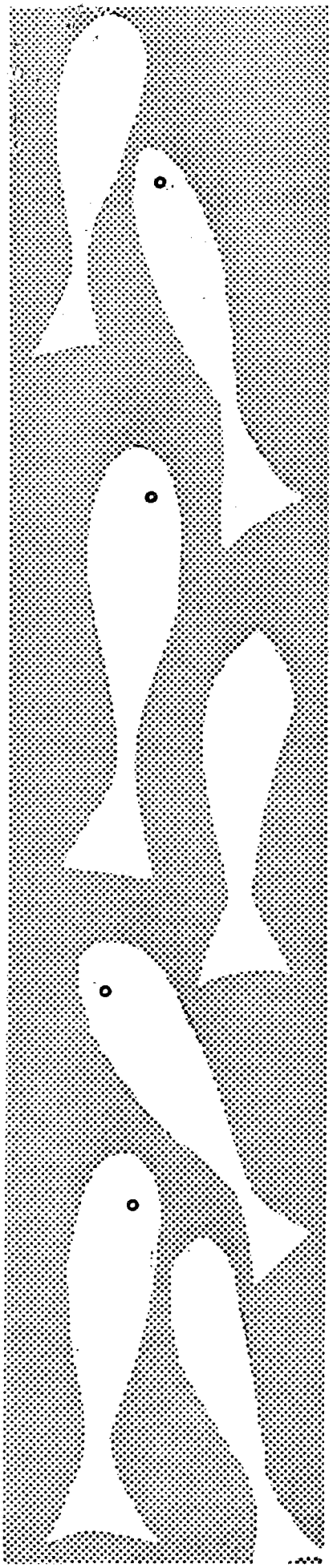

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TECHNICAL ADVISORY COMMITTEE
COLUMBIA RIVER THERMAL EFFECTS STUDY

THERMAL POLLUTION AND THE COLUMBIA RIVER SMELT

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The smelt fishery of the Columbia River and its tributaries is indeed unique. Fish are caught commercially in the mainstem with gill nets, but commercial and sport fishermen are allowed to use dip nets in the tributaries.

Smelt provide the public with an accessible item for the winter dinner table. They are relatively easy to capture in the tributaries, and the commercial harvest provides a timely income to the fisherman. Although the final tabulation of the 1969-70 season is not complete, the 1968-69 harvest (1,120,000 pounds) was worth more than $280,000; the economic value of the sport fishery was estimated at $570,000. Last winter's season was estimated to have equalled or exceeded the 1968-69 catch.

Most smelt enter the Columbia River in late November or early December when the river temperature averages 45°F. If the temperature varies above or below normal, schools of smelt act erratically--they are delayed, migrate farther upstream, or simply fail to enter the tributaries that they spawn in. The 1969 season was a cold-water year; hence the smelt run of the Cowlitz River was delayed. The 1970 season was another atypical year in the Cowlitz, the run was delayed but market saturating runs ascended the Lewis River during April.

The Columbia River smelt is an anadromous fish. The adults spawn in freshwater but spend most of their life cycle in salt water. The major tributary spawning occurs in the Cowlitz River, but runs have been observed in the Lewis, Kalama and Grays Rivers. In past years, smelt were common in the Sandy River and migrated as far upstream as Cascade Locks in the Columbia River. The distribution of schools of smelt in the Columbia River is not well known; some are found between Puget Island and Vancouver. Schools enter tributary streams to spawn, but some remain in the mainstem.

Apparently the males move into the tributaries first. Smelt spawn at 3 and 4 years, and most of them die soon after. Spawning occurs primarily at night.

Female smelt deposit what are known as demersal eggs; that it, eggs that sink slowly toward the bottom of the river. A female of average size produces about 25,000, possibly ranging from 7,000 to 60,000 eggs per female.

Smelt eggs are adhesive and surrounded by double membranes. As the egg settles to the bottom of the river and touches an object, the outer membrane ruptures and attaches to the substrate--usually to sand grains or debris. The inner membrane contains the embryo.

