THE SALMON RESOURCES OF THE WILLAMETTE BASIN

Presented to

The Governor's Natural Resources Committee

By

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Introduction

The history and development of the Pacific Northwest is to a large degree a story of the development and utilization of natural resources. Lewis and Clark, crossing the Continental Divide in 1805-6, found not only heavily timbered hillsides and unequaled waterways, but large tribes of Indians who made their homes along the great rivers and existed easily from the seemingly inexhaustible supply of fish and wildlife.

At this time the Indians of the region had certain historic sites where they fished and where these early explorers and others have recorded that hundreds of Indians visited these fishing sites each season to catch fish and barter with tribes from the interior. Without question, these some 50,000 Indians inhabiting the Columbia River Basin utilized salmon and other fishes as their main source of food. In fact estimates which have been made, based on the accounts of Lewis and Clark, David Thompson, and Charles Wilkes, would indicate that some 18,000,000 pounds of salmon may have been landed each year by the Indians along the Columbia, of which as much as two million may have been taken at Willamette Falls, one of the favorite lower river fishing sites. Thus, even before the advent of the white man a prosperous and relatively large cultural group of people were depending upon the natural resources of the region.

After the advent of the white man, the commercial fisheries developed rapidly. At first by buying fish from the Indians and later by catching them themselves a lucrative salt fish trade was erected with the East Coast.

The development of the Northwest has been closely linked with the fisheries resources of the region, and even today the Columbia River fisheries alone produce 20 millions of dollars annually of new wealth to the region.

The past fifty years have seen a rapid expansion and development of the region, and during the past twenty years the industrialization and development has been at an even greater rate. The soils, mining, forestry, and fisheries of the region have been harvested at an alarming rate and now that the "cream" of the resources is gone comes the painful but necessary change to sustained yield harvesting of these resources. The more recent "boom" has been in developing the water resources of the region, and unfortunately, in the development of water-use programs, as in the rapid development and utilization of other natural resources, unwise planning and the lack of a coordinated well-organized program of water use has been the major cause in the unheralded decline of the fisheries and the complete absentation of many important and essential uses of water.

It would seem that the people of the Northwest might well remember the example set on the East Coast on the Delaware River for example or almost any one of their valuable river systems. Ignorant, destructive, and selfish water use programs have not only destroyed the majority of streams as producers of food and game fish--the Atlantic salmon in the United States is almost extinct--but have so maltreated the river basin that today they are little more than open, disease laden, evil-smelling sewers. Plans are now being proposed to expend millions upon millions of dollars in the attempt to restore these streams, to bring back the fisheries, and to recapture the multiplicity of benefits available in fresh, clean, accessible waters. Oregon would be wise to study more

carefully the history of these waterways and the basic causes for their destruction as a resource. With the proper planning, taking into account all uses of rivers, these river basins can continue to provide great and varied benefits for the multiple use water programs for this and future generations.

Attention is drawn to Figure 1 which is a sketch map of the Willamette Basin.

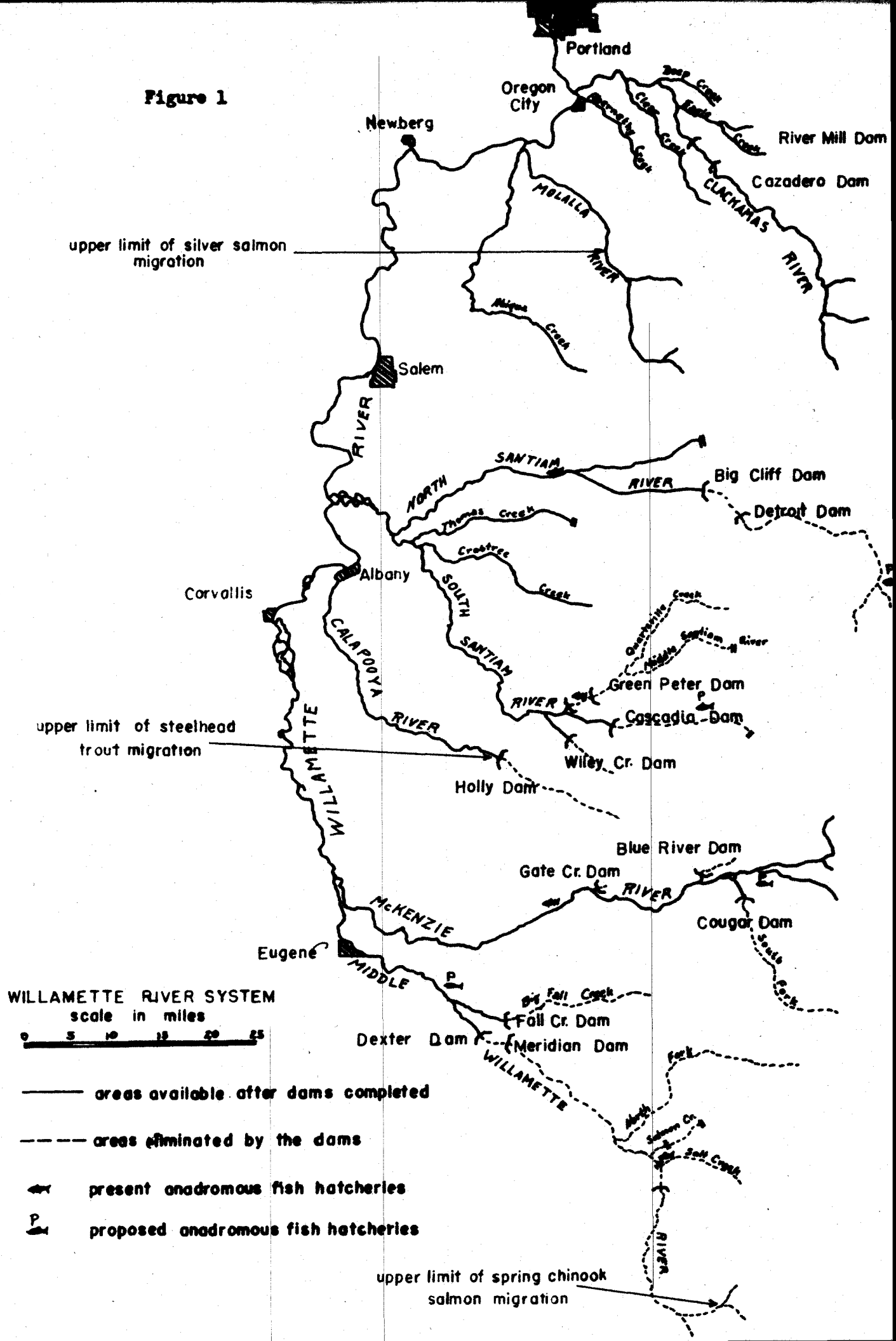
The Willamette River basin is the most heavily populated area in Oregon. Civilization with all its ramifications has probably involved more changes in the Willamette than in any other stream in the Columbia drainage. The main stem of the stream has been altered by dredging, river traffic, a dam (at Willamette Falls), pollution, and artificial channel alterations. In addition the tributaries and even the rivulets have been altered in varying degrees during the last century by agriculture and industry. Most of these changes have adversely affected the fish populations, but the Willamette is, nevertheless, one of Oregon's major streams from the standpoint of salmon production. Although the 11,000 square miles in the Willamette drainage amounts to only two or three percent of the area in the Columbia basin, its importance from the standpoint of fisheries production is immense.

Condition and Magnitude of the Salmon Populations of the Willamette River System

Spring Chinook Salmon

The spring chinook have always surpassed the other Columbia River salmon in abundance, distribution, and desirability to man; consequently they constitute the greatest salmon resource in the Willamette River watershed. Even with the advent of the white men and accompanying civilization,

Figure 1


Portland
Oregon City
Newberg
River Mill Dam
Cazadero Dam
upper limit of silver salmon migration
MOLALLA RIVER
CLACKAMAS RIVER
Salem
NORTH SANTIAM RIVER
Big Cliff Dam
Detroit Dam
Albany
Corvallis
SOUTH SANTIAM RIVER
CALAPOOYA RIVER
Green Peter Dam
Cascadia Dam
upper limit of steelhead trout migration
Wiley Cr. Dam
Holly Dam
WILLAMETTE
Blue River Dam
Gate Cr. Dam
McKENZIE RIVER
Cougar Dam
Eugene
MIDDLE
Fall Cr. Dam
Dexter Dam
Meridian Dam
WILLAMETTE
upper limit of spring chinook salmon migration
WILLAMETTE RIVER SYSTEM
scale in miles
0 5 10 15 20 25
areas available after dams completed
areas eliminated by the dams
present anadromous fish hatcheries
P proposed anadromous fish hatcheries

these superb fish have been able to maintain themselves on a gradually diminishing scale. It has become necessary to begin comprehensive studies of the present runs of spring chinooks now utilizing the rivers and streams of the Willamette River basin, and of the factors influencing these populations.

Life History of the Spring Chinook Salmon (Oncorhynchus tshawytscha)

The adult spring chinook salmon, ranging in weight from one to 45 pounds, enter the Willamette River from February to May, and then migrate to the various rivers in which they were spawned. Spring chinook salmon populations are now present in the following river systems: the Clackamas, Molalla, North and South Santiam, Calapooya, McKenzie, and Middle Willamette Rivers and Pudding River (Abiqua Creek). All of these rivers have their headwaters in the Cascade Mountains. No chinook salmon populations are found in those rivers and streams flowing down into the Willamette River from the Coast Range.

These fish will reach their ultimate destination, unless blocked by natural or man-made obstructions, by the middle of June at the latest. As they do not spawn immediately upon arrival, the salmon seek the deeper pools and channels of the main rivers and quietly await the maturity of their sex products. Once having entered fresh water, salmon cease feeding and exist upon the stored fat content of their body.

