The Trapping and Marking of Sockeye Salmon Fry *(Oncorhynchus nerka)* at Fulton River, Babine Lake B.C., (1966-1968)

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FISHERIES RESEARCH BOARD OF CANADA

TECHNICAL REPORT NO. 348

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THE TRAPPING AND MARKING OF SOCKEYE SALMON FRY (ONCORHYNCHUS NERKA) AT FULTON RIVER, BABINE LAKE, B.C., (1966-1968)

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Pacific Biological Station, Nanaimo, B.C.

NOVEMBER 1972

INTRODUCTION

Babine Lake is one of the most important sockeye salmon producers in British Columbia and provides the major part of the nursery area for Skeena River sockeye. Studies by Johnson (1956-1958, 1961, 1965) suggested that Babine's main lake basin is underutilized as a lake nursery area for sockeye because of the limited capacity of adjacent spawning streams to produce fry. The Department of Fisheries of Canada is currently carrying out a development project at Babine Lake with the aim of increasing production by making fuller use of the lake as a sockeye nursery area. The project involves extending and improving spawning grounds by the construction and operation of artificial spawning channels and dams, to provide for water flow regulation (Dept. of Fisheries of Canada 1965, 1968). In 1965, Channel No. 1 was completed on Fulton River, a major spawning tributary of Babine Lake (Fig. 1).

A comparative study of the distribution, growth, and survival of sockeye salmon fry resulting from the same parental stocks, but reared in natural and artificial conditions began in 1966 (McDonald 1969). Fry produced from natural spawning in the Fulton River and in the adjacent artificial spawning channel (in 1966, channel fry were from planted eyed eggs) were marked distinctively, released, and later recovered in the lake nursery area and at the lake outlet at time of seaward migration (McDonald 1969; Scarsbrook and McDonald 1970). Recovery of the marked fish at the adult stage is being carried out in the commercial fishery and on the spawning grounds.

This report describes the equipment and methods developed and used to collect and mark sockeye fry and the problems and procedures related to maintenance of marking quality.

Location and description

Babine Lake is the largest lake on the Skeena River drainage and one of the largest in British Columbia. Fulton River is located about mid-point on the west side of the lake (Fig. 1). It is one of the principal sockeye spawning streams. An impassable falls at the outlet of Fulton Lake confines the spawning sockeye to the lower four miles of the river. Flows range between 25 c.f.s. and 6700 c.f.s. Generally, peak flows coincide with the peak of the fry movement from stream to lake.

Channel No. 1 (Fig. 2) is located along-side the Fulton River approximately half way between Babine and Fulton Lakes. The channel was completed in the fall of 1965. It is 4900 ft. long and 30 ft. wide. It was designed for water flows up to 75 c.f.s. at a velocity of 1.8 ft/sec and a depth of 1.3 ft. The water is supplied by gravity flow through a pipe from the main river and controlled by a gate valve. A low-level weir was constructed across the river to maintain the head required for mimimum flow to the channel. The designed capacity of the channel is 22,000 adult sockeye salmon.

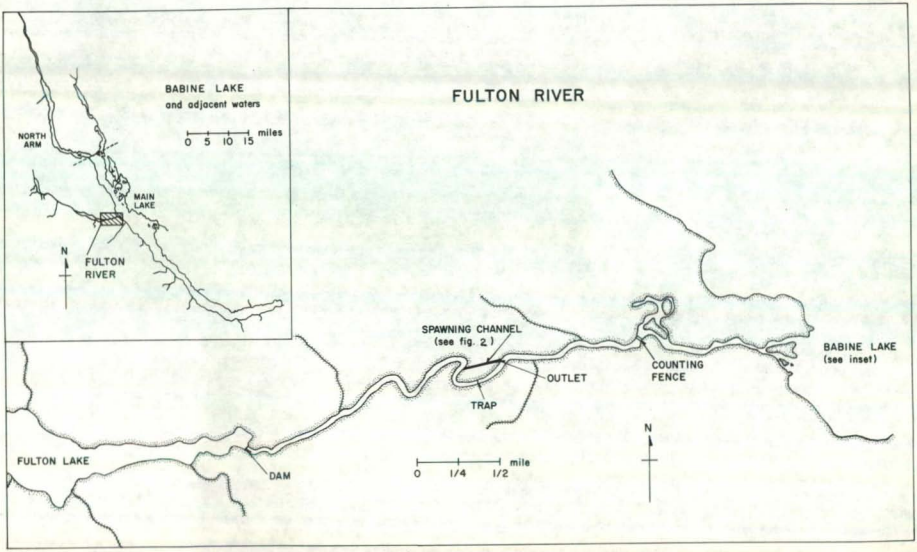


Fig. 1. Fulton River with inset of Babine Lake.

Fig. 2. Fulton Spawning Channel No. 1.

Methods

Sockeye fry produced in the Fulton River and the Fulton spawning channel were captured by inclined screened traps during the course of their downstream migration from spawning bed to lake. This movement occurred almost entirely at night. In 1966, to augment limited supplies of fry for marking, approximately 50,000 fry resulting from natural spawnings in the river were collected along the beaches adjacent to the river mouth (mainly within a range of 200-300 yards) at a time when fry were not being released from the channel and mixing of fry from the two sources was not possible. During the three years of the marking operation at Fulton River (1966-68) the two groups of fry were marked distinctively. Fry produced in the Fulton River (henceforth called River fry) were marked by removing the right pelvic fin and fry produced in the channel (henceforth called Channel fry) were marked by the removal of the left pelvic fin. After being marked the fry were released again into the Fulton River to continue their migration to Babine Lake.

Preliminary work

In 1965, trials were carried out to test the feasibility of marking sockeye fry at the migrant stage. Larger pink fry (Oncorhynchus gorbuscha) had been marked successfully by Parker (1964) and the methods he developed were used, with some modifications. However it was found that only the pectoral or pelvic fin of sockeye could be marked. The anal and adipose fins still remained part of the embryonic fin-fold.

FACILITIES AND EQUIPMENT

Accommodation

In the spring of 1966 a trailer camp was set up at Fulton River near the top end of the Channel, for living and working accommodation (Fig. 3). The camp consisted of two six-man bunkhouses, a mobile home unit, a kitchen unit, and a double unit to provide a small lab and suitable working space for marking fish. A 20 kw diesel generator was used to supply the electrical power for the camp. A $7\frac{1}{2}$ H.P. electric pump supplied water from the river to a three thousand gallon wood-stave head tank, from which water was supplied to the marking and holding tanks by gravity flow.

Marking Facilities

The marking unit consisted of two 10×40 ft. trailers joined side by side. This provided a working space 20×30 ft. for marking fry, a 10×10 ft. lab, a washroom, and a furnace room. The unit was heated by a thermostatically-controlled propane fired hot-air furnace. The walls in the marking unit were sheathed with white marlite for ease of cleaning and brightness and the ceiling was finished in white prefinished plywood. Adequate light was supplied by flourescent fixtures.

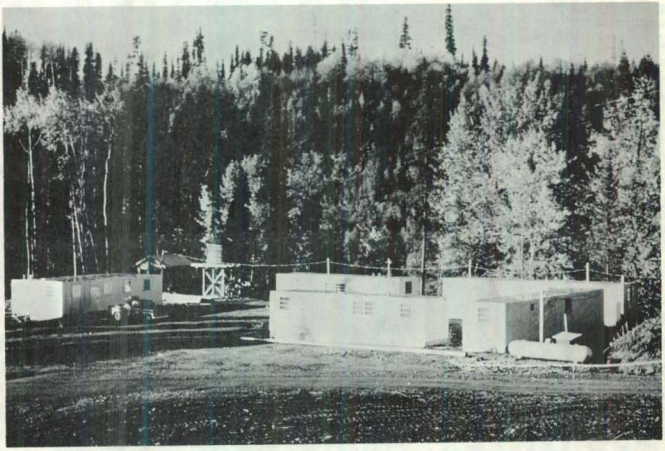


Fig. 3. Working and living accommodation for marking at Fulton River, 1966-1968.

Equipment and its arrangement

In the marking unit, fibreglas tanks (Alderdice et al. 1966) were installed, so that along the centre line of the room, four 43.3 Imp. Gal. tanks and a constant temperature bath were arranged together (Fig. 4). The fibreglas tanks were approximately 20 × 44 × 16 in. deep with a standpipe drain in each to maintain the water level. Two of these tanks were used to hold stock fish for marking and were connected to the freshwater supply and a drain. Two of the tanks were coupled in a closed circuit with a General Regrigeration constant temperature bath Model B-R. H. 150T-1A03 and were used for anaesthetizing fry. The constant temperature bath had an electric stirrer to prevent formation of ice on the sides of the tank and an air breaker for aeration of the anaesthetic. The anaesthetic was carried through a pipe from the constant-temperature bath to the two tanks by gravity flow and was controlled by valves on the tanks. The anaesthetic, overflowing the standpipes to the drain, was returned by a Cole Parmer centrifugal pump Model #700 through an inline "Fulflow" filter to the constant-temperature bath. The two tanks were also connected to the fresh-water main and outside drains with valves so that the equipment could be drained, cleaned and refilled.

