FISH COMMISSION RESEARCH BRIEFS

FISH COMMISSION OF OREGON
307 State Office Building
PORTLAND 1, OREGON

Volume Five—Number One

MARCH, 1954

FOREWORD

These short reports are intended to inform the public, industry, and other interested parties of the current studies of the Commission's staff and of the basis for conservation measures. Reports will be published from time to time when studies are sufficiently complete to provide reliable biological evidence for conclusions upon which regulations are based. Research Briefs are free and may be obtained upon request from the editor.

Fish Commission of Oregon
John C. Veatch, Chairman
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POPULATION LIMITS OF THE SILVER SALMON RUN IN TILLAMOOK BAY DURING THE 1951 FISHING SEASON

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Introduction

In 1949 the Fish Commission of Oregon began a continuous program of marking silver salmon *(Oncorhynchus kisutch)* fry and yearlings in Spring Creek, a small tributary located about 25 miles up the Wilson River. The Wilson River flows into Tillamook Bay, which is about 60 miles south of the Columbia River. In this report, the number of silver salmon available to the fishery in Tillamook Bay is calculated, based on the recoveries of marked adult fish recovered in the 1951 catch. The 1951 run was the first cycle to return in the Spring Creek program.

Methods

A fine mesh weir with two traps (one for catching fingerlings and adults migrating upstream, the other for catching fingerlings moving downstream) was used in 1949 for trapping the 1948 brood fry, and in 1950 for catching the 1948 brood yearlings at Spring Creek. Periodically in April, May, and June of 1949 and 1950, numbers of hatchery-reared fry and yearlings equal to those migrating naturally were hauled to Spring Creek, marked differently, and released below the weir. These fry and yearlings of the 1948 brood entered the 1951 commercial fishery as adults returning to spawn.

Marking was done by the excision of various combinations of fins. The adipose and left pectoral fins were removed from 1,759 Spring Creek fry (1948 brood) in 1949 as they passed through the weir. The adipose and right pectoral fins were removed from 1,691 Trask River hatchery fry in the spring and summer of 1949, and these fish were released immediately below the weir at Spring Creek. In 1950, 1,037 of the 1948 brood natural yearlings were marked anal-left pectoral at the Spring Creek weir, 989 hatchery yearlings were marked anal-right pectoral, and the fish from both lots were released just below the weir. The above-mentioned hatchery fish were taken from Gold Creek at the Trask River hatchery, while all natural fish were native to Spring Creek of the Wilson River. The Wilson River and the Trask River roughly parallel each other, 5 miles or so apart, and both are tributaries of Tillamook Bay.

The silver salmon migrating downstream at Spring Creek were caught, marked, and released below the weir at daily intervals during peak periods of migration and every other day or every third day or so at other times, depending on the numbers of fish migrating and the time available. All marked fish were placed in a bucket of water for periods varying from about 10 minutes to one-half hour to allow them to recover from being handled.

Many of these young silver salmon migrated to sea and subsequently returned to Tillamook Bay as adults on their spawning migration in 1951. At that time they were subjected to a commercial gill-net fishery. The 1951 Tillamook Bay commercial catch was taken by drift-nets and set-nets the meshes of which varied from 5 inches to about 9¾ inches.

There were six buying stations on Tillamook Bay, and the catch was inspected at all stations at daily intervals whenever possible. The method of sampling the catch for marks involved the inspection of all fins on all the fish sampled prior to butchering. The numbers of fish bearing no marks and the number of marked fish were recorded. The length, weight, sex, kind of marks, condition of marks, location of capture, and date of capture were obtained for each marked fish. Scale samples were taken from all but one of the marked fish for future use. Only the marks observed by biologists have been used in the calculations. A total of 4,824 silver salmon caught in Tillamook Bay were inspected from August 15 to November 27, 1951. The fishing season extended from August 15 to December 10; other work prevented inspection of the catch after November 27. Data involving jacks (defined as fish 20 inches or less in length) are not used because the mesh sizes commonly used do not catch these small salmon effectively.

The silver salmon catches were recorded in pounds, and in order to compute the numbers of fish caught, the average weights of Tillamook Bay silvers were calculated in monthly intervals from receipts to fishermen on which both the numbers and weights of fish were recorded by day (Table 1).

TABLE 1.
AVERAGE WEIGHT DATA FOR SILVER SALMON TAKEN IN TILLAMOOK BAY IN 1951.

	Numbers of fish	*Weight in pounds (in the round)*	*Average weight*
Aug. 15-31	0	....	....
September	653	6,570	10.06
October	2,380	25,695	10.80
November	1,397	15,814	11.32
Dec. 1-10	173	1,879	10.86

The number of silver salmon caught commercially, computed from the monthly average weights, and the number of fish sampled for marks are shown in Table 2. The total Tillamook Bay catch of silver salmon for 1951 is calculated to be 13,052 fish.

TABLE 2.
1951 TILLAMOOK BAY SILVER SALMON CATCH AND RECOVERY OF MARKED FISH AT MONTHLY INTERVALS.

	Computed catch in numbers	*Numbers of fish sampled*	*Marked Recoveries in Sample*			
			Hatchery Fish		*Natural Fish*	
			Ad-RP	*An-RP*	*Ad-LP*	*An-LP*
Aug. 15-31	2	2	....	....	....	....
September	1,539	492	1	....	....	....
October	8,413	3,483	1	4	....	4
November	2,778	847	....	....	2	....
Dec. 1-10	320	0	....	....	....	....
Totals	13,052	4,824	2	4	2	4

Results

A total of 12 Spring Creek marked fish were recovered in the commercial fishery. Of these 12 marks, six were from hatchery fish and six were from naturally propagated fish. Marked fish were designated as those with either clean-cut double marks or one clean-cut mark and one partially regenerated mark, but not two questionable marks. The total number of silver salmon inspected for missing fins (4,824) represents 37 per cent of the total calculated catch.

Assuming the 12 marked fish recovered in the commercial fishery to have been sampled from a Poisson distribution, the true number of marked fish in the sample should lie between 6 and 21 in whole numbers with 95 per cent confidence (Ricker, 1937, p. 354). By extrapolation from the sample to the entire catch, two limits are calculated for X (the number of marks caught in the fishery) as follows:

$$\frac{6}{4{,}824}=\frac{X}{13{,}052} \qquad X=16$$

$$\frac{21}{4{,}824}=\frac{X}{13{,}052} \qquad X=57$$

In Table 3, the returns of the adult salmon to Spring Creek are shown. Every fish entering the upstream trap was inspected for missing fins, and all adults spawning below the weir were caught with a dip-net and inspected. Fish caught below the weir were tagged to prevent being counted again. There exists the possibility that some adults entered Spring Creek in the 350 feet of stream below the weir and went back out undetected, but these are believed to be few in number, if any. As summarized in Table 3, a total of 52 marks were recovered at Spring Creek. These marks, added to the above calculated marks in the fishery, give 68 and 109 for 95 per cent confidence limits of T, the number of marked fish calculated to be available in Tillamook Bay. All the marked fish are assumed to return to spawn in Spring Creek, their home stream; other possibilities are discussed later under sources of error.

TABLE 3.

SILVER SALMON MIGRANTS OVER 20 INCHES TO SPRING CREEK, WILSON RIVER, IN 1951 AND 1952 AT WEEKLY INTERVALS.

Week ending	*Hatchery Stock Ad-RP An-RP*	*Natural Stock Ad-LP An-LP*	*Unmarked*	*Total*
10-27-51	....	....	....	....
11-3-51	....	....	2	2
11-10-51	....	....	....	....
11-17-51	12	....	14	26
11-24-51	....	....	3	3
12-1-51	7	3	17*	27
12-8-51	1	5	17	23
12-15-51	....	....	2	2
12-22-51	....	6	11	17
12-29-51	....	....	3	3
1-5-52	....	....	5	5
1-12-52	....	....	2	2
1-19-52	....	....	....	....
1-26-52	....	7	9	16
2-2-52	....	10	1	11
2-9-52	....	....	3	3
Totals	20	31	89	140

* Includes one mismarked (hatchery) which added to other marks gives a total mark return of 52. This fish, a female, was marked as a hatchery fry and released at Spring Creek. It was later mismarked as a natural yearling and released again to be subsequently recovered at the Spring Creek weir as an adult after apparently being troll-hooked at sea. Entering into a different experiment to test a new type of tag, this fish was then jaw-tagged and released above the weir. Ten days later it was recovered dead and well spent of its eggs.

The population estimate of the 1951 silver salmon run of Tillamook Bay is based on the formula $N = \frac{(n+1)\ \ (T+1)}{(t+1)} - 1$, as used by Schaefer at the suggestion of Dr. S. Lee Crump (Schaefer, 1951, p. 10). N is the population estimate, n is the sample size or total number of fish inspected for marks in the fishery, T is the number of marks calculated to be available to the fishermen (T has been given two values, above, at the 95 per cent confidence level to adjust for sampling error), and t is the number of marked fish found in sample n.

In using these two T values, at the 95 per cent confidence level (Chapman, 1948, p. 6), four limits of N are obtainable, viz.

(1) $n+1=4{,}825$, $T+1=69$, $t+1=13$ gives
$\underline{N}=13{,}317$ and $\overline{N}=44{,}279$.

(2) $n+1=4{,}825$, $T+1=110$, $t+1=13$ gives
$\underline{N}=21{,}230$ and $\overline{N}=70{,}590$.

The extreme of $\underline{N}$ and $\overline{N}$ in (1) and (2) place the population, N, between 13,317 and 70,590.

Discussion

It is obvious that only 12 marked returns among 4,824 silver salmon examined gives a very small marked-to-unmarked ratio, and consequently causes wide confidence limits.

Calculations involving the use of marked hatchery returns and marked natural returns separately have been omitted for the reason that when considered separately neither of the two groups of fish is evenly distributed throughout the run.

There are numerous sources of error in the analyses of these data. The number of marked fish in the sport catch is not known, nor is the number of marked fish which strayed to other streams.

There is only a small silver salmon sport fishery on Tillamook Bay and the Wilson River. Therefore, the number of marked fish in the sport fishery is believed to be insignificant. However, the exclusion of any marked fish caught in the non-sampled sport fishery would effect only one value, T, in the above equation by producing a lower value in this paper. A lower T value in turn would produce lower limits for the population estimate.

Similarly, the exclusion of marked strays, and marked fish with both fins regenerated, if any, would have the same effect on the estimated limits of the population.

Another source of error in the computations lies in the assumption that all of the marks included in T were available to the fishermen. This assumption is not believed to be strictly true, as it is very possible that some of the latest marked returns at Spring Creek passed through Tillamook Bay after the end of the fishing season on December 10. For example, it is quite possible that the last of the marked natural fish that entered Spring Creek in January and February were not subjected to the commercial fishery. Such an error would make the population estimates too high. Another error has been introduced by the use of average weight data to compute the total number of fish caught in the fishery.

Conclusions

The population of the 1951-52 run of adult silver salmon in Tillamook Bay during the fishing season is calculated to lie between 13,317 and 70,590. These figures were obtained by computing 95 per cent confidence limits for T, the calculated number of marked fish in the run. By using the upper and lower values of T and by calculating new limits for each of these T values, four resulting population estimates are obtained, the extremes of which are 13,317 and 70,590.

Acknowledgments

The writer wishes to express his appreciation to Mr. F. C. Cleaver who suggested the methods of analysis used in this paper. Mr. Kenneth A. Henry generously helped with some of the problems. Mr. Cleaver and Mr. Raymond N. Breuser aided also in the collection of data. The writer is especially grateful to Dr. Douglas G. Chapman of the Laboratory of Statistical Research, University of Washington, for his criticisms and suggestions.