Spawning activities generally begin in late summer when the water temperatures begin decreasing. The earliest spawning occurs usually in late August in the colder headwaters of the various rivers and becomes progressively later in the lower sections, with the very latest activities ending about mid-October. A variation of a few days up to two weeks may occur in the time of spawning from year to year; this being influenced

directly by the water temperature. After spawning all Pacific salmon die.

The chinook female may lay from 4,000 to 6,000 eggs in nests dug into gravel. The period of egg incubation will vary from two to four months or more depending upon the water temperatures. After hatching, the young fry do not feed until the yolk has been completely absorbed from the yolk sac. The young fish will emerge from the gravel during the winter months or early spring. The length of time spent by the young salmon in the parent stream may vary with the individual fingerling; some will begin migrating to the sea during the spring or early summer of their first year; there is virtually no migration during the late summer low water period (at this time the Willamette River pollution is so great that no salmonoids could exist for any length of time in the river between Newberg and the Columbia River). With the advent of the fall rains and pollution abatement by dilution, the young salmon begin moving down, and some of these, now over one year of age, have been found near Oregon City as late as April. Thus the young salmon may spend a length of time in fresh water varying from about one-half year to almost two years.

Once having reached the ocean the young fish find excellent feeding conditions and begin growing very rapidly. The growth in the ocean environment is far greater than that in fresh water. The length of time in the ocean may vary from less than a year to four and even five years. When the urge to return to the parent stream appears, the fish cease feeding and enter the Columbia River to begin upstream migration.

Spring chinook salmon in the Willamette River system have been found to vary in age from three to four, five, or even six years at maturity; the greatest number being five years old, followed next by four year olds.

The comprehensive studies of the Willamette River spring chinook salmon were begun during the spring of 1946, and have continued since that time. The scope of this investigation now includes studies of the following factors associated with salmon populations in general and pertaining specifically to spring chinook: the effect of commercial fisheries, past and present; the magnitude of the sport fishery for spring chinook salmon on the lower Willamette River below Oregon City; the effect of the Willamette Falls upon migrating salmon and annual fishway counts of fish passing through the ladder; natural and man-made obstructions that might delay or entirely eliminate passage into upper areas on various streams; hatcheries; summer holding areas; efficiency of natural spawning and pollution of the main Willamette and several tributary rivers from various sources. In addition studies are being conducted on the downstream migration of the young fish in relation to the magnitude and time of passage to the ocean, and scale studies of young and adult salmon to correlate the time and size of fish in downstream migration with maximum return of adults.

Willamette Falls Fishway Counts

The magnitude of the annual escapement of adult spring chinook salmon through the fishway at the Willamette Falls at Oregon City was first determined with considerable accuracy during the spring migration of 1946, and the results of the counts for all years since then were as follows: 1946 - 53,000; 1947 - 45,000; 1948 - 30,000; and 1949 - 27,000 spring chinooks. Although these counts would indicate that there was a steady decline for the four year period, such is not the case. The spring chinook salmon of the Willamette River system are predominately

five years old at maturity, and consequently the first parent-progeny relationship cannot be compared until 1951.

In addition to the magnitude of the annual escapement of salmon beyond Oregon City, these studies have shown that above certain water levels the fishway became impassable to salmon due to extremely turbulent flows within the ladder. Another important factor causing numerous salmon to be delayed below the falls each year is the false attraction caused by large discharges of water from the industrial plants at Oregon City and West Linn. These heavy flows attract salmon into dead-end areas, where the fish make fruitless attempts at these blocks until completely exhausted. The ensuing delay might continue until the pollution has become so great in the river above the dam that the salmon will perish from lack of oxygen in the water if they are fortunate enough to find the fishway during the low flows following the spring run-off.

Stream Surveys of the Spring Chinook Salmon Tributaries

After the salmon have successfully ascended the barrier formed by the Willamette Falls at Oregon City, they disperse to the various streams from which they originated. The fish are followed up with surveys made periodically to the tributaries in order to see that the salmon are able to complete their upstream migration with minimum delay. All of the known barriers are visited. Wherever fish migration appears to be blocked, steps are taken to alleviate the condition causing the delay. In some cases a few minutes work will render a debris-blocked fishway passable again. Dams with inadequate fishways or lacking any facility

to enable fish migration are brought to the attention of the owners who must then assume the responsibility of correcting the condition in the immediate future. Log jams caused by recent logging along the river banks are brought to the attention of the offending party and they are given an opportunity to remove the obstruction. Where such barriers are caused by natural forces such as storms and floods, the Fish Commission engineering crew will remove the jam if it is deemed necessary. Natural falls that prevent salmon from ascending into favorable spawning areas are examined, the amounts of available spawning areas above are determined, and a fishway is recommended whenever the situation would be greatly improved. A case in point is a ladder over Eagle Creek falls, which was installed jointly by the Game and Fish Commissions.

Once the salmon have reached their ultimate destinations, they seek the deeper pools and eddies where they await the coming of cooler temperatures of late summer and fall. These holding or summer resting areas are visited periodically to obtain estimates of fish present, suitability of the holding area, occurrence and amount of mortalities prior to spawning, and any indications of law violations by poachers are reported to the State Police who are responsible for law enforcement. Good law enforcement would eliminate some of these losses, and the known areas of constant violations should be kept under close surveillance by the State Police.

Spawning Ground Surveys

With the approach of fall and the accompanying drop in river temperatures, the spring chinook salmon move from the deep pools and channels to the shallow gravelled riffles where they begin their spawning activities. As the most efficient and accurate coverage can only be obtained during the short period of maximum spawning activity, schedules of the surveys for

the various rivers are planned to occur as nearly as possible at the most appropriate times.

A brief description of the rivers and streams utilized by spring chinook salmon, and the results of the stream surveys made since 1946 follows: The order of sequence will be from south to north, beginning with the Middle Willamette River.

Middle Willamette River

The Middle Willamette River is the southernmost tributary in the Willamette River system with a spring chinook salmon population. The head-waters of this river are found on the western slopes of the Cascade Range in the vicinity of the Willamette Pass. Populations of these fish are found in the following tributaries: North Fork of the Middle Willamette River, Salt Creek, Salmon Creek, and Big Fall Creek. This river system is surpassed only by the McKenzie River in importance as a spawning and rearing area for spring chinook salmon.

A Fish Commission hatchery has been in operation on Salmon Creek since 1918. The records of egg takes at this station indicate that since 1942 there has been a noticeable decrease over the previous parent cycle. The existing facilities will be enlarged to accomodate the increased egg takes resulting from construction of the Meridian Dam after which virtually all Middle Willamette fish must be handled artificially.

An estimated escapement into the Middle Willamette River has been made since 1947, and is as follows: 1947 - 2,500; 1948 - 1,775; 1949 - 1,500. These are estimates based upon surveys, observed mortalities, utilization of the spawning grounds, and hatchery operations.

The future perpetuation of the Middle Willamette spring chinook population is not very encouraging as the Meridian Dam on the main stem and the Fall Creek Reservoir will eliminate all of the natural spawning areas

now being utilized, and the utilization of the suitable areas below the dams may not occur. The Fish Commission has repeatedly stated that the maintenance of the Middle Willamette salmon runs by artificial propagation must be regarded as an experiment, and there is no assurance of success. Unless the pollution in the main Willamette River is overcome, this stock of fish will continue to suffer losses due to that factor.

McKenzie River

The greatest spring chinook river of the Willamette basin is, without question, the McKenzie. Having as its source, Clear Lake high in the Cascade Mountains, this superb stream flows a distance of approximately 86 miles before joining with the Willamette River below the town of Coburg. Salmon can ascend up to the base of Tamolitch Falls, which is approximately 18 miles below Clear Lake.

Among the numerous tributaries, the following streams have had runs of salmon entering them: the South Fork--largest salmon producer of the tributaries; Smith River; Horse Creek; Lost Creek; Blue River; and Gate Creek.

The McKenzie Salmon Hatchery located near Leaburg has been in operation since 1918. The present egg taking station is located just above the Hendricks Bridge at Walterville. Each spring a large weir is erected across the river at this point and part of the salmon reaching the rack are held until fall when they have reached maturity. The fish are spawned at the rack, eggs fertilized, and then transported by truck to the hatchery above Leaburg.

The estimated escapement of spring chinook salmon have been, since 1947, 2,830; 2,200; and 5,000. Data obtained since 1947 indicate that the

estimate of 2,830 fish made at that time was low and the number of fish in the McKenzie River in that year was nearer 6,000 spring chinook. There is no question but that the McKenzie River is the best spring chinook salmon producer in the Willamette basin.

The future of the McKenzie River spring chinook salmon is brighter than for most of the Willamette River tributaries. The greatest threat to these fish is from the steadily increasing pollution problem in the main Willamette, and also from the large paper mill recently put into operation at Springfield. Loss of spawning areas by the construction of the three dams proposed would affect only a small proportion of the entire spawning population. The unscreened diversions at Leaburg and Walterville will continue to cause losses to young fish diverted into the canals and caused to pass through the power turbines at Leaburg and Walterville.

Calapooya River

The Calapooya River, which has a relatively small watershed lying between the McKenzie and South Santiam River basins, flows into the Willamette at Albany. It is one of the less important spring chinook streams, but a small run of steelhead trout utilizes the river.

At one time the spring chinook salmon run was considerable in size, but after the construction of the Finley Dam below Crawfordsville in 1848 the runs began diminishing. As no fishway has ever been provided at this dam the fish have been forced to spawn on less desirable areas below.

Stream surveys made since 1946 have indicated the near exhaustion of the spring chinook salmon population as the following summary will show. In 1946 a total of 15 salmon were found, 12 in 1947, none in 1948 and 1949. Although no fish were observed during the past two years, small numbers of salmon may have entered the river and escaped observation. One dam, the

Holly Reservoir, has been planned for this stream.