Arranged on three sides of the stock and anaesthetizing tanks, and separated from them by a two-foot walkway, 16 twenty-gallon fibreglas tanks were set up with six on either side and four across the end. These are referred to as "recovery tanks". The recovery tanks, 18 in. × 25 in. × 14 in. were set side by side at 30 in. centres in a counter 36 in. high (Fig. 5). The front of the recovery tanks sloped back from top to bottom to allow knee space for ease of sitting. The water supply was controlled by a plastic valve. Plastic pipe and fittings were used extensively in both the fresh-water supply lines and discharge lines. Drains with a standpipe to control the water level of the tanks were set near the back of the tanks. This allowed space for a stainless steel "marking tray" to be suspended into the water of the tank near the front, in a stainless steel frame made of 3/8 in. steel rod. These frames sat on the top of the tank and held the marking trays in the recovery tank so that the water in the recovery tank served as a water bath to control temperature of anaesthetic solution in the marking tray. A stainless steel frame covered with marquisette was used on the top of the marking trays and on the anaesthetizing tank to keep the fry near the surface and readily available to the marker.

The main drain from all the tanks was tee'd off and controlled with gate valves so that the water and fish from the recovery tanks could be drained directly into the river or diverted to a tank truck for transfer elsewhere.

Each recovery tank had an individually controlled air supply with a breaker. The compressed air was supplied by a portable Webster Compressor Model #14-0 with a half horsepower motor, through a plastic main line. The compressor was set to operate between 70 and 100 lbs. p.s.i. pressure and was connected through a carbon dioxide regulator set at 15 p.s.i. to the main line. As a safety measure, in case of compressor or power failure, two large cylinders of oxygen were connected into the air main through oxygen regulators set at 5 p.s.i. Reduction of pressure in the airline below 5 p.s.i. automatically started the flow of oxygen.

Each of the recovery tanks was equipped with an Illuminating Magni-

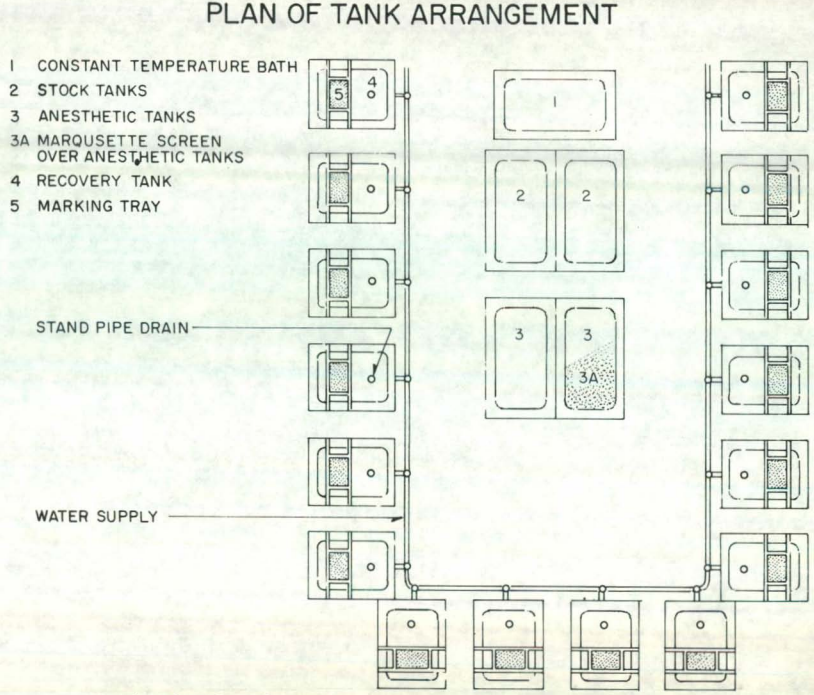
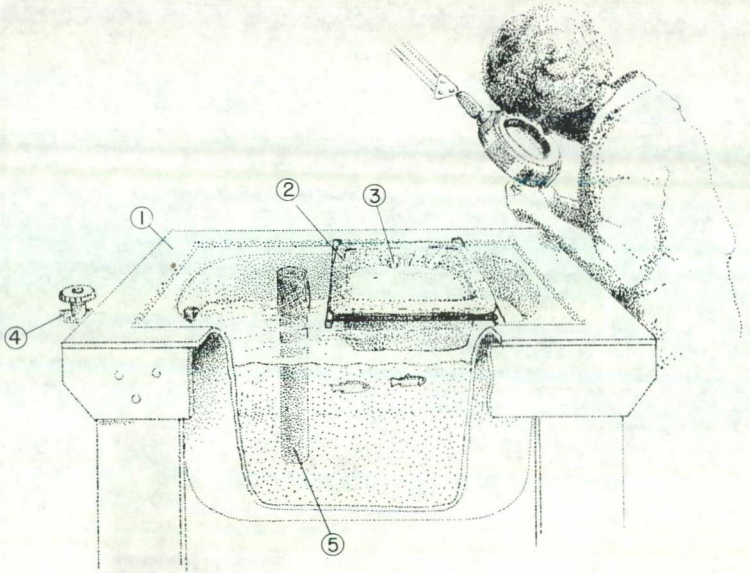


Fig. 4. Plan of stock, anesthetic and recovery tanks as arranged for marking at Fulton River, 1966-1968.



1 RECOVERY TANK
2 MARKING TRAY
3 MARQUSETTE
4 WATER SUPPLY
5 DRAIN

Fig. 5. Recovery tank as set up for fry marking at Fulton River, 1966-1968.

fier with a five-inch diameter, three diopter lens. Beside each tank a Veeder Root Counter was fastened to the tank support. There was also an adjustable-height office stool for each marker.

Holding facilities

Outside of the marking unit, plastic swimming pools, 10 ft. in diameter and 27 in. high, were set up on a level base of fine sand. These provided temporary holding facilities for stock fish held for marking. The water supply was introduced over the top edge of the pools and directed to produce a circular motion of the water. The water level was maintained with a stand pipe set near the edge to facilitate cleaning and adjusting. To set the standpipe in the pool, a hole the size of the outside diameter of the pipe was cut through the plastic bottom. A heavy rubber gasket (6 in. diameter) was placed around the bottom and top side of the hole. A threaded standpipe (2 in. plastic) went through the gaskets and pool bottom, and threaded into a 2 in. metal elbow of the main drain underneath. A lock nut on the threaded end of the standpipe was tightened down, sandwiching the plastic pool bottom securely between the rubber gaskets. The top of the standpipe was supported by a bracket fastened to a stake outside the pool. The two inch drains from the pools were connected to a 6 in. plastic main drain that carried the waste water back to the river.

Each pool was equipped with an air breaker. This was connected to the main compressed-air supply line with a plastic tube and controlled with a small valve.

Temporary pool covers were made from sheets of plywood or black polyethylene plastic to shield the fish from the sun.

Small holding pens (24 in. × 24 in. × 30 in.) made of nylon marquisette and supported on pipe frames were set in the holding pools to keep river and channel fish separate and according to time of capture.

Holding pens (48 in. × 48 in. × 48 in.) supported on pipe frames, were also used to hold stock fish. These pens were placed in a pool at the upstream end of the artificial spawning channel and were suspended by floats or by a framework of pipe.

Fish transportation tank

A tank for transporting fry was made from a circular fibreglas tank (4 ft. × 30 in. deep) model #82C, made by Heath Tecna Plastic Inc. (Kent, Wash., U.S.A.). The lid was sealed with a rubber gasket and bolted down. An inspection cover in the lid provided access for loading and cleaning. A 2 in. pipe elbow was connected to the bottom drain and from this a flexible hose. The end of the hose was tied off and fastened at the top of the tank during loading and transportation. The transporting tank was carried on a half-ton pickup truck and was set on two 6 in. × 6 in. timbers to give clearance for the drain underneath. The tank was loaded directly from the outlet pipe of the marking unit. To release the fry and water from the tank, the drain hose was lowered into the river, the end was untied and the tank emptied by gravity flow. A

garden hose was used through the inspection hole to flush out any fry that might be left in the tank. The maximum load carried was about 31,000 fry but usually no more than 25,000 were carried at one time. The time taken for the transfer was sufficiently short (25 to 30 min.) so that aeration was not necessary.

Fry traps

In planning the project it was recognized that not all collecting problems unique to the Fulton River could be anticipated. A permanent collecting structure was considered to be too costly. Therefore a variety of floating inclined screen-type traps appeared the most feasible. Because of the extreme range in river discharge (200-6700 c.f.s.) through April to mid-June, the period of fry movement, several types of traps, screen sizes and trapping sites were tested.

