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A METHOD OF ENUMERATING BLUEBACK SALMON SMOLTS FROM QUINAULT LAKE
AND BIOLOGICAL PARAMETERS OF THE 1974 OUTMIGRATION

by

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ABSTRACT

A simple, inexpensive method of sampling outmigrating blueback salmon smolts, Oncorhynchus nerka (Walbaum), in the lower Quinault River, Washington, was designed, tested, and put into operation. Biological parameters of the 1974 smolt migration and of the induced migration of pen-reared blueback fry were determined.

The sampling apparatus consisted of a downstream net equipped with a submersible live tank which could be sent rapidly above water to any desired location across the river and fished there by means of a supporting cable and two driven lines. Mechanical power and flood lighting of the river during nighttime operation was supplied by a second-hand automobile modified by the attachment of gypsyheads bolted to the rear wheels. The apparatus was operable by one person.



INTRODUCTION

The Quinault Tribal Council has undertaken a program to increase the runs of blueback salmon to the Quinault River, Washington, by improving its management techniques and by artificially increasing the fry or smolt recruitment.

A pilot study was initiated in 1973 in which blueback eggs from the upper Quinault River were hatched in gravel incubators, transferred to rearing pens in Quinault Lake, and intensively fed (Fig. 1). Their rapid growth encouraged the Quinault Tribal Council to increase hatching and rearing capacities and to explore the possibility that blueback fry may be induced to smoltify and migrate during their first spring rather than during the second spring as occurs naturally. Induced migration at age 0 would remove the artificially-produced fry from competition in the lake with naturally-produced blueback and would yield returns to the Quinault fishery one year earlier than the return of the wild stock.

Whether increased productivity will be achieved will not be known until the fish return two or three years hence; however, whether induced migration occurs at age 0 can be determined by marking the fry before their release into Quinault Lake followed by a recovery effort in the lower Quinault River.

In order to properly manage the blueback salmon runs and to evaluate the rearing program it is essential that a system for monitoring the smolt production be established. The primary objective of this study was to develop a method of estimating the outmigration of wild smolts and artificially-produced fry from Quinault Lake.

For many years blueback salmon smolts have been enumerated extensively on the larger rivers entering Bristol Bay, Alaska. During the 1950's and early 1960's the method entailed fishing one or two anchored fyke nets along the river banks in order to develop indices of abundance which, when compared with respective returns, served as bases for forecasting the runs (Burgner 1958; Kerns 1961).

Recently, the index method of forecasting has been replaced by an improved method in which estimates of total abundance are derived from catches made with a net fished randomly at multiple, pre-selected locations across the river. The principle advantage of this method is that the resulting forecasts are not affected by changed smolt migration paths which may result from changes in the river channel (Shroeder 1971). The method entails suspending a net randomly for 1-hr intervals in turn at each of five or so standard fishing sites located at equal intervals across the river. The net is suspended from fixed warp lines attached to a cable which is stretched across the river, is detached and re-attached at a new location hourly on a random schedule so that all sites are fished daily between 2100 and 0200 hours, and is re-set by several persons from an outboard skiff.

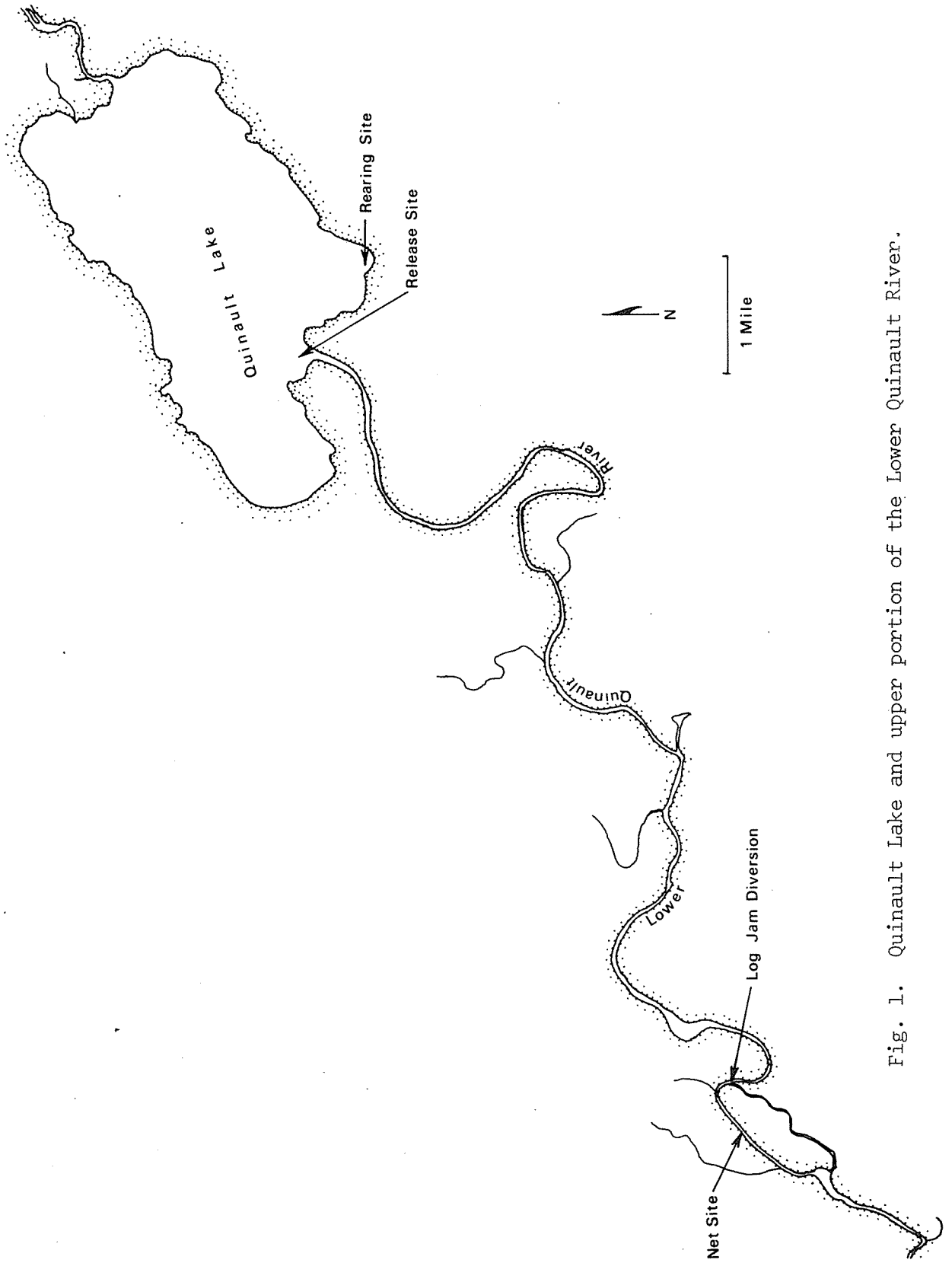


Fig. 1. Quinault Lake and upper portion of the Lower Quinault River.

This method was considered feasible for use on the Quinault River but not ideal because of its personnel requirements and because it entails working from a skiff at night during high-flow conditions. Our specific objective was to develop a method by which the net could be handled entirely from shore by one or two persons. Toward this end we designed, tested, and put into operation an adaptation of the suspended-cable method which enabled one person to operate the sampling net and its supporting apparatus quickly and easily from shore. By applying this method we obtained information on the daily and seasonal timing, length, and age composition of the natural blueback smolts, and of the outmigration of pen-reared blueback fry.

This study is one of several conducted by the Fisheries Research Institute under contract to the Quinault Tribal Council. Other objectives include the development of a manual for acoustical assessment of juvenile and adult blueback salmon in Quinault Lake and the development of a management program for the Quinault blueback salmon fishery.

METHODS AND EQUIPMENT

Because the principal objective of this study was to develop a sampling method, our effort at first was devoted largely to the design, construction, and testing of the sampling apparatus and to the selection and preparation of the sampling site. Once the equipment was operational the work was devoted to minor improvements and adjustments of the apparatus, to testing its use under varying flow conditions, to determining the suitability of the sampling site as a permanent location for smolt sampling, and to determining the parameters of the 1974 migration. In order that work proceed on all of these objectives it was necessary to employ a simplified, flexible sampling strategy entailing sampling at semi-weekly intervals until the run diminished. Generally, the net was checked hourly during periods of low migration rate (<10 smolts per hour) and semi-hourly when higher. Weekly samples of smolts were preserved for length frequency determinations and scale analysis. Initially, two persons operated the gear, but after its operation had become familiar and was determined to be reliable, the sampling was done by one person.

The sampling apparatus including the net, net frame, live tank, arrangement of lines and pulleys, and the gypsyheads were designed by the senior author.

