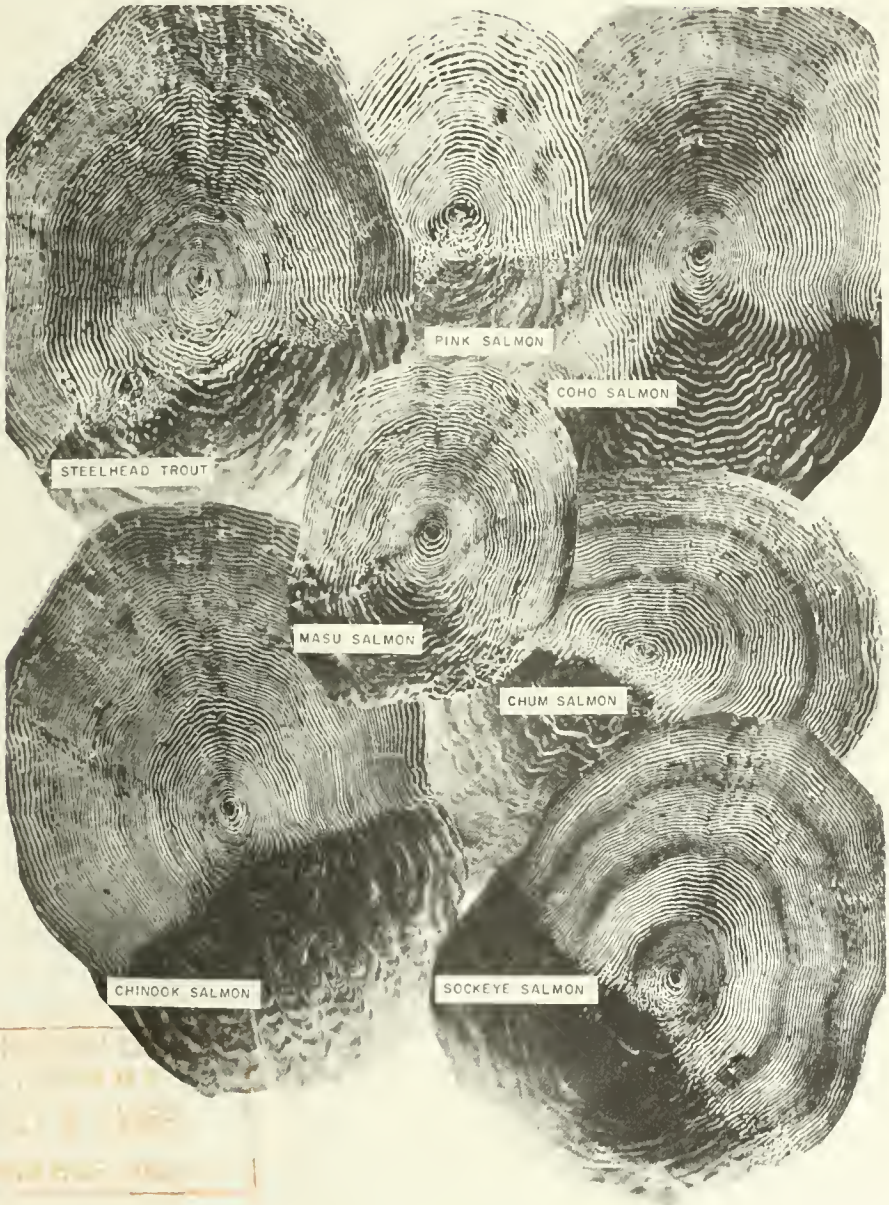
Identification of Pacific Salmon and Steelhead Trout by Scale Characteristics



UNITED STATES DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES

Circular 317

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By

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ABSTRACT

Descriptions and illustrations of the scales of each species, a key to identifying species by use of scale characters, and a section on the appearance of juvenile salmon scales are presented.

INTRODUCTION

Identification of species of salmon (genus Oncorhynchus) and steelhead trout (Salmo gairdneri) in the sport and commercial catch of the Pacific coast is important in assessing the relative production and value of each species and in performing biological research.

Methods of identifying the species from the examination of whole or gutted fish are available; however, at times it may be necessary to determine the species from a portion of a fish such as a steak or fillet. Any scales on these portions offer a means of identification. Although Koo (1962b) and Bilton, Jenkinson, and Shepard (1964) have published on identification of species of Pacific salmon by scales, the masu salmon (O. masou) and the steelhead trout were not included in their studies.

This illustrated guide has been prepared to show the differences among scales of species of Pacific salmon and steelhead trout. With a minimum of preinstruction, fishery inspectors in the field or on shipboard can use this guide. The species differ from each other in their life histories, and some scale features clearly show certain aspects of these life histories. The paper is organized as follows: The general scale features are described, then each species is described separately, with photographs of scales of postjuvenile fish (fish that have lived in the ocean for some time); a key to identification of species of postjuveniles by scale characters; a section on identification of juvenile fish (from the time scales first appear on the fish body until the fish migrates to the sea); and finally a glossary of terms used in these studies.

CHARACTERS OF SCALES USED FOR SPECIES IDENTIFICATION

In the following sections various subjects bearing on the use of scales for identification of species will be discussed:

1. The visual appearance of the scales, including the growth features of the anterior field which are used in determination of age of the fish, and the features of the posterior field which assist in identification of species.
2. Life history features that are revealed by the scales of the various species and behavioral patterns that influence the utility of age and other characters for identification purposes.

[1] This paper is based on one by J. T. Barnaby and A. C. Delacy, [no date, but circa 1944]. Identification of Pacific salmon and steelhead trout by means of scale examination. U.S. Fish Wildl. Serv., Seattle, 3 pp. (processed). Copy is available at Bureau of Commercial Fisheries Biological Laboratory, 2725 Montlake Boulevard E., Seattle, Wash. 98102.

VISUAL APPEARANCE OF THE SCALES

If a single scale is removed from the scale pocket of a salmon or trout, cleaned, and examined under a microscope or projector, two major areas will be seen: First, inbedded in the scale pocket is the anterior field, the larger portion of the scale, which contains a series of concentric lines called circuli; and, second, a smaller clear area, the posterior field, which protrudes from the scale pocket and shingles over the pockets of the adjacent scales toward the tail of the fish. Both the anterior and posterior fields are important in identification of species.

Scales of an individual fish vary considerably in size and shape. Those from the back, along the belly, near the fins, and operculum are often small and odd-shaped. Some of these scales are unsuited for identification. The scales used to illustrate this paper were all taken from the middle of the side of the fish, the "A" zone, Mosher (1963). The illustrations (negative prints) of the various species are of about the same magnification so they indicate the relative size of normal scales. Examination of a few scales from a number of species soon makes the relative sizes obvious.

Anterior Field

The features used in age determination of the fish are found on the anterior field of the scale and consist of the circuli and their patterns of growth. The circuli are concentric ridges on the outer surface of the scale separated by valleys so that the scale roughly resembles a fingerprint, or a cross section of a tree where a light and dark ring show 1 year's growth. On a salmon or trout scale, however, a year's growth is indicated by a zone of widely spaced circuli, the summer growth, plus a zone of closely spaced circuli, the winter growth. When the scale is growing rapidly, from May to August or September, the circuli are wide with broad interspaces. When growth slows in the winter, the circuli are deposited closer together, broken, or otherwise interrupted. This latter area is called an annual mark, winter zone, or annulus. Thus, it is possible to tell the age of the fish by study of these scale features.

