FISH COMMISSION RESEARCH BRIEFS

FISH COMMISSION OF OREGON
510 GOVERNOR 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 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 Fish Commission office.

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Fish Commission of Oregon
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PRESENT STATE OF THE BAY CLAMS OF OREGON

Introduction

A number of species of clams are present along the Oregon Coast. On the exposed outer coast the razor clam is the most important, followed by the rockboring clams, or rock oysters. In most areas of the Oregon Coast,

TABLE 1
IMPORTANT CLAMS OF OREGON

Most Widely Used Common Name	Other Local Names	Scientific Name	Identifying Characteristics
BAY CLAMS:			
Cockle	Cockerel	*Cardium corbis*	Very prominent raised rounded ridges radiating from apex of shell; scalloped appearance at edge. Length about 3 inches.
Horse clam	Empire, horse-neck, blue-neck, blue, gaper, quahog.	*Schizothaerus nuttallii.*	Large size with pronounced opening at end of shell. A long neck present which cannot be entirely withdrawn into shell. Shell covered with thin brown covering which tends to peel off. Length 4 to 6 inches.
Soft-shell clam	Eastern, mud, blue	*Mya arenaria*	Elongated shape, white chalky shell more or less covered towards the edges with a brown or black covering. Long neck which can be withdrawn into the shell. Length 3 to 4½ inches.
Butter clam	Washington, quahog, Coney Island, New York, rock.	*Saxidomus giganteus.*	Thick hard shell with concentric lines parallel to the edge of the shell; no radiating lines. Length 3 to 5 inches.
Little-neck clam	Rock, butter	*Venerupis (Paphia) staminea.*	Lines radiating from top center of shell as well as concentric lines, giving a criss-cross appearance. Length 2 to 3 inches.
OCEAN BEACH CLAMS:			
Razor clam	Razor-back	*Siliqua patula*	Oblong shape with yellow, smooth, leathery-like outer covering and found primarily on open ocean beaches.
Rock borers	Rock oysters, piddock	*Zirphaea gabbi, Pholadidea sp.*	Siphon end elongated, opposite end rounded with rasp-like projection. Found buried in sandstone rocks and hard clay on ocean beaches.

however, it is within the respective bays and river mouths where the important clam fisheries are concentrated. Some of these bay clams are also found on the outer coast but very seldom in any numbers. In the summer of 1947 the Fish Commission of Oregon began a study of edible clams of Oregon to determine what measures would be required to permit the greatest possible utilization of this resource without endangering the existing supply.

There are five important species of edible bay clams in the state with numerous others present as incidental forms. The important species which are shown on Plates 1 and 2 are listed in Table 1.

Table 2 gives the relative abundance of clams for many of the Oregon bays as far as has been determined at the present time. A blank space indicates the clam is not known to be present in any appreciable numbers in that area. The number of X's indicates abundance (i. e., XXX, very abundant; X, present, but not abundant).

TABLE 2

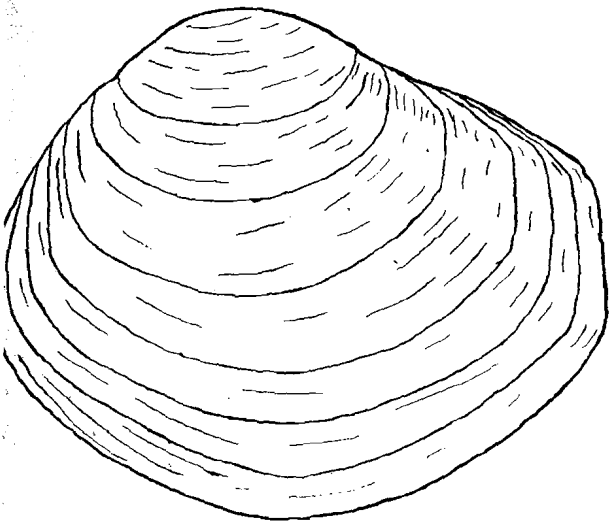
MAJOR SPECIES OF CLAMS OCCURRING IN CERTAIN OREGON BAYS AND THEIR RELATIVE ABUNDANCE

	Cockle	Horse Clam	Soft-Shell	Butter Clam	Little-Neck
Nehalem			XX		
Tillamook	XXX	XXX	XX	X	X
Netarts	XXX	XXX		XX	X
Nestucca			XX		
Salmon			X		
Siletz	X	X			
Yaquina	XXX	XXX	XX		X
Alsea	X	X	XX		
Umpqua			XXX		
Coos Bay	XX	XXX	X	X	X

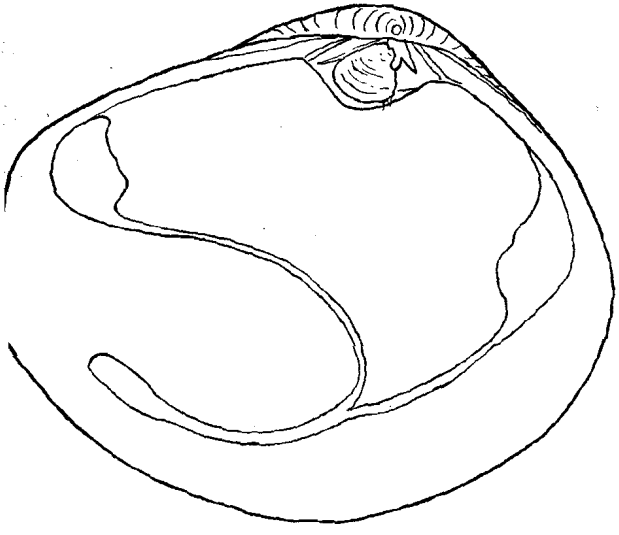
In general the magnitude of the clam beds are directly proportional to the size of the respective bays since most of the tidelands are suitable for at least one of these clams. Cockles tend to predominate on the more sandy areas. Soft-shell clams are found in the higher muddy areas where the water is less saline. Horse clams are best suited to the intermediate sandy-mud flats. The butter clams and little-necks are also found here, but are usually more abundant in more gravelly formations.

Clam Fishery

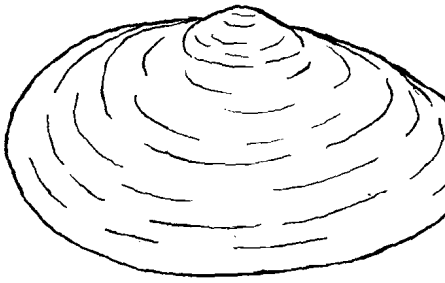
The cockle and horse clam are the only two dug commercially at the present time. Large quantities of cockles are dug for crab bait, this being the main bait used by both commercial and sport bay crabbers. Cockles are also used to a limited extent by some of the outside crab fishermen. A minor quantity is sold to sportsmen as bait for bay, jetty, and surf fishing. Considerable amounts are sold for human consumption. Substantial numbers of horse clams are dug and sold for human use and soft-shells may be dug commercially when they can be obtained in large quantities. The majority of the cockles taken for crab bait (this being the only bay clam permitted to be used as such) are dug personally by the crab fishermen using them, while the clams dug and sold for human consumption are sold by the commercial diggers in small lots directly to local restaurants, meat markets,



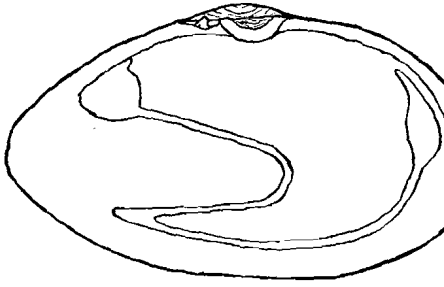
(a) Outside View of Horse Clam Shell



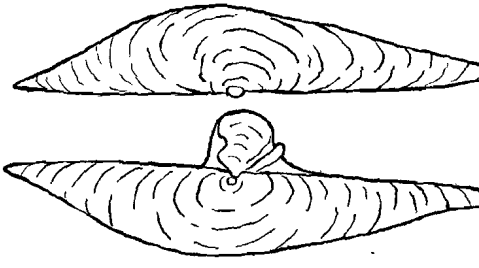
(b) Inside View of Horse Clam Shell



(c) Outside View of Soft-Shell Clam Sl

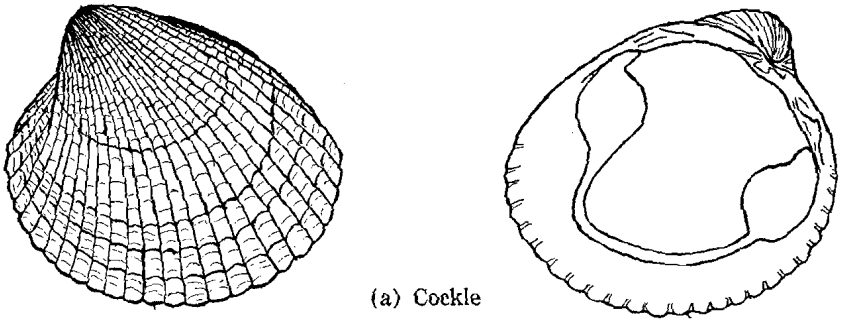


(d) Inside View of Soft-shell

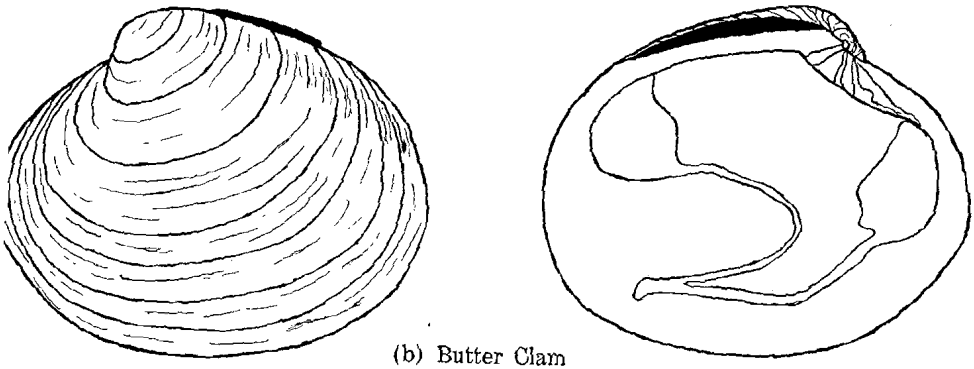


(e) Top View Showing Prominent Shelf-li
Protrusion near the Hinge of Left Valv

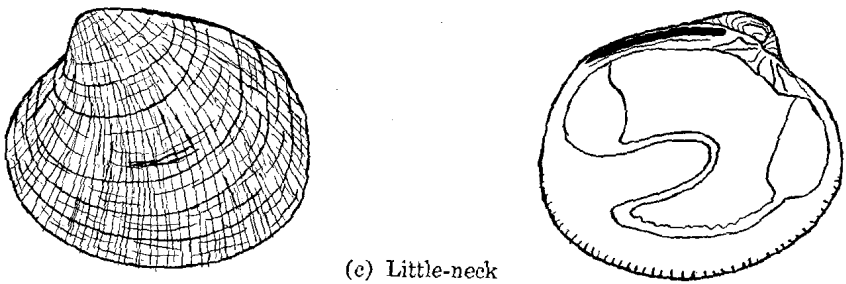
PLATE 1 DIAGRAMS OF HORSE CLAMS AND SOFT-SHELL CLAMS



(a) Cockle



(b) Butter Clam



(c) Little-neck

ATE 2 SHELL DIAGRAMS OF THE COCKLE, BUTTER, AND LITTLE-NECK CLAMS FOUND IN BAYS ALONG THE OREGON COAST

etc. Due to the nature of this commercial clam fishery and the fact that the diggers have not been required to report their take according to species, it has been almost impossible to obtain any accurate figures on the total take of clams.

A very large and active sport fishery exists on these bay clams. To obtain figures on the take by both sport and commercial diggers, an intensive census was run on the main tide flats of Yaquina Bay during the low tide series of July 14 through July 23, 1947. Counts (estimates made in some cases where necessary) on both number of diggers and take of clams for the main six days of the series gave the results shown in Table 3.

TABLE 3

CALCULATED TAKE OF CLAMS IN YAQUINA BAY, JULY 17–23, 1947

	Total Number of Diggers (man tides)*	Total Take in Pounds		Grand Total in Pounds
		Horse Clams	Cockles†	
Commercial	45	1,100	5,500	6,600
Non-commercial	990	5,400	16,500	21,900
Total—All diggers	1,035	6,500	22,000	28,500

It is seen that the take of clams is considerable. Although on this series of tides the non-commercial take was three to five times that taken by commercial diggers, it is not believed that the yearly take for each group follows these proportions. This is occasioned by the fact that most of the non-commercial digging is done in the summer while the commercial take is comparatively consistent the year around. Clamming is carried out on virtually every one of the twenty-four low tidal cycles in the year, but to a considerably smaller extent during the winter night tides and the neap series of each month. Even when conservatively figured the take of clams in the Oregon bays is very large, running well into the hundreds of thousands of pounds.

Apparent Trends in Populations

The effect of such intensive digging on the horse clam populations is readily seen. In Tillamook Bay the most heavily dug area is out from Bay Ocean, due primarily to its accessibility. Here, the total numbers of clams present are strikingly less than in the other more remote areas of the bay. The population present is composed almost entirely of young clams which are removed about as fast as they grow large enough to enter the fishery. On the south side of Yaquina Bay in the area of heaviest digging the horse clams are also very few in numbers while the more inaccessible, less dug area on the north side, while still supporting a fair population, is apparently also on the decline. Studies on the clams made at intervals since June, 1947 show a decided reduction in size following the heaviest summer digging. Since that time (to July 1948), the size of the clams has remained small. The area along the east side of the lower portion of Coos Bay in the vicinity of Empire also has been dug out to a considerable extent. Here again, the

* Equivalent number of diggers if all clams had been dug on one tide only.
† Includes small numbers of little-neck and butter clams.

great bulk of the population consists of small, young clams. In all other areas visited where horse clams are found, the common complaint encountered is that the clams are less abundant than they used to be. Since isolated, little-dug areas in the larger bays have been found to support comparatively heavy populations of much larger, older clams, this decline is attributed entirely to over-digging.

