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THE HOMING INSTINCT AND AGE AT MATURITY OF PINK SALMON

(ONCORHYNCHUS GORBUSCHA)

By FREDERICK A. DAVIDSON

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THE HOMING INSTINCT AND AGE AT MATURITY OF THE PINK SALMON (*ONCORHYNCHUS GORBUSCHA*)[1]

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INTRODUCTION

The pink salmon, *Oncorhynchus gorbuscha* (Walbaum), like the other species of Pacific salmon spend part of their life cycle in the sea and part in the rivers and creeks where they spawn and die. In southeastern Alaska, the pink salmon begin their spawning migration from the sea in the latter part of June and continue until late in September. Although the salmon migrate into the streams during the early summer months spawning does not begin until the second or third week in August. In March and April of the following year, the fry which have developed in size to a little over an inch in length (see fig. 1) and weigh less than 0.008 of a pound, emerge from their nests in the gravel and migrate directly to the sea. During their sojourn in the sea the fry develop into adult salmon weighing from 3 to 8 pounds and upon reaching maturity return to the streams to spawn.

The population of mature pink salmon that returns to spawn in any stream varies in size from year to year. This is due not only to the influence of changes in the natural elements of the habitats (stream and ocean) in which the population develops but likewise, and to a far greater extent, to the changes in the intensity of the commercial fishery that is imposed upon it during its migration from the sea. In view of this fact the Bureau of Fisheries is endeavoring to regulate the intensity of the commercial salmon fishery in Alaska so as to provide for an adequate run of pink salmon in every stream each season.[2] In order to secure an accurate count of the number of mature pink salmon migrating each season into each of several important salmon streams in southeastern Alaska, the Bureau has constructed weirs (see fig. 7) through which the salmon are counted on their way to the spawning grounds.

[1] Bulletin No. 15. Approved for publication, Feb. 21, 1934.

[2] On June 6, 1924, Congress approved an act which provided that not less than 50 percent of all the adult salmon returning to any stream should be permitted to ascend the stream to spawn.

The operation of these weirs each season is providing records of the size of the pink-salmon runs in each of the several streams on successive years. Hence it is possible, by means of these records, to make a study of the returns in numbers of adults resulting from the spawning of pink-salmon populations of varying size in an individual stream. However, in making such a study it is essential to know the extent to which the pink-salmon fry, after reaching maturity, return to spawn in the streams from whence they came and likewise the age at which they mature and return to spawn.

In life history studies of other species of Pacific salmon[3] it has been shown that their homing instinct and age at maturity can be determined by marking the fry (removing two of their fins) as they leave a particular stream and then examining the subsequent runs of mature salmon for individuals bearing the marks. In this way the extent to which the adult salmon return to spawn in their parent stream and likewise the age at which they return may be readily determined. Two experiments of this type have been carried on with pink-salmon fry, one at the Federal hatchery on the Duckabush River in the State of Washington and one in Snake Creek at Olive Cove, Alaska.

MARKING PINK-SALMON FRY

The marking experiment at the Duckabush River hatchery was carried on in the spring of 1930 and is the first known attempt to mark pink-salmon fry at the time they normally migrate from the streams. The fry in this experiment, as well as in the Snake Creek marking experiment, were marked by the removal of both their dorsal and adipose fins. This double mark was used because mature salmon are quite frequently found with one fin missing due to natural causes.[4] Furthermore it is not only necessary to remove 2 fins but likewise 2 fins that are widely separated on the body. In this way, the chances are remote of finding a mature salmon with an identical mark which is due to natural causes.

The 36,000 fry that were marked in this experiment were taken from the hatchery tanks where they had previously hatched under artificial conditions. The dorsal and adipose fins were removed by clipping them close to the backs of the fry with a pair of straight-bladed finger-nail clippers. The two fry pictured in figure 1 show the appearance of normal and marked individuals. Owing to the small size of the fry it was necessary to select apparatus that would facilitate their marking and minimize their mortality during the marking operation. The apparatus shown in figure 2 was found to give satisfactory results.

The shock due to the operation in removing the fins from the fry did not appreciably affect their mortality. In fact, the mortality of the fry during confinement in the tanks was practically the same in both the unmarked and marked stocks. Under normal conditions when there was an abundant supply of fresh water in the tanks the mortality during a 24-hour period did not exceed 2 percent of the total numbers in either of the stocks. However, if the supply of fresh water was reduced, the mortality would, in extreme cases, mount to 25 percent of their total number within a few hours.

The marking experiment in Snake Creek at Olive Cove, Alaska, was carried on in the spring of 1931. The 50,000 fry that were marked in the experiment were

[3] See the following references: Gilbert (1913) for coho salmon, Rich and Holmes (1928) for chinook salmon, Snyder (1921 to 1924) for chinook salmon,and Foerster (1929) for sockeye salmon.

[4] See page 37 for a discussion of the errors resulting from the use of only single fin marks in salmon marking experiments.

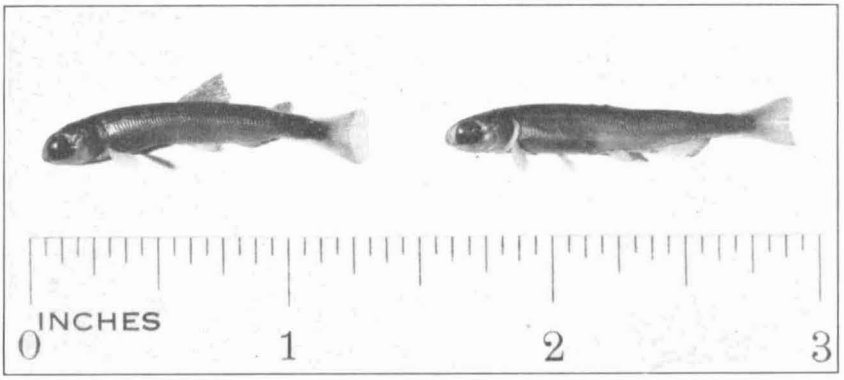

FIGURE 1.—Normal and marked pink-salmon fry at time of seaward migration.