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THE TOXICITY OF ZINC OR CADMIUM FOR CHINOOK SALMON

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Introduction

Early in January, 1951, a heavy mortality occurred at the Marion Forks hatchery on the Santiam River among fall chinook salmon fry which had been transferred from the Bonneville hatchery on the Columbia River as "eyed" eggs. Later, mortalities also occurred in the fall chinook salmon fry from the Ox Bow hatchery on the Columbia River, also transferred in the "eyed" egg stage. The Ox Bow fry were about a week behind the Bonneville fry in development. About one million Bonneville eggs were transferred on December 1, 1950, and of this number 51.1 per cent had died by March 4, 1951. About one-half million Ox Bow eggs were transferred on November 13, 1950, and 25.4 per cent of them had died by March 4, 1951.

Because the fry were put in new, unpainted trays made with galvanized screen, and unpainted galvanized baffle plates were used, it was suspected that the zinc and cadmium used in the galvanizing process were affecting the fish. Water samples were collected from the lower and upper ends of the troughs and analyses were made for zinc and cadmium content, pH, and the oxygen content.

As there was ample trough space in the hatchery, all of the fry were removed from the trays and placed free in the troughs as soon as the heavy mortality was observed. However, the abnormal mortality continued until the fish had absorbed their yolk and were actively feeding.

The Marion Forks spring chinook salmon were still in the "eyed" egg stage during most of the period when the heavy mortality occurred in the fall chinook salmon fry. They were removed from the trays before hatching took place and they did not suffer any abnormal loss.

Observations

The live fry in the trays were examined and it was noted that many had a characteristic white spot in the yolk material indicating a coagulation of the egg protein. A great number of the yolk sacs of the dead fry had broken, allowing the yolk material to precipitate and the oil globules to escape, which made an oily film on the water surface. Many of the dead fry were in clusters with their mouths open, giving the appearance of suffocation from the lack of oxygen.

It was observed that there were more dead fish in the stacks of trays at the lower ends of the troughs, indicating that some toxicant was accumulating as the water passed through the trays. Upon closer examination of the trays and baffle plates a reaction was seen to have taken place between the water and the galvanized metal of the tray screens and baffle plates. A white precipitate had formed on the tray screens, and the baffle plates were darkened and also had some white precipitate on them.

Water Tests

It is known that both zinc and cadmium, which are used in coating other metals, are toxic to fish. Samples of water from the lower and upper end of a trough were analyzed for zinc[1] and cadmium[2] content (Table 1). The water from the lower end of the trough contained much more zinc and cadmium than water from the upper end.

TABLE 1.

ANALYSIS OF WATER SAMPLES FOR ZINC AND CADMIUM CONTENT, 1951.

	Zinc	*Cadmium*
Sample No. 1 from lower end of trough[3] (5,000 cc. evaporated)	0.110 p.p.m.	0.060 p.p.m.
Sample No. 2 from upper end of trough[4] (10,000 cc. evaporated)	0.001 p.p.m.	0.004 p.p.m.
Portland, Oregon, water supply	<0.001 p.p.m.	<0.002 p.p.m.

[3] Trough contained 126 trays and 18 baffle plates.
[4] At intake before passing through any trays.

An analysis of the water proved that there was an abundant supply of oxygen present at both ends of the troughs (Table 2).

TABLE 2.

ANALYSIS OF WATER SAMPLES FOR OXYGEN CONTENT, 1951.

	Temperature	*Oxygen at upper end of trough*	*Oxygen at lower end of trough*
Trough with Bonneville fry	38°F.	12.2 p.p.m.	10.0 p.p.m.
Trough with Ox Bow fry	38°F.	12.0 p.p.m.	9.2 p.p.m.

The water was found to be slightly alkaline, pH 7.4, at both ends of the troughs, indicating that the toxicant was not affecting the hydrogen ion concentration.

Controlled Experiment, 1951-1952

As a follow-up on the observations made in 1950-51, a controlled experiment was conducted in the winter of 1951-52 in an effort to duplicate the situation which occurred accidently the previous winter.

On November 1, 1951, 32,000 "eyed" fall chinook salmon eggs were shipped to the Marion Forks hatchery from the Bonneville hatchery in sealed, 5-gallon, wide-mouth pickle jars. The trip took 4½ hours and the temperature of the water in the jars was 44°F. at Bonneville and 46°F. upon arrival at Marion Forks. Marion Forks water was 40°F. at that time, so the eggs were tempered by slowly mixing Marion Forks water with the water in the pickle jars until 40°F. was reached.

[1] Zinc determined by Charlton Laboratories by the method published in "Industrial and Engineering Chemistry" Vol. 16, page 256 (1944).

[2] Cadmium determined by Charlton Laboratories by the Nikitinas method in the text "Trace Elements in Food" Monier and Williams (1949).

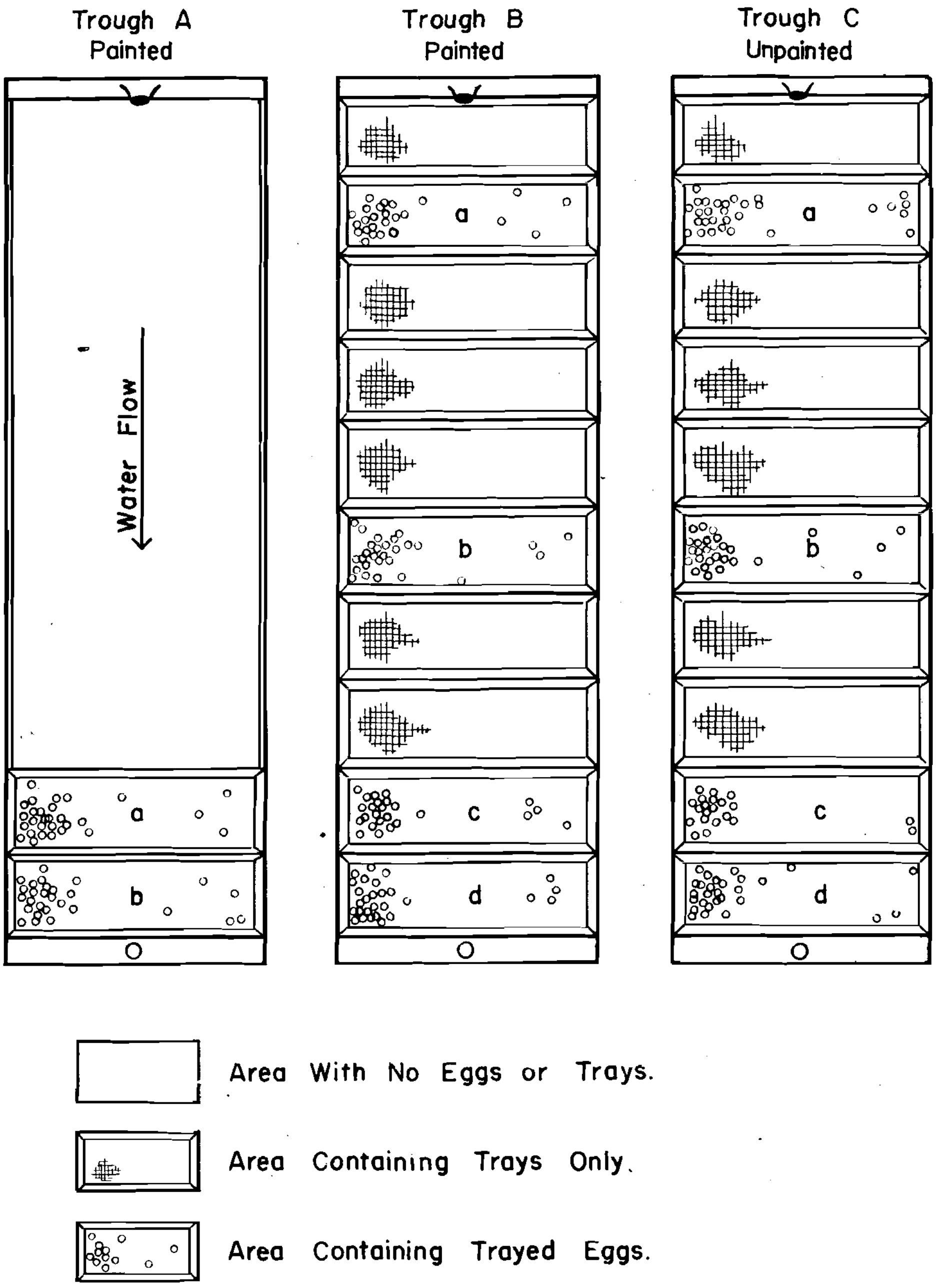

Figure 1. ARRANGEMENT OF TROUGHS AND TRAYS.

On November 11 the eggs were trayed down in three troughs (Figure 1). The control trough, *A*, contained only two compartments (13 trays, plus false bottom and cover, to the compartment) of painted trays and four painted baffle plates. The rest of the trough was empty. The second trough, *B*, contained the normal number of trays (10 compartments with 13 trays, plus false bottom and cover, to the compartment) and baffle plates (two per compartment) all of which were painted. Only four of the compartments, designated *a*, *b*, c, and *d*, contained eggs. The third trough, *C*, contained the same number of trays and baffle plates as trough *B*, but all were galvanized and none were painted. Again only four compartments, designated as *a*, b, *c*, and *d*, contained eggs. As the number of eggs per compartment was much smaller than normal, eggs were put only in the upper three trays. Approximately 1,066 eggs were put in each tray. The fish were kept in the trays until February 3, 1952, at which time the trays in each trough were taken out and the fish placed free in the troughs. The trays were removed because the tray screens which contained no fish became clogged with debris and the circulation of water in the troughs was stopped.

TABLE 3.
MORTALITY RECORD
WITH TRAYS IN TROUGHS

Date	*Trough A*		*Trough B*				*Trough C*			
	Compartment		*Compartment*				*Compartment*			
	a	*b*	*a*	*b*	*c*	*d*	*a*	*b*	*c*	*d*
Nov. 15, 1951	13	9	4	3	4	6	3	7	3	7
26	22	22	18	20	15	18	17	23	18	27
Dec. 5	16	22	11	20	15	19	19	23	12	15
10	7	9	5	4	7	11	6	9	9	10
17	19	16	8	14	11	20	16	14	6	14
24	6	12	10	2	0	8	8	8	12	21
Jan. 18, 1952	10	12	26	20	14	9	164	88	69	52
28①	0	0	0	0	0	0	93	12	18	21
Feb. 1, 1952①	0	0	0	0	0	0	50	88	42	268
3①	0	0	0	0	0	0	30	72	153	634
Totals through Feb. 3	93	102	82	83	66	91	406	344	342	1,069

WITHOUT TRAYS IN TROUGHS

Date	*Trough A*	*Trough B*	*Trough C*
Feb. 29, 1952	39	70	346
Mar. 24, 1952	42	81	777
Mar. 31, 1952	10	15	77
Apr. 8, 1952	12	14	86
Totals for entire experiment	298	402	3,427
Eggs used per trough	6,400	12,800	12,800
Percent mortality	4.7	3.1	26.7

① The eggs were not picked in troughs *A* and *B* on these dates as there was no visible mortality.

Observations

The dead and dying fry in trough *C* displayed characteristics not shown by fish in troughs *A* and *B*. The first indications of distress were very rapid breathing, gill cavities expanding more than normal, and wide open mouths. The lower jaw was often eroded or malformed and was much shorter than the upper jaw. Most of the fish died at this stage, with their mouths open and their spines curved in an arc, giving the appearance of suffocated fish. Other regions of the fish also showed definite abnormalities. The blood vessels in the neck area and extending into the yolk sac appeared to be ruptured. Also, a white spot of coagulated protein was often seen near the lower front of the yolk sac. When a dead infected fish was left in the tray for a few days most of it was eroded away. The head was entirely gone, and occasionally nothing but the vertebral column remained.

