Robert N. Thompson

RESEARCH BRIEFS

FISH COMMISSION OF OREGON
307 State Office Building
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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.

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SIZE COMPOSITION, GROWTH, AND SEASONAL ABUNDANCE OF JUVENILE ENGLISH SOLE *(Parophrys vetulus)* IN YAQUINA BAY

SIGURD J. WESTRHEIM

Introduction

The need for information concerning the early life history of the principal species of fish utilized by the Oregon otter-trawl fishery led to exploration in 1951 of certain bays and beaches along the Oregon coast for juvenile forms of these species.

Yaquina Bay, which is located approximately 100 miles south of the Columbia River, proved to contain appreciable numbers of small sand dab, mostly *Citharichthys sordidus*, starry flounder (*Platichthys stellatus*), and English sole (*Parophrys vetulus*). The latter, one of the important species which support the Oregon otter-trawl fishery, was selected for further study in Yaquina Bay.

This report deals with the results of studies undertaken in July 1951 and continued through June 1953 concerning the size composition, growth, and seasonal abundance of the juvenile English sole which inhabit Yaquina Bay.

Materials and Methods

A small otter-trawl net, known as a "try-net" to the shrimp fishermen in the Gulf of Mexico, was used to catch juvenile English sole throughout the two-year study. The net was approximately 16 feet long, and 4 feet wide at the mouth. Two bridles, each 18 feet long, connected the top and bottom of each wing to a small, 12- by 20-inch otter board. A 100-foot, ½-inch Manila line connected each otter board with the towing vessel. Stability of the otter boards was enhanced by the addition of a sheet of steel approximately ½ by 4 by 16 inches which was bolted to the inside lower section of each otter board.

The net was constructed of 1½-inch tarred cotton mesh. A "liner" of ½-inch cotton mesh was added in February 1953 to retain the English sole in the 2 to 6 cm. range which could escape through the 1½-inch meshes of the net (Table 1).

A 26-foot motor launch was chartered for one-half day each month to tow the net. During every day of fishing, 4 to 10 drags were taken whose average duration was 20 minutes. Fishing took place in water 5 to 30 feet deep. The net was hauled by hand at the end of each tow.

A record was maintained for each drag, of the time, duration, location, and numbers of specimens caught, by species. Flounder (*P. stellatus*), sand dab (*C. sordidus*), sand sole (*Psettichthys melanostictus*), and crabs (*Cancer magister* and *C. productus*) were encountered frequently. Other species included juvenile ling cod (*Ophiodon elongatus*), juvenile green sturgeon (*Acipenser medirostris*), blennies (*Lumpenus anguillaris*), cottids, embiotocids, and assorted invertebrates.

Usually all English sole caught were measured to the nearest millimeter. However, during the summer months when large catches were taken, only a representative portion of the catch was retained. The remainder was counted, or the numbers estimated, and released. In only 9 of the 147 drags was it necessary to estimate the numbers caught.

TABLE 1. **LENGTH-FREQUENCIES OF ENGLISH SOLE CAUGHT BY TRY-NET IN YAQUINA BAY, BY MONTH AND YEAR, 1951-53**

Length① (cm.)	February '52	February '53	March '52	March '53	April '52	April '53	May '52	May '53	June '52	June '53	July '49②	July '51	July '52	August '51	August '52	September '51	September '52	October '51	October '52	Nov. '52	December '51	December '52	Length① (cm.)
0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	0
1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1
2	......	2	......	1	......	......	......	2	......	......	......	......	......	......	......	......	......	......	......	......	......	......	2
3	......	18	......	6	......	3	......	2	......	7	......	......	......	......	......	......	......	......	......	......	......	......	3
4	......	42	1	33	1	36	1	3	......	10	......	......	......	......	......	......	......	......	......	......	......	......	4
5	1	17	5	45	3	54	52	29	26	4	......	1	2	......	......	......	1	......	1	......	......	......	5
6	0	4	5	15	7	41	177	66	122	6	......	6	2	1	......	1	5	......	8	3	......	......	6
7	1	3	3	4	6	19	163	114	115	15	1	21	23	16	4	8	3	1	8	11	1	1	7
8	0	2	1	5	4	7	104	75	124	36	2	13	47	18	9	16	11	4	9	13	1	8	8
9	4	3	0	7	1	0	27	29	83	25	19	28	72	25	25	12	16	16	13	23	5	2	9
10	5	6	1	5	0	0	4	12	58	37	34	85	105	18	81	18	21	27	20	16	20	7	10
11	4	6	2	7	1	0	1	2	28	11	21	104	99	45	144	13	32	32	39	42	21	10	11
12	0	10	2	8	1	2	......	0	6	7	11	51	62	59	179	31	76	16	89	41	16	10	12
13	1	1	1	3	......	......	......	1	3	1	4	21	32	65	132	44	77	31	213	50	6	2	13
14	......	1	......	4	......	......	......	1	......	2	......	9	11	40	92	22	36	21	274	48	......	2	14
15	......	......	......	1	......	......	......	2	......	2	......	1	......	14	36	12	13	8	171	27	......	1	15
16	......	......	......	......	......	......	......	1	......	1	......	2	......	2	13	1	4	6	38	4	......	......	16
17	......	......	......	......	......	......	......	......	......	......	......	1	......	1	1	......	......	......	10	......	......	......	17
18	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	......	18
Total	16	115	21	144	24	162	529	339	565	164	92	343	455	304	716	178	295	162	894	278	70	43	Total

① Grouped to nearest lower cm.
② Sample taken from bait seine catch in Yaquina Bay, July 11-12, 1949.

Areas in the bay where fishing proved to be feasible and successful had been located by the autumn of 1951 (Figure 1). Subsequently, each monthly fishing trip included tows at four or five proven locations. The general area involved in this study extended from Number 6 Light downstream to the "Dolphins," a moorage for cargo ships.

Results

The English sole caught in Yaquina Bay were from 2 to 18 cm. in total length (Table 1). Although the largest English sole caught in the

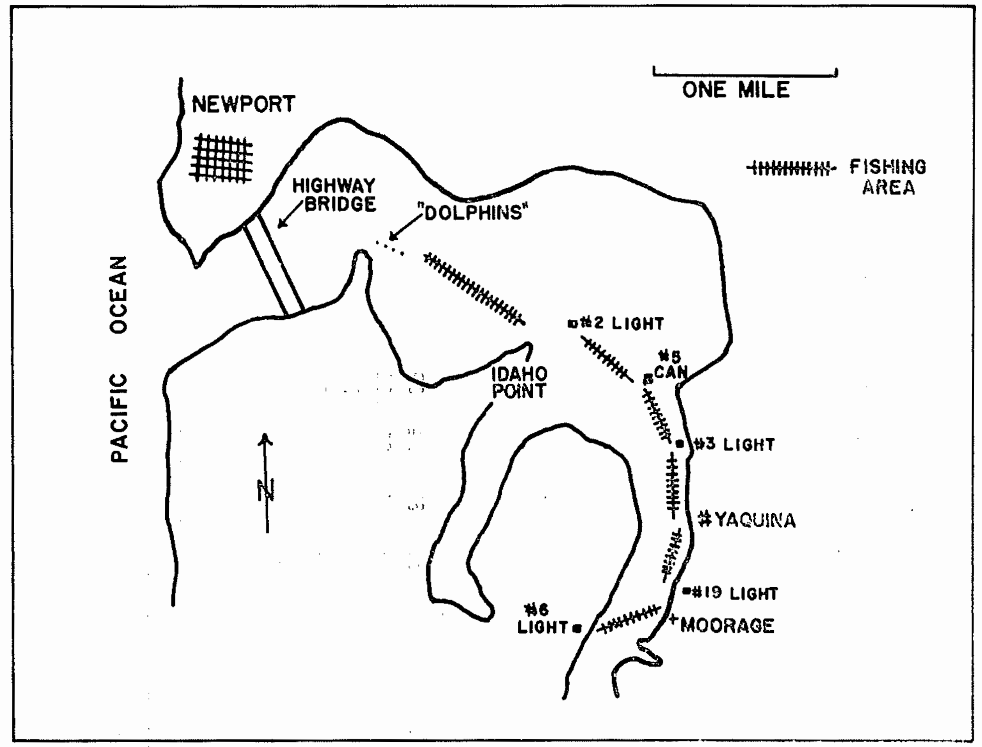

FIGURE 1. CHART OF YAQUINA BAY SHOWING LOCATION OF PRINCIPAL TRY-NET FISHING GROUNDS.

try-net was only 18 cm. long, adult sand sole and starry flounder 35 to 55 cm. long were frequently caught. The adult English sole landed for filleting in Oregon range in size from 25 to 50 cm. (unpublished data). Presumably Yaquina Bay contains only juvenile English sole which may be transported into the bay as pelagic eggs and larvae.

During July 1949 a series of bait seine catches from Yaquina Bay was examined for species composition and yielded 92 small English sole. The length-frequency distribution of these fish has been included in Table 1 for comparison with English sole caught in the try-net during 1951 and 1952. The three distributions are similar. The modes for 1949, 1951, and 1952 are located at the 10-, 11-, and 10-cm. intervals, respectively. Likewise the mean lengths are 10.7, 10.9, and 10.6 cm., respectively. The presence of juvenile English sole in Yaquina Bay appears to be no capricious event, and seasonal growth patterns of different year classes are similar.

The growth of these fish during a hypothetical year has been depicted in Figure 2 by combining all samples for alternate months, beginning with February, and converting each combined length-frequency to per cent.

The 4-cm. modal group in February is thought to represent the 0-age group, and the steady modal progression to the 14-cm. size interval in October probably represents the growth during the first year of life. The modal regression to the 11-cm. interval in December is probably due to emigration from the bay of the larger members of the year class. The 10- to 12-cm. modal group in February and the 12-cm. modal group in April probably represent the holdovers from the preceding year class. The presence of 7-cm. fish throughout the year leads one to suspect that the spawning season may be prolonged for this species.

TABLE 2. **TRY-NET CATCHES OF ENGLISH SOLE IN YAQUINA BAY: NUMBERS CAUGHT, NUMBERS OF DRAGS, AND NUMBERS CAUGHT PER DAY, BY MONTH, 1951-53**

Year	*Month*	*Numbers Caught*	*Numbers of Drags*	*Numbers Per Drag*
1951	July	343	4	86
	August	304	4	76
	September ①	203	12	17
	October	162	8	20
	November	....	No Sample	......
	December	70	6	12
1952	January	....	No Sample	......
	February	16	8	2
	March	21	10	2
	April	24	7	3
	May	658	8	82
	June	1,194	10	119
	July	2,629	8	329
	August	2,279	8	285
	September	316	6	53
	October ①	2,052	13	158
	November	278	6	46
	December	57	4	14
1953	January	....	No Sample	......
	February	115	7	16
	March	144	4	36
	April	162	5	32
	May	339	4	85
	June	164	5	33

① Two sampling days.

The size range of 14 cm. encountered in October 1952 is thought to contain only members of the 0-age group (Table 1). It is interesting to note that the size range for commercial landings of English sole in Oregon is about 25 cm., but includes more than 15 age groups (unpublished data).