South Santiam River

The South Santiam River, with its source in the Cascade Mountains, has a drainage basin between the North Santiam, Calapooya, and McKenzie Rivers. It joins the North Santiam River near the town of Jefferson and the two form the main Santiam River. The South Santiam ranks below the McKenzie, Middle Willamette, and North Santiam Rivers in the production of spring chinook salmon. The main salmon bearing tributaries are the following: the Middle Santiam River, Thomas, Crabtree, and Wiley Creeks. In addition to the spring chinook salmon, considerable numbers of steelhead trout frequent the same areas as salmon do.

The estimated escapement for 1947, 1948, and 1949 were respectively: 1,290 (a very low estimate); 1,345; and 1,500. No estimate was made in 1946.

The future of the anadromous fish populations in the South Santiam River system is not very encouraging as these runs have been steadily declining, due mainly to dams, diversions, and pollution. Now the future threatens to deny these fish their only spawning and rearing areas by the construction of four impassable dams.

North Santiam River

The North Santiam River with headwaters in the Mt. Jefferson Primitive Area has a drainage basin of 750 square miles. Tributary streams supporting both spring chinook salmon and steelhead trout are the following: the Little North Santiam and Breitenbush Rivers, Blowout and Marion Creeks.

The Oregon Fish Commission has maintained a salmon hatchery at Mehama since 1918. The adult fish have been held each summer by weirs erected

just below the mouth of the Breitenbush River. The annual egg collections at this station have been below the 1918-1945 average since 1935; thereby clearly indicating a decline over the earlier runs. The construction of the Detroit Dam has advanced so far that beginning with the 1950 spring chinook migration, these fish will have to be held below the dam and artificially spawned. A new station which will appreciably augment the capacity for artificial propagation on the North Santiam River is being constructed at Marion Forks. The majority of the spring chinook salmon in the North Santiam may have to depend upon artificial propagation in the future, since Detroit Dam will eliminate most of the spawning area.

Estimates of the total yearly escapements were made in 1947, 1948, and 1949, with the respective totals as follows: 2,825; 2,075; and 1,750 salmon.

The future of the spring chinook salmon, and steelhead as well, will depend upon artificial propagation to a great extent after the loss of the natural spawning areas. It is hoped that some of these fish will utilize the suitable areas that are available below the Detroit Dam. However, before the spring chinook salmon and steelhead trout runs can be substantially increased, the losses of young downstream migrants into unscreened diversions on the lower North Santiam River and polluted sections of the main Willamette must be greatly reduced, and the upstream migration past the low diversion dams assured.

Abiqua Creek

This stream, a tributary of the Pudding River, is approximately 24 miles long, and drains an area of farm lands and wooded foothills lying between the Butte and Silver Creek drainages. There are no sizeable tributaries entering this stream.

Both spring chinook salmon and steelhead trout entered this stream in considerable numbers as recently as fifteen or twenty years ago. These anadromous fish have dwindled in numbers so that at the present time they are nearly extinct. Surveys made in 1947, 1948, and 1949 have failed to reveal the presence of spring chinook salmon. However, a small number apparently spawned in the stream in 1948 as young spring chinook salmon migrants were observed there during the summer of 1949.

Molalla River

This river, with headwaters in the foothills of the Cascade Mountains between the North Santiam and Clackamas River sources, is one of the lesser spring chinook tributaries of the Willamette River system. The main salmon bearing tributaries are the North and Middle Forks, but the bulk of the fish are found spawning within the main stem of the river.

As late as the 1920's the spring chinook salmon were so abundant in this river that local farmers gathered the fish by wagon loads for use as fertilizer. This extravagant waste has long since ceased, but it was undoubtedly one of the major factors contributing to the rather rapid decline in populations suffered by these fish. During the past few years the escapement has been only around 1,000 fish. There are no hatcheries located on this stream.

Estimates of the escapement since 1947, based on stream surveys, indicate less than 1,000 fish in each year.

The future success of the spring chinook salmon runs into this stream depend greatly upon the abatement of the Willamette River pollution and some method of reducing losses at the power and industrial plants at Oregon City. All of the original spawning areas are still available, and with adequate management it may be possible to reverse the present decline and build up the runs to somewhat more normal size.

Clackamas River

This river is the northernmost of the large salmon tributaries of the Willamette River system. It has its source high in the Cascades to the south of Mt. Hood, and its confluence with the main Willamette River is several miles below the Willamette Falls. According to old reports the Clackamas River was considered the finest chinook salmon river in the Columbia River system. Many of the fine upper spawning areas are now virtually inaccessible to spring chinook salmon and only in part for the steelhead trout. Eagle Creek is the main spring chinook salmon and steelhead trout stream available on the lower section devoid of artificial barriers.

During the 1890's a large commercial fishery occurred during May and June in this river, and in one year about 140 tons of the highest quality spring chinook salmon were taken. Large runs of fall chinook and silver salmon were present, a s well as steelhead trout. The most disastrous decline of a fisheries resource to be found on the Willamette system occurred on this river, and now only remnants of the spring chinook and silver salmon, and steelhead trout populations exist.

Fish hatcheries have been in operation on this river as early as 1876, and with various periods of inactivity, up until the present time. Despite these attempts at artificial propagation, the stocks have been steadily declining. A small U. S. Fish and Wildlife Service hatchery is operating on Delph Creek, a tributary of Eagle Creek. Eggs are taken from spring chinook salmon that enter a holding weir located at the mouth of Eagle Creek. The spawning operations at the mouth of Eagle Creek have not been very successful since 1947. In 1946 the egg take was 495,500 spring chinook eggs, but only 10,000; 60,000; and 13,000 the following three years.

The estimated escapements of fish into this river have varied between 1,000 and 2,000 fish during the past three years.

The Clackamas River can support a far greater population of spring chinook salmon than now present. Major limiting factors are the dams, unscreened power station intakes, and pollution.

Since the Oregon Fish Commission began making annual studies of the Willamette River fisheries in 1946, the magnitude of the sport catch, Willamette Falls fishway counts, and spawning ground observations have been assessed (Table1). Records of hatchery operations have been available since 1946, and graphs of these are presented later in this report, (Figures 4 and 5).

Table 1
Summary of Willamette River Observations
Made Since 1946

	1946	1947	1948	1949	Totals
Estimated Escapement into Willamette River	75,000	60,000	40,000	38,000	213,000
Sport Catch	12,300	12,000	8,300	9,100	41,700
Willamette Falls Fishway Counts	55,000	45,000	30,000	27,000	157,000
Hatchery Operations	4,906	3,522	1,747	1,357	11,532
Observed Spawning	4,583	1,798	1,427	2,605	10,413

Willamette River Fall Chinook Salmon

The fall chinook salmon entered the Clackamas River in large numbers as late as 1924, but within four years of that date they had virtually disappeared. The fall chinook salmon have a life cycle similar to the spring run, but with several exceptions. The time of upstream migration occurs during August, September, or October instead of the spring and summer months.

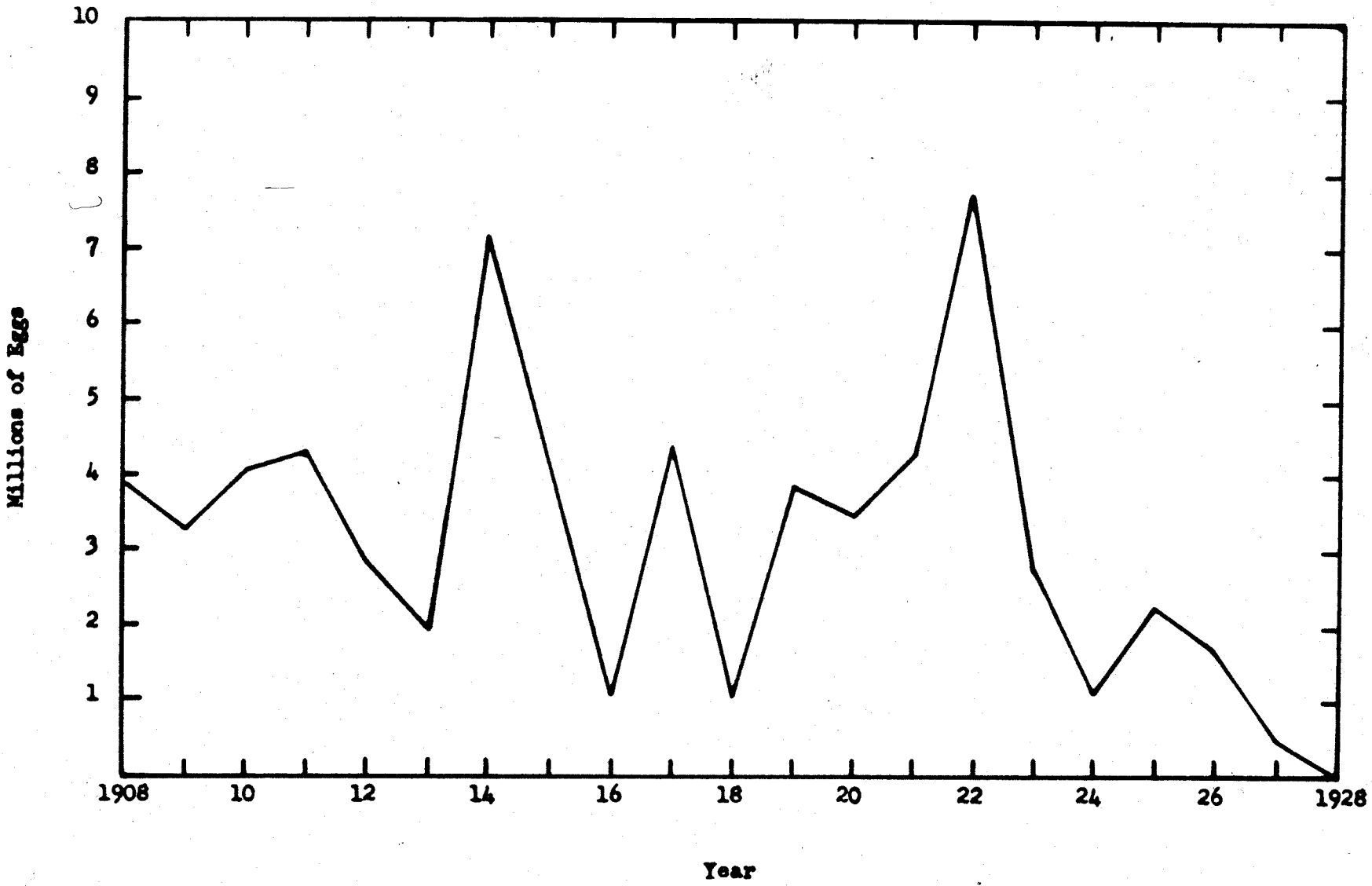
Upon arrival at the native spawning area, they begin spawning without appreciable delay because they are usually sexually mature on arrival at the spawning grounds. The adults die after spawning. The young fish develop at a similar rate to the spring run progeny, but instead of spending a year or more in fresh water, they begin migrating to the ocean during the first year. The returning adults are generally four years of age at maturity instead of five years as with the spring chinook salmon.