Results

The mortality is shown in Table 3, per compartment until February 3, and from then until April 8 by the trough only. The mortality remained normal in the control lot and in trough *B*, both of which had painted trays and baffle plates. The mortality in trough *C*, which contained the unpainted trays and baffle plates, was very high, much as it had been the previous year.

On January 17, 1952, a water sample was taken from the lower end of each of the three troughs and analyzed for zinc and cadmium content (Table 4). The water from the lower end of the unpainted trough contained much more zinc than water from the lower end of the other two troughs. The difference was not as great for cadmium.

TABLE 4.

ANALYSIS OF WATER SAMPLES FOR ZINC AND CADMIUM CONTENT, JANUARY 17, 1952.

	*Zinc*①	*Cadmium*②
Trough *A* (Control)	0.034 p.p.m.	0.015 p.p.m.
Trough *B* (Painted trays)	0.037 p.p.m.	0.030 p.p.m.
Trough *C* (Unpainted trays)	0.150 p.p.m.	0.030 p.p.m.

① Analysis by Charlton Laboratories, same method as used in 1951.
② Analysis by Charlton Laboratories, same method as used in 1951.

On February 14, 1952, after removal of the trays February 3, another water sample was taken from the lower end of trough *C* and analyzed for zinc and cadmium content (Table 5). The concentration of zinc evidently was maintained by the dam tins, alone.

TABLE 5.

ANALYSIS OF WATER SAMPLE FOR ZINC AND CADMIUM CONTENT, FEBRUARY 14, 1952.

	*Zinc*③	*Cadmium*④
Trough *C* (Unpainted trays)	0.120 p.p.m.	$<$0.010 p.p.m.

③ Analysis by Charlton Laboratories, same method as used in 1951.
④ Analysis by Charlton Laboratories, same method as used in 1951.

On February 14, 1952, a sample of dead fish was also taken from each trough and analyzed for zinc and cadmium content (Table 6).

TABLE 6.

ANALYSIS OF DEAD FISH FOR ZINC AND CADMIUM CONTENT.

	*Zinc*⑤	*Cadmium*⑥
Trough *A* (Control)	17.6 p.p.m.	less than 1 p.p.m.
Trough *B* (Painted trays)	9.3 p.p.m.	less than 1 p.p.m.
Trough *C* (Unpainted trays)	12.1 p.p.m.	less than 1 p.p.m.

⑤ Analysis by Charlton Laboratories, same method as used in 1951.
⑥ Analysis by Charlton Laboratories, same method as used in 1951.

Effects of Zinc and Cadmium

A study of the literature was undertaken to find as much as possible about zinc and cadmium toxicities. The papers studied consistently gave the following three general causes of death resulting from contact with a solution of the heavy metals (quoted from Ellis, 1937).

(1) "The heavy metal ions may combine with the organic constituents of the mucus secreted by the skin, mouth, and gills to form a flocculent precipitate. This precipitate coating may prevent the water pumped over the gills from reaching the cells of the gill filaments. Aeration of the blood is prevented and death results."

(2) "In the case of the higher concentrations of the metals or prolonged periods of exposure, large masses of the precipitate may accumulate. The interlamellar spaces become clogged and movement of the gill filaments becomes impossible. The movements of the gills are important in maintaining the gill capillary circulation, and the cessation of gill movements causes stasis of the blood in the capillaries, resulting in death."

(3) "The heavy metal ions may cause direct damage by precipitating the proteins in the living cells or by creating an osmotic unbalance due to the hypertonic solutions of the various salts. In a particular instance this damage may occur to the gill filament cells, causing stopping of the blood in the capillaries and impairment of the excretory functions of the gills. If any of the solution is swallowed, damage may also occur to the cells of the gastrointestinal tract."

Goodman (1951) found that rainbow trout fry 10-14 days old could withstand 1 p.p.m. of zinc for 48 hours with no apparent mortality, but that 4 p.p.m. was toxic to 90 per cent of the test fish in that time limit. He found that the tolerance of 8-week-old rainbow trout had increased so that they could withstand 4 p.p.m. of zinc for 48 hours.

Conclusions

The death of the fry appeared to have been caused by suffocation. This suffocation was probably caused by the action of the zinc and possibly cadmium on the gills of the fish. A precipitate either covering the filaments or plugging the interlamellar spaces of the gills made it impossible for the fish to maintain adequate circulation, and caused the fish to die. In comparing the amount of zinc in the water samples (Tables 1, 4, and 5) with the amount of zinc in the fish samples (Table 6) it appears that there is no appreciable relationship between the amount of zinc in the water and the amount of zinc contained within the bodies of the fish. This would indicate that the cause of death is something other than the absorption of the zinc salts into the body of the fish.

The painting of the tray screens and baffle plates kept the water from reacting with the galvanized coating as is shown by the analyses in Tables 1, 4, and 5. The mortality (Table 3) for troughs *A* and *B* was kept to a minimum and no symptoms similar to those in trough *C* were noted.

The fish in trough *C* were subjected to concentrations of 0.150 p.p.m. zinc, compared with 0.034 p.p.m. for trough *A* and 0.037 for trough *B* (Table

4). There was little difference in the concentration of cadmium among the three troughs. If zinc or cadmium was the cause of death it would appear that some fish were able to tolerate the concentrations encountered longer than others.

There was a 26.7 per cent mortality for trough *C* fish from November 11, 1951, through April 8, 1952, which was over five times the percentage loss of either trough *A* or *B* for the same period. The mortality for trough *C* would have been much higher had it not been necessary to remove the fry from the trays on February 3, 1952, because the accumulation of debris in the empty trays stopped water circulation in the trough.

The oxygen content of the water and the pH were both considered to be normal and did not enter into the toxic effect caused by the zinc and cadmium.

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OYSTER DRILL PRESENT IN OREGON

The Japanese oyster drill, *Tritonalia japonica,* a native snail of Japan originally introduced into West Coast waters with the importation of Japanese oyster seed, is present in Netarts Bay, Oregon. Seventeen specimens collected October 30, 1952 averaged 32.1 mm. in height and ranged from 10.7 to 44.4 mm. Although this is a small sample, the range in size indicates the presence of several age groups and a reproducing population. When present in sufficient numbers the drills can inflict a great amount of damage to young oysters, although they will, on occasion, attack older oysters. In the state of Washington large populations of drills on oyster grounds have caused enough damage to force oyster farmers to abandon some beds.

Lowell D. Marriage

THE 1951 ALSEA RIVER CHINOOK SALMON INVESTIGATION

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Introduction

During the fall of 1951, a salmon tagging program was conducted on the Alsea River by Oregon Fish Commission biologists for the purpose of collecting data which would lead to improved management of the salmon populations of that stream. The location of the Alsea River is shown in Figure 1.

Chinook salmon *(Oncorhynchus tshawytscha)* and silver salmon *(Oncorhynchus kisutch)* were tagged. The silver salmon data are being presented in another paper (Morgan and Cleaver, in press) and in this report the tagging of chinook salmon will be discussed.

While the commercial catch of fall-run chinook salmon in the Alsea River has never approached the catch of silver salmon, it has provided a substantial number of fish to the commercial fishery each year. The average annual catch from 1923 to 1948, inclusive, was approximately 54,000 pounds.

Sport fishing intensity for fall chinooks in the Alsea River is relatively light. Estimates of the annual sport catch for 1947-49 are about 150 adult fish (Henry, Morgan, and Rulifson, 1950).

Chinook salmon were tagged for the following reasons: (1) to obtain an estimate of the size of the fall chinook population available to the commercial fishery in the Alsea River, and (2) to determine the fishing intensity of the commercial fishery.

Tagging Methods

The first fall-run chinooks usually enter the lower Alsea River in late July and early August. In 1951, the commercial season opened the night of September 2. Tagging was begun in August so tagged fish would be available when the commercial fishing season opened in September.

A commercial fisherman using a standard, large-mesh gill-net (about 9¼ inches) was employed to obtain fish for tagging. The fish were taken from the net as soon as they were caught, and were immediately tagged and returned to the water. The tagging location, tag number, length in centimeters, and apparent condition when released were recorded.

Fish in condition 1 had no apparent injury and swam away quickly when returned to the water. Fish which appeared slightly distressed or were bleeding slightly at the gills but swam away quickly were placed in condition 2. Fish which had serious open wounds from seal bites or other injuries were placed in condition 3, unless obviously in worse condition. Condition 4 contained fish which floated when released as a result of being in the net too long or because of excessive bleeding at the gills.

The lengths of the fish were taken from the tip of the snout to the fork of the tail by reading a meter stick which had been attached to the tagging box. These lengths were recorded to the nearest centimeter.

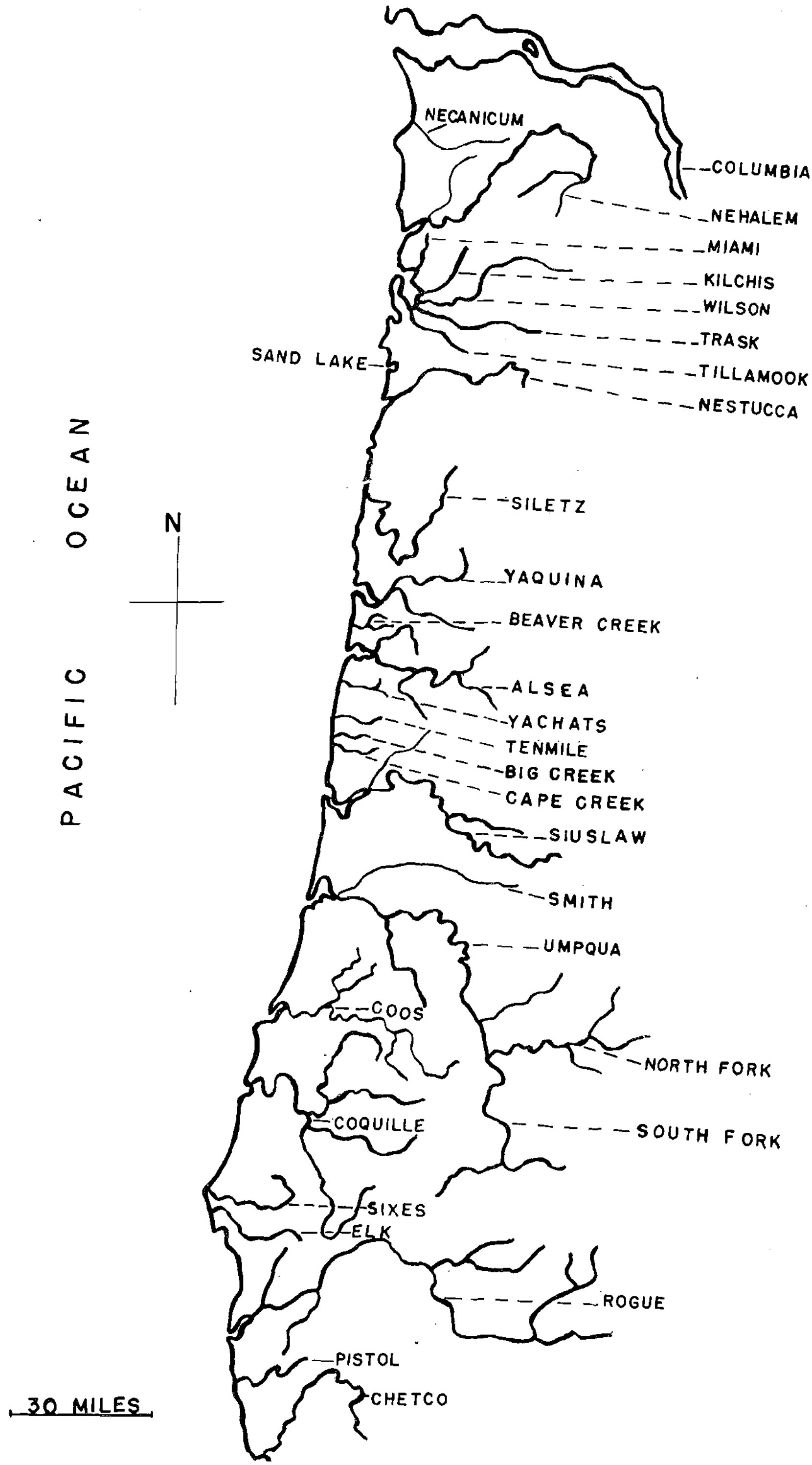

Figure 1. OREGON COAST AND COASTAL RIVERS SHOWING THE LOCATION OF THE ALSEA RIVER AND OTHER COASTAL STREAMS.