The eggs are not attended by the adults. Development of the eggs, from time of deposition to hatching of fry, takes about 3 weeks at 47°F. The fry emerge from the egg "shell" with the yolk sac attached and are about 4 millimeters long (60 fry placed end on end would measure one inch). The fry are weak swimmers and must leave the freshwater and enter salt or brackish water soon after hatching. They are swept along with the river current. Sensitive to light, they stay near the bottom of the river during their downstream migration to the ocean.

Smelt seem to prefer narrow ranges of water temperature. However, recent industrial development in this section of the river includes proposals to install large thermal nuclear electric plants. These plants have the capability of altering local river temperatures.

Two thermal nuclear electric plants have been proposed upstream from the mouth of the Cowlitz River; (1) the Trojan Electric Plant at Prescott, Oregon, and (2) the Kalama Plant above Kalama, Washington. The proposed sites, about 4 and 13 miles above the Cowlitz River, lie directly in the migration route of smelt that ascend the Kalama and Lewis Rivers and other anadromous species of fish in the Columbia River.

Thermal nuclear plants require large quantities of water to cool their condensers. For each unit of heat converted into electricity, two units of heat are ejected into the adjacent waterways.

The Kalama Plant is scheduled to produce 2,000 megawatts of electrical power upon completion (about 4 times the power production of Bonneville Dam). The proposed Kalama Plant will utilize 4,000 c.f.s. (cubic feet per second) of water (based on an average water use of 2,000 c.f.s. per 1,000 megawatts). The temperature of this large quantity of water will be raised about 15°F. Thus, without "offstream" cooling facilities, this plant could discharge large quantities of heated water directly into the path of migrating fish.

The proposed Trojan Plant, 9 miles downstream of the Kalama Plant at Prescott, Oregon, will produce 2,000 megawatts of electricity; fortunately, the Portland General Electric Company plans to install cooling towers to prevent the discharge of all but 35 c.f.s of waste heat into the river.

Because of the impending installation of large thermonuclear plants on major migration waterways of valuable anadromous fish and the effect that these plants could impose on the fish, the Bureau of Commercial Fisheries initiated an investigation to determine what effect temperature increases would have on the aquatic animals and plants between Kalama

and Longview, Washington. The Bureau is working in close cooperation with State and Federal agencies to investigate the effects of thermal pollution on anadromous fish, such as salmon, trout, sturgeon, shad, and smelt in the Columbia River.

During August 1967, a covered barge was towed to Carter's Marina at Prescott, Oregon, and was converted to a modern aquatic research laboratory. Equipped to determine the thermal tolerance of anadromous fish, the laboratory uses Columbia River water, cooling it with chillers or heating it with heaters on a once-through system. Fish are taken with purse seines, beach seines, trawl nets, and dip nets. Fish captured are subjected to increases in water temperature to determine the lethal and sublethal levels for egg, fry, and adults.

During the winter of 1968, adult smelt were examined to determine their thermal tolerance. Fish were killed directly by subjecting them to minor temperature increases. Most females placed in water heated 7°F. above river temperature failed to deposit eggs.

Extensive experimentation was conducted during 1969 to verify these preliminary observations, namely that adult smelt are intolerant to temperature increases. The first group of fish were taken from the mainstem of the Columbia River by commercial fishermen who were working in cooperation

with the Washington Department of Fisheries.

Additional fish were obtained from the Cowlitz River by the laboratory staff. Fish were dip-netted from a boat and on the beach and transported by tank trucks to Prescott, where they were placed in tanks aboard the floating laboratory. (They were first transferred to holding tanks to determine handling mortalities andplaced in test tanks with heated water.)

The general results of the temperature tolerance studies verified earlier results; that is, that adult smelt are sensitive to slight increases in temperature. Increases of 10°F. killed all test fish in 8 days. Temperature increases of 5°F. inflicted a 50-percent mortality in the same time period. Higher temperatures killed the fish in a shorter period. Studies with smelt eggs indicated that eggs are more resistant to temperature increases than the adults. It was observed again in 1969 that adult fish are reluctant to deposit eggs after being subjected to increased temperatures.