Net

The net measured 4 ft² at the entrance and tapered uniformly 16 ft to a 6-inch circular opening at the cod end to which was sewn a 6-inch diameter by 6-inch long vinyl sleeve (Fig. 2). The sleeve provided a

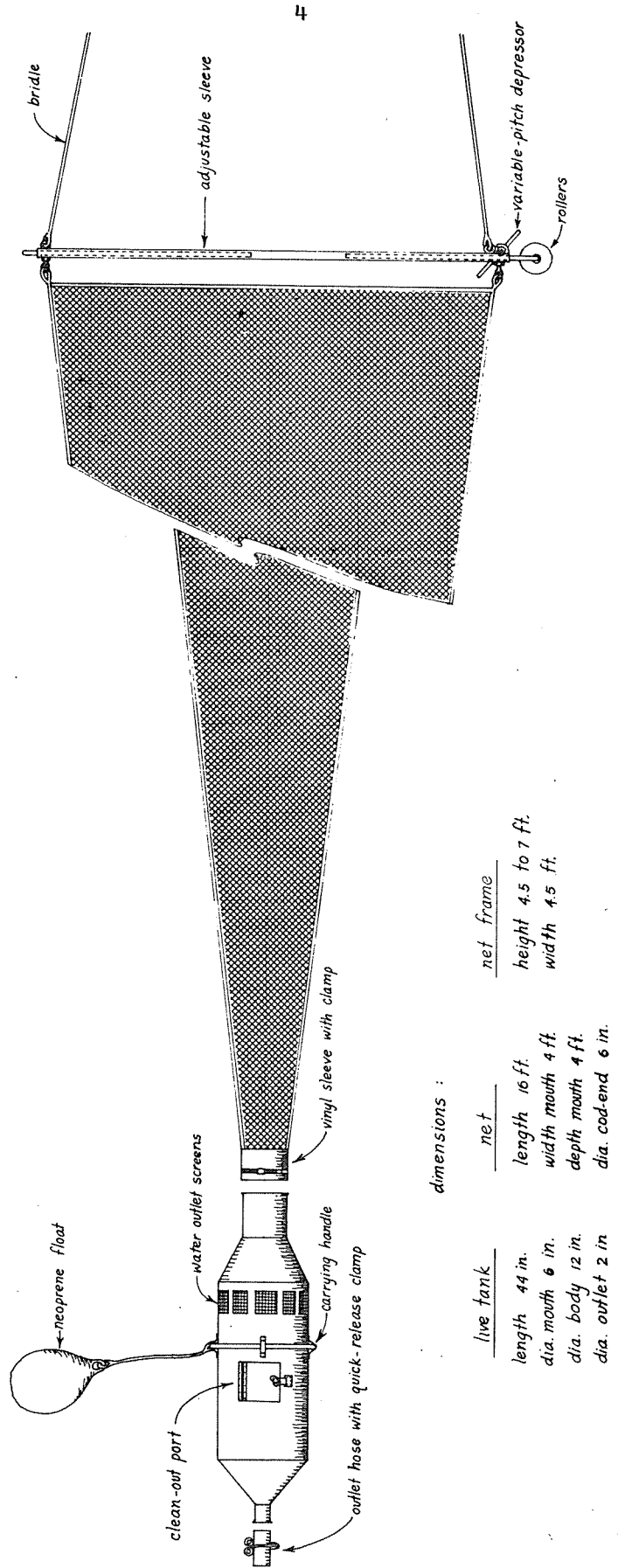


Fig. 2. Downstream sampling net with live tank and adjustable frame used for sampling blueback salmon smolts and pen-reared blueback fry.

strong, abrasion-resistant surface for clamping to a live tank. Fykes were unnecessary because current velocities exceeded 3 fps. The net was constructed of four panels of 1/2-inch nr. 147 2-stitch knotless nylon sewn together by nylon tapes reinforced by 7/16-inch polypropylene lines. These lines also encircled the entrance and were looped at the forward corners for attaching the net to a suspension frame.

Net Frame

The net was held open by a rectangular frame of 1/2-inch steel rod 4-1/2 ft wide and adjustable in height from 4-ft-3-inches to 7 ft by means of telescoping sides (Fig. 2). This feature enabled the net to be fished at various levels in the water column. A variable-pitch depressor measuring 4-ft long by 4-1/2-ft wide by 3/16 inch thick was bolted to the frame near the bottom to sink the net. The bottom bar was equipped with two bronze-bushed rubber rollers which facilitated the movement of the frame over the bottom during outhaul and inhaul.

Live Tank

A submersible live tank was attached to the vinyl sleeve of the cod end of the net to retain the catch (Fig. 2). The tank was cylindrical, 44-inches long by 12-inches diameter, and was constructed of 14-gauge galvanized steel sheet. It featured a 6-inch diameter entrance over which the net cod-end sleeve was clamped, an expanded holding area with water venting screens, lifting ring, hinged door for debris removal, and a drain funnel. Water turbulence in the tank was minimized by expanding the middle section and by locating the water-venting screens forward. The forward location of the screens also enabled the fish to be retained live while the tank was lifted out of water. The lifting ring served as carrying handle, lifting point, and for attachment of a flotation buoy. Out of water, the tank retained 1.64 ft³ of water, and weighed a total of 105 lb. The catch was released through a 2-inch drain tube to which a short section of flexible hose was clamped. The hose was blocked during fishing by means of a spring clamp. Removal of sticks and leaves which accumulated on the interior of the screens and in the outlet tube was accomplished by reaching through a 6-inch circular door in the side of the middle section. The door was hinged, secured by means of an aircraft latch, and was sealed against water leakage by a strip of foam rubber covering the contact surfaces.

The live tank was lifted out of water at shore and water and fish were drained into a 15-gal floating, tethered wash tub. The lifting apparatus consisted of a 12 ft by 2 inch by 4 inch level arm supported by two bipods. The fulcrum of the lever arm was located 4 ft from the lifting end which afforded a mechanical advantage of 2:1. The lever arm was operated by pulling a rope which was attached to the opposite end through a pulley anchored to the ground. The lifting apparatus was operated easily by one person.

The live tank worked well as a means of retaining captured fish alive so long as the current was moderate and the tank was emptied at half-hour intervals. Considerable mortality occurred when water velocity exceeded 4.5 fps or when the net was fished for hourly periods.

The Netting Site

The selected site was 12.5 mi downstream from Quinault Lake near the end of logging road 9105 (Fig. 1). Here the river measures 210-ft wide and during periods of moderate flow the maximum water depth is 5-1/2 ft and the current velocity is 4 fps. The bottom consists of gravel and small boulders up to 10-inch diameter. Large cottonwood and maple trees line both banks.

A small side channel by-passed the net site to the south. This channel originated in a log jam 1 mi upstream and re-entered the main channel 3/4-mi downstream from the set site. Comparisons of flow and rate of smolt migration were made between this channel and the main channel.

Net-handling Tackle

A 1963 station wagon equipped with an automatic transmission (Fig. 3) was used as the power source for moving the net back and forth across the river and for setting and hauling the net at desired locations. The car was driven to the north river bank and positioned to line up with spar trees and so that its headlights could be used to light the river during setting and hauling at night. The rear wheels were elevated off the ground and the front wheels were braced fore and aft by 6-inch logs. Gypsyheads were bolted to the rear wheels (Fig. 4). In addition to providing the winch power, the car furnished other conveniences including locked storage space for tools and materials, heated and lighted cover for the operator, flood lighting of the entire river width during setting and hauling, electrical power for lighting the river bank during processing of the catch.

A 3/8-inch fixed, steel support cable was suspended across the river and secured to large cottonwood trees which were standing approximately 50 ft back from either bank (Figs. 5 and 6). The tension on the cable was adjustable from the north shore by a pair of double rope blocks with 1/2-inch line. The height of the cable at mid-river was approximately 10 ft above the water surface in order not to hinder boat traffic. The net was moved back and forth across the river and held in desired fishing locations by a 1/2-inch polypropylene line (positioning line) which ran through pulleys and over the right gypsyhead. This line could be braked independently by applying the parking brake lever from which the left brake cable had been disconnected. The ends of the positioning line were secured to the ends of a 10 ft by 1-inch galvanized



Fig. 3. Second-hand automobile adapted as a power source for shore-based net sampling of the Lower Quinault River. Lever for lifting live tank appears at left.



Fig. 4. Gypsyhead which provided power for lowering and lifting the sampling net.

