STUDIES ON AGE, GROWTH, AND MIGRATION OF STEELHEAD TROUT, *Salmo gairdneri gairdneri*, IN THE ALSEA RIVER, OREGON

by

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INTRODUCTION

Wise management of the steelhead trout, *Salmo gairdneri gairdneri* Richardson, is dependent upon an understanding of its life history. Since existing knowledge of steelhead management requirements in Oregon is incomplete, a comprehensive life history investigation was initiated in 1954 by the Oregon Cooperative Wildlife Research Unit[1] at the request of the Oregon State Game Commission. The objective of the study was to assemble information concerning steelhead trout in the state, with particular emphasis on distribution, abundance, life history, differentiation between winter and summer runs, racial characteristics, contribution of immature and adult fish to the sport fishery, and effect of the artificial propagation program of the Oregon State Game Commission. Research was to be aimed at producing facts important to the maintenance and improvement of runs throughout the range of the fish in the state.

The initial phase of the study involved analysis of all available scale samples from Oregon streams. Since this portion of the steelhead study was general in scope, it was desirable that a particular steelhead stream be investigated in order that more specific information be secured. The Alsea river was chosen because it represented a rather typical Oregon coastal stream and because of its proximity to Oregon State College, where the Research Unit is based. The study

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1 Oregon State Game Commission, U. S. Fish and Wildlife Service, Wildlife Management Institute, and Oregon State College cooperating.

reported here is concerned with age, growth and migration of steelhead trout in the Alsea river.

Physiography

The river rises on the west slope of the Coast Range, and flows through parts of Benton, Lane and Lincoln counties, entering Alsea bay near Waldport, Oregon. The principal tributaries are the North and South forks, Five Rivers, and Fall Creek. The area of the Alsea drainage basin, Figure 1, is approximately 450 square miles, and the terrain encompassed in the drainage is generally rough and steep, with little flat land other than small portions found intermittently along the main river. Some of the forest lands are newly-logged, some are covered with hardwood reproduction, and others are in some stage of coniferous growth.

The main stem of the river is generally paralleled by State Highway 34, which leads from Waldport over the Coast Range to Philomath in the Willamette valley. Most of the tributary streams are accessible by means of side roads connecting with Highway 34. The Alsea bay area is readily reached by the Oregon Coast Highway, U. S. 101.

An estuary about 10 miles in length is located at the mouth of the river and meets the ocean at Waldport. The lower portion of the bay is quite saline, and gradually grades into freshwater toward the head of tidewater. No closure of the river mouth occurs during the summer. Drift creek is the only important stream, other than the main Alsea river, draining into the bay.

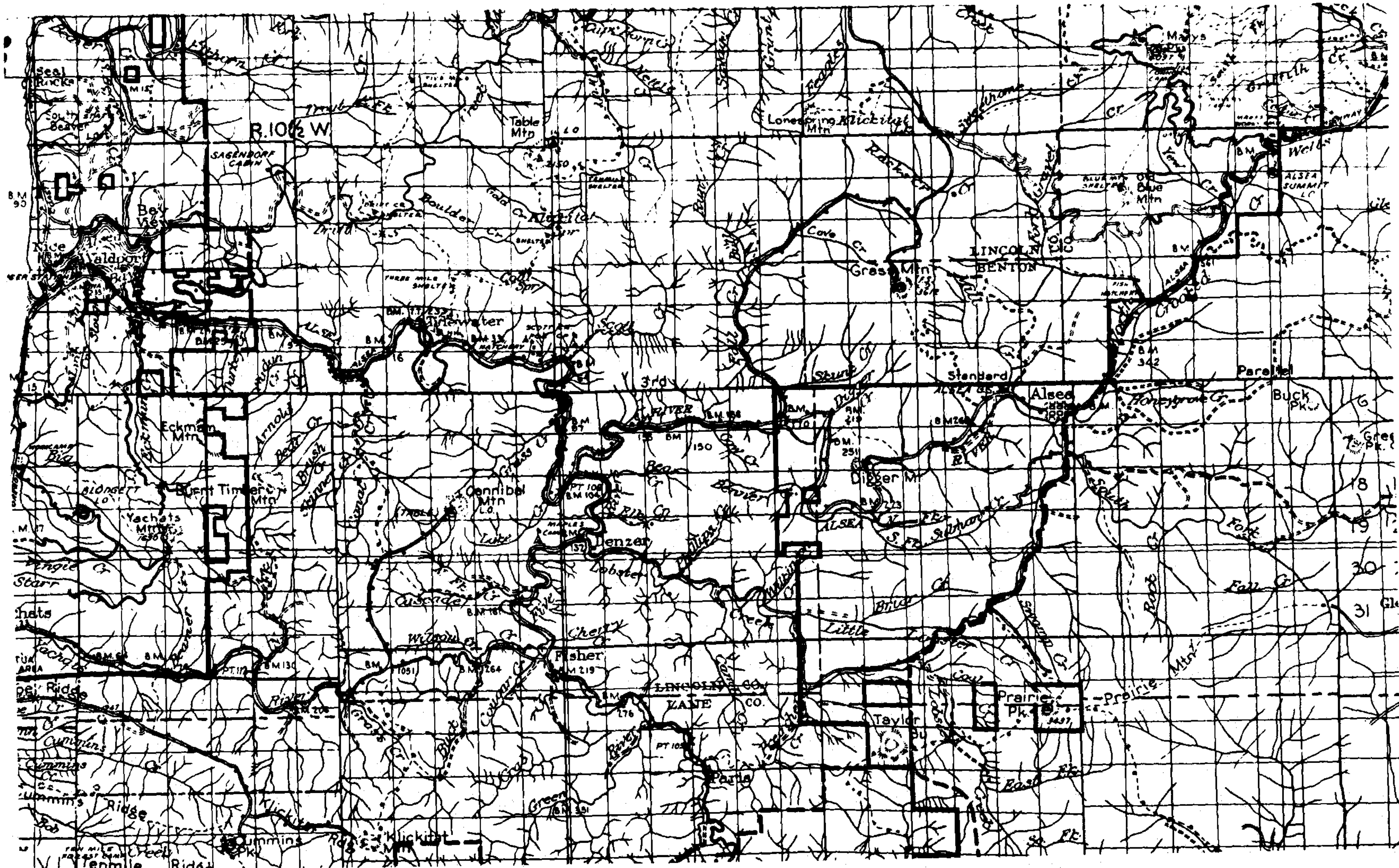

Figure 1. Map of Alsea Drainage.

The main-stem river bed and the stream bed in the lower portions of Five Rivers are composed largely of bedrock. The North and South Forks, Fall Creek, and upper Five Rivers each have a greater proportion of gravel and rubble areas than bedrock.

Water flow of the Alsea river, Appendix A, is characterized by great seasonal fluctuations. Runoff during the period October through April is usually heavy, but decreases markedly in the summer months. Extremely low stream volumes occur in August and September. Flows in the former month averaged 3,757 second-feet-days from 1949 to 1955, and the September average was about 3,425 second-feet-days during the same period, as measured at a United States Geological Survey flow meter near the head of tidewater. These low flows may be contrasted with the heavy runoff in January which averaged 147,710 second-feet-days for the same 7-year period.

METHODOLOGY

Juvenile Sampling

Information concerning the downstream migration of juvenile steelhead is essential to the success of the long-range investigation initiated by the Research Unit. Interpretation of adult scale samples is facilitated by analysis of scales secured from young fish, and information regarding peak periods of migration, rapidity of downstream movement, and growth of juveniles is quite important to proper management of the species.

Initial effort in the juvenile sampling program was devoted to development of marking and trapping methods. It was important that the downstream migrants be trapped at several locations, preferably on each of the major tributaries of the Alsea river, marked for later identification, and released to continue normal migration. It was hoped that sufficient downstream recoveries could be made so that the rate of migration might be roughly established.

Three types of downstream traps were tried in an effort to determine the most practical means for taking the moving trout. The first of these was a portable "scoop" trap of a design furnished by the Washington State Department of Fisheries. The scoop, Figure 2, was originally used by that agency to take seaward-migrating Chinook salmon, <u>Oncorhynchus tshawytscha</u> (Walbaum), of small size. The trap was simple in design and easily constructed, but required close attention because of a tendency to clog with debris.

The open end of the scoop faced upstream. Water was strained through the bottom and sides of the scoop until only two inches of water was allowed to pass over the lip of the live box. Water passed into the live box over a baffle intended to prevent juveniles from jumping out. The scoop was about seven feet long, three feet wide, and two feet deep. Traps of the scoop type were found to be inadequate for taking young steelhead of migrant size, but were efficient in catching salmon as fish of the year.

The second apparatus utilized an inclined screen. Two types of inclined-screen traps, Figures 3 and 5, were used, depending upon characteristics of the trap location. Where the water fell from a sufficient height, the design pictured in Figure 3 was used. The hardware cloth (8 mesh per inch) was attached to a 2 by 3 feet grate fabricated of 3/8 inch steel round. The grate was held beneath the water flow by means of 1/8 inch cable which could be adjusted to place the screen at any desired height or angle.

An eight-foot section of four-inch, semi-rigid suction hose, such as that used on liberation tank trucks, was attached to the downstream end of the inclined screen. The top half of the hose was removed along the end of the screen in order to allow water, fish, and debris to pass into the tube. It was necessary that the screen angle be such that some water would pass into the hose to maintain water depth and an adequate dissolved oxygen content in the live box (3 x 2 x 1.5 feet), which was placed to the side of or below the screen. The box, Figure 4, had six-inch cedar sides and bottom in order to hold water, and 8-mesh

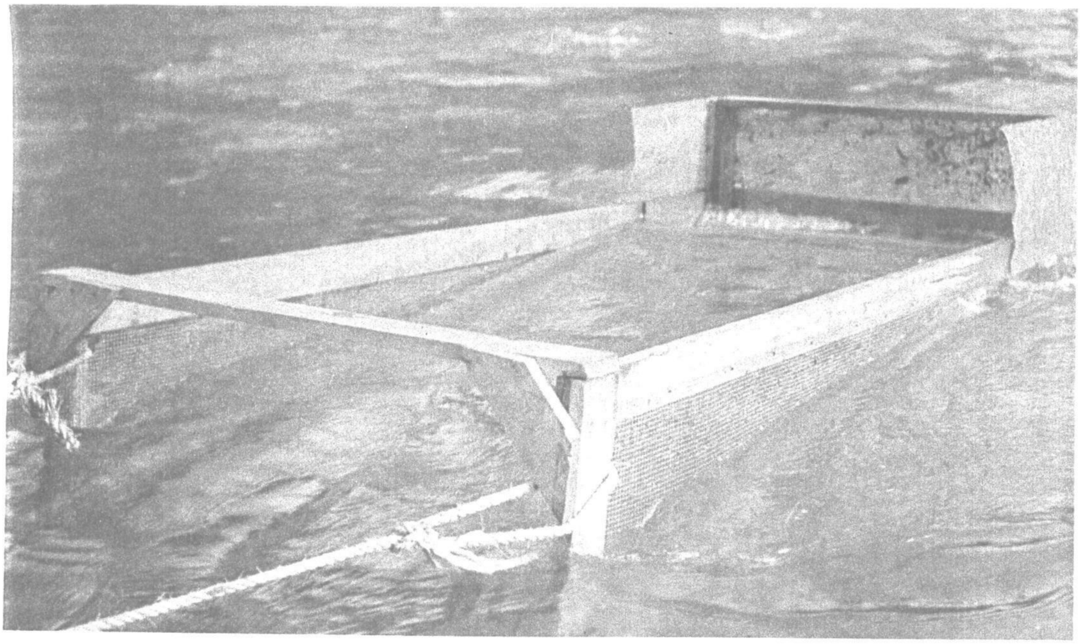

Figure 2. Scoop Trap

hardware cloth over the remainder of the sides. Fish entering the box passed over a grate and into the water. The lower part of the container was divided and the grate was intended as a crude grader, to remove small fish from large. This, however, was found to be impractical.

When water to be strained fell less than about three feet, the design shown in Figure 5 was used. This was an inclined screen (8 mesh/inch) laid over a 5 x 3 feet grate. A live box with screen cover was attached to the lower end of the grate. The live box (1 x 1 x 3 feet) was screened on the downstream side only. The solid ends, bottom, and upstream side formed a pocket of relatively calm water within the box.

