Aspects of the life histories of steelhead trout, Salmo gairdnerii gairdnerii Richardson, from 14 coastal streams in Oregon were investigated through interpretation of 632 scales and measurement of 612 scales. The study, under the direction of the Oregon Cooperative Wildlife Research Unit, represented the preliminary segment of a long-range investigation into the life history and management needs of the steelhead trout in Oregon. The study was aimed primarily at determining: (1) whether the steelhead populations in the various streams of Oregon had different life histories; (2) what the characteristics of the various populations were; (3) the relationships, if any, between the characteristics of the populations.

The biological characteristics of the steelhead populations indicated that distinct differences existed between the populations with respect to their geographic locations. Therefore, the streams were separated into northern and southern sections. Streams which were considered as being of north coastal distinction were, starting with the northernmost: the Necanicum River, Nehalem River, Wilson River, Trask River, Sand Creek, Nestucca River, Salmon River, Siletz River, and Coos River. The south coastal streams were, commencing with the northernmost: the Sixes River, Elk River, Chetco River, and Winchuck River. The Coquille River, located between the Coos River and the Sixes River, was not included in either the northern or southern region because the characteristics which its steelhead showed were remarkably intermediate between the extremes exhibited by the two regions.

The population characteristics of the 14 streams considered were presented separately and specifically. Also, the combined characteristics of the steelhead from the north coastal region were compared with those from the southern region, and the individual stream populations were compared briefly. The Coquille River steelhead were considered separately to point out the transitional relationships of their characteristics to those of the fish from the northern and southern regions.

From the dates on which all the males and females were taken, and from the sexual development of the fish at the time of capture, it was indicated that more males entered freshwater
earlier than the females. The south coastal region showed twice as many repeat spawning steelhead as did the northern region. The females showed greater survival after spawning than did the males, so in samples where females predominated, the percentage of repeat spawners was greater.

Steelhead from the southern region returned to spawn predominantly as grilse. The northern populations showed the predominant characteristic of remaining in salt water two years before returning to freshwater to spawn. The predominant patterns of the northern steelhead were 2/1.S and 2+/1.S, while in the southern samples the distinctly predominant patterns were 3/S, 3+/S, 2/S, and 2+/S. The southern steelhead tended to remain more years in freshwater and fewer years in salt water than the northern fish.

Hatchery reared steelhead represented 6.7 per cent of the total north coast sample. Only one hatchery fish was present from the southern streams.

Juvenile steelhead showed slightly greater growth in the southern streams. The average length and weight at maturity and capture was slightly greater among the northern steelhead. There was little difference in size, weight, or age between the sexes in any of the streams.

The scales of both regions showed that the males tended to spend more years in freshwater and mature earlier in salt water than the females. In the northern stream samples the sex ratio at capture was nearly equal, but in the southern samples the females were twice as numerous as the males.

The intermediate relationships were shown by the Coquille steelhead; those which were most striking being as follows: number of repeat spawners; types of life history patterns; age, growth, and weight at maturity and at capture of all the samples, and also of the individual sexes; sex ratio at capture, and sex ratio among the repeat spawners.

From the findings in this study, it was proved that the steelhead of Oregon do have different life histories. The different stream population characteristics were shown and the relationships were considered and discussed.
SCALE ANALYSES OF STEELHEAD TROUT,
Salmo gairdnerii gairdnerii RICHARDSON,
FROM VARIOUS COASTAL WATERSHEDS OF OREGON

by

JOHN MERTON BALI

A THESIS

submitted to

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degree of

MASTER OF SCIENCE

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Head of Department of Fish and Game Management
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Dean of Graduate School

Date thesis is presented

Typed by Lenora Bond
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INTRODUCTION

This thesis presents the data and findings which resulted from the examination, interpretation, and measurement of scales from 691 adult steelhead trout, *Salmo gairdnerii gairdnerii* Richardson, from 14 coastal steelhead streams in Oregon. The study, under the direction of the Oregon Cooperative Wildlife Research Unit, represents the preliminary segment of a comprehensive investigation into the life history and management needs of the steelhead trout in Oregon.

Such an all-inclusive investigation of the steelhead trout of Oregon, inquiring into all phases of the life history and management needs, has not previously been carried out by any persons or organizations, as far as is known, although several contributions made in the past have provided valuable data. Therefore, the Oregon Cooperative Wildlife Research Unit, at the request of the Oregon State Game Commission, embarked on a complete investigation of the life history and racial characteristics of the steelhead in the state. Such an ambitious investigation requires many separate facets of inquiry,
and it is the findings of the first of these integral studies which are reported in this thesis.

In some instances, analysis of the data in this thesis has been presented in more specific detail than it would seem the available material warrants. However, since this study is to act as an initial step to more intensified investigations, the presentation has been given in fairly detailed fashion to facilitate easy comparison with future work which will be of a more specific nature.

This initial study was aimed primarily at determining: (1) whether the steelhead populations in the various streams of Oregon have different life histories; (2) what the characteristics of the various populations are; and (3) the relationships, if any, between the characteristics of the populations. These kinds of facts should have vast application by the Game Commission in its management of steelhead.

No standardized method could be exercised in the collecting of scale samples, since only scales already collected were utilized. Many men using different techniques collected the samples and supplied varying degrees of information on them. Because of this there were disparities in the number of samples from the various streams, in year classes, size groups, and with respect
to time of collection. Since the scale collecting program was adopted only recently by the Oregon State Game Commission, there is also a general lack of adequately large samples from many of the streams. However, these samples are worthy of consideration in that they give broad indications of the population characteristics in each instance. Despite the shortcomings, the information which these data yield is both unique and valuable in view of the present lack of such knowledge.

DESCRIPTION OF THE COASTAL STREAMS

Distinction of the Streams

The biological characteristics of the Oregon coastal steelhead trout populations indicate that distinct differences exist in those populations with respect to their geographic location. Therefore, the coastal steelhead streams of Oregon are here separated into two sections, although the sections are by no means equal in area, or number of streams (figure 1). Only streams from which scale samples were examined are considered specifically and shown in figure 1.

Streams which are here considered as being of north coast distinction are, starting with the northernmost: the Necanicum River, Nehalem River, Wilson River, Trask
Figure 1. Streams of the Oregon coast from which steelhead scales were examined.
River, Sand Creek, Nestucca River, Salmon River, Siletz River, and Coos River. The south coast streams are, commencing with the northernmost: The Sixes River, Elk River, Chetco River, and Winchuck River (figure 1). The Coquille River, located between the Coos River and the Sixes River, was not included in either the northern or southern region because the characteristics which its steelhead showed were remarkably intermediate between the extremes exhibited by the two regions. The intermediate position of the Coquille steelhead geographically and biologically seems to justify the consideration of them as transitional between the steelhead of the northern and southern coastal streams.

Physical Characteristics

The physical characteristics of the streams in the two regions of the Oregon coast show only slight distinctions so they are compared simultaneously. Comparisons are made of only the more obvious differences between them. The coastal streams of Oregon are generally clear in spring, summer, and fall, most often becoming muddied and swollen in winter from heavy rains. Moderately rapid flows and steep channel gradients typically describe most of the streams. With two exceptions, the head waters of these streams are in the Coast Range mountains. The two
largest systems, the Umpqua and Rogue rivers, which are not considered in this thesis, head in the Cascade Range about 100 miles from the ocean.

The streams in the Coast Range originate from a maximum elevation of about 2500 feet. These streams course a maximum distance, in the Nehalem River, of about 113 miles, to a minimum distance, in the Necanicum River, of roughly 25 miles (30, p.6).

All coastal streams have a wide range of water flows, because of heavy rainfall in the winter months, and comparatively dry spring, summer, and fall seasons, at which times water temperatures may rise even above 70 degrees Fahrenheit (22, p.3). The average annual rainfall along the entire Oregon coast west of the Coast Range varies between 50 and 100 inches, decreasing from north to south by no more than three or four inches (32, p.3). The normal annual precipitation in the Coast Range varies from 50 to 130 inches with the southern portion of the range receiving slightly less than the northern portion. Precipitation on the western slopes of the Coast Range above 2000 feet in elevation averages about 138 inches annually (10, p.948-949; 32, p.3; 33, p.1-38).

The mean annual air temperature west of the Coast Range varies from 50-52 degrees Fahrenheit, with the southern temperatures ranging only two or three degrees
warmer than those in the north. The mean annual temperature for the Coast Range is slightly below 50 degrees Fahrenheit, but is somewhat warmer in the southern portion (32, p.3).

The mildest winter nights are on the southern coast, and the coolest summer days are on the middle and south coast. The cooler summer temperature on the south coast is due largely to the direct cooling effect of the ocean, which is particularly cold along the coast of southern Oregon and northern California in the spring and summer months (32, p.2). The cool temperature of the ocean in the summer and spring is due to extensive upwelling of the cold lower water strata. The coldest surface temperature in the area of upwelling is generally centered around Point Arena, California, with the water temperature as far north as the vicinity of Cape Blanco, Oregon, still considerably lower than the water further north (3; 26, p.6-7; 34, p.10-23). In four separate samples of surface sea temperatures taken during the summers of 1949 and 1950 by Scripps Institute research vessels, the temperatures at Point Arena, California, averaged about 52 degrees Fahrenheit, and at Cape Blanco, Oregon, located near the mouth of the Sixes River, they approximated 54.6 degrees, while the temperatures off the Columbia River averaged about 62 degrees. In late summer, a single sample showed Point Arena and
Cape Blanco surface temperatures to be equal at 51.4 degrees Fahrenheit, while at Monterey, located between Arena and Blanco, the surface temperature was 51.8 degrees (3; 26, p.31).

**Biological Characteristics**

The biological, physical, and chemical characteristics of the Oregon coastal streams have been altered to an unknown degree by development and settlement of the basins. Logging and cultivation have generally stripped much of the good cover from areas of moderate elevations to sea level. Winter floods, resulting in scouring of stream beds, are thought to cause huge losses of eggs and bottom fauna in some instances. During summer months, extremely low water levels often occur with consequent elevation of water temperatures to near maximum tolerance levels (22, p.7; 30, p.10).

Most of the coastal streams are divided about equally between pools and riffles. Most of the riffles are of fine gravel and rubble. Aquatic foods generally appear to be adequate in supply to support the fish populations, but limitations of this food are noticeable. In general, mayflies, caddisflies, and aquatic Diptera are fairly abundant. Snails, crayfish and stone-flies are often less predominant. Aquatic beetles, dragonflies, and water bugs
(Hemiptera) are only common in specific habitat areas that are as a rule sparsely represented in the coastal streams. Vegetation in these streams is not at all abundant (22, p.8-9; 30, p.13-17).

Steelhead Runs

With the exception of the Siletz River, all the streams which head in the Coast Range and flow directly to the ocean have only winter run steelhead. The Siletz River has not only a winter migration of fish but it also has a unique summer run. Definitions of winter and summer steelhead are given on page 13.

BIOLOGY AND NOMENCLATURE

A brief outline of the general biology of the steelhead trout is given here to facilitate a better understanding of the presentation made in this thesis.

The steelhead trout is a member of the family Salmonidae, and is defined in this study as the coastal rainbow trout Salmo gairdnerii gairdnerii Richardson, which migrates to and from the ocean at various phases of its life history.

The common name steelhead trout and the scientific name Salmo gairdnerii are herein used from recommendations
of the American Fisheries Society (1, p.360). The subspecific name *Salmo gairdnerii gairdnerii* is employed in compliance with Shapovalov and Taft, and with general acceptance on the West Coast (25).

Present differences in the use of the common name for the steelhead trout are slight, such as "steelhead rainbow trout", "steelhead trout", and just "steelhead". Other common names that are applied to the steelhead trout include the following: "rainbow", applied to individuals in freshwater as juveniles, or as residents which mature and spawn in freshwater; "sea-run rainbow", applied to steelhead trout that have migrated to the ocean; and "half-pounder", applied to small sea-run individuals weighing usually from one pound to two and one-half pounds, a term used particularly on the Rogue River in Oregon and the Eel River in California (13, p.187-199; 21, p.2; 25, p.20-21).

The unofficial, though often used, common name "steelhead" appears in this thesis for the sake of brevity, but the reference is to the same fish.

The migratory rainbow trout typically inhabits coastal streams of the Pacific Coast of North America, with a general distribution from the Santa Margarita River in San Diego County, California, northward to Bristol Bay, Alaska. It also occurs in eastern Siberia (37, p.15).
Steelhead trout are ordinarily anadromous, staying in freshwater during juvenile life for a period of two years, but may stay less than one year or as long as four years. The great majority of steelhead, as far as is known, migrate to the ocean, gain their greatest growth, and attain sexual maturity there, at which time they generally return to spawn in their "home" streams in which they were reared. These fish, both male and female, generally return to freshwater to spawn after two seasons in the ocean, although some reach maturity after one year at sea, and some may require three years of ocean residence. All steelhead are capable of spawning more than once, since their life does not always end after spawning as is the case with Pacific salmon. Therefore, those steelhead that survive the rigors of spawning may make their way back to the ocean and return again to spawn in freshwater in subsequent years. Occasionally individuals may spend their entire life in freshwater as resident fish. Such freshwater residents are capable of attaining sexual maturity and spawning without descending to the ocean. Also, exceptions occur where a few steelhead may spawn in freshwater before their initial migration to the ocean.

The eggs are deposited in depressions called redds, dug in the gravel of the stream by the female. Immediately upon extrusion, the male fertilizes the eggs and they are
covered with gravel by the female. After a period in the gravel, varying from 19 days at an average temperature of 60 degrees Fahrenheit to about 80 days at an average temperature of 40 degrees, the eggs hatch and the young steelhead, after absorbing the yolk sac, make their way out of the gravel to the open stream bed (25, p.144,154-156). The young fish spend a period of time in freshwater and then migrate to the ocean. It is the general opinion today that evidence obtained through marking experiments carried out by scientific workers has definitely established the existence of "homing" in the steelhead. Individuals reared in a particular stream as juveniles will generally return as adults to the same stream each year to spawn (21, p.10; 25, p.197; 39, p.24).

Terms Applied to Life History Stages

The following is a list of terms in general use by fishery workers as applied to various stages in the life history of the steelhead. The definitions are adapted mainly from Shapovalov and Taft (25, p.21).

Fish of the year. Fish in its first year of life, which has not passed through a full winter.

Yearling. Fish in its second year of life, which has not passed through a second full winter.

Juvenile. Fish which is sexually immature.

Immature fish. Fish which is sexually immature.
Adult. Fish which has matured sexually in one or more summers of sea life. This term includes grilse.

Grilse. Fish which has matured sexually after only one summer of sea life.

Resident fish. Fish which is an offspring of parents that spawned without having been to sea.

Sea-run fish. Fish which has entered a stream to spawn after one or more summers of sea life.

Stream fish. Fish which has not been to sea, irrespective of its parentage or sexual maturity.

Native fish. Fish which has hatched and lived in the stream its full life, as opposed to hatchery fish which are hatched and reared artificially.

Green fish. Fish whose sexual products are in a primary stage of development for spawning.

Ripe fish. Fish which is ready for spawning.

Spent, or spawned out, fish. Fish which has spawned in culmination of the spawning migration.

Maturity. Stage in life when fish has matured sexually.

Initial spawner. Fish which has succeeded in spawning for the first time.

Repeat spawner. Fish which has spawned one or more times previously.

Winter run fish. Fish which enters a stream at any time from the late summer through the following spring and will spawn sometime during that same period.

Summer run fish. Fish which enters a stream in summer or fall, but will not spawn until the following fall, winter, or spring.
DESCRIPTION OF SCALES

Formation and Purpose of Scales

A scale from the steelhead trout is an epidermal structure which is deeply pocketed anteriorly in a fold of skin. Its primary purpose is to greatly increase the effectiveness of the skin as a protective covering for the fish. Each scale first appears on the surface of the body of the very young fish as a somewhat circular plate with thickened edges, which when examined microscopically looks like a more or less complete ring. As the fish increases in length, succeeding plates, which appear as additional rings, are added with the growth of the scale, and are termed circuli. Barring accident, the scales are permanent, and the growth of the scale is usually in proportion to the growth of the body (27, p.359-361).

Typical Scale Features

In order to illustrate clearly the parts, and the formation of a steelhead trout scale, a photomicrograph of a scale magnified about 10 diameters is presented in figure 2. This illustration represents a typical scale of a steelhead trout, from a five year old female 31 1/2 inches in length and 14 pounds in weight, which was taken February 14, 1955 in the Coquille River.
Figure 2. Typical scale of Oregon steelhead trout (*Salmo gairdnerii gairdnerii* Richardson). A sport caught female from the Coquille River, five years old, 31\(\frac{1}{2}\) inches in length, and 14 pounds in weight, captured February 14, 1955. A, annuli; Ant., imbedded anterior portion of the scale; N, nucleus; Post., exposed posterior portion of the scale; S, spawning check.
When the scale is in normal position on the fish, the imbedded, differentiated area (Ant.) at the top in figure 2 is directed anteriorly and is therefore designated as the anterior area. The area (Post.) opposite the anterior is designated as the caudal, or posterior, area. The anterior area is the portion which was embedded in the skin, while the posterior end is the exposed part. Near the center of the scale is a small, clear area (N) called the nucleus or focus. This area represents the primitive plate which is first laid down in the early development of the scale. Around this primitive plate are concentric striations termed rings, lines, or circuli which represent the edges of additional plates laid down through added growth (27, p.361; 36, p.381).

By careful examination, two distinct zones can be seen to exist in the scale, an inner zone, definitely characterized by more closely spaced circuli, and an outer zone in which the circuli are much farther apart. The inner zone, with its closely spaced circuli, represents the entire freshwater growth of the young steelhead previous to entrance into salt water, while the outer zone, with its widely spaced circuli, represents rapid growth of the fish after migration into the sea.

The distance between the circuli of the two zones clearly shows the marked contrast between the slow fresh
water growth, and the rapid ocean growth. Within both of the above mentioned and described areas, the circuli succeed each other in fairly regular fashion, and are quite complete, with only occasional breaks and irregularities. Than at a region (A) in figure 2 they become somewhat broken, anastomosed, and much closer together. This region of closely apposed and broken circuli is termed an annulus, or year check, which stands out as a rather sharply defined band. Beyond the annulus, circuli are again quite complete and farther apart. The annulus is known to mark the annual slow down or retardation of growth caused by the adverse conditions of winter. The regions of bold, widely spaced circuli represent periods of rapid growth, generally during spring and summer (27, p.361-362; 36, p.381-382).

In such fish as the steelhead, which spawn during the winter, a period of slow growth, the spawning check (S) is identifiable in the scale due to the effect of the rigors of spawning. Such checks are generally assumed to be caused by the absorption of the scale periphery due to insufficient food and excessive utilization of stored body reserves (6, p.48-49; 39, p.38-40). As a result of this action, parts of the scale and even its circuli are erased. When growth is again resumed after spawning, the affected, indented areas of the scale are usually replaced rapidly
without the formation of circuli. However, the uniformly clear area which constitutes a spawning scar, or check, varies in prominence with different individuals and populations. In some instances there is no rapid addition to the scale resulting in an obvious spawning check, and the only indication of the fish having spawned is the crossing over of outer circuli across the paths of partly obliterated ones. In other cases the clear spawning scar may be of a width equal to that of at least four or five circuli.

Irregular Scale Features

The most typical scales from each individual scale sample were chosen for examination. This choice was made to take advantage of the scales which provided the easiest and most accurate interpretations. The two most common types of irregular scales are here discussed to better illustrate their drawbacks for scale interpretation.

By far the most common aberration among the steelhead scales examined was that of regeneration. A regenerated scale is a new scale grown in replacement of one lost by the fish. Such a scale is characterized at the center by an undifferentiated plate which lacks any sign of circuli or annuli. This is due to rapid growth which is carried on until the scale has again filled in the area made
vacant by the loss of the scale. When the scale has attained a size nearly proportionate to the other scales on the fish, the circuli and annuli are again regularly formed. The regenerated plate may therefore vary in size from one equal only to the diameter of one or two circuli, to one constituting the entire scale of an adult fish. The size of the replaced portion is determined by the time in the fish's development when the previous scale was lost (6, p.46-48). The only other irregular scale feature which occurred often enough to warrant mention was scale absorption. Scale absorption, as described on page 17, was a very common irregularity. It was most often observed in repeat spawners or fish of greater age than the average.

METHODS AND MATERIALS

Scale Samples and Scales

Sources of Collections

Nearly all scale samples available for use in this study were collected by Oregon State Game Commission personnel. A few samples were supplied by interested individuals who were aware that the steelhead investigation was being conducted. The scales were received at the Wildlife Research Unit at Oregon State College.
All scale samples dealt with in this thesis were from adult steelhead captured in freshwater on spawning migrations. Scale samples were taken in the field, generally from sport caught steelhead, but in some instances from fish captured in Game Commission stream traps. Nearly all samples were taken from steelhead captured prior to spawning. Only a few fish were taken in a spent condition.