Ketchen (1947) conducted similar experiments on English sole in Departure Bay (Vancouver Island) during the spring and summer of 1946. He reports that "on the average" the English sole attain a length of over

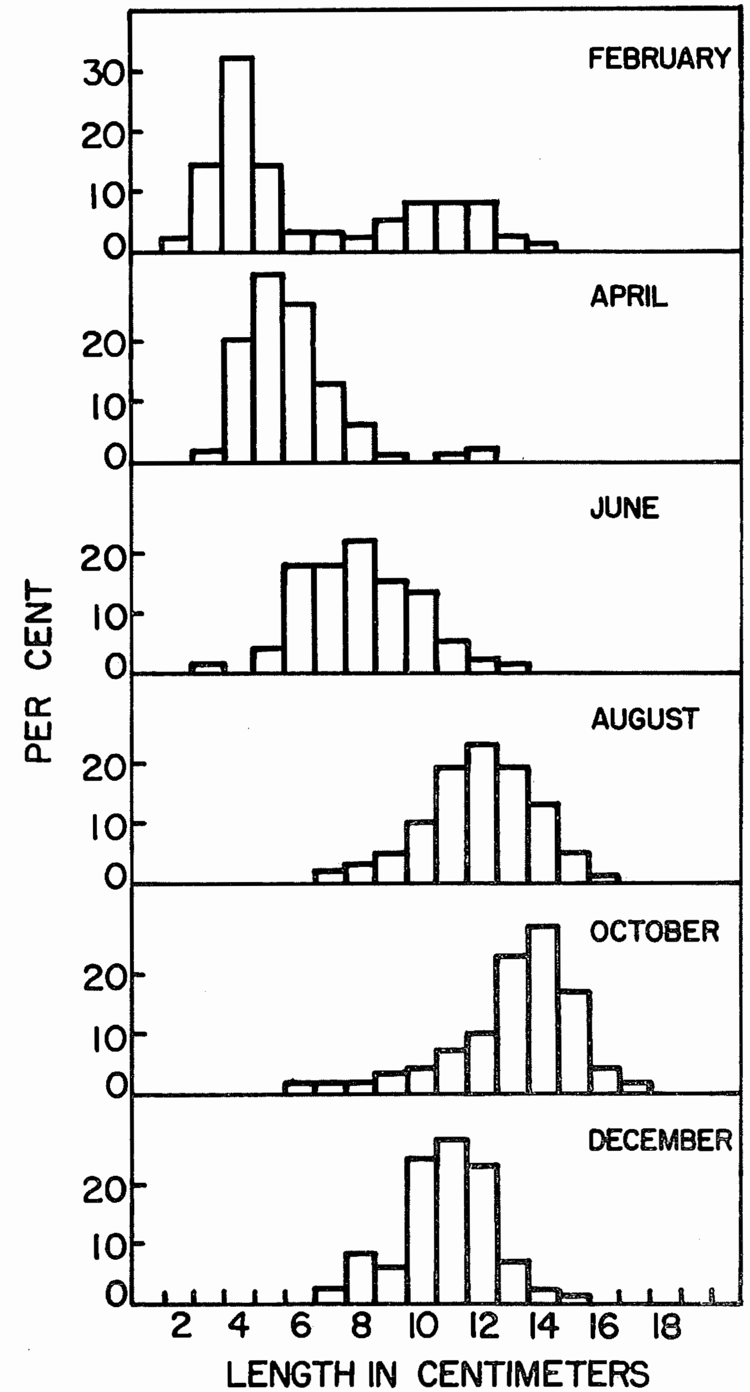

FIGURE 2. LENGTH-FREQUENCIES OF YAQUINA BAY ENGLISH SOLE FOR ALTERNATE MONTHS.

100 mm. by August of their first year. In contrast, the Yaquina Bay English sole reached a length of over 100 mm. by July, and their average length by August was 124 mm.

Although this experiment was not designed to yield a measure of the relative seasonal abundance of English sole in Yaquina Bay, it rapidly became apparent that a seasonal rise and fall in catches did occur. A portion of this variation may well be a reflection of a real change in seasonal abundance.

Table 2 presents the numbers of English sole caught, numbers of drags, and numbers caught per drag, by month, for the period July 1951 through June 1953. In July 1951 the average number of English sole caught per drag was 86. Subsequently, the catch per drag declined to a minimum of 2 in February and March 1952. Thereafter the catch per drag rose steadily to a peak of 329 in July 1952, and then declined once more to a low of 14 in December 1952. The catch per drag rose once more to a peak of 85 in May 1953. A decline to 33 per drag occurred in June 1953, which was the last sampling period.

The rise in catch per drag during the period February through July 1952 cannot be explained with the information now at hand. It is possible that intrabay migrations, immigration, or net selectivity may have caused this phenomenon.

The decline in the catch per drag following the summer maxima in 1951 and 1952 has been interpreted to indicate an emigration from the bay. The magnitude of this emigration in 1952 has been estimated to be 96 per cent of the year class present in the bay in July, i. e., the decline in numbers per drag from 329 in July to 14 in December. This estimate is based upon the assumption that the try-net catches represent a reasonable measure of the relative abundance of English sole in Yaquina Bay.

Summary

A small otter-trawl net was utilized to capture juvenile English sole in Yaquina Bay for early life history studies. Monthly fishing trips extended over the period July 1951 through June 1953.

The size range of these fish was 2 to 18 cm. No adults were caught, and presumably none were present in the bay. The juveniles may have been transported into the bay as pelagic eggs and larvae.

The monthly length-frequencies indicate a modal growth to 14 cm. during the first year of life.

Most of these fish presumably emigrate from Yaquina Bay during the late summer and autumn of their first year. However, a small portion, perhaps less than 5 per cent, remain in the bay through the winter and presumably emigrate in the late winter or early spring of their second year.

Acknowledgments

Thanks are due to Mr. Fred H. C. Taylor, of the Fisheries Research Board of Canada, who suggested the use of the try-net.

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FIFTH PROGRESS REPORT ON SALMON DIET EXPERIMENTS[1]

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Introduction

The quantity of fish hatchery food fed annually in Oregon and Washington exceeds 10 million pounds. It is estimated that about 25 million pounds will be used in these two states if the proposed dams and new hatcheries are completed. Faced with a problem of meeting this food demand, the Fish Commission of Oregon and the Oregon State Agricultural Experiment Station Seafoods Laboratory are jointly engaged in a series of studies to develop and evaluate existing and potential hatchery food. Scrap ocean fish and by-products of the fillet industry are available at low cost. These materials are excellent sources of high quality animal protein and could be good fish food. Burrows *et al* (1951) reported that tuna viscera and rockfish offal were deficient in the anti-anemia factor and were not recommended for inclusion in sockeye salmon *(Oncorhynchus nerka)* diets. They also found hake deficient in the anti-anemia factor, but reported that it had an excellent growth potential for sockeye salmon. Condemned beef liver, unsuitable for human food, is a highly desirable component of hatchery food (Karrick, 1948). However, limited supplies and increasing costs require that beef liver be used sparingly. Wood *et al* (1955) stated that a diet with only 10 per cent beef liver with certain other ingredients provided satisfactory growth for chinook salmon (*O. tshawytscha*) under cold water conditions.

The present study was designed primarily to evaluate beef liver at a 10 per cent level combined with other potential hatchery foods in feeding chinook salmon under 40-50° F. water conditions. The components selected were turbot *(Atheresthes stomias)*, hake *(Merluccius productus)*, and shad *(Alosa sapidissima)*, all in the round; rockfish *(Sebastodes sp.)* fillet scrap without livers; commercial chinook salmon meal; and a meal mixture (Table 1). Seven of the ten diets used were for the beef liver with other component evaluation. The control was an all-meat diet composed of equal parts of beef liver, hog liver, and salmon viscera, plus 2 per cent salt (McKee *et al,* 1952). In another ration similar to the control, the salmon viscera was replaced by yellowfin tuna *(Neothunnus macropterus)* viscera, without livers. The final diet was identical with the control, but with the addition of a small amount of terramycin (Bi-Con TM-5). This antibiotic provided a growth stimulus when included in poultry and swine rations at levels of 8 grams of terramycin per ton of dry feed (Pfizer, 1950).

Procedure

The hatchery is supplied with water from Marion and Horn Creeks. Marion Creek water was utilized until the temperature dropped below

[1] Technical Paper No. 936 Oregon Agricultural Experiment Station.

that of Horn Creek, at which time the Horn Creek water was used. This is the usual hatchery practice.

Ten circular ponds, each 25 feet in diameter, with a water depth of 24 inches, were used in the experiment. On June 1, 1951, approximately 60,000 fingerling spring chinook salmon were separated from the other fish at the Marion Forks Hatchery and put into the experimental ponds. These fish were the youngest of those hatched from the 1950 North Santiam River egg take and had been feeding approximately 3 weeks. Each pond was stocked with 6 pounds of fish, averaging 900 per pound, or approximately 5,400 fish.

The experimental feeding was conducted for a 22-week period from June 6 to November 7, 1951. All lots were fed 3 or 4 times daily, 6 days a week. Each lot of fish received a daily allotment of food computed on a dry weight basis and equal to a definite per cent of their body weight (McKee, Sinnhuber, and Law, 1949). The per cent food fed on a dry weight basis is shown in Figure 1 and it was changed from time to time throughout the experiment as the fish evidenced greater or lesser feeding activity.

All the food components with the exception of the meals were stored in a frozen condition. Only the amount needed for the day's ration was thawed before preparation of the diet. Diets were prepared each morning and any food unfed at the end of the day was weighed and discarded. Afternoon was found to be the best time to feed; warmer water at this time made the fish more receptive to food. Because of the variable consistency of the foods, a hand-type potato ricer was used on some diets and a spoon on others to present the food to the fish.

A sample of 10 per cent of the fish from each lot was weighed at 2-week intervals by the procedure of Wood *et al* (1955). This information was used to calculate the lot gains and the food to be fed during the succeeding periods.

Gill color checks to determine the possible existence of anemia were made as described by McKee, Sinnhuber, and Law (1951). The Tallquist hemoglobin method was also used to supplement the gill color checks.

Results

The component percentages by weight of each of the ten diets, the observational results obtained, and the total per cent gain for the lots which completed the experiment are shown in Table 1.

The biweekly weight gain and total per cent mortality for the individual lots as well as the weekly mean water temperatures are shown in Figure 1.

Conclusions

The fish on Diets 4 through 10 exhibited evidences of anemia despite the presence of 10 per cent beef liver.

The all-meat control diet proved very successful at Marion Forks Hatchery. However, it is not a practical hatchery ration because of its high liver content.

Yellowfin tuna viscera without livers, when substituted in the control diet for salmon viscera, did not produce as much growth, although the mortalities were low and the fish appeared to be in good condition. Improved methods of binding this diet are needed.

TABLE 1. **DESCRIPTION OF DIETS AND OBSERVATIONAL RESULTS**

Lot Number	*Diet*	*Total Per Cent Gain*	*Observations*
1	Control: Equal parts beef liver, hog liver, and salmon viscera plus 2% salt	1,510	Best growth of any lot. Fish in excellent condition. Mortality low. A superior diet.
2	Equal parts beef liver, hog liver, and tuna viscera plus 2% salt	889	Growth fair. Fish in good condition. Mortality low. Diet poorly bound.
3	Equal parts beef liver, hog liver, salmon viscera plus 2% salt and Bi-Con TM-5①.	1,464	Growth very good. Fish in excellent condition. Lowest mortality. A superior diet.
4	Beef liver 10%, salmon viscera 44%, rockfish fillet scrap 44%, salt 2%	....	Growth good for 12 weeks, then a sudden increase in mortalities forced discontinuation of the diet after 14 weeks. Anemia.
5	Beef liver 10%, salmon viscera 44%, turbot 44%, salt 2%	....	Growth good for 16 weeks, then a sudden increase in mortalities forced discontinuation of the diet after 18 weeks. Anemia.
6	Beef liver 10%, salmon viscera 34%, rockfish fillet scrap 44%, shad 10%, salt 2%	....	Growth good for 10 weeks, then a sudden increase in mortalities forced discontinuation of the diet after 12 weeks. Anemia. Possible vitamin B_1 deficiency symptoms.
7	Beef liver 10%, salmon viscera 34%, turbot 34%, meal mixture② 20%, salt 2%	....	Growth good for 14 weeks, then an increase in mortalities forced discontinuation of the diet after 18 weeks. Fish generally in poor condition. Anemia.
8	Beef liver 10%, salmon viscera 39%, turbot 39%, meal mixture② 10%, salt 2%	866	Growth good for 12 weeks. Constant above average mortality, but fish survived to end of experiment. Anemia.
9	Beef liver 10%, salmon viscera 39%, turbot 39%, salmon meal 10%, salt 2%	1,275	Growth good for 20 weeks, then mortalities increased. Some anemia.
10	Beef liver 10%, salmon viscera 44%, hake 44%, salt 2%	732	Growth poor. Mortality fairly high. Diet difficult to bind and present to the fish. Some anemia.

