UNITED STATES DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES

Spawning Areas and Abundance of Chinook Salmon (Oncorhynchus tshawytscha) in The Columbia River Basin--Past and Present

By

LEONARD A. FULTON

United States Fish and Wildlife Service
Special Scientific Report--Fisheries No. 571

Washington, D.C.
October 1968

CONTENTS

Spawning Areas and Abundance of Chinook Salmon (Oncorhynchus tshawytscha) in The Columbia River Basin--Past and Present

By

LEONARD A. FULTON, Fishery Biologist

Bureau of Commercial Fisheries Biological Laboratory
Seattle, Washington 98102

ABSTRACT

Chinook salmon, the most abundant species of salmon in the Columbia Basin, formerly spawned in nearly all tributaries of the Columbia River and in many areas of the main river. Over the past 60 years, the construction of dams has inundated, impeded, or blocked access to spawning areas.

Despite these heavy losses, large areas of spawning grounds in the middle and lower portions of the drainage are still available to chinook salmon. Stream improvements by State and Federal fishery agencies have rehabilitated some areas and have brought others into production for the first time.

Important spawning areas are listed and charted in this report according to their past use (before 1965) and present use (1966). Estimates of recent spawning populations in major tributaries and in segments of the main stem are also given. Former and present levels of abundance are listed according to three major runs--spring, summer, and fall.

INTRODUCTION

Chinook salmon (Oncorhynchus tshawytscha) formerly spawned in the main stream and in nearly every accessible tributary of the Columbia River.

This species is the most important of the area in total poundage harvested and in value to the commercial and sport fisheries. Commercial production reached an alltime high of nearly 19.5 million kg. (kilograms) in 1883 (fig. 1). Evidence of impending decline appeared as early as 1889, when only 8.2 million kg. were taken. Catches fluctuated between 7.7 and 16.8 million kg. in 1890-1920, and gradually declined during 1921-66. The average annual catch during 1962-66 was about 2.3 million kg.

The decline in catch has been attributed to the advance of civilization in the Pacific Northwest. Irrigation, logging, mining, dam construction, and other activities reduced the size and capacity of spawning areas. Resolution of the problems of safely passing migrating salmonids--particularly of young downstream migrants--has not kept pace with dam construction in the Columbia River drainage.

The Bureau of Commercial Fisheries began intensive research in 1961 on problems of fish passage; the work was closely coordinated between State and other Federal agencies. To plan research effectively and to aid management of the remaining runs of Columbia River chinook salmon, it was necessary to review the many reports available on spawning of salmonids.

Evermann (1896) reported on the salmon runs in Idaho during the early 1890's. He listed information from local residents and observed the extent of salmon migrations into the upper Snake River and tributaries.

The Pacific Salmon Investigations of the U.S. Bureau of Fisheries and its successor agency, the Fish and Wildlife Service, surveyed the Columbia River Basin from 1934 to 1946. The data were published in the Special Scientific Report series of the Service, entitled "Survey of the Columbia River and its Tributaries" in eight parts by the following authors: Rich (1948); Bryant (1949); Parkhurst, Bryant, and Nielson (1950); Bryant and Parkhurst (1950); Nielson (1950); and Parkhurst (1950a, 1950b, and 1950c). These reports contain information on the past spawning areas, size of runs, location and amount of spawning gravel, location of obstructions, and estimates of the capacity of part of the streams to support successful spawning. These reports have been valuable aids in locating spawning areas, so that improvements could be made at the most desirable locations.

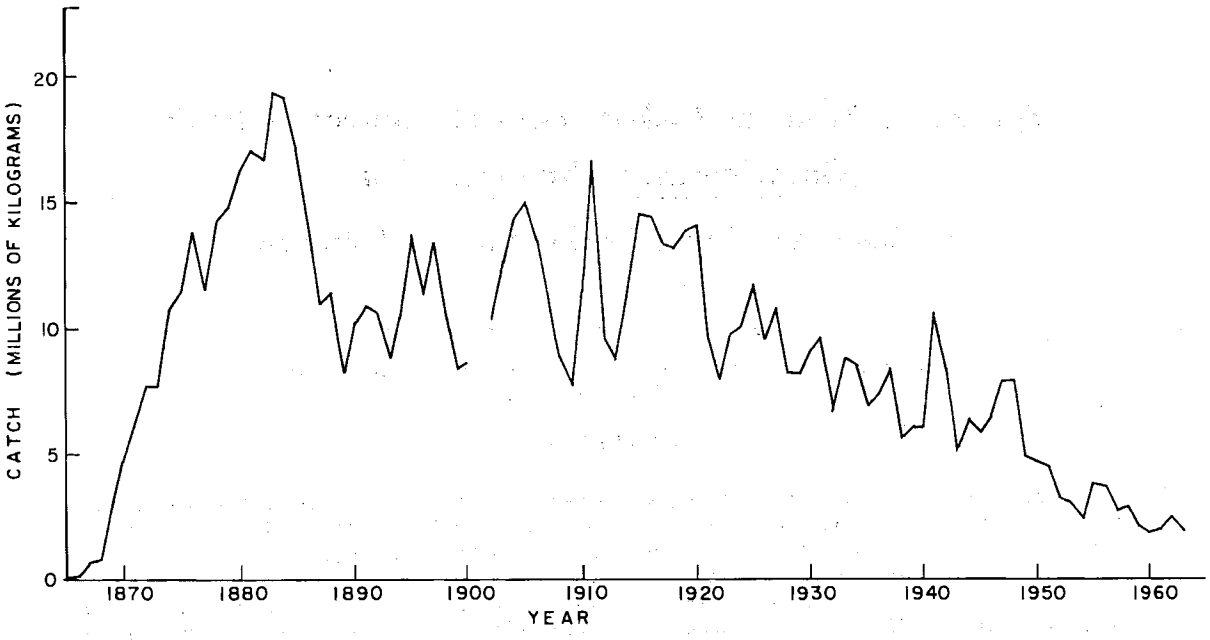

Figure 1.--Commercial catch of chinook salmon in the Columbia River, 1865-1962. Data for 1865-1937 from Craig and Hacker (1940) and for 1938-62 from Ward, Robison, and Palmen (1964).

More recent reports by State fishery agencies deal with specific sections of the Columbia River drainage. The Willamette River was surveyed from 1958 to 1960 by biologists of the Fish Commission of Oregon (Willis, Collins, and Sams, 1960). Eastern Oregon rivers (Umatilla to Owhyee) were also surveyed by the Commission from 1957 to 1960 (Thompson and Haas, 1960). These extensive surveys included information on the species of fish, environment, obstructions, diversions, potential hatchery sites, projected impoundment areas, and recommendations for corrective measures. Surveys based on aerial observations were also made by the Fish Commission of Oregon on the Deschutes and John Day Rivers and on Fifteen Mile Creek (Haas and Warren, 1961).

Surveys of Idaho tributaries of the Columbia River started about 1955 by the Idaho Department of Fish and Game and are still being continued. Hauck[1] provided information on past and present spawning areas in Idaho and on the relative importance of the Salmon River and its tributaries for the production of chinook salmon. A report on the Clearwater River was released in 1962 by the Idaho Department of Fish and Game (Murphy and Metsker, 1962); the report gives comprehensive data on spawning gravel in the Clearwater River and on its important tributaries (excluding the North Fork). Spawning ground surveys on the North Fork were made by personnel of the Bureau of Commercial Fisheries in connection with the proposed Dworshak Dam (Tunison and McKernan, 1960).

Locations of principal spawning areas and estimated runs in Washington streams were provided through correspondence[2] and personal interviews. Further information on the lower Columbia tributaries in Washington appears in subbasin reports of the Columbia River Fishery Development Program and the Washington Department of Fisheries. Joint reports were made on the Abernathy, Cowlitz, Elokomin, Grays, Kalama, Klickitat, Lewis, and Wind River areas (Washington Department of Fisheries and Fish and Wildlife Service, 1951). The Fish and Wildlife Service (1951) reported independently on the Big White Salmon, Little White Salmon, and Washougal River areas.

Many streams were rehabilitated under Federal-State public works programs in the 1930's by installing screens, improving fishways, and removing obstructions such as logjams or splashdams.

More recently, the Columbia River Fishery Development Program, a cooperative Federal-State program for construction and rehabilitation, has continued to restore formerly productive areas and put previously inaccessible areas into use. This program was activated in 1949, when maximum emphasis was placed on development of fishery production in the

[1] Personal communication, Forrest R. Hauck, Idaho Department of Fish and Game, October 24, 1961.

[2] Henry O. Wendler, Washington Department of Fisheries, table entitled "Salmon runs of the Columbia River watershed," July 12, 1961.

Columbia River drainage below McNary Dam and was extended in 1957 to include areas above McNary Dam. Present emphasis is centered on the Willamette River system and the area above McNary Dam. Current activities are stream clearing, fishway construction, screening, and an evaluation of hatchery production.

Largest expenditures under the Program were for artificial propagation facilities (Bureau of Commercial Fisheries, 1960). Improvements made on streams of the Columbia River Basin are listed in the Annual Progress Reports of the Columbia River Fishery Development Program (Fish and Wildlife Service, 1952-57; Bureau of Commercial Fisheries, 1958, 1960, 1961, 1964).

The present report condenses information from various sources. Maps show the general location of past and present spawning areas. Other information is tabulated. Fishery scientists and administrators associated with the present Fish-Passage Research Program have already used information from the manuscript. On the basis of this use they have expressed the need for published summaries that are comprehensive and cover the entire Columbia River Basin.

This report on chinook salmon is intended to fill that need. A second report is to cover sockeye salmon (O. nerka), coho salmon (O. kisutch), chum salmon (O. keta), and steelhead trout (Salmo gairdneri).

SPRING- AND SUMMER-RUN CHINOOK SALMON

Chinook salmon in the Columbia River were divided arbitrarily into three runs--spring, summer, and fall--on the basis of timing of returns from the sea to fresh water (table 1). Spring- and summer-run chinook salmon are treated as one group in this section and the fall run as a separate group in the next. Spring and summer runs of chinook salmon had to be combined because of the difficulty of separating the two groups on their principal spawning ground--the mid-Columbia tributaries.

Characteristics of the major runs of chinook salmon (table 1) are listed in terms of type of spawning stream, spawning period, average size, and period of migration. The average weights were calculated from samples from the commercial fishery by the O.F.C. (Fish Commission of Oregon) for 1959-62 (Pulford, Woodall, and Norton, 1963). Spawning areas and the abundance of spring- and summer-run chinook salmon will be discussed in the following sections.

Spawning Areas

As noted in table 1, spring chinook salmon generally spawn in small- and medium-sized tributaries of the middle Columbia River, whereas summer chinook salmon generally

Table 1.--Characteristics of spring, summer, and fall runs of Columbia River chinook salmon

Run	Usual type of spawning stream	Spawning period	Average weight	Period of migration			
				Lower river	Bonneville Dam	The Dalles Dam	McNary Dam
			Kg.				
Spring	Smaller tributaries and upper reaches of principal tributaries	Late July to late September	6.8	February through May	March 1 to May 31	March 31 to June 5	April 1 to June 15
Summer	Main stem, large and medium-sized tributaries	Mid-August to mid-November	6.4	June through mid-August	June 1 to August 15	June 6 to August 20	June 16 to August 31
Fall	Lower river tributaries, main stem Columbia and Snake Rivers	September to December	8.2	Mid-August through October	August 16 to October 1	August 21 through October	September 1 through mid-November

spawn in intermediate and large tributaries and in middle reaches of the main stem.

Spring-run chinook salmon spawn in some lower Columbia River tributaries such as the Willamette, Cowlitz, and Kalama Rivers. They also are distributed in middle tributaries of the Columbia and Snake Rivers. (Fall-run chinook salmon, discussed later in the report, share spawning grounds in some sections of the Cowlitz and Kalama Rivers.) These are not all of the areas in which such duplications occur but are cited as examples.

French and Wahle (1960, 1965) observed that some spring-run chinook salmon spawned in the same areas as the summer-run chinook salmon in the middle Wenatchee and Methow Rivers. Summer-run chinook salmon were more numerous in the lower and middle Wenatchee and Methow Rivers, whereas spring-run chinook salmon were found principally in the tributaries and upper parts of these rivers. The examples are typical of the spawning distribution of spring- and summer-run chinook salmon in tributaries of the Columbia River.