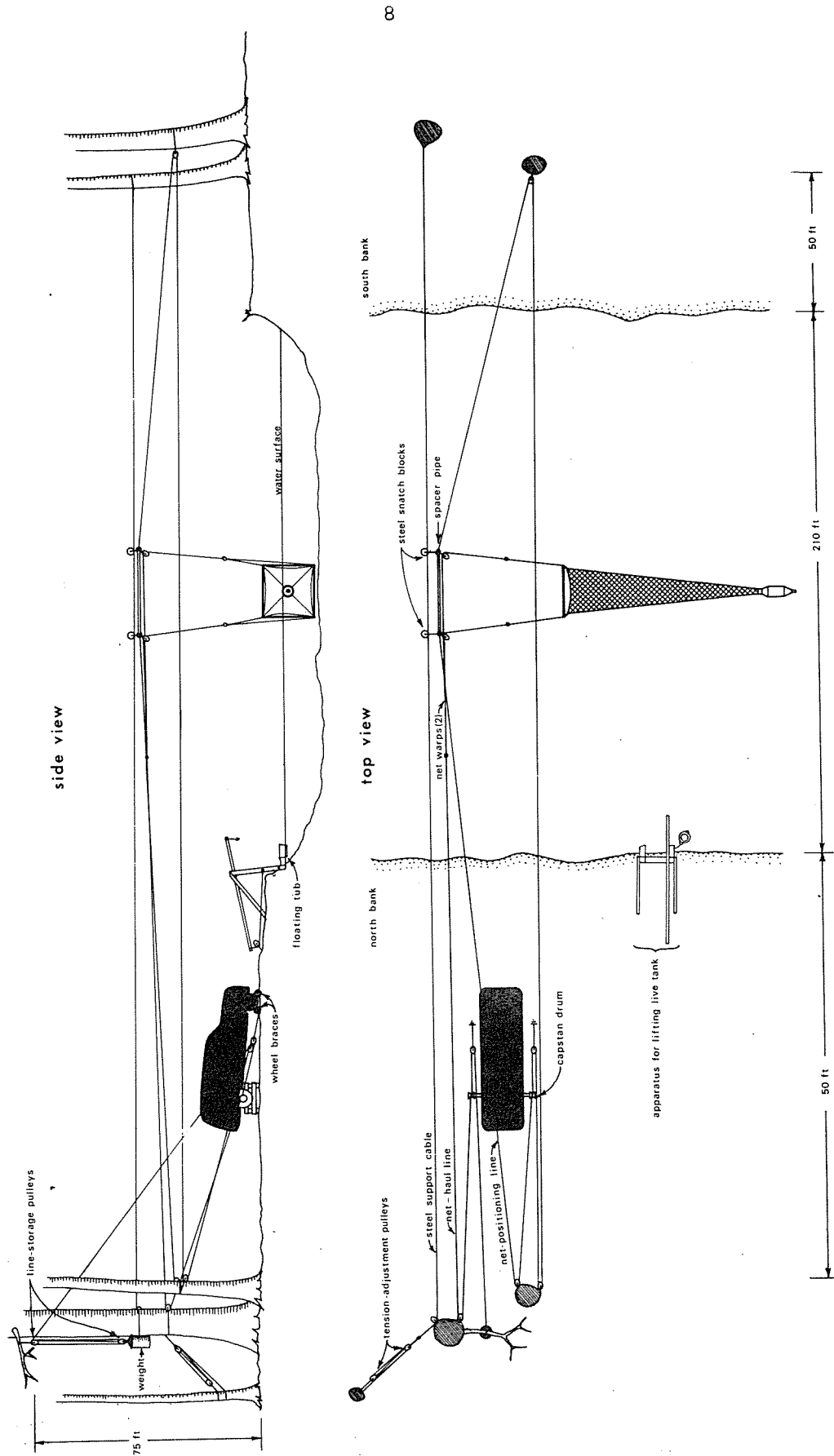


Fig. 5. Schematic diagram of the tackle and apparatus used to position a sampling net across the Lower Quinault River.

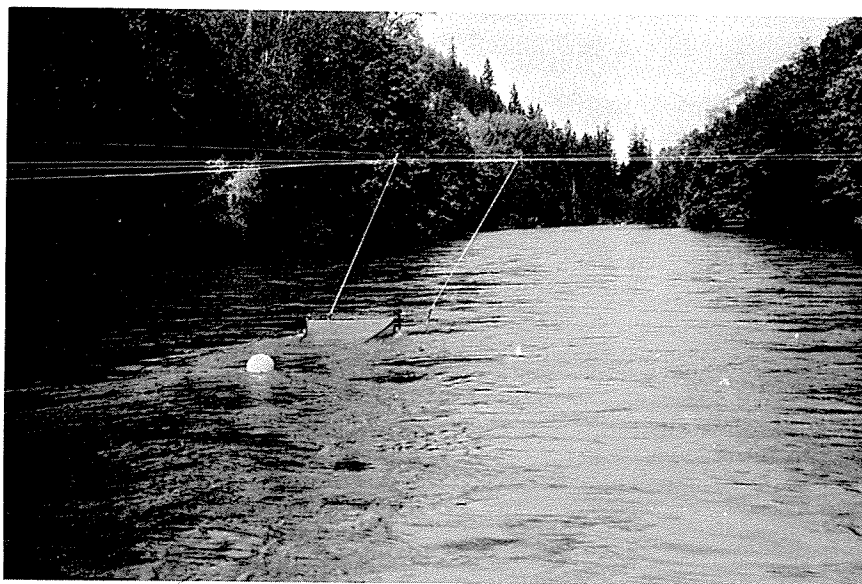


Fig. 6. Sampling net suspended in fishing position from a cable across the Lower Quinault River.

spacer pipe to which 3-inch diameter rings had been welded. The rings were secured overhead by 1-ft rope tethers to steel snatch blocks on the support cable. Hung below the rings were a single and a double pulley through which the net was raised and lowered by means of a second line.

A second polypropylene line (net-haul line), driven by the left gypsyhead through pulleys, served to set and haul the net at desired fishing locations. This line could also be braked independently by a simple modification of the left rear brake cable in which the cable was lengthened and brought forward through the floor under the drivers seat to a crude, hand-operated brake lever. The net-haul line was divided into two warps 40 ft from the pulleys which hung from the steel pipe. The warps were led through the pulleys to 10-ft bridle lines to which the net and frame were fastened. This arrangement permitted the net bridles to be let downstream from the support cable any distance up to 40 ft as necessitated by water conditions.

The system required that both lines be driven in and out at the same rate in order to prevent unwinding while the net was being brought ashore. This precluded the net-haul line from being stored on a wheel-mounted storage drum. Instead, the line was stored by passing the shore-end through a pair of double rope pulleys which were suspended from a tree branch 75 ft above ground. The pulleys were capable of

storing nearly 300 ft of line in this manner. A garbage can filled with rocks and weighing approximately 350 lb was suspended from the lower block to maintain tension and thereby prevent slippage of the line on the left gypsyhead.

The net was operated from the driver's seat of the car; outhaul was accomplished by shifting into forward gear which caused both lines to be driven forward at approximately 100 fpm at idle speed. Slight friction was applied to the left rear brake drum by the hand brake to prevent unwinding of the net. When the net reached the desired fishing location, as indicated by marks taped on the positioning line, the parking brake was applied to the right gypsyhead thereby immobilizing the positioning line. As the left gypsyhead continued to rotate the warps were let out until the net was in correct fishing position. Both lines were then locked by moving the gear selector to "park." Inhaul was accomplished by reverse gear. No tension was needed on the left brake drum during inhaul. Depending on current velocity, approximately 1/4 to 1/3 throttle was necessary to pull the net upstream during inhaul. Cross-river movement of the net was accomplished at idle speed. Both lines could be locked simultaneously at any time with the foot brake. The time required to bring the net ashore from mid-river, empty the catch, clean out debris, and return the net to fishing position in mid-river was 5 min.