A trap, used by the Department of Fisheries and commonly referred to as a "4 × 4" (described by Clay 1961) was modified by extending the lead by 2 ft. and by covering the screening surface with 3/16 in. flattened expanded metal. The collecting box was made 1 ft. longer and was covered with 1/8 in. mesh aluminum screen. The collecting box had a baffle, adjustable to height, positioned about 7 in. back from the lip of the lead. Its purpose was to reduce turbulence in the box. The trap was suspended between two steel pontoons, 26 ft. long and 21 in. in diameter, with a carrying capacity of 3300 lbs. (Steelcraft floats by Russel-Hipwell Engines Ltd., Owen Sound, Ontario, Canada). The front of the trap was suspended from a beam (steel channel 2 in. × 2 in. × 3/16 in.) mounted above the pontoons on steel channel posts. Two half-ton chain blocks connected to the beam with eye bolts were fastened, one to each bottom corner of the leading edge of the trap. The boat trailer winches, one to each side, were mounted on a bracket above the pontoons at the junction point of the lead and collecting box. With the trap suspended in this way it was possible to adjust it for the depth of water to be fished and the amount of water spilling into the collecting box. It was also possible to raise the trap completely clear of the water for cleaning, maintenance and for protection from floating debris during non-fishing hours. All the metal surfaces of the trap susceptible to rust, were painted with Rustoleum primer and a finish coat.

Another set of traps (called Tsolum Traps) made to the design described by Lister et al. (1969) was also used. This was an inclined screen trap with an entrance opening of 12 in. wide and 33 in. high. The sides of the lead were parallel, ten feet in length and connected to a plywood collecting box. Screened openings in the box allowed the excess water to escape while a baffle reduced turbulence. These traps were used in various ways in 1966. They were intended primarily to test for the best screen sizes and trap location but time permitted very limited testing. It was found, however, that the 3/16 in. flattened expanded metal made a satisfactory screening surface for sockeye fry. The 3/8 in. flattened expanded metal had too large an opening for fry and the 1/8 in. mesh aluminum was difficult to clean. In May 1966 the average catch per Tsolum Trap per night was 114 fry (range 37-300). During low water periods it was possible to attach wings or leads of 3/16 in. expanded metal to these traps thus greatly increasing their effectiveness.

In 1967 the Tsolum Traps were modified by widening the entrance of the lead to 3 ft. and tapering back to 1 ft. at the collecting box. The screening surface of the lead was made of 3/16 in. flattened expanded metal. New collecting boxes were made with a 1 in. × 1 in. × 3/16 in. angle iron frame 27 in. × 28½ in. × 20 in. deep. A plywood baffle positioned 7½ in. from the front of the live box was adjustable to height. One-eighth in. aluminum screen was used as a screening surface for the box. One of these traps was fished as a single unit suspended between 20 ft. × 18 in. diameter aluminum pontoons. Six of these traps were fished as three double units suspended between pontoons similar to the previously mentioned 4 × 4 trap. River fry were also obtained from the traps on the Fulton River Fence prior to channel release. These traps were described by Walker et al. (1969).

One method of securing the floating traps on the river proved very effective. A 5/8 in. steel cable was securely anchored below the cement weir in the river near the top of the channel and run down the centre of the river approximately one hundred yards to the traps. The trap floats were secured together side by side and fastened to the main cable with a bridle. Two 5-ton hand winches were mounted on a platform on the bank of the river. A 3/8 in. steel cable was run from one winch across the river to a snatch block fastened to a tree then back to the bridle. The cable from the second winch was fastened directly to the bridle producing a "clothes-line" effect. The two winches were used to position and hold the traps in the fishing position. During the non-fishing hours, the traps were brought in against the bank of the river. This afforded some protection from floating debris and it also made them accessible for cleaning and repairing.

Fan Traps

The channel water supply was taken directly from the Fulton River main stream. In order to obtain a pure stock of channel fry, a set of inclined screen traps referred to as "Fan Traps" was installed in the head works of the channel by the Resources Development Branch. These traps effectively removed the fish originating in the river and provided another source of river fry for marking. Instead of being a flat surface like many inclined screen traps, the bottom was made of a series of V-shaped troughs formed from perforated sheet aluminum. This method of construction increased the strength and screening area of the trap. The fish were carried by a 6 in. plastic pipe from the traps to holding pens set in a float on a pond immediately below the traps. In 1967 a barrier screen made of marquisette was set up below the fan traps to test their effectiveness. Very few fry were caught and these were thought to originate from eggs deposited between the net and the fan traps.

Fry trapping

Because most of the sockeye fry in Fulton River emerge at night and move downstream to the lake almost entirely in darkness and because the peak of the fry migration usually coincides with the peak spring water levels of the river, collecting fry for marking posed many problems. River fry were particularly difficult to obtain. The spawning channel is located about mid-point in the most productive spawning area of the river (Fig. 1). During the early

part of the season, when the number of fry from the channel was small, they were transported by truck and released at the Fulton River Fence, approximately one mile downstream. This allowed the river traps to be fished, for pure river fish, near the river mouth and resulted in larger catches. An added advantage was that the fry taken would have been produced from all sections of the river rather than only the upper half. When the nightly counts of channel fry reached 100,000 fish, they were no longer transported but released directly into the river. At this time the river traps were moved above the channel outlet to avoid taking channel fry. However, this move reduced the number of river fry. The traps were fished in various locations on the river. Location was shifted to provide the largest catches (always in the fastest current) but at the same time to collect fry without damage. Five main locations were used. These were:

1. The fan traps at the top end of the channel.

2. The river immediately above the channel inlet.

3. The river between the inlet and outlet of the channel.

4. The river at the Fulton Fence and immediately above.

5. The beaches adjacent to the river mouth.

In 1968 all the "river" traps (Fig. 6) were fished at location number three. This consolidation of effort allowed more time for cleaning and adjusting the traps, thus increasing their fishing efficiency. The fry could be removed more often, protecting them from the turbulance and accumulation of debris. The baffles in the collecting boxes did afford some protection for the captured fry by reducing turbulance but they would become exhausted if left for long periods.

The traps were lowered into the water, adjusted for fishing depth and then positioned out on the river in the late evening before the fry movement started. They were checked about every hour throughout the night. Each hour the bulk of the fry were removed and the traps cleaned and adjusted if necessary. They were fished from approximately 2200 hours until daylight (0500 hr.) The fry removed from the traps were transported to the marking unit where they were sorted from the debris and put into the stock tank for the day's marking.

Cleaning the traps also presented a problem with the high dirt load of the river when in freshet. The large material had to be removed by hand. During the fishing period the screening surfaces were kept operative by manually scrubbing them with a stiff, short-bristle deck brush. If the dirt load was very heavy it was found that by raising the lead of the trap and using a high pressure jet of water considerable time could be saved in the cleaning. A small gasoline-powered pump (Paramount Model 7505) with a capacity of 7000 gallons per hour connected to a 1-1/4 in. hose with a half-inch nozzle was set up on the trap float and used for cleaning purposes.

A problem arose from the early stage of development of some of the fry migrants. The marking mortality increased considerably when handling fry with prominent yolk sacs as compared to fry without visible yolk sacs and marking

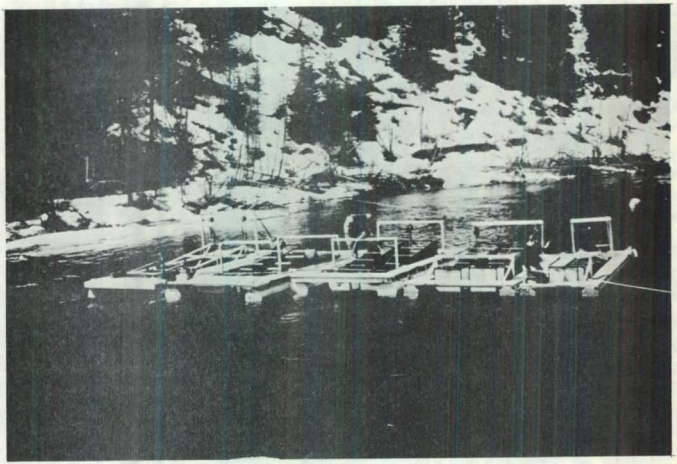


Fig. 6. Inclined screen traps in fishing position on Fulton River, 1968.

quality decreased also. The yolk sac fry burrowed into the fine debris and were quite difficult to separate. To alleviate this problem the fry and fine debris were placed in a 4 ft. × 4 ft. × 4 ft. marquisette pen supported from a float. As the fry developed into the free swimming stage they schooled together near the surface and could be removed with a dipnet. Four of these pens were used with approximately three days' accumulation of fry to the pen (order of 10,000 fry). The free-swimming fry were immediately removed for marking. Four of these pens were used on a rotating basis and by the time the fourth was used the first pen was again available.

Sorting the fry in this manner greatly reduced the handling mortality and labour costs.

The river fry, collected along the beaches adjacent to the river mouth, prior to channel release, were caught with marquisette covered dipnets as they schooled in shallow water. These fry were transported to the marking unit by truck, in containers lined with plastic bags. Water and fish were placed in the plastic bag, partly filling it. The air was replaced with oxygen and the bag was sealed. No problems were encountered in transporting the fish in this manner. The plastic bags were the type commonly used for garbage and available in most grocery stores.