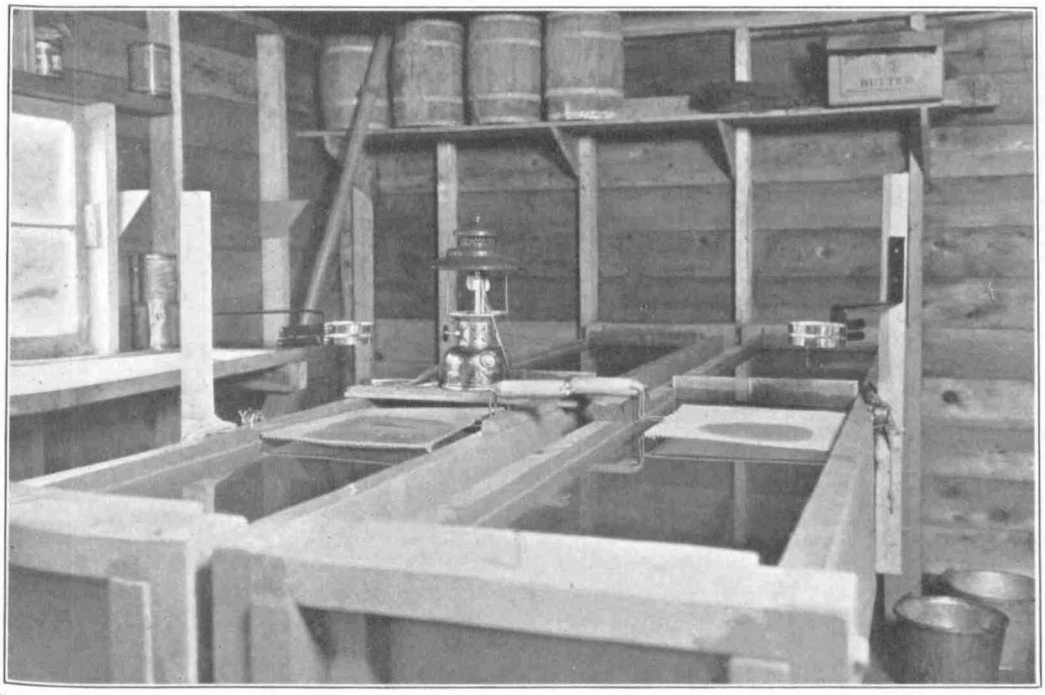

FIGURE 2.—Apparatus used in marking pink-salmon fry. Operator stands in front of shallow square net that rests on sides of tank just at surface of water. The small amount of water in the center of the net is sufficient to maintain fry in a semiasphyxiated state when they are placed there preparatory to marking. The two reading lenses, 4 inches in diameter, suspended above near side of net more than double image of a fry when it is held under them while being marked. The gas lamp beside net provides a direct light for operator and incidently radiates heat upon the hand that is used to catch the fry and hold them while being marked. Tanks are supplied with running water from stream. In order to keep an accurate account of number of fry marked the tally counter mounted on side of tank near frame that supports the reading lenses, is tripped every time operator marks a fry. Upper compartment of each tank is used to provide temporary storage for unmarked fry. After marking, fry are released in lower compartments where they are held from 12 to 24 hours before liberation in stream.

caught in the stream during their seaward migration from the spawning grounds where they had hatched under natural conditions. The fry were caught with a small screen wire trap net (see fig. 6) that was anchored in the middle of the stream where the current was the swiftest. Although thousands of fry were caught in the trap, not one was caught during the day, the fry migrating only at night. Many trips were made to the spawning grounds throughout the period the fry were migrating, but invariably no pink-salmon fry could be found during the daytime, either in the stream or in the pools along the sides of the stream. With the aid of a lantern they could be found in the stream any time during the night, but at dawn they disappeared, and those that did not reach the bay hid under the rocks or in the gravel.

The actual marking of the fry did not involve any difficulties for the method of marking had been worked out at Duckabush the year before. The only change in the routine from that used at Duckabush was that the marking was done at night so that the fry could be liberated at the time they normally migrated.

INTERPRETATION OF RESULTS FROM MARKING EXPERIMENTS

HOMING INSTINCT

The 36,000 pink-salmon fry that were marked at the Duckabush River hatchery in the spring of 1930 came from the spawn of 1929. Working upon the supposition that the pink salmon mature at 2 years of age,[5] the 1931 run of mature salmon in the Duckabush River was examined for individuals bearing the marks. In order to determine the extent to which the Duckabush River pink salmon returned to their parent stream to spawn, the 1931 runs in all the streams along the south shore of the Strait of Juan de Fuca, east of Port Angeles (see fig. 3) were likewise examined for individuals bearing the marks.

The hatchery operations on the Duckabush River made it possible to examine each one of the 3,800 mature pink salmon that composed the 1931 run. This was done at the time they were removed from the river and put in a retaining pond where they were held until fully mature and ready to spawn. The runs in the other streams along the canal and the south shore of the strait were examined by frequent observations of the schools of salmon as they migrated into the shallow waters on the spawning grounds. Where possible the salmon were collected in the shallow areas by means of a large net and carefully examined for individuals bearing the marks. The hatchery attendants at the State hatchery on the Dungeness River examined the 40,000 pink salmon in that stream that were spawned artificially. The observation of the schools of salmon on the spawning grounds began in the latter part of August and continued until late in September.

Out of the 3,800 pink salmon examined in the Duckabush River 5 females and 3 males were found bearing distinct adipose and dorsal scars. One female bearing both a dorsal and adipose scar was observed in the Hamma Hamma River in which approximately 1,500 pink salmon were spawning. One male bearing both a dorsal and adipose scar was found dead along the banks of the Dosewallips River in which approximately 5,000 pink salmon were spawning.[6] The dorsal scars on most of the marked

[5] Gilbert (1913) from a study of the markings on the scales of pink salmon taken in various localities came to the conclusion that the pink salmon invariably mature at 2 years of age. Furthermore, since the runs of pink salmon in the Duckabush River and neighboring streams occur only on alternate years, the pink salmon in these streams must either mature at 2 or 4 years of age. A further discussion of Gilbert's work is given in this paper under the section "Age at maturity of pink salmon."

[6] The Hamma Hamma, Duckabush, and Dosewallips Rivers are the only streams on Hood Canal in which pink salmon spawn in any numbers. The pink-salmon runs in these streams usually occur at the same time during the season.

salmon were roughened by the partial regeneration of a few spines. A marked salmon of this type is shown in figure 4. Only a few of the dorsal scars were perfectly smooth, showing no signs of regeneration, as seen on the marked salmon in figure 5. The adi-