RESULTS

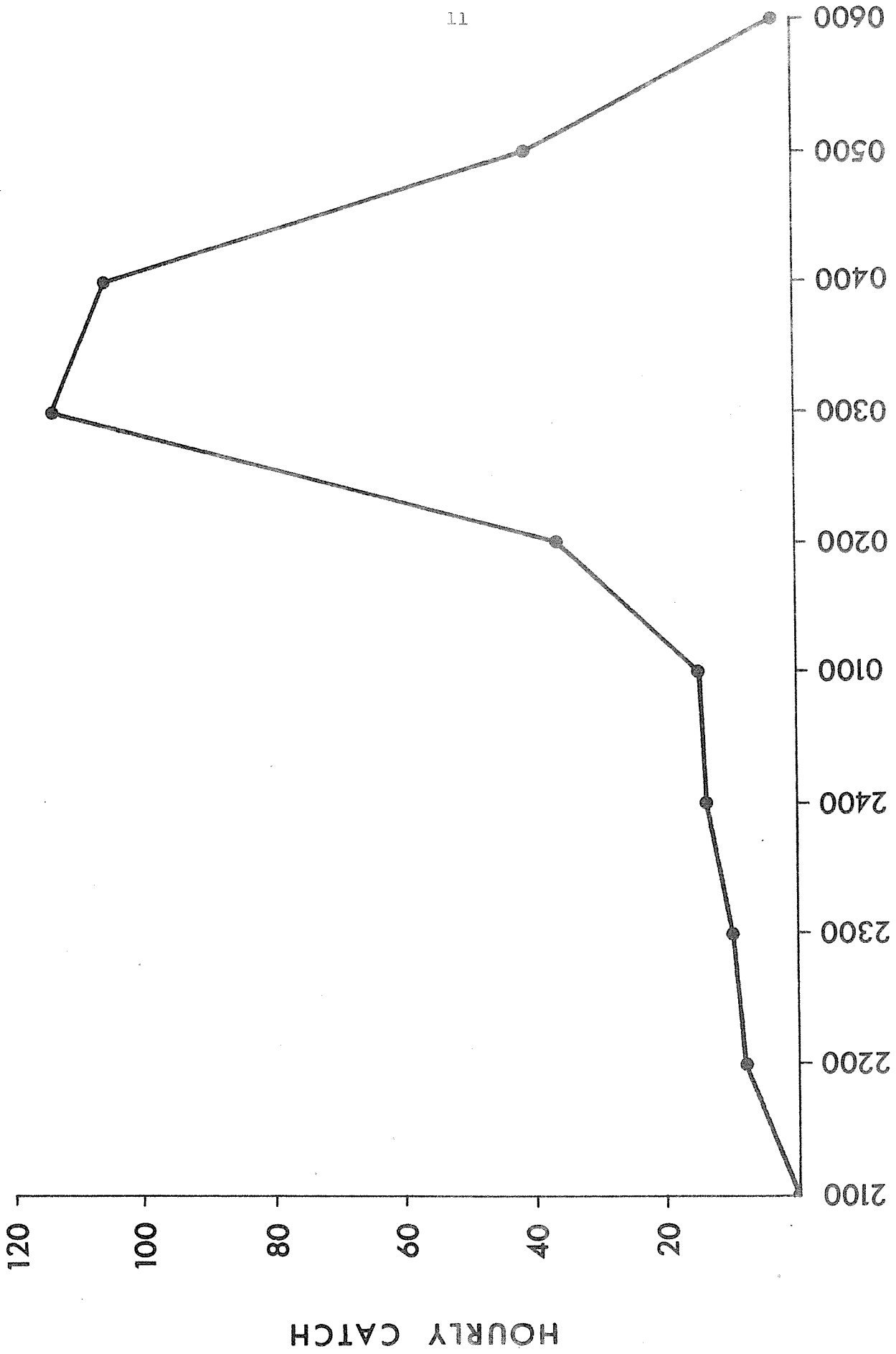
Timing of the Natural Outmigration

Daily Timing

The daily migration past the net site occurred from dusk to dawn (2130 to 0600 hours) and peaked between 0100 and 0400 hours (Fig. 7, Appendix Table 1). No live blueback smolts were caught during daylight hours. The timing of the daily migration peak depended on current velocity as influenced by flow; high flows resulted in faster migration rates and consequently earlier arrivals at the net site; low flows resulted in slower rates and later arrivals.

The daily outmigration of blueback smolts from several other lakes of similar latitude in Washington and southern British Columbia peaks about 2230 hours (Traynor 1971; Brannon¹). Assuming that this is true for Quinault Lake smolts, the 12.5-mi trip downriver to the net site averaged 3.0 hr during high flows (4.2 mph) and 4.5 hr during low flows (2.8 mph). Fish which were in the river at daybreak apparently ceased migration until the following night. This was reflected in the daily catch curves which were characterized by a period of small-to-moderate catches from darkness until 0100 or 0200 hours (fish which probably held during daytime in the river) and then a pronounced increase as the direct migration from the lake reached the net site.

¹Brannon, Ernest L. Unpublished data, 1970. Available at International Pacific Salmon Fisheries Commission, New Westminster, British Columbia.



TIME OF DAY

Fig. 7. Hourly catch of blueback smolts in the lower Quinault River during the night of April 29-30, 1974.

Seasonal Timing

The peak of the outmigration was not determined precisely due to the late beginning of our scheduled sampling and to the large day-to-day fluctuations in catch which tended to mask the catch trend. The principal period of outmigration began before April 18 and continued until May 20, after which the catches declined greatly (Fig. 8). No attempt could be made to estimate the total outmigration.

Size and Age

The smolts ranged in size from 51 to 115 mm standard length with a frequency mode at 67.5 mm (Fig. 9). The average size decreased during the season due to the early outmigration of the large smolts. Smolts longer than 85 mm occurred regularly in the early catches but none were caught after May 6. The length frequencies typically were skewed to the left.

Analysis of scales of 177 smolts revealed that all were age 1 except for two measuring 111 and 115 mm which were age 2 (Appendix Table 2). The wide range of age 1 smolts likely resulted from the extended spawning period which spans several months.

Water Flow and Temperature

A stream gauge and maximum-minimum thermometer were installed in late April to provide preliminary information on water levels and temperatures (Appendix Table 3). The river flow at the net site was gauged on May 7 at 2495 cfs at which time the relative water level was 23.5 inches (Appendix Table 4). A side channel which by-passed the net site on the south bank was gauged May 8 at 728 cfs (water level = 24.5 inches).

Water levels fluctuated between 14.8 and 62.0 inches (nearly 4 ft). Current velocities at mid-stream ranged from an estimated 3.5 to 6.0 fps. The apparatus was operated successfully in a current velocity of 5.0 fps., however, because of stresses imposed by drag, 5.0 fps appeared to be the maximum fishable velocity for the net.

The rate of outmigration did not appear to be affected by varying flows, but did appear to be greatly reduced by a severe storm on May 22-25. A pronounced decline in the outmigration rate was observed during the storm.

Smolt Migration Through the South Channel

Comparative net fishing was done on the main and south river channels May 7 and 8 to determine whether the migration of smolts through the south channel was proportional to its flow. Because only one net was available, the channels were necessarily fished on consecutive nights and therefore the comparison is valid only to the extent that the May 7 and 8 migrations were identical. Based on the portions of the flows fished and the daily catch totals from each channel, the south channel

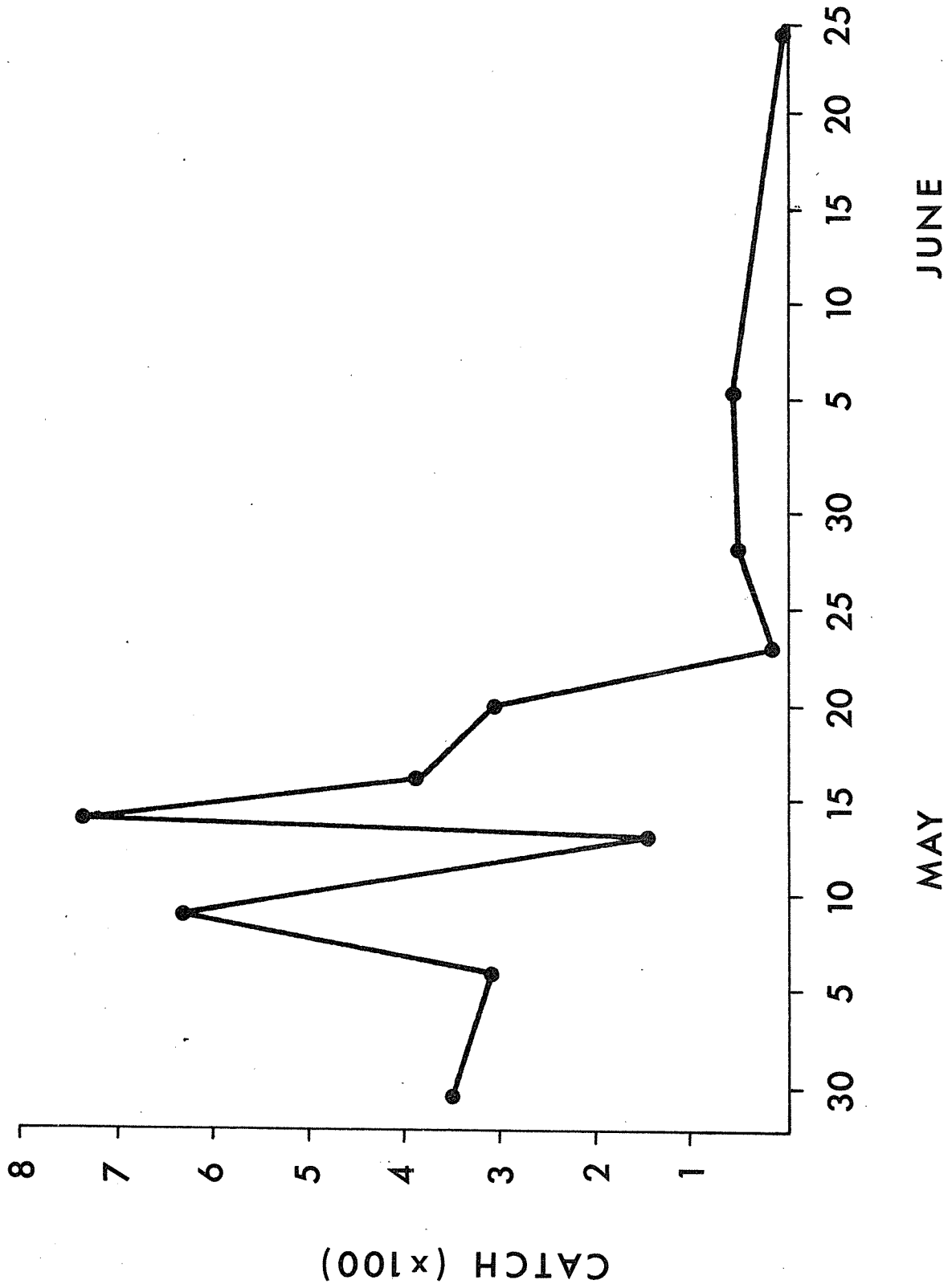


Fig. 8. Seasonal catch of blueback smolts in the Lower Quinault River, 1974.