In referring to the major sections of the Columbia River drainage, I have defined the lower Columbia River as the area below McNary Dam, the middle Columbia River as the area between McNary and Chief Joseph Dams, and the upper Columbia as the area above Chief Joseph Dam. Former or past spawning areas are those known to have been used before 1965. Present spawning areas are those that were still in use in 1966.

Map 1 shows the approximate location of present and former spawning areas of spring and summer chinook salmon in the Columbia River. The Willamette River, the principal tributary of the lower Columbia, has an extensive tributary system with many excellent spawning grounds (map 2).

Table 2 lists the length of streams in kilometers and distance of the stream from the mouth of the Columbia or of the contributing drainage. The table also indicates present and former principal spawning areas and carries notes on special features of the tributaries or runs.

Spring- and summer-run chinook salmon formerly migrated almost the entire length of the Columbia River (map 1). From information obtained from residents of the upper Columbia River area in 1936, Bryant and Parkhurst (1950) reported that large chinook salmon (probably summer-run), weighing from 18 to 27 kg., migrated nearly 1,932 km. up the Columbia River to spawn in the main stem just below the outlet of Windermere Lake in British Columbia. After the construction of Grand Coulee Dam, runs were intercepted at Rock Island Dam (1939-43) for transplanting into the Wenatchee, Entiat, Methow, and Okanogan Rivers.

Migrations of spring-run chinook salmon into the upper Snake River were documented by Evermann (1896). Spring-run chinook salmon were observed spawning as far upstream as Rock Creek, a tributary that enters the Snake River just below Augur Falls--a distance of more than 1,442 km. from the ocean. The runs that migrated into Rock and Salmon Falls Creeks and into the Bruneau River were depleted or lost many years ago because of inadequate or no provisions for fish at irrigation dams and diversions.

In summary, some of the more obvious factors responsible for the destruction of spawning and rearing areas for spring and summer chinook salmon in the Columbia Basin are: (1) reduction of stream flow and blockage by irrigation projects and splash-dams; (2) blockage by hydroelectric projects; (3) inundation of spawning areas by impoundments; and (4) destruction of spawning and rearing areas by siltation, debris, or pollution from sewage, farming, logging, and mining.

Abundance of Spring- and Summer-Run Chinook Salmon

Commercial salmon fishing in the Columbia River initially was confined almost solely to the spring and summer runs of chinook salmon. The size of the catch (up to nearly 19.5 million kg.), the extent of the fishery, and the reports by early settlers of the large runs observed in nearly all of the accessible tributaries attest to the magnitude of these stocks during the early Columbia River salmon fisheries. Inevitably, the runs began to decline as major upriver producing areas were cut off because of factors previously mentioned.

Some of the more important spawning areas of spring- and summer-run chinook salmon no longer in production include: (1) Lower Columbia tributaries--major portions of the John Day and Umatilla Rivers; (2) Snake River tributaries--most of the Clearwater and Powder Rivers; all of the Burnt, Weiser, Malheur, Payette, Owyhee, Boise, and Bruneau Rivers; and all of the Salmon Falls and Rock Creeks; (3) middle and upper Columbia tributaries--the major portion of the Walla Walla River system, considerable area in the Yakima and Okanogan Rivers, and the entire area above Chief Joseph Dam (including the main stem Columbia, the San Poil, Spokane, Kettle, Pend Oreille, and Kootenay Rivers).

In a report prepared for a hearing on regulations for commercial salmon fisheries of the Columbia River (Fish Commission of Oregon and Washington State Department of Fisheries, 1967), the fishery agencies of Washington and Oregon provide current estimates of the size of spring and summer runs of chinook salmon. These estimates (table 3)

Table 2.--Present and former spawning areas of spring and summer chinook salmon, Columbia River and tributaries

Stream				Location of spawning areas		Notes	References[3]
Number[1]	Name	Length	Distance above mouth[2]	Present	Former		
		Km.	Km.				
1.	Cowlitz R.	209	105	Upper section of main river and Ohanapecosh R.	About same as present.	Has numerous good spawning areas. Mayfield Dam (completed in 1961) and Mossyrock Dam (under construction) pose difficult fish passage problems.	2, 39
1A.	Toutle R.	84	27	Upper tributaries and South Fork.	Same as present.	South Fork has many good riffles and pools.	2, 39
1B.	Cispus R.	80	148	Lower 40 km. of main stem and lower 10 km. of North Fork.	Same as present.	This stream has many kilometers of excellent spawning and rearing areas.	2, 39
2.	Kalama R.	68	121	Middle and upper portions of main river.	About same as present.	Forty-eight km. of prime spawning area made available by laddering a falls and dam about 18 km. above the mouth in 1956. Spring runs are small, but new areas should be favorable for increased production of spring-run chinook salmon.	2, 39
3.	Lewis R.	145	137	Lower portion below Merwin Dam.	Middle and upper Lewis R. and tributaries removed from production by Merwin, Yale, and Swift Dams.	Remnant spring runs are now confined below Merwin Dam. Hatchery formerly handled spring chinook salmon and young were released in upper streams and the reservoir. Spring run last appeared at hatchery in 1955.	2, 39
4.	Willamette R.	303	162	None in main river.	None.	Used as passageway to spawning areas in tributaries.	29, 40
4A.	Clackamas R.	129	34	Middle and upper portions of Clackamas R.; North Fork, Eagle Creek, Collawash R., and Hot Springs Fork.	Eighteen km. of main river.	River Mill and Cazadero Dams, constructed in early 1900's, had an adverse effect on runs. Lack of fishway at Cazadero for 35 years prevented use of preferred upstream spawning areas. Cazadero was laddered in 1938, allowing migrants to pass above. When North Fork Dam was built in 1958, improved fish passage facilities were installed at all three dams. Present facilities and use of upriver spawning areas believed to be responsible for increasing runs over previous years.	29, 40
4B.	Mollala R.	80	58	Upper Mollala and upper North Fork.	About same as present.	Extensive good spawning areas are located in the upper Mollala and North Fork.	29, 40
4B1.	Pudding R.	88	2	Abiqua Creek.	Butte and lower Abiqua Creeks.	Pollution from cannery waste caused destruction of runs in Pudding R., but conditions have since been improved. Most of the spring-run chinook salmon spawn in Abiqua Creek. A few salmon have been reported in Butte Creek, but no runs are established.	29, 40
4C.	Santiam R.	18	175	None in main stem.	None.	Low flows, high temperatures, and pollution are problems, but migrants are able to pass through the main stem to the tributaries.	29, 40
4C1.	North Santiam R.	148	18	Lower 66 km. of main stream, and lower 24 km. of Little North Santiam R.	Spawning areas in Breitenbush R. and upper tributaries of N. Santiam R. were cut off by Detroit and Big Cliff Dams.	Second most important contributor in Willamette system. Fish that formerly spawned above Detroit and Big Cliff Dams are collected at Minto racks for propagation at Santiam Hatchery of the O.F.C. (Fish Commission of Oregon).	29, 40

See footnotes at end of table.

Table 2.--Continued

Stream				Location of spawning areas		Notes	References[3]
Number[1]	Name	Length	Distance above mouth[2]	Present	Former		
		Km.	Km.				
4C2.	South Santiam R.	139	18	Sixty-nine km. stretch of main river and lower Wiley Creek.	Same as present.	Important producer of spring chinook salmon. Present spawning area threatened by proposed water-use developments.	29, 40
4C2a.	Middle Santiam R.	48	68	Well distributed throughout most of its course. Also 26 km. of Quartzville Creek.	Same as present.	Numerous good spawning areas and resting pools.	29, 40
4D.	Calapooya R.	116	184	Stretches in middle and upper portions of main river.	About same as present.	Finley Dam, built in 1847, about 72 km. above the mouth, blocked runs for 102 years. Best spawning area became available after this dam washed out in 1949. Stream improvement work has been accomplished, but runs are still small.	29, 40
4E.	McKenzie R.	138	272	Throughout length of main river and portions of Gate Creek, Blue R., Horse Creek, Separation Creek, and Lost Creek.	Mohawk Creek removed from production by past logging practices.	River has remained a good producer in spite of losses of both upstream and downstream migrants at following projects: Irrigation District Canal, Eugene-Springfield Supply Diversion, and Walterville Canal. A barrier and bypass at Walterville Canal and bypass at Leaburg Power Plant are needed for adults. Screens are needed at the diversions. Stream has excellent water supply, proper size of gravel, and suitable gradient for spawning. Produces largest run in Willamette system (estimated at 45-50 percent).	29, 40
4E1.	South Fork McKenzie R.	50	93	Main river and French Pete Creek.	Eleven km. of main stream inundated by Cougar Dam.	Cougar Dam, dedicated May 9, 1964, is about 6 km. from mouth. Strube Dam, to be constructed 3 km. down from Cougar, will regulate flow. Important spawning area will be inundated, but area above dams will be kept in production by fish passage devices.	29, 40
4F.	Middle Fork Willamette R.	124	304	Fall, Little Fall, Big Fall, Winberry, and Lost Creeks.	About 1,508 km. of streams cut off by Dexter and Lookout Point Dams. No record of spawning in river below Dexter Dam.	Spring runs which formerly spawned above Dexter Dam are now maintained by the Willamette Hatchery (O.F.C.). Many fish lost in holding ponds because of disease in former years. Improved treatment and handling have reduced losses in recent years. Good-sized runs returned in 1963.	29, 40
4G.	Coast Fork Willamette R.	80	304	None.	Former runs were present in the upper Coast Fork.	Domestic and mining pollution depleted runs before construction of Cottage Grove Dam in 1942, which blocked runs 45 km. above mouth. Releases of warm water from the dam prevent use of downstream areas by spring chinook.	29, 40
4G1.	Row R.	27	34	None.	Upper and lower Row R.	Little information on extent of former runs. Dorena Dam blocked Row R. in 1949.	29, 40
5.	Sandy R.	72	192	Upper Sandy R.	Portions of lower Sandy and tributaries.	Sandy Hatchery (O.F.C.) rears part of the spring chinook run and the rest spawn in upper watershed.	29

See footnotes at end of table.

Table 2.--Continued

Stream				Location of spawning areas		Notes	References[3]
Number[1]	Name	Length	Distance above mouth[2]	Present	Former		
		Km.	Km.				
6.	Wind R.	52	249	Main river and limited amount in tributaries.	None.	Many kilometers of good spawning area became available when Shipperd Falls were laddered in 1956. River promises to be good producer of spring chinook salmon. Carson National Fish Hatchery rears part of run.	2, 14
7.	Big White Salmon R.	61	270	None.	Middle portion.	Condit Dam blocked runs in 1912. Indians fished salmon at a falls near Husum, Wash. Salmon (probably spring chinook) were found above these falls to Trout Lake.	2, 14
8.	Klickitat R.	143	290	Upper main river.	Not as large as now.	About 3 km. above the mouth, a series of five falls were passable with difficulty to spring-run fish. Passage conditions were recently improved at these falls. Laddering of Castile Falls (river 97 km.) has made available many excellent spawning areas. The Klickitat Hatchery of W.D.F. (Washington Department of Fisheries) operated since 1952, has been instrumental in developing the run.	2, 39
9.	Deschutes R.	394	333	Main river near Squaw Creek; Warm Springs R. and its tributary, Beaver Creek; Metolius R.; and Squaw Creek.	Crooked R. and Trout Creek.	Water-use developments and about 20 natural barriers restrict migration in this system. Crooked R. and Trout Creek runs were wiped out chiefly by removal of water for irrigation. Pelton Dam, constructed in 1958, has created problems in maintaining upriver runs. Round Butte, recently completed above Pelton, adds to the difficulties of fish passage.	20, 21, 23
10.	John Day R.	365	362	Upper main river, upper North and Middle Forks, Granite Creek and its tributary, Clear Creek.	Many areas of middle and upper main river and tributaries.	Insufficient flow for fish caused by irrigation demands has removed much of the middle portion of John Day R. and tributaries from salmon production. Gold dredging has removed additional area from production. These areas has been depleted for about 50 years. Present upper areas are reached by salmon before seasonal depletion of flows by irrigation. John Day R. was formerly a good producer of spring chinook salmon.	21, 23
11.	Umatilla R.	192	483	Small section in upper part of main river.	Upper half of Umatilla R. and tributaries.	A remnant run of spring chinook salmon is reported. Recently O.F.C. has tried to counteract fish loss. Lower Umatilla is almost dry in summertime.	23, 24, 34
12.	Walla Walla R.	90	507	None.	Upper and middle parts of main river and tributaries.	Reported to have been a good producer of spring chinook salmon about 40 years ago. Nine Mile Dam (built in 1905) and other dams destroyed the runs. Good spawning areas in upper 40 km. of main stream.	9, 23, 24, 34
12A.	Touchet R.	100	32	Small portion of Upper North and South Forks.	Throughout main river, part of North and South Forks.	Stream was reported to have had excellent runs in the past. It has greatest potential value of any stream in Walla Walla system. Irrigation practices caused loss of all but a remnant run.	9, 23, 34

See footnotes at end of table.