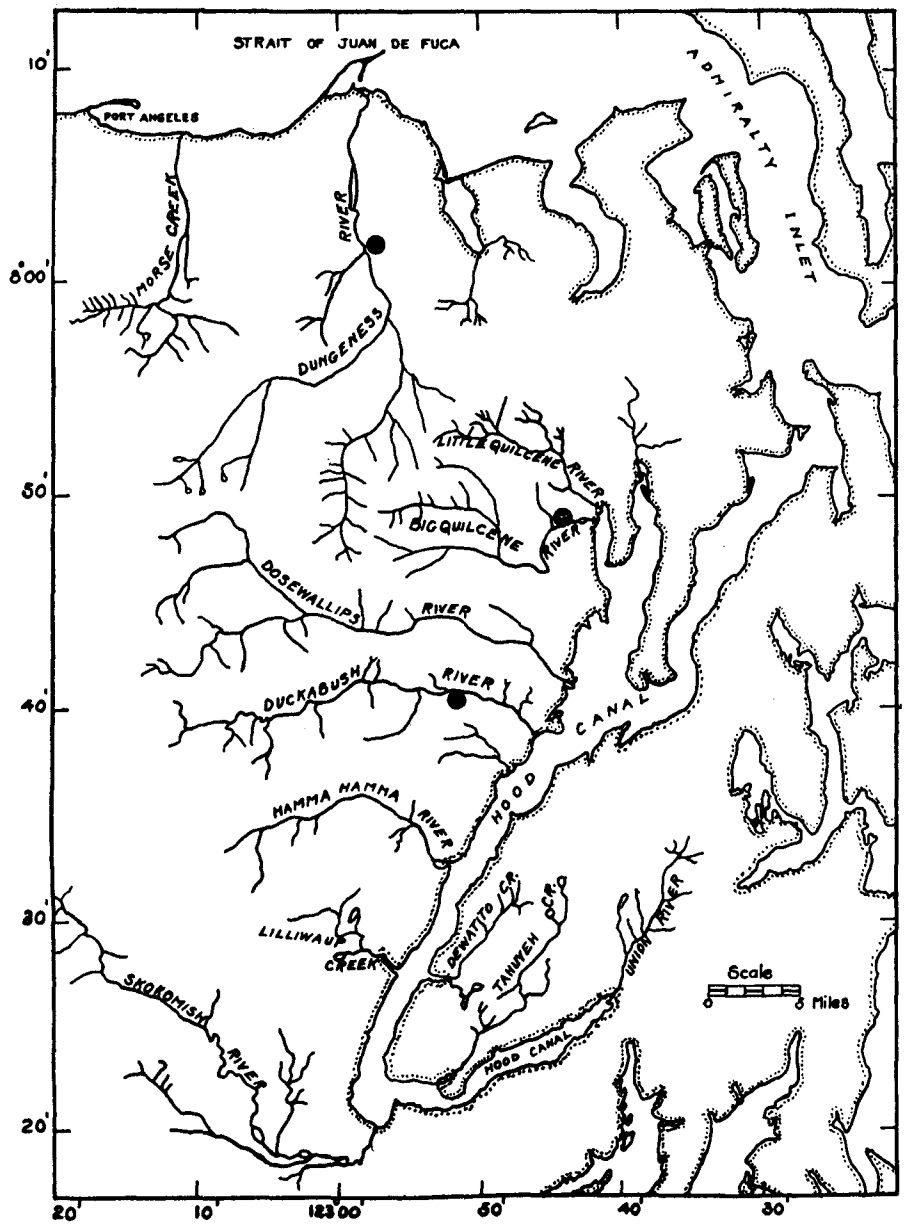

FIGURE 3.—Hood Canal and the south shore of the Strait of Juan de Fuca, Wash. The large dots mark the location of fish hatcheries. The pink salmon spawn only in the Hamma Hamma, Duckabush, Dosewallips, and Dungeness Rivers, and Morse Creek.

pose scars, with a few exceptions, were perfectly smooth and showed no signs of regeneration.

A number of pink salmon with only adipose fin scars were also recovered in the streams during the survey in the fall of 1931. Thirteen were found in the Duckabush

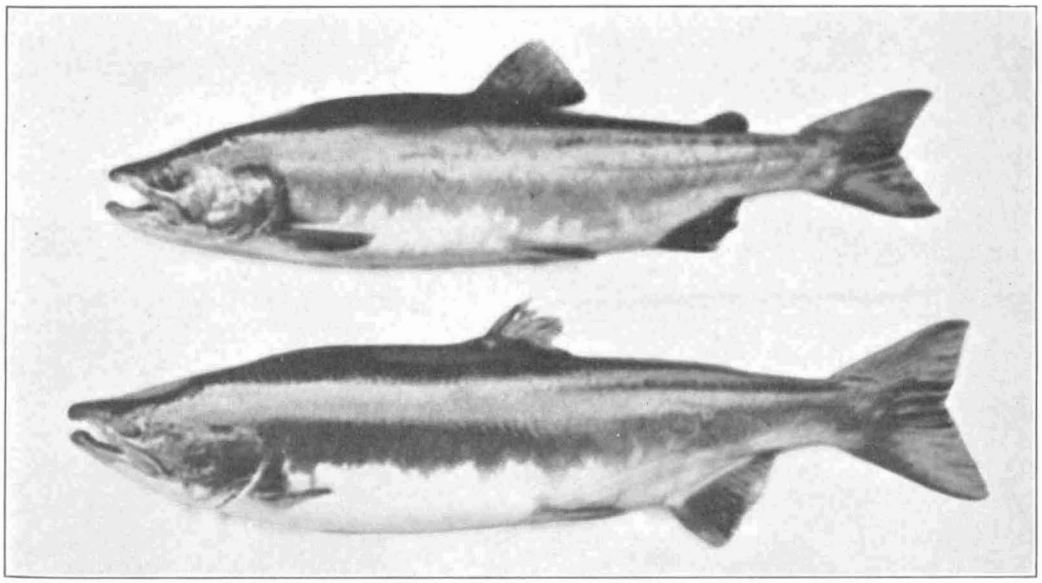

FIGURE 4.—Normal (upper) and marked (lower) adult pink salmon. The dorsal fin on the marked individual has partially regenerated.

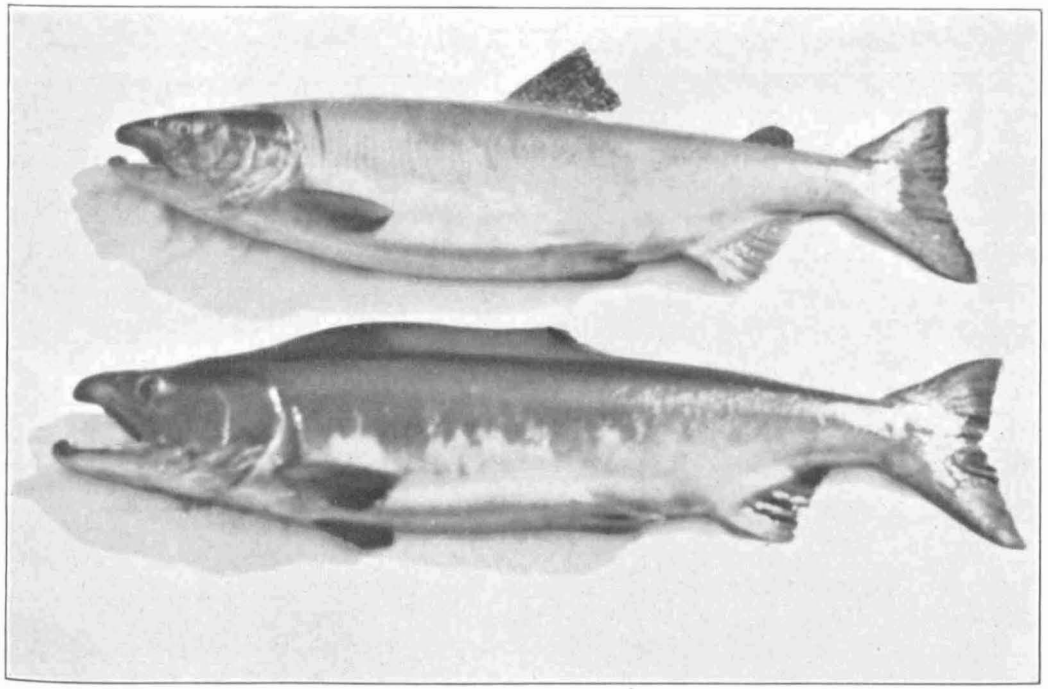

FIGURE 5.—Normal (upper) and marked (lower) adult pink salmon. Neither the dorsal nor adipose fin on the marked individual show signs of regeneration.