① Bi-Con TM-5: One gram per 1,000 grams of food, equivalent to 11 milligrams of terramycin.
② Meal mixture: Salmon meal 55%, crab meal 10%, wheat germ 5%, alfalfa meal 10%, tomato pulp 10%, Argentine beef liver meal 10%.

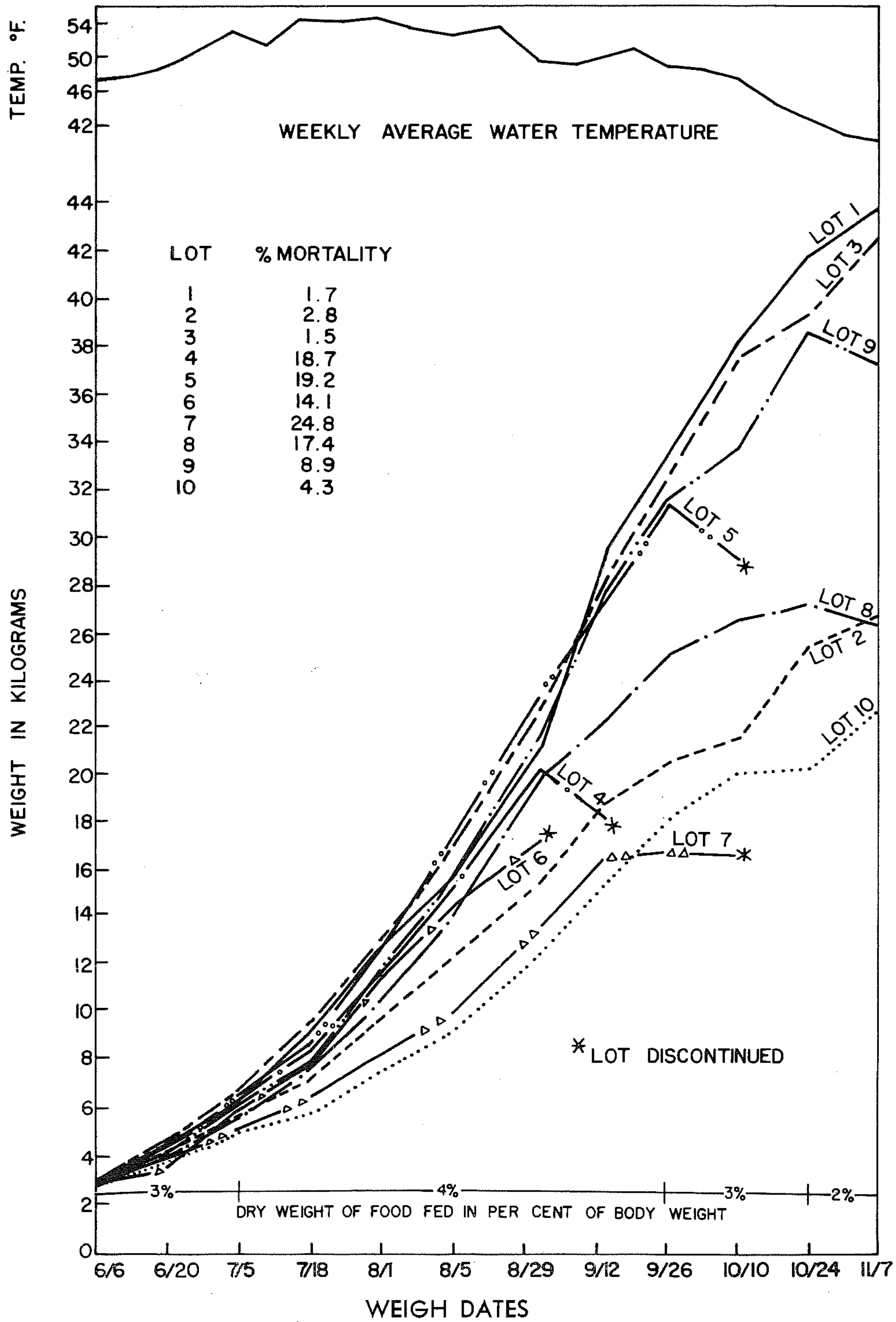

FIGURE 1. WEIGHT GAINS, PER CENT MORTALITY, AND WEEKLY AVERAGE WATER TEMPERATURE.

The addition of trace amounts of terramycin to the control diet appeared to be of no measurable benefit. It is unfortunate that terramycin was not used in some of the poorer diets.

Rockfish fillet scrap without livers provided only moderate growth. The fish showed symptoms of anemia.

Turbot in the round provided better growth than rockfish, but as in other diets the fish exhibited symptoms of anemia.

Shad, when added to a diet containing rockfish scrap and other components, resulted in cessation of growth in 10 weeks and high mortalities. The presence of thiaminase is suggested.

Commercial salmon meal, when added to a diet containing turbot, improved growth. Salmon meal as a diet component was superior to the meal mixture used in Diets 7 and 8.

The fish on Diet 10, which included hake, showed good appetite but poor growth. Improved methods of binding this diet are needed, as much of the food was unavailable to the fish.

Further experimentation with turbot, hake, salmon meal, rockfish, and tuna viscera is desirable since these components showed promise. The problem of anemia and the means of preventing this condition remain to be solved in diets with a reduced liver percentage.

Acknowledgments

We are indebted to Charles Pfizer Company, Inc., Brooklyn, New York, for the Bi-Con TM-5 feed supplement used in this experiment and to the Columbia River Packers Association, Astoria, Oregon, for the supply of salmon and tuna viscera.

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A SURVEY OF THE BULL KELP RESOURCES OF THE OREGON COAST IN 1954

KENNETH D. WALDRON ①

During 1954 a survey of existing kelp beds in Oregon's coastal waters was undertaken to determine the location, acreage, concentration, and harvestability of the larger kelp beds.

Kelp is a general name applied to some of the brown algae *(Phaeophyta)*. Common kelps along the west coast of North America are the giant kelp of California *(Macrocystis pyrifera)* and the bull kelp *(Nereocystis luetkeana)*. The latter was the object of this survey. Previous surveys of kelp resources of the West Coast (Cameron *et al.*, 1912) did not include measurements of kelp areas along the Oregon coast.

Measurement of kelp areas along other portions of the Pacific Coast have been made by means of boat surveys combined with observations from shore where the topography and location of the kelp beds permitted. Aerial photography was utilized successfully by Chapman (1944) for a survey of kelp which did not float at the surface. Because *Nereocystis* has fronds and a stipe which float at the surface, it was felt that this method of estimating area would be satisfactory.

Examination of existing aerial photographs of the Oregon coastline, borrowed from various agencies (see acknowledgments), combined with an inspection of pertinent areas from vantage points ashore, bore out the hypothesis that beds of *Nereocystis* could be identified from aerial photographs. Kelp beds appear as dark areas (Figure 1) on photographs of suitable quality, and the area of each bed can be measured with a polar planimeter. Excessive reflection, rough water, and cloud shadows are a few of the conditions which complicate interpretation of aerial photographs of kelp beds. In general, photographs taken near noon are apt to contain undesirable reflections. Because reefs also appear as shadow areas on aerial photographs, the shoreline inspections were included. Photographs at scales up to 1:20,000 were utilized in the preliminary survey, but the majority were at a scale of 1:12,000. The latter scale is desirable because the kelp beds are more easily detected and the accuracy of measurements is greater.

Examination of these aerial photographs indicated possible kelp beds off the coasts of Clatsop and Tillamook Counties, but observations from shore failed to verify their presence. Areas off Lincoln, Coos, and Curry Counties proved to have kelp beds. No kelp beds were detected in the waters off Lane and Douglas Counties, either by examination of aerial photographs or by shoreline surveys.

On the basis of this preliminary work, an aerial survey was planned to cover the areas in Lincoln, Coos, and Curry Counties which had been found to contain kelp beds. A scale of 1:12,000 was chosen for this survey. Since this kelp grows quite rapidly during the summer months, it was desirable to have the photography done relatively late in the summer, yet early enough to avoid an autumn storm which could cause the disintegration of some of the beds.

① Formerly Aquatic Biologist with the Oregon Fish Commission; now with Pacific Oceanic Fisheries Investigation of the U. S. Fish and Wildlife Service.

FIGURE 1. AERIAL PHOTOGRAPH OF DEPOE BAY SHOWING KELP BEDS AS SHADOW AREAS.

The photographs were taken on September 4 and 5, 1954, an optimum time with respect to the above two factors. The kelp beds shown on these photographs were verified through observations from shore where possible, and from a boat in the case of the offshore beds.

At the time of observation, estimates were made of the concentration or density of kelp in each bed or area. The following criteria were used in classifying the concentration of the various beds. (1) Thin: scattered plants throughout the area, no visible mats; (2) Moderate: scattered plants and small mats of entangled fronds and stipes throughout the area; and (3) Dense: plants forming large mats of vegetation with few single plants in the area.

Reports by residents of coastal areas indicate that the density and extent of kelp beds may vary noticeably from year to year. For example, it was reported that kelp on the Orford and Blanco Reefs was much more dense and covered a larger area prior to the winter storms of 1952. These storms destroyed much of the beds which had not regained their former size or density by 1954. Similar reports were received concerning the Crook Point beds.

Growth of the kelp is amazingly rapid during the summer months. Beds marked by only a scattering of plants in June appear as almost solid mats of stipes and fronds in September. The optimum harvesting period would seem to occur during August and early September when the ocean is generally calm. This period coincides somewhat with the time at which the plants attain their greatest growth and would permit maximum yield per plant.

The harvestability of each bed during August and September was estimated and classified as follows: (1) Unknown: harvestability not known, associated with an unconfirmed area; (2) Unharvestable: kelp cannot be harvested owing to shallow or turbulent water; or (3) Harvestable: large portion of the kelp may be harvested.

The most abundant species in all areas examined was *N. luetkeana*. Many beds, especially those in shallow water, contained some *Egregia* sp., another species of brown algae. *M. pyrifera* and *M. integrifolia* were not observed in any of the areas surveyed.

In general, the kelp beds were found within 1 mile of shore in water less than 60 feet deep, and situated so that they were protected from the prevailing winds. Very little kelp was seen on the seaward side of reefs or along exposed portions of headlands. The beds most distant from shore were those on the Orford Reef where the outer limit was about 4 nautical miles from shore. However, the water depth at this point was only 60 feet.

The results of this survey are included in Table 1. The total acreage of all kelp beds for the three counties was 3,704 acres (see Figure 2 for location). Of this total, 2,037 acres (55 per cent) were classified as of moderate or dense concentration, but only 1,766 acres (48 per cent of total) were classified as of both moderate or dense concentration and harvestable.

Lincoln County's offshore waters contained 625 acres of kelp beds of which 520 (83 per cent) were considered of moderate to dense concentration. There were 396 acres (63 per cent of total) classified as of both moderate or dense concentration and harvestable. The largest single bed, comprising 344 acres, was located between Whale Cove and Boiler Bay.

The waters off Coos County contained 370 acres of which 369 were of moderate to dense concentration, and 357 acres (96 per cent of total) were considered moderate to dense and harvestable. The largest single bed (358 acres) was between Coos Bay and Cape Arago.

Curry County's kelp beds totalled 2,709 acres of which 1,148 acres (42 per cent) were considered to be of moderate or dense concentration. The area classified as of moderate to dense concentration and harvestable amounted to 1,013 acres (37 per cent of total). The largest single bed (791 acres) was located on the Orford Reef.