Collecting Procedure

The scales were usually removed from the left side of the body, midway between the lateral line and the dorsal fin. Scales were deposited in standard Oregon State Game Commission scale envelopes. Spaces for collection number, species, locality, date, length, weight, sex, stage of organs, year, gear used for capture, and collector were provided on each envelope.

As far as is known, all fish were measured to fork length; that is, from the tip of the snout to the fork of the caudal fin. Hereafter, reference to length will automatically refer to this measurement.

Measurements were made using a small steel tape in a straight line not following the curvature of the body. Nearly all measurements were recorded in inches to the nearest quarter or eighth. Where length measurements were reported in millimeters, they were converted to inches in
the analyses. The majority of fish were weighed with Chatillon 10 and 30 pound capacity spring scales. The weights in all cases were reported in pounds and ounces. These units are also the same used throughout this thesis.

The stage of development of the reproductive organs of individuals was designated on the scale envelopes as green, ripe, or spawned out, with varying qualifications sometimes added to any one of the three terms, such as very ripe or partly ripe. The terms refer to the condition of the gonads at the time each fish was captured.

Selection

There were more samples available from some watersheds than could be used. Under such circumstances, the samples were sorted carefully to select those with complete data that would best represent the stream populations. In the majority of cases, all the scale samples were used.

The selection of scales for mounting and reading was accomplished by sorting the scales under a Spencer binocular dissecting scope of 50X magnification. The scales selected were those most nearly normal in appearance and showing the fewest irregularities. In some instances, when the full complement of five normal scales per slide could not be provided, some abnormal or regenerated scales,
with disfigurement not too severe, were added to help clarify certain phases of the life history of a particular fish.

Cleaning

Scales were cleaned for mounting by first immersing them in a dilute 15:1 solution of sodium hypochlorite (Clorox or Purex) and water for about two or three minutes to loosen mucus and dirt. The scales were then cleaned physically of the more persistent particles. They were generally cleaned merely by rubbing between the fingers. Small scales were cleaned by holding them with a dissecting needle and brushing with a trimmed camel's hair brush. Large, exceptionally dirty scales were often cleaned by rubbing with cheesecloth between the fingers.

Mounting

Five scales of each sample were arranged in the center of a standard microscope slide and covered with a second slide. Both ends of the slide were then bound with drafting tape. The scales were arranged on each slide with the anterior edges all pointed in the same direction, i.e., perpendicular to the length of the slide. This arrangement of the scales facilitated reading and comparison of one scale with another on the same slide. None of
the mounted slides were labeled or marked. Instead, each slide with its mounted scales was slipped back into its respective scale envelope. Not labeling the slides saved time and alleviated errors through transcription of data.

**Scale Reading**

**Validity of Determining Age from Scales**

The use of fish scales as indices to age has been known and applied for many years. It is generally known that Leeuwenhoek (1632-1723), the pioneer Dutch microscopist, conjectured from the sculpturing of scales that the circular lines might be records of age (17, p.1; 23, p.304). Rounsefell and Everhart (23, p.304) stated that Hoffbauer (12, p.341-343) in 1898, who worked with carp of known age, was able to interpret correctly the age of the fish from their scales. The validity of aging fish by examination of their scales has since been established by many workers, such as Taylor (31, p.285-330), Van Oosten (36, p.387-395), J. O. Snyder (28, p.1-6), and Hile (11, p.201-205). More recently, some of the workers who have proven the scale method valid for steelhead are Meigs and Pautzke (16, p.4-15) and Shapovalov and Taft (25, p.206-239).
Validity of Back Calculated Fish Lengths from Scales

In addition to age determinations from scales, it is possible to calculate the size of fish at given periods earlier in life from measurements on the scales (4, p.6). The procedure used in this thesis for measuring the scales is given on pages 27 to 30. Dahl (7, p.1-141) originated the method of utilizing scale measurements in conjunction with fish measurements at the time of capture to determine the size of fish at any given periods in earlier life on the assumption that scale growth is proportional to fish growth throughout life.

That is: 

\[
\frac{\text{Length of fish at end of year } X}{\text{Length of fish when scale was removed}} = \frac{\text{Length of scale radius to annulus } X}{\text{Total length of scale radius when scale was removed}}
\]

The accuracy of this scale method depends on three primary conditions (35, p.278):

1. The scales must remain constant in number throughout life.

2. Growth of the scales must be proportional to the growth of the fish.

3. The annulus must be formed yearly and at the same approximate time each year.

Since the direct proportion relationship was first established, numerous fishery biologists have demonstrated for many different species of fish that for practical
purposes this simple relationship may be utilized to determine the length at the end of any given year. Some such presentations were by Van Oosten (35, p.301-344) for the whitefish, Hile (11, p.189-337) for the rock bass, and Greeley (9, p.361-378) for the rainbow trout. The validity of the body scale relationship has been demonstrated for the Pacific salmon and other salmonids by many biologists; specifically, for the rainbow trout by Mottley (18) and Bishop (2).

Since the scales in the steelhead trout, as well as many other species, do not appear until growth of the young has commenced, and since scale growth rarely is exactly proportional to body growth, correction for such discrepancies are generally considered necessary. Numerous investigators have made modified formulas from Dahl's original direct proportion formula to allow for discrepancies caused by disproportionate growth of the scales and body. Fraser (8) presented a formula modified from the above mentioned formula which was found to be best suited for this study, and it is employed here as described on page 31.

Terminology of Scale Reading

Any closely spaced and irregular group of circuli is termed a check. A check that forms between annual growing
seasons is termed a **year check** or **annulus**, while one that forms as a result of some disturbance during the course of the growing season is termed a **false check** or **false annulus**. The part of the scale which is formed during residence in freshwater is termed **freshwater growth**, and the checks formed during that time are termed **freshwater checks** or **freshwater annuli**. Likewise, the part of the scale formed at sea is referred to as representing **ocean growth** or **salt water growth**, and the characteristics of that part of the scale are generally referred to with the saltwater or ocean prefix (25, p.22). The portion of the scale formed after the last freshwater annulus and before entrance to salt water is generally referred to as **plus growth** or **intermediate growth**, or in the life history pattern formulas is symbolized with a \(^+\). **New growth** indicates the portion of the scale formed during the growing season after the last annulus and up to the next annulus, or up to the time of capture of the fish. The spawning check, scar, or mark is called a **spawning check**. Scales which have replaced others and have blank centers as a result are, as described on page 18, termed **regenerated scales**, or simply **regenerated** (25, p.22).
Reading and Measuring

Scales studied were read and measured on a scale projection machine with magnification of 112 diameters. This machine is the latest model developed by Drs. John Van Oosten, Hilary J. Deason, Frank W. Jobes and Ralph Hile of the United States Fish and Wildlife Service (17, p.2). A photograph and description of this machine is provided by Moffet (17, p.2-3).

Scales which proved difficult to interpret and caused uncertainty as to the accuracy of their interpretations from the microprojector were then read with the aid of a binocular microscope of 50 X magnification. When interpretation was still uncertain, a new slide of five different scales was made, or if no normal scales remained, the sample was omitted from consideration.

The scales from each stream were given a brief, preliminary scanning to gain a familiarity with their characteristics. The first examination dealt only with interpretation and recording of the annuli. At the second examination, measurements were made of those scales whose readings matched the interpretations of the first. At the third reading, the questionable interpretations were checked again. If they agreed with the first two they were then measured. Interpretations still considered questionable were so designated, and the scales were then
read with the microscope to make the interpretations definite, and to determine whether the samples in question would be retained or omitted from consideration.

After the fish lengths had been back-calculated from the scale measurements, extraordinary growth shown by the calculated lengths in any particular year of any individual fish was checked with the aid of the microscope or microprojector to note any errors.

When interpreting the scale characteristics, reference to the initial or previous interpretations was seldom made until the subsequent reading had been completed. This was done to avoid injecting prejudice into the readings. The data accompanying the scales was referred to readily to better facilitate the interpretations.

Measurements were made from the focus to all freshwater annuli, to the point of entry into salt water, to all subsequent salt water annuli, and to the very edge of the scale. The scales were measured along the antero-posterior axis of each scale. For these measurements, the ruler was placed slightly diagonally to the midantero-posterior axis where the annuli were generally most obvious. Measurements were made from the focus of the scale to the outer extremity of each annulus just at the point where abrupt new growth was again evident. The final
measurement was made at the anterior edge of the scale. All measurements were recorded to the closest millimeter. The rule was always placed at about the same diagonal for measuring. In order to do this the scale from each fish sample which provided the clearest reading in that plane was chosen.

In the case of fish such as the steelhead that spawn at the end of or between growing seasons, an annulus often is obscured by a spawning check. Therefore, scale measurements were made at the beginning of the new growth, thus including the annulus or the spawning check or both within the measurement. Measurements were made at the beginning of the growth season rather than at the end, because from scale examinations it was usually difficult to mark the exact point where new growth began. This is not a clearly marked point, but it appears as a gradual narrowing of the distance between the circuli. On the other hand, the end of the formation of the annulus and commencement of new growth is nearly always quite clearly marked (25, p.23-24).

A major difficulty existed in making measurements. The difficulty was a result of disfigurement of the scale caused by spawning. Spawning checks present in older individuals usually showed such extreme absorption that the circuli, and even whole annuli, were sometimes
obliterated. Where absorption had obscured the circuli, accurate measurements were difficult to obtain. However, absorption in most instances affected the lateral fields most seriously, although in some cases even the anterior field was affected, thus undoubtedly injecting error in the measurements and underestimating growth after spawning. The effect of absorption was minimized somewhat by measuring to the most distal point of the last circulus remaining in the anterior field.

Hatchery Fish

Scales from steelhead that had been reared in hatcheries were recognized in most cases by notations on the scale envelopes that both ventral fins and the adipose were absent. Otherwise, since not all Oregon hatchery released fish are marked, they were recognized as being hatchery reared by the wide, evenly spaced circuli representing freshwater growth while in the hatchery.

Few of the steelhead scales from hatchery reared fish showed more than just a few constricted annuli, if any, beyond the widely spaced circuli, thereby suggesting that these fish must move to the ocean very shortly after they are released.

In the years prior to and including 1951, hatchery
reared steelhead in Oregon were released as fish of the year, and therefore showed no annuli in the freshwater hatchery growth. In 1951, some of the hatchery steelhead were held until the following year and released as yearlings after spending one winter in the hatchery. Since 1951, all of the steelhead have been released in the coastal streams of Oregon as yearlings after spending one winter in the hatchery, and these exhibit one annulus in the hatchery growth.

It is not likely that all unmarked hatchery fish were recognized, because scale growth from unmarked fish that showed any variations from that normally encountered in hatchery growth were considered native fish. In streams from which no marked fish were taken, scales were not considered to be from hatchery released fish unless the characteristics they showed were unmistakably a result of growth in a hatchery.

Back Calculations

Back calculations of fish lengths were made with C. McLean Fraser's direct proportion formula

\[ l_1 = \frac{c + s_i(L-c)}{S}, \text{ or } \frac{l_1 - c}{L - c} = \frac{s_i}{S} \]

modified from Dahl (7, p.1-141; 8, p.29-35). The symbols are defined as:
L = length of fish when scale was removed;

S = length of scale radius when scale was removed;

\( l_i \) = length of fish when the annulus \( i \) was formed (age \( i \) years);

\( s_i \) = length of scale radius to annulus \( i \) (age \( i \) years), where \( i \) can take values up to the age of the fish involved;

c = constant, correcting for low computed values for the sizes of young fish.

It is assumed for the valid use of this formula that the fish-scale relationship is proportional and describes a linear regression. This formula introduces the constant (c), or correction factor, into the scale equation which relieves much of the discrepancy resulting in low computed values for the sizes of young fish caused by scale formation after growth of the young fish has commenced, and for any discrepancies caused by disproportionate body and scale growth (6, p.48-60; 24, p.298-303).

The value for the constant (c) used in the formula for this thesis is 1.10 inch. The value 1.10 inch was adopted as the result of a plotted regression line, computed by the method of least squares, comparing scale and body length relationships of 97 Oregon steelhead, 69 adults and 28 immatures of the same year class from Sand Creek on the north central coast of Oregon. The constant, 1.10 inch, derived from the Sand Creek specimen comparison is used in computing lengths for all the other
streams, since none of the other streams had samples sufficiently large to meet the requirements of such a regression; i.e., sufficient numbers of samples to provide scales from fish of a wide range of lengths which were hatched in the same year (6, p.48-60; 38, p.22).

Snyder (27, p.365), working with rainbow trout in California, found that scales first appeared on the body when the fish were 35 to 40 mm., or 1.38 to 1.57 inches; Meigs and Pautzke (16, p.5) found initial scale formation in steelhead trout examined from Washington to occur at a length of 32 mm., or 1.26 inches; and Bishop (2, p.1-10) reported rainbow trout from Prickly Pear Creek, Montana as having a body-scale relationship which closely fitted a straight line with an intercept, or correction value of 1.10 inch.

In view of the close comparison of the value 1.10 inch obtained from Oregon steelhead with the values reported in the literature, it seems justifiable and satisfactory to use the 1.10 inch constant in this study for computing the back lengths of steelhead of Oregon. This view is further justified by Schuck (24, p.300) where he explains that the length of the fish at the time of scale formation does not necessarily best represent the intercept, (c), although it is generally quite close and may act as a good estimate of that value.
Designation and Recording of Age and Spawning

The designation and recording of age as used here is modified from Shapovalov and Taft (25, p.23-25). The year in which the fish is hatched is considered as the brood year, and the end of a growing period and beginning of a new growing period have been chosen as the point marking the completion of one year of life. It seems logical, especially in the case of steelhead, to consider the year in which a fish hatched as the brood year, or first year of life, rather than the year the egg was fertilized. As pointed out by Shapovalov and Taft, in steelhead, as is true of many other fish, the beginning of the calendar year occurs during the middle of the spawning season, while the hatch is always within a calendar year. The time of hatching in all fishes is ordinarily followed by a growth period within the same calendar year, while the time of fertilization often is not. The time of hatching marks the beginning of growth of the fish in its approximate final form.

In the case of steelhead, it is thus logical to consider the end of a growing period and beginning of a new growing period as the end of one year of life. Salmonids spawn only once a year and a definite growing period normally intercedes between the spawning seasons. Thus, growing periods are used as indices of years of
life, and the end of a growing period marks the end of a year of life.

Total Age

In accordance with the system outlined above, a fish is in its first year of life from the time that it hatches until the beginning of formation of new growth following completion of the first annulus. The age group of such a fish is recorded by the sign "+". From the time that new growth begins following completion of formation of the first annulus until completion of the second annulus, the fish is in its second year, and its age is recorded by the numeral "1". Upon completion of the second annulus and commencement of new growth, the fish's age is recorded as "2", and so on. In other words, the numerals used to show the age of the fish also show the number of annuli.

Age at Life History Stages

The procedure outlined in the preceding paragraph is adequate when the discussion is concerned only with total age. In presenting the details of the entire life histories of individuals or groups, the following system is used, as modified from Shapovalov and Taft (25, p.24-25).

The sign "/" is used to separate life in freshwater from that in salt water. Thus the numerals on the left
of the slant-line represent freshwater, and those on the right, salt water. A fish that had migrated to sea in its first year of life and had completed that year at sea would be represented by the formula \(+/1\); and a fish which migrated to the sea at the end of its first year in freshwater and spent two years of sea life would be designated by the formula \(1/2\); while the formula \(1+/2\) would denote a fish which spent its first year and part of the second in freshwater, then completed the second year at sea and spent its third year of life also in that environment.

**Spawning Designation**

A capital "S" is used to indicate a spawning check, or that the fish had returned to freshwater on a spawning migration. Therefore, a fish which spent two full years in freshwater, and matured at the end of the first year in the ocean would be described as showing a life history of \(2/S\). A fish which had spent two years in freshwater and matured after its second year in the ocean would be described as having a life history of \(2/1.S\). The period in the formula is used to separate years (growing seasons) followed by a spawning from years not followed by a spawning. In the formula \(2/1.S\) it is apparent that the fish did not mature after its first year in the ocean,
but after the second.

Life history patterns as used here describe the life histories of the steelhead only up to maturity, and do not take into consideration the number of spawning migrations. The scale formulas are therefore not used to describe the number of spawning migrations made by repeat spawners. The number of spawning migrations made by the fish are described in the text and in the tables.

NECANICUM RIVER

Thirty-one of 39 samples were read for age and 30 were measured for growth determination. Thirty-five of the 39 samples were supplied with the year of collection. Four of the samples were taken in 1951, 22 in 1952, three in 1953, two in 1954, and four in 1955. The dates of collection for the five years ranged from December 1 to February 26.

Spawning History

Fifteen of the 39 samples had information included which related to development of the reproductive organs of the fish when caught. Sex of the fish and month of capture were available from 31 of the samples.

In December, eight fish, including six males and two
females, were taken. The samples from December with data pertaining to gonad development showed that five males were undeveloped and one male and female were ripe. In January, seven fish of each sex were captured. They showed, from the data available, that one male was undeveloped, and one was ripe, and a single female was fully developed for spawning. In February, two males and seven females were taken; two green females were represented, one ripe male and female, and one spawned out female.

As can be determined from table I, 19 fish, or 61.3 per cent of the 31 steelhead represented in the sample were initial spawners, and 12, or 38.7 per cent had spawned previously. In the total sample, second spawning fish represented only 6.4 per cent, while 32.3 per cent of all the fish were third spawners. The second spawners made up only 16.7 per cent of the fish that had spawned before, while the third spawners accounted for an unusually high 83.3 per cent.

Life History

Seven different life history patterns were found in the 31 scale samples examined from this stream. These patterns are given in figure 3 and table I.
Figure 3. Migration habits and age-growth comparisons by life history patterns of steelhead in the Necanicum River. (figures represent average lengths in inches)
As shown in Table I, the steelhead from the Necanicum River exhibited principally the following life history patterns: 1+/1.S; 2/1.S; and 2+/1.3. These three patterns comprised 77.4 per cent of the entire sample; the last two patterns above were represented in 54.8 per cent of the samples.

Of the 31 samples, six, or 19.4 per cent, were recognized as from hatchery released steelhead. All six were reported as fin-clipped fish. Five of these steelhead showed the life history pattern 1+/1.3, and one showed the pattern 1+/S. Four of the hatchery released fish were males and two were females.
As can be determined from table I, 71.0 per cent of the steelhead remained in freshwater 2/ or 2+ years before they migrated to the ocean. No fish stayed as long as three years in freshwater.

Of the 31 samples studied, three, or 9.7 per cent, represented grilse. Twenty-four, or 77.4 per cent, represented steelhead that had returned to spawn after two years in salt water. Four, or 12.9 per cent, represented steelhead that had three years of salt water existence before they returned to freshwater to spawn for the first time.

**Age, Growth, and Weight**

Back calculations of fish lengths were made from 30 samples. The same number were also considered for weight at capture, while only 18 were analyzed for weight at the time of maturity. In figure 3 the average lengths of the fish are given at the various life stages up to maturity.

The lengths of all fish upon entering salt water averaged 6.9 inches, and ranged from 4.3 to 9.1 inches. Six steelhead were under six inches in length at the time of entry to salt water. Only one fish, 4.3 inches, was less than five inches in length upon entrance to the ocean.

None of the hatchery fish were under six inches in length when they entered the ocean. Of the three fish
from the total sample that were over eight inches in length at entry to the sea, the two largest were hatchery reared fish.

The average length of the steelhead that entered salt water after 2/ and 2+ years in freshwater was 6.4 inches and 7.6 inches respectively. The three native fish that entered salt water as 1+ fish averaged 6.2 inches in length. All the hatchery fish averaged 7.5 inches in length.

The average length of all fish at maturity was 29.0 inches, and the lengths ranged from 20.8 to 36.0 inches. The weights at maturity of 18 fish averaged nine pounds, five ounces, and ranged from six pounds, four ounces to 16 pounds, two ounces. The ages at the time of initial spawning ranged from two to five years.

The lengths of all steelhead at the time of capture ranged from 27.5 to 36.0 inches and averaged 31.1 inches. The average weight at time of capture was 11 pounds, two ounces, and ranged from six pounds, four ounces to 17 pounds, eight ounces. The ages at capture ranged from three to seven years.
Sex, Age, Growth and Weight

The males exceeded the females in average length, except at the following times: at entry to salt water, the first salt water year before maturity, and at the time of capture.

Of the 14 males represented in the sample, five entered the ocean in the second years of life as yearlings, as did four of the 16 females. Nine of the males and 12 of the females were 2/, or 2+/ fish when they entered the salt water environment. None of the fish had remained in freshwater as long as three years before migrating to the sea.

Three fish, all females, returned to freshwater to spawn as grilse. Of all 16 females, 10 spent two years in salt water before they reached maturity, as did 13 of the 14 males. One male, and three females remained in salt water three years before they returned to freshwater to spawn.