According to the old records these fish entered the Clackamas River during September and October. A commercial fishery was present within this river until 1897, when it was abolished by state law. The major factor in closing the commercial fishery was to preserve this river for the propagation of salmon, both by artificial and natural means.

Artificial propagation was first used in 1876 on the Clackamas River, and except for short periods, has continued up to the present. A record of the Clackamas Hatchery fall chinook egg collections from 1908 until 1927 have been compiled and presented in Figure 2. As shown by this graph there was a very definite decline beginning in 1923 and ending in 1928, when there were so few fish present in the river that hatchery operations were deemed infeasible.

Thus, within a five year period the fall chinook egg takes fell from over seven and one-half million eggs to zero. The two dams on the Clackamas undoubtedly decreased the amount of spawning areas available to the fish, but the major influencing factor responsible for this sudden disappearance of these fish was pollution in the Willamette River below Oregon City. Tests made in 1929 showed that pollution was so great in the Willamette River below the mouth of the Clackamas that no salmon migration could have occurred.

Figure 2 Egg Collections of Fall Chinook Salmon
at the Clackamas Hatchery, Clackamas, Oregon from 1908 until 1927.



Willamette River Silver Salmon

The lower tributaries of the Willamette River still contain the remnants of a once abundant population of silver salmon. No definite data are available of the magnitude of the former abundance of these fish, and consequently a definite amount of decline cannot be readily given.

Life History of the Silver Salmon (Oncorhynchus kisutch)

The adult silver salmon are considerably smaller in size than the chinook salmon, ranging in weight from less than a pound for jacks to a maximum of ten or twelve pounds for a full grown fish. The adult fish enter the Willamette River during the months of October, November, and December after the fall rains have increased water flows from the summer low period. Silver salmon populations are found in the Clackamas, Tualatin, and Molalla Rivers as well as a number of small streams entering the Willamette River below the mouth of the Molalla and Pudding Rivers, and have been reported from still other tributaries. They are most abundant in the Clackamas and its tributaries.

The fish are nearly mature when they arrive at their parent stream spawning areas. Unlike the spring chinook salmon, the silver salmon spawn shortly after reaching their destination. After spawning the adult fish die.

The young hatch out the following spring; and generally remain about a year in fresh water before going to the ocean.

The period in the ocean is not so long as for the spring chinook salmon, as the adults average three years old upon spawning. Generally, two summers are spent in the sea. Growth in the ocean is very rapid, but ceases when the fish enter the Columbia River and stop feeding as they

migrate to the spawning areas. Small precocious males, called "jacks", migrate with the adults and die after maturing and spawning.

Distribution of the Silver Salmon

Spawning ground surveys made since 1947 have shown that silver salmon are found as far up the Willamette River tributaries as the Molalla River, where a few spawn each year above the town of Molalla. This run is extremely small, and rarely are young silver salmon migrants found in the lower areas enroute to the ocean.

The Tualatin River has an introduced run of silvers now present. Several decades ago silver salmon fingerling were planted in several streams in the upper reaches such as Scoggins and Dairy Creeks. These plants produced sizeable runs, but apparently they are on the decline, as very few fish have been reported the past few years.

The Clackamas River has a number of tributaries that have small escapements of silver salmon each year. The two main tributaries to the lower Clackamas River are Eagle Creek and Clear Creek, both with numerous tributary streams utilized by silvers. Deep Creek and Rock Creek are smaller tributaries, the latter with less than one mile of stream available.

The silver salmon population in the Willamette River should be improved. The greatest factor that must be overcome is pollution in the main Willamette River. With the elimination of pollution and adequate fish management, this now depleted stock could be increased appreciably.

Steelhead Trout

The Willamette River system has small runs of steelhead trout, anadromous rainbow trout, that spawn in certain tributaries. Although never as abundant as the spring or fall chinook salmon, they have not suffered such serious declines as the former. With a smaller range in distribution and a different life cycle from the spring chinook salmon, they have been able to maintain

themselves in spite of the hazards introduced by civilization.

The migration of adult steelhead into the Willamette River generally is from November to April, with the bulk appearing during February and March. The main tributaries entered are the South and North Santiam, Molalla, and Clackamas Rivers, and most of the accessible smaller streams below the Willamette Falls at Oregon City such as Abernethy, Johnson, and Kellogg Creeks. The Calapooya River apparently has a small number of steelhead entering it each year, and this is the southernmost point of distribution in the Willamette system.

These fish spawn generally in April and May, and the spent adults may survive and migrate again to sea and return a year later for further spawning. The young fish spend from one to two years in fresh water before migrating to the ocean.

Artificial propagation of those steelhead trout denied their natural spawning areas will be resorted to in the case of the large dams destined for the North and South Santiam Rivers. The enforcement of the abatement of pollution remains up to the Sanitary Authority of Oregon.

Factors Affecting Willamette Salmon Runs

The Fishery

As is the case with most salmon populations, a variety of factors have affected the runs. First among these from the standpoint of early importance and initial impact of the white man on the Willamette salmon is the commercial fishery. As has been pointed out previously, old records indicate that there was an Indian fishery at Willamette Falls. The early commercial fishery, which in the mid-1800's, was largely concerned with spring chinook salmon and, inasmuch as this fishery was prosecuted not only in the Columbia but in the lower Willamette also, it follows that the Willamette was affected

much like the Columbia. In that regard Craig and Hacker (1940) have remarked that some races of chinook salmon showed signs of depletion in the late 1880's. They ascribed most of the early decline to the fishery. While it may be assumed that Willamette spring chinook salmon were affected in like degree, they were still very abundant in the early 1900's. About 1927 the gill net fishery between Willamette Falls and the mouth of the Willamette was eliminated by legislative act. Since that time the only fisheries operating on Willamette salmon have been the Columbia River fishery, the ocean troll fishery and the sport fishery. Most Willamette spring chinook move through the lower Columbia in March and April, during which time no commercial fishing is permitted, so it is probable that the gill net take of Willamette chinooks is small.

The troll fishery takes Columbia and presumably Willamette chinooks from California to Alaska. Based on estimates of Columbia River chinooks caught in the troll fishery and those entering the river the approximate number of Willamette chinooks taken at sea in recent years is 20 to 25 thousand fish annually.

Recent studies by the Fish Commission and Game Commission have indicated a sport catch of roughly 12,000 spring chinooks annually.

These data are in no case precise but they do indicate that the ocean troll and river sport fisheries are of first importance and that the river commercial fisheries are of minor importance insofar as the fisheries are concerned.

As has been pointed out the spring chinook is the most abundant and most highly prized salmon in the Willamette system. Briefly the situation as regards the other anadromous species is this: The ocean troll fishery

has a definite effect upon the silvers, but not the steelhead. Commercial fisheries in the lower Columbia River during late October and November catch an unknown proportion of silver salmon destined for the Willamette River. The February fishery is too late for silvers, but steelhead are caught to some extent. Sport angling in the lower tributaries of the Willamette, and the Clackamas River in particular, results in small catches of silvers in November and December, and larger catches of steelhead in January, February, and March.

Pollution

Pollution is second, chronologically, to the fishery in affecting the Willamette fish populations, but its present importance may well exceed all other factors.

From Eugene to the Willamette's mouth pollution is choking the life out of aquatic animals that must live in or pass through the main stem of the Willamette River. Studies of this problem were begun about 1929 under the auspices of the Oregon State College Engineering Experiment Station. These studies have clearly shown (1) that the Willamette from Newberg down has been rendered untenable for fish life since 1929 and that the situation is getting more serious, and (2) that acute pollution conditions are extending progressively farther upstream.