Table 2.--Continued

Stream				Location of spawning areas		Notes	References[3]
Number[1]	Name	Length	Distance above mouth[2]	Present	Former		
		Km.	Km.				
13.	Snake R.	1609	521	None.	None.	Main Snake not believed to have been used by spring and summer chinook salmon.	13, 26, 27, 28
13A.	Palouse R.	241	97	None.	None.	Palouse Falls, 10 km. above mouth, blocks runs. River is not known to have been a producer of salmon.	26
13B.	Tucannon R.	97	101	Middle and upper parts of main stream and Cummings Creek.	Some reduction in habitat.	Excellent spawning area throughout most of stream. Obstructions and diversions destroyed the former large runs. Remnant run present today.	26
13C.	Clearwater R.	121	225	None in main stem.	Spawning gravel is present, but no record exists of past use.	Unsatisfactory conditions for fish passage at Lewiston Dam, located 6 km. above the mouth, prevented passage from 1927 to about 1940. Area was made available again by improvement of fishway in 1940. Fish passage was recently further improved. A few chinook salmon have been returning annually from restocking.	22, 26, (4)
13C1.	Potlatch Creek	80	24	None.	Upper two-thirds of main stem.	Withdrawal of water for irrigation has made stream unsuitable for spawning owing to stagnation of water, high temperatures, and silting.	22, 26, (4)
13C2.	North Fork Clearwater R.	217	69	Lower half of Little North Fork.	Most of main stream and nearly all lower portions of tributaries. (This area is now available but not now used.)	North Fork formerly supported a large run of chinook salmon. Dworshak project, to be constructed 3 km. above the mouth, will inundate about 45 percent of spawning area. Fish-passage problems in connection with this project have not been resolved.	26, 35, (4)
13C3.	Middle Fork Clearwater R.	39	121	None.	Believed to have been used throughout entire length.	Gradient is moderate with numerous good shallow riffles and adequate resting pools.	22, 26, (4)
13C3A.	Lochsa R.	121	39	A 6-km. stretch in upper main stem.	Most of main stream and lower portions of tributaries.	Area under study to determine corrective measures needed to increase production. Drains a forested, mountainous area. Tributaries contain many falls, logjams, and other barriers to upstream migration. Lochsa system has many kilometers of good spawning areas.	22, 26, (4)
13C3B.	Selway R.	161	39	None believed in use.	Most of main river, lower portions of tributaries.	Selway Falls, about 32 km. above the mouth and a partial barrier to all anadromous fish, will have ladders. Eyed eggs are being planted for 8 years (1960-68) above the falls in an effort to establish chinook salmon runs. Many kilometers of excellent spawning areas in this stream.	22, 26, (4)
13C4.	South Fork Clearwater R.	121	121	None.	Scattered areas along main river and parts of many tributaries.	Present and past gold dredging has limited the value of the South Fork. Improvements needed are: corrective work in dredged areas, removal of logjams, and installation of ladders on falls in some tributaries. A dam at river km. 32 was removed in 1963 to make upper area available for spawning. Stream is being restocked.	22, 26, (4)

See footnotes at end of table.

Table 2.--Continued

Stream				Location of spawning areas		Notes	References[3]
Number[1]	Name	Length	Distance above mouth[2]	Present	Former		
		Km.	Km.				
13D.	Grande Ronde R.	322	274	Upper half of main river and tributaries.	Middle and upper Joseph Creek and tributaries. Some reduction of spawning area in upper main stream.	Grande Ronde system was formerly an excellent producer and still has significant runs. Withdrawal of water for irrigation and gold dredging has reduced the production potential. Summer flows are very low between Elgin and La Grande.	26, 34
13D1.	Wenaha R.	35	72	Upper and middle reaches of main stream and tributaries.	About the same as now.	Substantial numbers of chinook spawn from mid-August to September. Wenaha has a large amount of spawning gravel located in isolated forested area.	26, 34
13D2.	Wallowa R.	88	130	A 40-km. section extending downstream from a few kilometers below Wallowa Lake. Also several small tributaries in upper watershed.	Small portion of lower main stem.	Largest producer of Grande Ronde tributaries. Water is used for irrigation, but volume of flow is generally satisfactory from fishery viewpoint.	26, 34
13D2A.	Minam R.	72	16	Middle portion of main river and lower Little Minam R.	Same as present.	Blasting of Minam Falls and removal of an old splash dam have made upper spawning areas more available to spawners.	26, 34
13D2B.	Bear Creek	40	35	Twelve-km. stretch in lower creek.	Some reduction of spawning area caused by irrigation diversion.	Low summer flow limits the use of this tributary by spring-run chinook salmon.	26, 34
13D2C.	Lostine R.	40	44	Upper and middle sections of main stream and other areas from near mouth to forks.	Same as present.	Small irrigation and water supply diversions do not materially deplete flows. Lostine R. remains a fair producer of spring chinook.	26, 34
13E.	Salmon R.	644	301	Small amount of spawning area scattered throughout lower 322 km. Many good riffles in next 258 km., but the most productive area is in upper 56 km.	About same as present.	Some of the best and unquestionably the most productive spawning areas for spring chinook salmon in the entire Columbia River Basin are in this system. The Salmon River watershed, owing to its rugged topography, has remained relatively unmolested by man. This system has 1,952 km. of stream channel, excluding minor tributaries.	1, 27, 32, 33, (4)
13E1.	Little Salmon R.	69	132	Main stream and Rapid R.	Same as present.	Good spawning areas throughout length of stream. Some partial barriers exist.	1, 27, 32, 33, (4)
13E2.	South Fork Salmon R.	132	214	Main stream and tributaries, Secesh R., East Fork, and Johnson Creek.	About same as present but reduced use of upper portion of East Fork and Johnson Creek.	Large runs attest to the qualities of spawning gravel and water supply in this system.	1, 27, 32, 33, (4)
13E3.	Middle Fork Salmon R.	171	307	Upper half Middle Fork and portions of Big, Camas, Loon, Sulphur, Marsh, and Bear Valley Creeks.	About same as present.	This is the largest and most productive tributary of Salmon River. Has many excellent spawning and rearing areas.	1, 27, 32, 33, (4)
13E4.	Panther Creek	69	327	Throughout most of main stream.	About the same as now.	Most of the spawning gravel is concentrated in a 16-km. stretch just above lower half of stream. Former good-sized runs were depleted chiefly by placer mining and irrigation diversions. Mining ended in early 1960's.	1, 27, 32, 33, (4)

See footnotes at end of table.

Table 2.--Continued

Stream				Location of spawning areas		Notes	References[3]
Number[1]	Name	Length	Distance above mouth[2]	Present	Former		
		Km.	Km.				
13E5.	North Fork Salmon R.	37	368	Lower two-thirds main river.	Lower 18 km. out of production for a period of years owing to dredging in upstream areas.	Silt from placer mining has been carried away, permitting use of spawning areas in lower stream. Small runs present.	1, 27, 32, 33, (4)
13E6.	Lemhi R.	97	404	Most of main stream.	About same as present.	Spawning areas of excellent quality are abundant and well distributed. Recently 98 irrigation diversions have been screened.	1, 27, 32, 33, (4)
13E7.	Pahsimeroi R.	48	475	Lower 16 km. of main river.	About same as present.	Has many good spawning areas. Recently 19 diversions on this tributary have been screened.	1, 27, 32, 33, (4)
13E8.	East Fork Salmon R.	48	541	Most of East Fork, and lower parts of some tributaries.	About same as present.	East Fork system supports a good-sized run and has many excellent spawning areas.	1, 27, 32, 33, (4)
13E9.	Yankee Fork Salmon R.	40	579	Most of its length and chief tributary, West Fork.	About same as present.	Former gold dredging in upper areas reduced value of this stream. Now it is a good producer of chinook salmon, and has many good spawning areas.	1, 27, 32, 33, (4)
13E10.	Valley Creek	34	599	Most of its length.	About same as present.	Former gold dredging adversely affected the spawning area. Silt from dredging has been removed by river action. Now a good producer.	1, 27, 32, 33, (4)
13F.	Immaha R.	121	306	Upper river, Big Sheep Creek, and Lick Creek.	Little Sheep Creek.	Reported to be the most consistent producer of spring chinook salmon in eastern Oregon. Flows through a rugged mountainous section. Diversion of water and many log jams caused loss of run in Little Sheep Creek.	9, 27, 34
13G.	Pine Creek	52	336	Main stream, middle portion.[5]	Believed to have been larger, but no information on specific areas lost.	Irrigation has decreased flows somewhat. Present runs are believed to be small in comparison with former ones.	27, 34
13H.	Indian Creek	24	434	Middle portion.[5]	Areas below diversions were probably used formerly.	Irrigation diversions deplete flows in the summer. Small runs use portion of stream above agricultural area.[5]	(4)
13I.	Powder R.	184	473	Eagle Creek.	Middle and upper portions of main stem.	Thief Valley Dam, built in 1931, is believed to have eliminated previously depleted runs in main river. In early days, river had excellent spawning areas used by large runs. Current run to Eagle Creek is intercepted in Snake R. and transported to Rapid R. propagation facility. Fish in excess of plant capacity are transported and released in Eagle Creek.[5]	27, 34
13J.	Burnt R.	126	525	None.	Entire middle and upper portions of main river and South Fork.	Early runs were depleted by mining and heavy use of water for agriculture without provisions for fish. Unity Dam, constructed in 1940, blocked remaining runs from upper spawning areas.	27, 34
13K.	Weiser R.	132	550	None.	Upper main river, Little Weiser, Middle Fork, Mann Creek, and Crane Creek.	Irrigation diversions take almost all the water during summer, leaving lower main stem nearly dry. Irrigation diversions are not screened. This stream still had a few spring spawners through 1963. Run is now intercepted in Snake R. and transported to Rapid R. propagation facility.[5] Some fish of this stock may be included in groups transported and released in Eagle Creek of the Powder R. system.	1, 27, 32, 33, (4)

See footnotes at end of table.

Table 2.--Continued

Stream				Location of spawning areas		Notes	References[3]
Number[1]	Name	Length	Distance above mouth[2]	Present	Former		
		Km.	Km.				
13L.	Payette R.	116	574	None.	Main Payette; North, South, and Middle Forks; and tributaries.	A diversion dam cut off upper Payette R. from salmon more than 47 years ago. Black Canyon Dam, built in 1923, cut off most of the remaining spawning area. A small fragment of formerly great spawning area was used through 1963. Fish were intercepted at Oxbow Dam in 1964 and transported to Rapid R. facility or to Eagle Creek.[5]	27, (4)
13M.	Malheur R.	269	579	None.	Upper half main river, Willow and Bully Creeks, and most of North Fork.	Storage and diversion dams made principal spawning grounds inaccessible. Moreover, unfavorable stream conditions--low flows, excessive water temperatures, unscreened ditches, and siltation--made the accessible areas unsuitable. Formerly, large chinook salmon runs used this stream. Upstream areas still appear excellent for spawning.	28, 34
13N.	Boise R.	122	610	None.	Main river and most tributaries.	More than 50 years ago this river had good runs of spring chinook salmon. Water diversions and storage dams soon depleted the runs. No record of use in recent years.	28, (4)
13O.	Owyhee R.	241	612	None.	Main river and tributaries.	Once this stream supported a good run of spring chinook salmon, but irrigation diversions and dams depleted run. Owyhee Dam installed in 1933 finished the destruction.	28, 34
13P.	Bruneau R.	64	774	None.	Lower section.	Several reservoirs and numerous unscreened irrigation diversions removed this stream from production many years ago.	28, (4)
13Q.	Salmon Falls Creek	64	922	None.	Lower portion.	No salmon runs for many years. Loss due to irrigation.	13, 28, (4)
13R.	Rock Creek	72	958	None.	Lower portion.	Historical upper limit of spawning for spring chinook salmon in Snake River. Loss due to irrigation.	13, 28, (4)
14.	Yakima R.	319	539	Upper Yakima R. and Naches R.	Satus, Toppenish, Ahtanum, Wenas, and Teanaway R.	Irrigation diversions without provision for fish took much of the Yakima R. out of production in past. Screening of ditches has corrected most of the deficiencies in the main stem, but tributary areas still have many unscreened ditches. Intensive Indian fishery at Prosser and Sunnyside and other sections of river depletes brood stock.	3
15.	Wenatchee R.	88	753	Most of main river; portions of Chiwawa, Little Wenatchee, and White Rivers; and Nason, Icicle, and Peshastin Creeks.	Areas in Peshastin Creek and areas above Leavenworth National Fish Hatchery on Icicle Creek.	Runs depleted by early irrigation practices. Screening program during late 30's and Grand Coulee transplantation program improved production. Peshastin Creek has 8-km. section now used by spring chinook salmon. Main Wenatchee is one of best producers of large summer chinook salmon and also has an important spring sun.	17, 18, 19, 38

See footnotes at end of table.