Evidence indicates the same trend occurring for the eastern soft-shell clams. In the Nestucca and Salmon Bays, for example, where the grounds are easily reached the clams are very scarce. In the Nehalem and Umpqua Bays where it is necessary to go by boat to reach the beds the soft-shells are still numerous. However, there may well be some other phenomenon, such as silting, also acting as a limiting factor on this clam since some areas have been found in Alsea and Yaquina Bays which are known to be little dug but still have very small clam populations. Large numbers of dead shells are found indicating general suitability of the areas but probable periodic or occasional kills from outside causes.

It is not believed that there ever have been any great concentrations of butter clams but without question there are less now. For example, at the present time they are seldom found in Yaquina, in only a few small spots in Tillamook, and in localized areas of Netarts. In the heavily dug portions of Coos Bay those found are again predominately small, young clams indicating an advanced state of decline existing in these areas. The little-neck clam is sparsely, though rather uniformly, distributed in most areas suitable for its growth. It is seldom sought after or dug for specifically, and its present state probably represents its normal level of abundance. The cockle alone seems to show evidence of maintaining itself under current intensive digging.

Problems in Management

The first task facing the Fish Commission in the proper management of this fishery is a comprehensive survey of the present clam stocks in all areas. Considerable data have been gathered to date, and it is expected that by the end of the summer (1948) this survey will be completed. The second problem is a matter of determining as closely as possible the take of clams in each area. The records of the commercial diggers turned in to the Commission are being analyzed, and studies such as that made for the Yaquina, July, 1947 are being continued and have been started in the other main clam producing areas. This, together with continuous surveys of the stocks, will show any changes in abundance of the clams and probably the effect of digging.

To obtain maximum production it will not only be necessary to regulate the total take of clams but also to restrict this take to the seasons when the clams yield the maximum food. In the case of the horse clam, regulation of the season is very important since it has been found that following spawning in February and March the clams yield approximately one-half the normal amount of meat due to their poor condition at that time. Accordingly, considerable work has been and is being done to determine exactly at what times these clams should be dug. Similar studies are being made for the other species. In the case of the hard-shelled clams where regulation might be practical, the matter of proper size for harvesting is being investigated. It is also necessary to determine the age of the clams in order that the annual growth may be found. A slow growing clam such as the horse clam will require different management than a fast growing type such as the cockle.

Another problem is that of the granting of oyster leases on state lands which remove that much more clam land from public use. However, within reason such leases do serve an important function by providing clam reserves which guarantee adequate spawning stocks for the bay. This is a problem requiring careful analysis to provide fair distribution of the land resources.

The findings of these investigations will form the basis of management policies. These will be placed in operation as rapidly as data become available.

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Fish Commission of Oregon

Shad Caught at Celilo Falls on the Columbia River

Indians at Celilo Falls reported that during the early part of the 1948 spring season considerable amounts of shad were caught in dip nets. Sometimes as much as 600 pounds daily were taken by a single net. As the season progressed, however, fewer shad were caught. Only an occasional fish was caught in late July and early August.

Chinook Salmon Found Ripe in Spring of Year

On April 30, 1948 some Indian dip net landings of salmon were sampled at the Columbia River Packers Association's buying station at Spearfish, which is located about five miles above The Dalles on the Washington shore of the Columbia River. One female chinook about 35 inches long was examined and found to be mature. Upon slight pressure on the belly, ripe eggs flowed freely. The fish was in good condition with no marks or bruises, but was darker in color than most of the other fish sampled. This is highly unusual as the earliest known spawning of chinook salmon on the Columbia River is in July.

Herring Spawning

A heavy spawning of Pacific herring occurred in many of the Oregon bays the latter part of February and first of March, 1948. In Yaquina Bay the peak came on February 28, and at approximately the same time in Tillamook Bay. Boat bottoms, piling, floats, etc. were coated with from one layer of eggs up to deposits of one-half inch in thickness. The tidal range for deposition of the eggs ranged from a plus five feet to an undetermined minus level. The eggs hatched in about a week depending upon the tide level, the higher ones hatching first. For some time following, the larvae were consistantly found in plankton samples.

OREGON PILCHARD FISHERY

The Oregon fishery for pilchards *(Sardinops caerulea)* began in 1935 when the state laws were changed to permit the use of pilchards for reduction purposes. In 1935 four plants were established at Coos Bay and three at Astoria. Over twenty-six thousand tons of pilchard were taken the first summer of operation, 62 per cent of the catch being landed at Coos Bay and the remainder at Astoria. This proved to be a record catch which has not been equalled since.

In 1936, 54 per cent of the catch was landed at Coos Bay and the remainder at Astoria, except for a few tons landed in Reedsport. By 1939 the Coos Bay catch had declined to an insignificant amount of the total

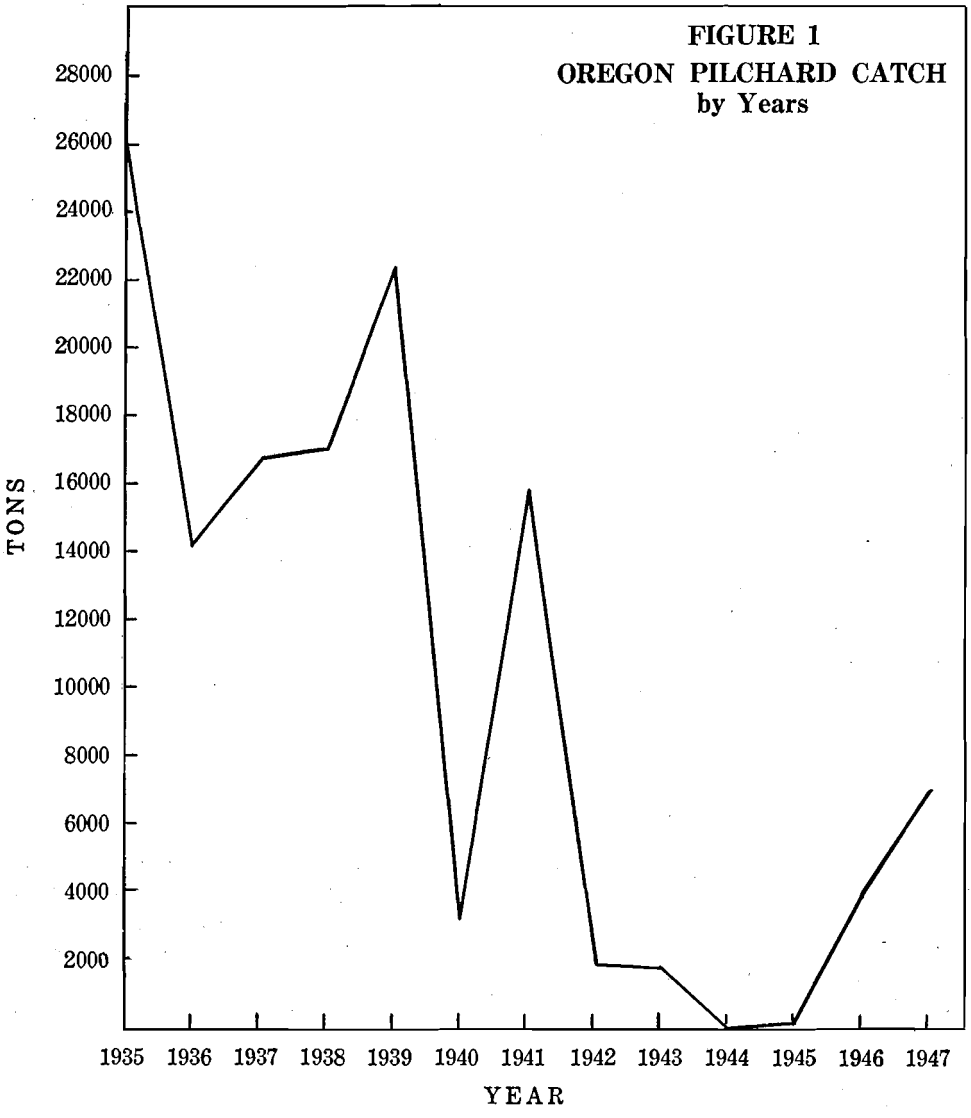


FIGURE 1
OREGON PILCHARD CATCH
by Years

and in 1940 all of the pilchard plants were located in the Astoria vicinity. Since that time all of the Oregon landings have been made in the vicinity of Astoria.

In the early years of the fishery, pilchards were taken off southern Oregon to supply the plants in that region. Since 1937, however, very few pilchards have been caught in this southern region. In recent years much of the catch has been made close to the Columbia River.

The yearly pilchard catch in Oregon through 1947 is shown in Figure 1. A general decline is evident, reaching the lowest point in 1944 when no pilchards were landed in the state. Since then the catch has increased somewhat, but in 1947 it was still less than one third that of 1935.

During the first year of operation, the pilchard season extended over a period of six months, from June into November. Since then the season has been somewhat shorter. August has almost always been the peak month, with good catches occasionally being made in July and September.

The age composition of the pilchard catch in Oregon for 1940 is indicated in Figure 2 by dotted lines. The age readings were made by the California Fish and Game Department and Fish and Wildlife Service. The majority of the fish were four years old. The solid line shows the age composition of the Oregon catch for the year 1947. A striking change is at once apparent, the catch in the latter year consisting of a greater portion of older fish. In 1940 about 29 per cent of the catch was six years or older while in 1947 approximately 59 per cent of the catch was six years or older. The fish originating from the 1939 and 1940 spawning contributed a much greater percentage to the 1947 catch than would normally be expected, while the contribution of the 1943 and 1944 year classes was far below normal. This indicates that the spawning success of the pilchards has been very poor in recent years, and that the present fishery in Oregon is dependent on the older year classes. This also seems to indicate that there is little hope for a successful pilchard season in Oregon until there is again an abundance of the younger age groups. In fact, as the older, more abundant age groups leave the fishery, it seems likely that there will be a further decline in the Oregon pilchard fishery.

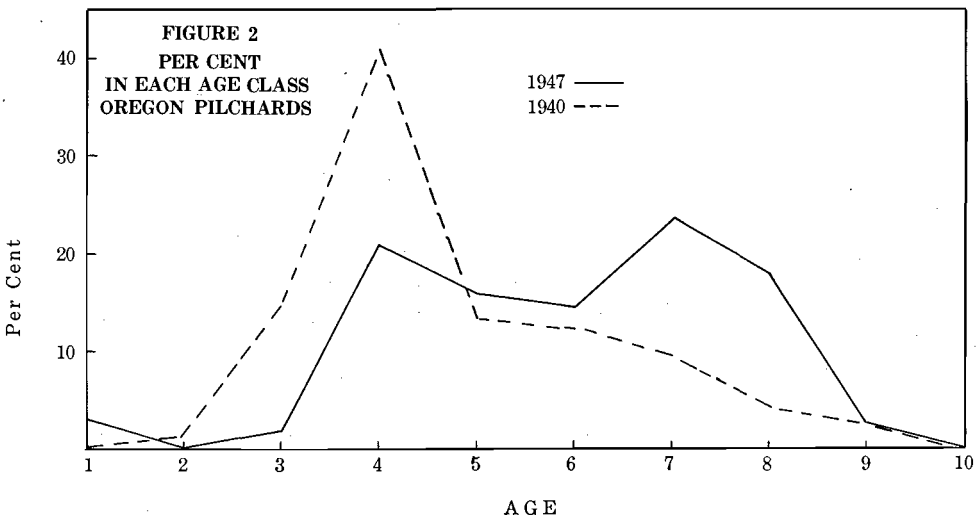
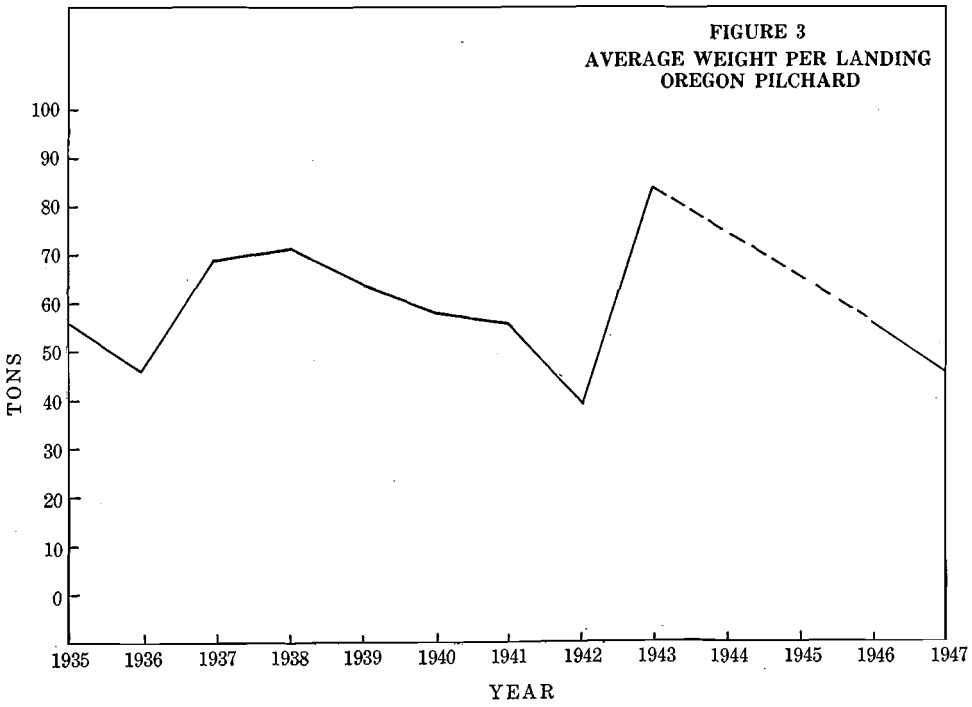


Figure 3 shows the average weight per landing of pilchards for each year since the beginning of the fishery. In 1944 no fish were landed, and in 1945 the total landings amounted to only 90 tons. No attempt was made to compensate for factors which might change the efficiency of fishing operations through the years. This rough measure of abundance shows no definite trend.