All of the fish tagged in August were tagged with Petersen-type tags which consist of a pair of plastic disks held to the back of the fish with a nickel pin. These tags were placed on the fish below the anterior edge of the dorsal fin. After the commercial season began, a few stainless steel jaw tags were alternated with Petersen tags, but this was discontinued because the jaw tags available were too small for large chinook salmon.

Numbers Tagged, Time and Areas of Tagging

During the period from August 16 until August 30, 129 chinooks (including three fish 20 inches or less, called jacks) were tagged. Of this total, 37 were released near the mouth of Drift Creek, and the remainder were released just above the mouth of Darkey Creek (Figure 2). After the com-

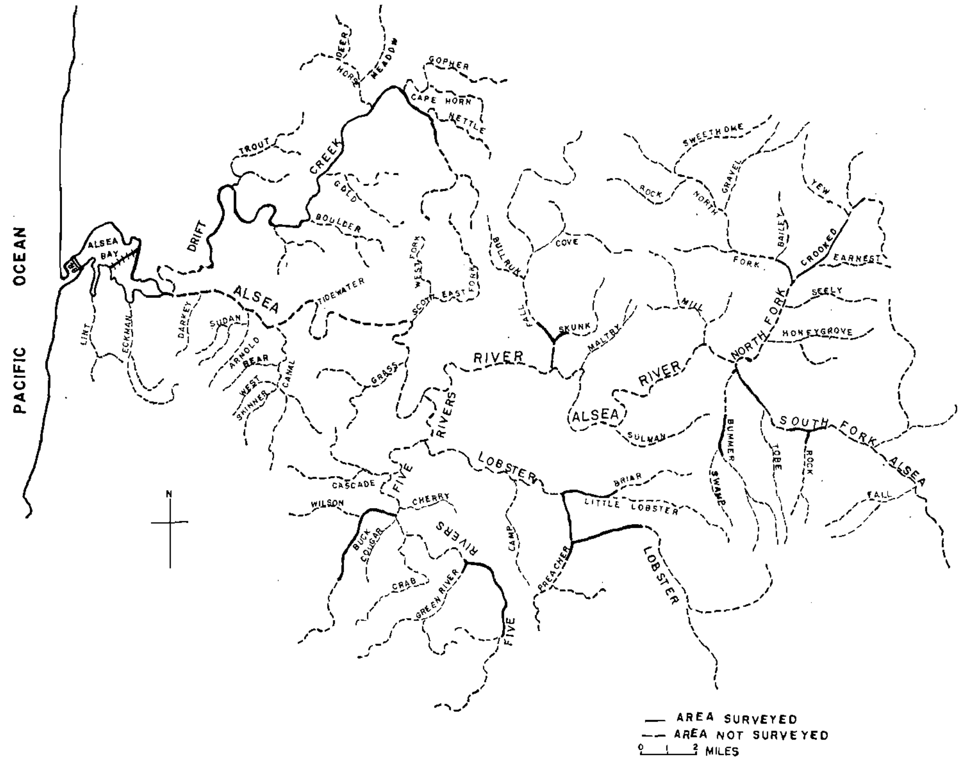

Figure 2. THE ALSEA RIVER SYSTEM SHOWING AREAS SURVEYED.

mercial season opened in September, tagging was continued in the bay area between the bridge (indicated as BR and by parallel lines near the mouth of the bay in Figure 2) and the mouth of Eckman slough, which is the confluence of Eckman Creek and Alsea Bay.

Although the tagging crew fished for silver salmon with a 7-inch mesh net (which is a smaller mesh than is commonly used for chinook salmon) after the commercial season opened, an occasional chinook was caught and tagged. During the commercial season, 19 chinook salmon were tagged with Petersen tags and eight with jaw tags. The number of fish tagged according to week tagged and the recoveries in the commercial fishery from each week's tagging are shown in Figure 3.

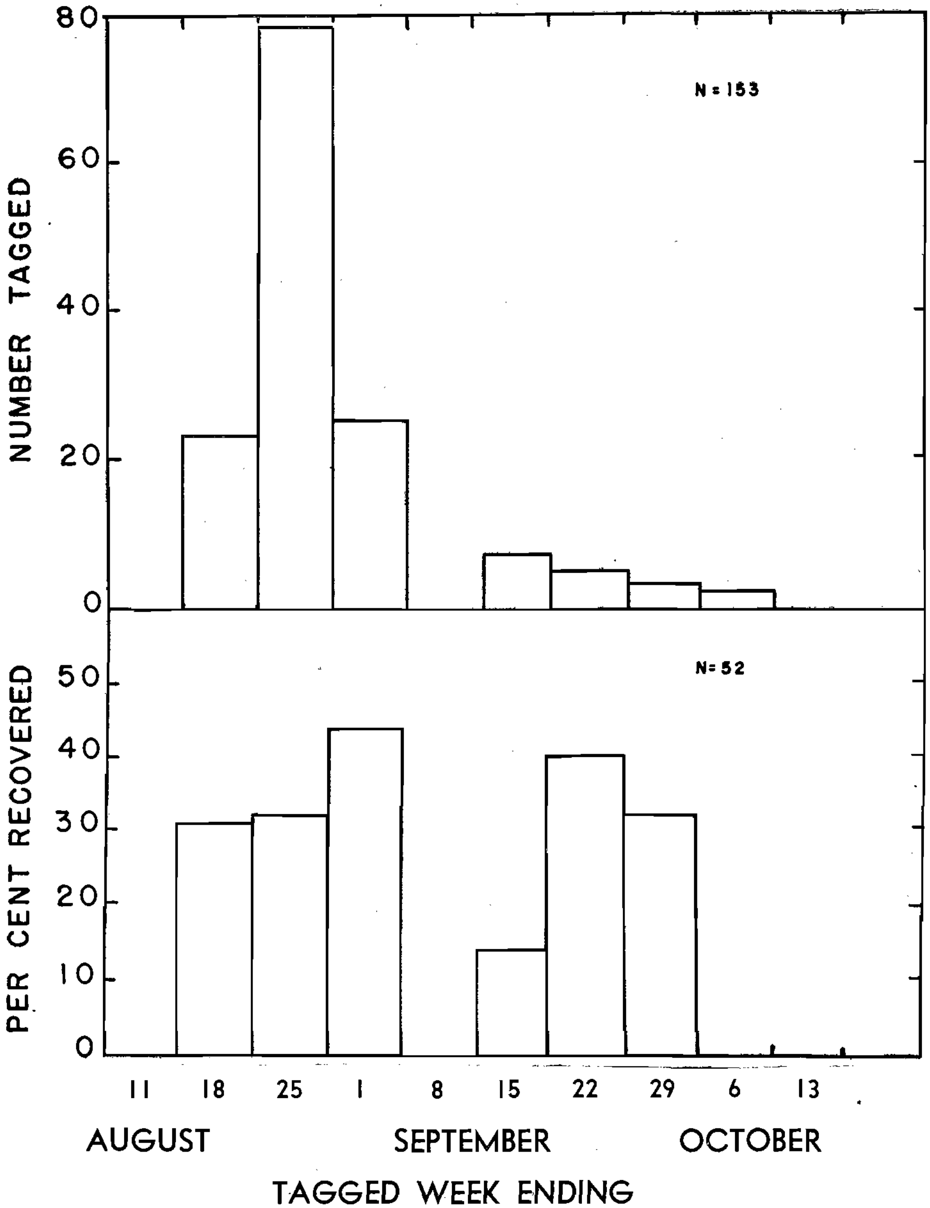

Figure 3. NUMBERS OF FISH TAGGED BY WEEKS WITH PETERSEN TAGS AND PERCENTAGE RECOVERED FROM EACH WEEK'S TAGGING IN THE COMMERCIAL FISHERY FOR THE ENTIRE SEASON

Recoveries From the Commercial Fishery

The commercial catch was sampled as completely as possible in order to obtain a reliable tagged-to-untagged ratio of fish. Observers were aboard the pickup boats as the fish were taken from the fishermens' floats, and each fish was examined for tags and tag scars. Most of the fish were also weighed so that average weight data were obtained for the fish in the catch each day. If a pickup trip was missed, the fish were sampled as they were unloaded from the pickup boat at the dealer's float.

The total number of pounds in the catch each week was divided by the average weight of the fish in the samples for that week in order to find the total number of fish taken during the week (Table 1). It was necessary to use weekly totals because the average weight varied from week to week, throughout the season. The average weight of chinooks in the commercial catch for the season was 14.2 pounds.

TABLE 1.

DATA USED IN CALCULATING THE NUMBER OF CHINOOK SALMON TAKEN IN THE COMMERCIAL FISHERY ON THE ALSEA RIVER, 1951.

Week ending	*Number fish in sample*	*Weight of sample*	*Average weight*	*Weight of catch*	*Number of fish in total catch*
Sept. 8	530	6,771	12.8	11,761	918
15	262	2,888	11.0	5,075	461
22	191	2,915	15.3	4,127	270
29	188	3,329	17.7	4,396	248
Oct. 6	194	3,132	16.1	3,784	235
13	48	1,008	21.0	1,373	65
	1,413	20,043	14.2	30,516	2,197

The tagged-to-untagged ratio also varied by weeks during the season. As with the average weights, weekly totals were used to calculate the number of tagged fish taken in the commercial catch during the season. The fish-per-tag ratio for the season was 31:1. The total number of fish taken each week was divided by the fish per tag for that week to find the approximate number of tags taken by the fishery. It was calculated that approximately 70 tagged fish were taken in the fishery during the season (Table 2). The percentage of the tags released each week which was recovered in the commercial fishery during the entire season is shown in Figure 3.

TABLE 2.

DATA USED IN CALCULATING THE NUMBER OF TAGGED CHINOOK SALMON TAKEN IN THE COMMERCIAL FISHERY ON THE ALSEA RIVER, 1951.

Week ending	*Number examined*	*No. tags and tag scars in sample*	*Fish per tag*	*Number of fish in catch*	*Calculated tags and tag scars in total catch*
Sep. 8	711	42①	16.9	918	54.3
15	262	3	87.3	461	5.3
22	231	4	57.7	270	4.7
29	217	3	72.3	248	3.4
Oct. 6	205	1	205.0	235	1.1
13	48	1	48.0	65	1.4
	1,674	54	31.0	2,197	70.2

① Includes two tag scars.

Spawning Ground Surveys

Spawning ground surveys for chinook salmon were begun the first week in October and were continued through November. The areas surveyed are shown by solid lines in Figure 2. Additional chinooks were observed during the later surveys for silver salmon, although these surveys were not made in areas where chinooks preferred to spawn. Low stream flows at the time the chinook salmon spawn confine them to the larger streams. The later fish appear to spawn in about the same areas as those spawning earlier, even though there is sufficient water for them to spawn elsewhere.