Table 2.--Continued

Stream				Location of spawning areas		Notes	References[3]
Number[1]	Name		Distance above mouth[2]	Present	Former		
		Km.	Km.				
16.	Entiat R.	84	779	Most of main stream.	About same as present.	Steep gradient of tributaries prevents use by salmon. Stream contains many wide, shallow riffle areas that are ideal for spawning. Used by both spring and summer runs. Translocation of fish during Grand Coulee construction helped restore some of the production formerly lost because of dams and diversions.	17, 18, 19, 38
17.	Methow R.	114	843	Main stream and large tributaries noted below.	About same as present. Some areas may be reduced in size owing to irrigation diversion.	Large runs of 40 years ago depleted by an impassable dam. Dam removed in 1930. Grand Coulee transplant program helped restore runs. Stream is now a good producer.	17, 18, 19, 38
17A.	Twisp R.	44	45	Lower portion of main stream.	About same as present.	Good spawning gravel throughout most of main stream, but best area is in central portion. Supports a good-sized run.	17, 18, 19, 38
17B.	Chewack R.	64	77	Main stream to 52 km. above the mouth.	Same as present.	Numerous excellent spawning riffles throughout the available portion below Chewack Falls. This stream has largest spring chinook run of any single stream above Rocky Reach Dam.	17, 18, 19, 38
18.	Okanogan R.	129	859	Intermittent riffles throughout its length, and lower 2 km. of Similkameen R.	Salmon and Omak Creeks were lost to production due to irrigation and dams. Most of Similkameen R.	Main stream has high summer temperatures that limit use of stream. Similkameen R. was blocked at river km. 10 when a dam was built just above a passable falls.	17, 18, 19, 38
19.	San Poil R.	121	985	None.	About the lower 97 km.	Grand Coulee Dam cut off salmon runs in 1939. This stream formerly had a good run of chinook salmon.	3
20.	Spokane R.	145	1,035	None.	Lower 80 km. of main river, Little Spokane R., and other small tributaries.	Historically, salmon ascended this stream to Spokane Falls, about 80 km. above the mouth. In 1909, Little Falls Dam blocked runs at river km. 44. Subsequently other dams were built. Large runs spawned in this stream before the hydroelectric developments, but only remnant runs were left by 1939.	3
21.	Colville R.	64	1,117	None.	Lower 6 km.	Two falls, 24 and 12 m. high, blocked runs at river 6 km., but many salmon were reported to use the available portion in the early years.	3
22.	Kettle R.	258	1,128	None.	Lower 40 km.	A falls at river 40 km. may have been a total barrier to salmon. A dam was later superimposed on this falls. Spawners used lower part until 1939.	3
23.	Pend Oreille R.	161	1,189	None.	Lower 32 km.	A falls, 32 km. above the mouth, probably always blocked salmon. Heavy runs reported below falls in early years, but they declined after 1878. Small runs were present when Grand Coulee Dam was built.	3
24.	Kootenay R.	644	1,249	None.	Lower 32 km.	A falls, 32 km. above mouth, blocked runs in former years.	3

See footnotes at end of table.

Table 2.--Continued

Stream				Location of spawning areas		Notes	References[3]
Number[1]	Name	Length	Distance above mouth[2]	Present	Former		
		Km.	Km.				
25.	Columbia R.	1,947		Some spawning may occur in areas below Chief Joseph Dam.	Above Grand Coulee Dam, 958 km. to Windermere Lake.	Chinook salmon ascended to headwaters of Columbia River as late as 1939. They usually appeared during last week in August and started spawning shortly thereafter. These fish were large--18 to 27 kg.--and during some years were seen in large numbers. This stock was transferred during the Grand Coulee salvage program, and fish of this size now spawn in the main stems of Columbia and Wenatchee Rivers.	3, 8, 38

[1] The streams are listed in numerical sequence, proceeding upstream from the mouth of the Columbia. Streams that are direct tributaries of the Columbia are identified by numerals only; subtributaries are designated by a combination of numerals and letters.
[2] Location in kilometers above mouth of Columbia or kilometers above mouth of contributing drainage.
[3] References have been numbered for easy location in Literature Cited, pages 24-26.
[4] Unpublished information provided by Forrest R. Hauck, Biologist, formerly with the Idaho Department of Fish and Game, now with the Federal Power Commission, Washington, D.C.
[5] Subject to change when additional dams are built in Snake River.

Table 3.--Estimated number of spring- and summer-run chinook salmon in the Columbia River and tributaries, 1939-66.[1]

Year	Lower river, spring[2]	Upper river, spring[3]	Total, spring	Summer[3]	Total, spring and summer
	Numbers of fish				
1939....	(4)	151,937	[5] 203,937	191,887	[5] 395,824
1940....	(4)	89,977	[5] 141,977	112,674	[5] 254,864
1941....	(4)	107,631	[5] 159,631	106,471	[5] 266,102
1942....	(4)	77,213	[5] 129,218	94,869	[5] 224,087
1943....	(4)	131,286	[5] 183,286	57,029	[5] 240,315
1944....	(4)	56,275	[5] 108,275	67,090	[5] 175,365
1945....	(4)	82,680	[5] 134,680	52,643	[5] 187,323
1946....	68,600	123,853	192,453	72,049	264,502
1947....	59,000	185,436	244,436	86,265	330,701
1948....	40,100	125,754	165,854	86,896	252,750
1949....	37,850	138,123	175,973	57,783	233,756
1950....	24,800	119,653	144,453	69,350	213,803
1951....	49,600	205,860	255,460	116,397	371,857
1952....	67,500	245,844	313,344	114,452	427,796
1953....	96,800	229,403	326,203	94,973	421,176
1954....	44,400	188,717	233,117	114,751	347,868
1955....	32,500	281,004	313,504	147,683	461,187
1956....	77,600	216,910	294,510	195,202	489,712
1957....	52,800	252,990	305,790	206,995	512,785
1958....	62,800	198,543	261,343	187,497	448,840
1959....	53,400	137,511	190,911	169,737	360,648
1960....	24,200	133,909	158,109	142,606	300,715
1961....	27,500	161,448	188,948	129,164	318,112
1962....	38,200	199,769	237,969	108,022	345,991
1963....	48,100	147,299	195,399	100,016	295,415
1964....	58,400	147,376	205,776	91,175	296,951
1965....	41,000	157,701	198,701	75,974	274,675
1966....	44,200	150,939	195,139	71,997	267,136

[1] Data from Fish Commission of Oregon and Washington State Department of Fisheries (1967).
[2] Includes only the Willamette River run, which was derived by adding the sport catch in the Lower Willamette River, the Clackamas River run (count at River Mill Dam), and the count at the Willamette Falls fishway.
[3] Landings in the river fishery below Bonneville Dam plus the fishway count at Bonneville Dam.
[4] No estimates available.
[5] Run to Willamette River included. Assumed run of 52,000 fish based on 10-year average (1946-55).

are based on the commercial catches made in the Columbia River plus the fish counts at Bonneville Dam and the Willamette River run. Since these estimates do not include fish taken in the river sport fishery below Bonneville Dam and the offshore sport fishery, the spawning escapement to the Cowlitz (estimated to be about 10,000 fish), and the take of the commercial troll fishery (United States and Canadian) in the Pacific Ocean,[3] they must be regarded as minimum runs rather than total runs. Trend lines through 1966 (fig. 2) indicate improvement in spring-summer runs of chinook salmon since 1939.

Estimated average numbers of spring and summer chinook salmon entering each tributary of the Columbia River are given in table 4; streams with estimated populations of less than one thousand fish are not included.

[3] Large numbers of chinook salmon are caught in the ocean troll fishery, but it is difficult to determine what part of this catch is from the Columbia River. Tagged and fin-clipped chinook salmon from the Columbia River have been recovered in the ocean during several studies, but because of limited data it has not been possible to make firm estimates of the total contribution from the Columbia River. Rough estimates have been made, however, by the Bureau of Commercial Fisheries, Columbia River Development Program (1960) for the 1957 run. The ocean fishery caught an estimated 711,450 chinook salmon of Columbia River origin in 1957 (569,000 in the commercial catch and 142,450 in the sport catch), and the sport fishery in the Columbia River and tributaries below Bonneville Dam caught an estimated 62,080 chinook salmon. So the total estimate for all runs in 1957 was 1,563,000 chinook salmon. The total minimum run as shown in tables 3 and 7 for 1957 is 789,428 fish or about 50 percent of the total run.

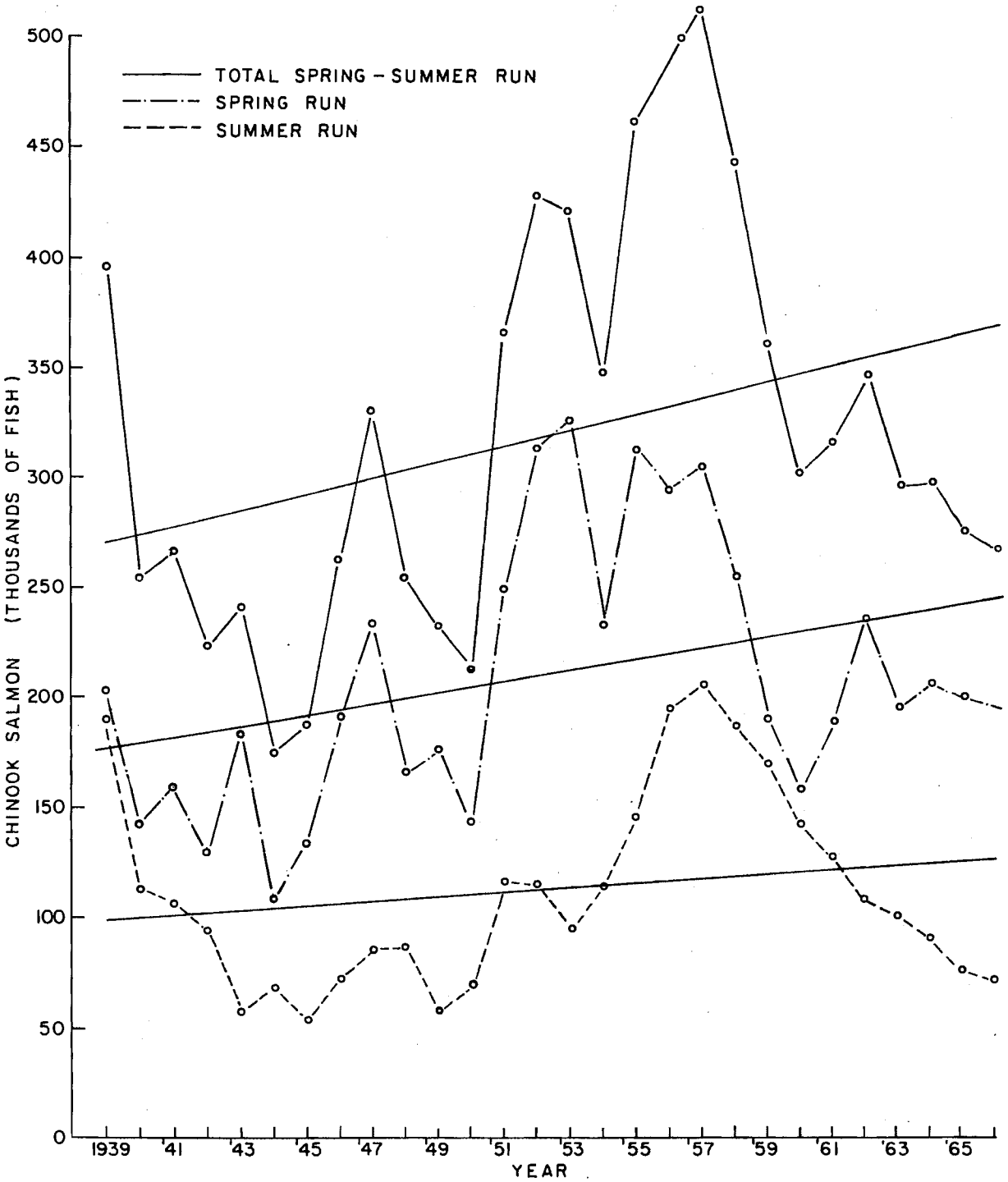

Figure 2.--Runs of spring and summer chinook salmon in the Columbia River, 1939-66. Runs exclude catches by the sport fishery in the ocean and lower Columbia River, landings by the offshore troll fishery, and the escapement to tributary streams entering the Columbia River below Bonneville Dam with the exception of the Willamette River run. The straight lines have been derived from the least squares method.