Smelt populations could face serious problems if thermalnuclear plants are allowed to discharge heated water into the river. The problems could be compounded if water temperature regulations and standards for the Columbia River are based on the tolerance limits of steelhead trout and salmon, the most valuable of the anadromous fish. The most favorable temperatures for salmon and trout range from 42 to

about 60°F. Representatives of the thermal electric power industry have voiced opinions that more heat could be allowed into the Columbia River during the winter; they indicate this increase could theoretically benefit salmon production during near freezing temperatures. However, our present knowledge of thermal tolerance levels for smelt indicates that some temperature increases could be detrimental.

Water temperature standards for the Columbia River--recommended by the State of Washington--allows for the addition of more heat into the river at lower temperatures than allowed during the summer. Oregon standards for the Columbia River allow only 2°F. increases at any time of the year, not to exceed 68°F. Water temperature standards for interstate waters should be consistant and designed to protect all commercial and sport fish in the river.

It is interesting to note that many experts predicted that because of the severe winter temperatures during December and January, 1968-69 smelt would fail to enter the Cowlitz River to spawn. The smelt did enter the river, but they were 5 weeks late. Does colder water temperature produce the erratic and non-predictable occurrence of a smelt run, and if it does, would warmer water produce a similar situation? What will be the fate of the smelt runs in the lower Columbia River as industrialization increases?