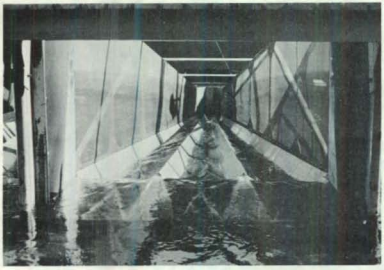
Fan traps were also installed at the bottom end of the channel for enumerating the channel fry (Fig.7). It was from these traps that fry were secured for marking purposes. All the fry leaving the channel had to pass through the traps and were readily accessible. The stage of development was not a problem as the yolk sac was almost completely absorbed on most of the channel fry. The fry required for the day's marking, were set aside by Fisheries Service personnel during the night enumeration. These were held in floating marquisette pens (4 ft. × 4 ft. × 4 ft.) in the bottom end of the channel until required. In 1966 nearly 90% of the channel migration occurred in a 7-day period from June 7-13 and some fry were held up to 3 days for marking, but generally throughout the 3 years of the marking, the channel fry marked were from the previous night's migration.

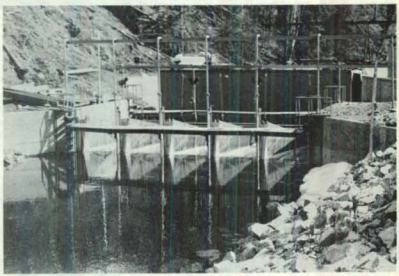
Preparation for marking

Prior to marking, all the tanks and equipment in the marking unit were washed and disinfected by soaking them in 100 p.p.m. chlorine solution for one hour. The tanks and equipment were flushed with fresh water and left to dry overnight. This was repeated at least once a week for all the equipment except the anaesthetic tanks and constant-temperature bath.

Anaesthetic

The two anaesthetizing tanks and the constant-temperature bath combined held 122 gal. (Imperial) of water and to this was added 210 ml of 2 phenoxyethanol (made by Eastman Organic Chemicals, Rochester 3, New York). It was found that if the 2 phenoxyethanol was first emulsified in warm water it would diffuse more readily with the cold water. The river water temperature





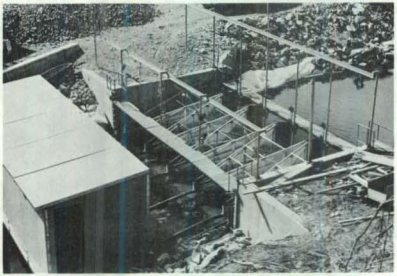


Fig. 7. Fan traps installed at the downstream end of Fulton Spawning Channel No. 1.

range from 4° to 12°C during the fry migration. The temperature of the constant-temperature bath was maintined to correspond generally with that of the river. With a 1:2643 solution of 2 phenoxyethanol at 6°C it required from 2-4 min. for most fry to be immobilized. Because the anaesthetic affected the fish differently (larger fry were immobilized before smaller ones), each batch of anaesthetic was tested with a small number of the fish to be marked. During the anaesthetizing, with the fry being transferred from the stock tank to the anaesthetic, a certain amount of dilution took place and at times had to be compensated for by the addition of 2 phenoxyethanol. The anaesthetic was mixed the day prior to marking and was allowed to circulate through the constant-temperature bath and anaesthetic tanks until required. An advantage in using 2 phenoxyethanol is that it is a chemotherapeutic agent and quite effective against bacterial and fungal diseases of fish (van Duijn 1967). The maximum time the fry were held in the anaesthetic was about an hour. Tests were not carried out to find the maximum time the fry could be held in a state of anaesthesia. On one occasion several fry were accidentally held for several days in the anaesthetic. They recovered quickly when placed in fresh water. The anaesthetic tanks and constant-temperature bath were drained and flushed out once a week and a fresh batch of anaesthetic solution prepared. The filter was changed at this time also.

Temperature control

In the 1965 marking trials, very heavy mortality occurred in the marking trays when the temperature of the anaesthetic was not controlled. Heat from the air and the marker's hands, transferred to the liquid in the plastic marking trays created as much as 4°C difference in temperature in a depth of 6 in. of liquid. This problem was alleviated by setting the marking trays as low as possible in the recovery tanks, and by increasing the water flow. The water supply was pumped from the lake and colder water was obtained by lowering the suction line in the lake. An air breaker was used to aerate and circulate the anaesthetic during work breaks.

This heating problem was avoided at Fulton River by using stainless steel marking trays, instead of plastic, thus allowing for a faster transfer of heat to the surrounding water bath. With a good supply of fresh water to the recovery tanks and aeration and circulation of the anaesthetic in the trays during work breaks, heating in the marking trays was kept below a level which resulted in fry mortality. However, aeration of the anaesthetic caused another problem. It created foam that collected in the marquisette tray holding the fry thus making the individual fry difficult to see, thereby reducing marking speed. To avoid foaming, the air breakers were not used continually in the marking trays. A silicon defoaming agent was available but it was never used because time did not permit testing for effects on the fry.

Daily preparation for marking fry consisted of:

- Filling the stock tank with fry to be marked.
- Filling the recovery tanks with water and adjusting the valves for adequate flow throughout the holding period.

- Shutting off one of the anaesthetic tanks from the closed-circuit system and filling the stainless steel marking trays from this tank.

- Suspending the marking trays on a stainless steel support framework into the recovery tanks.

- Placing the marquisette-covered stainless steel framework over the marking trays to keep the anaesthetized fry close to the surface and therefore easily available to the marker.

- Checking the tally counters to see that each is zeroed.

- Placing a marquisette tray in the anaesthetizing tank.

The fry from the stock tank were transferred to the marquisette tray in the anaesthetic tank in batches of approximately 1000. By separating the tray into two sections it was possible to have two fresh batches of anaesthetized fry ready at all times from the one tank. The uninterrupted flow of fry to the markers as they were required assisted greatly in the output of marked fish.

The sockeye fry when placed in the stock tanks usually had a small number of other fishes (coho, sculpins, dace, trout and squawfish) mixed with them as well as some damaged or dead fry. As many of these as possible were removed. The underdeveloped sockeye fry (with visible yolk sacs) were also removed and held under subdued light until they were sufficiently developed for marking.

Fry marking

The anaesthetized fry (75-100 at a time) were placed on the marquisette in the marking trays by using a small dipnet. The markers, sitting at the recovery tanks, picked up the fry, one at a time, in the left hand (right-handed person) with the head toward the palm of the hand. They were held between the index and middle finger by the thumb with the underside of the fish uppermost. The right pelvic fin (river fry) or left pelvic fin (channel fry) was cut off with surgical scissors and the marked fry were dropped into the recovery tank. Two types of surgical scissors were used:

1. Cornea Snips obtained from the Tsurumi Precision Instruments Co. Ltd., 1506 Tsurimi-cho Tsurumi-hu, Yokohama, Japan.

2. Iris scissors (1R-111 de Wecker) obtained from German Surgicals Irex, Box 788 Adelaide Street P. O., Toronto 1, Canada.

The iris scissors cost almost four times the price of the cornea snips but it was felt that the expense was justified by the service, life and dependability of the instrument. A very important point in fish marking by fin removal is that the markers understand which is the right or left side of the fish and care should be taken to see that each marker is removing the designated fin. Part of the confusion seems to arise when the fish is placed on its back.

During the marking procedure, the marked fry were counted and every tenth one entered on a counter. The numbers from the counters were recorded on a daily record sheet at the time of coffee breaks, lunch, and at the end of the marking day. Each time the counts were recorded the counters were returned to zero. This served as a check on the tally counters and helped to prevent errors in the counts. Anaesthetic from the markers' hands could enter the counter and at times the counter mechanism would become sticky. Placing a small plastic freezer bag over the counter prevented this. Periodic checks on the markers' counts were made because as speed developed with practice so did competitive spirit and attempts to cheat might be expected. Competitive spirit could also lead to a greater number of fry marked but of poor quality, thus strict control was essential at all times. Damaged fry were set aside and counted and recorded during break periods.

Each recovery tank was equipped with an illuminating magnifier of three power. Most of the markers used these for additional light and actually only used the magnifying lens towards the end of the day when they were tired or if the fry were smaller than usual. In 1966, emergent river fry ranged between 24 mm and 29 mm and the channel fry ranged from 21 mm to 29 mm. This small size together with their almost transparent fins made good vision and visibility essential for marking.

The first week of marking was devoted almost entirely to instruction, practice, and constant checking of the marked fry with the aid of a 10 power binocular microscope. It was found that by using the microscope to show the markers exactly what the finished mark looked like, quality improved very quickly. Quality of marks and accuracy of counts were the two main points stressed. These were checked throughout the marking period. Speed of marking was acquired with practice and varied considerably between markers. The record sheet of May 30, 1968 is an example of this (Table 1). Approximately half of the season's marking had been completed by this time. Markers A to F marked for the same time periods on May 30. Marker G had other duties besides marking and should not be considered as an example. Based on the marking of May 30, the average number of fish marked per hour varied from 329 to 667 fish for the different markers. The number of fish marked per hour also varied for individuals between marking periods.