At maturity the males averaged 29.6 inches in length, and nine pounds, two ounces in weight, while the females averaged 28.6 inches in length, and nine pounds, 11 ounces in weight. The ages of the males ranged from three to five years and the females from two to five years. At capture the males averaged 29.9 inches in
length, and weighed 10 pounds, five ounces as an average, while the females averaged 32.1 inches in length and 11 pounds, seven ounces in weight. The ages of the males ranged from three to six years and the females from three to seven years.

The 30 samples compared for sex ratios indicated a ratio at time of capture of 1:1.1, with 14 males and 16 females represented. Eighteen sexed fish taken as initial spawners exhibited a sex ratio of 2:1. Two females, but no males, returned to spawn a second time, and two males and eight females returned to spawn a third time. Two of all the males, or 14.3 per cent, were taken as repeat spawners, while 10 females, or 62.5 per cent, had returned to spawn more than once.

NEHALEM RIVER

Forty-six of 48 samples were read for age and measured for growth determination. Forty-five of the 48 samples were supplied with the year of collection. Thirteen of the samples were taken in 1951, 24 in 1952, one in 1953, and seven in 1955. The dates of collection for the five years ranged from December 11 to February 26.
Spawning History

Thirty-one of the 48 samples had information included which related to development of the reproductive organs of the fish when caught. All 48 samples had the sex and month of capture included.

In December, 17 fish, including 14 males and three females, were taken. The samples from December with data pertaining to the reproductive organs showed that 12 males were green and one female was ripe. In January, ten males and nine females were taken, showing from the data available that three males and three females were green.

In February, five males and seven females were taken; all the males were green and five of the females were green, while one was ripe and another spawned out.

As can be determined from table II, 35 fish, or 76.1 per cent of the 46 steelhead represented in the samples read were initial spawners, and 11, or 23.9 per cent had spawned previously. Second spawners were represented by six fish, or 13.0 per cent of the total sample; third spawners represented by one fish comprised 2.2 per cent; and four fish back to spawn for a fourth time represented 8.7 per cent of the total sample. The second spawners accounted for 54.5 per cent of the fish that spawned previously, third spawners for 9.1 per cent, and the fourth spawners for 36.4 per cent.
Life History

Nine different life history patterns were found in the 46 scale samples examined from this stream. These patterns are given in figure 4 and table II.

As shown in table II, there are no noticeably predominant life history patterns displayed in this sample. However, patterns 2/1.8, 2+/1.8, and 2+/2.8 comprised 58.7 per cent of the total sample, and the first two patterns above represented 32.6 per cent of the total. No samples were recognized as from hatchery reared steelhead.

As can be determined from table II, 73.9 per cent of the steelhead stayed in freshwater 2/ or 2+/ years before they migrated to the ocean; 39.1, 34.8, 21.7 and 4.4 per cent remained in freshwater 2/, 2+/, 3/ and 3+/ years respectively.

Of the 46 samples studied, 30.4 per cent showed the fish remained in salt water only one year before they returned to freshwater as mature fish; 43.5 per cent remained two years, and 26.1 per cent stayed in salt water three years before they matured.

Of 34 steelhead that spent 2/ or 2+/ years in freshwater, seven, or 20.6 per cent, returned to spawn as grilse. Seven of the 12 fish that entered the ocean after three years of freshwater existence returned to
spawn as grilse. Twelve fish remained in the ocean for three years before reaching maturity; all of these steelhead had migrated to the sea as 2/ or 2+/ fish.

**Age, Growth, and Weight**

Back calculations of fish lengths were made from 46 samples. Forty-two samples were considered for weight at capture and 34 at maturity. In figure 4, the average lengths of the fish are given at the various life stages up to maturity.

The lengths of all fish upon entering salt water

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**TABLE II**

Life History Patterns of 46 Nehalem River Steelhead, with Spawning Status at Time of Capture, and Frequency of Fish Occurrence in the Various Life History Patterns

<table>
<thead>
<tr>
<th>Life History Patterns</th>
<th>Spawning Migrations</th>
<th>Total Per Pattern</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
<tr>
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<tr>
<td>2. 2+/S</td>
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<td></td>
</tr>
<tr>
<td>3. 2/1.8</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>4. 2+/1.8</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>5. 2/2.8</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>6. 2+/2.8</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>7. 3/S</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>8. 3+/S</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>9. 3/1.8</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Totals</td>
<td>35</td>
<td>6</td>
</tr>
</tbody>
</table>
Figure 4. Migration habits and age-growth comparisons by life history patterns of steelhead in the Nehalem River. (figures represent average lengths in inches)
averaged 6.5 inches and ranged from 4.1 to 10.1 inches. Only three steelhead were over eight inches in length upon entrance to salt water. They ranged in length from 8.2 to 10.1 inches. Fourteen fish, representing 30.4 per cent of the total sample, were under six inches in length at entry to salt water, and four of these were between four and five inches in length.

The average length of the steelhead that entered salt water after 2/ years in freshwater was 6.0 inches, after 2+/ years in freshwater, 6.8 inches, 3/ years, 6.7 inches, and after 3+/ years, 7.0 inches.

The average length of all fish at maturity was 27.5 inches, and the lengths ranged from 15.5 to 38.0 inches. The weights at maturity of 42 fish averaged seven pounds, 15 ounces and ranged from one pound, eight ounces to 17 pounds, eight ounces. The ages at the time of initial spawning ranged from three to five years.

The lengths of all steelhead at time of capture ranged from 15.5 to 38.5 inches and averaged 28.7 inches. The average weight at time of capture was nine pounds, six ounces, and the weights ranged from one pound, six ounces to nineteen pounds, nine ounces. The ages at capture ranged from three to eight years.
Sex, Age, Growth, and Weight

The males nearly always exceeded the females in average length at all stages of the life history, but the females showed a greater average size at capture than the males.

Eighteen of the 27 males, or 66.7 per cent remained 2/ or 2+/ years in freshwater before migrating to the ocean. Of 19 females, 16, or 84.2 per cent also remained in freshwater for 2/ or 2+/ years.

Fourteen fish, 12 of which were males, returned to freshwater to spawn as grilse. Of all 27 males, 10, or 37.0 per cent, spent two years in salt water before they matured, as did 10 of the 19 females, or 52.6 per cent. Five males and seven females remained in salt water three years before they returned to freshwater to spawn.

At maturity the males averaged 26.3 inches in length and seven pounds, four ounces in weight, while the females averaged 29.1 inches in length and nine pounds, three ounces in weight. The males ranged from three to five years of age at maturity, as did the females. At capture the males averaged 27.2 inches in length and weighed eight pounds, one ounce as an average, while the females averaged 30.9 inches in length and 11 pounds, 11 ounces in weight. The males ranged from three to six years of age at maturity, and the females ranged from
three to eight years of age.

The 46 samples compared for sex ratios indicated a ratio at time of capture of 1.4:1, with 27 males and 19 females represented. Thirty-five fish were taken as initial spawners and produced a ratio of 1.9:1. The second spawners showed a 1:1 ratio with three individuals of each sex represented. Only one fish, a male, had returned to spawn a third time, but four females and no males were taken returning to spawn after three previous migrations. Of the males, 14.8 per cent were taken as repeat spawners, while 36.8 per cent of the females had returned to spawn before.

WILSON RIVER

Thirty-six of 38 samples were read for age and measured for growth determination. Thirty-six of the 38 samples were supplied with the year of collection. Seven of the samples were taken in 1949, eight in 1950, 17 in 1951, and four in 1952. The dates of collection for the four years ranged from November 12 to March 8.

Spawning History

Thirty-four of the 38 samples had information included which related to development of the reproductive
organs at capture, sex of the fish, and month of capture. Two males and three females captured in November were sexually undeveloped. In December, 21 fish, 14 males and seven females were taken. Eleven males and all the females were undeveloped, while three males were ripe. One male taken in January was in a green condition, and a single female taken in the same month was ripe. In February, one male and three females were taken; the male was undeveloped, as were two of the females, but one female was in spawning condition. Two fish taken in March, one male and one female, were reported as ripe and green, respectively.

As can be determined from table III, 27 fish, or 75.0 per cent of the 36 steelhead represented in the sample were initial spawners, and nine, or 25.0 per cent, had spawned previously. Second spawners were represented by eight fish, or 22.2 per cent of the total sample. There was only a single third spawner. The second spawners accounted for 88.9 per cent of the repeat spawners.

**Life History**

Ten different life history patterns were found in the 36 scale samples here considered. These patterns are given in figure 5 and table III.
The steelhead in the Wilson River, as shown in table III, exhibited mainly the following life history patterns: */1.S, 2/1.S, 2*/1.S, and 3/S. These patterns constituted percentages of 13.9, 25.0, 19.4, and 13.9 per cent of the total sample respectively. The four patterns combined accounted for 72.2 per cent of the total sample. The patterns 2/1.S and 2*/1.S comprised 44.4 per cent of the total sample.

Of the 36 samples, five, or 13.9 per cent, were recognized as from hatchery released fish. Four of these fish were fin-clipped; the other sample was recognized as

### Table III

<table>
<thead>
<tr>
<th>Life History Patterns</th>
<th>Spawning Migrations</th>
<th>Total Per Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>one</td>
<td>two</td>
</tr>
<tr>
<td>1. */1.S</td>
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<tr>
<td>2. 2/S</td>
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<tr>
<td>3. 2*/S</td>
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<td>2</td>
</tr>
<tr>
<td>5. 2*/1.S</td>
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<tr>
<td>6. 2/2.S</td>
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</tr>
<tr>
<td>7. 2*/2.S</td>
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<td>1</td>
</tr>
<tr>
<td>8. 3/S</td>
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<tr>
<td>9. 3*/S</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>10. 3/1.S</td>
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<td></td>
</tr>
<tr>
<td><strong>Totals</strong></td>
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<td>8</td>
</tr>
</tbody>
</table>
from a hatchery fish by the characteristic growth shown in the scales. All the hatchery reared steelhead, three males and two females, were $+/1.5$ fish, and were the only representatives of that life history pattern.

As can be determined from table III, all immature steelhead from this stream, except the hatchery released fish, remained in freshwater at least two years; 33.3, 33.3, 16.7, and 2.8 per cent remained 2/, 2+/, 3/, and 3+ years respectively.

Of the 36 scale samples studied, nine, or 25.0 per cent represented grilse. Twenty-two fish had returned to spawn after two years in salt water and represented 61.1 per cent of all samples. Five samples, or 13.9 per cent showed the fish remained three years in salt water before they returned to spawn.

Of the 24 fish that spent 2/ or 2+/ years in freshwater, only three returned to freshwater to spawn as grilse. Six of the seven fish that entered the ocean after three years of freshwater existence returned to spawn at the end of their first salt water year. All five fish that remained in the ocean three years before reaching maturity entered the sea as 2/ or 2+/ fish.

**Age, Growth, and Weight**

Back calculations of fish lengths were made from all
36 samples. Only 32 samples were considered for weight at capture, and 21 were considered for weight at maturity. In figure 5, the average lengths of the fish are given at the various life stages up to maturity.

The lengths of all fish upon entering salt water averaged 6.4 inches, and ranged from 4.4 to 8.6 inches. Three of the steelhead, or 8.3 per cent, were over eight inches and averaged 8.5 inches at entrance to salt water; none were over nine inches. Ten fish, representing 27.8 per cent of the total sample, were under six inches in length at entry to the ocean. One of these fish was less than five inches in length. The average length of the five hatchery fish upon entering salt water was 6.6 inches.

The average length of the fish that entered salt water after 2/ years in freshwater was 6.3 inches, after 2+/ years, 6.0 inches, 3/ years, 6.6 inches, and after 3+/ years, 9.6 inches.

The lengths of all fish at maturity averaged 26.0 inches, and ranged from 15.7 to 36.7 inches. The weights at maturity ranged from two pounds, four ounces to 12 pounds, eight ounces and averaged six pounds, 14 ounces. The ages at maturity ranged from two to five years.

The lengths at time of capture averaged 27.0 inches and ranged from 15.7 to 40.0 inches. The average weight at time of capture was eight pounds, six ounces and the
weights ranged from one pound, five ounces to 19 pounds, 12 ounces. The ages at capture ranged from two to six years.

Sex, Age, Growth and Weight

The females averaged slightly longer than the males at the end of the first two freshwater years. Thereafter the males exceeded the females at all life history stages except at capture.

Ten males, or 52.6 per cent of that sex, remained in freshwater 2/ or 2+ years before migrating to the ocean. Of the females, 82.4 per cent migrated to the ocean after 2/ or 2+ years in freshwater. Only 5.9 per cent of the females remained in freshwater as long as three years, while 31.6 per cent of the males remained that long.

Of the nine fish that returned to spawn at the end of the first year of ocean existence, eight were males. Three males and two females remained in the ocean three years before returning to spawn. Of the 17 females represented in the sample, 14, or 82.4 per cent, spent two years in salt water before maturing, while 42.1 per cent of the males remained for this same duration.

At maturity the males averaged 25.3 inches in length, and six pounds, seven ounces in weight, while the females averaged 26.7 inches in length, and seven pounds, six
Figure 5. Migration habits and age-growth comparisons by life history patterns of steelhead in the Wilson River. (figures represent average lengths in inches)
ounces in weight. The ages at maturity ranged from two to five years in both sexes. At capture, the males averaged 26.6 inches in length and weighed eight pounds, three ounces as an average. The females averaged 27.5 inches in length and eight pounds, nine ounces in weight. The ages ranged from two to six years in both sexes.

The 36 samples compared for sex ratios indicated a sex ratio at time of capture of 1.1:1 with 19 males and 17 females represented. Twenty-seven fish were taken as initial spawners and exhibited a male to female sex ratio of 1.1:1. Five males and three females were taken as second spawners. Only one fish, a female, was found to have returned for a third time to spawn. Of the males, 26.3 per cent were repeat spawners, while 23.5 per cent of the females had returned to spawn more than once.

TRASK RIVER

Twenty-four of 33 samples were read for age and measured for growth determination. All 33 samples were supplied with the year of collection. Six of the samples were taken in 1954 and 27 in 1955. The dates of collection for the two years ranged from December 12 to February 26.
Spawning History

Twenty-seven of the 33 samples had information included which related to development of the reproductive organs of the fish when caught. The sex of the fish and the month of capture were available from 33 of the samples.

In December, six fish, including four males and two females, were captured. Only one of the six, a green female, had data which gave the stage of the reproductive organs development. In January, 21 fish, 13 males and eight females, were taken. Six of the males were green, six were ripe or near ripe, and one had no data provided. Seven of the eight females were in an undeveloped condition and one was ripe. Of six fish taken in February, all were females; three were green, two nearly ripe, and one was spent at the time of capture.

As can be determined from table IV, 18 fish, or 75.0 per cent of the 24 steelhead represented in the sample, were initial spawners, and six, or 25.0 per cent, had spawned previously. Five of the 24 fish were second spawners and one had returned to spawn for a third time.

Life History

Seven different life history patterns were found in the 24 scale samples examined. These patterns are given
in figure 6 and table IV.

The samples from this river showed only two major life history patterns. None of the other patterns were represented in more than 8.3 per cent of the samples. The major pattern was $2^+/1.5$ and the second most predominant was $2^+/8$. The pattern $2^+/1.5$ was shown by 45.8 per cent of the samples, while the pattern $2^+/8$ was represented in 20.8 per cent.

One sample was identified as from a hatchery reared fish. This fish was a male and was the only individual which showed the $1^+/1.5$ pattern. Fish that remained in freshwater $2^/$, $2^+/$, and $3^/$ years represented 4.2 per cent, 75.0 per cent, and 16.7 per cent of the total sample respectively.

Of the 24 samples studied, 33.3 per cent showed the fish remained in salt water only one year prior to maturity; 58.3 per cent remained two years; and 8.3 per cent stayed in the ocean three years before returning to freshwater to spawn.

Of 19 fish that spent $2^/$ or $2^+/$ years in freshwater before migrating to the sea, six returned to spawn as grilse. Two of the four fish that entered the ocean after three years of freshwater existence returned to spawn as grilse. The two fish that remained in the ocean for three years before reaching maturity migrated to the
Back calculations of fish lengths were made from 24 samples. The same number of samples were also considered for weight at capture, but only 18 for weight at maturity. In figure 6 the average lengths of the fish are given at the various life stages up to maturity.

The lengths of all fish upon entrance to salt water averaged 6.8 inches and ranged from 5.3 to 8.4 inches. Three fish, or 12.5 per cent of the entire sample, were over eight inches in length at the time they entered the ocean as 2+ year fish.

**TABLE IV**

<table>
<thead>
<tr>
<th>Life History Patterns</th>
<th>Spawning Migrations</th>
<th>Total Per Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>one</td>
<td>two</td>
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<td>1. 1+/L.S</td>
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</tr>
</tbody>
</table>
ocean; they averaged 8.3 inches in length. Two fish were slightly under six inches in length at entry to salt water.

The length of a single steelhead that entered salt water as a $1^+$ fish was 6.7 inches, and a single $2^+$ fish was 5.3 inches. The fish that entered as $2^+$ migrants averaged 6.8 inches in length. The $3^+$ year migrants also averaged 6.8 inches in length.

The average length of all fish at maturity was 24.9 inches and the lengths ranged from 17.0 inches to 33.0 inches. The average weight of all initial spawners was six pounds and ranged from two pounds to 13 pounds, eight ounces. The ages of all 24 fish at maturity ranged from three to five years.

The lengths at time of capture ranged from 17.0 to 35.0 inches and averaged 26.0 inches. The weights at time of capture ranged from two pounds to 14 pounds and averaged seven pounds, 10 ounces. The ages of all the fish at capture ranged from three to six years.

**Sex, Age, Growth, and Weight**

The males nearly always exceeded the females in length at all stages of the life history. The females showed only a slightly longer size than the males at time of capture.
Figure 6. Migration habits and age-growth comparisons by life history patterns of steelhead in the Trask River. (figures represent average lengths in inches)
Ten of the 13 males, or 76.9 per cent, remained in freshwater 2/ or 2+/ years before entering the ocean. Of 11 females, nine, or 81.8 per cent, also remained for 2/ or 2+/ years in freshwater. Two males and two females remained in freshwater for 3/ years before migrating to the sea. Only one fish, a hatchery reared male, remained less than two years in freshwater before migrating to the sea.

Of the 13 males, 46.2 per cent reached maturity after one year in the ocean, while only 18.2 per cent of the 11 females reached maturity after the same period of time. Of the males, 53.8 per cent spent two years in the ocean before reaching maturity, while 63.6 per cent of the females showed the same duration in salt water. No males remained in salt water over two years before returning to freshwater to spawn, but two females remained three years in the ocean before maturing.

At maturity the males averaged 23.5 inches in length, and five pounds, four ounces in weight, while the females averaged 26.3 inches in length and eight pounds, 10 ounces in weight. At maturity the males were aged three and four years and the females ranged from three to five years of age. At capture the males averaged 23.8 inches in length and six pounds, three ounces in weight, while the females averaged 28.5 inches in length and weighed nine pounds,
five ounces as an average. The males ranged from three to five years of age at maturity and the ages of the females ranged from four to six years.

The 24 samples compared for sex ratios indicated a ratio at time of capture of 1.2:1, with 13 males and 11 females represented. Eighteen fish were taken as initial spawners and exhibited a male to female ratio of 2:1. Of the males, 92.3 per cent were initial spawners, as were 54.6 per cent of the females. Of five second spawners, the male to female ratio was 1:4 and the only third spawner was a female. Of the males, 7.7 per cent were taken as repeat spawners while 45.5 per cent of the females had returned to spawn more than once.

SAND CREEK

One hundred-seventy of 178 samples were read for age determination and 169 were measured for growth. The year of collection was given with 177 of the samples. Seventy-seven samples were collected in 1947, 66 in 1948, 32 in 1949, and two in 1955. The dates of collection for the four years ranged from October 4 to July 24.

Spawning History

All but five of the 177 samples had information
included which related to development of the reproductive organs at capture, sex of the fish, and month of capture.

A single fish taken in October was a male with the reproductive organs immature, and in December one sexually undeveloped female was taken. A single male and female were taken in January; both were in a green stage of development sexually. In February, of 18 males taken, all were ripe except one which was undeveloped. Eight females were taken in February; five were green, two near ripe, and one was listed as almost spent. Fifty-five males and 68 females were captured in Sand Creek in March and April. All the males were ripe except one taken in April. Sixty-one of the 68 females were ripe, or near ripe, and seven were spent or partly spent. Two males and four females taken in May were in spawning condition. The other thirteen fish, all females, taken in May, June, and July were spent.

As can be determined from table V, 130 fish, or 76.5 per cent of the 170 steelhead represented were initial spawners and 40, or 23.5 per cent were repeat spawners. Thirty-one fish, or 18.2 per cent of the total sample were second spawners; seven, or 4.1 per cent, were third spawners; and two, or 1.2 per cent, were fourth spawners. The second spawners accounted for 77.5 per cent of the fish that spawned before; the third spawners for
17.5 per cent of the repeat spawners and the fourth spawners for 5.0 per cent.