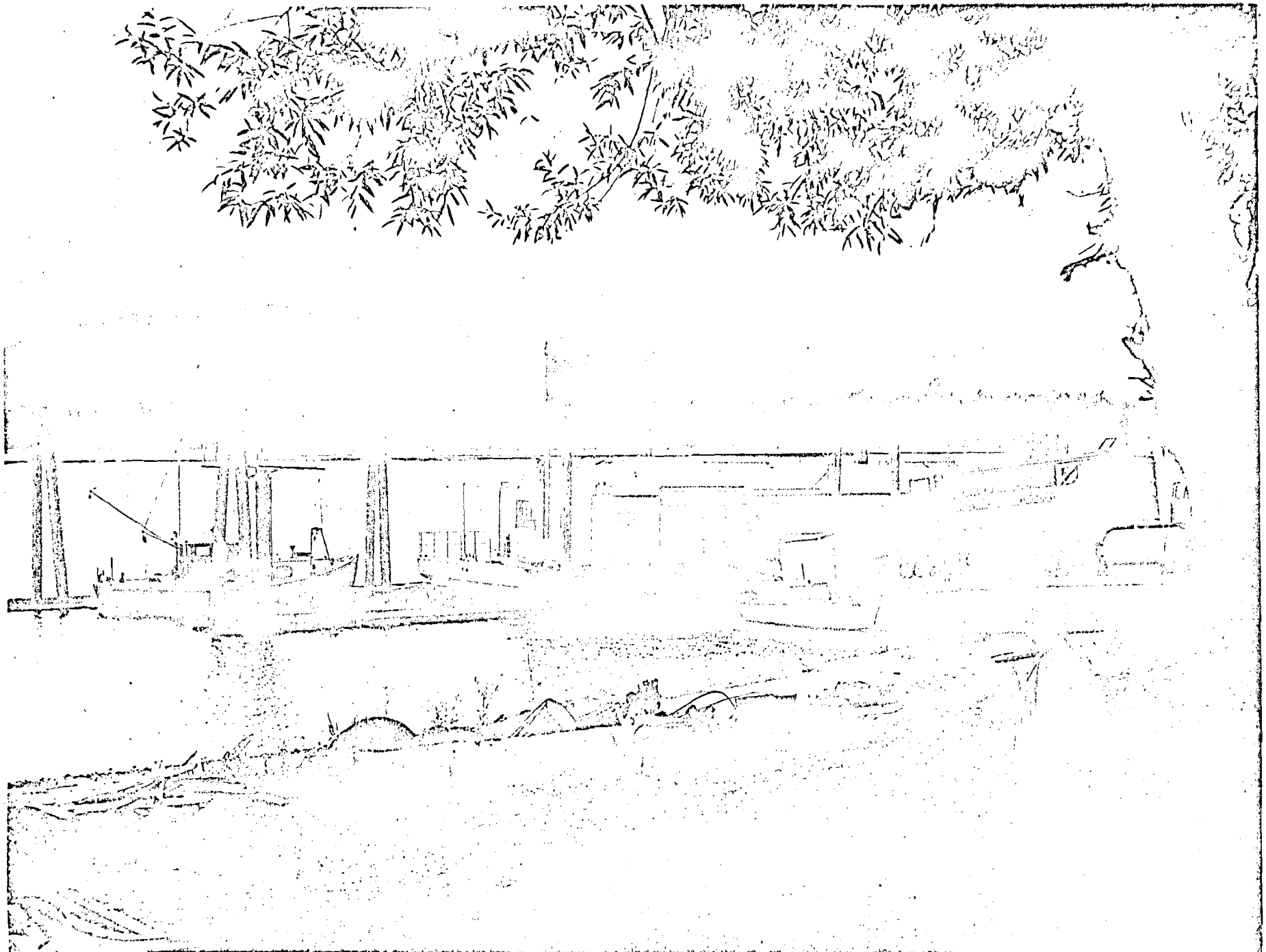

Figure 1.--BCF Water Temperature Laboratory on the Columbia River--$\frac{1}{4}$-mile below the proposed Trojan thermal nuclear electric plant site.