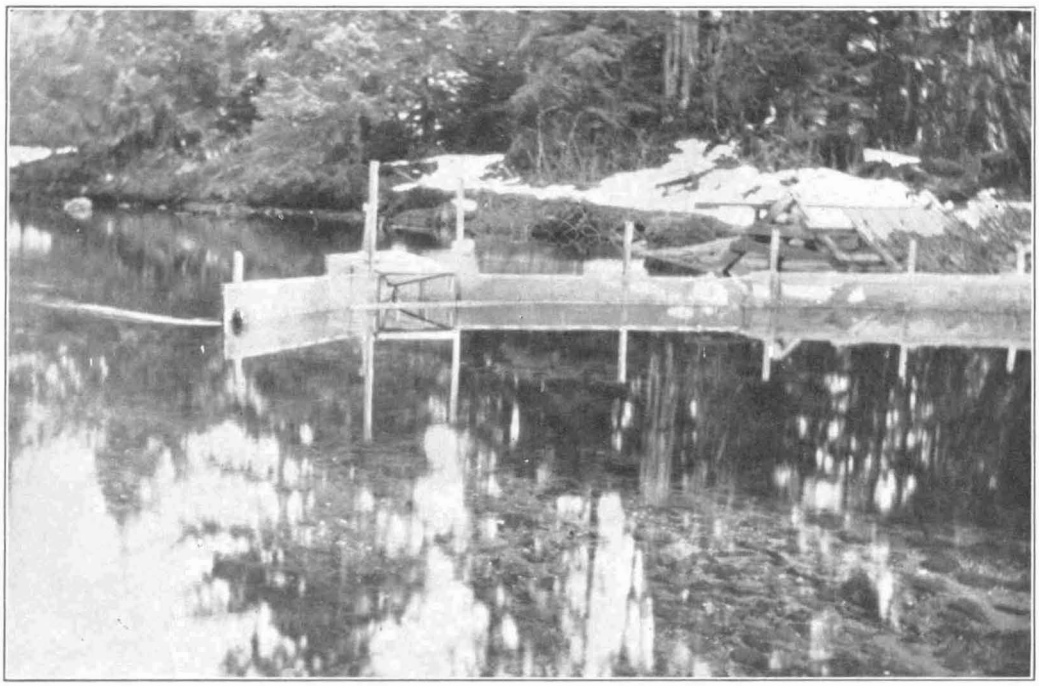

FIGURE 6.—Screen-wire trap and net used in catching the pink-salmon fry in Snake Creek.

FIGURE 7.—Fish trap built in weir at Snake Creek. The large dip nets held by the operators were used to lift the salmon out of the trap. The sliding gate in the weir just to the right of the trap was opened when the salmon were counted through the weir.

River, 1 in the Dosewallips River, 3 in the Dungeness River, and 1 in Morse Creek. In a controlled experiment wherein 500 fry were kept for a number of months after being marked it was found that their dorsal fins had a greater tendency to regenerate than did their adipose fins. It may be that some of the 13 salmon with only adipose scars that were found in the Duckabush River were marked individuals whose dorsal fins had regenerated. However, owing to the frequent occurrence of salmon whose adipose fins are missing due to natural causes,[7] it is exceedingly illogical as well as hazardous to consider any of the individuals with only adipose scars as marked salmon whose dorsal fins regenerated. Especially is this true of the 3 pink salmon with only adipose scars that were found in the Dungeness River, for out of the 40,000 pink salmon that were examined in that stream when they were spawned artificially not one was found with both its dorsal and adipose fins missing.

The 50,000 pink-salmon fry, marked in Snake Creek at Olive Cove, Alaska, in the spring of 1931, hatched from the eggs spawned in the stream in the fall of 1930. Since marked pink salmon returned to the Duckabush River at 2 years of age, it was believed that they would likewise return to Snake Creek at 2 years of age. Hence the run of mature pink salmon in Snake Creek and the runs in the neighboring streams were examined during the summer of 1932 for individuals bearing both dorsal and adipose fin scars.

The runs of pink salmon in Snake Creek are usually rather large, ranging between 50,000 to 100,000, so that it was impractical to try to catch and observe each fish in the run. By making use of the counting weir that is operated in the creek it was possible to devise a method whereby a large portion of the individuals composing the run could be examined. An enclosure or trap was built above the weir, as shown in figure 7, into which the salmon could pass through a V-shaped opening in the weir. The opening into the enclosure was never blocked so that the salmon could pass through it at all times. The salmon that were trapped in the enclosure were removed by means of large dip nets, examined for missing fins, and then thrown into the stream above the weir so that they could continue on their way to the spawning grounds. At times during the day the salmon collected in such large numbers in the stream that it was necessary to open the gates of the weir (see fig. 7) and count them as they passed through on their way up stream. An accurate account was kept each day of the number of pink salmon lifted from the trap and the number counted through the weir. Although only a portion of the entire run of pink salmon in the stream was examined for marked individuals as it passed through the trap, it was possible, as will be shown later, to calculate the number of marked individuals in the entire run. The 1932 run of pink salmon in Anan Creek, a neighboring stream (see fig. 8), was examined for marked individuals in a similar manner by the operation of a trap that was built in its weir.

In addition to the examination of the 1932 pink-salmon runs in Snake Creek and Anan Creek a survey, similar to that made in the streams along Hood Canal in 1931, was made of the other pink-salmon streams in the vicinity of Olive Cove.

An examination of the 1932 run at Olive Cove shows that out of a total of 7,944 pink salmon lifted out of the trap, 23 (10 males and 13 females) had both dorsal and adipose fin scars, 5 had only dorsal fin scars, and 10 had only adipose fin scars. Although the marked individuals (those with dorsal and adipose fin scars) are the

[7] In both marking experiments it was not uncommon to find a fry whose adipose fin had never developed. By marking the fry under the reading lenses it was not difficult to determine the presence or absence of the fins.

only individuals that can be considered as returns, it is interesting to note that the dorsal scars on the 5 salmon having only these scars were identical to the dorsal scars on the 23 marked salmon. It is not at all unlikely that these 5 individuals resulted from the fry whose adipose fins were missed when they were marked. Regardless of this close resemblance, these 5 individuals cannot be considered as returns, for by so doing, the 10 salmon with only adipose scars would likewise have to be considered as returns. This as previously pointed out [8] would be a hazardous thing to do.