Growth is much more rapid at sea than in fresh water; thus circuli laid down in fresh water are finer lined and more closely spaced than those deposited in the ocean. These differences make it possible to define the periods a fish spends in each environment.

The important scale features are identified in figure 1.[2]

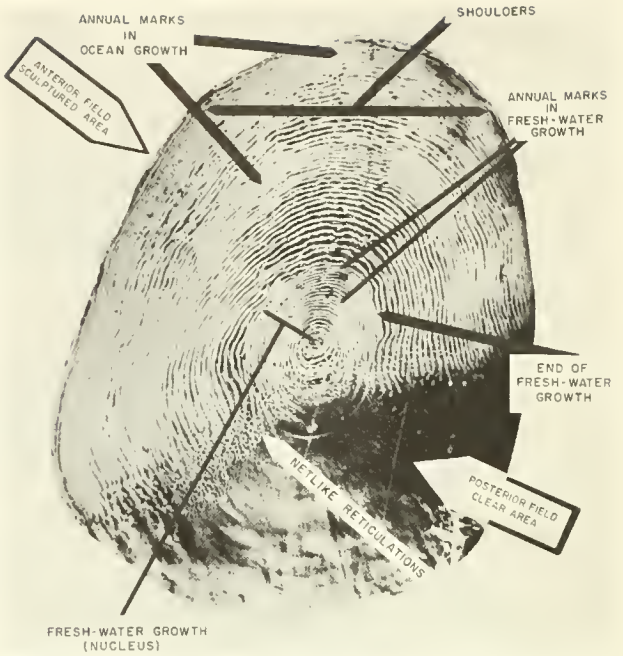

Figure 1.--Features of the anterior field (sculptured area) of a salmon scale (a scale from a sockeye salmon, age 2.2).

In this paper I have used the European system of age designation recommended by Koo (1962a). The number of winters the fish spent in fresh water (not counting the winter the egg was in the gravel) is shown as an Arabic numeral followed by a dot, then the number of winters in the ocean. For instance, a salmon of age 2.3 spent 2 winters in fresh water after hatching and 3 winters in the ocean; the fish is 5 years old and is in its sixth year. In many studies of Pacific salmon, the age is recorded by the system of Gilbert and Rich (1927). The first digit is the number of winters from the time the egg was deposited in the gravel to the time of maturity (or capture); a number, usually written as a subscript, shows the number of winters from the time the egg was deposited to time of migration to the sea. For instance, an age designation of 6_3 corresponds to age 2.3 in the European system.

Posterior Field

The posterior field or clear area[3] of the scale has certain features which help to identify the species: (1) the number of circuli which are complete below the focus or center of the scale when viewed with the anterior field away

[2] On all the figures the winter growth zones, or annual marks, in fresh water are indicated by narrow arrows and the ocean ones by wide arrows. Some of the features in the figures can be seen more clearly with a magnifying glass of 3- to 5-power.

[3] Because this area of the scale is usually difficult to examine under a microscope or microprojector, it may be necessary to vary the lighting for each scale to find the best intensity and angle of illumination to reveal the structures. In these negative prints the posterior field tends to photograph black because it is relatively transparent.

from the viewer (as the figures in this paper are shown); (2) whether broken circuli or segments of circuli are present in the posterior field, (3) whether circuli invade the posterior field from their bases; (4) the occurrence of radial striations or ridges; and (5) the presence and type of reticulations. Figure 2 shows the features of the posterior field.

LIFE HISTORY FEATURES THAT INFLUENCE SCALE CHARACTERS

Pacific salmon usually spawn and deposit their eggs in the gravel of a suitable stream or lake in the late summer and fall. The eggs develop, and the fry hatch in the gravel during the winter and spring. Steelhead trout usually spawn late in the winter or spring, and the young hatch within a few weeks. The young fish of both groups emerge from the gravel at about the time the yolk-sac has been absorbed.

Young of the pink salmon (O. gorbuscha) and chum salmon (O. keta) migrate to the sea soon after emerging from the gravel, usually before the scales have started to grow. Young of the other species usually remain and grow in fresh water from 1 to 4 years before migration to the sea although a large portion of the

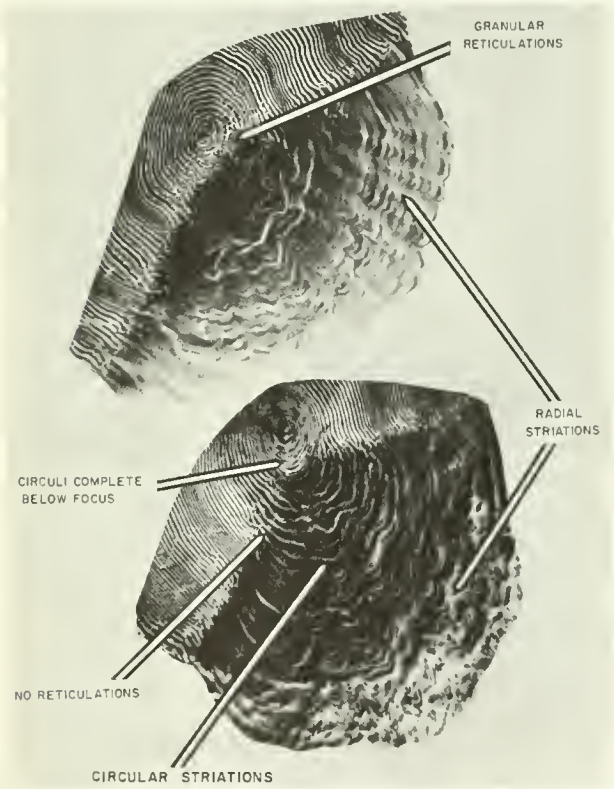

Figure 2.--Features of the posterior field (clear area) of value in species identification--posterior sections of a chum (upper) and a chinook (lower) salmon scale--are shown.

chinook salmon (O. tshawytscha), especially those from British Columbia southward to California, may migrate seaward after only a few months in fresh water.

After the period of fresh-water growth, most of the sockeye (O. nerka), chinook, coho (O. kisutch), and masu salmon and steelhead trout migrate to the ocean in early spring just as rapid scale growth begins, so that the scales usually show a definite winter mark at the margin of the fresh-water growth zone. As mentioned previously, since growth is much more rapid at sea, it is possible to determine the exact boundary of the fresh-water growth on most scales.

Salmon and trout do not develop scales until they are between 25-50 mm. long (1 to 2 inches); thus their scales have no record of the first winter in the gravel. Those fish that migrate to the sea immediately after leaving the gravel show rapid growth on the scale directly from the focus.

After a period at sea that varies from a few months to a maximum of 5, or occasionally 6 or 7 years, depending on the species, the salmon return to the stream where they originated to spawn and die. Sometime during this migration, the fish stop feeding and utilize the protein and fat stored in the body. As the migration progresses, the drain on the body becomes greater, and the fish resorb portions of the scales. By the time spawning is completed, only small central sections of the scales are left on most individuals. Determination of total age or identification of species from such scales is difficult or impossible.

Unlike the Pacific salmon, steelhead trout do not necessarily die after spawning. Instead they may return to the sea where they recover from spawning and continue to grow until they again return to fresh water to spawn. This species also resorbs scales at the time of spawning, but generally to a lesser extent than do salmon. After spawning, the irregular scale margins caused by the resorption are repaired by new growth. These repaired areas or scars are called spawning checks. The scales of steelhead trout may show one or more spawning checks, which can assist in identification of this species.