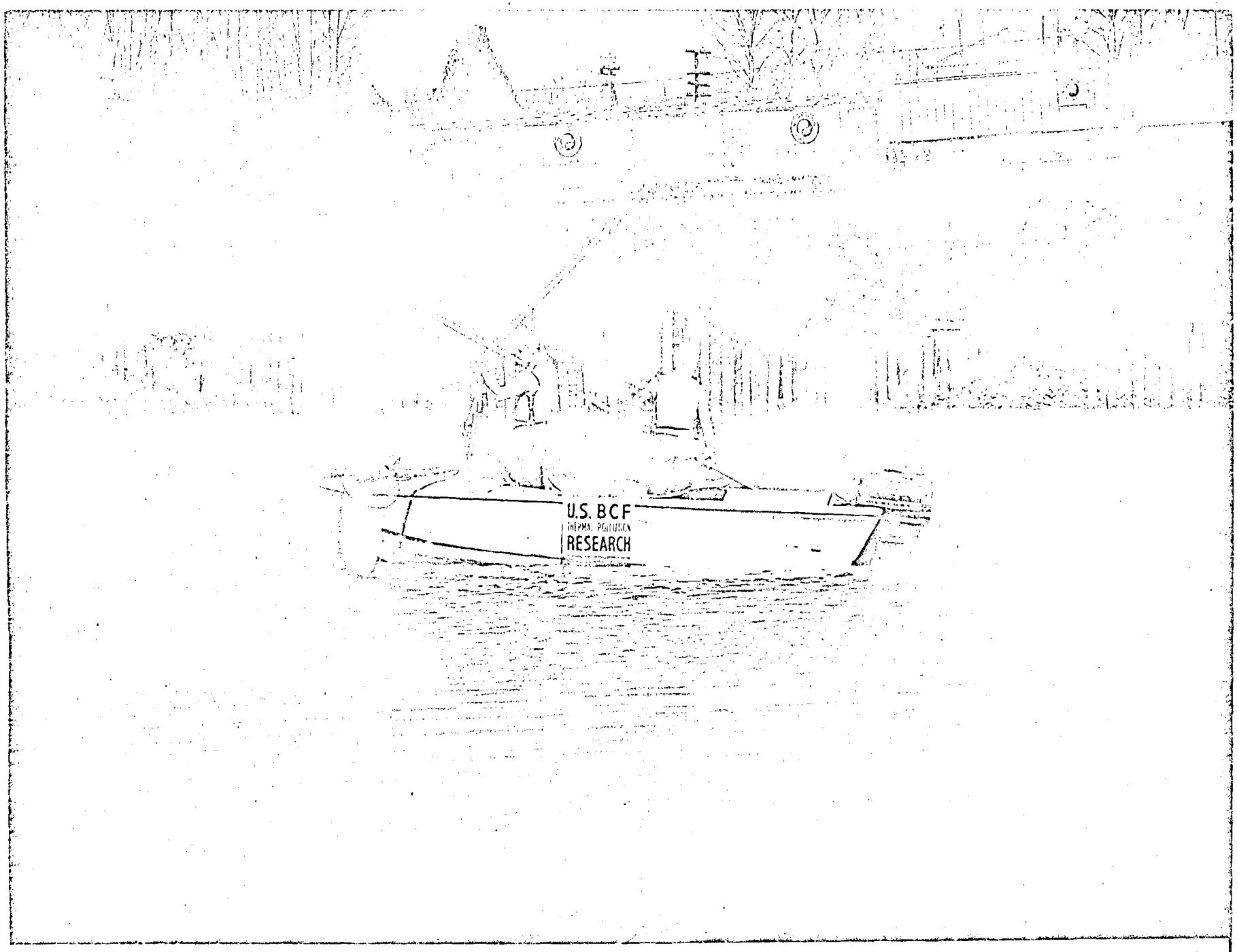

Figure 2.--Technicians collect smelt for experimentation from the Cowlitz River with dip nets.