Table 4.--Estimated average numbers of spring- and summer-run chinook salmon entering tributaries of the Columbia River[1]

Stream	Period[2] (years)	Number of fish
		Thousands
Cowlitz River	([3])	10
Willamette River	1952-62	56
Sandy River	([3])	1
Wind River	1960-61	1
Klickitat River	1950-60	5
Deschutes River	([3])	5
Snake River tributaries:		
Tucannon River	1950-60	2
Grande Ronde River	1948-60	10
Salmon River	1957-60	104
Imnaha River	1948-60	5
Powder River (Eagle Creek)	1948-60	2
Weiser River	1951-59	2
Yakima River	1957-61	6
Wenatchee River	1957-60	16
Entiat River	1957-60	1
Methow River	1957-60	11
Okanogan River	1957-60	1
Total		238

[1] Estimates of numbers entering individual tributaries are based on counts in spawning areas.
[2] Period of years on which estimate is based.
[3] Specific years unknown.

State and Federal fishery biologists made the estimates after surveying or observing spawning in tributaries of their respective districts. I believe (as do many other biologists) that most of the streams are capable of supporting more chinook salmon than are listed in the table. Estimates in the Willamette River are based on a combination of fish counts at the Willamette Falls fishway (1952-62), the sport catch below Willamette Falls, and the run into the Clackamas River. Above the main stem dams--Bonneville, The Dalles, and McNary--average counts for the 4 years, 1957-60 (U.S. Army Corps of Engineers, 1964), were used to determine the numbers of fish available for spawning above each dam. For example, the average count of spring- and summer-run chinook salmon for the 4 years at McNary Dam was about 160,000 fish. Major[4] estimated that runs to the Yakima River averaged 6,000 on the basis of surveys and counts at dams for 1957-61. Counts of fish at Rock Island Dam provided a record of populations above the mouth of the Yakima; these counts averaged about 29,000 for the same period. The sum of the above figures was subtracted from 160,000 to leave an average of about 125,000 for the Snake River.

Figure 3 shows that the differences of spring- and summer-run chinook salmon counted at McNary and Bonneville Dams during 1954-56 vary from 62,000 to 162,000 fish. The difference during 1957-61 was 25,000 to 51,000 fish. The greater numbers lost between the two dams before 1957 was due to the take at Celilo Falls by the Indian dip net fishery. Construction of The Dalles Dam in 1958 inundated the Celilo Indian fishery and allowed a greater number to pass McNary Dam. An Indian gill net fishery was established above Bonneville about 1961, which again widened the gap between numbers counted at Bonneville and McNary Dams.

Distribution and size of present spring-summer runs of chinook salmon are given in map 3.

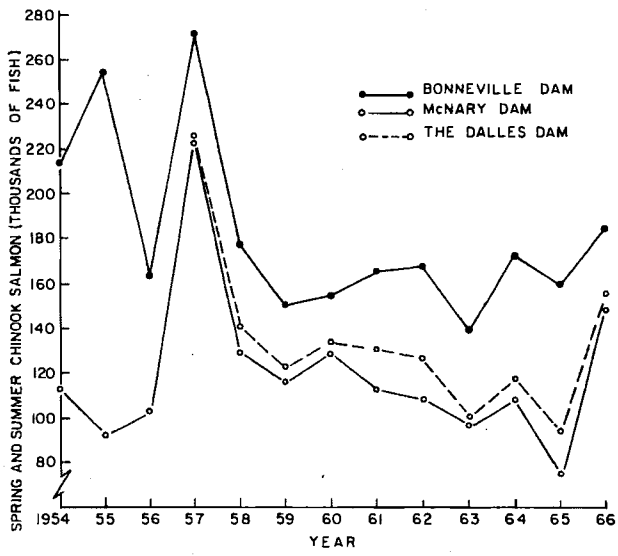

Figure 3.--Total counts of spring and summer chinook salmon at Bonneville, McNary, and The Dalles Dams, 1954-66.

[4] Personal communication, Richard L. Major, Fishery Research Biologist, Bureau of Commercial Fisheries Biological Laboratory, Seattle, Wash. 98102, October 26, 1961.

The importance of the Salmon River as a major contributor to runs of spring and summer chinook salmon in the Columbia River is readily evident. On the average, about 44 percent of the spring and summer runs entered the Salmon River. The Willamette River and the Columbia River network above the mouth of the Snake River ranked second and third in importance according to population of chinook salmon.

FALL-RUN CHINOOK SALMON

Fall-run chinook salmon are distinguished from the other runs by their period of migration; the fish enter the lower Columbia River from late summer to late fall. Those spawning in the tributaries of the lower Columbia River enter from August through October; spawning occurs shortly thereafter. The peak of fall chinook salmon runs destined for the middle reaches of the river arrives at Bonneville Dam about the first of September; it is followed by peaks at The Dalles and McNary Dams 1 and 2 weeks later.

Spawning Areas

Fall-run chinook salmon in the Columbia River drainage spawn principally in the lower tributaries and in sections of the lower and middle main stem (map 4). Spawning areas of fall chinook salmon in tributaries of the lower Columbia River are presented in greater detail in map 5. Table 5 gives the location and extent of all known areas used by these runs with brief descriptive notes. The numbering system was described previously for spring- and summer-run chinook salmon.

Logging by early white settlers was especially destructive to spawning areas for fall chinook salmon in the lower Columbia Basin. Stream beds were scoured by flushing logs downstream to the mills. Logging wastes were deposited in stream channels and often formed logjams that became so large they blocked access to the stream. Removal of cover from the watershed caused erosion, and the resulting siltation choked the streambeds.

Many watersheds now have a second growth cover, and productive capacity of the streams for rearing salmonids has improved accordingly. Under the Columbia River Fishery Development Program, conditions for spawning in tributaries of the lower Columbia have been further improved by removal of obstructions in streams and construction of fish ladders at natural falls and at dams.

Construction of large river-run dams on the main stem of the Columbia River has unquestionably removed some of the most valuable spawning grounds for fall-run chinook salmon. Other dams, either under construction or in the planning stage, will form reservoirs that will inundate nearly all of the remaining spawning areas in the main Columbia and Snake Rivers. Efforts are being made to maintain these runs with artificial spawning channels and hatcheries. Maintenance of future runs in the rivers above Bonneville Dam will hinge largely on the success of these artificial means of production.

The upper reaches of the main Columbia River were used by fall chinook salmon before the construction of Grand Coulee Dam started in 1939. This run, however, had been reduced considerably before the fish counts were begun at Rock Island Dam in 1933. Fall-run chinook salmon in this part of the Columbia River used the main stream and lower portions of the San Poil, Spokane, Pend Oreille, and Kootenay Rivers. The upper limit of spawning by fall chinook salmon in the Columbia River has not been clearly defined because of the difficulty in distinguishing between fall- and summer-run chinook salmon on the spawning grounds.

Chapman (1943) described spawning of chinook salmon in the main stem of the Columbia River and estimated that in 1938, before the blockage of salmon runs by Grand Coulee Dam, 800 to 1,000 chinook salmon spawned in a 3.2-km. (2-mile) area below Kettle Falls. Thus, between 15 and 20 percent of the total run of 4,801 chinook salmon passing Rock Island Dam in 1938 spawned in this area. Other spawning areas reported by Chapman were at Daisy and Rogers Bar--about 32 and 64 km. below Kettle Falls. I believe that these chinook salmon spawners in this area of the Columbia River were both summer- and fall-run migrants.

Additional spawning in the main stem was reported by Fish and Hanavan (1948) during aerial surveys of the Columbia River from Grand Coulee Dam to the confluence with the Snake River. Edson (1958a and 1958b) also located main stem spawning areas during preimpoundment studies at Priest Rapids, Wanapum, and Rocky Reach Dams. Salmon redds and spawning were observed on gravel bars along the shore and at the mouths of tributaries.

The areas below the confluence of the Snake River are more turbid, and it has been difficult to distinguish redds and spawning salmon in this reach of the Columbia River. Evidence indicates, however, that a large population of fall chinook salmon spawns in the 160-km. stretch of river below McNary Dam. This area will be inundated when John Day Dam is completed in 1968.

Historically, chinook salmon (believed to be fall-run fish) were reported by fishermen to have ascended the Snake River to the foot of Shoshone Falls, 976 km. above the mouth of the Snake River, but probably most of the run never reached this falls owing to difficult, turbulent rapids at Augur Falls, 16 km.

Table 5.--Present and former spawning areas of fall chinook salmon, Columbia River and tributaries

Stream				Location of spawning areas		Notes	References[3]
Number[1]	Name	Length	Distance above mouth[2]	Present	Former		
		Km.	Km.				
1.	Youngs R.	29	16	Two-km. section of of Youngs R., and lower section of Klaskanine R.	Same as present.	Youngs River Falls blocks upper 16 km. of main stream. A succession of excellent spawning riffles exists in 1-km. stretch below falls. Klaskanine River Hatchery of the O.F.C. supplements production.	29
2.	Grays R.	26	34	Section above tidal influence.	Spawning formerly limited by falls; more available now.	Grays River Hatchery of the W.D.F. was put into operation in 1961 to supplement natural spawning. Falls 11 to 13 km. above tidewater were recently made passable to salmon.	2, 39
3.	Big Creek	21	37	Small stretch above tidal area.	About same as present.	Big Creek Hatchery (O.F.C.), 5 km. above mouth, rears most of fish.	29
4.	Gnat Creek	14	39	Intermittent sections in lower 10 km. above tidewater.	Same as present.	Has little suitable spawning area because of preponderance of bedrock and large rubble.	29
5.	Elokomin R.	24	61	Most of main stream above tidewater, and lower West Fork.	About same as present.	Natural production is supplemented by Elokomin River Hatchery (W.D.F.)	2, 39
6.	Clatskanie R.	40	80	Chiefly in lower section.	Same as present.	This small stream has fair spawning area up to an impassable falls 19 km. upstream.	29
7.	Mill Creek	10	85	Above tidewater for several kilometers and Little Mill Creek.	Spawning formerly limited by falls.	A ladder was constructed in 1951 over a falls 4 km. above mouth.	2, 39
8.	Abernathy Creek	21	87	Lower 8 or 10 km. exclusive of tidewater area.	Runs introduced in 1950.	Abernathy National Fish Hatchery, constructed in 1960, supplements natural production. Fishway was built at a falls 6 km. above mouth in 1951. Streams has excellent spawning areas.	2, 39
9.	Cowlitz R.	209	105	Throughout most of main stem and many tributaries (given below). Most productive area in section from mouth of Toutle R. to Mayfield Dam.	Thirteen km. of intermittent spawning in main river inundated by Mayfield Reservoir.	This large stream has one of the most productive spawning areas for fall chinook salmon in the Columbia Basin. Mayfield and Mossyrock Dams (the latter under construction) are posing special problems in maintaining runs above these projects.	2, 39
9A.	Coweeman R.	53	2	Most extensive spawning area is within 13 to 26 km. from mouth.	Less than now.	Stream improvement work and provisions for passage at barriers have increased spawning areas.	2, 39
9B.	Toutle R.	84	27	Throughout most of main river, and lower North Fork.	About same as present.	Excellent areas for fall chinook are located in the Toutle system. Toutle River Hatchery (W.D.F.) on Green River supplements natural production.	2, 39
9C.	Salmon Creek	56	53	Lower 5 km.	About same as present.	Past logging operations nearly exterminated runs, but reforestation has led to some improvement. Supports a small run.	2, 39
9D.	Tilton R.	42	103	Lower portion.	Lower 3 km. Extent of spawning in upper river unknown.	Many excellent spawning areas above lower canyon. Mayfield Reservoir now floods the lower 3 km. of stream. Three-meter dam near Morton blown out in 1944.	2, 39
9E.	Cispus R.	80	148	Main Cispus R. and lower North Fork.	Same as present.	Lower 53 km. contains excellent spawning areas.	2, 39

See footnotes at end of table.