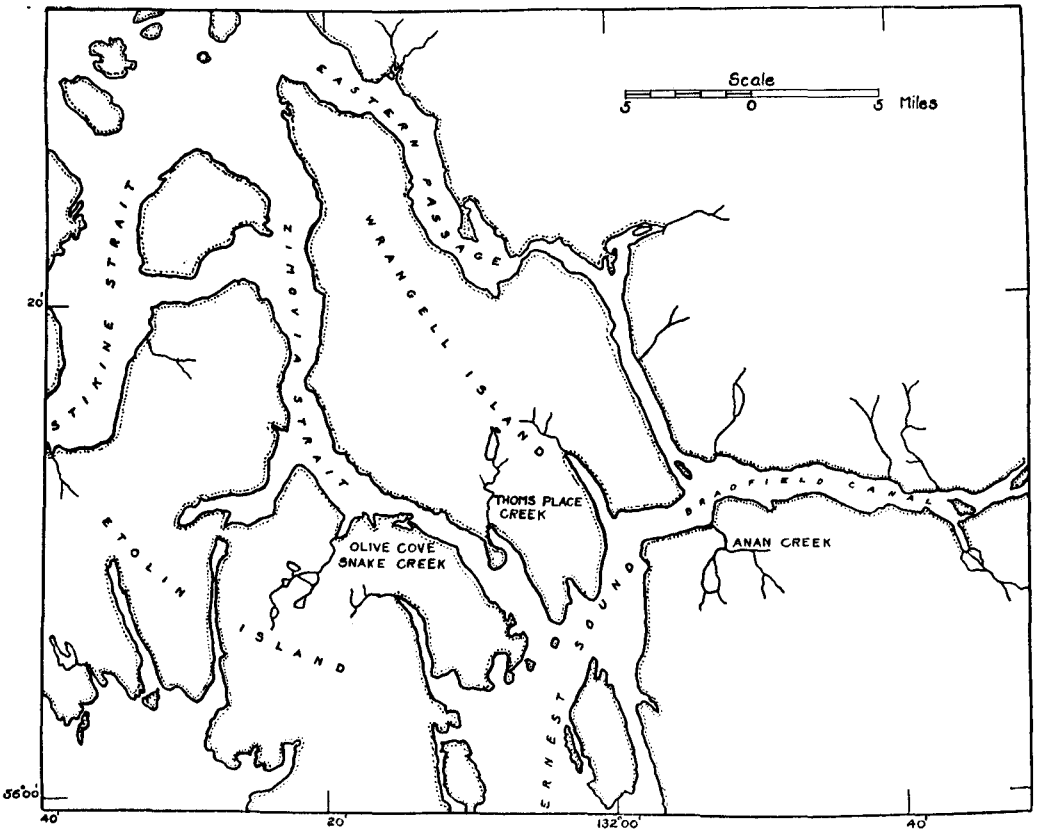

FIGURE 8.—Snake Creek at Olive Cove, Alaska, and vicinity. All of the streams shown on the map support a large population of pink salmon each season.

The method used in calculating the number of marked salmon in the entire run of pink salmon in Snake Creek in the summer of 1932 is given in the following equation: [9]

$$23+\left(10{,}640\times\frac{23}{7{,}944}\right)=54$$

where 23 equals the number of marked salmon found in the trap, 10,640 equals the total number of salmon counted through the gates in the weir, 7,944 equals the

[8] See discussion on page 29.

[9] This equation is based upon the assumption that there was the same proportion of marked salmon in the numbers counted through the weir as in the numbers lifted out of the trap. There is no reason to believe that the trap was selective in regard to the marked salmon; i. e., that more of the marked salmon in the run passed through the trap than through the gates in the weir. On days when the water in the creek was low and the visibility good, marked salmon were observed passing through the gates in the weir. During these times a total of 9 marked salmon were seen passing through the gates.

total number of salmon lifted out of the trap, and 54 equals the number of marked salmon in the entire run of pink salmon.

Out of the 132,351 pink salmon that composed the 1932 run at Anan Creek, 13,965 were examined as they were lifted out of the trap. Two individuals bearing fin scars were found among the salmon caught in the trap, one had only a dorsal fin scar and the other had only an adipose fin scar. No marked salmon were either caught in the trap or observed in the stream. Although the salmon with only the dorsal fin scar might have originated from a fry whose adipose fin was missed when marked, the absence of any marked individuals (those with both dorsal and adipose fin scars) in the salmon caught in the trap makes it rather improbable that this individual was a Snake Creek salmon.

The stream located nearest to Snake Creek in which pink salmon spawn in large numbers is Thoms Place Creek, approximately 10 miles south of Olive Cove and on the opposite side of Zimovia Strait. This stream was visited a number of times during the summer when the pink salmon were migrating into Snake Creek. During these visits only a few pink salmon were seen in the stream and none of these was marked. Toward the last of August when the run in Snake Creek was practically completed, a large run of pink salmon migrated into Thoms Place Creek. A survey of this stream was again made at this time, but no marked pink salmon were observed in the run.

A survey was made of the streams along Eastern Passage, the streams in Bradfield Canal other than Anan Creek, and the streams along the shores of Stikine Strait. Owing to the unusual lateness of the pink-salmon runs throughout the whole district it was not until late in August that the pink salmon collected in the shallower regions of the streams where they could be observed. About 200,000 pink salmon in all were observed as they swam about in the shallow waters of the streams. No individuals with both their dorsal and adipose fins missing were found in any of the streams that were visited.

In view of the returns from these marking experiments, it is conceivable that the extent to which the pink salmon return to their parent streams to spawn may be dependent upon the proximity of other pink-salmon streams in the vicinity. That is to say, the pink salmon composing the runs in streams that are more or less isolated from other pink-salmon streams may show very little or no tendency towards straying whereas the pink salmon in streams flowing into bays and in close proximity to other pink-salmon streams may stray more or less into the neighboring streams. The straying of the marked Duckabush River pink salmon into the Hamma Hamma and Dosewallips Rivers may be due to the close proximity of these streams to the Duckabush River. The Dosewallips River is located 4 miles north of the Duckabush River and the Hamma Hamma River is located 9 miles south of the Duckabush River.

The apparent lack of straying of the Snake Creek marked pink salmon might well be due to its isolation from the other large pink salmon streams in the district. Although Thoms Place Creek is only 10 miles south of Olive Cove, the main run of pink salmon in this stream is usually much later than the run in Snake Creek. No marked individuals were found either among the pink salmon in this stream during the early part of the summer or in the large run that occurred late in August. The other pink-salmon streams in the district are all located more than 20 miles distant from Olive Cove. Anan Creek, in which a weir trap was operated in a manner similar to the operation of the trap in Snake Creek, is 25 miles distant from Olive Cove. The

run of pink salmon in Anan Creek also appears at practically the same time during the season as the run in Snake Creek. If the Snake Creek marked salmon strayed any distance from their parent stream in perceptible numbers, it is highly probable that they would have been picked up by the trap in the Anan Creek weir. However no marked pink salmon were either found in the trap or observed in the stream. This, together with lack of recovery of marked pink salmon in any of the other more distant streams in the vicinity, makes it rather improbable that the Snake Creek pink salmon strayed in perceptible numbers from their parent stream.