Acknowledgments

Appreciation is extended to Dr. James E. McCauley and Lowell D. Marriage of the Fish Commission of Oregon, and Mr. John O'Hara of Port Orford, for assistance in collecting data for this report. Many residents of coastal areas of Oregon were helpful in providing information with

TABLE 1. **LOCATION, ACREAGE, CONCENTRATION, AND HARVESTABILITY OF KELP BEDS OFF THE OREGON COAST, BY COUNTY, 1954**

AREA	CONCENTRATION (Acres)					HARVESTABILITY (Acres)		
	Not Confirmed	*Thin*	*Moderate*	*Dense*	*Total*	*Unknown*	*Unharvestable*	*Harvestable*
Lincoln County								
Delake	18				18	18		
Boiler Bay-Whale Cove		57	222	65	344			344
Rocky Creek		14			14		14	
Cape Foulweather-Otter Crest		9	36	32	77		77	
Otter Rock		6	8	30	44		44	
Gull Rock			3	6	9		9	
Yaquina Head			5		5		5	
Yaquina Bay State Park			100	9	109			109
Seal Rocks		1	4		5		5	
Total	18	87	378	142	625	18	154	453
Coos County								
Coos Bay-Cape Arago		1	107	250	358			358
Fivemile Point			12		12		12	
Total		1	119	250	370	0	12	358
Curry County								
Blanco Reef		30	130	63	223			223
Orford Reef				791	791			791
Port Orford-Humbug Mountain		167	23	11	201		201	
Sisters Rocks		14	1	4	19		19	
Rogue River Reef	61				61	61		
Hunter Island		3			3		3	
Crook Point		152	7	22	181			181
Yellow Rock	87				87	87		
Burnt Point-Thomas Point	77				77	77		
Whales Head	24				24	24		
House Rock		16			16		16	
Cape Ferello	124				124	124		
Twin Rocks-Goat Island	117	87			204		204	
Brookings		200	8		208		208	
Chetco River-Red Point		300			300		300	
Winchuck River		102	88		190		190	
Total	490	1,071	257	891	2,709	373	1,141	1,195
Total for Lincoln, Coos, and Curry Counties	508	1,159	754	1,283	3,704	391	1,307	2,006

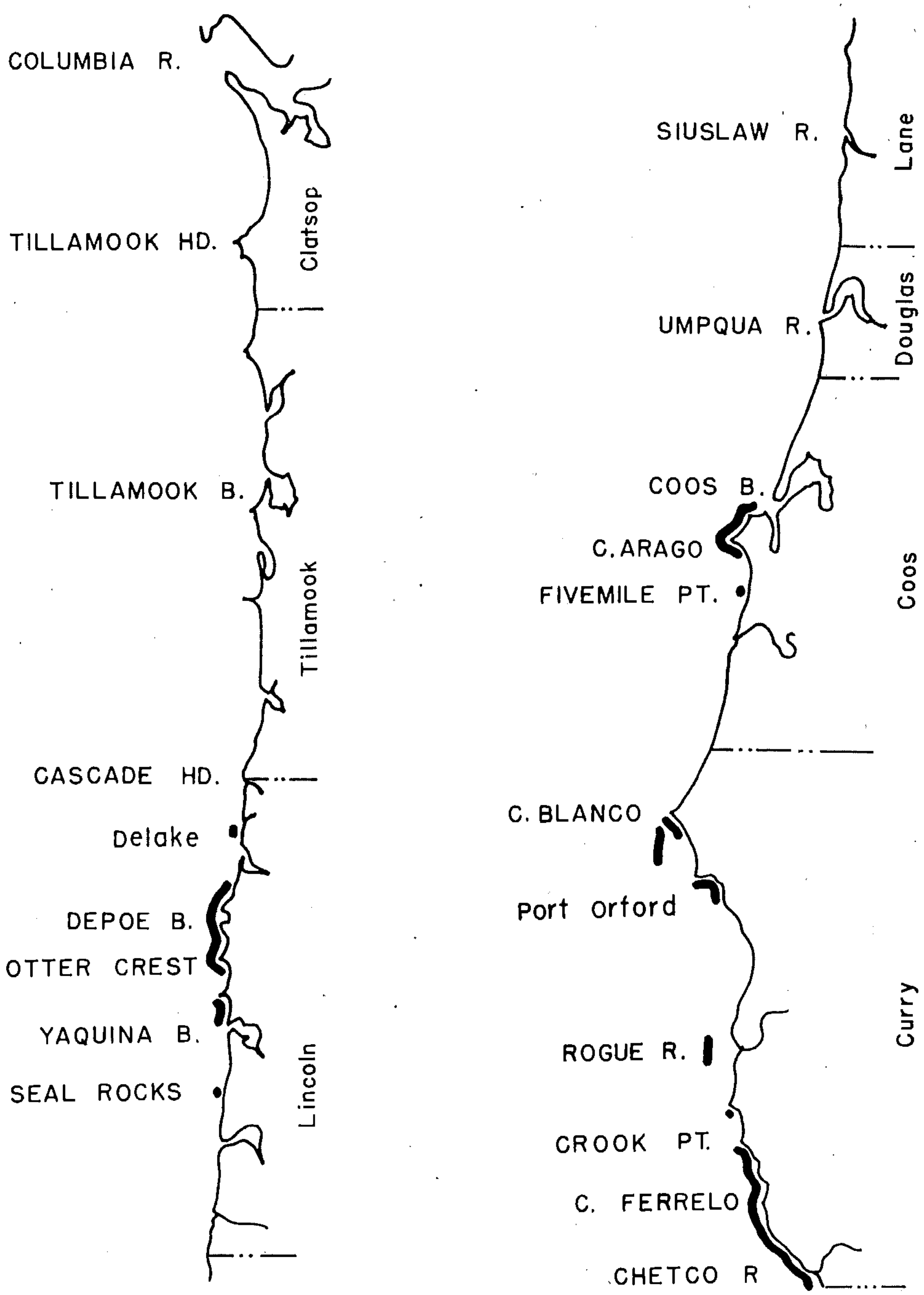

FIGURE 2. OREGON COASTLINE SHOWING LOCATION OF PRINCIPAL KELP BEDS (BLACK AREAS).

respect to location of kelp beds. Special thanks are due the various agencies and individuals from whom aerial photographs were borrowed for the preliminary survey. These were Coos County Assessor, Curry County Assessor, Lincoln County Agricultural Agent, Oregon State Highway Department, Oregon State Tax Commission, Tillamook County Assessor, United States Forest Service (Waldport, Oregon), and United States Soil Conservation Service (Florence, Oregon).

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PINK SALMON CAUGHT IN NECANICUM RIVER

A pink salmon (*Oncorhynchus gorbuscha*) was taken on sport tackle in the Necanicum River 7 miles above the mouth on August 13, 1955. The fish, a 24-inch male, was nearly ripe when caught. Pink salmon seldom spawn in Oregon streams. They commonly appear in the commercial troll fishery off Oregon and Washington in the years of the Puget Sound run however, and a few are usually found in the commercial fishery of the coastal streams during these seasons. This is the first known record of one being taken in the Necanicum River.

Robert J. Ayers

CARP TAKEN WITH BOW AND ARROW

One of the few carp tagged in the Columbia River at McGowan trap near Astoria was recently recovered by rather unusual gear. The 18-inch fish, tagged May 27, 1953, was recovered April 11, 1954 by Garry Lowe of Astoria, who used a bow and arrow to capture it. It was taken in Youngs River, across the Columbia from Astoria.

Lesley Belt

ESCAPEMENT OF SPRING CHINOOK SALMON AND STEELHEAD OVER WILLAMETTE FALLS IN 1954

EARL F. PULFORD

Introduction

A counting station has been operated at Willamette Falls on the Willamette River each spring since 1946 to enumerate the runs of spring chinook salmon *(Oncorhynchus tshawytscha)* and steelhead trout *(Salmo gairdnerii)* which pass through the fishway at this obstruction.

This report deals with the results obtained from the 1954 enumeration.

Methods

The same procedure was used in operating the counting station during 1954 as had been used in previous years of study (Pulford, 1955). The daily counting period of 13 hours extended from 7:00 a. m. to 8:00 p. m., and was divided into two shifts. The counting periods were further divided into 25-minute units commencing on the hour and half-hour, followed by 5-minute rest periods during which the counters recorded data and rested their eyes. Corrections for these 5-minute periods were made by assuming the same rate of fish passage as observed during the previous 25 minutes of counting.

Salmon continue to move through the fishway after the daily counting period ends. Since it is not feasible to man the counting station continuously during the hours of darkness, a correction must be made for estimating migration at night. During previous years' studies of salmon migration at Willamette Falls, it was found that the best correlation existed between the 12:00 m.-8:00 p. m. count and the night movement following this period. It appears that the bulk of the night migrants counted are salmon that enter the ladder during the late afternoon and evening, and that relatively few enter during the hours of darkness.

During 1954 two 24-hour counts were obtained. These counts were made on May 11-12 and 12-13. The night migration factor is based upon 24-hour counts made during the years 1947-49, 1951, and 1953-54. This factor changes slightly from year to year as more 24-hour counts are made and their results averaged with the preceding data. The night migration factor calculated in 1954 was 31.6 per cent, i. e., total night migration was considered to be 31.6 per cent of the total noon to 8:00 p. m. count. This compares with the factor of 31.1 per cent calculated in 1953.

Discussion of 1954 Escapement

Nineteen hundred and fifty-four was an unusual year in that counting was uninterrupted by high river flows during the entire period of spring chinook migration. A count was made every day from April 19 when counting was initiated until June 17 when it was discontinued due to the threat of high water. Thus the only estimations made were for fish migrating at night and for the few fish that used the fishway after June 17. This latter estimate of 400 fish was based upon observation from the shore on June 18 and occasional visits to the ladder throughout the remainder of the month.

The counts during the first week of counting were dominated by steelhead, but subsequently spring chinook salmon formed the bulk of the counts. Most of the chinook moved through during a relatively short period extending from about April 28 until May 13 (Figure 1).

On about May 20, flashboards were placed on the crest of the dam at Willamette Falls, as is done each year when river flows drop to a low level. This resulted in the almost complete diversion of flow through the industrial plants in the area, and very little attraction water available to lead the fish up to the fishway. As a result, thousands of fish were attracted to the discharge from these industrial plants and were delayed in blind channels from which they had difficulty in finding their way upstream. The situation became so serious that the operators of the plants were contacted by representatives of the Fish Commission. The operators agreed to a temporary closure of 2½ hours, and on May 26 all industrial plants at Willamette Falls ceased water usage at 5:30 a. m. This resulted in water flowing over the crest of the falls and cessation of flow from the blind channels so that the fish were attracted to the base of the fishway. At 8:00 a. m. the mills resumed water usage, but even this short 2½-hour period proved to be highly successful in reducing concentrations of fish below the plants. Its success is evident by the fishway count of approximately 5,000 adult chinook salmon on that day (Figure 1).