Pollutants may affect aquatic life in two different ways. The most commonly noted effect is the reduction of the oxygen content of the water. A second effect involves toxicity; some pollutants simply kill fish directly. Reduction of oxygen content is the more serious in the Willamette and results primarily from dumping pulp mill and cannery wastes and domestic sewage into the river. These substances decompose as time goes on and in so doing they rob the water of its oxygen. Because of the time required for decomposition

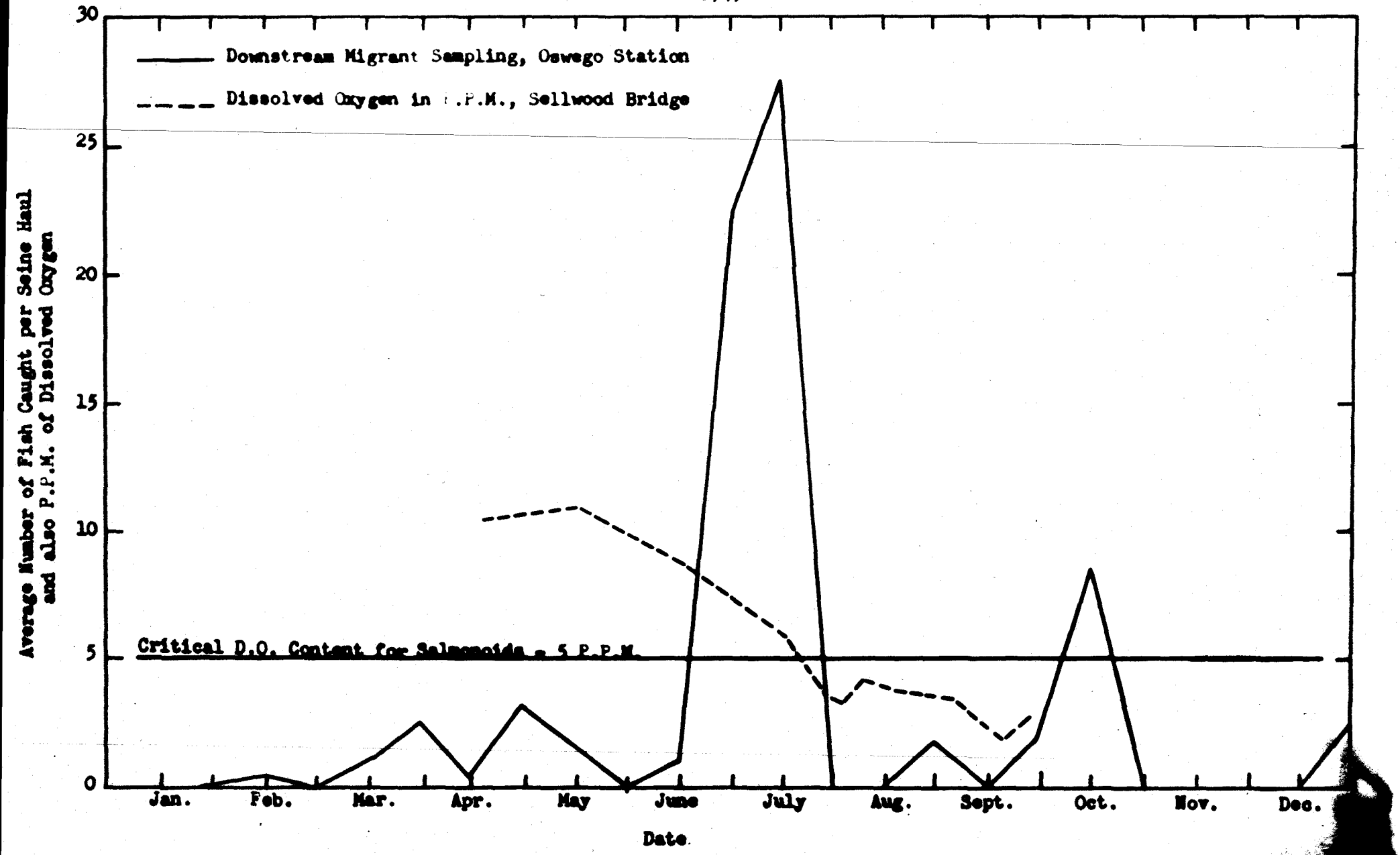
to get well underway the effect of pollutants is most acute some distance downstream from the entry of the waste material. This accounts for the fact that pollution from Salem industries causes the oxygen content to nose-dive in the vicinity of Newberg. The additon of further waste at Newberg, Oregon City, and Portland has resulted in lethal oxygen levels from Newberg to the mouth of the Willamette during the summer and early fall each year. The fall rains seasonally alleviate the pollution problem by diluting the pollutants, but, of course, the animals that must live in the river throughout the year have been virtually wiped out.

Pollution in the Willamette River is unquestionably responsible for the elimination of the fall chinook salmon run. It likewise is responsible for mortalities among the early part of the silver run and the late portion of the spring chinook run. The effects on adult steelhead are unknown, but are probably less.

The effect of pollution on immature downstream migrants must not be overlooked. Studies by the Fish Commission show that a substantial migration of seaward-bound spring chinook salmon continues until the oxygen content in the Willamette drops sharply, after which no more young salmon can be found (Fig. 3). Considering the conditions prevailing, the migration pattern in the Willamette and elsewhere, only one conclusion is possible. Pollution annually closes the door to the summer seaward migrants or wipes out this segment of the young fish, or both.

Pollution has been responsible for much of the fish population declines in such rivers as the Rhine, the Hudson, and the Connecticut. Pollution, alone, can and probably will completely eliminate salmon and steelhead from the Willamette River system within the life span of people living on the Willamette River today unless the present trend is changed.

Figure 3 Results of the Downstream Migration Studies on Spring Chinook Salmon at the Mouth of Oswego Creek with Respect to the Dissolved Oxygen Content in Parts Per Million of the Willamette River at the Sellwood Bridge, Located Six Miles below the Sampling Station.
1949



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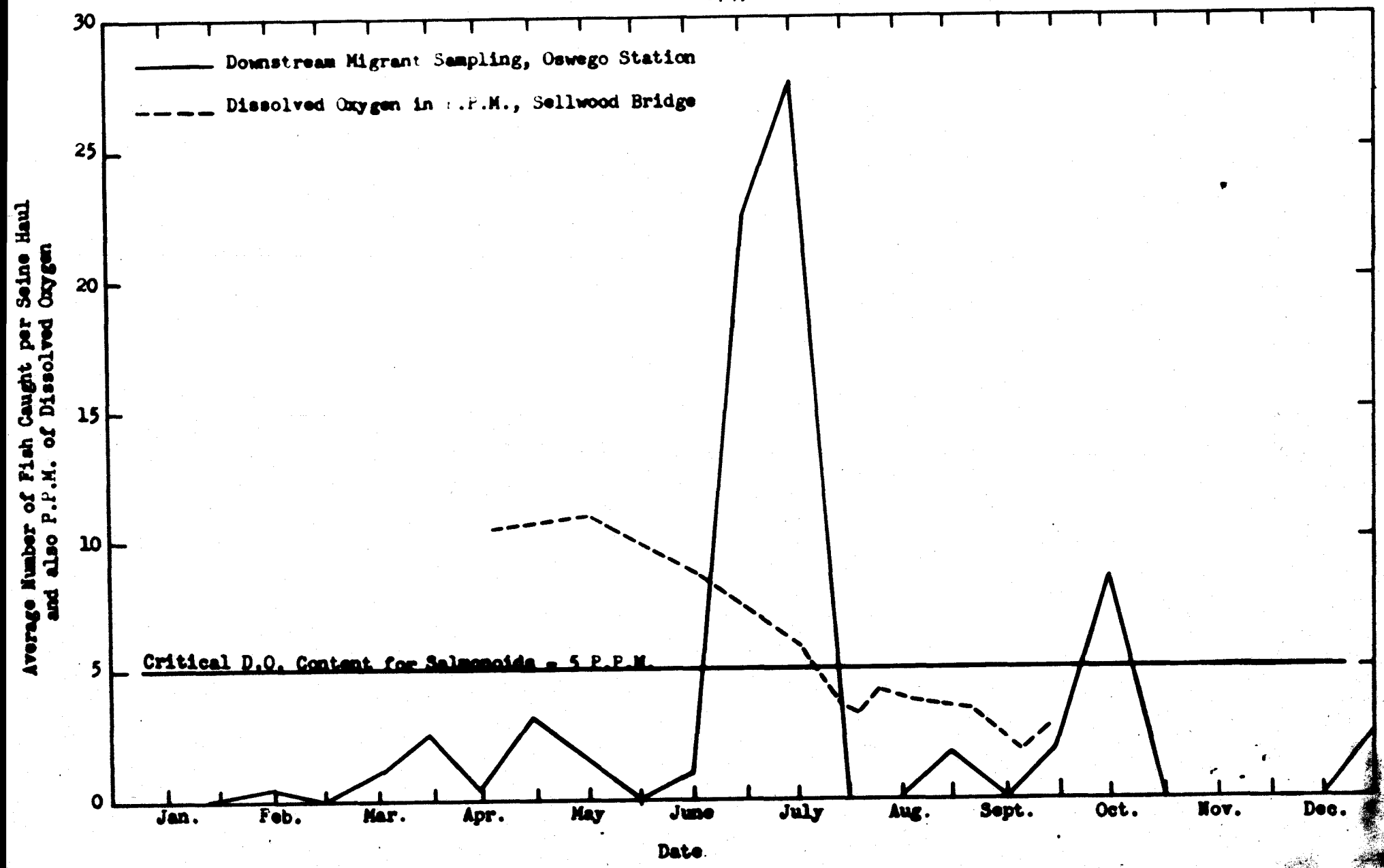


The State Sanitary Authority was organized and activated a number of years ago. Their staff, although competent, is woefully small and their accomplishments have been limited by the recent war. Theirs has been the problem to arrest the trend of ever-increasing pollution loads and reverse it, and in this they have the wholehearted support of the Fish Commission.

This organization is cheered by the assurances of the Sanitary Authority that the Willamette River pollution problem will be solved by the end of 1951. Nevertheless, in all fairness to the people, the resource for which the Fish Commission is responsible, and the Sanitary Authority itself, it should be noted that the pollution problem is not becoming less. The myriads of fish that died because of Willamette River pollution last year are presumably no longer interested in the problem, but the fisheries agencies and the people of the state are very much interested in seeing the Willamette made fit once again for not only fish life, but for recreation and domestic use. If the Sanitary Authority lacks the power or staff to solve the pollution problem this lack must be remedied immediately.