AGE OF PINK SALMON AT MATURITY

The scales of the pink salmon like the scales of the other species of Pacific salmon, tend to grow at a rate proportional to the growth of the fish. This is accomplished by the deposition of new material around the border of the scale. Delicate ridges appear on the surface of the scale at intervals during its growth which form concentric rings separated by spaces of varying width. (See fig. 9.) The variation in the width of the spaces between the rings may be attributed to a corresponding variation in the rate of growth of the fish. That is during the spring and summer when the fish grows rapidly the rings on the scale are widely separated whereas during the fall and winter when growth is greatly retarded the rings are crowded together. In this way the surface of the scale is marked by bands of widely spaced rings followed by bands of closely spaced rings. Since the wide band of rings is formed in the spring and summer and the narrow band in the fall and winter, the two together represent a year's growth.

C. H. Gilbert (1913) in his paper "Age at maturity of the Pacific coast salmon" pointed out that the pink salmon all mature at 2 years of age as judged by the age reading of the growth rings on their scales. He described the pink-salmon scale as having three definite bands of growth rings. A central band of widely spaced rings of the sea type [10] followed by a band of closely set rings, which is in turn followed by another band of widely spaced rings. The first two bands of rings represent the growth of the fish during the first spring and summer in the sea and the first and only winter in the sea. The second band of widely spaced rings represents the growth of the fish during the second spring and summer in the sea. Since the second summer's growth band is never followed by a winter band of rings, Gilbert came to the conclusion that the pink salmon always mature at the close of the second year of their life.

Owing to the rapid growth the pink salmon must make, during their 16 or 17 months' sojourn in the sea, in order to mature at 2 years of age, some doubt has been expressed in regard to their age at maturity as determined from the bands of growth rings on their scales. In view of this fact a study was made of the scales on the marked pink salmon that were known to return to the Duckabush River and to Snake Creek at 2 years of age. The scale pictured in figure 9 is from a marked salmon that returned to Snake Creek and the scale pictured in figure 10 is from a marked salmon that returned to the Duckabush River. These scales were chosen because they are representative of the scales of the other marked pink salmon found in these streams.

The growth rings on the scale in figure 9 may be divided into the three characteristic bands described by Gilbert (1913). The first band of widely spaced rings, i. e., those laid down in the life of the salmon during its first spring and summer in the sea,

[10] Since the pink salmon fry in most cases leave the streams before their scales have appeared, the only rings that are formed in their scales are those that form during their life in the sea.

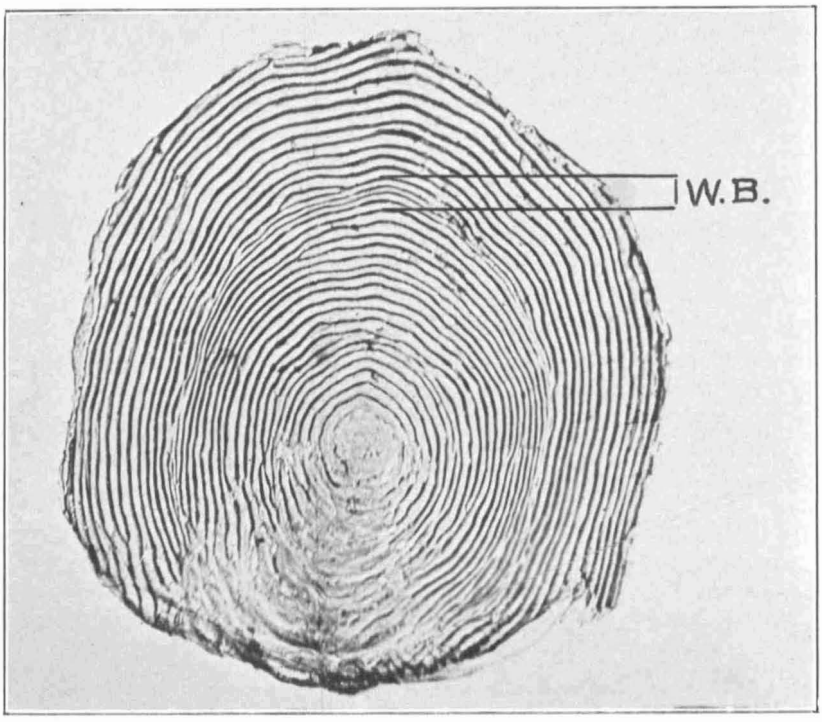

FIGURE 9.—The scale of a marked pink salmon recovered in the 1932 run of pink salmon in Snake Creek at Olive Cove, Alaska. The letters "W.B." indicate the winter band of growth rings.

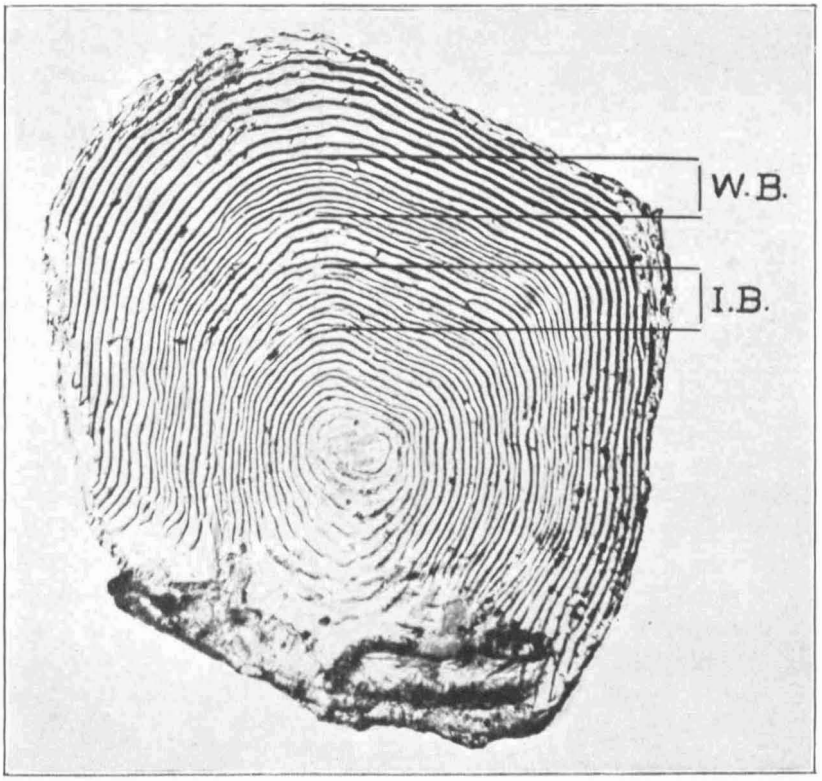

FIGURE 10.—The scale of a marked pink salmon recovered in the 1931 run of salmon in the Duckabush River, Wash. The letters "W.B." indicate the winter band of growth rings and the letters "I.B." indicate the incidental band of growth rings.

occupies the central area of the scale. This band is terminated at its outer border by a narrow band of closely set growth rings or the winter band (*W.B.*). The second band of widely spaced growth rings, i. e., those laid down in the life of the salmon during its second spring and summer in the sea, immediately follows the winter band (*W.B.*) and terminates at the margin of the scale.