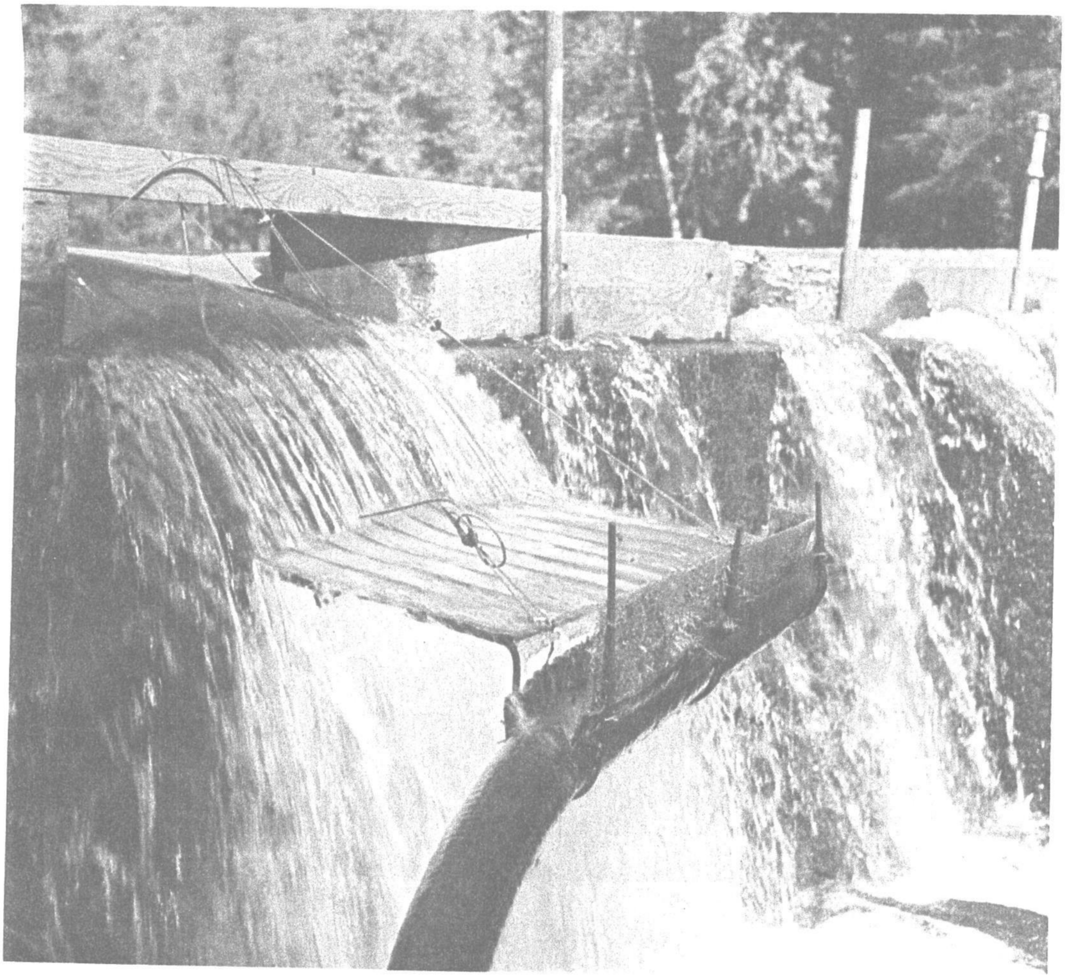

Figure 3. Inclined Screen with Tube

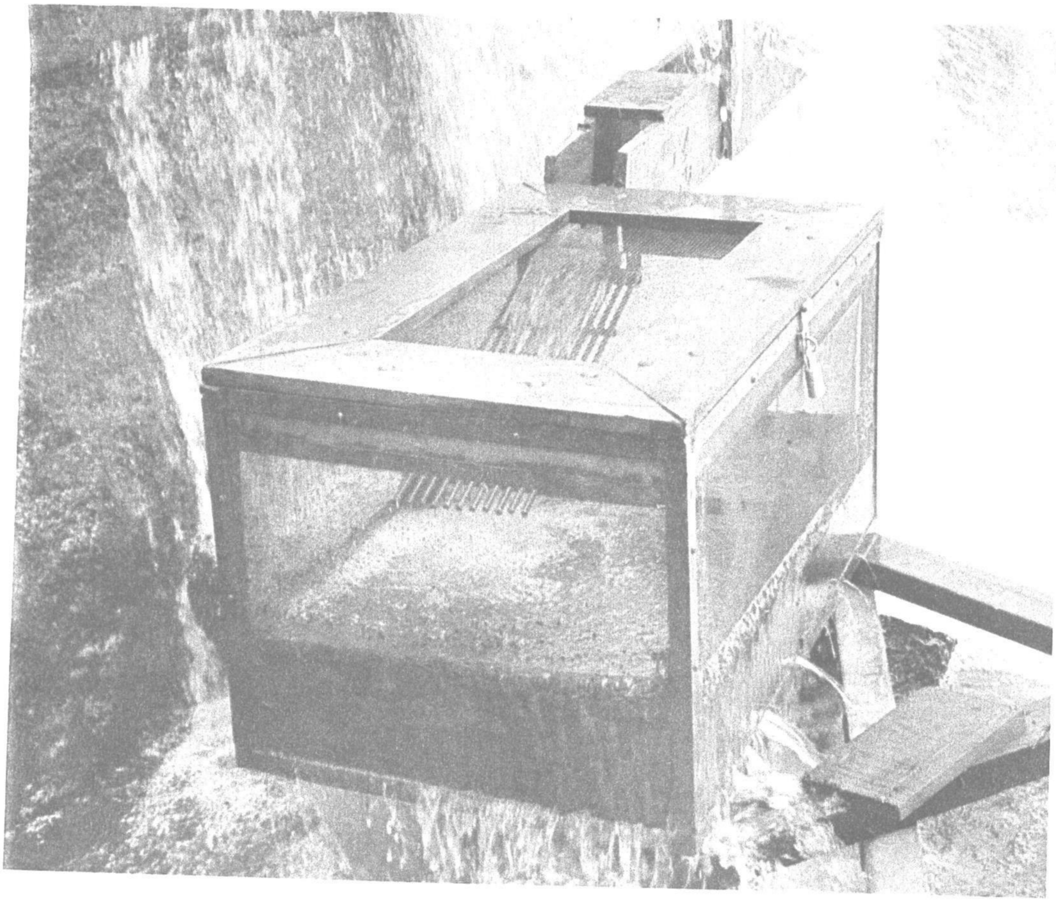

Figure 4. Live Box

Figure 5. Inclined Screen Trap

The trap was placed below the outflow from a fish ladder or at a small fall in the stream. Fish coming downstream landed on the screen and very quickly flopped down into the live box, which was found to hold as many as 300 fingerling trout and salmon without mortality. The trap was held at the desired level by means of stilts from the box to the stream bed. Inclined plane traps of both the foregoing designs were found to be most satisfactory, and were easily maintained.

A third type of trap was used to take juveniles in the main river. The device consisted of a "V" and live box, with the open end of the "V" facing upstream. Water was strained through the sides of the "V" and fish passed through a five-inch vertical opening at the point. A second, smaller "V" was employed to pass fish into the live box. This box was provided with a removable bottom which could be raised to the surface in order that the trap contents might be checked. The trap was about 15 feet long, with the open end of the "V" measuring eight feet. Height of the trap was four feet. Frame material was 1¼ inch pipe, and screening was ½ inch-mesh hardware cloth.

The "V" trap was not completely satisfactory, in that fish could easily avoid entering the "V". Some fish were taken, however. Efficiency of the trap appeared to improve when crude diverters were placed at an angle upstream from each wing. These diverters were discarded tennis net, weighted at the bottom with 1¼ inch pipe, and attached at the top to a 2 x 4 inch board. The nets were about 15 feet in length, and increased the total width of the water fished to about 20 feet. No specific information was secured as proof of increased efficiency. It was merely apparent that more salmon and trout were caught by the trap immediately after the tennis nets were installed. This may, of course, have been due to an increase in the number of fish migrating downstream.

A crude set of louvers was used in conjunction with a scoop trap in an attempt to increase the catch. Again, no proof of efficiency was available, but it was apparent that more migrating silver salmon, *Oncorhynchus kisutch* (Walbaum), of the year were caught immediately after the louvers were emplaced. There was also an increase in numbers of lamprey ammocoetes, *Entosphenus tridentatus* (Gairdner), taken.

Marking

Since it was important that juvenile steelhead be marked with some type of identification if any measure of success in tracing movement was to be achieved, several marking methods were investigated. These were: Tags, dye and liquid latex injections, and tattoos. The term "marking" is used here to denote some means of identifying fish other than by fin removal.

One hundred steelhead and cutthroat trout, *Salmo clarki clarki* Richardson, were marked with tags in early June of 1955, and were held under observation at Alsea trout hatchery for seven months. Tags used were made of clear plexiglas, 1/16 inch thick, 1/4 inch wide, and 3/4 inch long. Clear plexiglas was chosen because of its comparative invisibility in water. Little is known of predation on young steelhead in the ocean, and of possible differential predation due to tag colors. Hence, it was assumed that a clear tag would be as nearly neutral in effect as possible.

The tags were attached to fish of three to nine inches in length by means of nylon monofilament. Both 12 and 25-pound test material was used. In all cases the 12-pound nylon was superior. The larger material caused much irritation to the flesh, and the monofilament usually worked free of the fish.

Since size increase of steelhead after migration to the sea added a complication to the problem, it was necessary to take this factor into consideration. Three types of attachment were used; internal anchor, loop, and back. The first proved unsatisfactory because of excessive tag shedding. The "loop" attachment consisted of a loop, two inches in diameter, run through the body posterior to dorsal or anal fins. Heavy darning needles were used to affix nylon to the fish. Attachments for the "back" tags were run through the dorsal ridge (either posterior or anterior to dorsal fin), forward 1/2 inch on the far side, and again laterally through the body, forming a "U" shape with the tag affixed to the free ends of the "U". About one inch of free nylon was allowed for growth of the fish.

Mortality and tag shedding was negligible for back-tagged fish and growth was normal. Some loop-tagged fish died because tags abraded the flesh of the caudal peduncle down to the vertebral column. Shedding of loop tags was excessive. Where the use of tags is necessary, the back tag should be useful for fish which have rapid growth rates. Very light and flexible nylon of 12 or 6-pound test is recommended.

Upon release about seven months after tagging, most back-tagged fish still had tags affixed, but some individuals had severely worn spots at the point of attachment. The latter condition was particularly true in the case of fish tagged with 25-pound test nylon. Refinement in methods of attaching and knotting light-weight nylon should help to reduce wearing.

Subcutaneous color injections were tried on 40 young silver salmon, using trypan red, trypan blue and India ink. A No. 27 hypodermic needle and a 1 cc. tuberculin syringe were used to make injections. India ink was used undiluted, and both biological stains were one per cent solutions by weight in .085 per cent NaCl. Injections were made in the caudal peduncle by inserting the needle into muscles just under the skin. Less than 0.1 cc. was injected in each instance.

India ink tended to localize at the injection point, usually becoming a mere dot where the needle entered the skin. These dots remained visible for four months. The biological stains usually spread over the entire fish within 24 hours. The injected fish became brightly tinged with blue or red, and this effect held intensity for about three months. Mortality due to injections was negligible. All injected fish were released after seven months and marks were indistinguishable at that time.

Liquid latex injections were used by Davis (4, p.111-116) in Indiana to mark spiny-rayed fishes, and the method offered such promise that it was tried on experimental groups of young steelhead. The methods employed in the injection of liquid latex have been previously reported by Chapman (2). An injection made between anus and ventral fins or just ahead of the ventral fins was found most successful. The necessary equipment consisted of a 10 cc. "B-D Champion" veterinary syringe, no. 21 needle, and dispersions of red, yellow and blue latex.

Marks produced by tattoo machines which tamp pigment into the flesh of fish have been used successfully by the Washington State Department of Fisheries, Dunstan and Bostick (5, p.70-79) and by the Research Unit, Chapman (3). Tattoos were utilized as the basic identification mark for juvenile steelhead trapped in the Alsea river. Gray dot combinations were placed on the ventral surfaces of fish taken at each trap location. A dot at the base of the left pectoral fin indicated a fish taken on the North Fork; right pectoral - South Fork; left ventral - Fall Creek; right ventral - Five Rivers.

To indicate date of release at the trap location, another combination of dots was used. Five marking spots were chosen on each side of the ventral midline; three between pectoral and ventral fins and two between ventral fins and anal fins. Thus, by using a maximum of three dots, it was possible to designate more than 30 marking days, enough to last through the juvenile migration. For example, a fish taken in the North Fork trap on the first day of marking would be indicated by a gray dot at the base of the left pectoral fin, and by a gray dot immediately posterior to the left pectoral fin. A smolt taken at the same location on the second marking day would also have a gray dot at the base of the left pectoral fin, but would have the date mark moved back to a position midway between left pectoral and left ventral fins. Identification marks of this type were simple and rapid to use.

Trapping

Initial trap installations were located on the North Fork at the hatchery diversion dam located one-half mile upstream from the Game Commission's Alsea trout hatchery. An inclined screen was placed beneath the overflow from the hatchery intake on March 26, 1956, and a second inclined screen was installed on the dam face in April. A scoop trap was placed just below the hatchery, and an inclined screen was positioned on the South Fork at an irrigation diversion dam located about 200 yards upstream from the mouth of Toby Creek. Scoops were tried on Fall Creek and on the main Alsea river at Digger Creek during April, but no steelhead of migrant size were taken at these locations.

On May 1, an inclined screen was placed on Fall Creek at the Oregon Fish Commission hatchery diversion dam. The next day, another inclined screen was installed at a small fall on Five Rivers, about three miles from its junction with the Alsea river.

Scoop traps were used only intermittently after May 1, but all inclined screens were fished almost continuously from time of installation until June 21. One trap at the North Fork dam was left in position until water flow was insufficient for operation, in mid-July. This trap was again placed in operation as soon as freshets began in the fall of 1956, on about October 18.

On May 15, the "V" trap was placed in position about four miles above tidewater to provide a check on downstream movement of marked fish. It was hoped that a tidewater or bay trap would be operable in time to be useful in the 1956 migration, but circumstances made this impossible.

After about mid-April, when young fish began moving into live boxes in numbers, the traps were checked at least daily. No particular order or time of check was maintained.

Fish were segregated as the traps were checked. Steelhead and cutthroat trout were placed in buckets and anesthetized with urethane. Other species were counted and released.

After the steelhead were under the influence of the anesthetic, they were measured, tattooed, scale samples were taken, and the processed fish released. A ten-inch rule was etched on the operating table of the tattoo machines, giving measurements to the nearest quarter-inch. Fork length was used in all cases.

Scale samples were taken from 738 of the 1819 young steelhead, and also from 276 of the 777 cutthroat which were trapped. Scales were usually taken from the left side of the fish between dorsal fin and lateral line. When scales were missing from this area, the right side of the fish was used.

Adult Sampling

Scale samples from adult steelhead were procured from a variety of sources; angler cooperation, creel checks, from commercial buyers, the upstream adult trap at the North Fork dam, and from downstream juvenile traps. The bulk of the samples were secured at the Game Commission's North Fork trap with the cooperation of Commission personnel.

Scales were taken from the left or right side of the adult fish, between dorsal fin and lateral line. Lengths were measured from tip of snout to fork of tail, to the nearest quarter-inch and all weights taken were to the nearest one-quarter pound on a spring scale. Sex was determined by inspection, using characteristics such as body conformation, head and mouth shape, and appearance of the genital pore.

Scale Analysis

Scale samples were examined beneath a binocular microscope in order to pick out scales with non-regenerated centers for mounting. It was found that the easiest method of choosing scales was to pick them directly off the scale sample envelope or envelope-insert with a pair of forceps, manipulating a table light to illuminate the surface of the paper. The light-brown sample envelopes were found to provide a better background than did the white insert, which tended to cause glare in the microscope field.

At least three adult scales were taken from each sample. These non-regenerated scales were placed in small bottles containing a liquid detergent mixed with warm water. After about five minutes the scales were individually removed, rinsed twice, scrubbed between a forefinger and thumb, then placed on a paper towel to dry. As soon as excess moisture had disappeared, the scales were placed on glass micro-slides and covered with a rectangular cover slip. The cover slip, secured in place by means of cellulose tape, was flexible and provided sufficient tension to hold three scales in place.

Most juvenile scales were sufficiently translucent to be utilized without cleansing. Four scales were chosen from each juvenile sample and mounted in the manner described for adult scales. Scale samples were arranged by number in microslide display boxes holding 100 samples.

All samples were analyzed with the aid of a microprojector which had a magnification of 112 diameters. Measurements in millimeters were taken directly from the image projected on the glass screen. Adult scales were examined at least twice, with particularly doubtful samples receiving one or two additional examinations. Juvenile scales, being less opaque and showing year marks more clearly than did adult scales, were analyzed only once unless falling in the "doubtful" category.

Measurements to annuli, or year marks, were taken from focus to the outside of the annulus at the last constricted circulus, or ring, of the annulus. This method of measurement was considered to be more definitive than the measurement to the center of the annulus used by Maher and Larkin (8, p.29).

Age of adults, as determined from scales, was recorded upon first examination of the sample, and measurements tabulated after the second examination. Juvenile ages and measurements were recorded upon first analysis, unless doubt existed concerning validity of the reading.

Measurements were taken to each annulus, to the point at which the fish entered salt water, and to the margin of the scale. The latter measurement was subject to some error because of marginal resorption, Figure 6, of the scale after the fish spent some time in freshwater. An attempt was made to allow for this resorption by examining non-eroded portions of the scale, then estimating the true location of the margin at the point of measurement.

All radius measurements were made on the anterior field of the scale, but some variation of measurement location was necessary within the field itself in order to secure exact measurements at all year marks. No measurements were made on scales which showed previous spawnings because of resorption at these spawning years.

Whenever possible, the number of circuli after the most recent annulus was counted on juvenile scales from all tributaries. Number of circuli between the last freshwater annulus and time of entrance into salt water was also counted on adult scales in order to secure some information regarding time spent in freshwater after the final stream annulus was formed.