Table 5.--Continued

Stream				Location of spawning areas		Notes	References[3]
Number[1]	Name	Length	Distance above mouth[2]	Present	Former		
		Km.	Km.				
10.	Kalama R.	68	121	Main river throughout most of lower half.	Dam and falls blocked runs for many years, but area above falls now available.	Kalama Hatcheries Nos. 1 and 2 (W.D.F.) supplement production on this stream. Fishways built at falls and dam 18 km. upstream opened 48 km. of new spawning in 1956.	2, 39
11.	Lewis R.	145	137	Lower portion below Merwin Dam.	About 48 km. inundated by reservoirs.	Formerly runs of fall chinook spawned above Merwin Dam. Remnants of these runs are artificially propagated at Lewis River Hatchery (W.D.F.) and remainder spawn below Merwin Dam.	2, 39
11A.	East Fork	68	8	Lower 34 km.	Same as present.	Lucia Falls is uppermost limit of salmon passage.	2, 39
11B.	Cedar Creek	32	26	Lower 24 km.	See next column.	An old milldam 3 km. above mouth blocked runs for 70 years until removed in 1946. Cedar Creek Falls had ladders installed in 1957, which opened about 24 km. for salmon.	2, 39
12.	Willamette R.	304	162	None in main stem.	Small amount below mouth of Clackamas R.	Willamette Falls, 75 km. upstream, probably always blocked fall chinook salmon. Improved fishway planned at the falls should open up many kilometers of stream for fall spawners. Plants of fall-run progeny commenced in 1964. First adults returned in 1966. Pollution problems still exist in lower river.	29, 40
12A.	Clackamas R.	129	34	Lower 8 km.	Eighteen km. inundated by hydroelectric impoundments.	Formerly believed to have had a large fall run. Fish passage is provided at a three-dam hydro complex, but fall chinook salmon are not known to migrate above River Mill Dam at present.	29, 40
12A1.	Eagle Creek	37	26	Lower 16 km.	Unknown	Eagle Creek National Fish Hatchery supplements production. Stream improvement increased value of stream. Recent introductions have been moderately successful.	29, 40
13.	Washougal R.	58	190	Lower portion of Washougal.	Some areas probably lost due to small dams. New area gained. See note.	Washougal Hatchery, operated by W.D.F., supplements natural production. Ladder built at Salmon Falls in 1957 opened up several kilometers for spawning.	2, 14
14.	Sandy R.	72	193	Lower part of main Sandy.	About same as present.	Main Sandy has excellent spawning areas, but power dams and diversions have reduced the value for salmon production.	29
15.	Tanner Creek	6	232	Little natural spawing.	A falls blocks runs 2 km. above mouth.	Bonneville Hatchery (O.F.C.) maintains the run in this tributary, which enters the Columbia immediately below Bonneville Dam.	29
16.	Eagle Creek	18	235	Little natural spawing.	A falls historically blocked runs 3 km. above mouth.	O.F.C. intercepts salmon run about 1 km. upstream. Eggs are reared at Cascade Hatchery (O.F.C.).	29
17.	Herman Creek	11	243	Little natural spawning.	Limited by falls about 2 km. above mouth. Now nearly all fish are taken for hatchery rearing.	Oxbow Hatchery (O.F.C.) supports the fall run in this small tributary.	29

See footnotes at end of table.

Table 5.--Continued

Stream				Location of spawning areas		Notes	References[3]
Number[1]	Name	Length	Distance above mouth[2]	Present	Former		
		Km.	Km.				
18.	Wind R.	52	249	Lower and middle portions of main stream and limited amount in tributaries.	Limited to lower 2 km., which was flooded out by Bonneville pool. See note.	Carson National Fish Hatchery supplements natural production. Lower section of the stream was the only original natural producing area. Falls were made passable in 1956, opening up new area.	2, 39
19.	Little White Salmon R.	29	261	About 1 km. of spawning below hatchery rack.	Lower 1 km. inundated by Bonneville pool.	Nearly all fall chinook are reared at the Little White Salmon National Fish Hatchery. Series of falls short distance above mouth prevents upstream migration.	2, 14
20.	Spring Creek	.1	269	All artificial propagation.	No former run.	Run started by artificial propagation from salmon taken at Rowland lake bar and Big White Salmon R. Water supply for Spring Creek National Hatchery orginates from several large springs about 91 m. above mouth at Columbia R.	2, 14
21.	Big White Salmon R.	64	270	Lower 4 km.	Probably lower km. and midsection.	The Big White Salmon National Fish Hatchery supports about 60 percent of run. Northwestern (Condit) Dam blocked migration at 4 km. in 1913. Extent of former spawing area not clearly defined. Indians had a dip net fishery at town of Husum, and some fish passed falls near town. Lower 2 km. of stream flooded by Bonneville pool in 1938.	2, 14
22.	Hood R.	18	272	First 10 km. of main river.	More extensive than present.	A diversion dam 6 km. above mouth limits migration somewhat. Irrigation demands have reduced habitat. Runs much depleted.	25, 29
22A.	East Fork Hood R.	42	19	None.	Lower main stem.	Some scattered spawing areas in lower part of stream.	25, 29
22A1.	Middle Fork Hood R.	14	3	None.	No information.	Appears to have some potential spawning area.	25, 29
22B.	West Fork Hood R.	22	19	Limited use at present.	Probably lower half of main stream.	Many years ago, before irrigation diversion, salmon ascended Punchbowl Falls (1 km. above mouth). Fishway built at falls in 1957. A few fall chinook salmon were observed passing fishway in 1963. Stream has best potential in Hood Basin.	25, 29
23.	Klickitat R.	153	290	Lower 44 km. of main stem.	Confined to area below Castile Falls.	Fish ladder at Castile Falls has opened up many miles of additional area for spawning. Klickitat Hatchery (W.D.F.), operated since 1952, is providing stock for establishing runs in section above falls.	2, 39
24.	Main Columbia R. (Bonneville Dam to McNary Dam)	237	470	Above The Dalles pool to McNary Dam.	Bonneville and The Dalles reservoirs inundated some spawning area.	When completed, John Day Dam will inundate extensive spawning areas in section between John Day and McNary Dams.	Unpublished information

See footnotes at end of table.

Table 5.--Continued

Stream				Location of spawning areas		Notes	References[3]
Number[1]	Name	Length	Distance above mouth[2]	Present	Former		
		Km.	Km.				
25.	Snake R.	1,609	521	From Palouse R. junction, scattered areas for 32 km.; areas near Lewiston, Idaho; and scattered riffle areas up to Hells Canyon damsite.	Main river spawning above Hells Canyon damsite to Shoshone Falls. Ice Harbor, Oxbow, and Brownlee Dams have flooded spawning areas, and Hells Canyon Dam under construction will soon flood 32 km. more.	This large stream has extensive valuable spawning habitat. Recent surveys by air and boat indicate that a considerable expanse of the river course is used for spawning. Salmon are trapped at Hells Canyon damsite and taken to Oxbow propagation facility for rearing. Spawning areas below Oxbox will eventually be inundated by dams now authorized for construction. Fall chinook salmon possibly use the lower Salmon, Imnaha, and Grande Ronde.	13, 26, 27, 28
26.	Yakima R.	319	539	Lower portion.	Extent of former use unknown.	A few fall chinook salmon are reported to use lower Yakima (personal communication, Robert French).	3
27.	Section of main Columbia R. above McNary Dam.	539	879	Above McNary pool to Priest Rapids Dam, and a small area near mouth of Wenatchee R.	McNary, Priest Rapids, Wanapum, Rock Island, Rocky Reach, Wells, Chief Joseph, and Grand Coulee pools inundated spawning area. In addition, areas above Grand Coulee were taken out of production when runs were cut off by high dam.	Wells Dam, just completed, inundated most of the remaining spawning area for fall chinook salmon in this section of the Columbia R. Many excellent spawning areas are scattered throughout available areas which should be saved for salmon.	3, 8, 11, 12, 17, 18, 19, 38

[1] The streams are listed in numerical sequences, proceeding upstream from the mouth of the Columbia. Streams that are direct tributaries of the Columbia are identified by numerals only; subtributaries are designated by a combination of numerals and letters.
[2] Location in kilometers above mouth of Columbia or kilometers above mouth of contributing drainage.
[3] References have been numbered for easy location in Literature Cited, pages 24-26.

downstream (Evermann, 1896). Construction of a dam at Swan Falls in 1907 blocked runs of fall chinook salmon above this point. Although the fishway at Swan Falls was improved in 1940, the run was not reestablished. The Hells Canyon damsite now marks the upper limit of spawning of fall-run salmon.

During the early 1900's, the Fish Commission of Oregon placed a weir in the Snake River near Ontario, Oreg. to take fall chinook salmon for hatchery production. Although only a part of the run was intercepted at this site, more than 20 million eggs (requiring 4,000 females) were taken in 1 year, indicating the former size of the run migrating into the upper reaches of the Snake River (Parkhurst, 1950c).

Abundance of Fall-Run Chinook Salmon

Fishing for fall-run chinook salmon did not begin until about 1890, after a sharp decline in production of the more highly prized spring and summer runs in the late 1880's. The fall run made up the major portion of the catch for most years from 1928 to 1966 (table 6). The table does not include catches made by the troll fishery in the ocean, a large portion of which is believed to originate in the Columbia River.

Landings of fall chinook salmon and the escapement above Bonneville Dam for 1938-66 are recorded in table 7. Estimates of the minimum runs exclude catches by the sport fishery (in the river below Bonneville Dam and in the ocean), landings by the offshore troll fishery, and the escapement to tributary streams entering the Columbia below Bonneville Dam. The run has declined markedly despite a fairly uniform escapement over the years (fig. 4). Two levels of production (in numbers of fish) are indicated--(1) 550,000 to 1,200,000 (1938-50) and (2) 232,000 to 393,000 (1951-66).

Counts of fall chinook salmon at the three main stem dams--Bonneville, The Dalles, and McNary--are plotted in figure 5. After completion of The Dalles Dam in 1957, the number of fall chinook salmon passing McNary Dam increased considerably. This increase coincided with the end of fishing at Celilo Falls, the historical Indian fishing site that was lost because of backwater from The Dalles Dam. Indians recently developed a set net fishery above Bonneville Dam, and catches in this general area are again substantial.