Quality Control

Sampling of the marked fry for mark quality was carried on throughout the program. A daily sample of ten fry from each tank was killed in formalin and then examined under a microscope. This method of killing the fish made the fins stand out and thus more easily observed. The fin marks were recorded on sampling sheets (Fig. 8) and scored on the basis of length of fin remaining. Three points were given for a mark between complete removal and 1/20th remaining. Two points for a fin with between 1/20-1/10 remaining and one point for a fin with between 1/10 and 1/5 remaining, and no points for fins with more than 1/5 remaining. The markers were shown the grading sheets and if they were having problems with the marking they were shown how to correct them and further sampling was carried out as a check.

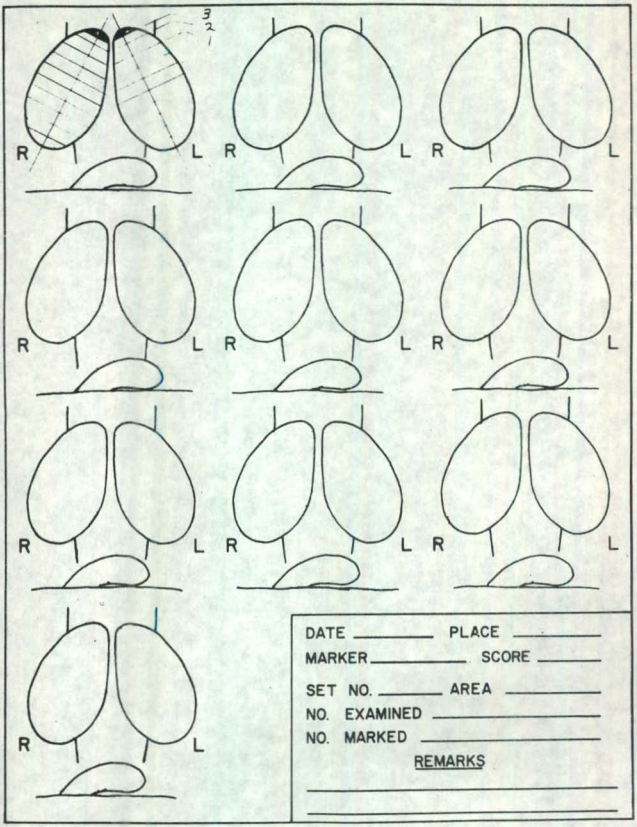
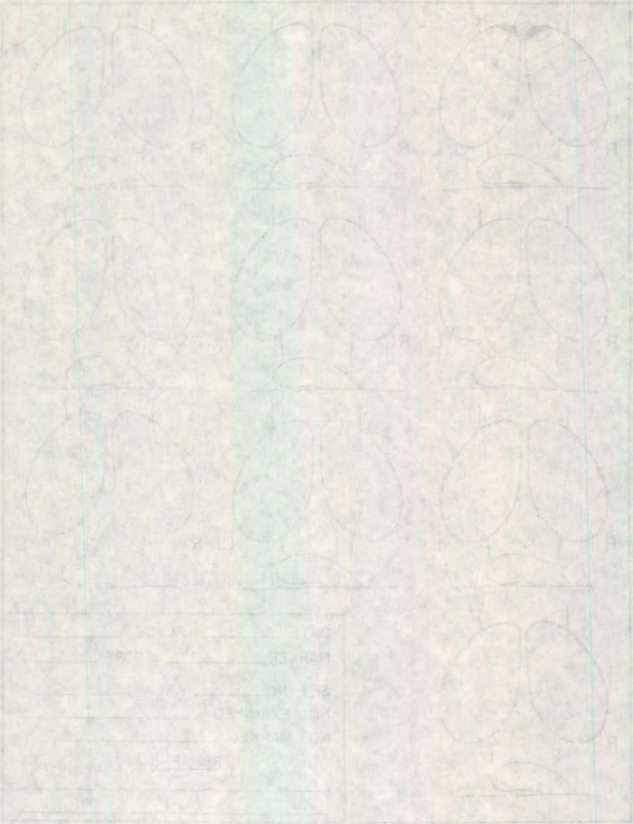


Fig. 8. Master grading standard used for Fulton sockeye fry marking quality control, 1966-1968.



A good deal of concentration is required for good mark quality and it was found that disturbances such as people talking, loud noises and visitors had a considerable effect. Every effort was made to maintain a serene atmosphere in the marking unit. Comfortable room temperature also helped to maintain high quality marks.

Tables 2, 3, and 4 give the scores for the quality sampling for the years 1966-1968. Where two numbers are given in one day, two samples were examined. Using Table 3 from 1967 as an example it will be seen that the mark quality from each marker could vary from day to day. It also varied between markers and between right and left marks. The markers' average score (for the season) for right pelvic marks varied from 21.4 to 26.5. The seasonal average was 24.3 for all right pelvic scores combined. The markers' average score for left pelvic marks varied from 25.5 to 28.8 for the season. The seasonal average was 27.0 for all left pelvic scores combined. This difference suggests that the quality of the left pelvic marks was better than that of the right pelvic marks (based solely on the length of fin remaining.)

At the end of the marking day, the anaesthetic from the marking trays was returned to the anaesthetic tanks, and the trays and other marking equipment were washed, dried and stored away. The water and air supply for the recovery tanks were adjusted and the tanks covered with plywood lids. Prior to the release of the marked fry, the dead and damaged fry from each tank were removed and counted and this number deducted from the number marked (Table 1).

Release

In 1966 and 1967, the fry were released from the recovery tanks directly into the river through a 2 in. plastic pipe approximately 600 ft. long. Tests were made on the effect of releasing the fry in this manner. After removing and counting damaged and dead fry from the recovery tanks, the stand pipe drains were removed, releasing the fry into the drain. The fry were caught again in a marquisette dipnet partly suspended in the river at the pipe outlet. The marked fry were transported back to the marking unit where they were placed in tanks and held for 48 hours. No mortalities occurred during the holding period.

In 1968 when the traps were fished lower down the side of the channel and it was necessary to release the fry below them it was not practical to extend the pipe. The marked fish were transported in a tank (described earlier) by truck to the Fulton Fence and released to continue their migration into Babine Lake.

Marking mortality

Mortality arose mainly from 3 procedures:

1. Trapping (particularly in the river where water flows, turbulence, and debris were occasionally extreme);

2. Removal from the traps, separation from debris and transport; and

3. anaesthetizing, marking and release.

Probably much of the mortality observed during the second and third procedures resulted primarily from trapping. Table 5 gives the total number of river and channel fry handled in 1966 and the apparent causes of mortality. Total mortality for river and channel fish was about 2%. Mortality from trapping and handling river fish was higher but this was compensated for by a subsequently lower mortality from marking. Comparable mortalities were observed in 1967 and 1968.

Marking mortality varied from day to day. Probably mainly as a result of varying trapping conditions, and varied between markers and between river and channel fish. For example, for 3 days of marking in the period May 27-June 1, 1968, the average number of dead per thousand marked for 6 markers varied from 0.82 to 5.81 for channel fish and from 2.50 to 40.95 for river fish (Table 6). The higher rate of mortality for river fish probably reflects the more severe trapping conditions.

Rearing and marking experiment

When the mark and recovery program was first considered it was intended to apply a double mark using ventral and adipose fins. This combination would almost eliminate any confusion of marked fish with those lacking a fin or fins from natural causes. Also some regeneration of clipped ventral fins could be expected but not of the adipose. Thus by using the ventral-adipose mark identification at later stages would be made easier. However, close examination of fry migrants revealed that at this stage the adipose fin was not yet formed and marking had to proceed using only the ventral fin. In 1967, an attempt was made to rear fry until the adipose was sufficiently formed to be marked.

In June sockeye fry were collected from the Fulton River (75,000) and channel (360,000) and held in pools. The channel fry were held in four 4 ft. diameter $\times$ 27 in. plastic pools and two fibreglas fish culture tanks, 4 ft. in diameter, and 30 in. deep. The river fry were held in one 10 ft. diameter plastic pool. The water and air supply were from the same supply as used for the marking operation.

An Allen feeder (supplied by G. Z. Products, Inc., 2401 Gold River Road, Rancho Cordova, California 95670) was used on each pool to automatically feed Abernathy fry food on a continuous basis during daylight hours. The feeders were controlled with an electric time-clock and were adjusted to start feeding at daylight and stop at dark. The feeders did not work well with the Abernathy mash. The moisture in the mash caused it to block up the outlet holes, often completely sealing them. They did work well with Clarks (J. R. Clark Company, 1674 Beck Street, Salt Lake City 16, Utah, U.S.A.) fry fine which was dry but only a limited supply of this food was available. It was found soon after the collecting of fry started that there were diseased fry among the channel stock. In looking for the source of this disease it was found that some newly-emerged channel fry were diseased. The first indication of disease was the poor condition of some of the fry and closer examination revealed fungus on the gills. This condition was not noticed in the river fry at the time of collection but it developed later in the holding tank and could have been present but at an earlier stage of development.