Life History

Ten different life history patterns were found in the 170 samples examined. These patterns are given in figure 7 and table V.

In this stream sample, the outstanding life history pattern, from the standpoint of individual predominance, was the pattern 2+/1.S. It comprised 47.7 per cent of the total number of samples.

Three of the 170 samples, representing 1.8 per cent of the total sample, were fin-clipped hatchery released fish. The scales from the three hatchery fish showed life history patterns 2/S, 3/1.S, and 3+/1.S. The 2/S fish was a male and the other two were females. The male and the 3/1.S female had not returned to spawn before, but the 3+/1.S female was a second spawner.

As can be determined from table V, 12.4 per cent and 61.2 per cent of all the steelhead remained in freshwater 2/ and 2+/ years respectively; 15.9 per cent remained 3/ years and 10.6 per cent remained 3+/ years. No fish remained in freshwater less than two years.

Of the 170 samples studied, 25.3 per cent showed the adult fish returned to freshwater to spawn as grilse;
72.9 per cent matured after two years in the ocean; and only three fish remained three years in salt water before maturing.

Of 125 fish that entered the ocean after 2/ or 2+/ years in freshwater, 24, or 19.2 per cent, returned to spawn as grilse. Of the 45 fish that spent 3/ or 3+/ years in freshwater, 42.2 per cent returned after one year in the ocean. All of the three year ocean residents had entered salt water after only two winters in freshwater.
Age, Growth, and Weight

Back calculations of fish lengths were made from 169 samples. Only 72 samples were considered for weight at capture and 55 at maturity. In figure 7, the average lengths of the fish are given at the various life stages up to maturity.

The lengths of all fish at entrance to salt water averaged 6.4 inches and ranged from 4.6 to 9.0 inches. Seven fish, or 4.1 per cent of the total sample were over eight inches in length upon entering salt water. They ranged in length from 8.1 to 9.1 inches. Forty-one fish were under six inches in length, three of which were less than five inches long.

The average length of the fish which entered salt water after spending 2/ years in freshwater was 5.8 inches; of fish that spent 2+ years in freshwater, 6.3 inches; 3/ years, 7.0 inches; and 3+ years, 6.7 inches.

The average length of all fish at maturity was 23.3 inches. The lengths ranged from 15.0 to 29.8 inches. The average weight of 55 fish at maturity was five pounds, with the weights ranging from one pound, six ounces to 10 pounds. The ages at maturity ranged from three to five years.

The lengths at time of capture ranged from 15.0 to 32.0 inches and averaged 24.2 inches. The average weight
of 72 fish at time of capture was five pounds, seven ounces and the weights ranged from one pound, six ounces to 11 pounds, five ounces. The ages at capture ranged from three to seven years.

**Sex, Age, Growth, and Weight**

The males averaged longer throughout the freshwater existence than the females, while in salt water the females averaged longer than the males.

Forty-nine of the 77 males, or 63.6 per cent, remained in freshwater 2/ or 2+/- years before migrating to the ocean. Of the 92 females, 75, or 81.5 per cent, migrated to the ocean after that same amount of time. Twenty-eight males remained in freshwater as long as 3/ or 3+/- years, while only 17 of the females stayed that long in freshwater.

Of the 42 sexed fish that returned to freshwater as grilse, 38 were males. Of all the males, 49.4 per cent were grilse while only 4.4 per cent of all the females were grilse. Females maturing after two years of ocean existence represented 92.4 per cent of all that sex, while only 50.7 per cent of the males remained in the ocean two years before maturing. Three fish, all females, stayed in the ocean three years before maturing.

At maturity the males averaged 21.5 inches in length
Figure 7. Migration habits and age-growth comparisons by life history patterns of steelhead in Sand Creek. (figures represent average lengths in inches)
and four pounds in weight, while the females averaged 24.7 inches in length and six pounds in weight. The males and females both ranged from three to five years of age at maturity. At capture the males averaged 22.1 inches in length and four pounds, two ounces in weight while the females averaged 26.0 inches in length and six pounds, seven ounces in weight. The ages of the males ranged from three to five years while the females ranged from four to seven years of age.

The 169 samples compared for sex ratios indicated a ratio at time of capture of 1:1.2 with 77 males and 92 females represented. The 129 initial spawners produced a ratio of 1:1. Eleven males and 20 females were second spawners, one male and six females were third spawners, and two females were the only fish that returned to spawn a fourth time. Of the males, 15.6 per cent were taken as repeat spawners, while 30.4 per cent of the females had returned to spawn more than once.

NESTUCCA RIVER

All 55 Nestucca River samples were read for age and 52 were measured for growth determination. All 55 samples were supplied with the year of collection. Three samples were taken in 1947, 11 in 1948, 22 in 1949, five in 1950, two in 1951, one in 1952, one in 1953, eight in
1954, and two in 1955. The dates of collection for the eight years ranged from November 13 to May 7.

**Spawning History**

Thirty-one of the 55 samples had information included which related to development of the reproductive organs of the fish when caught. Fifty-four samples had the sex and month of capture included.

In November, two males and three females were taken. The samples with data pertaining to the reproductive organs showed that two males were green and one female was ripe. In December, 11 males and six females were taken, showing from the data available that two males were green and one was ripe, and four females were green while two were ripe. Seven males and seven females were obtained in January. One green male and one ripe male were indicated as were three undeveloped females and four females in spawning condition. In February, seven males and 10 females showed from the available information that two males were green and one was ripe while five females were undeveloped and two were ripe or near ripe. Only one sample was taken in May. This was from a male, but no information on gonad development was given.

As can be determined from table VI, 39 fish, or 70.9 per cent of the 55 steelhead represented in the sample
were initial spawners and 16 fish, or 29.1 per cent, were repeat spawners. Second spawners were represented by 10 fish, or 18.2 per cent of the total sample; four fish, or 7.3 per cent, were third spawners, and two fish had returned to spawn for a fourth time. The second spawners accounted for 62.5 per cent of the steelhead that returned to spawn more than once; the third spawners accounted for 25.0 per cent and the fourth spawners for 12.5 per cent.

Life History

Twelve different life history patterns were found in the 55 scale samples examined from this stream. These patterns are given in figure 8 and table VI.

The samples from this river showed a marked predominance of two patterns, 2/1.3 and 2+/1.3. Of the other ten patterns, 1+/1.3 was the only one represented by more than 10 per cent of the total sample. Forty per cent of the fish represented in the total sample were of the patterns 2/1.3 and 2+/1.3. About 18 per cent of the fish showed the patterns 2/2.3 and 2+/2.3 and 12.7 per cent showed the pattern 1+/1.3. These five patterns comprised 70.0 per cent of the total sample.

Nine of the 55 samples, or 16.4 per cent, were recognized as hatchery released fish. Seven of these fish
Life History Patterns of 55 Nestucca River Steelhead, with Spawning Status at Time of Capture, and Frequency of Fish Occurrence in the Various Life History Patterns

As can be determined from table VI, 18.2 per cent of
the steelhead stayed in freshwater less than two years before migrating to the ocean. However, all but one of those fish were identified as hatchery reared. Fish that remained in freshwater 2/, 2+/, 3/, and 3+/ years represented 27.3, 38.2, 12.7, and 3.6 per cent of the total sample respectively.

Of the 55 samples studied, 14.5 per cent showed the fish remained in salt water only one year before they returned to freshwater to spawn, while 63.6 per cent remained two years and 21.8 per cent stayed three years.

Of 36 steelhead that spent 2/ or 2+/ years in freshwater, only four returned to spawn as grilse while four of the nine fish that entered the ocean after 3/ or 3+/ years of freshwater existence returned to spawn after the first year in the ocean. Twelve fish remained in the ocean for three years before reaching maturity; none of these fish spent three years in freshwater before migrating to the sea.

**Age, Growth, and Weight**

Back calculations of fish lengths were made from 52 samples. Only 41 samples were considered for weight at capture and 36 at maturity. In figure 8, the average lengths of the fish are given at the various life stages up to maturity.
The lengths of all fish upon entering salt water averaged 6.5 inches and ranged from 3.9 to 9.0 inches. Three fish were over eight inches in length upon entrance to salt water. They ranged from 8.1 to 9.0 inches. Of the four fish that were less than six inches at entry to salt water, one was just under four inches and three were under five inches.

The average length of fish that entered salt water after less than two years in freshwater was 6.9 inches; after 2/ years, 5.7 inches; 2/ years, 6.6 inches; 3/ years, 7.1 inches; and 3/ years, 7.2 inches.

The average length of all fish at maturity was 27.2 inches and the lengths ranged from 18.0 to 37.7 inches. The weights at maturity of 36 fish averaged seven pounds, 12 ounces and ranged from one pound, 14 ounces to 17 pounds, six ounces. The ages at the time of initial spawning ranged from two to five years.

The lengths of all steelhead at time of capture ranged from 18.0 to 37.7 inches and averaged 28.5 inches. The weights at time of capture averaged nine pounds, with the range from one pound, 14 ounces to 19 pounds, two ounces. The ages at capture ranged from two to eight years.
Sex, Age, Growth, and Weight

In this sample the females exceeded the males in average lengths at entry to salt water, at maturity, and at capture.

Nineteen of the 28 males, or 67.9 per cent, remained 2/ or 2+ years in freshwater before migrating to the ocean. Of 24 females, 15, or 62.5 per cent, also remained in freshwater for 2/ or 2+ years. Four of the males and five of the females stayed in freshwater as long as three years.

Of the eight fish that returned to spawn at the end of the first year of ocean existence, six were males and two were females. Five males and five females remained in the ocean three years before returning to freshwater to spawn. Seventeen males and 17 females remained in the ocean two years before reaching maturity.

At maturity the males averaged 27.1 inches in length and eight pounds in weight, and the females averaged the same length and weight as the males. The males ranged in age from three to five years and the females from two to five years. At capture the males averaged 28.4 inches in length and nine pounds in weight while the females averaged 28.7 inches in length and also weighed nine pounds as an average. At capture the males ranged from three to six years of age and the females ranged from two
Figure 8. Migration habits and age-growth comparisons by life history patterns of steelhead in the Nestucca River. (Figures represent average lengths in inches)
to six years of age.

The 52 samples compared for sex ratios indicated a ratio at time of capture of 1.2:1 with 28 males and 24 females represented. Thirty-seven fish were taken as initial spawners and produced a ratio of 1.3:1. Of 10 second spawners, the male to female ratio was 1:1.5, and of four third spawners, 1:3. The only fourth spawner of the fifty-two sexed samples was a male. Of the males, 21.4 per cent were repeat spawners, while 37.5 per cent of the females had returned to spawn more than once.

SALMON RIVER

Twenty-seven of 30 samples were read for age and measured for growth determination. All 30 samples were supplied with the year of collection. Eleven of the samples were taken in 1954, 15 in 1955, and four in 1956. The dates of collection for the three years ranged from December 4 to February 26.

Spawning History

Twenty-nine of the 30 samples included information which related to development of the reproductive organs of the fish at capture, sex of the fish, and the month of capture. In December, six samples were taken from fish
with the reproductive organs in an undeveloped stage. Three of these fish were males. Five fish, all males, were taken in the month of December in a ripe condition. In January, nine green fish were taken. Only one of these was a male. Three ripe fish were taken in January, two were males and one a female. The six fish taken in February were all ripe; five of these were females.

As can be determined from table VII, 19 fish, or 70.4 per cent of the 27 steelhead represented in the sample, were initial spawners and eight, or 29.6 per cent, had spawned previously. Second spawners were represented by seven fish, or 25.9 per cent of the total sample. Only one fish had returned a third time to spawn. The second spawners accounted for 37.5 per cent of the fish that had returned to spawn more than once.

Life History

Seven different life history patterns were found in the 27 scale samples examined. These patterns are given in figure 9 and table VII.

As shown in table VII, the major life history patterns are 2/1.5, 2+/1.5, and 3/3. The per cent of fish showing these patterns are 14.8, 29.6, and 29.6 of the total sample respectively.
TABLE VII

Life History Patterns of 27 Salmon River Steelhead, with Spawning Status at Time of Capture, and Frequency of Fish Occurrence in the Various Life History Patterns

<table>
<thead>
<tr>
<th>Life History Patterns</th>
<th>Spawning Migrations</th>
<th>Total Per Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>one</td>
<td>two</td>
</tr>
<tr>
<td>1. 1+/S</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2. 1+/1.S</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3. 2/S</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>4. 2+/S</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>5. 2/1.S</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>6. 2+/1.S</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>7. 3/S</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Totals</td>
<td>19</td>
<td>7</td>
</tr>
</tbody>
</table>

Three of the 27 samples examined were recognized as from hatchery reared fish; all were males. One fish was designated on the scale envelope as fin-clipped; the other two were recognized by the characteristic hatchery growth shown in the scales. One of these hatchery fish was the only steelhead of the entire sample showing the life history pattern 1+/S. The other two hatchery reared steelhead were 1+/1.S fish.

As can be determined from table VII, the majority of the immature steelhead had stayed in freshwater at least two years; 22.2, 33.3, and 29.6 per cent remained 2/, 2+/, and 3/ years respectively. Only 14.8 per cent of
the immatures remained in freshwater less than two years and three-fourths of these were hatchery released fish.

Of the 27 samples studied, 12, or 44.4 per cent, showed the fish remained in salt water only one year before they returned to freshwater to spawn. Fifteen fish, or 55.6 per cent, remained two years in the ocean environment before maturing.

Of the 19 fish that spent less than three years in freshwater as juveniles, only four returned from the ocean to spawn as grilse. All eight fish that entered the ocean after three years of freshwater existence returned to spawn as grilse.

Age, Growth, and Weight

Back calculations of fish lengths were made from all 27 samples. Twenty-five samples were considered for weight at capture and 10 at maturity. In figure 9, the average lengths of the fish are given at the various life stages up to maturity.

The lengths of all fish upon entering salt water averaged 6.6 inches and ranged from 4.2 to 8.1 inches. Only two fish were less than six inches in length at the time they entered salt water. They were between four and five inches in length. Two fish were just over eight inches in length at entry to the ocean.
The average length of the steelhead that entered salt water as 1+/ fish was 6.7 inches; after 2/ years in freshwater, 6.1 inches; after 2+/ years, 6.5 inches; and after 3/ years, 6.2 inches.

The average length of all fish at maturity was 23.5 inches and the lengths ranged from 18.0 inches to 29.2 inches. The weights at maturity of 25 fish averaged five pounds, 15 ounces and ranged from two pounds, two ounces to nine pounds. The ages at the time of initial spawning ranged from two to four years.

The lengths of all steelhead at time of capture ranged from 18.0 to 30.0 inches and averaged 24.9 inches. The average weight at time of capture was six pounds, eight ounces and the weights ranged from two pounds, two ounces to nine pounds, four ounces. The ages at capture ranged from two to six years.

Sex, Age, Growth, and Weight

The males averaged longer in length than the females only the first year in freshwater and the first year in salt water.

Only 25.0 per cent of the males but 80.0 per cent of the females remained in freshwater 2/ or 2+/ years before migrating to the ocean. Fifty per cent of the males and only 13.3 per cent of the females remained in freshwater.
Figure 9. Migration habits and age growth comparisons by life history patterns of steelhead in the Salmon River. (figures represent average lengths in inches)
3/ years as juveniles. Twenty-five per cent of the males remained in freshwater less than two years, but only 6.7 per cent of the females stayed for such a short duration.

Of the 12 males in the total sample, eight, or 66.7 per cent, returned to spawn as grilse, while only four of the 15 females, or 26.7 per cent, returned after just one year in the ocean. Four males and 11 females remained in the ocean two years before returning to freshwater.

At maturity the males averaged 22.1 inches in length and four pounds, three ounces in weight, while the females averaged 24.6 inches in length and seven pounds, six ounces in weight. The males ranged in age from two to four years and the females were three and four years of age. At capture the males averaged 22.9 inches in length and four pounds, ten ounces in weight while the females averaged 26.6 inches in length and seven pounds, five ounces in weight. The males ranged from two to five years of age and the females ranged from three to five years of age.

The 27 samples compared for sex ratios indicated a ratio at time of capture of 1:1.3 with 12 males and 15 females represented. Ten males and nine females were initial spawners. Of seven second spawners, only two were males. One fish, a female, had returned to spawn for a third time. Of the males, 16.7 per cent were taken as
repeat spawners while 40.0 per cent of the females had returned to spawn more than once.

SILETZ RIVER

Fifteen of 16 samples from winter run steelhead were read for age and measured for growth determination. Fourteen samples were taken in 1954 and 1955. Two samples had no year of collection. The dates of capture for the two years ranged from December 5 to February 18.

Spawning History

No information which related to development of the reproductive organs was included with the samples. Only three males were represented in the sample. Two were taken in December and one was captured in January. Of the twelve females, six were taken in December, four in January, and two in February.

As can be determined from table VIII, nine fish, or 60.0 per cent of those represented in this sample of 15 were initial spawners and six fish had spawned previously. One fish, a female, had spawned four times previously, and was captured on its fifth spawning migration.
Six different life history patterns were found in the 15 scale samples read. These patterns are given in figure 10 and table VIII.

The small size of the sample allows little comparison of the patterns, but it does show that the patterns 2/1.5 and 2/2.5 are slightly predominant. No samples were recognized as from hatchery fish.

All the fish represented in this sample remained in freshwater only 2/ or 2+/ years before migrating to the ocean. Four of the 15 fish returned to freshwater to spawn after one year in salt water, six returned after two
years and five returned after three years.

**Age, Growth, and Weight**

Back calculations of fish lengths were made from 15 samples. The same number were considered for weight at capture and nine were considered for weight at maturity. In figure 10, the average lengths of the fish are given at the various life stages up to maturity.

The average length of all fish upon entrance to salt water was 7.1 inches with the range from 5.0 to 9.7 inches. Four fish were over eight inches in length at entry to salt water. They were all females and ranged from 8.4 to 9.7 inches. Four fish were below six inches at entry to salt water. Two of these were males and two were females. No fish were below five inches when they entered the ocean.

The average length of the steelhead entering the ocean as 2/ year fish was 6.7 inches and those entering as 2/+ fish averaged 8.0 inches.

The average length of all fish at maturity was 27.8 inches with the range from 17.0 to 38.0 inches. The average weight of nine fish at maturity was 11 pounds, 13 ounces and the weights ranged from two pounds to 20 pounds. The ages of all 15 fish at maturity ranged from three to five years.
The lengths of all fish at capture averaged 29.8 inches and ranged from 17.0 to 38.0 inches. The weights of all 15 fish at time of capture averaged 11 pounds, two ounces, ranging from two pounds to 20 pounds. The ages at capture of all fish ranged from three to eight years.

**Sex, Age, Growth, and Weight**

The females averaged longer than the males throughout the freshwater existence, but the males averaged longer after reaching the ocean environment.

One of the three males in this sample matured after just one year in the ocean. The other two matured after three years in salt water. Three of the 12 females had matured after one year of ocean existence, six after two years, and three after three years.

At maturity the males averaged 30.0 inches in length and weighed 12 pounds, 12 ounces. The females at maturity averaged 27.2 inches in length, and nine averaged 11 pounds, six ounces in weight. The males at maturity were three and five years of age, and the females ranged from three to five years of age. The three males were all initial spawners, so their lengths, weights, and ages were the same at capture as at maturity. The females at capture averaged 29.8 inches in length and weighed 10 pounds, 15 ounces. The females ranged in age at
Figure 10. Migration habits and age-growth comparisons by life history patterns of winter run steelhead in the Siletz River. (figures represent average lengths in inches)
capture from four to eight years.

The 15 samples compared for sex ratios indicated a ratio of 1:4 at the time of capture, with three males and 12 females represented. All the males and half the females were initial spawners. Five females had returned to spawn for a second time and one had returned four times previously.

COOS RIVER-SOUTH FORK

Twelve of 13 samples were read for age and measured for growth determination. All the samples, five males and seven females, were collected on February 17, 1955.

Spawning History

No information was included with the samples on the stage of sexual development of the fish at the time of capture. Four of the 12 fish were initial spawners. Seven of the fish were second spawners, and only one was back to spawn a third time, as can be seen in table IX.

Life History

Five different life history patterns were found in the 12 scale samples read. The patterns are given in figure 11 and table IX.
TABLE IX

Life History Patterns of 12 Coos River Steelhead, with Spawning Status at Time of Capture, and Frequency of Fish Occurrence in the Various Life History Patterns

<table>
<thead>
<tr>
<th>Life History Patterns</th>
<th>Spawning Migrations</th>
<th>Total Per Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>one</td>
<td>two</td>
</tr>
<tr>
<td>1. 2/S</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2. 2/1.S</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>3. 2+/1.S</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>4. 3/S</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>5. 3/1.S</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>4</td>
<td>7</td>
</tr>
</tbody>
</table>

The small size of the total sample allows little comparison of life history pattern predominance; however, two years in freshwater and two in salt water was shown by half of the individual samples.