Different species behave differently and are found in coastal and offshore waters during different parts of their life histories. These differences in habit and habitat can influence the age of the fish at the time of capture and consequently the utility of age as an item for identifying species. Maturing chum, sockeye, and to a lesser extent pink salmon generally do not take a lure or bait in coastal or fresh-water areas and must be caught with various types of nets. Commercially caught chum salmon are 3 to 6 years old; 5- and 6-year old fish are more common in Alaska and the Western Pacific Ocean than from British Columbia southward where the 3- and 4-year

old fish are more abundant. Commercially caught sockeye salmon range from "jacks" which return to spawn after 1 year at sea as 2- or 3-year olds to 5-, 6-, or rarely 7-year olds. Three-year-old sockeye salmon (in their fourth year) with 2 years at sea predominate in the Fraser and Columbia Rivers, but the 5- and 6-year olds are more abundant in Alaskan and Asian waters. Commercially caught pink salmon are almost invariably in their second year, with only one winter zone on the scales.

Although coho and chinook salmon and steelhead trout are often caught on their spawning migrations, they are also taken at any age up to maturity in coastal waters by trolling with baits and lures. Coho salmon usually mature after 1 year at sea--in their third year in the southern areas and in their fourth year in the northern localities. Some chinook salmon mature after one or two summers at sea ("jacks" as 2- or 3-year olds). Others may require as many as 6 or 7 years to reach maturity. Steelhead trout of any age up to a maximum of 5, 6, or even 7 years old may be caught.

In the Japanese offshore commercial fishing and in research fishing by Canada, Japan, and the United States, fish of all ages and stages of maturity are now caught from soon after they reach the sea to just before they enter their natal streams on the spawning migration. Ages may not be as important a diagnostic feature of species for these fish as for adults taken inshore.

SPECIES IDENTIFICATION FROM SCALES

This section of the paper is divided into 3 parts:

1. Descriptions and photographs of the scales of each species. Differences among species are noted, including those which are not diagnostic enough to enter into the dichotomous key, but which may assist in identification of species, especially when the differences between species are small.
2. A key to the species identification of scales of salmon and steelhead trout taken in the ocean or in fresh water in the year of spawning.
3. A section on the species identification of scales of juvenile fish.

DESCRIPTION OF THE SCALES OF THE VARIOUS SPECIES

Pink Salmon (fig. 3)

Pink salmon scales are easily distinguished by their small size relative to the size of the fish, single winter zone or year mark, and absence of a fresh-water nucleus. Scales of pink salmon are more variable in their posterior field than the other species; only a small percentage, however, have radial striations, circuli in the posterior field, or have more than six complete circuli below the focus of the scale.

Chum Salmon (fig. 4)

Scales of chum salmon can be distinguished from those of the other species by the absence of a fresh-water nucleus, less than seven circuli complete below the focus (usually 0 to 3), heavy granular reticulations between the two fields, rough sculpturing of the posterior field with radial striations, and no circuli or

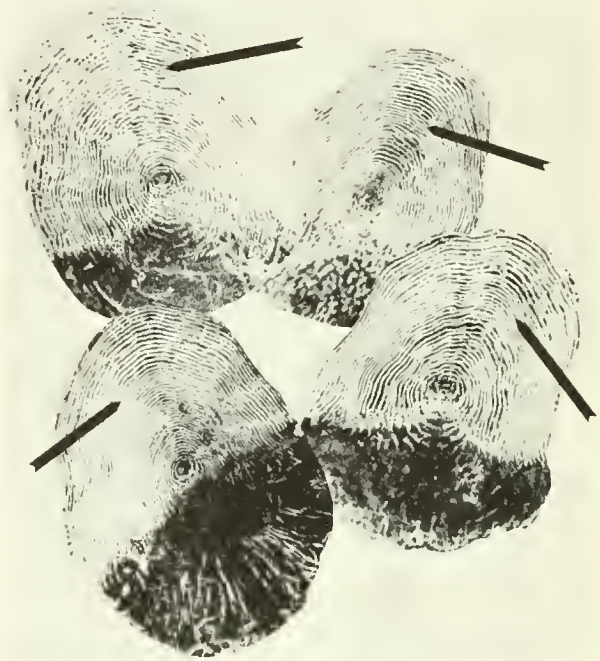

Figure 3.--Scales of pink salmon, age 0.1.

segments of circuli in the posterior field. In addition they usually have large scales for the size of the fish. The whole scale has a "bolder", more open appearance, with broader shoulders than the scales of the other species.

Sockeye (Red) Salmon (fig. 5)

Scales of sockeye salmon generally have a pronounced fresh-water nucleus often with one or more winter marks. The ocean zone has two or three winter marks as a rule, except for the "jacks" which have one. Generally, no more than six circuli are complete below the focus. The circuli are generally not as bold or distinct as those of chum salmon; thus, sockeye

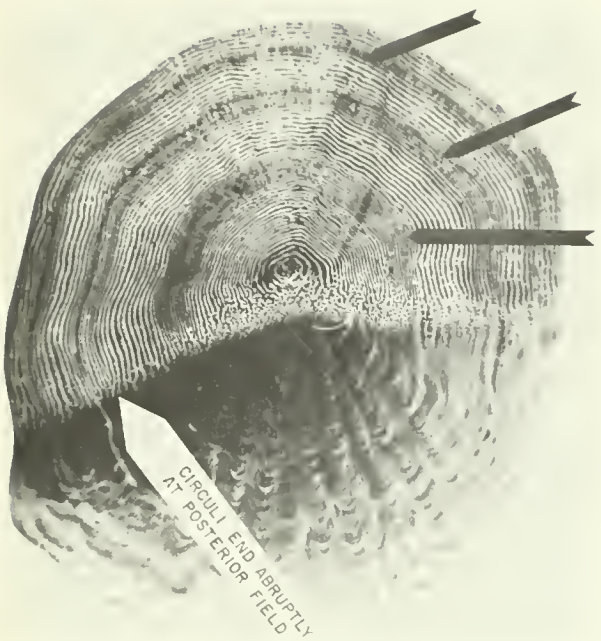

Figure 4.--Scale of a chum salmon, age 0.3.

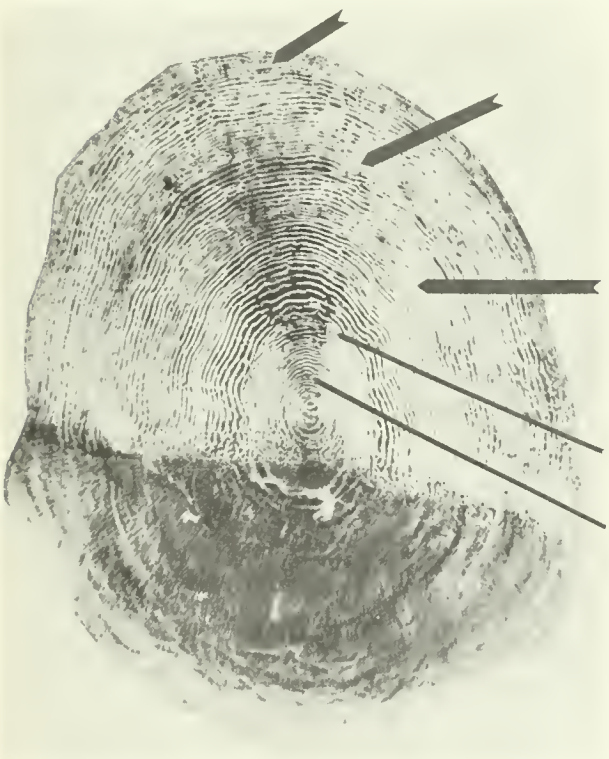

Figure 5.--Scale of a sockeye salmon, age 2.3.

salmon scales usually lack the "open" appearance of the chum salmon scales. Usually, the anterior field is not as broad at the base, where it joins the posterior field, and the shoulders of the scale are not as prominent as those of the chum salmon scales. The posterior field is clear; it has no prominent markings. Any markings that do occur are faint and ill-defined and tend to be concentric with the scale margin, but not circuluslike. See Mosher (1968) for additional information on sockeye salmon scales.