During the 1947 season the Oregon pilchard fishery began in the central part of the state and moved toward the north. This is illustrated by Figure 4. The season was divided into four consecutive periods, the earliest at the top of the page and the latest at the bottom. The horizontal axis is in degrees of latitude, southern latitudes being toward the left. The southernmost area is centered off Waldport and the Alsea River while the northern area extends to Grays Harbor which is 180 miles due north. This figure shows the northern movement of the fishery as the season progresses.

Most of the 1947 pilchard catch was made during two periods, the first from July 20–24 and the second from August 9–23. The great fluctuations in the catch were probably due in part to weather conditions and also due in part to the tendency of most of the fishermen to stay in port during the light of the moon. This was done even though the fishery is carried out during the day.

During 1947 season, samples were taken of the Oregon pilchard landings. The seasonal average lengths of males and females are shown in Table 1. The average sizes tended to increase as the season progressed.

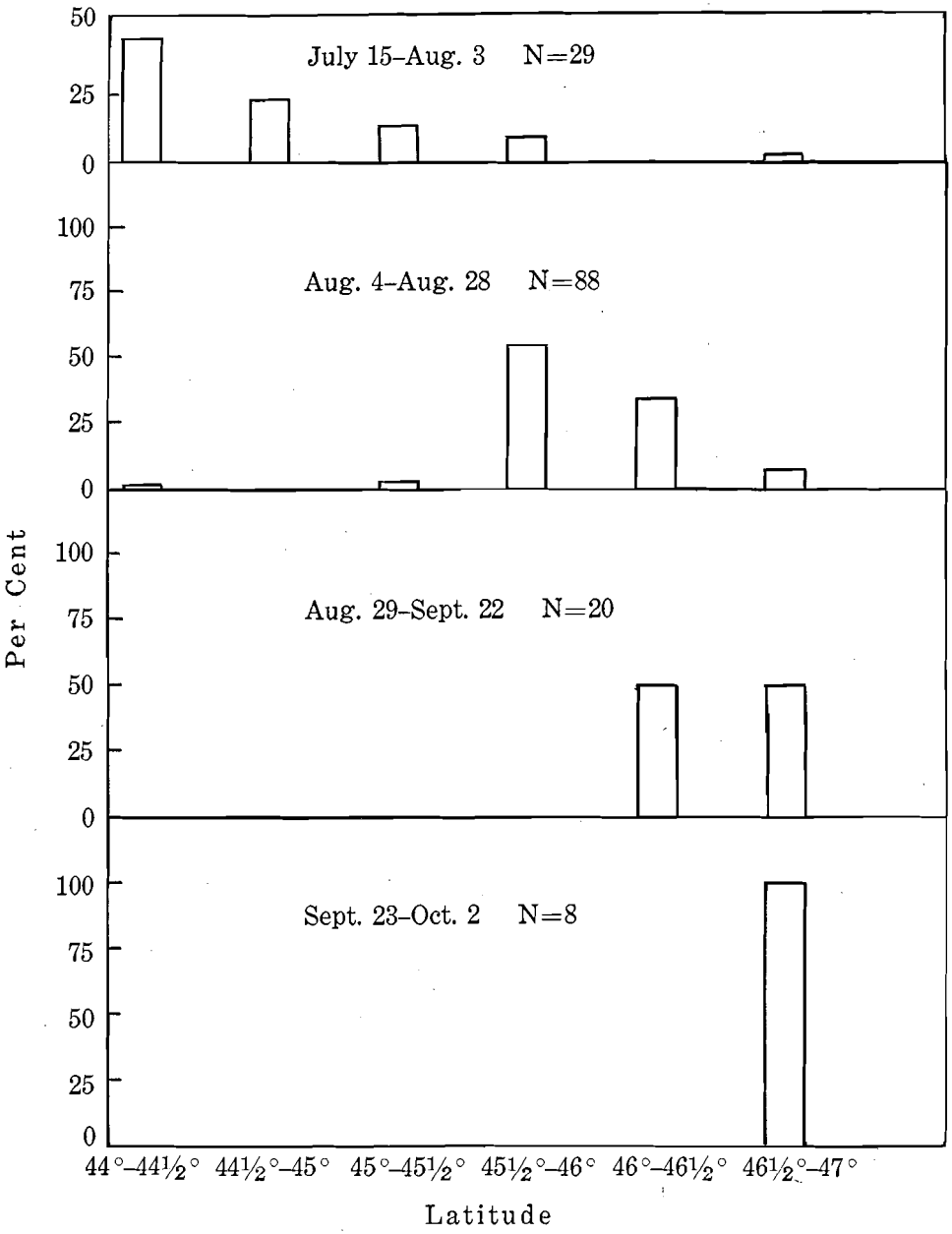


FIGURE 4

AREAS OF PILCHARD CATCHES, OREGON 1947

TABLE 1

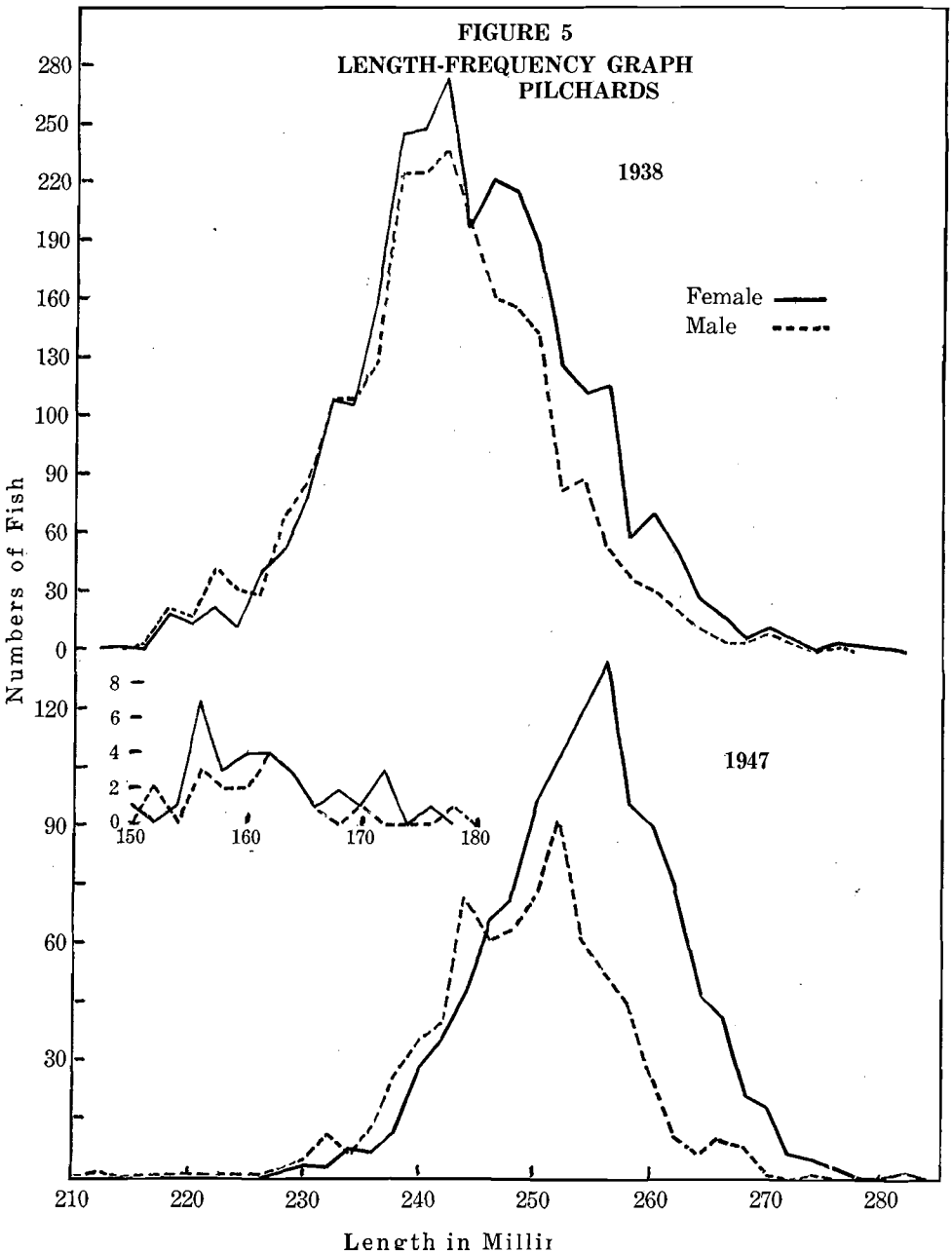
SEASONAL AVERAGE LENGTHS OF PILCHARD LANDED IN OREGON IN 1947*

Season	Males	Females
June 14–29	246.4 mm.	248.4 mm.
July 30–Aug. 13	248.0 mm.	252.9 mm.
Aug. 14–21	251.5 mm.	255.3 mm.
Aug. 22–Sept. 24	249.7 mm.	254.5 mm.

* Does not include a single sample of one-ring fish.

FIGURE 5

LENGTH-FREQUENCY GRAPH
PILCHARDS



The length-frequency graph for the combined samples of the 1947 season showed the most common size at about 251 mm. for males and 255 mm. for females with the females comprising a greater portion of the landings (Figure 5).

For comparison, the length-frequency graph for the 1938 season in Oregon is also shown. In 1938 the mode was at 242 mm. for both the males and the females. This contrasts with a mode of 251 mm. for the males and 255 mm. for the females in 1947, again showing that the Oregon fishery is now dependent on the older, larger fish. Of interest is the fact that one landing on September 15 consisted mainly of small fish in their second year.

The average lengths of pilchards landed in Oregon during other years are shown in Table 2.

TABLE 2

LENGTHS OF PILCHARDS LANDED IN OREGON
1938, 1939, 1940 and 1947

Year	Males	Females
1938	242 mm.	242 mm.
1939	241 mm.	241 mm.
1940	229 mm.	231 mm.
1941	221 mm.	235 mm.
1947	251 mm.	255 mm.

Here again it is indicated that the 1947 Oregon pilchard fishery was supported by the larger, older fish.

Summary

1. The Oregon pilchard fishery, which at first landed fish from all along the Oregon coast and made sizeable landings in Coos Bay, now operates out of the Columbia River alone.

2. The fishery normally transpires during July, August, and September with August being the peak month.

3. Studies of the size and age of the pilchards showed a dearth of the young in recent years.

4. The 1947 fishery started south and moved north as the season progressed.

5. It appears that the pilchard will not become numerous in northern waters until a more successful spawning occurs. Prospects are for the fish size in the northern catch to remain large and for the fish to become even less abundant in the next few years.

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SALMON CATCH BY THE SPORT FISHERY ON CERTAIN OREGON COASTAL RIVERS, 1947[1]

Introduction

The coastal rivers of Oregon support an intensive sport fishery for salmon. Residents from all parts of the state and tourists from all parts of the United States come to the Oregon Coast to fish. The number of anglers participating in this fishery has increased sharply in recent years, and the money spent to supply their needs yields a substantial income to the local communities on the various rivers and to the state as a whole.

The silver salmon *(Oncorhynchus kisutch)* comprises the greatest portion of the catch while the chinook salmon *(Oncorhynchus tshawytscha)* is taken to a lesser extent. The fall chinook run is present in all of the rivers but the spring run in only a few.

The size of the salmon runs, as indicated by the commercial river fishery catches, has shown a downward trend since 1924. At the present time the chinook runs are in a seriously depleted state, and the silver runs are apparently far below their optimum levels of abundance. Investigations are therefore being conducted to determine the magnitude and fate of the present runs after they enter the rivers in order that such remedial measures as prove necessary may be developed to increase the runs to their optimum size. A study of the sport fishery is one phase of this program.

Methods

The river sport fishery may be roughly divided into two categories: boat fishing and bank fishing.

BOAT FISHERY

When the fish first enter the rivers, they congregate in the tidal areas until the heavy fall rains increase the river flows sufficiently for them to ascend to the spawning grounds. While the salmon are thus congregated in the bays, they are subjected to a heavy fishery by anglers trolling from skiffs.

The method used in estimating the catch of the boat fishery was patterned after that used by McKernan and Jensen[2] on the Willamette River:

1. Log books were distributed to the moorage operators who made daily records of the numbers of fish caught, the numbers of boats rented, and when possible the weights of fish caught. From these records were determined the average catch per boat-day per week and the average weight of the fish.
2. Boat counts were made periodically from an airplane or car to determine the total number of boats fishing at any one time. Only on the Nehalem and Alsea Rivers could a good count of the boats be made from the roads along the river. It was then possible to determine the percentage of the total boats fishing represented by those reported by the moorages on the days that counts were made by airplane or car. The total number of boats fishing on other days of the season was then calculated.

[1]This work was conducted under the supervision of John T. Gharrett, who is in charge of the Coastal Rivers Investigation.

[2]McKernan, D. L. and C. C. Jensen—1946 Willamette River Spring Chinook Sport Fishery. **Bull. Oregon State Game Commission,** Vol. 1, No. 6, Portland, 1946.

3. Since only a portion of the total number of boats fishing on any day will be observed by an instantaneous count from an airplane or car, it was necessary to determine the distribution of fishing intensity throughout the day and correct the counts accordingly. This was done by making day-long observations at various moorages to determine the percentage of the total boats out during the day that were on the bay at any time. From the corrected weekly totals of boat-days and the average catch per boat-day per week was derived the total catch.