In past years a belated group of fish generally has passed over the falls on July 4 when the mills closed down for one day. Such was not the case in 1954 when observations on July 4 failed to reveal any use of the ladder by migrating fish. It is believed that the short cessation of water usage

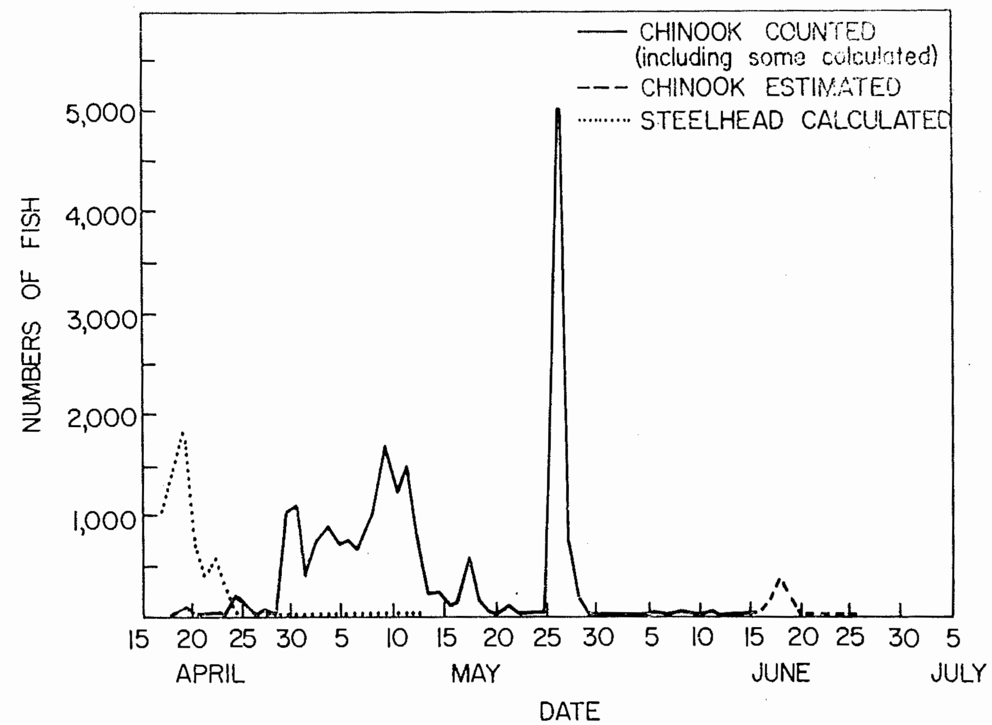

FIGURE 1. DAILY MIGRATION OF CHINOOK SALMON AND STEELHEAD OVER WILLAMETTE FALLS IN 1954.

by the industrial mills on May 26 enabled the salmon to resume upstream migration at an earlier and more favorable date than the 4th of July.

Results

The 1954 spring chinook salmon escapement over Willamette Falls was calculated to be 29,300 adults (salmon over 20 inches in length) and 1,800 jacks (salmon under 20 inches in length). The number of salmon recorded by the counters totaled 18,709 adults and 1,157 jacks. Corrections for the 5-minute rest periods increased these totals to 22,447 adults and 1,388 jacks. The remainder of the migration was composed of the calculated night migration plus 400 salmon estimated to have used the ladder after counting was discontinued.

During the first portion of the counting season steelhead were migrating in significant numbers. The counters recorded 4,322 steelhead, which, after the rest period corrections were made, totaled 5,197 fish. This figure is considerably higher than the 1953 figure of 1,216 steelhead, and is the greatest number of steelhead recorded through the fishways during any season since 1946 when counting began. No calculations have been made for the night passage of steelhead during the time that this species was ascending the ladder.

The season of 1954 is the fourth time that a comparison can be made between the parent and progeny runs on a 5-year cycle basis. The 1954 comparison indicates an increase over the parent run for the third consecutive year. The 1949 escapement amounted to 27,000 fish compared to the 1954 escapement of 31,100. This is an increase of 15 per cent over the parent run as indicated by fishway counts. Comparison of the total estimated Willamette runs including the sport catch and the Clackamas River escapement (unpublished data) of 1949 and 1954, indicates an increase of 17 per cent.

A further comparison may be made by relating the escapement over Willamette Falls with the progeny run to the river. This comparison is of particular value because the sport catch fluctuates widely from year to year, and drastically affects escapement. For the period 1946 through 1954 the sport catch has varied between 17 and 35 per cent of the total Willamette run.

Thus the escapement-progeny run ratio better indicates the amount of production actually realized from the stream. For every salmon escaping over Willamette Falls in 1949, 1.6 returned to the river in 1954. For the three immediately preceding cycles (1946-1951, 1947-1952, and 1948-1953) the values were 0.9, 1.4, and 3.2, respectively.

Summary

1. The 1954 Willamette Falls fishway escapement of spring chinook salmon was estimated to be approximately 31,100 including 29,300 adults and 1,800 jacks.
2. For the third consecutive year the spring chinook salmon progeny escapement surpassed the parent escapement, based on a 5-year cycle.
3. The bulk of the salmon migration occurred from April 28 to May 13.
4. The sharp increase in migration that occurred on May 26 was due to the closure of the industrial plants at Willamette Falls for a few hours in order to eliminate false flow attractions created by these plants.

5. A correction factor of 31.6 per cent of the preceding afternoon's counts was used to calculate the night migration.

6. The largest steelhead count in 9 years of counting was made in 1954, amounting to 5,197 fish after inclusion of the rest period correction factor.

Acknowledgments

Thanks are due the operators of the following industrial plants at Willamette Falls who cooperated in the highly successful effort to reduce the concentration of fish below the plants on May 26, 1954: Crown Zellerbach Corporation, Publishers Paper Company, and Portland General Electric Company. Thanks are also due to Mr. Marion G. Christenson for his cooperation in providing boat transportation for the fish counters. The fish counters were Jack C. Joyner and Lee T. Critchlow.

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LAMPREYS AND SALMON

Although the Pacific lamprey (*Entosphenus tridentatus*) is generally thought to be a salmon predator and scars believed to be attributable to it are relatively common, actual observations of its predation are extremely rare.

On June 29, 1954 the troller "Veni", while trolling on the Rockpile off Newport, Oregon, landed a 12-pound chinook salmon to which a small Pacific lamprey was attached. The lamprey measured 141 mm. (5½ inches) and was attached just posterior to the pectoral fin, but left no visible scar when removed.

Lampreys are not believed to be of any consequence as food for salmon, but during the course of a routine stomach examination of troll-caught chinook salmon off the mouth of the Columbia River on May 19, 1954, a 26-inch salmon was found to contain a 6-inch lamprey which was still alive when the salmon was examined. Of the 18 other chinook caught that day, 13 had empty stomachs and 5 contained only from 1 to 3 anchovies or smelt. The large percentage of empty stomachs suggests that desirable food was scarce at this particular time and place. This is the first occurrence of a lamprey in several hundred salmon stomachs examined during the past 7 years.

Jack M. Van Hyning

RIVER RECOVERIES OF MARKED SILVER SALMON OF THE 1949 BROOD RELEASED FROM THE NEHALEM RIVER HATCHERY

KENNETH A. HENRY

Introduction

This particular marking experiment is part of a coast-wide endeavor wherein large numbers of small salmon are marked and released in order to obtain information on such important problems as the contribution of the runs of an individual river to the ocean troll catch, migration of the salmon in the ocean, and the percentage of salmon caught by the different fisheries (i. e., ocean troll, sport, and river gill-net).

This report discusses only the river returns and recoveries of marked fish in an experiment on the Nehalem River in Oregon. The Nehalem River flows into the Pacific Ocean about 40 miles south of the mouth of the Columbia River. Data gathered from the river recoveries of these marked fish have provided valuable information such as fishing intensity and population estimates, but the picture will not be complete until the results from the river and ocean recoveries are combined.

The fish utilized in this marking experiment were silver salmon *(Oncorhynchus kisutch)* of the 1949 brood which were spawned and reared at the Oregon Fish Commission hatchery on Foley Creek, a tributary which enters the Nehalem River about 11 miles above its mouth.

Marking and Liberation

The dorsal and left ventral fins were removed from each fish by means of bone forceps. The fish were marked as yearlings during the period February 13 to 23, 1951. On March 13, 1951, a total of 104,194 was liberated at the hatchery 3 miles above the mouth of Foley Creek.

The fish were in fair condition at the time of marking and averaged 39 fish per pound and were about 4 inches in length. Many of the fish became infected with fungus subsequent to marking. None of the mark wounds examined, even those without fungus, showed any indication of healing over by the time of release.

Recovery of Marked Fish at the Hatchery and On the Spawning Grounds

All fish taken at the hatchery were examined for marks by the hatchery superintendent. Twelve marked two-year-old jacks (fish which mature in two years) were observed at the hatchery during the 1951-52 run, but no effort was made to recover jacks spawning in Foley Creek below the racks which were located at the hatchery. During the 1952-53 run, 88 of the marked adult fish were observed at the hatchery. The area between the mouth of Foley Creek and the racks was intensively surveyed at approximately weekly intervals during the 1952-53 run in an attempt to determine whether any of the marked adult fish stayed below the racks to spawn. These surveys indicated that there were very few silver salmon spawning in this area. Whenever possible any silvers observed were captured, tagged with a Petersen tag, and released. It was hoped that by this method enough fish could be tagged and subsequently recovered to form a basis for estimating the number of marked fish present. However, because of the shortage of silver salmon and the swiftness of the water, great difficulty was experienced in catching fish, and only 17 were tagged, 14 of which were caught in a small tributary created by the overflow from the hatchery ponds. Furthermore, only 7 dead adults were recovered, 2 of which had been tagged. In view of these small numbers it seemed impractical to attempt to calculate the number of marked fish present; instead, the 8 marked fish actually recovered below the racks were assumed to be the total number in this area. No attempt was made to determine whether any of the marked fish strayed to nearby streams to spawn.

Recovery of Marked Fish in the Fisheries

The commercial landings on the Nehalem River were periodically sampled, and on the basis of these samples, the total number of marked fish caught by the commercial fishery was calculated. This estimate was made by using the equation $x = \frac{sC}{n}$ where n = the number of fish sampled, s = the number of marked fish in the sample, C = the number of fish in the catch, and x = the number of marks in the catch.

Inasmuch as the commercial landings are reported in pounds, average weight data were obtained to convert to numbers of fish by two-week periods (Table 1). It should be realized that the use of average weights introduces a possible source of error into all future calculations based on numbers of fish in the catch.

TABLE 1. **SUMMARY OF NEHALEM RIVER SILVER SALMON COMMERCIAL CATCH SAMPLING IN 1952**

Two-Week Period Ending	*Number Caught*	*Number Sampled*	*Marks in Sample*	*Marks in Catch (Calculated)*	*95 Per Cent Confidence Limits*
September 13	1,116	1,116	3	3	1– 9
September 27	5,237	5,233	12	12	6–21
October 11	9,626	6,506	13	19	10–33
October 25	4,215	2,266	2	4	0–13
November 15	2,874	1,613	3	5	2–16
November 29	500	477	3	3	1– 9
Entire Season	23,568	17,211	36	46 ①	36–65
				49 ②	36–68

① Calculated by two-week periods.
② Calculated by single combined sample.

The commercial fishery for silver salmon on the Nehalem River operates under a quota system, i. e., after a predetermined poundage of silvers is caught, the fishery is stopped. Thus, in 1952 the commercial fishery operated from September 1 to October 14, when the quota was reached. However, there was an additional season from November 1 to November 20 to permit the harvest of chum salmon *(O. keta)*, although some silvers were also caught. In this analysis the silver salmon catch during these two periods was combined.

Assuming the numbers of marked fish were from a Poisson frequency distribution, limits on the total number of marks in the catch can be determined with a desired degree of confidence (Ricker, 1937, p. 354). A total of 36 marked fish was observed in samples of the Nehalem River commercial fishery. With 95 per cent confidence the total number of marks in the sampled catch should be between 25 and 50, or a ratio of 1 marked fish for every 344 and 688 unmarked fish, respectively. Using these upper and lower limits and extrapolating from the sample ($n = 17{,}211$) to the entire catch ($C = 23{,}568$), the number of marks (x) in the entire catch would be:

$$x = \frac{(23{,}568)\ (25)}{(17{,}211)} = 34 \qquad x = \frac{(23{,}568)\ (50)}{(17{,}211)} = 68$$

Since 36 marked fish were actually observed in the samples, this is a more realistic lower limit than 34.

The commercial catch in Tillamook Bay, which is located about 7 miles south of the Nehalem River mouth, was also sampled. The fishing season on Tillamook Bay extended continuously from August 15 to December 10. Average weight data were used to convert pounds to numbers of fish caught.

Twelve Nehalem River marked fish were observed in samples of the Tillamook Bay fishery. Within the 95 per cent confidence limits the total number of marks in the sampled catch should be between 6 and 21. Using these upper and lower limits and extrapolating from the sample ($n = 10{,}222$) to the entire catch ($C = 18{,}107$), the number of marks (x) in the entire catch would be:

$$x = \frac{(18{,}107)\ (6)}{(10{,}222)} = 11 \qquad x = \frac{(18{,}107)\ (21)}{(10{,}222)} = 37$$

The 12 marked fish actually observed is a more appropriate lower limit.