Occasionally sockeye salmon go directly to the sea after emerging from the gravel; these fish are called "ocean-run sockeye." Their scales can be distinguished from the scales of chum and ocean-run chinook salmon (the only other species with which they might be confused) by the difference in the posterior field of the three species: chum and chinook salmon scales have strong radial striations; they are absent on sockeye salmon scales (fig. 6).

Coho (Silver) Salmon (figs. 7 and 8)

Coho salmon scales are generally large for the size of the fish. The fresh-water zone varies in size and usually has 1 or 2 annual marks. The large ocean zone generally has only 1 annual mark, but occasionally two occur in Alaskan and Asian fish. The circuli are fairly distinct, as a rule. Often the scales are pinched-in at the base of the anterior field.

The scales of this species are fairly distinct from those of the sockeye salmon and may be distinguished from them by:

1. More than six complete circuli (often many) below the focus.

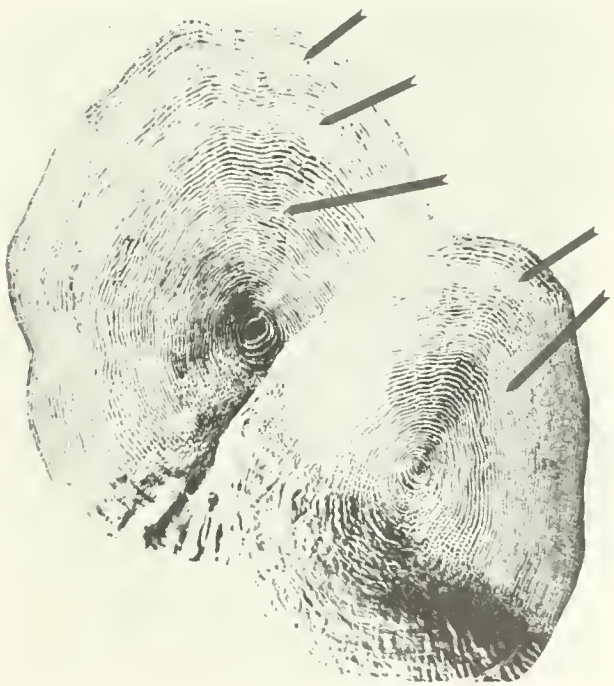

Figure 6.--Scales of ocean-run sockeye salmon, ages 0.3 and 0.2.

Figure 7.--Scale of coho salmon, age 1.1.

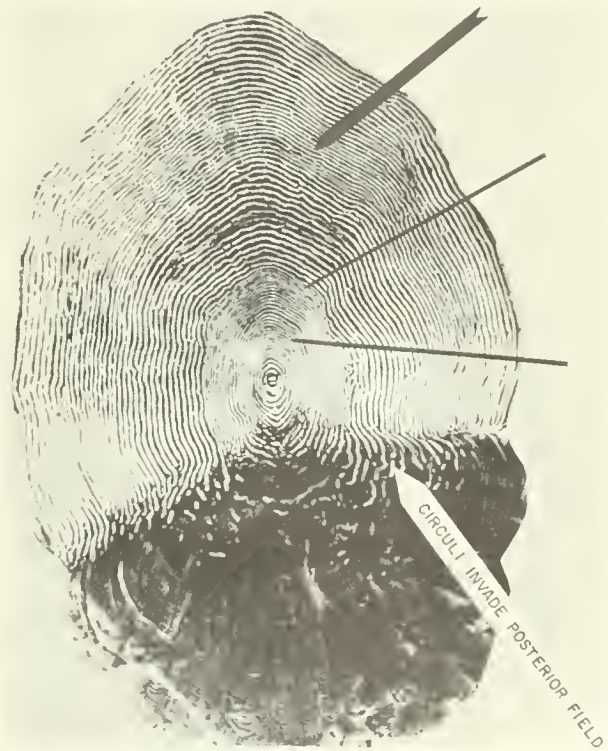

Figure 8.--Scale of coho salmon, age 2.1.

2. The presence of strong radial striations in the posterior field.

3. The presence of circuli or segments of circuli in the posterior field.

Coho and chinook salmon scales are fairly similar, and subtle differences must be evaluated to distinguish between them:

1. The fresh-water zone of the coho salmon scale is usually larger and more distinctly marked than that of the chinook salmon. Many chinook salmon migrate seaward at less than 1 year of age, whereas most coho salmon migrate to the ocean after 1 or 2 full years in fresh water.

2. Usually coho salmon scales have more circuli that are complete below the focus than those of chinook salmon.

3. Circuli or segments of circuli are usually prominent in the posterior field of the coho salmon scales. On scales of chinook salmon, some of the ridges of the circuli may extend into the posterior field as circular striations. These are weak and unlike true circuli.

4. Chinook salmon scales also tend to be large for the size of the fish with a large first ocean zone, but mature chinook salmon may have more than one annual mark in the ocean zone, often 3 or 4.

5. Reticulations are seldom present on the scales of either species, but if they do occur, they are netlike and are more likely on the chinook salmon scales than those of the coho salmon.

Chinook (King or Spring) Salmon (figs 9 and 10)[4]

Usually more than six circuli are complete below the focus of the scales, but often only 7 or 8. Radial striations are strong in this species. The circuli seldom invade the clear field from their bases, but some of the first ocean circuli may be followed into this area as weak, irregular markings, the circular striations. Few scales show reticulations, which are usually netlike, if present. The first ocean zone is usually large and has numerous circuli. Mature chinook salmon may have as many as four, or rarely five, annual marks in the ocean zone.

A substantial percentage of the chinook salmon (ocean-run type), especially in the rivers from California northward to British Columbia, migrate to the sea during their first spring or summer. The scales of these fish may show a small nucleus of fresh-water growth, or none at all. Ocean-run chinook salmon can be distinguished from the ocean-run sockeye and chum salmon by the number

[4] The incidence of regenerated or atypical scales is high in this species; it is often necessary to examine a number of scales to find a suitable one to study.

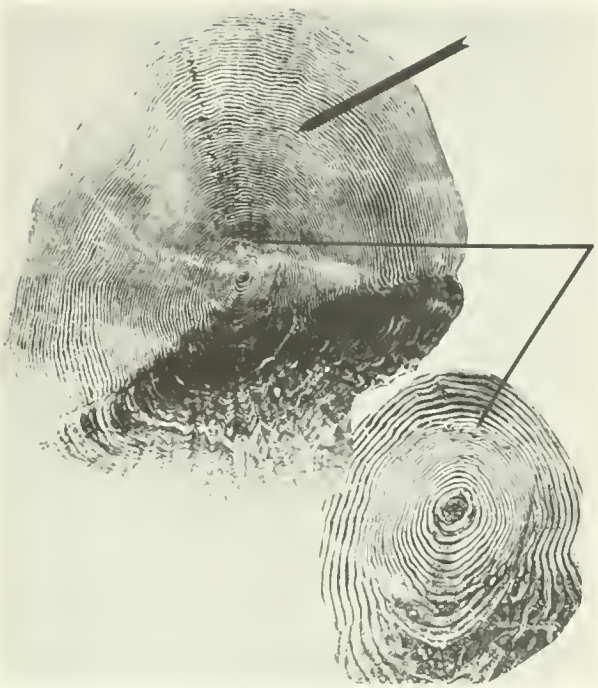

Figure 9.--Scale of a chinook salmon with a magnified portion of the center, age 1.1.