The growth rings on the Duckabush River pink-salmon scale shown in figure 10 likewise may be divided into the three characteristic bands. The first band of widely spaced growth rings is, however, not very distinct since the rings near its center are in such close proximity that they form a rather definite incidental band of closely spaced rings (*I.B.*). The winter band of closely spaced growth rings (*W.B.*) and the succeeding second band of widely spaced growth rings are on the other hand very distinct and well marked around the circumference of the scale. This incidental band of closely spaced rings (*I.B.*) that occurred in the life of the salmon during its first spring and summer in the sea is no doubt due to a temporary retardation in its rate of growth. The occurrence of such aberrations on the scales of the Pacific salmon was recognized by Gilbert (1913, p. 5), who says:

> Thus it comes that the surface of the scale is mapped out in a definite succession of areas, a band of widely spaced rings always followed by a band of closely crowded rings, the two together constituting a single year's growth. That irregularities occur will not be denied, and this is natural, inasmuch as growth may be checked by causes other than the purely seasonal one.

Had not the scale in figure 10 been known to have come from a pink salmon that matured at 2 years of age, it would still be illogical to assume the incidental band of closely spaced rings (*I.B.*) to be a true winter band. Such an assumption would mean that the salmon bearing this scale spent 3 summers and 2 winters in the sea and matured at 3 years of age. This, however, would be impossible since the pink salmon runs in the streams on Hood Canal and along the Strait of Juan de Fuca occur only on alternate years. Hence the salmon composing these runs must mature at 2 or some multiple of 2 years of age.

Since the pink-salmon runs in the Duckabush River occur only on the odd years, it is impossible for any of the pink salmon in this stream to mature at 3 years of age. In order to check the possibility of any of the pink salmon in this stream maturing at 4 years of age, the run in this stream was examined for individuals bearing the marks in the summer of 1933. No marked salmon were found in the 1933 run and every fish was examined carefully at the time it was spawned artificially by the hatcherymen.

The runs of pink salmon in Snake Creek occur every year, hence the 1933 run in Snake Creek was examined in order to check the possibility of the pink salmon in this stream maturing at 3 years of age. The salmon run in this stream was examined in the same way that it was examined during the summer of 1932. No marked pink salmon was found in the 1933 run. There was, however, a number of pink salmon with deformed and missing adipose fins found in this run, which is further evidence that pink salmon with missing adipose fins due to natural causes are not infrequently found in the runs.

There is still other evidence which indicates that the pink salmon mature at 2 years of age. In 1913 and 1915 large shipments of eyed pink-salmon eggs were sent from the Pacific coast to the fish hatcheries in the New England States. These eggs were hatched artificially and in the spring of 1914 and the spring of 1916 the fry were liberated in a number of streams along the coast. In the summer and fall

of 1915 a large number of mature pink salmon returned to the streams in which the fry were liberated. A number of ripe eggs were removed from some of the females and after fertilizing them they were taken to the hatchery where they later developed into normal fry. In the summer and fall of 1917 another large run of pink salmon appeared in the streams in which the fry were liberated. Some of these salmon were sent to Dr. C. H. Gilbert who, after examining their scales, claimed that they had retained their original habit of migrating directly to the sea upon leaving their nests in the gravel and returning to the rivers to spawn and die at 2 years of age.[11]

The scales of the pink salmon that have appeared in Snake Creek and in other streams in southeastern Alaska on different years have been examined and all show bands of growth rings similar to those on the scale in figure 9. The scales of the unmarked as well as those of the marked salmon that appeared in the 1931 run in the Duckabush River were also similar to the scale shown in figure 10. In fact all the evidence thus far collected indicates that the pink salmon mature at 2 years of age and until contradictory evidence is found it may be assumed with relative certainty that they mature consistently at the close of their second year of life.

PINK SALMON MARKING EXPERIMENT IN BRITISH| COLUMBIA

In the spring of 1931 Dr. A. L. Pritchard, of the Canadian Pacific Biological Station, working at McClinton Creek in Massett Inlet, British Columbia, marked 185,000 pink-salmon fry by the removal of only their adipose fins. The returns from this marking experiment are reported in table 1.[12] In discussing the significance of these returns Pritchard (1932, p. 10) makes the following statements:

> The return of 95 marked fish (52 percent of the recoveries) to McClinton Creek definitely establishes that there is a tendency on the part of the pink salmon of this locality to return to its native spawning area and that maturity is reached at the end of 2 years.
>
> It is not unlikely that the 22 fish taken in Massett Inlet and 16 in Naden Harbour and Otard Bay would have ultimately appeared in McClinton Creek had they not been caught by the commercial nets, in which case the return to McClinton Creek would have been 73 percent of the recoveries.
>
> The capture in other localities of 50 fish lacking the adipose fin (27 percent of the recoveries) is evidently indicative of a certain degree of wandering. Although not a single fin abnormality was discovered among 310,000 pink-salmon fry handled at McClinton Creek and the Tlell River, reports from other areas indicate the possibility that such abnormalities may exist to a very small extent. It is felt, however, that the indications shown by the large returns from some of the outlying districts should not be considered insignificant.

According to these statements Pritchard is apparently of the opinion that little hazard was involved by the use of only the adipose-fin mark for the future indentification of the salmon, and that all of the salmon reported in table 1 were originally McClinton Creek fry.

[11] For a detailed discussion of the results from this transplantation of the pink salmon on the Atlantic coast see Reports of the Commissioner of Fisheries, 1916 and 1917, pp. 30 and 75, respectively.

[12] See A. L. Pritchard (1932) for data on recoveries of the adipose-marked salmon in the various localities as given in this table.

TABLE 1.—*Returns from the pink-salmon marking experiment at McClinton Creek, British Columbia*

[As reported by A. L. Pritchard (1932)]

Locality of recovery	Number of recoveries [1]	Approximate distance from McClinton Creek	Locality of recovery	Number of recoveries [1]	Approximate distance from McClinton Creek
		English miles			*English miles*
Alaska:			Southern British Columbia, Johnstone Strait	24	400
Karluk Beach [2]	8	1,000	Queen Charlotte Islands area:		
Snake Creek, Olive Cove [3]	10	180	Naden Harbour	14	40
Anan Creek [3]	1	180	Otard Bay	2	110
Northern British Columbia (exclusive of Queen Charlotte Islands):			Massett Inlet	22	10
Wales Island	1	120	McClinton Creek	95	0
Naas River area	1	140			
Skeena River	4	130			
Chatham Sound	1	110			

[1] Pritchard assumed that pink salmon with only adipose fin scars recovered in the summer and fall of 1932 originated from the McClinton Creek marking experiment.
[2] The data from Karluk Beach were reported by J. T. Barnaby of the U.S. Bureau of Fisheries.
[3] The data from Snake Creek at Olive Cove and Anan Creek were reported by F. A. Davidson of the U.S. Bureau of Fisheries.