Tagged-to-untagged ratios on the spawning grounds were obtained by observers who walked along the bank of the stream and counted all tagged and untagged fish, both dead and alive. Any fish which could not be seen clearly as tagged or untagged was omitted from the count.

In Table 3 are shown the number of live and dead fish examined on the spawning grounds for tags, the tags recovered, and the fish per tag for each week of the season. All tags recovered were of the Petersen type. Most of the fish were observed during the period October 7 to November 3, and all of the tags were recovered during that period. A total of 219 chinook salmon was examined during the season, and five tags were recovered, all from live fish. The fish-per-tag ratio on the spawning grounds was 44:1 for the season.

TABLE 3.

TAG RECOVERIES FROM LIVE AND DEAD PETERSEN-TAGGED CHINOOK SALMON ON THE SPAWNING GROUNDS, ALSEA RIVER, 1951.

Week ending	*Live adults*	*No. tags*	*Fish per tag*	*Dead adults*	*No. tags*	*Fish per tag*	*Total exam.*	*No. tags*	*Fish per tag*
Oct. 6	18	0	....	1	0	....	19	0	....
13	67	2	34	13	0	....	80	2	40
20	0	....	....	0	....	....	0	....	....
27	0	....	....	0	....	....	0	....	....
Nov. 3	56	3	19	6	0	....	75	3	25
10	8	0	....	2	0	....	10	0	....
17	1	0	....	0	....	....	1	0	....
24	16	0	....	2	0	....	18	0	....
Dec. 1	0	....	....	1	0	....	1	0	....
8	0	....	....	0	....	....	0	....	....
15	11	0	....	12	0	....	23	0	....
22	3	0	....	2	0	....	5	0	....
	180	5	36	39	0	....	219	5	44

Recoveries According to Condition Released

It was not known how tagging would affect the behavior of the fish, nor to what extent a fish might be injured in the tagging operation and survive. An attempt was made to measure the effect of the tagging operation by recording the apparent condition, as mentioned in a previous section, and observing the numbers of each condition group in the catch and in stream surveys.

A non-significant chi-square value was calculated according to recovery by the various condition groups (Table 4). From this it was concluded that the recovery of the fish was independent of the apparent condition of the tagged fish at the time of release, and that the fish listed under the different conditions did not suffer differential mortalities. Therefore all the recoveries were grouped together. No comparisons could be made from spawning ground recoveries because of the small number of tags recovered.

TABLE 4.

THE VALUE OF CHI-SQUARE CALCULATED FOR RECOVERIES IN THE COMMERCIAL FISHERY OF CHINOOK SALMON, TAGGED WITH BOTH PETERSEN AND JAW TAGS, ACCORDING TO CONDITION RELEASED IN THE ALSEA RIVER, 1951.

Condition group	*Re-covered*	*Not re-covered*	*Total*	*Expected recovered*	*Expected not recovered*	*Chi-square*
1	34	57	91	30.9	60.1	.471
2	8	22	30	10.2	19.8	.719
3 & 4	10	22	32	10.9	21.1	.112
Total	52	101	153	52.0	101.0	1.302

Chi-square = 1.302 *d.f.* = 2 *P* = .52

Tag Selectivity

Few data are available to measure possible selection of tagged fish by the nets. The fish-per-tag ratio on the spawning grounds was 44:1 compared to 31:1 in the commercial fishery. In view of the numbers involved (see Tables 2 and 3) differences of this magnitude could easily arise by chance among samples from a single population. Further, the probability of overlooking a few tags on live fish on the spawning grounds was large despite all precautions. Consequently, it is concluded that no evidence for or against selectivity can be found from this comparison.

Population Estimate From Recoveries in the Commercial Fishery

An estimate of the population of fall chinook salmon available to the commercial fishery was made from tags recovered in the commercial catch.

The method used was that suggested by Schaefer (1951a) for the estimation of a population where neither tagging nor sampling are proportional to the number of fish available, and where there is a positive correlation between the time of migration past some point below the spawning grounds and the time of appearance on, and of death at, the spawning grounds. The existence of such a correlation between the time of tagging and the time of recovery in the commercial fishery is indicated in Figure 4. The method was proposed as a means of obtaining an estimate of the population from spawning ground recoveries, but was used here to obtain an estimate of the population from tags recovered in the commercial fishery.

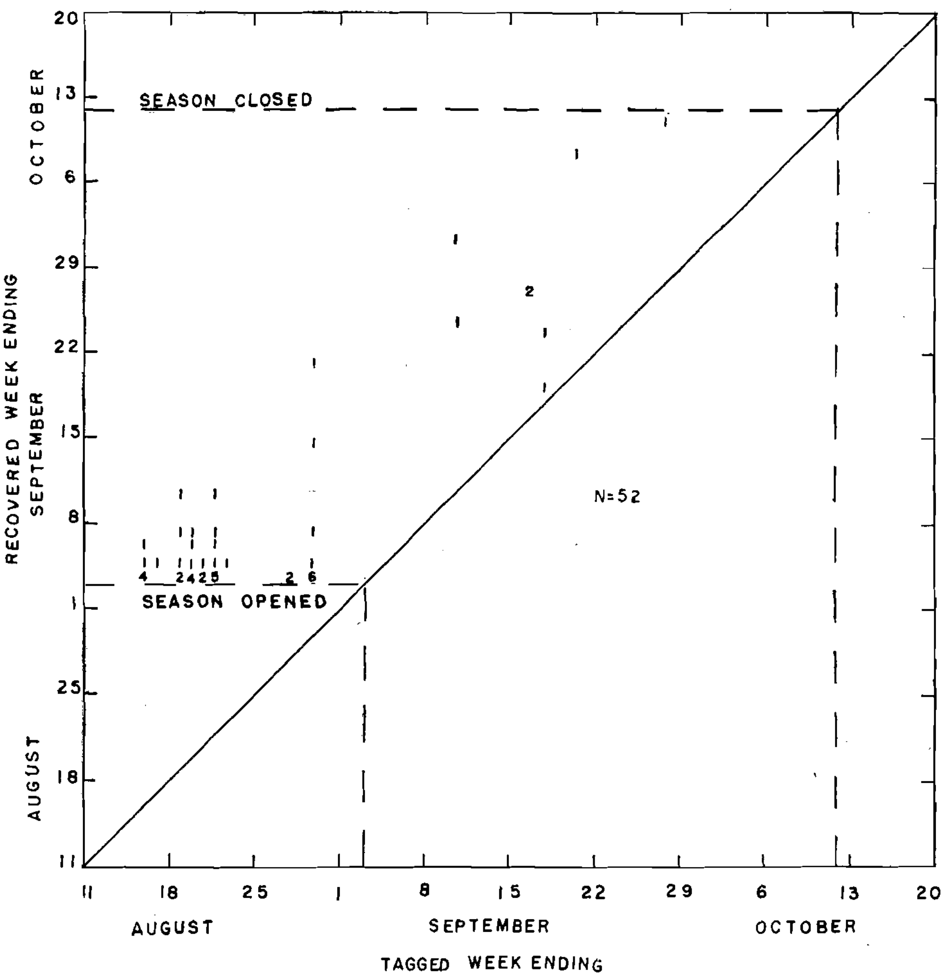

Figure 4. RECOVERIES OF TAGGED CHINOOK SALMON IN THE COMMERCIAL FISHERY ACCORDING TO DATE TAGGED, ALSEA RIVER, 1951.

Table 5 contains tag recoveries from sampling the commercial catch by date of tagging and date of recovery, with the total number tagged and the total number recovered for each weekly period. The values in Table 6 were calculated from the data in Table 5 by using Schaefer's equation 25 (Schaefer, 1951b, p. 200). The estimate of the population calculated from recoveries in the commercial fishery was slightly more than 5,000 fish. The total catch by the commercial fishery of approximately 2,200 fish amounted to about 44 per cent of the calculated population available to the fishery. This fishing mortality of 44 per cent on the portion of the population available to the commercial fishery is considerably greater than the 15 per cent fishing mortality found for silver salmon in the Alsea River (Morgan and Cleaver, in press).

TABLE 5.

DATA FOR THE POPULATION ESTIMATE OF FALL CHINOOK SALMON AVAILABLE TO THE COMMERCIAL FISHERY, ALSEA RIVER, 1951.

Week of recovery	*Week of tagging*									*Tags (c)*	*Number (d)*	*(d/c)*
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*Recovered*	*Sampled*	
1	....	....	....	....	....	....	....	....	....	0	0	....
2	....	....	....	....	....	....	....	....	....	0	0	....
3	....	....	....	....	....	....	....	....	....	0	0	....
4	8	22	10	....	....	....	....	....	....	40	711	17.8
5	....	2	1	....	....	....	....	....	....	3	262	87.3
6	....	....	1	....	....	1	....	....	....	2	231	115.5
7	....	....	....	....	1	3	....	....	....	4	217	54.3
8	....	....	....	....	1	....	....	....	....	1	205	205.0
9	....	....	....	....	....	1	1	....	....	2	48	24.0
Tags recovered *(a)*	8	24	12	....	2	5	1	....	....	52	1,674	
Number tagged *(b)*	23	78	25	....	11	10	3	3				
(b/a)	2.9	3.3	2.1	....	5.5	2.0	3.0	....				

TABLE 6.

AN ESTIMATE OF THE SIZE OF THE POPULATION OF FALL CHINOOK SALMON AVAILABLE TO THE COMMERCIAL FISHERY, ALSEA RIVER, 1951, OBTAINED FROM DATA IN TABLE 5.

Week of recovery	*Week of Tagging*									*Total*
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	
1	......	....	......	....	....	......	....	....	....	....
2	......	....	......	....	....	......	....	....	....	....
3	......	....	......	....	....	......	....	....	....	....
4	413	1,292	374	....	....	......	....	....	....	2,079
5	......	576	183	....	....	......	....	....	....	759
6	......	....	243	....	....	231	....	....	....	474
7	......	....	......	....	299	326	....	....	....	625
8	......	....	......	....	1,128	......	....	....	....	1,128
9	......	....	......	....	....	48	72	....	....	120
Total	413	1,868	800	....	1,427	605	72	....	...	5,185

An estimate of the population available to the commercial fishery, based on the above data, was also calculated by using the equation $N = \frac{nt}{s}$ where N = the estimate of the total population, n = number of fish sampled on the spawning grounds, t = total number of fish tagged, and s = the number of tags recovered in the samples of the commercial catch. Using this equation with $n = 1,674$, $t = 153$, and $s = 52$, N (the total population) is 4,832 fish.

The 95 per cent confidence limits for the population estimate using the above equation were calculated by using equations 43 and 44 proposed by Chapman (1948, p. 78). The upper limit was approximately 6,500 fish, and the lower limit was slightly more than 3,600 fish.

Time Between Tagging and Recovery

When a tagged fish was released, the tagging location, tag number, and the date of tagging were recorded. Whenever one of these tagged fish was known to be recovered at a certain location, it was possible, by referring to the tagging data, to determine the minimum distance this fish had traveled after it was tagged and the length of time since tagging. Recoveries were made in the commercial fishery and in stream surveys.

Ninety-one per cent of the total fish recovered in the commercial fishery from the August tagging were taken by September 8, indicating that by that date most of these fish were no longer available to the commercial fishery. No fish tagged during August were recovered in the fishery after September 14. The single recovery on September 14 had been tagged August 29, immediately before the commercial season opened.

The longest time between tagging and recovery in the commercial fishery was 23 days. This was one of the first fish tagged in August and was taken after the commercial season had been open six days. The shortest time between tagging and recapture was two days. Of the chinooks tagged in September after the commercial season opened, eight were recovered. The average time between tagging and recovery for these eight fish was slightly less than 13 days.