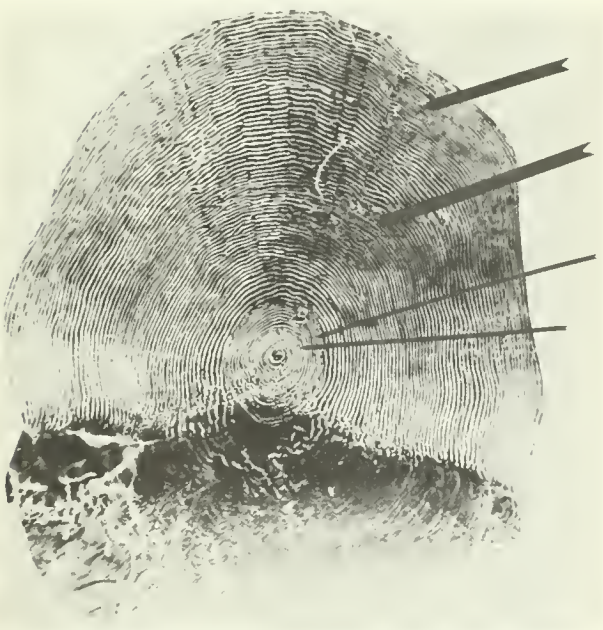

Figure 10.--Scale of a chinook salmon, age 2.2.

of circuli which are complete below the focus of the scale: the sockeye and chum salmon, six or less; the chinook salmon, more than six (fig. 11).

Figure 11.--Scale of an ocean-run chinook salmon, with a magnified portion of the center, age 0.1.

Masu Salmon (figs. 12 and 13)[5]

This species occurs only on the Asian side of the Pacific Ocean, and research fishing by United States and Canadian scientists has not yet included any masu salmon.

Life history and offshore distribution data on the masu salmon were summarized by Tanaka (1965). He reported that masu salmon resemble the coho salmon in many morphological and ecological aspects.

My examination of a series of masu salmon scales showed that they resemble scales from coho salmon in several features, but are different in some others.

The features that are similar to those of the coho salmon are:

1. Age. Tanaka reported that in Hokkaido, Japan, over 90 percent of the masu salmon mature at age 3_2 (1.1), the others at age 4_3 (2.1). In Kamchatka, some fish stay over another year at sea to mature at age 4_2 (1.2) or 5_3 (2.2), depending on their fresh-water history.

[5] Since Koo (1962b) and Bilton, Jenkinson, and Shepard (1964) did not include the masu salmon or steelhead trout in their papers, I am including a number of examples of scales of these two species to illustrate some of the variations that may be encountered in the study of these fish.

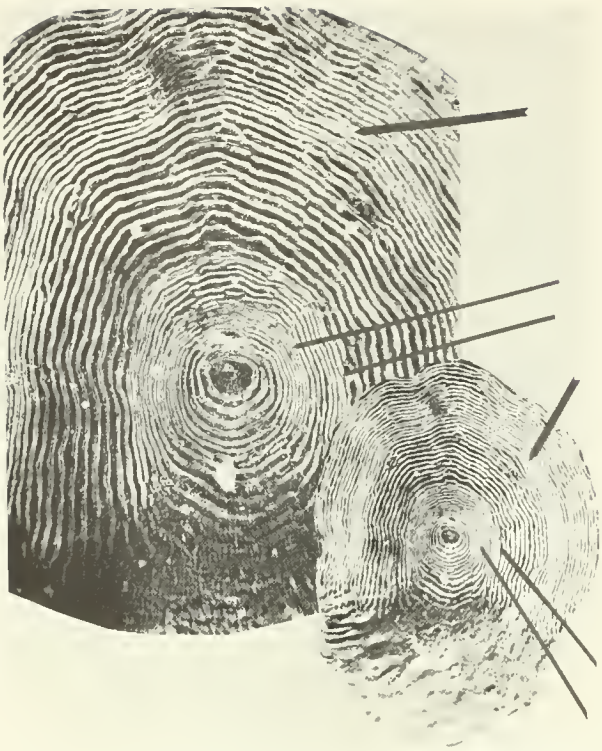

Figure 12.--Magnified central portion of a masu salmon scale; entire scale is superimposed to show fresh-water and ocean zones in detail, age 2.1.

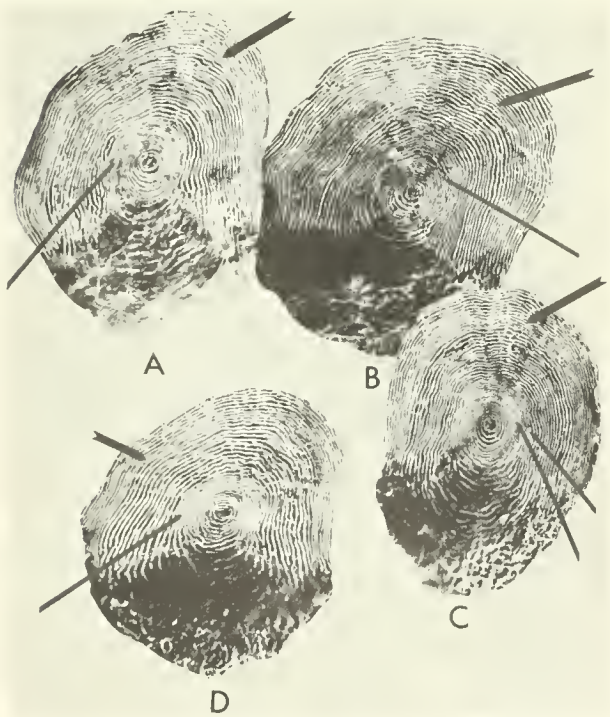

Figure 13.--Scales of masu salmon: A, B, and D, age 1.1, and C, age 2.1.

2. The number of circuli that are complete below the focus of the scale is variable, but usually there are many.
3. The circuli often invade the posterior field from their bases; often many can be traced through that area of the scale.
4. Reticulations are usually absent, but if present they are few in number and net-like.

The features that differ from those of the coho salmon are:

1. Masu salmon have no radial striations.
2. Compared with scales of coho salmon, the scales of masu salmon tend to be small for the age of the fish (scales of masu salmon are about the same size as those from pink salmon).

Steelhead Trout (figs. 14, 15, and 16)[6]

Scales of this species usually show considerable fresh-water growth, often with bold appearing circuli. A wide range of age combinations may be found: one to three, or more, winter marks in the fresh-water zone and from one growing season (no winter mark) to four, five, or occasionally even more winter marks in the ocean zone. Many of the circuli of the fresh-water growth are continued around the scale into the posterior field; in fact, the whole

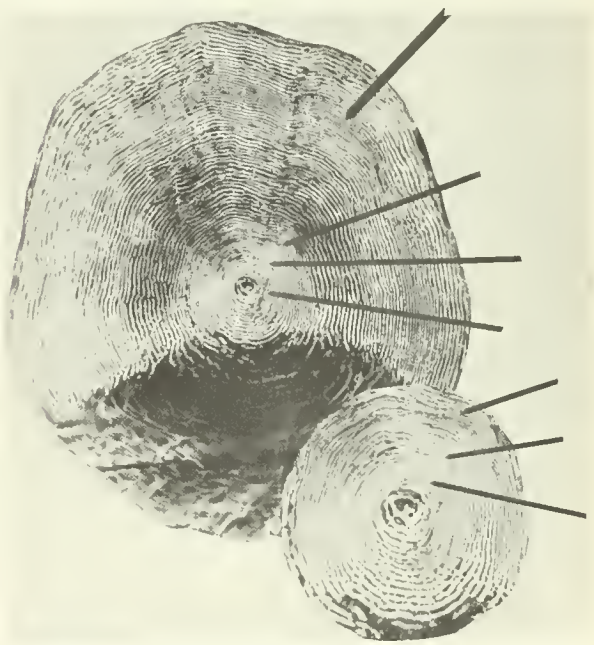

Figure 14.--Scale of steelhead trout with a magnified portion of the center, age 3.1.