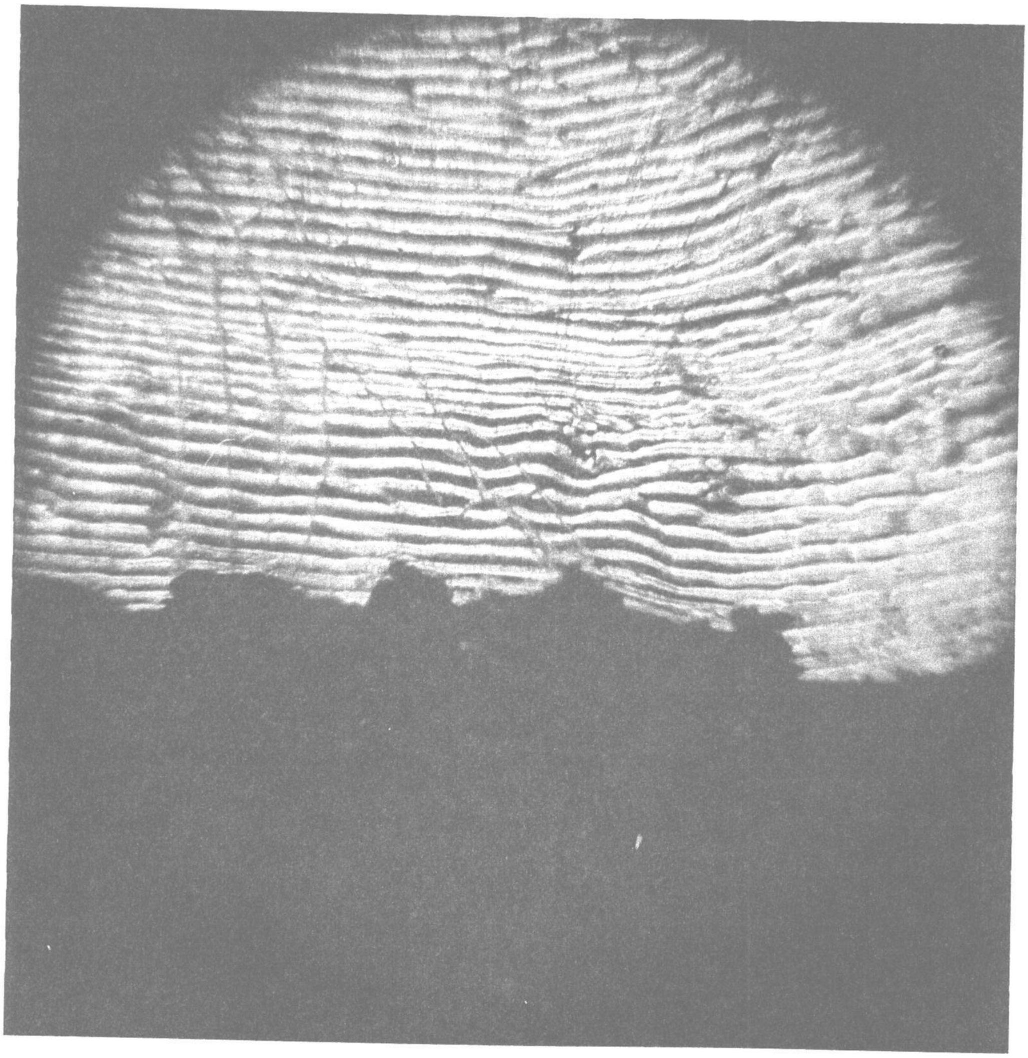

Figure 6. Marginal Resorption of Scale.

DATA:

Length - 25.5 inches

Sex - Female

Location - North Fork

Date - March 29, 1955

Terminology

It is necessary to define certain terms used in relation to scale analysis in this study. Circulus, annulus, focus, radius, anterior field and margin are terms commonly defined in most scale-analysis literature or fishery biology texts, Lagler (7, p.102-106). Ages and life history patterns of steelhead, however, have a special system of designation such as that used by Maher and Larkin (8, p.29-30).

Freshwater ages are noted by numerals on the left of a slash line; saltwater ages by a numeral on the right, as 2/2. This refers to a steelhead with scales showing two freshwater annuli, one salt water annulus, and an additional summer growth period. This fish would have formed a salt water annulus during the winter of capture, had the spawning migration not been made. This example, then, indicates a fish near the end of the fourth year of life. Juvenile steelhead are designated with numerals on the left side of the slash only, as 1/, 2/, or 3/. When adult fish are designated by salt water age only, the numeral to the right of the slash is used as /1, /2, /3, or /4.

Steelhead spawning more than once are denoted by placing an "S", followed by a period, after the salt water year of spawning, then placing the salt water year of capture after the spawning year. For example, a fish listed as 2/2S.3 is one which spent two winters in freshwater, spawned at the end of the second salt water year, and was captured near the end of the fifth year of life. Another example might be 2/1S.2S.3, a fish which spawned at the end of the first and second years of salt water life, and was taken near the end of the third year of ocean life, or the fifth year of life.

Hatchery steelhead released in the Alsea river have been marked for several years by the removal of both ventral fins and the adipose fin. These fish may be listed as "BVA". This term is also applied to the few unmarked hatchery fish in adult samples. The adipose fin is removed from all adult fish returning to the North Fork upstream trap, so returns of these fish in subsequent years are termed "adipose" or abbreviated to "ad.".

Certain other terms may lead to confusion if not defined. These are listed below:

Juvenile - A steelhead which has never entered the sea.

Adult - A fish which has matured after a period of ocean life.

Grilse - A fish which has matured sexually and returns to spawn after only one summer of ocean life. By this definition a grilse is also an adult.

Spent fish or kelt - One which has recently spawned and is still in freshwater.

Ripe fish - One ready for spawning.

Green fish - One whose gonadal development is not advanced.

Smolt - A juvenile which is migrating seaward, or is at a size normally associated with readiness for migration.

0 age class - Indicates fish of the year.

Brood year - Year in which a particular age class of fish was hatched.

Growth Calculations

Back-calculation of the past growth of adult steelhead is complicated by two factors; marginal resorption of the scale, Figure 6, and the possibility that growth of the fish and growth of the scale are not proportional at all ages. Either factor makes back-calculation based upon total scale measurements impractical.

Since all adult scales were taken from a "key" area on the body Maher and Larkin (8, p.28), and since scales were available from many steelhead of all age classes, an attempt was made to determine the relationship of fish growth to scale growth. Average scale radius measurements for each fork length were tabulated, and weighted means for fish lengths and scale radii were calculated.

Upon plotting of the weighted means, arbitrarily grouped by intervals, it was evident that fish growth and scale growth were roughly proportional. The weighted means are plotted in appendix B. It may be seen that more samples are needed from large fish in order to determine the trend on the right of the distribution.

Marr (9, p.164-165) found that scale growth of chum salmon, Oncorhynchus keta (Walbaum), was slower than fish growth in the case of large chums. Herrmann (6) found that kype formation on large, maturing chum salmon was the probable cause of the apparent change in growth rate of the scales. The lower jaws of male steelhead do not appear to undergo prolongation sufficient to alter the fish length-scale radius relationship, but this possibility is worthy of investigation.

Calculations based on total scale measurements from resorbed scales would lead to over-estimates of juvenile growth. If it is true that the rate of scale growth is not proportional to the rate of fish growth, either over-estimates or under-estimates might result from use of total scale measurements to back-calculate growth.

Mottley (10, p.74-79) found that scale size provided an unbiased estimate of fish size in the rainbow trout, Salmo *gairdnerii gairdnerii* Richardson, of Paul Lake, British Columbia. Maher and Larkin (8, p.30) used scale diameters to predict fork lengths of steelhead at juvenile sizes by means of a log-log regression of fork length on scale diameter, based on observations of 132 pre-smolt steelhead.

In order to secure the best possible method for calculating past growth, scale size and fish length of 400 juvenile samples were tabulated and a regression was calculated. This was a regression of fish length upon the logarithms of scale radii. Using this regression to estimate back lengths of steelhead, it was possible to take logarithms of the scale measurements at any given age, place this figure in the regression equation, and solve directly for estimated fish length. The equation is: $y = -3.74 + 5.89 \log x$, where y is the predicted length in inches and x is the scale measurement. Calculations used to develop the equation may be found in Appendix C. No attempt was made to back-calculate growth of individual fish, but rather for groups of fish only; all fish of one brood year, for example.

RESULTS AND DISCUSSION

Characteristics of Adult Population

Adult Life History Patterns

A total of 1221 scale samples from adult winter steelhead was analyzed. Of this total, 243 fish were of hatchery origin, as determined by fin marks and scale characteristics. Most of the samples were secured during the winters of 1953, 1954, and 1955. Of the wild fish, 848 were taken at the North Fork trap; 130, including 15 Fall Creek fish, were taken in the lower Alsea river from the junction of the North and South forks downstream to the mouth.

Table 1a shows the composition of the 1951-1955 sample of wild fish by pattern. About 52 per cent of the adults showed a 2/2 pattern, 21 per cent a 2/3 pattern, 13 per cent a 3/2 pattern, and about four per cent were 2/1 fish. All other patterns combined made up about 10 per cent of the sample.

Table 1b presents a somewhat different picture for BVA fish. About 46 per cent were 1/2, 27 per cent were 2/2, and about nine per cent were 1/3, eight per cent 1/1, and the remainder of the patterns made up about 10 per cent of the sample.

The markedly different pattern composition of wild and hatchery fish is due to the fact that BVA steelhead were released after the first winter of life (age 1/) and most of these fish migrated immediately. Thus, the adult BVA patterns show more fish of age 1/ than do adult wild patterns. No scales from captured hatchery fish showed more than two winters of freshwater life.

As will be noted in a later section, not all BVA fish migrate to sea soon after release. About 33 per cent of all BVA adults had spent the winter in freshwater after liberation. About 57 per cent migrated soon after release. The difference in percentages of 1/ and 2/ BVA adults may be due to one or both of two factors: mortality of residual BVA fish and movement downstream at age 1/ or 2/ .

Certain other outstanding differences may be seen between Tables 1 a and 1 b, although it is unwise to draw firm conclusions when a larger sample of hatchery fish might change the sample composition. It appears that relatively few hatchery fish reach the third (/3) or fourth (/4) years of salt water life. The proportion of wild fish in these two salt water age groups is about 28 per cent, while the ratio for hatchery fish is about 14 per cent. No explanation for this trend has yet been advanced, but a later section will discuss the possibility that smolt size may have contributed to the difference.

It is also evident that fish which reached the first (/1) year of salt water life made up only about five per cent of the wild sample, while /1 BVA fish made up over 12 per cent of the total BVA sample.

Tables 1 c and 1 d, which tabulate wild fish taken in the winters of 1953, 1954, and 1955 at the North Fork trap and in the lower river, compare these two areas with respect to pattern differences. North Fork fish were about 54 per cent in 2/2, 19 per cent in 2/3, 14 per cent in 3/2, three per cent in 2/1, and 10 per cent in the remaining patterns. Steelhead from the lower river were about 40 per cent in

Table 1 a

Patterns of all wild fish,
winters of 1951-1955

years out \ years in	1	2	3	4
1		39* / 3.98	13 / 1.33	1 / .10
2	2 / .20	513 / 52.45	133 / 13.60	1 / .10
3	9 / .92	213 / 21.78	28 / 2.86	
4	3 / .30	19 / 1.94	4 / .41	

* upper number is fish in pattern
lower figure is percentage in pattern

Table 1 b

Patterns of all BVA fish,
winters of 1951-1955

years out \ years in	1	2	3	4
1	20 / 8.23	11 / 4.53		
2	112 / 46.09	66 / 27.16		
3	24 / 9.87	5 / 2.05		
4	4 / 1.65	1 / .04		

Table 1 c

Patterns of North Fork fish,
1953-1955

years out \ years in	1	2	3	4
1		31 / 3.76	10 / 1.21	
2	1 / .12	448 / 54.40	121 / 14.70	1 / .12
3	6 / .73	162 / 19.70	24 / 2.92	
4	2 / .24	13 / 1.58	4 / .49	

Table 1 d

Patterns of lower river fish,
1953-1955

years out \ years in	1	2	3	4
1		5 / 4.00	3 / 2.40	1 / .80
2	1 / .80	50 / 40.00	9 / 7.20	
3	3 / 2.4	44 / 35.20	2 / 1.60	
4	1 / .80	6 / 4.80		

2/2, 35 per cent in 2/3, seven per cent in 3/2, five per cent in 2/4, four per cent in 2/1, and less than 10 per cent in the remaining patterns. It is obvious that fish taken in the lower river were older, in general, than those taken in the North Fork. It is probable that the advanced age of fish in the lower river would be even more apparent if steelhead destined to enter the North Fork could be removed from the sample.

Number of Repeat Spawners

The percentages of repeat spawners in the winter samples of 1953, 1954 and 1955 are shown in Table 2. About 17 per cent of the 556 fish sampled in 1953 were repeat spawners. Of these 95 fish, about 81 per cent were returning for the second time and 19 per cent for the third time. Of the 12 per cent, or 24 repeat spawners, returning in 1954, about 83 per cent were on the second migration; 17 per cent on the third. In the 1955 run, only about three per cent, or 14 fish, were repeat spawners; 13 on the second migration, one on the third.

The variation in percentage of repeat spawners in different years may be caused by one or more of several factors. One of these appears to be the effect of magnitude of the previous winter run on the succeeding winter run. Trap counts for winters from 1951-52 through 1954-55 are shown in Table 3. Total number of steelhead entering the North Fork trap in the winter of 1954-55 was 254, one of the poorest runs in several years. Total return in 1955-56 was about 500 fish.

Table 2

Percentage of Repeat Spawners, 1953-1955

Winter	Total fish in sample	Number of repeat spawners	Per cent of repeat spawners	Per cent on second migration	Per cent on third migration
1953	556	95	17.09	81.05	18.95
1954	194	24	12.37	83.33	16.67
1955	445	14	3.15	92.86	7.14

Table 3

Adult Fish Counted at North Fork Upstream Trap
1951-1954

Winter	Adults	Grilse
1951	1175	64
1952	1848	33
1953	1039	15
1954	254	25

The low repeat-spawner percentage in 1955-56 was probably, in part, a reflection of the poor 1954-55 run.

Flows for the period 1949-1955, as recorded by the U. S. Geological Survey flow station above tidewater, are presented in Appendix A. There is no apparent correlation between the tabulated flows in late spring and the return of repeat spawners in the succeeding winter, Table 2. Other possible factors causing a poor survival of spent steelhead might be capture by anglers, disease, parasites, or mortality of a marine nature.

A total of 133 repeat spawners had a sex ratio of one male to 2.5 females. Of the 38 males, 32 fish, or 84.3 per cent, were on the second spawning migration, and six, or 15.8 per cent, were on the third migration. Of the 95 females, 82.1 per cent were on the second run; 17.9 per cent on the third migration. Of the 12 BVA fish, nine individuals, or 75 per cent were on the second run, and three, or 25 per cent, were on the third spawning run.

The outbalanced sex ratio in favor of females suggests that the rigors of spawning affect the males more seriously. This view is supported by Shapovalov and Taft (11, p.285), who believe a low return of males is probably due, in part, to the fact that males often serve more than one female, hence are subjected to prolonged physical exertion and to the danger of being stranded by lowering stream flows.

Contribution of Hatchery Fish to the Adult Sample

Hatchery fish formed about 24.8 per cent of the 1216 scale samples secured in the period from 1951-52 through 1955-56. This, however, is in no way indicative of the actual contribution of artificially-reared steelhead to the Alsea winter catch, since most of the scale samples were secured at the North Fork upstream trap.