Figure 4 shows the relation between the time of tagging and the time of recovery of 52 tagged fish recovered in the commercial fishery. A larger number of tagged fish were recovered, but occasionally the numbered tag had been lost, and only a blank tag or scar remained.

The small number of tags recovered above tidewater gave only a limited amount of information on the movements of the fish after they left the tidewater area. The first stream recovery was made 31 days after the fish had been tagged. This fish was recovered about one-half mile above the head of tidewater in Drift Creek and was unspawned. Live fish which were recovered in a spent condition had been out 52 to 63 days from the time they were tagged.

Distribution of Tagged Fish

The small number of recoveries contributed only a limited amount of information on the destination of fish tagged in tidewater during August. However, the recovered tags were well distributed throughout the Alsea River drainage. Fall-run chinook salmon tagged in the lower tidewater areas in August were found later on widely separated spawning grounds and were not confined solely to a few lower river tributaries. Recoveries were made in Drift Creek, Buck Creek, and Crooked Creek.

Summary

During the fall of 1951, a tagging program was conducted on the Alsea River by the Fish Commission of Oregon in order to gain information on the fall run of chinook salmon.

Before the commercial season opened in September, 129 fall chinook salmon were tagged with Petersen-type plastic tags. Following the opening of the commercial season, 27 additional chinooks were tagged.

Tags were recovered in the commercial fishery. It was calculated that approximately 70 tags and tag scars were included among the 2,197 fish taken in the commercial fishery.

Only five tags were recovered in spawning ground surveys.

Tagged fish were placed in one of four condition groups. On the basis of a non-significant chi-square it was concluded that the recovery of the fish was independent of the condition of the fish when released.

No data were available to test for tag selectivity by the nets.

It was calculated from tag recoveries that the fall-run chinook salmon population available to the commercial fishery in the Alsea River in 1951 was slightly more than 5,000 fish. The upper and lower 95 per cent confidence limits were calculated from recoveries in samples of the commercial catch and were found to be approximately 6,500 and 3,600 fish, respectively.

A fishing mortality of 44 per cent was found in the portion of the population available to the commercial fishery. This mortality is considerably greater than the 15 per cent fishing mortality found for Alea River silver salmon (Morgan and Cleaver, in press). The bulk of the chinooks were taken during the first week in September.

The length of time which elapsed between the time of tagging and the time of recovery in the commercial fishery ranged from 2 to 23 days. By September 8, 91 per cent of the recoveries of fish tagged in August had been made.

Fish which were recovered on the spawning grounds, alive and spawned out, had been tagged from 52 to 63 days.

The few recoveries made on the spawning grounds were made in widely separated areas of the Alsea drainage.

Acknowledgments

The authors wish to express their sincere appreciation to Mr. Donald L. McKernan, former Director of Research, who offered advice and assisted in the collection of data; to Mr. Kenneth Henry, who offered constructive criticism and assisted in preparing this report; and to Messrs. Raymond Breuser, Robert Gunsolus, Earl Pulford, Eldon Korpela, Robert Rulifson, Stanley Rutz, Raymond Willis, and Ed Wright who assisted in the tagging and collection of data. Messrs. James Kent and L. E. Le May captured the fish for tagging.

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NATURALLY MISSING SINGLE FINS FROM CHUM SALMON

In the fall of 1952 Oregon Fish Commission biologists observed five chum salmon from the Columbia River commercial catch that apparently had naturally missing single fins. Of 3,491 chum salmon observed by the biologists, two had missing right ventral fins. In addition, fish butchers at the canneries discovered three chums missing left ventral, right pectoral, and left pectoral fins, respectively. These were not in the group sampled by the biologists but were brought to their attention and were thus verified.

Since no marking experiments with chum salmon have been conducted south of Puget Sound in recent years and those carried on to the northward have not involved the use of these single fins, the occurrence of these marks must be attributed to natural causes.

The occurrence of naturally missing fins emphasizes the desirability of using two fins for marking experiments.

H. L. Rietze

THE LENGTH OF TIME THAT SILVER SALMON SPENT BEFORE DEATH ON THE SPAWNING GROUNDS AT SPRING CREEK, WILSON RIVER, IN 1951-52

RAYMOND A. WILLIS

Introduction

Mature silver salmon *(Oncorhynchus kisutch)* were tagged at Spring Creek, a small tributary of the Wilson River, in the winter of 1951-52 to determine the length of time that elapsed between their entrance into the creek and death after spawning. Spring Creek silver salmon frequently begin to spawn immediately after entering this tributary, as they apparently use the main Wilson River for ripening. During the 1951-52 spawning season, salmon were observed throughout the 1,200 foot stream except in the uppermost 100 feet.

Description

Spring Creek is located about 25 miles up the Wilson River from Tillamook Bay. This bay is approximately 60 miles south of the mouth of the Columbia River. The water flow of Spring Creek ranges from a summer flow of about ¾ c.f.s. to 5 or 6 c.f.s. at high winter flows. A fine-meshed weir is athwart the stream 350 feet above its mouth, and there are upstream and downstream traps at opposite ends of this weir. Except during conditions of flood, most of the stream flows through the upstream trap and out a V-shaped entrance with swinging, mesh-lined doors. The doors are constructed to allow one-way passage of adults into the trap.

Methods

Each time the weir was visited a fine-mesh net was secured across the stream near its mouth. The observer then carefully searched the area below the weir and with a 19-inch diameter dip-net captured the newly arrived silver salmon that chose to spawn in this area. These visits were made each day during the main part of the run and were at a maximum of 3-day intervals at other times, except for one period of 4 days at the beginning of this study. During this initial 4-day period it is believed that no salmon were present for the first 2 days, after which the first fall freshet occurred. Salmon may have been in the stream the latter 2 days before being tagged. The stream is very small, from 3 to 8 feet wide, and any salmon lingering in the lower part of the stream were usually readily caught. The salmon were then tagged with a Petersen-type plastic tag placed just below the dorsal fin, and were released at the spot of capture. This type of tag consists of two colored plastic disks slightly less than one-half inch in diameter, one of which is numbered. The disks are on each side of the fish, just under the dorsal fin, and are connected by a nickle pin.

The net across the stream was then removed and the upstream trap was tended. All fish in the trap which had been tagged previously below the weir were released upstream. The untagged fish were tagged while in the water with a stainless steel jaw tag and were also released above the weir.

These jaw tags, when straightened, were about 60 mm. long, 6 mm. wide, and less than 1 mm. in thickness (Figure 1). Each tag had a separate number engraved on it. The tag was placed in the specially constructed jaws of a heavy pair of pliers and was secured around the dentary. During the tagging operation the fish was kept in the water, either in the dip-net or on its back in a floating tagging box. Pressure on the pliers closed the ends of the tag around the dentary, and the fish was then released upstream.

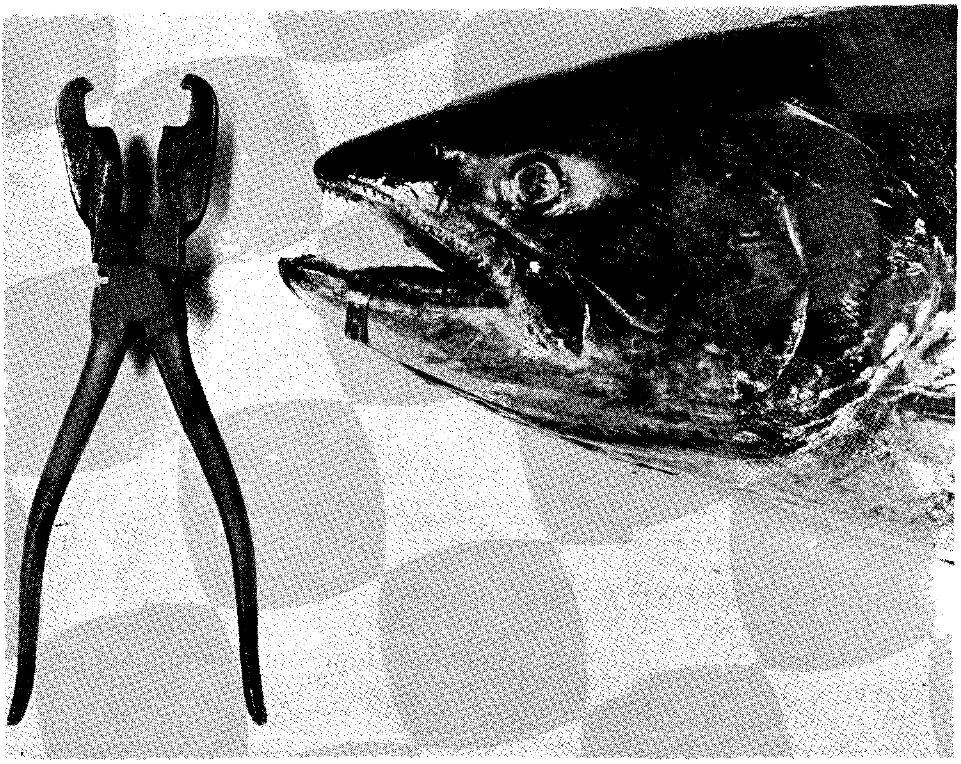

Figure 1. STAINLESS STEEL JAW TAG AND PLIERS USED AT SPRING CREEK, WILSON RIVER, 1951-52.

Two males were taken in the trap in the week ending October 27. No more adults appeared until the week ending November 17; hence the intensive surveys of the spawning grounds did not commence until November 17. The stream was surveyed at approximately 3-day intervals, and occasionally every day, to the middle of March, 1952. Tags were recovered from most dead, spawned-out salmon although some fish had lost tags and therefore could not be used in this study.

The length of time the spawning salmon spent in Spring Creek includes the tagging date and extends to, but does not include, the date of the dead fish recovery. Most of the salmon were believed to have been tagged either on the day they arrived in the tributary or on the day after. Also, the recovery effort was daily for the most part. Therefore, the maximum error for the bulk of the run is believed to be one day.