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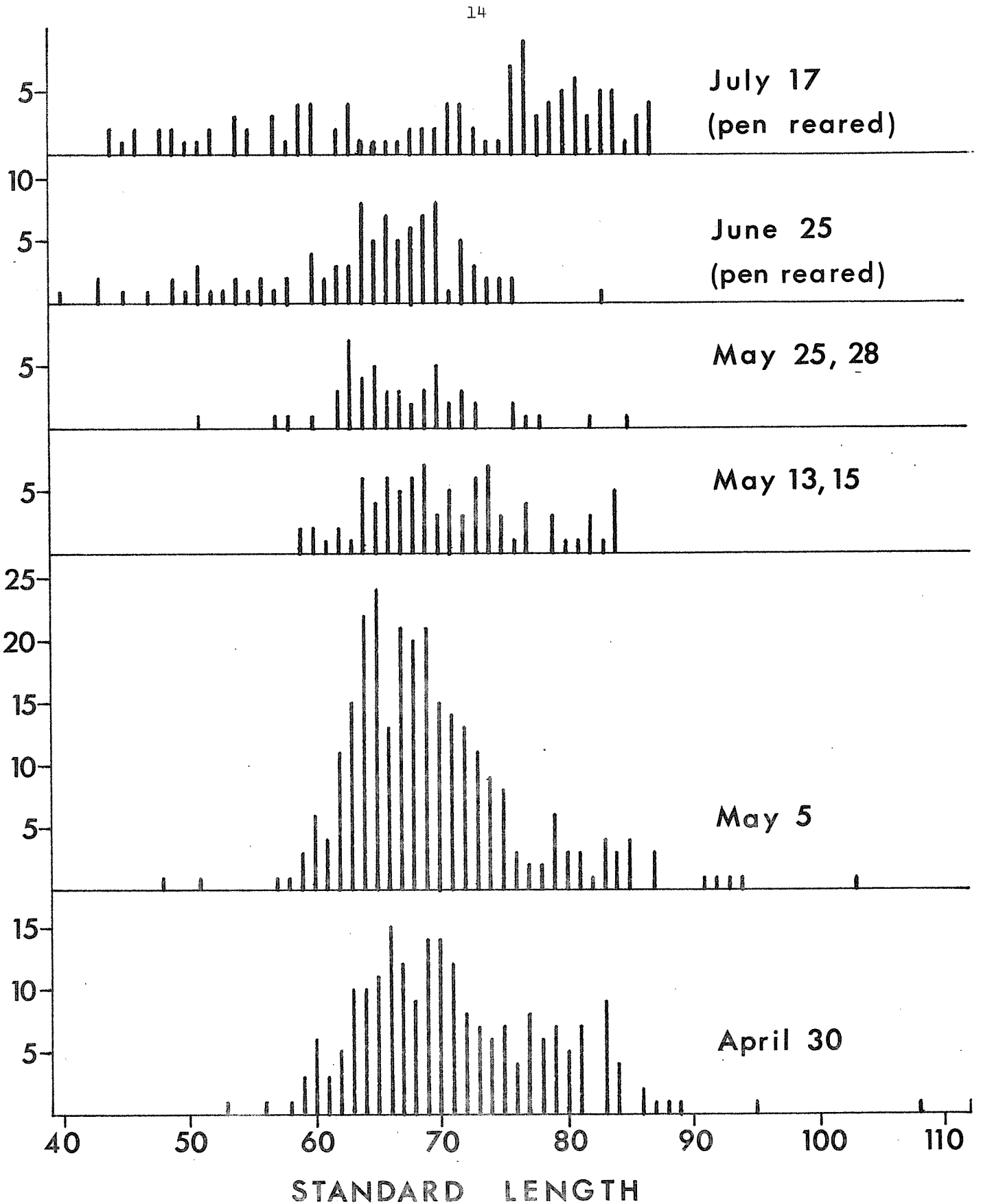


Fig. 9. Seasonal comparison of the length frequencies of blueback smolts and pen-reared blueback fry caught in the Lower Quinault River, 1974.

carried an estimated 93 smolts--a negligible portion of the migration (Table 1). Had the migration rate been proportional to its flow, the south channel should have carried an estimated 8,618 smolts. The little information obtained on daily catch variation indicates that twofold variations occur frequently and that fourfold variations occur occasionally. Increasing the catch of the south channel fourfold raises the estimated smolt migration to 374, which is still a small fraction of the number expected had the migration through the south channel been proportional to its flow.

Table 1. Comparison between main and south channels of estimated smolt migrations, May 7, 8, 1974

Channel	CFS	CFS fished	Percent total CFS fished	Catch	Estimated smolts
Main	2495	53.92	2.16	638	29,537
South	728	31.13	4.28	4	93

The south channel was formed by a series of small flows through a log jam which extends for approximately 1/4 mi along the south bank. Because migrating smolts tend to seek deeper channels with higher velocities they are probably screened out of the south channel by the thick network of logs and sticks through which the channel originates.

Incidental Species

Several species of fish were caught incidental to the blueback salmon smolts. The species and their abundances were: silver salmon fingerling and fry, O. kisutch 143; chum salmon fry, O. keta 121; sculpin, Cottidae 28; northern squawfish, Ptychocheilus oregonensis 9; Pacific lamprey, Entosphemus tridentatus 6; steelhead trout, Salmo gairdnerii 1, stickleback, Gasterosteus aculeatus 1.

Fingerling silvers first appeared in the catches May 6 and last appeared on June 26. The chum fry, even though small enough to escape through the 1/2-inch² mesh of the net and the 3/8-inch² screen openings in the live tank were caught in moderate numbers from the beginning of sampling until May 23.

The occurrence of silver fingerlings and chum fry in the catches indicate that outmigrations of these species as well could be enumerated by means of the sampling apparatus described. The substitution of several feet of 1/4-inch netting at the cod end of the net and of 1/4-inch screen on the live tank vents would increase the catch of chum fry.

Outmigration of Pen-reared Blueback Fry

The artificially-hatched blueback fry were reared in three separate groups in Quinault Lake according to their dates of emergence and were released by groups into Quinault Lake when their lengths approximated that of the wild smolts. The outmigrations of the first two groups were monitored at the net site.

The earliest and largest group of 86,000 was released June 25 at 2230 hours 100 yd from the lake outlet. These had been marked during the previous week by removal of their adipose fins. The downstream net was fished during the nights of June 25, 26, and 27 and captured totals of 368, 41, and 13 pen-reared fry respectively. Only one wild smolt was caught during this period. The fastest migrating fry reached the net site between 0200 and 0300 hours the night of release and the peak period of migration occurred between 0330 and 0400 hours. These times correspond closely with previously observed travel rates for wild smolts during similar stream levels (stream gauge = 28.0 inches). The outmigration diminished greatly during the second and third nights.

In proportion to the flow which was sampled by our net, the catch represents a maximum outmigration of 18,147 fry or 21.1 percent of the releases. This estimate is maximum because migrating smolts are somewhat selective toward mid-river current where our net was positioned.

A second group of 60,000 unmarked fry was released at the outlet on July 16 at 2130 hours. Catches during the nights of July 16 and 17 totaled 170 and 19 respectively which represent a maximum outmigration of 8,360 or 13.9 percent of the total release. The fastest migrants reached the net site between 0100 and 0215 hours and the peak occurred between 0245 and 0315 hours. A single, marked fry from the June 25 release was caught on July 17.

Physical Characteristics of the Pen-reared Blueback Fry

Pigmentation

A sample of blueback salmon fry from the earliest pen-reared group was examined on May 29 and found to be easily distinguishable from the wild smolts on the basis of parr marks and silvery sheen. On that date the fry ranged between 35 and 55 mm and all bore parr marks which were noticeably darker and extended farther down the sides than those of the wild smolts caught downriver. As well, their appearance was generally less silvery than that of the wild smolts. However, by June 25 the pigmentation of the pen-reared blueback fry had become smolt-like and similar to that of the wild smolts. This change was true for all fry caught downriver including individuals as small as 40 mm. The second group of fry also bore smolt-like pigmentation at the time of their release on July 17.

Body Depth

As was expected, the pen-reared blueback fry were easily distinguished from wild smolts by their much greater body depth. In fact, the adipose mark of the first group was unnecessary as a means of identification at the net site.

However, this difference is not apparent in a comparison between the length and weight distributions of preserved wild smolts and pen-reared fry (Fig. 10), but is readily apparent in a comparison between length and body-depth distributions in which the fry were deeper bodied (Fig. 11). Thus, the pen-reared fry weighed approximately the same as wild smolts of comparable size but had a greater proportion of their body weight distributed in the gut region and less elsewhere in the body as muscle tissue. Examination of the gut cavities revealed that the pyloric caeca of the pen-reared fry were greatly enlarged and were interspersed with deposits of solid fat. Because these measurements were made on fish which had been preserved for two months in 50 percent ethyl alcohol, it is probable that body fat had been dissolved and lost to solution. The pen-reared smolts with their greater fat content would have lost more body weight by dissolution than the wild smolts.

The greater body depth apparently was lost by blueback fry which remained in the lake, as evidenced by a single, marked fry caught downriver on July 18. During a 23-day period of lake residence this individual had become identical in shape and coloration to the wild smolts.

Scale Morphometry

Circuli counts from the scales of 175 age 1 blueback smolts were plotted against body lengths (Fig. 12). The distribution indicates that a circuli was formed with each average length increment of 2.5 mm.