Some of the diseased fry were sent to the Nanaimo laboratory where the disease was identified as Columnaris Disease. A ten-day treatment program was started involving a one-hour daily bath in Pyridylmercuric acetate (PMA) 0.5 PPM and the feeding of a frozen wet diet containing Terramiazine (1 g to 1 lb of food). This relieved the problem but never completely eradicated it. The intensity of the outbreak was probably a result of the high temperature (up to 20°C) in the holding pools. At the time this temperature was considered satisfactory because it was only slightly higher than the surface temperature of the lake (19°C) where available evidence suggested they normally remained. However, subsequent work (Narver 1970; McDonald MS 1971) revealed that young sockeye in the lake were at the surface of the lake for only short periods of evening and morning twilight and at other times they were at greater depths in water as cold as 6°C.

During the period July 17 and July 29, 1967, a total of 141,443 channel fry and 29,394 river fry were marked with combined pelvic and adipose fins removed. A PMA treatment prior to their release on August 2, resulted in a heavy mortality which reduced the numbers released to 124,683 left pelvic-adipose marked channel fry and 28,751 right pelvic-adipose marked river fry.

A very small number of these fish were recovered in the lake in 1967 and as smolts leaving the lake in 1968. Apparently survival was poor.

One interesting point was noted when holding these sockeye fry. There was a small number of coho fry mixed with them. Under what appeared to be extremely poor conditions for rearing sockeye fry, the coho fry did extremely well and were virtually unaffected by the disease affecting the sockeye.

Results

Newly-emerged sockeye fry from the Fulton River and spawning channel were marked successfully in the three years 1966-1968. The daily marked release of fry and accumulated totals for each of the three years are shown in Tables 7, 8, and 9. Proportional marking was not achieved. The daily and accumulative sockeye fry migration from the Fulton River and channel for the three years is given in the Appendix. Recoveries of marked underyearling sockeye were made from Babine Lake (McDonald 1969; Scarsbrook and McDonald 1970) and as smolts at the time of seaward migration (McDonald 1969). Estimated survival from fry to smolts for the three years is shown in Table 10. The survival rate for the year subsequent to release ranged between 9 and 29% for river fish and 10 and 33% for channel fish. The average for the two groups was 19.2%. This average rate is higher than the hypothetical rate for unmarked fish proposed by Foerster (1968) after he examined data from a variety of lakes. The survival rates of marked fish at Babine indicates that the effects of the mark and of the trapping, handling, and marking techniques used were not severe.

ACKNOWLEDGMENT

The authors wish to thank personnel of the Operations Branch of the Fisheries Service for making available the sockeye fry estimates from Fulton River for the years 1966-1968, and especially to Iain A. Maclean for his cooperation throughout the project and for his pictures of the channel fan traps.

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Table 1. Daily record sheet for number of sockeye fry marked at Fulton River between 1966-1968.

Date - May 30, 1968 Source - River Mark - Right Pelvic

Marker	Number marked 0800-1000 hr.	1020-1200 hr.	1300-1500 hr.	1520-1640 hr.	Total marked	Dead after marking	Sample	Held	Balance released
A	910	740	740	560	2,950	48	20	-	2,882
B	830	880	900	580	3,190	4	20	-	3,166
C	1,150	770	850	530	3,300	8	20	-	3,272
D	1,200	800	830	640	3,470	32	20	-	3,418
E	810	450	700	390	2,350	2	20	-	2,328
F	1,130	1,070	1,440	990	4,630	1	20	-	4,609
G	70	540	760	360	1,730	1	20	-	1,709
Total	6,100	5,250	6,220	4,050	21,620	96	140	-	21,384

Total marked	21,620
Less dead after marking	96
Less sampled	140
Less held	-
Balance released	21,384

Table 2. Quality control sampling of marked sockeye fry at Fulton River 1966

Score: right pelvic (River)

Markers	A	B	C	D	E	F
Date						
May 25	-	23	25	-	17	27
27	-	18	25	-	26	-
28	-	26	-	25	29	23
June 3	-	24	24	26	28	25
4	26	23	23	25	29	24
6	26	20	21	25	26	24
7	26	25	25	20	25	23
8	23	25	28	23	26	26
10	21	17	25	24	24	21
16	22-28	21-25	24-27	23-24	26-27	20-24
Means	24.57	22.45	24.7	23.88	25.72	23.7
Grand mean	24.15					

Score: left pelvic (Channel)

Date						
May 23	-	-	25-26	20-25	-	-
24	-	13	-	-	-	-
26	-	25	-	17	24	-
28	-	24	-	-	-	23
June 8	28	25	27	27	26	25
9	23	21	24	25	23	28
11	24-27	27-29	14-25	23-26	28-28	29-27
13	28	26	27	27	27	29
14	-	27	30	25	29	28
15	24-25	25-27	27-28	26-28	28-28	24-23
17	23	29	30	28	27	26
18	28	25	28	27	25	29
20	26	26	30	27	27	28
21	27	28	28	26	26	25
22	23-26	27-27	21-21	27-27	25-26	23-24
23	27	28	29	29	28	30
Means	25.64	25.50	25.88	25.55	26.56	26.31
Grand mean	25.89					

Table 3. Quality control sampling of marked sockeye fry at Fulton River 1967

Score: right pelvic (River)

Markers	A	B	C	D	E	F
Date						
May 9	23-24	21-25	19-20	21-23	22-24	23-25
11	20-23	24-26	24-24	27-27	24-27	-
15	19-22	26-27	20-22	24-29	21-26	27-27
17	20-23	23-23	22-23	25-25	24-26	26-26
19	22-22	22-23	-	26-27	25-25	-
22	21-21	22-25	23-25	24-26	23-24	27-28
24	20-22	23-23	22-23	27-28	25-27	24-25
26	21-22	22-23	26-27	28-30	27-28	24-25
29	22-22	21-22	27-27	29-30	28-29	25-26
June 2	16-18	19-22	26-26	27-28	25-27	26-29
4	20-22	21-25	23-27	26-27	26-28	27-29
7	24-24	17-18	26-27	26-27	26-27	27-28
Means	21.37	22.62	24.04	26.54	25.58	26.20
Grand mean	24.34					

Score: left pelvic (Channel)

Date						
May 13	28-30	27-27	21-29	26-28	28-30	27-27
16	29-30	27-27	27-27	28-29	30-30	26-27
20	27-29	28-28	24-26	27-29	30-30	24-27
23	27-29	28-30	26-27	27-28	27-29	23-27
25	26-26	25-29	22-25	23-25	28-30	25-26
27	30-30	29-30	26-29	29-29	30-30	27-28
30	27-29	28-30	27-27	28-29	30-30	26-27
31	26	27	23	24	28	24
June 6	-	28-29	26-27	27-27	28-29	25-26
9	26-28	28-29	25-26	24-25	28-29	26-27
10	-	-	-	23-25	-	-
16	24-25	24-25	23-23	23-26	25-27	24-25
Means	27.68	27.76	25.52	26.47	28.85	25.90
Grand mean	27.01					

Table 4. Quality control sampling of marked sockeye fry at Fulton River 1968

Score: right pelvic (River)

Markers	A	B	C	D	E	F	G
Date							
May 14	15	15	18	18	14	21	-
15	17-13	22	22	27	15-22	25	12
17	14-23	24	27	29	19-23	27	20
20	26	25	27	28	22	27	18
21	19	18	26	27	19	26	20
22	23	26	27	27	-	27	18
24	17-29	28	28	28	21-26	27	-
25	27	27	26	27	21	30	23
28	30	30	24	26	20-21	28	28
30	24-28	27-25	22-19	24-29	19-23	28-29	23-30
June 1	27	27	25	28	27	30	30
4	26	26	23	27	26	30	30
6	20-24	26-30	20-25	23-29	16-21	22-27	26-26
11	28	29	-	28	30	30	30
12	24	30	-	26	30	30	30
Means	22.70	25.58	23.93	26.52	21.75	27.29	24.26
Grand mean	24.47						

Score: left pelvic (Channel)

Date							
May 16	28	27	24	28	29	28	19
23	28	27	27	27	26	30	29
27	29	30	30	25	30	30	30
29	29	30	28	29	29	25	28
31	27	30	29	30	24-26	29	30
June 3	28	30	29	30	27	29	30
5	29	30	29	30	30	30	30
7	23	30	28	23	-	-	27
8	23	30	26	24	26	28	29
10	28	30	-	29	30	30	27
13	27	30	-	27	29	30	-
14	29	30	-	30	27	29	-
17	24	30	-	28	29	30	-
18	29	30	-	29	30	29	-
Means	27.21	29.57	27.77	27.78	28.00	29.00	27.90
Grand mean	28.23						

Table 5. Mortality of river and channel fry attributed to trapping and marking, 1966.

River			Channel		
Total handled	207,934 fry			305,684 fry	
Procedure	Number	%	Procedure	Number	%
Trapping	3,084	1.48	Trapping	2,510	.82
Handling	623	.30	Handling	1,366	.45
Marking	425	.20	Marking	2,445	.80
	4,132	1.98		6,321	2.07

Table 6. Mortality of river and channel fry attributed to each marker for the period May 27-June 1/68.