A more realistic concept of the percentage of hatchery fish in the adult runs entering the Alsea drainage may be secured by a check of the scale samples taken in the lower river from the junction of the North and South forks to tidewater. Table 4 gives numbers and percentages of BVA fish in samples from the main-stem Alsea from 1953-54 through 1955-56. The sample of 129 fish is actually a small one, but is more definitive than the one secured from all locations. A total of 13 BVA fish made up about 10 per cent of the 129 steelhead. The 1953-54 sample was secured from commercially-caught fish in Alsea bay. Eight of the nine fish in the 1954-55 sample came from the same source. All the 1955-56 fish were angler-caught.

Table 4

Fish of Hatchery Origin in Adult Samples
from Lower River, 1953-1955

Winter	BVA Fish	Total Fish	Hatchery fish, Per cent of total
1953	6	69	8.3
1954	1	9	12.5
1955	6	51	11.5
Total	13	129	10.01

It is probable that BVA fish contribute more to the total catch on the entire river than is indicated by the lower river sample. There is a considerable amount of angling on the upper river and North Fork, and hatchery fish make up an important percentage of the catch in the latter stream. Anglers who frequently fish the North Fork often have a bag which is made up of 25 to 50 per cent BVA fish early in the season.

Some steelhead which had no BVA mark were placed in the hatchery-released category by means of scale analysis. Scales from hatchery fish demonstrated unique characteristics not shown in scales of any wild fish. On one occasion, an attempt was made to pick out BVA fish from a group consisting of both wild and hatchery fish. The accuracy possible was surprisingly high. Typical "wild" and BVA scales are shown in Figures 7 and 8. Circulus spacing during hatchery growth is quite uniform and the first annulus is very indistinct. Wild juveniles have obvious annuli and great variability in circulus spacing.

Included in the total of 81 BVA fish in the 1953-54 winter sample are 30 steelhead placed in the BVA category on the basis of scale characteristics. Three of the BVA fish in the 1954-55 sample were also recognized by scale examination. No unmarked steelhead were found in the 114 BVA fish of the 1955-56 sample.

The occurrence of these unmarked hatchery fish in the samples may have been caused by one or both of two possible factors. The more obvious reason may be that some fish released as smolts were not marked. Of the 33 fish recognized from their scale appearance, seven

Point of entrance to sea

Annulus II

Annulus I

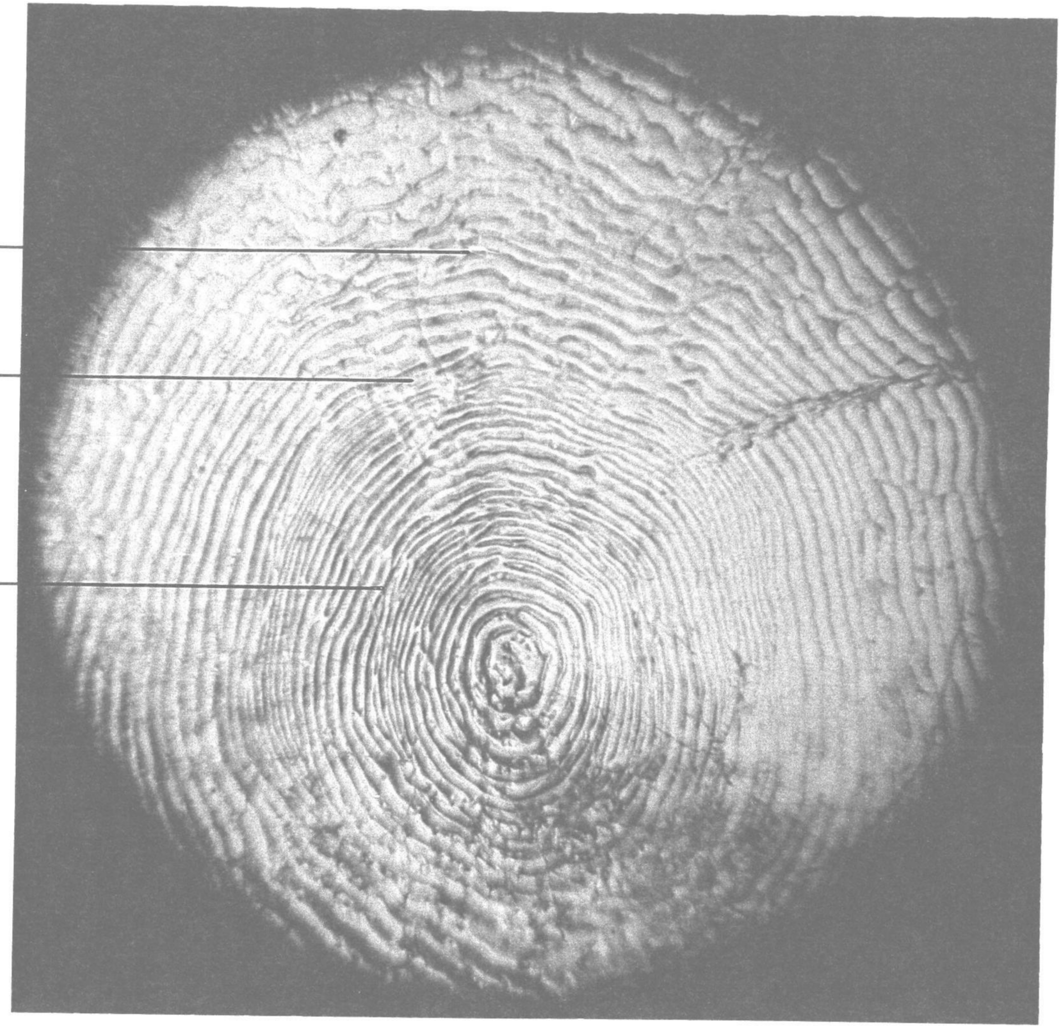

Figure 7. Freshwater Growth on Scale from Wild Fish.

DATA:

Length - 27 inches

Sex - Female

Location - North Fork

Date - January 19, 1954

Point of entrance
to sea

Annulus I

Figure 3

Freshwater Growth on Scale from Hatchery-reared Fish.

DATA:

Length - 25 inches

Sex - Male

Origin - Hatchery reared

Date - March 27, 1956

were of brood years 1948, 1949, or 1950. This means that most of these fish were released before 1951, a period when only a part of the releases were marked.

Game Commission personnel relate that all fish released after 1951 were marked. The occurrence of three unmarked hatchery steelhead of release year 1952 and four of 1953 may be due to an accidental release of unmarked fish. Another possibility is that of an error in scale analysis. If an analysis error were made, it seems likely that this factor would also have operated on the 1955-56 sample. Since no unmarked hatchery fish were found in 1955-56, it seems logical to assume that some unmarked fish were released in the Alsea system in 1952 or 1953.

Variation in Adult Run During Winter Season

Variations in the adult run entering the North Fork trap during the 1955-56 season were determined. This run was chosen because a tabulation of virtually all steelhead was available. Information from other years was based on scale samples and did not include all steelhead which passed through the trap.

Variations by date as to sex, average length, and percentage of BVA fish entering the North Fork trap are shown in Table 5. The trap was checked on Tuesday each week from January 24 through May 8. Few fish moved in the period from January 24 through March 13, probably because of very low water temperatures.

There was little apparent variation in the average size of adults over the four-month migration season. The sex ratio of 473 fish was

52.7 males to 47.3 females. The percentage of males checked in each week decreased steadily as the spring progressed, but never dropped below 39.1 per cent.

The curve for percentage of males entering the trap over the season is best represented by the formula:

$$y = .6654 + .05392\, x - .01135\, x^2 + .0004393\, x^3$$

where x is the number of weeks after January 24, 1956, and where y is the ratio of males to the total number of fish in the trap. Calculations for this formula may be found in Appendix D.

Hatchery-released steelhead made up 29.2 per cent of the 473 fish, but the weekly percentage of BVA fish decreased steadily as the season progressed. As shown in Table 5, the BVA fish made up about 50 per cent of the fish checked in the trap early in the season. By April 24, the percentage of BVA steelhead was negligible.

The curve for percentage of BVA fish entering the trap during early 1956 is best represented by the formula:

$$y = .5113 + .01813\, x - .003785\, x^2$$

where x is the number of weeks after January 24, 1956, and y is the ratio of BVA fish to the total number of steelhead in the trap. Calculations for this formula may be found in Appendix D.

About 1.7 per cent of the adults had been marked previously by removal of the adipose fin, signifying that they had been checked through the trap in an earlier year. This percentage is not a true indication of the repeat spawners, however, since scale analysis of 383 samples showed that 2.4 per cent, or nine fish, were repeat spawners. It should be noted that the figure of 2.4 per cent is an abnormally low proportion of repeat spawners, as discussed in an earlier section.

Most of the difference between per cent of adipose-marked fish and per cent of repeat spawners can be attributed to the occurrence of previous spawners in the BVA group which, of course, had the adipose fin missing when they made their first spawning migration.

It is interesting to conjecture about possible reasons for the changing percentage of BVA fish as the season progresses. It is the practice of hatchery personnel to secure the winter quota of steelhead eggs first, and secondly to allow passage of fish upstream to spawning grounds. This means that early steelhead are held until ripe, then stripped for eggs and sperm. If the number of eggs to be secured is large, the upstream passage of all fish is delayed until late in the spring.

It is possible that fish of early-migrating strain are the ones which contribute most to the ultimate release of hatchery steelhead, thus causing a return of BVA adults early in the winter. By the same reasoning, the fish which are allowed to spawn naturally are usually those which are late migrants, entering the trap after the egg quota has been secured and contributing most to the late run.

Table 5

Variation in Adult Run in North Fork
Upstream Trap, 1955

Date	Number of fish	Mean length	Number of males	Per cent males	Number of females	Per cent females	Number of BVA fish	Per cent of BVA fish	Number of wild fish	Per cent of wild fish	Number of ad. fish
Jan. 24	57	25.6	38	66.7	19	33.3	28	49.1	29	50.9	2
Mar. 13	50	25.1	30	60.0	20	40.0	29	58.0	21	42.0	0
Mar. 20	95	26.0	57	60.0	38	40.0	38	40.0	57	60.0	0
Mar. 27	49	26.0	30	61.2	19	38.8	20	40.8	29	59.2	2
Apr. 3	24	25.5	12	50.0	12	50.0	2	8.3	22	91.7	1
Apr. 10	27	24.2	13	48.1	14	51.9	9	33.3	18	66.7	0
Apr. 17	46	25.3	18	39.1	28	60.9	11	23.9	35	76.1	1
Apr. 24	42	25.2	17	40.5	25	59.5	1	2.4	41	97.6	0
May 1	41	25.9	17	41.5	24	58.5	0	0.0	41	100.0	0
May 8	42	26.1	17	40.5	25	59.5	0	0.0	42	100.0	2
Total	473		249		224		138		335		8

Adult Condition Analysis

Condition factors were calculated for 263 adult winter steelhead, of which 100 were taken on the lower river and 163 at the North Fork trap. About 70 per cent of the lower river samples were secured from steelhead commercially-caught in Alsea bay. The remaining 30 per cent were taken in the lowest five miles of river by sportsmen. Table 6 shows the composition of the sample. A summary of the computations is shown in Appendix E. The calculated condition factors are ratios of weight to length, and are indications of the conformation of the fish.

The sample was subjected to statistical analysis in order to determine the magnitude of these important influences upon adult condition: Sex, freshwater age, salt water age, origin (hatchery or wild), location of capture, and number of previous spawnings. The influences are additive, so that the condition factor of a given group of fish is equal to overall effect plus effects of sex, freshwater age, salt water age, origin, capture location, and number of previous spawnings.

Comparisons are made between various groups after the above principal influencing factors are accounted for in the analysis (1, p.153-206). In other words, all other factors being equal, males are compared to females, wild fish to hatchery fish, and so on. For example, given two groups of steelhead; one group of the 2/3 pattern, and one group of the 2/2S.3 pattern, both groups females of wild origin, and taken in the North Fork; the first spawners will have a significantly better condition factor than the repeat spawners.

At a significance level of five per cent, the following groups were found to be in significantly better condition than their complementary groups: Males were better than females; wild fish better than fish of hatchery origin; steelhead taken in the lower river better than fish from the North Fork; first spawners better than repeat spawners. Fish of the /4 pattern were in better condition than /3 fish; /3 better than /2; and /2 better than /1.

There was no significant difference in condition of adult steelhead in the 1/ , 2/ , or 3/ freshwater patterns. No significant condition difference existed between hatchery-reared fish migrating to sea in the year of release and those migrating after a winter in the stream.

Values of constants for the analysis are listed in Table 7, which can be used to predict the condition of a particular group of steelhead. For instance, the condition of all wild 2/2, male steelhead taken in the North Fork on the first spawning migration can be estimated by adding the constant values for each of the descriptive categories, plus the overall effect listed at the top of Table 7. Thus, the condition factor would be 0.289 for this example.

Such a prediction table is valuable in attempting to learn more about the Alsea river steelhead population, but may have a more extended use if it is found feasible to control adult characteristics by manipulating juvenile characteristics. Number of juveniles in the stream environment, or time and age of release for hatchery steelhead are factors which may be controlled by man in order to control adult population characteristics.

Most of the differences between various groups, Table 7, whether significant or not, were in keeping with results to be logically expected. The higher condition ratio for male steelhead (highly significant) is somewhat surprising, since females generally appear to be plumper for their length than males.

Wild fish may have a better start than BVA fish when entering upon ocean life, hence the better adult condition of the former. The difference is not highly significant, however. It may be that a more advanced age of wild fish returning to spawn is reflected in a higher condition factor. Since more BVA fish returned as grilse, this fact alone would tend to decrease the condition factor for hatchery fish.

The condition of repeat spawners is probably influenced by the winter and spring spent in the river during each previous spawning migration, as evidenced by their relatively poor condition factor.

Fish taken in the North Fork trap apparently have decreased in weight during the upstream migration, although their poor condition factor could conceivably be explained by variations in condition due to tributary strains or races in the lower river. This explanation appears less logical than that of condition loss due to the distance of migration and passage of time.

Adult Length Analysis

Lengths of the same 263 winter steelhead used in the condition calculations were subjected to an analysis of variance testing the magnitude of the following influences upon adult length: Sex, freshwater and salt water age, origin (hatchery or wild), location of capture, and number of previous spawnings. As in the condition analysis, the influences are additive. Comparisons are made between groups after the above influencing factors are all accounted for.

At the five per cent significance level, the following groups were found to be significantly larger than their complementary groups: males were longer than females and wild fish were longer than steelhead of hatchery origin. First spawners were longer than repeat spawners. For example, if two groups of female fish are compared, one in the 2/2 pattern, the other 2/1S.2, both groups of wild origin and taken in the lower river, the first-spawners will be longer than the repeat spawners.

Steelhead of the /4 pattern were significantly longer than /3 fish, /3 were longer than /2, and /2 were longer than /1. There was no significant difference between steelhead taken in the North Fork and in the lower river, or among fish of the 1/ , 2/ , or 3/ patterns . There was no significant length difference between BVA fish which migrated in the season of release and those which migrated after overwintering in the stream.