Dams

Without question dams have taken a heavy toll of Willamette salmon. Much damage occurred years ago and chance remarks and paragraphs in old reports reveal the destruction. For example, Cazadero and River Mill dams were built on the Clackamas River several decades ago. When they were built vast numbers of fish were blocked below. Neither of these dams has ever had good fishways and the responsibility for this lies with both the Fish and Game Commissions and the U. S. Fish and Wildlife Service. In spite of the fact that it is known that very heavy mortalities occur among downstream migrants at these structures, absolutely no protection is provided seaward-bound salmon and steelhead. Because of these factors the runs above these

dams have been largely eliminated.

Briefly the overall situation as regards dams is as follows: The best areas in the Clackamas have been rendered unavailable for the major part of the runs. Willamette Falls, which has become virtually a dam, due to industrial developments and alterations in the original cataract, is a constant menace to successful upstream migration. The Molalla River is free from obstructions. The North Santiam River has three low dams in the main channel, two near Stayton and another at Mill City. An estimated 2,000 spring chinooks were blocked for weeks at the upper Stayton Dam in the summer of 1947 and only action by the Fish Commission forced the owner to alter the situation. This dam now has a fishway and the one at Mill City has two. The upper Lebanon diversion dam on the South Santiam River has held up substantial numbers of fish at times. It now has two functional fishways. Wiley Creek Dam on Wiley Creek, tributary to the South Santiam River has a poor fishway. Two dams exist on Thomas Creek, one at Scio and the other at Jordan. The Scio Dam has a good fishway; the one at Jordan Dam is abominable. Plans have been formulated to correct the conditions at Jordan Dam.

The Finley Dam on the Calapooya River, which blocked spring chinooks for 100 years, washed out in 1948 and fish are now partially blocked only at a low dam near Brownsville.

The Leaburg Dam on the McKenzie River holds up salmon migrations, but two fishways make it passable.

The Middle Fork of the Willamette is entirely free of obstructions on its main stem, as is Fall Creek a small tributary used by spring chinook. The North Fork of the Middle Willamette, however, has a dam which in 1946 held up the entire salmon run. A previous dam at the same site had washed out a short time before and the 1946 run was blocked because no fishway was

erected during the construction period. When the new dam was finished in late 1946 a permanent fishway was installed and the runs since then, although delayed because of improper construction of the entrance (now being corrected) have been able to surmount this barrier.

Salmon and steelhead are not abundant in the west side tributaries of the Willamette and only the Tualatin will be mentioned. Dams on the Tualatin include the Oregon Iron and Steel Company dam above the town of Willamette, which diverts water into Oswego Lake, and smaller dams on Gales and Scoggins Creeks. The dam on Gales Creek is equipped with a fishway.

The purposes for the dams are indicated below:

Dam	River	Purpose
River Mill	Clackamas	Power
Cazadero	Clackamas	Power
Willamette Falls	Willamette	Power and pulp mill, etc.
Stayton	North Santiam	Power
Mill City	North Santiam	Power
Lebanon	South Santiam	Power
Wiley Creek	Wiley Creek	Lumber mill
Scio	Thomas Creek	Mill
Jordan	Thomas Creek	Power
Finley	Calapooya	Mill
Brownsville	Calapooya	Mill
Leaburg	McKenzie	Power
Westfir	No. Fork Willamette	Lumber mill

These are by no means all the dams and a complete list would involve several times this amount. This can easily be verified by examining the permits granted to obstruct a stream for irrigation storage, which involves a multitude of small structures, many of which affect fish life.

To this imposing array of dams must be added the immense structures under construction or recommended by the U. S. Army Engineers. According to the original plans, the main McKenzie River was to be dammed below the

Hendricks Bridge at the Nimrod site. Opposition to this proposed project by sportsmen, fisheries, and other organizations caused this dam site to be discarded, and others substituted on three tributaries in the upper McKenzie River. Thus at the present the Cougar Dam will go on the South Fork, the Blue River Dam on Blue River, and the Gate Creek Dam on Gate Creek. These streams are not heavily utilized as spawning and rearing areas. Consequently no serious problem exists on the McKenzie River concerning the dams now proposed. Dams that will vitally affect anadromous fish include Detroit and Big Cliff on the North Santiam (spring chinook and steelhead) of which Detroit is under construction; Green Peter, White Bridge, and Cascadia on the South Santiam (spring chinook and steelhead), which are not yet under construction; and Meridian and Dexter on the Middle Willamette (spring chinook). These structures will block 80 percent of the fish inhabiting the Santiam and Middle Willamette Rivers.

The Fish Commission strenuously opposed the location of these structures so far down on the tributaries and suggested they be placed farther up in order to leave as much spawning areas available as possible. In this the fisheries agencies and other fishing interests stood alone and were opposed--, or, at least, were not supported, to our knowledge--by other agencies, including the Willamette Basin Commission. As a result of this the Fish Commission is faced with the problem of maintaining large salmon runs by artificial propagation, which has not yet proven to be effective with these species. In short, although large investments in hatcheries are being made, several segments of the priceless spring chinook runs are jeopardized.

Gravel Operations

Gravel operations actually remove the materials in which salmon lay their eggs, and reduce the productivity of streams accordingly. In some

cases such operations have blocked streams. A case in point is a deposit of gravel by such an operation across Crabtree Creek, a tributary of the South Santiam River, in the summer of 1946. Gravel operations of considerable magnitude are underway on the Middle Willamette River and Gales Creek, and Crabtree Creek.

Logging

Logging and lumbering have both a direct and indirect effect on the fish populations. The direct effect is obvious when logs are left in streams, bulldozers operate in stream beds, and mill dams block the fish migrations. Examples of jams left by logging can be found on Eagle Creek, the Molalla River, and South Santiam River. Mill dams are in evidence at Westfir, Crabtree, and Gales Creek.

Logging has a profound, though indirect, effect on fish populations by altering run-offs. The general result of heavy logging or forest fires is that the rains run off rapidly into the streams instead of being held in the timber. Consequently the high waters become higher and the low flows lower. In addition, the summer water temperatures tend to be higher in denuded areas.

Diversions

There are literally hundreds of diversions in the Willamette Basin, varying from large canals such as the Walterville Canal on the McKenzie River to innumerable small pipes inserted into the streams for pumping purposes. Permits to divert water are obtainable upon application to the State Engineer and are granted, apparently, without regard to the fish life present, the normal flows in the streams, or previous water diversions. Notices of water-right applications, of which there are roughly 50 per month,

numbers only to suffer severe mortalities, particularly in the Walterville Canal.

In order to remedy this deplorable situation it was deemed fair to require that governmental sub-divisions screen their diversions first. Specifically the Eugene Water Board was directed to screen the Leaburg and Walterville diversions. This they have not yet done.

The City of Corvallis intends to divert water from the Willamette River in amounts up to four million gallons per day, and their preliminary plans indicate an entirely inadequate screen. A problem, therefore, is arising with that governmental sub-division.

The draft tubes of power dams at Willamette Falls and River Mill are unscreened.

The major diversions take a maximum of 80 to almost 100 percent of the stream flows where they are situated, and the cumulative amount of water involved in the minor diversions is astounding.

The question immediately arises, "Why has so little been done?" The reasons are manifold. In the first place screening of draft tubes is, at this time, well-nigh impossible. Screening of large diversions is expensive. The screening of small diversions involves extensive patrol, for they are very numerous. In spite of all these factors the diversions must be screened. The Game Commission has, by informal arrangement, assumed the duty of screening in Oregon. This set-up has worked to the advantage of the taxpayer in that the screens installed under authority of the previously mentioned 1945 law are all built at one well-equipped plant. It has not yet worked to the benefit of the fish in all areas because the screening has by no means caught up with the diversions.

Flood Control Program

Mention has already been made of the major Willamette flood control dams. The program also involves revetments, dikes, dredging, channel straightening, etc. It is impractical to discuss all aspects of the program; they have been covered in a report of the Oregon Fish Commission and the Game Commission dated March 1, 1948. Nevertheless, certain salient features must be reviewed.

Storage of water in the spring of the year in the various Willamette tributaries will reduce spring flows at Willamette Falls, which, within certain flow limits, will tend to make it more difficult for salmon to ascend the falls. Under low flow conditions salmon are sidetracked away from the fishways by the attraction from the power plants. Should storage procedures result in low flows during the height of the salmon runs a serious delay and mortality of salmon may occur. This is a very real danger and the addition of two fishways as suggested by the fisheries agencies and now planned by the Corps of Engineers at Willamette Falls will materially help in safeguarding the runs.

One additional factor must be mentioned before dropping the discussion of this huge project and the factor is stream flows and the rapidity with which changes in flow occur. From June through September the adult Willamette spring chinooks must lie below the dams encountered while waiting to spawn, and during the entire year the young are present. Likewise equipment to take the eggs of blocked salmon (100 percent of the fish now go above the dam sites in some places) must be maintained and utilized. The crux of this matter is that the flows and consequently the fish are dependent upon, and at the mercy of, the man who controls the valves in the dams. There is every reason to believe that adjustments deleterious to anadromous fish will

be made in the operations of these dams. Evidence of this danger may be found in Appendix H of the U. S. Engineer's Willamette Report, particularly Table 3. It can be seen that the plans called for maximum variation of discharges from Meridian Dam from zero to 16,000 cubic feet per second. Immediate reductions from 13,000 to zero cubic feet per second would occur in flood regulation. Such shifts in flow will be disastrous to fish life. Likewise high summer flows may make spawn taking operations difficult.

The administrative distance between fisheries personnel working on the river and the Army Engineer personnel in charge of the Willamette project is too great to expect that adjustments in flow in behalf of fish life will be made. While the dams have obviously been constructed in the interest of power, flood control, irrigation, navigation, etc., it is to be hoped that some means for adjusting flows in behalf of fish life can be found. In the meantime the fate of the Willamette salmon populations hangs in the balance.