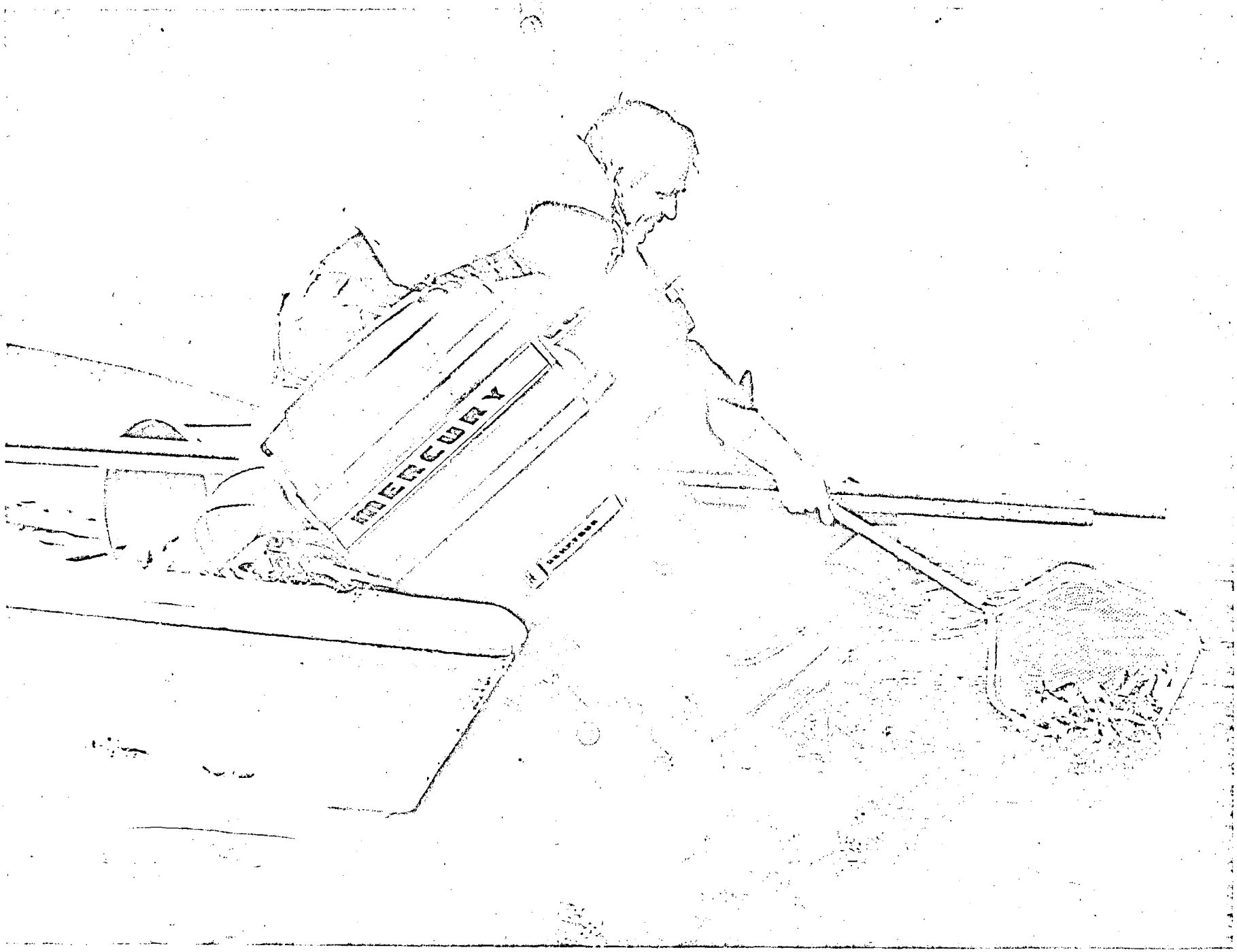

Figure 3.--Adult smelt can be captured with a short-handled dip-net when the major run is in the river.