DISCUSSION

The substantial outmigration of pen-reared fry immediately following their release appears to have resulted largely from the nearness of the release point to the river outlet rather than from migrational urge. Because the river mouth occupied approximately 15 percent of the dispersal area available to the released fry it is reasonable to assume that the outmigration during the first night resulted from dispersal effects and not from intentional outmigration.

The catch downriver of a single marked blueback fry 23 days after its release in Quinault Lake indicates that intentional migration of pen-reared fry occurred later; however, the magnitude and duration of this outmigration is unknown.

The downstream movements of the pen-reared fry in the river appeared to be identical to those of the wild smolts in regard to rate of travel and hours of movement.

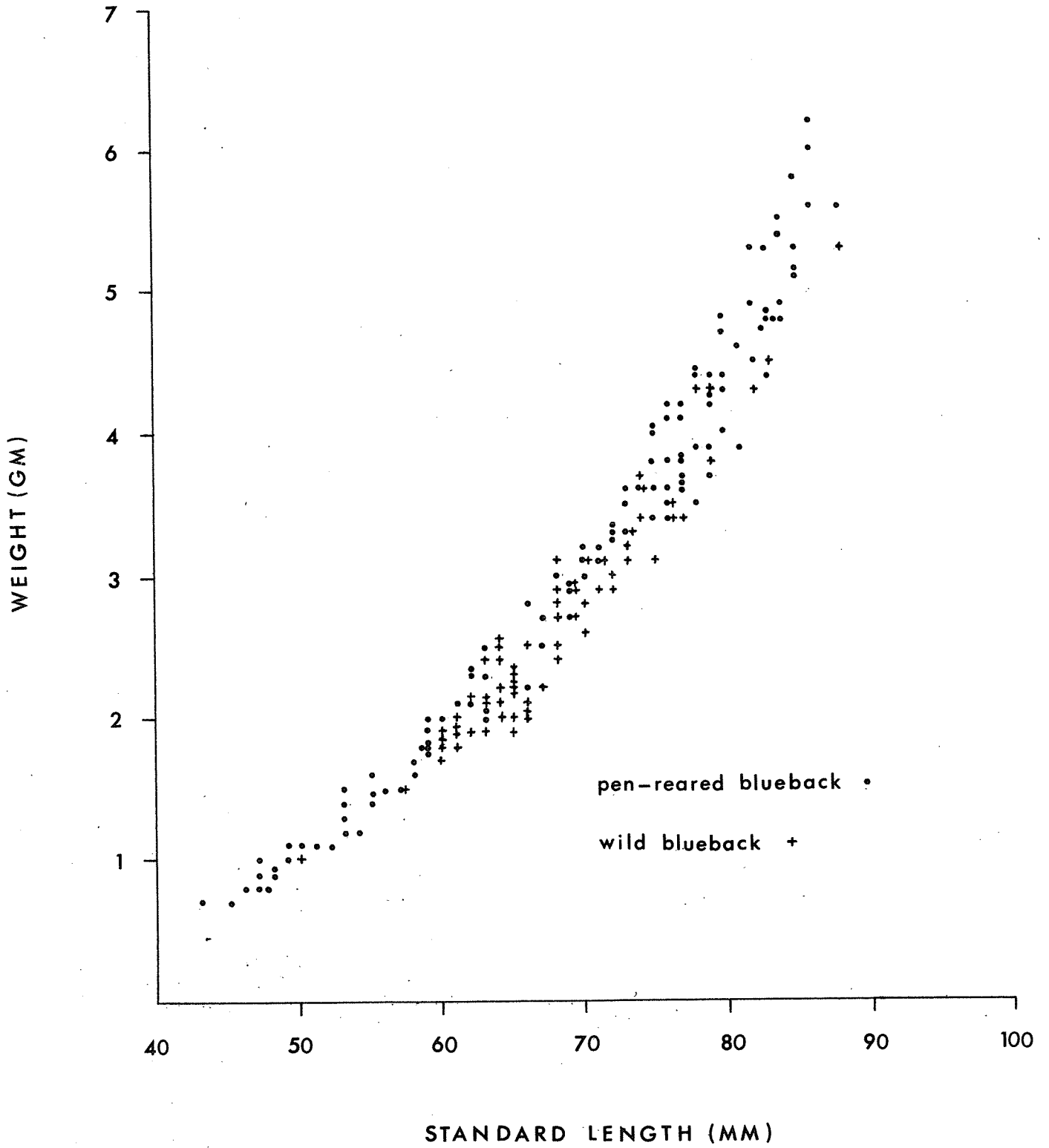


Fig. 10. Comparison between length-weight distributions of wild smolts and pen-reared blueback fry.

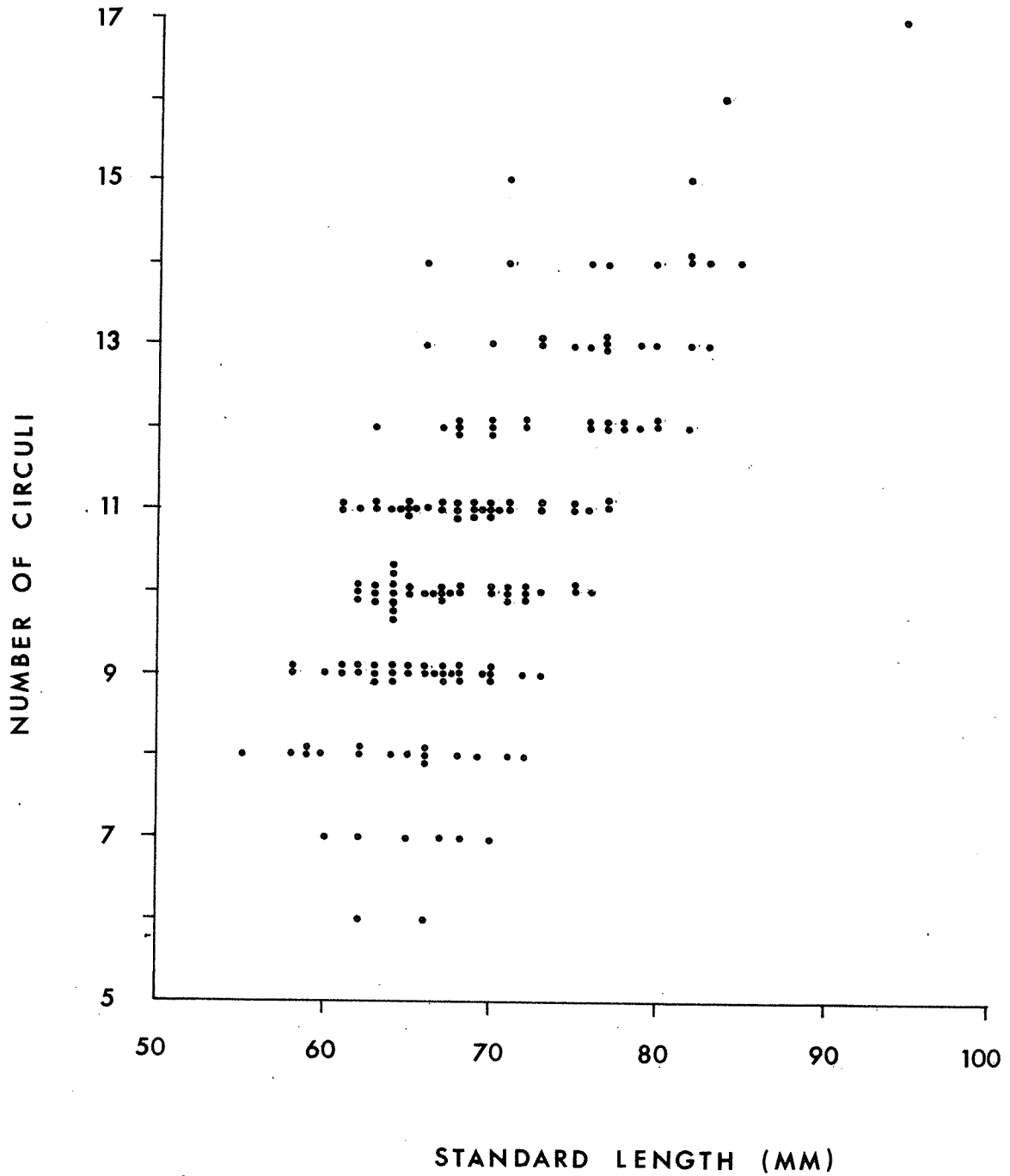


Fig. 12. Distribution of length vs. number of scale circuli of blueback smolts.

SUMMARY

A simple, inexpensive method of capturing outmigrating wild and artificially-produced blueback salmon fry from Quinault Lake was developed and tested. The apparatus was operable by one person and consisted of a downstream net equipped with live tank which could be sent above water to any desired location across the river and fished there by means of a supporting cable and two driven lines. Mechanical power and flood lighting for nighttime operation were provided by a second-hand automobile with minor adaptations.

Test fishing with this apparatus at intervals during May, June, and July enabled determinations of the daily migrational timing of wild and pen-reared blueback fry, silvers, and chums and yielded information on the seasonal timing of these species. The size and age composition of the blueback smolts was determined by measurement and scale analysis.