Estimates of the fall chinook salmon returning to major tributaries and main stem areas of the Columbia and Snake Rivers are pre-

Table 6.--Catch of chinook salmon in the Columbia River by seasons, 1928-66

Year	Spring	Summer	Total spring-summer	Fall
	Thousands of kilograms			
1928.....	1,000	2,318	3,318	4,140
1929.....	1,166	2,272	3,438	3,012
1930.....	1,324	1,900	3,224	4,118
1931.....	1,362	2,506	3,868	5,666
1932.....	1,164	2,510	3,674	3,509
1933.....	731	3,044	3,775	4,514
1934.....	743	2,264	3,007	5,344
1935.....	1,157	2,224	3,381	3,494
1936.....	958	1,661	2,619	4,595
1937.....	1,551	1,328	2,879	5,572
1938.....	815	992	1,807	3,857
1939.....	740	1,544	2,284	3,849
1940.....	360	847	1,207	4,924
1941.....	665	883	1,548	8,977
1942.....	503	660	1,163	7,307
1943.....	604	404	1,008	4,188
1944.....	490	528	1,018	5,367
1945.....	710	233	943	4,959
1946.....	559	207	766	5,710
1947.....	556	449	1,005	6,882
1948.....	902	289	1,191	6,699
1949.....	774	137	911	3,984
1950.....	595	196	791	3,936
1951.....	903	286	1,189	3,365
1952.....	1,322	319	1,641	1,658
1953.....	808	321	1,129	2,025
1954.....	660	269	929	1,515
1955.....	1,583	504	2,087	1,823
1956.....	1,158	776	1,934	1,794
1957.....	879	606	1,485	1,264
1958.....	1,066	658	1,724	1,243
1959.....	628	577	1,205	982
1960.....	451	366	817	998
1961.....	532	418	950	1,005
1962.....	793	259	1,052	1,460
1963.....	675	254	929	1,067
1964.....	538	149	687	1,390
1965.....	650	50	700	2,050
1966.....	305	8	313	1,304

Table 7.--Estimated number of fish in runs of fall chinook salmon, Columbia River, 1938-66[1]

Year	Landed, lower river	Count at Bonneville Dam	Landed above Bonneville	Escapement to areas above Bonneville	Minimum run[2]
	Number of fish				
1938.....	347,447	234,651	77,169	157,482	582,098
1939.....	364,248	186,051	59,104	126,104	550,299
1940.....	439,635	303,244	103,152	200,092	742,879
1941.....	803,039	372,740	187,803	184,937	1,175,779
1942.....	642,192	336,834	162,714	174,120	979,026
1943.....	366,808	234,139	93,471	140,668	600,947
1944.....	512,498	197,294	79,155	118,139	709,792
1945.....	485,257	226,353	59,295	167,058	711,610
1946.....	504,662	327,295	124,569	202,726	831,957
1947.....	595,622	307,955	156,294	151,661	903,577
1948.....	588,604	310,590	149,897	160,693	899,194
1949.....	369,687	180,891	69,469	111,422	550,578
1950.....	338,060	250,482	95,789	154,693	588,542
1951.....	247,943	137,617	57,065	80,552	385,560
1952.....	102,534	220,396	77,204	143,192	322,930
1953.....	152,820	140,371	49,312	55,059	257,191
1954.....	125,069	106,784	44,027	62,757	231,853
1955.....	176,271	105,318	29,675	75,643	281,589
1956.....	176,428	136,268	38,234	98,034	312,696
1957.....	144,830	131,813	2,232	129,581	276,643
1958.....	143,888	249,314	3,480	245,834	393,202
1959.....	101,081	194,943	1,220	193,723	296,024
1960.....	136,830	101,282	1,589	99,693	238,112
1961.....	115,601	116,824	5,703	111,121	232,425
1962.....	158,942	118,024	4,982	113,042	276,966
1963.....	98,947	139,075	23,459	115,616	238,022
1964.....	154,477	172,463	24,535	147,928	326,940
1965.....	203,331	157,685	29,006	128,679	361,016
1966.....	145,928	155,445	7,672	147,773	301,373

[1] Data from Fish Commission of Oregon and Washington Department of Fisheries (1967).

[2] Minimum run is given because of unknown number of fish which originated in the Columbia River that were caught in troll fishery.

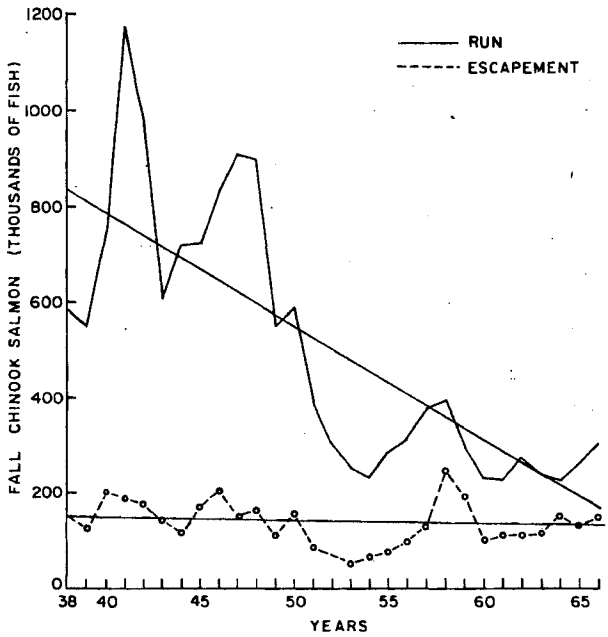

Figure 4.--Runs of fall chinook salmon in the Columbia River and escapement to areas above Bonneville Dam, 1938-66. Runs exclude catches by the sport fishery in the ocean and lower Columbia River, landings by the offshore troll fishery, and the escapement to tributary streams entering the Columbia River below Bonneville Dam. Straight lines have been derived from the least squares method.

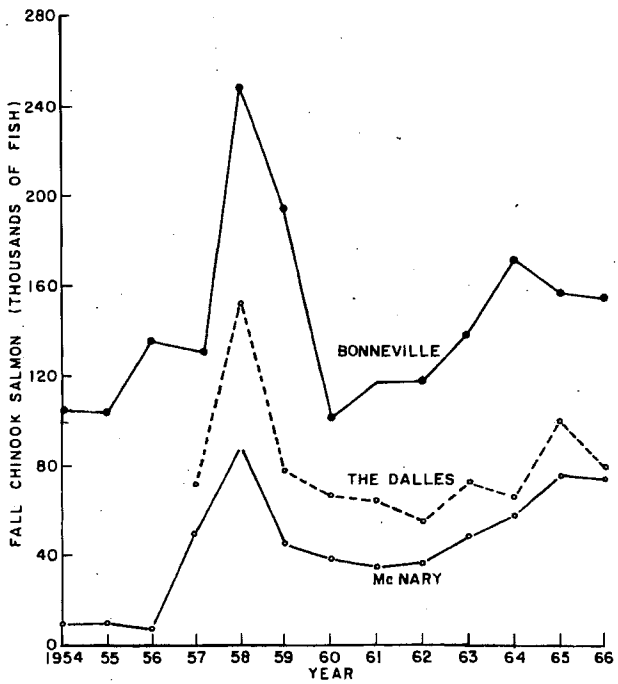

Figure 5.--Counts of fall chinook salmon at Bonneville, The Dalles, and McNary Dams, 1954-66.

Table 8.--Average number of fall-run chinook salmon entering sections of the Columbia River and its tributaries[1]

Stream	Period[2]	Number of fish
		Thousands
Klaskanine, Grays, Elokomin, Clatskanie Rivers, and Big and Gnat Creeks	([3])	4
Cowlitz River	([3])	31
Kalama River	([3])	20
Lewis River	([3])	5
Washougal River	([3])	3
Tanner Creek (Hatchery)	1958-60	7
Eagle Creek (")	1958-60	5
Herman Creek (")	1944-60	4
Wind River	1960-61	4
Little White Salmon River	1957-59	10
Spring Creek (Hatchery)	1957-59	34
Big White Salmon River	1957-59	5
Hood River	([3])	1
Klickitat River	1957-63	2
Columbia River, John Day damsite to McNary Dam	1957-60	[4] 34
Snake River:		
Main Snake, mouth to Salmon River junction	1957-60	[5] 13
Main Snake from mouth of Salmon River to Oxbow Dam	1957-60	[5] 20
Main Snake above Brownlee Dam	1957-60	[6] 8
Columbia River, Pasco to Chief Joseph Dam	1957-60	15
Total		225

[1] Estimates of numbers entering individual tributaries are based on counts in spawning areas or numbers appearing at hatchery racks.
[2] Period on which estimate is based.
[3] Specific years unknown.
[4] Estimates of population using this reach are based on aerial surveys.
[5] Estimates based on apportionment of total run entering Snake River.
[6] Counts at Oxbow and Brownlee Dams.

sented in table 8 and map 6. (Streams having estimated spawning populations of less than 1,000 fish are not included.) Average counts of fall chinook salmon at Bonneville, The Dalles, and McNary Dams were 163,000, 90,000, and 56,000, respectively, for 1957-60. These counts were considered in estimating runs above each dam.

Runs to the uppermost spawning areas in the Snake River have been greatly reduced in recent years primarily because of the failure of juvenile salmonids to pass through Brownlee Reservoir. All fall chinook salmon bound for spawning areas above Brownlee Reservoir are now intercepted at the Hells Canyon damsite and propagated artificially. The most important production areas for fall chinook salmon, according to average returns during 1957-60, were as follows: (1) Snake River, (2) main Columbia River from John Day to McNary Dams, (3) Spring Creek (hatchery production only), (4) Cowlitz River, and (5) Kalama River.

SUMMARY AND CONCLUSIONS

Irrigation, logging, mining, dam construction, and other activities have reduced the productive capacity of many of the spawning streams for chinook salmon throughout the Columbia Basin.

Much of the information contained in this report on spawning is based on reports published in 1948-50 by the Fish and Wildlife Service. The data in the reports were obtained by extensive surveys of the Columbia River Basin which were started in 1934 by the U.S. Bureau of Fisheries and continued under the Fish and Wildlife Service until 1946. Subsequent reports by both Federal and State fishery agencies were used to obtain more specific information on certain sections of the Columbia River Basin.

Cooperative Federal-State public works programs in the 1930's corrected conditions in many problem areas by installation of fish screens on water diversions, improvement of fishways, and removal of logjams and splash-dams. The Columbia River Fishery Development Program (a Federal-State construction and rehabilitation program started in 1949) has restored productive areas, made new areas available, and provided numerous hatcheries.

The Columbia Basin has three runs of chinook salmon--spring, summer, and fall--based on the periods when the adults migrate from the ocean to the river. Spring and summer runs dominated the catches until about 1928, when catches from the fall run became larger.

Adult spring-run chinook salmon start their spawning migrations by entering the Columbia River from February to mid-May and spawn in smaller tributaries and upper reaches of large streams from late July to late September. Summer-run chinook salmon enter from June through mid-August and spawn in the main stem and medium and large midriver tributaries from mid-August to mid-November. Fall-run chinook salmon enter the Columbia River from August 15 through October. They spawn from September to December in tributaries of the lower and middle river; the main stem above The Dalles, McNary, and Rocky Reach pools; and in the Snake River from above Ice Harbor pool to Hells Canyon damsite.

Spring- and summer-run chinook salmon now migrate in largest numbers to spawning grounds of the Salmon River in Idaho and its tributaries; these runs constitute 44 percent of the recent (1957-60) Columbia River escapements. Other tributaries having substantial

to modest runs of these fish are the: Willamette, Wenatchee, Methow, Cowlitz, Grande Ronde, Yakima, Imnaha, Klickitat, and Deschutes Rivers. In recent years the escapement to the Yakima River has been seriously depleted by an intensive Indian fishery. Small runs of this group of fish migrate to the Tucannon, Sandy, Wind, Entiat, Okanogan, Kalama, Clearwater, John Day, Umatilla, and Walla Walla Rivers and several smaller tributaries of the middle Snake River.

Spawning areas for spring- and summer-run chinook salmon have been taken out of production by water-use developments in nearly every tributary of the Columbia Basin. Grand Coulee, Dexter, and Lewiston Dams are notable examples of obstructions that cut off large areas from access to migratory fish in the upper Columbia, Middle Fork Willamette, and Clearwater Rivers. Irrigation practices were responsible for the loss of runs in most of the John Day, Umatilla, and Walla Walla Rivers in addition to a number of tributaries of the middle and upper Snake River.

Fall-run chinook salmon spawn in the following tributaries of the Columbia River: Youngs, Grays, Elokomin, Clatskanie, Cowlitz, Kalama, Lewis, Willamette, Washougal, Sandy, Wind, Little White Salmon, Big White Salmon, Hood, Klickitat, and Yakima Rivers; and Big, Gnat, Mill, and Abernathy Creeks. They also use spawning areas in the main stem of the Columbia River above The Dalles pool to McNary Dam, above the McNary pool to Priest Rapids Dam, off the mouth of the Wenatchee River near the head of Rock Island pool, and in the main Snake River from above the Ice Harbor pool to areas below Hells Canyon damsite.

Fall chinook salmon runs in Tanner, Eagle (Cascade), and Herman Creeks and Little White Salmon River are maintained almost entirely by State and Federal hatcheries because little natural spawning occurs in these streams. Hatcheries also supplement natural production in numerous other tributaries of the lower Columbia River. A hatchery maintains all of the production in Spring Creek.