While conducting this census, observations were made from time to time on the number of lines being fished from each boat. From these data the catch per fisherman was determined. The samples from which the estimates were derived for these rivers are small since it was deemed better to obtain data on several rivers rather than concentrating on any one. No estimate of the catch of jack salmon (precociously developed males) was made since many of the moorage operators did not consider them of enough importance to record.

BANK FISHERY

Following the first high waters in the fall, most of the salmon leave the bays and ascend the rivers. There follows a heavy sport fishery by anglers fishing from the banks of the streams. This fishery extends practically to the spawning grounds. The distance varies with the size and accessibility of the rivers. A comprehensive census of this bank fishery could not be made with the staff available, so rough estimates of the catches were made based on periodic surveys, interviews with anglers, and records kept by the state police officers when they checked anglers. It is believed that these estimates are minimal.

Nehalem River

A brief discussion of the above procedures as applied to the determination of the sport catch on the Nehalem River will serve to illustrate the procedures used on other coastal rivers as well.

NEHALEM BOAT FISHERY

The boat fishery takes place on Nehalem Bay and the lower part of the river as far up as the Mohler Bridge, a distance of approximately ten miles. In this area there are about fourteen moorages from which boats are rented. Boats brought to the area on trailers are launched at some moorages and other places along the river.

Log books were distributed to eleven of the moorages. Of these, seven kept good records which were used in calculating the catch of the boat fishery. The fishery on the bay and lower river commenced about September 1 and continued through the first week of November.

Figure 1 shows the distribution of the fishing intensity throughout the day as determined by day-long observations on two Sundays and one weekday. The three curves are quite similar. For the purpose of converting airplane and car counts to total boats fishing those days, an average of the three curves was used.

The percentage of boats reported by cooperating moorages in relation to the total number of calculated boats as determined from the airplane counts is shown in Table 1. A higher percentage of boats was reported by the moorages on week days (48.0 per cent) than on week ends (29.2 per cent). This is as expected since a greater percentage of private boats are brought in on week ends.

3. Since only a portion of the total number of boats fishing on any day will be observed by an instantaneous count from an airplane or car, it was necessary to determine the distribution of fishing intensity throughout the day and correct the counts accordingly. This was done by making day-long observations at various moorages to determine the percentage of the total boats out during the day that were on the bay at any time. From the corrected weekly totals of boat-days and the average catch per boat-day per week was derived the total catch.

While conducting this census, observations were made from time to time on the number of lines being fished from each boat. From these data the catch per fisherman was determined. The samples from which the estimates were derived for these rivers are small since it was deemed better to obtain data on several rivers rather than concentrating on any one. No estimate of the catch of jack salmon (precociously developed males) was made since many of the moorage operators did not consider them of enough importance to record.

BANK FISHERY

Following the first high waters in the fall, most of the salmon leave the bays and ascend the rivers. There follows a heavy sport fishery by anglers fishing from the banks of the streams. This fishery extends practically to the spawning grounds. The distance varies with the size and accessibility of the rivers. A comprehensive census of this bank fishery could not be made with the staff available, so rough estimates of the catches were made based on periodic surveys, interviews with anglers, and records kept by the state police officers when they checked anglers. It is believed that these estimates are minimal.

Nehalem River

A brief discussion of the above procedures as applied to the determination of the sport catch on the Nehalem River will serve to illustrate the procedures used on other coastal rivers as well.

NEHALEM BOAT FISHERY

The boat fishery takes place on Nehalem Bay and the lower part of the river as far up as the Mohler Bridge, a distance of approximately ten miles. In this area there are about fourteen moorages from which boats are rented. Boats brought to the area on trailers are launched at some moorages and other places along the river.

Log books were distributed to eleven of the moorages. Of these, seven kept good records which were used in calculating the catch of the boat fishery. The fishery on the bay and lower river commenced about September 1 and continued through the first week of November.

Figure 1 shows the distribution of the fishing intensity throughout the day as determined by day-long observations on two Sundays and one weekday. The three curves are quite similar. For the purpose of converting airplane and car counts to total boats fishing those days, an average of the three curves was used.

The percentage of boats reported by cooperating moorages in relation to the total number of calculated boats as determined from the airplane counts is shown in Table 1. A higher percentage of boats was reported by the moorages on week days (48.0 per cent) than on week ends (29.2 per cent). This is as expected since a greater percentage of private boats are brought in on week ends.

FIGURE 1
DAILY DISTRIBUTION OF FISHING INTENSITY ON THE NEHALEM RIVER, 1947

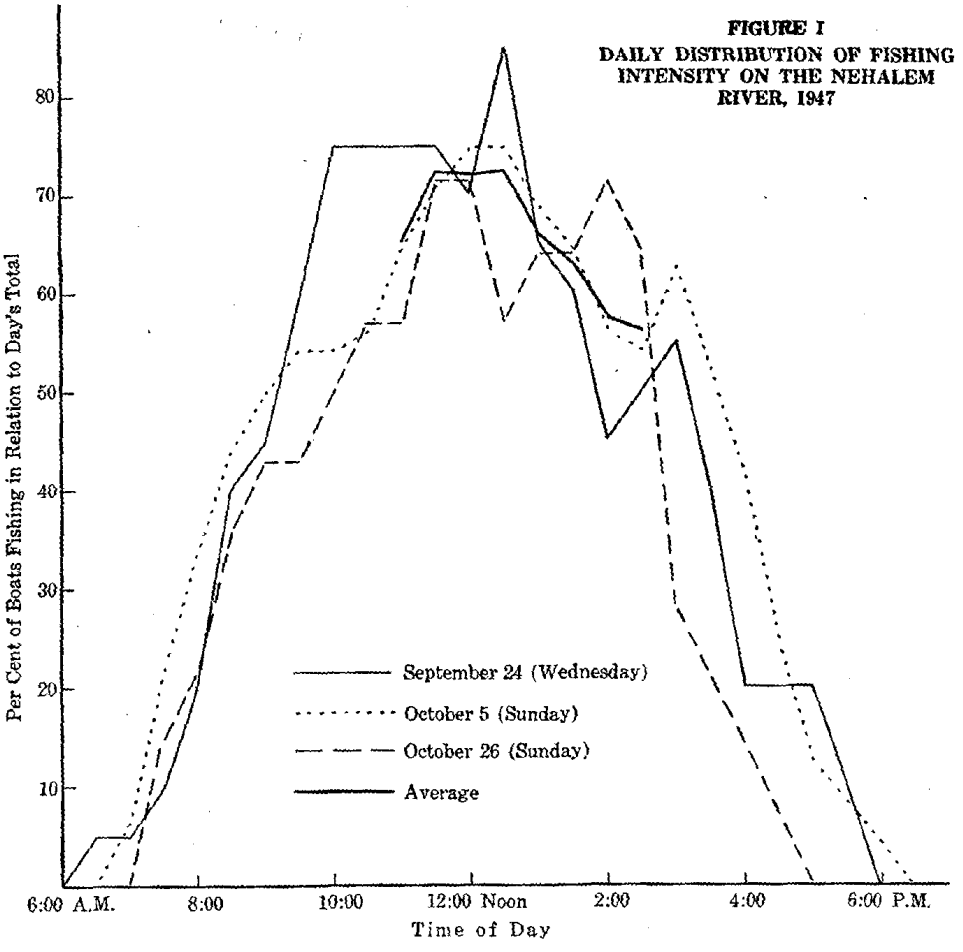

TABLE 1
COUNTS OF BOATS ON NEHALEM RIVER WITH COMPUTATION OF TOTAL NUMBER OF BOATS ON RIVER DURING DAY AND PER CENT REPORTED BY COOPERATING MOORAGES, 1947.

te	Day	Method	Time	Observer Count	Per Cent[1] Available	Total Boats Calculated	Reported by Moorages	Per Cent Reported
				WEEK ENDS				
5	Sun.	Plane	12:15	173	72.2	240	75	31.2
1	Sat.	Plane	11:05	164	66.7	246	67	27.2
							Average.....	29.2
				WEEK DAYS				
	Mon.	Car	1:55	50	58.4	86	34	39.5
	Tues.	Car	1:40	28	61.2	46	26	56.5
							Average.....	48.0

[1] entage of total boats for day that were on the river at the time of the count.

The calculated weekly catches are shown in Table 2. The success of chinook angling was relatively consistent from the first week of the census, September 14 to 20, through the week of October 12 to 18. Following that time it appeared that the chinooks ascended the river and were not available to the boat fishery. Silver fishing was best during the week of October 5 to 11. Heavy storms during the first week of November put an end to the boat fishery.

TABLE 2

NEHALEM RIVER WEEKLY SPORT CATCHES FROM BOATS, 1947

Week	Calculated Boat-Days	Average Catch per Boat-Day		Calculated Catch	
		Chinook	Silver	Chinook	Silver
Sept. 14–20	700	.09	.23	63.0	161.0
Sept. 21–27	759	.03	.12	22.8	91.1
Sept. 28–Oct. 4	599	.08	.43	47.9	257.6
Oct. 5–11	868	.09	.90	78.1	781.2
Oct. 12–18	456	.10	.54	45.6	246.2
Oct. 19–25	66	.00	.14	0.0	9.2
Oct. 26–Nov. 1	110	.00	.20	0.0	22.0
Nov. 2–8	5	.00	.00	0.0	0.0
Total	3,563	.07	.44	257.4	1,568.3

The average number of lines per boat throughout the season was 2.3. The average weight of the fish caught was obtained from the moorage operators and from samples obtained at the time of the day-long observations. Weights were obtained for 20 chinooks averaging 19.8 pounds, and 170 silvers averaging 9.0 pounds.

The boat fishery on the Nehalem started several weeks before this census was undertaken. From interviews with the moorage operators at the time the log books were distributed, it was estimated that 70 chinooks and 250 silvers had been caught prior to that time. The addition of these to the calculated catch during the period of the census gives an estimated total catch for the boat fishery of 327 chinooks, and 1,818 silvers. Converted to pounds by the average weights determined above, the total catch was 6,475 pounds of chinooks and 16,362 pounds of silvers.

BANK FISHERY

The bank fishery for salmon on the Nehalem River system took place for the most part from the head of tidewater to the mouth of the Salmonberry River on the main stream and to the falls on the North Fork. A few fish were reported to have been taken along the entire length of the river. The intensity of this upriver fishery was not determined, but, judging from meager reports, it is apparently very low in comparison with the lower river fishery. It is estimated from these reports that the bank fishery took 350 silvers (3,150 pounds) and 50 chinooks (990 pounds) from October 15 to December 15, 1947.

TOTAL CATCH

The total estimated sport catch of salmon from the Nehalem River system is shown in Table 3.

TABLE 3
TOTAL ESTIMATED SPORT CATCH OF SALMON ON THE NEHALEM RIVER 1947

	Date	Number Silvers	Pounds Silvers	Number Chinooks	Pounds Chinooks
Boat Fishery:					
Estimated	Before Sept. 14	250	2,250	70	1,386
Calculated from census	Sept. 14 to Nov. 8	1,568	14,112	257	5,089
Total		1,818	16,362	327	6,475
Bank Fishery:					
Estimated	Oct. 15 to Dec. 15	350	3,150	50	990
Total Catch		2,168[1]	19,512	377[1]	7,465

Discussion

In addition to the Nehalem survey, studies were conducted in 1947 to determine the size of the sport catches on several other coastal rivers. These are summarized in Table 4. The silver catches in numbers of fish ranged from 7 to 23 per cent of the various river gill net landings. The chinook catches ranged from 4 to 17 per cent of the gill net catches.

TABLE 4
ESTIMATED SPORT CATCHES FOR ALL RIVERS STUDIED IN 1947

River System	Fall Chinook			Silvers		
	Number[2]	Pounds	Fish/ Angler Day[3]	Number[2]	Pounds	Fish/ Angler Day[3]
Nehalem	380	7,330	.03	2,150	19,350	.19
Tillamook Bay and Tributaries	340	8,740	.01	2,150	19,350	.10
Nestucca	590	19,530	.06	1,500	18,750	.13
Alsea	150	3,000	.01	4,750	42,750	.44

In addition to the catches shown in the above table, it was estimated that 300 spring chinooks were caught in Tillamook Bay and its tributaries and 1500 chum salmon were caught in the Miami River. Most of the chums were taken by snagging, with only an occasional one striking a lure or bait.

These surveys indicate that the recreational fishery for salmon along the Oregon Coast is of major importance in any management program on Oregon coastal rivers.

John I. Hodges
Aquatic Biologist
Fish Commission of Oregon

[1] The total catches of 2,168 silvers and 377 chinooks have been rounded off to 2,150 and 380, respectively, in Table 4.
[2] Combined boat and bank fisheries.
[3] Based on boat fishery only.

SPAWNING GROUND STUDIES OF WILLAMETTE RIVER SPRING CHINOOK SALMON[1]

Introduction

The importance of the Willamette River spring chinook run is not fully realized by the people of the Northwest, due partly to the small size of the Willamette drainage in relation to that of the Columbia River. However, comparison of the Willamette River migration over Oregon City Falls with that of the Columbia River passing Bonneville Dam during a similar period reveals the importance of the Willamette run. For example, in 1946 the count of spring chinook salmon over the Bonneville Dam for the three month period April, May, and June was 97,543; the Willamette River run over Oregon City Falls during the same period was about 55,000 fish.

The size of the Willamette River spring chinook runs before 1946 was never ascertained, but estimates based on egg takes at the various salmon hatcheries indicate that the runs of two decades past were approximately five times as great as those of the present. During the past ten years the runs have diminished rapidly, and present studies are designed to arrive at the causes for the decline.