Marker		Channel (left pelvic)				River (right pelvic)			
			Numbers				Numbers		
		Date	Handled	Dead	Dead per 1000	Date	Handled	Dead	Dead per 1000
A		May 27	4,437	28	6.31	May 28	3,905	100	25.60
		29	4,748	12	2.52	30	3,055	153	50.08
		31	4,125	36	8.72	June 1	3,074	158	51.39
	Total		13,310	76			10,034	411	
	Average		4,437	25	5.63		3,345	137	40.95
B		May 27	4,100	12	2.92	May 28	3,731	49	13.13
		29	4,505	24	5.32	30	3,239	53	16.36
		31	3,785	35	9.24	June 1	2,814	94	33.40
	Total		12,390	71			9,784	196	
	Average		4,130	24	5.81		3,261	65	19.93
C		May 27	3,651	1	.27	May 28	3,934	9	2.28
		29	3,900	6	1.53	30	3,312	20	6.03
		31	3,341	3	.89	June 1	3,289	16	4.86
	Total		10,892	10			10,535	45	
	Average		3,631	3	.82		3,512	15	4.27
D		May 27	5,037	8	1.58	May 28	4,717	32	6.78
		29	5,276	19	3.60	30	3,546	108	30.45
		31	4,428	10	2.25	June 1	3,910	41	10.48
	Total		14,741	37			12,173	181	
	Average		4,914	12	2.44		4,058	60	14.78
E		May 27	4,593	4	.87	May 28	3,109	15	4.82
		29	4,462	10	2.24	30	2,365	17	7.18
		31	3,464	28	8.08	June 1	3,571	20	5.60
	Total		12,519	42			9,045	52	
	Average		4,173	14	3.35		3,015	17	5.63
F		May 27	4,884	6	1.22	May 28	5,002	14	2.79
		29	4,510	6	1.33	30	4,635	6	1.29
		31	4,814	5	1.03	June 1	4,760	15	3.15
	Total		14,208	17			14,397	35	
	Average		4,736	6	1.26		4,799	12	2.50

Table 7. Sockeye fry marking : Fulton River and Channel
1966

Date	River		Channel			
	No. marked and released		No. marked and released			
	Daily	Cum.	Daily	Cum.	Daily total	Cum. total
May 8	1,626	1,626	-		1,626	1,626
9	7,985	9,611	-		7,985	9,611
10	1,769	11,380	-		1,769	11,380
11	2,864	14,244	-		2,864	14,244
12	1,304	15,548	-		1,304	15,548
13	1,287	16,835	-		1,287	16,835
14	-		-		-	
15	-		-		-	
16	2,763	19,598	-		2,763	19,598
17	1,509	21,107	-		1,509	21,107
18	1,459	22,566	-		1,459	22,566
19	1,288	23,854	-		1,288	23,854
20	-		597	597	597	24,451
21	-		-		-	
22	-		-		-	
23	22	23,876	178	775	200	24,651
24	167	24,043	218	993	385	25,036
25	1,291	25,334	253	1,246	1,544	26,580
26	2,327	27,661	227	1,473	2,554	29,134
27	3,021	30,682	287	1,760	3,308	32,442
28	3,226	33,908	730	2,490	3,956	36,398
29	-		-		-	
30	2,084	35,992	-		2,084	38,482
31	-		-		-	
June 1	8,825	44,817	1,685	4,175	10,510	48,992
2	13,786	58,603	-		13,786	62,778
3	16,777	75,380	-		16,777	79,555
4	18,571	93,951	-		18,571	98,126
5	-				-	
6	29,098	123,049	-		29,098	127,224
7	29,265	152,314	-		29,265	156,489
8	7,649	159,963	14,337	18,512	21,986	178,475
9	6,730	166,693	19,275	37,787	26,005	204,480
10	7,294	173,987	10,086	47,873	17,380	221,860
11	5,410	179,397	18,870	66,743	24,280	246,140
12	-		-		-	
13	-		21,277	88,020	21,277	267,417
14	-		21,761	109,781	21,761	289,178
15	-		25,354	135,135	25,354	314,532
16	24,405	203,802	3,140	138,275	27,545	342,077
17	-		21,960	160,235	21,960	364,037
18	-		26,024	186,259	26,024	390,061
19	-				-	
20	-		26,681	212,940	26,681	416,742
21	-		29,747	242,687	29,747	446,489
22	-		29,657	272,344	29,657	476,146
23	-		27,019	299,363	27,019	503,165

Table 8. Sockeye fry marking : Fulton River and Channel
1967

Date	River		Channel			
	No. marked and released		No. marked and released			
	Daily	Cum.	Daily	Cum.	Daily total	Cum. total
May 8	9,418	9,418	-		9,418	9,418
9	2,072	11,490	2,709	2,709	4,781	14,199
10	2,927	14,417	-		2,927	17,126
11	3,170	17,587	-		3,170	20,296
12	1,624	19,211	-		1,624	21,920
13	1,294	20,505	2,347	5,056	3,641	25,561
14	-		-			
15	4,245	24,750	-		4,245	29,806
16	2,956	27,706	3,467	8,523	6,423	36,229
17	3,356	31,062	1,193	9,716	4,549	40,778
18	4,414	35,476	-		4,414	45,192
19	4,203	39,679	-		4,203	49,395
20	6,349	46,028	6,307	16,023	12,656	62,051
21	-		-			
22	11,813	57,841	-		11,813	73,864
23	1,804	59,645	10,621	26,644	12,425	86,289
24	15,810	75,455	1,469	28,113	17,279	103,568
25	2,844	78,299	15,443	43,556	18,287	121,855
26	13,181	91,480	7,293	50,849	20,474	142,329
27	-		21,914	72,763	21,914	164,243
28	-		-			
29	24,974	116,454	-		24,974	189,217
30	11,742	128,196	10,462	83,225	22,204	211,421
31	-		27,787	111,012	27,787	239,208
June 1	21,359	149,555	-		21,359	260,567
2	11,213	160,768	5,201	116,213	16,414	276,981
3	-		5,551	121,764	5,551	282,532
4	-		-			
5	21,673	182,441	-		21,673	304,205
6	-		18,176	139,940	18,176	322,381
7	9,533	191,974	11,621	151,561	21,154	343,535
8	17,474	209,448	4,269	155,830	21,743	365,278
9	-		23,919	179,749	23,919	389,197
10	6,099	215,547	19,941	199,690	26,040	415,237
11	-		-			
12	-		19,446	219,136	19,446	434,683
13	7,390	222,937	23,708	242,844	31,098	465,781
14	-		32,368	275,212	32,368	498,149
15	-		26,676	301,888	26,676	524,825
16	-		22,507	324,395	22,507	547,332
17	923	223,860	23,281	347,676	24,204	571,536
18	-		-			
19	-		24,381	372,057	24,381	595,917
20	-		26,802	398,859	26,802	622,719
21	-		30,505	429,364	30,505	653,224

Table 9. Sockeye fry marking : Fulton River and Channel
1968

Date	River		Channel			
	No. marked and released		No. marked and released			
	Daily	Cum.	Daily	Cum.	Daily total	Cum. total
May 14	17,055	17,055	-		17,055	17,055
15	18,258	35,313	-		18,258	35,313
16	-		23,226	23,226	23,226	58,539
17	23,549	58,862	-		23,549	82,088
18	-		-			
19	-		-			
20	26,048	84,910	-		26,048	108,136
21	25,174	110,084	-		25,174	133,310
22	17,885	127,969	-		17,885	151,195
23	-		23,873	47,099	23,873	175,068
24	20,441	148,410	-		20,441	195,509
25	25,388	173,798	-		25,388	220,897
26	-		-			
27	-		29,762	76,861	29,762	250,659
28	26,608	200,406	-		26,608	277,267
29	-		30,483	107,344	30,483	307,750
30	21,384	221,790	-		21,384	329,134
31	-		26,688	134,032	26,688	355,822
June 1	23,864	245,654	-		23,864	379,686
2	-		-			
3	-		29,618	163,650	29,618	409,304
4	25,351	271,005	-		25,351	434,655
5	-		27,692	191,342	27,692	462,347
6	20,772	291,777	-		20,772	483,119
7	-		7,482	198,824	7,482	490,601
8	-		22,689	221,513	22,689	513,290
9	-		-			
10	-		23,000	244,513	23,000	536,290
11	20,133	311,910	-		20,133	556,423
12	13,817	325,727	5,430	249,943	19,247	575,670
13	-		22,837	272,780	22,837	598,507
14	-		24,299	297,079	24,299	622,806
17	-		22,466	319,545	22,466	645,272
18	-		22,062	341,607	22,062	667,334

Table 10.