[6]The incidence of regenerated or atypical scales is high in this species; it is often necessary to examine a number of scales to find a suitable one to study.

Figure 15.--Scale of steelhead trout with a magnified portion of the center, age 4.1.

Figure 16.--Magnified central sections of steelhead trout scales:
Upper left--3 winters in fresh water,
Lower right--4 winters in fresh water. The last two winter marks may also be fresh-water spawning checks.

fresh-water zone, with sometimes more than 30 circuli, may be complete in this area. A few of the ocean circuli may continue into the clear field as weak circular striations, but radial striations do not occur. Granular reticulations are usually present. Steelhead trout scales are usually large and may show one or more spawning checks (fig. 17).

KEY TO IDENTIFICATION OF POSTJUVENILE FISH

1A. Nucleus (fresh-water zone) absent.
  2A. Scales small relative to size of fish.
    . . . . Pink salmon Oncorhynchus gorbuscha (page 4 and figure 3).
  2B. Scales large relative to size of fish.
    3A. Seven or more circuli complete below the focus.
      . . . . Ocean-run chinook salmon Oncorhynchus tshawytscha (page 6 and figure 11).
    3B. Less than seven circuli complete below the focus.
      4A. Radial striations strong.
        . . . Chum salmon Oncorhynchus keta (page 4 and figure 4).
      4B. Radial striations absent. (If any markings are present in the posterior field, they are

Figure 17.--Section of a steelhead trout scale showing a spawning check, 3 winters in the ocean. The spawning check is in the second ocean winter.

faint and concentric with the scale margin, but are not like circuli.).

. . . Ocean-run sockeye salmon Oncorhynchus nerka (page 4 and figure 6).

1B. Nucleus (fresh-water zone) present.

5A. Radial striations absent.

6A. No more than six circuli complete below the focus.

. . . Sockeye salmon Oncorhynchus nerka (page 4 and figures 1, 5, and 20).

6B. More than six circuli complete below the focus.

7A. Reticulations generally present, granular; large scales. One or more spawning checks may be present.

. . . . Steelhead trout Salmo gairdneri (page 8 and figures 14, 15, 16, 17, and 23).

7B. Reticulations generally absent, but if present, netlike; small scales, about the size of pink salmon scales. No spawning checks are present.

. . . . Masu salmon Oncorhynchus masou (page 7 and figures 12 and 13).

5B. Radial striations present.

8A. Generally no circuli in the posterior field; if present, they are weak and discontinuous as circular striations.

. . . Chinook salmon Oncorhynchus tshawytscha (page 6 and figures 9, 10, 18, 19, and 22).

8B. Circuli generally present in the posterior field.

. . . Coho salmon Oncorhynchus kisutch (page 5 and figures 7, 8, 18, 19, and 21).

SCALES OF JUVENILE SALMON

Usually it is more difficult to identify the species of juvenile salmon than of adults. This is true whether scales or characters of the whole fish are used. Often the determination of species from scales, especially of young fish, depends on the evaluation of small differences among the scales of the various species.

This difficulty of identification extends even into some of the postjuvenile stages, for instance:

1. The scales of some pink salmon and chum salmon with only one winter mark are very difficult, if not impossible, to differentiate because of the variable character of the posterior field of the pink salmon scale; and

2. The scales of coho and young chinook salmon are extremely difficult to separate; the younger the fish, the more difficult it is to distinguish between them. Figure 18 shows scales from a "jack" chinook salmon and a coho salmon of similar age. Figure 19 shows scales of a "jack" chinook and a "jack" coho salmon, each with only one summer at sea.

Although it is sometimes not possible to separate positively the young of some species of salmon by their scales, at other times they can be identified at a relatively early age. The small size of the scales of young fish makes it difficult to clean all guanin and tissue from the posterior area. If they can be cleaned, however, the characteristics of the circuli that are complete below the focus and the features of the posterior field generally will enable one to identify the species. The features that distinguish the species are those that are formed early in the life of the fish:

1. The presence of fresh-water growth.

2. The number of complete circuli that encircle the focus.

3. Whether circuli are present in the posterior field, or invade the posterior field from the bases of the incomplete circuli.

4. The presence of radial striations in the posterior field, if it is large enough to have any.

5. The number of annual marks in the fresh-water zone, if the scales are from fish over 1-year-old.

In contrast, features which are present in adult scales only, such as the total age of the fish and the appearance of the ocean growth zones, are not applicable to identification of young salmon by species. To assist in species identification of young fish, series of photographs of the scales of the four species with normal fresh-water residence (except the masu salmon) are shown in figures 20, 21, 22, and 23.

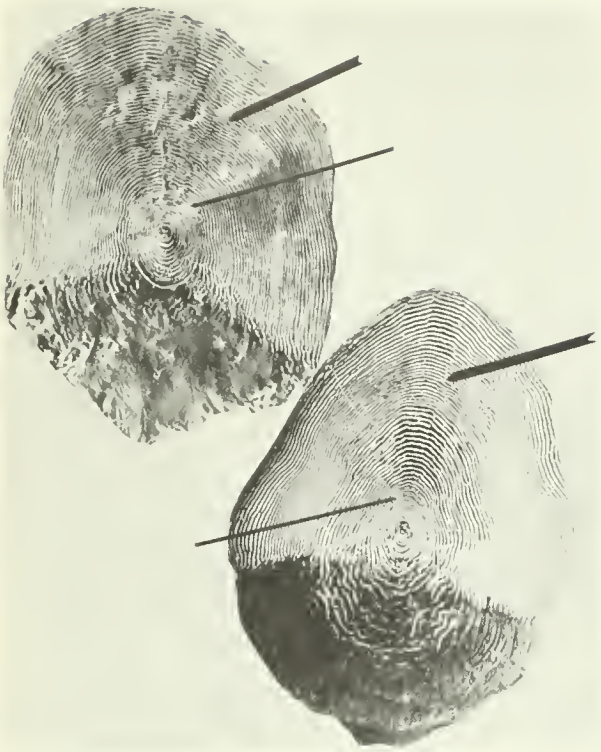

Figure 18.--Scale of a "jack" chinook salmon (upper left), age 1.i, and a coho salmon (lower right), age 1.1.

Figure 19.--Scale of "jack" salmon: chinook salmon (upper left), age 1.0 and coho salmon (lower right), age 2.0.

Figure 20.--Scales of juvenile sockeye salmon.