The Fish Commission operates salmon hatcheries on the North and South Santiam, the McKenzie, and Middle Willamette Rivers. These hatcheries are responsible for the collection of eggs from a part of each run and the subsequent rearing and liberation of young fish. In order to collect eggs racks are placed across the above rivers each spring, the fish are held throughout the summer behind these racks, and the eggs are taken in late August and throughout September.

The future outlook for the Willamette River spring chinook run is serious indeed, and the Fish Commission is bending every effort toward anticipating and solving the problems involved. The comprehensive plan for the development of The Willamette Valley Project calls for numerous multiple-purpose high dams to be constructed on every major salmon producing river in the Willamette River drainage. The approved and proposed dams and their relationship to the Willamette spring chinook spawning areas are shown in Table 1 and Figure 1. In addition to these, the Clackamas, which already has several large dams, and Molalla Rivers have been surveyed for various dam sites and irrigation projects.

When the proposed dams are constructed, the continuance of the salmon runs will probably be a problem of hatchery maintenance, as, except for the McKenzie, the major spawning areas will be cut off by these structures. Maintaining the present size of the runs for each river system by means of hatcheries will be difficult. This will involve enlarging and relocating some of the present hatcheries and the construction of new ones. Serious problems associated with rapidly changing water flows below dams, high water temperature in the late summer, and extremely low flows at certain times are expected to complicate the matter of fisheries maintenance.

Purpose

The purposes of the spawning ground surveys were to determine: (1) the proportion of fish injured prior to spawning in the upper reaches of the

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[1]This paper represents a phase of the Columbia River investigations being carried on jointly with the Washington Department of Fisheries and was prepared under the direct supervision of Donald R. Johnson of the Oregon Fish Commission.

TABLE 1
PERCENTAGE OF 1947 SPRING CHINOOK SALMON UTILIZING AREAS ABOVE THE PROPOSED WILLAMETTE RIVER SYSTEM DAMS

River System	Proposed Dams	Location in Miles Above Mouth	Percentage of Run Utilizing Spawning Areas Above Each Dam	Percentage of Estimated Willamette Spawning Population Affected by Dams
Middle Willamette..	Meridian.....	21.3	98	
	Dexter.....	18.0	98	
	Fall Creek.....	7.1 (Fall Creek Mouth)	2	
		TOTAL..	100 per cent of Middle Willamette Run.	21
McKenzie.....	Cougar.....	4.4 (South Fork Mouth)	2	
	Gate Creek....	0.4 (Gate Creek Mouth)	Not determined in 1947.	
	Blue River....	0.6 (Blue River Mouth)	Not determined in 1947.	
		TOTAL...	2 per cent of the McKenzie Run.	1
South Santiam.....	Cascadia.....	59.8	33	
	Green Peter...	4.0 (Middle Santiam)	(50% Middle Santiam Run).	
	White Bridge..	0.8 (Middle Santiam)	52 (100% Middle Santiam Run).	
	Wiley Creek...	4.7 (Wiley Creek)	Not determined in 1947.	
		TOTAL...	85 per cent entire South Santiam Run.	9
North Santiam.....	Detroit.....	48.5	71	
	Big Cliff.....	45.7	Not determined in 1947.	
		TOTAL...	71 per cent entire North Santiam Run.	17
			TOTAL.....	48

various rivers; (2) the cause of these injuries; (3) the cause of mortality prior to spawning; (4) salmon spawning areas in relation to the proposed damsites; (5) the size of the spawning populations in the various river systems; (6) the effects of water temperatures on the salmon; and, (7) the effects of hatchery holding areas on the salmon.

Procedure

Spawning ground surveys were begun during the summer of 1946 and expanded in 1947. They were started during the first week of July and completed by the end of the spawning season (early October). The stream and river surveys were made either by foot or boat.

Middle Willamette River

The Middle Willamette River is the southernmost river in the Willamette River drainage containing a spring chinook population (Fig. 1). The main salmon bearing tributaries of this river are the following: the North Fork of the Middle Willamette River, Salt Creek, Salmon Creek, and Big Fall Creek. A mill dam is located one mile above the mouth of the North Fork, but a fishway provides access to the river above the dam. Two sets

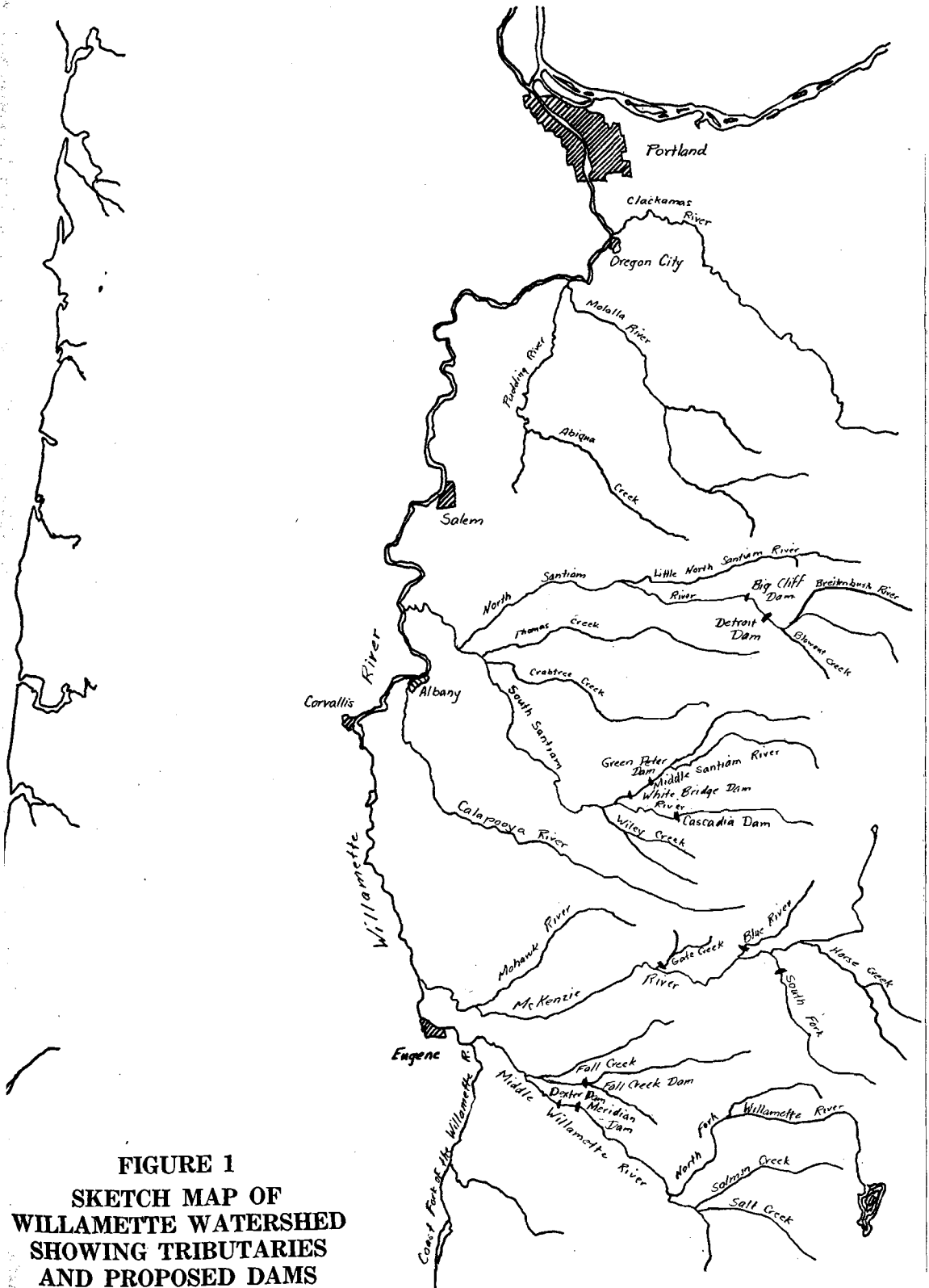

FIGURE 1
SKETCH MAP OF WILLAMETTE WATERSHED SHOWING TRIBUTARIES AND PROPOSED DAMS

of racks are used in intercepting the salmon migrants for artificial propagation. One is constructed each year on the main river about two miles above Oakridge, and the other one is erected on Salmon Creek about one mile above its mouth.

Prior to spawning comparatively few salmon were observed except immediately below the racks, but when spawning activities commenced the salmon appeared in greater numbers, presumably migrating there from farther down the river. A total of 1,246 salmon were observed during spawning; of these 1,188 fish were handled at the two egg collection stations located at the racks, and the remainder were observed on the spawning grounds (Table 5). The proposed dams would have eliminated all of the spawning areas utilized during the 1947 season (Table 1).

The spawning operations at the racks resulted in the processing of 616 or 52 per cent males and 572 or 48 per cent females. The spring chinook salmon population migrating into the Middle Willamette River was estimated at 2,550 fish (Table 6). The actual number observed was 1,246 or 49 per cent of the estimated total.

McKenzie River

The McKenzie River system is the most productive of the Willamette River drainage. Most of the spawning occurs in the main river with additional spawning occurring in the following tributaries: Smith River, Lost Creek, Horse Creek, South Fork, Blue River, and Gate Creek. Two sets of racks were used to intercept the adult migrants. The main river was racked at a point about a quarter of a mile above the Hendricks bridge on highway 58. The second rack was located on the Walterville Canal and was not intended to hold fish for artificial propagation. It will be discussed in greater detail later.

There are two large diversions, the Leaburg and Walterville canals, which divert river water for two power stations. The uppermost canal, the Leaburg diversion, is supplied with water by the Leaburg Dam, a structure equipped with two passable fishways. The Walterville Canal diverts water directly from the river. It will be discussed in greater detail with regard to mortalities.

The proposed McKenzie River dams would effect only three tributaries supporting small salmon populations (Table 1).

Few salmon were observed in this river during the summer, but during the last week in August they began to appear on the various spawning grounds. During the month of September a total of 2,070 salmon were observed, including 1,105 fish handled at the main rack during the spawning operations. The remainder of the salmon were found during the final surveys of each spawning area. The principle grounds were located in the main McKenzie River near the Hayden, Coburg, and Hendricks bridges. Fish were also located in large numbers at Wilson's Bend near the mouth and the lower section of the Walterville Canal (Table 5).

The sex ratio of the salmon handled at the egg collection station was found to be 48.7 per cent males and 51.3 per cent females. The McKenzie River spring chinook salmon population was estimated at 4,780 salmon, of which actually 43 per cent of the total were observed during the surveys in September (Table 6).

Calapooya River

The Calapooya River, which lies between the South Santiam and McKenzie River drainages, was surveyed on several occasions. This stream has a

mill dam that has blocked the migration of salmon to the upper river for approximately one hundred years. As a result of this barrier the salmon have had to spawn in unfavorable locations, and the present population is depleted. The summer water temperatures are rather high in this river as a reading of 72° F. was obtained on July 16, 1948. Perhaps as a result of the high temperatures, spawning was late in occurring. The spawning survey was conducted on September 20, when 12 salmon were observed on the spawning grounds. No spawning had occurred at this time. The spawning population was estimated at 30 fish, of which 12, or 40 per cent, were observed.

South Santiam River

The South Fork of the Santiam River supports a fair run of spring chinook salmon. The main salmon bearing tributaries are the following: The Middle Santiam River, Wiley, Crabtree, and Thomas Creeks. The main river has a low diversion dam near Lebanon, and dams are located on Wiley and Thomas Creeks. All of these dams have fishways which enable fish to pass over the structures. A holding rack was erected on the Middle Santiam River about six miles above its mouth. High water in June and the local beaver population kept the rack damaged throughout the summer so that the bulk of the salmon escaped upstream.

The South Santiam and its tributaries have been surveyed for possible damsites, and at present four sites have been selected (Table 1).

Prior to spawning the main holding areas were examined and 368 salmon were observed at the various locations. However, during the spawning activities only 280 salmon were observed, of which 24 fish were spawned at the rack. The principle spawning areas were found at the following locations (Table 5): the Middle Santiam River near the Green Peter damsite, from the hatchery down to the White Bridge damsite, and from Cascadia to five miles upriver on the main South Santiam River. Although no salmon were observed by the Fish Commission biologists on either Thomas or Crabtree Creeks, estimates, based on reliable reports of salmon migrations during the early summer by local residents, were made in order to indicate the general magnitude of the runs in these two streams in relation to the rest of the South Santiam escapement. The total spring chinook salmon population of the South Santiam River was estimated at 1,300 fish (Table 6). The total number of salmon observed during the surveys was 270 or 21 per cent of the total.

North Santiam River

The North Santiam River has a larger spring chinook salmon population than the South Santiam. The main salmon producing tributaries are the following: the Little North Santiam, Breitenbush, Marion Forks, and Blowout Creek. A holding rack was erected just below the mouth of the Breitenbush River at the accustomed racking site, and the salmon were held in the area below that weir until maturity in late August and September.

Two large diversion dams formed partial barriers to the migrating salmon in this river. It was found that the block was due to inadequate fishways at these dams. The Bennett Dam, which was located several miles above the town of Stayton, formed a complete block during the early part of the season, and as many as 2,000 salmon were delayed by this structure during early June. At the insistence of the Fish Commission, the fishway was made passable shortly after June 20. Nevertheless, many fish never

passed the dam and during September large numbers were found in the area immediately below. The Mill City diversion dam, the uppermost of the two structures, was provided with a very inadequate fishway and many salmon were not able to pass over readily. Undoubtedly many were never able to ascend into the upper river. Construction was begun on new fishways for both diversion dams during the summer.