Spawning areas for fall-run chinook salmon have been lost in the Cowlitz, Lewis, Willamette, Wind, Little White Salmon, and Hood Rivers, in sections of the main Columbia River inundated by reservoirs or cut off by Chief Joseph Dam, and in the Snake River above Hells Canyon damsite.

The reservoir at John Day Dam, under construction, will soon inundate all of the remaining spawning areas in the main stem of the Columbia River with the exception of the 161-km. stretch from the head of McNary Pool to Priest Rapids Dam. Most of the spawning grounds in the main stem of the Snake River also will eventually be inundated by dams.

The largest group--about 41,000--of fall chinook salmon (based on 1957-60 averages) migrated to the Snake River. The second largest unit, a group of about 34,000 fall-run chinook salmon, used the main Columbia River from John Day damsite to McNary Dam. Other current production areas in descending order of estimated runs for the above period are: Spring Creek (hatchery), Cowlitz, Kalama, and Little White Salmon Rivers.

Estimated size of the fall chinook salmon run for 1938-66 ranged from 231,835 to 1,175,779 fish, and runs of spring and summer chinook salmon for the same years ranged from 175,365 to 512,785. These estimates were derived by converting the commercial catch in pounds to numbers of fish and adding the number of fish passing Bonneville Dam. Unknown landings by the ocean troll fishery and catches by sport fishermen (though believed to be considerable) were not included. Trend lines since 1938 indicate some improvement in spring and summer chinook salmon runs, whereas fall runs show a serious decline.

Many tributaries of the Columbia and Snake Rivers have spawning and rearing areas of good quality. The key to increased production probably lies in better survival of the eggs, fry, and fingerlings--not to mention the safe, timely migration of juveniles from the rearing areas to the ocean. If passage and rearing conditions were improved in the main stems of these rivers, the runs would increase and eventually lead to a greater harvest by the fisheries.

ACKNOWLEDGMENTS

Many State and Federal officials supplied unpublished information on the location of spawning gravel throughout the Columbia Basin. The following fishery biologists either reviewed the original draft or pointed out chinook salmon spawning areas in their districts: Henry O. Wendler, Washington Department of Fisheries; Robert Rennie and Dorian Lavier, Washington Department of Game; Robert T. Gunsolus, Jack Van Hyning, Lawrence Korn, and Jack Thompson, Fish Commission of Oregon; Charles J. Campbell and Jim Hewkin, Oregon State Game Commission; and Forrest R. Hauck, formerly with the Idaho Department of Fish and Game.

LITERATURE CITED

(Citations have been numbered to permit easy reference in tables)

1. BJORNN, TED C., and MONTE RICHARDS.
   1961. Aerial survey of chinook salmon redds in the Salmon and Weiser River drainages, 1960. Dep. Fish Game, Idaho, 11 pp. + add. 26 pp. [Processed.]
2. BRYANT, FLOYD G.
   1949. A survey of the Columbia River and its tributaries with special reference to the management of its fishery resources--Part II. Washington streams from the mouth of the Columbia to and including the Klickitat River (Area I). Fish Wildl. Serv., Spec. Sci. Rep. 62, ii + 110 pp.
3. BRYANT, FLOYD G., and ZELL E. PARKHURST.
   1950. Survey of the Columbia River and its tributaries--Part IV. Area III. Washington streams from the Klickitat and Snake Rivers to Grand Coulee Dam, with notes on the Columbia and its tributaries above Grand Coulee Dam. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 37, ii + 108 pp.
4. BUREAU OF COMMERCIAL FISHERIES.
   1958. Fishery development program of the Columbia River, progress report. Bur. Com. Fish., Portland, Oreg., 120 pp. [Processed.]
5. 1960. Review report, Columbia River fishery development program. Bur. Com. Fish., Portland, Oreg., vol. 1, 33 pp.; vol. 2, append. A-I, 149 pp. [Processed.]
6. 1961. Report of activities 1959-60. Columbia River Program Office, Bur. Com. Fish., Portland, Oreg., 21 pp. [Processed.]
7. 1964. Columbia River program--1963. U.S. Fish Wildl. Serv. Circ. 192, iii + 20 pp.
8. CHAPMAN, WILBERT M.
   1943. The spawning of chinook salmon in the main Columbia River. Copeia 1943(3): 168-170.
9. COLUMBIA BASIN INTERAGENCY COMMITTEE.
   1957. Columbia River Basin fishery program--Part 2, Inventory of streams and proposed improvements for development of the fishery resources limited to tributaries above McNary Dam. Fish. Steering Comm., Portland, Oreg., 100 pp. [Processed.]
10. CRAIG, JOSEPH A., and ROBERT L. HACKER.
    1940. The history and development of the fisheries of the Columbia River. Bull. U.S. Bur. Fish. 49: 133-216.
11. EDSON, QUENTIN A.
    1958a. Biological report, Priest Rapids fisheries research program. Wash. Dep. Fish., 15 pp. [Processed.]
12. 1958b. Biological report, Rocky Reach fisheries research program. Wash. Dep. Fish., 24 pp. [Processed.]
13. EVERMANN, BARTON W.
    1896. A preliminary report on salmon investigations in Idaho in 1894. Bull. U.S. Fish Comm. 15: 253-284.
14. FISH AND WILDLIFE SERVICE.
    1951. Lower Columbia River fisheries development program sub-basin reports, Portland, Oreg. Separate area reports; varied pagination. [Processed.]
15. 1952-57. Fishery development program of the Columbia River, progress reports for fiscal years 1952 to 1957, Portland, Oreg. Varied pagination. [Processed.]
16. FISH COMMISSION OF OREGON and WASHINGTON STATE DEPARTMENT OF FISHERIES.
    1967. The 1966 status report on the Columbia River commercial fisheries. 97 pp. [Processed.]
17. FISH, FREDERIC F., and MITCHELL G. HANAVAN.
    1948. A report upon the Grand Coulee fish-maintenance project, 1939-47. Fish Wildl. Serv., Spec. Sci. Rep. 55, iv + 63 pp.
18. FRENCH, ROBERT R., and R. J. WAHLE.
    1960. Salmon runs--upper Columbia River, 1956-57. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 364, iii + 15 pp.
19. 1965. Salmon escapements above Rock Island Dam, 1954-60. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 493, iii + 18 pp.
20. GUNSOLUS, ROBERT, and GEORGE J. EICHER.
    1962. Evaluation of the fish-passage facilities at the Pelton project on the Deschutes River in Oregon. Fish Comm. Oreg. and Portland Gen. Elec. Co., Portland, Oreg., 133 pp. [Processed.]
21. HAAS, JAMES B., and H. C. WARREN.
    1961. Environmental survey report pertaining to salmon and steelhead in certain rivers of Eastern Oregon and the Willamette River and its tributaries--Part III, Survey

reports of the Deschutes and John Day Rivers and Fifteen Mile Creek. Fish Comm. Oreg., 52 pp. [Processed.] (U.S. Fish Wildl. Serv., Bur. Com. Fish., contract 14-19-001-178, amend.)

22. MURPHY, LEON W., and HOWARD E. METSKER.
1962. Inventory of Idaho streams containing anadromous fish including recommendations for improving production of salmon and steelhead--Part II, Clearwater River Drainage. Idaho Dep. Fish Game, 197 pp. [Processed.] (U.S. Fish Wildl. Serv., Bur. Com. Fish., contract 14-19-001-431, June 1962.)

23. NIELSON, REED S.
1950. Survey of the Columbia River and its tributaries--Part V. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 38, ii + 41 pp.

24. OREGON STATE GAME COMMISSION.
1963a. The fish and wildlife resources of the Umatilla Basin, Oregon, and their water use requirements. A report to the State Water Resources Board, 36 pp. + append. 33 pp. [Processed.]

25. 1963b. The fish and wildlife resources of the Hood Basin, Oregon, and their water use requirements. A report to the State Water Resources Board, Fed. aid to fish restoration, progr. rep., 33 pp.+ append. 20 pp. [Processed.] (Proj. F-69-R1, Job 1.)

26. PARKHURST, ZELL E.
1950a. Survey of the Columbia River and its tributaries--Part VI, Area V - Snake River system from the mouth through the Grande Ronde River. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 39, ii + 58 pp.

27. 1950b. Survey of the Columbia River and its tributaries--Part VII, Area VI. Snake River from above the Grande Ronde River through the Payette River. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 40, ii + 95 pp.

28. 1950c. Survey of the Columbia River and its tributaries--Part VIII, Area VII. Snake River above Payette River to upper Salmon Falls. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 57, ii + 19 pp.

29. PARKHURST, ZELL E., FLOYD G. BRYANT, and REED S. NIELSON.
1950. Survey of the Columbia River and its tributaries--Part III. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 36, ii +103 pp.

30. PULFORD, EARL F., LAWRENCE M. WOODALL, and JAMES S. NORTON.
1963. Chinook and silver salmon average weight sampling statistics, an evaluation of variability associated with conversion factors, landings and numbers sampled for marks from the Columbia River commercial fishery for the years 1951-62. Fish Comm. Oreg., 2 pp. + 24 tables. [Processed.]

31. RICH, WILLIS H.
1948. A survey of the Columbia River and its tributaries with special reference to the management of its fishery resources--Part I, Introduction. Fish Wildl. Serv., Spec. Sci. Rep. 51, i + 26 pp.

32. RICHARDS, MONTE, and STACY GEBHARDS.
1959. Aerial surveys of spring chinook salmon redds in the Salmon and Weiser River drainages, Idaho, 1958. Dep. Fish Game, Idaho, 46 pp. [Processed.]

33. RICHARDS, MONTE, and TED C. BJORNN.
1960. Aerial survey of chinook salmon redds in the Salmon and Weiser River drainages, Idaho, 1959. Dep. Fish Game, Idaho, 40 pp. [Processed.]

34. THOMPSON, ROBERT N., and JAMES B. HAAS.
1960. Environmental survey report pertaining to salmon and steelhead in certain rivers of Eastern Oregon and the Willamette River and its tributaries--Part I, Survey reports of eastern Oregon rivers. Fish Comm. Oreg., 432 pp. + append. A-C, 79 pp. [Processed.] (U.S. Fish Wildl. Serv., Bur. Com. Fish., contract 14-17-001-178, June 1960.)

35. TUNISON, ABRAHAM V., and DONALD L. McKERNAN.
1960. A report on the fish and wildlife resources affected by the Bruces Eddy Dam and Reservoir, North Fork Clearwater River, Idaho. U.S. Bur. Sport Fish. Wildl. and U.S. Bur. Com. Fish., River Basin Studies, letter rep. (6 pp.) with substantiating rep., 40 pp. + 4 figs. [Processed.]

36. U.S. ARMY CORPS OF ENGINEERS.
1964. Annual fish passage report, North Pacific division, Bonneville, The Dalles, McNary, and Ice Harbor Dams, 1963. Portland and Walla Walla Dist., 20 pp. + 74 tables, 33 figs., 7 pages of photographs. [Processed.]

37. WARD, DALE, ROBERT ROBISON, and ARTHUR PALMEN.
1964. 1963 fisheries statistical report. Wash. State Dep. Fish., 73rd ann. rep., pp. 125-216.
38. WASHINGTON DEPARTMENT OF FISHERIES.
1938. Report of the preliminary investigations into the possible methods of preserving the Columbia River salmon and steelhead at the Grand Coulee Dam. Prepared for Bur. Reclama. by Wash. Dep. Fish., in cooperation with Dep. Game, and U.S. Bur. Fish., 121 pp. [Processed.]
39. WASHINGTON DEPARTMENT OF FISHERIES and U.S. FISH AND WILDLIFE SERVICE.
1951. Lower Columbia River fisheries development program sub-basin reports. Wash. Dep. Fish. in collaboration with Fish Wildl. Serv., separate area reports, varied paginations. [Processed.]
40. WILLIS, RAYMOND A., MELVIN D. COLLINS, and ROY E. SAMS.
1960. Environmental survey report pertaining to salmon and steelhead in certain rivers of Eastern Oregon and the Willamette River and its tributaries--Part II, Survey reports of the Willamette River and its tributaries. Fish Comm. Oreg., 554 pp. + append. A-C, 87 pp. [Processed.] (U.S. Dep. Interior, Fish Wildl. Serv., Bur. Com. Fish., contract 14-17-001-178, June 1960.)

MS. #1655

GPO 994-665