One marked hatchery reared steelhead was present in the sample. It was a male and exhibited a life history pattern of 2/S, as did one native fish.

As shown in table IX, all immature steelhead remained in freshwater at least two years. Eight remained 2/ years, or 2+/ years, and four stayed in freshwater 3/ years. Three fish returned to freshwater to spawn after one year. All the others matured after two years in the ocean.
Age, Growth, and Weight

Back calculations of fish lengths were made from 12 samples. Twelve were also considered for weight relationships at time of capture, but only four could be considered for weight at time of maturity. In figure 11, the average lengths of the fish are given at the various life stages up to maturity.

The average length of all fish upon entrance to salt water was 6.9 inches, with the range from 4.3 to 10.3 inches. Three fish, representing 25.0 per cent of the sample were over eight inches at entry to salt water; they ranged from 8.6 to 10.3 inches. Only one fish, 4.3 inches in length, was less than six inches upon entering the ocean.

At entry to salt water the 2/ fish averaged 5.6 inches, 2+ fish 7.2 inches, and those leaving freshwater as 3/ fish averaged 8.8 inches.

The lengths of all fish at maturity averaged 26.3 inches and ranged from 19.9 to 30.0 inches. The average weight of four fish at maturity was eight pounds with the range from six pounds to ten pounds. The ages of all 12 fish at maturity ranged from three to five years.

The lengths of all fish at capture averaged 28.9 inches, and ranged from 25.5 to 32.5 inches. The weight of all fish at capture ranged from six pounds to sixteen
pounds and averaged nine pounds, 10 ounces. The ages at capture ranged from four to six years.

**Sex, Age, Growth, and Weight**

The females averaged larger than the males at entry to salt water and throughout the salt water life.

Four of the five males remained in freshwater 2/ or 2+/ years, and one remained 3/ years. Four females remained in freshwater 2/ years and three stayed 3/ years.

Of the three fish that matured after only one year in the ocean, two were males, one a female. Three of the males remained in salt water two years before reaching maturity, and six of all the females spent that same amount of time in the ocean before returning to freshwater to spawn.

The males at maturity averaged 25.2 inches in length and two averaged nine pounds in weight, while the females averaged 26.4 inches in length and two weighed seven pounds as an average. The males were three and four years of age at maturity and the females ranged from three to five years of age. At capture the males averaged 28.3 inches in length and the females 29.4 inches. The weights of the males averaged nine pounds, four ounces and the females, nine pounds, 15 ounces. The males were four and five years of age at capture and the females ranged in
Figure 11. Migration habits and age-growth comparisons by life history patterns of steelhead in the Coos River. (figures represent average lengths in inches)
age from four to six years.

The 12 samples compared for sex ratios exhibited a 1:1.4 ratio with five males and seven females represented. Four fish, two males and two females, were taken as initial spawners. Seven fish, three males and four females, were taken as second spawners, and only one fish, a female, was taken which had returned to spawn for a third time.

COQUILLE RIVER

Eighty-one of 100 samples were read for age, and 79 were measured for growth determination. The majority of the samples were collected in the Main Coquille, but some samples were taken in the South Fork. All 100 samples were supplied with the year of collection. Fifty-three samples were collected in 1954 and 47 in 1955. The dates of collection for the two years ranged from November 2 to February 24.

Spawning History

No information was included with the samples which related to the development of the reproductive organs of the fish when caught. The sex of the fish and the month of capture was available from 98 of the samples.

Two males were collected in November, 17 males and
22 females in December, 20 males and 25 females in January, and one male and 11 females in February.

As can be determined from table X, 50 fish, or 61.7 per cent of the steelhead represented in the 81 samples read were initial spawners, and 31, or 38.3 per cent were repeat spawners. Twenty-five steelhead in this sample were second spawners, representing 30.9 per cent of the total sample, while four fish, or 4.9 per cent were third spawners, and two, or 2.5 per cent returned for a fourth time to spawn. The second spawners accounted for 80.6 per cent of the repeat spawners.

Life History

Eleven different life history patterns were found in the 81 scale samples examined from this stream. These patterns are given in figure 12, and table X.

The steelhead in the Coquille River, as shown in table X, exhibited mainly the following four life history patterns: 2+/S, 2+/1.S, 3/S, and 3/1.S. The percentages of these four individual patterns, as represented in the total sample, are 14.8, 19.8, 24.7, and 16.1 per cent respectively. The four patterns combined accounted for 75.4 per cent of the total sample.

Patterns 2/3 and 2+/3 comprised 22.2 per cent of the 81 samples read; patterns 2/1.S and 2+/1.S made up 28.4
TABLE X

Life History Patterns of 81 Coquille River Steelhead, with Spawning Status at Time of Capture, and Frequency of Fish Occurrence in the Various Life History Patterns

<table>
<thead>
<tr>
<th>Life History Patterns</th>
<th>Frequency of Fish Occurrence</th>
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</thead>
<tbody>
<tr>
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<td>Spawning Migrations</td>
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<tr>
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<tr>
<td>3. 2/1.8</td>
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</tr>
<tr>
<td>5. 2/2.3</td>
<td>1</td>
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<tr>
<td>6. 2+/2.3</td>
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<td>7. 3/S</td>
<td>11</td>
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<td>8. 3+/S</td>
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<td>10. 3/2.8</td>
<td>1</td>
</tr>
<tr>
<td>11. 4/S</td>
<td>1</td>
</tr>
<tr>
<td>Totals</td>
<td>50</td>
</tr>
</tbody>
</table>

No samples were recognized as from hatchery reared steelhead.

As can be determined from table X, all juvenile steelhead remained in freshwater at least two years before migrating to the ocean. Thirty-six of the total 81 fish, or 44.4 per cent, remained 3/ or 3+/ years in freshwater before entering the ocean. One fish remained in freshwater four years before entering the ocean. Young steelhead that remained in freshwater 2/ or 2+/ years
were represented by 44 fish, or 54.3 per cent of the total sample.

Of the 81 samples studied, 41, or 50.6 per cent, showed the fish remained in salt water only one year before they returned to freshwater to spawn. Thirty-six fish, or 44.4 per cent, remained two years in the ocean before maturing, and four fish matured after three years of ocean life.

Of 44 steelhead that spent 2/ or 2+/ years in freshwater, 18, or 40.9 per cent, returned to spawn as grilse. Twenty-two fish, or 61.1 per cent, of the 36 that entered the ocean after 3/ or 3+/ years spawned as grilse. The one fish that entered the ocean after four years in freshwater returned to spawn as grilse. Of the four fish that matured after three years in the ocean, three had entered that environment after 2/ or 2+/ years in freshwater, and one entered after 3/ years.

Age, Growth, and Weight

Back calculations of fish lengths were made from 79 samples. Seventy-nine samples were considered for weight relationships at the time of capture, and 48 at maturity. In figure 12, the average lengths of the fish are given at the various life stages up to maturity.

The lengths of all fish upon entering salt water
averaged 7.2 inches, and ranged from 4.9 to 9.3 inches. 
They averaged 8.7 inches in length. One fish, a female 
4.9 inches in length, was the only fish under six inches 
in length upon entering salt water.

The average length of the steelhead that entered 
salt water after 2/ years in freshwater was 5.8 inches; 
after 2+/ years in freshwater, 7.2 inches; after 3/ years, 
7.6 inches; after 3+/ years, 7.7; and the one fish that 
stayed in freshwater for four years measured 8.4 inches 
at the time it entered the ocean.

The average length of all fish at maturity was 23.9 
inches with the range of lengths from 17.5 to 36.0 inches. 
The average weight of 48 fish at maturity was six pounds, 
three ounces and the range was from one pound, eight 
ounces to sixteen pounds, eight ounces. The ages at 
maturity ranged from three to six years.

The average length of all fish at capture was 26.3 
inches, and the range was from 17.5 inches to 36.0 inches. 
The weights at capture for 79 fish ranged from one pound, 
eight ounces to 20 pounds, four ounces and averaged seven 
pounds, 11 ounces. The ages at time of capture ranged 
from three to seven years.
Sex, Age, Growth, and Weight

The females exceeded the males in average length only at the time of capture.

Fifty per cent of the 34 males in the total sample read spent 2/ or 2+ years in freshwater before migrating to the ocean, and 57.8 per cent of the 45 females in the total sample spent the same time in freshwater prior to migrating to salt water. Fifty per cent of the males remained in freshwater 3/ or 3+ years before entering salt water while only 40.0 per cent of the females remained this long in freshwater. However, the one fish that remained in freshwater four years before migrating to the ocean was a female.

Of the 34 males, 58.8 per cent reached maturity after one year in the ocean and 44.4 per cent of the 45 females reached maturity after only one year in that environment. The males were represented by 35.5 per cent spending two years in salt water before reaching maturity while 51.1 per cent of the females showed this characteristic. Two males and two females remained in the ocean three years before returning to spawn, comprising 5.9 per cent and 4.4 per cent of their respective totals.

At maturity the males averaged 23.7 inches in length and weighed five pounds, 13 ounces as an average while the females averaged 24.1 inches in length and six pounds,
Figure 12. Migration habits and age-growth comparisons by life history patterns of steelhead in the Coquille River. (figures represent average lengths in inches)
10 ounces in weight. The males ranged in age from three to five years of age and the females ranged from three to six years. At capture the males averaged 25.0 inches in length and six pounds, 14 ounces in weight, and the females averaged 27.4 inches in length and eight pounds, six ounces in weight. The males at capture ranged in age from three to five years and the females from three to seven.

The 79 samples compared for sex ratios showed a ratio at time of capture of 34 males to 45 females or 1:1.3. Forty-eight fish were taken as initial spawners and produced a ratio of 1.3:1 with 79.4 per cent of the males as initial spawners and 46.7 per cent of the females as such. Six males and 19 females were taken returning to spawn for a second time, showing a ratio of 1:3.2, with the males representing 17.7 per cent and the females 42.2 per cent of their respective totals. One male and three females returned to spawn for a third time and two females were taken as fourth spawners. The males showed 20.6 per cent had spawned previously, as had 53.3 per cent of the females.

SIXES RIVER

Fourteen samples were read for age and measured for growth determination. Two of the samples were collected
in 1952, nine in 1954, and three in 1955. The dates of capture for the three years ranged from December 8 to February 14.

**Spawning History**

No information was included with the samples on the stages of sexual development of the fish at the time of capture. Of six males and eight females, one male and one female were taken in November, five males and three females were collected in December, and two females were taken in both January and February.

Table XI shows that five of all the steelhead represented were initial spawners and nine had spawned previously. Six fish were second spawners and three were third spawners. Second spawners accounted for two-thirds of the repeat spawners.

**Life History**

Five different life history patterns were found in the 14 scale samples read. These patterns are illustrated in figure 13 and table XI.

The small size of the total sample allows little comparison of life history pattern predominance. However, the patterns 2/S and 3/S were most predominant. No
samples were recognized as from hatchery reared steelhead.

As can be determined from table XI, all steelhead remained in freshwater at least two years as juveniles before migrating to the ocean. Steelhead that remained 2/ or 2+ years represented some two-thirds of the total, while those that remained 3/ years comprised about one-third. No scales showed any steelhead to have remained in freshwater more than three years as juveniles.

Of the 14 steelhead represented in the sample, 12 matured after just one year in salt water. Three of the five patterns exhibited this characteristic. The other two patterns, with only one sample in each, indicated that the fish remained two and three years in the ocean.
before returning to spawn.

**Age, Growth, and Weight**

Back calculations of fish lengths were made from the 14 samples. Thirteen samples were studied for weight relationships at time of capture while only four could be considered for weight at maturity. In figure 13, the average lengths of the fish are given at the various life stages up to maturity.

The average length of all fish upon entering salt water was 6.7 inches with the lengths ranging from 4.7 to 8.5 inches. Two fish, or 14.3 per cent, were eight inches or over upon entering the ocean. Three fish at entrance to salt water were under six inches in length; one of these was under five inches. At entry to salt water, the nine 2/ and 2+/ fish averaged 6.4 inches in length, and the five 3/ fish 7.1 inches.

The average length of all fish at maturity was 22.4 inches with the lengths ranging from 17.0 to 37.0 inches. The average weight of four fish at maturity was six pounds, one ounce. The weights ranged from two pounds to 16 pounds, 12 ounces. The ages at maturity ranged from three to five years.

The lengths of all fish at capture averaged 27.5 inches and ranged from 17.0 inches to 39.0 inches. The
weights at capture ranged from two pounds to 20 pounds, eight ounces and averaged nine pounds, 14 ounces. The ages at capture ranged from three to five years.

**Sex, Age, Growth, and Weight**

The males exceeded the females in length after the first year in salt water and throughout all the life history stages, even at time of capture.

Of six males in the total sample, three remained in freshwater 2/ and 2+ years before migrating to the ocean, while three remained 3/ years. Of eight females, six stayed in freshwater 2/ or 2+ years; two remained for 3/ years.

Five of the six males reached maturity after only one year in the ocean as did seven of the eight females. One female remained two years in salt water before reaching maturity, and one male remained three years in that environment before returning to freshwater to spawn for the first time.

At maturity the males averaged 23.3 inches in length and three weighed an average of seven pounds, one ounce. The females averaged 21.7 inches in length and one weighed three pounds. The males ranged in age from three to five years and the females were three and four years old. At capture the males averaged 28.2 inches in length and six
Figure 13. Migration habits and age-growth comparisons by life history patterns of steelhead in the Sixes River. (figures represent average length in inches)
averaged 10 pounds, three ounces in weight. The females averaged 26.9 inches in length and seven averaged eight pounds, 14 ounces in weight. The males at capture were three and four years of age and the females were aged four and five years.

The 14 samples showed a sex ratio at the time of capture of 1:1.3 with six males and eight females represented. Five fish, three males and two females, were taken as initial spawners. Two males and four females were taken as second spawners, and one male and two females were third spawners. Of the males, three, or 50 per cent, were taken as repeat spawners, while six of the females, or 75 per cent, had returned to spawn previously.

ELK RIVER

Twelve samples were read for age and measured for growth determination. All the samples were taken in February 1955.

Spawning History

No information was included with the samples as to the stage of sexual development of the fish at the time of capture. Six males and six females were taken in February.
Table XII shows that nine of the steelhead represented in the twelve samples were initial spawners and three were repeat spawners. The three repeat spawners had spawned only once before.

**Life History**

Six different life history patterns were found in the 12 samples examined. These patterns are given in figure 14 and table XII.

The small size of the sample allows little comparison of the life histories, but the 3/5 pattern does stand out in lone predominance.

Of the 12 samples read, nine of the fish matured after one year in salt water, while the other three matured after two years in the ocean. Five steelhead had remained in freshwater 2/ or 2+/ years and seven stayed 3/ or 3+/ years. No hatchery fish were recognized in the sample.

**Age, Growth, and Weight**

Back calculations of fish lengths were made from 12 samples. Seven samples were considered for weight at maturity and 10 at time of capture. In figure 14, the average length of the fish is given at the various life
TABLE XII

Life History Patterns of 12 Elk River Steelhead, with Spawning Status at Time of Capture, and Frequency of Fish Occurrence in the Various Life History Patterns

<table>
<thead>
<tr>
<th>Life History Patterns</th>
<th>Spawning Migrations</th>
<th>Total Per Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>one</td>
<td>two</td>
</tr>
<tr>
<td>1. 2/S</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2. 2+/S</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3. 2+/1.5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>4. 3/S</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>5. 3+/S</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>6. 3/1.5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>9</strong></td>
<td><strong>3</strong></td>
</tr>
</tbody>
</table>

stages up to maturity.

The average length of all fish upon entrance to salt water was 7.9 inches with the range from 6.7 to 9.2 inches. Five fish were over eight inches in length at entry to salt water; they ranged from 8.1 to 9.2 inches.

The average length of all fish at maturity was 23.3 inches with the range from 20.8 to 29.0 inches. The average weight at maturity was five pounds, nine ounces, with the range from three pounds, eight ounces to ten pounds, four ounces. The age of all 12 fish at maturity ranged from three to five years.

The lengths of all fish at capture averaged 24.6 inches and ranged from 20.3 to 30.8 inches. The weights
at capture ranged from three pounds, eight ounces to 11 pounds, 12 ounces, and averaged seven pounds, four ounces. The ages at capture of all fish ranged from three to five years.

**Sex, Age, Growth, and Weight**

The females averaged longer only at maturity and at time of capture, while the males were longer at all other stages of life.

Two of the six males in the sample remained in fresh-water 2/ or 2\(\pm\) years. Four males stayed in freshwater 3/ years. Three of the six females remained in freshwater 2/ years and three remained 3/ or 3\(\pm\) years.

All the males matured after just one year in the ocean. Three of the females matured after the same time in the sea and three matured after two years.

The males at maturity averaged 21.3 inches in length and three averaged three pounds, 12 ounces in weight; the females measured 25.3 inches in average length and four averaged six pounds, thirteen ounces in weight. Both sexes were three and four years of age at maturity. At capture the males averaged 22.5 inches in length and five pounds, 12 ounces in weight, while the females averaged 26.7 inches in length and eight pounds, four ounces in weight. The males were three and four years
Figure 14. Migration habits and age-growth comparisons by life history patterns of steelhead in the Elk River. (figures represent average lengths in inches)
of age at capture and the females were four and five years of age.

The 12 samples compared for sex ratios indicated a ratio at the time of capture of 1:1, with six males and six females represented. The three repeat spawners had spawned only once previously; one was a male, the other two were females.

CHETCO RIVER

Ninety of 95 samples were read for age and 85 were measured for growth determination. All 95 samples were supplied with the year of collection. Twelve samples were collected in 1953, 46 in 1954, and 37 in 1955. The dates of collection for the three years ranged from October 29 to February 28.

Spawning History

No information was included with the samples as to development of the reproductive organs of the fish at the time of capture. Of 30 males and 65 females taken, one female was collected in October and one in November. Fifteen males and 23 females were taken in December. Three males and 17 females were taken in January, and 12 males and 23 females in February.
As can be determined from table XIII, 42 fish, or 46.7 per cent of the steelhead represented in the 90 samples read, were initial spawners and 48, or 53.3 per cent were repeat spawners. Second spawners were represented by 32 steelhead, or 35.6 per cent of the sample. Third spawners were represented by 12 fish, or 13.3 per cent of all the samples. Four fish that returned for a fourth time to spawn represented 4.4 per cent of the total sample. The second spawners accounted for 66.7 per cent of the repeat spawners. Four fish, or 4.4 per cent of all the fish were found to have spawned in freshwater before migrating to the ocean. They all spawned in their last year of freshwater existence and returned from the ocean to spawn after just one year in the salt water environment.

**Life History**

Ten different life history patterns were found in the 90 scale samples examined from this stream. These patterns are given in figure 15 and table XIII.

The spawning populations of steelhead in the Chetco River, as shown in table XIII, are mainly composed of the following four life history patterns: 2/S, 2+/S, 3/S, and 3+/S. The percentages of these four individual patterns as represented in the total sample are 13.3,
TABLE XIII

Life History Patterns of 90 Chetco River Steelhead, with Spawning Status at Time of Capture, and Frequency of Fish Occurrence in the Various Life History Patterns

<table>
<thead>
<tr>
<th>Life History Patterns</th>
<th>Spawning Migrations</th>
<th>Total Per Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>one</td>
<td>two</td>
</tr>
<tr>
<td>1. 1+/S</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2. 2/S</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>3. 2+/S</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>4. 2+/1.5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>5. 3/S</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>6. 3+/S</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>7. 3/1.5</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>8. 3+/1.5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>9. 4/S</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>10. 4+/S</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Totals</td>
<td>42</td>
<td>32</td>
</tr>
</tbody>
</table>

22.2, 27.8, and 20.0 per cent respectively.

One steelhead, a male, was recognized as hatchery reared by the characteristic growth of the scales. This single fish showed the life history pattern 1+/S and was the only representative of that pattern.

As shown in table XIII, all juvenile steelhead, except the one recognized hatchery fish remained in freshwater at least two years before entering the ocean. Young steelhead that remained 2/ or 2+/ years in freshwater represented 38.9 per cent of the sample, while those that remained 3/ or 3+/ years made up 55.6 per cent.
of the sample and 4.4 per cent remained in freshwater 4/ or 4+/ years.

Each of the four fish that spawned in freshwater before entering the ocean spent different amounts of time in the stream before migrating to sea. The single male which was captured on its first spawning migration from the sea entered the ocean after 3/ years in freshwater. The three females entered salt water as 2+/, 4/, and 4+/ fish. The 4+/ female was the only individual of the four that had returned more than once to freshwater to spawn. All the others were on their first migration from the ocean.

The four predominant patterns all showed the fish to have matured at the end of the first year in salt water. In fact, of the 90 samples read, 80, or 88.9 per cent, showed the fish matured after just one year in salt water. Seven of the ten patterns showed this characteristic. The other three patterns showed the fish to have matured after two years of ocean existence and were represented by only ten fish, or 11.1 per cent of the total sample. No scales showed three years of ocean growth before initial spawning.