Values of constants for the analysis are contained in Table 7. The mean length of a particular group of fish can be predicted by using this table. For instance, the lengths of all BVA, 1/3, female fish taken in the North Fork on a first spawning migration can be predicted by adding the constant values for each of the descriptive categories in length analysis, plus the overall effect. This total would be 31.08 inches.

Principal worth in predicting adult lengths lies in the knowledge concerning steelhead derived from such predictions, and in possible manipulations of juvenile populations to produce an adult run with certain desirable characteristics.

The differences between groups, Table 7, are not unusual and are in keeping with results to be logically expected. The differences noted in condition analysis are also evident in length analysis, with the exception of the lower river-North Fork comparison. Adults do not change in length during the migration upstream. It is interesting to note the lack of effect of freshwater age upon adult length. It appears that smolt size at migration, discussed in a later section, has a greater effect upon ultimate length of hatchery fish than does freshwater age.

Characteristics of Juvenile Population

Composition of Smolt Sample

Of the scale samples from 100 smolts analyzed from each tributary, percentages of each year class were calculated. These are shown in Table 8. On the North Fork, eight per cent were 3/ , 90 per cent were 2/ , and two per cent were 1/ . On Fall Creek, 24 per cent were 3/ , 76 per cent were 2/ , and none were 1/ . On the South Fork, three per cent were 3/ , 97 per cent were 2/ , and none were 1/ . On Five Rivers, 15 per cent were 3/ , 83 per cent were 2/ , and two per cent were 1/ .

Table 6

Composition of Sample for Length and Condition Analysis of Adults Taken from 1952 to 1955

	total	males	females	in 1 year	in 2 years	in 3 years	out 1 year	out 2 years	out 3 years	out 4 years	BVA	wild	lower river	North Fork	repeat spawn	first spawn	BVA in 1 year	BVA in 2 years
Total	263	132	131	37	198	28	21	154	77	11	44	219	100	163	38	225	31	13
Males		132	0	25	89	18	20	79	29	4	33	99	49	83	14	118	22	11
Females			131	12	109	10	1	75	48	7	11	120	51	80	24	107	9	2
In 1 year				37	0	0	2	26	7	2	31	6	11	26	1	36	31	0
In 2 years					198	0	14	114	61	9	13	185	83	115	30	168	0	13
In 3 years						28	5	14	9	0	0	28	6	22	7	21	0	0
Out 1 year							21	0	0	0	7	14	3	18	0	21	2	5
Out 2 years								154	0	0	32	122	42	112	2	152	24	8
Out 3 years									77	0	4	73	49	28	26	51	4	0
Out 4 years										11	1	10	6	5	10	1	1	0
BVA											44	0	7	37	1	43	31	13
Wild												219	93	126	37	182	0	0
Lower river													100	0	16	84	6	1
North Fork														163	22	141	25	12
Repeat spawn															38	0	1	0
First spawn																225	30	13
BVA in 1 year																	31	0
BVA in 2 years																		13

Table 7

Influences of Variables upon Condition and Length of Adults Taken from 1952 to 1955

	Condition analysis[1]			Length analysis[2]		
Effect[3]	Constant value	Difference	Significance	Constant value	Difference	Significance
overall	.269017	.4605421	*	26.658063	34.156040	*
male	.0133615	.0267230	*	.727986	1.455971	*
female	-.0133615			-.727986		
in 1 year	.0060453	.0084377		.324775	.464182	
in 2 years	-.0036530	-.0012606		-.185369	-.045962	
out 1 year	-.197334	-.3462316	*	-9.754709	-16.571587	*
out 2 years	-.049128	-.198-264	*	-1.216442	-8.033320	*
out 3 years	.097564	-.0513340	*	4.154275	-2.662603	*
out 4 years	.148898			6.816878		
hatchery	-.0139316	-.0278631	*	-.438345	-.876689	*
wild	.0139316			.438345		
lower river	.0153928	.0307855	*	-.066869	-.133737	
North Fork	-.0153928			.066869		
repeat spawners	-.0598422	-.0598422	*	-1.043278	-2.086555	*
first spawners	.0598422			1.043278		

1- The hypothesis tested was that there was no difference between condition factors, such as between males and females.

2- The hypothesis tested was that there was no difference between lengths of groups, such as between males and females.

*- Indicates a significant difference at P = .05.

3- (1, p.153-206).

No possible reasons are immediately evident in accounting for the high percentage of age 3/ fish on Fall Creek or on Five Rivers. Upon first thought, it could be reasoned that in situations of strong competition or poor environment it might be necessary for some juveniles to remain in freshwater an extra year in order to reach migration size. This idea seems unlikely, however, since competition should be somewhat less on Fall Creek than on the South Fork or Five Rivers due to the removal of many adult silver salmon in the course of Oregon Fish Commission hatchery operations.

Table 8

Percentages of Smolts in Freshwater Age Classes, 1956

Tributary	Age		
	1/	2/	3/
North Fork	2%	90%	8%
Fall Creek	0	76%	24%
South Fork	0	97%	3%
Five Rivers	2%	83%	15%

Average Length of Smolts

Average lengths of smolts passing through each trap location are presented in Table 9. Averages were calculated for the entire trapping period on each tributary and also for shorter periods. The Student's "t" test was used to determine if these calculated means were equal. Values for t are shown in Table 10.

The mean lengths of smolts taken in May on each tributary were

Table 9

Mean Length of Smolts at Each Trap Location by Date, 1956

Trap	Time period	Number of fish	Mean length
North Fork	May	304	6.63
	April	38	5.79
	May 1-11	124	6.59
	May 12-20	180	6.65
Fall Creek	May 2-30	686	6.23
	May 2-9	335	6.18
	May 10-30	351	6.31
Five Rivers	May 4-20	153	6.18
	May 4-11	82	6.14
	May 12-20	71	6.14
South Fork	May	156	6.20
	May 4-12	61	6.27
	May 13-26	95	6.22

compared. North Fork smolts were 6.63 inches long; Fall Creek fish were 6.23 inches long; Five Rivers smolts were 6.18 inches long; and South Fork fish were 6.20 inches in length.

The mean length of smolts on the North Fork was found to be significantly larger than the lengths of fish at all other trap locations, at the five per cent significance level. These steelhead also had a more robust appearance than smolts from other streams. These differences merit some speculation. They may have been caused by one or both of two general factors. One of these is the action of physical conditions in the stream, embodying such aspects as grade and availability of food, water temperatures, chemical constituents, and stream flows. The other factor is competition. The removal of adult

Table 10

Values of "t" for Smolt Length Comparison Tests, 1956

	North Fork	Fall Creek	Five Rivers	South Fork
North Fork		11.02*	9.31*	9.38*
Fall Creek			1.12	.72
Five Rivers				.38
April vs. May	4.87*			
May 1-11 vs. May 12-20	1.14			
May 4-12 vs. May 13-26				.75
May 1-10 vs. May 10-20		2.99*		
May 4-11 vs. May 12-20			0.00	

*Significant at 5 per cent level

steelhead at the North Fork trap for spawning undoubtedly has had some influence upon the number of young fish produced in the upper North Fork.

A decline in returning silver salmon, as recorded by Game Commission personnel, has occurred in the last few years until only a few adults, or none at all, are allowed to pass the North Fork dam. Reduced numbers of young silver salmon and steelhead should reduce competition for available food organisms. This may be the explanation for the large size of smolts. The relatively large size of Fall Creek smolts appears to be caused by the advanced age of fish in the sample. More age 3/ fish were taken on this tributary than on any other stream. The .05 inch difference in length between smolts on Fall Creek and Five Rivers was not significant at the five per cent level. No significant difference was found in smolt lengths between Fall Creek and the South Fork. A larger sample of South Fork fish would have been desirable.

Average lengths of smolts at different time periods at each trap were statistically tested. North Fork fish taken in May were larger by .84 inches than all those taken in April. This was a significant difference. Since no fish were found with post-annular circuli formed until the last week in April, this change in mean length can probably be attributed to growth. The .06-inch length difference between fish taken in periods from May 1 to 11 and May 12 to 20 was not significant.

South Fork smolts taken in the May 13 to 26 period were not significantly larger than those taken from May 4 to 12. Fall Creek smolts taken from May 10 to 20 were significantly longer than those taken from May 2 to 10. This difference was .13 inches. No significant difference was found between Five Rivers smolts taken from May 4 to 11 and May 12 to 20. All the foregoing tests for length differences at time periods might indicate significant differences if the sample sizes were larger.

The large size of North Fork smolts may have had an effect on the ultimate salt water age of adult fish returning to the North Fork.

This would help explain the fact that adults from this tributary were younger than those from the lower river, as mentioned in the section concerning adult steelhead.

Growth

Growth of Juveniles

One of the indications of growth of wild smolts between formation of the final freshwater annulus and entrance into the sea is the number of circuli formed during this period. Table 11 shows number of circuli formed by 400 juveniles in the 1956 pre-migration period, and the circuli counted on scales of 410 adult steelhead of several brood years. The number of circuli changed little for each brood year.

Overall average number of circuli for brood years 1949-1953 was 4.69. Mean number of circuli formed by 400 smolts of the 1956 migration was 3.03. These figures mean little unless the rate of circulus formation is roughly established.

On the North Fork, the first smolt found to have a circulus after annulus was taken on April 20. Each of the 11 fish caught between April 1 and 15 showed no circulus. Eight fish caught from April 16 to 30 showed an average of one circulus. From May 1 to 14, the 64 fish taken had a mean of 2.2 circuli. On May 10, 10 fish had a mean of 2.5 circuli. It appears that about one circulus was formed every 10 days.

Fall Creek samples showed that on May 2, 26 fish had a mean of 1.7 circuli; on May 10, nine fish had a mean of 2.3 circuli; and on May 24, five smolts had a mean of 4.8 circuli. The rate of formation was about one circulus each nine days.

On the South Fork, eight smolts had a mean of 2.8 circuli on May 7, and 12 had a mean of 3.4 circuli by May 18. A rough measure of the rate of formation might be one circulus each 14 days.

Five Rivers samples showed that 16 fish had a mean of 4.2 circuli on May 8, and 19 fish had a mean of 4.8 circuli on May 15. The circuli appeared to form at a rate of about one each 11 days.

If it is assumed that the early springs of 1951 through 1956 were similar in terms of available food, temperature, and a number of other factors affecting rates of growth, the number of pre-migration circuli formed by fish of brood years 1949 through 1953 would tend to indicate that the smolts spent little time in the river after annulus formation.

If it is further assumed that the 1949-53 broods migrated at about the same time of year as the 1956 migration occurred, it appears that little time was spent in the river after the fish left tributary streams; possibly about 15-20 days.

Examination of adult scales revealed no evidence that smolts might migrate to sea in the fall. If such a migration did occur, the first salt-water annulus would be quite close to the end of freshwater growth. All scales examined had a summer of ocean growth between time of migration and first ocean annulus.

The possibility that steelhead smolts spend some time in estuarine waters has been the subject of considerable speculation by workers concerned with steelhead management. The spacing of circuli laid down after the last freshwater annulus, and before entrance into

Table 11

Freshwater Circuli Laid Down After Final Stream Annulus by Adults of Brood Years 1949-1955, and by Smolts Migrating in 1956

Brood year	Fish checked	Total circuli	Mean circuli
1949	43	155	3.60
1950	36	151	4.19
1951	118	579	4.91
1952	201	999	4.97
1953	12	41	3.42
Total	410	1925	4.69
Location*	**Fish checked**	**Total Circuli**	**Mean circuli**
Fall Creek	100	210	2.10
Five Rivers	100	444	4.44
North Fork	100	206	2.06
South Fork	100	353	3.53
Total	400	1213	3.03

* trapped smolts

the sea, has caused this speculation. The spacing is often quite wide, Figure 9, and strikingly different from circuli laid down in the preceding year of freshwater life.

The wide spacing was found to occur in tributary streams. Most smolts which migrated through the downstream traps in May had already formed these growth rings. The lack of an important difference,

Stream growth before
seaward migration

Annulus II

Annulus I

Figure 9. Scale from Wild Smolt.

DATA:

Length - 6.75 inches

Location - Five Rivers

Date - May 14, 1956

Table 11, between number of freshwater circuli laid down after the final stream annulus by fish of brood years 1949-1953, and by smolts from four tributaries, makes it likely that little growth takes place in tidewater.

Length of Juveniles at Annulus Formation

Lengths at annuli were calculated for the 400 juvenile scale samples which were analyzed. Table 12 presents calculated lengths at annuli for smolts of brood years 1953, 1954, and 1955 taken on four tributaries. Also shown are weighted mean lengths at each annulus on each stream.

At annulus I, North Fork fish had a weighted mean length of 4.67 inches; Fall Creek - 4.20 inches; South Fork - 4.36 inches; Five Rivers - 3.89 inches. At annulus II, North Fork juveniles were 6.05 inches long; Fall Creek - 5.66 inches; South Fork - 5.78 inches; Five Rivers - 5.32 inches. At annulus III, North Fork fish were 6.73 inches long; Fall Creek - 6.21 inches; South Fork - 6.09 inches long; Fall Creek - 6.21 inches; South Fork - 6.09 inches; Five Rivers - 5.80 inches. Sample size is small in the III group, except in the Fall Creek sample.

Upon first glance at scale calculations, it appears that the 1954 brood apparently grew more rapidly than the 1953 brood on all streams sampled. Juveniles were uniformly larger at each annulus in the former group. It should be noted that the 1953 sample is based entirely on steelhead which were age 3/ when trapped. The final size may have been a result of the fact that these fish of the 1953 brood

Table 12

Lengths of Juveniles at Annulus Formation,
Brood Years 1953-1955

Tributary	Brood	No. fish	Annulus I	Annulus II	Annulus III
North Fork	1953	8	3.97 in.	5.62 in.	6.73 in.
	1954	90	4.74	6.09	
	1955	2	4.09		
weighted mean			4.67	6.05	6.73
Fall Creek	1953	24	3.56	5.21	6.21
	1954	76	4.39	5.80	
	1955	0			
weighted mean			4.20	5.66	6.21
South Fork	1953	3	3.45	5.21	6.09
	1954	97	4.39	5.80	
	1955	0			
weighted mean			4.36	5.78	6.09
Five Rivers	1953	15	3.68	4.96	5.80
	1954	83	3.91	5.39	
	1955	2	4.39		
weighted mean			3.89	5.32	5.80

were of smaller size all through life, ultimately staying longer in freshwater than the rest of their brood, which migrated in 1955.

Reference to the earlier section on average size of smolts at each trap location will reveal that North Fork fish were larger at smolt size, as well as at each year of freshwater life, than those of all other tributaries.

Lengths at each juvenile annulus were calculated for wild adult steelhead taken in the North Fork and are recorded in Table 13. These calculated lengths correspond rather closely to those calculated from the North Fork smolt sample in Table 12. Also shown in Table 13 are lengths at juvenile annuli for wild adults taken in the lower river below the mouth of Five Rivers. If the superiority of juvenile growth in the North Fork can be considered as a reasonably established fact, then it would appear that fish from the other three major tributaries contributed materially to the lower river sample. This hypothesis is stated only on the basis of the differences in size of the lower river sample at juvenile annuli, and needs further sampling and testing.