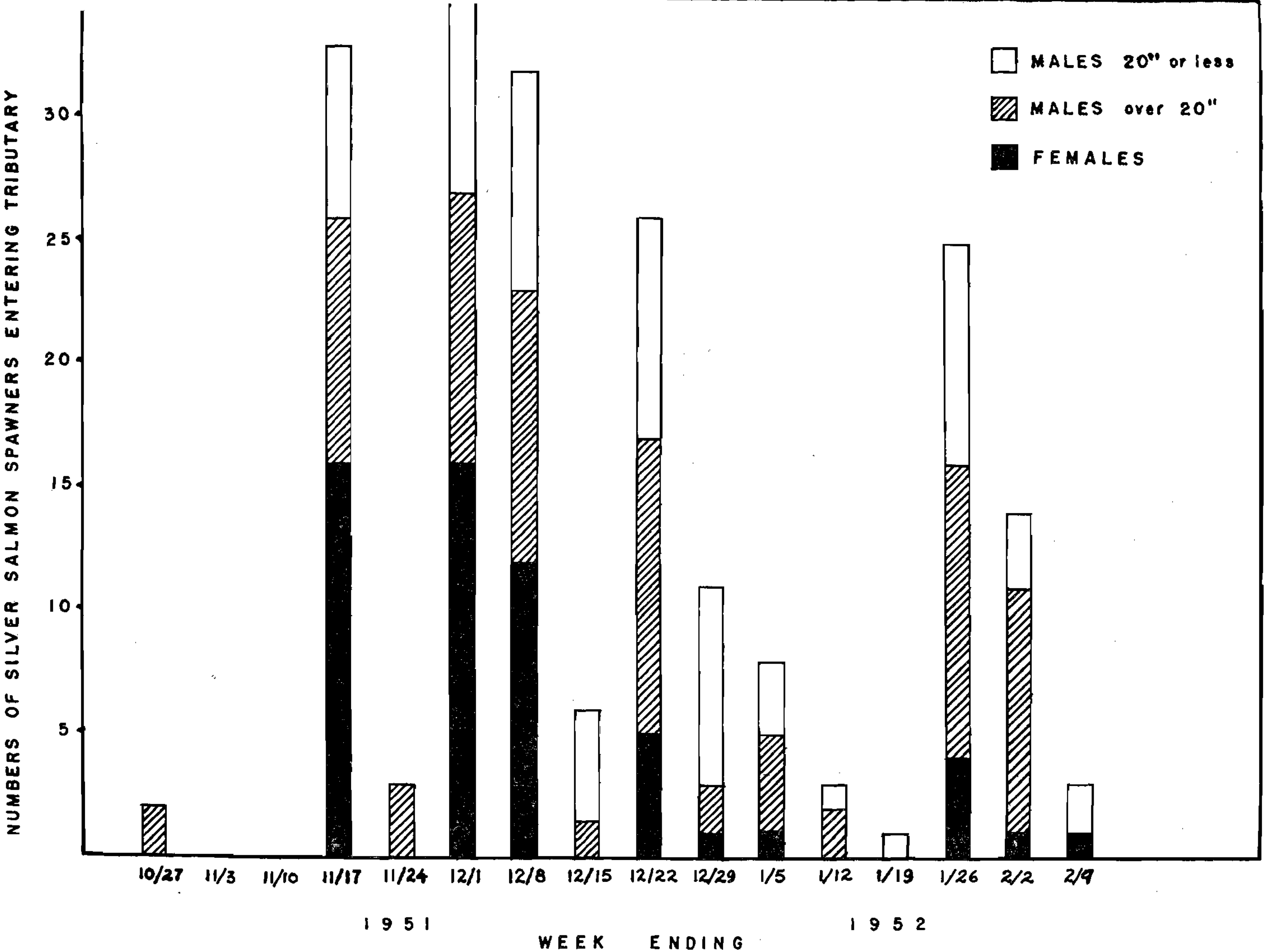

Figure 2. 1951-52 SILVER SALMON ADULT RUN AT SPRING CREEK.

During the first and last parts of the run, tagging periods and recovery efforts were at approximately 3-day intervals. At these times the maximum error would be 2 days. On one occasion a survey was not made for 7 days and the maximum error for the length of time a salmon lived in this tributary could be 6 days too high. However, the exclusion of tag recoveries on decomposed fish and the exclusion of tags found in the stream bed alleviates the above errors somewhat.

Results

A total of 200 silver salmon were tagged in Spring Creek from November 12, 1951, to February 5, 1952. The first two fish (both males over 20 inches in length) of the 1951-52 run arrived at the Spring Creek weir on October 24, but were not tagged. Fifty-seven of the tagged fish were females, 83 were males over 20 inches in length (to the fork of the tail), and 60 were males 20 inches or less in length. Figure 2 shows the time of appearance of the spawners in Spring Creek in weekly intervals. It is possible that some of the fish shown in the week ending November 17 should be in the preceding weekly period because the first fall freshet started November 10.

There were 78 (39 per cent) usable tag recoveries from the 200 fish tagged. Twenty-seven of these recoveries were from males over 20 inches in length, 28 were jacks (precocious 2-year-old males, arbitrarily segregated by being 20 inches or under in length to fork of tail) and 23 were females.

Figure 3 shows the regression, by sex, of the number of days alive in the stream (vertical axis) on the weekly tagging dates (horizontal axis). The

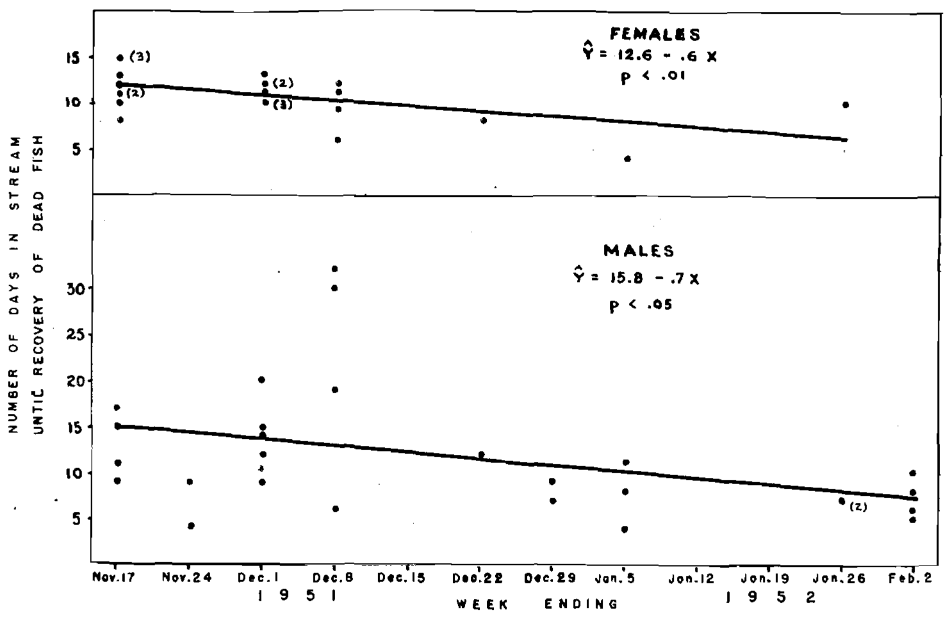

Figure 3. TIME FROM STREAM ENTRY TO RECOVERY OF DEAD SILVER SALMON, FEMALES AND MALES OVER 20 INCHES IN LENGTH, SPRING CREEK, 1951-52

results for females ($P<.01$) indicate that the probability of getting such a regression coefficient by chance alone, under the hypothesis that it actually equals zero, would be about one in a hundred; for males ($P<.05$) about one in twenty, and both values are significant. This demonstrates that the early arrivals of both sexes remained alive longer than the later arrivals. Also, the data indicate that the mean length of time the 23 females spent in Spring Creek before they were found dead was about 11 days and the range was about 4 to 15 days. The mean length of time for the 27 adult males was about 12 days and the range was about 4 to 32 days. Twenty-eight jack silver salmon lived approximately 3 to 57 days with a mean of about 15 days. A relatively high percentage of this latter group was unspawned or partially spent.

The 1951-52 adult run to Spring Creek was composed of hatchery reared and naturally reared fish. The hatchery fish, which had been marked by excision of certain fins, entered the stream from the week ending November 17 to the week ending December 8, 1951, while the natural fish entered the stream from the week ending December 1, 1951, to the end of migration on February 5, 1952.

Summary

Two hundred of 202 silver salmon spawning adults were tagged as they entered Spring Creek in the winter of 1951-52. Those captured at the weir were jaw tagged with stainless steel bands around the dentary; those captured below the weir were tagged just under the dorsal fin with Petersen type plastic disks.

The average length of time the spawners spent in Spring Creek until death was about 11 days for females, 12 days for males over 20 inches in length, and 15 days for males 20 inches and under in length. Jack silver salmon were alive in the stream a maximum of about 57 days and a minimum of about 3 days.

The regressions of the number of days in the stream until the recovery of dead fish, on the weekly tagging dates were significant for both the females and males over 20 inches in length. This indicates that the early arrivals to the tributary remain alive longer than do the later arrivals.

Acknowledgments

Appreciation is extended to Messrs. F. C. Cleaver and Raymond N. Brueser for gathering a sizeable portion of the data presented in this report.

THIRD PROGRESS REPORT ON SPRING CHINOOK SALMON DIET EXPERIMENTS[1]

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Introduction

Because it is becoming more difficult to provide adequate food for fish hatcheries, the Fish Commission of Oregon and the Oregon Agricultural Experiment Station Seafoods Laboratory are cooperating in a series of experiments designed to develop satisfactory beef liver substitutes, test present hatchery food components, and appraise potential hatchery food components.

The second progress report of this series (McKee *et al,* 1952) revealed that the Wisconsin diet (McLaren *et al,* 1947) modified by the addition of vitamin B_{12}, procaine penicillin, and a small quantity of beef liver produced good weight gains when fed to spring chinook salmon fingerlings. The modified Wisconsin diet was used to evaluate various substitutes for beef liver. In the same experiment an all-meat diet composed of equal parts of fresh-frozen beef liver, hog liver, and salmon viscera, plus 2 per cent salt gave good growth. When Argentine beef liver meal was substituted for fresh-frozen beef liver in the all-meat diet, good growth was obtained.

This present study describes a further modification of the Wisconsin diet used to evaluate both actual and potential hatchery food components. This study also compares Argentine beef liver meal and two other beef liver substitutes (air-dried grasshopper meal and condensed sardine solubles) with fresh-frozen beef liver when each is used as a supplement to the further-modified Wisconsin diet.

Procedure

The experimental work was conducted at the Bonneville hatchery located on the Columbia River. The water used was from Tanner Creek. The same tanks employed in the preceding experiment for holding fish were used. These consisted of 12 circular firwood tanks, each 6 feet in diameter, with a 16-inch water depth. Each of the 12 tanks was stocked with 2,000 grams of spring chinook feeding fry. This weight of fry was equivalent to approximately 1,300 fish.

The tanks were arranged in the hatchery building in such a manner that some were subject to more light than others and some were adjacent to visitors' areas while others were more secluded. In order to equalize the effects of surroundings, the tanks were randomly moved every 6 weeks.

[1] Published as Technical Paper No. 788 with approval of the Director of the Oregon Agricultural Experiment Station as a contribution of the Seafoods Laboratory of the Department of Food Technology.

The tests were started on May 22, 1951, and ended on October 24, 1951, after a 22-week feeding period. All lots were fed two to four times a day and 6 days each week. All lots were fed on a dry weight basis as described in the second progress report. In the present experiment all diet components were chemically analyzed and the diets compounded to give the same proximate chemical composition and caloric content. By this method it is possible to compare the values of the various foods fed.

The lots were weighed every 2 weeks and a gill check of 25 fish was made every weigh day. No medication was given the fish.

The Wisconsin diet was further modified to match the proximate chemical composition of the all-meat ration, which has proven to be an excellent diet for rearing chinook salmon. This modification is now composed of 55 per cent vitamin-free casein, 18 per cent dextrin, 1 per cent calcium carbonate, 4 per cent crab *(Cancer magister)* meal, 6 per cent supplemental salts (Phillips and Hart, 1935), and 16 per cent corn oil. Ten parts gelatin were added for a binding agent to each 100 parts of the above mixture. The vitamin level was adjusted to be equivalent insofar as possible to the all-meat ration used as one of the control diets. This diet shall henceforth be referred to in this study as the Oregon diet.

There were three control diets in this experiment. These were as follows: (1) an all-meat diet used successfully in the previous experiment, (2) the Oregon diet plus 10 parts fresh-frozen beef liver[1], and (3) the Oregon diet 100 per cent.

To test beef liver substitutes (liver meals are classed as substitutes) and their relative efficiency, the amounts of these substitutes were adjusted on a dry weight basis to be comparable to the amount of fresh-frozen beef liver in the control diet. Two different liver products, Argentine beef liver meal and a drum-dried beef liver meal specially prepared at the Astoria Seafoods Laboratory, were compared in this manner. Two other substitutes, air-dried grasshopper meal and condensed sardine solubles, were also tested. The latter material was used at a level slightly lower than the fresh-frozen beef liver equivalent because of limitations arising from the high ash content of the sardine solubles.

For testing potential and existing hatchery food components other than beef liver substitutes, the casein portion of the Oregon diet was replaced with other types of proteinaceous material insofar as the proximate analysis would allow. These included the following: drum-dried hake *(Merluccius productus)*, drum-dried turbot *(Atheresthes stomias)*, drum-dried chinook salmon *(Oncorhynchus tshawytscha)* viscera, and commercially prepared chinook salmon carcass meal.