Of 35 steelhead that spent 2/ or 2+/ years in freshwater, 32 returned to spawn after only one year in the ocean. Forty-three of the 50 fish that entered the ocean
after 3/ or 3+ years in freshwater returned to spawn as grilse. All the 4/ and 4+ fish were grilse.

**Age, Growth, and Weight**

Back calculations of fish lengths were made from 85 samples. Only 60 samples were considered for weight at time of capture and only 30 at maturity. In figure 15, the average lengths of the fish are given at the various life stages up to maturity.

The lengths of all fish upon entrance to salt water averaged 8.6 inches and ranged from 5.4 to 13.9 inches. Fifty-three fish, or 62.4 per cent of the total sample, were eight inches or over when they entered the ocean, and they averaged 9.0 inches in length. Twenty-seven of these fish were between nine and 10 inches in length, 10 were between 10 and 11 inches, and six measured between 11 inches and 12 inches. Two females, 5.4 and 5.9 inches in length at entry to salt water, were the only fish to enter the ocean under six inches in length. The single hatchery fish entered salt water at a length of 6.2 inches.

The lengths at entry to salt water averaged for the years spent in freshwater as follows: 2/ years, 7.2 inches; 2+ years, 8.4 inches; 3/ years, 8.5 inches; 3+ years, 9.5 inches; 4/ years, 12.0 inches; and 4+ years,
10.3 inches.

The average length of all fish at maturity was 22.1 inches with the range from 14.0 to 28.3 inches. The weights at maturity of 30 fish averaged four pounds, 12 ounces and ranged from two pounds, five ounces to nine pounds. The ages at maturity ranged from two to five years.

The lengths of all fish at capture averaged 25.6 inches and ranged from 14.0 to 37.0 inches. The weights at capture ranged from two pounds, five ounces to 21 pounds and averaged seven pounds, 11 ounces. The ages of all fish at time of capture ranged from three years to seven years.

Sex, Age, Growth, and Weight

The females averaged slightly longer than the males in freshwater. At entry to salt water, and as initial spawners the males averaged longer, but as second spawners, and at the time of capture, the females again exceeded the males.

Of 28 males in the total sample, nine, or 32.1 per cent remained in freshwater 2/2 or 2+ years before migrating to the ocean, and of 57 females, 43.9 per cent spent the same time in freshwater. The samples from the males showed that 18, or 64.3 per cent, stayed in freshwater.
Figure 15. Migration habits and age-growth comparisons by life history patterns of steelhead in the Chetco River. (figures represent average lengths in inches)
3/ or 3+/ years before migrating to the ocean, while only 50.9 per cent of the females remained in freshwater for that long a time. Only one male but three females migrated to salt water as 4/ or 4+/ fish.

Of the 28 males, 92.9 per cent reached maturity after only one year in the ocean as did 89.5 per cent of the 57 females. The males were represented by a mere 7.1 per cent that spent two years in salt water before reaching maturity and the females by 10.5 per cent. No fish were found to remain in the ocean more than two years before returning to freshwater to spawn.

The males at maturity averaged 22.4 inches in length and five pounds, one ounce in weight while the females averaged 22.0 inches in length and four pounds, six ounces in weight. The males ranged in age from two to five years and the females from three to five. At capture the males averaged 25.0 inches in length and seven pounds, 11 ounces in weight, and the females averaged 25.9 inches in length and averaged the same as the males in weight. The sexes showed the same range in age, three to seven years.

The 85 samples compared for sex ratios indicated a ratio at the time of capture of 1:2.0, with 28 males and 57 females represented. Of 41 initial spawners, 19 were males and 22 were females, and they showed a ratio of 1:1.2. Of all the males, 67.9 per cent were initial
spawners as were only 38.6 per cent of all the females. Seven males and 21 females were taken returning for a second time to spawn, and they showed a ratio of 1:3, with 25.0 per cent of the males represented and 36.8 per cent of the females. One male and 11 females returned to spawn for a third time. Of the females, 19.3 per cent were third spawners. One male and three females had returned for a fourth time to spawn. Repeat male spawners totaled 32.1 per cent, while 61.4 per cent of the females were taken returning to spawn more than once.

WINCHUCK RIVER

Nineteen of 20 samples were read for age and measured for growth determination. Nineteen were also supplied with the year of collection. Seven samples were collected in 1954 and 12 in 1955. The month of capture and sex were given with all 20 samples. The dates of capture for the two years ranged from December 8 to February 14.

Spawning History

No information was included with the samples as to the stage of sexual development of the fish at the time of capture. Of eight males and 12 females, three males were taken in December as were three females. Five males and
eight females were captured in January, and a single female was taken in February.

Table XIV shows that seven fish, or 36.8 per cent of the steelhead represented in the 19 samples read, were initial spawners and 12, or 63.2 per cent, were repeat spawners. Eight fish, or 42.1 per cent of the total sample, were second spawners; four fish, or 21.1 per cent, were third spawners. The second spawners accounted for two-thirds of the fish that had spawned previously.

**Life History**

Six different life history patterns were found in the 19 scale samples read. These patterns are given in figure 16 and table XIV.

The small size of the total sample does not allow a good comparison of life history pattern predominance. However, the patterns 3/S and 3+/S do represent the predominant patterns, accounting for 52.6 per cent of all the samples studied. None of the samples were recognized as from hatchery reared fish.

As can be determined from table XIV, all immature steelhead remained in freshwater at least two years before migrating to the ocean. Young steelhead that remained 2/ or 2+/ years in freshwater represented 47.4 per cent of the total sample, while those that remained 3/ or 3+/
TABLE XIV

Life History Patterns of 19 Winchuck River Steelhead, with Spawning Status at Time of Capture, and Frequency of Fish Occurrence in the Various Life History Patterns

<table>
<thead>
<tr>
<th>Life History Patterns</th>
<th>Frequency of Fish Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spawning Migrations</td>
</tr>
<tr>
<td></td>
<td>one two three</td>
</tr>
<tr>
<td>1. 2/S</td>
<td>1</td>
</tr>
<tr>
<td>2. 2+/S</td>
<td>1 2</td>
</tr>
<tr>
<td>3. 2/1.S</td>
<td>1 1</td>
</tr>
<tr>
<td>4. 2+/1.S</td>
<td>2 1</td>
</tr>
<tr>
<td>5. 3/S</td>
<td>2 4</td>
</tr>
<tr>
<td>6. 3+/S</td>
<td>1 1 2</td>
</tr>
<tr>
<td>Totals</td>
<td>7 8 4</td>
</tr>
</tbody>
</table>

years comprised 52.6 per cent in two patterns.

Of the 19 samples studied, 14, or 73.7 per cent, showed the fish matured after just one year in salt water. Four of the six patterns showed this characteristic. The other two patterns representing 26.3 per cent of the sample showed the fish to mature after two years of ocean existence.

All the fish that remained in freshwater 3/ or 3+/ years returned to spawn after only one year in the ocean, while only four of the nine fish that entered the ocean after 2/ or 2+/ years in freshwater returned to spawn after the first year in the ocean.
Age, Growth, and Weight

Back calculations of fish lengths were made from 19 samples. Eight samples were considered for weight at time of capture, and only two could be considered for weight at maturity. In figure 16, the average length of the fish are given at the various life stages up to maturity.

The lengths of all fish upon entrance to salt water averaged 7.9 inches with the range from 6.0 to 12.4 inches. Seven fish, or 36.8 per cent of all the samples, were over eight inches in length upon entering the ocean. They averaged 9.4 inches in length with the range from 8.1 to 12.4 inches.

At entry to salt water, the 2\text{/} year fish averaged 6.4 inches in length; the 2\text{+}/ fish, 8.3 inches; the 3\text{/} fish, 8.0 inches; and the 3\text{+}/ fish, 8.4 inches.

The average length of all fish at maturity was 24.1 inches and the lengths ranged from 21.5 to 32.0 inches. The average weight of two fish was 10 pounds at maturity. The ages of all 19 fish at maturity ranged from three to four years.

The average length of all fish at capture was 28.0 inches, and the range was from 21.5 to 34.5 inches. The weights at capture for eight fish ranged from four pounds, eight ounces to sixteen pounds, eight ounces and averaged 10 pounds, 10 ounces. The ages at time of capture of all
fish ranged from three to six years.

**Sex, Age, Growth, and Weight**

The males generally exceeded the females in length only at entry to salt water.

Of seven males in the total sample read, one remained in freshwater 2/ years and one remained 2+/ years before migrating to the ocean. Of 12 females, three spent 2/ years in freshwater and four spent 2+/ years. The samples from the males showed that five stayed in freshwater 3/ or 3+/ years before entering the ocean, while five of the females remained for that same length of time.

Of the seven males, six reached maturity after only one year in the ocean, as did eight of the 12 females. One male and four females remained two years in salt water before reaching maturity. No fish were found to remain in the ocean more than two years before returning to spawn.

The males at maturity averaged 23.8 inches in length and one weighed 12 pounds, while the females averaged 24.3 inches in length and one weighed eight pounds. Both sexes were three and four years of age at maturity. At capture the males averaged 26.9 inches in length and four averaged nine pounds, two ounces, while the females averaged 28.6 inches in length with four averaging 12 pounds, one ounce in weight. The males ranged in age from three to six.
Figure 16. Migration habits and age-growth comparisons by life history patterns of steelhead in the Winchuck River. (figures represent average lengths in inches)
years and the females ranged from four to six years of age.

The 19 samples compared for sex ratios indicated a ratio at the time of capture of 1:1.7 with seven males and 12 females represented. Seven fish were taken as initial spawners and showed a male to female ratio of 1.3:1 with four males and three females represented. Two males and six females were taken returning to spawn for a second time. One male and three females were taken on their third spawning migration. The males showed that three, or 42.9 per cent, were taken as repeat spawners, while nine females, or 75.0 per cent, had returned to spawn previously.

COMPARISON OF POPULATION CHARACTERISTICS

In this section the combined characteristics of the steelhead from the north coastal region are compared with those from the southern region, and the individual streams are compared briefly. The Coquille River steelhead are considered separately to point out the transitional relationships of their characteristics to those of the fish from the northern and southern regions.
North Coastal Region

Four hundred sixteen of 450 samples from the nine north coastal streams were read for age and life histories, and 411 were measured for growth determination and considered for sex ratios. The dates of collection ranged from October 4 to July 24.

Spawning History

Three hundred thirty-nine of the 450 samples from the north coast streams had information included which related to development of the reproductive organs of the fish when caught. The sex of the fish and the month of capture were available from 428 of the samples.

In October, one green male was captured. In November, ten fish, including four males and six females, were taken. The samples with data pertaining to the gonad development showed that all four males were green as were three of the females, and one female was in a ripe condition. In December, 57 males and 32 females were captured, showing from the data available that 33 males were green and ten were ripe, while 16 females were green and four were ripe. Forty-three males and 46 females captured in January showed from the available data that 14 males were green and ten were ripe, while 22 females were green and eight were ripe. In February, 40 males
and 55 females were taken. They showed that nine males were green and 20 were ripe, while 22 females were green, 14 ripe, and four spent or nearly spent. In March and April, 57 males and 68 females were collected. Two of the males were reported as green and 55 were ripe, while no green females were reported but 61 were ripe or nearly ripe, and seven were partly spent. Four males and nine females were taken in May. One male was reported as ripe, the other three were spent. Four of the females were ripe and five were spent. In June, one male and one female were captured; both were spent. One spent male and three spent females were taken in July.

From the dates on which all the males and females were taken and the sexual development of the fish at the time of capture, it seems possible that more males may enter freshwater earlier than females and also may tend to be advanced sexually for spawning sooner. The above characteristics were exhibited in the individual stream samples with only slight variations.

The predominance of females taken in the latter months of the spawning season should not necessarily suggest an uneven sex ratio in the populations, or that many of the males move out of the streams sooner than the females. Actually, the sportsmen taking the fish may exercise the practice common among steelhead anglers of
releasing the males in preference to the heavier, deeper bodied egg-laden females (22, p.43; 29, p.77). If the females are not well represented early in the season, such selection could logically only be carried on later in the season, thus causing the samples to suggest that males represent a minority in the streams during the latter part of the season, which is not necessarily the case.

Shapovalov and Taft (25, p.115-116) found that in the latter part of the spawning migration in Waddell Creek, the females tended to exceed the males in numbers moving into freshwater, while in the earlier months prior to January and February, the males tended to be slightly more numerous.

As can be determined in table XV, 72.1 per cent of the fish from the north coast were initial spawners and 27.9 per cent were repeat spawners. Second spawning fish comprised 19.5 per cent of the total north coast sample, third spawners represented 6.3 per cent, fourth spawners 1.9 per cent, and only one fish, from the Siletz River, had returned to spawn for a fifth time. The second spawners in the northern streams represented 69.8 per cent of all the repeat spawners. None of the fish were noticed to have spawned in freshwater before migrating to the ocean.

The per cent of repeat spawners here reported,
although lower than in the southern streams, is noticeably higher than recorded in the literature, but the proportions of repeat spawners correspond quite closely with reports in the literature (5, p.29; 16, p.7; 16, p.10; 21, p.18; 25, p.119-122).

It is interesting to note that Shapovalov and Taft (25, p.118), working in California with steelhead from Waddell Creek, showed 17.2 per cent sea run fish were repeat spawners, and Pautzke and Meigs (21, p.18) in Washington found 5.1 per cent were repeat spawners, and Neave (20, p.20-21) in British Columbia reported seven per cent, while Sumner (29, p.81) in Oregon showed the sport caught steelhead from Tillamook County were represented by an intermediate per cent of 12.7. The suggested trend of progressively fewer repeat spawners on the Pacific coast from south to north was also born out in this study on material only from Oregon, as is shown in further considerations of the northern and southern regions in the state. No such definite progression, however, could be established from examinations of the individual streams within each region.

Aside from the fact that Oregon steelhead survival after spawning may generally be greater than in most streams of the coast, the marked predominance of repeat spawners in this study is believed to be due partly to
the known tendency of anglers to release small fish and keep larger individuals. The larger fish, more apt to be survivors of previous spawning migrations, undoubtedly caused the results from the available samples to be affected. It is possible that collectors of the samples, not necessarily striving for an impartial sample, were most attracted by larger fish, thinking that scales from such specimens would be of the most value and interest. Also, sportsmen seem to be more likely to present larger steelhead for inspection and turn in the scales of such fish rather than of smaller individuals.

Another important feature to consider in regard to the number of repeat spawners in the samples is the effect of sex ratio on the number of returning spawners represented. As is shown later, the females represented in this study exhibited greater survival after spawning than the males, so it is understandable that samples which are represented by noticeably more females will show a greater predominance of fish returning after previous spawning migrations. This effect of sex ratio on the number of returning spawners represented was no doubt partly responsible for the high 53.3 per cent repeat spawners found in the south coastal region where the sex ratio was 47 males to 83 females. Shapovalov and Taft (25, p.128) found 41 per cent of the steelhead from Scott Creek, California
were repeat spawners, with the males represented as 26 per cent of the total sample and the females as 74 per cent. In Waddell Creek, where 47 per cent of the total were males and 53 per cent were females, only 28.2 per cent of all the fish had spawned previously (25, p.118 and 140).

Realizing the relatively low number of repeat spawners generally reported in the literature, spawning checks in the scales were carefully considered but never ignored. It seems significant that Rivers (22, p.42) reported a large percentage of repeat spawners in the Rogue River of Oregon. Fifty-two per cent of all the Rogue River sport caught steelhead he examined were repeat spawners, which had spawned at least once previous to capture in freshwater.

In six north coastal streams, the percentages of initial and repeat spawning fish coincided quite closely with those proportions for the whole region. However, in the Necanicum, Siletz, and Coos river, the proportions varied to a considerable extent. The 12 Coos River samples showed the greatest divergence from the 27.9 per cent repeat spawners of the entire region, showing 66.7 per cent of the captured steelhead had spawned previously. This was even a higher percentage than was present in any of the populations in the southern region. However the Coos sample was very small and from only the South Fork.
The Siletz River showed the next highest per cent of repeat spawners with 40 per cent, then the Necanicum River with 38.7 per cent. The least numbers of repeat spawners were present in Sand Creek and the Nehalem River with each exhibiting about 24 per cent.

In all the streams of the entire coast, except in the Necanicum River, the second spawners were most numerous among fish that had returned to spawn more than once. The Necanicum River steelhead showed a unique characteristic in that the third spawners represented 32.3 per cent of the total stream sample, while only 6.4 per cent of all the samples were from fish returning to spawn a second time.

Life History

Fourteen different life history patterns were found in the 416 scale samples read from the nine north coast streams. These patterns and their frequency of occurrence are given in table XV.

As shown in table XV, there were two distinctly predominant patterns in the combined samples from the north coast streams. The two patterns were 2/1.8 and 2+/1.8, which comprised 48.8 per cent of all the samples, 15.4 per cent and 33.4 per cent respectively. Each of the other 12 patterns was represented by less than 10 per
The combined percentages of the two predominant patterns mentioned above compare closely with the findings reported from Oregon, Washington, and British Columbia (16, p.8; 19, p.16; 20, p.20; 21, p.15; 29, p.81), but are much higher than the findings of Shapovalov and Taft in Waddell Creek, California (25, p.284). The difference shown by the steelhead of Waddell Creek in relation to
the fish of the Oregon north coast is fully understandable since the California steelhead would be expected to, and do, coincide more closely with the characteristics exhibited by the south coastal fish of Oregon.

The six life history patterns, each represented by more than five per cent of all the north coast samples, are as follows in order of decreasing predominance: 2+/1.5, 2/1.5, 2+/S, 3/S, 3/1.5, and 2/2.5. The patterns 2/1.5 and 2+/1.5, as mentioned previously, comprised 48.8 per cent of the total sample; the 2/S and 2+/S patterns, 13.0 per cent; 3/S and 3+/S, 11.3 per cent; 3/1.5 and 3+/1.5, 10.1 per cent; and 2/2.5 and 2+/2.5, 9.9 per cent. The two patterns 2/2.5 and 2+/2.5 were actually more prevalent in many of the stream samples than suggested here, but since these patterns were represented by less than two per cent of the large Sand Creek sample, their frequency of occurrence in the other streams was masked.

The most predominant north coastal pattern, 2+/1.5, was present in all the northern stream samples. The second most predominant pattern, 2/1.5, was present in all the stream samples except the Trask River. However, in the Trask River the related pattern 2+/1.5 was present in 45.8 per cent of the samples. The two patterns 2/1.5 and 2+/1.5 were not only dominant in the region as a whole but were also most prevalent in each of the individual
streams. The four most predominant patterns of the north coast region were present in seven of the nine streams. The pattern 2/S was present in every north coastal stream sample, even though it was represented by only 3.8 per cent of the total number of samples.

Twenty-eight of the 416 samples read were recognized as from hatchery reared steelhead and represented 6.7 per cent. Seventeen of these fish were males and 10 were females. The sex of one was not available.

In only a few instances did the scales from artificially reared steelhead show that the fish remained in freshwater for any appreciable length of time after release in the streams. Only the three Sand Creek hatchery released steelhead and the one Coos River hatchery fish remained in freshwater through one or more winters after release in the stream. Nearly all the scales from the other streams showed only two or three circuli, if any, suggesting stream growth after release from the hatchery.

The 6.7 per cent hatchery reared steelhead found in the total sample of the north coast region corresponds closely with the percentages of returned hatchery steelhead found in several streams of Washington where tagging experiments were made and reported by Larson and Ward (14, p.261-267). These investigators reported that hatchery fish released at or slightly above the migrant size of
native fish produced the highest returns as adults (14, p.264-265). The hatchery fish from the streams of the north coastal region that were read and measured in this study were of an average size at time of release from the hatchery of approximately 7.5 inches, or about one inch larger than the average migrant size of all the fish of the region.

Although hatchery released steelhead were not very common in any of the stream samples, only the Nehalem and Siletz river samples had none present. The Necanicum, Wilson, Nestuca, and Salmon River samples had over 10 per cent hatchery released fish. The Necanicum River showed the greatest representation, with 19.4 per cent.

Of the 416 steelhead represented in the total region, 1.4 per cent entered the ocean after less than one year in freshwater as juveniles; 5.5 per cent entered the ocean after 1/ or 1+ years in freshwater; 71.6 per cent entered the ocean after 2/ or 2+ years; and 21.4 per cent entered salt water after 3/ or 3+ years in freshwater. These percentages closely match those reported by investigators in Oregon, Washington, and British Columbia (5, 19, 21, and 22).

The Necanicum River and Siletz River samples showed no fish remained as long as three years in freshwater before they migrated to the ocean. On the other hand,
about 33 per cent of the fish represented in the Coos River sample remained in freshwater as long as three years before entering salt water as did 29.6 per cent of the Salmon River fish. In the other five streams, the fish that remained as long as three years in freshwater as juveniles comprised about 16 to 26 per cent of the samples of the respective streams.