Table 13

Calculated Lengths of Adults at Freshwater Annuli, Brood Years 1949 - 1953

	Mean length (inches)					
Brood year	No. fish	I	No. fish	II	No. fish	III
		North Fork				
1949	191	4.21	191	5.80	77	6.57
1950	205	4.39	201	6.03	15	6.45
1951	133	4.27	133	5.98	42	6.73
1952	217	4.62	215	6.33	6	6.57
1953	6	6.01	6	7.56		
total	752	4.59	746	6.09	140	6.57
		Lower river				
1949	38	4.21	38	5.86	1	6.61
1950	25	4.27	23	5.87	1	6.09
1951	12	4.09	9	5.27	7	6.22
1952	22	4.39	24	5.86	2	5.62
1953	4	4.69	4	6.45		
total	101	4.24	98	5.86	11	6.21

No striking variation is evident among the brood years from 1949 to 1952. The six steelhead which migrated upstream to the North Fork as grilse show a larger size at annuli I and II than fish in all other brood years. This probably is a further reflection of the tendency for large smolts to return from the sea as grilse. It is interesting to compare the calculated juvenile sizes of these 1953 fish with size at annulus III of the North Fork 1953 brood which is shown in Table 12. The age /1 fish were larger at annulus II than the smolts at annulus III.

Effect of Smolt Size on Time in Salt Water

An interesting trend is evident in Table 14, which shows average migration size of smolts for each salt water age. Average size of 50 wild /1 fish at entrance to the sea was 6.95 inches; for 639 wild /2 steelhead the size was 6.90 inches; for 237 age /3 fish the average was 6.74 inches; for 22 age /4 steelhead the migration size was 6.61 inches. The same trend was evidenced in fish of hatchery origin. The average size of 29 BVA grilse at entrance to the sea as smolts was 7.19 inches; for 158 /2 BVA fish the smolt size was 7.17 inches; for 20 /3 fish the size was 7.01 inches; and for five /4 hatchery-reared fish the migration size was 6.98 inches.

The averages tabulated are intended to show only that the foregoing phenomenon occurs. The magnitude of the effect of migration size on salt water age has not been investigated.

The larger size of ~~15~~ BVA fish at entrance to the sea, ~~7.19~~ 7.15 inches compared to ~~6.95~~ 6.85 inches for ~~15~~ the wild fish, is reflected in a larger percentage of /1 BVA fish. As mentioned previously, and shown in Table 1a and 1b, 12 per cent of the BVA fish sampled were /1, while only five per cent of the wild fish sampled were of this salt water age.

In an earlier section, it was noted that about 28 per cent of all wild steelhead reached age /3 or /4, while only about 14 per cent of all BVA fish reached these ages. The comparatively large mean size of BVA smolts at entrance into the sea may have been related to a relatively early return as adults. Wild fish were smaller upon reaching the sea, but stayed there longer before returning to the river.

Table 14

Lengths of Smolts at Entrance into the Sea, Calculated from Adult Fish in Runs from 1952 to 1955

Age at Return	Number of Fish Wild	Number of Fish BVA	Mean Length at Migration Wild	Mean Length at Migration BVA
/1	50	29	6.95	7.19
/2	639	158	6.90	7.17
/3	237	20	6.74	7.01
/4	22	5	6.61	6.98

Movement

Movement of Adults

The first winter steelhead usually enter the Alsea river in early November. The earliest appearance recorded among the 1221 adult samples consisted of three females taken on November 2, 1953, by a gill-net operator in Alsea bay. The first angler-caught fish each year is usually taken in one of the large pools just above tidewater in the first or second week of November. Depending upon water conditions, the main stream catch usually increases steadily through November and December, peaking in the latter month.

Steelhead begin entering the North Fork trap in December and continue their movement until early May. Some of the adults checked at the trap appear to have been in freshwater for some time, being rather dark in coloration, while others are very bright with an appearance like that of fish caught near tidewater. The latter fish may have made a rapid journey from salt water.

In most recent years a large part of the North Fork run has been trapped after the legal end of the winter angling season. It is important to determine the amount of time these fish are available to the angler. If most of the late fish enter the river after the angling closure, it may be that a substantial proportion of steelhead in this and other tributaries is not being harvested. Tagging studies now being conducted by the Research Unit are necessary to the procural of this information.

About 20 adult fish were caught in early May in the downstream trap on Fall Creek. Some of these steelhead were spent, but since others were quite green, it is possible that a post-season run of fish enters Fall Creek as well as the North Fork.

Movement of Smolts Through Traps

Table 15 records numbers of smolts moving into each trap by date. It is unsafe to base conclusions concerning peaks of movement on this table since effectiveness of the traps varied at different dates. Some trends are apparent, however.

The trap on the North Fork began taking smolts on April 9. It is believed that most of the migrating smolts tended to enter the hatchery intake, and to reach the trap through the overflow, since the greatest water flow attraction at the dam was provided by the intake. The top of the dam was boarded up as water conditions permitted and the trap reached its probable peak of efficiency in the first week of May. The largest numbers of smolts taken on the North Fork were caught during the period from May 6 to May 23.

Traps on Fall Creek and Five Rivers were not installed until May 1 and May 2, respectively. The catch on Fall Creek was rather uniformly heavy from time of installation through about May 25. There is no way to ascertain how many smolts moved before May 1 during the sample year.

Movement of smolts on Five Rivers was noted as soon as the trap became operative and continued through the end of May. No conclusions can be made concerning Five Rivers movement, since the effectiveness of the trap decreased as water flow decreased. Figure 10 pictures the physical arrangement of the trap. Effectiveness was dependent upon sandbags placed at an angle upstream.

The catch on the South Fork was heaviest between May 10 and

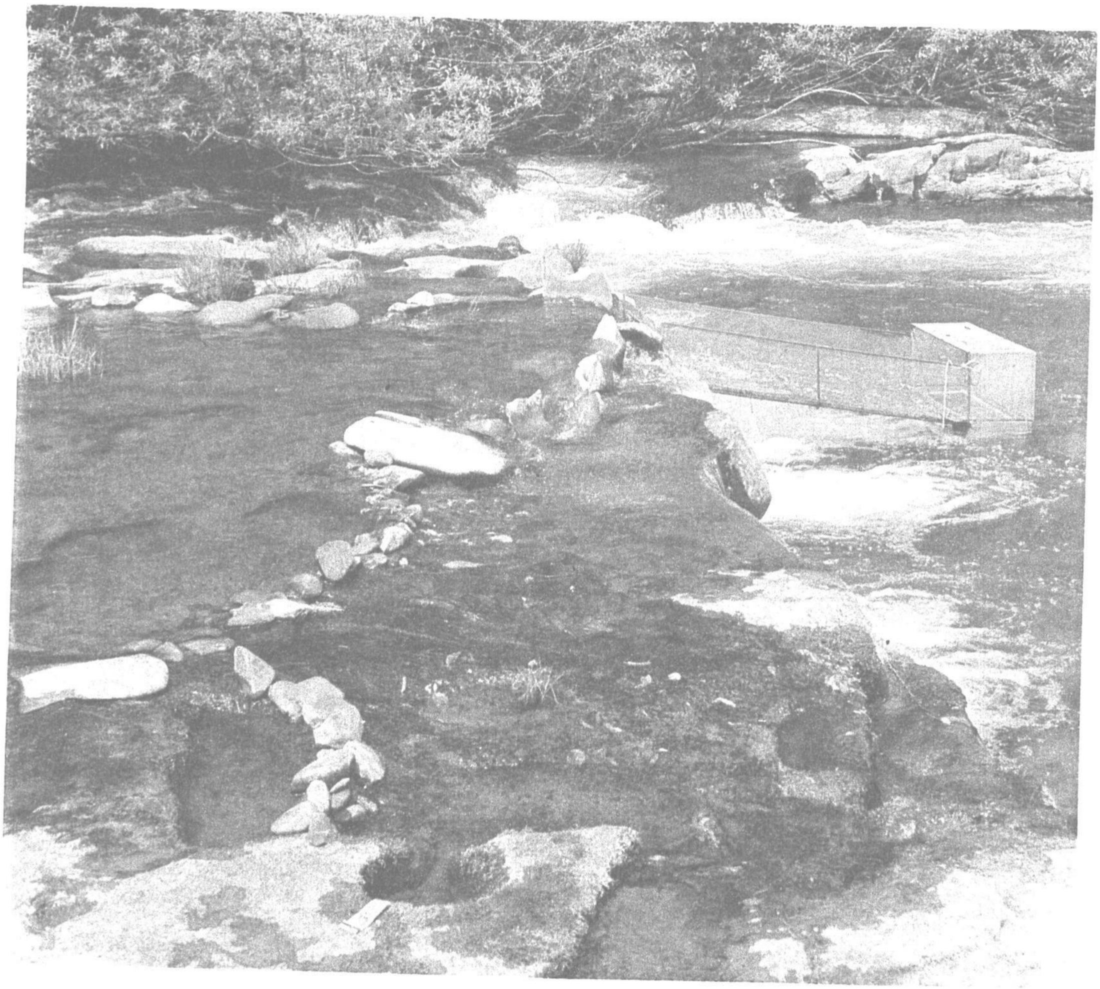

Figure 10. Five Rivers Trap.

Table 15

Movement of Steelhead Smolts Through Downstream Traps, 1956

Date	North Fork	South Fork	Fall Creek	Five Rivers
April 9	5			
10	3			
12	1			
13	1			
14	2			
15	2			
19	6			
20	6			
22	2			
25	3	1		
29	4			
May 1	4			
2	9		63	
3	3		23	
4	5	3	48	11
5	9	5	26	11
6	16	3	52	9
7	9	3	79	13
8	18	1	75	11
9	20	2	8	7
10	15	22	23	9
11	11	14	55	12
12	7	16	22	8
13	11	22	40	6
14	34*	17*	90	16
15	34*	17*	66	22
16	47	19	46	17
17	54		36	12
18	45	12	23	7
19	24	15	18	2
20	16	3	7	1
21	21	3	19	
22	32	5		
23	13	2	14	
24	4		11	
25	5	1	19	
26	5	1	7	

Continued on following page

Table 15 (Continued)

Date	North Fork	South Fork	Fall Creek	Five Rivers
May 27	3			
28			8	2
29	3		4	
31	6		3	
June 2	1		1	
4	1		2	1
5			1	1
Total catch	565	187	889	178

* Mean of two-day catch counted on May 15

May 25, a period when the trap at this location was fishing quite effectively.

The catch figures in Table 15 are in no way an indication of relative abundance of smolts on the four tributaries listed. The figures tend to indicate that the peak movement of smolts took place in the middle two weeks of May, but further trapping is essential in order to validate this information.

A total of 1819 wild smolts were caught on all tributaries. Only one recovery was made. This was a seven-inch smolt caught, tattoeed, and released at the North Fork dam on May 29, 1956, and found in the "Y" trap six days later. Mean rate of travel for this fish was about six miles per day.

No downstream movement of smolts through the inclined screen trap at the North Fork dam occurred during the 1956 fall freshets.

Characteristics of Smolt Movement

Operation of the several inclined screen traps gave some indications concerning preference of smolts for certain types of water flow. An inclined screen placed on the North Fork dam face caught only an occasional smolt at times when the same type of trap beneath the hatchery overflow caught large numbers of juveniles. The hatchery intake entrance was about six feet deep and four feet wide. Most of the water entering this intake was strained through a screen before passing down a pipe to the hatchery. The overflow water which did not pass down the pipe flowed over the inclined screen at the outlet. Fish evidently preferred to use this outlet rather than to move back out of the intake to use the 8 to 10 inches of water passing over the dam top.

At the South Fork dam, the trap was placed on the north side and did not strain the deepest, most concentrated volume of water passing over the dam. When flows decreased to the point where boards and sandbags could be used to force virtually all water into the trap, the catch of smolts immediately rose sharply.

The number of smolts taken on Five Rivers never reached a high level, probably because the inclined screen was not straining a deep, high water-volume portion of the river.

Movement of Wild Smolts During Day

Information regarding time of movement during the 24-hour day is sparse, but Table 16 lists fish taken during known time periods. On May 2 at Fall Creek, 39 fish were taken from the inclined screen trap at 9:00 a.m. By 4 p.m., 24 more smolts had entered the live box, and six more entered in the period from 4:00 p.m. to 4:15 p.m.

On May 9, three smolts entered the South Fork inclined screen trap between noon and 3:30 p.m. On May 15, at the same trap, 34 smolts were present at 9:00 a.m. and one entered between that time and 6:00 p.m.

During the period May 22 to May 25, the North Fork trap was checked at short intervals. Table 16 records counts at each checking time. Movement was intermittent through the day, showing little definite pattern. More extensive checks might indicate periods of peak movement, but it is obvious that smolts do move during daylight hours as well as at night.

Movement of Fish of the Year

Movement of 0 age class trout was noted from about June 1 through the early summer. Ten of these fish were taken at the South Fork trap on May 28, 107 on May 31, and the movement continued through July 21, when the trap was removed. Movement of 0 fish into all traps is tabulated in Table 17. These figures give no indication of daily movement, since the traps were checked at irregular intervals after June 1. It is obvious that there is a downstream movement of 0 trout which is of considerable magnitude.

It is not known whether these 0 trout were steelhead or cutthroat trout. Their small size made identification impractical. It seems likely that the influx of 0 fish in late May consisted of steelhead.

A scoop trap was placed in the main Alsea river about two miles above tidewater on June 19, and fished for one week. No 0 trout were

Table 16

Movement of Wild Smolts During Day, 1956

Tributary	Date	Number of smolts	Time of capture
Fall Creek	May 2, 1956	39	9:00 a.m.
	May 2	24	4:00 p.m.
	May 2	6	4:15 p.m.
South Fork	May 9	0	12:00 a.m.
	May 9	3	3:00 p.m.
	May 15	34	9:00 a.m.
	May 15	1	6:00 p.m.
North Fork	May 22	32	11:00 p.m.
	May 23	5	1:30 a.m.
		2	2:30 a.m.
		5	5:00 a.m.
		0	7:30 a.m.
		0	9:00 a.m.
		2	1:30 p.m.
		0	3:00 p.m.
		2	5:00 p.m.
		0	8:00 p.m.
		2	10:00 p.m.
	May 24	0	1:00 a.m.
		2	5:30 a.m.
		0	8:30 a.m.
		2	11:30 a.m.
		2	4:00 p.m.
	May 25	5	7:00 a.m.

caught in this period. Very few <u>0</u> fish were taken at the Five Rivers inclined screen trap during periods when other traps were taking large numbers.

One possible theory is that the young fish moved out of small tributaries where they were hatched, and drifted downstream to find a niche with less competition. The paucity of movement into the Five

Table 17

Catch of 0 Class Trout, 1956

Date	North Fork	South Fork	Fall Creek	Five Rivers
April 27	1			
May 1		1		
May 5		1		
May 7		4		
May 28		10		
May 31		107	20	
June 2	15	75	35	
June 4	10	95	15	1
June 6	8	49	11	1
June 8	10	35	85	
June 11	20	55		
June 13	57			2
June 14	33			
June 19	10	45		
June 21		1		
Total	164	479	166	4

Rivers trap would lend credence to this theory since the trapping point was located in the lower reaches of the stream in an area similar to the lower Alsea river. It is possible that the moving fish of the year had already found living room upstream from the trap. Lack of any catch in the scoop above tidewater might be explained in the same manner. It is also possible, of course, that both traps failed to catch the migrants.

In all the adult scale samples examined, no fish were found to have entered the ocean before the first freshwater annulus. If any 0 steelhead moved out to sea soon after hatching in the brood years contributing to the adult runs of 1952-55, it appears that survival was very low, if existent at all.