By applying the ratios of marked to unmarked fish estimated in the Nehalem River commercial fishery to the calculated sport catch based on the 95 per cent confidence limits, it was determined that limits for the number of marked fish caught by the sport fishermen should be 2 and 4. Three sport caught marked fish were actually observed, so 3 is a more appropriate lower limit.

Finally, 3 of these marked fish were recovered in other river systems in addition to those caught in Tillamook Bay. One was reportedly caught in the Columbia River by a commercial fisherman, another in the Columbia River by a sport fisherman, and a third in Grays Harbor, Washington, by a sport fisherman.

Figure 1 depicts the time of appearance of these marked fish in the commercial fisheries and at the hatchery. However, the hatchery figures for time of appearance are not precise inasmuch as some of the fish were held several days before being examined for marks.

The first marked fish in the Nehalem River commercial fishery was taken the first week of the season in early September, and the peak catch of marked fish occurred at about the time of the closure—October 14.

The first known capture of marked fish in the Tillamook Bay commercial fishery occurred during the week ending September 27, and most of the captures occurred during the time the fishery was closed on the Nehalem River—between October 14 and November 1.

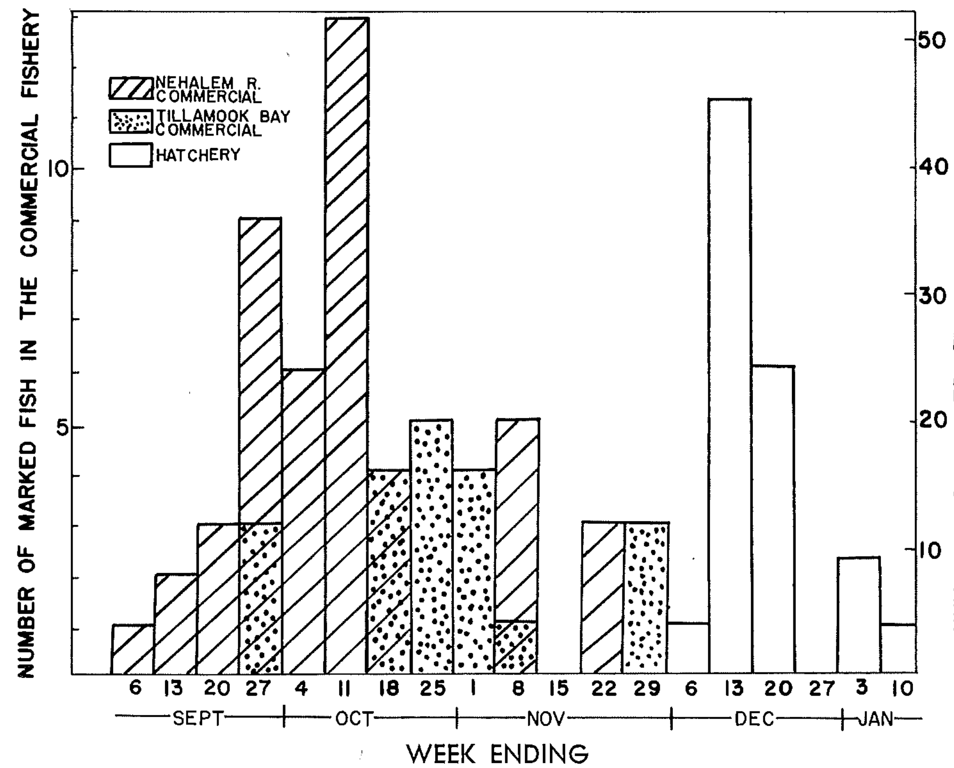

FIGURE 1. NUMBER OF 1949 BROOD NEHALEM RIVER MARKED SILVER SALMON TAKEN IN THE COMMERCIAL FISHERY (CALCULATED) AND AT THE HATCHERY (ACTUAL) IN 1952 AND 1953.

The first marked fish appeared at the hatchery racks on December 3. Apparently the peak of migration at the hatchery occurred during the following week, although some of these fish were undoubtedly held over for ripening from the previous week.

Sex Ratio, Length, and Weight Data

Whenever possible, the sex, fork length, and round weight of the marked fish were also obtained. Of the 12 marked fish caught by the commercial fishery on Tillamook Bay, 7 were males and 5 were females. Of 35 marked fish caught by the commercial fishery on the Nehalem River, 21 were males and 14 were females. Of the 88 marked fish examined by the superintendent at the hatchery, 43 were males and 45 were females. There were 71 males and 64 females from the hatchery and fisheries combined. It should be noted that 40 per cent of the marked fish caught in the commercial fishery were females while 51 per cent of the marked fish reaching the hatchery were females.

Lengths were measured to the nearest one-half inch. Twenty-seven marked males averaged 27.6 inches in length with a range of from 24.0 to 31.5 inches, and 19 marked females also averaged 27.6 inches in length with a range of from 25.0 to 31.0 inches.

Weights were measured to the nearest one-half pound. Twenty-one marked males averaged 9.2 pounds while 19 marked females averaged 9.1 pounds. This compares with an average weight of 10.1 pounds in a sample of 15,384 silver salmon in the commercial catch.

All the above lengths and weights were obtained from fish caught in the commercial fisheries. No length or weight data were obtained for the 12 marked jacks which were observed during the 1951-1952 season at the hatchery.

Fin Regeneration

In examining 49 marked fish for fin regeneration, it was noted that in only one case did any of the ventral fins show signs of regeneration and that one about 50 per cent. None of the dorsals regenerated more than 50 per cent, although some signs of regrowth appeared in all but 3.

In view of this almost complete lack of regeneration of the ventral fin in combination with no more than 50 per cent regeneration of the dorsal fin, it was concluded that marked fish were not overlooked in the samples because of regenerated fins.

Population Estimates

The marked fish appeared to be well distributed throughout the commercial fishing season with their greatest abundance coinciding with the peak of the run at about the time of the closure on October 14 (Table 1). Thus it would appear that a significant number of the marked fish passed through the fishing area during the closed period and were not available to the fishery. The population estimates in this report probably will most nearly apply to the population in the Nehalem River throughout the entire run rather than just during the period of the fishery because the calculations included hatchery recoveries. In order to apply these data based only on the recovery of the marked fish to the entire run, it is naturally assumed that the marked fish were distributed throughout the run in somewhat the same proportion as the unmarked fish. No attempt was made to estimate the population of Nehalem River fish which strayed into Tillamook Bay or other coastal rivers, even though marked fish were recovered in other areas.

As explained previously, the 95 per cent confidence limits for the calculated number of marked fish in the entire Nehalem River commercial catch were 36 and 68, based on a combined sample for the entire season. Therefore, the 95 per cent confidence limits for the total number of marked fish in the river would be 135 and 168 (obtained by addition of 88 from the hatchery and 8 from the spawning grounds to the confidence limits of 3 and 4 for the sport fishery and 36 and 68 for the commercial catch). Based on the sampling and using the formula $\hat{N} = \frac{nt}{s}$, where $n =$ number of fish in the sample (17,211), $t =$ total number of marks available (135 and 168), and $s =$ number of marks in the sample (36), confidence limits for the population estimate ($\hat{N}$) may be estimated (Chapman, 1948, p. 76). For $t = 135$, 95 per cent confidence limits for $\hat{N}$ are 44,727 and 89,222. For $t = 168$, the 95 per cent confidence limits for $\hat{N}$ are 55,660 and 111,032.

Taking the extremes we have 44,727 and 111,032 as limits of the population estimate.

An alternative procedure for making the population estimates is to use the number of marks caught by the commercial fishery as calculated by two-week periods instead of as a single combined sample for the entire season. By using two-week periods, it was calculated that there were 46 marked fish caught by the commercial fishery. When calculated as a single combined sample, the total was 49 with 95 per cent confidence limits of 34 and 68. From these data 95 per cent confidence limits on the 46 total may be expected to be 31 and 65; however, the 36 marks actually observed is a more practical lower limit. Then, by substituting these values (36 and 65) in place of 36 and 68, extremes on the population estimate would be 44,727 and 109,049.

This alternative procedure is particularly applicable where the discrepancy between the total number of marks caught in the fishery as calculated by the two methods (i. e., either from a number of small samples or from a single combined sample) is quite large. This discrepancy is caused by the variation in the number of unmarked fish for each marked one present throughout the season and the fact that the landings from the different periods were not sampled in the same proportion.

Fishing Intensity

Inasmuch as it could not be determined how many marked fish were actually available to the fishery and how many passed through the river during the closed commercial season, it was not possible to determine the fishing intensity for any particular part of the season, but only for the entire period from September 1 to November 20. The 95 per cent confidence limits for the number of marks in the catch were 36 and 68, based on a single combined sample, and for the total number of marks available, 135 and 168. Therefore, limits on the estimates of fishing intensity for the Nehalem River commercial fishery, based on marked fish, would be $\frac{36}{135}$ and $\frac{68}{168}$ or 27 and 40 per cent. Using the limits based on the two-week samples for the number of marks in the catch (36 and 65), intensity figures would be 27 and 39 per cent.

Based on the actual catch (23,565) and the limits of the population estimate (44,727 and 111,032), the limits on the fishing intensity are 21 and 53 per cent. It should be emphasized that figures for fishing intensity are maximal since the assumption was made that all marked fish which escaped the fishery were recovered at the hatchery or on the spawning grounds. Any marked fish which were not observed would reduce these intensity figures.

Summary

A total of 104,194 marked silver salmon of the 1949 brood was liberated at the Foley Creek Hatchery on the Nehalem River on March 13, 1951.

The first marked fish was taken in the Nehalem River commercial fishery the first week in September 1952, and the peak catch of marked fish occurred about the time of the closure of the fishing season—October 14. On Tillamook Bay the first recorded capture of a marked fish was during the week ending September 27, 1952, and most of the captures occurred during the time the fishery was closed on the Nehalem River. The first marked adult fish was recovered at the hatchery racks on December 3 and the majority appeared to arrive the following week.

Lower and upper limits on a population estimate for the 1952-53 silver salmon run in the Nehalem River were 44,727 and 111,032 based on a single combined commercial catch sample, or 44,727 and 109,049 based on the two-week catch samples.

Lower and upper limits on the Nehalem River commercial fishing intensity, based on recovery of marked fish only, were 27 and 40 per cent based on a single combined sample or 27 and 39 per cent on two-week samples. Based on actual catch and the calculated population limits, these limits were 21 and 53 per cent. These are maximum figures inasmuch as any unobserved marked fish at the hatchery or on the spawning grounds would reduce the calculated intensity.

Acknowledgments

Mr. Raymond A. Willis collected most of the sampling data used in this report. Hatchery superintendents William E. Hankins and Joe H. Nelson also gave valuable assistance.

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KIDNEY DISEASE IN ADULT CHINOOK SALMON AND ITS TRANSMISSION BY FEEDING TO YOUNG CHINOOK SALMON

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Introduction

Outbreaks of kidney disease in Pacific salmon have been recorded in chinook salmon (*Oncorhynchus tshawytscha*), silver salmon (*O. kisutch*), and sockeye salmon (*O. nerka*), by Earp, Ellis, and Ordal (1953). These epidemiological observations of kidney disease were of young fish previous to their migration to salt water. The literature reveals no apparent record of the disease being found in the adults of these fish.

Salmon hatcheries in the Pacific Northwest frequently utilize for fish food the raw flesh and viscera of salmon killed for the artificial propagation of their spawn. The possibility of the adult fish's being infected with kidney disease and offering a possible source of infection to young fish prompted a search for the disease in the adults.

During the seasons of 1954 and 1955, adult spring chinook salmon in the Middle Willamette River, Oregon, were examined for kidney disease. Spring chinook salmon are notable in that they leave the ocean during the spring of the year and spend several months in fresh water before spawning in September and October.