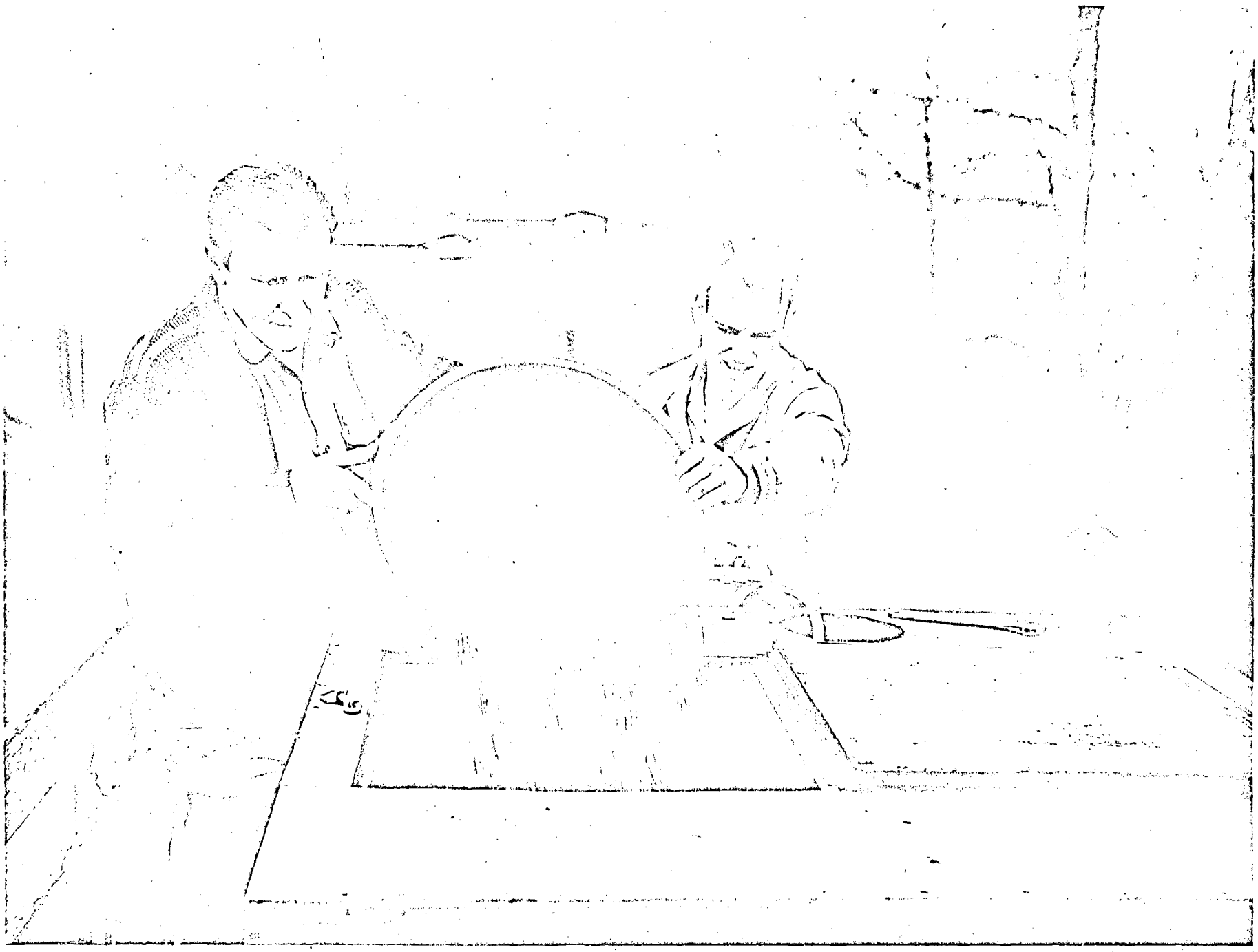

Figure 4.--Smelt are transferred from the Cowlitz River to a transportation tank--oxygen is provided to insure maximum survival.

Figure 5.--Smelt are placed in holding tanks on the floating laboratory for several days prior to testing.