To check the effectiveness of the Oregon diet, one other type of purified ration described by Wolfe (1951) was included in this series. This purified ration has been used successfully by Wolfe to feed rainbow trout for a period of 25 weeks.

The formulas of the dry diets, with one exception, were adjusted so that when fed to the fish the proximate composition of all diets was the same.

[1] The term "fresh-frozen beef liver" in this experiment refers to undenatured fluky beef liver obtained directly from the packing house and brought to the Seafoods Laboratory at Astoria where it was ground, canned, and frozen. This is distinct from fluky beef liver that has been denatured and frozen at a packing house.

This proximate composition was as follows: 67 per cent moisture, 4 per cent fat, 18 per cent protein, 3 per cent ash, and 8 per cent carbohydrate. An exception was made for Wolfe's purified ration. In this diet an increase in the

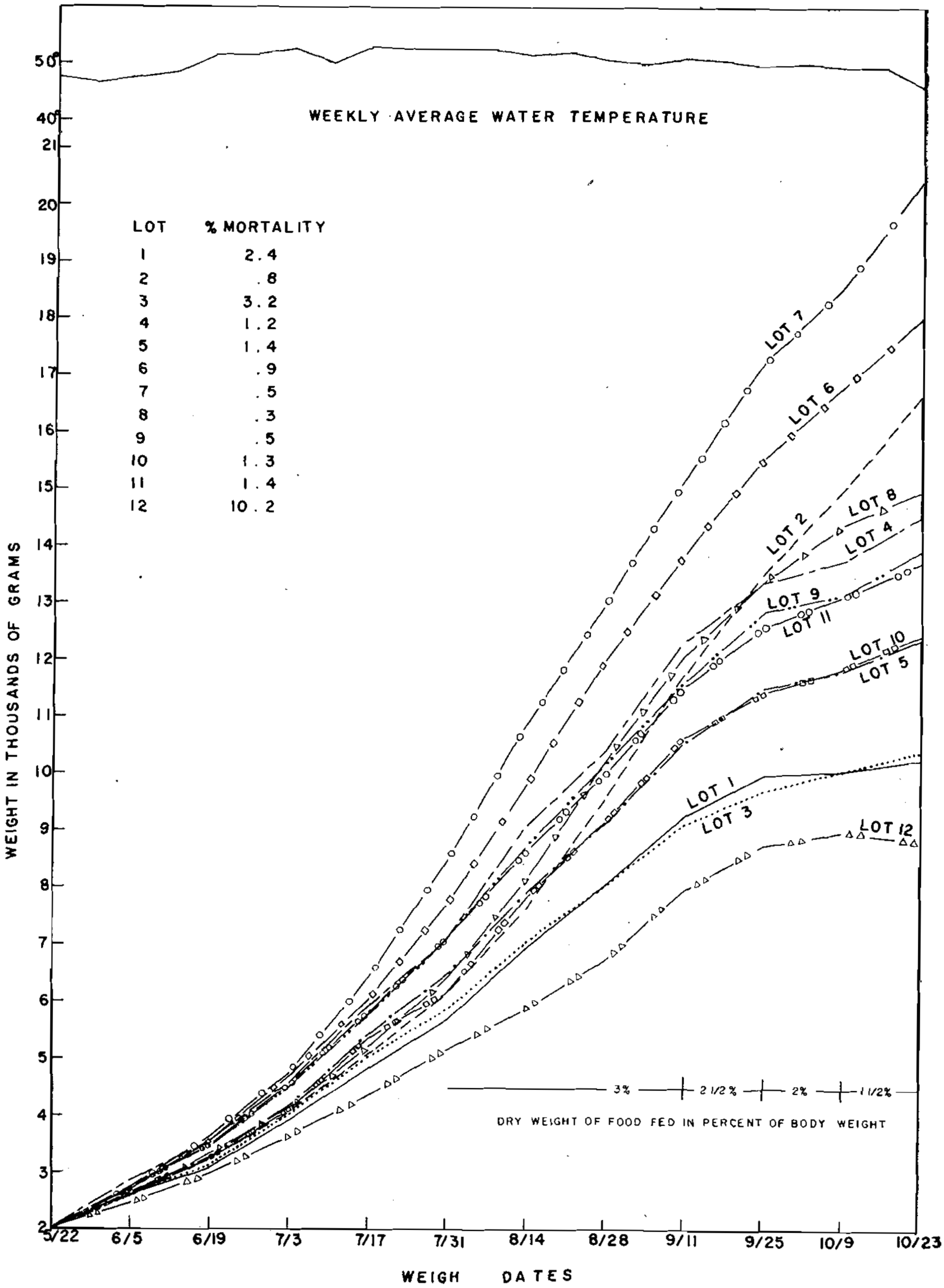

Figure 1. WEIGHT GAINS, PER CENT MORTALITY, AND WEEKLY AVERAGE WATER TEMPERATURE.

amount of water overcame a mechanical difficulty in feeding. However, all lots received the same amount of dry food each day in proportion to body weight.

Results

The total weight gain, mortality, and the water temperature are shown in Figure 1.

The component percentages by weight of each of the 12 diets and the results obtained from each diet are given in Table 1.

TABLE 1.
DESCRIPTION OF DIETS AND OBSERVATIONAL RESULTS.

Lot Number	Diet	Observations
1	Control diet: Oregon diet 100%. Water added to yield same moisture content as Lot 2.	Losses considered low, general condition good, no anemia, low weight-gain.
2	Control diet: Equal parts of beef liver, hog liver, and salmon viscera, all fresh-frozen, plus 2 per cent salt.	An excellent diet. Fish in good condition at all times.
3	Oregon diet 90 parts, Argentine beef liver meal equivalent to 10 parts fresh-frozen beef liver. Water added to yield same moisture content as Lot 2.	Weight gain similar to 100% Oregon diet. Some evidence of anemia at close of experiment.
4	Control diet: Oregon diet 90 parts, fresh-frozen beef liver 10 parts. Water added to yield same moisture content as Lot 2.	Balanced diet, good weight gains, mortality low.
5	Oregon diet 90 parts, Astoria Seafoods Laboratory drum-dried beef liver meal equivalent to 10 parts fresh frozen beef liver. Water added to yield same moisture content as Lot 2.	Weight gains not as good as Lot 4 but better than Lot 1. Mortality low, fish in good condition.
6	Oregon diet with partial casein replacement 90 parts, fresh-frozen beef liver 10 parts. The casein replacement was drum-dried hake *(Merluccius productus)* meal. Water added to yield same moisture content as Lot 2.	Superior to all control diets. Very low mortality. Second most successful diet of series.

TABLE 1.—Continued

Lot Number	Diet	Observations
7	Oregon diet with partial casein replacement 90 parts, fresh-frozen beef liver 10 parts. The casein replacement was drum-dried turbot *(Atheresthes stomias)* meal. Water added to yield same moisture content as Lot 2.	Superior to all control diets. Very low mortality. Most successful diet of series.
8	Oregon diet with casein replacement 90 parts, fresh-frozen beef liver 10 parts. The casein replacement was drum-dried salmon *(Oncorhynchus tshawytscha)* viscera. Water added to yield same moisture content as Lot 2.	Well balanced diet. Only slightly lower weight gains than Lot 2. Lowest mortality. Most active feeders. Fish in good condition at all times.
9	Oregon diet with partial casein replacement 90 parts, fresh-frozen beef liver 10 parts. The casein replacement was commercially prepared salmon *(Oncorhynchus tshawytscha)* meal from spawned-out fall chinook carcasses. Water added to yield same moisture content as control Lot 2.	Considerably below control Lot 2 in weight gain. Growth and weight classified as average. Low mortality. Appetite only fair.
10	Oregon diet 95 parts, sardine fish solubles 5 parts. Water added to yield same moisture control as Lot 2.	Weight gain fair. Below control Lot 4 in growth.
11	Oregon diet 90 parts, grasshopper meal equivalent in total solids to 10 parts fresh-frozen beef liver. Water added to yield same moisture content as Lot 2.	Slightly lower than control Lot 4 in growth. Mortality low. Fish active and alert. Ate well.
12	Wolfe's synthetic 100%, water added to yield moisture content of 80% (vitamin-free casein used in place of commercial casein for this diet).	Unsatisfactory. High mortality. Low net growth. Some anemia at termination of experiment.

Conclusions

A modification of the Wisconsin diet, designated as the Oregon diet, will support growth of spring chinook salmon fingerlings.

Fresh-frozen beef liver appears to contain a factor or factors which promote growth in chinook salmon fingerlings. It is probable that this factor is affected adversely by heat since the drum-dried beef liver gave a lesser growth response than the fresh-frozen beef liver. Supplementation of the Oregon diet with Argentine beef liver meal gave no additional growth perhaps because commercially prepared liver meals are normally subjected to high-temperature drying methods.

Condensed sardine solubles and air-dried grasshoppers give a growth response similar to that of drum-dried beef liver.

When combined with 10 per cent beef liver, turbot and hake meals are an excellent source of protein for use in feeding spring chinook salmon fingerlings. It is likely that the factor or factors that promote rapid growth are also present in turbot and hake.

The essential material responsible for rapid growth is different from any of the commonly described vitamins including vitamin B_{12} and procaine penicillin.

Acknowledgments

We wish to thank Mr. Donald L. McKernan, former Director of Research of the Fish Commission, for advice and assistance in carrying on this work. Mr. John Wold of Casper, Wyoming, and Dr. A. N. Tissot and his staff of the Department of Entomology, College of Agriculture, University of Florida, Gainsville, Florida, very kindly supplied the grasshoppers used in Lot 11. We are indebted to Hoffman-LaRoche, Inc., Nutley, New Jersey, and to Merck & Co., Inc., Rahway, New Jersey, for the generous supplies of vitamins used in this work. We wish to thank the Columbia River Packers Association, Astoria, Oregon, for the salmon viscera used in these diets. We also wish to thank A. E. Staley Manufacturing Company, Decatur, Illinois, for the inositol used in these experiments and the American Maize-Products Company, New York City, New York, for the dextrin they kindly furnished. We are indebted to the American Cyanamid Company, Calco Chemical Division, Bound Brook, New Jersey, for the folic acid they generously furnished, and to Bioproducts Oregon, Ltd., Warrenton, Oregon, for the crab meal used in these experiments.

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UNUSUAL SALMON MIGRATIONS

Several unusual recoveries of salmon marked in Oregon Fish Commission hatcheries were made during 1953 as part of the research program being coordinated by the Pacific Marine Fisheries Commission.

On August 1, 1953, a marked silver salmon from the Klaskanine hatchery (lower Columbia River) was caught by a troller near the Farallon Islands off San Francisco. This fish was about 520 nautical miles from its home stream when captured.

At the other extreme, two marked spring chinook salmon from the Willamette River were taken by the Alaskan troll fishery and landed at Pelican during July, 1953. One of these was taken at Lituya Bay, at the northern limit of the present troll fishery, which is over 1,000 miles from the Willamette River.

Jack Van Hyning

UNUSUAL BIVALVE FOUND BY CRAB FISHERMAN

A small bivalve was found by Mr. Phil Horn, a crab fisherman, "clinging" to the wire mesh of a crab pot which had just been pulled from 20 fathoms of water off the mouth of the Alsea River, January 6, 1951. The specimen, measuring 1¼ inches in length, subsequently was identified as *Pandora punctata* Conrad. The shell is oblong, thin, and pearly on the interior; the right valve is flat, the left convex; the ligament margin is recurved; the posterior end is produced into a beak-like process. The range of this species, as quoted by Oldroyd, 1924, is Vancouver Island to the Gulf of California.

Lowell D. Marriage