Hatcheries and their Uses

Hatcheries have long been used to bolster and assist in the maintenance of the Willamette River spring chinook salmon. Salmon hatcheries are now located on the four main salmon producing tributaties of the Willamette River: the North Santiam; the South Santiam; the McKenzie; and the Middle Willamette. There is also a small establishment operated by the Fish and Wildlife Service on the Clackamas River. These hatcheries have been maintained first by the old Fish and Game Commission and since 1921 by the Fish Commission.

The hatcheries during this period have taken each year a relatively small but important portion of the Willamette River spring chinook for artificial propagation. Figures 4 and 5 show the trend of egg takes in each hatchery. It is easy to observe that the hatchery egg take has been

Figure 4 Egg Collections of Willamette River Spring Chinook Salmon at Oregon Fish Commission Hatcheries, 1918 to 1949.

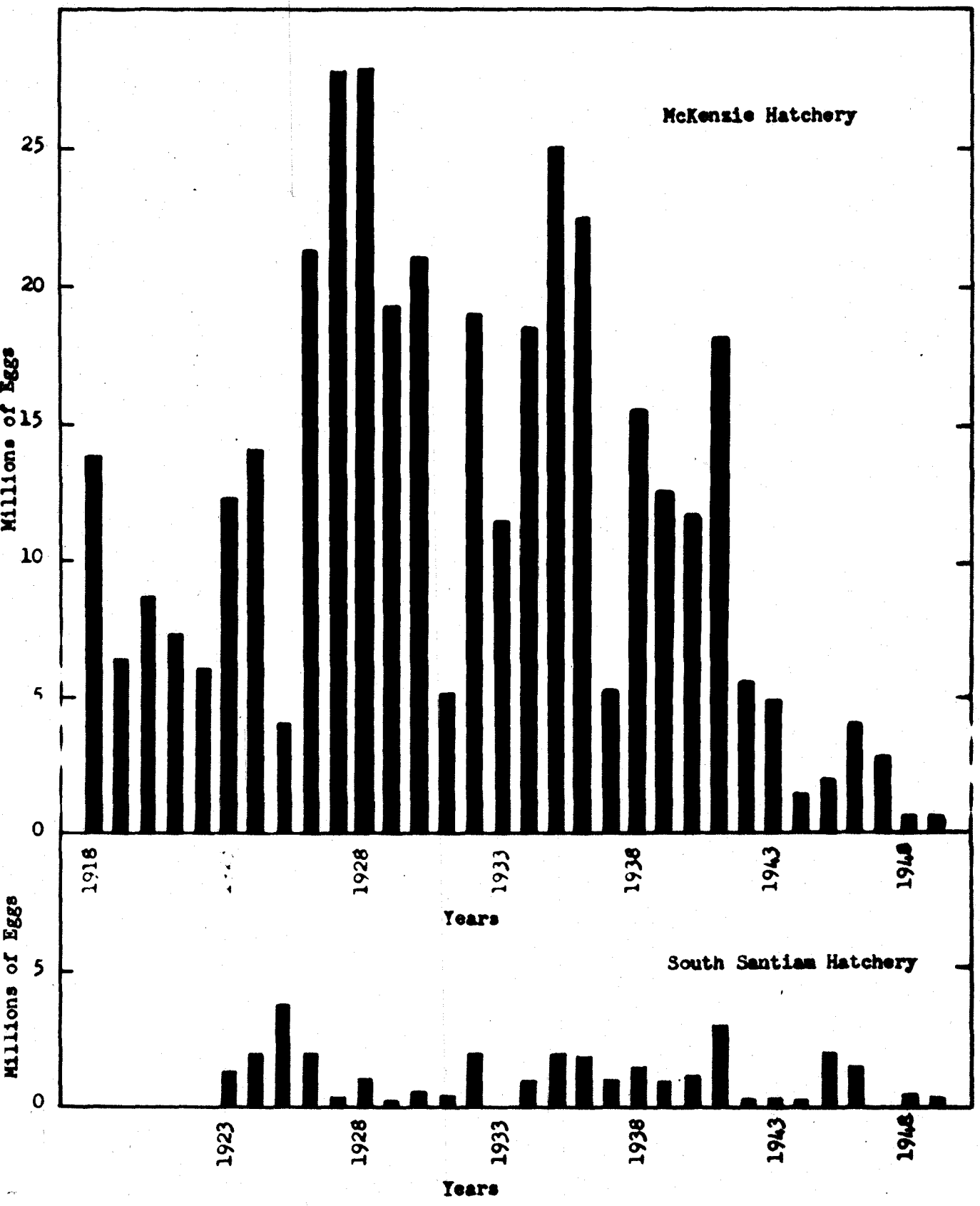
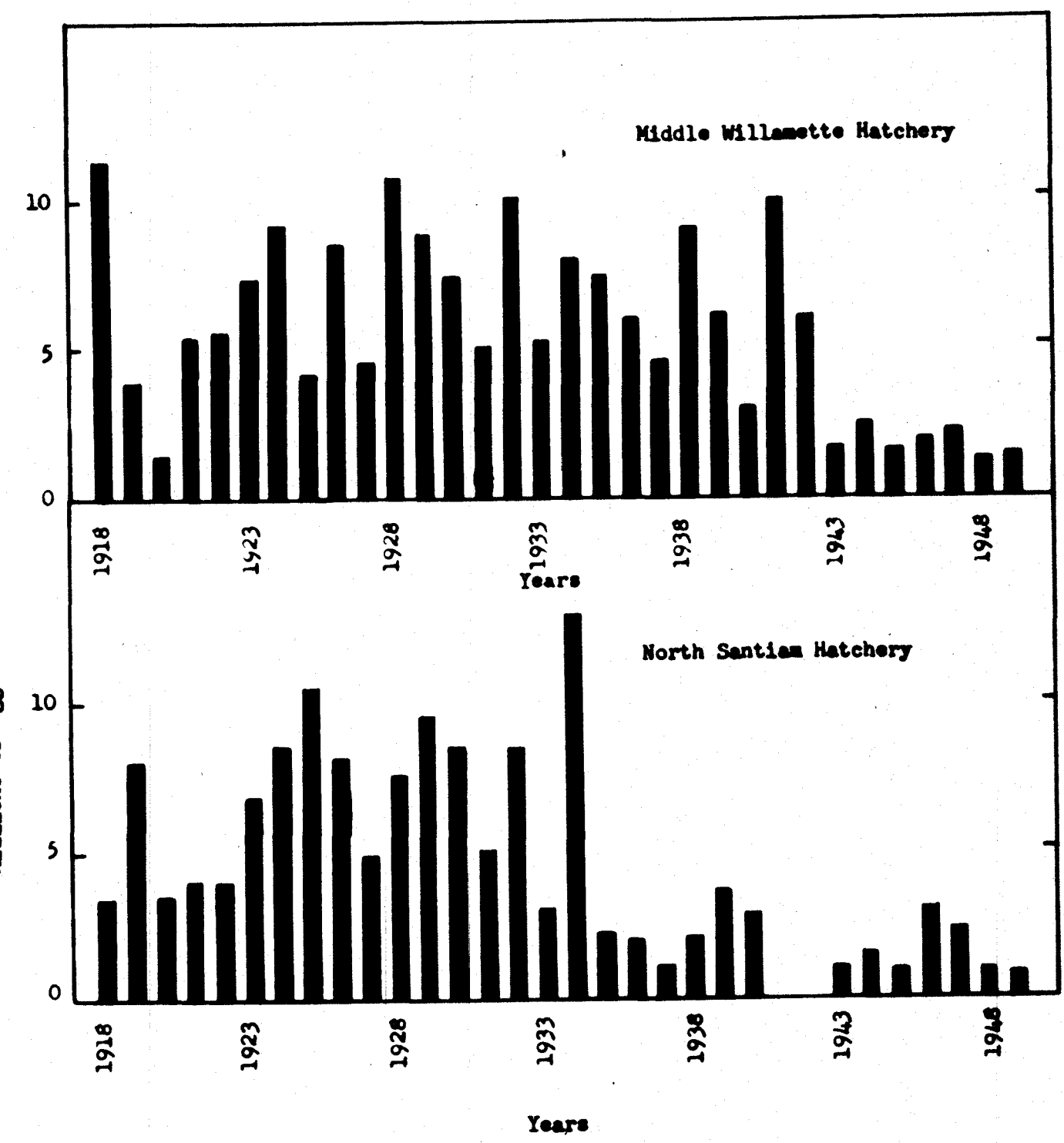


Figure 5 Egg Collections of Willamette River Spring Chinook Salmon at Oregon Fish Commission Hatcheries, 1918 to 1949.



declining and to a degree this depicts the general decline of the Willamette River spring chinook populations. Only the general situation is revealed by these egg-takes since the take in any one year may have been affected by floods, which occasionally washed out racks. In recent years only part of the eggs available have been taken, as many adults have purposely been permitted to go on up to spawn naturally.

As was the case throughout the Pacific Coast during past years, large quantities of eggs were taken at the hatcheries and were either planted as eyed eggs, or very young fry and fingerlings, or were transferred to other hatcheries. Recent advances in hatchery management studies have shown that the best results from hatchery planted fingerling salmon are obtained when the young are planted in their native streams. Exotic stocks unless planted only after careful study usually do not contribute significantly to the increase in the runs in their new environment. Now, whenever it is necessary to transfer runs--unless the two rivers are closely adjacent and environmental conditions very similar--experimental lots are transferred and marked by excising two of the small fins and can be recognized when they return as adults.