One of the causes of error in the earliest marking experiments was the use of single fin marks for the future indentification of the salmon. Rich and Holmes (1928, p. 217) in reviewing these experiments make the following statements:

> The greatest cause of error in the earlier experiments was the failure of the investigators to realize that salmon occasionally lose one or more of their fins in other ways, and that as a result, if only one fin is removed experimentally, the mark may be duplicated accidently. For example, Hubbard removed the adipose fin from chinook fingerlings at the Clackamas hatchery in Oregon in 1895. The reported returns from this marking are so greatly opposed to the known facts of the life history and growth of chinook salmon that they are obviously in error, and there can be no question that they included fish not marked by Hubbard.

That the adipose fins of pink salmon are likewise missing due to natural causes was pointed out by the author in discussing the returns from the Duckabush River marking experiment. (See pp. 29–31 of text.)

In reporting the 10 pink salmon with only adipose fin scars from Snake Creek in Olive Cove, Pritchard failed to mention the fact that 50,000 pink-salmon fry were marked in this stream at the same time the fry were marked in McClinton Creek. Since the fry in Snake Creek were marked by the removal of both their dorsal and adipose fins, these 10 salmon were probably native to Snake Creek and consisted of salmon whose adipose fins were naturally missing or marked salmon whose dorsal fins had regenerated. (See discussion on p. 31 of the text.) The 8 pink salmon with only adipose fin scars reported by Barnaby from Karluk Beach were found during a 2-day examination of approximately 45,000 pink salmon composing part of the run into the Karluk River. Had Barnaby examined the entire run of 3,500,000 pink salmon in the Karluk River it is conceivably possible that, if the above proportion prevailed, he would have found in the neighborhood of 600 pink salmon with deformed or missing adipose fins. This together with the great distance that separates these 2 streams makes it highly improbable that these 8 pink salmon were of McClinton Creek origin. Furthermore if all the pink salmon with only adipose fin scars recovered in the Alaskan streams were of McClinton Creek origin, then it is conceivably possible that pink salmon with both dorsal and adipose fin scars, those of Snake Creek origin, should likewise have been found in the British Columbia streams. However no pink salmon bearing both dorsal and adipose fin scars were reported from Canadian waters.

In view of the returns from the Duckabush River and Snake Creek marking experiments, it is doubtful if the adult pink salmon often stray into streams other than those in the close proximity of their parent stream. The Dungeness River is approximately 60 miles distant from the Duckabush River, and in the examination of the 40,000 pink salmon at the Dungeness hatchery no salmon were found that could be considered as originating in the Duckabush River. Anan Creek is approximately 25 miles from Snake Creek in Olive Cove and during the examination of the 13,965 trap-caught salmon at Anan no pink salmon were found that could be said to have originated in Snake Creek. In fact no pink salmon were found in any of the streams in the vicinity of Olive Cove that could be said to have come from the Snake Creek marked fry.

It is not improbable that the 22 adipose marked pink salmon picked up by the commercial fishermen in Massett Inlet were of McClinton Creek origin. However for Pritchard to assume that all the salmon with adipose fin scars recovered in the other localities were likewise of McClinton Creek origin is to make an assumption too broad to remain within the realm of probability.

SUMMARY

In the spring of 1930, 36,000 pink-salmon fry were marked at the Duckabush River hatchery, Washington, by the removal of both their dorsal and adipose fins. These fry were hatched artificially from the spawn of 1929. In the summer and fall of 1931, 3,800 pink salmon returned to the Duckabush River, 8 of which were found to have both their dorsal and adipose fins missing. The Dosewallips River is located 4 miles north of the Duckabush River, and the Hamma Hamma River is located 9 miles south of the Duckabush River. One pink salmon with both its dorsal and adipose fins missing was found in each of these streams. Since the pink-salmon run in these streams occurs only on alternate years no run appeared in the summer and fall of 1932.

In the spring of 1931, 50,000 pink-salmon fry were marked in Snake Creek at Olive Cove, Alaska, by the removal of their dorsal and adipose fins. These fry hatched in the stream under natural conditions and came from the spawn of 1930. In the summer and fall of 1932, 18,584 pink salmon returned to Snake Creek, 54 of which had both their dorsal and adipose fins missing. The nearest pink-salmon stream in the vicinity of Snake Creek is Thoms Place, a small stream about 10 miles south of Snake Creek. The pink-salmon run in this stream, however, does not occur until the run in Snake Creek is practically completed. The other pink-salmon streams in the vicinity are all more than 20 miles distant from Snake Creek. No pink salmon with both their dorsal and adipose fins missing were found in any of the streams in the vicinity.

In view of the returns from these marking experiments is conceivable that the extent to which the pink salmon return to their parent streams to spawn may be dependent upon the proximity of other pink-salmon streams in the vicinity. That is to say, that the pink salmon composing the runs in streams that are more or less isolated from other pink-salmon streams may show very little or no tendency toward straying, whereas the pink salmon in streams flowing into bays and in close proximity to other pink-salmon streams may stray more or less into the neighboring streams.

The marked pink salmon that have thus far returned from these marking experiments have all returned at 2 years of age. Their age at maturity, as determined by

the number of bands of growth rings on their scales, was in every case consistent with the age at which they actually matured and returned to spawn. The scales of the pink salmon that have appeared in Snake Creek and in other streams in southeastern Alaska on different years have been examined and all show bands of growth rings on their scales similar to those on the scales of the marked Snake Creek salmon. The scales of the unmarked pink salmon that appeared in the 1931 run in the Duckabush River were likewise similar to the scales of the marked salmon that were recovered in the run.

Additional evidence in regard to the age at which the pink salmon mature is found in the original establishment of pink-salmon runs in a number of streams in the New England States. Large shipments of eyed pink-salmon eggs were sent to the hatcheries in the New England States in 1913 and 1915. The fry that developed from these eggs in the spring of 1914 and the spring of 1916 were liberated in a number of streams along the coast. In the summer and fall of 1915 a substantial run of adult pink salmon returned to the streams in which the fry were liberated. A similar run of pink salmon occurred in the summer and fall of 1917. Dr. C. H. Gilbert, an authority on the Pacific salmon, examined some of the scales taken from the adult pink salmon in these streams in 1917 and claimed that, in spite of their new environment, the pink salmon retained their original habit of returning to the rivers to spawn and die at 2 years of age.

All of the evidence thus far collected indicates that the pink salmon mature at 2 years of age and until contradictory evidence is found, it may be assumed with relative certainty that they consistently mature at the close of their second year of life.

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