Substantial outmigrations of pen-reared fry occurred during the nights of their release into Quinault Lake, but the outmigrations apparently resulted largely from the nearness of the release point to the river rather than from migrational urge.

Pen-reared blueback fry had a greater proportion of their body weight distributed in the gut region due partly to greatly enlarged pyloric caeca and solid fat deposits.

RECOMMENDATIONS

It is recommended that future studies incorporate the following changes in the apparatus: that the live tank be widened in the mid-section and the venting area be increased in order to reduce turbulence; that both ends of the support cable have vertical adjustments to compensate for fluctuating water levels; that a smaller net be used when current velocities exceed approximately 4.5 fps. It is further recommended that the statistical aspects of sampling be studied to determine the necessary fishing effort in order to meet a specified accuracy of population estimates; that the effect on migrational timing and survival of pen-reared fry be determined for various release locations in Quinault Lake; and that a more detailed analysis of juvenile scale morphometry be made to establish criteria for differentiating the wild and pen-reared origins of returning adults.

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Appendix Table 1. Catch data from Lower Quinault River, 1974

Date	Start	End	Catch*	Date	Start	End	Catch*
4-18	1045	1100	5 B	4-30	0200	0230	62 B
	1100	1115	1 B, 1 C		0230	0300	52 B, 2 C
	1115	1130	2 B		0300	0330	31 B, 1 C, 1 Sc
	1130	1145	2 B		0330	0400	75 B, 8 C
	Total:		10 B, 1 C		0400	0430	32 B, 3 C
4-24	2045	2115	7 B, 1 C		0430	0500	10 B, 2 C, 1 Sc
	2115	2145	17 B, 1 C, 1 Sc		0500	0530	3 B, 2 C
	2145	2215	26 B, 1 C, 1 Sc		0530	0600	0
	2215	2230	9 B	Total:			349 B, 30 C, 2 Sc
	2230	2245	7 B, 1 C	5-6	2010	2100	0
	2245	2300	5 B		2100	2200	5 B, 4 C
	2300	2315	6 B, 1 C		2200	2300	12 B, 2 C
	2315	2330	5 B, 2 Sc		2300	2400	21 B, 7 C, 1 S
	2330	2345	10 B		2400	0100	66 B, 3 C
	2345	2400	13 B		0100	0200	170 B, 7 C, 8 S
	2400	0015	7 B, 1 C		0200	0300	18 B
	0015	0030	12 B		0300	0330	5 B, 1 C, 1 S
	0030	0045	6 B, 1 C, 1 Sc		0330	0400	5 B, 2 C
	0045	0100	13 B, 1 Sc		0400	0430	5 B
	Total:		143 B, 7 C, 6 Sc		0430	0500	7 B, 3 C
4-25	1730	1800	0		0500	0530	2 C
	1800	1945	0		0530	0600	0
	1945	2015	0	Total:			314 B, 31 C, 10 S
	2015	2045	1 C	<u>South Channel</u>			
	2045	2115	0	5-8	2000	0900	4 B, 3 Sc
	2115	2130	1 B, 1 Sc	Total:			4 B, 3 Sc
	Total:		1 B, 1 C, 1 Sc	5-9	2100	2130	1 B
4-26	0900	1000	0		2130	2200	2 B, 2 C, 2 S
4-30	2030	2100	0		2200	2230	14 B, 1 C
	2100	2130	4 B		2230	2300	11 B
	2130	2200	4 B		2300	2330	40 B, 1 C, 2 Sc
	2200	2230	8 B		2330	2400	30 B, 3 C, 1 S
	2230	2300	2 B, 3 C		2400	0030	59 B, 2 C
	2300	2330	6 B		0030	0100	167 B, 1 S
	2330	2400	8 B, 6 C		0100	0130	94 B, 3 C, 1 Sc
	2400	0030	6 B		0130	0200	87 B, 4 S
	0030	0100	9 B		0200	0230	35 B, 2 S
	0100	0130	20 B, 1 C		0230	0300	31 B
	0130	0200	17 B, 2 C		0300	0330	23 B

*Species code: B = blueback, C = chum, L = lamprey, P = pink, S = silver,
Sq = squawfish, St = steelhead, Sc = sculpin

Appendix Table 1. Catch data from Lower Quinault River, 1974
- continued

Date	Start	End	Catch*		Date	Start	End	Catch*		
5-9	0330	0400	13 B,	1 S	5-20	2100	2200	2 B		
	0400	0430	14 B,	1 S		2200	2300	1 B,	2 C	
	0430	0500	9 B,	2 C		2300	2400	2 B,	4 S, 1 St, 1 Sc	
	0500	0530	7 B			0000	0100	12 B,	1 Sc	
	0530	0600	1 B,	1 S		0100	0200	48 B,	2 S, 1 L	
Total:		638 B, 14 C, 13 S, 3 Sc		0200		0230	53 B,	1 S, 1 P		
5-13	2130	2200	1 B			0230	0300	103 B		
	2200	2230	5 B,	1 Sc		0300	0330	43 B		
	2230	2300	3 B,	1 Sc		0330	0400	37 B,	1 C, 2 S	
	2300	2330	4 B,	2 C		Total:		301 B, 3 C, 9 S, 2 Sc		
	2330	2400	2 B,	1 C				1 St, 1 L, 1 P		
	2400	0030	6 B,	3 C	5-23	2145	2230		1 C, 1 Sq	
	0030	0100	3 B,	2 C		2230	2330	0		
	0100	0130	15 D,	1 C		2330	2400	1 B		
	0130	0200	23 B,	2 C, 1 S		0000	0030	1 B,		1 L
	0200	0230	32 B,	1 C, 1 Sc		0030	0100	1 B,	1 C, 1 S	
0230	0300	22 B,	2 C	0100		0130	1 B		1 S	
0300	0400	25 B		0130		0200	1 B,	2 C, 1 S		
Total:		141 B, 14 C, 1 S, 3 Sc		0200		0230	1 B,	1 C, 2 S, 1 L		
5-14	2330	2400	40 B,	2 C		0230	0300	2 B,	2 S	
	2400	0030	39 B,	4 C		0300	0330	3 B,	1 C, 2 S, 1 L	
	0030	0100	55 B,	1 C, 1 S	0330	0400	2 B,	2 S		
	0100	0130	189 B,	3 C, 1 S, 1 Sc	Total:		13 B, 5 C, 11 S, 3 L			
	0130	0200	176 B,	3 C, 1 S	5-28	2100	2200		8 S	
0200	0230	86 B,	1 C, 1 S	2200		2230	1 B,	1 C, 6 S		
Total:		585 B, 14 C, 4 S, 1 Sc		2230		2300	4 B,	3 S		
5-16	1100	1400	3 B,	1 C, 1 S		2330	2330	4 B,	3 S	
	1400	1900	0			2330	2400	5 B,	3 S	
	1900	2100		1 St		0000	0030	4 B,	2 S	
	2100	2130	3 B			0030	0100	7 B,	1 S	
	2130	2200	2 B			0100	0130	3 B,	1 S, 2 Sc	
	2200	2230	0		0130	0200	2 B,	1 S		
	2230	2300	1 B		0200	0230	2 B			
	2300	2330	3 B		0230	0300	3 B,	1 S		
	2330	0030	18 B,	1 Sc	0300	0330	1 B,	2 S		
	0030	0100	4 B		0330	0400	4 B,	1 S		
0130	0200	85 B,	1 S, 1 Sc	Total:		49 B, 1 C, 32 S, 2 Sc				
0200	0230	122 B,	1 C, 1 Sc							
0230	0300	61 B,	1 C							
0300	0330	59 B								
0330	0400	22 B								
Total:		380 B, 3 C, 1 S, 1 Sc								
		1 St								

*Species code: B = blueback, C = chum, L = lamprey, P = pink, S = silver,
Sq = squawfish, St = steelhead, Sc = sculpin