Aside from the salmon observed at the various obstructions during the summer, few were found until the final survey in mid-September on the spawning grounds. A total of 398 salmon were observed during this survey, including 287 fish found in the Little North Santiam River and 111 between Mill City and Stayton. No surveys were conducted during spawning above the Mill City Dam. The spawning operations at the rack accounted for 1,195 salmon and, in addition, 267 spawned naturally in the vicinity. The main spawning area found on the Little North Santiam River was a one mile reach of river immediately below Elkhorn Falls (Table 5). More spawning salmon were found in the mile long section below the Bennett Dam than in any other equivalent section of the river. No spawning was observed below the town of Stayton. The Detroit Dam would have blocked 71 per cent of the North Santiam salmon from the spawning areas utilized during the summer (Table 1).

The sex ratio of the salmon processed at the spawning station was found to be 55 per cent males and 45 per cent females. The spawning population for the entire North Santiam River system was estimated to have been 2,825 salmon (Table 6). The spawning surveys and spawning operations totaled 1,593 fish or 62 per cent of the estimated salmon population.

Miscellaneous Salmon Streams and Rivers

Not all of the salmon rivers and streams were surveyed as thoroughly as those listed above. However, short surveys were made at practically all of the minor salmon-producing streams during the summer and fall. Tentative estimates were made concerning the salmon populations of these streams based on earlier summer surveys, nests, carcasses, live fish, and reliable reports of local inhabitants. While it is recognized that information of this nature can at best provide only approximate figures, it is thought that the estimates so given provide useful information as to the general magnitude of the runs.

In the above manner, the following estimates were made: Clackamas River, 1,500 fish; Molalla River, 500 fish; and Abiqua Creek, a tributary of Pudding River, 50 fish.

Injuries and Mortalities

When the salmon first appeared at the various hatchery racks during June they were generally in excellent condition, except for an occasional fish injured prior to its arrival. Within a period of a week or ten days, a few salmon were observed with minor bruises on the tips of their noses. The skin had been worn away from the very tip of the nose, presumably from constant contact with the wooden pickets of the weir as the fish attempted to force their way upstream. These nose bruises increased constantly during the early summer in those groups confined by racks (Table 2). Salmon observed in areas without racks appeared to be free of similar nose injuries. Body injuries were far less numerous than head injuries, both at the racks and elsewhere.

Some of the salmon fought the racks constantly throughout the sum-

mer, and as a result they received more serious bruises in the head region. In many cases these injuries became infected with fungus and caused a condition commonly known as a "sorehead" or "whitehead" fish. The increase of soreheads at the Middle Willamette and McKenzie main racks was quite similar during the months of July and August (Table 2). Similar conditions were observed at the North Santiam, Salmon Creek, and Waterville Canal racks. The South Santiam rack did not confine the salmon as efficiently as the other racks, mainly because of damages incurred by high water and beavers. As a result, the South Santiam salmon that were observed in areas without racks were in excellent condition, and only a small percentage of injuries was found, generally being less than ten per cent.

TABLE 2

PERIODIC OBSERVATIONS OF INJURIES AT THE VARIOUS RACKS

McKenzie River Main Rack

Middle Willamette River Rack

McKenzie River Main Rack

Date	Number Observed	Severe Head Injuries and Fungus	Per Cent	Minor Injuries Including Nose Bruises	Per Cent
July 10	26	6	23.0	15	58.0
14	43	4	9.3	30	70.0
21	34	5	14.7	.....	.....
23	20	2	10.0	18	90.0
Aug. 4	75	10	13.3	All August observations made within a holding pen opened on Aug. 1. Over 90 per cent nose injuries suffered by the fish in this pen.	
7	96	26	27.0		
11	133	34	25.7		
18	125	39	31.3		
21	165	59	35.8		
25	193	73	37.8		

Middle Willamette River Rack

July 2	250 (est.)	11	4.4	.....	.....
7	250 (est.)	15	6.0	.....	.....
10	350 (est.)	18	5.0	.....	.....
	150 (est.)	8	5.3	37	24.7
23	150 (est.)	22	14.5	.....	.....
24	25	.....	.....	13	52.0
25	19	7	37.0	18	95.0
Aug. 5	13	4	30.8	Aug. 5th and 14th observations made in resting pool below rack. Aug. 19th and 26th observations made in holding pen opened Aug. 1st.	
14	57	25	44.6		
19	83	40	48.0		
26	170	68	40.0		

In many cases, the head and body injuries became severely infected with fungus, and occasionally with extremely severe head infections the fish became blind. Death generally resulted within a period of ten days after the blindness, but death came to many before blindness. Of the mortalities recovered at the McKenzie main rack, 85 per cent were associated with fungus infections of previous injuries and the remaining 15 per cent were due to direct injuries or unknown causes.

During August each of the main racks had additional pens constructed in order to hold the salmon in enclosed areas for the spawning operations. Excellent mortality records were obtained from these holding pens, where all the dead fish were recovered and recorded. The actual mortality rates

from the various holding pens were as follows: North Santiam, 18 per cent for seven weeks extending from the last of July; Middle Willamette, 17 per cent for the month of August; and the McKenzie, 13 per cent for a 25 day period from August 1 to 25. The mortality rates, which were based on observations of the pens and adjacent rack areas, were estimated to have been approximately 15 per cent for the entire summer.

Although only an occasional dead fish was observed during the stream surveys, numerous recoveries were made at the various holding racks (Table 3). Only a few salmon were recorded in June; a slight increase in numbers occurred during July, but in August the mortalities increased very sharply.

TABLE 3

MORTALITIES OF UNSPAWNED ADULTS AT THE VARIOUS HOLDING RACKS, JUNE, JULY AND AUGUST, 1946 and 1947

Holding Racks		June			July			August			Total			[2]Per Cent of Total Number of Fish Handled
		M	F	U[1]	M	F	U	M	F	U	M	F	U	
Middle Willamette.....	1946	No Record			No Record			8	13	0	8	13	0	2.8
	1947	No Record			1	1	2	22	23	0	23	24	2	4.7
McKenzie Main Rack..	1946	2	4	0	5	15	0	2	7	0	9	26	0	11.9
	1947	0	0	2	3	4	2	15	13	4	18	17	8	3.6
Walterville Canal.....	1946	2	5	0	56	101	0	298	551	0	356	647	0	26.6[3]
	1947	0	0	0	0	0	0	0	0	1	0	0	1	0.4
South Santiam.....	1946	No Record			No Record			26	12	0	26	12	0	9.9[4]
	1947	No Record Obtained During 1947.												
North Santiam.....	1946	No Record			5	7	0	129	313	0	134	320	0	21.2
	1947	0	0	0	0	0	0	35	76	0	35	76	0	7.4

Comparison of the 1946 and 1947 mortalities revealed a sharp decline for the Walterville Canal racks in 1947 (Table 3). Prior to 1947 salmon had been allowed to enter this canal, and an egg collection station had been located below the Walterville power house. However, huge losses, as much as 55 per cent loss in 1946, had occurred during the summer prior to the spawning operations. These losses may have been due to the lack of adequate and proper holding pools in the canal where the fish could have remained while maturing. Instead of remaining quiescent in large pools as spring chinooks normally do while awaiting the spawning season, the salmon had to swim constantly against a strong current. In 1947 a rack was placed across the entrance to the canal in order to prevent the fish from entering the diversion. As a result the salmon remained in the main river. Some of them undoubtedly proceeded farther up the main stream, but many were observed in a deep pool located one-quarter of a mile below the canal outlet. The rack was damaged late in August and about 300 fish entered the canal in time for spawning. However it had served the purpose of preventing large losses resulting prior to the spawning season. It was estimated the mortalities occurring among the salmon immediately below this rack were approximately 15 per cent instead of the 60 per cent of the

[1]Males are indicated as M, females as F, and undetermined as U.

[2]Calculated from the total number of salmon mortalities recovered and those handled during the spawning operations.

[3]The total loss including September was 55 per cent of the potential egg take.

[4]Does not include the number of males handled during the spawning operations.

year before. Losses elsewhere were reduced in 1947 but not so markedly.

The losses at the North Santiam rack were about one-half of the 1946 losses (Table 3). The Middle Willamette and McKenzie rack losses in 1947 were comparable to those of the year previous. The South Santiam rack was damaged and no data were obtained.

Temperatures During Spawning

Numerous temperature readings were recorded during the surveys. In addition, daily temperatures were taken at the Salmon Creek, McKenzie, and North Santiam racks (Table 4). During the actual spawning, temperature readings varied from a maximum of 64.5° F. recorded on Big Fall Creek September 20, to a minimum of 43.0° F. obtained at the North Santiam rack on the same day.

The spawning activities were, or appeared to be, influenced by water temperatures as invariably the earliest spawning in a river system began in the colder headwaters. The first observed spawning occurred at the North Santiam rack on August 22 when the temperatures ranged from 52° to 59° F.. Big Fall Creek, a relatively warm water stream was surveyed on September 20 when the water temperature was 64.5° F.. The salmon observed had not begun their spawning activities. Egg-taking operations were carried out first at the North Santiam rack, followed by the Salmon Creek, McKenzie and Middle Willamette stations. The spawning operations on Salmon Creek reached a peak ten days before those carried out at the main Middle Willamette River, which was about five or six degrees warmer. In general the spawning activities first occurred in the colder headwaters of the various streams and rivers, and grew progressively later farther downstream. Spawning had virtually ceased by the end of September except in the lower, warmer sections of the rivers and streams.

TABLE 4

TEMPERATURE RECORDS AT VARIOUS LOCATIONS ON THE WILLAMETTE RIVER SYSTEM, 1947 (Degrees Fahrenheit)

	Salmon Creek[1]	McKenzie River Rack	North Santiam Rack
July			
July Maximum Temperature	56.0	64.0	64.0
July Minimum Temperature	46.0	54.0	50.0
Monthly Maximum Temperature	53.0	59.8	60.7
Monthly Minimum Temperature	47.4	56.3	52.0
August			
August Maximum Temperature	57.0	67.0	64.0
August Minimum Temperature	46.0	52.0	50.0
Monthly Maximum Temperature	53.5	63.5	60.0
Monthly Manimum Temperature	48.5	56.1	52.8
September			
September Maximum Temperature	58.0	64.0	59.0
September Minimum Temperature	46.0	50.0	43.0
Monthly Maximum Temperature	53.5	58.3	53.7
Monthly Minimum Temperature	49.9	52.0	49.0

[1] The temperatures were taken from a diversion of Salmon Creek, which is a tributary of the Middle Willamette River. These temperatures generally are six to eight degrees colder than the main Middle Willamette River near the mouth of Salmon Creek.

TABLE 5

THE PRINCIPLE SPAWNING AREAS OF THE MAIN SALMON BEARING TRIBUTARIES OF THE WILLAMETTE RIVER SYSTEM

River System	Extreme Range	Principal Spawning Areas
MIDDLE WILLAMETTE.....	Rigdon G. S. to Duval Creek.	Westfir bridge down five miles to Duval Creek.
North Fork.....	Camp Five to five miles above Brock G. S.	Brock G. S. to four miles below.
Salmon Creek.....	Rack to mouth, one mile in length.	One-half a mile below the rack.
Big Fall Creek.....	Puma Camp to Fall Creek G. S.	Below the mouth of Portland Creek to Fall Creek G. S.
MCKENZIE.....	Tamolitch Falls to mouth.	Hendricks bridge to mouth; Walterville Canal.
South Fork.....	Eighteen miles above mouth to mouth.	Five to eight miles above the mouth.
Horse Creek.....	Separation Creek to mouth.	Four miles above the mouth.
SOUTH SANTIAM.....	Foster to an unknown distance above.	Near the town of Cascadia.
Middle Santiam.....	Thirty-five miles above to mouth.	Hatchery rack to the mouth.
Thomas Creek.....	Not determined.	Above the Jordan Dam.
Crabtree Creek.....	Not determined.	Above the State Game trout hatchery.
NORTH SANTIAM.....	Headwaters to Stayton.	Breitenbush River to one mile above Stayton.
Little North Santiam..	Elkhorn Falls to mouth.	Elkhorn Falls to one mile below.
Blowout Creek.....	Not determined.	

Conclusions

1. The estimated spring chinook salmon escapement over Oregon City Falls fishway was 45,000 fish in 1947.

2. The estimated spawning ground population of spring chinook salmon in the Willamette River system above Oregon City as determined from stream surveys was 12,040. This is only 27 per cent of the escapement calculated from counts made at the Oregon City Falls.

3. The four salmon hatcheries spawned 3,512 salmon, 28.8 per cent of the estimated spawning population and 8 per cent of the total passing over the Oregon City Falls.

4. From observations made throughout the summer, a tentative estimate of 15 per cent loss of adults prior to spawning was estimated among salmon held behind racks.

5. The sexes of the spring chinooks, based on records obtained during the spawning operations at the various racks, averaged 52 per cent males and 48 per cent females.

6. The temperature range during the spawning period varied from a maximum of 64.5° F. recorded at Big Falls Creek September 20, to a minimum of 43.0° F. obtained at the North Santiam rack the same day.