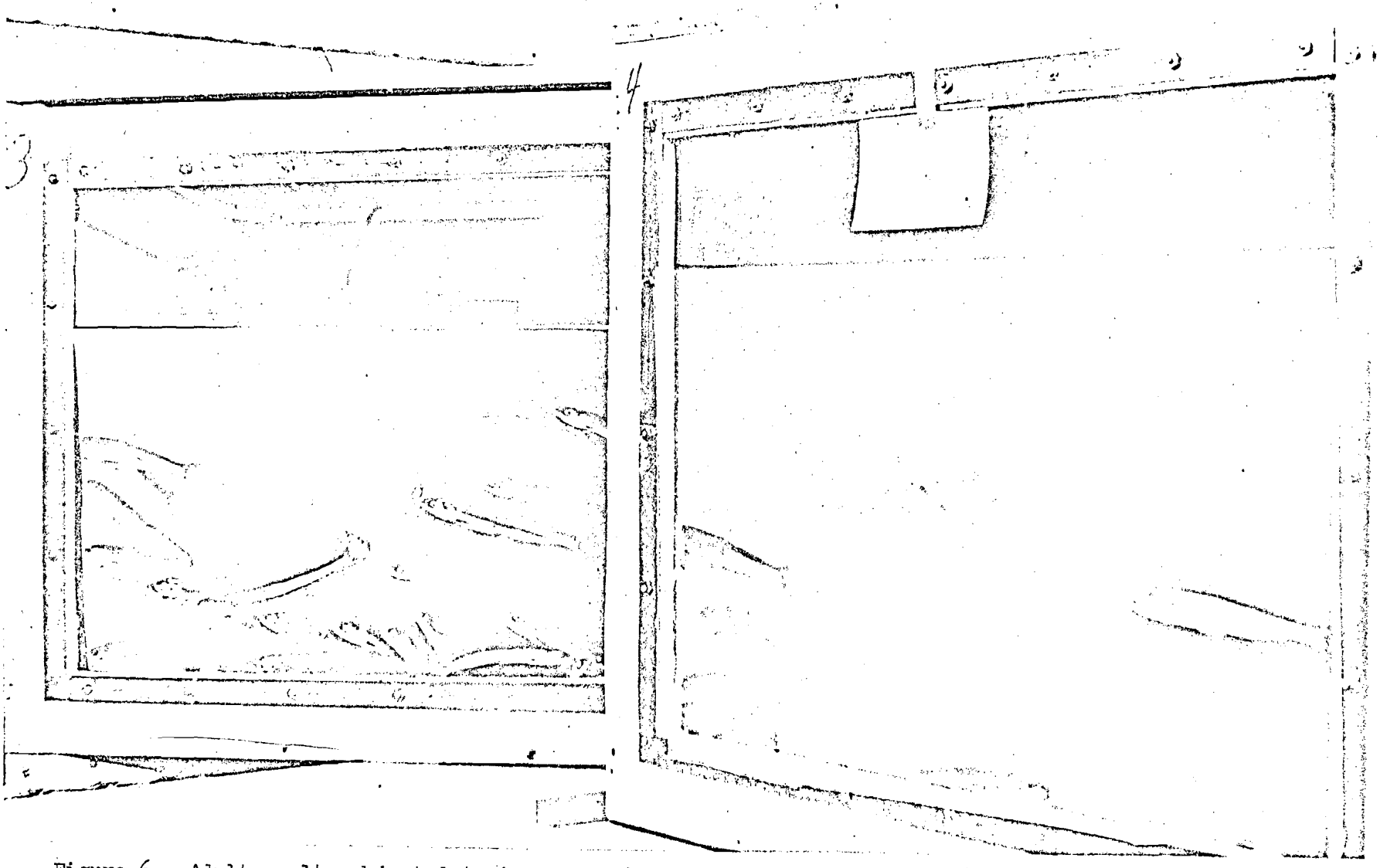

Figure 6.--Adult smelt subjected to increases in water temperature in 50-gallon test tanks--each tank contained a similar number of fish--the tank on the right was 1°C warmer than the tank on the left.

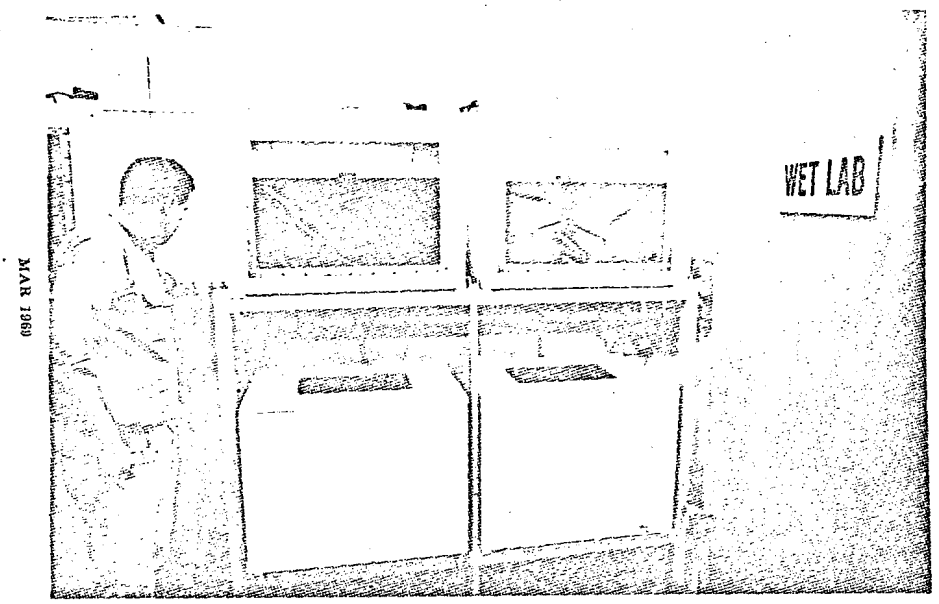

Figure 7.--Biological technician periodically checks test tanks to assess how smelt are affected by increasing temperatures.