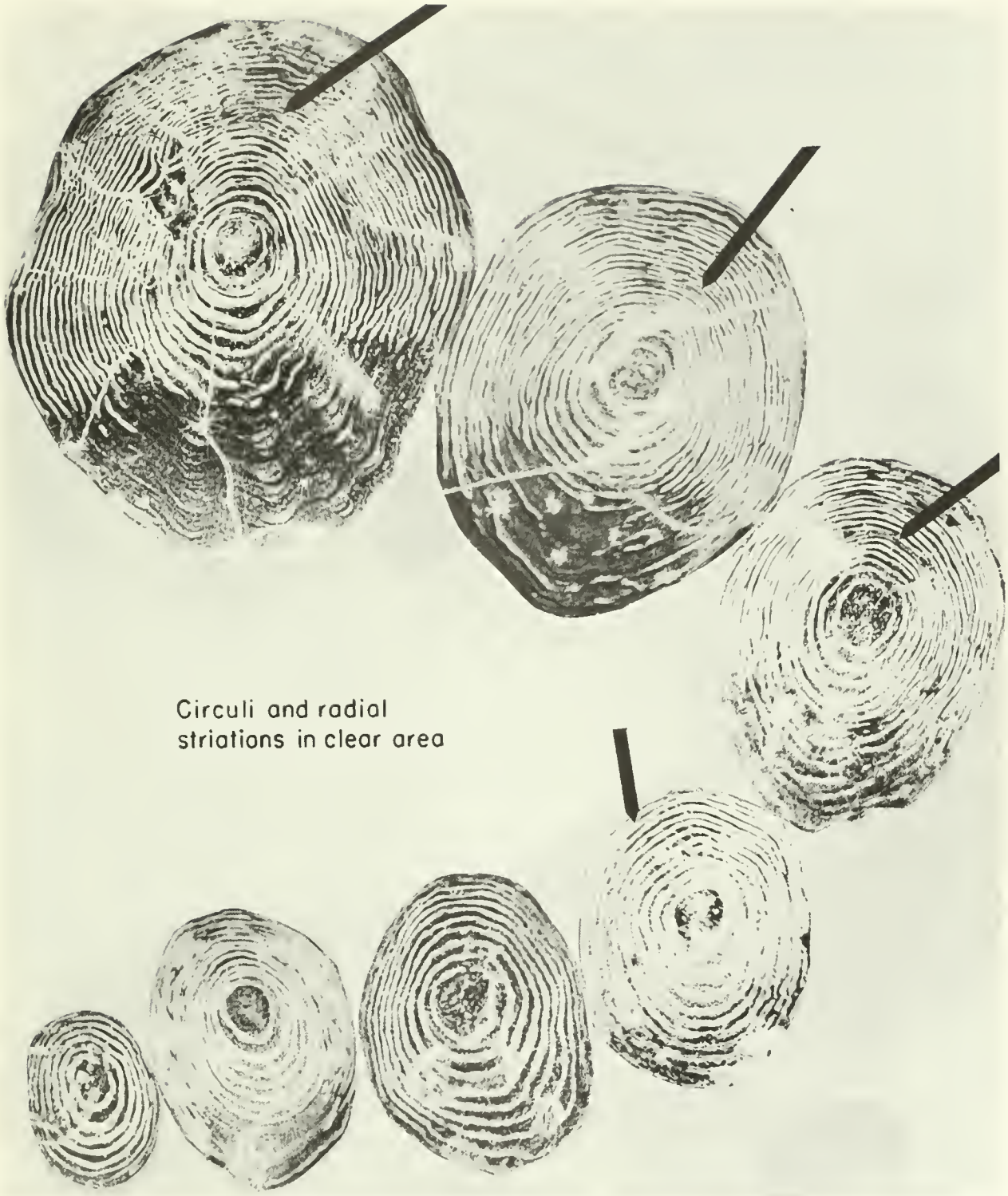

Figure 21.--Scales of juvenile coho salmon.

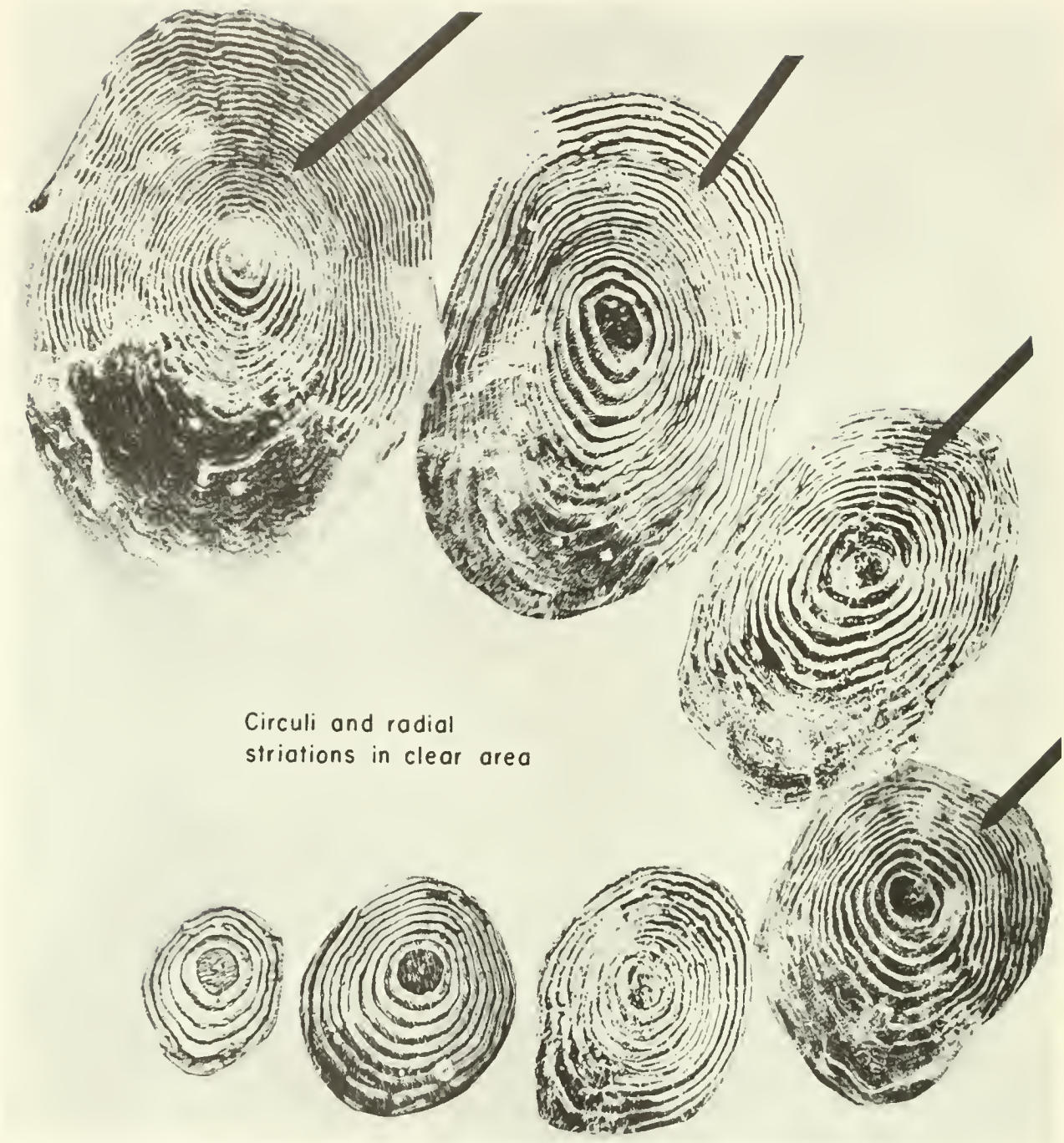

Figure 22.--Scales of juvenile chinook salmon.