The construction of Lookout Point Dam in 1953 by the U. S. Army Corps of Engineers eliminated most of the former natural spawning grounds of spring chinook salmon in the Middle Willamette River. The perpetuation of the run is now largely dependent on artificial propagation at Oakridge Hatchery which was completely rebuilt by the Corps as partial compensation for the elimination of the natural spawning areas.

Facilities for trapping and holding the adult fish awaiting sexual maturation are located near the base of Dexter Dam, the re-regulating dam for Lookout Point Dam and located approximately 3½ miles below it. The facilities in 1954 consisted of a weir structure and a simple trap in the main river. In 1955 two new permanent holding ponds were utilized for holding the fish. The confinement of the fish in the holding ponds for the taking of spawn simplified the securing of a large number of fish for observation.

No systematic method of examining the adult fish was followed in 1954. Therefore this report is based mainly on the 1955 observations when a systematic attempt was made to determine the abundance of diseased fish.

Description

Kidney disease is a generalized infection usually characterized in young salmon by the presence of marked lesions of internal organs, especially the kidney (Rucker, Earp, and Ordal, 1954). Large numbers of a very small Gram-positive diplobacillus are always present in these lesions. Infection experiments have shown this small unclassified diplobacillus to be the etiological agent of kidney disease (Earp, Ellis, and Ordal, 1953). Observations of kidney disease in young chinook salmon, silver salmon, and steelhead trout (*Salmo gairdnerii gairdnerii*) reared at hatcheries in Oregon have revealed a variety of syndromes which will be discussed only briefly here. Externally the abdomen is often swollen by the effusion of fluid into the peritoneal cavity due to extensive renal damage. Exopthalmos often results if the fluid is under pressure. External abscesses are rarely noted. Petechiae are often observed in the skin and musculature of fish thought to be in advanced stages of the disease. Necrotic areas, usually white watery pustules, are nearly always found on the kidney and to a lesser extent on the liver and spleen. At times, especially during an epidemic, the pathogen can be found in the organs of a fish showing no macroscopic evidence of the disease.

The syndromes of kidney disease that have been observed in adult spring chinook salmon also vary considerably, but differ only slightly from those seen in young salmon. On gross examination the liver seems to be the most frequently affected organ and usually exhibits white watery pustules, although caseous necrotic areas and large abscesses occasionally occur. The abscesses are filled with a turbid fluid containing large numbers of the pathogen. The spleen appears to be only slightly less affected than the liver and usually exhibits the same general syndromes. The kidney seems to be affected less frequently than the liver or spleen. Renal damage on gross examination appears to be relatively minor in comparison with that in young salmon. No effusion of fluid into the peritoneal cavity has ever been noted, and for this reason no abdominal swelling or exopthalmos has been observed in the adult fish. External blisters in the region of the lateral line and abscesses in the musculature occasionally occur. Petechiae in the musculature and peritoneal membranes seem to be quite common. Gross lesions or other macroscopic evidence were not always observed in fish found to be infected with kidney disease.

Methods of Examining the 1954 and 1955 Runs

Kidney disease in adult salmon was first noted among the recovered natural mortalities in 1954 shortly preceding spawn taking. Periodically thereafter gross examinations were made of the fish which died prior to or were deliberately killed during spawning operations. Fish exhibiting macroscopic evidence of kidney disease were taken to the laboratory where smears were prepared and examined. It was often found that the presumptive evidence of kidney disease based on mascroscopic examination proved to be myxosporidian cysts or tubercles formed by acid-fast bacteria. A total of 9 fish was observed to be infected with kidney disease. No count was made of the total number of fish examined, but it was about 800.

Cultures of the diseased material were made by Dr. Erling J. Ordal at the University of Washington in Seattle. The etiological agent was isolated in pure culture from liver and spleen lesions in the adult salmon. The pure culture successfully reproduced the disease when inoculated into young salmon, and the etiological agent was reisolated from these experimentally infected fish. Koch's postulates were thereby fulfilled.

Starting shortly after the first fish arrived at the Dexter holding ponds in the latter part of May 1955, some of them were found dead in the ponds. The cause of death was not definitely determined in most instances. All of the mortalities that were recovered in a suitable condition were examined for kidney disease. Putrification prevented the examination of some of the mortalities. Gross observations were first made, after which smears were prepared from liver tissue for microscopic examination. Smears of liver instead of kidney tissue were prepared because of the apparent affinity of the pathogen for the liver in the adult fish. The fork length and sex of each fish examined were noted for future reference. The examination of mortalities continued through the completion of spawn taking on October 27, by which time a total of 955 smears representing 83.4 per cent of the mortalities had been prepared and examined.

By September 6 the earliest maturing fish were suitably ripe for the artificial taking of their spawn. Sexually mature fish were killed periodically thereafter by hatchery personnel until the latest maturing fish were taken on October 27. A sample was obtained of the males and females killed each day during this period. These fish were examined for kidney disease in the same manner as the mortalities (fish which died in the ponds prior to maturation). Smears were prepared and examined from 538 males and 273 females representing 21.9 per cent and 40.1 per cent, respectively, of the total numbers of males and females killed during the spawn taking operations.

Observations of Kidney Disease in the 1955 Run

The first adult spring chinook found to be infected with kidney disease was recovered from the mortalities occurring on July 19, approximately 7 weeks after the first fish arrived at the Dexter holding ponds. Only a few mortalities had occurred previous to July 19. Infected fish were recovered thereafter until the completion of spawn taking on October 27. In Table 1 the number and per cent of infected fish by sex are shown. The mortalities

TABLE 1. **NUMBER AND PER CENT BY SEX OF ADULT SPRING CHINOOK INFECTED WITH KIDNEY DISEASE IN THE MIDDLE WILLAMETTE RIVER, 1955①**

	Mortalities Before September 6	*Mortalities After September 6*	*Fish Killed For Spawning*	*Total*
Total Males	206	265	2,462	2,933
Infected Males	28	15	74	117
Per Cent	13.6	5.7	3.0	4.0
Total Females	134	540	680	1,354
Infected Females	13	41	13	67
Per Cent	9.7	7.6	1.9	4.9
Total Males and Females	340	805	3,142	4,287
Infected Males and Females	41	56	87	184
Per Cent	12.1	7.0	2.8	4.3

① Per cents and numbers based on weighted samples.

occurring prior to September 6 (the first day of seining) are separated from those occurring after that date because of an apparent influence on the mortality rate caused by the repeated seining and handling of all of the fish in the ponds in the process of removing the mature ones. The total numbers of males and females are actual counts, while the estimated numbers of infected fish are based on weighted samples. The weighting of the numbers of infected fish among the mortalities occurring previous to September 6 is based on the examination of 53.4 per cent of the males and 78.4 per cent of the females, while for those occurring on and after September 6 it is based on the examination of 91.3 per cent of the males and 92.4 per cent of the females. The numbers of infected fish among the total killed for spawning are weighted from random samples by weekly periods. As mentioned previously, infected material was fed to Lot V_1 for only 41 instead of 52 days. An additional lot of 500 spring chinook fingerling was designated Lot V+S and fed the same diet as Lot V_2 except for the addition of sulfamethazine at a level of 2 grams per 100 pounds of fish. This level of sulfamethazine was used successfully by Earp in 1954 to control kidney disease in silver and spring chinook salmon in unpublished work. It was desired to determine if this low level would control kidney disease if it proved to be transmissible by the feeding of the flesh and viscera of infected adult salmon.

Both experiments were conducted at Oakridge Hatchery. The water supply for the hatchery is obtained from Salmon Creek, a tributary of the Middle Willamette River entering above Lookout Point Dam. Since 1952 no anadromous fish have entered Salmon Creek.

Results of the 1955 Transmission Experiments

Smears were made from kidney tissue of all mortalities and fish sacrificed during the course of these experiments. The smears were stained by Gram's method and examined for the presence of the etiological agent of kidney disease.

Two mortalities occurred in Lot V_1 during the second week of the experiment. Neither of these fish showed evidence of being infected with kidney disease. The third mortality in this lot occurred on the thirty-third day. This and all subsequent mortalities were found to be infected with kidney disease. Ten fish were sacrificed during the fifth and sixth weeks of the experiment and all showed evidence of kidney disease infection. The experiment was terminated on October 28 by which time 482 fish (96.4 per cent) had died (Figure 1). The 8 fish remaining in the lot were sacrificed and found to be infected with the disease. Kidney disease, therefore, had been transmitted to all of the 498 fish surviving the apparent 33-day minimum incubation period. Five fish (1.0 per cent) died in Lot C_1 during the course of the experiment. No evidence of kidney disease was found in any of these 5 fish or in 101 fish sacrificed from this lot at intervals following the fifth week.

The first mortality occurred in Lot V_2 on the thirty-second day following the initial feeding of infected material. This mortality and 5 fish sacrificed from this lot during the fifth week were found to be infected with kidney disease. All subsequent mortalities were also infected. The experiment was terminated on October 28 by which time 477 fish (95.4 per cent) had died (Figure 2). The 13 fish remaining in this lot were sacrificed and all were found to be infected with kidney disease. Five fish were unaccounted for at the end of the experiment. Thus 100 per cent transmission of infection was accomplished in this lot also. The losses in Lot C_2 amounted to 7 fish (1.4 per cent) during the course of the experiment. None of these fish showed evidence of kidney disease infection. A total of 96 fish was sacrificed from Lot C_2 at intervals following the fifth week and none of these fish were found to be infected with kidney disease.

Only 2 fish (0.4 per cent) died in the lot receiving a low level of sulfamethazine, Lot V+S. Neither these fish nor 96 sacrificed periodically after the fifth week were found to be infected with kidney disease. The dramatic effect of the low level of sulfamethazine on the mortality rate can be seen in Figure 2 by comparing the mortality curves of Lot V_2 and Lot V+S. The transmission of the pathogen by feeding was evidently blocked by the presence of sulfamethazine in the diet. However, as an attempt to determine if the sulfonamide completely or only temporarily suppressed the etiological agent, the remaining 400 fish in Lot V+S were separated into two lots of 200 fish each following the termination of Experiment 2. Sulfamethazine is