7. The salmon confined below a rack tended to show an increase in injuries during the summer holding period. Salmon not confined by racks were found to suffer fewer injuries. Severe head and body injuries were observed on more than 45 per cent of the salmon examined at the Middle Willamette and McKenzie racks. Minor head injuries, principally slight

TABLE 6

SUMMARY OF ESTIMATED SALMON POPULATIONS OF THE WILLAMETTE RIVER SPRING CHINOOKS IN 1947

River System	Estimated Populations			Fish Processed in Hatcheries				
	Fish in Tributary System		Percentage of Established Spawning Populations[1]	Number Processed (spawned)	Percentage of Run in Tributaries	Percentage of all Systems above Oregon City[1]	Percentage of Sex[2]	
	Estimated Run	Percentage of Run					Males	Females
McKENZIE RIVER DRAINAGE:								
Above Main Rack (Tributaries included)	1,010	21.2	.....	.....	.....	.....	.....	.....
Main Rack	1,420	29.6	.....	1,105	23.1	9.1	48.7	51.3
Below Main Rack	2,350	49.2	.....	.....	.....	.....	.....	.....
TOTAL	4,780	100.0	39	.....	.....	.....	.....	.....
NORTH SANTIAM RIVER DRAINAGE:								
Above Detroit Damsite	2,015	71.0	.....	1,195	42.2	9.8	55.0	45.0
Below Detroit Damsite	435	15.4	.....	.....	.....	.....	.....	.....
Little North Santiam River	380	13.6	.....	.....	.....	.....	.....	.....
TOTAL	2,830	100.0	23	.....	.....	.....	.....	.....
MIDDLE WILLAMETTE RIVER DRAINAGE:								
Main River	1,620	64.0	.....	929	57.3	7.6	51.0	49.0
Salmon Creek	490	19.0	.....	259	53.0	2.1	55.0	45.0
N. Fork Middle Willamette	380	15.0	.....	.....	.....	.....	.....	.....
Big Fall Creek	60	2.0	.....	.....	.....	.....	.....	.....
TOTAL	2,550	100.0	21	1,188	.....	9.7	.....	.....
SOUTH SANTIAM RIVER DRAINAGE:								
South Santiam (Cascadia Fork)	425	33.0	.....	.....	.....	.....	.....	.....
Middle Santiam	665	51.0	.....	24	.9	.2	.....	.....
Crabtree and Thomas Creeks	200	16.0	.....	.....	.....	.....	.....	.....
TOTAL	1,300	100.0	12	.....	.....	.....	.....	.....
Molalla River Drainage	500	.....	4	.....	.....	.....	.....	.....
Abiqua Creek (50), Calapooya (30)	80	.....	1	.....	.....	.....	.....	.....
TOTAL	12,040	.....	100	3,512	.....	28.8	.....	.....

nose bruises, were suffered by more than 90 per cent of the salmon in the rack areas. The various injuries on salmon not confined by racks were less than 10 per cent.

8. Mortalities seemed to result from severe fungus infection of head and body injuries. Of the dead unspawned adult fish recovered, 85 per cent had severe fungused lesions; the remaining 15 per cent mortality was largely attributed to direct injuries.

9. Water temperatures generally limited the salmon to areas colder than 70° F., and fish were found in the coldest headwaters of the various tributaries. Spawning occurred first in the colder headwaters of the various systems and became progressively later downstream.

[1] Based on the estimated spawning ground population of 12,040 for the Willamette River drainage.
[2] Based on records obtained during the spawning operations.

10. The earliest spawning occurred at the North Santiam rack on August 20 when the temperatures ranged between 52° and 59° F. Spawning had almost ceased when the surveys were completed September 30.

11. The dams proposed for the Willamette Valley Project, if completed, would have eliminated about 48 per cent of the Willamette spring chinook spawning areas used in 1947.

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Blue-Fin Tuna Taken in Oregon Waters

During the first part of the 1947 albacore season, a number of blue-fin tuna were brought into Astoria. One of the Astoria plants set aside about 90 of these fish, almost all of which were landed before August 15. They had an average weight of almost 11 pounds and an average length of about 62 centimeters.

Blue-fin tuna are a fish of the temperate waters and do not usually take live bait or a trolled lure. For these reasons it is hoped that there might be schools of blue-fin of the Oregon and Washington Coast. It might be possible to develop a fisheries for this species if efficient methods for catching them are developed. These fish are caught by purse seines in California waters.

Striped Bass in Columbia River

Gill netters fishing between Vancouver and Bonneville have caught several striped bass during the summer of 1948 and it appears that they are becoming established in the Columbia. The fish were adults, the fish caught by Alva Hansen in Corbett drift weighing 37 ponds.

Striped bass are not native to the west coast and were introduced into the Sacramento River in California before the turn of the century. They rapidly established themselves there and soon spread to other waters. They are now common in Coos Bay and the lower Umpqua River in Oregon. Occasional strays have been found in the Columbia for a number of years, but the capture of several adults in one season as far up as the Vancouver-Bonneville sector is unusual.

Steelhead Tags

Two steelhead, tagged as they were ascending the Umpqua River on December 5, 1946, were recaptured the following winter in the Umpqua estuary.

These fish had ascended the river to spawn, and had probably returned to the ocean and entered the river again on their way to the spawning grounds the following year.

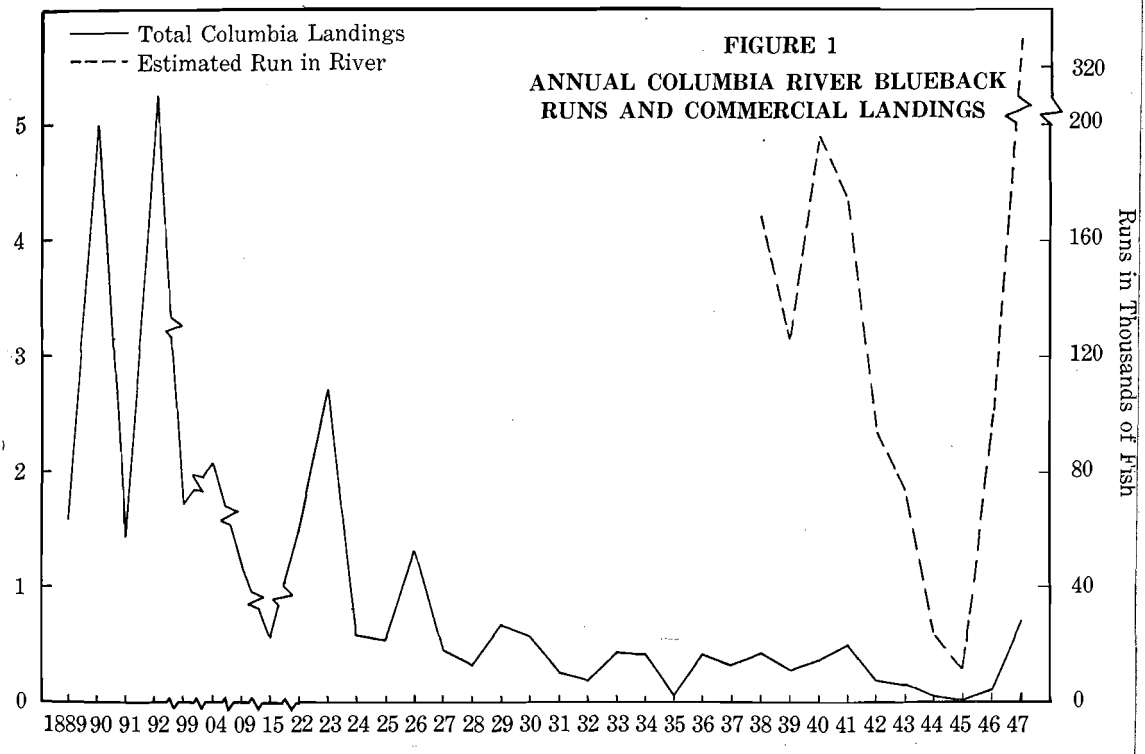
Unfortunately, the biologists were not afforded an opportunity to examine these fish so their growth during this period was not determined.

TRENDS OF COLUMBIA RIVER BLUEBACK SALMON POPULATIONS 1938-1947[1]

Introduction

For many years the blueback runs of the Columbia River have been decreasing in size. Many reasons for the decline are apparent. The most serious causes are dam construction, which not only kills fish but renders previous spawning grounds inaccessible; irrigation ditches, which trap downstream migrants; and over-fishing. It has not been definitely shown which is the major cause, but regardless of the cause the bluebacks are becoming less numerous and are approaching extinction. Landings of bluebacks in the 1890's were always well over a million pounds, and in two years were five millions or more (Figure 1). In 1923 about 2,750,000 pounds were landed. This was the last big year for blueback fishing, although about 1,250,000 pounds were caught in 1926. Averaging the yearly landings for 1889-1892 gives a value of 3,334,345 pounds. The average annual landing for the twenty-year period 1928-1947 inclusive was 322,594, or less than one-tenth that of the former years.

From these data it was obvious that immediate measures were necessary to prevent complete extinction of this formerly valuable species. It



[1]This paper represents a phase of the Columbia River investigations being carried on jointly by Washington and Oregon and was prepared under the direct supervision of Donald R. Johnson, who is in charge of the Columbia River work for the Oregon Fish Commission.

was especially apparent after the very poor catches of 1942-1946. With conservation measures in mind, a study of the blueback fishery was begun in 1947 by the Oregon Fish Commission and the Washington Department of Fisheries.

There are certain peculiarities in the life history of the blueback which limit their distribution in the Columbia River. The adults always spawn in lakes or streams tributary to them. The young upon emerging from the gravel move into the lake where the food (plankton) and temperature conditions satisfy their requirements. They usually spend one year in the lake, but occasionally some stay two years in fresh water. The adult bluebacks in the Columbia River predominantly return on the spawning migration as four year old fish, although a few five year olds normally appear. None are known to spawn in any of the Columbia River tributaries below Bonneville.

Procedure

For statistical purposes, the Columbia River has been divided into six zones, extending from the mouth of the river (Zone 1) to the vicinity of Celilo Falls (Zone 6). Five of these are below Bonneville and one above. Commercial landings are tabulated by zones or areas by the Washington and Oregon fisheries departments. Consequently, the reports show when the majority of the blueback are caught in the various parts of the river. In order to determine the peak of migration in each zone, the date on which half the run passed a given point was determined. These mid-points were averaged by zone for 1940-1946. The results obtained showed that the bulk of the blueback landings occurred at approximately the same time in the five lower areas. Below Bonneville the majority of the blueback were landed between June 20 and July 3, the average occurring about June 28. Above Bonneville the peaks varied from July 4 to July 19 and averaged July 11 (Table 1).

TABLE 1

MIDPOINTS OF YEARLY BLUEBACK LANDINGS BY ZONES IN OREGON
1940–1946

Year	Below Bonneville					Fish passing Bonneville	Above Bonneville Zone 6
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5		
1940	June 25	June 22	June 28	.....	July 6	July 3	July 8
1941	June 26	June 27	June 30	.....	July 2	July 3	July 4
1942	June 25	June 25	June 26	.....	June 30	July 6	July 8
1943	July 1	June 30	June 30	July 1	July 6	July 12	July 9
1944	June 26	June 27	June 24	July 2	.....	July 7	July 13
1945	June 21	June 20	June 20	June 25	.....	July 10	July 19
1946	July 2	June 26	June 27	July 2	.....	July 10	July 13
Average	June 27	June 25	June 26	June 30	July 3	July 7	July 11

The blueback counts over Bonneville, as supplied by the Corps of Engineers, were also studied. The dates of the period in which most (approximately 90 per cent) of the fish passed over the dam for each year were determined by inspection. Normally the vast majority ascend the Bonneville ladders during the last week in June and the first three weeks in July.

The date of the mid-point of the run was determined for each year and averaged for 1940-1946. The time varied from July 3 to July 12 with an average at July 7. In short, the average peak of the commercial landings below Bonneville occurred nine days before the Bonneville Dam peak and thirteen days before the upriver peak.

All commercial landings are recorded in pounds. In order to better compare the annual runs and determine the escapement, it was decided to convert pounds to numbers of fish. This conversion is advantageous in comparing the commercial catch with counts at Bonneville and Rock Island Dams. Rock Island Dam is several hundred miles above Bonneville in the vicinity of Wenatchee, Washington and counts are made there by the U. S. Fish and Wildlife Service. Average weight data for bluebacks are exiguous, especially so for the fishery above Bonneville. As a result, various authors have used values varying from two and one-half to four pounds. For example, Fish (1948) used four pounds; Chapman (1938), 3.9; Rich (1943), 3 for the lower and 2.5 for the upper river; U. S. Fish and Wildlife Service (unpub. m.s.), 3.5. Available information indicated 3.5 pounds for the entire river as probably the most accurate value; consequently, it was used for conversions in this paper.

In a salvage attempt to preserve the blueback runs blocked by Grand Coulee Dam, the U. S. Fish and Wildlife Service began a five year relocation program in 1939 by trapping the fish in the Rock Island fish ladders for transference to streams below Grand Coulee. Some of the adults were to be handled in the hatcheries and the remainder were to be allowed to spawn naturally. Since the hatchery was not ready to handle the eggs in 1939, the adults were planted in Osoyoos Lake on the Okanogan River and Lake Wenatchee on the Wenatchee River. The first eggs were taken and the resultant fry raised artificially in 1940. The progeny of the 1939 transplants returned to their relocated home in 1943.

Discussion

The year 1941 proved to be the most disastrous spawning year for bluebacks in the history of the Columbia River salmon runs. An analysis of the statistics offers reasons for this catastrophe. The Bonneville counts declined sharply in 1941 to 44 per cent of the 1940 count while the Rock Island counts fell to only four per cent of the preceding year's total and six per cent of the previous cycle year's total. In direct contrast the commercial landings for the entire river in 1941 were higher than for any other year from 1938 through 1946. In that year 83 per cent of the estimated run entering the river was taken by the fishery as compared with the annual average of 62 per cent. With the exception of 1947 the computed run entering the river was second in numbers only to that of 1940 which was 195,800 as compared to 174,000 for 1941 (Fig. 1). The average annual run from 1938 through 1947 was 129,700 fish.

From the mid-point of the landings nothing unusual was noted in the passage of the fish through the lower zones, but the blueback entered the upper river fishery sooner than in any previous year. The fishery above Bonneville usually takes approximately 32 per cent of the fish passing the dam each year, but in this atypical year the upper-river fishermen caught 55 per cent of the blueback counted over the dam. Fish (1948) estimated that 65 per cent were caught in 1941 as compared with an annual average of 40 per cent. His conversion weight was 4.0 pounds per fish against 3.5 used in this paper.