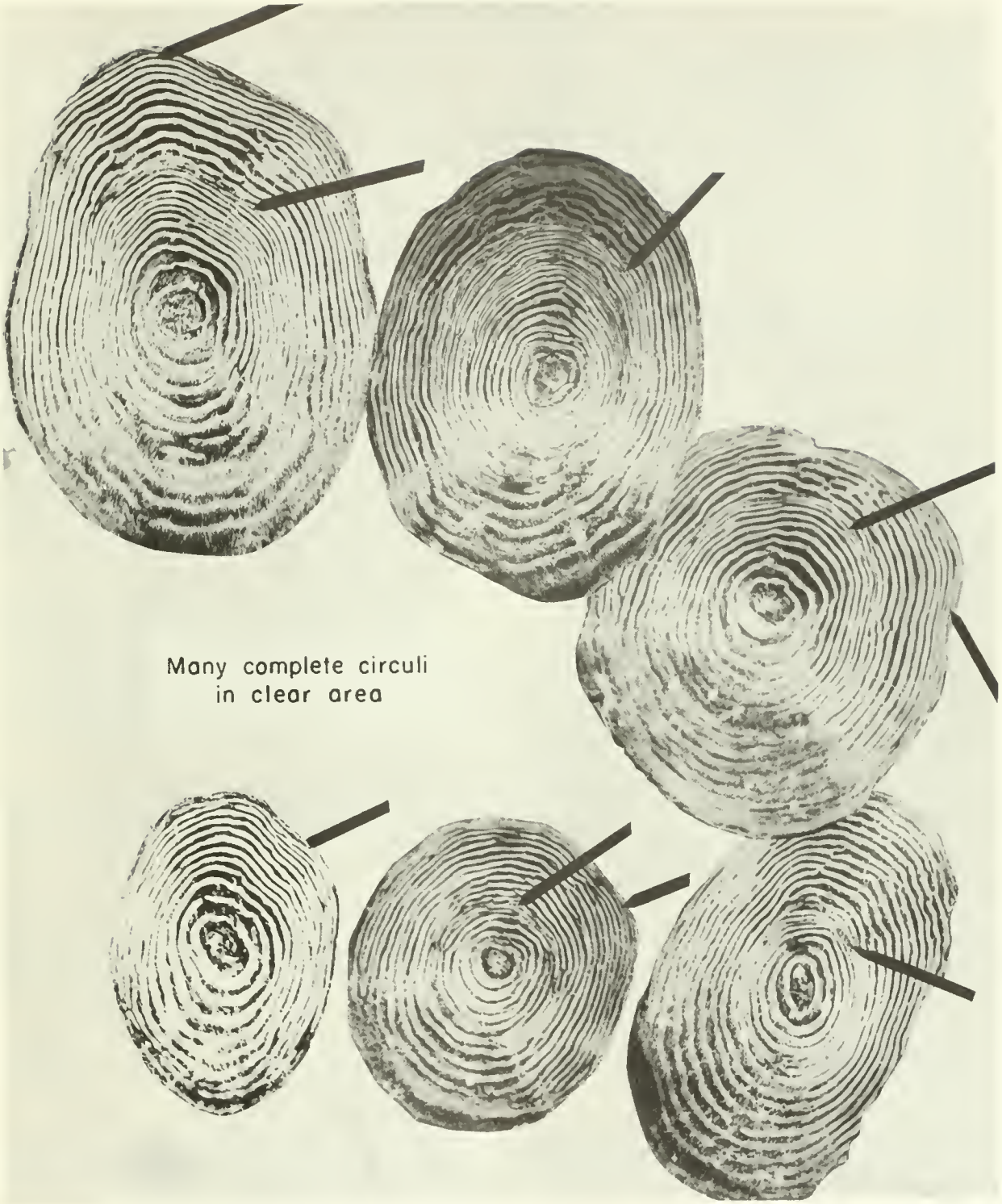

Figure 23.--Scales of juvenile steelhead trout.

GLOSSARY OF TERMS

Annual mark or winter zone.--The concentration or interruption of the growth pattern of circuli, which indicates the reduced scale growth of the late fall, winter, and early spring. These marks are formed each year and can be counted to determine the age of the fish. See figure 1. (Annual marks on all the figures are indicated by arrows: Broad arrows in the ocean zone, narrow arrows in the fresh-water zone.)

Anterior field (sculptured area).--The part of the scale that is nearest the head of the fish, lies in a dermal pocket, and has most of the circuli. See figure 1.

Bases of the circuli.--The ends of the circuli where they adjoin the posterior field of the scale.

Circular striations.--Continuation of circuli around the posterior field. Circular striations are weak but usually present on the scales of chinook and masu salmon and steelhead trout; they are strong and often resemble enlarged circuli on scales of coho salmon. See figure 2.

Circuli.--The ridges on the upper surface of the anterior field of the scale. Visually these ridges and interspaces appear as light and dark rings around the scale. They are formed on the margin as the scale grows. Additional information on the growth and structure of scales can be found in Neave (1936), Welander (1940),[7] Wallin (1957), and Koo and Finn (1964). The first few circuli of most species completely encircle the focus; the number that do is a character in species identification. After the complete circuli, the others are arcs that tend to end abruptly at the junction with the posterior field. In some species of salmon and trout, the bases of the circuli may not end abruptly, but may extend into the posterior field for varying distances, or the circuli may be broken or enlarged in this area.

Focus (central platelet).--The center of scale growth, the area enclosed by the first circulus. See figure 1.

[7] Arthur D. Welander. 1940. A study of the development of the scale of the chinook salmon, (Oncorhynchus tschawytscha). M.S. thesis, Univ. Wash., Seattle, 59 pp. (typescript).

Posterior field (clear area).--The portion of the scale toward the tail of the fish that protruded from the scale pocket. This area of the scale is important in identification of species. Sockeye and most pink salmon scales have only faint, irregular markings in this area. Chum, chinook, and coho salmon scales have strong radial striations that radiate from the center of the scale. These striations often produce a scalloped edge of the posterior field. Some of the circuli on the chinook and masu salmon and steelhead trout and on some pink salmon extend into or around the posterior field as faint irregular circular striations. On the coho salmon scale these extentions are strong and appear as enlarged circuli or segments of circuli. In the area of these circuli, radial striations may be obscured on the coho salmon scale. This part of the scale is often difficult to examine. Because it is uniformly translucent, the features are often obscured by too much light. Thus it is usually necessary to vary the angle and intensity of the lighting on the scale to reveal the features of this area. See figure 2.

Radial striations.--Markings on the posterior field that tend to radiate from the focus as ridges and troughs. They are usually strong on the scales of chum, chinook, and coho salmon, but on the coho salmon they may be obscured in the area of the circular striations or enlarged circuli, See figure 2.

Regenerated scale.--A scale that replaces one that has been lost. The new scale grows without the formation of circuli until it reaches the approximate size of the scale that was lost. See Mosher (1968).

Reticulations.--The network of lines or dots that occurs along the bases of the circuli of some scales. Reticulations may be either net-like (a series of interconnecting lines between circuli) or granular-appearing (a series of dots or little o's). See figures 1 and 2.

Shoulders of the scale.--The wide portion of the anterior field of the scale on both sides of the longest axis. See figure 1.

Winter zones, winter marks.--The concentration of circuli that indicates the reduced scale growth of the late fall, winter, and early spring. See annual mark and figure 1.

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Mr. Takashiba of the Fishery Agency of Japan provided a series of masu salmon scales.

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