SURVIVAL - FRY TO SMOLT

YEAR	RIVER	CHANNEL
1966-'67	9.0%	10.1%
1967-'68	19.0%	14.6%
1968-'69	29.3%	33.2%

APPENDIX

The Department of Fisheries has carried out a sockeye fry enumeration program at Fulton River since 1962 in connection with the Fulton River and channel development. The daily and accumulated estimates of the fry migration have been made available for the years 1966-1968 and are shown in Tables 1, 2 and 3. In 1966 the estimates from the river were made from the catches of marked fry (stained with Bismarck Brown) in a floating vertical sampler. Estimates for the period May 9-14, 1966 were not made because high water conditions and debris made trapping impossible. In 1967 and 1968 the estimates were made from counts of fry captured in converging throat traps (Walker et al. 1969) installed on the Fulton River fence. The estimates of channel fry for the three years were made from the catch of fry in the fan traps installed at the downstream end of the spawning channel.

Appendix Table 1. The daily and accumulated sockeye fry migration estimates* from Fulton River and Fulton Spawning Channel No. 1. 1966

Date		River		Channel	
		No.	Cum.	No.	Cum.
April 13-May	1				762
	2	45,000	45,000	32	794
	3	158,600	203,600	97	891
	4	271,800	475,400	44	935
	5	386,400	861,800	29	964
	6	501,000	1,362,800	106	1,070
	7	542,600	1,905,400	369	1,439
	8	584,400	2,489,800	398	1,837
	9	-		433	2,270
	10	-		121	2,391
	11	-		299	2,690
	12	-		995	3,685
	13	-		611	4,296
	14	-		20	4,316
	15	63,600		363	4,679
	16	62,800		240	4,919
	17	63,000		269	5,188
	18	63,400		340	5,528
	19	60,200		370	5,898
	20	62,200		555	6,453
	21	64,200		349	6,802
	22	74,000		305	7,107
	23	88,200		363	7,470
	24	102,400		466	7,936
	25	95,800		345	8,281
	26	95,200		477	8,758
	27	94,800		328	9,086
	28	116,800		954	10,040
	29	126,200		580	10,620
	30	135,600		600	11,220
	31	147,800		497	11,717
June	1	157,400		756	12,473
	2	218,400		738	13,211
	3	460,400		1,150	14,361
	4	419,400		2,569	16,930
	5	497,200		4,135	21,065
	6	589,600		14,726	35,791
	7	512,200		52,952	88,743
	8	451,200		79,659	168,402
	9	390,200		160,919	329,321
	10	405,200		329,427	658,748
	11	161,600		114,726	773,474
	12	59,600		102,185	875,659

Appendix Table 1 (cont'd)

Date	River		Channel	
	No.	Cum.	No.	Cum.
June 13	68,600		55,981	931,640
14	52,000		34,442	966,082
15			15,816	981,898
16			10,270	992,168
17			15,783	1,007,951
18			4,701	1,012,652
19			3,645	1,016,297
20			3,485	1,019,782
21			3,032	1,022,814
22			1,695	1,024,509
23			248	1.024,757
	8,449,000		1,024,757	

- May 9-14th vertical sampler was not fished because of high water and debris.

* The total estimate of 8,449,400 river fry is based on a dye-marked fry recovery (average recovery 0.5%) and does not include the migration during the period May 9-14 when the vertical sampler could not be fished.

The channel fry were all trapped. Small numbers were counted and larger numbers were estimated by counting samples and weighing.

Appendix Table 2. The daily and accumulated sockeye fry migration estimates from Fulton River and Fulton River Spawning Channel No. 1.
1967

Date		River		Channel	
		No.	Cum.	No.	Cum.
April	30	720		533	
May	1	920	1,640	457	990
	2	1,240	2,880	615	1,605
	3	6,620	9,500	226	1,831
	4	20,980	30,480	925	2,756
	5	95,800	126,280	1,338	4,094
	6	198,820	325,100	937	5,031
	7	300,980	626,080	840	5,871
	8	397,180	1,023,260	606	6,477
	9	382,160	1,405,420	877	7,354
	10	331,140	1,736,560	1,348	8,702
	11	308,700	2,045,260	1,883	10,585
	12	193,380	2,238,640	2,148	12,733
	13	207,640	2,446,280	2,103	14,836
	14	210,900	2,657,180	2,077	16,913
	15	217,040	2,874,220	1,936	18,849
	16	262,720	3,136,940	2,698	21,547
	17	320,220	3,457,160	2,651	24,198
	18	360,500	3,817,660	2,475	26,673
	19	389,440	4,207,100	3,332	30,005
	20	402,220	4,609,320	5,733	35,738
	21	431,760	5,041,080	3,895	39,633
	22	431,780	5,472,860	7,019	46,652
	23	484,940	5,957,800	11,968	58,620
	24	408,740	6,366,540	20,063	78,683
	25	355,720	6,722,260	18,534	97,217
	26	440,560	7,162,820	58,096	155,313
	27	334,860	7,497,680	65,166	220,479
	28	328,640	7,826,320	99,533	320,012
	29	402,320	8,228,640	111,604	431,616
	30	431,480	8,660,120	181,776	613,392
	31	503,320	9,163,440	215,461	828,853
June	1	642,300	9,805,740	430,515	1,259,368
	2	702,662	10,508,402	571,185	1,830,553
	3	885,080	11,393,482	750,600	2,581,153
	4	867,420	12,260,902	1,151,145	3,732,298
	5	798,240	13,059,142	1,512,540	5,244,838
	6	1,113,769	14,172,911	2,642,683	7,887,521
	7	1,300,000	15,472,911	2,675,693	10,563,214
	8	1,800,000	17,272,911	3,423,002	13,986,216
	9	900,000	18,172,911	2,401,564	16,387,780
	10	600,000	18,772,911	2,530,921	18,918,701
	11	400,000	19,172,911	3,300,571	22,219,272
	12	100,000	19,272,911	1,183,072	23,402,344

Appendix Table 2 (cont'd)

Date	River		Channel	
	No.	Cum.	No.	Cum.
June 13	52,000	19,324,911	970,200	24,372,544
14	61,000	19,385,911	488,414	24,860,958
15	23,000	19,408,911	243,452	25,104,410
16	12,000	19,420,911	160,206	25,264,616
17	5,000	19,425,911	95,485	25,360,101
18	2,000	19,427,911	59,616	25,419,717
19	7,000	19,434,911	32,568	25,452,285
20	1,193	19,436,104	43,680	25,495,965
21			20,384	25,516,349

Appendix Table 3. The daily and accumulated sockeye fry migration estimates from Fulton River and Fulton Spawning Channel No. 1. 1968

Date	River		Channel	
	No.	Cum.	No.	Cum.
April 24-28		16,520		
29	12,900	29,420	4,876	4,876
30	12,240	41,660	3,287	8,163
May 1	14,740	56,400	3,530	11,693
2	20,560	76,960	2,796	14,489
3	26,000	102,960	4,152	18,641
4	60,280	163,240	4,830	23,471
5	66,300	229,540	2,816	26,287
6	116,240	345,780	2,268	28,555
7	302,860	648,640	8,454	37,009
8	532,380	1,181,020	10,216	47,225
9	745,500	1,926,520	12,405	59,630
10	1,164,880	3,091,400	14,748	74,378
11	1,410,600	4,502,000	31,143	105,521
12	1,270,600	5,772,600	31,958	137,479
13	1,584,980	7,357,580	41,211	178,690
14	1,118,400	8,475,980	63,490	242,180
15	1,045,960	9,521,940	54,029	296,209
16	1,007,280	10,529,220	85,001	381,210
17	1,049,160	11,578,380	84,289	465,499
18	1,243,360	12,821,740	106,594	572,093
19	1,499,160	14,320,900	184,012	756,105
20	3,230,093	17,550,993	231,967	988,072
21	1,896,444	19,447,437	300,216	1,288,288
22	1,536,201	20,983,638	414,819	1,703,107
23	1,005,017	21,988,655	438,463	2,141,570
24	569,686	22,558,341	480,034	2,621,604
25	294,119	22,852,460	520,441	3,142,045
26	232,767	23,085,227	601,533	3,743,578
27	215,797	23,301,024	652,023	4,395,601
28	352,831	23,653,855	668,069	5,063,670
29	248,937	23,902,792	732,163	5,795,833
30	294,893	24,197,685	1,029,757	6,825,590
31	340,850	24,538,535	939,970	7,765,560
June 1	186,762	24,725,297	1,032,738	8,798,294
2	243,089	24,968,386	1,120,771	9,919,069
3	222,200	25,190,586	922,660	10,841,729
4	259,940	25,450,526	953,724	11,795,453
5	259,940	25,710,466	925,231	12,720,684
6	297,680	26,008,146	774,435	13,495,119
7	213,960	26,222,106	971,602	14,466,721
8	226,940	26,449,046	560,900	15,027,621
9	239,920	26,688,966	380,960	15,408,581
10	114,140	26,803,106	261,869	15,670,450

Appendix Table 3 (cont'd)

Date	River		Channel	
	No.	Cum.	No.	Cum.
June 11	115,140	26,918,246	283,394	15,953,844
12	62,980	26,981,226	49,523	16,003,367
13	45,500	27,026,726	18,211	16,021,578
		27,026,726		16,021,578