Hatchery Release Experiment

In order to obtain information regarding rate and times of downstream movement of planted hatchery-reared juvenile steelhead, an experimental release of 7900 fish at 10 per pound was made. These steelhead, with both ventral fins and the adipose fin removed, were released as follows: Lower Alsea, five miles above tidewater - 2500 fish; North Fork, six miles upstream from the Oregon State Game Commission Alsea trout hatchery - 2700 fish; South Fork, four miles upstream from junction with the North Fork - 2700 fish. Latex injections were used to mark 200 fish released at each location; tattoos were used to mark the remainder. These tattoos were placed on the side or dorsal ridge of the fish, and titanium dioxide was used as a pigment.

The first recoveries of marked fish were made at the South Fork inclined screen trap, located two miles below the point of release. The hatchery fish were liberated at 7:15 p.m. on May 22 and the first recovery was made at about 10:15 p.m. Four more fish entered the trap by 12:30 a.m., 10 by 2:00 a.m., and eight more by 5:30 a.m. Table 18 lists the time and date of capture of these fish. The largest catch was made on the night of May 25, when 98 marked steelhead were taken.

A total of 302 tattoo and 18 Latex marks were recovered. The physical arrangement of the trap on the South Fork made it likely that most migrating fish entered the trap. The diversion dam face was sandbagged and blocked with boards in order to force almost all the flowing water over the inclined screen. It may be seen, then, that more than 2300 juvenile steelhead from the experimental release did not move downstream. These fish either remained upstream or perished.

Samples taken at the South Fork point of release with rod and line, on July 18, included 10 BVA juveniles. Two of these were marked with liquid latex. The remaining eight, having no evident tattoo marks, may have been from a routine release of steelhead made in early May or it may be that the tattoo marks had faded severely on some experimental fish. Four more BVA fish were caught with rod and line on September 15, 1956. These may have been either routine releases or experimental fish since no mark was evident, but these catches, in addition to the fact that all BVA fish upstream from the trap were liberated in late spring, would indicate that some planted steelhead do not migrate to sea immediately. These residual fish did not appear to be in good condition.

The North Fork plant was made at 5:00 p.m. on May 22. Table 18 shows that the first recoveries at the North Fork inclined screen, about six miles below the liberation point, were made between 47 and

63 hours after release. A total of 303 tattoo and 22 latex marks were recovered. It is interesting to note the similarity in the number of recoveries on the North and South Forks. About 12 per cent of the liberated smolts were caught on each tributary. The North Fork dam was also blocked with boards and it is believed that most of the smolts passed into the trap placed beneath the hatchery intake overflow.

On July 27, nine BVA fish from the North Fork experimental release were caught on rod and line within 300 yards of the point of liberation. These fish appeared to be in fair physical condition. Examination of scales from these fish, and from those taken on the South Fork, appeared to indicate no change in growth rate after planting. This condition seems illogical, for a change of some type in the growth rate after planting seems inevitable. An alternative explanation may be that fish size actually was static after liberation. It is unfortunate that no attempt was made to measure lengths of migrating and residual BVA fish, and lengths of fish before planting. Some resorption was evident at the margins of scales from residual fish. This lends credence to the above-mentioned alternative explanation.

Only two BVA steelhead from the lower river release were recovered. These were taken in the "V" trap, located about one-half mile downstream from the point of liberation, two days after release. The lack of recoveries was probably due to trapping difficulties.

The earliest lower-river trap recoveries of North and South Fork experimental BVA fish were made at seven and six days, respectively,

Table 18

Trap Recoveries of Tattooed and Latex-injected BVA Smolts
Released on May 22, 1956

Trap Location	Date	Time	Recoveries by Liberation Group: North Fork Tat.	North Fork Lat.	South Fork Tat.	South Fork Lat.	Sthd. Park Tat.	Sthd. Park Lat.
South Fork	May 22	11:30 p.m.			1			
	May 23	12:30 a.m.			4			
		2:00 a.m.			10			
		5:30 a.m.			8			
		4:00 p.m.			1			
		6:00 p.m.			1			
		8:30 p.m.			3			
		12:00 p.m.			88	8		
	May 24	4:30 a.m.			42	6		
		8:00 a.m.			2			
		3:00 p.m.			1			
North Fork	May 25	8:30 a.m.	10					
South Fork	May 25				95	3		
North Fork	May 26		50	3				
South Fork					16	1		
North Fork	May 27		57	4				
South Fork					6			
North Fork	May 28		60	5				
South Fork					4			
North Fork	May 29		58	5				
South Fork					15			
North Fork	May 31		53	2				
South Fork					2			
North Fork	June 2		18	2				
South Fork					1			
North Fork	June 4		3	1				
South Fork					1			
North Fork	June 6		1					
South Fork					1			
North Fork	June 8		2		1			
North Fork	June 11		1					
		Total	313	22	302	18		
Quarry V trap	May 24						2	
Quarry	May 28				2			
	May 29		1				1	
	May 31		1		1			
	June 2		1					
	June 6				1			

after planting. Table 18 shows all recoveries in the lower river. The "V" trap was about 40 miles, by stream, below the North Fork release point and 34 miles below the South Fork release point. Thus, a rough estimate of mean rate of travel for the early arrivals at the "V" trap would be about five miles per day.

The longest time to recovery was established by a South Fork fish which took 15 days to reach the "V" trap. This fish traveled at a mean rate of about two miles per day.

The first BVA fish to reach the North Fork trap were allowed to continue their migration two and one-half days after planting. If the first downstream recovery, seven days later, was one of these early migrants, the mean rate of migration was about 7.8 miles per 24-hour period. The initial recovery took 4.5 days to travel the 35 miles between the North Fork trap and the "V" trap.

One North Fork BVA fish which was trapped, tattooed and released on the afternoon of May 28, was removed from the "V" trap in the afternoon of May 31. Mean rate of travel for this fish was at least 11.6 miles per 24-hour period.

Another North Fork BVA fish, which had been caught in the North Fork trap and released on May 28, was taken six days later at the "V" trap. Mean rate of travel was about six miles per 24-hour period.

Since only 10 downstream recoveries were made at the lower site, it is undesirable to draw conclusions regarding general rate of movement of all experimental fish. Movement is relatively rapid for some of the fish.

One North Fork fish, caught July 27 on rod and line just below the trap location, had been tattooed and released on June 2. On November 18, two latex-marked BVA smolts were caught by an angler about one mile below the North Fork dam. He observed that these fish were in rather poor condition. It is not known whether these fish passed over the dam in the spring or during the brief freshets which occurred in October. Hence, it is possible that more of the fish which were trapped and released may not have continued the downstream movement.

On January 2, 1957, two BVA grilse were caught in the Alsea river on rod and line near Digger Creek. Each fish appeared to have a white tattoo mark in the area near the anal fin. One fish had the spot on the left side, one on the right side. No proof that these were actually tattoo marks is available.

SUMMARY

1. A steelhead trout life history study was initiated in 1954 by the Oregon Cooperative Wildlife Research Unit. Initial work involved analysis of scale samples from the major steelhead streams of Oregon. Subsequent work has been conducted on the steelhead trout of the Alsea river, a stream which rises on the Coast Range and drains into the Pacific ocean at Waldport, Oregon. The study reported here concerns the age, growth, and migration of steelhead trout in the Alsea river and its tributaries.

2. A total of 1221 scale samples from adult Alsea river steelhead were analyzed. There were 243 fish of hatchery origin in the sample, which was secured in the winters from 1951-52 to 1955-56.

3. Life-history patterns of wild fish were as follows: 52 per cent were 2/2, 21 per cent were 2/3, 13 per cent were 3/2, four per cent were 2/1, and all other patterns were 10 per cent of the total sample.

4. Scale patterns from hatchery-reared fish were as follows: 46 per cent were 1/2, 27 per cent were 2/2, nine per cent were 1/3, eight per cent were 1/1, and all other patterns were 10 per cent of the sample.

5. Of 823 wild steelhead taken at the North Fork trap, 1953 to 1955, 54 per cent were 2/2, 19 per cent were 2/3, 14 per cent were 3/2, three per cent were 2/1, and 10 per cent were in all other patterns.

6. Of 125 wild steelhead taken in the lower river, 1953 to 1955, 40 per cent were 2/2, 35 per cent were 2/3, seven per cent were 3/2,

five per cent were 2/4, four per cent were 2/1, and nine per cent were in all other patterns.

7. About 17 per cent of the 556 adult fish sampled in 1953 were repeat spawners. Of this group, 81 per cent were returning for the second spawning, 19 per cent for the third. About 12 per cent, or 24 fish, of the 1954 sample were repeat spawners. Of this group, 83 per cent were on the second migration, 17 per cent on the third. About three per cent, or 14 fish, of the 1955 sample were repeat spawners. Of the 14 fish, 93 per cent were on the second run, seven per cent on the third.

8. A total of 133 repeat spawners had a sex ratio of one male to 2.5 females. Of the 38 males, 84 per cent were on the second migration, 16 per cent on the third. Of the 94 females, 82 per cent were on the second run, 18 per cent on the third.

9. Of 129 steelhead taken below Five Rivers on the Alsea river in the winters of 1953-54 through 1955-56, 10 per cent were of hatchery origin.

10. It was found to be possible to segregate fish of hatchery origin by means of scale inspection.

11. A total of 473 steelhead were sexed and measured in the 1955-56 winter run entering the North Fork trap. No change in average size of steelhead was evident as the season progressed. The percentage of males decreased from a high of 66.7 per cent on January 24, 1956, to a low of about 40 per cent in late April and early May. The changing relationship is best described by the formula:

$$y = .6654 + .05392x - .00135\,x^2 + .0004393x^3,$$

where y is the ratio of males to the total number of fish in the trap, and x is the number of weeks after January 24, 1956. The percentage of BVA fish (steelhead of hatchery origin) at the North Fork trap was near 50 per cent early in the season, and decreased to zero in May. This relationship is described by the formula: $y = .5113 + .01813\,x - .003785\,x^2$, where x is the week number and y is the ratio of BVA fish to the total number of fish in the trap.

12. Condition factors, or ratios of weight to length, were calculated for 263 adult fish. When subjected to statistical analysis, the data yielded these results: Males were in better condition than females, wild fish better than BVA fish, fish taken in the lower river were in better condition than those taken in the North Fork trap, first spawners were in better condition than repeat spawners. Fish of age /4 were in better condition than /3, /3 better than /2, /2 better than /1. Duration of freshwater residence made no difference in adult condition. Adult BVA fish which had migrated to sea soon after liberation were not significantly different from those which spent a winter in the stream. Comparisons were made after all important influencing factors had been accounted for in the analysis. In other words, after all other effects were considered and accounted for, males were compared to females, and so on.

13. Length analysis with the same sample as was used in No. 12, above, yielded these results: Males were larger than females, wild fish larger than BVA fish, first spawners larger than repeat spawners.

Age /4 fish were larger than /3, /3 larger than /2, /2 larger than /1. No significant difference was found between size of steelhead taken on the North Fork and in the lower river, or among fish of the 1/ , 2/ , or 3/ patterns. Comparisons were made after all important influencing factors had been accounted for in the analysis. In other words, after all other effects were considered and accounted for, males were compared to females, and so on.

14. Smolt life histories in the 400 samples analyzed were: North Fork - eight per cent in age 3/ , 90 per cent in 2/ , and two per cent in 1/ ; Fall Creek - 24 per cent were 3/ , 76 per cent were 2/ , and none were 1/ ; South Fork - three per cent were 3/ , 97 per cent were 2/ , none were 1/ ; Five Rivers - 15 per cent were 3/ , 83 per cent were 2/ , and two per cent were 1/ .

15. Average lengths of all smolts taken and measured on four tributaries in May, 1956, were: North Fork - 6.63 inches; Fall Creek - 6.23 inches; South Fork - 6.20 inches; Five Rivers - 6.18 inches. The North Fork fish were found to be significantly larger than smolts on all other tributaries, at the five per cent significance level.

16. Smolts taken in May on the North Fork were found to be significantly larger than those taken in April, at the five per cent level.

17. Counts were made of the number of scale circuli formed by 410 adults and 400 smolts after the last freshwater annulus and prior to salt water growth. Mean number of circuli was 4.69 for the former group and 3.03 for the smolts. Rate of formation was found to be about one circulus each 12-15 days.

18. It appears likely that little time was spent by smolts of brood years 1949 to 1953 in the lower river or tidewater after formation of the last freshwater annulus, if environmental conditions of 1956 can be compared with those of earlier years.

19. The regression equation, $y = -3.74 + 5.89 \log x$, was used to back-calculate lengths of fish at juvenile ages. The symbol y is the size to be predicted, in inches, and x is the radius (x 112) in millimeters of the scale at the desired age.

20. Mean length of 400 smolts at annulus I was 4.28 inches; at annulus II - 5.70 inches; at annulus III - 6.16 inches. North Fork fish were consistently larger at each annulus.

21. Mean length at freshwater annuli was calculated for 752 adults from the North Fork and 101 from the lower river. North Fork fish were larger at each annulus.

22. Mean size of 50 wild /1 fish at entrance into the sea was 6.95 inches; for 639 age /2 steelhead - 6.90 inches; for 237 age /3 fish - 6.74 inches; for 22 age /4 adults - 6.61 inches. Mean size of 29 BVA grilse at entrance to the sea was 7.19 inches; for 158 /2 BVA fish the smolt size was 7.17 inches; for 20 /3 fish - 7.01 inches; for five /4 fish - 6.98 inches.

23. BVA smolts had a mean length of 7.15 sc ~~7.19~~ inches at entrance into the sea, while wild smolts averaged 6.85 sc ~~6.95~~ inches in length. This difference appears to be reflected in the fact that 12 per cent of all BVA fish sampled were grilse, while only five per cent of the wild fish were in this category. About 28 per cent of wild steelhead were

age /3 or /4, while only about 14 per cent of BVA fish reached these ages. The comparatively large size of BVA smolts may have resulted in an early return as adults.

24. Adult winter steelhead make their first appearance in the Alsea in early November, with the peak of the run occurring in December and January. Adult fish enter the North Fork trap from December through early May.

25. A total of 1819 wild migrating smolts were caught in traps on four tributaries of the Alsea river in the spring of 1956. The bulk of the catch was made in mid-May. All smolts were marked at each trap location. One recovery of a wild marked smolt released from an upriver trap was made in the lower river. The mean rate of travel was six miles per day.

26. No downstream movement of smolts through a trap located at the North Fork dam occurred during the 1956 fall freshets. No adult scales showed that any smolts migrated in the fall.

27. Smolts moved in daylight hours as well as at night, and seemed to prefer the stream portions with the greatest water volume in the smallest cross-sectional area.

28. A downstream movement of fish of the year was found to occur. A total of 813 0 age class trout were caught, with more than 50 per cent of these taken on the South Fork. Some of these fish may have been coastal cutthroat trout.

29. In the scales examined from all adult fish, none indicated any survival of fish which entered the sea before acquiring the first

freshwater annulus.

30. An experimental release of 7900 BVA smolts was made on May 22, 1956, with 2700 fish each going to the North and South forks and 2500 to the lower river. The nature of the 670 recoveries indicated that some liberated smolts migrated immediately, while others remained in the stream, some probably over the winter. Fish which stayed in the tributaries lost condition rapidly and no growth was apparent on scales taken from fish in September. Six lower river recoveries of BVA smolts from the North and South forks indicated that the rate of travel for these fish varied from two to 11.6 miles per 24-hour day.