Twenty-five per cent of all the samples showed the steelhead matured at the end of one year in salt water, while 64.7 per cent matured after two years in the ocean. Steelhead that remained three years in salt water before maturing represented 10.3 per cent of all the samples.

The findings in this study suggest that the number of years a fish spent in freshwater did influence the number of years it remained in the ocean environment before maturing. Maher and Larkin (15, p.30-31) found no significant correlation between freshwater and salt water existence. However, Shapovalov and Taft (25, p.117-130) reported that freshwater residence affected steelhead in such a correlation. Chapman (5, p.58-59) showed a correlation existing between size of juveniles entering salt water and the age of returning adults; the greater length at entrance to salt water, the fewer years spent in the ocean. Chapman's findings correspond well with those in this study in that the older smolts would be expected to
measure longer than the younger ones and would logically be expected to return to freshwater sooner.

Fish three years of age or more at entrance to salt water seemed to show, in this study, a greater tendency toward early maturity in the ocean than did those fish which entered at less than three years of age. This tendency was greatly reduced in the southern region, because large numbers of the fish returned as grilse no matter how many years were spent in freshwater as juveniles.

Of 298 fish that spent 2/ or 2+/ years in freshwater before entering the ocean, 18.1 per cent returned to freshwater to spawn as grilse, 68.1 per cent returned to spawn after two years of sea life, and 13.8 per cent remained in the ocean three years before maturing. Of 89 fish that spent 3/ or 3+/ years in freshwater before entering the ocean, 52.8 per cent returned to freshwater to spawn as grilse, 47.2 per cent returned to freshwater to spawn after two years of sea life, and none remained in the ocean as long as three years before maturing. Of the 29 fish that spent less than two years in freshwater before migrating to the sea, 24 were hatchery reared. The other five were native fish; one showed the pattern 1+/S, the others the pattern 1+/1.5.

In considering the individual stream samples in
relation to the number of years spent in the ocean before maturity, it is apparent that the variation is quite extreme. The percentages of fish maturing after the first year of ocean existence ranged from 10 per cent in the Necanicum River sample, which had no fish that stayed in freshwater as long as three years, to 44 per cent in the Salmon River, which showed the second highest per cent of 3/ and 3+/ fish in the north coast. The Nestucca River steelhead showed that a low 14 per cent of the fish spawned as grilse, while in the other streams the percentages were the same or slightly higher than shown for the entire region.

In all the northern stream samples, steelhead maturing after two years in the ocean were present in the greatest numbers. Fish maturing after three years of ocean existence were more numerous than grilse only in the Necanicum and Nestucca river samples. The three most northern streams, Necanicum, Nehalem, Wilson, and the southerly Nestucca and Siletz were represented by percentages of fish maturing after three years in the ocean that were greater than the percentages of those fish in the region as a whole. The southern Salmon and Coos river samples showed no fish to have remained in salt water three years before returning to freshwater to spawn. In Sand Creek, less than two per cent of the steelhead
represented in the sample showed they remained three seasons in the ocean environment before maturing.

From the compared data as explained in the two paragraphs above, it is suggested that there exists a possible tendency of the fish in the southern streams of this region to remain longer in freshwater and spend less time in the ocean than is characteristic in some of the more northern streams. However, it is obvious that the tendency is slight and erratic, at least in the samples available for this study. Since the populations of the southern region are represented by greater numbers of fish that remain in freshwater for extended periods and by many fish that returned to freshwater to spawn as grilse, it seems conceivable that the southerly streams of the northern region could exhibit more of such a tendency than the streams farther north.

Age, Growth, and Weight

Back calculations of fish lengths were made from 411 samples. Only 293 samples were considered for weight relationships at time of capture and 205 for weight at maturity.

The lengths of all fish upon entering salt water averaged 6.5 inches and ranged from 3.9 to 10.3 inches. Thirty-one fish were over eight inches upon entering the
They represented 7.5 per cent of all 411 samples measured. Eighty-four fish, or 20.4 per cent, were under six inches in length upon entering salt water and 16 of these fish were under five inches in length. The males and females were quite equally represented among the fish under six inches and over eight inches at the time of entry to salt water. The average age at entrance to salt water of the fish from which 416 samples were read was two years.

The steelhead represented in the samples from the individual streams showed a difference in average length at entry to salt water of less than three-fourths of an inch. The Siletz and Necanicum Rivers had no samples from fish that had remained in freshwater up to three years, yet the average length of the fish from these two rivers at entry to salt water and at the two freshwater annuli was greater than in any of the other streams. The Siletz River steelhead showed the most vigorous freshwater growth of any of the north coast populations. The Sand Creek and Trask River steelhead showed the slowest freshwater growth although the difference was not great. The Siletz and Coos rivers showed the highest per cent of fish that entered the ocean over eight inches in length. Only four per cent of the fish represented in the Sand Creek sample were over eight inches in length, while about 25 per cent
from in the Siletz and Coos rivers were longer than eight inches.

The average length of all fish at maturity was 25.3 inches. The average weight of 205 fish at time of maturity was seven pounds, one ounce. At capture the average length of all fish was 26.5 inches. The average weight of 293 fish at capture was eight pounds, one ounce.

The range of ages at maturity for all the north coast steelhead was from two to five years. At capture the ages ranged from two to eight years. The modal age at maturity was four years with 252 of the 416 individuals represented as four year olds, and 83 as five year olds. The modal age at capture was also four years with 202 individuals of 416 represented as four year olds and 117 of the fish as five years old.

Modal ages of the fish in the individual streams have not been considered, because four year old fish showed the most predominance over all other ages. This was true at maturity and at capture for the entire sample of each stream as well as for the individual sexes of the stream.

The greatest growth was made the first year in freshwater and the first year in salt water. In salt water, the growth rate decreased most noticeably after maturity, and continued to decrease further after each
successive spawning.

The steelhead represented in the Sand Creek and Salmon River samples showed the smallest average lengths at maturity, 23.3 and 23.5 inches, respectively. The Necanicum River fish at maturity exhibited the greatest average length in the northern region of 29.0 inches. The same streams above also showed the smallest and largest fish length averages respectively at time of capture.

The Salmon River and Sand Creek were represented by steelhead which weighed less at maturity on the average than the fish of any of the other streams of the region, while the Siletz and the Necanicum River fish were represented by the heaviest fish. The average weights at capture for the fish of the two former streams mentioned above were five pounds, seven ounces, and six pounds, eight ounces, respectively, while for each of the two latter mentioned streams, the average weights at capture for both were 11 pounds, two ounces.

The Necanicum River steelhead showed the lowest accumulated ages in the region at maturity. The large number of hatchery fish present in this stream sample influenced the age of the fish represented in the sample to a considerable extent. The Nehalem River fish showed the highest accumulated ages at maturity. The Salmon and
Trask river fish exhibited the lowest accumulated ages at capture.

The average lengths and weights of steelhead in the various streams at time of maturity, and at capture probably represent more the influence of the life histories of the fish than any difference of growth rate, due to differing physical influences, or divergent physiological characteristics. A population with fish remaining in salt water longer before reaching maturity will have individuals with greater average lengths than a population with fish which spend little time in the ocean before maturing (25, p.134). Therefore, in the Salmon River, where a considerable number of fish returned to spawn as grilse, and none remained in the ocean more than two years before maturing, the average length and weight at maturity and at capture were noticeably less than in the Necanicum or Siletz rivers where such a life history situation was somewhat reversed, with individuals rarely returning to freshwater as grilse, and a considerable per cent maturing after three years in the salt water environment. The predominance, or lack of repeat spawners, also influences to a certain extent the average length and weight of fish at time of capture.
Sex, Age, Growth, and Weight

In freshwater and at entry to salt water, the males and females showed little difference in size; the males did average slightly longer in the regional averages. However, in some stream samples the females exceeded the males in length while in freshwater, and even at entry to salt water. As a rule, the difference between the lengths of the males and females in freshwater was too slight to warrant any confidence being placed in comparisons of that factor. Slight differences in lengths of the sexes were also evident during periods of salt water growth. In considering all the samples, the males were generally longer than the females the first few years in salt water. In the later years the females tended to exceed the males in length and also in weight. The females generally weighed more than the males at maturity and at capture.

It seems most likely the greater length of the females in the later years and at time of capture was due mainly to the tendency of the females to spend more years in the ocean before maturing and for them to have a greater survival after spawning (15, p.32).

The males showed a tendency to spend more time in freshwater and mature earlier in salt water than the females. The females, even though they spent three years
in freshwater, proved to be more inclined than the males to remain in the ocean more than one year before maturing. This is well illustrated in the patterns 2/2.8, 2+/2.8, 3/8, 3+/8, 3/1.8, and 3+/1.8. In the first two patterns listed above, the male to female ratio of 40 fish was 1:1.7, with the females more than one-half times as numerous as the males. In the second two patterns, the ratio of 47 fish was 8.4:1, and the males far outstripped the females in numbers represented. In the last two patterns, for 42 fish the ratio was 1:1.5, with the females more numerous.

Of the total 198 males and 213 females considered, 17 males, or 8.6 per cent, remained in freshwater less than two years before migrating to the ocean, and 11 females, or 5.2 per cent, remained in freshwater for about the same short period of time. However, only four of these steelhead were native fish, all the others were hatchery reared. Of the four native fish, two were males and two females. Males having spent two winters in freshwater numbered 125 and represented 63.1 per cent of all the males, while 169 females having spent the same time in freshwater comprised 79.3 per cent of the total number of females. Males that spent three winters in freshwater comprised 56 of the total number of males, or 28.3 per cent, and 33 females that spent the same amount
of time in freshwater represented only 15.5 per cent of all the individuals of that sex. The Nestucca and Coos rivers were the only streams from which females were more numerous than males among fish that remained in freshwater three years.

It seems conceivable that a large sample from native fish that spent less than two years in freshwater might show a predominance of females represented. This would add further weight to the point discussed in the preceding paragraphs, that the males showed a tendency to spend more time in freshwater and to mature sooner in salt water, and that the females showed the reverse tendency.

Of the total 198 samples from males considered, 81, or 40.9 per cent, reached maturity after one year in salt water, which was true of only 22, or 10.3 per cent of the 213 females. The males were represented by 101, or 51.0 per cent, spending two years in salt water before reaching maturity, and the females by 166, or 77.9 per cent. Only 8.1 per cent of the males remained in the ocean three years before returning to spawn for the first time and 11.8 per cent of the females remained for that length of time.

The males at maturity averaged 24.3 inches in length and six pounds, 10 ounces in weight, while the females averaged 26.1 inches in length and seven pounds, nine
ounces in weight. The males ranged in age from two to five years, with the modal age of four being represented by over twice as many individuals as any of the other ages. The females ranged from two to five years of age with the modal age being four. The four year old fish were about three times more numerous than the five year fish which were next most common.

At capture the males averaged 25.1 inches in length and seven pounds, 10 ounces in weight, while the females at capture averaged 27.8 inches in length and eight pounds, three ounces in weight. The males showed a predominant modal age of four years with the range from two to six years. The females exhibited a range in age from two to eight years with modal age of four being represented by 99 individuals and the age five by 74.

The 411 samples read and measured showed the north coast steelhead to have a nearly equal sex ratio at the time of capture of 1:1.1, with 198 males and 213 females represented. A total of 296 fish were taken as initial spawners and showed a sex ratio of 1.2:1, with 163, or 82.3 per cent of all the males, and 133, or 62.4 per cent of all the females entering freshwater to spawn for the first time. Twenty-nine males and 52 females were taken returning for a second time to spawn, showing a ratio of 1:1.8, with 14.6 per cent of the males represented and
24.4 per cent of the females. Five males and 21 females which returned to freshwater to spawn for a third time showed a ratio of 1:4.2. The five males represented 2.5 per cent of all the males and the 21 females, 9.9 per cent of all their respective totals.

Seven fish, one male and six females, were captured as fourth spawners, and a single female was taken returning to spawn for a fifth time. Repeat male spawners totaled 35 individuals, or 17.7 per cent of all the males, while 80 females, or 38.5 per cent, were taken returning to spawn at least a second time.

**South Coastal Region**

One hundred thirty-five of 141 samples from four south coastal streams were read for age and life histories. One hundred thirty samples were measured for growth determination and considered for sex ratios. The dates of collection ranged from October 29 to February 28.

**Spawning History**

Information pertaining to development of the reproductive organs of the fish for spawning was not given with any of the samples of this region. The sex of the fish and dates of collection, however, were given.

One female was captured in October, and one male and
two females were collected in November. Twenty-three males and 29 females were taken in December, while only eight males but 27 females were captured in January. In February, 18 males and 32 females were captured.

It may be inferred from the dates of collection that perhaps the four streams of the south coastal region are similarly characterized as in the north coastal streams by having more males entering freshwater earlier in the spawning season, and also possibly maturing earlier than the females.

The per cent of all south coast steelhead returning to spawn more than once was about twice that of the north coast fish. From table XVI it can be determined that 46.7 per cent of the fish from the south coast were initial spawners, and 53.3 were repeat spawners. Shapovalov and Taft (25, p.128-129) found that of all the steelhead studied over a period of nine years in Waddell Creek, California, 17.2 per cent had spawned at least once before and the greatest number in any one year represented 30 per cent of that year's total.

Second spawners in the southern region of Oregon comprised 36.3 per cent of all the samples, third spawners represented 14.1 per cent, and fourth spawners, 3.0 per cent. All three percentages of repeat spawners represented about twice those of the north coast. The second
spawners of the southern streams represented 68.1 per cent of all the fish that had spawned previously. This is about the same proportion as was found in the northern streams and which has generally been reported in the literature. The frequency of third and fourth spawners also corresponded with the findings of other investigators. This shows that although the per cent of repeat spawners in the south coastal streams was much higher than found in the northern region and generally reported in the literature, the proportions of all the repeat spawners to each other were comparable with other populations of the Pacific Coast.

The Elk River, unlike the other three southern streams showed a large variation from the average number of initial and repeat spawners. The 12 Elk River samples had only three repeat spawners represented, and each had returned but one time previously. The other stream percentages of repeat spawners were quite uniform but somewhat larger than the percentage of the whole region. The Chetco River was the only stream of the entire coast from which scales were recognized as from fish which had spawned in freshwater before entering the ocean. Four such fish were represented. All samples from the entire Oregon coast showed that after reaching maturity steelhead returned to spawn each successive year as long as they
Life History

The 135 samples from the four south coast streams with 12 life history patterns suggest more pattern variation than the samples from the north coast. However, as can be determined from table XVI, about 81 per cent of all the individual samples from the southern streams represented four patterns and less than 20 per cent of the samples comprised the other eight patterns. Therefore, while the steelhead of the southern streams showed a wide range of life history types from 1+/S to 3+/1.5 and 4+/S, the fish represented in the patterns other than the four predominant ones were relatively rare. An even greater per cent of the samples represented steelhead with the same characteristic of returning to freshwater to spawn as grilse.

For a species which shows a high degree of variation (16, p.10; 25, p.117), the southern steelhead of Oregon exhibited remarkable conformity in two respects as just mentioned in the previous paragraph. That is, 81.5 per cent of the southern steelhead populations, as suggested by the samples examined, showed only four life history patterns, all relatively similar, and about 85 per cent of the fish in the total sample showed the predominant
characteristic of returning to spawn in freshwater at the end of the first year in the ocean. In contrast, the same percentage of steelhead in the north coastal streams exhibited eight widely different life histories, and the predominant characteristic of fish returning to spawn after two years in the ocean was shown by only 65.0 per cent of all the fish.

The two patterns 3/S and 3+/S of the south coast represented 47.4 per cent of the total sample, 30.4 per cent and 17.0 per cent respectively; and the patterns 2/S and 2+/S comprised 34.1 per cent of the total sample, 14.1 per cent and 20.0 per cent respectively. The next most predominant pattern, 2+/1.5, was exhibited by only 5.9 per cent of all the samples. The two patterns 2/1.5 and 2+/1.5, which were the most predominant in the north coast region, were represented in the southern region by only 8.1 per cent of all the samples.

The four predominant life history patterns of the south coast were present in all the streams of that region, with the exception of the Sixes River where the pattern 3+/S was not represented; however, the pattern 3/S was shown by a large 35.7 per cent of the samples from that stream. The patterns 2/1.5 and 2+/1.5, which represented the most fish in the north coastal region, were very poorly represented in the southern region. Only in
TABLE XVI

Life History Patterns of 135 Steelhead from Four South Coastal Streams of Oregon, with Spawning Status at Time of Capture, and Frequency of Occurrence in the Various Life History Patterns

<table>
<thead>
<tr>
<th>Life History Patterns</th>
<th>Spawning Migrations</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>one</td>
<td>two</td>
</tr>
<tr>
<td>1. 1+/S</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2. 2/S</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>3. 2+/S</td>
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<td>14</td>
</tr>
<tr>
<td>4. 2/1.S</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>5. 2+/1.S</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>6. 2+/2.S</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>7. 3/S</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>8. 3+/S</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>9. 3/1.S</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>10. 3+/1.S</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>11. 4/S</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>12. 4+/S</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>63</strong></td>
<td><strong>49</strong></td>
</tr>
</tbody>
</table>

In the Winchuck River, both patterns were present.

In the Winchuck River, five of the samples represented fish with the patterns 2/1.S and 2+/1.S, but twice as many samples showed 3/S and 3+/S patterns, and four samples showed 2/S and 2+/S patterns. The Sixes, Chetco, and Elk rivers showed life history pattern proportions quite characteristic of what has been described for the region.

As shown in table XVI, all the fish represented by
the south coast samples had remained in freshwater two
years or more before migrating to the ocean, with the
exception of the only hatchery fish of the region, which
was from the Chetco River. It had remained in freshwater
1+ year. Steelhead that spent 2/ or 2+ years in fresh-
water were represented by 43.0 per cent of all the
samples; those that remained 3/ or 3+ years were
represented by 53.3 per cent of all the samples; and 3.0
per cent of the fish remained in freshwater 4/ or 4+ years
before migrating to the ocean. All the fish that
remained as long as four years in freshwater as juveniles
were from the Chetco River.

The four predominant patterns in the southern region
all showed the fish to have matured at the end of the
first year in salt water. Of the 135 samples from this
region, 115, or 85.2 per cent, showed the fish returned
to freshwater to spawn as grilse. This great predominance
of steelhead maturing after one year in the ocean is in
extreme contrast to the findings from samples of the
northern region, where only 25 per cent of the total
number were grilse. Fourteen per cent of the southern
steelhead had matured after two years of ocean life, and
only one fish from the southern region had remained in
the ocean three years before reaching maturity. Of the
northern region fish, 64.7 per cent reached maturity
after two years of ocean life and 43 fish, or 10.3 per cent, matured after three years in that environment.

The steelhead in the four southern streams showed a very predominant tendency to mature sooner in salt water and to a lesser extent to spend more time in freshwater as juveniles than the fish in the northern streams. Even the majority of the fish that remained in freshwater only 2/ or 2+/ years matured at the end of the first year in the ocean. The Winchuck River sample represented a slight aberration in this respect, where about 26 per cent of the patterns 2/1.S and 2+/1.S were represented in contrast to about 21 per cent of the patterns 2/S and 2+/S.

Shapovalov and Taft (25, p. 133 and 158) explained that the relative percentage of males and females maturing precociously in freshwater was greatest among the fish that returned after one year at sea. Since no samples from the north coastal region of Oregon were definitely recognized as from fish that had matured precociously in freshwater, and four from the south coastal region were recognized as such, it seems probable that a greater per cent of precocious steelhead might be present in the streams of the southern coast, and therefore may be partly responsible for the higher per cent of individuals returning as grilse.

It seems possible that the extended amount of
freshwater existence shown by the steelhead of the southern region may also have at least some effect on the number of grilse represented, although the high per cent of grilse that spent only two winters in freshwater tends to lessen the credence of this possibility. However, Shapovalov and Taft (25, p.123 and 128) showed that survival beyond first spawning is a function of age as well as of number of spawnings. It seems logical that the time of reaching maturity might also be a function of total age. A fish that entered the ocean at three or four years of age would be more likely to mature after only one year in salt water than a fish which entered the ocean at only two years of age.

This is quite well illustrated in this study where 52.8 per cent of the 3/ and 3+ north coastal steelhead returned from saltwater to spawn as grilse, and 47.2 per cent returned to spawn after two years in the ocean, while only 18.1 per cent of the fish that remained in freshwater 2/ or 2+ years returned to spawn at the end of one year in salt water, and 81.9 per cent returned after two or three years in the ocean. In the south coastal region, this tendency was greatly reduced, but was still apparent. Of the fish from the south coastal streams that had remained three years or more in freshwater before migrating to the ocean, 89.5 per cent returned as grilse, while
of the fish that migrated from freshwater after less than three years, 79.7 per cent returned as grilse. Only about one-fourth of the $2/\text{and }2^{+}$/ fish remained in the ocean more than one year before maturing, but the four year migrants all spawned as grilse.