Spring chinook salmon are the most difficult of all salmon to rear successfully in hatcheries for several reasons. First, their food requirements are complex and not well understood; second, the early life history of these fish is such that the best survival--according to present data--of the fish occurs if the young are reared for over one year before liberation. Third, the young fingerling are subjected to various diseases that reduce the output of fish during years of heavy infestations.

With the future prospect of having large, impassable dams on every one of our large salmon streams in the Willamette River system, the future

of the anadromous fish populations will depend largely upon artificial propagation. The Detroit Dam construction on the North Santiam has reached the stage where no more salmonoids will be able to ascend beyond this structure. Consequently the spring chinook salmon and steelhead trout will have to be intercepted this spring at some suitable point below the dam and held until ripe for spawning. As over half of the salmonoids ordinarly spawn above the point of interception, the facilities of the Oregon Fish Commission salmon hatchery at Mehama would be far from adequate. Therefore a large new hatchery is now under construction at Marion Forks, where a suitable supply of water is available, and this station will then provide the necessary facilities for the artificial propagation of both the spring chinook salmon and the steelhead trout. Liberation of fish will be below the Detroit Dam as this station is located nearly 25 miles above the dam.

The Middle Willamette hatchery will be enlarged to handle approximately 95 percent of the spring chinook in that stream, where the Meridian Dam is now under construction. The South Santiam station located above Foster will have to be relocated and enlarged for the propagation of spring chinook salmon and steelhead trout denied ancestral spawning areas by the Green Peter and White Bridge dams on the Middle Santiam River, the Cascadia Dam on the main South Santiam River, and the Wiley Creek Dam on Wiley Creek. Nearly all of the spawning areas of the South Santiam River will be eliminated from production by these dams. The McKenzie River will have three dams that would affect a small fraction of the now utilized spawning areas, but fortunately the bulk of the salmon are taken by the McKenzie salmon hatchery at Leaburg, or spawn naturally in the lower areas of the river.

These hatcheries, although enlarged many times as in some cases, may not be able to successfully propagate the anadromous fish present in the respective streams because of several limiting factors. The first and foremost problem is that of food, can sufficient and adequate diets be provided for the young fish; second, can the liberated fish migrate to the ocean through the polluted areas of the Willamette River and its tributaries without excessive losses; and third, will unscreened diversions and power station intakes reduce the numbers of migrants below the level necessary to maintain the present level of abundance?

Program and Results

The program of investigation on the Willamette River has several phases, each of which will be briefly explained and what has been accomplished. Except for the hatchery program of artificial propagation, these efforts have been instigated since the establishment of the research division during the fall of 1945.

Beginning with the oldest program, that of hatcheries, there have been three stations in continuous operation since 1918, and a fourth since 1923. Despite the efforts of these hatcheries during the past years, there has been a very definite decline in the annual egg collections made. In order to improve the efficiency of these stations, an experimental diet study is now being conducted on Willamette River spring chinook yearlings at the Bonneville hatchery, and it is believed that with better diets, larger and healthier fish with a higher survival rate can be released in future years from the salmon hatcheries. Other hatchery practices have been examined, and, as has been mentioned, it is now thought that the indiscriminant transfer of eggs and fingerling from one river system to

The North Santiam River diversion dams have been responsible for the delaying of innumerable fish from reaching their spawning areas. Within the last few years four new fishways have been completed at three dams on this river. New fish ladders have also been erected at Scio on Thomas Creek, Eagle Creek on the Clackamas, and Westfir on the Middle Willamette River.

For a number of years spring chinook salmon were permitted to enter the lower section of the Walterville Canal, and losses of these fish during the summer holding period were great due to the lack of adequate holding pools. In 1947 the mouth of this canal was closed by a wooden rack at the suggestion of the Fish Commission, and no fish were able to enter. Immediately the losses (amounting to nearly 2,000 fish in 1946) were reduced to practically zero, and the saving of many millions of eggs was thus accomplished.

Migration studies of the seaward movement of young fingerling and yearling in the lower Willamette River below Oregon City have shown that the fish begin moving down the rivers in great numbers during the months of March, April, and May, and sometimes continuing into June (Fig. 3). No appreciable migration has occurred during July, August, and September, when the pollution in the main river is so great that the dissolved oxygen content is lowered below the critical level for salmonoids of five parts per million. Some migrations have been found to occur in October, and November, but little or none in December, January, and February.

Scale studies of both young and adult spring chinook salmon have indicated that the most fish have spent a number of months in this freshwater habitat prior to moving seaward. So far no case has been found where the surviving adults had passed to the ocean without some growth occurring in fresh water. These studies combined with the marking and liberation

experiments, will be valuable in determing the most appropriate time for the release of young fish from hatcheries in order to obtain the most favorable survival rate and yet be economically feasible.

Summary

The anadromous fish populations within the Willamette River system have suffered consistent declines since the industrialization of this valley was begun. The major factors contributing to these declines are the following: overfishing, dams, water diversions, and pollution. In general the lack of wise planning and a coordinated program of water use has been the major cause for the decline of the fisheries.

The entire population of fall chinook salmon has been completely eliminated from this river system. The spring chinook salmon have been reduced 80 percent within the last 15 years, the silver salmon have suffered a very noticeable downward trend, and the steelhead trout have been reduced in abundance.

The earliest cause of a decline in these fish populations was due to overfishing by commercial fishermen. However, the spring chinook salmon, the most abundant salmon, has been protected for several score years by a closed season on the lower Columbia River and the fishery within the Willamette has been eliminated completely. The silver salmon and steelhead trout still are subjected to the fishery in the Columbia River. In recent years this factor has been completely over-shadowed by several other causes of decline.

Pollution became a problem as early as the mid 1920's when the fall chinook salmon were prevented from reaching their spawning areas within the Clackamas River. Each year pollution has increased and spread farther and farther along the main stem and some of the tributaries, until now the

main river from Newberg to the mouth is unsuitable for salmonoid fish during the mid-summer low water flow period.

Dams of the past have been responsible for the loss of natural spawning areas, but previous losses are minute compared to the future losses to be caused by the new multiple purpose dams to be constructed. Hatcheries are being planned to substitute for the natural spawning areas, but they certainly are only a partial replacement.

Power and irrigation installations have and are continuing to exact a toll upon the downstream migrating young fish. Until these diversions are properly screened, they will continue to eliminate innumerable migrants that otherwise might have survived to maturity.

Very recently considerable progress has been made and some of the contributing factors causing losses to both young and old fish migrants have been eliminated.

Research into the life history of the salmon has indicated that larger and older fish released from hatcheries probably will result in greater returns. Diet studies now being made may improve the stocks of hatchery fish to be released in the future. Migration studies have shown that the greatest seaward movement generally occurs during late March, April, May, and early June. Pollution is unquestionably responsible for the complete lack of migration during the low water flows in summer. Some migration occurs during the fall months, but virtually none in the winter.

The annual sport fishery census on the lower Willamette River provides a fairly accurate record of the spring chinook catch each spring. The magnitudes of the annual catches since 1946 have been as follows: 12,300; 12,000; 8,300; and 9,100 fish.

Migration of the spring chinook salmon through the Willamette Falls fishway at Oregon City is a reliable indication of the escapement of fish to the spawning areas above. The calculated migrations since 1946 have been 55,000; 45,000; 30,000; and 27,000 spring chinook salmon. The only river with spring chinook salmon below Willamette Falls is the Clackamas River.

By combining the annual sport fishery catch, the fishway counts, and the Clackamas River escapement, a reliable estimate of the spring chinook escapement into the Willamette River is thus available. Since 1946 the annual runs of these fish have been as follows: 75,000; 60,000; 40,000; and 38,000.

The work of the Oregon Fish Commission within the past few years should begin showing results by better adult escapements into the Willamette River system. Nevertheless pollution within the last few years, and construction now under way may nullify some of the increases that might have been expected.

Recommendations

1. All possible legal, legislative, and technical support must be provided to make possible the enforcement of the order made by the Oregon State Sanitary Authority that industrial and domestic pollution be eliminated to the satisfaction of the Authority before December 31, 1951. The greatest and most immediate threat to all migratory salmon and steelhead populations in the Willamette River system is pollution. Efforts within the past few years and those now being made to improve the salmon runs may be seriously imperiled and possibly nullified by pollution unless it is corrected.

2. With large dams, such as the Meridian and Detroit structures, now being constructed the migratory fish enroute to their natural spawning areas above these structures must be prevented from reaching these impassable

barriers by racks, and held until sexually mature and spawned by artificial means. In order to prevent undue losses to fish concentrations below these dams, the water release schedules at these structures should provide for suitable flows, temperatures, and other conditions necessary for the success of the holding and spawning operations.

3. An operating manual involving all procedures affecting water temperatures and water flows at the large Federal dams now in existence or proposed should be designed and should be both available to, and satisfactory to, the Fish Commission and Game Commission.

4. The four large dams to be erected on the South Santiam River will eliminate approximately 90 percent of the spawning areas. It is recommended that the Cascadia and Wiley Creek damsites be utilized prior to the Green Peter and White Bridge sites; the latter two sites are on the lower Middle Santiam River, which has, by far, the most suitable spawning and rearing areas available within the entire South Santiam River system.

5. The construction of the proposed Willamette Falls fishways within the immediate future is recommended. Additional fishways would be of great benefit to the anadromous fish inhabiting this river. The present fishway cannot be adjusted during high water flows, and, because of heavy flows emanating from the mills and power plants, fish tend to be attracted away from the fishway entrance during low flows.

6. The state law requiring the screening of all water diversion inlets should be strictly enforced. Countless numbers of fry, fingerling, or yearling salmon, steelhead, and other fish are lost each year due to the complete lack, or inadequate screening of innumerable water diversions in the State of Oregon. Therefore, before any water could be diverted, a suitable screening device should be required at a diversion.

7. Selective logging practices and the removal of logging debris from streams should be carried out in all operations located in this state.