By subtracting the Rock Island count and the upper-river catch from the Bonneville count, the number of fish which remained in the river system between the two dams was obtained. From these computations it was determined that annually an average of 36 per cent of the Bonneville count is not definitely located. In 1941 approximately 43 per cent was not found. Although higher than the average, this value was not too much greater than for all the years 1938 through 1942 when a value of at least 40 per cent was not uncommon. Subsequently, the percentage unaccounted for has been less. Fish infers that unusual numbers of fish perished during the summer of 1941, perhaps due to the myxobacterium parasite *(Chrondrococcus columnaris.)* The above data do not substantiate Fish's hypothesis. The unaccounted for fish may spawn in some tributaries in this area or even in the main Columbia. It is difficult to say if any or all of these bluebacks spawn before their death. Examination of available data, as will be pointed out later, indicates little blueback spawning below Rock Island. In recent years a few have entered Drano Lake at the mouth of the Little White Salmon River, and for years there has been a natural run of unknown magnitude entering Redfish and Alturas Lakes on the Upper Salmon River. The total run of these spawning populations is believed to be small.

The much greater Celilo catch coupled with the slightly higher than average percentage of unaccounted for fish caused an abnormally low count at Rock Island in 1941. Only 1.5 per cent of all the bluebacks which passed Bonneville survived to go over Rock Island Dam in contrast with the ten

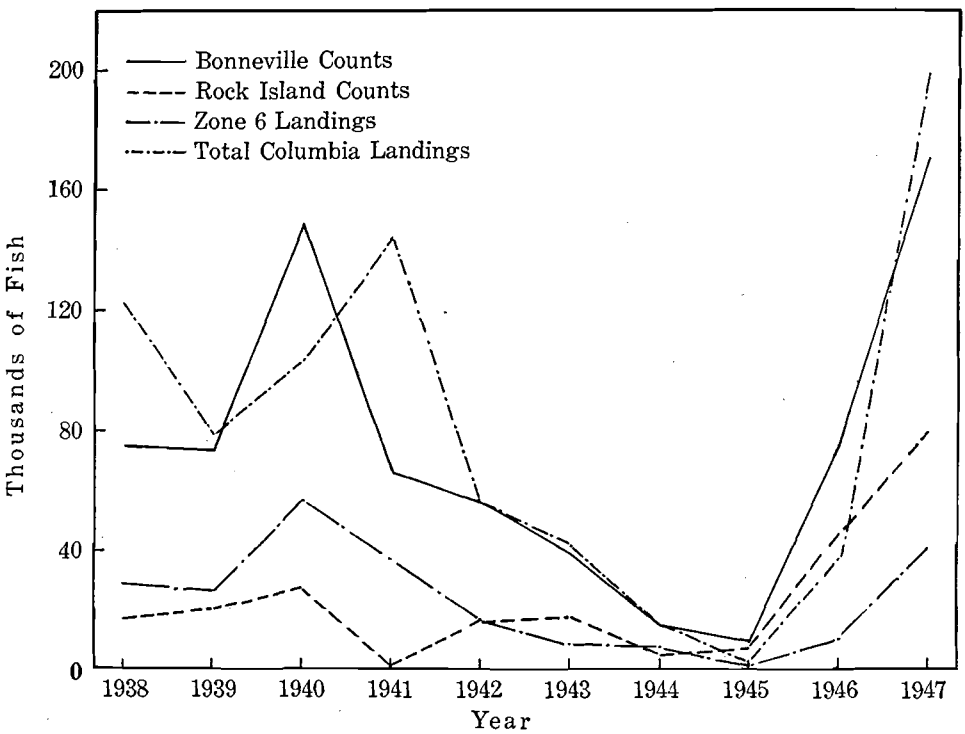


FIGURE 2

BONNEVILLE AND ROCK ISLAND COUNTS AND TOTAL COLUMBIA AND ZONE 6 LANDINGS OF BLUEBACKS, 1938-1947

year average of 32 per cent. This was by far the lowest count of bluebacks on record for that place.

Figure 2 shows the Bonneville and Rock Island counts in addition to the blueback landings for the entire river and for the area above Bonneville for 1938 through 1947. The Celilo landings correspond very closely with the Bonneville counts as would be expected. The total landings for the entire river also follow the trend of the numbers passing Bonneville fairly well except for 1941 when the commercial landings increased and the Bonneville counts decreased sharply.

An analysis of the upriver blueback catch reveals several interesting facts. The catch annually represents about 29 per cent of the total Columbia River landings and has varied from 19 to 54 per cent. Of the blueback passing Bonneville Dam an average of 32 per cent is destined to be caught in the commercial fishery above the dam. The bulk of the blueback taken above Bonneville are caught by Indians. Their annual take averages 82 per cent of the total upriver landings, varying between 62 and 97 per cent. Dip nets annually catch 26 per cent or one out of every four bluebacks landed commercially on the entire Columbia River. This serves to emphasize the importance of the Indian fishery and points to the necessity of having regulations apply to both Indians and white men alike.

The catch below Bonneville plus the Bonneville count provides a close approximation of the total number of bluebacks entering the river. In this way the yearly run can be computed (Fig. 1). Substracting the total catch from the calculated run gives the spawning escapement in numbers of fish (Table 2). The escapement varies from 17 per cent in 1941 to 77 per cent in 1945 with an average value of 38 per cent.

TABLE 2

BREAKDOWN OF COLUMBIA RIVER BLUEBACK RUNS IN NUMBERS OF FISH 1938–1947

Date	Estimated Run in River	Total Commercial Catch	Total Escapement	Rock Island Count	Number Unaccounted for
1938	168,952	122,249	46,703	17,123	29,580
1939	125,788	78,075	47,713	19,591	28,122
1940	195,777	103,198	92,579	26,894	65,685
1941	174,001	144,524	29,477	949	28,528
1942	94,434	54,957	39,477	15,782	23,695
1943	73,533	41,788	31,745	17,665	14,080
1944	23,653	15,595	8,058	4,932	3,126
1945	10,868	2,473	8,395	7,140	1,255
1946	100,436	36,135	64,301	45,555	18,746
1947	330,023	199,048	130,975	79,496	51,479
Average	129,747	79,804	49,942	23,513	26,430

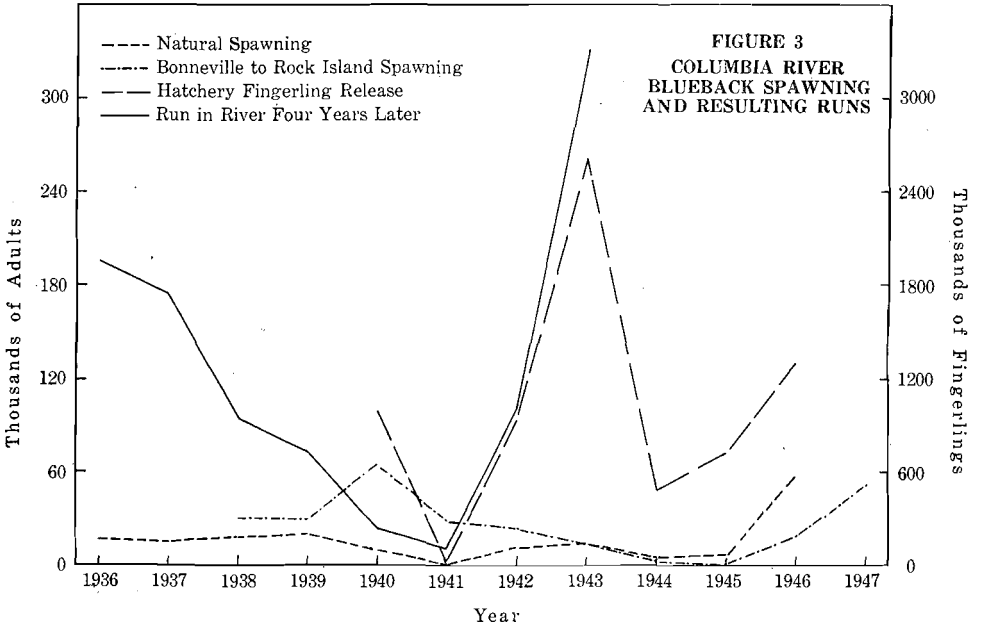
The number of fish entering the river continued to decline through 1945 even though the Grand Coulee program had been in effect long enough to allow two year classes to return. Lack of knowledge on optimum hatchery procedures resulting in poor condition of the fish is the attributed cause for the continued decline (Fish, 1948). By 1943 some improved techniques were developed and used on the 1942 brood; these may have caused the increased run in 1946. The 1942 Rock Island counts showed a decided increase over

the previous year's count (949 to 15,782). Consequently, both natural and artificial propagation increased in the latter year and it was logical to expect a greater run in 1946 than in 1945.

In 1943 the Rock Island count continued to show an increase and natural spawning was greater. The number handled in the hatchery was less, although the fingerling release was almost three times that of 1942. Fish attributed this to the tremendous advances made over the hatchery practices used the previous year. The 1944 return to Rock Island was less than one-third that of the preceding year. Of the 4,932 returning adults only 168 were handled in the hatchery. It is believed that the primary reason for the successful return in 1947 of the 1943 brood was the large number of fingerlings released from the hatcheries. If this is true, the return of the 1944 brood in 1948 should be small—smaller than 1947 and about the same size as 1946—because of the fewer fingerlings released. The run in 1949 will probably be light also, although larger than that of 1948.

Factors Affecting Run

There seems to be little correlation between the numbers of fish possibly spawning in tributaries between Bonneville and Rock Island Dams and the run resulting from that spawning (Fig. 3). For several of the years the trends are dissimilar. One will increase many fold while the other will decrease. From the available data it seems probable that fish which escape the commercial fishery above Bonneville but do not migrate as far up the Columbia as Rock Island contribute little to the run. As pointed out previously an annual average of 36 per cent of the bluebacks which escape the upriver fishery do not pass over Rock Island Dam.



Since the beginning of the salvage program arising from construction of Grand Coulee Dam, some of the fish passing Rock Island each year have

been allowed to spawn naturally. The yearly number has been compared with the total run entering the river four years later (Fig. 3). In general the trends from 1937 through 1942 were somewhat similar, although major changes in one were not reflected to a like degree in the other.

The closest correlation seems to be between the number of fingerlings released from the hatcheries and the resulting runs entering the river (Fig. 3). This tends to substantiate the similar hypothesis offered by Fish (1948). If the size of the run is directly proportional to the number of hatchery reared fingerling released three years previously (four years from the egg), it is logical to assume that major changes in one would be reflected in the other. The general patterns in this case are very similar; the only incongruous year being 1941. The total run returning from the 1941 spawning was only slightly less than that of 1940, but the hatchery releases were vastly smaller. In other words the number of returning adults per thousand fingerlings planted was greater in 1941 than in 1940. This may possibly have been due to the condition of the liberated fish. Of the total number of eggs taken in 1940 only 16.1 per cent survived to be released as fingerlings (Fish, 1948). It seems logical to assume, therefore, that an abnormally large proportion of the fingerlings which were released may have died before reaching maturity. If this hypothesis is true, it would explain the lack of correclation in 1941. As more knowledge is obtained about correct hatchery procedures, the ratio of returning adults to fingerlings released should increase. This occurred in the return of the 1943 brood.

The question immediately arises as to the possible size of the 1948 run—the return from the 1944 spawning. It is difficult to accurately predict the number as there are many variable factors which might influence the run. It is especially true this year (1948) because of the very abnormal water levels and general river conditions. During 1948 the worst flood in fifty years played havoc with the Columbia River. The fish may have been prevented from entering the river, killed by the high muddy water, or retarded in their migration enough to cause early death. If the unusual river conditions do not appreciably affect the migration, the blueback run in 1948 should approximate 100,000 fish, or 30,000 fish less than the average run for the last ten years. As shown above, the runs this year and next are expected to be small. For that reason it is imperative that some action be taken to protect these two cycles if the blueback are to continue to support a commercial fishery.

From the analysis of the catches for the last few years, it was decided that a new closed fishing period should be inaugurated. The regulation which has been in effect did not take into account the difference in time between the upper and lower river seasons and, consequently, the closed period was the same for the entire river. As a result, many of the fish which passed through the lower river during the closed season were caught above Bonneville Dam when the season reopened. Furthermore, it did not protect the blueback because the vast majority migrated through the fishing areas after the closed period.

The new regulation staggers the closed seasons above and below Bonneville, the former beginnnig and ending eight days after the latter. In this way the run receives maximum benefit possible under existing laws. The times were selected in order to allow the greatest possible number of bluebacks to escape the fishery. If the runs this year and next are approximately normal in time of arrival, the desired results should be accomplished, and the Columbia River blueback runs can be expected to continue to increase.

Summary

The Columbia River blueback runs have steadily declined for fifty years, the annual landing for the last twenty years averaging less than one-tenth that of 1889-1892.

The total number of fish entering the river each year was correlated with the following factors existing during the previous cycle: the fish remaining between Bonneville and Rock Island Dams, the number spawning naturally above Rock Island, and hatchery fingerling releases. The best correlation occurred between the fingerling releases and the run entering the river three years later, i.e. four years after spawning. The data indicate an estimated 100,000 adult bluebacks should enter the Columbia River this year.

The average annual take by the commercial fishery on the Columbia River from 1938 through 1947 was 62 per cent of the calculated total blueback runs.

The fate of the fish passing over Bonneville Dam was studied. Statistics for the last ten years (1938-47) indicate that 32 per cent were caught in commercial gear, 32 per cent went above Rock Island and 36 per cent either died in the Columbia above Bonneville Dam or entered some tributary below Rock Island Dam.

Fishing regulations designed to protect the expected small blueback run were inaugurated in 1948.

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Shad Tagging in the Umpqua River

A shad, tagged on its way to the spawning ground in the Umpqua River on June 9, 1948 was caught in the Siuslaw River on June 22 the same year.

The fish was tagged near the town of Gardiner, ten miles up from the mouth of the Umpqua. It was recovered fourteen miles up the Siuslaw which enters the ocean about twenty miles north of the Umpqua.