Correlation of the area of cold ocean temperatures and high productivity of the upwelling waters off the coasts of southern Oregon and northern California (discussed on page 7) with the tendency of a great number of steelhead in the same area to mature after one year in salt water can hardly be ignored, and may be significant. However, investigation of such a relationship was beyond the scope of this study, so the possibility of a correlation existing can only be presented here as speculation.

From the findings of this study, it is most logical to assume that the predominance of grilse in the southern streams is partly due to precocious spawning in freshwater and partly due to the relationship of age to time of reaching maturity. Also it may be possible that limiting factors exist, which restrict survival of those fish that remain in the ocean several years before returning to spawn, thus decreasing their survival before and after spawning and reducing their return in successive years to add to the population spawning potential (25, p.139-140).
Age, Growth, and Weight

Back calculations of fish lengths were made from 130 samples. Ninety-one samples were considered for weight relationships at time of capture and only 43 for weight at time of maturity.

The average length at entrance to salt water of all 130 steelhead of the southern streams was 8.2 inches, thus averaging 1.7 inches longer than the fish of the northern region. The range of all the southern steelhead at entrance to salt water was 4.7 inches to 14.9 inches. Sixty-seven fish, 22 males and 45 females, were over eight inches upon entering the ocean.

The percentages of fish from this region entering the ocean at lengths over eight inches and under six inches were opposite the percentages for the same characteristics in the northern region. The fish over eight inches represented 51.5 per cent of the total number of samples measured while only six fish were below six inches at entrance to salt water. Only one fish from the southern region measured less than five inches in length when it entered the ocean.

The Chetco River fish showed the greatest lengths at entrance to the ocean of any in the southern region. They averaged 8.6 inches in length at the time they entered the ocean, and over 60 per cent were eight inches or more in
length at that time. The Sixes River fish averaged the smallest, being only 6.7 inches in length at the time they entered the sea, and only about 14 per cent were over eight inches at that time.

The average length and weight at maturity was less among the south coast steelhead than among the fish of the northern region. The south coast steelhead averaged 22.5 inches in length at maturity and the average weight of 43 fish at maturity was five pounds, four ounces. The ages at maturity ranged from three to five years, the same as found in the north coast.

The average length of all fish at capture was 26.1 inches, slightly smaller than the north coastal average. The average weight at capture of 91 fish was eight pounds, also slightly less than the north coastal average weight. The ages at capture ranged from three to seven years with the modal age being four, as in the northern region. The four and the five year fish were most predominant, as in the northern streams. The greatest growth, as in the northern region, was made the first year in freshwater and the first year in salt water. Steelhead of the entire coast showed that the earlier they entered the ocean, the greater the growth; the difference, however, was not profound (25, p.134).

No noticeable extremes, or trends, were evident in
the individual stream samples of the southern region.

Sex, Age, Growth, and Weight

In freshwater the males and females of the south coastal region showed little difference in size, but the females did average slightly longer at all stages except at the time of entering salt water when the males averaged longer. The fact that the males exceeded the females in length at entry to salt water, even though they averaged shorter after each growing period prior to that time, is explainable at least in part by the fact that a greater per cent of the males remained in freshwater 3/ or 3+/ years, thus attaining lengths which brought their average slightly above that of the females at the time of entering salt water. However, the growth of the males appeared to be slightly faster than that of the females during the latter years in freshwater, as also seemed to be the case in the north coastal fish. The females averaged longer throughout most of the salt water life, especially at the later stages. The males, however, at maturity and at capture, in contrast to the northern samples and reports in the literature, weighed more than the females. The small number of samples available with information on weights very likely caused the discrepancy.

The males and females showed the same characteristic in the streams of this region as in those of the north
coast in regard to the amount of time spent in freshwater and salt water. That is, a greater per cent of females than males remained in freshwater 2/ or 2+/ years before entering salt water, and a greater per cent of the males remained 3/ or 3+/ years in freshwater before migrating. However, three of the four fish that remained in freshwater through four winters were females. One of the samples had no sex given.

Of 47 males, 16, or 34.0 per cent, remained in freshwater 2/ or 2+/ years before migrating to the ocean, and of 83 females, 41, or 49.4 per cent, spent the same time in freshwater. The samples from the males showed that 30, or 63.8 per cent, stayed in freshwater 3/ or 3+/ years before entering the ocean, while 39, or 47.0 per cent of the females remained for that length of time in freshwater. The single hatchery reared fish was a male, which entered salt water in its second year of life.

Of the 47 males, 91.5 per cent reached maturity after one year in the ocean, as did 83.1 per cent of the females. The males were represented by 6.4 per cent which spent two years in salt water before reaching maturity, and the females by 16.9 per cent. Only one fish, which was a male, remained in the ocean three years before returning to freshwater to spawn for the first time. The male grilse of the south coastal streams were more than
twice as prevalent as those of the north coast, while the female grilse were about five times more numerous.

The males at maturity averaged 22.6 inches in length and five pounds, six ounces in weight, and the females averaged 22.6 inches in length and four pounds, 13 ounces in weight. The ages of the steelhead represented in the southern stream samples corresponded well with the ages of the fish from the northern streams. The males ranged in age at maturity two to five years, with the modal age of four being about three times as well represented as the next closest age. The females ranged from three to five years of age, with four years of age being the mode; three year old fish were represented by thirty-three individuals.

At capture the males averaged 25.4 inches in length, eight pounds, six ounces in weight, while the females averaged 26.4 inches in length and weighed eight pounds, two ounces. Both sexes showed the same range of ages at capture, that being from three to seven years. The modal age of the males was four, also being the same for the females.

The 130 samples compared for sex ratios from this region showed the females very predominant at time of capture in contrast to the north coastal samples where the males and females were taken in nearly equal numbers. Forty-seven males and 83 females were represented in the
southern samples, and produced a sex ratio of 1:1.8. A total of 62 initial spawners represented an exact 1:1 sex ratio, with 66.0 per cent of the males and 37.3 per cent of the females entering freshwater as grilse. Twelve males and 33 females were taken returning for a second time to spawn, showing a ratio of 1:2.8 with 25.5 per cent of the males and 39.8 per cent of the females represented. Three males and 16 females that returned to freshwater to spawn for a third time showed a sex ratio of 1:5.3. One male and three females were captured as fourth spawners. Repeat male spawners totaled 16 individuals, or 34.0 per cent of all males, while 52 females, or 62.7 per cent of that sex, had returned to spawn at least a second time.

Coquille River

On the basis of the scales examined from 81 Coquille River steelhead, the fish of this stream show life history characteristics intermediate to those of the fish of the northern and southern coastal regions. The geographic location of the Coquille River is also intermediate to the streams of the two regions.

Spawning History

In considering one of the striking differences of the two coastal regions, that of the contrast in number of
repeat spawners, the Coquille scale samples showed that 38.5 per cent of the fish entered freshwater as adults returning to spawn for at least a second time. This percentage is distinctly centered between the 27.9 per cent of the north coast steelhead and the 53.3 per cent of the south coastal fish. The second and fourth spawners also were represented by percentages between those of the two regions, although the third spawners of the Coquille were less numerous than in either of the regions.

Life History

Eleven different life history patterns were found in the scales examined. In considering the types of patterns exhibited, the transitional relationship of the Coquille fish is striking. Four types of life histories comprised about 75 per cent of the entire sample. Of these four patterns, the most common was 3/3, the predominant pattern of the south coastal stream steelhead, while the second most common Coquille pattern was 2+/1.8, the most predominant life history in the samples of the northern streams. The third most common pattern of the Coquille steelhead was 3/1.8, a life history which seemed to combine the south coastal steelhead characteristic of extended freshwater growth with that of the tendency for extended ocean growth shown by the north coastal fish. This seemed true
also in the pattern 3/2.S, a life history combination which was found only in the Coquille River. The pattern 3/1.S was present in some of the individual streams of the north coastal region, but its representation was not important in the region. It was even less important in the southern region. The fourth most common pattern was 2+/S, one of the four patterns which comprised a combined total of about 81 per cent in the south coast samples.

In respect to the time spent in freshwater as juveniles, and in salt water prior to maturity, the Coquille steelhead do not imitate the proportions of either region, but again show independent characteristics which are medial between the differences of the northern and southern stream samples. The per cent of Coquille steelhead that remained 2/ or 2+/ years and 3/ or 3+/ years in freshwater before migrating to the ocean, and one, two, or three years in salt water before maturing, varied only eight percentage points at the most from the midpoint between the percentages of the two regions.

Age, Growth, and Weight

The Coquille steelhead even showed an average growth in freshwater and an average length at entrance to salt water, which was nearly medial to the two regional differences. The same was also true of the number of
juveniles which measured over eight inches in length at entry to salt water. Even with the small difference between the average lengths at maturity of the steelhead in the two regions, the Coquille fish still represented an intermediate length of 23.9 inches at maturity. The same relationship was also true in regard to the weight at maturity. The average age at maturity coincided closely with the average of four years in the north coastal region. The average length at time of capture, 26.3 inches, was between the averages of both regions.

Sex, Age, Growth, and Weight

The females in this river, as in most of the other streams of the coast, showed the tendency to remain fewer years in freshwater and more in the ocean, with the reverse situation true of the males.

The Coquille sample did not show the females as severely predominant as in the southern samples, but the ratio of females to males was greater than in the northern region, thus once again an intermediate relationship was apparent. Perhaps even more striking is the fact that the Coquille samples showed the same median position in the individual sexes as well as in the combined sexes. This was true at capture and also among the various repeat spawners.
It seems conceivable that the Siuslaw and Ten Mile rivers, from which no samples were available for this study, and also the Coos River, all located just north of the Coquille River, might have steelhead that show the same transitional characteristics as do the Coquille fish. This possibility is suggested slightly in the samples from the Coos River, and even the Salmon River, as mentioned previously in the section on the north coastal region. Chapman's findings on the Alsea River (5), however, do not suggest southern region characteristics.

In view of the findings of Shapovalov and Taft (25) in California, the variance of the southern populations might not actually be as extreme as the available samples indicated. It is also conceivable that the Coquille steelhead could have just chanced to express a transitional relationship between the northern and southern samples. However, it seems unlikely that such a remarkable relationship could be afforded to chance alone. The medial geographic location of the Coquille River and the transition which the samples suggest between the sample characteristics of the northern and southern regions of the coast adds credence to the possibility that the populations of each region are actually distinct.

From the findings in this study, it has certainly proven that the steelhead of Oregon do have different life
histories, and they cannot all be considered as following any single one, or even any specific type, nor can they necessarily be expected to exhibit equal characteristics of age, length, weight, sex ratio, etc. Indications of the different stream population characteristics have been shown, and they suggest that the variances are quite large, even sometimes between populations located in close proximity to each other.

The relationships of the differences between the populations were exhibited very well by the extreme differences in the north and south. The transition which the characteristics of the Coquille River sample showed between the northern and southern samples of the coast certainly adds weight to the indications of the data that the populations of the two established regions are distinctly different.

How distinct the populations of the individual streams are from each other and exactly in what ways they are different remains to be discovered in future investigations where the individual stream populations can be dealt with explicitly. From the findings of such future inquiries it will be possible to determine conclusively if the relationships suggested by this initial study are truly valid.
SUMMARY AND CONCLUSIONS

This study was based on examination of scales from 691 steelhead trout from 14 coastal streams in Oregon. Scales from 632 fish were read for age and life histories. The study was aimed primarily at determining: (1) whether the steelhead populations in the various streams of Oregon have different life histories, (2) what the characteristics of the various populations are, and (3) the relationship of the differences between the populations. The scale samples utilized for the study were mainly collected by Oregon Game Commission personnel.

The biological characteristics of the Oregon coastal steelhead indicated that distinct differences existed in the populations with respect to their geographic locations. Therefore, two distinct regions were established: the north coastal region, comprised of the nine most northern streams considered, and the south coastal region, composed of the four most southern streams. The intermediate relationship of the Coquille River steelhead, geographically and biologically, seemed to justify the consideration of them as transitional between the steelhead of the northern and southern streams, so the Coquille fish were considered in neither region and were reviewed separately.

The physical characteristics of the streams on the
Oregon Coast are noticeably comparable. They are generally clear in spring, summer, and fall, most often becoming muddied and swollen in winter from heavy rains. Moderately rapid flows and steep channel gradients, with headwaters in the Coast Range mountains typically describes most of the streams. In the southern portion of the state, the ocean temperatures are distinctly cooler during the spring and summer than in the north. This is due to extensive upwelling of the cold lower water strata.

With the exception of the Siletz River, all the streams that head in the Coast Range and flow directly to the ocean have only winter run steelhead. The Siletz River has both a winter run and summer run of steelhead, but only the winter run was considered.

The steelhead trout is a member of the family Salmonidae, and is defined in this study as the coastal rainbow trout, *Salmo gairdnerii gairdnerii* Richardson, which is typically anadromous, although at times individuals may remain strictly as freshwater residents.

Each scale first appears on the surface of the body of the very young fish as a somewhat circular plate which looks like a more or less complete ring. As the fish increases in size, succeeding plates, which appear as additional rings, are added with the growth of the scale, and are termed circuli. Barring accident, the scales are
permanent, and the growth of the scale is usually in proportion to the growth of the body. The life history of individual fish can be ascertained through interpretation of the varied arrangements of the scale circuli.

The validity of determining the age of fish from scales was established as early as the 19th century, and has since been supported by many workers. The validity of back calculated fish lengths from scales has also been established by many workers since Dahl first presented the original method in 1911.

Few of the steelhead scales recognized as from hatchery reared fish showed more than a few constricted annuli, if any, beyond the widely spaced circuli denoting hatchery growth. It was therefore apparent that the hatchery fish generally moved to the ocean shortly after release in the stream.

The following information was utilized from that recorded on each scale envelope: locality of collection, date of collection, sex, length, weight, and stage of reproductive organs.

In designating age and life history stages by scale formulas, the method used was modified from Shapovalov and Taft. Scales were read and measured at 112 X magnification on a scale projection machine developed by biologists of the United States Fish and Wildlife Service.
calculations of fish lengths were made with C. McLean Fraser's direct proportion formula, \( l_i = c + \frac{s_i}{5} (L-c) \), modified from Dahl. It was assumed for the valid use of this formula that the fish-scale relationship was proportional, and described a linear regression. This formula introduces a constant \( c \), or correction factor, into the scale equation, which relieves much of the discrepancy resulting in low computed values of young fish.

The value for the constant \( c \) used in this thesis was established a 1.10 inch. The value 1.10 inch was adopted as the result of a plotted regression line computed by the method of least squares, comparing scale and body length relationships of 97 adult and juvenile steelhead from Sand Creek, Oregon.

Findings for each of the 14 streams were presented separately in detail. In each instance, details of the following subjects were presented: Number of scales and dates of collection, spawning history, relationships of age, growth and weight, and relationships of sex, age, growth and weight.

The combined population characteristics of the northern and southern regions were compared with each other and with the Coquille River. The individual streams were compared briefly.

Of the entire number of samples examined from the
north coast streams, 416 were read for age and life histories, 411 were measured for growth determination and compared for sex ratios. Of the scales from the southern streams, 135 were read for age and life histories, and 130 were measured for growth determination and considered for sex ratios.

From the dates on which all the males and females were taken, and from the sexual development of the fish at the time of capture, it was indicated that more males entered freshwater earlier than females and also seemed to be advanced sexually for spawning sooner than the females.

The per cent of all south coast steelhead that returned to spawn more than once was about double that of the north coast fish. The second, third, and fourth spawners were in the same proportions to each other in each region, but were twice as numerous in the southern region.

The number of repeat spawners present in the samples studied were high in comparison to reports in the literature. Aside from the fact that Oregon steelhead survival may be greater than elsewhere on the coast, the marked predominance of repeat spawners in this study was believed to be due partly to the tendency of anglers and collectors to select large fish in preference to the smaller ones.
The females showed a greater survival after spawning than did the males, so in samples where females predominated, the per cent of repeat spawners was greater. This effect was especially apparent in the southern stream samples.

In the northern region, the Coos, Siletz, and Necanicum rivers had the greatest per cent of repeat spawners. The Nehalem River and Sand Creek showed the reverse situation, with the least numbers of returning spawners. In the southern region, the Sixes and the Winchuck rivers showed the largest per cents of repeat spawners, while the Elk River showed only about half as many returning spawners.

The Chetco River was the only stream of the entire coast which showed scales definitely from fish that had spawned in freshwater before entering the ocean. All steelhead from the Oregon coast showed that after reaching maturity they returned to spawn each successive year as long as they survived.

The samples from the four southern streams suggested more life history variation than the northern samples. However, the southern steelhead showed remarkable conformity in that about 81 per cent of the samples represented only four life history patterns which were quite closely related, and about 85 per cent showed the fish to have the same characteristic of returning to spawn in freshwater.
after only one year in the ocean. In contrast, about 81 per cent of the north coastal samples showed eight life histories which differed widely; and the predominant characteristic of returning to spawn after two years in the ocean was exhibited by only 65 per cent of all the fish.

The two predominant patterns of the northern steelhead were 2/1.S and 2+/1.S while in the southern samples the four distinctly predominant patterns were 2/S, 2+/S, 3/S, and 3+/S.

The steelhead of the four southern streams showed a very definite tendency to mature sooner in salt water and to spend more time in freshwater as juveniles than did the fish in the northern streams. The predominance of grilse in the southern fish was possibly due in part to precocious spawning in freshwater, and also to limiting factors which may act to restrict the survival of fish that leave freshwater after only a few years and remain several years in the ocean before returning to spawn. The longer time spent in freshwater by the southern fish undoubtedly also influences the number of fish that return to spawn as grilse.

Hatchery reared steelhead represented 6.7 per cent of the total number of fish from the north coast region. Nearly all appeared to have gone directly to the ocean.
upon release. They averaged 7.5 inches in length upon entering salt water. Among the samples from the southern streams, only one was noticed to be from a hatchery reared fish.

Juvenile steelhead of the southern streams not only remained in freshwater longer than the steelhead of the northern streams, but they also showed more rapid growth during their years in freshwater than did the north coastal fish. The northern steelhead averaged 6.5 inches in length upon entering the ocean and the southern steelhead averaged 8.2 inches in length.

The average length and weight at maturity was slightly greater among the northern steelhead, undoubtedly due largely to the longer time they spent in the ocean prior to maturity. The average length and weight at capture of the northern steelhead was also slightly greater, but the ages were generally slightly less than the age of the southern fish at capture.

There was little difference in size, weight, or age between the sexes in any of the samples. In the northern fish, the females exceeded the males slightly at maturity and capture. The males of the southern streams however exceeded the females in weight at maturity and at capture. This contrast to the findings in the northern populations and to reports in the literature was probably due to the
small number of samples from the southern streams with available information on weights.

The scales of both regions showed that the males tended to spend more years in freshwater and mature earlier in salt water than the females. In both regions, the females showed much greater survival after spawning. In only the Wilson River did the per cent of repeat spawning males exceed the per cent of female repeat spawners. In the northern stream samples, the sex ratio at capture was nearly equal, but in the southern streams the females were nearly twice as numerous. In the northern region, 17.7 per cent of all the males were repeat spawners as were 38.5 per cent of the females. In the southern region, 34.0 per cent of all the males had returned to spawn more than once as had 62.7 per cent of all the females.

The intermediate relationships shown by the Coquille steelhead which were most striking were as follows: number of repeat spawners, types of life history patterns, age, growth and weight at maturity and at capture of all the samples, and also of the individual sexes. The sex ratio at time of capture, and also the sex ratio among the repeat spawners were intermediate in the Coquille to the northern and southern regions.

It seemed unlikely that such a remarkable
relationship in so many respects could be afforded to chance alone, especially when the geographic location of the Coquille River between the northern and southern streams was considered.

It was suggested that the Siuslaw and Ten Mile rivers, from which no samples were available, and the Coos River, all located just north of the Coquille River might have steelhead that show the same transitional characteristics as do the Coquille fish.

From the findings in this study, it was proved that the steelhead of Oregon do have different life histories, and they cannot all be considered as following any single life history. Indications of the different stream population characteristics were shown and they suggested the variances to be quite large, even between some populations located in close proximity to each other.

The relationship of the differences between the populations was exhibited very well by the extremes in the north and the south. The transition which the Coquille River sample showed between the northern and southern samples added weight to the indications of the data that the populations of the two established regions were distinctly different. How distinct the populations of the individual streams are from each other, and exactly in what ways they are different from each other remains to
be discovered in future investigations. From such inquiries it will be possible to determine conclusively if the relationships suggested by this initial study are truly valid.


25. Shapovalov, Leo and Alan C. Taft. The life histories of the steelhead rainbow trout (Salmo gairdneri gairdneri) and silver salmon (Oncorhynchus kisutch) with special reference to Waddell Creek, California, and recommendations regarding their management. Sacramento, California, Department of Fish and Game, 1954. 375p. (California. Department of Fish and Game. Fish Bulletin no. 93)