CONCLUSIONS

Analysis of 978 scale samples taken in the winters of 1951 through 1955 from wild adult steelhead indicates that over 90 per cent of these fish remained in freshwater as juveniles for at least two winters. A total of 1221 scale samples from wild fish and steelhead of hatchery origin indicates that the proportion of repeat spawners in the adult population each winter may vary from about three per cent to more than 17 per cent. Adults of hatchery origin appeared to form about 10 per cent of the runs in the main-stem Alsea river from 1953-54 to 1955-56. The contribution of hatchery fish to the North Fork run is much higher, averaging over 25 per cent in some years.

Analysis of 400 scale samples from steelhead smolts moving downstream in the spring of 1956 indicates that over 86 per cent of these fish had spent two winters in tributaries before migrating seaward. This figure corresponds closely with the proportion of adults found to have spent two winters in freshwater as juveniles.

North Fork smolts were found to have a greater mean length than smolts on all other tributaries. Back-calculation of juvenile lengths at each annulus further established the fact that North Fork fish have a superior growth rate. This superior growth may be due to one or more ecological factors. One of these may be the influence of reduced competition in stream portions upstream from the North Fork adult trap due to removal of silver salmon and winter steelhead for purposes of artificial propagation.

Smolts of large size appear to return from the sea as adults at an early salt water age. Conversely, smolts of small size return as adults at a comparatively advanced salt water age. This means that large smolts return from the sea as adults at a relatively small size. Small smolts return as adults at a larger size.

Scales from fish of hatchery origin demonstrate unique characteristics in the pattern of freshwater growth. It is possible to separate wild fish of the Alsea river system from steelhead of hatchery origin by means of scale pattern inspection.

Fish of hatchery origin form a greater part of the North Fork run early in the season rather than late. The ratio of hatchery fish decreases rapidly as the season progresses, dropping to a negligible figure in April and May. The percentage of males in the North Fork run also decreases as the winter passes.

The run entering the North Fork trap peaks in March and April, after the closure of winter angling season at the end of February. Many of these fish are bright, appearing to have entered the river after angling season has closed.

Some hatchery-reared steelhead smolts remain in freshwater over the winter following liberation. About 33 per cent of 243 scale samples from adult fish of hatchery origin showed a stream annulus after liberation. It appears that these residual fish lose condition rapidly, growing little if at all during the summer immediately following liberation. Most hatchery-reared steelhead which migrate in the year of release probably do so within three or four weeks after liberation. Downstream recoveries of marked hatchery-reared steelhead show that the rate of travel for these fish is relatively rapid and that the migration to the sea may be completed in as little as one week.

The peak migration period for the 1956 smolt run probably occurred in mid-May. It appears, on the basis of scale analysis, that little time is spent by smolts in tributaries, in the lower river, or in tidewater, after formation of the last freshwater annulus. Adult scales indicate that this delay before smolts enter the open sea is probably less than six weeks. There are few, if any, steelhead smolts which enter the sea in the fall. Smolts move in daylight as well as at night, apparently preferring stream portions with the greatest water volume in the smallest cross-sectional area.

A downstream movement of fish of the year occurs in May and June in tributary streams, but, as such, these fish do not contribute to the adult steelhead population. It is possible that these 0 age class juveniles remain in the main-stem Alsea river for a year or more before migrating to sea.

The effect of certain important influences upon adult condition factors (ratios of weight over length), was determined. The influences considered were these: Freshwater and salt water ages, sex, origin of fish, number of previous spawnings and location of capture. Comparisons were made between groups such as between males and females, after all other influences were accounted for in the analysis. Condition becomes better with increasing salt water age. Males are in better condition than females, wild fish are in better condition than fish of hatchery origin, and first spawners are in better condition than repeat spawners. Fish lose condition during the migration from the lower river to the North Fork. Hatchery-released smolts migrating soon after liberation do not have a better adult condition than those which migrate after a winter in the stream. Freshwater age makes little or no difference in adult condition.

The effect of the foregoing influences upon adult length was also determined. The influences were treated in a manner similar to that used in the condition analysis. Length of adults increases with increasing salt water age. Males are larger than females, wild fish are larger than fish of hatchery origin, and first spawners are larger than repeat spawners. Fish taken in the North Fork and lower Alsea river are not of different sizes, and fish spending one, two, or three years in freshwater are not of different adult lengths. Hatchery-released smolts migrating soon after liberation do not have a length different from that of hatchery fish which remain in the stream for a winter.

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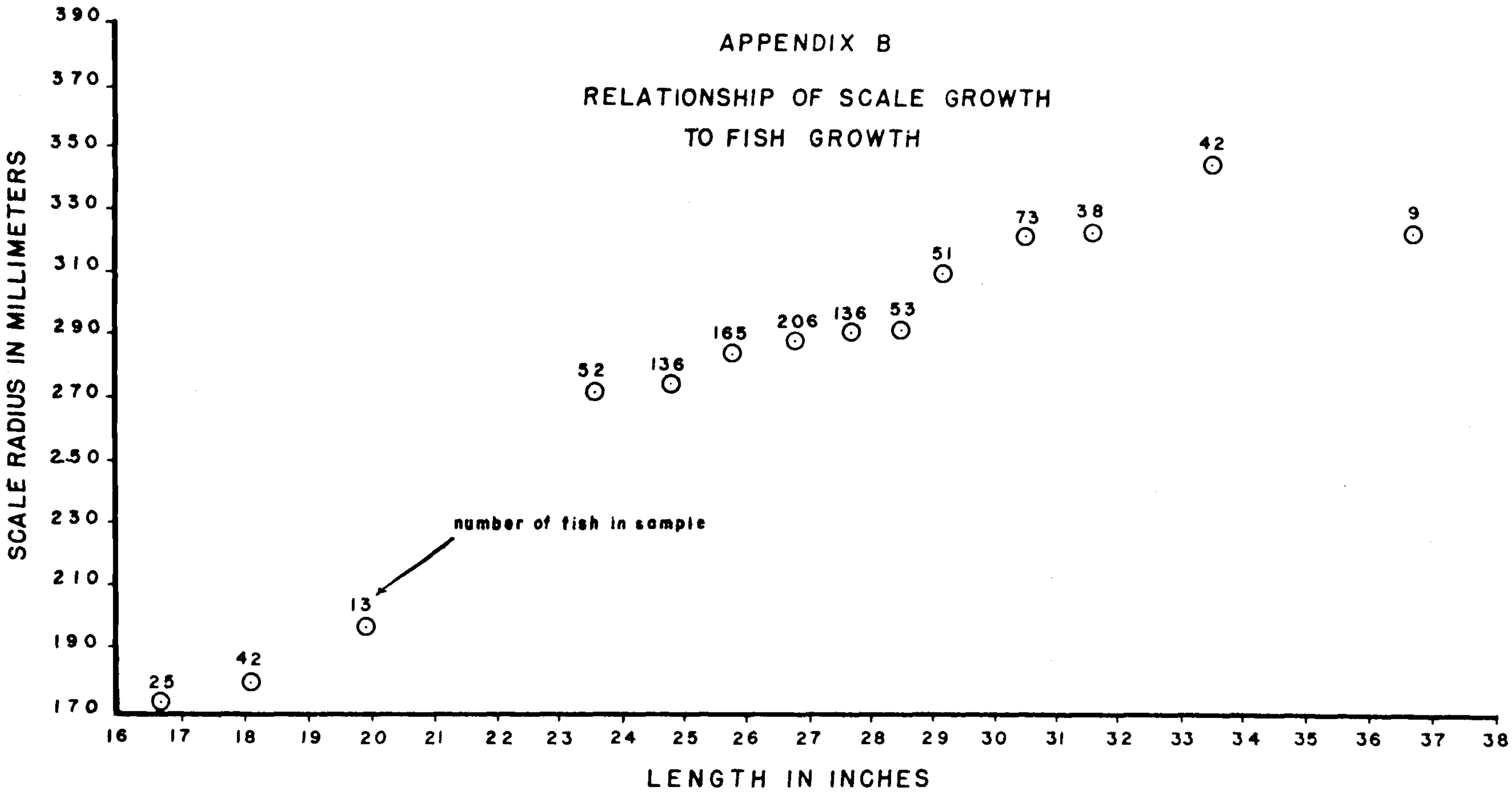
APPENDIX


APPENDIX B
RELATIONSHIP OF SCALE GROWTH
TO FISH GROWTH
SCALE RADIUS IN MILLIMETERS
LENGTH IN INCHES
390
370
350
330
310
290
270
250
230
210
190
170
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
number of fish in sample
25
42
13
52
136
165
206
136
53
51
73
38
42
9

APPENDIX C

Regression Calculations for Equation Used to Predict Fish Lengths from Scale Radii

y = Mean length of groups of smolts

x = Log of mean scale radius of groups

$\Sigma y = 131.49$		$\Sigma x = 35.6577$
$N = 21$		$N = 21$
$\bar{y} = 6.26$		$\bar{x} = 1.6979$
$(\Sigma y)^2$ 17.289.62	$(\Sigma x)(\Sigma y) = 4688.6310$	$(\Sigma x)^2 = 1271.4715$
$\frac{(\Sigma y)^2}{N} = 823.31$	$\frac{(\ x)(\ y)}{N} = 223.2681$	$\frac{(\Sigma x)^2}{N} = 60.5463$
$\Sigma y^2 = 827.25$	$\Sigma xy = 223.8743$	$\Sigma x^2 = 60.6492$
$SSy = 3.95$	$SP = 0.6062$	$SSx = 0.1029$

$b = \frac{SP}{SSx} = 5.891$

$y = a + bx$

$a = 6.26 - 5.891\ (1.6979) = -3.74$

$y = -3.74 + 5.89 \log x$

APPENDIX D

Computations for Determining Constants in Formulas Describing Changing Sex Ratio and Percentage of Hatchery Fish in North Fork Run Entering Upstream Trap

Code 10'	10^{-1}	10^{-2}	10^{-3}
n	x	x^2	x^3
n 10	9.9	11.49	13.959
x	11.49	13.959	17.6037
x^2		17.6037	22.86999
x^3			30.415749

Covariance Matrix for % Males					g	decoded b.
.9990554	-2.8767169	2.6639799	-.7966321	n	5.076	.6653924
	57.7480323	-95.3865027	39.619784	xy	4.6641	.05392002
		165.1039967	-70.159635	x^2y	5.2279	-.01135653
			30.221697	x^3y	6.1704	.00043933

Covariance Matrix for % BVA				g	decoded b.
.978056	-1.832358	.814603	n	2.5580	.511257831
	5.807627	-3.4092196	xy	1.8605	.01813419
		2.228481	x^2y	1.7433	-.00378578

APPENDIX E. Covariance or Inverse Matrix of Condition and Length Analysis

overall	males	1 year in	2 year in	1 yr. out	2 yr. out	3 yr. out	hatchery	lower riv.	repeat spawners
.2060742	-.0078749	-.0645568	-.0490818	-.1620317	-.1532154	-.1308198	.0122393	-.0122710	-.0603084
	.0176006	.0026221	.0032709	.0095351	-.0025220	.0000246	-.0044557	-.0020837	-.0001504
		.1183148	.0455851	.0407524	.0230496	.0184910	-.0585766	-.0057782	.0145985
			.0444400	.0153219	.0094962	.0091019	-.0083345	-.0038160	.0066916
				.2095810	.1487976	.1244761	-.0201446	.0123881	.0546907
					.1486035	.1212472	-.0094978	.0102169	.0512092
						.1236526	-.0050593	.0012433	.0317622
							.0672240	.0061306	-.0028653
								.0204262	.0060528
									.0541122

NOTE: Upon completion of the forward solution of condition and length analyses, it was obvious that there was no significant difference between hatchery-reared fish spending one or two years in freshwater. These effects are not included in the inverse matrix.

APPENDIX F

Suggestions for Management

If the actual yearly contribution of hatchery fish is not materially greater than the contribution in the period from 1953-54 to 1955-56, it is possible that a complete cessation of hatchery liberations in the Alsea river might not seriously affect the total steelhead population of the drainage. This suggestion assumes that fish presently spawned by artificial means would be allowed to spawn naturally.

Since it is possible to distinguish wild fish of the Alsea river system from fish of hatchery origin on the basis of scale pattern inspection, it would be possible to release all hatchery-reared steelhead without marks, take scales from a random sample of the adult runs in the year of expected return, and arrive at an estimate of the contribution of hatchery fish to the total population. Mutilation of fish could be avoided, and the labor and time spent in fin-clipping eliminated. The work involved in securing, mounting, and analyzing scale samples would require less time and expense, and the results would probably be more accurate than reports of marked fish from sportsmen. One disadvantage of the method would be the problem of convincing sportsmen that many hatchery fish were returning to the river.

If the appearance of steelhead taken in March and April is a valid indication of a late run of winter fish, it might be possible to allow angling later in the spring on certain portions of the Alsea river, such as that area of the stream below the mouth of Five Rivers. The most important disadvantage to an extended season would be the effect upon spent steelhead which have reached the lower river on the way back to sea. Kelts which have covered most of the distance to tidewater probably constitute a substantial proportion of the returning repeat spawners in the succeeding year.

Many steelhead anglers will probably return kelts to the water. If, through effective public relations, most fishermen can be sufficiently encouraged to release all spent fish taken, the principal objection to an extended season would be removed. An extension of winter steelhead season would probably help remove some objections to a late May or early June trout season opening; a measure desirable if steelhead smolts are to be adequately protected from hooking injury.

Since the peak migration of steelhead smolts in the spring of 1956 occurred in mid-May, the majority of the smolts were legally available to fishermen after the May first opening of trout season. The eight-inch minimum legal size limit on coastal streams adequately protects virtually all Alsea river steelhead smolts on all tributaries, provided that hooking mortality is not considered in judging the adequacy of the protection.

It seems worthwhile to investigate the effect of fish size, date of release, and liberation location on the proportion of hatchery-reared smolts migrating immediately after release. These fish will be in the best condition upon entrance to the sea and probably will have a better survival rate to adulthood than residual fish, or those which stay in the stream for a winter after liberation.

It appears that it may be possible to manipulate the characteristics of a wild juvenile population in order to achieve certain desirable characteristics in the resulting adult population. This manipulation may necessarily be confined initially to regulation of the number of competing juveniles on tributary streams. If smolt sizes or ages can be regulated, it may be possible to cause a return of adults which are either younger and smaller, or older and larger. Such regulation is dependent upon intensive research and management. Small impoundments appear to offer immediate possible areas for testing theories of population manipulation.

A downstream migration of zero age-class fish may be assumed to occur each year shortly after hatching. Since these fish do not contribute as such to the adult run, it would be desirable to conduct marking studies to determine whether fish of the year contribute to the adult run after moving downstream until they find suitable environmental conditions where they remain one or more winters. In such studies, it would be necessary to mark all fish hatched in a given stream section, then re-mark any fish of the year which pass out of the stream section. In this way, survival to adulthood of 0 age-class fish which move downstream shortly after hatching could be compared with survival to adulthood of juveniles which remain in the tributary environment until reaching smolt size.

It might be found that no fish of the year which migrate downstream soon after hatching ever survive to adulthood. If such a situation exists, it may be feasible to trap these fish of the year at certain locations in large numbers and transfer them to holding ponds for rearing.