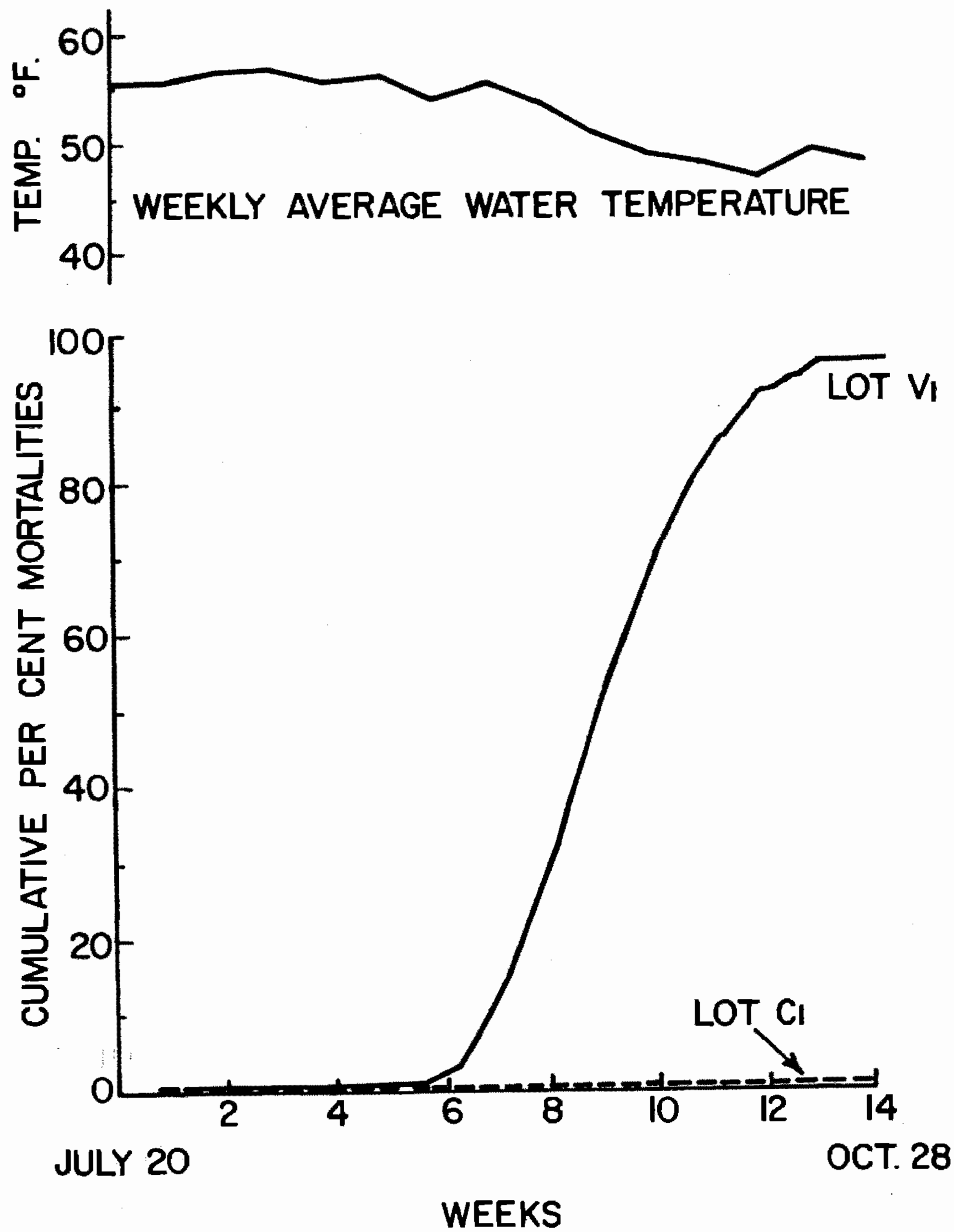

FIGURE 1. CUMULATIVE PER CENT MORTALITIES OF LOTS C_1 AND V_1 AND WEEKLY AVERAGE WATER TEMPERATURE.

21.9 per cent of the males and 40.1 per cent of the females killed were examined for kidney disease.

The weighted data in Table 1 show that 4.3 per cent of the fish comprising the 1955 run were infected with kidney disease. The percentages of infected males and females were nearly equal. Infected fish, both males and females, exhibited a higher mortality rate in the holding ponds than noninfected fish.

Length measurements of infected and noninfected fish did not disclose any apparent difference in the proportions of large and small females that were infected with kidney disease. However, there was an indication that a larger proportion of the males over 30 inches in fork length were infected than were males less than 30 inches. This difference was noted only among the males killed during spawning and did not occur among the males which died before spawning.

Transmission by Feeding Experiments

When kidney disease was discovered in adult spring chinook salmon in the Middle Willamette River in 1954, the feeding of the carcasses to the young fish at Oakridge Hatchery was discontinued, as it was thought this practice might transmit the disease. However, attempts in the past to transmit the disease by feeding have not been met with uniform success. Earp, Ellis, and Ordal (1953) were successful however, in infecting fingerling sockeye salmon by feeding, while Snieszko and Griffin (1955) were unsuccessful in doing so to fingerling brook trout by this method.

An attempt was made to transmit kidney disease by feeding the viscera of infected adult chinook to fingerling spring chinook salmon at Oakridge Hatchery in 1954 following the discovery of kidney disease in the adult fish. Control and experimental groups both suffered losses of fish infected with kidney disease during the course of the experiment. The results were generally inconclusive as the fingerling salmon apparently had been infected with the disease prior to the start of the experiment.

In 1955 two experiments were conducted utilizing infected flesh and viscera that were either fresh or had been frozen for only a short time. The fingerling salmon in these experiments initially weighed approximately 2 grams each and as a precaution against premature infection, were fed, prior to the start of the experiments, a diet containing no salmon products.

The following notations were used to differentiate the lots:

V_1=fed infected viscera, Experiment 1 C_1=control, Experiment 1

V_2=fed infected viscera, Experiment 2 C_2=control, Experiment 2

V+S=fed infected viscera plus sulfamethazine, Experiment 2

Each lot in Experiment 1 contained 500 fingerling spring chinook salmon which were placed in circular wooden tanks 6 feet in diameter. Commencing on July 20, Lot V_1 was fed a diet consisting of 50 per cent pork or beef products and 50 per cent infected adult salmon flesh and viscera. The infected material was included in the diet for a 52-day period. Lot C_1 was fed a meat diet containing no salmon products.

Experiment 2 was begun on August 1. In this experiment Lots V_2 and C_2 were identical in size and diet to Lots V_1 and C_1, respectively, except that being continued at a low level in the diet of one lot while it is no longer being fed to the other lot. Two additional lots are being held as controls. This portion of the experiment is still in progress. At this time the effect of feeding a low level of sulfamethazine to chinook salmon over an extended period is unknown.

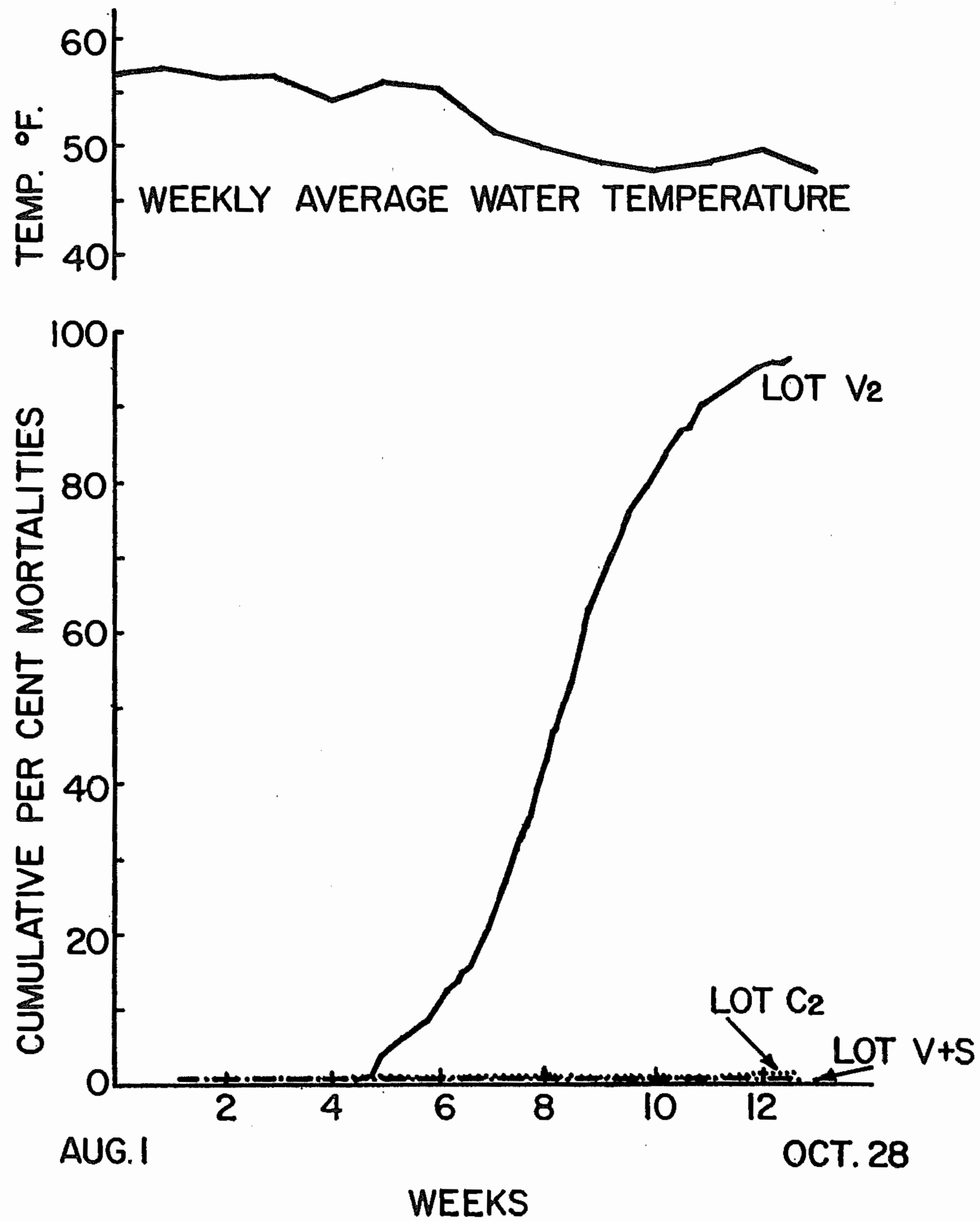

FIGURE 2. CUMULATIVE PER CENT MORTALITIES OF LOTS C_2, V_2, AND V+S AND WEEKLY AVERAGE WATER TEMPERATURE.

The water temperatures during both experiments are shown accompanying the respective mortality curves in Figures 1 and 2. The average weekly water temperature existing during the apparent 32-or 33-day minimum incubation period in both experiments was approximately 55° F.

Discussion

The finding of kidney disease in adult salmon and the demonstration of its transmission by feeding suggests a very likely method by which an epizootic may be initiated among young salmon, since the feeding of the carcasses to the young is a practice carried on at many Pacific Northwest hatcheries.

The syndromes exhibited by a number of the infected adult salmon recovered during July and August 1955 are suggestive of advanced stages of the disease. Abscesses and necrotic areas were extensively developed in some of these fish, and tremendous numbers of extracellular pathogens were noted in prepared smears. There is no indication that the disease advanced, either in extent of infection or in numbers of fish infected, after the fish arrived at the holding ponds; in fact, kidney disease appeared to have become less prevalent as the spawning season progressed. These observations suggest that the adult fish contracted the disease prior to their arrival at the holding ponds.

In view of the finding by Earp, Ellis, and Ordal (1953) that kidney disease persisted in young salmon held in salt water, it is possible that the disease is contracted by them previous to their migration to the ocean and is carried by the fish through the remaining portion of their life cycle. If such is the case, the feeding to young salmon of the viscera from commercially caught adult salmon also could be a means of transmitting kidney disease.

Kidney disease does not appear to have been a primary cause of mortality in the holding of the adult fish awaiting maturation in 1955. During the period previous to the killing of the first mature fish, only 12.1 per cent of the 340 mortalities were found to be infected with kidney disease, leaving at least 87.9 per cent to be explained by other causes. Kidney disease evidently was a contributing cause to this holding mortality however, as the percentage infection in the early mortalities was much higher than it was among the fish that survived until they were sexually mature. It may be noted that 35.4 per cent of the 340 mortalities occurring previous to the initiation of spawn taking were infected with the typical acid-fast bacteria of tuberculosis. In addition, a considerable but undetermined percentage were infested with a myxosporidian (*Ceratomyxa* sp.). It is believed that both the tuberculosis bacteria and the myxosporidian may cause mortalities among adult salmon.

Summary and Conclusions

1. Kidney disease was found in adult spring chinook salmon in the Middle Willamette River in 1954 and 1955, and an extensive examination in 1955 revealed that 4.3 per cent of the chinook handled at the Dexter holding ponds were infected.
2. Kidney disease in 1955 was not a major cause of mortality among spring chinook salmon awaiting maturation in the Dexter holding

ponds, although those infected with the disease did not appear to be so capable of surviving the holding period as noninfected fish.

3. Kidney disease was found to be transmissible to young salmon by feeding as evidenced by the fact that the infected flesh and viscera of adult spring chinook salmon, when fed in the diet of young spring chinook for a 41-to 52-day period, transmitted the disease to 100 per cent of the fingerlings.
4. A low level of sulfamethazine (2 grams per 100 pounds of fish) evidently blocked the transmission of kidney disease to young spring chinook when fed in a diet containing the flesh and viscera of infected adult spring chinook salmon.

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