Appendix Table 1. Catch data from Lower Quinault River, 1974
- continued

Date	Start	End	Catch*	Date	Start	End	Catch*
6-5	1720	2010	2 S	6-27	2150	2300	4 B (pen-reared)
	2030	2200	0		2300	2400	2 B (pen-reared)
	2200	2300	2 S		0000	0130	0
	2300	2400	5 B, 23 S		0130	0230	2 B (pen-reared)
	0000	0100	13 B, 31 S, 1 Sc		0230	0330	2 B (pen-reared)
	0100	0200	15 B, 11 S		0330	0430	1 B (pen-reared)
	0200	0300	14 B, 8 S, 1 Sc		0430	0530	2 B (pen-reared)
	0300	0830	13 B, 7 S, 1 Sc				
	Total:		60 B, 84 S, 3 Sc		Total		13 B
6-25	2210	2300	2 sq	7-16	2150	2300	0
	2300	2400	0		2300	2400	0
	0000	0100	0		0000	0100	1 Sq
	0100	0200	1 sq		0100	0215	31 B (pen-reared)
	0200	0300	37 B (36 pen-reared)		0215	0245	21 B (pen-reared)
	0300	0330	81 B (all pen-reared)		0245	0315	33 B (pen-reared)
	0330	0400	89 B (all pen-reared)		0315	0345	21 B (pen-reared)
			1 S		0345	0415	13 B (pen-reared)
	0400	0430	85 B (All pen-reared)		0415	0445	34 B (pen-reared)
	0430	0500	47 B (all pen-reared)		0445	0515	9 B (pen-reared)
	0500	0530	20 B (all pen-reared)		0515	0545	8 B (pen-reared)
	0530	0600	10 B (all pen-reared)		Total:		170 B, 1 Sq
	Total:		369 B, 1 S, 3 Sq	7-17	2155	2300	1 B, 1 L
6-26	2140	2200	0		2325	2400	3 B (pen-reared)
	2200	2230	2 B (pen-reared), 1 S		0000	0100	2 B (pen-reared)
	2230	2300	1 B (pen-reared), 1 Sc		0100	0200	5 B (pen-reared)
	2300	2400	2 B (pen-reared), 1 L		0200	0300	8 B (7 pen-reared, 1 fin-clipped)
	0000	0100	3 B (pen-reared)		0300	0400	0
	0100	0200	7 B (pen-reared), 1 S		0415	0445	0
	0200	0230	7 B (pen-reared)		Total:		19 B, 1 L
	0230	0300	5 B (pen-reared)				
	0300	0400	5 B (pen-reared)				
	0400	0500	4 B (pen-reared)				
	0500	0530	5 B (pen-reared)				
	Total:		41 B, 2 S, 1 Sc, 1 L				

*Species code: B = blueback, C = chum, L = lamprey, P = pink, S = silver,
Sq = squawfish, St = steelhead, Sc = sculpin

Appendix Table 2. Age determination of Quinault blueback smolts

Date	Card No.	Length mm	Weight gm	Circuli	Age	Date	Card No.	Length mm	Weight gm	Circuli	Age
4-25	1-1	80	-	14	1	5-15	1-30	62	-	8	1
	1-2	75	-	11	1		1-31	76	-	14	1
	1-3	78	-	12	1		1-32	60	-	9	1
	1-4	77	-	12	1		1-33	66	-	14	1
	1-5	67	-	11	1		1-34	115	-	24	2
	1-6	75	-	10	1		1-35	84	-	16	1
	1-7	62	-	6	1	4-30	1-36	67	-	10	1
	1-8	68	-	7	1		1-37	70	-	12	1
	1-9	67	-	7	1		1-38	68	-	9	1
	1-10	67	-	9	1		1-39	69	-	8	1
	1-11	64	-	10	1		1-40	76	-	11	1
	1-12	70	-	10	1		1-41	77	-	11	1
	1-13	66	-	8	1		1-42	82	-	12	1
	1-14	72	-	12	1		1-43	82	-	14	1
	1-15	71	-	10	1		1-44	65	-	11	1
	1-16	67	-	10	1		1-45	63	-	10	1
	1-17	64	-	10	1		1-46	67	-	9	1
	1-18	68	-	8	1		1-47	68	-	12	1
	1-19	68	-	11	1		1-48	76	-	10	1
	1-20	70	-	9	1		1-49	70	-	7	1
	1-21	72	-	10	1		1-50	-	-	-	-
	1-22	66	-	13	1		2-1	111	12.8	19	2
	1-23	75	-	7	1		2-2	80	5.0	12	1
	1-24	61	-	11	1		2-3	77	4.4	13	1
	1-25	68	-	9	1		2-4	79	5.0	13	1
	1-26	72	-	9	1		2-5	89	7.0	-	-
	1-27	65	-	11	1		2-6	76	4.6	12	1
	1-28	64	-	8	1		2-7	75	4.3	-	-
	1-29	59	-	8	1		2-8	70	3.0	12	1

Appendix Table 2. Age determination of quinalt blueback smolts
- continued

Date	Card No.	Length mm	Weight gm	Circuli	Age	Date	Card No.	Length mm	Weight gm	Circuli	Age
4-30	2-9	60	2.2	7	1	5-23	2-38	66	-	9	1
	2-10	66	3.0	11	1		2-39	65	-	9	1
	2-11	66	2.7	8	1		2-40	66	-	10	1
	2-12	62	2.8	9	1		2-41	70	-	9	1
	2-13	64	2.7	-	-		2-42	71	3.6	10	1
	2-14	71	3.7	14	1		2-43	67	-	10	1
5-23	2-15	71	3.9	15	1		2-44	70	-	10	1
	2-16	85	5.8	14	1		2-45	66	-	9	1
	2-17	55	2.3	8	1		2-46	59	-	8	1
	2-18	76	4.8	12	1		2-47	71	3.6	11	1
	2-19	80	5.2	12	1		2-48	64	-	9	1
	2-20	80	4.6	13	1		2-49	65	-	7	1
	2-21	77	4.6	12	1		2-50	64	-	10	1
	2-22	75	4.0	11	1	-	3-1	82	5.3	14	1
	2-23	72	4.1	10	1	-	3-2	95	7.8	17	1
	2-24	62	2.9	8	1	-	3-3	82	4.6	13	1
	2-25	70	3.8	13	1	5-16	3-4	78	3.7	-	-
	2-26	70	3.3	11	1		3-5	62		10	1
	2-27	70	3.6	12	1		3-6	67		11	1
	2-28	65	2.8	10	1		3-7	75		11	1
	2-29	63	2.4	10	1		3-8	65		9	1
	2-30	73	3.7	10	1		3-9	63		11	1
	2-31	70	-	9	1		3-10	63		9	1
	2-32	62	2.1	7	1		3-11	62		10	1
	2-33	70	-	11	1		3-12	67		9	1
	2-34	77	5.1	14	1		3-13	68		9	1
	2-35	73	-	13	1		3-14	61		9	1
	2-36	70	-	9	1		3-15	68		10	1
	2-37	64	-	9	1						

Appendix Table 2. Age determination of quinalt blueback smolts
- continued

Date	Card No.	Length mm	Weight gm	Circuli	Age	Date	Card No.	Length mm	Weight gm	Circuli	Age
5-6	3-16	76	4.0	13	1	5-6	3-47	72		12	1
	3-17	101	9.6	22	2		3-48	64		10	1
	3-18	75	3.6	10	1		3-49	77		13	1
	3-19	62	2.3	10	1		3-50	73		13	1
	3-20	78	3.9	12	1		4-1	71	-	8	
	3-21	77	4.5	13	1		4-2	71	-	10	
	3-22	73	3.2	11	1		4-3	61	-	11	
	3-23	64	2.1	10	1		4-4	64	-	11	
	3-24	68	3.0	12	1		4-5	66	-	6	
	3-25	83	5.0	14	1		4-6	60	-	8	
	3-26	79	4.3	12	1		4-7	68	-	11	
	3-27	68		11	1		4-8	72	-	8	
	3-28	69		11	1		4-9	66	-	8	
	3-29	69		11	1		4-10	64	-	9	
	3-30	58		8	1		4-11	67	-	10	
	3-31	68		11	1		4-12	63	-	9	
	3-32	83	4.5	13	1		4-13	64	-	10	
	3-33	64		10	1		4-14	58	-	9	
	3-34	67		9	1		4-15	65	-	10	
	3-35	77		11	1		4-16	68	-	10	
	3-36	73		11	1		4-17	62	-	9	
	3-37	70		11	1		4-18	67	-	10	
	3-38	67		9	1		4-19	68	-	12	
	3-39	73		9	1		4-20	63	-	-	
	3-40	70		11	1		4-21	63	-	11	
	3-41	67		12	1		4-22	58	-	9	
	3-42	70		13	1		4-23	65	-	8	
	3-43	72		10	1		4-24	63	-	10	
	3-44	71		11	1		4-25	62	-	9	
	3-45	64		11	1		4-26	62	-	11	1
	3-46	82	5.0	15	1		4-27	63	-	12	1

Appendix Table 3. Water temperature and relative water level of Lower Quinault River, 1974

Date	Temperature °C		At observation	Water level inches	Time	Remarks
	Maximum	Minimum				
4-18			7.8	-	1100	
4-25			8.8	-	1800	
4-26			7.8	19.0	0800	
4-30			9.3	17.0	2030	
5-1			7.8	20.0	1520	
5-6			10.8	21.0	2030	
5-7			-	23.5	1500	
5-8			-	24.5	0900	
5-9	10.0	8.5	8.5	24.5	0920	rain, cold
5-10	9.0	8.5	8.5	24.5	0600	rain, cold
5-13			8.5	20.8	2100	
5-14	11.0	8.0	9.5	23.5	1700	heavy rain
5-15			8.5	22.5	1220	heavy rain
5-16	9.5	7.5	8.5	21.3	1100	fair
5-20	11.0	8.5	9.0	14.8	2045	fair
5-23				27.5	2145	heavy rain
5-24				35.0	1100	heavy rain
5-25				62.0	1530	heavy rain
5-28				40.0	2100	fair
5-29				34.3	1230	fair
6-5			10.2	39.0	1720	
6-6				37.0	0830	
6-25			11.5	28.0	2215	rain
6-26	12.0	11.0	12.0	26.8	2145	rain showers
6-27	12.5	10.5	11.5	25.0	2240	
7-16	14.5	10.5	12.5	25.0	2200	very heavy rain
7-17				40.0	2200	